Book of Abstracts

Rome2015 SCIENCE SYMPOSIUM on CLIMATE

November 19-20

Co-organized by

Food and Agriculture Organization of the United Nations

Organized by

Società Italiana per le Scienze del Clima SISC

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ROME2015
Science Symposium on Climate

November 19-20 2015, Rome - Italy

Book of Abstracts

ISBN 978-88-97666-07-3

Venice, Italy - November 2015

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Introduction by Maria Helena Semedo

In the lead-up to COP21 and beyond, the Food and Agriculture Organization of the United Nations (FAO) has been working to increase awareness of the opportunities for climate action in the agricultural sectors to ensure food security for the billions of persons who depend on agriculture and natural resources.

FAO's mandate is to support member states in eradicating hunger and poverty, and in creating sustainable and productive food systems. Climate change makes this enormous challenge even more difficult.

To better address climate change – one of the most important issues of our time - FAO actively supports more productive, inclusive, resilient and low-emissions agricultural development that can boost incomes and food security for the world's poorest. As such, FAO promotes actions that reduce deforestation and overfishing and improve soil fertility and the sustainable management of natural resources.

FAO is pleased to host and be co-sponsor of the Science Symposium on Climate – Rome2015 aimed at highlighting knowledge, experience and research in climate sciences.

The themes discussed during the Symposium provide a unique opportunity to explore action areas that hold significant potential to support food security, climate change adaptation and mitigation.

Multidisciplinary discussions on technical topics – ranging from the physics of climate change, ocean, water, energy and food nexus in agriculture, landscape and biodiversity - in the context of negotiations during the Climate Conference (COP21), actions to be taken during the implementation of Intended Nationally Determined Contributions (INDCs) and the policies to address climate change emphasize the key role the scientific community plays to support evidence-based decision making in preparing needed adaptation and mitigation strategies, with explicit linkages to food security and sustainable development goals of developing countries.

This Symposium takes place two months after the adoption in New York of the 2030 Agenda for Sustainable Development, a historic commitment: a universal, time-bound blueprint for sustainable development in all its dimensions; and one week before the crucial COP21 meeting in Paris that intends to achieve a new international agreement on climate, applicable to all countries, with the aim of keeping global warming below 2°C.

I am sure that the debate and exchanges during this Symposium will highlight needed response actions and related policies on adaptation and mitigation activities to ensure food security in the face of climate change.

Maria Helena Semedo
Deputy Director-General / Coordinator for Natural Resources

Foreword by Donatella Spano

Dear Convenors,

Rome2015 SCIENCE SYMPOSIUM on CLIMATE is an unprecedented event that has been jointly organised by 14 Italian Scientific Societies involved in the study of climate, and it will address the interdisciplinary dimension of climate change to comprehensively address impacts and the socio-economic implications by overcoming the traditional borders between scientific disciplines.

The primary mission of the Symposium is to highlight the most significant results accomplished by the scientific community in the field of climate research and investigate future perspective for the environment and the society.

We all know that climate change is one of the most complex challenges the international community is facing. Addressing climate change is one of the most important objectives that needs to involve the widest possible international cooperation: as highlighted in our statement, the choices that we make today and in the very near future will affect our society. On the other hand, strategies to deal with climate change and its negative impacts must be part of a decision- making process involving the scientific community, stakeholders, and policy makers.

Only the cooperation and common work can make the difference in contrasting and reducing climate change impacts.

With this purpose, the second mission of the Symposium is to provide a unique and fruitful platform for dialogue, exchange of ideas and sharing of experiences within the scientific community, the stakeholders, the policy makers, the service providers, as well as the business and general public. Furthermore, the Symposium works toward the COP21 United Nations Climate Change Conference that will be held in Paris in december 2015, aiming to provide scientific knowledge in support of evidence-based adaptation and mitigation strategies and improve the public awareness on climate change impacts and sustainable growth.

The two-day program of the event alternates plenaries and parallel sessions.

Gianluca Galletti (Italian Minister for the Environment Land and Sea) will attend the opening sessions. Keynote lectures will be given in plenary sessions, in order to provide in-depth analyses on specific topics related to climate change sciences and policy. The Symposium has the honor to host Prof. Carlo Carraro (Director

of International Center for Climate Governance, Scientific Director of Eni Enrico Mattei Foundation, and Vice Chair of the Intergovernmental Panel on Climate Change Working Group III), Prof. Laurence Tubiana (Special Representative of the French Minister of Foreign Affairs for the 2015 Paris Climate Conference, COP-21, and French Ambassador for Climate Negotiations) and Dr. Martin Frick (Director of Climate, Energy and Tenure Division at FAO). The Director of Environment and Climate Division at IFAD (The International Fund for Agricultural Development, a specialized agency of the United Nations), Dr. Margarita Astralaga, will also contribute to the Symposium to share experiences to be transformed into operations-oriented learning and knowledge.

Parallel sessions will be dedicated to scientific presentations selected and evaluated by the Scientific Committee. The call for papers attracted submissions not only from all over Europe (e.g., Italy, Portugal, Spain, Germany, Greece) but also from India, Iran, Philippines, Bangladesh, Pakistan, Australia and many African Countries. More than 250 presentations and posters are gathered in parallel sessions grouped in six topics: “The physics of climate change; Ocean and climate change on the way to COP21; Water, energy and food nexus in agriculture; Climate change and the future of land system and biodiversity; Climate change response actions; COP21, the INDCs and policies to address climate change.”

Putting together Rome2015 SCIENCE SYMPOSIUM on CLIMATE was a team effort. We first thank the authors for their enthusiasm in sharing ideas and results from their scientific work by contributing to the program. We are also grateful to the Scientific Committee and the Organizing Committee who contributed to keep the high scientific level of this Symposium. A work of thanks to the Scientific and Organizing Secretariats here, at the end of a six-months of great effort and care in the preparation of the Symposium, is certainly in order. Their hard work will make, we are sure, these two days here in Rome productive and fulfilling.

The Symposium is supported by the PARIS2015 (COP21/CMP11) United Nations Climate Change Conference and by the Euro-Mediterranean Center on Climate Change. We would like to extend our thanks to the Ministry for the Environment, Land and Sea, the Regions of Sardinia and Latium, and the Italian Association for the United Nations for their advocacy. The Food and Agriculture Organization of the United Nations is greatly acknowledged also for having kindly made their headquarters available. Finally, we would also like to thank our partners Lenovo and Intel, who have generously contributed and collaborated with us to make this event happen.

We hope that you will find the program interesting, inspiring and stimulating, and that the Symposium will provide you with a profitable chance to share and exchange ideas with other researchers, stakeholders, and policy-makers from Institutions around the world.

Donatella Spano

Donatella Spano
SISC President

About ROME2015 Science Symposium on Climate

Few days before the COP21 in Paris, the Italian Scientific Community organizes an event in Rome aiming at fostering the international scientific debate on climate.

Scientific societies, Institutions and Associations dealing with the study of one of the most important issue of our times, its impacts and its socio-economic implications, share their experiences and their expertise with the participation of:

• internationally renowned keynote speakers

• experts gathering in parallel sessions for scientific multidisciplinary in-depth analyses

• decision makers and experienced people whose activities are related to the scientific knowledge on climate

The Symposium aims at:

• Highlighting the most relevant results achieved by the scientific community in the field of international climate research and policy;

• Emphasizing the role and the activity of the scientific community that carries out an interdisciplinary, cutting edge, innovative and international research in the field of climate to support public stakeholders in preparation of long and mid-term adaptation and mitigation strategies;

• Exploring future perspective for the research on climate;

Providing a fruitful opportunity of dialogue, exchange ideas and share experiences among the scientific community and with all the experts interested to know more about the up-to- date scientific knowledge on climate.

Organizing institutions

ROME 2015-SCIENCE SYMPOSIUM ON CLIMATE is jointly organized by: **SISC** - Società Italiana per le Scienze del Clima, **AGI** - Associazione Geofisica Italiana, **AIAM** - Associazione Italiana di AgroMeteorologia, **AIEAR** - Associazione Italiana degli Economisti dell'Ambiente e delle Risorse naturali, **ATIt** - Associazione Teriologica Italiana, **CATAP** - Coordinamento delle Associazioni Tecnico-scientifiche per l'Ambiente ed il Paesaggio, **COI** - Commissione Oceanografica Italiana, **FLA - GII** - Gruppo italiano di Idraulica, **HOS** - Historical Oceanografic Society, **SIDEA** - Società Italiana di Economia Agraria, **SIF** - Società Italiana di Fisica, SMI - Società Meteorologica Italiana, **UNASA** - Unione delle Accademie di Agricoltura.

The Symposium is hosted and co-organized by **FAO – Food and Agriculture Organization of the United Nations**. FAO provides its expertise to ensure that the Conference findings – which are sole responsibility of the organizers – are relevant to member countries goals of food security, sustainable natural resources management and rural development.

ROME2015 – SCIENCE SYMPOSIUM ON CLIMATE was granted the label "COP21", the official label of the UN Climate Change Conference. COP21 is 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21/CMP11), otherwise known as "Paris 2015" from November 30th to December 11th.

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CLIMATE CHANGE AND THE FUTURE OF LAND SYSTEM AND BIODIVERSITY

INDIRECT LINK TO CLIMATE CHANGE: LONG-TERM EFFECTS OF MEGAFAUNA ON TROPICAL FOREST STRUCTURE AND CARBON CYCLING

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Megafauna perform a broad range of functions in tropical ecosystems and have coevolved with plants for thousands of years[1,2]. Because tropical megafauna are rapidly being lost, many of these co-dependencies will cease[3,4]. Changes in tropical forests function might influence climate at different scales and their role in the global carbon cycle[5,6]. In fact, megafauna have been reported to have direct and indirect impacts on forest structure, function, and carbon cycling[7–9]. However, most tropical forest ecology research focusing on the effects of megafauna on vegetation rely on relatively short-term data or are spatially limited and can be biased by micro-habitat heterogeneity[10]. These limitations do not allow evaluating long-term changes in forest structure and carbon stocks as they only capture the early successional stages of forest regeneration. Specifically, changes in above ground biomass might not be noticeable in short term studies as carbon mass is linked to forest structure and species composition that require several years to reach steady-state after disturbance. Whether these changes will have any detectable consequences on tropical forests carbon stocks and atmosphere-biosphere dynamics is currently unknown. We reviewed research literature investigating the short and long-term impacts of megafauna on tropical forests dynamics and carbon cycling spanning across disciplines. We highlighted the current limitations of field-based studies in evaluating long-term consequences of loss of megafauna on tropical forest dynamics. Additionally we present further evidence of a research gap in assessing changes in carbon content in post defaunated tropical ecosystems. Lastly, we advocate the use of a modeling approach that could address some of these questions and present the most suitable model to do so. The modeling approach we propose could provide insights not only on forest dynamics but also on atmosphere-biosphere feedbacks. Keywords: megafauna, tropical forests, modeling, forest dynamics, carbon cycling

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CLIMATE CHANGE AND THE QUEST FOR WATER IN THE HIGH TOWERS OF ASIA

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Rivers from the glaciers of the Himalayas are a lifeline for a population of billions, and yet their dynamics, water budgets, and response to global change are little studied, and poorly understood. The accelerated melting of glaciers from the water towers of Asia, in response to diffuse warming, and more erratic rainfall patterns are expected to result in increasing variability of hydrological cycle, with larger floods in the melting season, and diffused and extended droughts otherwise. In addition, transient hydrology may bring into unrealistic plenty of water availability associated with runoff production from melting. However, while large literature worldwide provides conjectures of the potential state and fate of these mountains, experimental investigation and ground-based knowledge are lagging behind. The harsh environmental and climatic conditions of these high mountains make field investigation logistically complex, and physically challenging, and scientists are struggling in the need for data. This presentation narrates the quest for water of our POLIMI team on the highest mountains of the world, reporting of a four-year activity from the Khumbu glacier of Nepal at the toe of Mount Everest, to the majestic Baltoro glacier of Pakistani K2, seeking for the water into the ice. The presentation will illustrate how we gathered precious field data, including snow cover, ice thickness and melt, ice flow, and water flows, then used to set up credible hydrological models, and eventually quantify the water budgets of these areas, unraveling the hidden nexus between ice, climate and water. Then, we used climate projections from the IPCC to answer the question whether future ice cover and hydrological cycle will change significantly. Are the water towers of Asia indeed at stake? Attend at the presentation to find out.

DETECTING CHANGES IN ANNUAL MAXIMA RAINFALL SERIES AT REGIONAL SCALE

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Several studies investigating temporal changes in rainfall pattern over the Mediterranean area have shown that, although the average number of annual rainy days is decreased during the last decades, precipitation intensity is increased instead (Brunetti et al., 2001 and 2004; Bonaccorso et al., 2005; Caloiero et al., 2011; Arnone et al., 2013). Indeed, an intensification of extreme rainfall events have characterized several areas of peninsular and insular Italysince the early 2000s, suggesting an upward ongoing trend likely driven by climate change. To this end, in the present study temporal changes in 1-, 3-, 6-, 12- and 24-hour annual maxima rainfall series from more than 200 sites between 1928 and 2009 in Sicily region (Italy) are examined. As detection of changes in extreme rainfall series could be highly uncertain, due to the generally limited length of the available records of observations, a regional study is performed. More specifically, annual maxima series are treated according to a standard regional frequency analysis based on L-moments approach (Hosking and Wallis, 1997) to produce growth curves for homogeneous regions. First a cluster analysis using at-site characteristics is used to determine homogeneous rainfall regions. Then, potential changes in regional L-moment ratios are analyzed using a 11-year moving window. Furthermore, the shapes of regional growth curves,derived by splitting the records into separate decades, are compared. In addition, Monte Carlosimulations are used to assess uncertainty in the fitted growth curves and to identify significant trends in quantile estimates. Results reveal that, despite L-moment ratios show a general decreasing long term trend and that growth curves corresponding to the last decade (2000-2009) are usually less steep than the ones of the previous periods, rainfall quantile estimates have increased during the 2000s due to a large increase in regional average median, mainly in Western Sicily.

Keywords: Extreme rainfall, Changes, Sicily, Regional Analysis, L-moments.

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LANDSLIDE AND FLOOD HAZARD ASSESSMENT IN A CLIMATE CHANGE ENVIRONMENT

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It is generally accepted that climate change exists. Already the Intergovernmental Panel on Climate Change (IPCC) in the 2007 Synthesis Report confirmed that warming in climate system is unequivocal and that impacts of human-caused climate change are evident worldwide. Instrumental observations over the past 100 years (between 1906 and 2005) show that global average surface air temperatures have increased by about 0.74°C and that, albeit with a large variability, changes are occurring also on the amount, intensity, frequency and types of precipitation globally [1]. Indeed as a result of thermodynamic effect, a warming atmosphere will translate into higher air moisture content, which in turn may increase the potential for more frequent and intense heavy precipitation events [2]. As a consequence, in some regions, there will be increases in occurrences of extreme events such as floods and landslides. The objective of this work is to assess climate change impact on landslide and floods occurrence in Umbria Region, Central Italy. After the application of downscaling and stochastic generation procedures [3], rainfall and temperature data provided by five General Circulation Models (GCMs) are used as input into an early warning system [PRESSCA, 4] to obtain the expected occurrence of landslide events for present (1990-2013) and future (2040-2069; 2070-2099) periods. Similarly, the downscaled GCM data are considered to force a rainfall-runoff model [MISDc, 5] for estimating the impact on floods occurrence and magnitude. The comparison between present and future period results suggests a general increase both in landslide events occurrence (up to more than 40%) and on annual maximum discharge (up to 120%) for the Umbria territory in the future periods. The results also reveal that identifying the effect of climate change on flood and landslide is not straightforward and the close interaction between rainfall magnitude/intensity, temperature and soil moisture should be analysed in-depth.

Keywords: Climate change, extreme events, flood, landslide

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ESTIMATION OF LANDSLIDE-TRIGGERING PROBABILITIES MODIFICATION DUE TO CLIMATE CHANGE

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Rainfall-induced shallow landslides are one of the most hazardous phenomena occurring in mountainous environments. Recently, there are growing concerns about intensification of extreme rainfall due to climate change or low frequency variability in climate. Thus the question arises as to whether modifications in high frequency rainfall temporal patterns may lead to substantial changes of landslide occurrence probabilities [1,2]. In our study, analyses aimed to assess the potential modifications of landslide probabilities and return periods due to climate change are carried out, making use of a combination of stochastic and physically-based modelling approaches.

First a stochastic rainfall model is calibrated on the basis current observations, and the generated rainfall series is used as input to a physically-based hillslope hydrologic and slope stability model to estimate the current probabilities of landslide triggering. Then, changes in rainfall characteristics are formulated consistently with recent studies assessing the trends exhibited by extreme rainfall [3,4] and the CMIP5 experiments as well, and the stochastic rainfall generator is adjusted accordingly. The modified rainfall input is finally used to estimate the potential modification of landslide-triggering probabilities related to climate change. Results may thus serve as an aid for climate change preparedness and adaptation.

Applications are conducted with reference to real case-study areas in Italy for which models predict, an increase of rainfall intensity on the short durations and an overall decrease of daily rainfall of the order of some tenths of mm/day.

Keywords: Rainfall, Extreme events, Trends, CMIP5, Monte Carlo

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BIODIVERSITY MONITORING IN MOUNTAIN ECOSYSTEMS: A MULTI-TAXA APPROACH

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Elevational gradients are natural laboratories to study species diversity and community level responses along patterns of environmental variation. Understanding how multiple taxa respond to elevation along the same gradient, as well as how the same taxa respond to different elevational gradients, is still an important and urgent task in conservation biology [1]. In this framework, in 2012-2014, 6 Italian Parks, located in the Alpine Region and covering its natural variability, shared a common protocol. Along 24 altitudinal transects (132 sampling stations, 550-2700 m a.s.l.), seven taxa were sampled (Coleoptera Carabidae, Coleoptera Staphylinidae, Araneae, Formicidae, Orthoptera, Lepidoptera Rhopalocera, Aves), using semi-quantitative sampling techniques. Such protocol has been developed in order to be repeated every 5 years (2 ys monitoring – 4 ys stop; next session 2018-2019). Main aims are: i) identify the parameters influencing species' distribution; ii) identify the species and the habitat type more sensitive to environmental and climatic changes, which can be used as biodiversity/ecological indicators; iii) estimate the risk of biodiversity loss, also through the application of climate change scenarios; iv) set the basis for the development of a long term monitoring scheme, focused on multi-taxa community data.

To recognize common points and differences between geographic areas and altitudinal zones, we decomposed β-diversity into ist nestedness and turnover components [2] and quantified the proportion of variation due to different factors. Both climate and altitude have a fundamental role in shaping the communities, but at the same time a well-defined proportion of variation depends on the geographical position of each parks, showing how each of them has its peculiar faunistic composition.

To identify the parameters influencing species' distribution across large spatial scales represent an important tool for estimating current conservation value and obtaining a baseline against which measure the response of alpine biodiversity to climate and land-use changes.

Keywords: biodiversity, elevational gradients, protected areas, environmental changes

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THE EFFECT OF GLOBAL WARMING ON FLOODS IN MOUNTAIN CATCHMENTS

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Annual and winter temperatures have been recently observed to increase in time. We will devote our attention to investigate the sensitivity of mountainous systems to this temperature increase. Other studies have shown that all the major continental mountain chains exhibit a change in the freezing levels, melting season indicators, temperature lapse rates and snow cover, and these changes are generally found to be of greater amplitude at higher elevations. Mountains are therefore fragile ecosystems, prone to rapid and intense reactions to the temperature changes. In this study the discharge response to temperature increase of snow-dominated basins is investigated by means of a simple contributing area model. In the model, the occurrence of snow over the portion of basin above the freezing elevation produces a mitigation of floods that depends on simple features of the precipitation process, of the temperature regime and on distribution of elevation within the basin. The response in t

erms of flood risk sensitivity to different climatic impulses is evaluated for classes of basins with different elevation characteristics. Model results in terms of temporal variation of the mean of the flood frequency distribution are compared with a database of long-term discharge series measured in the Western Alps. Good agreement between modelled and empirical trends is found, making us confident on the possibility to transpose this simple modelling framework to scarcely gauged or ungauged regions.

MELTING GLACIERS IN MOUNTAIN BASINS: MEASURE TODAY'S RUNOFF AND SEDIMENT TRANSPORT TO UNDERSTAND TOMORROW'S RIVER CHANGES

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High-elevation catchments are highly dynamic systems which are undergoing rapid hydrological changes due to shrinking glacier masses as well as to variations in snowmelt timing and magnitude. Seasonally, headwatersare responsible for the transport of large volumes of runoff and sediment to the downstream channel network, which tend to adjust to the upstream-imposed liquid and solid fluxes. Understanding the relationship between runoff origin and sediment transport rates would enable to infer how mountain rivers will modify their geometry and habitats under different climatic scenarios, potentially posing relevant management issues.

The presentation will focus on the recent results obtained in a glacierized basin of the Eastern Italian Alps (Saldur River), whererunoff and sediment transport have been monitored at two cross-sections (11 and 19 km^2 drainage area). An array of differentmethodologies to measure sediment transport have been deployed from 2011 to 2014, encompassing PIT-tagged clasts tracking, acoustic pipe sensor, turbidimeter and direct sampling. In parallel, hydrologic tracers (electrical conductivity and stable isotopes of water) were used to understand timing and relative contribution to runoff of different water sources, in particular snowmelt and glacier melt. Additionally, a morphological monitoring of the main channel was carried out by repeated topographic surveys to detect changes in sediment storage.

Results indicate that the relationship between sedimenttransport and water discharge is strongly season-dependent at both monitored cross-sections, with bedload rates and suspended sediment concentrationsconsistently much higher (1-2 orders of magnitude) during glacier melt than during snowmelt flows,for identical water discharges. However, contrasting hysteresis loops were found for bedload and suspended transport in relation with snow- vs. ice melt flows, which highlight the

complexity of sediment supply mechanisms in mountain basins. As a result, channel network's response to current deglaciation is likely to be strongly site-specific and spatial scale-dependent.

Keywords: deglaciation, stable water isotopes, sediment transport monitoring, morphological changes

TREE-RING BASED REGIONALIZATION OF CLIMATE-CHANGE IMPACT ON BEECH FORESTS AT DIFFERENT ELEVATION ACROSS THE TEMPERATE-MEDITERRANEAN BIOMES IN ITALY

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We used a tree-ring network with more than 70 European beech forests on the Alps and the Apennines to identify regions of homogeneous climatic control over tree growth variability and assess the long-term climate-change impact within them. Basal Area Increment (BAI) of dominant trees served to measure stand productivity. Sampled forests represented a wide range of bioclimatic (Temperate vs. Mediterranean climate, lowland to treeline) and past management (mature to old-growth) conditions.

Classification/ordination techniques applied to standardized high-frequency tree-ring data (with amplified climatic signal), allowed to spatially identify bioclimatic zones and belts within the network, i.e. the main climatic factors affecting tree growth according to latitudinal and altitudinal variations [1]. Bootstrapped correlation/response functions served to detect the climatic factors acting within each bioclimatic unit at the annual timescale. Climate variability was described by monthly temperature, precipitation and drought indices [2,3].

Multidecadal productivity variations in each bioclimatic unit were obtained by filtering BAI composite chronologies with smoothing splines. The climatic factors identified at the annual timescale were similarly filtered: they significantly controlled BAI variations even in the long-term. BAI is influenced more by temperature than precipitation on the Alps, while in the Apennines summertime drought plays a dominant role.

The recent climate warming produced divergent productivity trends between the Alps and the Apennines [4]: on the Alps, productivity increased, thanks to the more favorable growing season and the milder winter; on the Apennines, increasing dry conditions caused widespread productivity losses along most of the altitudinal gradient. BAI increase on the Alps may even be connected to synergistic interactions between warming and N deposition and/or CO_2 fertilization. Nonetheless, hilly alpine sites are starting to suffer productivity declines, as significant warming extends to temperate regions. The forest naturalness seemed to control beech response to climate changes, with old-growth stands following more closely climate variations.

Keywords: Tree-ring networks, Alps and Apennines, Bioclimatic Classification, Climate-change impact, Climate reconstructions

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SCORCHING ALPS: INSIGHTS FROM THE 2015 SUMMER HEAT WAVE

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Understanding the processes affecting the land-surface is essential to evaluate the future impacts of climate change on Earth and the consequent feedbacks to the climate system. Mountain systems, from glaciers to living communities, in the European Alps are expected to be particularly impacted by future rising temperatures, changes in precipitation patterns, and by the increasing frequency in extreme events. Europe witnessed a record breaking heatwave from the end of June 2015 which anomalously warmed the most of the continent until the beginning of August. This spell did not spare the Alps where the temperature anomaly reached ~4°C.

In this multidisciplinary study we present an overview of the main impacts of the 2015 summer heat wave on the biosphere and the cryosphere of the Alps in Aosta Valley (Italy). Key alpine ecosystems such as grasslands, forests and crops have undergone severe changes related to phenology, carbon cycle, biomass production and water use. The effects on living organisms was associated to important reduction in the water reserves of the region and changes in the timining and magnitude of snow and glacier melt. Completing the picture of the 2015 heatwave effects on land systems, significant impacts on permafrost dynamics were also recorded.

Keywords: climate extremes, biosphere, cryosphere, Alps

EVALUATION OF HEAT WAVES OVER THE NORTH WESTERN ITALIAN ALPS

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The aim of this study was to identify the increase in frequency of heat waves within the last 90 years in the North Western Italian Alps by examining data from high-altitude weather stations in the period 1924–2013. Furthermore a comparison between high-altitude and lowland weather stations were performed.

The data used in this study consist of daily observations of temperature from ARPA Piedmont, ARPA Valle d'Aosta and ENEL ground stations datasets. In addition a dataset from MODIS sensors from “Terra” and “Aqua” satellites (availability in according with their launch) were analyzed to evaluate their usability in alpine extremes analysis.

All the data were quality controlled using the Rclimdex package [1] for R software. Stations with high potential of erroneous data and missing data more than 20% were removed from the study [2]. The identified outliers are daily values outside the mean plus or minus four times standard deviation of the daily value (in agreement with [3] and [4]). The daily temperature data were subject to the homogenization process SPLIDHOM [5,6] to have an homogeneous time series where all the remaining variations are due only by variations in climate [7, 8].

The 90 years period was split in 3 sub-periods of 30 years (1924-1953; 1954-1983 and 1984-2013) and an additional sub-period (2000-2013) was created to compare the results between satellite and ground stations data.

Fixed thresholds (according with the alpine vertical lapse rate) and 90th, 95th and 99th for maximum temperature and and 10th, 5th and 1st for minimum temperature percentile and their frequency were calculated on the series. Then the MAKESENS procedure [9], based on the nonparametric Mann-Kendall test for the trend and the nonparametric Sen’s method for the magnitude of the trend, were applied.

Keywords: Heat Waves, North Western Italian Alps, Extremes, Temperature

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THE EFFECTS OF CLIMATE CHANGE ON THE SEDIMENT YIELD IN MOUNTAINOUS AREAS

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A change in the mean and variability of some variables of the climate system is expected to affect the sediment yield of mountainous areas in several ways: soil temperature change, permafrost thawing, snowmelt and ice melt time shifting may be listed as some of the potential causes. The sensitivity of sediment yield estimates to a change of condition of the climate system may be investigated through the application of different models, each characterized by its own features and limits. Sensitivity analysis are here presented with reference to two case studies. For the first one the sediment yield of a small mountainous basin is dealt with the Universal Soil Loss Equation approach. In the second one the physically based WEPP model is applied to estimate the sediment yield on vegetated steep slopes, before and after a wildfire. On the basis of the results of these analyses some general considerations are drawn.

Keywords: water erosion, sediment yield, climate sensitivity analysis, empirical and physically based approach

CLIMATE CHANGE EFFECTS ON THE DISTRIBUTION OF LARGE MOUNTAIN HERBIVORES

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Climate change can significantly affect wildlife species living in mountain habitats (particularly vulnerable due to their adaptation to extreme conditions) both directly and indirectly, by changes in snow amounts and vegetational shifts. This is particular important for herbivores such as ungulates, for which changes in plant communities mean variations in the availability of food resources. With the expected increase in temperature, mountain ungulates could be forced to move upward, with a reduction in suitable habitat.

Taking advantage of a time-series of summer (2000-2013) count data of Alpine ibex *Capra ibex* and chamois *Rupicapra rupicapra* in the Gran Paradiso National Park (GPNP), Italy, we investigated the climatic effects on the average elevation of the populations through a series of GLMs. To predict the response of the studied populations to expected climate change, we projected the elevation of both species under the climatic conditions predicted by the PROTHEUS regional model. Finally, to create a map of the future distribution of ungulates in GPNP, we projected to the new scenario the current suitability distribution obtained with MaxEnt.

Average summer elevation of chamois (2332.19±6.63 m) was positively affected by spring-summer precipitation (probably affecting the quality of meadows) and by higher temperatures in September. Summer elevation of ibexes (2612.69±12.71), showed a positive trend and was negatively affected by higher temperatures in late winter (maybe through an earlier snowmelt, which lead to a shorter availability of high-quality forage) and positively affected by temperatures in September. Chamois is expected to keep a stable summer elevation in the next decades, while, for ibex, projections forecast a slight increase of average elevation (years 2014-2023: 2662.27±12.11 m). Future distribution of both species didn’t change significantly, and no further increasing of fragmentation emerged. Demographic rates are likely more important to understand the fate of these populations in face of climate change.

Keywords: Mountain ungulates, Upward shift, Altitudinal migration, Onset of vegetation, Habitat suitability models

TRENDS IN FREQUENCY OF FLASH FLOODSPHENOMENA OVER THE COASTAL URBANIZED AREAS OF CAMPIFLEGREI VOLCANIC DISTRICT, SW ITALY

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Human activity is altering the climate system and challenging the sustainability of our planet[1,2]. In particular, human activities are continuing to impact earth surface processes with increasing responses and non-analog effects if compared to Holocene landscape dynamics [3].At the same time, climate change is affecting the frequency and severity of extreme meteorological, hydrological and geo-hydrological events.

In this study we focus on the geo-hydrological hazard of the Campi Flegrei, a highly urbanized, volcanically and seismically active district that develops at the periphery of the metropolitan area of Naples, Italy. The results of the research are also analyzed in a multi-hazard perspective.

In the last century, the coastal area of Campi Flegrei was hit by several flash flood events that caused heavy damage in densely populated area, including the city of Pozzuoli and the western sector of Naples[4].A database of these events has been created on the basis of existing studies, inventories, archive and historical documents, newspapers and meteorological (mostly rain) time series.

The last events that struck the city of Pozzuoli in 2009, 2010, 2011, were analyzed in detail, with specific reference to the properties of the triggering rainstorms, as well as to flood propagation simulations. The results of this study show the high frequency of flash floods events that occurred in the study area and their evolution through time. The extreme nature of the triggering rainfalls, as well as hazardous conditions related to flow propagation in the urban center have been also analyzed. Hydraulic flow simulations document the role of anthropic structures in modifying the drainage network, thus increasing the levels of risk.

Understanding climate variability and associated atmosphere-landscape feedbacks in temperate areas is critical in order to assess the potential threshold response of earth systems, and specifically the geo-hydrological system, as the climate warms into the twenty-first century[2].

Keywords: geo-hydrological hazard, flash flood, Campi Flegrei, Italy

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A METHODOLOGY TO ASSESS VARIATION IN SHALLOW-LANDSLIDES HAZARD INDUCED BY CLIMATE CHANGE

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Rainfall severity in terms of potential damage strictly depends on the intensity and duration of weather and climate extremes. A quantification of the potential changes induced by climate changes (CC) in precipitation patterns inducing shallow landslides hazard represents in many geomorphological contexts a preeminent issue. Such phenomena are generally induced by heavy rainfall lasting few hours requiring data at hourly or sub-hourly scale. Current climate models (also if downscaled through dynamical or statistical approaches) provide reliable precipitation data until the daily scale [1]. Into the framework of the understanding of how assess the effects likely caused by CC on the occurrence of shallow landslides, the problem of the mismatch between the outputs provided by climate models and the small scale (spatial and temporal scale) at which impact analysis has to be performed represents one of most significant debated issue [2].

In order to attempt resolving the deficiencies related to the scale discrepancy between CC scenarios and potential impacts, statistical downscaling/disaggregate methods have been proposed [3].

In this work, first aim concerns the understanding of stochastic models (Bartlett-Lewis based) capabilities to capture the physical structures of precipitation events at fine time scale starting from daily outputs. After this, comparisons among critical rainfall thresholds (CTR) for shallow landslides inception and intensity-duration (ID) curves based on disaggregated rainfall data scenarios have been performed on current period to validate the approach and on future time spans to assess the potential variations in occurrence and magnitude. The above mentioned CTRs [4] represent the couples of ID for which a given hazard level in terms of percentage of the "unstable" basin has been simulated; the test area is a steep coastal watershed of Amalfi Peninsula in southern Italy.

Keywords: shallow landslides, disaggregation, RCM, hazard, CTR

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DOES A HIGHER FUNCTIONAL DIVERSITY ENHANCE THE DYNAMIC STABILITY OF FOREST ECOSYSTEM?

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Ecological theory predicts that ecosystems with a higher functional diversity would be more productive, more resistant to perturbations and have greater dynamic stability. Forest researchhasmainly focused on the effect of functional diversity on ecosystem productivity, with some idiosyncrasy in the results, but often supporting the positive effect of functional diversity at least for some biomes. The effect of diversity on the dynamic stability of forest ecosystems - i.e. a lower variation of productivity over time in the absence of important perturbations - has not been addressed yet to our knowledge and is the focus of this presentation. Notably, management to improve a higher dynamic stability would increase the reliability on future yields and could contribute in curbing the effects of climate change.

The accumulated Enhanced Vegetation Index (EVI) over the growing season from MODIS was used as a proxy of annual productivity of the state of Quebec (Canada) at a resolution of 250m. For each pixel, stability was estimated as the coefficient of variation of the annual accumulated EVI over the period 2001-2008. The community composition and basal area for each pixel were obtained from the Quebec forest survey dataset (QFS) which covers the temperate and boreal climatic zones. Functional diversity and the community weighted mean (CWM) of each pixel was calculated using five functional traits (Wood density, seed mass, Leaf Mass per Area, Maximum Height, Nitrogen per unit leaf mass) obtained form the literature.

Structural Equation Modeling (SEM) was used to assess the importance of functional diversity and community weighted means on the dynamic stability of boreal and temperate forests in Quebec. Results show that more diverse forests have in general a higher dynamic stability although the strength of the correlation between Functional diversity and stability is weak. When separating the analysis between boreal and

temperate forests, results reveal that FD is not significant in boreal forests but is in the temperate biome. Previous studies reported thatmore diverse forests are more productive but that the effect is strongestin boreal forests. It is thus found that FD promotes either productivity or stability depending on the biome, perhaps revealing some trade-off.

Keywords: Functional diversity, climate, Dynamic stability, forests, SEM, remote-sensing, EVI

HISTORICAL CLIMATE CHANGE OF THE SARDINIAN HYDROLOGY: THE DRAMATIC RUNOFF DECREASE IN THE LAST THREE DECADES

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From 80' surface runoff decreased systematically in main Sardinian basins with dramatic consequences on water resources system. Indeed, Sardinian water resources system is regulated by more than 50 main dams, which accumulate runoff during the rainy seasons. The effect is that in last years the water levels in the reservoirs decreased significantly and systematically.

An analysis of the precipitation, temperature and runoff regimes for the whole Sardinia has been performed. We collected an innovative database of rainfall, temperature and runoff observations from 1918 to 2011, including data of more than 400 rain stations, 30 discharge stations and 180 thermometric stations. Historical trends are detected using the Mann Kendall, with a significance level of 5%, showing a decrease of the rainfall in the winter period and, more marked, of the runoff, for the whole Sardinia generally, with dramatic consequences for agriculture and water availability. Interestingly, the decrease is more marked for the rain and discharge stations of the Sardinian west coast, exposed to the west European climate dynamics. In this sense, several studies have shown a significant correlation between the main meteorological variables and indices related to fluctuations in global scale, for example NAO (North Atlantic Oscillation). A negative NAO brings to an increased storm activity and rainfall to southern Europe and North Africa.

We found high negative correlations between NAO and precipitation and runoff during the winter season, and the correlations decrease with the increase of rain station longitudes. The results show a strong negative correlation at the stations and basins of the Sardinian west coast, which is due to the exposure to the mistral winds and the storm track dynamics. Instead a less negative correlation has been estimated for the east coast stations, due to the impact of the orography that attenuate the large scale atmospheric dynamics.

Keywords: runoff, climate change, precipitation, NAO

CLIMATE CHANGE IMPACTS ON BIODIVERSITY: A GIS APPROACH FOR BIOCLIMATIC STUDIES AND VEGETATION TRENDS

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Bioclimatic studies deal with the interrelation between climate and living organisms, in particular plant communities, considering the main climate variables relevant for species distribution and structure[1]. These studies are essential to enhance the comprehension of habitat dynamics and the definition of potential natural vegetation[2]. Bioclimatic models can predict potential ecosystem responses to changing climates better than raw climate time series, because they integrate and combine biologically relevant information, focusing on climatic thresholds of species distributions. Rivas-Martinez Worldwide Bioclimatic Classification System[3] was applied to obtain a bioclimatic map of Sardinia (Italy) based on a high-resolution (40 m grid) spatial interpolation of monthly temperature and precipitation data referred to the 1951-2000 period[4]. In order to evaluate climate change impacts on bioclimatic and vegetation types the same methodology was implemented on WorldClim data series. The two maps showed smooth differences concerning bioclimatic indexes changes due to the spatial resolution and interpolation methods. The higher 30-second resolution, and the most severe Representative Concentration Pathway RCP85 (2061-2080) from Hadley Center (UK) and Goddard Institute of NASA, were used as climate change models for bioclimatic classification. Evident changes in Mesomediterranean and Thermomediterranean bioclimatic types can be outlined, due to the different values of Ombrotype and Thermotype indexes. Therefore, a consequent loss of particular vegetation series can be detected and hypothesized: the most threatened in the hypothesized scenario seem those vegetation types linked to temperate islands with humid ombrotype on mountains, first of all the alpine juniper series *Juniperetum nanae,* followed by the deciduous European Hop Hornbeam series (*Cyclamino repandi-Ostryetum carpinifoliae*) and deciduous oak (*Glechomo sardoae-Quercetum congestae*). Rivas-Martinez WBCS resulted an appropriate system for bioclimatic classification and for evaluating the impacts of climate change on biota and vegetation series; accurate bioclimatic maps can be important tools for land management and biodiversity conservation.

Keywords: Bioclimate, Climate change, Biodiversity, Vegetation trends.

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CLIMATE CHANGE EFFECTS IN A MEDIUM-SIZED MEDITERRANEAN BASIN

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In the framework of the Climate Induced Changes on the Hydrology of Mediterranean Basins (CLIMB) EU FP7 research project [4], we evaluate the effects of climate change in a medium size basin located in an agricultural area of southern Sardinia, Italy, the Rio Mannu at Monastir basin (473 km^2). We use the process-based spatially distributed hydrologic model TIN-based Real time Integrated Basin Simulator (tRIBS) [2, 3] to assess its hydrologic response. The model has been calibrated and validated with reasonable accuracy using two statistical downscaling strategies for precipitation and potential evapotranspiration, which have been designed to obtain the required high-resolution input data [5]. The outputs of four climate models, selected as the best performing and bias corrected within the CLIMB project [1], have been downscaled by the same disaggregation tools and used to force the tRIBS during a reference (1971-2000) and a future (2041-2070) period. The outputs of the hydrologic simulations have been compared both to assess the variation in Rio Mannu water resources budget in the future period as compared to the reference one [6] and to investigate the propagation of precipitation extremes into discharge extremes [7]. Furthermore, the production of one of the most important rain fed crops in southern Sardinia, the durum wheat, has been simulated with the AquaCrop model [8].

Our results confirm what is generally predicted for the Mediterranean area, showing a basin future condition of more water shortages due to both reduced precipitations and increased temperatures. The analyses of extremes reveal high variability in projections of maximum annual precipitation and discharge. The uncertainty in fall and early winter period rainfall affects also the productivity of durum wheat which, on the other hand, could be potentially improved by the increased CO_2 concentration.

Keywords: Mediterranean basin, tRIBS, climate models.

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IMPACTS OF CLIMATE CHANGE ON ECOSYSTEMS AND BIODIVERSITY AND CHALLENGES FOR OFFICIAL STATISTICS

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The growing recognition that climate change may contribute to degradation of ecosystems and loss of biodiversity is a challenge for the statistical community: proper statistical information is needed to support studies and decision making that bring together both climate change related phenomena and ecosystem issues at the same time. Within official statistics, though climate change and biodiversity are emerging concerns as compared to more traditional statistical domains, it is time to start investigating how to establish proper linkages between statistics related to climate change and environmental statistics focused on land and biodiversity. The main international frameworks according to which official statistics are to be developed with relation to these global themes are crucial to identify possible advancements. Among main achievements recently reached by the United Nations statistical community, three are of specific interest for the purposes of the present study: the work carried out by the UN-ECE Conference of European Statisticians on climate change related statistics; the Framework for the Development of Environment Statistics 2013, in particular as concerns land and biodiversity; the Experimental Ecosystem Accounting part of the System of Environmental-Economic Accounting 2012, welcomed by the UN Statistical Commission as an important first step in the development of a statistical framework for ecosystem accounting. An exploratory attempt is made to find out relevant connections between the guidelines provided by these three distinct sources. This is intended to possibly contribute to further reflections which the international statistical community is expected to develop in due time with a view to define in more operational terms sets of statistics suitable to describe climate change related phenomena that may adversely affect ecosystems and biodiversity. Such an advancement in official statistics would be beneficial for analytical work and decision making focused on linking climate change and ecosystem issues.

Keywords: climate change, land cover, biodiversity, official statistics, ecosystem accounting.

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POTENTIAL CLIMATE CHANGES IN ITALY AND CONSEQUENCES ON LAND STABILITY

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In 2014, the Joint Technical Committee (JTC1) on Natural Slopes and Landslides, established by the Federation of the International Geo-engineering Societies (FEdIGS), promoted the project "*Slope Safety Preparedness for Effects of Climate Change*" with the aim of exchanging information and knowledge on how climate change could affect the frequency and magnitude of landslide events in different areas of the world, and for discussing initiatives undertaken by various countries and regions to face the problems posed by climate change on slope stability. On 17th and 18th November 2015, scientists from twelve countries will gather in Naples to present and discuss the main findings of their research on the topic during a specific international Forum. The Forum represents one of the earliest opportunities to share knowledge, and for reviewing the current understanding and consolidating the state of practice on the potential impact of climate change on land instability. The different expertise involved in the research (meteorology, climatology, hydrology, geology, geomorphology, geotechnical engineering, social sciences) reveals the complexity of the problem, and the need for a multidisciplinary approach to address the problem.

At the Climate Conference in Rome we will present the main content of the Italian report on the effects of climate change on land stability in Italy prepared for the Joint Technical Committee on Natural Slopes and Landslides. A general overview of the current knowledge on the expected climate changes in Italy will be followed by an analysis on the complex relationships between weather and landslide risk. This will be followed by a presentation of some scenarios for typical geomorphological settings in Italy. As current uncertainties in climate simulation prevent quantitative assessments, our contribution aims at determining realistic scenarios focusing on vulnerable areas. Next, we consider the vulnerability to landslides of landscapes and infrastructures in view of the expected climatic changes in Italy. We conclude with considerations on appropriate strategies for the mitigation of landslide risk in a changing climate in Italy.

Keywords: geo-hydrological hazards, landslides, soil-atmosphere interaction, vulnerability, geomorphological contexts.

THE RED CORAL POPULATIONS OF THE GULFS OF NAPLES AND SALERNO: GLOBAL WARMING AND DEEP MASS MORTALITIES

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Since the 19th and 20th centuries, the presence of deep red coral *(Corallium rubrum)* banks in the gulfs of Naples and Salerno (South Tyrrhenian Sea, Mediterranean Sea) is well documented due to the heavy coral harvesting by both trawling gears and scuba diving. Recently, in 2010 and 2012, two Remotely Operated Vehicle (ROV) surveys on board of the Research Vessel Astrea (ISPRA), investigated red coral banks in 16 sites, between 45 and 150 m depth. Seven of these banks, in the inner part of the Gulf of Naples, were previously explored in 1918. Healthy populations (densities > 90 colonies m^{-2}) were present only in Ischia and Procida Islands. In the remaining sites of the Gulf of Naples rather low densities (< 5 colonies m^{-2}) or even absence of coral were recorded, and a consistent percentage of dead colonies was observed. This evidence might suggest a considerable state of stress likely due to the hydrodynamic conditions in the Gulf, increasing water temperature and sedimentation rate. Also, documented high fishing pressure might play a role in the hard-bottom communities' degradation. Recently, a mass mortality episode was recorded along the Amalfi coast, around Li Galli Islands (Gulf of Salerno), at a depth range between 80 and 100 m, where the mortality affected 80% of the largest colonies, estimated to be around 70 years old. A wide range of possible reasons for this mortality have been hypothesised, but possible thermic anomalies inducing an unusual drop of the thermocline along with the formation of turbidity currents, need to be taken into account.

Keywords: *Corallium rubrum*, mass mortality, Mediterranean Sea, ROV-imaging

CLIMATE IMPACT ON LAND DEGRADATION AND DESERTIFICATION IN ITALY

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The present work aims to measure the impacts of climate on land degradation using remote sensed vegetation index for the years 2000-2013. The Normalized Difference Vegetation Index (NDVI) data of the Moderate Resolution Imaging Spectroradiometer, or MODIS are used to compute time series of standardized NDVI annual sums index. Linear least square regression and Mann-Kendall (MK) test are used to detect significant trends of the annual sum index. Statistically significant negative and positive trends at pixel level are assumed to be proxy of declining and improving land productivity. In Italy, considering trends with p-value of the MK test below 0.1, the amount of land with increasing and decreasing LP is respectively 46792 km^2 (15.5% of national territory) and 32781 km2 (10.9% of the national territory). At national level, increasing LP exceeds decreasing LP in all land cover classes except in forests.

Southern Italian regions show a general “greening up” and only limited hot spots of LP decline. Central and Northern regions have a LP decrease affecting particularly forest and semi natural vegetation. Pearson correlation coefficient between LP and yearly precipitation trends is positive in southern regions. In northern regions LP decline is negatively correlated to yearly precipitation trends but positively correlated with the vegetation growing season precipitation trends.

Keywords: Climate Impacts, Land Degradation, Desertification, Remote sensing, GIS

CLIMATE CHANGE IMPACTS ON PO RIVER WATER AVAILABILITY AT 2021-2050

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In the last decades the climate over Po River basin shows changes in precipitation and temperature [2,5,16-19] and projections indicate that in future the area will experience a decrease of total precipitation, with the exception of the Alps in winter while the frequency of extreme precipitation events and temperature are expected to increase [3,8]. All this, will result in an increase of droughts and floods occurrence [6, 13,20-21] that may significantly impact on activities and citizens located within Po river basin [1,4].

The projections under the IPCC scenarios RCP4.5 and RCP8.5 [11], for the period 2021-2050, presented here are obtained forcing the RCM COSMO-CLM [3,12,14] with the GCM CMCC-CM [9,15]; daily precipitation and temperature data are bias corrected applying the quantile mapping method [22]. Simulated daily precipitation and temperature timeseries [3] are used to feed the spatially distributed hydrological model TOPKAPI [7] and the basin balance model RIBASIM [10]. The error, over the control period 1982-2011, introduced at each step of the modelling chain is estimated and reported, the average error on simulated discharges is -8% [20].

Projections at 2021-2050 shows that with respect to the control period (1982-2011) the projected discharges are expected to (1) reduce in summers with more prolonged droughts and (2) increase in winters, coherently with the precipitation and temperature anomalies. In particular, high flows (a proxy for floods) could occur during winter (now it is a low flows period) and summer droughts could double their durations.

The methodology presented here can be applied to other Italian river basins to prevent the risk of water crisis, to promote hydraulic security and mitigate the potential impacts of future droughts to energy and agriculture sectors.

Keywords: climate projections, water availability, Po River basin, floods, droughts

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HEAT WAVES AND MORTALITY IN TURIN

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Concern for human health is one of the most compelling reason to study the effects of global climate change. Health reflects the combined impact of climate change on the physical environment and society [1]. Good health, which requires physical, mental and social well-being, is a key of quality of life.

The relationship between health and climate is demonstrated by the strong seasonal variability in the incidence of infectious diseases and the persistent seasonal pattern in mortality [2]. An important strong linkage between climate and human health is seen in the impacts of extreme climate events. Flooding, drought, heat waves and several storms can damage health by leading to an increased risk of injury, illness and death [3].

In these study we analyze the impact of extreme events in particular heat waves in Turin, city that is including in Heat Health Watch Warning Systems (HHWWS). We have provided to estimate of death attributable to the heat waves in particular we aimed to quantify the total mortality burden attributable to extreme events and their contribution on different causes of death.

The extreme events were analyzed using the Heat Stress index – HSI – The HSI combines the effects of different weather variables for example temperature, humidity and wind. When the heat stress index is high, humans can experience heat stress, which can lead to particularly dangerous conditions.

We estimated HSI and causes of death associations with a Distributed Lag Non-Linear Model (DLNM) calculating for every causes of deaths the critical values of indices [4,5].

Keywords: heat wave, heat stress index, human health, death and Turin

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CLIMATE CHANGE AND PHENOLOGICAL IMPLICATIONS IN SOUTHERN ITALY

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Plant development and its relationship with meteorological conditions are often taken into account in order to investigate the influence of climate change on the various crop characteristics.

In this work we report some results related to the study of the impact of climate change on the flowering of the olive tree (Olea europaea L.) in Southern Italy [1].

Firstly, we studied the behaviour of olive tree in Calabria Region and the influence of temperature on phenological phases of this crop. An aerobiological method is used to determine the olive flowering dates through the analysis of pollen data collected in three experimental fields for a 11-years study period (1999-2009).

Hence, we performed the study of climate change in Calabria at high spatial and temporal resolution. A dynamical downscaling procedure is applied for the regionalization of large-scale climate analysis derived from GCMs (general circulation models) for two representative climatic periods (1981-2000; 2081-2100); the A2 IPCC-scenario is used for future climate projections.

The integration of previous results permitted to predict the olive flowering variation on the basis of future climatic changes.

This phenological response is a useful bio-indicator to study global and local atmospheric warming for the 21st century. More in detail, the expected temperature increase is more than 3°C over mountains and less than 2°C near the coasts. This corresponds to a phenological advance between 10 and 34 days, depending on the area.

Keywords: climate change, olive phenology, atmospheric models

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LAND AND FIRE MANAGEMENT TOWARDS FIRE EMISSION MITIGATION: THE CASE STUDY OF CENTRAL AND SOUTHERN ITALY

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In Southern Europe, the projected wildfire increase due to climate change and the concurrent exacerbation of extreme weather conditions could lead to a significant rise in CO_2 and other greenhouse gases (GHG). Fire emission mitigation can be achieved through several different options and among these fuel management is one of the most widespread. Despite this, overall there is a lack of studies about the effectiveness of fire emission mitigation strategies. Furthermore, the complexity of a landscape, the undeniable ecosystem services a forest provides, the fire effects to be avoided or reduced, the ecosystem's health maintenance, preservation, and protection; all these are aspects to be carefully considered and integrated when evaluating the fire mitigation approach opportunity.

This work primary aims to evaluate the potential of a combination of fuel management practices in mitigating emissions from forest fires across Central and Southern Italy, also taking into account the normative and low regulating the forest exploitation and rural development. This objective was achieved throughout the application of an integrated approach combining a fire emission model (FOFEM - First Order Fire Effect Model) with spatially explicit, comprehensive, and accurate fire, vegetation and weather data for the period 2004-2012.

The results showed that reasonable estimations and bias reduction in quantifying the source and the composition of fire emissions could be achieved by using appropriate fuel, fire behavior, and weather data. Furthermore, the study suggested that a balanced combination of fuel management techniques could be a viable mean to reduce fire emissions and, at the same time, prevent future wildfires and the related threat to human lives and activities.

Keywords: fire emission, fuel management, fire mitigation, Central and Southern Italy

RESILIENCE OF RIVER FLOW REGIMES

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Landscape and climate alterations foreshadow global-scale shifts of river flow regimes. However, a theory that identifies the range of foreseen impacts on streamflows resulting from inhomogeneous forcings and sensitivity gradients across diverse regimes is lacking. In this contribution, we derive a dimensionless index embedding simple climate and landscape attributes (the ratio of the mean interarrival of streamflow-producing rainfall events and the mean catchment response time) that discriminates erratic regimes with enhanced intra-seasonal streamflow variability from persistent regimes endowed with regular flow patterns. The proposed classification is successfully applied to 110 seasonal streamflow distributions observed in 44 catchments of the Alps and the United States, allowing the identification of emerging patterns in space and time. In the same framework, the impact of multi-scale fluctuations of the underlying climatic drivers (temperature, precipitation) on the streamflow distributions can be analyzed. Theoretical and empirical data show that erratic regimes, typical of rivers with low mean discharges, are highly resilient in that they hold a reduced sensitivity to variations in the external forcing. The proposed classification of flow regimes is based on a few measurable climate/landscape attributes, and as such it provides a framework for characterizing the hydrology of freshwater ecosystems and improve water management strategies in data-scarce regions undergoing climate change.

Keywords: climate change, flow variability, hydroclimatic shift, water uses

IMPACTS OF CLIMATE CHANGE ON SPATIAL DISTRIBUTION OF SNOW, EVAPTRANSPIRATION AND SOIL MOISTURE IN AN ALPINE REGION

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Mountains are particularly sensitive to climate change and at the same time represent a key water resource not only locally but as well for the population in the surrounding low-elevation areas. Because of the complexity of mountain landscapes and the high climatic variability at a local scale, a detailed quantification of the changes in spatial and temporal distribution of key water balance components as snow cover, soil moistureand evapotranspiration is required.

In this work,a climate change impact study was performed in the Venosta valley (South Tyrol, Italy), a dry alpine region, which is already affected by water scarcity issues.

The GEOtop hydrological model was used by means of a multidimensional sampling of the most important aspects of land surface heterogeneities, astopography and land cover. An ensemble of 7 regional climate models (ENSEMBLES project) was downscaled using a Δ-change approachto drive the hydrological model for the scenario period 2080-2099. A baseline simulation covering the period 1990-2009 was validated for three locations along an elevation transect, where observations of evapotranspiration, snow cover and soil moisture were available.

Simulations show that the elevation belt between 1500 and 2000 m a.s.l.is the area which might suffer of the strongest problems in terms of snow reliability in the future. Besides decreasing snow water equivalent and summer precipitation, enhanced evapotranspiration rates were simulated for the regions.

The results suggest significant impacts on the water cycle of the region, with a possible change in the groundwater recharge patterns of the catchment. In particular, south faced slopes within the elevation band of 1000 – 1500 m a.s.l. seem to be the most sensitive locations, with more frequent water stress conditions in future.

Therefore, this study suggests that new water management policies are needed to face future climate change impacts in this region.

Keywords: climate change, evapotranspiration, snow, soil moisture, hydrological modeling

I-AMICA: A HIGH TECHNOLOGY INFRASTRUCTURE REALISED TO MONITOR FOR ITALIAN SOUTH MEDITERREAN ENVIRONMENTAL AND CLIMATE

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I-AMICA (Infrastruttura di Alta tecnologia per il Monitoraggio Climatico Ambientale - Infrastructure of High Technology for Environmental and Climate Monitoring -) is an infrastructure created during a three years project, co-funded by Italian National Operative Program (PON) and European Regional Development Fund. A lot of effort distinguished the infrastructure realization to strengthen the environmental monitoring in Italian South Mediterranean with the aim to support the integration among research, high training, and innovation. A special issue was to work in synergies among public and private research organizations. The activities focused on actions addressed to strengthen the observational infrastructures for atmosphere, forest and coastal areas in the regions of Southern Italy, whose economic growth and social well-being are strongly related to the environment quality. In such Convergence Regions (Campania, Apulia, Calabria and Sicily), instrumental networks (e.g. advanced sensors, software tools, integrated platforms and mobile laboratory and stations) dedicated to the environmental and climatic monitoring in the Mediterranean area, in terms of air quality, forest and agriculture, coastal marine ecosystems were promoted and developed.

In order to raise the national and international competitive capacity, four "pillar" activities were pursued (1) strengthen observing infrastructures for climate and environment and data processing systems, (2) promote innovation, technological development and industrial transfer, (3) integrate these observational activities into international programs (i.e. GAW-WMO, ACTRIS, EARLINET, GMOS, ICOS) that will allow I-AMICA to effectively be integrated with important networks. Finally, (4) through the implementation of observations, networking, technological applications and territorial services in the Convergence Regions, I-AMICA provides an important support to the local and regional communities.

Keywords: WMO, integrated infrastructure, ACtris

EFFECTS OF TEMPERATURE RISE ON MULTI-TAXA DISTRIBUTION IN MOUNTAIN ECOSYSTEMS

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Mountain ecosystems host rare and fragile biota and are expected to be highly sensitive to climate change [1, 2]. Detailed information on biodiversity and vulnerability drivers are needed to assess the effects of temperature rise, but they are still largely lacking for many invertebrates [3]. In this framework, species distribution models represent essential tools to estimate the impact of temperature changes and to develop conservation strategies [4].

We applied presence-only distribution models to field data obtained from a systematic survey of 5 taxonomic groups (birds, butterflies, carabids, spiders, staphylinids), monitored along the altitudinal gradient, from the montane to the alpine belt, in 3 protected areas in northwestern Italy. We estimated the effects of a moderate temperature increase (associated with 3 different conceptual scenarios) on the multi-taxa distributions, described at species and community level. The model results indicate only small changes in the overall biodiversity patterns, but highlight different responses depending on taxonomic group and degree of specialization. In particular, we observed that changes in species richness could be significant in the alpine belt and particularly strong for vulnerable species. Community composition significantly changed, but a gradual and clear separation between the three vegetation belts was retained also in the warming scenarios. These results suggest that even a moderate temperature increase could influence animal biodiversity in mountain ecosystems. Our conservative approach will allow for comparing, in the near future, model results with real changes in species response. Long-term field data are indeed essential for revising and fine-tuning model predictions and for designing effective conservation strategies.

Keywords: predictive models, altitudinal gradient, community composition, species richness

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MEDITERRANEAN SHRUBLAND RESPONSES TO CLIMATE CHANGES: THE RESULTS OF A LONG-TERM CLIMATE MANIPULATION EXPERIMENT

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Understanding and predicting long-term ecosystem reponses to global changes require experiments on decadal time scales, being strongly regulated by slow processes, such as changes in species composition, soil carbon dynamics and accumulation of nutrients [1].

Shrublands are important elements of global terrestrial vegetation, especially in the Mediterranean region where they cover substantial portion of the coastline. Shrublands generally appear quite resistant to long-term experimental warming and drought [2].

A comprehensive investigation approach was applied in a Mediterranean garrigue in Sardinia, subjected to climate modification (nigh-time warming and prolonged summer drought), investigating several processes at plant and soil level.

In this work we report an overview of this long-term climate manipulation experiment, focusing on the temporal variation and treatments effects on the carbon balance of the ecosystem, on plant species composition, on the temperature sensitivity of the soil CO_2 efflux, and on the responses of the microbial community and its carbon use efficiency.

Keywords: long-term experiments; Mediterranean shrublands; drought; warming

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FREQUENCY ANALYSIS OF FUTURE LANDSLIDE OCCURRENCES BY USING RAINFALL POINT PROCESSES AND HYDROLOGICAL MODELS

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Analysis of climate change impact on induced phenomena, like landslides, is a topic with increasing interest in scientific community. The recent 5th Assessment Report of the Intergovernmental Panel on Climate Change [1] points out that, for Europe and Mediterranean area, several studies indicate a general increase in the intensity and frequency of extreme precipitation, especially in winter during the last four decades, but however there are inconsistencies among studies. Moreover, future rainfall scenarios are usually provided by using Climate Models, characterized by spatial and temporal resolutions which are not completely suitable for analyses of induced phenomena at hydrological scale. For this reason, in this work the evaluation of climate changes for landslide analysis is carried out by using rain gauge data at several temporal resolutions. Attention is focused on process of occurrences and on intensity and duration of rainfall events, and the presence of possible trends is investigated. A stochastic rainfall generator is implemented to generate future rainfall scenarios, with parameters which respect particular mathematical forms of variation in time, derived from the previous step. The obtained scenarios are finally used as input for hydrological models of landslide forecasting; in detail, classical Intensity-Duration schemes (I-D, [2]; [3]; [4]) and FLaIR model (Forecasting of Landslides Induced by Rainfalls, [5]) are adopted. In these models, a landslide event occurs when rainfall critical thresholds are exceeded; consequently, frequency analysis of future mobilizations is carried out in terms of number of exceedances, and time interval between two consecutive predicted events. As study area, sites located in Calabria region (southern Italy) are considered, where heavy and persistent rainfall events induced thousands of shallow landslides and hundreds of deep-seated landslides during the period 2008-2010, with more than 2,000 crisis points and damages related to about 94 % of the municipalities.

Keywords: Landslides induced by rainfall, future rainfall scenarios, process of occurrences

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CLIMATE CHANGE IMPACT ON FRESHWATER RESERVE FROM A PHREATIC AQUIFER IN CENTRAL ITALY

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Future availability of freshwater will be strongly affected by both climate change and growth of world population. The latter has been recognized to be the most relevant factor at the global scale [5], while site specific characteristics could make the role of climate change predominant at the local scale. In the present work we assess the impact of climate modification on the phreatic aquifer of Mount Amiata, in central Italy. Its significant vulnerability to climate change origins from having snowmelt as the main source of recharge (more than 50%) at the higher elevations of the recharge area. Given the expected strong reduction of snowfall in the future, and the majority contribution of Amiata groundwater to water supply of the surrounding area [1], the quantification of how much this water reserve could reduce becomes urgent. This evaluation is here performed using a physically based, distributed, hydrological model, with coupled surface-groundwater dynamics [2, 3, 4]. The model is first calibrated on the present climate, on the basis of both rivers and springs measurements. Moreover, considering the fundamental role of snowmelt in the case study, the snow dynamics module is calibrated using a long series of snow extent estimates from Landsat imagery. Subsequently the model is forced by various climate change scenarios. Simulations are performed at the detailed resolutions of 1 day and 100 m. Results reveal a dramatic reduction of snowmelt, from almost 5 mm/month of the current climate in January, February and March to less than 1 mm/month in the future scenarios. Both the total recharge and its spatial distribution modify, with the stronger impact at the higher elevations. As a consequence, the total outflow from springs is found to diminish between 20-30%, with a potential relevant impact on local water supply.

Keywords: Groundwater, Climate change, Snowmelt recharge

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INCREASED FLASH FLOODING AND CLIMATE CHANGE IN THE GENOA METROPOLITAN AREA (ITALY)

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The Genoa Metropolitan Area (GMA) is historically affected by flash floods for two main reasons: the meteorological conditions due to the *Genoa Low* and the city's geomorphologic arrangement: a narrow coast belt bounded by mountains [3].

In the last years in GMA there is also an increase in flash floods due to man-made landforms and changes in rainfall regime. In 2014 several floods took place [1] [2]: in some areas of the hinterland the cumulate year rainfall has exceeded 4000 mm, while 2000 mm fell on the coast.

The research analyses the thermo-pluviometric statistics collected over more than 100 years, registered by Genoa University (since 1833) and Chiavari (since 1877) stations, which represent the central and the eastern zone of the GMA.

An analysis was based on mean annual air temperatures, rainfall, rainy days and rainfall rate, which means an annual rainfall and rainy days ratio. The air temperatures show a positive trend, statistically significant, rising from an average of 15 °C in the 19th Century to a current average of 16° C. The annual rainfall does not show any trend, remaining at an average of 1270 mm for Genoa and 1180 mm for Chiavari [5]. The number of rainy days shows a negative trend, statistically significant [4] [6] [7], from more than 110 days in the 19th Century in Genoa (90 in Chiavari) to 90 nowadays (80 days in Chiavari). As a consequence, the rate of daily rainfall shows a positive trend: we can say that rainfall is more intense.

The scenario above is confirmed by the analysis of maximum precipitation recorded by the two pluviographs for 1,3,6,12 and 24 hours in 1945-2014 period; although there is no statistical relevance, all the analyzed values indicate an increasement over time, showing the intensification of flood events in recent decades.

Keywords: Flash flood, Heavy rainfall, Climate change, Geo-hydrological risk, Genoa Metropolitan Area

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Keywords: Flash flood, Heavy rainfall, Climate change, Geo-hydrological risk, Genoa Metropolitan Area

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ENVIRONMENTAL CONTROL ON FLUXES OF GREENHOUSE GASES AND BIOGENIC VOLATILE ORGANIC COMPOUNDS IN A HOLM OAK FOREST

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Mediterranean forest ecosystems are often located at the interface between the sea coast and polluted urban areas. While they sequestrate carbon from the atmosphere and phytoremediate the air by removing atmospheric pollutants, Mediterranean forests are among the most threatened ecosystems on Earth by climate changes. In order to fully explore the plant-atmosphere interactions, eddy covariance technique was used to measure bi-directional exchanges of greenhouse gases (carbon dioxide, water vapour, methane and ozone) in a Mediterranean Holm oak forest located in Castelporziano presidential Estate, a peri-urban forest near the coast of Tyrrhenian sea, 20 km from Rome downtown, Italy.

The concentration gradient along the canopy profile of Volatile Organic Compounds (VOCs) and nitrogen oxides (NOx) was measured during intensive field campaigns using a proton transfer reaction - mass spectrometer (PTR-MS). Fluxes of VOCs and NOx, important precursors of tropospheric ozone and aerosol formation, were calculated by means of an inverse lagrangian model.

Overall, the Holm Oak canopy exhibited a bi-directional dynamic of fluxes. Our results integrated over the last three years showed that the Holm Oak forest is a net sink of carbon and that the sink strength is related to inter-annual variations in water availability. Methane budget was close to neutrality. Fluxes of VOC were largely represented by reactive monoterpenes and were mostly recorded in the central hours of the day in response to elevated light intensities and temperatures. Ozone was sequestrated by plants mainly through stomatal uptake. However, the ozone forming potential of the emitted VOC is high in a polluted atmosphere enriched in NOx and this must be considered for computing a realistic ozone balance in peri-urban forest ecosystems.

Our study contributes to better understanding the complex interactions between biosphere and atmosphere in a densely populated Mediterranean area where pollution and climate changes represent a major threat to terrestrial ecosystems.

Keywords: Carbon sequestration, ozone fluxes, BVOC, Mediterranean Holm Oak forest.

ASSESSING VULNERABILITY OF FOREST FIRES TO FIRE RISK WITHIN THE CONTEXT OF CLIMATE CHANGE ON A GLOBAL SCALE

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While some forest ecosystems depend on fire for their regeneration, in others forest fires can be devastating. A series of factors are thought to be influencing fire activity, such as weather conditions, human activities, topography, land use changes and climate change. Forest fires are highly sensitive to climate change because fire behavior responds immediately to fuel moisture. Thus, projected increases in temperature increase fuel dryness and reduce relative humidity and this effect worsens in those regions where rainfall decreases. Accordingly, increases in climate extreme events are expected to have a great impact on forest fire vulnerability.

The potential impact of climate change to forest fires is assessed in terms of their sensitivity and exposure according to the definitions of IPCC. Potential impact is the product of exposure and sensitivity.

In order to estimate the exposure factor, mean monthly Fire Weather Index (FWI) maps for the control period and their changes between the control and the future period were produced. FWI is a meteorologically based index used worldwide to estimate fire danger. In order to calculate FWI values daily output from the atmospheric chemistry GCM ECHAM5/Messy2 in a horizontal resolution of 50km have been used.

For the estimation of the sensitivity factor, land cover / vegetation data were obtained from the 10 year MODIS-Global Land Cover Climatology database at 0.5km horizontal resolution. For each of the 17 land cover categories available, a flammability index was assigned and subsequently a Land Cover Land Use (LCLU) map was produced.

Finally, for the estimation of fire risk impact, FWI maps for the current and future climate and the LCLU maps were combined.

Potential fire risk impact varies spatially throughout the year. By the end of 2054 and from September to April the most vulnerable areas are expected to be the Tropic and North Sub-tropic zones. In these geographic zones very flammable vegetation, mainly evergreen broadleaf forests are combined with high FWI values resulting in high fire risk values.

INCORPORATING TIDES INTO LOCAL LEVEL SEA LEVEL RISE LOSS ESTIMATES

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Sea levels are rising as a result of climate change and thereby amplifying the risk of tidal flooding in coastal communities, leading to many types of damages, particularly degradation of property due to contact with floodwater. This study develops a spatially detailed model of coastal damage with tides to evaluate the direct economic costs of coastal flooding from sea level rise, taking into account local complexities and subtleties in fine detail. Tide gauge data is analyzed and used to incorporate tides into sea level rise damage estimates. Coastal flooding damages are assessed using depth-damage functions. High-resolution topographic data provides the accurate elevation data necessary to determine which properties will be affected under different flood scenarios. Results show that it is critical to incorporate tides in local level sea level rise assessments as they can have a significant effect on water level and when a property is damaged by flood waters. While the existing flood damage assessment methodology can be modified to calculate the potential economic impacts of sea level rise on structures in coastal communities, a separate loss function is necessary to estimate land losses.

Keywords: sea level rise, tides, coastal flooding, climate change, depth-damage functions

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ANALYSIS OF THE PRECIPITATION REGIME IN A WIDE MEDITERRANEAN AREA

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The precipitation climate regime of a region is characterized by the distribution of the monthly precipitation contribution. Its temporal and spatial analysis is of particularly interest for many fields of applied sciences, such as climatology, hydrology and water resources management especially in arid or semi-arid environment [1, 2]. With the aim to describe the climate regime, its spatial feature and relevant potential temporal shift, for a large area of southern Italy (Mediterranean basin), a database of about 559 stations, has been explored through the statistical analysis of rainfall time series spanning between 1917-2006. After a change point analysis, aimed at the assessment of data quality, a trend analysis has been performed on both monthly precipitation, monthly percentage of annual rainfall amount and Precipitation Concentration Index (PCI) series [3]. The broad extension of the area under investigation highlights a better understanding of precipitation distribution patterns over space, illustrating how particular geographical location are characterized by climatic features apart from the average climate regime predicted for a particular period of the year [4,5]. Results of PCI trend analysis indicate a significant shift, for about 40%-50% of total gauging station, over the time toward a more uniform climate regime, especially for the hilly areas. Results of monthly rainfall series trend analysis further indicate that the shift is produced by a reduction of rainfall amount during the winter season, particular consistent over the Tyrrhenian side of the peninsula, and an increase during the summer season quite widespread over the whole investigated territory [6].

Keywords: Precipitation, PCI, climate regime, trend, Mediterranean basin

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IMPACT OF CLIMATE CHANGE ON HYDROPOWER POTENTIAL IN THE SOUTH-EASTERN ALPINE REGION

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Climate change is expected to cause alterations of streamflow regimes in the Alpine region, with possible relevant consequences for several socio-economic sectors including hydropower production. The impact of climate change on water resources and hydropower production is evaluated with reference to the Noce catchment, which is located in the Southeastern Alps, Italy. Projected changes of precipitation and temperature, derived from an ensemble of 4 climate model (CM) runs for the period 2040–2070 under the SRES A1B emission scenario, have been downscaled and bias corrected before using them as climatic forcing in a hydrological model. Projections indicate an increase of the mean temperature of the catchment in the range 2–4 K, depending on the climate model used. Projections of precipitation indicate an increase of annual precipitation in the range between 2% and 6% with larger changes in winter and autumn. Hydrological simulations show an increase of water yield during the period 2040–2070 with respect to 1970–2000. Furthermore, a transition from glacio-nival to nival regime is projected for the catchment. Hydrological regime is expected to change as a consequence of less winter precipitation falling as snow and anticipated melting in spring, with the runoff peak decreasing in intensity and anticipating from July to June. Changes in water availability reflect in the Technical Hydropower Potential (THP) of the catchment, with larger changes projected for the hydropower plants located at the highest altitudes. Finally, the impacts on THP of water use policies such as the introduction of prescriptions for minimum ecological flow (MEF) have been analyzed. Simulations indicate that in the lower part of the catchment reduction of the hydropower production due to MEF releases from the storage reservoirs counterbalances the

benefits associated to the projected increases of inflows as foreseen by simulations driven only by climate change.

Keywords: Climate change, Alpine region, Water use policies, Streamflow alterations, Hydropower potential

EXTREME RAINFALL EVENTS AND CLIMATE CHANGE

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There is no scientific evidence that "climate change" have effect on extreme rainfall events. The Italian absolute record in terms of extreme hydro-meteorological events, still unbeaten, do not refer to recent years. Increasingly, however, the media talk of exceptional weather events, using phrases and neologisms as "water bomb", "tropicalization of climate", "climate change", "rains never seen before", and the like. But the analyzes carried out show that there are no such climatic factors to justify these trends, as the complex of man-made changes. Several studies on rainfall and hydrological disasters demonstrate the general downward trend in rainfall and intensity of rain, while disasters are increasing due to the use of the territory with the growing use of areas with significant hydro-geological hazards. In Italy, in fact, they are decades that on average 75 hectares of land per day is consumed. The growing waterproofing of the soils greatly reduces the power of retention, infiltration and evapotranspiration of soil, and totally increase the flow coefficients. We should assess the effects of policy area planning risks and design alternatives to combat risk with positive or negative effects. Knowledge is necessary to illustrate to community risk scenarios and then to consider what happens if we do nothing or if we implement policies of land use planning. It is unavoidable get to the planning of acceptable risk, for sustainable development. We need to assess the vulnerability of settlements to natural disasters and increase ability to react.

Keywords: rain, intense, climate, change, instability

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EXTREME RAINFALL EVENTS AND CLIMATE CHANGE

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SOIL EROSION DUE TO RAINFALL: THE ROLE OF DROP SIZE DISTRIBUTION

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Most climate change scenarios allow the description of increasing frequency and severity of extreme rainfall events. Hydrological systems may be very sensitive to these changes, for example in terms of increasing runoff and soil erosion. In particular, soil erosion by water is the result of rain detaching and transporting vulnerable soil that can trigger soil loss from cultivated lands and the reduction of water storage capacity in reservoirs due to sediment yield. An accurate estimation of the factors that control soil erosion is very important to recommending appropriate measures to protect soils and reduce their vulnerability.

Most mathematical models describe potential soil loss in terms of empirical factors, which include the rainfall erosivity factor and the soil erodibility factor. The rainfall erosivity factor is usually calculated by empirical laws that involve the total amount of kinetic energy contained within a storm and the intensity of the storm [2]

Recently an approach based on exploiting knowledge enclosed in the drop size distribution (DSD) of the storm and the rain drop fall velocity was used to characterize the rainfall's erosivity energy and to verify traditional empirical laws [1].

An investigation on the use of the drop size distribution to characterize rainfall erosivity capacity was here carried out, with the aim to contribute to the discussion over land consumption due to intense rainfall events.

Keywords: Rainfall erosivity, kinetic energy, Drop Size Distribution (DSD)

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EVENT AND LONG TERM SCALE ANALYSIS OF RAINFALL TRIGGERING MDHE IN A PERI-URBAN SYSTEM

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During the last decade, the Solofrana catchment (Southern Italy – Mediterranean basin) has been called to face the problem of an increased frequency of Multiple Damaging Hydrological Events [1]. On a general perspective, this could be related to the intensification of the hydrological cycle due to two major issues: the urbanization on one side and the evolving climate on the other. With reference to the climate, the Mediterranean basin appears a particularly vulnerable environment because of potential future alternations of extreme rainfall [2]. A large fraction of the precipitation occurring in autumn and winter, when about 58% of MDHE are detected within the studied catchment, is related to the Mediterranean cyclones ([3], [4], [5]).
The aim is the investigation of the role played by the climate in the intensification of the hydrological catchment response. A number of about 25 MDHE, within the period 1951-2014, have been selected and analyzed in terms of cumulate rainfall amount and profile (Binary Shape Code), duration extent, maximum intensity and temporal occurrences [6]. The comparison with statistical results of historical precipitation records, tested for trend detection [7], for the same catchment, has also enabled the possibility to assess the occurrences probability or the return periods of the selected events, to verify or reject their exceptional nature. The main findings of the reported study relate to the fact that climate evolving tendencies do not appear significant in most of the cases and that MDHEs occurred within the studied catchment also for rainfall events of very moderate intensity and/or severity. The illustrated results seems to indicate that climate variability has not assumed the main role in the large number of damaging event, and that the relative increase hazardous hydro-geological events in the last decade, is instead most likely caused by incorrect planning policies and dissolute increase in urbanization.

Keywords: MDHE, climate change, Solofrana basin

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CLIMATE CHANGE AND COASTAL EROSION: EFFECTS ON SANDY HABITATS

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Mediterranean coastal zones are characterized by landscapes of outstanding natural value, in terms of biodiversity and functional complexity. At the same time, coastal environments are extremely sensitive and vulnerable transitional zones, strongly influenced by climate change, increased urbanisation and human activities that have directly or indirectly turned coastal erosion into a problem of growing intensity [1, 2, 3]. The marine coastal areas, commonly inhabited by typical sandy bottom assemblages, are characterized by the presence of some species with high commercial value, such as the wedge clam *Donax trunculus* (Linnaeus, 1758). It is considered to be a substrate-sensitive organism because of its sensitivity to sediment grain size variations during its life cycle. *D. trunculus* is an exclusive species of the Superficial Fine Sand, which is preferentially distributed on sandy sediments (0 - 2 m) [4, 5, 6]. Some studies documented that sediment grain size is the chief factor controlling the distribution of *D. trunculus* populations; suitable grain sizes allow the settlement and the subsequent growth of well-structured populations. The species declined or disappeared in presence of eroded or not stable beaches [5, 6].

It is known that coastal erosion induces loss of beach habitat, with significant consequences on biodiversity [7, 8]; in a perspective of sustainable management, coastal defences should be realized with the aim to reduce the loss of natural habitats or to restore habitats. In the case of *D. trunculus* populations beach nourishment interventions carried out using suitable grain size sediments allowed the habitat recovery and the subsequent colonization of this species [5, 6].

Considering the lack of knowledge concerning the prediction and the assessment of impacts induces by coastal defence works on coastal ecosystems [9], a win-strategy could be to develop effective ecosystem-based adaptation strategies [10], able to combine shoreline protection and biodiversity conservation in coastal zones.

Keywords: Climate change, coastal erosion, habitat loss, *Donax trunculus*

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CLF.P.03 – CLIMATE CHANGE AND WILDFIRE EXPOSURE IN SARDINIA (ITALY)

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The goal of this work was to assess the potential impacts of future climate change on wildfire exposure in Sardinia (Italy), the second largest island (about 24,000 km2) of the Mediterranean Basin. We used climate projections obtained from the CMCC-CLM regional climate model (Rockel et al. 2008) and based on the A1B IPCC emission scenario. Spatial and temporal resolution of the climate data were respectively 14 km and 6 hours. From the climate data, we characterizedclimate/weather conditions and fuel moisture considering three different study periods of 30 years (1981-2010; 2011-2040; 2041-2070) and we informed fire modeling with these data. Wildfire exposure was analyzed using a spatially explicit fire spread modeling approach based on the Minimum Travel Time algorithm (Finney 2002), as implemented in the last version of RANDIG (Salis et al. 2015). The wildfire simulations were run at 250 m of resolution for the whole island, considering a set of 50,000 fire ignitions for each study period; ignitions were randomly sampled from the historical database provided by JRC. We hypothesized no spatial and temporal changes in fire ignition pattern and land cover, to analyze variations in fire exposure only due to climate change. We analyzed fire exposure profiles (burn probability, flame length, fire size) for each study period and we then compared the outputs of the fire modeling exercise. The main findings of the work were the lengthening of the future fire seasons, the likely reduction of the days characterized by strong winds, as well as the increase in fuel dryness conditions, and the limited variations in terms of fire exposure profiles. This methodology allows developing guidelines for fire management and prevention policies considering the future climate

change projections in Mediterranean areas, and could be easily extended to other areas.

Keywords: climate change, fire risk, fire modeling, Mediterranean areas

FIRE EXPOSURE AND VULNERABILITY OF WILDLAND-URBAN INTERFACES: A CASE STUDY FROM NORTHERN SARDINIA, ITALY

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In this work, we analyzed fire exposure and vulnerability of a 46,000 ha study area located in North-East Sardinia. The study area is very prone to fire, and is characterized by predominant and dense shrublands, extensive wildland-urban interfaces and relevant touristic pressure mostlyin summer. We first analyzedthe vulnerability to firesof about 13,000 housing units, and the closest neighboring (10-m buffer) combining aerial photographs and field surveys. About 40% of the housing units of the study area was classified as wildland-urban interface since it was in contact with the vegetation.Afterwards, we used simulation modeling based on the MTT algorithm of FlamMap (Finney 2006) to estimate fine scale fire exposure. For this analysis, we selected 32 different scenarios to represent the most common and critical conditions for fire occurrence and spread in the study area. For each scenario, we fixed 10,000 fire ignition points and we simulated the spread ofwildfires at a resolution of 20 m. We analyzed fire exposure profiles considering burn probability, flame length, fire size and source-sink ratio (SSR). We finally combined the WUI mapping and characterization results with the outputs obtained from the fire simulations, and we identified and quantified the level of risk of the housing units. As expected, the houses surrounded by shrublands and complex topography, particularly when isolated, showed very high fire exposure profiles and overall risk, while the lowest exposure was observed in compact villages and towns and in areas characterized by strategic fuel management.

Keywords: fire risk, Mediterranean areas, WUI, burn probability

RAINFALL EVENTS AND FLOODING EPISODES IN RIO DE JANEIRO METROPOLITAN AREA (BRAZIL): CHANGES IN CLIMATE PATTERNS AND PRODUCTION OF URBAN SPACE CHALLENGES

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The relationship between climate elements variability and its possible influences on life in megacities is one of the main ways to approach the understanding of its impacts. Rainfall is in the tropical world, a felt element in the daily life. Disorders can be triggered, particularly in urbans realities in Latin America socio-spatial forming and/or deforming countries. This paper aims to analyze the rain genesis that cause flooding in the researched area. Atmospheric elements analysis were performed by its dynamics, (through rhythm analysis), with qualitative flooding identification in Rio de Janeiro using Geography of Climate as a way of approaching. Rainfall hourly data from 1999 to 2012 was used to identify duration and intensity precipitation patterns,so as spatial-temporal rainfall variability at different scales in detail was made to identify the atmospheric systems main generators of an extreme rainfall. Historical studies on the production of urban space, its dynamics and natural forms changes were considered. Thirdly, sites of flooding occurrence were determined, by both civil defense public data and news published by the press. An extreme event (days with rainfall above average) and extreme episodes (days with repercussion in urban space, no necessarily with intense rainfall) decomposition of its genesis was performed. Atlantic Polar Front was accounted for most of the extreme events and episodes followed by Stationary Front and the Convergence Zone of the South Atlantic. Not all heavy rains triggered episodes. Changes in urban site, as well as patterns of city building are related to episodes occurrence and reflects an uneven and combined production of urban space in Rio de Janeiro metropolitan area.

Keywords: rainfall, floods, urban climate, Rio de Janeiro

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EXTREME RAINFALL STATISTICS IN THE MARCHE REGION, ITALY

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Many studies have been available in Italy on the detection of the trends in daily, seasonal and extreme rainfalls [Bartolini et al., 2014, Arnone et al., 2013]. Some recent analyses [Manetti et al., 2014; Soldini et al., 2014] showed that in two regions of the Central Italy (Tuscany and Marche) is not possible to detect trends (increasing or decreasing) in the maximum annual rainfalls with 1, 3, 6, 12 and 24 h duration.

In the present study a statistical analysis of the rainfalls is carried out for detecting a possible trend in the observed data. On the one hand, annual maximum daily rainfall, and annual maximum rainfalls for 1, 3, 6, 12 and 24 h, 15 and 30 minutes duration have been analyzed, on the other hand two ETCCDI Extremes Indices (RR1, R20) have been computed to verify the variation of the frequency of these extreme events.

The rainfall dataset refers to the historical series collected in the hydrographic basins of the Marche region. In the study of the annual maximum events have been taken into account only the stations that have recorded at least 30 years in the period 1918-2013 and that the last year of functioning was at least 2007. Instead, for the ETCCDI Indices have been analyzed the data series in the 1951-2014 period. The time series have been processed by using the nonparametric Mann-Kendall test for three significance levels (α = 0,1 - 0,05 - 0,01).

The obtained results confirm that most of the historical series relating to the annual maximum daily, hourly and sub-hourly rainfalls does not exhibit any trend and show that, if a trend is present, it is mainly negative. The absence of trend or the presence of negative trend are also confirmed for the two ETCCDI Extremes Indices.

Keywords: historical rainfall series, extreme rainfall, trend analysis, Mann-Kendall test, Central Italy

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ENVIRONMENTAL RISK ASSESSMENT OF NUTRIENTS ON COASTAL AQUATIC ECOSYSTEMS UNDER A CHANGING CLIMATE

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Coastal waters face several threats primarily caused by human activity [1,2]. Here we focus on the loadings of nutrients from upstream watersheds which can cause a significant degradation of the receiving aquatic environments. Moreover, the expected increase of global warming can have remarkable impacts on the availability and quality of freshwaters and then coastal waters [3,4]. According to literature [5,6,7], climate change is already affecting the cycling of nutrients thus increasing the risks for living organisms. Future climate scenarios and SWAT [8] will be used to evaluate the change of nitrogen and phosphorous loads conveyed into the lagoon of Venice from the highly cultivated and populated watershed of the Zero river. AQUATOX [9] will be then used to assess the consequent impacts on the aquatic ecosystem of the receiving waters.

Flow rate and nutrient loads calibration (2007-2009) and validation (2010-2011) were performed using the tool SWAT-CUP SUFI2 [10]. The Nash-Sutcliffe model efficiency (NS) [11] and R^2 statistics were examined. Flow rate was calibrated on a mean monthly basis. Nutrient calibration was performed based on monthly loads of nitrate (NO_3^-), ammonium (NH_4^+), total phosphorus (TP) and Orthophosphate (PO_4^{3-}). Total Organic nitrogen (TON) and phosphorus (TOP) loads were adjusted according to the inorganic/organic ratios estimated in previous studies.

Future climate scenarios (8 km spatial resolution) were provided by the GCM CMCC-CM [12] coupled with the RCM COSMO-CLM [13] and forced by the IPCC RCPs 4.5 and 8.5 [14]. A bias-correction method [15] has been applied in order to reduce the observed biases for temperature and precipitation. At a later stage, climate scenarios from the CORDEX project [16] will be also implemented.

Preliminary results show a satisfactory match (NS > 0.4) between observed data and SWAT simulations of flow rate and nutrient loads. Finally, the bias-correction method reduced the observed spread between the monthly means of monitored and climate model values for temperature and precipitation.

Keywords: climate change, risk assessment, nutrients, coastal ecosystems.

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LARGE WOODY DEBRIS IN RIVER CHANNELS AND RIVER ECOLOGY

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Extreme meteorological, hydrological and geo-hydrological events result in increasing availability of woody debris and LWD – Large Woody Debris mobility in river catchments. The abundance of wood and the dichotomy in wood actions in rivers: essential ecologic role [1], stabilizing effects on the river corridor [2], improvement to the destructive power of a flood event; lead to the necessity of management practices for LWD in rivers.

Systematic removal of woody material in river channels, which has been for long time the common practice in woody debris management, is far to produce a reliable risk protection, while it results with evidence, in a detrimental action on river ecology and stability [3], [4]. At time, countless interventions all over the world, have reintroduced wood in rivers with restoration and banks protection aims [5], [6].

Understanding LWD dynamics in river channels represents a basic step to produce management strategies allowing matching safety, and morphologic and ecologic benefits.

The research activity has been aimed to improve management skills for the assessment of the hydrologic risk associated to the presence of LWD in rivers, improving knowledge about LWD dynamic processes.

Among wood's dynamic processes, logs entrainment has been considered a crucial one, making the difference between the available material and the amount of wood that would be mobilized with high probability during a high flow.

For this reason, appraising the current state of the art([7], [8], [9]) an improved theoretical mechanistic model has been proposed, combining knowledge from different disciplines, which takes into account more complexity of the flow field surrounding a partially submerged object lying on a flume bed. Under the new theoretical approach a threshold parameter is obtained and tested with flume experiments, to characterize the incipient motion condition that represent one of the essential starting points for the construction of hazard scenarios in occurrence of extreme events.

Keywords: LWD – Large Woody Debris, geo-hydrologic risk assessment, LWD entrainment, flume experiment.

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VOLUNTARY CARBON CREDITS BY FOREST MANAGEMENT IN THE ITALIAN ALPS

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We illustrate the steps being taken to design guidelines for the generation of voluntary carbon credits [1] by forest management activities in mountain forests of the southwestern Alps (Piedmont, Italy). The guidelines are a joint effort by academia, regional administrations, forest owners and professional consultants. In particular, we show how to compute the additionality of credit-generating forest management activities, defined as an additional biomass retention for carbon stocking relative to both legally and consuetudinary harvestable biomass [2], for each forest type in the Piedmont region.

In order to illustrate the profitability of carbon credit generation, we simulated the application of carbon credit guidelines to a forested catchment in the south of the region, dominated by chestnut (*Castanea sativa* Mill.) and beech (*Fagus sylvatica* L.) coppices. Here, we computed current forest carbon stocks, potential credits generated in a 20-year time, and revenues from carbon credits. On a harvestable area of 1550 ha, 62000 tons of CO2 could be stocked, producing a yearly income of 20 € per hectare with a price of ten €/ton.

The steps to generate baselines and to regulate carbon credit generation by forest management activities can be replicated in other mountain regions where there is interest in promoting this ecosystem service as an alternative or an addition to production-oriented forest management.

Keywords: Carbon stock, Coppice, Mitigation, Payment for ecosystem services, Silviculture

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OCEAN AND CLIMATE CHANGE ON THE WAY TO COP21

RELATIVE SEA-LEVEL CHANGE ALONG THE ITALIAN COAST AND PROJECTIONS FOR 2100: COASTAL PLAIN IMPACTS BASED ON HIGH-RESOLUTION DTMS AND GEODETIC DATA

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Sea-level change along the Italian coast is the sum of eustatic, glacio-hydro-isostatic, and tectonic factors. The first is global and time-dependent while the latter two also vary with location. The glacio-hydro-isostatic part (strictly related to the glacial climate in north Europe) exhibits a well-defined pattern and is readily predictable whereas the tectonic component exhibits a less regular pattern that is generally of shorter wavelength. Together, these components result in a complex spatial and temporal pattern of relative sea-level change around the central Mediterranean coast-line. Sea-level data are used to provide projections of sea-level change in Italy for the year 2100 by adding isostatic and vertical tectonic components to the IPCC 2013 and Rahmstorf projections. We focus on the North Adriatic coast and Venice, subsiding at -0.7 mm\yr, the tectonically stable Oristano and Cagliari coastal Plain (Sardinia) and the slightly uplifting area of Mar Piccolo (Taranto, Apulia). We used high-resolution DTMs to depict a multitemporal flooding scenario up to 2100. Data of sea level indicators are compared with the predicted sea-level curves providing estimates of the vertical tectonic contribution to the relative sea-level change. The results are based on the most recent ANU model and discussed against available GPS data for present day vertical land motion and sea level trend from tide gauge data. On the basis of eustatic, tectonic and isostatic components to sea-level change, projections are offered for those coastal plains currently placed at elevations very close to present-day sea level and are risk to be flooded for the next century.

CLIMATE CHANGE AND FEASIBILITY OF DEVELOPING AN ENVIRONMENTALLY SUSTAINABLE INTEGRATED MULTI-TROPHIC MARICULTURE SYSTEM IN THE NORTHERN PERSIAN GULF COASTLINES

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Large-scale and intensive mariculture of finfish is inevitable along the Iranian coastline in the Persian Gulf. Finfish mariculture at the proposed sites poses a serious threat to the environmental integrity of Iranian coastal and marine ecosystems. At the same time marine habitats are being affected by climate change effects as well.The Persian Gulf coast of Iran supports coral reefs, all the way from Khark Island in the north-west to Qeshm Island and beyond, in the south-east (Burt et al., 2014).As a measure of Ecological Conservation and protection of coral reefs, sea turtles, and sea grass beds, we propose a feasibility study for the development of an Integrated Multi-Trophic Mariculture system (IMTM), as an alternative to intensive mariculture of only finfish. IMTM is the primary environmental conservation tool in not only mitigating, but preventing the environmental destruction brought on by eutrophic pollution from finfish mariculture operations. IMTM preserves biodiversity by alleviating fishing pressure of wild fisheries, reduces or eliminates the reliance of net-caught "trashfish" as mariculture fish food, reduces the need for destructive fishing practices, and reduces anthropogenic-usage loads for coral reefs. Successful IMTM operations will also allow the Iranian government to enact more stringent regulations for the extraction of wild fisheries and protection of valuable coral reefs which are partly endangered due to climate change and coastal developments, while having a positive effect on the industries that rely on these natural resources. This paper summarizes the attempts which have done to achieve an Environmentally Sustainable Integrated Multi-Trophic Mariculture System in the Northern Persian Gulf Coastlines.

Keywords:Integrated Multi-Trophic Mariculture, the Persian Gulf

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LONG TERM VARIABILITY OF ANTARCTIC BOTTOM WATER PRECURSORS AND CLIMATE INDEXES IN THE PACIFIC SECTOR OF THE SOUTHERN OCEAN

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A multitude of observations confirm that the polar regions are the fastest and perhaps most dramatically changing areas of the planet.

In few areas around Antarctica is formed the Antarctic Bottom Water (AABW), the densest and coldest water that occupies the bottom layer of the world ocean. The production of the AABW plays a major role in determining the strength of the Meridional Overturning Circulation.

Observations within the Southern Ocean's Pacific sector indicate a decadal trend of reduced salinity of the shelf waters (Jacobs et al., 2002; Jacobs & Giulivi, 2010; Budillon et al., 2011), which are related to the AABW modification in the Australian sector (Shimada et al., 2012).

CTD data, and moored time-series collected in the Ross Sea since 1995 in the frame work of the Italian National Antarctic program show strong changes in the thermohaline characteristics of the shelf waters, precursor of the AABW. In Terra Nova Bay polynya, in the western sector of the Ross Sea, the salinity of the HSSW decreased of 0.08 in 17 years.

Along the Ross Ice Shelf the benthic layer freshened about 0.02 from 1995 to 2006 end 0.07 to 2012. While in the central sector is evident a freshening of the High Salinity Shelf Water (HSSW) of 0.04 from 1998 to 2006 and a strong reduction of the Ice Shelf Water presence. Our analyses showed that the NINO3.4 and the SAM indices are strongly correlate with shelf waters temperature anomaly in the central sector. In this work we analyzed the atmospheric patterns characterizing the different index phases, and their possible impacts on the shelf water formation and on the Ross Sea capability to ventilate the bottom layers.

ECOLOGICAL REGIME SHIFTS: A SCIENTIFIC AND SOCIO-ECONOMIC CHALLENGE IN AN INCREASINGLY CHANGING WORLD

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Ecological regime shifts or phase shifts or critical transitions, are abrupt changes in ecosystems structure and functioning. They can be explained with the theory of nonlinear systems crossing critical thresholds, suddenly bringing unexpected, system-wide, dramatic changes. These shifts can carry significant socio-economic impacts and losses of ecosystem services, for example when they involve fisheries collapses or reef degradations, and as such interest scientists and managers alike, as highlighted in a special issue on marine regime shifts on *Philosophical Transactions of the Royal Society B* and numerous other publications. They have been found in all environments (terrestrial, lacustrine, marine). In the marine realm regime shifts have been reported in multiple habitats worldwide, from benthic reefs to pelagic ecosystems. In this Anthropocene Era, ecosystems are increasingly affected by multiple, multi-scale stressors, from large (global change) scale, as the recent IPCC scenarios indicate, to regional (e.g., fishing) and local (e.g., pollution) scale. However, business-as-usual (or other) scenarios do not necessarily take into account critical transitions, and we note that the changes we have been experiencing (e.g., migrations to the north, changes in phenological cycles, extreme events, etc.) have happened with a +0.8 ºC increase in the last 50 years. It is therefore likely that we will experience more frequent and more encompassing regime shifts as the predicted scenarios progress. Taking this into account, new research is beginning to be directed towards novel ecosystems (resulting from shifts). Future ecosystem management approaches should incorporate knowledge on environmental resilience and critical thresholds, and develop tools that consider regime shift dynamics and characteristics.

A NEW ON LINE SERVICE FOR MARINE ENVIRONMENT AND CLIMATE CHANGE ASSESSMENT IN THE MEDITERRANEAN SEA

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A new web-based and mobile decision support system for supporting marine environment assessment has been developed. The service is called MARINENVIRONMENT and provides and displays information on the environmental quality of the Mediterranean Sea. In addition, also climate change indicators will be displayed on the website. The system is designed on the basis of environmental protection users requirements and is accessible via the website www.marinenvironment.com. In addition to the website, dedicated applications for iOS and Android have been created to optimise the user experience on mobile devices. The system is supposed to provide environmental information derived from model and remote sensing products to the users that need to assess the present and past status of the coastal and open ocean environment.

The oceanographic products related to currents, temperature and salinity comes from Copernicus Marine Monitoring Service and specifically from the MED-MFC and the Ocean-Colour TAC. Wave forecast are produced by the Mediterranean Forecasting System of the Italian Institute of Geophysics and Volcanology (INGV, Bologna, Italy).

The information available concerns environmental indicators, numerical model outputs and satellite data shown as maps or time-series.

The data catalogue considers:

1) environmental indicators: Chl-a trends, TRIX, Chl-a statistical analysis
2) numerical models products: wave, currents, temperature, salinity
3) remote sensing observations: chl-a, SST
4) climate change indicators: SST, heat content, sea level trends

The MARINENVIRONMENT allows users to select different timeframes for the variables shown (e.g. monthly, seasonal).

The products allow the users to extract and derived information relevant for the Marine strategy Framework Reporting and marine environment and climate assessment.

THE MARINE SECTION OF THE STATION FOR CLIMATE OBSERVATIONS AT LAMPEDUSA: AN AIR-SEA INTERACTION OBSERVATORY

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The Station for Climate Observations on the island of Lampedusa (35.5°N, 12.6°E; http://www.lampedusa.enea.it) is dedicated at studying climate variabiity and processes in the Mediterranean. The Station is operational since 1997. Measurements, also made in collaboration with different international Institutes, are mainly dedicated to atmospheric parameters and contribute to several global networks (GAW/WMO; NOAA Cooperative air sampling network; AERONET; ICOS, etc.).

The marine section of the observatory has been recently developed in the framework of the RITMARE Italian Project, and will contribute to the national fixed-point observatory network [1], as well as to other international networks. An elastic beacon type of buoy has been designed and built, and has been deployed in August 2015 at 35.50°N, 12.47°E, about 3 miles South West of Lampedusa. The ocean depth at the buoy site is 74 m. Primary scientific objectives of the marine observatory are: to investigate air sea interactions in the central Mediterranean; to study the surface energy budget; to characterize the oceanic optical properties, and to investigate links with the carbon cycle. The site will also be available as a cal/val facility for satellite observations, and to validate operational oceanographic model forecast. A first set of sensors was acquired, and the installation of the first set of sensors is ongoing.

The marine observatory will integrate the exisiting infrastructure for atmospheric measurements. Routine observations at the site include: meteorological parameters; greenhouse gases [2]; aerosol optical properties [3]; aerosol vertical distribution [4]; temperature and humidity vertical profiles [5]; cloud cover and optical properties; column water vapour and liquid water path; spectral surface irradiances from the UV to the near IR; broadband IR irradiances [6]; direct and diffuse radiation components in different bands; surface ozone; total column ozone; PM10 concentration and chemical composition at the daily scale [7]; black carbon; atmospheric aerosol deposition, etc.

Keywords: oceanic observations, air-sea interaction, satellite cal/val

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THERMAL CONSTRAINTS ON EARLY DISPERSAL MAY PREVENT POLEWARD EXPANSION OF MARINE ECTOTHERM WITH CLIMATE WARMING

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Climate warming is a major challenge to Earth' biota that forces species to adapt in situ or move to a different location in order to track shifts in their thermal niche[1]. Despite slower ocean warming over the last 50 years, the pace of isotherm migrations at the ocean surface has been comparable or even faster than at the terrestrial counterpart[2]. Many different marine taxa have already shifted their distributions to endure changes in ambient temperature[3]. In particular, thermal range conformers such as marine ectotherms, are expected to colonise northern habitats as they become suitable for colonists due to the ongoing climate warming[4]. However, the pace of redistribution depends on species-specific traits that may promote or hamper expansion to northern habitats[5]. Here we show that recently, the loggerhead turtle (*Caretta caretta*) has begun to nest steadily beyond the northern edge of the species' range in the Mediterranean basin. This range expansion is associated with a significant warming of spring and summer sea surface temperature (SST) that offers a wider thermal window suitable for nesting. However, we found that post-hatchlings departing from this location experience low winter SST that may affect their survival and thus hamper the stabilization of the site by self-recruitment. The inspection of the Intergovernmental Panel on Climate Change model projections and observational data on SST trends shows that, despite the annual warming for this century, winter SST show little or zero trends. Therefore, thermal constraints during the early developmental phase may limit the chance of population growth at this location also in the near future, despite increasingly favourable conditions at the nesting sites. This study highlights the importance of quantifying and understanding the interaction between dispersal and environmental changes at all life stages to predict marine ectotherm redistribution with climate warming.

Keywords: loggerhead turtle, colonization, climate warming, range expansion, marine ectotherms

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OPERATIONAL OCEANOGRAPHY AT THE ENEA CLIMATE LABORATORY

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Over the last fifteen years, operational systems for the forecasting of the sea state over the Mediterranean and of the circulation of the main Italian seas have been developed, which provide products of use for the management and safety of the marine activities and for the protection of the marine environment. Since 2009, a high-resolution primitive equation model of the Tyrrhenian Sea circulation (TYREM) is operative at ENEA, which provides daily forecasts over the whole basin, with a horizontal resolution of about 2 km. The model takes initial and boundary conditions from the MFS model and is forced by momentum, heat, and fresh water fluxes from operational atmospheric models (formerly, from ECMWF data; currently, from the SKIRON model at 5 km of resolution). Since 2013, a system for the daily forecasting of wave energy is also operative at ENEA, which was developed in the context of the Italian National Project "Ricerca di Sistema Elettrico". The system consists of a WAM model at 1/32° covering the whole Mediterranean Sea, plus 11 higher resolution zooms (1/128°) based on the SWAN model, nested in the basin scale system, which provide more detailed information in regions of interest surrounding the Italian coasts. The wave models are all forced by the winds provided by the SKIRON model. The data produced by these models are used to support operational activities related to environmental emergencies and to the development and management of devices for extracting energy from the sea. The accumulation of forecasts produces databases of use for studying the variability of the Mediterranean climate.

Keywords: Mediterranean, ocean forecasting, operational models.

DESCRIBING AND UNDERSTANDING THE INTRINSIC KUROSHIO EXTENSION DECADAL VARIABILITY

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The Kuroshio Extension (KE) decadal variability, often denoted as bimodal because of the existence of two main modes of circulation [1-3], is believed to be essentially due to intrinsic mechanisms of oceanic origin [4]. This does not prevent the KE oscillations to be in synchrony with the main decadal time-scale modes of the sea level pressure variability in the North Pacific region [2]. A recent model study [5] interprets this phenomenon as a case of intrinsic climate variability paced by external forcing, and suggests that its simulation may be very sensitive to model implementation.

To this respect, it is important to assess the ability and sensitivity of high-resolution state-of-the-art ocean general circulation models to correctly simulate the KE cycles. In this presentation the hindcasts from 1993 to present obtained from an eddy-permitting global configuration of the NEMO ocean model, with or without assimilation of hydrographic profiles and sea level anomalies [6], are compared with altimeter data. To reveal the main features of the variability, indices such as the KE path length L_KE and mean KE latitudinal position FI_KE are computed for both altimeter and model data. In addition, a combined index proposed in [7] (suggested to provide an unambiguous identification of each stage of the KE cycles, and based on L_KE modified through the application of the wavelet transform) is used as well. The results show a good performance of the model and suggest possible future sensitivity studies.

Keywords: Kuroshio Extension; intrinsic ocean variability; ocean models; altimeter data; climate indices

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C-CEMS: AN INTEGRATED OBSERVATORY FOR COASTAL MONITORING

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Marine coastal ecosystems monitoring is nowadays a main concern in the worldwide scientific community and requires a multidisciplinary and integrated approach. The study of the whole components of coastal ecosystem is fundamental to face potential pollution phenomena and habitat conservation, as expected by Marine Strategy Framework Directive (2008/56/EC) [1]. A significant effort has been invested in modelling marine coastal dynamics and processes and in the development of new technologies oriented to remote sensing data validation, in order to increase large data sets required for integrated approaches. Along these lines the Laboratory of Experimental Oceanology and Marine Ecology of University of Tuscia University has developed a multi-platform observing system (the Civitavecchia Coastal Environment Monitoring System, C-CEMS, [2]) along the Latium coasts, where multiple uses (industrial, commercial and tourist activities) and high ecological values (Posidonia oceanica meadows, hard-bottom benthic communities, priority species, etc.) closely coexist generating strong conflicts between human uses and ecosystem conservation. The system integrates both measurements, remote sensing data, models and technological development [3]. This work shows the components of C-CEMS and different examples of its application.

Keywords: coastal monitoring system, MSFD

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ANALYSIS OF THE SPATIAL AND TEMPORAL VARIABILITY OF THE PHYTOPLANKTON SIZE CLASSES IN THE MEDITERRANEAN SEA FROM SEAWIFS DATA

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Phytoplankton represents the first levelof the food web being the primary producer in the marine ecosystem. Nowadays, it is well known the great ecological role attributed to the phytoplankton community in most of the bio-geochemical cycles [1]. Phytoplankton is also usually usedas a good environmental status index [2], e.g. in terms of the eutrophication levels. Recently, a big effort was done to develop algorithms able to evaluate, from satellite sensors, the contribution of different algal types to the total content of chlorophyll *a*(Chl). In this work, we described the variability of three Phytoplankton Size Classes (PSCs), micro-, nano-, pico-phytoplankton, at different spatial and temporal scales, applying an abundance-based model [3] on the Mediterranean satellite chlorophyll *a* for the SeaWiFS era (1998-2010).

We analyzed the spatial variability at basin and sub-basin scales, starting from daily satellite chlorophyll fieldsand used toproducemonthly mean and climatological PSCs maps. In addition, the analysis of the PSC temporal variability was enforced by computing the inter-annual and seasonal time series from 1998 to 2010.

The results showed that the contribution to the Chl of the three PSCs is strongly influenced by the physical and chemical processes that occurs at basin and sub-basin scales. Indeed, during the spring season, the high values of Chl concentration are predominated by the micro-phytoplankton fraction, followed by the nano- and then pico-phytoplankton cells. This phenomenonoccurs againin autumn, during a second bloom characterized by lower intensity. Our analysis demonstrated that the pico-phytoplankton fraction dominatesall year, especially in the low-nutrient environments, in which the smallest cells results more suitable to survive.On the contrary, nano-phytoplankton showsa homogeneously distribution over the entire basin in all seasons. Our results, also, revealed a predominance of the larger cells in the coastal areas, all around the year.

Keywords: Ocean Colour, SeaWiFS, Phytoplankton Size Classes.

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VARIABILITY OF THE MEDITERRANEAN THERMOHALINE CIRCULATION IN MED-CORDEX HINDCAST SIMULATIONS

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The availability of atmospheric reanalysis products, such as ERA40 and ERA-interim, together with the subsequent numerous regional dynamical downscaling hindcast simulations performed so far, prompted the HyMeX/Med-CORDEX community to test the ability of current oceanographic models of the Mediterranean Sea to represent the response of the circulation to realistic inter-annual variability in the atmospheric forcing.

This work presents an inter-comparison of recent hindcast simulations of the Mediterranean Sea Circulation, at resolutions spanning from 1/8° to 1/12°. Differences in the mean circulation have been analyzed, on both the long-term and decadal time scale, showing significant discrepancies. The inter-annual variability of the modeled Mediterranean THC has been investigated at basin and sub-basin scale, and compared to available observations. Simulations generally appear to be in good agreement, the main differences being attributable to alternative prescriptions of the Atlantic boundary condition.

We also analyzed the represented inter-annual variability of intermediate and deep water mass formation processes in both the Eastern and Western sub-basins, finding that models agree with observations in correspondence of specific events, such as the 1992-1993 Eastern Mediterranean Transient, and the 2005-2006 event in the Gulf of Lion.

Keywords: Mediterranean, ocean hind-cast, deep water formation

FACTORS DETERMINING SEA LEVEL VARIABILITY AND ITS DEVIATION FROM THE GLOBAL MEAN IN THREE MARGINAL SEAS DURING 20TH CENTURY: BALTIC, ADRIATIC AND BLACK SEA

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This work aims at comparing the deviation of the sea level of three marginal semi-enclosed seas, (the Baltic, Adriatic and Black Sea), from the global mean in the 20th century. The time series of mean sea level in the Baltic, Adriatic and Black Sea are reconstructed from tide gauges data extracted from the Permanent Service of Mean Sea Level (PSMSL) [3,5]. Three seamless time series covering the whole period from 1901 to 2009 are computed using tide records from 13 stations in the Baltic Sea, 7 stations in the Adriatic Sea and 5 stations in Black Sea, by adopting a procedure based on PCA and Least Square Method [4]. The high spatial coherency of the involved stations in each different basin implies that the resulting time series can be considered a reliable representation of its mean sea level. The comparison between the reconstructed time series and mean sea level from satellite data (covering the period 1993 to 2009) shows very high correlation values for the Baltic and Adriatic Sea (0.97 and 0.87 respectively) and a lower value (0.70) for the Black Sea. The Global Mean Sea Level time series is extracted by the PSMSL database [1,2]. The factors determining the interannual variability of each basin are separately analyzed and their relative contribute estimated. We consider: the Inverse Barometer effect (IB) due to the local Sea Level Pressure (SLP), the steric effects due to sea temperature and salinity variation and the mechanic effect due to the wind. It is shown that these three local effects can explain a large fraction of the interannual variability of the sea level in these three basins. However, there is a residual variability whose source is more difficult to identify, but has an important role both in the variability of the annual cycle and in the interannual variability of the mean sea level.

Keywords: sea level, steric, wind effect, regression, Inverse Barometer effect

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MULTIDECADALNORTH ATLANTIC OCEAN CIRCULATION PATTERNS AND IMPACTS ON EUROPEAN EEL LARVAL MIGRATION

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The European eel recruitment declined seriously since the late 1970s and it is displaying a weak turnaround only in last few years [1]. North Atlantic Ocean circulation plays a big role in the multi-year larval migration of this catadromous species from the Sargasso Sea towards the European continent[2,3]. In particular, ocean circulation determines routes and timing of migration while ocean temperature affects larval metabolism and the structure of the plankton community. Climate change is therefore one of the possible causes (in addition to habitat loss, parasitic infection, water pollution and overfishing, during the adult phase) that might have contributed to the recruitment decline. Here we use the ocean global numerical experiments [4,5]generated with two general circulation models to simulate the eel larval migration between 1958 and 2010 via a physical-biological Lagrangian approach with different particle behaviors: purely passive particles (year-long uniform release, no mortality) and living particles that mimic the eel larvae (i.e. realistic birth distribution in time and space, body growth, survival and active horizontal and vertical locomotion [3]).The scenarios with living particles point out a southward shift in the mean latitude arrival and a negative temporal trend in the migration with possible desynchronization between the timing of arrivals and the suitable season of freshwater recruitment. We therefore analyze the passive particle scenarios to isolate the effects of oceanography on drift duration and trajectories. The aim is to study the ocean currents changes (Gulf Stream, North Atlantic Current, Azores Current) during last decades by comparing simulations with observational data [6] and to evidence the possible effects on the European eel early-lifetraits.

Keywords: European eel recruitment, physical-biological models, larval dispersal, North Atlantic Current

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MYOCEAN MEDITERRANEAN SEA REANALYSIS 1987-2013: FOCUSING ON THE ALGERIAN BASIN CIRCULATION

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A new Mediterranean Sea Reanalysis (MEDREA) covering the time period 1987-2013 has been produced in the framework of MyOcean Project and it is now available through the Copernicus Marine Environment Monitoring Service (CMEMS) online catalogue. The MEDREA system is based on the NEMO hydrodynamic model (Madec et al. 2008[1]) and OceanVarvariational data assimilation scheme (Dobricic and Pinardi 2008[2]). MEDREA ocean model has 1/16° horizontal resolution (6.5 km), 72 unevenly spaced vertical z levels and it uses vertical partial steps to better fit the bottom shape (Oddo et al. 2009[3]). MEDREA assimilated in situ temperature and salinity vertical profiles belonging from different instrumental data types (CTD, XBT, MBT, bottles, ARGO floats) collected from many European Marine databases (SeaDataNet, MEDATLAS, CMEMS in situ TAC, MFSPP, MFSTEP) and reprocessed satellite Sea Level Anomaly (SLA) provided by CMEMS Sea Level TAC. MEDREA system has been forced by ERA Interim atmospheric reanalysis (Dee et al. 2011[4]) at 0.75 degree of resolution every 6 hours and it uses reprocessed satellite Sea Surface Temperature data from CMEMS OC TAC to correct interactively the computed heat flux. The runoff is provided by monthly climatological data at 12 main river outlets and ERA Interim precipitations every 6 hours have been introduced.

The main MEDREA validation and consistency analysis results highlight ageneral improvement with respect to previous Mediterranean Sea reanalysis (Adani et al. 2011[5], Pinardi et al. 2015[6]). A new validation analysis of MEDREA circulation has been performed in the southwestern Mediterranean using observations of currents from MATER program in the time period 1997-2002 (Testor at al. 2005[7]). MEDREA is able to reproduce two large-scale barotropic cyclonic circulations, the Western and Eastern Algerian Gyres, setting the basis of a review of the Western Mediterranean circulation and of the return flow mechanism towards the Atlantic Ocean.

Keywords: Mediterranean, reanalysis, circulation, validation, Algerian

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RELATIVE SEA LEVEL RISE IN THE CENTRAL MEDITERRANEAN FROM TIDE GAUGE DATA: IMPLICATIONS FOR FUTURE PROJECTIONS AND FLOODING SCENARIO FOR THE SUBSIDING ISLAND OF LIPARI

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We analyzed the longest tidal records available for the Mediterranean region at eight tide gauge stations distributed along the coasts of Italy, France, Slovenia and Croatia. Data were retrieved from the Permanent Service for Mean Sea Level and were collected in the 1872-2014 time span. From these records we identified the contributions of the nonlinear global warming signal and the long term natural variability in the sea level trend. Through the development of a simple low order theoretical model we investigated the combined effect of the global sea level rise and the decadal natural variability on the future sea levels at the analyzed stations. Finally, we tentatively estimated the future sea level rise up to 2100, by including the IPCC predictions in our analysis.

Based on these results and from vertical land motion rates obtained from GPS data and marine and terrestrial very high resolution DTMs, we provided a detailed flooding scenario for 2100 for the island of Lipari. This area is subsiding at velocities even exceeding 10 mm/yr since the last two decades and up to about 8 mm/yr since the last 2000 years B.P., as witnessed from archaeological data of a submerged pier of Roman age. Finally, the combination of land subsidence and sea level rise at Lipari island is expected to cause one of the most severe coastal flooding in the central Mediterranean, which is representing a significant hazard factor for the local population living near the shore.

Keywords: sea level rise, Mediterranean, Lipari

NEXTDATA SIXTY YEARS OCEAN REANALYSIS FOR THE STUDY OF THE MEDITERRANEAN CLIMATE

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Historical records of the ocean are currently required by different users both research and institutional and also private companies for scientific and application communities.

Historical observations are too sparse in space and time to be used alone for understanding the ocean climate variability. The combination of information from numerical models and observations, by way of a data assimilation algorithm, has the potential to provide a better estimate of the ocean than obtained only by modelling or by sparse observations. The production of ocean reanalysis is a recent activity and its development aims at meeting research and social needs related to monitoring and management of the marine environment, marine resources and marine safety.

Nextdata project has produced 60 years reanalysis of the Mediterranean Sea three-dimensional essential state variables, available open and free from its services. The numerical model is based on Nemo code, the data assimilation scheme is variational and all historical insitu and satellite observations are used. The MedSea reanalysis is forced with atmospheric surface variables from an AMIP dataset (*Cherchi and Navarra, 2007*). We present the ability to reproduce the general circulation and the assessment of the reanalysis products, following basic principles of accuracy, consistency and quality (*Murphy, 1993*), also considering the previous version of the Mediterranean Reanalysis.

Keywords: Mediterranean sea, ocean reanalysis, misfits, assessment, variability

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ENVIRONMENTAL FORCINGS ON THE GLOBAL OCEAN BIOLOGICAL CONNECTIVITY

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Human activities are expected to significantly impact oceanic ecosystems but their resilience is difficult to assess and remains poorly predictable. Individual acclimation capacities, population diversity, and seascape-level connectivity can contribute to ecosystems resistance to disturbances, ensuring ecosystems stability. Environmental changes at the oceanic circulation choke points can thus have dramatic impact on the global ecosystem functioning. Investigating whether biocenoses while travelling through choke points are exposed to specific environmental forcings is thus of primary significance. As the main choke point of the global ocean circulation, the physics of the Agulhas leakage is intensively studied. The Agulhas leakage occurs as anticyclonic rings, formed at the Agulhas retroflection and moving eastward across the South Atlantic gyre for up to several years. Despite the significant impact on Earth climate, precious little is known about plankton fate when transported from the Indian Ocean to the Atlantic Ocean. During the global Tara Oceans expedition we specifically sampled two Agulhas rings and, thanks to our holistic approach (from physics to genomics),we created an unprecedented dataset for the exploration of the large-scale biological connections amongst basins. We found water in the younger ring to be 5°C lower in temperature than Indian source waters, with a particularly deep mixed layer, unusually high concentration of nitrite and a significant community shift. The presence of specific nitrogen-cycle related taxa and genes suggested that a large post-bloom remineralization was occurring as predicted by the MIT-GCM model. We also observed that plankton were not equally affected by environmental forcings during the ring formation. Ultimately, the intense community shift during the Indian-to-Atlantic journey is caused by the Southern Hemisphere storm track which, in turn, is expected to be highly impacted by the climate change. It has thus to be expected that a climate change will impact the global ocean connectivity.
Keywords: plankton, bio-physical coupling, connectivity, storm tracks, climate change.

INNOVATIVE COMPUTING APPROACHES FOR INTENSIVE DATA ASSIMILATION IN OCEAN APPLICATIONS

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Data Assimilation (DA) is a key outstanding challenge in research on climate change. Taking into account the uncertainties is essential for the acceptance of climate simulations for decision making. These uncertainties must be integrated in the verification and validation process of the simulation codes (VVUQ, Verification, Validation and Uncertainty Quantification).

As stressed in the "CMEMS Service Evolution Strategy: R&D priorities", numerical models with resolutions more compliant with the spatial scales captured from space by new Earth Observation observing platforms, introduce complexity in DA problems but result into reduced representativeness errors. This model complexity and data increasing makes DA an always more large scale problem that should be solved in near real-time. For that reasons, the introduction of strategies and algorithms to solve the model equations efficiently on next generation computing systems, which is crucial to sustain operational production, is necessary.

To enable DA models to take full advantage of the computational resources now available is not just a matter of harnessing more computer cycles; substantive mathematical and algorithmic advances are needed. "Adapting old programs to fit new machines usually means adapting new machine to behave like old ones." Alan J. Perlis 1982.

We present innovative computing approaches (based on the introduction of parallelism in time direction and on the problem/domain decomposition), we are developing for facing with intensive DA applications on real cases based on enclosed and semi-enclosed seas. These approaches aim to result in DA code performance improvements that will be deployed during a collaboration among UNINA and both INGV (Prof. Nadia Pinardi) and Imperial College of London (Prof. R. Toumi)

TRAMONTANA WIND AND COASTAL UPWELLING ALONG THE NORTHERN TYRRHENIAN SEA EAST COAST

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The present research aims to investigate the hydrographical response to Tramontana wind in order to identify the upwelling events in the Northern Tyrrhenian East coast, and to identify the relations between upwelling events and teleconnections pattern [1]. Coastal upwelling events are poorly represented in the Tyrrhenian Sea, nevertheless Bakun and Agostini [2] have demonstrated that this area are under the influence of winds that on average produce a mild net coastal upwelling tendency.

Wind-driven upwelling has been identified through wind fields and sea temperature[3]. Upwelling favourable winds have been defined in the sector between Northwest and Northeast (Wd >330°N & Wd < 30°N). Moreover, only wind speed greater than 7.5 m/s have been considered as significant for upwelling events.

In a first step, upwelling events at local scale have been identified through C-CEM System [4]. MyOcean (SST) and ECMWF (wind and barometric fields) data were used to correlate upwelling events with teleconnections pattern.

C-CEMS data were analyzed in order to identify the seasonal distribution of upwelling events. Sea temperature acquired between 2012 and 2014 were detrended whit seasonal and daily frequencies and compared with upwelling favorable winds.

The EOF was computed on SST data since 1982 to 2012, in order to identify the most significant SST patterns. SST minima along the coasts [5] were used to identify upwelling events. This dataset were correlated to upwelling favorable winds (ECMWF) in order to characterize the upwelling events.

The EOF were computed on this dataset, for clustering the upwelling events and barometric fields. Subsequently the number of events of each class, over the period 1982-2012, were correlated to most relevant teleconnection pattern indexes.

Keywords: Coastal Upwelling, Northern Tyrrhenian Sea, EOF Analysis, Teleconnections patterns.

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A PROCESS STUDY OF ADRIATIC-IONIAN SYSTEM BAROCLINIC DYNAMICS

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The driving mechanism of decadal reversal affecting the Ionian upper layer circulation raised a considerable discussion in the Mediterranean scientific community. It has been suggested indeed that the reversal can be driven either by variation in wind stress curl over the basin [2] or by baroclinic mechanisms acting within [1] or outside [3] the Adriatic-Ionian System.

In this framework, a coarse resolution primitive equation numerical model based on the MIT general circulation model (MITgcm) , has been used to assess the relative importance of remote forcings (wind stress and thermohaline fluxes, thermohaline open boundary conditions) on the vorticity and energy budget of the Ionian Sea. An approach based on an increasing complexity in the model forcings and domain has resulted in a more extensive understanding of Adriatic Ionian system (AIS) dynamics. This development took advantage of a parallel implementation of a two-layer quasi-geostrophic model set-up for a similar problem whose results corroborated the primitive equation experiments.

The major outcomes of these experiments are that the wind stress role appears to be marginal in the vorticity/energy budget of the Ionian Sea: it is able to reinforce/weaken the circulation but not to induce changes in sign in the circulation. Its role become dominant only in absence of inflows through the Sicily channel/Kythira Strait/Cretan Passage. Changes in the upper layer circulation of the Ionian Sea instead take place only in presence an active boundary in the Ionian Sea, on the Aegean Sea side and appears to be correlated with substantial exchange of APE (Availaible Potential Energy) between these two basins (as happened at the end of the East Mediterranean Transient). From an energetic point of view AIS can be explained therefore only if the role of the Aegean Sea is explicitly considered.

Keywords: Baroclinic circulation, Adriatic-Ionian System , Vorticity Balance , Energy Budget , MITgcm model

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DYNAMICAL DOWNSCALING OF CLIMATE CHANGE SIMULATIONS. THE COASTAL SEA PROBLEM, CRITICALITIES AND METHODOLOGICAL HINTS

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Modeling studies of future changes in coastal hydrodynamics, in terms of thermohaline circulation, storm surge effects and wave climate, need siutable modeling tools able to reproduce the spatial and temporal scale of processes, as well as the characteristic physics. A new frontier for modeling arises suggesting not only simple downscaling solutions to transfer the global scale climate effects to the local scale of the coastal zone, but also identifying open scientific questions connected with models' resolution, different scale processes interaction and combined effects of local (river inputs, wind action) and regional forcings (heat fluxes).

Preliminary modeling implementations in coastal seas, like the Adriatic Sea, were performed with two models, SHYFEM, based on finite elements, and MITgcm, this latter applied also in the nonhydrostatic configuration, both able to resolve the coastal morphologies and to include freshwater inputs from rivers. The models were implemented and a comparison was performed to highlight the need for suitable modeling tools able to include a wide range of forcings and reproduce hydrodynamic processes occurring at different scales in the coastal zone. Results of this work identified a number of critical issues that have to be taken into consideration, also, more generally, for climate implementations: the role of river discharge is central in reproducing coastal dynamics, therefore suitable inputs, realistic variability and scaled projections for this forcing are needed; surface heat and mass exchange between the atmospheric and the hydrodynamic models can modulate coastal processes, particularly on the shelf, therefore suitable datasets and coupling are needed, particularly in the long term; tidal dynamics, even if weak in coastal seas like the Adriatic (microtidal environment), enhance mixing processes, particularly in the coastal area, affecting the coastal dynamics. Therefore also this forcing, which to date is not included in climate modeling, coupled with surge, deserves further investigation.

Keywords: dynamical downscaling, coastal modeling, finite elements

INTEGRATED RISK ANALYSIS FOR MULTI-HAZARD ASSESSMENT IN MARINE AREAS: THE CASE STUDY OF THE ADRIATIC SEA

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Marine ecosystems and services are increasingly endangered by human activities and climate change [1]. The latter is triggering alteration of biological, chemical and physical processes, increasing ecosystems' sensitivity to disruption [2]. Accordingly, marine biodiversity and water quality are declining, compromising the achievement of the Good Environmental Status by 2020, as required the Marine Strategy Framework Directive (MSFD) [3].

The aim of this study is to develop a spatially explicit risk approach evaluating the cumulative impacts of climate and anthropogenic pressures on the state of the ocean and its services. By integrating quantitative and qualitative attributes of climate, ocean, bio-geochemical and anthropogenic pressures (e.g. temperature and salinity variation, abrasion and extraction) with exposure and vulnerability indicators, the methodology can be applied in baseline and future scenarios, identifying marine ecosystems and human activities at higher risk from multiple hazards (e.g. chemical hazard by oil spills, biohazard due to the introduction of non-indigenous species). It was recently tested in the Adriatic sea for the scenario 2000-2015, producing a range of hazard, exposure, vulnerability and risk maps and indicators for selected marine receptors (e.g. seagrasses, aquacultures).

Results showed that higher hazard scores are linked to exogenic pressures (i.e. surface temperature and salinity variation) while lower hazard scores resulted from endogenic and localized pressures (e.g. abrasion, underwater noise, input of organic matter). Relatively very high scores were found for vulnerability over the whole case study for almost all the considered pressures, showing seagrasses, maërl and coral beds as the most susceptible targets. The final risk metrics, including the extent of key habitats affected by human activities or by alterations of physical and chemical parameters, provided useful information both for evaluating the progress toward the implementation of the MSFD and to set priorities in planning and management of marine areas in view of climate change.

Keywords: multi-risk assessment, Adriatic sea, MSFD, GIS maps

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COP21, THE INDCs AND POLICIES TO ADRESS CLIMATE CHANGE

GLOBAL-SCALE IMPACTS AVOIDED BY THE INDCs

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This presentation describes an assessment of the effects of INDCs on the increase in global temperature by 2100 and the impacts that are avoided in comparison with reference cases with no new climate mitigation policies. The study is part of the UK's AVOID2 research programme for the Department of Energy and Climate Change.

The INDCs extend to 2030, and we make three different assumptions to estimate emissions to 2100: (i) emissions reduce in order to meet (with a 50% likelihood) the 2°C target, or (ii) emissions reduce towards the target but with additional constraints on rates of energy system transition based on historical precedents, or(iii) emissions remain at 2030 levels. The TIAM energy system model is used to simulate emissions trajectories for all greenhouse gases consistent with the above assumptions, and a version of the MAGICC simple climate model is used to estimate distributions of change in global mean surface temperature. Impact damage functions relating impact to global mean surface temperature are used to estimate the evolution of impacts in a number of sectors.

Under the reference cases with no new climate policies, the median estimated temperature increase by 2100 is between 4.2 and 5.2°C.The INDC scenario with constant emissions after 2030 results in a median change of 3°C, so further effort is needed after 2030 to reach the 2°C level; the constrained scenario produces an increase of 2.2°C, so this is feasible but challenging. By 2100, global impacts on river flood risk, plant habitats and exposure to heatwaves would be reduced by 80%, 70% and 85% relative to the high reference case respectively if the 2°C target was achieved, but only by 55%, 40% and 55% respectively if emissions remained at 2030 levels; the uncertainty range around these estimates depends on the shape of the relationship between temperature change and impact.

Keywords: INDC, emissions, global temperature, impacts, global-scale

BUILDING UNCERTAINTY INTO THE MITIGATION ADAPTTION DECISION: A RISK PREMIUM APPROACH

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The estimated costs of climate impacts are highly uncertain. The unreducible randomness of natural and social phenomena, is coupled with our incomplete knowledge of these phenomena, and with ambiguity, reflecting people different perceptions. Accounting for this uncertainty is a key issue in the Integrated Assessment (IA) of climate change especially, and most obviously, to determine how climate change policy decisions can be affected.

The existing approaches, based upon the development of expected utility/damage functions, of different specifications for damage functions, or of stochastic damage functions, tend to focus on mitigation. Furthermore, these approaches, implement ad hoc methodologies not easily generalizable.

The idea behind this paper is to develop a more general framework to build uncertainty reflecting different degrees of risk aversion as well as uncertainty in climate change damages into a deterministic integrated assessment model (the WITCH model by [Bosetti et al, 2006] further developed as in [Bosello et al 2014]). The concept underpinning our analysis it that of risk premium which allows us to estimate a ”damage mark-up” which varies with degrees of aversion to risk. Such damage ‘add-ons’, then affect the assessment of adaptation options, and their interaction with mitigation. Using risk premium offers some advantages: (a) it is relatively simple to model and (b) it allows us to reflect public attitudes to aversion to risk in a transparent way.

Our results show that the climate change risk premium is significant and thus the damage people really react to is potentially much greater than the average damage. Accordingly, both mitigation and adaptation efforts are substantively spurred by the risk premium corrected damage function, however, in relative terms, mitigation is privileged. We also emphasize the difference between a cooperative and non-cooperative climate policy environments.

Keywords: Climate change, integrated assessment, risk, mitigation, adaptation.

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CAN PARIS DEAL BOOST SDGS ACHIEVEMENT? AN ASSESSMENT OF CLIMATE-SUSTAINABILITY CO-BENEFITS

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The fall of 2015 will see a redefinition of international policy environment with the 21th UNFCCC Conference Of Parties (COP21) in Paris and the adoption of the Sustainable Development Goals (SDGs) by United Nations. SDGs will set more ambitious targets for developed and developing countries encompassing all sustainability dimensions (economic, social, and environmental). The COP21 agreement will directly affect countries' environmental performance through the adoption of the Intended Nationally Determined Contributions (INDCs), but also social and economic dimensions if we consider the possible recycling schemes of climate policy.

This paper aims at giving an ex-ante assessment of the co-benefits and side effects of this new policy setting and, in particular, to shed some light on the influence of COP21 agreement on achieving SDGs.

Our analysis relies on a recursive-dynamic Computable General Equilibrium (CGE) model developed and enriched with indicators representative of each SDGs. CGE framework are well suited to evaluate economic and environmental dimensions, whereas assessing social indicators, especially those implying dispersion measures such are poverty prevalence and inequality, is a challenging task. On this purpose, we relied on the empirical literature directly estimating the relations between indicators and endogenous variables of the model.

Our framework considers 33 indicators covering 16 SDGs, classified into the three sustainability pillars. The analysis has world coverage. The baseline reproduces a Shared Socio-economic Pathways 5 (SSP5) and it is used as a benchmark to assess the effects of two mitigation scenarios anticipating the outcome of COP21.

The two proposed mitigation scenarios consider a coordinated effort to curb GHG emissions from 2020:

- Post-Paris-Global-Trade scenario: the abatement pledges from INDCs are effective and achieved through an international emission trading scheme.
- Post-Paris-EU-ETS scenario: the European Union implements an Emission Trading System (ETS) while all other countries achieve their targets unilaterally with a domestic carbon tax.

Keywords: SDGS, COP21, Computable General Equilibrium, climate policy

DECOMPOSITION ANALYSIS OF GHG EMISSIONS AT FOUR GEOGRAPHIC LEVELS

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The paper discusses the main factors affecting energy related greenhouse gas (GHG) emissions trend at four geographic level (World, Europe, Italy and Lombardy region) using the Kaya identity. Decomposition analysis was carried out with LMDI approach (Logarithmic Mean Divisia Index) in order to breakdown the change of emissions into the changes of six driver factors: population, Gross Domestic Product (GDP) pro capita, final energy intensity of GDP, energy transformation efficiency, renewable energy, and carbon intensity. Affluence and population are the most important contributors to GHG emissions increments in Italy between 1990 and 2013, while renewable energy, carbon intensity, final energy intensity, and energy efficiency act in the opposite direction. The breakdown of the time series shows the changing role played by drivers before and after the crisis that hit Italian economy since 2008. Up to 2004 affluence and population effects led to emissions increase in spite of the offsetting effects of other factors. From 2005 to 2007 there was a decoupling between economy and carbon emissions driven by energy and carbon intensity effects. Since 2008 the drop down of GDP and renewable energy development are the main factors leading to GHG emissions reductions followed by energy efficiency. The analysis of abovementioned factors in the period 2005-2012 at regional and national level shows in Lombardy Region higher contribution to emission reduction from energy efficiency and lower contribution from renewable and GDP. This trend is substantially different from the one registered at European and global level.

National average annual GHG emissions in the first commitment period of Kyoto Protocol (2008-2012) was 4.5% below the base year (1990). Scenario analysis with Kaya identity and multiple linear regression model shows that GHG emissions in the first commitment period would have been 4.5%-6.0% higher than 1990 level with GDP growth rate as registered before 2008.

Keywords: GHG emissions, Kaya Identity, Kyoto Protocol

THE EVOLUTION OF AGRICULTURAL GHG EMISSIONS IN ITALY AND THE ROLE OF THE CAP. A FARM-LEVEL ASSESSMENT

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The Commission's Green Paper presenting climate and energy targets for 2030 [1], asked for views on the most appropriate range and structure of the policy approach to realise all sectors mitigation potential. Even if further analysis will be undertaken, it is clearly stated that accompanying policy measures should also build on the experiences from the Common Agricultural Policy-CAP (and ensure coherence with other Union policies).

In this contest, it seems helpful to analyse the impact of the past CAP measures and reforms on farmers' choices of production mixes and level and, thus, on farm-level GHG emissions, to understand to what extent the current reform proposal may improve the emission performance and, thus, contribute to reach the European ambitious mitigation targets, also at sectorial level.

To this porpuse, this paper firstly proposes a methodology to reconstruct the agricultural GHG emissions and the consequent Carbon Footprint (CF) at the farm level [2]. This allows investigating how the emission performance of Italian farms evolves over time, distinguishing among typologies of farms and territories. Secondly, the paper attempts to put forward some hypotheses explaining the observed heterogeneous evolution of the farm-level CF. In particular, the attention focuses on the possible role of the CAP. The empirical analysis concerns a balanced panel of Italian FADN (Farm Accountancy Data Network) farms observed over years 2003-2007. Results, although interesting and encouraging, deliver unclear and ambiguous evidence on the role of the CAP on the observed CF performance and evolution. Several improvements seem needed to achieve more conclusive evidence to make this assessment more sound and robust, in order to inform the debate and the decisions about the proper policies to mitigate agricultural GHG emission.

Keywords: agricultural greenhouse gases emissions, carbon footprint, farm-level data, CAP

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ANALYZING THE COORDINATED IMPACTS OF CLIMATE POLICIES FOR FINANCING ADAPTATION AND DEVELOPMENT ACTIONS

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Climate change might be seen as a remote issue compared with more urgent problems such as poverty, disease and economic stagnation. Yet, climate change can directly affect the efficiency of resource investments and eventually hinder the achievement of many development objectives [1]. During the last two decades, adaptation to climate change has increasingly gained “policy profile” in the EU development cooperation [2].This paper focus on the need for financing adaptation actions in a framework of development for LDCs, considering a particular climate change impact –sea level rise (SLR). Using a Computable General Equilibrium model (i.e. ICES) [4, 5, 6], we assess the economic impacts of alternative policies to adapt to SLR by 2030. As the EU commission recognizes, tight budgetary constraints in many EU countries could lead donors to reduce their commitment to fight climate change, and to foster development [3], thus there is the necessity of new alternative financing instruments.

When EU raises revenues through a carbon tax and uses them domestically, the possibility to have an additional source for investments reduces the need of public borrowing, thus lowering the burden for future generations. If the EU sets an Adaptation Fund for developing countries, this could set a scenario in which LDCs governments could eventually have greater room for other development policies besides adaptation needs. Pooling all revenues in an Adaptation Fund to finance LDCs does not reduce EU GDP drastically. It lowers only by 0.02 percent respect to the case when it uses the revenue domestically.

According to this paper, establishing an Adaptation Fund could be a viable solution. It is likely to assume that if several countries contribute to this Fund in an integrated climate policy framework, economic costs will lower with higher global gains besides the positive externalities of mitigating climate change.

Keywords: computable general equilibrium, mitigation, adaptation, climate change

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UNCERTAINTY DECOMPOSITION OF THE MITIGATION COSTS ESTIMATES FROM THE IPCC AR5

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Uncertain in the response of our climate system, and in its implications on natural, as well as human, processes is wide and research attention is devoted to quantifying and reducing it. Often, the aggregate cost of climate mitigation is presumed to be known with greater confidence. As claimed in [1, 2], mitigation costs are also widely uncertain and their uncertainty increases over time. In this paper, our objective is to shed light on what are the main drivers of the uncertainty associated with climate change mitigation costs. Mitigation policy costs estimates are the product of models projections. Model structures, key assumptions about parameters and their evolutions, and the various features of the climate change policy themselves are all driving engines behind the wide set of estimates reported in the literature. Our objective is that of disentangling these different sources and attempt to weight of their relative importance.

We based our analysis on a large database of estimates of mitigation costs that has been reviewed by the Working group III in the IPCC fifth assessment report [3]. We make use of a statistical tool, the correlation ratio [4], to measure the importance of the different factors that characterize the cost estimates [5], e.g. the class of model used, the stringency of the climate target, the socio-economic baseline, the policy implementation, the technology options…

Preliminary results show a very high importance of the type of model used (1st rank) and also of the baseline scenario emissions (2nd) while the type of policy implementation (3rd) and the climate target (4th) have a lower importance in the explanation of the mitigation cost variance. This highlights the relevance of the multi-model comparison exercises and the imperative attention that should be put into the non-policy scenarios used as benchmark for the estimation of the climate policy costs.

Keywords: mitigation cost, uncertainty, IPCC, correlation ratio

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THE POLITICAL FEASIBILITY OF LARGE-SCALE SOLAR RADIATION MANAGEMENT

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Climate change is already happening and evidence suggests that political, economic social, and technological inertia will prevent the world's major polluters from reducing greenhouse gas emissions (GHG) emissions fast enough to avoid its dangerous impacts (1, 2, 3, 4).

This has led to the increased consideration of a range of Climate Engineering (CE) technologies that have recently emerged as a third category of possible responses to climate change, alongside decreasing GHG ('mitigation') and lessening climate impacts ('adaptation') (3, 4, 5).

This article focuses on the political feasibility of large-scale solar radiation management (LS-SRM), a CE technique that aims to reduce the net incoming short-wave solar radiation and thus warmth reaching the Earth (3, 4). The main reason for this focus is the high leverage of LS-SRM, i.e., its capacity to have great influence over global climate from relatively small technological and economic inputs (6, 7). Unfortunately LS-SRM technologies are, paradoxically, also the most likely to create a number of complex and entrenched social, economic, ethical and political conflicts (8) that could seriously hamper their research and deployment. For these reasons the ultimate objective of this article is to explore the political feasibility of LS-SRM, since political feasibility is fundamental for gaining support and eventually fostering stable and effective LS-SRM systems. Specifically, the article first briefly investigates the potential of LS-SRM. It then frames and scrutinizes political feasibility according to the normative and positive perspectives relevant to understanding the actual possibility of effectively researching and deploying LS-SRM. Finally the article, in light of the analysis carried out, takes a prescriptive turn and indicates how politically feasible governance systems for LS-SRM may be forged and successfully implemented.

Keywords: climate engineering; governance systems; political feasibility; solar radiation management

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BENEFITS FOR HEALTH OF CLIMATE ACTION IN THE WHO EUROPEAN REGION

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The present and future effects of climate change are widely affecting population health, through a rise of mean sea level, an increase in global mean surface temperature, an increase in the frequency and duration of both heatwaves and extreme rainfall events; and changes in the abundance, distribution, and composition of plants and animals, as well as food and water safety and security. WHO estimated 250,000 extra deaths per year during the next decades. Current policies and plans for major countries and regions are, in aggregate, consistent with a medium to high emissions pathway, with emissions continuing to increase over the next few decades, and stretching over the 2 C target probably before the mid of the century. Security risks at high degrees of climate change seem likely to be of a different order of magnitude: extreme events, extreme water stress and competition for productive land, migration from some regions may become more a necessity than a choice, and could take place on a historically unprecedented scale, overwhelming the capacity of the international community for humanitarian assistance, and even the risks of state failure could rise significantly. Greater rates and magnitude of climate change increase the likelihood of exceeding adaptation limits for human health.
In 2010, Ministers of Health and the Environment of 53 Member States of the WHO European Region endorsed the Commitment to Act. The climate change objective highlights the need to integrate health into adaptation and mitigation strategies. Recent assessments of the Lancet Commissions, the International Panel on Climate Change and the WHO highlight the co-benefits for human health of reducing green house gas emissions and short lived climate pollutants. In particular the following measures are highlighted: to promote within a low carbon economy, integrated strategies to address growing demand for food, sustainable fishery, integrated land-use policies, promotion of low carbon diets, sustainable cities, and integration of environmental care into health systems. Long term transformational solutions include (a) addressing it's drivers through ethics, equity and incorporation of future

generations; (b) building resilience; (c) monetization of non-market benefits; (d) incentivization of behavior change; and (f) policies for taxes and subsidies with a health return as well as measures of human progress and wellbeing. In this presentation, several aspects of the above findings will be illustrated.

THE COST OF CLIMATE STABILIZATION IN SOUTHEAST ASIA, A JOINT ASSESSMENT WITH DYNAMIC OPTIMIZATION AND CGE MODELS

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Southeast Asia is at a time one of the most vulnerable region to the impacts of a changing climate, with millions of its inhabitants still trapped in extreme poverty without access to energy and employed in climate-sensitive sectors, and, potentially, one of the world's biggest contributors to global warming in the future. Fortunately, major Southeast Asian countries are also implementing policies to improve their energy and carbon efficiency and are discussing if and how to extend these further.

This study firstly offers an insight on the costs, not only in terms of GDP, but also in energy consumption possibility, that five developing Southeast Asian economies (Indonesia, Malaysia, Vietnam, the Philippines and Thailand) could experience in 2020 following the implementation of their national de-carbonization targets. Then focuses more on the long term investigating three different scenarios: a fragmented regime where countries continue with uncoordinated nationally-determined commitments (i.e. Durban Platform and INDCs), a coordinated, but mid-ambition global decarbonization goal aiming at stabilizing GHG concentration at 650 ppm, and one more ambitious aiming to a 500 ppm stabilization [3].

The analysis applies two energy-climate-economic models. The first, the fully dynamic Integrated Assessment model WITCH [1], is more aggregated in the sectoral and country representation, but provides a detailed technological description of the energy sector. The second, the ICES [3] Computable General Equilibrium model, offers a richer sectoral breakdown of the economy and of international trade patterns, but is less refined in the representation of technology. The joint application of these two complementary models allows to capture distinct and key aspects of low- carbon development paths in Southeast Asia.

Keywords: Climate policy; 2C° target; Durban Platform; Integrated assessment; energy scenarios

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DEVELOPMENT, CLIMATE CHANGE ADAPTATION, AND MALADAPTATION: SOME ECONOMETRIC EVIDENCE

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This paper examines the determinants of climate related disasters estimates the presence of adaptive capacity in terms of per capita income and population density elasticities. We find evidence of adaptive capacity in a *weak* form - both in terms of income and population density elasticities for the entire sample, suggesting that damages increase with income and population but less than proportionally. There is also evidence of countries improving their adaptive capacity over time but some maladaptation occurs in the short run. This could highlight either the fact that increase in damages in the last few decades may have been driven by greater development and more assets being at risk or that adaptation needs some time to exert its effects [Pielke et al., 2008].

We also split countries by per-capita income levels and find that higher income countries show adaptive capacity in a *strong form*, i.e. damages decrease with increasing GDP. On the contrary, in lower income countries, damages increase more than proportionally with per capita GDP. This provides empirical evidence that in earlier phases of development more "assets-at-risk" tend to prevail over adaptive capacity, increasing vulnerability to climate change. However, at higher income levels more resources are available and preferences likely shift toward building climate change/disaster resilience. This induces adaptive capacity, which eventually overcomes the *assets-at-risk* effect. Finally, using a panel data Granger causality test, we find that increasing GDP per capita Granger causes higher climate related damages in lower income countries only. This further supports the intuition that at earlier stages of economic development more assets are risk without being sufficiently compensated by investment to reduce vulnerability. This has an immediate policy implication; development per se is not sufficient to grant (climate

change) disaster resilience, but adaptive capacity needs proactive investment to be improved.

Keywords: Climatological Damages, Adaptation, Granger Causality

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IMPACTS OF CO_2 TAX ON ITALIAN ECONOMY: A CGE APPROACH

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This paper uses a top-down static Computable General Equilibrium (CGE) model for a small open economy to analyze the effects of carbon tax policy on Italian macroeconomic variables. Standard assumptions of CGE models are employed. By considering various direct and indirect effects, CGE models are appropriate for analysis policies like CO_2 reduction, which generate significant direct and indirect impacts. The approach of this study is to apply CO_2 tax instrument on burning input fossil fuel in production process.

The empirical basis for the model is a Social Accounting Matrix (SAM) that consists of several production sectors which employ primary factors as well as intermediate inputs to produce goods (output) for the domestic and foreign market. Domestic demand includes intermediate demand and final demand. The domestic goods are used as intermediate inputs in production processes or consumed by final users like households, government, and investment sector.

There are 57 production sectors in GTAP database which are aggregated into five production sectors. We modified the data to include private household, government, and the rest of the world. WIOD environmental accounts are used which consist of information on energy consumption that has broken down into a number of energy carriers. The model is formulated using GAMS.

Results show that reducing CO_2 emissions through carbon tax instrument would have small negative effect on GDP and consumer welfare. Under a carbon-tax-compensation by redistribution back to the household, welfare loss is lower and economy is less adversely affected by higher prices.

The Kyoto protocol has fixed the base year (1990) CO_2 emissions for Italy to 436 million tonnes. In order to meet Kyoto target, Italian sectors should reduce CO_2 emission around 1.2 million tonnes in each following year. Our simulation results show that by starting modest tax rate between 5 and 10 dollar per tCO_2 (18.35 and 36.7 dollar per tonne carbon) from base year Italy could meet the first commitment Kyoto target by 2012. This rate should rise through time gradually to meet second commitment (CP2) target as well.

CLIMATE CHANGE RESPONSE ACTIONS

THE ADVERSE EFFECTS OF CLIMATE VARIABILITY AND CHANGE ON THE WIDIKUM COMMUNITY IN CAMEROON

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In Cameroon generally and particularly in the Widikum area, rural farmers are central to agricultural production and therefore the foundation for household food security. The recent events of floods and landslides that have occurred in this area in addition acid rains and plant pathologies have already had a great toll on the effort of these farmers. The absence of figures on agricultural production actually does not help further in finding a solution. This is even worse with the insufficiency and inadequacy of agricultural extension in the area. The absence of weather stations in the area simply implies that the rural farmers have been left to the mercy of nature in their role as food producers.

This research has been some form of evaluation of the situation of climate change and it adverse effects on the Widikum community which this study covered. To analysis the situation, this research applied the participatory methods with the local community. Several participatory activities were carried out such as; mobilization workshops, diagnosis workshop, interviews, guided site visits and mapping. After careful analysis and discussion; seasonal differences, climatic hazards such as frequency of floods and landslides, vulnerable elements exposed to hazards such as food production, food security, agricultural areas, livelihoods and agricultural risks were identified as the main problems to be solved or concerns to be managed. The coping mechanisms and practices implemented by the rural farmers and local population to solve these problems were discussed and adopted. Also, the Adaptive strategies proposed by the project researchers and experts were discussed and adopted.

The major setback of this research project was that implementation and follow up of the adaptation measures was not done since the project lasted just for ten months.

Keywords: Climatic hazards, participatory diagnosis, coping mechanisms, Adaptive strategies, and farming and farmers

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A CLIMATE SERVICE PROTOTYPE FOR DROUGHT EARLY WARNING IN ETHIOPIA

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The EU-FP7 project EUPORIAS is developing a prototype climate service aimed at enhancing an existing droughtearly warning system developed by WFP and owned by the Government of Ethiopia based on a software platform(LEAP). The LEAP platform which enables the assessment of the number of people in need of food assistance due to drought.Currently, LEAP uses satellite based rainfall estimates to monitor drought conditions and to compute needs.This prototype climate service developed within EUPORIAS is based on engaging the end-users (WFP, DRMFSS)in the design of the workflow and will integrate seasonal precipitation forecasts into the early assessment, whichwill enhance the entire decision making process.

We will present the workflow of the prototype and the current modelling approach for the connection betweenthe climate driver (drought) and the corresponding impact (needs). We also present the expected value of theprototype given the expected level of skill of the underlying seasonal forecasting system and a preliminary costbenefit scenario for an operational impact prediction system that is able to anticipate the occurrence of the mostsevere drought events.

ENHANCING THE CLIMATE RESILIENCE OF AFRICA'S INFRASTRUCTURE: THE POWER AND WATER SECTORS

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To sustain Africa's growth, and accelerate the eradication of extreme poverty, investment in infrastructure is fundamental. In 2010, the Africa Infrastructure Country Diagnostic found that to enable Africa to fill its infrastructure gap, some US$ 93 billion per year for the next decade will need to be invested. Much of this investment will support the construction of long-lived infrastructure (e.g. dams, power stations, irrigation canals), which may be vulnerable to changes in climatic patterns, the direction and magnitude of which remain significantly uncertain.

This paper evaluates -using for the first time a single consistent methodology and the state-of-the-arte climate scenarios-, the impacts of climate change on hydro-power and irrigation expansion plans in Africa's main rivers basins (Niger, Senegal, Volta, Congo, Nile, Zambezi, Orange); and outlines an approach to reduce climate risks through suitable adjustments to the planning and design process. We find that failure to integrate climate change in the planning and design of power and water infrastructure could entail, in scenarios of drying climate conditions, losses of hydropower revenues between 5% and 60% (depending on the basin); and increases in consumer expenditure for energy up to 3 times the corresponding baseline values. In in wet climate scenarios, business-as-usual infrastructure development could lead to foregone revenues in the range of 15% to 130% of the baseline, to the extent that the larger volume of precipitation is not used to expand the production of hydropower. Despite the large uncertainty on whether drier or wetter conditions will prevail in the future in Africa, we also find that by modifying existing investment plans to explicitly handle the risk of large climate swings, can cut in half or more the cost that would accrue by building infrastructure on the basis of the climate of the past

Keywords: Africa, Infrastructure, Adaptation, Uncertainty, Hydropower

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TENURE AND 'CARBON RIGHTS' IN LOCAL REDD + PROJECT: INSIGHTS FROM COMMUNITY-BASED WORKSHOPS IN ANKASA CONSERVATION AREA, GHANA

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Reducing Emissions from Deforestation and Forest Degradation (REDD+) is a new climate change mitigation policy. REDD+ has been proposed as a way of reducing carbon emissions in the forest sector, whilst also protecting and improving the livelihoods of communities. Ghana, like other developing countries in Africa, is formulating new policies and strategies and strengthening existing ones in order to implement the REDD+ policy in order contribute to the climate mitigation. Despite these efforts towards REDD+ implementation, it appears a lot still has to be done for Ghana to get to this implementation stage. Key among these, are tenure reforms, carbon right attribution and the extent to which local communities/stakeholders are informed so that they can be able to participate in the preparation and implementation of this policy. Qualitative and quantitative research methods and ten communities in two administrative districts in South Western Ghana which are the sites for a local REDD+ project with financial support from the International Tropical Organization (ITTO) are used. The research questions addressed are; what is the state of land and tree ownership and what interventions are being done to align it to REDD+; What is the local stakeholder and communities knowledge on the REDD+ and what are their perceptions and preferences on carbon rights and future REDD benefit distribution. The discussion of the results of the paper focused on adequate education of local stakeholders and communities on REDD+ and the need for them to undertake land title registration; the need for national carbon rights definition and policy to be formulated and the need for communities preferences and suggestions to be taken into account. It is concluded that although reforms in land tenure may take a longer time to be completed in Ghana,

implementing these measures like land title registration and carbon right definitions among others could significantly move Ghana towards the REDD+ implementation stage.

Keywords: Local communities; education, participation; land title registration; REDD+ knowledge

HOW TO IDENTIFY CRITICAL ISSUES IN URBAN PLANNING THROUGH THE APPLICATION OF CITY BREATHABILITY CONCEPTS: A SHORT REVIEW

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The growth of world population, together with the development of the economy, continuously requires a large amount of resources to sustain human activities. As a consequence, pollution is increasing and in particular air pollution causes major concerns to people's health.

The control of air quality is very important for creating a healthy urban environment. Urban air quality is highly affected by several factors, such as wind speed and direction which are affected by city design. Densebuilding arrangements and narrow street canyons can block the air exchange between the canyon and the overlying atmosphere, thus reducing its air dispersion capability.

Given the high complexity of the problem, often field measurements are combined with numerical simulations and laboratory experiments. Specifically, Computational Fluid Dynamics (CFD) simulations allow to evaluate alternative design configurations which can help disperse air pollutants, improving the ventilation performance.

In the literature, different parameters have been proposed and used to evaluate the ventilation performance of urban areas. Here we provide a detailed review of the literature of urban air quality studies analysed in terms of ventilation efficiency parameters as a measure of city breathability, i.e. the potential of a city to remove and dilute heat, pollution and other scalars. In particular, the paper reviews and summarizes some of the most recent advances obtained by us as well as by other researchers who have looked at flow and turbulence around groups of buildings and real cities to adequately predict and evaluate outdoor ventilation.

This review will allow us to identify critical issues in current urban planning and propose best practices to develop strategies for improving city breathability which has direct consequences on resilience of urban areas.

CLIMATE CHANGE IMPACTS ON CULTURAL HERITAGE MATERIALS IN SINERGIES WITH AIR POLLUTION: THE EUROPEAN RISK ASSESSMENT

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Scientific interest is continuously increasing on the effects of climate change in combination with environmental pollution in degradation of Cultural Heritage materials exposed in urban areas. Indeed, Cultural Heritage situated in open air is very sensitive to the action of the environmental pressures they are exposed, such as meteorological stressors and atmospheric pollutants that can be responsible for aesthetic damage and material losses. This work aims to producing the first European risk maps for the assessment of potential stock at risk, due to the impact of climate pressure and air pollutants on cultural materials. In order to obtain this result, environmental data are fitted in dose-response functions for each materials, assessing the superficial regression and mass losses of limestone, copper and bronze in Europe. The results shown past (1980, 1990, 2000, 2010) and future trends (2030), in two scenarios. To estimate the most important predictor affecting surface regression and mass losses, Random Forests Analysis (RFA) has been performed.

Copper and bronze seems to be very sensitive to climate change in comparison to air pollution, while the conservation of limestone will be possible thanks to the reduction of acid rains and pollutants such as SO_2 and PM_{10}.

Keywords: climate impacts, Cultural Heritage, air pollution, Random Forest Analysis

ECOACOUSTICS, A NEW TOOL TO MONITOR CLIMATE CHANGE

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The role of natural and anthropophonic sounds on the ecology of individual species, populations, communities, ecosystems, and landscapes is the main object of ecoacoustics [1].

Several animals make sounds to communicate and use acoustic cues as additional elements to interact with the environment. Sounds of animal origin have been found to have highly plastic life traits that cope with even negligible variations of the physical environment (e.g., temperature, humidity, air turbulence, and pH) [2].

There is much evidence that the quality and dynamics of sounds are some of the first life traits modified under the effects of climate change by those species that use acoustic signals for communication or positioning in the environment. Modifications in physiology, phenology, behaviour, and biogeography have direct consequences on acoustic patterns. Changes of temperature and humidity have been proven to have an impact on amplitude, frequency, and temporal dynamics of biophonies in terrestrial habitats. Moreover, the forced displacement of species from one region to another to search for a climatic optimum poses problems in the acoustic communities' composition, reducing the frequency partitioning of the acoustic signals adopted by species to reduce the interspecific competition in the assemblages [3].

In aquatic habitats, especially in marine systems, the change in pH modifies the acoustic transmission of biophonic and anthropogenic sounds affecting communication in animals, such as whales and pelagic fishes [4].

Ecoacoustics for reactiveness of sounds, non-invasive sampling procedures, affordable technologies that allow maintaining activity in the field, and new generations of low cost automatic recorders (e.g., Soundscape Explorer [Terrestrial] SET) [5] with on-board real-time processing routines that use metrics like the Acoustic Complexity Index [6]) are considered important candidates to become new and important remote-sensing monitoring tools. These are useful for predicting and/or evaluating the effects of climate change on biological assemblages.

Keywords: Animal communication, Acoustic Complexity Index, Climate change, Ecoacoustics, Low cost recorders

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CLIMATE VULNERABILITY MAP OF ROME (CVMR) 1.0

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Public awareness about climate change adaptation of cities is still limited in Italy: few local authorities have started working towards this aim so far. However, the Italian Ministry of Environment has recently finalized the *National Adaptation Strategy*. Moreover, Rome has been included in the first 32 cities of the world funded by the Rockfeller Foundation to develop a Resilience Strategy. Within this evolving context, the Department of Architecture of Roma Tre University and the UTMEA department of ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) have started a joint research, aimed at testing a quick yet efficient and reproducible procedure that can provide – swiftly and with limited resources – a clear framework of the main climate vulnerability issues of a city.

The first advanced result of this research is the Climate Vulnerability Map of Rome 1.0 (CVMR 1.0): the map is at its first stage and is still open to improvements. Despite the limited available data, the map seeks to show the degree of climate vulnerability of the city. As the map will be improved, the city council will be able to use it as a starting point for its future climate strategies.

The chosen methodology is similar, though simplified and adapted to the urban scale, to the one used in Climate Change and Territorial Effect on Regions and Local Economies, developed by the ESPON 2013 Programme [ESPON, 2011]. The main concepts – Exposure, Sensitivity, Impacts, Adaptive Capacity, Vulnerability – have been incorporated in order to allow for future integrations.

Keywords: Urban Climate Adaptation, Vulnerability Map

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CLIMATE CHANGE ADAPTATION INDICATORS FOR CITIES: DO NOT REINVENT THE WHEEL

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The latest estimations published [1] determine that 54% of the world population lives in cities. European case is especially significant due to the relevance of medium and small cities. Currently, around 359 million people, approximately 73% of the total EU population, live in cities and peripheral neighbourhoods [2-3]. Moreover, North America and Europe are likely to surpass 80% in 2050. Therefore, climate change impacts will be particularly strong on urban areas and cities, as major centres of population, play a core role in enhancing the resilience degree through adaptation.

Urban planning is a basic tool for managing this phenomenon [4-5] and should ensure the integration of sustainability criteria with mitigation and adaptation measures. There is considerable experience in introducing sustainability and mitigation indicators in urban planning [6], but there is a knowledge gap about the way these parameters of adaptation are incorporated.

Adaptation is an iterative process that calls for close monitoring and regulating review in order to ensure its effectiveness. The definition of indicators could increase the capacity of resilience in cities [7]. If there are parameters in the planning process about green areas and public facilities, why not defining specific adaptation parameters in urban planning? After the devastating effects of Hurricane Sandy in 2012, New York City has defined a series of urban indicators that should materialize into concrete parameters [9], with the objective to increase the level of adaptation of the city. This can be seen in cases like the NYC Panel on Climate Change, which includes monitoring of green infrastructure or the degree of mass transit adaptation.

This work reviews the recent experience incorporating indicators and parameters in urban planning as adaptation policies in order to contribute to their integration in city planning based on previous knowledge.

Keywords: Climate Change Adaptation, Urban Planning, Indicators

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ECOPOTENTIAL: IMPROVING FUTURE ECOSYSTEM BENEFITS THROUGH EARTH OBSERVATION

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Terrestrial and marine ecosystems provide essential goods and services to human societies. In the last decades, however, anthropogenic pressures caused serious threats to ecosystem integrity, functions and processes, potentially leading the loss of essential ecosystem services.

Knowledge-based conservation and management policies are urgently needed to improve ecosystem benefits in face of increasing anthropogenic pressures and climate change effects. Fundamental to all these is effective monitoring of the state and trends in ecosystem conditions and services, fully accounting for the wide spectrum of interactions between the geosphere, ecosystems and climate. New monitoring methodologies are now available that combine approaches in geo- and bioscience, remote sensing observations, and field data. Best use should be made of existing and incoming Earth Observation (EO) and *in situ* monitoring data, complemented by appropriate interpretation tools and data services and ecosystem models able to incorporate the observations.

ECOPOTENTIAL is a large European-funded H2020 project which includes 47 partners in Europe and elsewhere, focusing its activities and pilot actions on a targeted set of internationally recognised protected areas in Europe, European Territories and beyond. These Protected Areas include mountain, arid and semi-arid, and coastal and marine ecosystems, blending Earth Observations from remote sensing and field measurements, data analysis and modelling of current and future ecosystem conditions and services. The definition of future scenarios is based on climate and land-use change projections, addressing the issue of uncertainties and uncertainty propagation across the modelling chain.

The ECOPOTENTIAL project addresses cross-scale geosphere-biosphere interactions and landscape-ecosystem dynamics at regional to continental scales, using geostatistical methods and the emerging approaches in Macrosystem Ecology and Earth Critical Zone studies, addressing long-term and large-scale environmental and ecological challenges adopting the view of ecosystems as complex adaptive systems.

Keywords: Global Change, Ecosystems, Ecosystem Services, Earth Observation, Future Scenarios

SHARING SKILLS AND NEEDS BETWEEN PROVIDERS AND USERS OF CLIMATE INFORMATION TO ENABLE DECISION MAKING BASED ON SCIENCE: LESSONS FROM THE NORTHERN ADRIATIC CASE STUDY

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The need to cope with the expected impacts of climate change on socio-ecological systems calls for a closer dialogue between climate scientists and the large community of climate information users (e.g. decision makers belonging to public institutions). Here we describe an interactive process designed to bridge this gap by designing a two-way communication, so that mutual learning occurs[1]. We analyse the need of climate information for the integrated assessment of climate change impacts on the coastal zone of the Northern Adriatic Sea, which is considered to be particularly vulnerable to several climate-related phenomena, including: heavy rainfall events, pluvial flood, sea-level rise, causing potentially high damages to coastal eco-systems and urban areas (e.g. acqua alta in the Venice Lagoon). A participatory process is designed to understand end-users' needs, engaging representatives from both the scientific and local stakeholders communities, and facilitated by the CMCC acting as a boundary organization [2–4].

End-users of climate information were selected among representatives of those public institutions having a specific mandate for Integrated Coastal Zone Management, and engaged to identify their needs: (1) data to support land-use planning, (2) data with greater resolution and longer time series, (3) data on climate impacts and risks, (4) precipitation patterns to improve irrigation, (5) sea level rise and tides, (6) climate variations and extreme events, (7) seasonal trend for tidal waves, and (8) hydraulic risk.

Three climate products were developed to address these needs: 1) short-term projections of sea-level rise; 2) seasonal predictions of extreme rainfall events; 3) long-term regional projections of climate extremes (including heat waves, dry spells and heavy rainfall events). Additionally, two risk products were developed: 4) Sea level rise inundation risk maps for the low-lying coastal areas of Veneto and Friuli-Venezia Giulia regions; and 5) Pluvial flood risk maps for the urban territory of the municipality of Venice.

Keywords: decision making, climate information, information users, risk assessment

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THE ROLE OF TEMPERATURE IN ESTIMATING RESIDENTIAL GAS CONSUMPTION IN THE USA AND EUROPE

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The International Energy Agency (IEA) calculates that US gas consumption per resident declined by 44.31% over the period 1970 - 2012. Differently, EU28 total per capita residential gas consumption incremented by 35% over the same period [1].

By making use of the Logarithmic Mean Divisia Index (LMDI) [2],[3],[4],[5] we decompose the variations of residential gas consumption into five drivers: an activity effect given by the Population, an economic effect given by the Gross Domestic Product per capita, a gas intensity of energy effect given by Residential Consumption of Natural Gas over the Total Energy Consumption, an energy intensity weather adjusted effect which is given by the ratio between the Total Consumption of Energy and GDP and a temperature effect represented with the associated number of heating degree days [6]. Unlike previous studies we focus on the role of temperature in explaining the variations of residential gas consumption over time [7],[8],[9]. The results suggest that GDP per capita and population play a positive role in explaining the upwards variations of residential gas consumption for the USA while the greater intensity of gas with respect to the total energy consumption is the main driver to positively affect residential gas consumption for the European countries analyzed. Moreover the effect of temperature on the US residential gas consumption is only slightly negative, while for the European countries the negative role of temperature on residential gas consumption is more evident. This last result proves that for the European economies analyzed energy intensity improvements have been in part the result of warmer temperatures. We conclude that not adjusting for the increasing temperature overestimates the role of energy efficiency improvements.

Keywords: Residential gas consumption, decomposition analysis, LMDI, energy intensity

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NEW TECHNOLOGIES AND KNOWLEDGE MANAGEMENT FOR THE CLIMATE CHANGE ADAPTATION

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In addressing the challenges posed by climate change becomes essential to promote, also at the local level, a kind of planning able to consider mitigation and adaptation measures in an integrated way[1-2].

The effects of climate change are already visible in the territory, this makes rise the urgency to consider adaptation strategies beside to mitigation actions.

One of the main problems that emerge during the analysis of the vulnerability caused by climate change is the unsuitable knowledge on which the process is based. The data normally processed by public authorities in the processes of land management never include useful variables to identify the vulnerability produced by the climate change[3].

Therefore, it is essential to develop systems and methodologies to find, organize and share the spatial information necessary to perform vulnerability analysis and action plan monitoring.

The Metropolitan City of Venice, with the University IUAV of Venice, its PhD school and 10 Municipalities during the last years, has coordinated and supported the Covenant of Mayors for drafting the SEAP, and then the Project Partner European Seap-Alps. This collaboration has produced an innovative analysis method with the use of Remote Sensing techniques to detect:

-Surface composition (distinguishing whether it is permeable or not every 0.25 m), height and volume of urban buildings;

- Energetic potential of buildings with renewable sources [4];
- Roof slope and orientation;
- Potentially floodable areas;
- Visualisation and calculation of waterproof areas;
- Assessment and mapping of urban green (public and private) and its relative height;
- Sky view factor[5].

This set of information has been used to support two pilot municipalities in the test drafting of adaptation actions. This methodology and the collaboration between the Metropolitan City of Venice and the IUAV University will be taken forward with the signature of the Mayors Adapt.

Keywords: adaptation, remote sensing analysis, climate change, mayor adapt, urban vulnerability

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AN ADAPTATION OPTION TO FACE CLIMATE CHANGE IN URBAN AND PERI-URBAN ECOSYSTEMS: WILDFLOWERS FOR WATER SAVING AND BIODIVERSITY ENHANCEMENT

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2014 IPCC Reports state that continued emission of anthropogenic greenhouse gases will cause further warming and long-lasting changes in all components of the climate system. In Mediterranean areas the effects of drought are likely to be intensified.

Wildflowers are defined as flowers that grow in natural places without being planted by people. However purpose-sown mixtures of native herbaceous species (wildflowers) are employed for ornamental purposes and/or restoration of degraded soils in urban and peri-urban ecosystems. In such contexts only native herbaceous communities are able to survive with low water requirements and simple cultivation techniques. Degraded soils, considered unsuitable for traditional ornamental plantings, can be successfully used for wildflowers as these plant communities are well-adapted to poor soil conditions. Wildflowers contribute not only to water saving but also to biodiversity through attraction of insects, especially bees and butterflies.

This low-cost technique for managing green areas, well-known in Northern countries, is gradually spreading in Italy but cultivation techniques need to be well defined for Mediterranean areas especially for what concerns the identification of suitable species for arid soils [1].

A survey was conducted in 2015 on a sample of 150 Italian citizens to evaluate the perception of this new model of urban green: a high level of acceptance and satisfaction was observed.

Keywords: wildflowers, adaptation option, water saving, biodiversity

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ENHANCING UNDERSTANDING OF THE IMPACTS OF CLIMATE CHANGE, CLIMATE VARIABILITY AND EXTREME EVENTS ON FISHERIES AND AQUACULTURE

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Worldwide, 10 to 12 percent of the population depends on fisheries and aquaculture for their livelihood. Fish provide almost 17 percent of the global population's intake of animal protein, in addition to being an ever-important source of micronutrients. Most people who depend on fisheries and aquaculture live in developing countries where food resources are limited and employment opportunities scarce. In industrialized countries, aquaculture and fisheries continue to support national and household economies as well as food and nutrition security. Given the growing world human population and increased demand for food, the fisheries and aquaculture sector is striving to be more productive and sustainable while increasing its resilience to external shocks and stresses, such as climate change, climate variability and extreme events.

Climate change affects the productivity and distribution of fish stocks and has impacts on fishers, fish farmers and their communities through, for example, changes in species composition, disease risks, or increased frequency and severity of storms. The Food and Agriculture Organization (FAO) of the United Nations has been assisting the sector in understanding these impacts, the vulnerabilities specific to the sector and in identifying adaptation options.

Despite global efforts, there is still inadequate understanding of the linkages between climate change impacts and fish population dynamics as well as of the specific implications of climate change impacts for the fishing and aquaculture industries and communities. The presentation will present some of the work undertaken by FAO in this regard, with special reference to data and capacity poor situations, and will highlight the questions and gaps that need further investigation by the scientific community. Improved understanding of the implications of climate change, climate variability and extreme events on fisheries and aquaculture systems will support FAO's role in building bridges between science and policy and in helping countries and stakeholders design and implement effective adaptation and disaster risk reduction measures.

Keywords: Climate change, fisheries, aquaculture

COMMUNITY-BASED ADAPTATION MEASURES TO CLIMATE CHANGE IN THE LAGOON OF CARMEN-PAJONAL-MACHONA (TABASCO)

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The Carmen-Pajonal-Machona lagoon system is located along the coast of Mexico Gulf in the State of Tabasco. It is a low-depth coastal wetland which is separated from the ocean from a fragile sand bar. It communicates with the sea through two inlets and hosts important mangrove habitats and medium-small human communities, strongly relying on the lagoon ecosystem services for their subsistence. The Consortium formed by Thetis, CMCC and Coastal Environments run a project funded by the World Bank and technically managed by the Instituto Nacional de Ecología y Cambio Climático [1], aiming to design adaptation measures to climate change and human-induced impacts which could be implemented and managed by the local communities.

Main current impacts were identified in the initial phase of the project, including: erosion of the littoral bar separating the lagoon from the ocean, high social and physical vulnerability to flooding, lack of treatment of wastewater and bacteria contamination of the lagoon, loss of mangrove areas, saltwater intrusion and salinization of soil, soil contamination due to oil extraction, consequent impacts on agriculture and fishery, and high vulnerability of local communities.

Based on the elaboration of regional climate change and sea-level rise projections (accordingly to RCP4.5 and RCP8.5 scenarios [2; 3] and considering 2030 and 2100 timeframes), the projects analysed how climate change can exacerbate those impacts and induce other effects.

Afterwards, the project identified most vulnerable areas and adaptation measures that might be realised to improve the system resilience. A number of criteria were considered for the selection of those measures, including in particular their relevance for local communities and the possibility to rely on their capacity for the construction and management of the identified measures. To achieve this scope engagement of local stakeholders was pursued in all phases of the projects and two interactive workshops were organised.

Keywords: community-based adaptation measures, coastal wetland, integrated assessment, medium and long term view, Tabasco

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RISK ANALYSIS AND EVALUATION TO IMPROVE CLIMATE ADAPTATION PLANNING IN WESTERN NIGER

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Agricultural droughts and floods are increasingly common in many Sahelian regions due to climate change. However risk is rarely taken into consideration in local adaptation planning. Risk analysis and evaluation can greatly improve adaptation planning if the probability of damages and the impact of risk reduction measures (adaptation) are considered.

The object of our action-research is to define a methodology for climatic risks analysis and evaluation appropriate to the micro scale and to test it in the Tillabéri region, Western Niger.

We selected 10 villages among those most affected by different types of floods (river, flash floods) and hit by drought as well. Than we identified flood/drought dynamics and exposed zones through community workshops and participatory mapping. Hydrometeorological and GIS analysis were then used to determine the probability of flood and drought, to identify receptors in exposed areas and their value. Finally, integrating local and technical knowledge we identified and budgeted most appropriate adaptation measures. Residual risk was as well evaluated.

The main findings of our action-research are twofold. First, through risk evaluation the cost of adaptation measures is kept under the value of expected damages considering also the residual risk. Second, risk analysis changes the perspective of disaster adaptation. In some communities, where drought seems to be the major stake, floods are the first threat to which communities are exposed, because of the likeliness and the value of damages. Vice versa in some riverside communities drought is the first threat due to the value of crops.

These outcomes are attended through a reproducible methodology integrating participatory and GIS tools. Actually, the results are particularly relevant in Niger, where second generation of local development plans is currently in process to include climate adaptation and risk assessment can largely improve the quality of adaptation local planning tools.

Keywords: Niger, Drought, Floods, Risk analysis, Risk evaluation, Climate adaptation

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WHY ARE WE NOT SO EFFECTIVE? THE NON-TECHNICAL ASPECTS THAT CAN UNDERMINE OUR POLICIES

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This work is based on the experience developed through the technical support given in the development and implementation of environmental plans at regional scale [1] and presents a set of social mechanisms that can, and often do, reduce deployment of technologies and penetration of policies devoted to the mitigation of environmental pressures and to the adoption of adaptation strategies. It is shown that, besides mere communication aspects, the non-technical component of each measure, i.e. the human response, can severely reduce the potential theoretical benefits. In detail, the mechanisms of “social evidence” (people do what people often do), “fear” (so called “titanic syndrome”), “deprivation” (people reject potential loss of perceived rights), “asymmetry” (far huge benefits weight less than near small incomes) [2] and “complexity burden” (people disaffection for complex solutions) are analysed in the frame of climate change policies.

An historical retrospective of successful and unsuccessful attempts are presented, and hints are supplied for the approaches devoted to the development of adaptation and mitigation policies related to climate change.

Keywords: Policy making, adaptation, mitigation

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NEW CHALLENGES FOR OFFICAL STATISTICS FOR THE UNDERSTANDING OF EXTREME EVENTS AND DISASTERS

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The increasing hazard on which people, human settlements, environment, are exposed due to the growing risks caused by always more strongest extreme events and disasters, lead to an urgent need for understanding the occurrence, magnitude and impacts of these events. Several international processes are facing directly or indirectly this challenge, deeply interconnected with Climate Change and Sustainability, in a global perspective, as all are transboundary subjects in nature. The UNECE task Force on Climate Change Related Statistics (CCRS) is building a system of internationally comparable indicators encompassing Impacts and Adaptation beyond Emission, Drivers, Mitigation aspects; the Sustainable Development Goals (SDGs) assign targets on safety, resiliency and sustainability of cities and human settlements as well as resilience of poor and those in vulnerable situation; the Sendai framework for Disaster Risk Reduction aims to the substantial reduction of disaster risk and losses; an UN ESCAP Expert Group deals with disaster risk reduction and building resilience to disasters, establishing internationally comparable statistics on disaster occurrences and impacts. National Statistical Offices (NSOs) are called to strengthen their contribute, addressing the production of official statistics to this purposes, enhancing national and international cooperation among producers and users of statistical data, providing guidelines, definitions and classifications, spreading knowledge and awareness on this subjects and their interconnections with traditional statistical domains, improving capacity building on technical statistical aspects and encourage developing of geospatial information at larger scale. In this context, an UNECE task force has been establish in 2015 to clarify the role of NSOs in measuring Extreme Events and Disasters Related Statistics and providing information for disaster risk reduction. To this work, important reference document is also the Framework for the Development of Environment Statistics (FDES, 2013). This presentations aims to illustrate the progress of ongoing processes and the active involvement and contribute of the Italian National Statistical Office in their development.

Keywords: Extreme events and disasters, Risk reduction, Official Statistics, National Statistical System, Istat

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EXPERIENCES OF APPLICATION OF OPERATIONAL OCEANOGRAPHY SERVICES AND TOOLS

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An important aspect of the development of services and tools for supporting decision making in several activities concerning the marine environment is certainly the involvement of end-users. It is a current and effective practice nowadays to approach users from the very beginning of the development, because their needs and inputs may help producing more user-friendly and fit-for-purpose services.

This is the approach that the teams of the TESSA [1] and Chemarefara'? [2] projects have adopted in developing the services for Situational Sea Awareness (SSA), including, among others, those related to the weather and marine forecasts, the safe navigation and the marinezed tablet Nautibox. Public authorities, such as coast guards, as well as private users, like sailors, surfers and fishermen, have been involved in the testing of the services and tools throughout their production, in order to get feedback sand include them as new features in the next versions of the tools.

This poster presents few examples of these successful experiences of interactions with the users. Among them, the Mediterranea group [3], a 5-year sailing, cultural, scientific expedition throughout the Mediterranean Sea, which applied the service of Sea-Conditions [1] for the weather and marine conditions forecasts. Another example concerns the use of the Nautibox, a tablet suited for use on sea and that may interface NEMEA bus on board instruments, which has been tested by several boat owners.

The poster will illustrate how the services have been used and how the outcomes have been useful for the different goals of the users.

Keywords: user-centered approach, co-production of services, operational oceanography, marine forecasting, safe navigation

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PUBLIC TRANSPORT AND CLIMATE CHANGE IN ROME: IMPACTS ON THE NETWORK

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Along with the rest of the world, Rome is going to be affected by climate change. Flooding, both from rivers and extreme rain, and extreme heat are the two most pressing climate issues for the eternal city.

Rome's public transport system is going to be among the sectors affected by the changing climate. The surface transport network, amounting to more than 3,500 km of bus lines, six tram lines, and one trolleybus line, will likely bear the most part of the effects (as opposed to the relatively small underground and light rail system, each amounting to three lines).

A study is being carried out, analysing and mapping how the public transport network coped during extreme weather events (i.e. heavy rain and temperatures above 35°C) between late 1999 and 2014, highlighting what kind of disruption took place, where it was located, which lines it affected, and for how long. Data was retrieved for 23 sample days (or series of days), 10 for heavy rain, 13 for extreme heat.

The provisional results reveal, unsurprisingly, that flooding of street and underpasses affects various parts of the network, both in central and peripheral areas. High temperatures affect the rolling stock, while fires affect the network in the countryside.

In the light of climate adaptation, this calls for action in the transport field, so as to minimise disruption of the public transport network. Possible physical actions range from improving drainage through green and grey interventions to purchasing new, climate-proof vehicles. On the management side, devising a plan of alternative routes in order to maintain service in case of disruption, and a reliable alert system for transport users, can be useful solutions.

Keywords: public transport; adaptation; flooding; heat; disruption

VANUATU AND THE CLIMATIC CHANGE: AN ETHNOGRAPHIC REPORT

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Drawn from an ethnographic research of four months conducted between September and December 2014, this paper offers an account of how climate change – in both its narrative and physical form – is affecting everyday life in Vanuatu, an independent archipelago located in the western Pacific.

The paper is organized as follows: a first part, a second part and a closure. In the first part climatic predictions for the Pacific zone in general, and for Vanuatu in particular, are briefly sketched using the data provided by the IPCC[1.] and the CSIRO[2.]. The second part is dedicated to the analysis of the data collected during the fieldwork through interviews, archival research and participant observation; here the former “Torres Climate Refugees case”[3.] and a public speech given by the Director General for the Ministry of Climate Change are examined in depth. During the closure, the main outcomes of the research are exposed.

The findings suggest that in Vanuatu climate change, rather than being simply a problem to be solved, has been adopted as a useful concept to cope with different critical issues, not always «climate-linked». Although this could be acknowledged as a positive outcome, “climate reductionism”[4.] should be avoided, recognizing the social, cultural and economic factors that are often at the basis of the problems experienced in the archipelago.

Keywords: Vanuatu, ethnography, Torres, climate reductionism

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MEASURING AND MODELLING CO_2 EMISSION IN THE CITY OF SASSARI

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Atmospheric CO_2 emissions due to traffic, household activities, human, animal and plant respiration together with the uptake from urban vegetation, represent the net exchange of vertical fluxes between the urban surfaces and the upper atmosphere. Improving our understanding about land-atmosphere interactions in urban ecosystems is crucial to mitigate the negative effects of urbanization and to address urban planning to our advantage.

In this context, the Eddy Covariance (EC) technique aims to measure surface mass and energy fluxes which are useful to verify land surface models under known conditions, and characterize and parameterize environmental constants used in numerical models. For that reason, an EC tower was set up in the municipality of Sassari: it is located in the North of Sardinia, in the middle of the Mediterranean area, and it is representative of many Italian cities characterized by having single detached houses or small buildings, narrow streets and few parks and gardens nearby.

The objectives of this work are to give information about current CO_2 emissions and absorptions at local scale, and evaluate the ACASA model (Advanced Canopy Atmosphere Soil Algorithm) to estimate net CO_2 exchanges. This could be useful to simulate the effect of different urban planning scenarios at a municipality level, and identify new strategies to reduce CO_2 emissions.

Keywords: Eddy Covariance, modeling CO2 emissions, urban environment, land surface models, Mediterranean city.

QUALITATIVE SCENARIO BUILDING FOR POST-CARBON CITIES

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Between 70 and 80 percent of global greenhouse gas emissions are attributed to cities[1,2]. Urban carbon reduction strategies therefore have great potential to support climate change mitigation.

There is a wealth of existing urban-level plans and projects aimed at defining measures and actions for reducing climate impacts. These include self-reported measures, such as survey questionnaires or interviews with city representatives and experts[3], or published mitigation plans or strategic policy and planning documents[4], which tend to show a relatively low-level of climate-relevant emissions reductions. Unlike these plans, which are frequently related to short-term policy priorities, plans for a post-carbon transition must consider time horizons extending beyond normal planning processes. This paper utilizes visioning and scenario development as forward-looking activities aimed at longer time horizons, from now until 2050.

In defining the transition towards a post-carbon future, understanding the needs and determinants for policy priorities in different types of cities will help tailor a common roadmap fit for various socio-economic contexts. This paper provides an analysis of results collected in a participatory scenario building exercise undertaken within a research project on post-carbon urban futures. It is based on local stakeholders workshops organized in nine European case study cities, which employed a three-step methodology consisting of an initial assessment, vision building and backcasting exercises. Comparison of visions and scenarios produced during these workshops provides insights on the drivers that determine priorities in policy action for cities working towards post-carbon futures. Results show similar elements in strategies proposed by stakeholders, focusing primarily on urban energy efficiency projects and transitioning to non-fossil energy resources. However, the specific mix of strategies envisaged for each city has been influenced by local issues, such as geographical location or size, as well as different points of departure with regards to emission reductions and sustainability strategies already achieved.

Keywords: post-carbon transition, scenario building, stakeholder workshops

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ASSESSING THE INSTITUTIONAL CONSTRAINTS TO ADAPTATION THROUGH SOCIAL NETWORK ANALYSIS: EVIDENCE FROM THE CARMEN-PAJONAL-MACHONA LAGOON SYSTEM IN TABASCO (MEXICO)

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Traditional frameworks to conceptualise and assess adaptive capacity have mostly focused on the physical assets endowment and economic conditions of nations or groups, largely using economic resources, poverty and equity as proxy indicators [1]. The institutional dimension of adaptive capacity, instead, has been less explored as a result of the emphasis placed by vulnerability research on quantitative indicators [2]. However, studying adaptive capacity from an institutional perspective is essential not only for carrying out several steps of the adaptation process, but also to identify potential barriers or constraints to adaptation.

By taking the state of Tabasco (Mexico) as a case study, and focusing in particular on the vulnerable Carmen-Pajonal-Machona (CPM) lagoon system, we draw attention to a specific element which could constrain the effective deployment of adaptation interventions: the (poor) level of *cooperation*i) among the formal institutions operating at the local level on Natural Resource Management (NRM) and Climate Change Adaptation/Disaster Risk Reduction (CCA/DRR) issues, and ii) between institutions and local communities [3]. We assess the strength of the existing links among organizations (public entities, Universities and NGOs) through a Social Network Analysis (SNA), performed with the NodeXL tool [4]. As a complement to the SNA, we explore the networks tying formal institutions and communities employing the concept of social capital and, in particular, that of *trust*. Our main results include: i) the detection of a highly sectoral approach in delivering CCA interventions, which fails to give full consideration to the critical social development needs of the area, and ii) the recognition of the deep mistrust of local communities in formal institutions as a major constraint in enhancing their adaptive capacity. We conclude by providing some insights to strengthen the adaptive capacity of institutions in Tabasco, so to support them in turning potential into actual adaptation outcomes.

Keywords: institutions, adaptive capacity, social network analysis, cooperation, trust

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CONSERVATION AGRICULTURE AS A SMART STRATEGY TO COPE WITH CLIMATE CHANGE IN THE MEDITERRANEAN BASIN

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The growing awareness of the common European agricultural policy (CAP) [1] in considering the environmental sustainability of agricultural activities, has led to a growing interest in the conservation agriculture (CA). CA is one of the most effective agronomic practice to cope with climate change as a smart strategy of adaptation and mitigation. Although it is generally accepted that CA protects soils from degradation processes and increases soil organic matter (SOM) and fertility, studies on this issue in the Mediterranean are limited and the observed effects on crops are often contradictory.

The aim of this study was to evaluate the effects of conservation tillage and rotation with legumes on phenology and yield of durum wheat in two field trials located in southern Sardinia (Italy), and describes the first evidences of the soil quality monitoring achieved after a decade of application of these techniques. Moreover, CA practices were tested under climate change conditions by using the DSSAT 4.5 software [2] and an ensemble of climate change projections developed with the pattern scaling technique [3,4] of three GCMs (HadCM3, NCAR-PCM and ECHAM5) and different emission scenarios. Shortening of crop cycle is expected and it increases moving from low to high climate sensitivities. We found a substantial irrelevance between tillage systems on yield while these increase with crop rotation. Such behavior has been observed either in field trials and in future climate scenarios. Conservation tillage promotes SOM accumulation in the soil, especially sod seeding in the first soil layer (5 cm depth). This seems to be favorite by compaction, which determines lower oxygenation and hence lower mineralization. Conservation agriculture is a smart agronomic practice in a Mediterranean environment allowing to obtain satisfactory yields with a management environmentally and economically more sustainable.

Keywords: conservation agriculture, climate change, adaptation, mitigation, SOM.

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SUSTAINABLE ENERGY DEVELOPMENT PATHS FOR UKRAINE: TOP-DOWN – BOTTOM-UP APPROACH

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The energy policy serves as one of the key factors of economic development in Ukraine, representing both threats and potential for further improvements. Energy accounts for 8,3% of households' expenditures, 22,5% of intermediate consumption and 30% value of imports, sector's enterprises vent over 77% (309 Mte CO2e in 2012) of total GHG emissions. At the same time energy efficiency level is extremely low: GDP energy intensity is almost 3 times higher than in OECD countries, the same ratio holds true for carbon intensity. This poses severe threats on Ukraine's future economic development and requires implementation of effective policy measures.

In this study a soft-link approach to TIMES-Ukraine and CGE models was applied to investigate sustainable energy development policies. Namely, Rational energy use scenario (considers national obligations within Energy Community being incorporated into domestic legislation and extrapolated till 2050), Low emission development scenario (includes GHG emissions abatement by at least 50% in 2050 from 1990 level) and optional for both scenarios enhancement of domestic fossil fuels production (including shale gas).

According to the results, if required investments are attracted, Ukraine has a fair opportunity to earn double dividends both for economy and environment. Although separate implementation of different policy measures has a high risk of failure due to the isolated effects. For instance, renewables development without intensive energy efficiency measures implementation may lead to a moderate decrease in households' income, output and GDP. Meanwhile a key issue of investigated policy measures success seems to be a motivational component. In most cases basic policy costs are born by households, while undercharged energy prices, low availability of energy efficient equipment and poor informational support for energy conservation do not create neither economic nor social incentives for measures implementation. To address this issue our study derives a set of additional policy options.

Keywords: CGE model, TIMES-Ukraine model, sustainable development, energy policy.

THE URBANFLUXES PROJECT: USING SATELLITE DATA TO ESTIMATE ANTHROPOGENIC HEAT FLUX

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In the future, temperatures in cities are predicted to keep on rising, resulting in increased energy demand for cooling systems in low and mid-latitude cities, modifying UEB and increasing heat wave risk. The URBANFLUXES (URBan ANthrpogenic heat FLUX from Earth observation Satellites) project, funded within the H2020 program, started in 2015 and aims at investigating the potential of Copernicus Earth Observation (EO) data [1], with particular attention to Sentinels missions [2], to retrieve anthropogenic heat flux as a key component of the Urban Energy Budget (UEB) [3]. The anthropogenic heat flux is estimated as a residual of UEB [4]. Therefore, the rest UEB components, namely, the net all-wave radiation, the net change in heat storage and the turbulent sensible and latent heat fluxes are independently estimated from Earth EO, whereas the advection term is included in the error of the anthropogenic heat flux estimation from the UEB closure. EO data is initially analysed to map urban surface morphology and cover, whilst a new approach has been developed to define Local Climate Zones (LCZ) [5]. Using the LCZ as a framework, advanced EO-based methods and radiation transfer models [6] are then used to estimate UEB fluxes. Within the project a dense network of conventional meteorological stations is used in each case study city: London, Basel and Heraklion. In-situ flux measurements (Eddy Covariance, scintilometry) and bottom-up approaches (inventories, building energy models) are also considered to evaluate URBANFLUXES outcomes, whereas uncertainties are specified and analysed. URBANFLUXES is expected to prepare the ground for further innovative exploitation of European space data in scientific activities (climate variability studies at local and regional scales) and future and emerging applications (sustainable urban planning, mitigation technologies) to benefit climate change mitigation/adaptation and civil protection.

Keywords: Earth Observation, Copernicus, anthropogenic heat flux, urban heat islands, climate change

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CLIMATE CHANGE IMPACTS ON CULTURAL HERITAGE MATERIALS IN SINERGIES WITH AIR POLLUTION: THE EUROPEAN RISK ASSESSMENT

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Scientific interest is continuously increasing on the effects of climate change in combination with environmental pollution in degradation of Cultural Heritage materials exposed in urban areas. Indeed, Cultural Heritage situated in open air is very sensitive to the action of the environmental pressures they are exposed, such as meteorological stressors and atmospheric pollutants that can be responsible for aesthetic damage and material losses. This work aims to producing the first European risk maps for the assessment of potential stock at risk, due to the impact of climate pressure and air pollutants on cultural materials. In order to obtain this result, environmental data are fitted in dose-response functions for each materials, assessing the superficial regression and mass losses of limestone, copper and bronze in Europe. The results shown past (1980, 1990, 2000, 2010) and future trends (2030), in two scenarios. To estimate the most important predictor affecting surface regression and mass losses, Random Forests Analysis (RFA) has been performed.

Copper and bronze seems to be very sensitive to climate change in comparison to air pollution, while the conservation of limestone will be possible thanks to the reduction of acid rains and pollutants such as SO_2 and PM_{10}.

Keywords: climate impacts, Cultural Heritage, air pollution, Random Forest Analysis

RETHINKING EUROPEAN UNION MATERIAL FLOW ANALYSIS NATIONAL ACCOUNT METHODOLOGIES

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In the last two decades, the concept of urban metabolism research has become an important tool used to create awareness on material and energy transformations, consumption patterns of resources, sustainability practices, and the management of hinterlands. Somewhat analogous to a living metabolism, cities can be analyzed in terms of their metabolic flow rates that arise from the uptake, transformation, and storage or materials and energy and the discharge of waste products (Baccini and Brunner, 1991). Transforming the European Union (EU)to be the most energy and resource efficient region in the world may drive forward innovation, create jobs, increase competitiveness and improve the state of the environment. There will be no sustainable development in the EU without reducing human demand on natural resources through enhance resource efficiency practices. Progress in cities therefore need to be measured against the ability to increase resource productivity and decrease the demand of natural resources. To monitor, it is necessary to implement an outdated material flow national account methodologyto serve the urban scale fabric (European Commission, 2001). As urban cities are unable to provide the necessary information, this proposed extended methodology will allow for all European urban cities to adapt natural resource and consumption awareness in order to become the most resource and energy efficient.
Keywords: urban metabolism, material flow analysis, natural resources, policy

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URBAN CLIMATE RESILIENCE: A FIRST FRAMEWORK FOR URBAN REGENERATION

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A urgent call for cities to *adapt* rapidly to the changing climate is in place, and nowadays many adaptation options are available for urban areas to contrast its major impacts. However, cities have to pursue *mitigation* ambitions too.

The potential for mitigation in urban areas is important for two main reasons:

1. Cities need to become *resilient* to climate change, therefore they must adapt to the new changing climate, but at the same time it is urgent that cities contribute to the mitigation of its effects too;
2. Through concrete and measurable mitigation efforts, cities could take an active part into the national CO_2 emissions reductions accounting, and also to possible "extended" Emission Trading Schemes.

The 2014 “Lima call for climate” emphasizes the need to examine technical opportunities “with high mitigation potential, including those with adaptation, health and sustainable development co-benefits”. Cities are therefore crucial in this debate.

The connection between cities and an effective resilience to climate change can be attained, especially in established European cities, through urban *regeneration* interventions. They may in fact result helpful in encompassing the constraints due to existing urban forms and infrastructure.

Reshaping the morphology of portions of cities, regenerating the environment with a sustainability oriented approach, may help cities on the whole improving their resilience to climate change.

The paper links high level policies on climate change to concrete action on a local level, to demonstrate how beneficial mitigation can be for cities, especially in Europe, and how high level decisions can be applied locally. A series of examples of urban regeneration projects in Europe are examined, which contain concrete urban design solutions that have a value also under the point of view of CO_2 emissions' accounting, in sight of Paris 2015.

Keywords: mitigation, adaptation, cities, urban regeneration

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IS A VINEYARD ABLE TO OFFSET GHG EMISSIONS RELEASED DURING THE GRAPE PRODUCTION PROCESS?

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Agriculture plays a double role in affecting the atmospheric greenhouse gases (GHG) emissions. It both emits a large amount of GHG, but it also contributes to sequester carbon. The main goal of this work was to investigate the capability of a Mediterranean mature vineyard in offsetting the GHG emitted during the grape production process. The research tried to identify the agronomic practices that mainly contributed to emissions and to include the vineyard biogenic contribution in the net carbon budget calculation.

The Carbon Footprint (CF) analysis was conducted to estimate the direct (CO_2) and indirect (Nitrogen emissions converted in $CO_{2\text{-eq}}$) emissions related to soil management, use of fossil fuel, and from activities affecting the short-term carbon cycle (e.g. pruning, harvesting, and human metabolism of workers). In addition, the Eddy Covariance technique was used to directly measure the CO_2 exchange over the vineyard.

The net CO_2 budget of the vineyard was computed by combining the measured fluxes and the GHG emissions estimated by the CF analysis. Results showed that the production of 1 kg of grape determined a total amount of GHG emissions of 0.39 kg CO_2-eq mainly from fossil fuel combustion and soil management. Since farmer already reduced the amount of applied fertilizers, this practice does not have a relevant impact in the total GHG emission quantification. The conversion from the current conventional management to organic one will not probably determine a significant improvement. A solution to reduce the global warming impact resulting from the use of agricultural machinery could be found in reducing soil tillage practices and using biodiesel fuel. In addition, results confirmed the capability of the vineyard to offset the CO_2 emissions released during the agronomic practices. Plants physiological processes, row cropping, and soil, in fact, contributed to sequester part of the carbon released during the year.

ECO-EFFICIENT FUEL CELLS IN A LOW CARBON ECONOMY

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As environmental concern about global warming and the need to reduce CO_2 emissions increases, interest in fuel cell (FC) technology has expanded. FCs are galvanic cells, in which the free energy of a chemical reaction is converted into electrical energy (via an electrical current). Because electrical energy is generated without combusting fuel, FC offers multiple benefits that make them a vital technology towards to a low-carbon economy. However, at present, sensitivity to fuel contaminants, high initial investment costs (3-4 times higher than conventional distributed generation systems)periodic maintenance operations in every 5 years, are inhibiting full market penetration. Nowadays, FC are under pressure to be fully developed in time to deal with the incumbent crises of primary energy use and CO_2 emissions sustainably and economically. To further approach this goal, along with technological development and innovation, radical improvements in eco-efficiency (EE) need to be realized. The EE concept is designed to capture the ecological efficiency of growth by measuring the efficiency of economic activity both in terms of consumption and production (resource-use) and its corresponding environmental impacts. A large number of companies using EE thinking approach claim to have achieved substantial economic savings as well as environmental benefits (e.g.,3MCompany, Toshiba, Toyota).However, today's economic reality is leading to concomitant increases in GHG emission mainly because in developing countries where demand for resources is driven by strong economic growth. Thus, by supporting eco-efficient processes and systemic eco-innovation the local actors consume resources, interact environmental friendly with local ecosystems and bring value to the local economy. In this context, development of eco-efficient FC requires proper stakeholder involvement, cultivation of all sectors of the economy chain and forward-looking policy making strategies to enforce or facilitate application and uptake of this technologies in low-carbon economy.

Keywords: green economy, sustainability, economic impacts, GHG emission

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THE CASE STUDY OF SORRADILE (SARDINIA, ITALY) AS A PARADIGM OF MAYORS ADAPT INITIATIVE ON LOCAL CLIMATE CHANGE ADAPTATION STRATEGIES

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Climate change global dimension, and the complexity of related phenomena, enforces difficulties in single communities in enhancing local actions towards resilience[1]. The case study of Sorradile, a rural small town of 400 people in the center of Sardinia, could be insignificant in itself if only the territorial dimension extent and the resident population were considered. Nevertheless, Sorradile is the typical example of an agricultural based center, where loss of population and ageing processes lead to the abandonment of rural areas, and expose the territory to greater risks related to climate change[2]. This paradigmatic situation is common to 90% of European territory (56% of total population), and the consequent study approach is replicable to a wide number of municipalities[3]. Sorradile is one of the subscribers of the Covenant of Mayors, and also one of the first 100 European municipalities that adopted the Mayors Adapt Convention aimed at enforcing commitments in local strategies in Climate Change adaptation[1]. Two climate change models (Hadley Center and Goddard Institute 30 sec. rep 85 W period 2070)[4] with different severity in temperature increase and rainfall shortage were applied to Sardinian territory and Sorradile area (1950-2000 climate baseline). With this purpose, a precise, holistic-analytic approach was developed referring to the relationships and connections between: (1) socioeconomic, environmental, landscape characteristics of the case study territory, and (2) potential risk of fire and heat waves occurring, sensitivity to drought, desertification and extreme meteorological events[5]. The analysis was also extended to a wider area (Barigadu region - Lago Omodeo Basin). An estimate of exposure, sensitivity, adaptation capacity and vulnerability of natural and human controlled ecosystems to climate change was developed through a participated process that involved the local community and the main competent stakeholders of the area. Resulted information can be useful for future land planning and resource allocation.

Keywords: Mayors Adapt, Climate change, Adaptation, Sensitivity, Land planning

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IMPROVING STRATEGIC ENVIRONMENTAL ASSESSMENT BASELINE TO PRIORITIZE ADAPTATION INTO LOCAL PLANS

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One of the most critical aspect of climate change is how it will affect the natural evolution of the environment.

Despite many uncertainties, there is a widespread recognition that climate change will inevitably increase the susceptibility of urban societies if no effective adaptation takes place (IPCC, 2007; UNHABITAT, 2011).

This mainly depends on the evolving state of the environment due to climatic influence.

Current environmental transformations are happening at a before unseen rate so there is a growing need of determining how far climate outcomes could alter the current natural balance in the future.

The majority of adaptation practices still hardly considered linkages between climate outcomes and local vulnerabilities. And current environmental baselines do not assess climate conditions as a primary pressure on the environment and, consequently, on the urban growth.

On this basis, this paper focuses on Strategic Environmental Assessment (SEA) framework. It provides a preliminary baseline to improve under heading of climate change adaptation.

The current SEA baseline is a starting point for managing a broad range of environmental risks and defines a more comprehensive model to take adaptation issues in consideration in every steps of the assessment process.

The main objective is outlining a methodology to improve the standard baseline to reflect future changes in the environmental condition due to climate at local scale.

This is the base to build an overview of how climate change could affect both environmental and urban existing vulnerabilities at local scale. And the key to define which of adaptation options should be prioritized in planning tools.

Keywords: adaptation, baseline framework, Strategic Environmental Assessment, environment, climate outcomes

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URBAN CLIMATE PLANNING IN SPAIN AND ITALY: BARRIERS AND OPPORTUNITIES

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Cities are where most of the overall primary energy is consumed, GHG emissions are released [1] and where people are more and more frequently affected by the adverse effects of climate change [2]. On the other hand, cities are the ideal framework for implementing low-carbon policies [3] and adaptation strategies through a strategic planning process shared with citizens and local stakeholders [4]. All these challenges converging in cities require integrated solutions to pick up the challenge of climate change, assuming a leading role in the transition pathway towards a more sustainable future [5].

This study presents the state-of-art of the urban climate action plans developed in two countries, Spain and Italy, which share similarities on many levels (i.e. cultural, geographical, climate vulnerabilities, urban configurations and institutional framework). In particular, the study analyses the climate actions undertaken by a sample of 26 and 32 Spanish and Italian cities respectively, which are included in the Eurostat Urban Audit database, as described in [6-8].

The study tries to understand why and how cities have started action to reduce their contribution to climate change and become more resilient, investigating also the influence of national and international climate alliances.

The willingness and preparedness of these cities to cope with climate change is investigated through an in-depth analysis of mitigation and adaptation plans and programs in the selected cities in terms of emission targets set, emissions accountability methods adopted, topics included and actions taken.

A careful review of the main institutional, socio-economic, environmental and vulnerability characteristics of the 58 analyzed cities allows to shed light on the potential barriers and opportunities to the development of urban climate change plans in these two Mediterranean countries.

Keywords: Urban climate planning; Mitigation; Adaptation; Spain; Italy

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SENSITIVITY OF METHANE LIFETIME AND TRANSPORT TO SULPHATE GEOENGINEERING

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Sulphate geoengineering, made by sustained injection of SO_2 in the tropical lower stratosphere, may impact the abundance of tropospheric methane through several photochemical mechanisms affecting OH abundance and hence the methane lifetime. Changes of the stratospheric Brewer-Dobson circulation also play a role in the upper tropospheric CH_4 transport. Three mechanisms lead to lower OH concentrations and a longer CH_4 lifetime: (a) solar radiation scattering increases the planetary albedo and cools the surface, with a tropospheric H_2O decrease as a response to this cooling. (b) The tropospheric UV budget is upset by additional aerosol scattering and stratospheric ozone changes: the net effect is meridionally not uniform, with a net decrease in the tropics, thus producing less tropospheric $O(^1D)$.(c) The extra-tropical downwelling motion from the lower stratosphere tends to increase the sulphate aerosol surface area density available for heterogeneous chemical reactions in the mid-upper troposphere, thus reducing the amount of NO_x and tropospheric O_3 production. On the other hand, the tropical lower stratosphere is warmed by solar and planetary radiation absorption by the aerosols. The heating rates perturbation are strongly latitude dependent, producing a significant change of the pole-to-equator temperature gradient and mean zonal wind distribution, with a net increase of tropical upwelling. A stronger meridional component of the Brewer-Dobson circulation increases the extra-tropical stratosphere to troposphere transport of CH_4 poorer air, resulting in less CH_4 transported in the UTLS. Three climate-chemistry coupled models are used to explore the above radiative, chemical and dynamical mechanisms (ULAQ-CCM, GEOSCCM, CCSM-CAM4). The CH_4 lifetime is found to be significantly longer (by approximately 10%) with a sustained injection of 5 Tg-SO_2/yr started in year 2020, which implies an increase of tropospheric CH_4

(200 ppbv) and a positive indirect radiative forcing of sulphate geoengineering due to CH_4 changes (+0.1 W/m^2).

Keywords: geoengineering, methane lifetime, climate-chemistry models.

CLIMATE IMPACTS, IMPLICATIONS AND ADAPTATION OPTIONS FOR THE URANIUM SUPPLY CHAIN IN AUSTRALIA

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Since the commencement of mining at the Jabiluka pit in the Northern Territory in 1982, uranium mining has been a significant economic activity in Australia for over three decades. Australia has the largest known reserves worldwide ([1], [2]) and prospects are that future uranium production may increase in volume per annum as global demand for uranium is projected to increase in coming years ([3], [4], [5]). This prospective increase in mining activity presents challenges, due to the nature and risks involved in the extraction and processing of the mineral, and also due to the potential impacts of climate change on mining activities. A growing scientific literature is under development that draws an inventory of the risks that mining companies face in the wake of climate change, while also indicating the lack of action on the part of many companies to undertake adaptation strategies. This may be due to lack of understanding and enumeration of risks, as well as lack of assessment of the expected costs and benefits of corresponding adaptation strategies. Cost assessments of climate change in the mining sector documented in the literature to date have been carried out in the context of activities outside Australia [(6)]. This paper examines aspects of the uranium supply chain in Australia focusing on the Northern Territory and South Australia and how it may be impacted by climate change. Vulnerability and adaptation capacity assessment of the mining firms and communities involved in the supply chain are addressed. The research demonstrates that a quantitative assessment is needed for the socio-economic and environmental costs and benefits of adaptation to climate change for the uranium supply chain in Australia.

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MULTI-DISCIPLINARY ASSESSMENTS OF CLIMATE CHANGE IMPACTS ON AGRICULTURE TO SUPPORT ADAPTATION DECISION MAKING

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Many existing climate change impact studies, carried out mainly by academic researchers, are disconnected from decision making processes of stakeholders. On the other hand, many climate change adaptation projects and programmes in developing countries lack a solid evidence base about current and future climate impacts and vulnerabilities at different scales. In order to fill this information gap, FAO implemented a project named Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security (AMICAF) in the Philippine and Peru from 2012 to 2015. This project employs a multi-disciplinary assessment approach to address climate change impacts and adaptation planning to improve food security, and consists of four components. The first component generates spatially downscaled climate change scenarios and a robust assessment of the impacts of climate change on agriculture (crop, water and economy) using MOSAICC[1], which is an integrated modeling system as well as a capacity development tool for impact assessments by national experts. Component 2 assesses household vulnerability to food insecurity under a changing climate with an econometric model. Component 3 promotes a community-based approach to identifying and evaluating adaptation options that increase capacities of vulnerable groups. Here, the top-down approach of component 1 links with bottom-up approaches of components 2 and 3 within the same framework. Component 4 supports policy planning processes. Thus, AMICAF produces evidence base to enable climate change adaptation and food security planning and decision making. The outputs of this project are nation-wide coverage, disaggregated at sub-national level to support strategic planning, investments and decisions by national policy makers. FAO also attempts to replicate the AMICAF approach through south-south cooperation during the second phase of the project in two new recipient countries. It also intends to share the knowledge, techniques and experiences obtained in the projects through technical guidance materials.

Keywords: Impacts, Adaptation, Food Security, South-South Cooperation, Agriculture

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MEDICANE RISK IN A CHANGING CLIMATE

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Extreme rainfall and related discharge events are among the most significant natural hazards, causing serious risk to life and destruction of buildings and infrastructure. Nevertheless, they often affect ungauged watersheds and remain a poorly documented phenomenon. Medicanes or “Mediterranean hurricanes” are extreme cyclonic rainstorms morphologically and physically similar to tropical cyclones. Owing to their potential destructiveness on the islands and continental coastal zones, medicane risk assessment is of paramount importance. There is increasing concern about the way these extreme phenomena could change in frequency or intensity as a result of human influences on climate. But there is also a great difficulty in formulating a clear cut distinction between medicanes and the broad spectrum of Mediterranean low-pressure systems. This paper aims at presenting the data compilation strategy, the content of the elaborated data base and some preliminary data analysis results.

To address the gap in available information and to describe the geography of the hazard across Italy, an intensive data compilation of maximum annual 24-hour rainfall has been carried out and a GIS of events which value is greater than 300 mm/day was obtained.

A simple statistical analysis indicates a perfect alignment of all the points of rainfall greater than 300mm/day on the maximum likelihood straight line in a Gumbel probability graph paper. On the contrary, the analysis of maximum annual 24-hour rainfall smaller than 300 mm/day requires the use of a PEV probability distribution, which generalizes the Gumbel law through a power transformation: a lower shape coefficient was obtained comprised between 1 and 2/3.

At a first sight, the most extreme rainfall (Medicanes) seems to occur almost exclusively near the coast: Genoa Gulf whose Gumbel straight line is the less sloped on the Gumbel graph, then eastern Sardinia, ionic Sicily, southern Calabria, Versilia and the Amalfi Coast.

Keywords: Medicanes, Rainfall, Gumbel graph

VALUING INSURANCE SERVICES EMERGING FROM A GENE BANK: THE CASE OF THE GREEK GENE BANK

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We develop a conceptual framework for determining the economic value associated to services provided by gene banks as means of highlighting the need to ensure support to the operation of gene banks. We develop an estimate for insurance values associatedwith a gene bank andwe apply the methodology to the Greek Gene Bank (GGB), the largest ex situ conservation program in Greece. To evaluate the insurance value generated by the holdings of the GGB genetic resources, the current study examined scenarios for alternative arrival probabilities of an adverse event also associated to climate change induced adversity that would negatively affect production of seven major staple crops held at the GGB within the next 100 years. Within the range of our estimates, it is indicated that insurance values considerably exceed the current operating costs of maintaining the GGB.

There are many challenges facing gene banks. Apart from collection, characterization and proper documentation, evaluation and maintenance are also required (Wright, 1997), while according to the Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture (FAO Commission on Genetic Resources for Food and Agriculture, 2010), gene bank collections are still at risk. For the GGB, the major challenges are continuation of collection, regeneration of aging stocks, documentation, evaluation and maintenance of facilities. The results of this study provide insights into values generated by the GGB, which even though they represent a subset of all the possible values generated by a gene bank, are sufficient to establish its importance.

<u>Keywords</u>: Gene bank, Valuation, Insurance value, Triggering event, Poisson arrival

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THERMOREGULATION IN NESTS OF SOCIAL INSECTS: BEYOND BIOMIMETIC ARCHITECTURE

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Most social insect species are able to regulate the temperature within their nests. Social insects' nests vary enormously in both structure and materials, but the different designs all have a common end point – maintenance of a more stable brood nest temperature than ambient.

Some structural features are important for retaining heat, while others are effective in dissipating it, as shown by a study with two dozen termite mounds that found that they are like a lung that takes a breath once a day, driven by the changes in temperature between day and night.

Air currents within the mounds expel carbon dioxide that builds up from underground termite activity what contrast to biologists' longstanding assumptions that the mound existed either to dissipate heat from the nest or provided ventilation in response to external winds.

This research aims to understand how they cooperate to build the structure — a crucial step toward finding ways to mimic that collective intelligence in robots. In this research, the variety of active and passive mechanisms that social insect species have evolved to regulate temperature is examined.

'Passive' temperature regulation includes such mechanisms as nest site selection to optimize internal nest temperature, nest structures that permit passive heating or cooling, or simple behavior such as brood translocation to regions within a nest where temperatures are most favorable, while 'active' temperature regulation refers to behavior where individuals modify nest temperature by physical activity like wing fanning or evaporative cooling. Although there is enormous variation in the thermoregulatory mechanisms, there are also many similarities.

All thermoregulatory mechanisms are self-organized and arise from simple rules followed by each individual worker. This research looks for the development ofbiomimetic buildings that are not simply inspired by lifebut that are, in a sense, as alive as their inhabitants and the living nature in which they are embedded.

Keywords:Climate change, biomimetics, termites, social insects

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CLIMATE CHANGE AND HYDROLOGICAL DROUGHT: RISKS AND ADAPTATION RESPONSES FOR THE IRRIGATION SECTOR IN THE APULIA REGION (ITALY)

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Climate change is already affecting the frequency of drought events which may threaten the current stocks of water resources and thus the availability of freshwater for the irrigation. This study evaluates the risk of hydrological drought on the irrigated agronomic compartment of Apulia, a semi-arid region in Southern Italy. We applied the previously developed Regional Risk Assessment (RRA) procedure [1], which is based on four steps i.e. hazards, exposure, vulnerability and risk assessments, integrating the qualitative and quantitative available information.

Future climate projections for the timeframes 2021-2050 and 2041-2070 were provided by COSMO-CLM under the radiative forcing RCP4.5 and RCP8.5 [2]. The run-off feeding the water stocks of the most important irrigation reservoirs in Apulia was then modeled with Arc-SWAT [3]. Hence, the hazard analysis was carried out in order to estimate the degree of fulfillment of actual irrigation demand satisfied by water supply of different reservoirs in future scenarios. Vulnerability of exposed irrigated crops was evaluated depending on three factors accounting for crop yield variation vs water stress, water losses along the irrigation network, diversification of water supply.

Resulting risk and vulnerability maps [4] allowed: the identification of Reclamation Consortia at higher risk of not fulfilling their future irrigation demand (e.g. Capitanata Reclamation Consortia in RCP8.5 2041-2070 scenario); the ranking of most affected crops (e.g. fruit trees and vineyards); and finally, the characterization of vulnerability pattern of irrigation systems. Major achievements included the definition of a portfolio of science-driven adaptation strategies to reduce the risk pattern at both agronomic level (preferring crops with low vulnerability score, as olive groves) and at structural level (differentiating the water stocks and supplies and reducing losses and inefficiencies).

Keywords: climate change, hydrological drought, risks for irrigated crops, adaptation response actions

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SOFTWARE ARCHITECTURES FOR REMOTE SENSOR BASED FARMING DECISION SUPPORT SYSTEMS AS TOOLS FOR AGRICULTURAL CLIMATE CHANGE ADAPTATION STRATEGIES

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Rural areas are expected to face the major impacts on water availability and supply, food security, infrastructure and agricultural incomes, due to climate change[1].

The subsequent high variability of climatic condition reflects in a change in timing of plants growth, causing hard management of production cycles for the farmers.

The impact of this phenomenon is particularly strong in low income countries, where instruments to develop effective agricultural adaptation strategies could lack.

In this scenarios, a possible support comes from ICT technologies. The role of ICT to enhance food security and support rural livelihoods is increasingly recognized and was officially endorsed at the World Summit on the Information Society (WSIS) 2003-2005[2]. This technologies in association with mathematical models, should provide useful tools to predict high variable environmental conditions ,hence allowing a better harvest management. Several crop simulation models like DSSAT[4] or AquaCrop[5] are nowadays available to predict the growth of various crops and crop mixes with different environmental constraints such as moisture stress, nutrient stress and water logging[3]. Predictive models can withstand wider decision support systems for farmers that could include also simple on-field network sensors as environmental information source and mobile devices as end-points. Field sensors are important elements in order to furnish data for testing and validation of the simulation models. Mobile devices, thanks to appropriate interfaces, allow farmers to remotely exploit data coming from simulation models to perform agricultural strategy, that are more adaptive to climate change.

This work studies the architecture of farming decision support system based on crop simulation models sensor networks and mobile devices, in order define the key elements, best practices and possible developments in the software architecture design that makes these kind of tools an effective instrument to implement end-user agricultural climate change adaptation strategies.

Keywords: agriculture, adaptation, climate change, ICT.

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THE PHYSICS OF CLIMATE CHANGE

CLIMATE CHANGE AND FIRE RISK IN ITALY

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Extreme meteorological events represent serious risks for human activities and infrastructures. About infrastructures of electric system, the overall overhead line assets around the world were designed and constructed between 30 and 50 years ago to design standards considered appropriate at that time. The meteorological conditions in this last decade indicate a trend for the increase in frequency and intensity of severe climatic events, whose impacts have a significant maintenance management issue in many regions of the world, including Italy.In particular, wildfire events are likely to become more severe in the future in response to the projected drier and warmer climate change.

This work represents a preliminary study about the impacts of climate change for the fire risk in Italy.

The effects of climate change on the fire risk have been characterized by analyzing the Fire Weather Index FWI [1] for the present and future RCP85 scenarios obtained on the basis of the results provided by a regional model of Med-CORDEX archive: ICTP-RegCM4 at 12.5 km (MED-11) resolution.

In line with previous experiments [2-3] and coherently with ENSEMBLES future A1B scenarios, fire risk is expected to increase in summer. In particular, the results indicate an increase of fire risks for the next decades in most of Italy.

Keywords: fire risks, regional modes, climate projections

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FLUXES OF ENERGY AND GREENHOUSE GASES IN MEDITERRANEAN FOREST ECOSYSTEMS DESCRIBED BY THE SOIL-PLANT-ATMOSPHERE (SPA) MODEL

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Quantification of the ecosystem services provided by the urban and peri-urban vegetation is highly needed especially in densely populated Mediterranean areas. With the intent to calculate the capacity of plants to sequestrate pollutants and carbon dioxide from the atmosphere, we elaborated a multi-layer and dynamic model composed of six different modules:

1. A hydrological component to predict soil water content in soil in response to precipitation, structure of the soil and evapotranspiration. 2. a canopy environmental model to determine leaf temperature and the radiative transfers at different levels from above to the bottom of the canopy [1–3]. 3. A deposition model based on calculation of different resistances to gas diffusion such as atmospheric resistance, leaf boundary layer resistance, and canopy resistances [4]. 4. A photosynthesis model to estimate net photosynthesis and stomatal conductance [5–7]. 5. A Volatile Organic Compounds (VOC) canopy emission module [8]. 6. Carbon balance computation model based on species-specific allometric relationships to calculate above-ground and below-ground biomass [9,10].

We validated the model with fluxes of energy, water and trace gases measured using the Eddy Covariance technique in a Mediterranean Holm oak forest located in Castelporziano presidential Estate, a peri-urban forest near the coast of Tyrrhenian sea, 20 km from Rome downtown, Italy. Results show a good agreement between modelled and measured fluxes, highlighting potential application of the model to a broad range of forest Ecosystems.

Keywords: leaf energy balance, photosynthesis, VOC, urban vegetation

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WEATHER RADAR BASED SHORT TERM CLIMATOLOGICAL ANALYSIS OF SEVERE STORMS OVER NORTHWESTERN ITALY

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The knowledge of the distribution of the extreme events, which represent a hazard for human activities, can represent an interesting tool in diagnosing, dealing and predicting them. A complete climatology of the events requires a spatially continue knowledge of the information on the events occurred during a meaningful period of time. Using the weather radar data, it is possible to obtain real-time information over its entire domain [1]. Other conventional ground-based weather instruments or human reports represent partial and discontinuous information. This study aims at supplying a complete overview of the spatial distribution of the convective events and their seasonal and diurnal cycle over northwestern Italy, through the definition of an objective severity index [2]. For this purpose, five years of data collected by the regional weather radar network between 2009 and 2014 have been analyzed using a storm tracking algorithm [3]. The resulting tracks, employed in the definition of the events, have been quality controlled. The achieved knowledge of the distribution of the storms provides an useful tool for supporting regional strategies of adaptation to climate changes. Moreover, some of the physical and dynamical processes, underlying the initiation and evolution of storms, are discussed. The effects of the synoptic, mechanic and thermodynamic forcings for some specific regions are also highlighted. This study defines a new approach for regional climatological studies of the storm events. Moreover, by focusing on extreme events, it can be employed in further studies, developing the future projections of the severe local climatology.
Keywords: extreme events, climatology, weather radar

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EXPLORING PRESENT AND FUTURE LINKAGES BETWEEN TANZANIA RAINFALL AND LARGE-SCALE CIRCULATION PATTERNS BY NON-HOMOGENOUS HIDDEN MARKOV MODEL (NHMM)

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A Non-Homogeneous hidden Markov Model (NHMM) is developed with the aims: a) to explore the link between rainfall characteristics in Tanzania and large-scale atmospheric circulation patterns; b) to predict future rainfall patterns for the 21st century under a global warming scenarios by IPCC AR5. The model is developed using a 40-year record (1950-1990) of daily rainfall at eleven stations in Tanzania and NCEP-NCAR re-analysis atmospheric fields of a number of meteorological variables. The following atmospheric fields (latitude from 25°S to 25°N and longitude from 25°E to 75°E), respectively of Temperature at 1000 hPa, Geopotential Height at 1000 hPa, Meridional Winds and Zonal Winds at 850 hPa, and Zonal Winds at the Equator from 10 to 1000 hPa, are identified to be best ensemble of atmospheric variables that allow the accurate downscaling of the seasonal regime of daily rainfalls in Tanzania. The model directly considers seasonality through changes in the driving variables thus addressing the question of how future changes in seasonality of precipitation can be modeled. The NHMM is then used to predict future rainfall patterns under a global warming scenario (RCP8.5), using predictors from the CMCC-CMS simulations from 1950-2100. The future downscaled simulations from NHMM, with predictors derived from the simulations of the CMCC-CMS CGM in the worst conditions of global warming as simulated by RCP8.5 scenario, indicate that in the XXI century Tanzania may be subjected to : (1) an slight decrease in the number of wet days and seasonal rainfall amount in MAM and JJAS, but not in OND; (2) a reduction of annual total rainfall amount; (3) an intensification of frequency and intensity of extreme rainfall, as identified by 90th, 95th and 99th percentiles. Such changes in rainfall patterns are, then, motivated on the basis of the analysis of large scale atmospheric patterns under global warming conditions.

Keywords: NHMM, Tanzania, climate change

THE EFFECT OF THE GLOBAL WARMING ON HADLEY CIRCULATION TRENDS IN ECMWF CENTENNIAL REANALYSES

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This study analyze the evolution of the Hadley Circulation (HC) during the 20th century in two new ECMWF products: ERA-20CM and ERA-20C. The former is an AMIP-like experiment, in which the ECMWF atmospheric model IFS is forced by ten different realization of prescribed SST and radiative forcing follows the CMIP5 protocol [1]. The latter, is similarly forced, but assimilates surface pressure and marine winds, additionally [2]. The comparison between ERA-20CM and ERA-20C is suitable to understand both the effect of SST forcing and the assimilation of atmospheric surface observations on HC trends, and hence to quantify differences between reanalysis products and AMIP simulations. The two datasets present important differences in the characteristics, in the magnitude and significance of the HC trends. In general ERA-20CM atmospheric circulation is stronger than ERA-20C, but trends are larger and more statistically significant in ERA-20C than in ERA-20CM, especially in the Southern Hemisphere (SH). In the SH, the poleward shift of the Southern edge of the HC, together with widening of the SH HC appears a robust feature in both datasets, with steeper trends from 1979 to 2010 respect to 1900-2010. However, the presence of large multidecadal variability across 20th century, raises doubts on the interpretation of all recent behaviors.

Keywords: Hadley Circulation, global warming, ERA-20CM, ERA-20C, trends

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WINDS DRIVEN BY THE SAHARA AND BY THE WEST AFRICA HEAT LOW

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In this paper we present an analysis of the winds driven by the Sahara heat low (SHL) and by the West Africa heat low (WAHL). These heat lows are generated by the sensible heat fluxes over the hot Sahara desert. The SHL is longitudinally as wide as the Sahara desert and seasonally oscillates between 8 degrees north and 25 degrees north. Whilst, the smaller and deeper WAHL in winter occupies its most south-easterly position to the east of the Gulf of Guinea and in summer migrates to its most north-westerly position to west of the Hoggar highland. These lows are important, because they drive the surface and the mid-tropospheric winds.

In the mixed layer above the surface, the desert winds have a cyclonic curvature up to 1.5 km in winter and up to 2.5 km in summer. In the free troposphere above the mixed layer, the winds are more intense with a small anticyclonic curvature.

The dry south-easterly surface winds to the north of the desert low are known as Harmattan; while the north-westerly surface winds to the south of the desert low carry moisture from the Tropical Atlantic. This moist air converges towards the thermal heat low, where it rises up to the mid-troposphere, and, subsiding to the north of the heat low, generates the Libyan anticyclone.

To the south of the desert low, the tropospheric winds are characterized by strong westerly jet. This jet is known as African easterly jet, and it is important for the sub-Sahara region, because is acts as waveguide for the westerly weather perturbations, which bring the rainfall to the Sahel. In addition, about half of the hurricanes, which cross the Tropical Atlantic, are generated by these perturbations.

EVALUATION OF SIMULATED DECADAL VARIATIONS OVER THE EURO-MEDITERRANEAN REGION FROM ENSEMBLES TO MED-CORDEX

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Med-CORDEX simulations over the period 1970-2011 are evaluated with regard to their capability to represent observed decadal variations over the Euro-Mediterranean region and improve upon previous generation simulations from the ENSEMBLES project in their various experimental set-ups. Such an evaluation is needed to inform the use of these simulations and also future model development.

For temperature, both Med-CORDEX and ENSEMBLES simulations tend to provide comparable results: they generally capture the sign and timing of the anomalies but not the amplitude. In general, no clear stratification appears when considering different types of regional modeling systems. Rather, it is remarkable that certain periods are poorly represented by all systems with a general underestimation of the observed long-term temperature trend, mostly in the summer season, even with respect to the corresponding global drivers. For precipitation, the Med-CORDEX simulations are closer to observations than the other datasets, with some improvement with respect to ENSEMBLES dataset. In general, all the systems experience difficulties in representing anomalies during specific periods or for specific regions. For instance, in the second part of 1980s, the spatial patterns of surface air temperature during DJF/MAM are generally poorly represented, as well as the surface air temperature decadal climate anomalies for MAM/JJA averaged over the Mediterranean region.

Overall, the evaluation suggests limited improvement in Med-CORDEX simulations compared to ENSEMBLES with persisting problems likely related to the representation of surface processes that could also affect the viability of future projections (e.g. the estimation of temperature trends). A set of decadal variability evaluation metrics, as applied in this study, could be useful in the context of a broader evaluation framework.

Keywords: regional simulations, models uncertainty, euro-mediterranean region, climate variability, decadal variation

UNCERTAINTIES IN FUTURE WATER RUNOFF OVER THE UNITED STATES

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Global multi-model ensemble experiments provide a valuable basis for the examination of potential future changes in runoff. However, these projections suffer from uncertainties that originate from different sources at different levels in the modelling chain. We partition the uncertainty in projections of annual maximum, median and low flows over the Central United States into four distinct sources. More specifically, we quantify the relative contribution of the uncertainties arising from internal variability, global impact models (GIMs), global climate models (GCMs), and representative concentration pathways (RCPs). We use a set of nine state-of-the-art GIMs driven by five GCMs under four RCPs from the ISI-MIP multi-model ensemble. We examine the temporal changes in the relative contribution of each source of uncertainty over the course of the 21st century. Results show that GCMs and GIMs are responsible for the majority of uncertainty over most of the study area, followed by internal variability, and ultimately, RCPs. Proportions vary with the runoff metric (annual maximum, median and minimum flow) and the region of analysis. In particular, for annual maxima, large fractions of uncertainty are attributable to GCMs throughout the century, with the GIMs increasing their share especially in mountainous and cold areas (perhaps owing to their difficulty in simulating snow-ice processes); for annual medium flows GCMs' contribution is smaller and decreases with time while GIMs contribution rises; for annual minima the GIMs contribution increases with time becoming the dominant source of uncertainty over the whole country at the end of the 21st century. Importantly, compared to the other sources, the RCPs contribution to uncertainty is generally negligible. This finding indicates that the efforts for more strict emission scenarios are barely noticeable in hydrological impact studies, suggesting that other uncertainty components like GIMs and GCMs need to be improved in order to reduce their uncertainty contribution.

Keywords: Runoff projections, Global Climate Models, Global Impact Models, Uncertainty quantification.

DOWNSCALING OF CLIMATE CHANGE PROJECTIONS IN SUPPORT OF ADAPTATION PLANNING

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In order to aid adaptation planning in the agriculture and food security sectors, researchers inthe Philippines and Peru produced the evidence base about climate impacts. As a first activity in a comprehensive project framework, we made localized nation-wide climate change projections for use by crop, hydrology and economicmodellers in a multi-disciplinary climate change impact and vulnerability assessments using the MOSAICC[1] tool. We statistically downscaledthree GCMs and two emissions scenariostowards the middle of the 21st century. The downscaled data atstation level were spatially interpolated to grids for use by crop and hydrology models. Theinterpolated data were further aggregated to provincial level for use in econometric modellingand vulnerability analysis.

In the Philippines, consistent signals of climate change were found in many seasons and variables, while conflicting signs of changes were found in a few cases. A larger warming is projected for daily minimum temperature than maximum temperature, thus reducing diurnal temperature range. Precipitation is projected to increase in most parts of the country. Regarding seasonality, dry months (March-May) will continue to remain dry but within the rainy season, July and November are likely to become more notable wet months in Cagayan Valley, one of the most important rice producing areas. There are also indications of increasing frequency of heavy rainfall events, number of prolonged dry spell events, and extreme day time temperature.

In Peru, although nation-average precipitation will increase, a high spatial variability (with increasing/decreasing changes for nearby locations) was found, except for the northwestern part of the country where the wetting signal is clear. For temperatures, the highest increase was found over the Altiplano region. As in the Philippines the projected warming signal is higher for minimum than for maximum temperature.

Keywords: The Philippines, Peru,climate projections, downscaling, RCP

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EVOLUTION OF ENERGY BUDGET AND MERIDIONAL TRANSPORT IN AMIP-LIKE EXPERIMENTS DURING THE 20TH CENTURY

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The 20th century evolution and spatial patterns of the Top-of-Atmosphere (TOA), atmospheric and surface energy budget (EB) as described in two AMIP-like experiments are investigated. Two ensembles are considered: the simulations carried out with the ECMWF Integrated Forecast System (IFS) of the ERA-20CM experiment and the simulations carried out with the ECHAM5-HAM model at ETH-IAC. The latter simulations include additional sensitivity experiments constraining either SST-SIC or aerosols to climatological values. While the two ensembles agree and are consistent with the available estimates of the EB in recent decades, they disagree on its past evolution. Particularly, ERA-20CM shows a fast transition from negative to positive EBs at Top of Atmosphere (TOA) in the 1970s that is absent in ECHAM5-HAM. The ECHAM5-HAM sensitivity experiments allow attributing to the variability of SST-SIC most of the surface and atmospheric budget and transport variability. On this respect a reasonable agreement is found between the two ensembles. On the other hand in ECHAM5-HAM simulations the aerosol forcing sets up after 1960 an inter-hemispheric gradient in the TOA and surface budget, which also corresponds to an increased (decreased) total poleward transport in the Northern (Southern) Hemisphere. This feature is not found in ERA-20CM.

Keywords: ERA-20CM, energy budget, meridional heat transport, aerosol

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RADIATIVE EFFECT OF DESERT DUST IN THE MEDITERRANEAN

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Aerosol particles impact the Earth-atmosphere energy balance by modifying the radiative budget [1], the atmospheric temperature profile [2], the cloud formation and lifetime [3].

Desert dust (DD), transported at great distances from the source areas, has a large radiative impact. DD induces a reduction of the downwelling solar (SW) radiation, cooling the surface, while increasing atmospheric heating. DD has also a non-negligible effect on the longwave (LW) radiation. This effect counterbalances the solar effect, due to emission of infrared radiation by the particles, leading to a heating of the surface and a cooling in the atmosphere.

The Mediterranean Sea is very often reached by Saharan dust. In the central-Southern sector of the basin the island of Lampedusa hosts the ENEA Station for Climate Observations, where the aerosol amount, its physical, chemical, and optical properties, and its effects on the solar and infrared radiation are continuously monitored (www.lampedusa.enea.it).

Various DD intrusions, which are summarized in this work, have been studied in detail with the aim of estimating the dust direct radiative effect (DDRE) at the surface, within the atmosphere, and at its top, by means of observations and radiative transfer simulations.

During one of the most severe DD event registered, on March 2010, the total (SW+LW) surface daily DDRE reached about -44 W m^{-2}, as a result of -85 W m^{-2} in the SW and +41 W m^{-2} in the LW, with a very large role of the LW radiation [4].

The GAMARF (2008) and the ChArMEx (2013) field campaigns took advantage of airborne measurements of the in situ dust optical properties, used to estimate the DD heating rates (DDHR) in the atmospheric column. During GAMARF, the SW and LW instantaneous DDHR were found to be comparable, with a net cooling effect at specific levels on a daily basis [5].

Keywords: aerosol, dust radiative forcing, solar irradiance, infrared irradiance, heating rate

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MULTI-APPROACH INVESTIGATIONS FOR TESTING THE ROBUSTNESS OF ATTRIBUTION STUDIES

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Global Climate Models (GCMs) are the fundamental dynamical tools for catching the complexity of the climate system and simulating its behaviour. In particular, their application to attribution studies clearly shows the fundamental role of anthropogenic forcings in driving the temperature behaviour of the last half century [1]. Here, following the evidence that complex systems often benefit from investigations performed by distinct methods, I compare these results with those coming from data-driven models, through application of neural network modelling and Granger causality analyses to the temperature attribution problem.

These data-driven methods lead to general results which are very similar to those obtained by GCMs [2-4] and, in the meantime, they shed new light on the role of natural forcings and natural variability, for instance discovering a peculiar causal decoupling between Sun and global temperature after the '60s [5]. Furthermore, natural variability appears at most as a "2nd-order" influence term, which is able to modify the temperature behaviour just on inter-annual, decadal or multidecadal time scales (as in the recent hiatus), but does not influence the long-term trend [6].

Thus, these investigations characterized by different approaches allows us to test and appreciate the robustness of the results about temperature attribution, leading to increase our confidence in their reliability [7].

This discovery of a great robustness in attribution results appears important also for the climatic debate on a public setting, where, claiming to "uncertainties" in GCMs, the influence of anthropogenic forcings is still subject to denial and the factor of natural variability is often over-emphasized. This leads naturally to argue that, if this is the case, mitigation policies should not be undertaken. Appealing to the robustness of attribution results can be a way to contrast such a denial.

Keywords: attribution, Global Climate Models, neural networks, Granger causality

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THE DAILY GRIDDED CLIMATIC DATA SET 1961–2010 FOR EMILIA-ROMAGNA (ITALY)

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A daily high-resolution gridded climatic data set, for the period 1961-2014, is presented for Emilia-Romagna region, Italy. Precipitation and temperature daily data, from 254 and 60 locations respectively, are first checked for quality, temporal homogeneity and synchronicity. Temperatures are interpolated with a daily best-performing detrending procedure and a modified inverse distance scheme, accounting for orographic barriers. Elevation, urban fraction and topographic position are the geographical proxy parameters used for detrending. Daily precipitation is interpolated using the same scheme, without detrending. Data are first spatially interpolated on a 500 m digital elevation model, then averaged on a triangulated irregular grid with variable resolution depending on topography.

The main climatological indices are computed on the gridded data set and on the regional spatially averaged series, producing average climatic and temporal trend maps, and regional time series plots. The average interpolation errors are also estimated in cross validation for both variables, so as to identify the main limitations and advantages of the data set.

The interpolation procedure was also applied to the data of a denser automated station network with higher quality, available for the years from 2001 to present. A comparison between the two data-set shows the advantages and disadvantages of both, indicating for each the preferred use.

Keywords: spatial interpolation; TIN; synchronicity; regional climate change; urban island effect

EXPLORING BASIC FEATURES OF A CHANGING CLIMATE: ANALYSIS OF A LOW-ORDER MODEL'S PULLBACK ATTRACTORS

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A low-order quasigeostrophic model [1] subject to an aperiodic forcing is used as a prototype of an excitable dynamical system to explore basic features of a changing climate [2]. The study is carried out in the framework of non-autonomous deterministic dynamical systems by using an ensemble of simulations; it represents an extension of a previous modeling study with periodic forcing [3] and is based on the analysis of the system's pullback attractors (PBAs). PBAs are time-dependent invariant sets attracting all trajectories initialized in the remote past [4,5]; the existence of a global PBA is proven using the model's dissipativity.

The model has two regimes, as a function of forcing amplitude: (i) self-sustained relaxation oscillations at low forcing; and (ii) a more chaotic and excitable state, at higher forcing. We assess the convergence time of the trajectories to PBAs by evaluating the time-dependent probability density function (PDF) of the ensemble of trajectories $E(t)$. A sensitivity analysis with respect to forcing amplitude shows that the PBAs experience large modifications if the model is in its excitable state, while less dramatic changes occur in the self-sustained relaxation oscillation regime.

We study next the dependence of the attracting sets on the choice of the ensemble $E_0 = E(0)$ of initial states, and find that the statistics in a chaotic regime depends on the initial data chosen in the remote past. Chaotic basins of attraction are identified within which the statistics does not depend on the subset of initial states, but non-chaotic basins are identified as well. This complex scenario needs separate PDFs for chaotic and non-chaotic trajectories to be estimated. General implications concerning climate predictability are discussed. Finally, we present preliminary results obtained for stochastic forcing, while using the framework of random dynamical systems.

Keywords: Low-order climate models; pullback attractors; climate predictability

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TERRESTRIAL UPTAKE DUE TO COOLING RESPONSIBLE FOR LOW ATMOSPHERIC CO_2 DURING THE LITTLE ICE AGE

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Models of future carbon cycle-climate changes predict a large range in atmospheric CO_2, mainly because of uncertainties in the response of the land carbon cycle to the future temperature increase[1]. The Little Ice Age (LIA, 1500-1750 AD) CO_2 decrease is the most significant pre-industrial atmospheric change over the last millennia[2] and has been used to derive the climate sensitivity[3] of the global carbon cycle (γ). While a recent study confirms that pre-industrial CO_2 variations were caused by changes in land carbon stores[4], there are open questions about the size of the atmospheric LIA CO_2 decrease reconstructed from ice cores[5], and about what caused the land to sequester CO_2[6]. To quantify the size of the LIA CO_2 decrease, we have produced new CO_2 measurements from DML ice, that support the DSS LIA CO_2 decrease as a real atmospheric feature. To partition the contribution of ocean and land, we have measured the $\delta^{13}C$-CO_2, showing that the cause of the CO_2 drop was uptake by the terrestrial biosphere. To identify whether the land uptake was caused by temperature, or by a decline in farming due to pandemics, we have simulated the effect of a temperature perturbation on atmospheric Carbonyl Sulfide (COS). In agreement with the previously published positive COS anomaly[7], our results indicate that Global Primary Productivity (GPP) decreased during the LIA, ruling out the early anthropogenic land use change hypothesis[8,9] as the dominant cause of increased terrestrial carbon storage. This allows us to obtain a new, more coherent estimation of γ in the range -10/-60 Pg of C K^{-1}.

Keywords: Paleoclimate, Global Carbon Cycle, Anthropocene

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FROM REGIONAL TO LOCAL CLIMATE SCENARIO: THE EFFECTS OF A STATISTICAL BIAS CORRECTION ON DIFFERENT SPATIAL SCALE CLIMATE CHANGE SIGNAL

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This study investigates the effects of a quantile-mapping bias correction method [1] on two different spatial scale climate scenarios (regional and local). Particular attention is devoted to the “local experiment”, where the capability of providing valuable local climate information by the newest generation of regional climate models is assessed. Simulated temperature and precipitation Climate Change Signal CCS (difference of climatological statistics between future and reference period) was assessed before and after correction, focusing on discrepancies between original and bias-corrected results [2–4].

Regional experiment investigates quantile-mapping effects on expected 21st century CCS over Italy, identified as high climate-change sensitivity area [5]. Bias correction technique is applied on a six-RCMs ensemble (25 km horizontal resolution) climate projections run in the ENSEMBLES project [6]. Grid-cell-wise correction function is derived from E-OBS dataset, providing observed daily time series (1971-2000) spatially averaged on the same RCMs grid[7].

Secondly, the same bias correction method was applied to adjust and refine RCMs results towards local point-wise observations. In this configuration, bias correction method combines error correction with the downscaling of simulation to local scale. Here, climate projections are referred to Marche region (central Italy) and are extracted from higher resolution (12.5 km) three-RCMs (EURO-CORDEX project)[8] ensemble. Station-wise correction function is built employing 9 precipitation and 21 temperature observed time series provided by Marche region Civil Protection observational network. The regional-experiment results show moderate dampen of summer CCS from +4°C to +3.2/+3.5°C, especially on coastal areas and plain areas. Summer negative precipitation CCS resulted not affected by the correction.

Dichotomous positive (negative) northern-Italy (southern-Italy) winter precipitation CCS was preserved after correction.

In the local experiment, the effect on CCS varies for the two variables and from coastal and mountainous stations. Temperature signal showed a reduction (up to 1°C) over the right tail of the statistical distribution.

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THE ROLE OF HIGH FREQUENCY ATMOSPHERE-OCEAN INTERACTION IN MODULATING TROPICAL CYCLONE ACTIVITY

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The interaction between Tropical Cyclones (TCs) and ocean is a major mechanism responsible for energy exchange between the atmosphere and the ocean. The ocean is the source of energy for TCs and modulates their number and intensity. On the other hand TCs affect the thermal and dynamical structure of the ocean. The wind structure associated with TCs is responsible for two important atmosphere–ocean feedbacks [1]: the first feedback — positive — is driven by the latent heat associated with the enhanced evaporation rate and leads to an increase of the available energy for TC. The second feedback — negative — is due to the upwelling of cold water induced by the increased wind stress at the ocean surface and by the shear-induced mixing at the base of the mixed layer. This second feedback is responsible for a significant cooling of the sea surface, leading to a weakening of the cyclone intensity due to the reduction of the total heat flux into the atmosphere. Very few CMIP5 [2] models demonstrated ability in representing TCs, mainly due to their horizontal resolution. We aim to improve TCs representation in next CMIPs experiments through the new CMCC-CM2 fully Coupled General Circulation Model (CGCM), having a horizontal resolution of ¼ degree in both atmospheric and ocean components. The model is capable to represent realistically TCs up to Cat-5 Typhoons. We found that a good representation of the TC-Ocean interaction strongly depends on the coupling frequency between the atmospheric and the ocean components, especially when simulating intense TCs. A measure of the energy released in the atmosphere by TCs is the Power Dissipation Index - PDI [3]. We found a reduction of the PDI up to 35% (20% if normalized by TC count), when increasing the coupling frequency from 1 day (the typical CMIP5 CGCM coupling frequency) to 1.5 hours.

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HEAT EXTREMES IN THE MIDDLE EAST AND NORTH AFRICA (MENA) REGION IN THE PAST AND THE FUTURE

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Heat extremes in the MENA region can have large socioeconomic impacts. A newly developed statistical framework, based on extreme value theory has been used to study the characteristics of heat waves in the region during the period 1973-2010 using data from fifteen measurement stations across the region. Observations and model projections from CMIP5 show increasing heat extremes, expected to accelerate in the future using both scenarios RCP4.5 and RCP8.5. Uncertainties estimates using the robustness metric indicate a good agreement for temperature, but not for precipitation. Our results show increasing trends in the number of heat waves in the recent past, as well as a sharp increase in the number of warm days and nights in the future, with a maximum temperature during a heat wave reaching up to 50°C by the end of the century according to the RCP85 scenario.

Keywords: Heat extreme, Middle Eat and North Africa, projections

THE CONTRIBUTION OF THE GREENLAND ICE SHEET TO CURRENT AND FUTURE SEA LEVEL RISE: A SURFACE MASS BALANCE PERSPECTIVE

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The Greenland ice sheet plays a crucial role in contributing to current and projected sea level rise, through the combination of both surface and ice dynamics mass losses. The ongoing and projected effect of rising temperature over the Arctic can enhance surface melting and meltwater production, which, in turn, can contribute to sea level rise through direct runoff. Surface melting, however, is also crucial because it also impacts ice dynamics through its impact on the subglacial and englacial hydrological systems and on ice dynamics (e.g., ice velocity or calving).

In this talk, I present an overview of current ongoing activities carried out over the United States whose ultimate goal is to shed light on the complex and yet crucial suite of processes that drive mass loss in Greenland. Results from the state-of-the-art of modeling efforts, from recent fieldwork activities and from spaceborne and airborne missions are presented. Updates on the recently-ended 2015 melting season will be discussed in the context of long term (1958 – 2015) trends. I will also present and discuss projected contribution to sea level rise from Greenland under two greenhouse gas future scenarios in which levels of CO_2 equivalent are, respectively, 850 and > 1370 ppm by 2100. Feedback mechanisms, such as the “darkening” of the Greenland ice sheet due to albedo decrease and changes in accumulation, and their role on projected sea level rise will be also discussed. Recommendations on potential ways to improve estimates of sea level rise contribution from Greenland will close the presentation.

Keywords: Greenland, sea level rise, melting

FLUXES OF ENERGY AND GREENHOUSE GASES IN MEDITERRANEAN FOREST ECOSYSTEMS DESCRIBED BY THE SOIL-PLANT-ATMOSPHERE (SPA) MODEL

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Quantification of the ecosystem services provided by the urban and peri-urban vegetation is highly needed especially in densely populated Mediterranean areas. With the intent to calculate the capacity of plants to sequestrate pollutants and carbon dioxide from the atmosphere, we elaborated a multi-layer and dynamic model composed of six different modules:

1. A hydrological component to predict soil water content in soil in response to precipitation, structure of the soil and evapotranspiration. 2. a canopy environmental model to determine leaf temperature and the radiative transfers at different levels from above to the bottom of the canopy [1–3]. 3. A deposition model based on calculation of different resistances to gas diffusion such as atmospheric resistance, leaf boundary layer resistance, and canopy resistances [4]. 4. A photosynthesis model to estimate net photosynthesis and stomatal conductance [5–7]. 5. A Volatile Organic Compounds (VOC) canopy emission module [8]. 6. Carbon balance computation model based on species-specific allometric relationships to calculate above-ground and below-ground biomass [9,10].

We validated the model with fluxes of energy, water and trace gases measured using the Eddy Covariance technique in a Mediterranean Holm oak forest located in Castelporziano presidential Estate, a peri-urban forest near the coast of Tyrrhenian sea, 20 km from Rome downtown, Italy. Results show a good agreement between modelled and measured fluxes, highlighting potential application of the model to a broad range of forest Ecosystems.

Keywords: leaf energy balance, photosynthesis, VOC, urban vegetation

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TWENTY SEVEN YEARS OF ATMOSPHERIC CO_2 OBSERVATIONS AT PLATEAU ROSA STATION, ITALY

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Carbon dioxide (CO_2) is the primary greenhouse gas contributing to the enhanced greenhouse effect. Long-term observations of its atmospheric concentration represent an useful tool to evaluate the success of mitigation activities vs climate change. We present and discuss continuous long-term CO_2 observations carried out at the very high mountain background station Plateau Rosa (Code: PRS, 45.93°N, 7.71°E, 3480 m a.s.l., North Western Alps, Italy). The PRS station has collected atmospheric concentrations of CO_2 since 1989. The station is located at a typical elevation of the free atmosphere upon a large snow–clad bare mountain plateau and far from urban and polluted zones.

Owing to its high altitude and position, it is suitable for the background measurement of greenhouse gases. The PRS CO_2 dataset currently covers about 27 complete years: the last 22 years, from 1993 up to now, are related to continuous monitoring. The atmospheric CO_2 concentration, referring to the WMO X2007 international mole fraction scale, is measured by means of a continuous non–dispersive infrared analyzer (ULTRAMAT 5E and 6E) working, nowadays, in the 360–420 ppm ranges.

The historical series of the monthly CO_2 background concentrations was obtained by applying a filtering scheme, able to distinguish the background data from the data influenced by CO_2 sources and sinks. The algorithm identifies as background values only that data characterized by a slow variability. The growth rate is equal to 1.99 ± 0.04 ppm/year, and is comparable with the global trend (1.9 to 2.1 ppm/year) computed for the years 2002–2011 by IPCC and 2.02 ppm/year (for the last decade) reported in the WMO Greenhouse Gas Bulletin [1,2]. The diurnal and seasonal oscillations were obvious due to the result of the activities of the terrestrial biosphere. The average value of the peak-to-peak annual cycle amplitude is 10.4 ± 0.9 ppm.

Keywords: carbon dioxide, variation of CO_2, growth rate, filtering

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A STUDY OF WIND RESOURCE AND EXTREME WIND THROUGH MESOSCALE ATMOSPHERIC MODELING

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The effective expansion of wind energy requires an exhaustive understanding of the wind resource over large areas. To cope with this issue a possible approach is the use of mesoscale atmospheric models, to develop an accurate climatological study of the wind at medium-high spatial resolution.

Atmospheric models offer several advantages for wind resource assessment, such as the ability to simulate, with reasonable accuracy, complex wind flows in areas where surface measurements are inadequate or non-existent.

In this work we present some results of 30 years of numerical simulations with a state-of-the-art mesoscale model (RAMS – Regional Atmospheric Modeling System) operatively used by CNR-ISAC. Two grids of 10km resolution are adopted and the ERA-40 Reanalysis are used as boundary conditions; model's grids cover the Italian peninsula and the central Mediterranean Basin. It should be emphasized the computational effort needed to perform 30-year simulations at medium-high resolutions.

The main objective of this work is to study mean winds and extreme winds, as well as their variability throughout the years, using a mesoscale model.

Firstly, we have analysed wind speed (WSP) and wind direction (DIR) over the whole area and for the whole ERA-40 period. Identical analyses have been performed for 4 different directions sectors (0°-90°, 90°-180°, 180°-270°, 270°-360°).

Secondly, we have identified 30 "extreme wind" case studies, one for each year, in order to study the phenomenology associated with these events and the ability of the model to well simulate them.

Although a mesoscale model cannot substitute in-situ measurements because their low spatial and temporal resolution, it can provide useful information for the identification of the areas most affected by the development of particular

anemological regimes and extreme winds, especially in zones with poor wind measurements such as the offshore Mediterranean area.

Keywords: wind resource, extreme winds, mesoscale model, wind climatology

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PRELIMINARY RESULTS ABOUT OFFSHORE WIND CLIMATOLOGY USING SAR IN MEDITERRANEAN SEAS

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Satellite observations like Scatterometers e.g. QuickScat, and Synthetic Aperture Radars (SAR) of the ocean surface provide information about the spatial wind variability over large areas.

This is a special issue in the Mediterranean, where spatial information is not readily available because buoys or masts are sparse, with long periods of missing data, and measurements represent only one point.

We are investigating SAR images from mission ENVISAT, sensor Advanced Synthetic Aperture Radar (ASAR) acquired in Wide Swath Mode -WSM- in the Mediterranean starting 1 March 2002 to 8 April 2012.

SAR images, have the advantage of high spatial resolution (down to 100m) allowing to derive information close to the coast but the disadvantage of low time resolution causing lack of information on regimes with low time scale.

Climatological indices were analyzed for chosen sites: the monthly, annual and seasonal wind indices were calculated at each site from the SAR data. Estimating wind indices minimizes biases and makes it possible to compare the year-to-year variability or the seasonal cycle as observed by the different data sets, also when two time series have a different wind speed range [1], [2].

Keywords: offshore wind, satellite, SAR.

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SENSITIVITY OF SNOW MODELS TO THE TEMPORAL RESOLUTION OF METEOROLOGICAL FORCINGS

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Several factors influence the modeling of snowpack temporal evolution in complex orography areas: among the most important, the high spatial and temporal variability of the meteorological parameters and the uncertainty of the measurements.

In this study we have assessed the impact of the accuracy of the meteorological forcing on the snow simulations at a specific site, by investigating the sensitivity of selected snow models to the temporal and spatial characteristics of the input data. We have forced the snow models with (i) the high-frequency and high-quality meteorological observations carried out in the site of Torgnon, at 2160 m a.s.l. in the Italian Alps ; (ii) the same dataset as in (i) but at coarser temporal resolution; (iii) GLDAS retrieved data; and (iv) ERA-Interim reanalysis data, characterized by coarse spatial and temporal resolution. For this exercise we have used four models: (I) the University of TOrino land Process Interaction in Atmosphere (UTOPIA) single-layer snow scheme; (ii) the Hydrology-Tiled ECMWF Scheme for Surface Exchange over Land (HTESSEL); (iii) the Snow Multidata Mapping and Modeling (S3M); and (iv) GEOtop.

The results show that snow models reproduce with good accuracy the snowpack evolution, both in term of accumulation and melting, when they are forced by the high-resolution station data. The degradation of the quality of input data produce a growing degradation of the output. Despite this, the simulations performed using low spatial resolution datasets can be improved by correcting the temperature for the elevation difference between the study site and the model pixel. In general, temperature is found to be the key parameter to accurately reproduce the snow depth and the date of snow melt for this Alpine environment.

Keywords: snow modeling; Alps; energy balance; sensitivity; snowpack evolution.

RELATIONSHIPS BETWEEN CLIMATE CHANGE AND PERIGLACIAL ENVIRONMENT ATCOL D'OLEN SITE (NW ITALIAN ALPS)

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The high altitude areas are characterized by periglacial environment, very sensible to climate change [1, 2]. At Col d'Olen site, situated in NW Italian Alps, a pilot study started in rock glacier, which front is located at 2710 m a.s.l. The aim of this project is understand the impact of climate-ground parameters on alpine permafrost. For this reason, in the rock glacier surface, 70 iButton®dataloggers have been installed at 5/10 cm into the ground to monitor the ground temperature every three hours [3]. A preliminary download has been carried out at the end of August 2015, allowing to achieve a complete year of data (starting in July 2014). The dataset has been analyzed to individuate the potential distribution of permafrost and to know the temperature variations throughout the year.To know the climate of study area, the data of Col d'Olen meteorological station, located near to the Institute Mosso (2900 m, Long Term Ecological Research site), has been analyzed,together with those of five meteorological stations situated in neighbouring; the climatic indices of ETCCDMI [4] and the trends of principal climatic parameters (temperature, precipitations and snow) have been calculated for the six stations. To better analyze the climate of study area, in July 2014 a portable automatic weather station has been installed in front of the rock glacier to collect a more punctual climatic information, which will be extend the data of Col d'Olen meteorological station.Furthermore, the climate data of last year (2014-2015) of Col d'Olen station have been related to rock glacier ground temperature data to look for a correlation between atmosphere and cryosphere.

Keywords:climate change, temperatures, permafrost, rock glacier, Alps

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THE CONCENTRATION OF TROPOSPHERIC OZONE AND ITS RELATIONSHIPS WITH WEATHER TYPES IN NW ITALY

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In this work we have analyzed the hourly tropospheric ozone data of four cities located in NW Italy, in inland (Piemonte) and coastland (Liguria) regions, for the period 2003-2014. The main objectives have been to compare the inland-coastland ozone concentration and its relationship with atmospheric conditions defined by Weather Types. Ozone mean daily data have been calculated by an average of 24 h (00.00-23.59 h). Daily, weekly and seasonal cycles are been detected. Generally the maximum values are in daytime, in weekend and in summer months; the minimum in nighttime, in weekday and in winter months. They depend by NO_2 emissions and by solar radiation, which is responsible of photochemical interaction of NO_x and VOC_s [1, 2]. These cycles are opposite to NO_2, a well-recognized precursor of ozone, and are influenced by temperature, precipitations and wind. The trends on analyzed period are very variables, depending on inter-annual variability, surface solar radiation and anthropogenic emissions. To understand the relationships between ozone and Weather Types, we have employed the daily data of Sea Level Pressure from the NCEP/NCAR Reanalysis Project [3]. The WTs have been determined by these pressure data using geometrical and physical procedure [4] and following the classification of Lamb's WT catalog [5,6]. The most frequent WT is anticyclonic type (19%), followed by northeasterly (16%) and northerly (12%). The ozone concentration is correlated to weather types: the highest ozone values occur with northerly, northeasterly and easterly types; the lowest with westerly, southwesterly and cyclonic types. Since tropospheric ozone is a potent greenhouse gas [7] with high oxidation capacity and negative effects recognized for organisms, the relation between his concentration and weather pattern could potentially be adopted for enforcing pollution level alert protocols depending on forecast weather types.

Keywords: ozone, NW Italy, weather types, inland-coastland

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MAJOR MECHANISMS OF ATMOSPHERIC MOISTURE TRANSPORT AND THEIR ROLE IN PRECIPITATION EXTREME EVENTS IN THE AMAZONIA

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The transport of moisture from oceanic sources to the continents represents the atmospheric branch of the water cycle, forming the connection between evaporation from the ocean and precipitation over the continents. In this regard two large scale dynamical/meteorological structures appear to play a key role, namely Low Level Jet (LLJ) systems and Atmospheric Rivers (ARs). The former are particularly important in tropical and subtropical regions; the latter is mostly confined to extratropical regions. A key question relates to the anomalies in the transport of moisture observed during natural hazards related to extremes of precipitation (i.e., drought or wet spells). In this study we will be focused on these two major atmospheric moisture transport mechanisms (LLJs and ARs) and its role in precipitation extreme events (droughts and wet spells) in the Amazonia paying particular attention to i) intensification (decreasing) of moisture transport by them and its role in wet spells (droughts), and ii) changes in their positions and occurrence with associated flooding and wet spells.

Keywords: atmospheric moisture transport, droughts, wet spells, Amazonia

ANALYSIS OF EXTREME RAINFALL EVENTS IN THE METROPOLITAN AREA OF TURIN WITH WEATHER RADAR AND A DENSE RAIN GAUGES NETWORK

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The occurrence of extreme rainfall events, especially the ones of short duration, often causes extensive damages in densely populated regions; in flat urban areas, the most frequent hazardous phenomenon linked to brief and intense rainfall is the urban flooding, which is due to the inadequate capacity of urban sewage system to drain high amount of water in a short time [1]. Successful monitoring of extreme events and forecasting of urban floods requires accurate precipitation estimation because of the complex hydrologic characteristics of the urban environment. In order to do this estimation, we focused on the metropolitan area of Turin, finding the extreme events and their thresholds, obtaining a climatic characterization of the area [2] and identifying some case study. To thoroughly analyze these events we used both a C-band polarimetric Doppler weather radar and a dense network made by tens of tipping-bucket rain gauges, which are installed and operated by ARPA Piemonte (the regional agency for environmental protection) [3]. Thanks to this instrumentation, we have compared radar observations with ground measurements given by rain gauges during every single event. In order to reduce uncertainties, biases and errors between the two, we have applied on the radar data a common statistical reflectivity / rainfall rate (Z-R) relation [4], correcting it with the spatialization information obtained by the gauges with a very simple method that permits to reconstruct the rainfall field with a good accuracy. As we are interested in intense precipitation, the main objective of this study is to evaluate the performances of the radar with our adjustment technique that is able to reproduce properly observed maximum rainfall intensities on hourly basis.

Keywords: rain gauges, weather radar biases, rainfall field reconstruction, extreme events.

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PRELIMINARY ANALYSIS OF GREENHOUSE GASES AND ATMOSPHERIC AEROSOL OPTICAL PROPERTIES AT COASTAL SITE OF LAMEZIA TERME, IN CENTRAL MEDITERRANEAN AREA, USING DIFFERENT INSTRUMENTS AND METHODOLOGIES

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In order to establish strategies for the mitigation of global warming and influence of anthropic activities, continuously monitoring of particulate and greenhouse gases are required. Atmospheric aerosol particles together with greenhouse gases and short lived gases, according to the IPCC(2013), are playing a major role in climate change affecting the Earth's radiative balance: directly by absorbing and scattering of solar radiation and indirectly by supporting for cloud condensation. In the GAW Regional Coastal Observatory I-AMICA in Lamezia Terme (38.88 LAT 16.24 LON, 6m agl) in Calabrian Region, greenhouse gas (GHG), and areosol are daily monitored in order to collect and investigate natural and anthropic sources affecting climate. The equipment allow us to detect global and local events of different nature that influence short lived gases and aerosol presence in our area. In particular here we present some preliminary results of hourly and daily variation of several parameters [1]. The influence of meteorological parameters [2,3] on the aerosol scattering properties and greenhouses gases are also analyzed.

<u>Keywords</u>: Aerosol, Greenhouse gases, Short lived gases, Coastal site

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LOOKING FOR A CONNECTION BETWEEN OCEANIC REGIONS WITH TRENDS IN EVAPORATION WITH CONTINENTAL ONES WITH TRENDS IN PRECIPITATION THROUGH A LAGRANGIAN APPROACH

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One of the hot spots of climate change is the increment of ocean evaporation. The best estimation of evaporation, OAFlux data, shows an strong increasing trends in evaporation from the oceans since 1978, with peaks during the hemispheric winter and strongest along the paths of the global western boundary currents and any inner Seas. The transport of moisture from oceanic sources to the continents is the connection between evaporation from the ocean and precipitation over the continents. A key question is to try to relate evaporative source regions over the oceans where trends have occurred in the last decades with their sinks over the continents to check if there has been also any trends in the precipitation amount or its characteristics. A Lagrangian approach based on FLEXPART and ERA-interim data is used to establish this connection. The analyzed period was 1980 to 2012. Results show that there is not a general pattern but a significant agreement was found in important areas of climate interest.

Keywords: atmospheric moisture transport, oceanic evaporation, continental precipitation, Europe.

SYNOPTIC CONDITIONS LEADING TO POSITIVE AND NEGATIVE SEA LEVEL EXTREMES IN THE MEDITERRANEAN REGION

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This study is based on a 44 year long hindcast of storm surges in the Mediterranean region [1] and aims to analyze the association between sea level extremes and cyclones crossing the region.

It shows that in many stations along the coast of the Mediterranean Sea storminess and sea level extremes are associated .This link strictly depends on cyclone position and may consist of positive and negative anomalies in different part of the basin. Atlantic cyclones produce mainly positive surges in the western basin while positive/negative surges in the south eastern/north western basin are produced by cyclones generated in the western basin. Negative surges in the Mediterranean appear to be caused by a redistribution of water within the basin as during these events the Mediterranean Sea acts partially as a closed basin with the water flow across Gibraltar not sufficient to allow the sea level to adjust the inverse barometer effect. Due to this link between cyclones and sea level extremes it is therefore plausible that a future reduction of storminess in the Mediterranean Sea will determine a reduction of both positive and negative large sea level anomalies

Keywords: storm surges, cyclones, Mediterranean Region, barometer effect, density

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TERRESTRIAL UPTAKE DUE TO COOLING RESPONSIBLE FOR LOW ATMOSPHERIC CO_2 DURING THE LITTLE ICE AGE

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Models of future carbon cycle-climate changes predict a large range in atmospheric CO_2, mainly because of uncertainties in the response of the land carbon cycle to the future temperature increase[1]. The Little Ice Age (LIA, 1500-1750 AD) CO_2 decrease is the most significant pre-industrial atmospheric change over the last millennia[2] and has been used to derive the climate sensitivity[3] of the global carbon cycle (γ). While a recent study confirms that pre-industrial CO_2 variations were caused by changes in land carbon stores[4], there are open questions about the size of the atmospheric LIA CO_2 decrease reconstructed from ice cores[5], and about what caused the land to sequester CO_2[6]. To quantify the size of the LIA CO_2 decrease, we have produced new CO_2 measurements from DML ice, that support the DSS LIA CO_2 decrease as a real atmospheric feature. To partition the contribution of ocean and land, we have measured the $\delta^{13}C$-CO_2, showing that the cause of the CO_2 drop was uptake by the terrestrial biosphere. To identify whether the land uptake was caused by temperature, or by a decline in farming due to pandemics, we have simulated the effect of a temperature perturbation on atmospheric Carbonyl Sulfide (COS). In agreement with the previously published positive COS anomaly[7], our results indicate that Global Primary Productivity (GPP) decreased during the LIA, ruling out the early anthropogenic land use change hypothesis[8,9] as the dominant cause of increased terrestrial carbon storage. This allows us to obtain a new, more coherent estimation of γ in the range -10/-60 Pg of C K^{-1}.

Keywords: Paleoclimate, Global Carbon Cycle, Anthropocene

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PHOTOSYNTHETICALLY ACTIVE RADIATION IN THE MEDITERRANEAN: LONG-TERM MEASUREMENTS AND INTERANNUAL VARIABILITY

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Solar radiation impacts climate through different mechanisms. This study focusses on the determination of PAR, the Photosynthetically Active Radiation [1], and its variability in the Mediterranean. PAR, which is the solar irradiance between 400 and 700nm, is the fraction of solar radiation available for photosynthesis, the photochemical process leading to the absorption of CO_2 by vegetation. An accurate determination of PAR is needed to understand biogeochemical processes occurring on Earth, and the carbon cycle. The measurement of PAR is also necessary as input in several models. This study was conducted to obtain calibrated PAR measurements over extended time periods, as a basis for the understanding of the Mediterranean biogeochemical cycle and carbon cycle [2], and was applied to measurements made at the Station for Climate Observations on the island of Lampedusa (35.5°N,12.6°E; http:\\www.lampedusa.enea.it), in the central Mediterranean. The method is based on the combination of measurements made with PAR sensors and with Multifilter Rotating Shadowband Radiometers (MFRSR). The MFRSR is a passive instrument that measures global and diffuse components of the solar irradiance in six narrowband and one broadband channel [3].

MFRSR measurements at Lampedusa are continuously calibrated [4] on-site by using the Langley plot method. The MFRSR signals at the four bands falling within the PAR spectral interval were combined to infer the corresponding PAR. The coefficients of the linear combination of the bands were determined with the least squares method.

Different approaches, using three, two, or a single MFSRS band, were also tested Best statistical results were obtained by using the four MFRSR bands.

By applying this method we obtain, from the long-term MFRSR measurements, a continuous PAR dataset with an accuracy of about 5% over about 15 years. This dataset has been used to study the long-term behaviour and interannual variability of PAR in the central Mediterranean.

Keywords: PAR (Photosynthetically Active Radiation), MFRSR, climate, carbon cycle, Mediterranean

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SENSORS MEASURING RAINFALL: WHICH IS THE MOST ACCURATE?

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There is a concrete local demand of accurate precipitation measurements for the hydrological balances, the intense precipitation monitoring and the comparison with recently developed devices for precipitation detection. The World Meteorological Organization realized different campaigns of measurement on this topic, publishing the results from 1984 to 2008 [1] and identifying ground-level gauges as the devices less affected from wind induced biases. Our study focuses on two tipping bucket PMB2/R-CAE gauges installed at ground level and at two-meter height, in a pluviometric site operated by Arpa Piemonte and located nearby Carmagnola, Italy. The purpose of the paper is to highlight the wind induced losses and to determining the best instrument to detect the actual precipitation. We analyzed measures recorded every ten minutes and daily cumulated data within a period of 11 years, from 01/01/2004 to 01/01/2015. Comparing biases occurring between the two gauges and wind speed measured at the same time resolution, we found that the loss of precipitation by the aboveground gauge is larger when wind speed is higher. Furthermore the bias is much evident in case of snow or drizzle. This analysis confirmed WMO studies suggesting that pit gauges are the most accurate instrument to detect precipitation. A secondary hypothesis of the influence of the grid covering the pit gauge had also been considered. The grid could determine the observed bias because of the possible collection of precipitation over it, but laboratory observations are necessary to confirm it. Finally we compared the tipping bucket PMB2/R-CAE gauge with the optical FD12P weather sensor. The latter is resulted most reliable than the former for light precipitations, while it underestimates precipitations in case of high intensities. Using data from the two instruments we estimated a curve to obtain more realistic measurements.

Keywords: pit gauge, wind induced error, precipitation measurement uncertainty

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WATER, ENERGY AND FOOD NEXUS IN AGRICULTURE

THE WATER-FOOD-ENERGY NEXUS IN THE MEDITERRANEAN BASIN

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The Water-Energy-Food Nexus is a key topic in the 2030 sustainable development agenda, and it aims to tackle simultaneously different issues, such as food and water security, the connection between global warming and water scarcity, and between climate change and food production, as well as energy security, and the connection between energy production and water and land use [1]. Global projections indicate that demand for freshwater, energy and food will increase significantly over the next decades under the pressure of population growth, economic development, urbanization, technological changes, and climate change [2]. The Mediterranean region is one of the most vulnerable to climate change [3]. Some of the most important risks are: more frequent and intense droughts; more extreme storms and flooding; reduction of river flow, with subsequent loss of hydroelectric power and drinking water; worsening of water quality, especially in dry seasons; and loss and changes in agriculture productivity, with serious consequences on food security [4]. All the previously mentioned impacts are very likely to create pressure concerning the appropriation of limited water and food resources, the worsening of human health conditions, and to provoke migrations towards countries less affected by such events or better able to adapt to them [5]. At the Mediterranean level there are a few strategy initiatives that could be undertaken, such as risk assessment; resilient actions in the sectors of agriculture, coastal protection, tourism, public health, urban development, and the modernization of water and energy infrastructure systems [6]. Gas is still dominant, but renewable energies are gaining prominence in the energy plans of most Mediterranean countries [7]. Investments are growing driven by raising energy demand and by natural resources that are still underexplored [8]. In conclusion, there are no blueprint solutions, nevertheless a number of areas of opportunity for sustainably improving water, energy and food security exist and they will be assessed [9].

Keywords: Water-Energy-Food Nexus, Renewable Energy, Climate Change, Water Security, Food Security

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AEROBIC RICE TECHNOLOGY: STRATEGY OF FARMERS TO FIGHT IMPACTS OF CLIMATE CHANGE IN CAGAYAN VALLEY, PHILIPPINES

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The Philippines is experiencing the impacts of climate change that affected the agriculture sector of Northern Philippines to a great extent, particularly El Nino. As adaptation strategy, aerobic rice technology, the use of water saving rice varieties to abate impacts of climate change and increase production among rice farmers was introduced and adopted in Cagayan Valley, Philippines way back in 2009. This study aimed to determine the extent of aerobic rice technology application of farmer-adopters in the region. The study utilized survey interviews and farm documentations to 120 rice farmers. The data was analyzed using descriptive statistics generated through SPSS.

Majority (73%) of the farmers were males and their average age is 48 years old. More than half (59%) had an annual income of US$900 to $1,300. All respondents reached 80 percent attended farming-related trainings. Respondents' type of rice farm is flat (with scarce irrigation and rainfed) and their average farm size is 2.2 hectare (ha). Some (44%) of them sourced their water from water pump and the National Irrigation Administration and 48% sourced their farm inputs from own funds. Sources of information about ART were through researchers (41%) and Department of Agriculture extensionists (39%). Majority (34%) are new adopters and more than half (52%) of the respondents affirmed to continue planting aerobic rice varieties.

Adopters applied the technology on land preparation, seeding rate, fertilizer management, weed management and irrigation management. Most of the farmers grew aerobic rice varieties using organic fertilizer and saved water by 75%. By applying the technology, their average yield ranged from 3.5 to 5 tons per ha. The yield is comparable to high yielding rice varieties that require huge amount of water and other farm inputs. The technology is highly recommended for water scarce and rainfed areas.

Keywords: Aerobic Rice Cagayan Valley, Philippines

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GLOBAL FRESHWATER DEMAND FOR ELECTRICITY GENERATION TO 2100 UNDER LOW CARBON SCENARIOS

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Over the last century population growth and economic development have driven a significant increase in water demand, and water scarcity could affect in the future several areas of the world, due to socioeconomic development and climate change [1]. Energy and water are strongly interdependent, as water is required throughout the whole electricity generation process: in the extraction and refining of fuels, in the cleaning processes, and in the electric-power generation itself [2]. Water demand for energy production is rapidly increasing and taking a larger and larger share of global freshwater resources [3]. A further electric-sector expansion could intensify the inter-sectoral competition for freshwater [4] and a lack in water supply would negatively affect the power generation sector [5], which makes essential an integrated development of energy and water policies.

The present study aims to evaluate the water demand for electricity generation throughout the century, both at global and regional scale, and to analyse the impact that mitigation policies will have on the freshwater demand. Using WITCH, an integrated assessment model designed to assess climate change mitigation and adaptation policies [6], current and future freshwater withdrawal and consumption were estimated for 13 geopolitical regions. Water usage intensities and shares of cooling systems were associated to the energy technologies considered in the model, and the future trend for cooling systems shares was assumed according to literature estimates. Four scenarios of decarbonisation strategies have been designed in order to assess the influence of the electricity generation technology mix on water demand.

Results show a remarkable influence of the generation mix on water demand, with divergent impacts on withdrawal and consumption. The foreseen replacement of high water-intensive once through flow cool systems by wet cooling towers will reduce water withdrawal but will imply a higher water consumption due to evaporative losses. These results are in line with the recent literature [7,8].

Keywords: water use, water withdrawal, water consumption, integrated assessment, WITCH

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BIOGASDONERIGHT IN AGRICOLTURE: IMPLICATIONS FOR WATER SAVINGS AND MITIGATION OF EMISSIONS OF GRENHOUSE GASES

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In Italy, the overall sector of biogas counts about 1,500 plants and a total installed electricity of about 1100 MWel. Most of biogas plants in Italy are of agricultural biogas (about 1150 plants for 850 MWe). These figures allow Italy to be the second European producer after Germany and the third worldwide after China.

The introduction of a biogas plant in a cattle farm generates huge benefits both for environment and for the farm economic sustainability.

The management of animal manure is a important cost for farmers in order to respect nitrate directive [1]. With the introduction of a biogas plant, cattle farms can valorise manure to product renewable electricity, heat or biomethane. Moreover manure is stabilized and becomes digestate, an organic bio-fertilizer that is returned on soils and closes farm production cycle. This helps to decrease the risk of nitrogen pollution with respect to typical cattle farms that uses manure as amendments in soils without any treatment.

A study in Veneto region demonstrates how the biogas process determines an average reduction about 13,3% of total nitrogen that would be present in agricultural areas without treatment. This contributes to a reduction nitrogen concentration in aquifer with an improved soil fertility [2].

In terms of water-saving, thanks to the correct use of digestate, it is possible to increase soil fertility and organic matter content [3] [4]. This generates improvements in carbon sequestration, water retention capacity of soils and the water use efficiency by crops. i.e. when the liquid fraction of digestate is used in fertirrigation at 10% of water solution [4].

Consequently, biogas, especially if done according to the model of Biogasdoneright, can improve the efficient use of water, natural resources and mitigation of greenhouse gas emissions, and it can become a true technology of "BioEnergy with Carbon Capture and Storage (BECCS)", because it contributes to the closure of the carbon cycle in the soil, thus creating efficien, sustainable productive and "Carbon Negative" agriculture [3].

Keywords: biogas, animal manure, digestate, soil, nitrates.

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ECONOMY-WIDE ASSESSMENT OF CLIMATE CHANGE IMPACTS ON AGRICULTURE: PRELIMINARY ASSESSMENT BASED UPON AN ISI-MIP ENSEMBLE DATA

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The economic assessment of climate change impacts in agriculture is traditionally performed with two different but complementary perspectives [1]. While *partial equilibrium* or *bottom-up* approaches analyze in depth the characteristics of agriculture productive processes and agents' behavior, *general equilibrium* or *top-down* frameworks provide a comprehensive view of feedbacks into the whole economic system. For instance: food processing industry's reaction due to observed changes in crop yields prices; consumers' demand shifting to cheaper commodities due to changes in relative prices; increased competition for scarcer (and more expensive) primary factors [2].

In this paper, we present preliminary results of a computable general equilibrium (CGE) assessment of worldwidefuture climate change impacts on crop yields carried out by the recursive-dynamic Intertemporal Computable Equilibrium System(ICES) [3]. Developed within the ISI-MIP community[1], the analysis builds upon the outcome of six crop models – GEPIC, IMAGE, LPJ-GUESS, LPJml, pDSSAT, PEGASUS – based on the drivers provided by the HadGEM2-ES Earth System Model[2]. All models consider two different scenarios - with and without CO_2 fertilization effect - and four crop categories: maize, rice, soy and wheat.

India and Sub-Saharan Africa result the most negatively affected areas ([+0.49:-2.51] and [+0.19:-3.43%]the range of GDP loss in 2050, respectively). This is due to both the magnitude of physical impacts andthe share of agricultural value added in

[1] Inter-Sectoral Impact Model Intercomparison Project => https://www.pik-potsdam.de/research/climate-impacts-and-vulnerabilities/research/rd2-cross-cutting-activities/isi-mip/about

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national economies. There is a worldwide drop in production in all sectors, more significant for wheat and maize. The food processing industry (Vegetable Oils and Fats, Processed Rice and Other Food Industry) also follows the same pattern. Unsurprisingly, when CO_2fertilization is switched on, this implies a generalized upward shift in GDP and crops' outputs.

Keywords: CGE, crop yields, macro-economic, fertilization effect

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NATION-WIDE ASSESSMENT OF CLIMATE CHANGE IMPACTS ON CROPS IN THE PHILIPPINES AND PERU USING MOSAICC TOOL

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Agriculture is vulnerable to environmental changes, and climate change has been reported as one of the most devastating factors. In many developing countries, however, few studies have focused on nation-wide assessment of crop yield in the future, and hence there is a large pressure on science to provide policy makers with yield predictions for main crops in the countries.

For this purpose, we present the cases of the Philippines and Peru, where we have recently been working with MOSAICC tool (Modelling System for Agricultural Impacts of Climate Change) [1]. The final aim is to simulate the yield change of main crops in the future under a changing climate, and three steps are required to get the results. First we collected the historical meteorological data such as temperature and precipitation for about 30 years, and statistically downscaled future climate projections to the local scale. Second, we collected the historical crop yield and made regression functions to estimate the yield by using observed climatic data and water balance during the growing period for each crop. And third we estimated the yield change in the future by using the future climate data, produced by the first step, as an input to the yield regression functions. In our presentation we focus on second and third steps and present the results in each case, and discuss the implications for agriculture policies.

Keywords: Climate Change, Crop yield prediction, The Philippines, Peru

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MODELLING IRRIGATION PRACTICE FOR LONG-TERM GROUNDWATER SUSTAINABILITY

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The impact of climate change on groundwater resources can be investigated through models simulating the hydrological and hydrogeological processes at the atmosphere/surface water/soil/groundwater interfaces. However, in aquifers extensively exploited for irrigation purposes, the water demand variability related to actual water availability, as well as to variation of the crops, and associated supply management options should be considered to evaluate impacts Moreover, in the case of a multi-resources water supply system it is necessary to develop models able to simulate also the variation of the total demand distribution among each resource.

We propose a methodological framework merging four sub-models: (i) a distributed soil water mass balance model, to take into account land use and soil heterogeneity for assessing the recharge to the aquifer and the irrigation demand through the soil water content deficit; (ii) a stochastic Rainfall-runoff model to reproduce inflow to surface reservoir even in the frequent case of low instrumented basin; (iii) a surface reservoir lumped budget model that integrates simple management rules as well as irrigation and conveyance efficiency to reproduce surface storage volumes; (iv) a groundwater lumped budget model that considers recharge and exploitations varying in relation to water soil deficit and available surface water storage. The overall framework has been implemented for the case study of the Fortore water supply system (Apulia region, South Italy). It permits to simulate the conjunctive use of the water from the Occhito artificial reservoir (160 Mm3) and from groundwater to supply domestic, industrial and agricultural demand. The overall model successfully reproduces the Occhito dam level variability (both seasonal and inter-annual) as well as the observed groundwater depletion. Finally, the hindacst simulation has been compared to an implementation (PROTHEUS) of an IPCC scenario (a1b) to illustrate impact of climate on the different terms of the groundwater budget.

Keywords: Climate change; Groundwater; Irrigation; Impact study.

ADAPTING TO CLIMATE CHANGE: MOSES, A NEW TOOL FOR IRRIGATION WATER MANAGEMENT

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The main objective of MOSES (Horizon 2020 innovation action, 2015-2018) is to put in place and demonstrate at the real scale of application an information system to support irrigation water management by facilitating planning of irrigation water allocation and operation of irrigation systems. MOSES is expected to help saving water by improving services to farmers and reducing water and energy costs, while maintaining current yields, i.e. by improving water productivity. To achieve these goals, the MOSES project combines in an innovative and integrated platform a wide range of data and technological resources: EO data, probabilistic seasonal forecasting and numerical weather prediction, crop water requirement and irrigation modelling, an INSPIRE-compliant WebGIS Decision Support System, allowing access to users depending on their needs. Spatial scales of services and information products range from river basin to farmers. Main system components are: early-season irrigated crop mapping, seasonal weather forecasting and downscaling, in-season monitoring of crop water requirements, seasonal and medium/short term irrigation forecasting. Four Demonstration Areas (DAs) are foreseen in Italy, Spain, Romania and Morocco. Different water supply and distribution scenarios are being constructed by collecting data and user needs through existing local water management actors, thus contributing to service definition. Demonstrative and training sessions are foreseen for service exploitation in the DAs. The MOSES system is targeting EIP on Water "thematic priorities" related to increasing agriculture water productivity, water resource monitoring and flood and drought risk management. The project is led by Esri Italia (SME) and addresses collective and individual actors in irrigated agriculture. The integrated and innovative water management solution under development is based on previous works by 15 partners such as Arpa (seasonal forecasting of irrigation needs [1]), CER (irrigation advice service to farmers), Albacete and Delft universities (remote sensing to assess and monitor crop water requirements and irrigation performance [2,3]).

Keywords: drought, floods, seasonal predictions, remote sensing, GIS

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ANALYSIS OF EXPOSURE AND VULNERABILITY OF AGRICULTURAL AREAS TO CLIMATIC RISK IN ITALY

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The agricultural sector is particularly vulnerable to climate change impacts, therefore in order to design the best solutions in terms of adaptation, it is crucial to improve the scientific knowledge about the exposure and vulnerability of the agricultural areas to climatic risk, as defined by IPCC [1]. The Italian agricultural production is characterized by a strong heterogeneity and complexity of environmental and climatic variables, consequently the risk assessment and the analysis of the impacts of adverse extreme weather events should be done at territorial level and with more scientific and innovative approach [2]. For these reasons, the study focuses on the analysis of the extreme events on Italian agricultural areas, through GIS elaborations of the Ministry of Agricultural Food and Forestry Policies official data on natural disasters in agriculture [3]. The research produced a geo-spatial database at NUT 3 level of natural disasters data and the first results refer to the period 2003-2012. The exposure is based on indicators of occurrence and frequency of each kind of adverse event (such as frost, hail, heavy and prolonged rain leading to flooding, drought, high temperature, etc.), while the vulnerability is esteemed through the economic damages caused by the events as officially declared. The data analysis shows a general high exposure of the areas to drought and heavy rain events in terms of days per year, and a huge amount of damages to agricultural production, structures and infrastructures (average more than 1.4 billion euros per year). The distribution is heterogeneous in time and space and the vulnerability depends also on different agricultural structural and productive characteristics. The results highlight a strong demand of climatic risk analysis in agriculture, in order to define more adequate interventions on climatic risk and adaptation solutions.

Keywords: agriculture, vulnerability, climatic risk, extreme events

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THE NEW URGENCY FOR AGRICULTURE: TO BE "CLIMATE SMART"

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A growing concern has been arising in the last few years in the international community on the need of agriculture to strictly cope with climate change and variability, as confirmed by the large recognition of the Climate Smart Agricolture Alliance, promoted by FAO and GFAR . Needs to produce more food for a growing population concur with increased needs to reduce vulnerability and enhance resilience. At the same time, mitigation issues should be promoted, and less impacts on GHG emissions should be looked for, mostly for heavly managed crops. Several technologies and tools are available from science, ranging from agrometeorological-based models, support systems and tools, to technologies that may promote sustainability and produce a climate impact. Farmer knowldege, consciousness and attitude should however be promoted with a systemic approach, as support policies should be exploited and put in action by makers and decisors. This presentation refers on some contribution to such actions, as the one from the CSA Booster of Climate Kic.

INCREMENTAL WATER CHARGING IN AGRICULTURE. A CASE STUDY FOR REGIONE EMILIA ROMAGNA IN ITALY

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This paper explores the role that incremental water charging (temporary levies on water use) can play in preventing the environmental costs that arise during drought events [1] [2]. Incremental charges have been already advanced in some regions in Mediterranean climate zones, where growing water demand meets an uncertain climate, with increasingly frequent and intense droughts. Nonetheless, literature on irrigation water charging mostly focuses on structural (i.e. long term) charges, with little to none research devoted to incremental charges (short term).

The paper combines a bottom-up micro-economic approach with a top-down macro-economic tool. The bottom-up Revealed Preference Model (RPM) calibrated at a local level (Agricultural District) and the top-down regionally-calibrated Computable General Equilibrium model (CGE) model are linked to estimate the impacts of incremental water charging on water use, water withdrawals and market income. The methodology is applied to the particular case of Regione Emilia Romagna in Italy.

Our simulation results confirm that incremental charges are an effective instrument to enhance water conservation during drought events in Emilia Romagna. The RPM model suggests that this policy contributes to this goal up to incremental charges of 55 Eurocents/m3. Above this limit, additional water charges would compromise the integrity of ligneous crops and affect the yields of the most productive crops, and water use becomes inelastic.

Finally, results using the CGE model indicate that not only the economy-wide market costs of water charging are higher than the local impacts, but that the gap between them grows as water charges increase. Policy makers must be aware of these caveats to avoid incurring in imbalanced trade-offs that compromise the potentialities of incremental charging as an environmental policy.

Keywords: Water conservation, Mathematical programming, CGE

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MULTI-PURPOSE FUNCTIONING OF PEDRA 'E OTHONI RESERVOIR, SARDINIA, FOR ENERGY PRODUCTION, AGRICULTURAL AND URBAN DEMAND UNDER CLIMATE CHANGE

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Water storage reservoirs play an important role in securing supply during periods of peak water demand and scarce resources. However, irregularities and uncertainties in the fluvial regime, largely attributed to climate change together with the increase in the demand for water are affecting the capacity of many reservoirs to fulfil water demands, while withstanding effects of climate change. Reservoirs supporting islands such as Sardinia, characterized by scarce water resources and by an economy largely depending on summer tourism and agriculture are particularly vulnerable to changes in climate, population and socio-economic activities.

A system dynamic model approach was used to assess the resilience of “Pedra 'e Othoni” reservoir (Sardinia, Italy) under different climate and socio-economic scenarios. The reservoir water balance model was first calibrated and validated against three years of measured flow data than forced with extensive ensemble climate data for representative concentration pathways (RCPs) 4.5 and 8.5, agricultural land use and with four socio-economic development scenarios. For all scenarios, future projections show a reduction in the annual reservoir inflow and increase in water demand, mainly for agriculture. This will raise the potential conflict for the diminishing water supply for hydropower and crop production.

Regardless of these changes, Pedra 'e Othoni presented a high withstanding capacity to future changes resulting from the relatively large size of the basin supplying the reservoir. As a matter of fact, the reservoir was initially built for flood control and hydropower which is not the case for all Sardinian reservoirs. A detailed resilience assessment of all reservoirs is needed where development plans should carefully account for the trade-offs and potential conflicts among water demanding sectors. For Sardinia, the option of a physical connection between reservoirs is possible as well as alternative water supply measures. Those reservoirs at risk under future scenarios should be identified, and mitigating measures investigated.

Keywords: hydropower; irrigation; tourism, water allocation; system dynamics;

SOLAR PUMPING SYSTEMS FOR SMALL-SCALE AGRICULTURAL GROUNDWATER WATER SUPPLY: A PROPOSAL OF APPLICATION IN A INDIAN VILLAGE

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Energy and water are two key elements in agriculture and their management is crucial for small-scale farming activities. The provision of these two resources, is important to sustain farmers work even in critical conditions. This is the case of India, that since 2008 is facing two major climate and financial[1] crisis which effects reflects into small-farmers poor economical conditions. Difficulties in the electricity supply and to the shortage of water worsen farmers' situation, leading several of them to even commit suicide[2].

In January 2010, India's Ministry of New and Renewable Energy (MNRE) announced the deployment of 2 GW of off-grid solar by 2022[3]. Hence, small-scale irrigation by for off-grid solar power represent an opportunistic but sustainable and appropriate solution to cope with the lacking access to water and energy by farmers. Solar radiation tends to be at its most intense when the need for pumped water is greatest and the energy supply is available at the point of use, making the farmer independent of fuel supplies or electrical transmission lines [4].

This work propose a study on a solar pumping system (SPSs) to improve water provision in Katgaon, a rural village of 7,800 individuals of the district of Osmanabad, Maharastra India. Currently, the water needs of the village are mainly satisfied taking groundwater by the 20 hand pumps distributed across the village. SPSs will be proposed instead of the hand pumps: they are composed by a solar module, a water pump, a storage system, and a pipeline three-staged phytodepuration plant. The technical details of the SPSs will be exposed, together with community cooperative strategies to allow the village to manage them on long term. Finally the impact, the strengths and the limitations of the use of SPS to enhance food security and sustainable agriculture , will be discussed.

Keywords: solar energy, water, agriculture, India, sustainability

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PROJECTION OFCLIMATE CHANGE IMPACTS ON HYDROLOGICAL REGIMES FOR AGRICULTURE ADAPTATION PLANNING

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Climate change will alter hydrological cycles globally, regionally, and at basin scales. The Philippines and Peru are two of the most vulnerable countries in the world to extreme weather events and climate change. Agricultural productions are highly dependent on river water resources and it is imperative to understand differentiated impacts of climate change among basins within a country for better national and provincial adaptation planning. 24 and 16 river basins located in the two countries were assessed in order to understand the potential impact of climate change on future hydrological regimes and water resources using the MOSAICC[1] integrated climate change impact assessment tool. The STREAM (Spatial Tools for River basins and Environment and Analysis of Management options) model was calibrated with historical interpolated climate data. The calibrated model was then used to assess future river flows derived under projected climate from three global climate models and two greenhouse gas emission scenarios, which were compared with baseline scenarios of the 20th century to derive robust climate change signals in river discharge changes. Results predict a general increase in water availability for most parts of both countries, but changes in peak and base flows highlight the needs for improved water and agriculture management against flooding risks. In some basins seasonal shifts in river flows are predicted.

The hydrological assessments were conducted as part of multi-disciplinary assessments of climate impacts on agriculture and food security. Combining assessments of hydrology, climate, crops and economy together, policy implications for adaptation planning will be explored.

Keywords: River flow, The Philippines, Peru, agriculture, impacts

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WATER ENERGY-FOOD-NEXUS FOR MEDITERRANEAN COUNTRIES: AN OPTIMIZATION PERSPECTIVE

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Water demand for food has been growing in the last decades due to improving economic conditions particularly in BRICS countries; the role of agriculture is vital for socio-economic conditions in the Mediterranean region providing food products also for Europe. This correspond to an increasing energy consumption on one hand and increasing pressure on water resources due to agricultural practices.

Desirable patterns of economic growth rely on a balanced exploitation of natural resources and development of new and traditional ways for energy production, which have to be evaluated as a truly integrated process to support the sustainable water and energy solutions accounting for socio-economic-environmental (SEE) factors. A conceptual model has been defined based on a three-dimensional metric to compare alternatives, and, therefore to explicitly addresses the technical, economic and socio-political barriers hampering the implementation of solutions, involving both the on-farm strategic planning, and regulation activity aiming at the societal acceptance of the foreseen technological innovations.

The model aims to evaluate the non-conventional water as an option to reduce the impacts of farming activities; to deepen the knowledge about the role of renewable energy costs in influencing farmers' decision; to support the socio-economic development of rural areas by improving the implementation of innovative energy saving solutions; to improve the integration between water and energy saving in irrigation management activities; to foster climate change mitigation and adaptation policies according to EU measures.

The paradigm that once water saving in agriculture is achieved, so energy costs of irrigation should be minimized will be successful only when the influence of social and environmental factors are properly considered. The proposed model has been built to evaluate the reliability and feasibility of new policies for obtaining sustainable conditions in resource exploitation by integrating the energy-food-nexus in the decision-making.

Keywords: water-energy-food nexus, DSS, not conventional water, renewable energy

ENHANCING EARLY WARNING SYSTEMS WITH WEB MOBILE PHONE APPLICATION

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In the last decades floods caused severe damages in terms of human hurts and had severe economic consequences causing inundation of agricultural areas, landslides and damages to infrastructures. The possibility to protect the territory from flood events is offered by non-structural flood protection strategies. Among the other methodologies, the rainfall threshold specifies the precipitation accumulated over a specific duration that exceeds the bankfull depth in a specific river cross-section. When the amount of observed rainfall exceeds the forecasted rainfall threshold value, the flood alarm is issued. Moreover, the application of spatial and geo-spatial data enhanced rainfall monitoring and forecasting which resulted in an improvement of early warning systems. Indeed, weather radar data provide fine space-time resolution rainfall, useful for hazard nowcasting and flood forecasting.

This work highlights the use of web mobile phone for early warning systems. Web mobile phone network can be applied to inform population about the occurrence and intensity of rainfall events and about the corresponding flooding. When the observed (or forecasted) cumulated rainfall reaches the critical threshold value, the alert is given through web mobile phone network. Depending on the intensity of the rainfall event, the corresponding actions of damage prevention can be undertaken (e.g. protect agricultural areas and safeguard livestock and agricultural tools). The widespread usage of web mobile phone and the low cost of the approach makes the project applicable also in developing countries.

Keywords: floods, early warning systems, rainfall threshold, weather radar, web mobile phone

A CROSS-READING OF OFFICIAL STATISTICS PRODUCTION TO IMPROVE THE ANALYSIS OF CLIMATE CHANGE RELATED PHENOMENA

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In the last decades the increasing interest on impacts and adaptation options of Climate Change (CC) has led to a growing demand of statistics. As a multidisciplinary approach is needed for improving CC effects analysis, the information required crosses a wide range of interlinked domains (hydro-meteorological, environmental, agricultural, economic and social). Referenced statistical frameworks have been developed within several international initiatives to structure the overwhelming amount of the information produced and to make them useful for CC analysis. Two main statistical frameworks such as the Framework for the Development of Environment Statistics (FDES 2013) and the System of Environmental-Economic Accounting (SEEA 2012), based on a multi-purpose conceptual and statistical approach developed in the UNECE context, can be used as primary sources to define an internationally comparable set of key CCrelated statistics (CCRS). Furthermore an UNECE taskforce is working to enhance the role of National Statistical Offices in the development of statistics on CCRS. In this presentation we'll illustrate the main projects carried out by Istat within this context. Since several years Istat is strengthening a significant contribution both to the development of the statistical frameworks mentioned, by building and implementing harmonized methods and definitions, and to the production of official statistics suitable to meet the increasing information demand on environment and CC related issues. In particular we'll focus on methodological improvements about Weather and Climate, Water resources, Water account and Agriculture. Such innovations have been addressed to enhance the availability of new relevant data necessary for the analysis of CC related phenomena. Moreover, our study highlights the need to strengthen the collection and use of administrative data, the cooperation among all institutions of National Statistical System involved, in order to exploit the existing

information assets and to develop new statistics consistent with the current international frameworks.

Keywords: Water resources, Official Statistics, National Statistical System, Methodological improvements

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NEW PERRENNIAL GRAINS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

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The creation of new Perennial Grain Crops is emerging as an effective strategy for climate change adaptation and mitigation with parallel benefits in terms of maintenance of biodiversity and reduction of soil degradation [1,2].

The environmental benefits of the paradigm shift from annual to perennial crops is mainly related to the wider and deeper root development of perennial crops that has the potential to: i) increase soil organic matter via the enhanced below ground biomass and the improved soil structure, ii) diminish soil erosion, water and nutrients leaching and the related pollution and iii) decrease the frequency of tillage and therefore of fossil fuels consumption.

Despite those advantages significant uncertainties and challenges remain, however, related to the increase of perennial crop yields [3], and on the way to mainstream perennial crops into common farming practices and market systems. This calls for further research to be made to test the performance and applicability of perennial crops in different agro-ecosystems.

This work reports the preliminary results of a field experiment in central Italy where four perennial wheat strains are compared to annual common wheat varieties to assess their performance in terms of above and below ground biomass, quantity and quality of grain productions.

Keywords: perennial grains, mitigation, adaptation

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RESERVOIRS PERFORMANCES UNDER CLIMATE AND DEMAND VARIABILITY. A CASE STUDY

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Water resources system management is a very complicated task and when dealing with non-stationarity, it becomes even more challenging. As an example, the climate variability, on which, during the last few decades, many researchers have focused their efforts, can indeed seriously compromise the operation of any hydraulic infrastructure. When such infrastructures are built to make water resources available to human consumption, more reliable estimates would only come if the water demand and its dynamic are further taken into account [1,2].

A case study, the Piano della Rocca dam (Southern Italy) is here discussed, in order to quantify the system performances under variable forcing conditions. In a first step, different climate scenarios have been stochastically generated according to the tendencies in precipitation and air temperature observed during the last decades for the studied area [3,4]. Runoff has been simulated from the upstream hydrological system and controlled release has been computed considering the reservoir is operated following the standard linear operating policy (SLOP). Reservoir performances have been assessed through the calculation of reliability, resilience and vulnerability indices [5], comparing current and future scenarios of climate variability [6]. In a second step, the variability of the water demand has also been considered. With specific reference to the agricultural consumption, water demand has been modelled by a binomial distribution, and climate variability has been propagated through the system to study ranges of parameters for the demand distribution. The effects on the distribution network planning have also been considered, as an increase in the peak discharge appears to be associated to future climate scenario.

Keywords: reservoir; drought mitigation; climate variability; water demand variability

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FOREST WOODY BIOMASS, CLIMATE CHANGE MITIGATION ACTIONS AND RURAL DEVELOPMENT

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In the Agenda for Sustainable Development [1] the Goal 15 aims to “Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss”

The Europe 2020 strategy objectives [2] represent a clear policy path for sustainable growth within the priority initiative "Resource Efficient Europe" [3] and outline a long-term path on the efficient use of natural resources. In the forest sector this results in the use of available resources to avoid impacts on the ecosystem services, biodiversity and climate, giving priority to the forest products in order to create added value both socially and environmentally.

In this study we present ISPRA results on the development of integrated strategies for the sustainable use of forest biomass as a renewable energy source. These actions aim at improving forest management systems, recovering the potential of forest biomass and developing new opportunities for better governance of renewable energy use and promotion in Italy.

One of the main results is the evaluation of the bioenergy potential of forest and out of forest in the Lazio region [4].

This assessment could be used to develop a method for estimating the biological and socio-economic amount of forest and out-of-forest biomass that can be capitalized in a sustainable way (within the limits of natural renewability of the resource) for energy purposes on a national level.

We also present an assessment of the CO_2 balance in a short rotation forestry plantation and its impact on GHG emissions, by applying the CO2FIX model [5].

Finally we underline the importance of the "cascade use" approach to the valorization of wood products, in accordance to the EU Forest Strategy [6].

Keywords: forest, short rotation forestry, biomass, bioenergy potential, cascade use

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PRESENT AND NEAR FUTURE CLIMATE CHANGE ON RICE CROP YIELD IN CASAMANCE (SENEGAL)

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The fifth Inter-governmental Panel on Climate Change (IPCC) assessment report [1] declared the African continent to be among the regions most vulnerable to climate change. The food security of Sahelian countries is dependent on the rainfed agricultural production. Casamance Region is located in the south of Senegal and it is characterized by traditional lowland rice crops cultivation. The season length is about 120-140 days with a precipitation amount that normally exceed the 1000mm per year. In these conditions it is possible to cultivate all the most important rainfed cereals such as millet, sorghum, maize, rice and some horticultural species. In recent years the sociopolitical instability of the region has delayed the development process. Nowadays the Senegal policies want to promote rice crops in this region to fill this gap and promote a food self-sufficiency of the country. Despite the high potentialities of the region, climate changes pose a threat to agriculture production.

In this study, conducted in the PAPSEN project framework, we focus the attention on the changes in the rainfall distribution in the most vulnerable stages of the rice growth and in the analysis of the changes in the evolution of the rainy season. These two are considered as the indicators that best describe the impact of climate variability on the rice yield [2].

We propose the analysis of recent trends and variability in such indices based Moreover we use a probabilistic approach to evaluate de risk of recurrence of critical conditions. The main findings of this work seem to predict a slightly humid conditions and the increase of season length that could benefit rice crop in Casamance. Nevertheless, the incertitude of distribution of rainfall in the next years, as evidenced by the IPCC report for West Africa, and the rising temperatures pose new constraints to cereal production.

Keywords: Climate change, Lowland rice crop, Senegal, Casamance, Rainfall estimation

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MICROMETEOROLOGICAL CONDITIONS OF VINEYARDS IN PIEMONTE REGION

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Viticulture in Italy is one of the economically most important agricultural sectors. Recent research allows eco-physiological and biophysical models to develop tools able to provide support to the crop management, in terms of optimizing production performance and limiting environmental impacts. The ability to check on a daily basis the activities of vegetative and productive phases of vines is certainly a fundamental tool for the vineyard organization and management, and for linking the trends of growth and productivity with the quality of the final product: the wine. In order to investigate vineyard microclimate and subsequently modeling the eco-physiological behavior of the vines, an experimental campaign has been carried out during the 2008, 2009 and 2010 vegetative seasons in three Piedmontese vineyards, where conventional measurements with 10 minutes acquisition rate, above and within the vines, and turbulence data with high acquisition rates (> 10Hz) have been performed. The database was filled also using the measurements recorded in several neighboring stations belonging to RAM and ARPA Piemonte meteorological networks. These measurements allowed the characterization of the physical, hydrological and physiological processes occurring during the vegetative and productive behavior of the vines. Contemporary, we evaluated also a biophisical modeling approach using the land surface scheme UTOPIA (University of TOrino land Process Interaction in Atmosphere). The aim of using such model is to understand if (and if yes, how precisely) it is possible to get such kind of information for all vineyards (and, in general, agricultural fields) in which such kind of invasive and expensive monitoring cannot be performed. Future application may also allow to determine the climate of vineyards or other cultivations. In this presentation, some experimental data and model outputs will be shown and discussed. One of the important aspects examined is the sensitivity of results to initial parameters and to boundary conditions.

Keywords: vineyards, microclimate, micrometeorology, temperature, radiation

GRAPEVINE WATER STATUS ESTIMATION USING THERMAL AND DIGITAL IMAGES FROM PROXIMAL SENSING APPROACH

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Vineyards are largely located in semi-arid areas, such as Mediterranean regions, where water deficit and high temperatures determine a drought season whose intensity largely affect the final yield and quality of production [1] [2] [3]. Therefore, efficiency of water use in vineyard management, and robust techniques to accurately detect plant water stress are necessary. Infrared thermography has been used as a non-invasive methodology for assessing grapevine water status, and as a tool supporting irrigation scheduling [4] [5]. Moreover, proximal sensing techniques based on digital images can be a valuable tool for detecting crop canopy spectral characteristics and for evaluating crop physiological status (RGBs indices) [6].

In this study, thermal and visible images of three varieties of grapevine, under two deficit irrigation regimes, were acquired during the maturation phase using a InfRec R500Pro thermal camera (Nippon Avionics Co., Ltd.). Moreover, digital images of the same plants were acquired daily, using a Campbell CC5MPx digital camera. Thermal and complementary visible images of the crop canopy were taken in four sampling days, between 10.00 and 11.00 a.m. hours. An artificial wet surface, made of cotton cloth, was used to estimate the reference wet temperature. The reference dry temperature was estimated using a black aluminum surface. Temperature values of each pixel were calculated and then converted into average values. Crop water stress index (CWSI) values were then obtained. The preliminary results showed that the low-frequency deficit irrigation treatment resulted in higher temperatures in the vegetation compared to the high-frequency deficit irrigation regime. These results were also confirmed by the seasonal pattern of both green and red chromatic indices.

Keywords: proximal sensing, infrared thermography, CWSI, image processing, grapevine

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OBSERVED AND EXPECTED SHIFT IN CLIMATIC AND BIO-CLIMATIC INDICES IN AN ALPINE REGION

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Climate change over a region can be quantitatively assessed by climate classifications and by climatic and bioclimatic indices. The Alpine region has experienced an important temperature increase in the last decades, which in some cases has shifted the main classification indices. In this work, Köppen - Geiger climate classification, aridity indices, and bioclimatic indices were calculated by the R-library “ClimClass” [1] to assess the change in an Italian Alpine region (Trentino). The same indices have been calculated for two future 30-year periods according to two IPCC scenarios (RCP 4.5 and RCP 8.5). The results show that the change affected - or is going to affect - climate sub-classes and aridity indices in a number of sites, in some cases pushing areas out of the “humid” climate macro-category. Global results [2] showed comparable results. Bioclimatic indices, particularly used in viticulture [3], show that vine-growing districts have a potential increase in more elevated areas in the region.

Keywords: climate classification, climate change, climatic indices, bioclimatic indices

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CLIMATE CHANGE IMPACTS ON WHEAT AND MAIZE IN EURO-MEDITERRANEAN AREA

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The consequences of climate change could be important for the agricultural sector, especially for crop development and yield. The Euro-Mediterranean agriculture in particular could suffer significant impacts due to climate change in the coming decades. However, the simulated effects vary depending on crop types and climate model/projections. The CSM-CERES-Wheat and CSM-CERES-Maize crop models implemented in DSSAT-CSM [1; 2] were used to assess the climate change impacts on phenology and yield of main cereals over the Euro-Mediterranean. This study was carried out using cultivar coefficients of the most representative varieties of durum wheat, common wheat and maize [3]. A spatially-explicit platform [4] and future climate projections, dynamically downscaled at high-resolution, were used considering two RCP scenarios. Responses of crops to climate change diverge spatially. A possible increase in yield for wheat was estimated in North-Eastern Europe and a significant reduction of yield is projected at southern latitudes (especially in North Africa). The maize yield varies with latitude (increase in northern Europe and decrease in southern areas). The main changes in yield were assessed for RCP8.5 scenario, especially for durum wheat and maize in 2080. However, a greater number of climate model simulations with higher resolution could enable to obtain more reliable results, emphasizing more precisely subsequent applications with crop modelling, mostly aiming at assessment of adaptation and mitigation strategies.

Keywords: Yield, DSSAT-CSM, CERES, spatial scale, crop modeling

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A MODELLING APPROACH TO ANALYZE THE OCCURRENCE OF GRAPEVINE PHENOLOGICAL STAGES UNDER CLIMATE CHANGE SCENARIOS

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Different studies estimating the impact of climate change on vineyards have shown that temperature plays an important role in the grapevine life cycle, especially by modifying the occurrence of phenological stages, with consequences on plant productivity. Several phenological models have been developed to simulate the grapevine growing cycle. This study aimed to evaluate the performances of some of these models in reproducing the phenology of grapevine and to estimate the impact of climate change on grape phenology in Italy.

We tested six different phenological models implemented in the Phenological Modelling Platform (PMP) for several of the most common wine grape cultivars. The phenological models tested were: three growing degree day models (GDD), with basal temperature of4°C (GDD4), 7°C (GDD7) and 10°C (GGD10), respectively; and two modifications of the Wang and Engel model by using a minimum temperature of 0°C and a maximum temperature of 40°C (Wang040), and with 7°C as minimum temperature and 35°C as maximum (Wang735). We adopted the cross-validation method to fit the available data, the most performing phenological model was then selected according to the minimum RMSE (Root Mean Square Error) and the maximum Model Efficiency (EF) for each variety. Such model was then linked with future climate projections to simulate phenological stages under climate change conditions. Climate data were derived from COSMO-CLM Regional Climate model (14 km of resolutions)for the historical period (1976-2005) and for future scenarios (2006-2035;2036-2065;2066-2095)according to RCP 4.5 and 8.5.The best representation of the phenology was obtained with the GDD,Wang735 and Wang040models. A shift in the phenological phases was observed in the diverse scenarios, with a different entity depending on the cultivar and the geographical area analysed.

Keywords: grape, phenology, climate change, Mediterranean area

CLIMATE CHANGE AND WHEAT YIELD IMPACT IN SPAIN

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This study aims to present new insight on the wheat yield historical response to climate processes throughout Spain by using statistical methods. Our data includes observed wheat yield, pseudo-observations E-OBS for the period 1979 to 2014, and outputs of general circulation models in Phase 5 of the Coupled Models Inter-comparison Project (CMIP5). In investigating the relationship between climate and wheat variability, we have applied the approach known as the Partial Least-Square regression, which captures the relevant climate drivers accounting for variations in wheat yield. We found that drought occurring in autumn and spring and the diurnal range of temperature experienced during the winter are major processes to characterize wheat yield variability in Spain. These observable climate processes are used for an empirical model that is utilized in assessing the wheat yield trends in Spain under different climate conditions. To isolate the trend within the wheat time series, we implemented the adaptive approach known as Ensemble Empirical Mode Decomposition. Wheat yields in the twenty-first-century are experiencing a downward trend that we claim is a consequence of widespread drought over the Iberian Peninsula and an increase in the diurnal range of temperature. These results are important to be compared with the ones obtained in Mediterranean countries.

Keywords: Climate Change impact, Empirical wheat yield model, Partial Least Square regression

USING SEASONAL CLIMATE FORECASTS TO PREDICT RICE YIELD OVER NEPAL'S TERAI

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This paper explores the potential of using seasonal climate forecast to predict rice yield for Nepal's Terairegion. Terai is the main rice growing area of Nepal with most of its rice production areas under rainfed conditions.

Skillful seasonal climate predictions paired with a dynamica lcrop model can assist the agricultural management and help the farmers to minimize risk. However, till today, the potential benefits of this approach have not been assessed. In this study, through the use of seasonal forecast in the CERES-Rice crop model, an attemptis made to evaluate the applicability of this approach. The CERES-Rice model is calibrated and validated with the experimental data from the regional agricultural research stations, while the predictive skill of the CMCC and CFSv2 hindcasts is examined against ERA-Interim reanalysis, station data and other observational data sets. The hindcast simulation of the CERES-Rice model fed with station meteorological data shows that climatic variability, mainly rainfall, can explain small part of the interannual variability of riceyield. Then, the hindcasts simulations of the CERES-Rice model are repeated using the hindcasts from the CMCC and CFSv2 seasonal prediction systems. The result from these simulations indicate that the application of seasonal climate forecasts to the dynamical crop model holds a moderate potential to predict rice yield, mostly limited by the skill of the seasonal forecasts. Before generalizing, further comparisons should be made, including a similar analysis for an area where quality meteorological and agricultural data are available and where the seasonal forecasts exhibit better skill.

Keywords: Seasonal climate forecast, CERES-Rice Yield, Nepal's Terai

LOOKING BACK CRITICALLY INSIDE THE BOX TO UNDERSTAND ECO-MIGRATION OF PASTORALISTS IN THE UNENDING QUEST FOR WATER AND PASTURE THROUGH A LIVELIHOOD MIRROR

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This paper is a literature review to throwing light on how migration by pastoralist in the face of climate change and the sustainable development agenda is the best tool for resilience and climate change mitigation. Pastoralism is a tested production system uniquely suited to dry lands for last 7,000 years [1]. Mobility enables pastoralists to inhabit areas of harsh and volatile climate and to transform seemingly unproductive 'wastelands' into productive assets. Dry lands occupy the biggest land cover in East and Horn of Africa, [3] supporting agriculture, livestock rearing, tourism and wild resource harvesting, and play a critical role in ensuring national food sucurity [6]. African grasslands extend to 13m km^2 and have vast carbon sequestration potential. Traditionally, whenever scarcity of pasture and water or disease depleted a community's livestock, it often sought to replenish numbers through raiding/rustling [5] which increases the pace and frequency at which pastoralists move. Legislative systems in the countries of the Horn and East Africa are largely based on those of the former colonial powers where customary rights and pastoral social institutions are not recognized by law e.g. in Ethiopia, Somaliland, South Sudan [2] and Uganda [7]. Strategies for 'modernizing' the pastoral sector, such as allocating parcels of land and controlling stocking rates, increasing off-take for markets and providing in-situ services like water, and veterinary care have performed poorly. Pastoralism is the best way to turn dry waste lands into meat and white gold, let us look back into the box and appreciate how pastoral communities have evolved and employ a 'freedom' to take action approach and allow them to choose either to remain in pastoralism, or to diversify their livelihoods and ensure economic well-being and resilience to climate change [4].

Keywords: Migration, pastoralists, climate change, water and pasture

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INTEGRATION OF 'SMART' DSS AND LOCAL WEATHER SERVICES TO SUPPORT FARM IRRIGATION MANAGEMENT AND ADAPTATION TO CLIMATE VARIABILITY

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In Mediterranean countries, water scarcity, climate change and environmental regulations are pushing farmers towards the 'sustainable' use of water resources, and Decision Support Systems (DSS) are foreseen as potential tools to improve the efficient use of water at all scales of management, based on recent advances in research and technology [1, 2].

In Southern Italy, a consortium of ICT companies and Research Institutions has recently developed a new DSS (registered as BLULEAF™) based on the 'integration' of models, weather data and forecast, sensor-based monitoring, software tools and remote control systems [3, 4].

The DSS has been included among the web tools of the agro-meteorological service of the Apulia Region, managed by the AssoCoDiPuglia consortium [5, 6]. Originally, the service is based on a distributed network of about 100 stations providing real-time weather data. Moreover, short-time and seasonal forecasts (based on the 'Sibilla' statistical downscaling system) are provided by the Italian Air Force Weather Service [7]. The DSS is enabled to use all these data to support farmers for both the short and the medium-time irrigation planning and management.

In the short-time (daily, weekly), the DSS supports the irrigation scheduling by using the measured climatic data for the daily crop water balance, and high-resolution weather forecasts for the simulation of a 3 to 7-days projected 'scenario' in order to predict the irrigation requirements for the forthcoming days. In this way, the DSS works as an 'early warning system', especially if extreme weather events and 'peaks' of water demand and crop stress are expected.

On the medium time-scale, the DSS can be used to run a 'simulation scenario' by selecting the available climate forecasts for the forthcoming months, and thus predicting the seasonal crop irrigation requirements. In this way, the DSS can support an appropriate crop planning and water management under limited resources.

Keywords: irrigation management, DSS, weather services, early warning system, seasonal forecasts.

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THE LANDSCAPE HOLISTIC APPROACH IN STUDYING A NEW AND SUSTAINABLE WINE PRODUCTION

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A new and particular attention is devoted, in the study of nature and territory, to the agricultural arrangement, the cultural settlement and –more generally- to the land use, eventually recognised as a very important factor in an integrated approach to the territorial analysis, that integrate both natural and cultural aspects of a landscape.

A proper technical and cultural approach to the question of managing and protecting the environment requires a multi scale and multidisciplinary methodology aiming at a balance between use and respect of the land, in order to have a development that is sustainable for both the natural and social ecosystems

In the "Carta della Natura" project, the entire Italian territory is studied at different scales of analysis. The methodology follows a holistic approach, taking into consideration all the components of a landscape and then integrating the information, according to the Landscape Ecology theories, which consider landscape as the result of interaction among physical, biological and anthropic phenomena acting in a different spatial-temporal scale

For example, the scale 1: 50,000 is useful in highlighting soil use, in particular the distribution of wine cultivation in the agricultural area. Referring to the climate trends, the need of some change in agricultural techniques and in wine production should be taken into account. The increasing average temperature may suggest a different distribution of the cultivations in higher areas: the map of Nature can help in identifying which areas, at different altitudes, could receive a replacement as a vineyard cultivation. Thanks to a multiscale approach, referring to climate changes and the geo-morphological evolution, it is possible to analyze the evolution of the vineyard cultivation and wine production, so that one can try -for example- the replanting of old vines in protected areas, as an experiment to integrate cultivations and culture, in a local approach.

KEYWORDS: Maps, Wine, Sustainable development, Climate trends

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UNCERTAINTIES ON FUTURE IRRIGATION DEMAND AND PRODUCTIVITY TO SUPPORT POPULATION IN AFRICA

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Sub Saharan Africa is a region expected to be particularly sensitive to climate change effects on crop yield [1]. Annual precipitation, calculated as averages for each African country, is expected to change by −39 to +64 mm by 2030 [2]. In order to develop the most appropriate policies to cope with climate threats, the use of soil water balance models provides useful information to farmers and stakeholders for understanding the effects of future climate on irrigation needs and crop yield.

The objective of this work is estimating climate change impacts on future irrigation requirements (ET_{aw}, mm) and crop productivity under the RCP 8.5 emission scenarios of the main crops (maize, millet, rice, and sorghum) in six case study of Africa (Burkina Faso, Malawi, Kenya, Ghana, Togo, and Sudan), by the use of the SIMETAW# model [3].

Each simulation was carried out considering both irrigated and rainfed conditions. In irrigated conditions, ET_{aw} and crop evapotranspiration (ETc, mm) values were computed considering the full irrigation requirement. Simulations in rainfed conditions allowed to estimate the actual crop evapotranspiration (ET_a, mm) and yield reduction relative to full irrigation.

Three global simulation models (CanESM2, NOAA-GFDL, and MIROC5) and two alternative downscaling methods, SOMD [4] and SMHI-RCM [4, 5] were employed for simulations. Four time step simulations were computed: baseline, 2025, 2055, and 2085.

Generally, SMHI-RCM estimated greater ET_{aw} and yield reduction values than SOMD. In some cases, an opposite impact on ET_{aw} in relation to the downscaling technique was observed. Kenya (Maize) showed the highest impact on ET_{aw} and yield reduction considering both downscaling techniques. In some countries, positive or no impacts (e.g., Ghana & Togo) were observed.

Keywords: SIMETAW# model; yield reduction; irrigation management; downscaling techniques.

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IMPACT OF CLIMATE CHANGE ON CROP WATER REQUIREMENTS AT MEDITERRANEAN BASIN SCALE

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Water scarcity will likely worsen due to climate change, demographic growth, socio-economic development, increasing demand for raw materials, extension of residential centers, and improvement to quality of life. About 24% of total water consumption in Europe is used in agriculture, with percentages up to 80% in Southern Europe. One of the main challenges for the agricultural sector is to produce more but in a sustainable manner (i.e. using the least amount of water). It is crucial to quantify crop water requirements, using reference evapotranspiration and related crop coefficients, while accounting for precipitation and soil to plan irrigation schedules and to evaluate climate impacts.

The aim of this work was to estimate the water demand of economically relevant crops at Mediterranean basin scale. For this purpose, a tool was developed to provide spatial simulation of standardized reference evapotranspiration rates for short canopies (ET_o).

Daily data from the COSMO-CLM regional climate model were used to estimate ET_o at European scale for past (1976-2005) and projected conditions. The climate scenarios Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 were used to project climate from 2006 to 2095. Spatial resolution used for simulations was 14x14 Km. The effect of increasing values of atmospheric CO_2 concentration on stomatal conductance were accounted for in the calculation of ET_o.

The results showed that ET_o will increase in the future for both scenarios and, consequently, crop evapotranspiration is also likely to increase in most areas. This will affect crop irrigation requirements.

Keywords: crop water demand, RCPs, evapotranspiration, Mediterranean crops, spatial modeling

EFFECTS OF CLIMATE DATA AT DIFFERENT SPATIAL SCALES ON CROP MODELING ANALYSIS IN REGIONAL CLIMATE IMPACT STUDIES

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The high vulnerability of the agricultural sector to climate conditions causes serious concern regarding climate change impacts on crop development and production, particularly in vulnerable areas like the Mediterranean Basin. Crop simulation models are the most common tools used to assess impacts on crop development and yields, both at local and regional scales. However, the use of these models in regional impact studies requires spatial input data for weather, soil, crop management, and other inputs, whose resolution could affect simulation results. Indeed, the uncertainty in projecting climate change impacts on crop phenology and yield at the regional scale is affected not only by the uncertainty related to climate models and scenarios, but also by the downscaling methods and the resolution of climate data.

The aim of this study was the evaluation of the effects of spatial resolutions of climate projections in estimating maturity date and grain yield for different varieties of durum wheat, common wheat and maize in Italy. The simulations were carried out using the CSM-CERES-Wheat and CSM-CERES-Maize crop models included in the DSSAT-CSM (Decision Support System for Agrotechnology Transfer - Cropping System Model) software [1, 2], parameterized and evaluated fordifferent experimental sites located in Italy. Dynamically downscaled climate data at different resolutions (8, 14 and 25 km) and different RCP scenarios were used as input in the crop models. A spatial platform developed in R programming language [3] was applied to perform DSSAT-CSMparallel simulations of maturity date and grain yield for durum wheat, common wheat and maize in each grid cell for Italy projections at different scales. Results are shown and discussed both at national and regional level.

Keywords: Yield, DSSAT-CSM, CERES, spatial scale, crop modeling

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WATER-ENERGY NEXUS: THE WATER FOOTPRINT OF BIOGAS PRODUCTION IN A CHANGING CLIMATE

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Biogas production from energy crops, similar to other sources of bioenergy, creates complications about its environmental effects, its competition with the food market as well as its related progressive change of land use. Biogas systems based on energy crops need to be analysed from a comprehensive perspective, considering ecological functions in agricultural and natural landscapes as well as broader livelihood and development implications [1]. Particularly, since water resources are often the limiting factor in energy production from energy crops, the nexus between bioenergy production and water, is analysed here. In this context, climate change might exacerbate the water-energy-land nexus issues within a water system and therefore the biogas production, which can be strongly affected by climate variability [2].

In the study, the environmental performances of biogas production are analysed through different Water Footprint (WF) methodologies [3]. Water scarcity footprinting indicators, whose aim is to identify water hotspots, represent, in fact, the attempt to assess potential environmental impacts of water use (both consumptive and degradative) in a life cycle sustainability analysis [4]. Different scenarios are considered, trying to figure out the performances of several combinations of locations (representative of all the different characteristics of Italian territory), crops (considering the most spread energy crops: maize, sorghum, wheat) and climate scenarios (comparing current situation with climate change scenarios).

A comparison is realized in the study in order to evaluate the WF methods behaviour and their capability to identify hotspots in terms of water scarcity. The evaluation of the dependency of WF estimation to climate variability is finally carried out in order to quantify the effects of future climate scenario on water resources availability and thus on the sustainability of bioenergy production.

Keywords: Water Footprint, climate change, bioenergy, energy crops

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FORECASTING CROP EVAPOTRANSPIRATION USING ENSEMBLE NUMERICAL WEATHER FORECASTS

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Weather widely affects agriculture, being a controlling factor in crop growth and in crop water requirements. In the last decade, the increasing quality of Numerical Weather Prediction (NWP) systems has been making weather forecasts a valuable information for a more efficient use of water resources in agriculture and a sustainable crop production. Moreover, ensemble weather predictions, which can explicitly take into account the uncertainty underlying the forecasting process, facilitate the development of advisory systems for irrigation scheduling and early-warning systems for preventing loss due to extreme weather conditions.

Here, we present a stochastic model for forecasting crop potential evapotranspiration that combines a crop growth model with ensemble numerical weather forecasts from a European limited area prediction system, COSMO-LEPS (16 members, 7.5 km spatial resolution, up to 5 days lead time). An ensemble Kalman filter technique has been used to update model states by assimilating both weather variables from ground based Automatic Weather Stations and crop parameters (such as Leaf Area Index) from high resolution satellite images in the visible and near infrared wavelengths.

The model has been adopted to develop a new operational advisory irrigation service in Campania region (Southern Italy). Results of the model performances for two years of experimental service suggested that the proposed model could be an effective tool for a sustainable use and management of irrigation water, under conditions of water scarcity and drought. Promising future developments could regard the application of the model with an advanced support system for water resources management in irrigation districts.

Keywords: crop water requirement, ensemble forecasts, Kalman filter, numerical weather prediction models, VIS-NIR high-resolution satellite images.

EFFECTS OF FLOOD INUNDATION UPON RICE PRODUCTION AS A RESULT OF CLIMATE CHANGE REINFORCED MULTI-DAY EXTREME PRECIPITATION

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Agricultural production is often under threats of climate and weather related disasters, among which flood is the most frequent and damaging. The primary cause of long-lasting floods is multi-day extreme precipitation. This study aimed to evaluate the effects of future floods triggered by climate change reinforced extreme precipitation upon rice production with the case study of the highly rice cultivated Ca River Basin of Vietnam, which is one of the leading rice producers and exporters in the world. Multi-day extreme precipitation and its recurrence interval were identified by applying Probability Weighted Moment to Generalized Extreme Value distribution using historical daily observations and output of ensemble median of 14 selected GCMs. The calculation was run under two Representative Concentration Pathways: RCP2.6 with low climate sensitivity (best case) and RCP8.5 with high climate sensitivity (worst case). The predicted future precipitation data was then used for flood modeling and inundation calculation using hydrological models. A simple method taking into account flood depth, inundation duration and crop calendar was then used for potential damage calculation. The results reveal a slight increase of extreme precipitation (from 1.3 - 1.9% depending on the recurrence interval) in the best case, but a sharp increase (24 - 36%) in the worst case in the 2070s compared to the baseline period (1986-2005). As a result, the overall variation shows a small increase in potential loss of rice production in the best case, but a significant increase in the worst case due to deeper and longer inundation. The results of this study are valuable for agro-economists in flood damage evaluation, and for policy maker in long-term agricultural and infrastructural planning to minimize potential damages of future floods, especially in the worst case of climate change.

Keywords: climate change, extreme precipitation, flood inundation, rice

A WEB PLATFORM INTEGRATING GEOSPATIAL DATA ON ENVIRONMENTAL AND ECONOMIC PHENOMENA IN A CLIMATE CHANGE PERSPECTIVE

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The impact of climate change on ecosystems and eventually on economic activities is very complex and much is still to be clarified. Integration of different types of information helps to progress towards a better understanding of the ways in which the natural system may interact with human activities whose purpose is economic development through production. A particularly interesting way to integrate different sets of data is to bring in a spatial dimension; in this way, the complexity of phenomena is still there but their analysis can be facilitated and early warning is made more at hand. StatView is an innovative tool which can conveniently support whatever analysis focused on agriculture and its interrelationships with climate-related environmental phenomena, including issues such as supply of food, water availability, or supply and use of energy: it is a user-friendly web platform developed by making use of open source technologies which allows to visualize statistical data in different formats, including plotter/density maps and dynamic graphs. Data produced by research institutes and government agencies, available according to different geographical units, can be disseminated through the web by making use of web-services complying with the json-STAT standard; also data other than official statistics can easily enter the platform. The release of map data in the form of Web Map Service is managed by Geoserver, which provides data on territorial boundaries and points of interest as open multi-source data. StatView may be seen as a json-STAT hub that can be used as a web-service to further disseminate the data in a machine-readable format. With the support of StatView, it is easier for research work to highlight how environmental and economic phenomena may be connected with each other as well as with climate change, thus facilitating analysis and the drafting of proper and early-warning advice for decision making.

Keywords: data integration, geospatial data analysis, data visualization.

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SHORT ROTATION FORESTRY ON DRAINED PEATLAND – A SURVEY OF DRIVERS FOR GHG EMISSIONS

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More than 95 % of German peatlands have been drained, primarily for agricultural use, over the past hundreds of years [1]. They constitute a significant source of greenhouse gases (GHG) [2]. In compliance with the regulations for the Bavarian Energy Turnaround former grassland on drained peatland near Rosenheim, Bavaria, is now used for short rotation forestry (SRF). Harvested trees will provide biomass for a wood chip plant. The study aims at determining how water table, tree species and method of establishment influence GHG emissions from SRF on drained peatland. Results will serve as a foundation for implementing Best Practice Guidelines for farmers. Understorey GHG fluxes are measured using closed-chamber methods. Gas samples are enclosed in vials bi-weekly and analysed for their CO_2/CH_4/N_2O content with a gas chromatograph at a laboratory. CO_2 fluxes are additionally monitored on site over the course of a day every three to four weeks with a dynamic closed-chamber technique. Allometric methods are employed to estimate tree carbon sequestration. Although water tables in the wet sites were lower than desired in 2014, there is a considerable difference in CO_2 fluxes compared with the dry sites. This can likely be attributed to slower tree growth around the former. Therefore the canopy there was not so dense during late summer and autumn, allowing for higher undergrowth GPP. In general alder sites display higher R_{eco}/NEE fluxes than poplar sites, which might at least partly be attributed to a difference in understorey vegetation. The main influence of ploughing seems to be that it has allowed for very fast tree growth resulting in low undergrowth GPP values. CH_4 and N_2O balances are similar for most sites. Only the wet alder site shows significantly higher CH_4 and very low N_2O fluxes, possibly influenced by it having the highest water table in 2014.

Keywords: Short rotation forestry, peatland, greenhouse gas emissions

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IRRIGATION SCENARIOS UNDER FUTURE CLIMATE CHANGES IN EMILIA-ROMAGNA

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This study aimed at the analysis of climate change impact on crop irrigation water needs under future scenarios of climate, land use and irrigation methods, for Emilia-Romagna region (North Italy).

We applied the water balance model Criteria at the regional scale, as evaluation tool of current and future irrigation demand in Emilia-Romagna plain.

Daily series from E-Obs gridded data set of maximum and minimum temperature and precipitation for 1995-2012 period have been compared to future climate projections (emission scenario RCP4.5) for 2021-2050 period, properly downscaled to the study areas.

The agricultural land use of the plain area was yearly mapped from 2009, using 5 main crop classes, by means of optical multi-date satellite imagery, and actual crops were estimated stochastically for the period 1995-2012, starting from data on crop areas and considering the sequence probabilities in typical rotations. Hypothetical crop map projections have been defined considering a decrease (increase) in crops with high (low) water needs.

Finally, two different irrigation techniques were also evaluated: sprinkler and sub-irrigation, respectively the most widespread in Emilia-Romagna and the most efficient methods. Four combinations of climate, crop and irrigation technique scenarios have been simulated and compared at the province scale: the highest irrigation demand is obtained by using future climate, current land use and sprinkler irrigation, reaching up to +15% the demand estimated using, as reference scenario, past climate, current land use and sprinkler irrigation. The combination future climate, future land use, sub-irrigation provides irrigation volumes equal or in same case lower to the reference scenario, suggesting that proper adaptation measures allow a sustainable irrigation in the next decades.

Keywords: water balance model, statistical downscaling, satellite maps, crop rotations