19 June 2019

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EXCELENCIA SEVERO OCHOA

Climate prediction research for operations and services

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EUCP European Climate Prediction system

ICREA

Climate time scales

Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.

The big challenge is to provide climate information as far as possible into the future for a set of identified users

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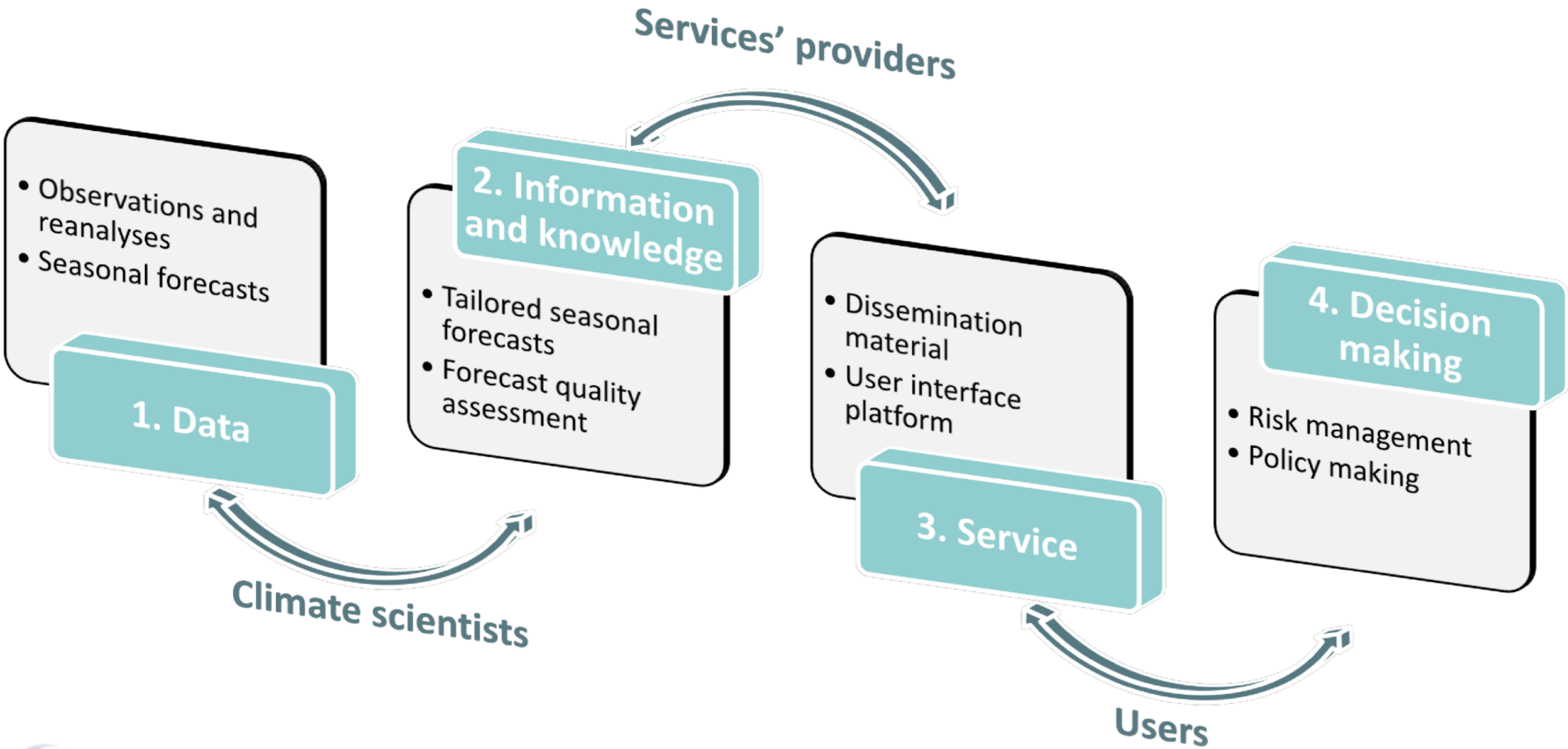
Adapted from Meehl et al. (2009)

The research-provider-service paradigm

A service-oriented research agenda requires the traditional chain "research development-operations-service provision" to be oriented both ways so that not only true value is demonstrated but user requirements are adequately addressed. This leaves a clear space for transdisciplinary research. This chain should not preclude basic research to take place though.



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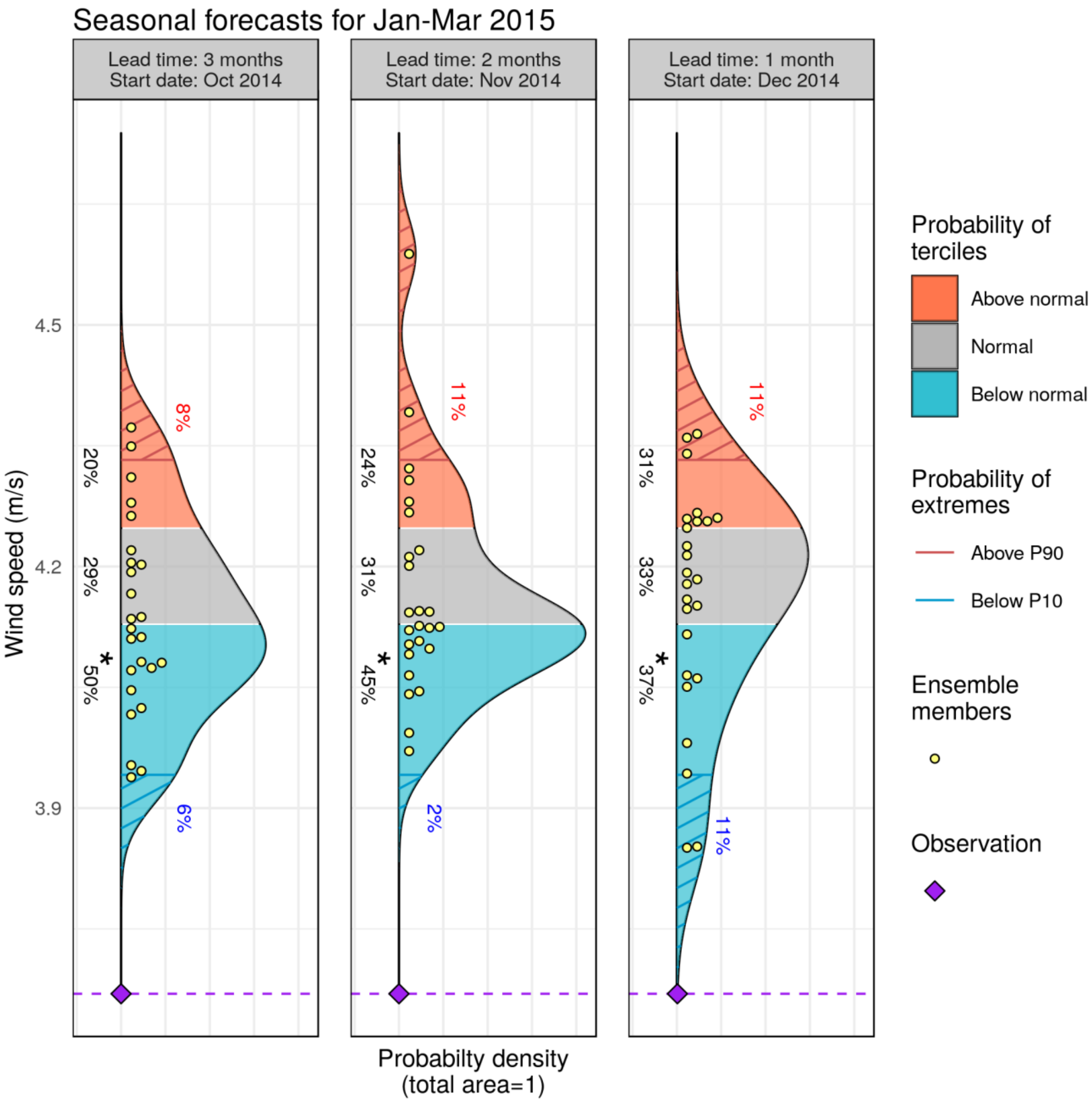
Forecast products and their quality

The prediction process follows a series of steps:

- Formulate a forecast product from a forecast system. The exact definition of the product is very important.
- Select the verification metrics of the product that allows to adequately represent the attributes of interest and an observational reference. No forecast product should be issues without a verification.
- Choose a comparison standard that provides a reference level (persistence, climatology or a previous forecast system).
- A product is of high quality if it predicts the conditions observed according to some objective criterion better than a reference prediction.
- Note that the forecast quality is valid for a specific forecast product. Different products from the same forecast system will show different forecast quality (and possibly a different winning "best" system).
- The prediction has value if it helps the user to obtain some kind of benefit from the decisions he has to make. How to make this compatible with the points above?

Forecast products



DJF wind speed predictions starting on the first of October, November and December for the first trimester of 2015, ECMWF SEAS5, reanalysis: ERA-Interim, hindcasts over 1993-2015.

	Start Date		
	Oct	**Nov**	**Dec**
RPSS	0.35	0.39	0.35
CRPSS	0.14	0.11	0.14
Corr	0.55	0.54	0.51

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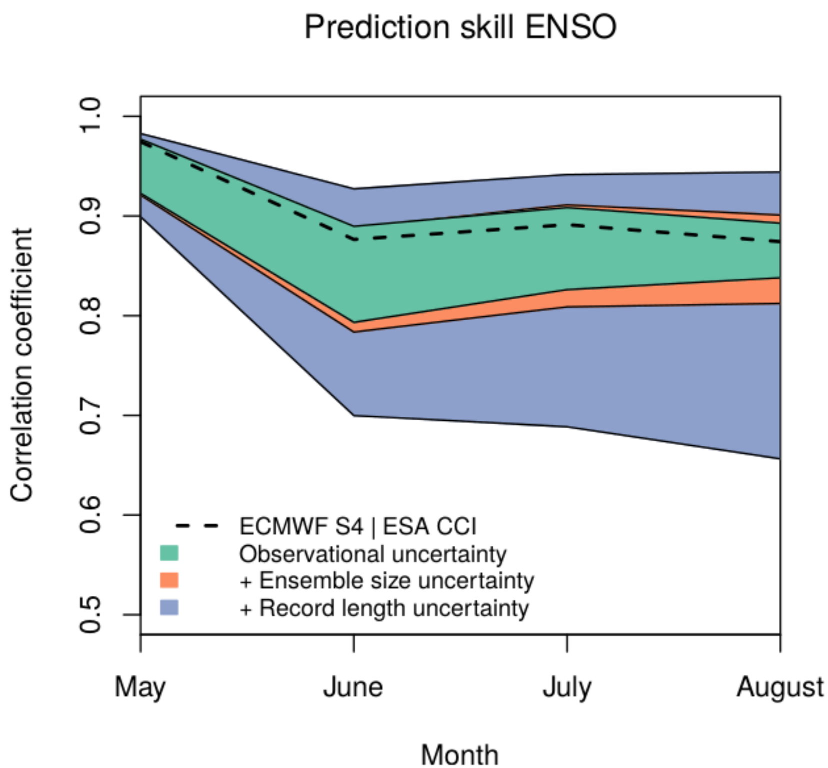
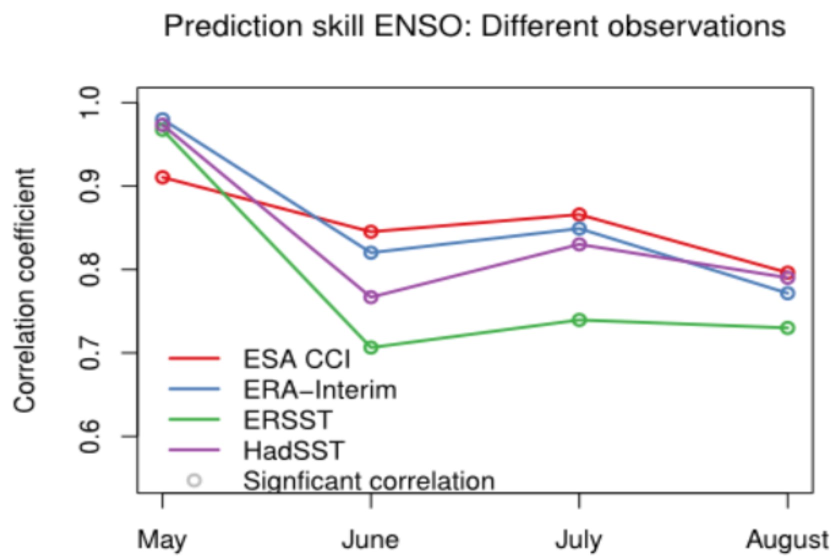
Sources of uncertainty of forecast quality

Niño 3.4 SST correlation of the ensemble mean for (right) EC-Earth3.1 (T511/ORCA025) predictions with ERAInt and GLORYS2v1 ics, and BSC sea-ice reconstruction and (left) ECMWF System 4, both started every May over 1993-2009.





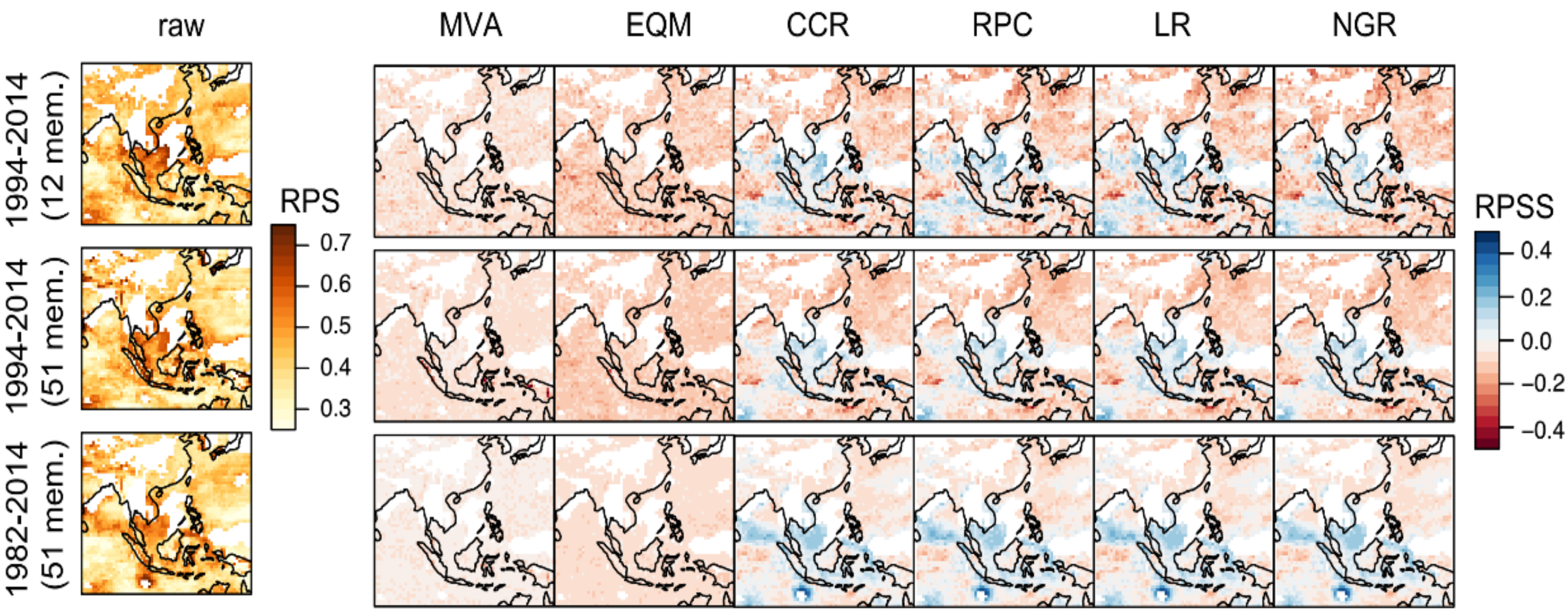
Bellprat et al. (2017, Rem. Sens. Env.)

Calibration, multi-model

- Calibration (or bias adjustment)
  - All bias adjustment and recalibration methods effectively remove bias
  - Cross-validation is fundamental
  - Added value of sophisticated methods small to inexistent due to limited hindcast length (and low skill)
- Multi-model combination
  - No forecast system consistently outperforms others
  - Multi-model combination is beneficial
  - Avoid the temptation of identifying inadequate data sources to e.g. discard “bad” forecast systems.

Bias adjustment and forecast quality

RPS of DJF temperature from ECMWF S4 with different bias adjustment methods, bias adjusted and verified against ERA Interim. Bias adjustment degrades the skill when performed in cross-validation except in areas where reliability can be improved.



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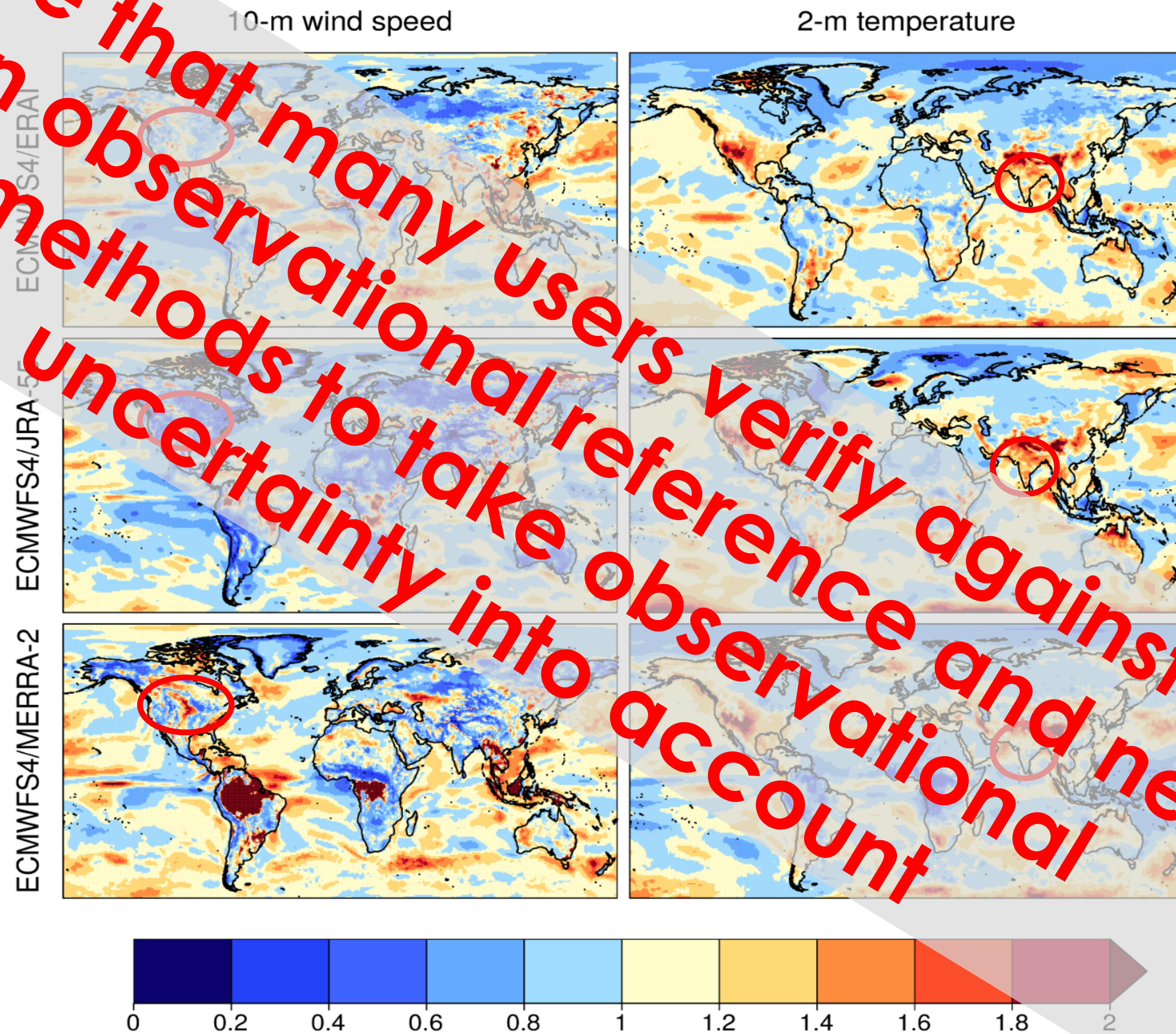
Manzanas et al. (2019, Clim. Dyn.)

Observational uncertainty is a big issue

Interannual standard deviation ratio between hindcasts and reanalyses (DJF for November start dates, 1981-2014, ECMWF S4).



Note that many users verify against their own observational reference and need methods to take observational uncertainty into account

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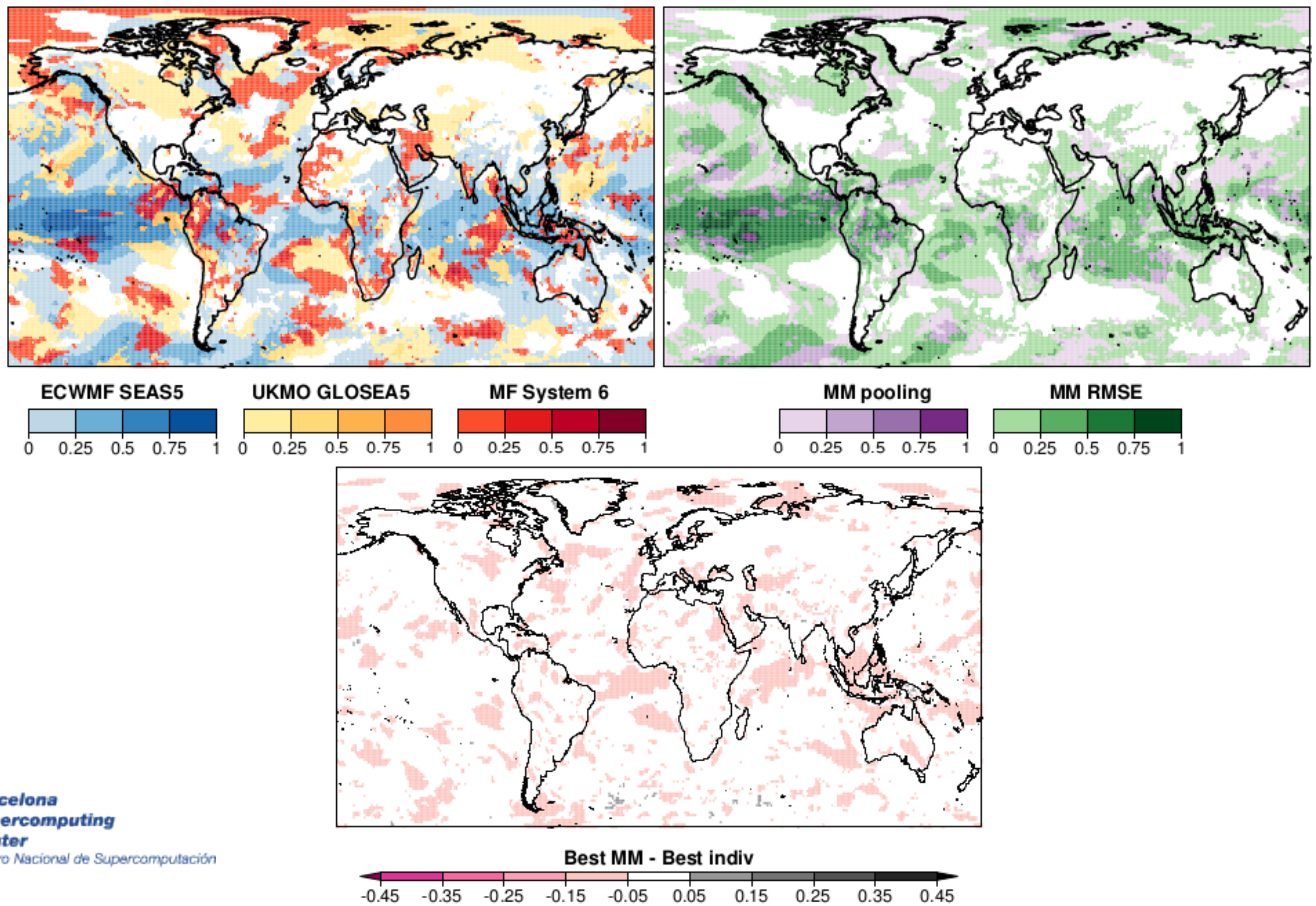
Torralba (2019, PhD thesis)

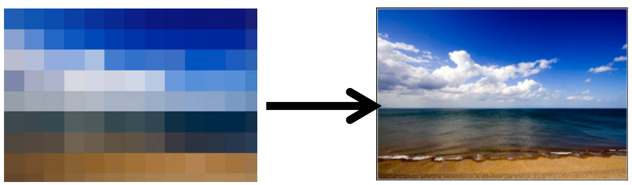
Multi-model and forecast quality

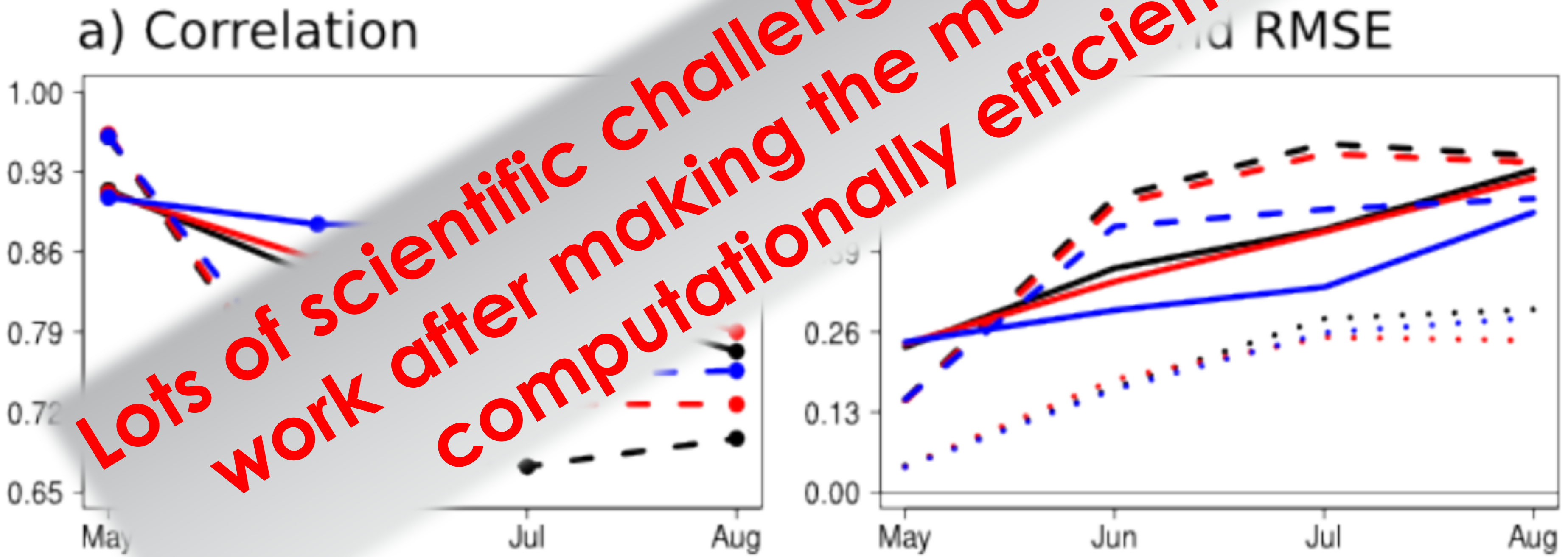
CRPSS of DJF two-metre temperature from ECMWF SEAS 5, Météo-France System 5, MetOffice GloSea5, initialized in November, all systems bias adjusted (MVA) compared to a simple and weighted multi-model (as an inverse function of the RMSE). Bottom gain of the best multi-model with respect to the best single system. Verified against ERA Interim for 1993-2015.



Improving the system: increasing resolution

Forecast quality from EC-Earth3.1 seasonal hindcasts (1993-2009 ... lorys2v1, ERAInt and ERALand initial conditions). Solid for ESA-CCI and d... ERSST. Blue for high resolution ocean and atmosphere, red for hi... cean, black for standard resolution.





Lots of scientific challenges, and will only work after making the models more computationally efficient

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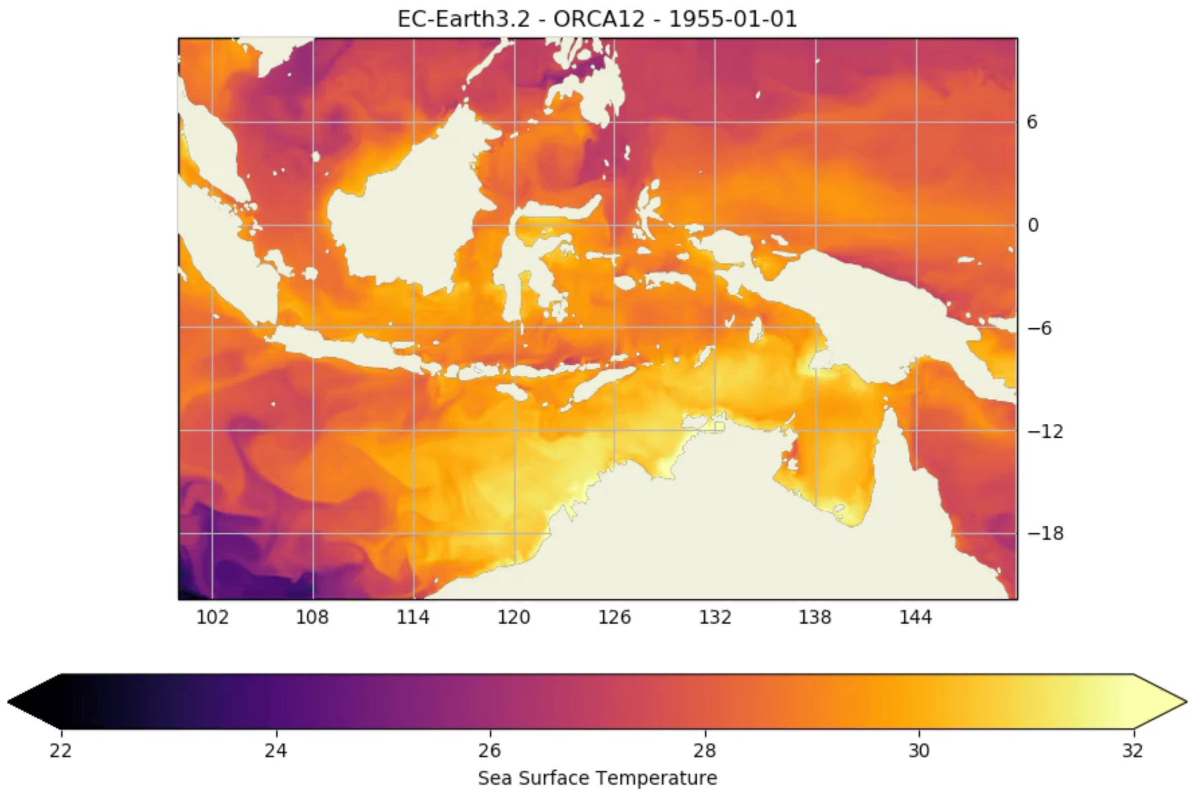
Prodhomme et al. (2016, J. Clim.)

Improving the system: increasing resolution

The very high resolution configuration of EC-Earth runs at ~10 km. The physical interaction between ocean and atmosphere is far more realistic at these resolutions. 220 kCPU hour per simulated year (typical simulation is 150 years times several members). **Optimization is indispensable to increase the performance of new configurations**.



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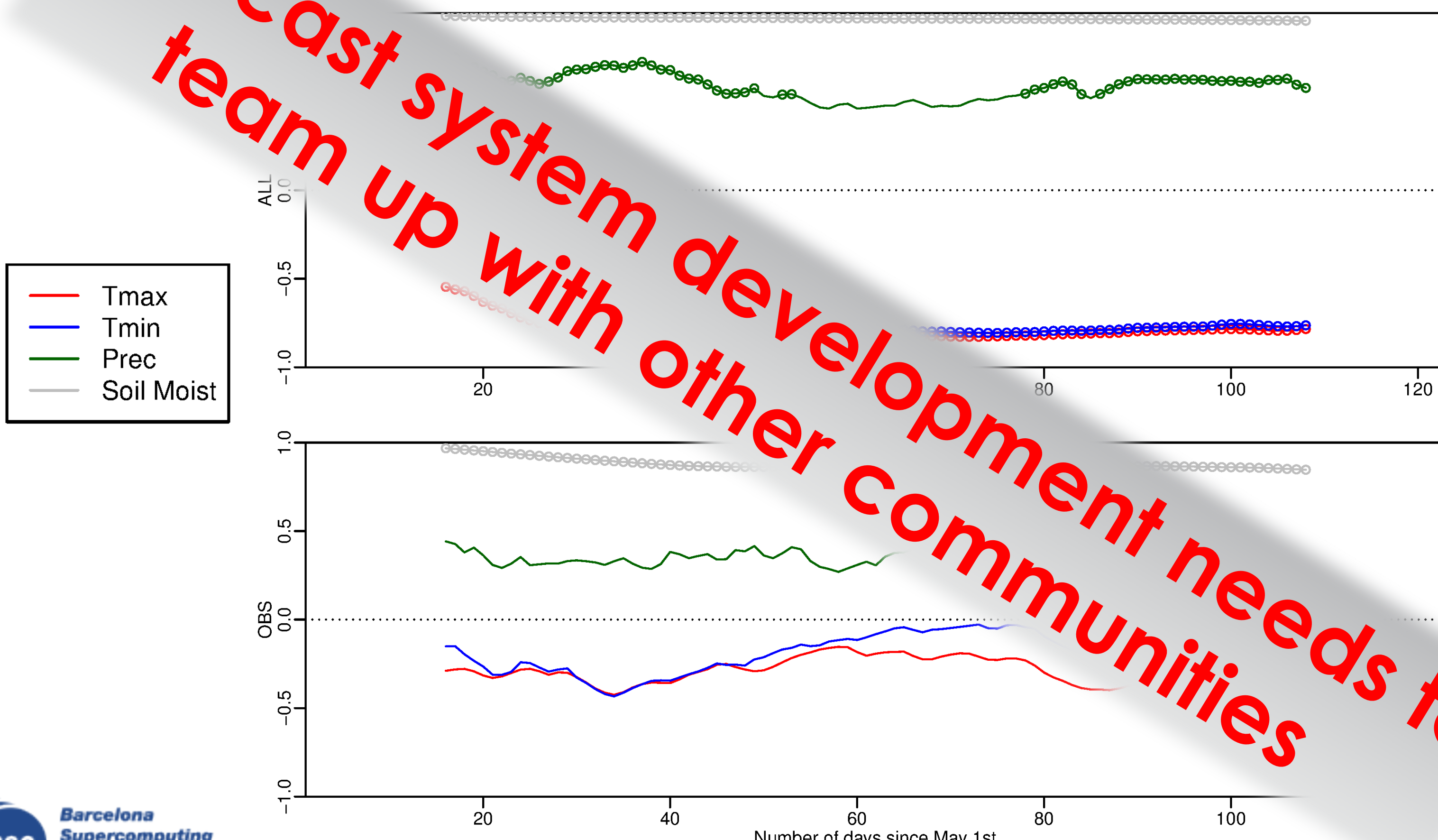
The big elephant: forecast shock and drift

Correlation between 1st of May total soil water content and 31-day running mean of variables from the SPECS multi-model seasonal forecast (…p) and ERAInt (bottom) over North American Great Plains.

Model… …kly to excessive land-atmosphere coupling.



Forecast system development needs to team up with other communities

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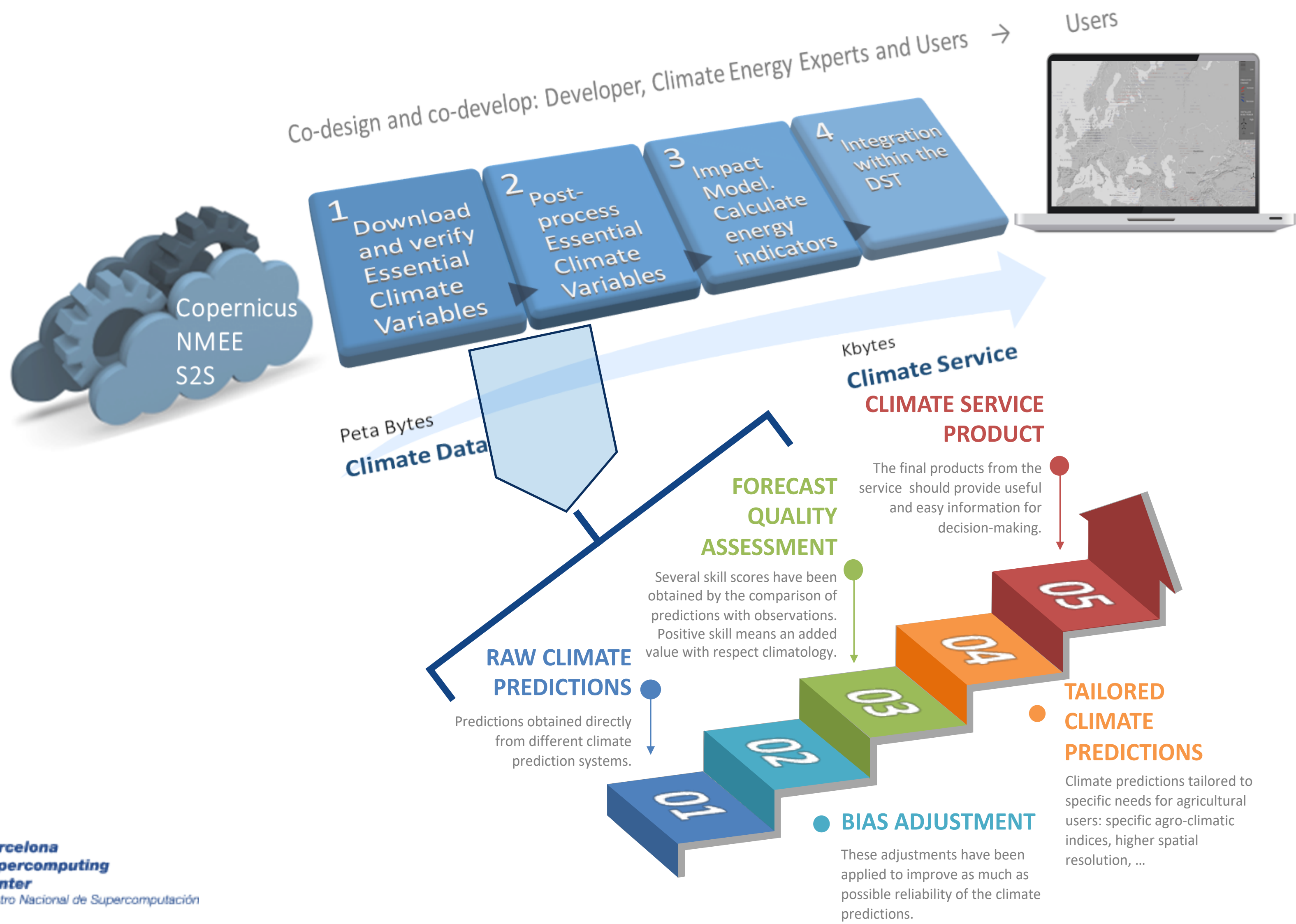
Ardilouze et al. (2017, Clim. Dyn.)

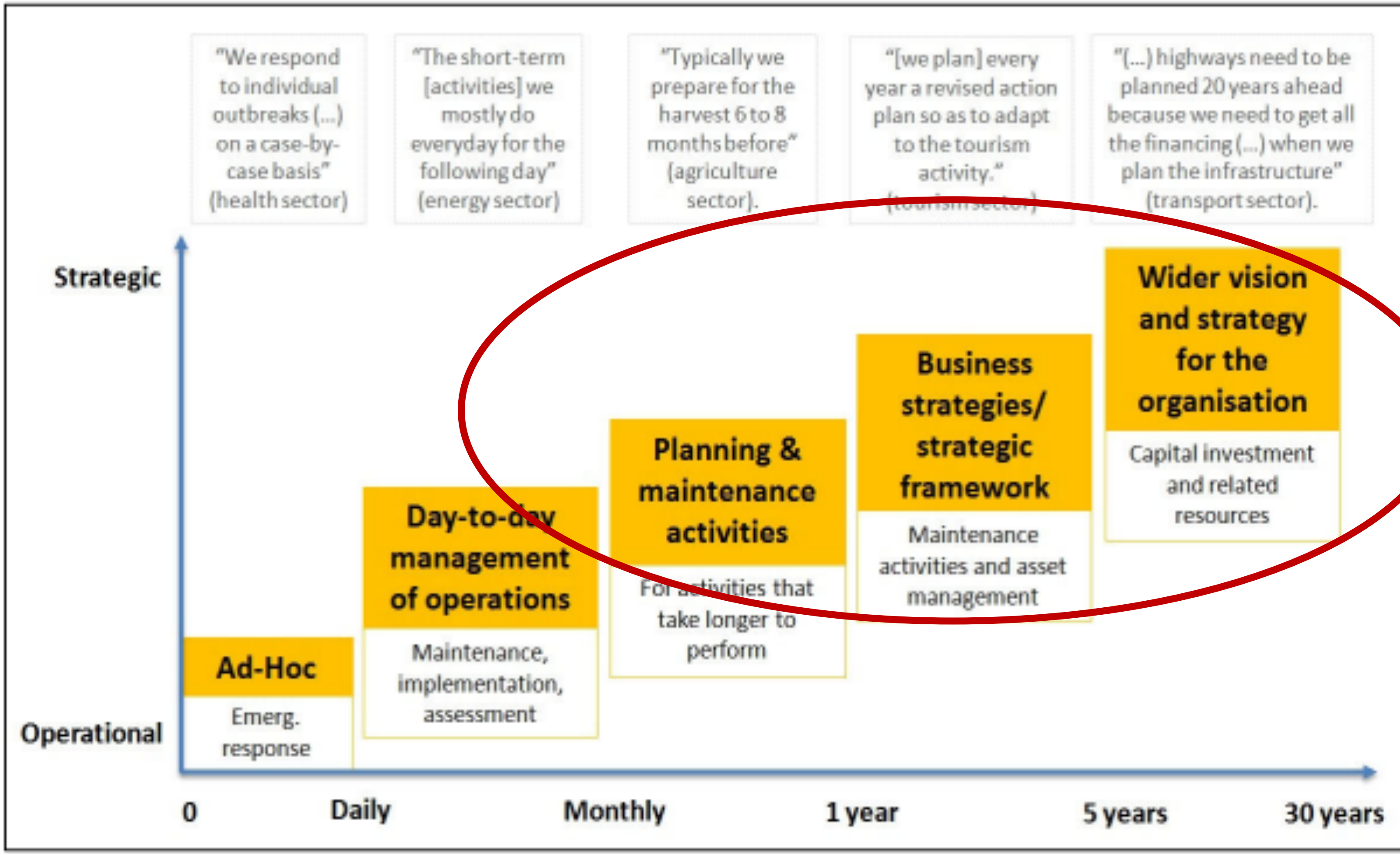
However, the chain goes well beyond climate

Even when there is skill in the climate variables, converting it into proven usefulness for a specific application involves a complex chain.



Uses of climate information

The users of climate predictions are more strategic than those of weather forecasts



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Dessai and Bruno-Soares (2013, SRI Paper 62)

Identified user requirements

- Targeted products need to become widely available, easy to access and understand by different professionals
- Need to understand how the information provided can be used and integrated in users' operations and activities.
- Added value of using climate predictions needs to be better understood. The chain product-verification-predictability source needs to be established.
- Need to reduce uncertainties and increase skill. The skill is too low to base decisions on them, since the cost/lost ratio can be high
- Better explanation of the link between climate predictions and climate change projections.
- The information needs to be reliable enough.
- Maybe need for fine spatial resolutions or allow focusing on local urban areas.

Extracted from project deliverables of EUCP (D6.4), PRIMAVERA (D11.6) and EUPORIAS (D12.3). Additional sectoral comments in user engagement by S2S4E, APPLICATE, MED-GOLD, HIATUS and VISCA.

The communication challenge

Gamification is useful to illustrate the challenges of using and the value of seasonal climate predictions addressed to the wind energy sector:

- Play against a reference taken from climatological frequencies.
- The bets are proportional to the predicted probabilities.
- The amount invested in the observed category is multiplied by 3.

play.google.com/store/apps

demo.predictia.es/roulette-app/mobile.html

Terrado et al. (2019, BAMS)

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EUPORIAS
European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales

S2S4E
Climate Services for Clean Energy

Evaluation and quality control

BSC is responsible of the development of the evaluation and quality control (EQC) function of the climate data store of the C3S to:

- Provide a user-led overarching EQC service for the whole CDS
- Provide an independent quality assessment for a number of data types (observations and model based)

- CDS datasets: provide information about the technical and scientific quality and fitness-for-purpose, along with independent assessment of the datasets

- CDS toolbox: assessment of maturity and fitness for purpose of the software provided to explore the datasets

- CDS service: performance assessment of the CDS infrastructure (e.g. speed, responsiveness, system availability)

- CDS users: user requirement assessment to measure users' satisfaction with the CDS. Map evolving user needs into viable user requirements to ensure a user-oriented evolution of the CDS

Moves towards operationalisation: decadal prediction

The multi-model real-time decadal prediction exchange is a research exercise that guarantees equal ownership to the contributors.

BSC is one of the four centres recognised as global producers of decadal climate predictions by WMO-CCl.

Multi-model decadal forecast exchange

The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

The contributing prediction systems are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

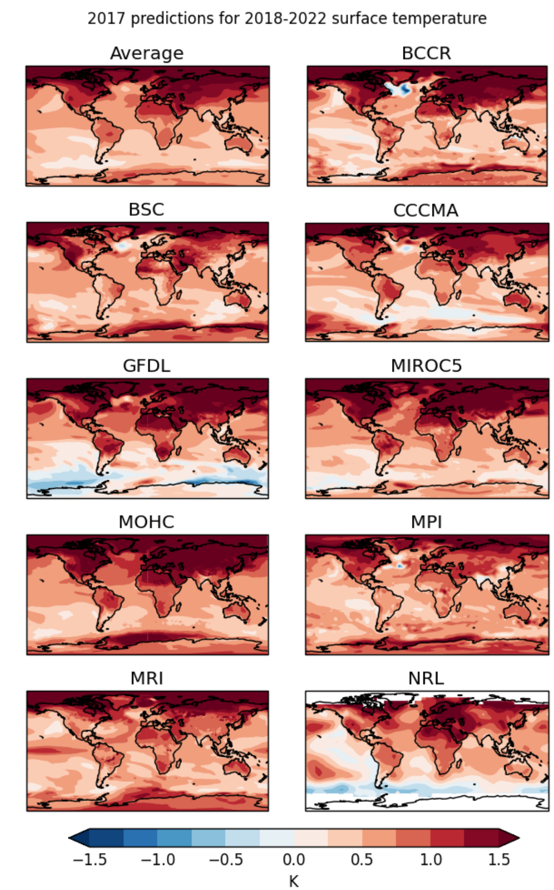
This work is supported by the European Commission SPECS project.

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

To learn more about decadal forecasts at the Met Office, see our current decadal forecast.

Images last updated 2014-06-25

Issued	Period	Element
2013	year 1	surface air temperature



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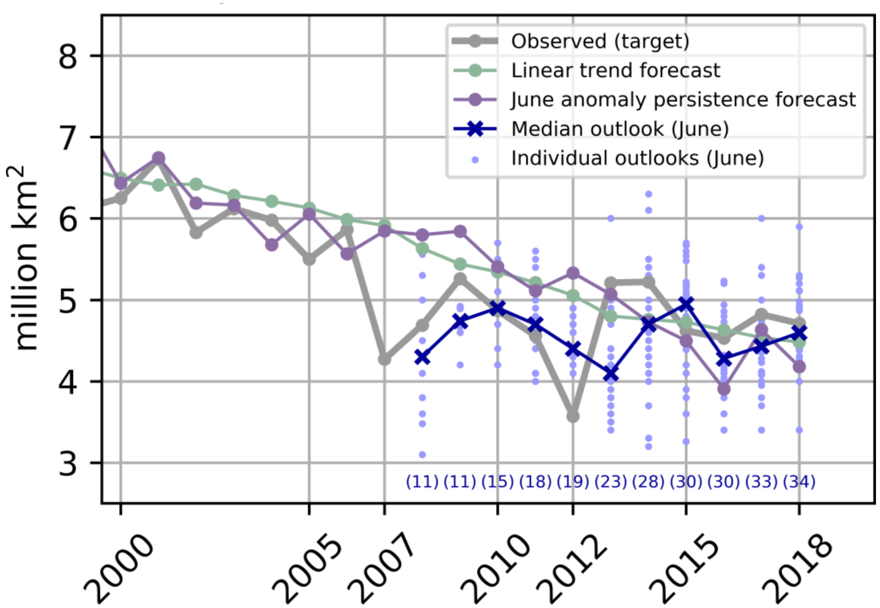
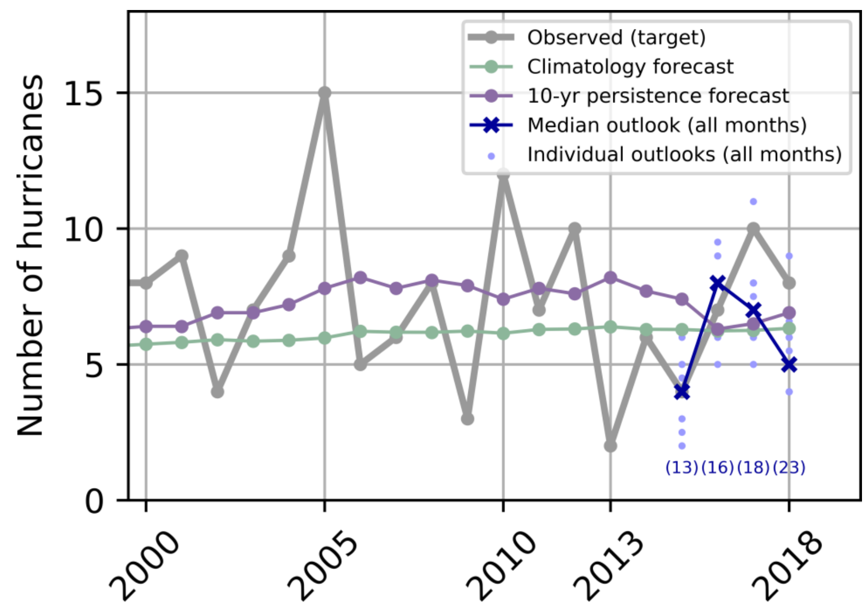
World Meteorological Organization

And the informal operationalisation efforts

Communities are becoming organised to publish collaborative seasonal outlooks such as the Sea Ice Prediction Network (with forecasts of September sea-ice extent) and the Seasonal Hurricane Prediction (with number of North Atlantic hurricane number) initiatives.





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Caron et al. (2019, BAMS)

Summary

- Requests for climate information for the next 30 years come from a broadening range of users and needs to be addressed from an operational climate services perspective. Addressing this requirement require a new paradigm for climate research.
- Standards for verification, data dissemination, and all aspects of quality control need to be improved and expanded.
- Research topics yet to be explored include the definition of benchmarks from the user perspective (not just climatology, persistence or projections), the integration of the observational uncertainty in the production chain, model weighting and model selection, prediction-projection merging and the use of new paradigms like storylines and emergent constraints.
- Entry-level documentation and training, as well as communication, become fundamental.
- None of this will materialise without appropriate investment in observational networks, increased collaboration and reduction of all aspects of model error, among many other critical aspects.