Barcelona, 31 May 2018

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

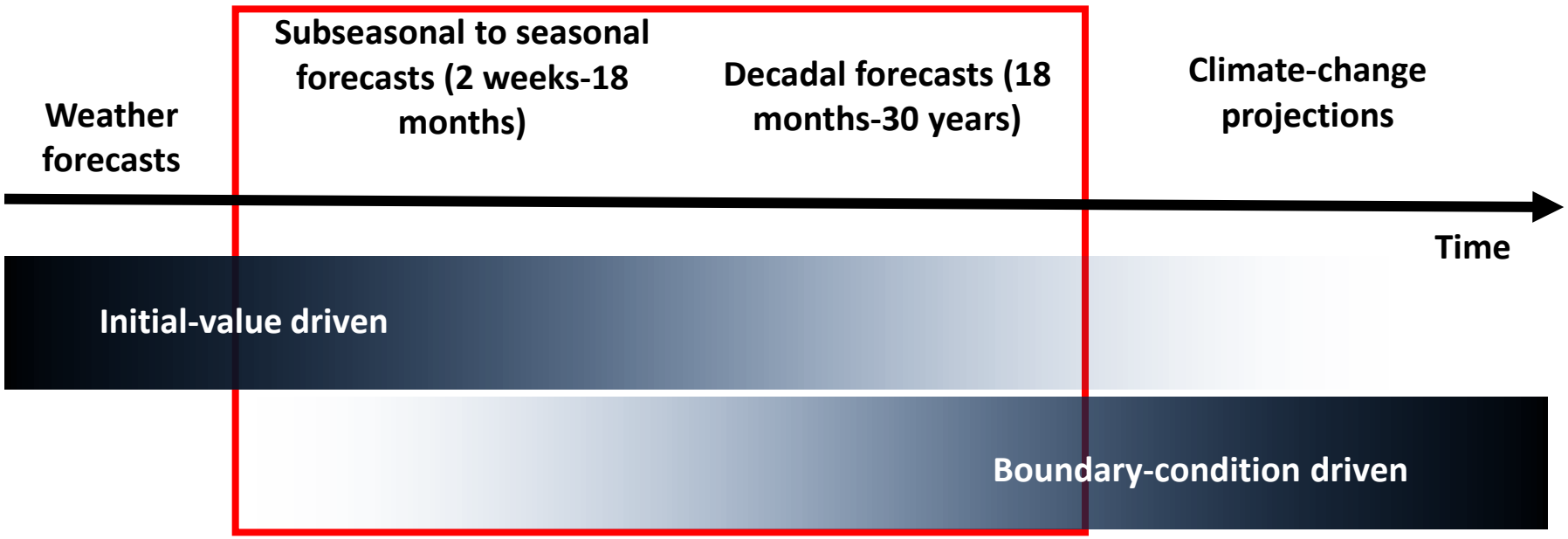
EXCELENCIA SEVERO OCHOA

Predictability at Different Time Scales

Francisco J. Doblas-Reyes

iCrea

Predictability and prediction



Adapted from Meehl et al. (2009)

Predictability: IPCC AR5

11

Near-term Climate Change: Projections and Predictability

Climate predictability

The term 'predictability', as used here, indicates the extent to which even minor imperfections in the knowledge of the current state or of the representation of the system limits knowledge of subsequent states. The rate of separation or divergence of initially close states of the climate system with time (as for the light purple lines in Box 11.1, Figure 1), or the rate of displacement and broadening of its

(continued on next page)

and vice versa. Formally, predictability in climate science is a feature of the physical system itself, rather than of our 'ability to make skilful predictions in practice'. The latter depends on the accuracy of models and initial conditions and on the correctness with which the external forcing can be treated over the forecast period.

Predictability: NRC (2010)

Assessment of Intraseasonal to Interannual Climate Prediction and Predictability

Committee on Assessment of Intraseasonal to Interannual Climate Prediction and Predictability

Board on Atmospheric Sciences and Climate

Division on Earth and Life Studies

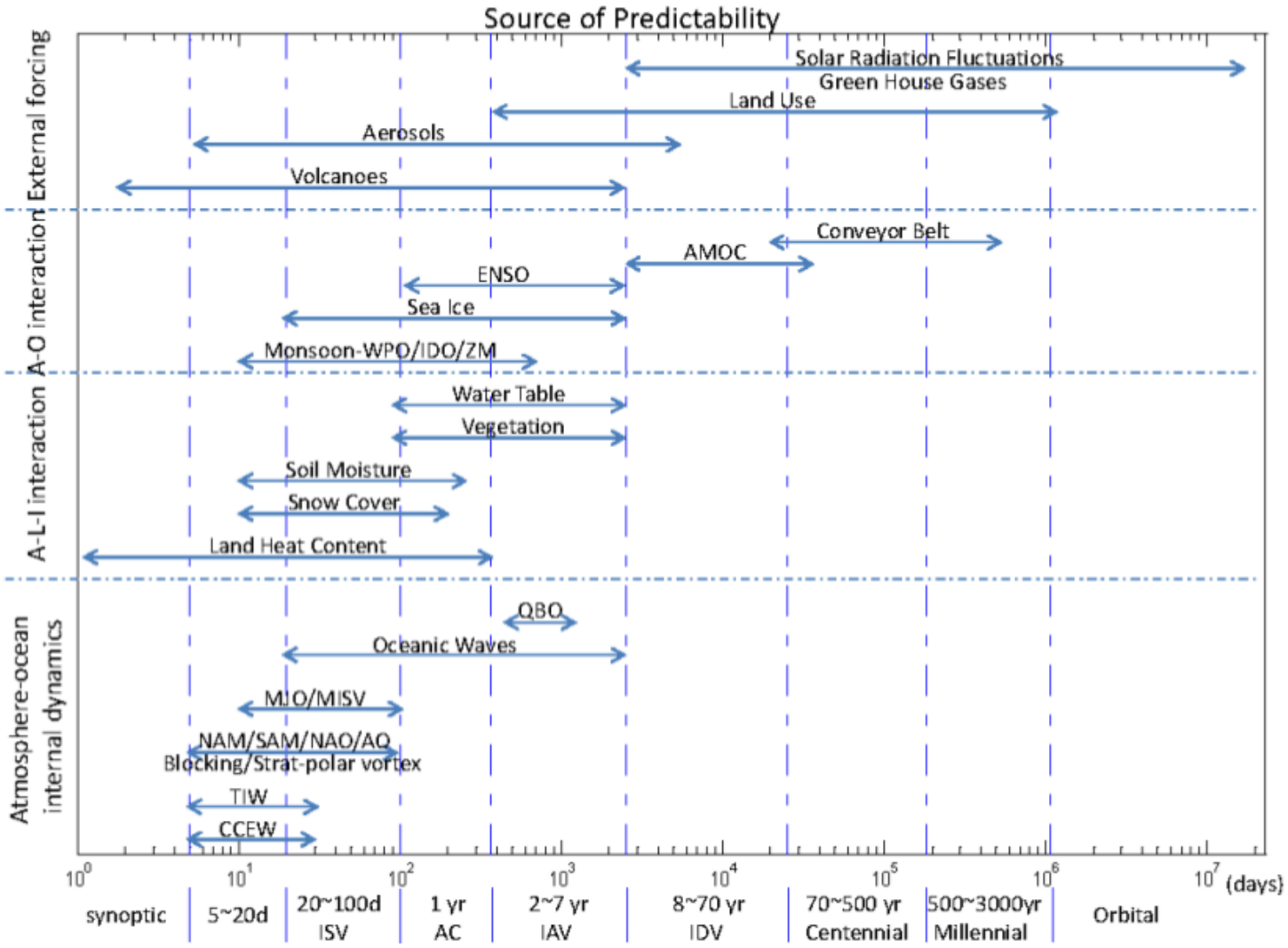
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

- It is not possible to quantify a true *limit of predictability* for the climate system.
- Quantitative statements can be made regarding the *lower bounds* of predictability, as derived by the performance of existing forecast systems. If a forecast system shows quantitative skill according to some metric, then at least that much predictability must exist in nature.

Predictability: NRC (2010)

The committee finds that presently observational estimates of predictability are severely limited—the observational record is too short and the estimates require assumptions about the observational data (e.g. stationarity) that are difficult to satisfy. Model-based estimates of the intrinsic predictability[2] can also be made but are severely limited by the fidelity of the model. For example, model predictability estimates of the ENSO cycle could in principle span the gamut from zero predictability (modeling the cycle as a white noise process) to perfect predictability (modeling it as a sine wave). Of course, modelers use much more physically-based representations of ENSO; nevertheless, the predictability a model produces is unequivocally a function of the underlying model assumptions—the discretization of flow equations, the parameterizations of physical processes, and so on. Model-based ENSO predictability estimates vary widely among models, and for this and any other such process a higher estimate of predictability is not intrinsically a more accurate one.[3]

Predictability sources



NRC (2010)

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Some European Activities

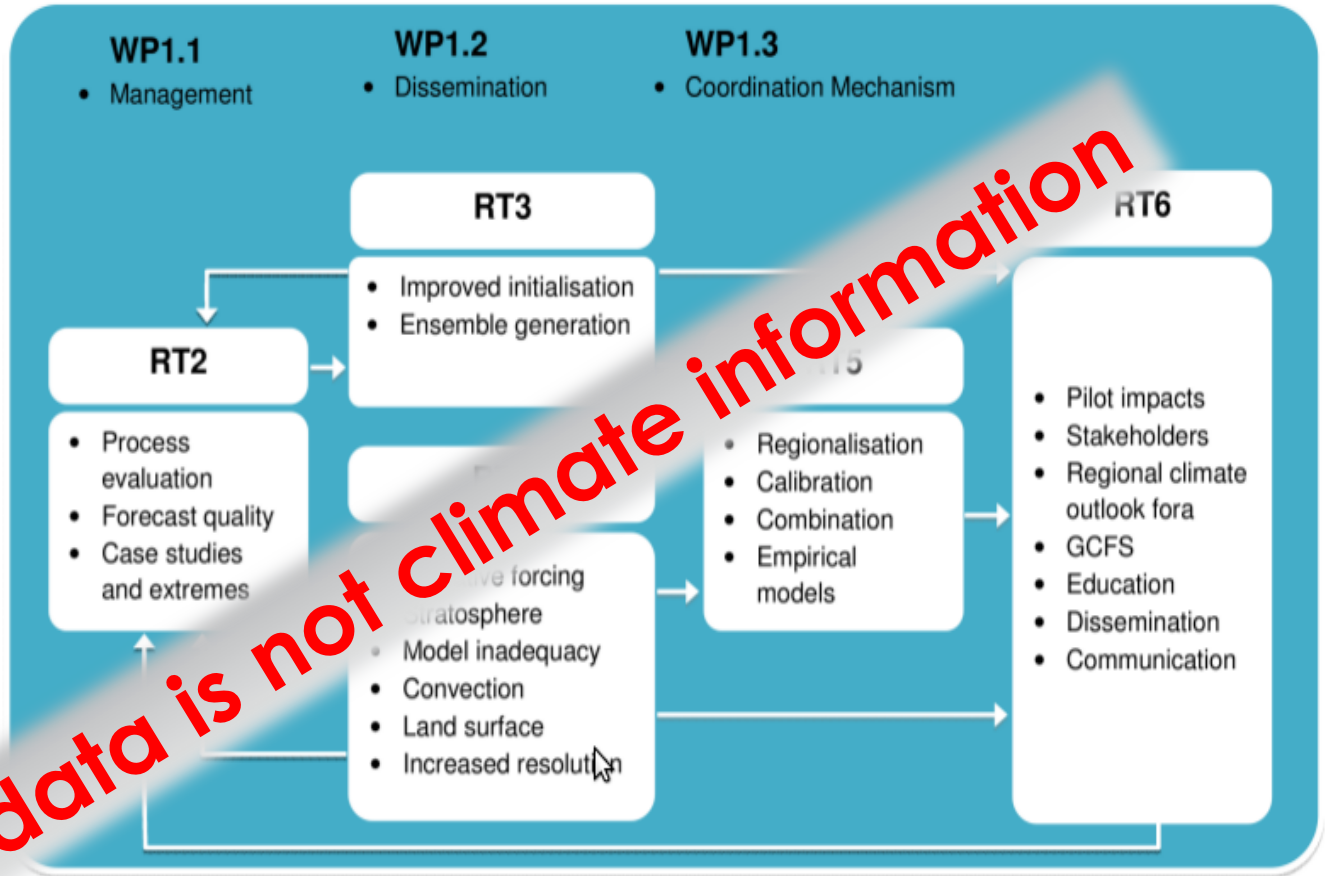
Francisco J. Doblas-Reyes

iCrea

SPECS

SPECS specs-fp7.eu produced quasi-operational and actionable local climate information with a new generation of reliable European climate forecast systems.

Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, BSC, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniH
UM	



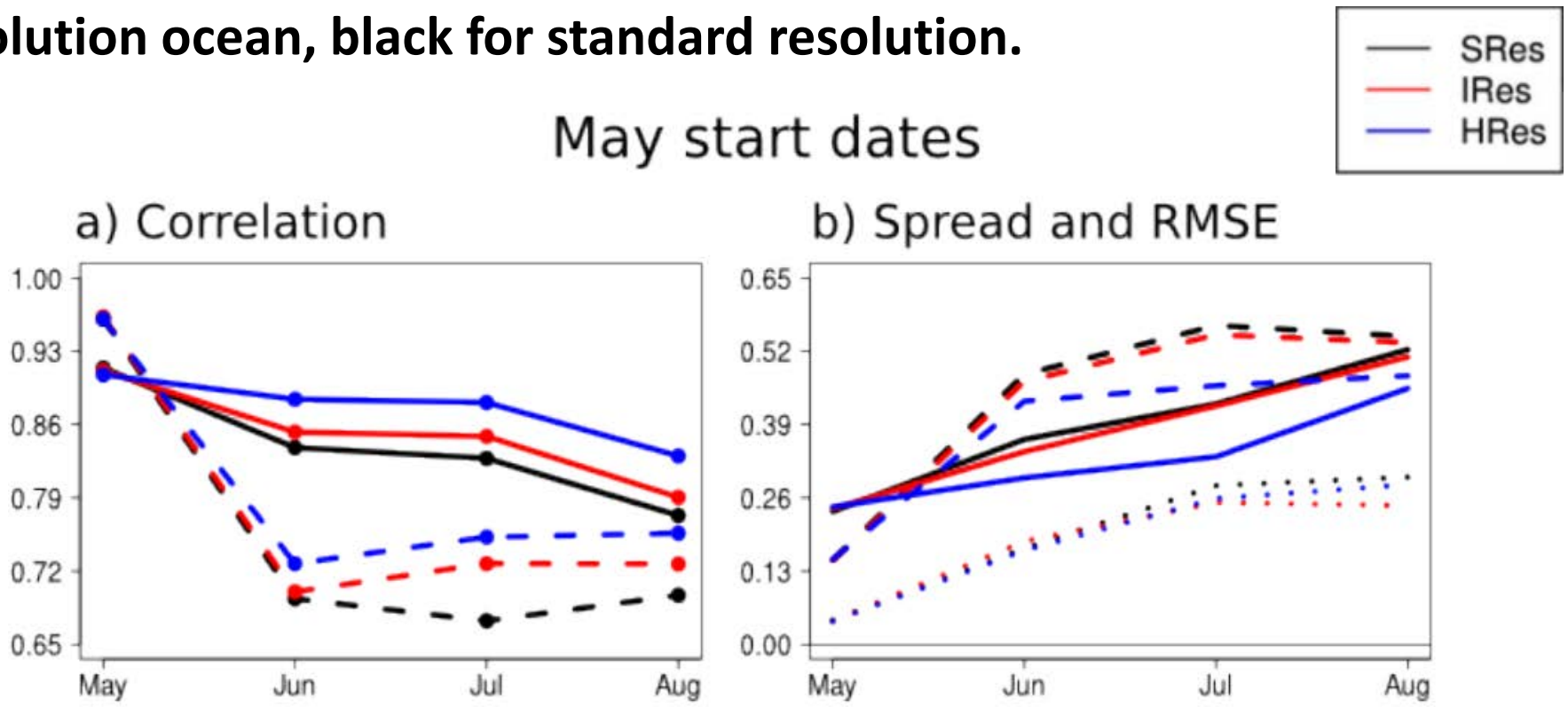
Climate data is not climate information

WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

SPECS: Impact of resolution

Forecast quality from EC-Earth3.1 seasonal hindcasts (1993-2009, Glorys2v1, ERAInt and ERALand initial conditions). Solid for ESA-CCI and dashed for ERSST.

Blue for high resolution ocean and atmosphere, red for high resolution ocean, black for standard resolution.

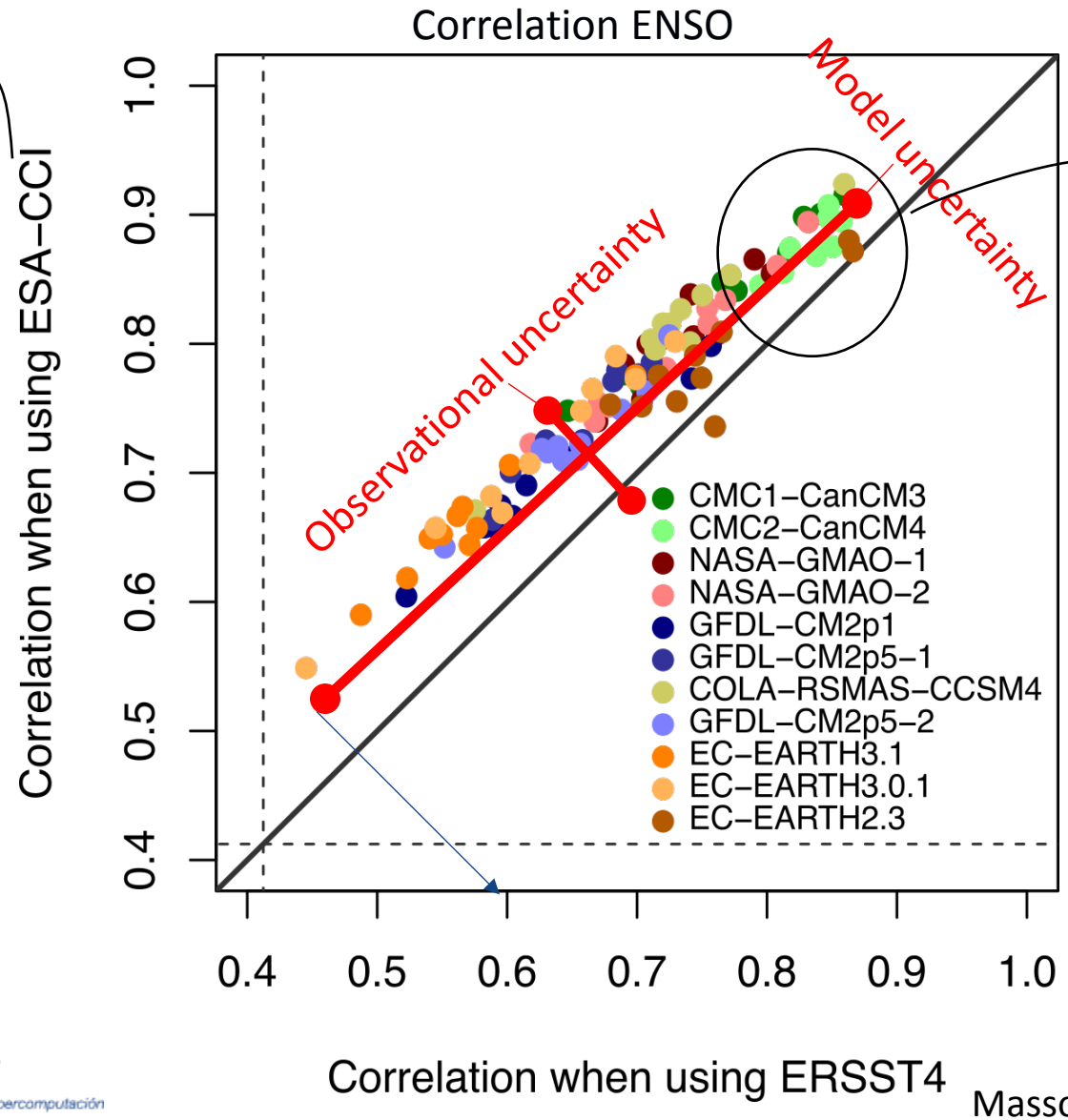


Prodhomme et al. (2016, J. Climate)

SPECS: A new look at model validation

Models can also be used to estimate the quality of observational estimates.

Independent from the models



How important for individual systems?

Massonnet et al. (2016, Science)

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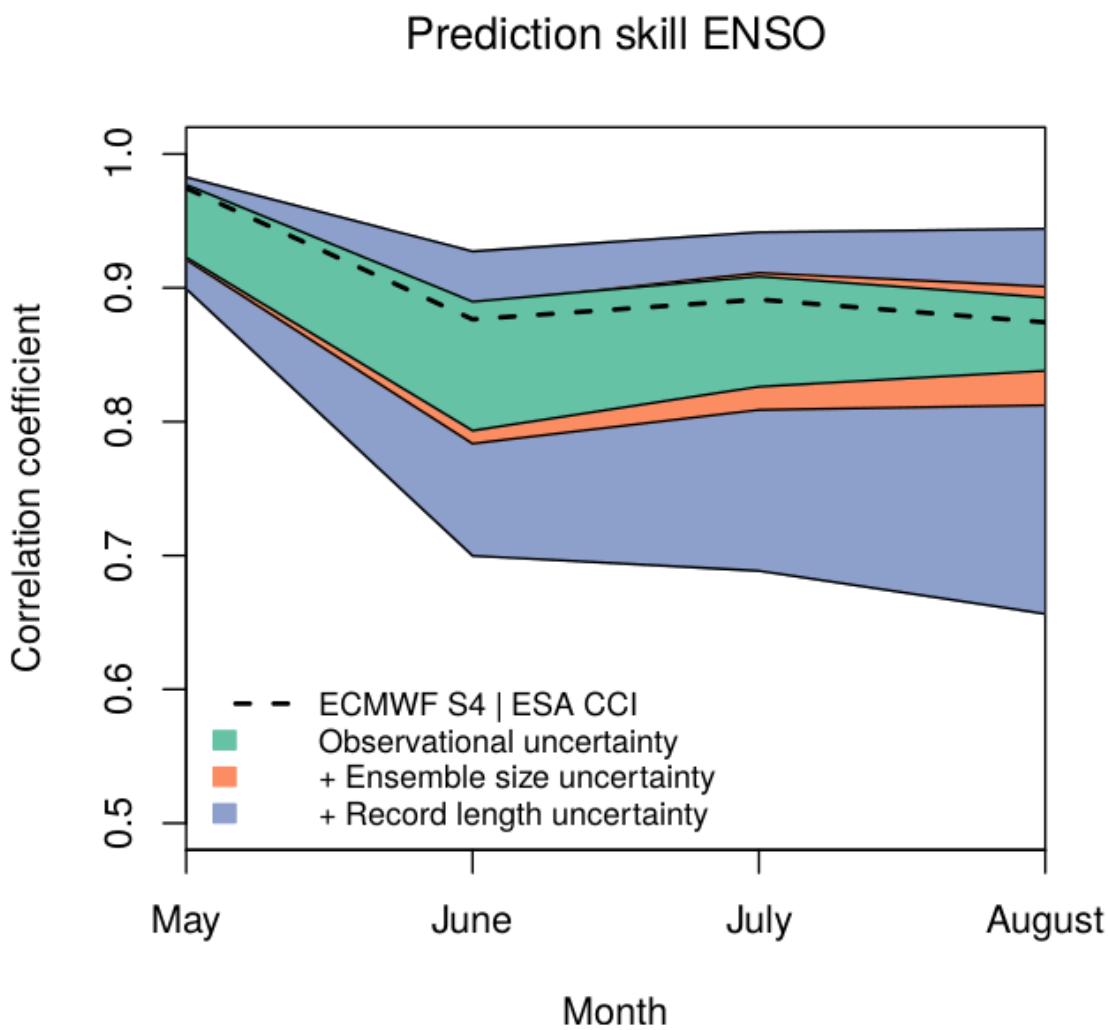
SPECS: Observational uncertainty

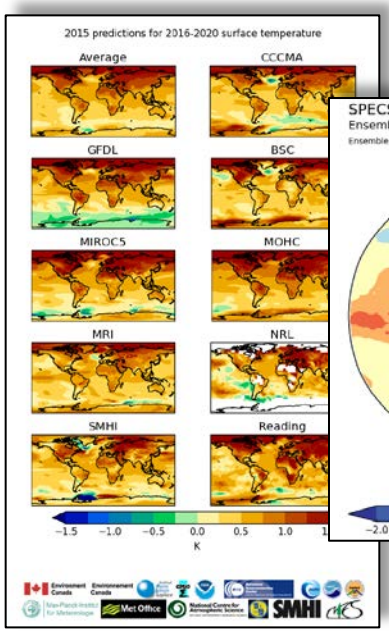
Niño3.4 SST correlation of the ensemble mean for ECMWF System 4 started every May over 1993-2010.

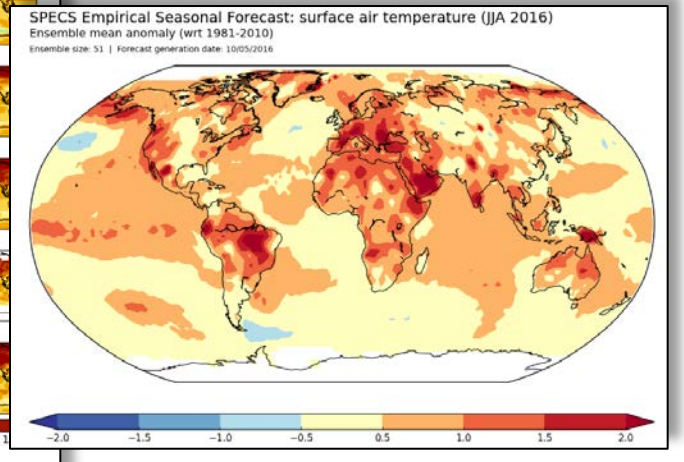


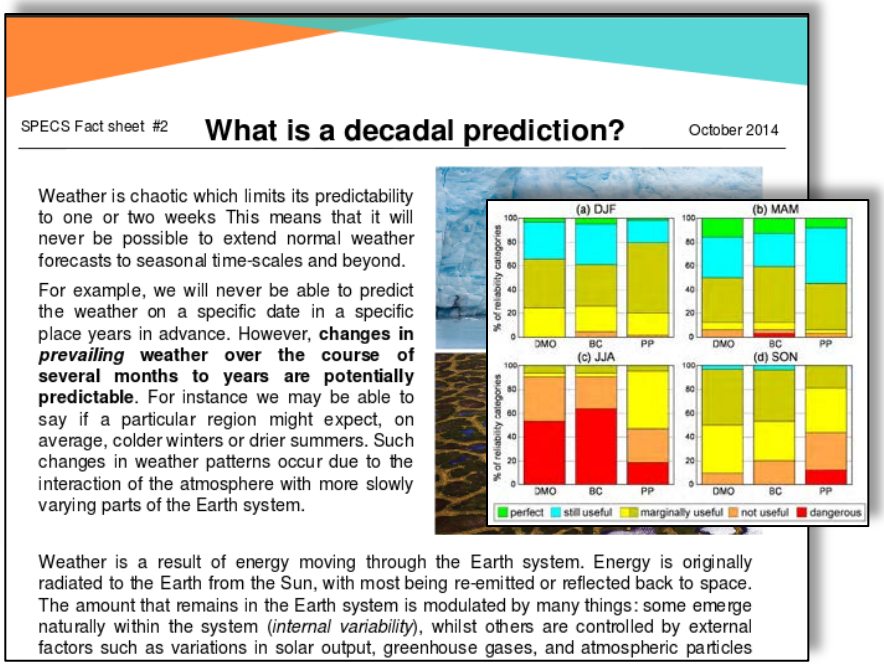
Bellprat et al. (2017, Rem. Sens. Env.)

SPECS: More than better predictions

The operationalisation of decadal forecasts, the creation of robust empirical benchmarks, the exhaustive illustration of the (limited) benefits of downscaling and model combination, the generation of entry-level documentation, and the definition of standards for climate prediction have been rewarding aspects of the project activity







SPECS Fact sheet #2 **What is a decadal prediction?** October 2014

Weather is chaotic which limits its predictability to one or two weeks This means that it will never be possible to extend normal weather forecasts to seasonal time-scales and beyond.

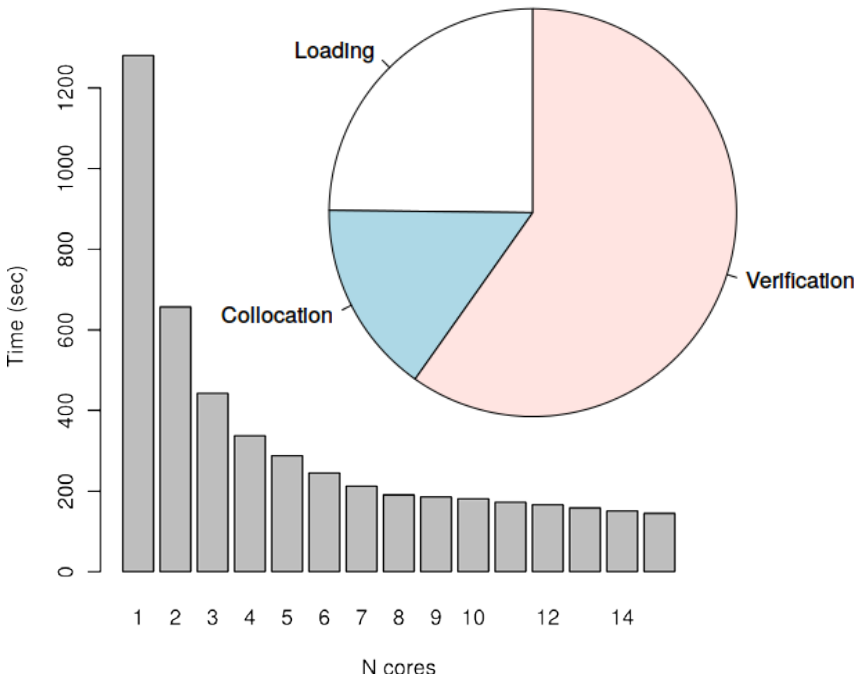
For example, we will never be able to predict the weather on a specific date in a specific place years in advance. However, **changes in *prevailing* weather over the course of several months to years are potentially predictable**. For instance we may be able to say if a particular region might expect, on average, colder winters or drier summers. Such changes in weather patterns occur due to the interaction of the atmosphere with more slowly varying parts of the Earth system.

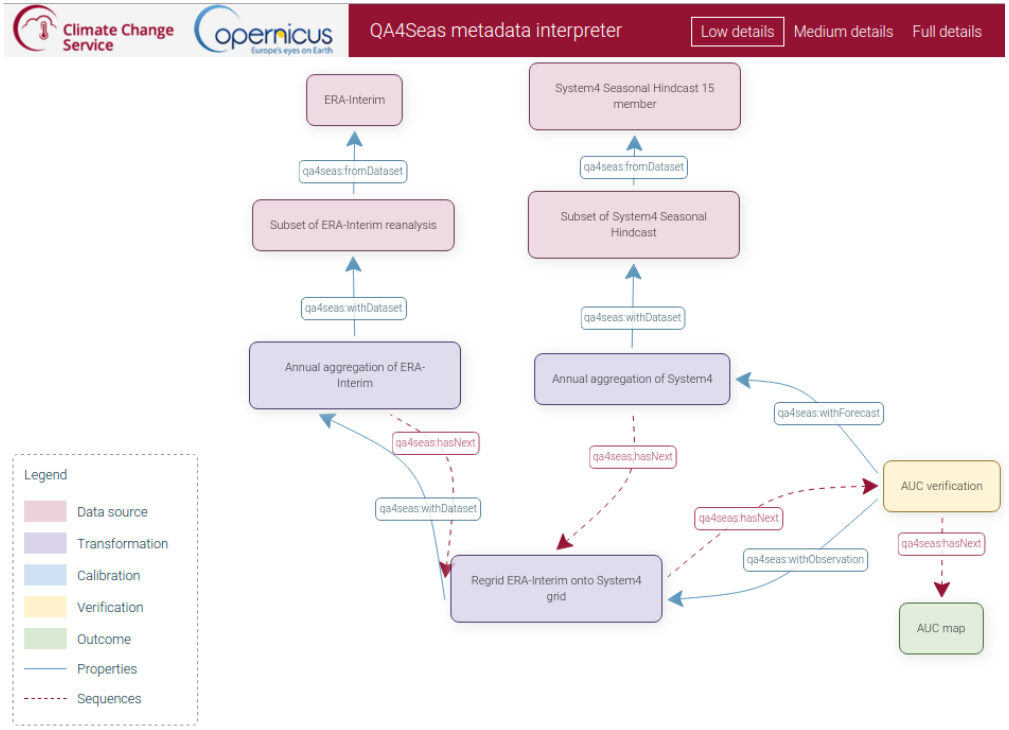
Weather is a result of energy moving through the Earth system. Energy is originally radiated to the Earth from the Sun, with most being re-emitted or reflected back to space. The amount that remains in the Earth system is modulated by many things: some emerge naturally within the system (*internal variability*), whilst others are controlled by external factors such as variations in solar output, greenhouse gases, and atmospheric particles

Multidisciplinarity is fundamental in climate services, and this should include climate modellers and forecasters, which requires profiles that are not readily available

C3S 51 Lot 3 contract (QA4Seas): verification

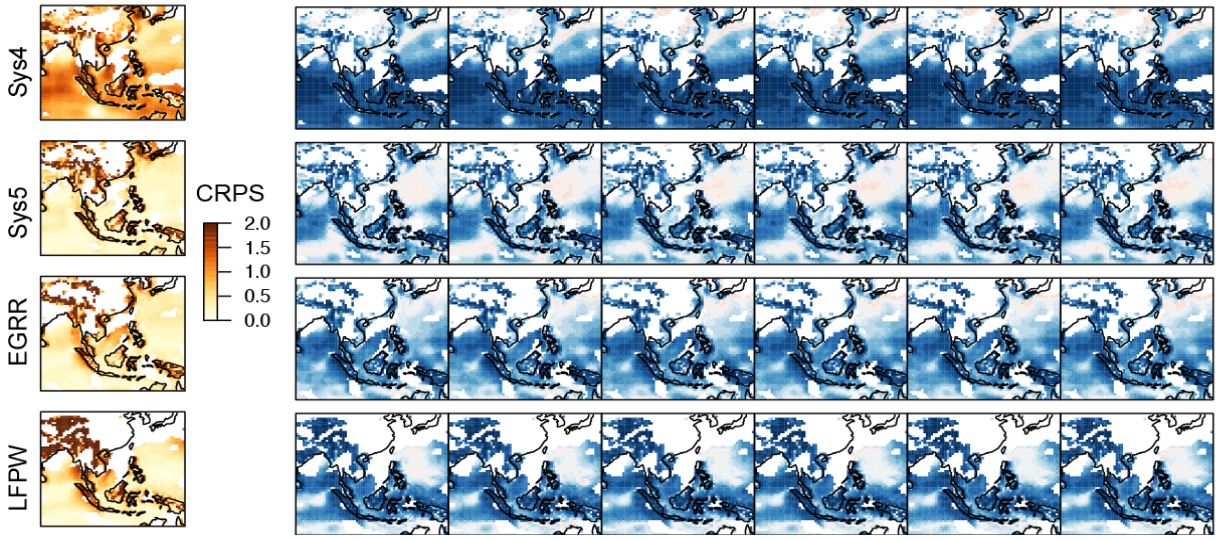
- **Computing performance is key**: (left) scalability of a ROC area estimate using loadeR, SpecsVerification and easyVerification.
- **Provenance**: An RDF-based approach aiming at the reproducibility of objects (NetCDF file, image) with human and machine-readable solution using a semantic metadata model has been created in QA4Seas.

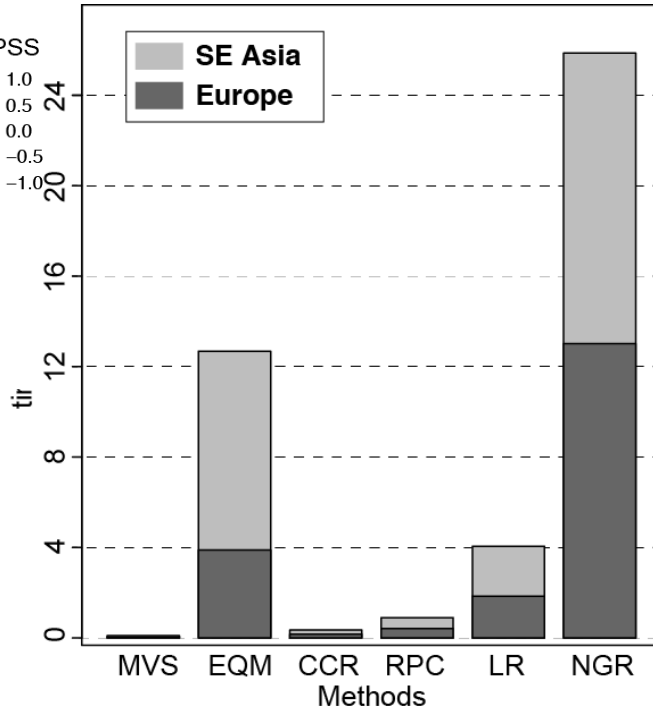




C3S 51 Lot 3 contract (QA4Seas): bias

CRPSS for near-surface temperature over South Asia in DJF from applying six different re-calibration methods (one per column) to four C3S forecast systems. For comparison purposes, the CRPS obtained for the raw model output is shown on the left.

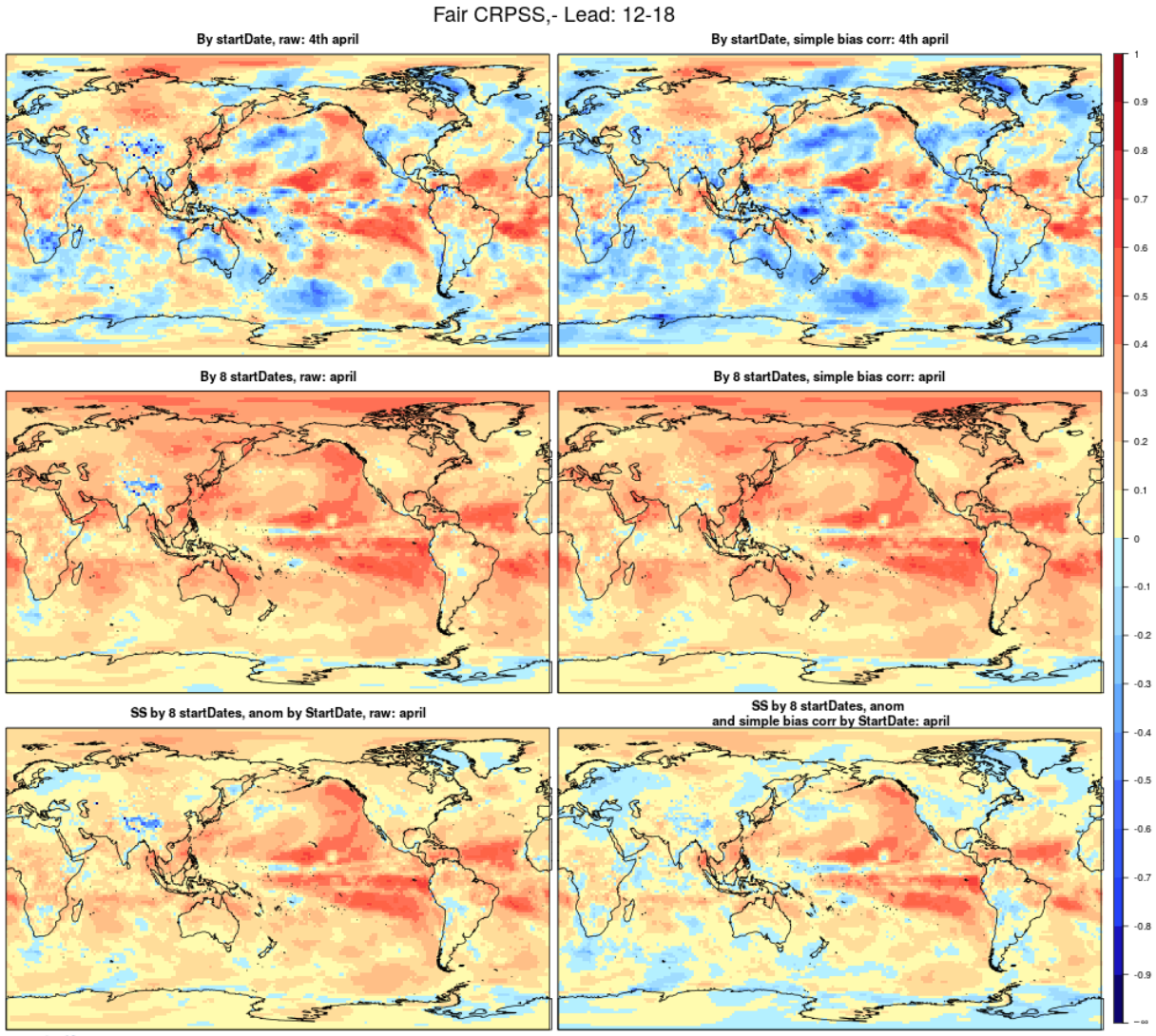




Manzanas et al. (2018)

More on bias correction: S2S

Fair CRPSS for the April monthly ECMWF forecasts (2016 vintage) of near-surface temperature from raw and bias-adjusted data.



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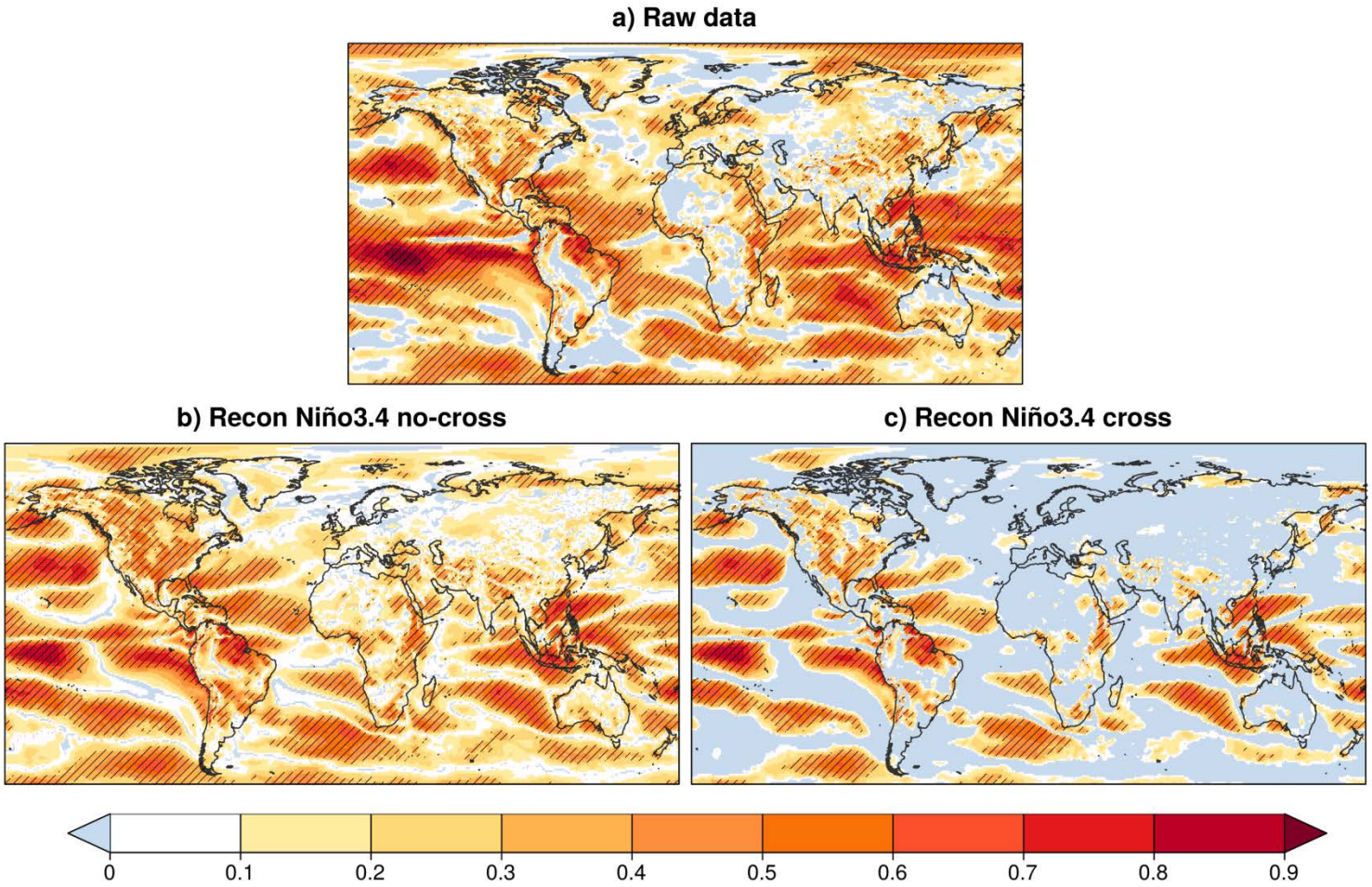
A. Manrique (BSC)

And more on postprocessing: reconstruction

Correlation of the ensemble-mean prediction of wind speed for DJF (one-month lead time) from ECMWF S4 for raw and reconstructed data using the Niño3.4 time series.



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V. Torralba (BSC)

EUCP: from decadal prediction 2 projections

- European Climate Prediction system (EUCP): 4 years (Dec 2017-Nov 2021), 16 partners, Met Office lead
- Objectives:
  - Develop an innovative ensemble climate prediction system based on high-resolution climate models for Europe for the near-term (1-40 years), including methods to characterise **uncertainty in climate predictions, downscaling, and evaluation against observations**.
  - Use the **climate prediction system to produce consistent, authoritative and actionable climate information**. This information will be co-designed with users to constitute a robust foundation for Europe-wide climate service activities to support climate-related risk assessments and climate change adaptation programmes.
  - Demonstrate the value of this climate prediction system through high impact extreme weather events in the near past and near future drawing on convection permitting regional climate models.
  - Develop, and publish, methodologies, good practice and guidance for producing and using **authoritative climate predictions for 1-40 year timescale**.