4 December 2020

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EXCELENCIA SEVERO OCHOA

# Climate forecasting

**Francisco J. Doblas-Reyes**
with contributions from Joaquín Bedia, Nicola Cortesi, Nube González, Carlo Lacagnina, Llorenç Lledó, Raül Marcos, Núria Pérez, Jaume Ramón, Albert Soret, Marta Terrado, Verónica Torralba, Ilaria Vigo and many more

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S2S4E Climate Services for Clean Energy

EUCP European Climate Prediction system

ICREA

# Climate and renewable energy

Renewable energy is growing fast to decarbonize the energy system.

Both energy supply and demand are strongly influenced by atmospheric conditions and its evolution over time in terms of climate variability and change.


Like 15M

Thursday, Aug 30th 2018 1PM 25°C 4PM 26°C 5-Day Forecast

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**Britain's turbines are producing 40% less energy as wind 'disappears' for six weeks across the UK causing record low electricity production**

- Britain got 15 per cent of its power from wind last year — twice as much as coal
- Since the start of June, wind farms have been producing almost no electricity
- The 'wind drought' has seen July 2018 be 40% less productive than July 2017
- In the still weather, solar energy has increased by 10% to help cover the drop-off

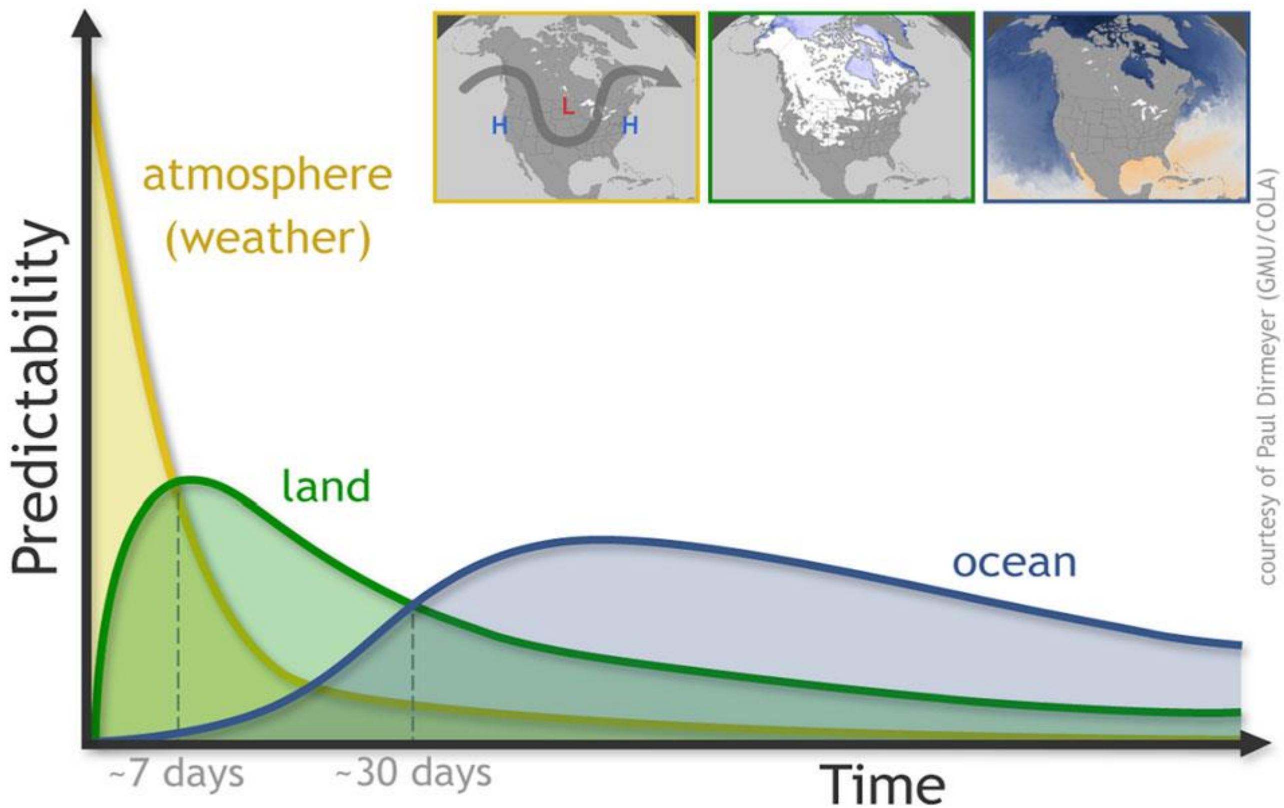
By JOE PINKSTONE FOR MAILONLINE

**PUBLISHED:** 15:48 BST, 18 July 2018 | **UPDATED:** 17:29 BST, 18 July 2018

# Predictability sources for weather and climate

Processes of the different components of the climate system act as predictability sources depending on the time scale.

Converting predictability (the possibility of predicting) into actual forecast skill (the ability to predict) is not a trivial task.

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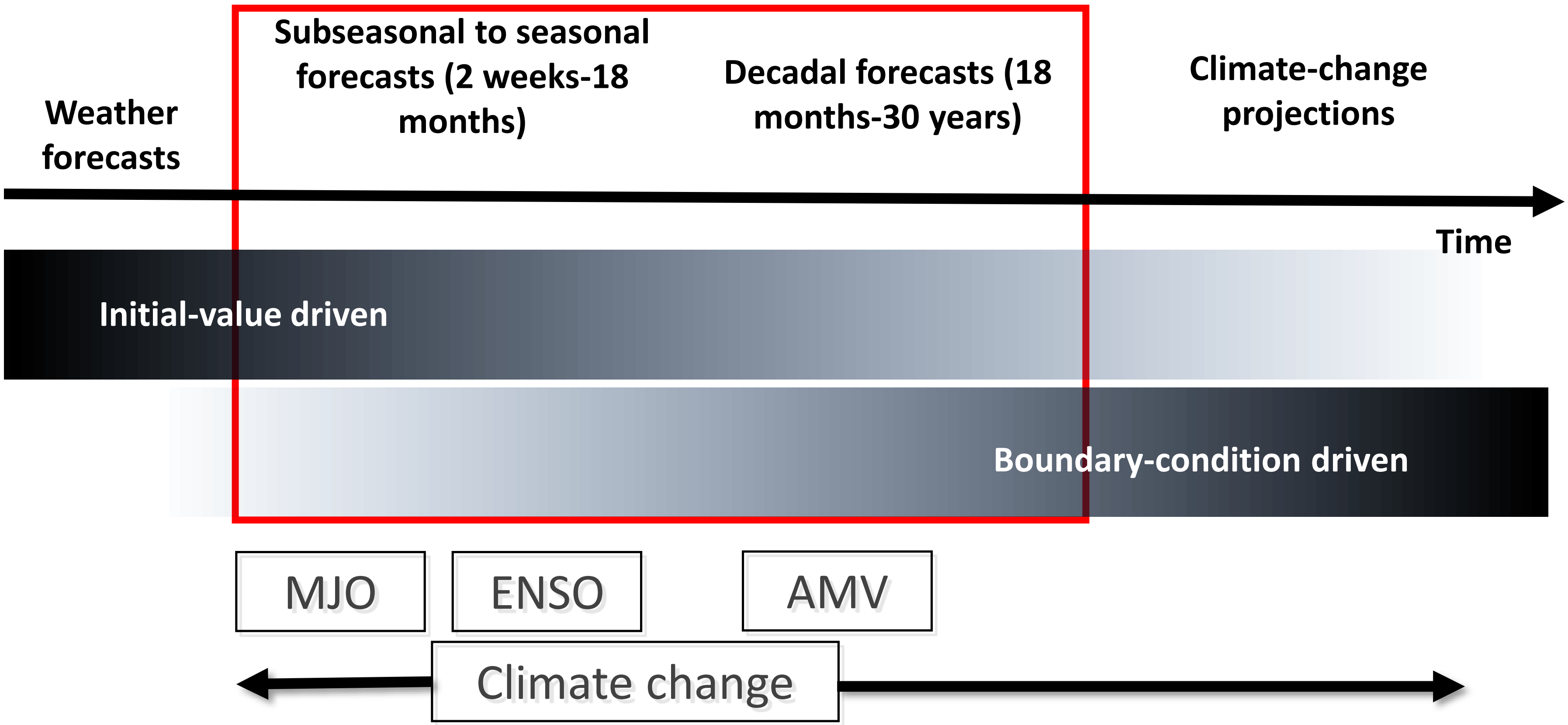
# Climate time scales

Observations, process-based or dynamical forecast systems, empirical models, process understanding, are all key pieces to build climate forecasts.

Dynamical forecast systems are used as the standard, but it is reductionist.

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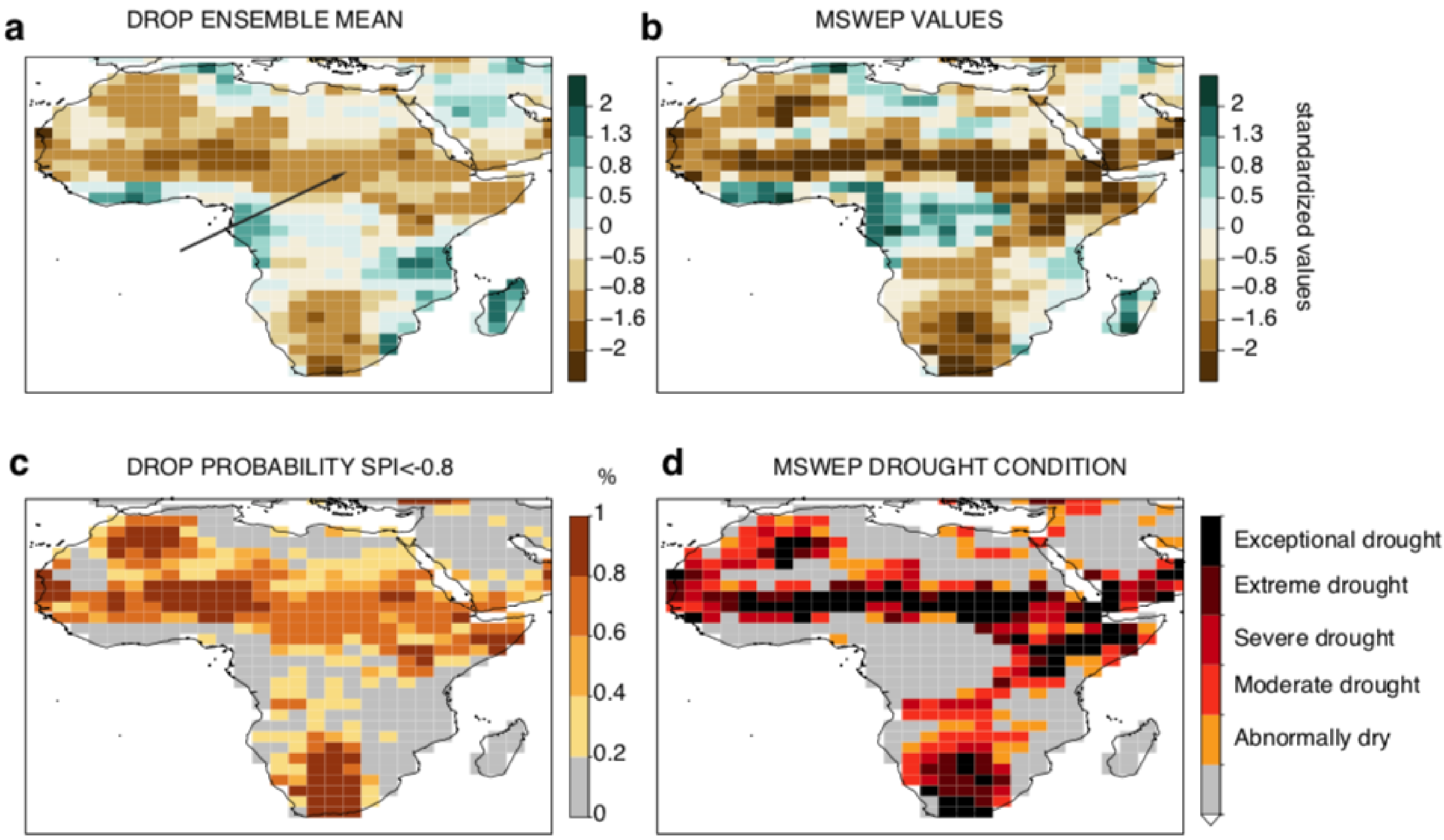
Adapted from Meehl et al. (2009)

# A non-exhaustive list of relevant elements

- Observational uncertainty: comparison between reanalyses/observations in a forecast production and verification context.
- Definition of standard procedures: standards are less common than one would expect.
- Traceability and quality control: quality control and reproducibility of data and products is increasingly important in the research community, but their operational aspects are not solved yet.
- User indicators: indicators do not have the same level of skill as the meteorological variables.
- Interpretation and communication: users are often not experts, and even when they are it is easy to misunderstand the existing information. Communication is a challenge
- Synthesis and narratives: how to deal with multiple lines of evidence in the message constructions.

# Monitoring is key: what we want to predict

Multisource observational estimates of drought using SPEI12 for 1984. Note the probabilistic observational estimates of drought.

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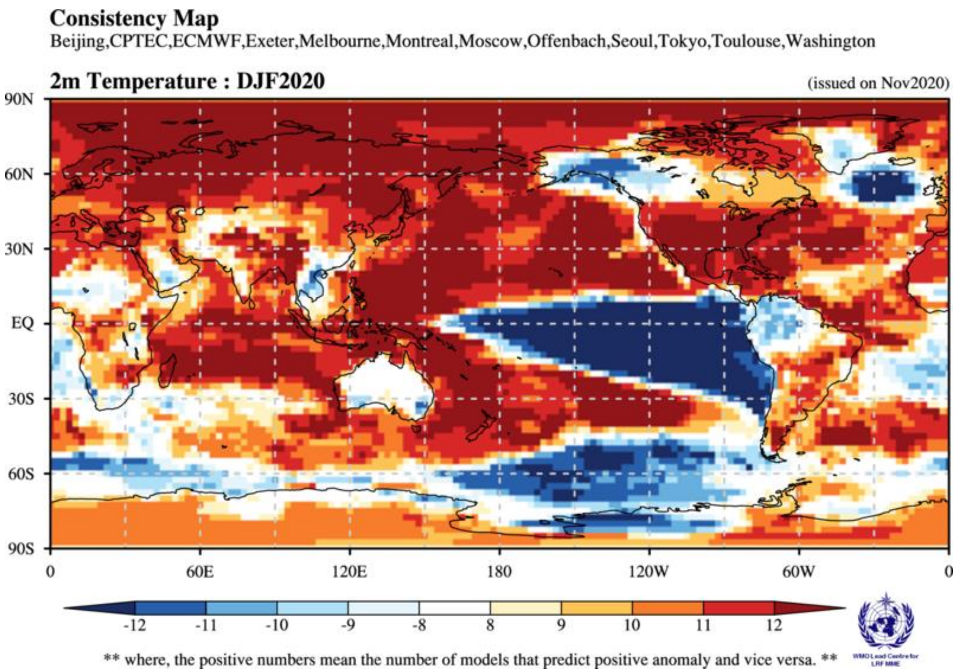
Turco et al. (2019, BAMS)

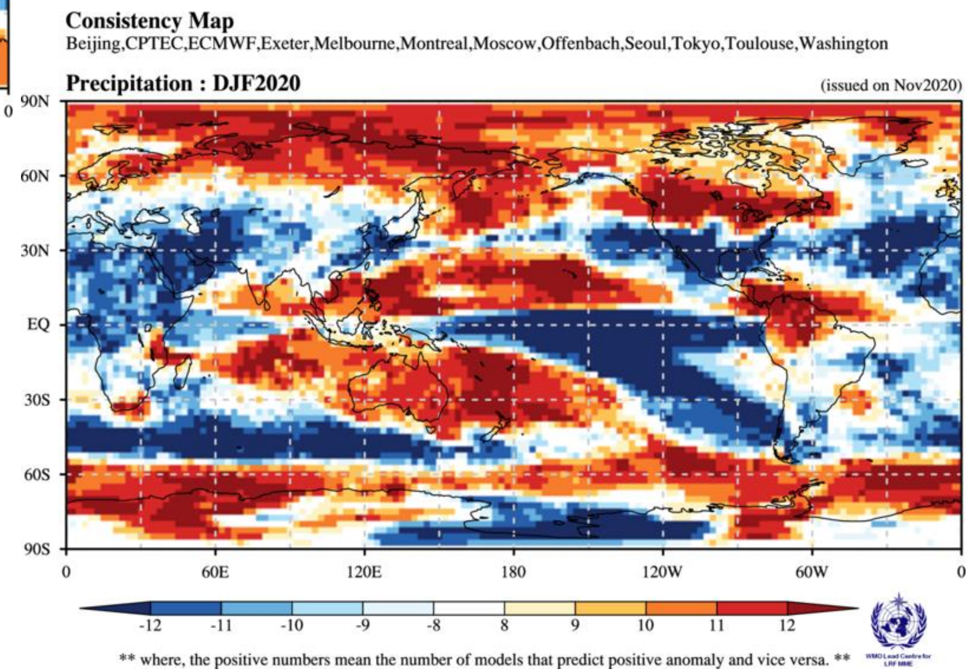
# Forecast products and their quality

The prediction process follows a series of steps:

- Formulate a prediction (a product) from the output of a forecast system. The exact definition of the product is very important.
- Select the verification metrics of the product that allow us to adequately represent the attributes of interest and an observational reference.
- Choose a comparison forecast reference that provides a reference level (persistence, climatology or a previous forecast system).
- A prediction is of high quality if it predicts the conditions observed according to some objective criterion better than a reference forecast.
- The prediction has value if it helps the user to obtain some kind of benefit from the decisions he has to make.
- Note that the forecast quality is valid for a specific forecast product. Different products from the same forecast system will show different forecast quality.

# Users often look for forecast products online

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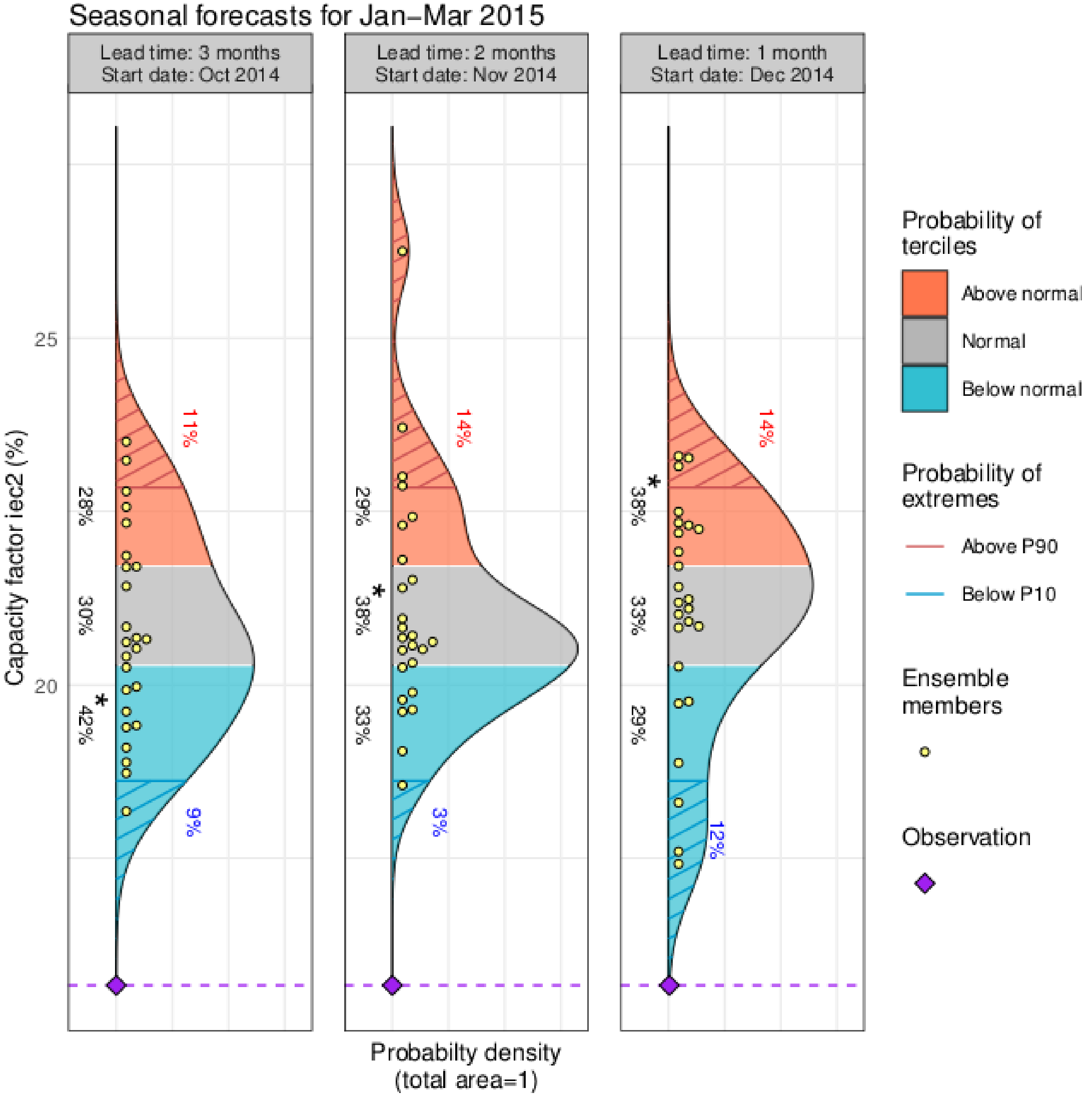
WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble

# What does a targeted prediction look like?




Seasonal predictions of DJF capacity factor over North America (124-95ºW, 26-44ºN) starting on the first of October, November and December for the first trimester of 2015, ECMWF SEAS5, reanalysis: ERA-Interim, hindcasts over 1993-2015.

| | Oct | Nov | Dec |
|---|---|---|---|
| *RPSS* | 0.23 | 0.25 | 0.24 |
| *BS P10* | –0.18 | –0.23 | –0.16 |
| *BS P90* | 0.06 | 0 | 0.03 |
| *CRPSS* | 0.11 | 0.08 | 0.08 |
| *EnsCorr* | 0.5 | 0.45 | 0.42 |

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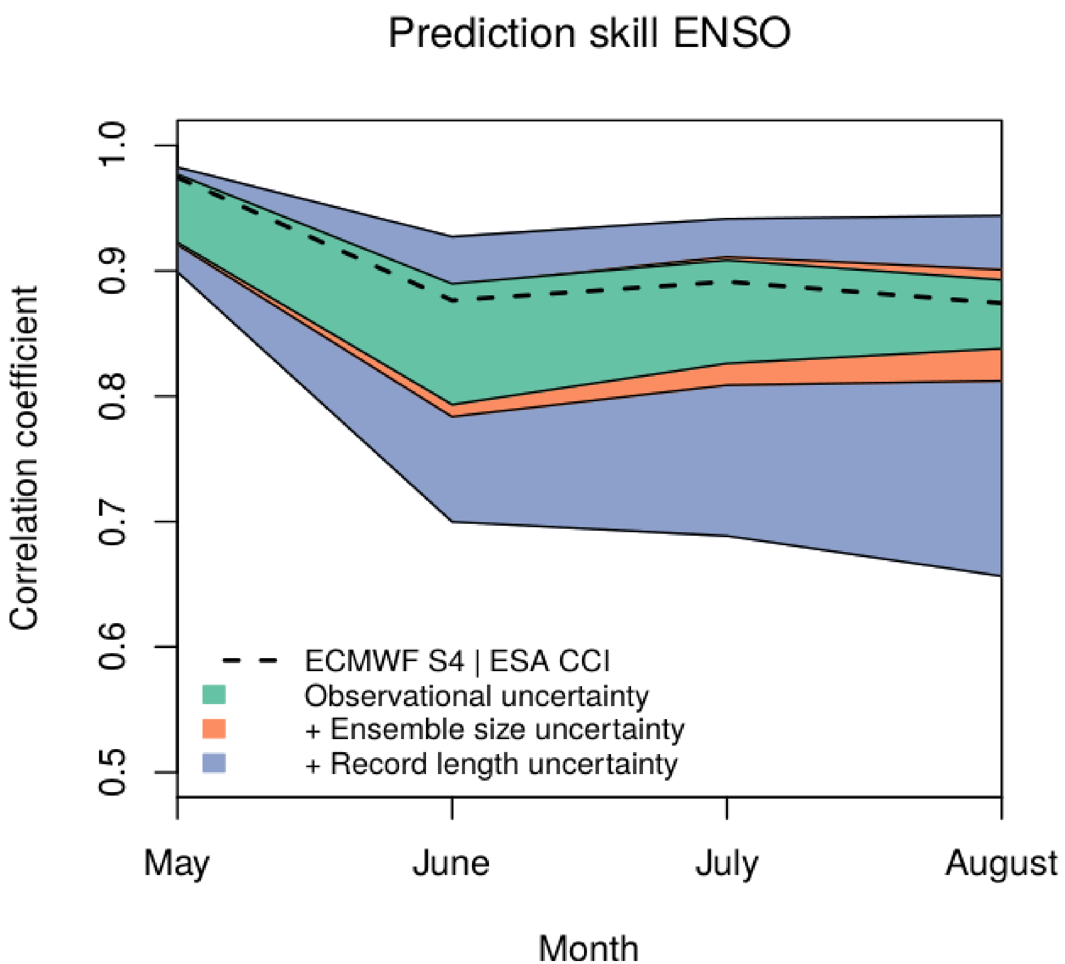
L. Lledó

# Sources of uncertainty of forecast quality

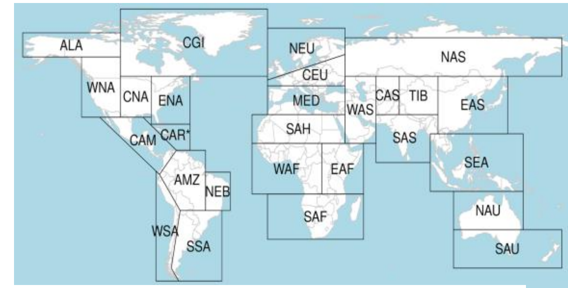
Niño3.4 SST correlation of the ensemble mean for EC-Earth3.1 (T511/ORCA025) predictions with ERAInt and GLORYS2v1 initial conditions, and BSC sea-ice reconstruction started every May over 1993-2009.



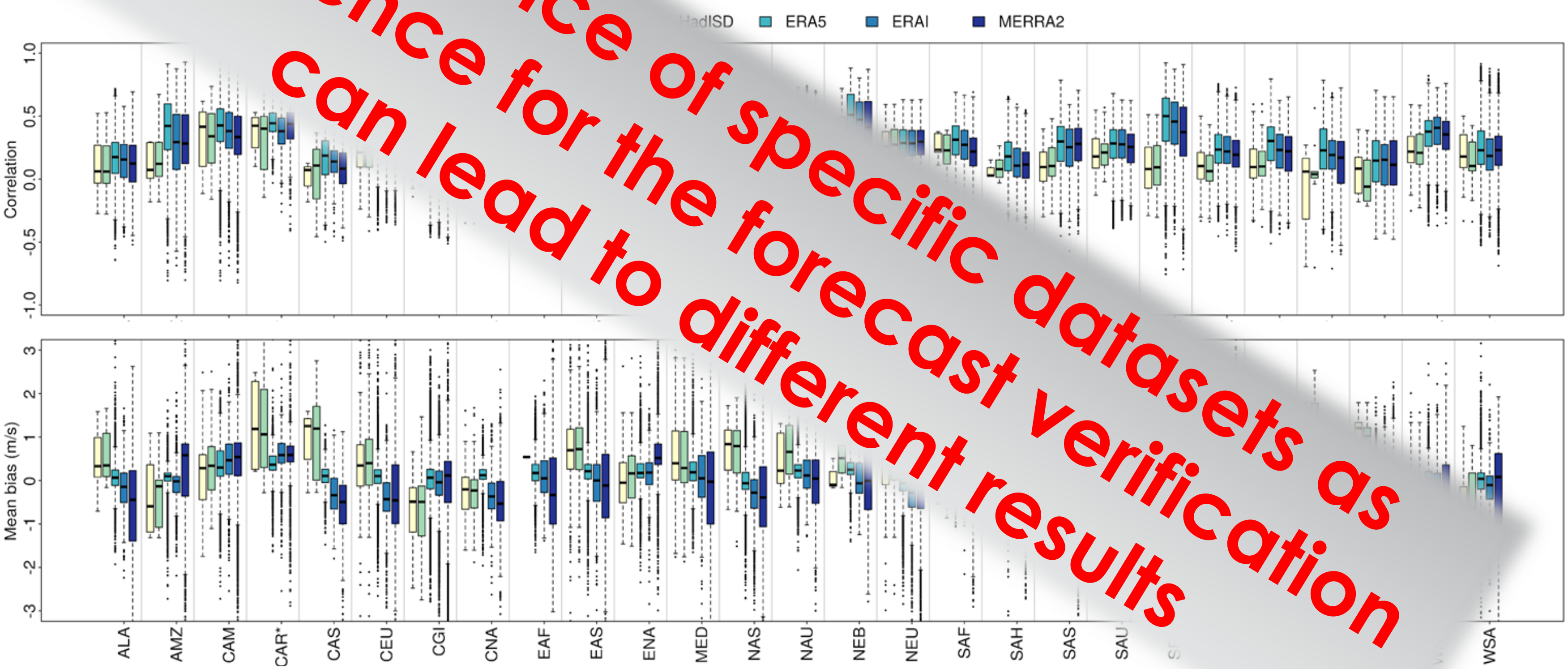

Bellprat et al. (2017, Rem. Sens. Env.)

# Observational uncertainty in verification

Verification using two ground-based observational datasets a ... ee reanalyses. The use of both types of datas ... formative for wind energy users as the ... he development of impact mod ... ource assessments.




**The choice of specific datasets as reference for the forecast verification can lead to different results**




ECMWF SEAS5 Period: 1981-2016
Season: DJF Start date: 1st Nov

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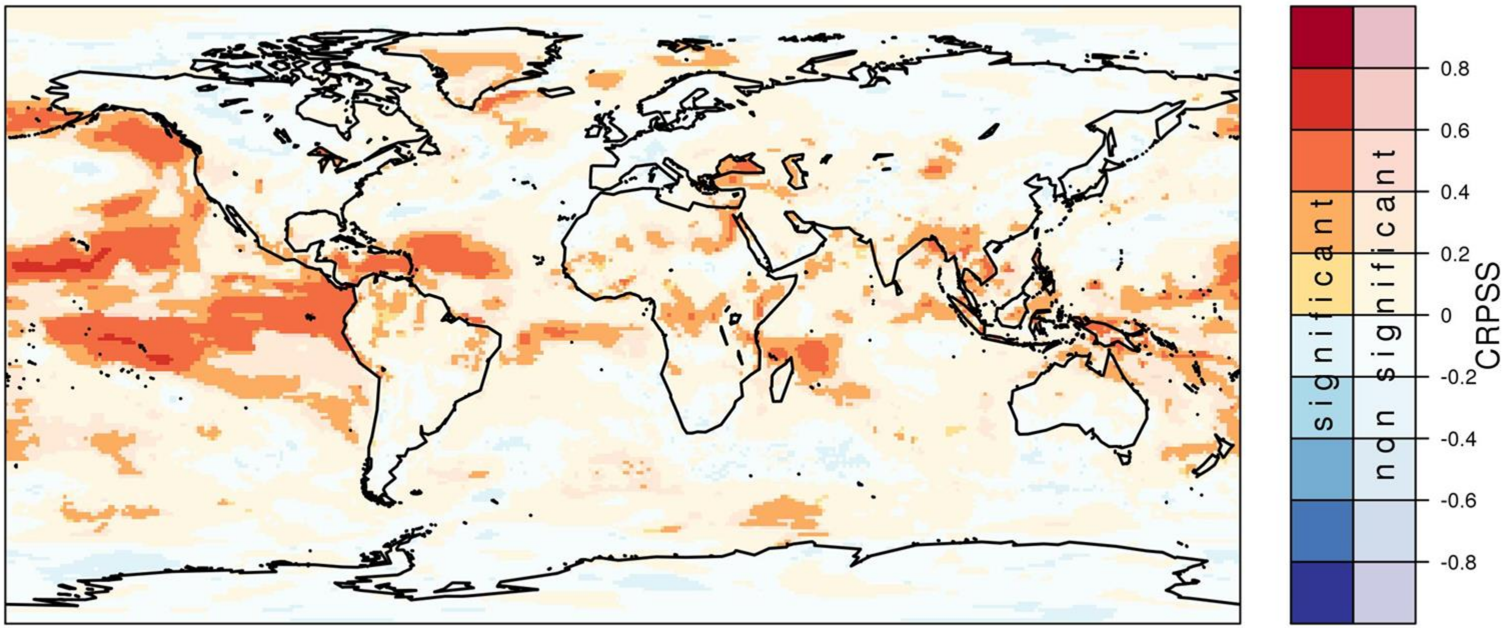
# Bias adjustment, multi-model

- Bias adjustment and calibration
  - All bias adjustment and recalibration methods effectively remove bias
  - Added value of sophisticated methods (e.g. EMOS) 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

Skill of JJA temperature from ECMWF SEAS5 + recalibration: CRPSs of JJA near-surface temperature from ECMWF SEAS 5 initialized in May, calibrated with the climate-conserving recalibration (CCR) and verified against ERA Interim for 1993-2014.




**Better**

**than constant climatological forecast**

**Worse**

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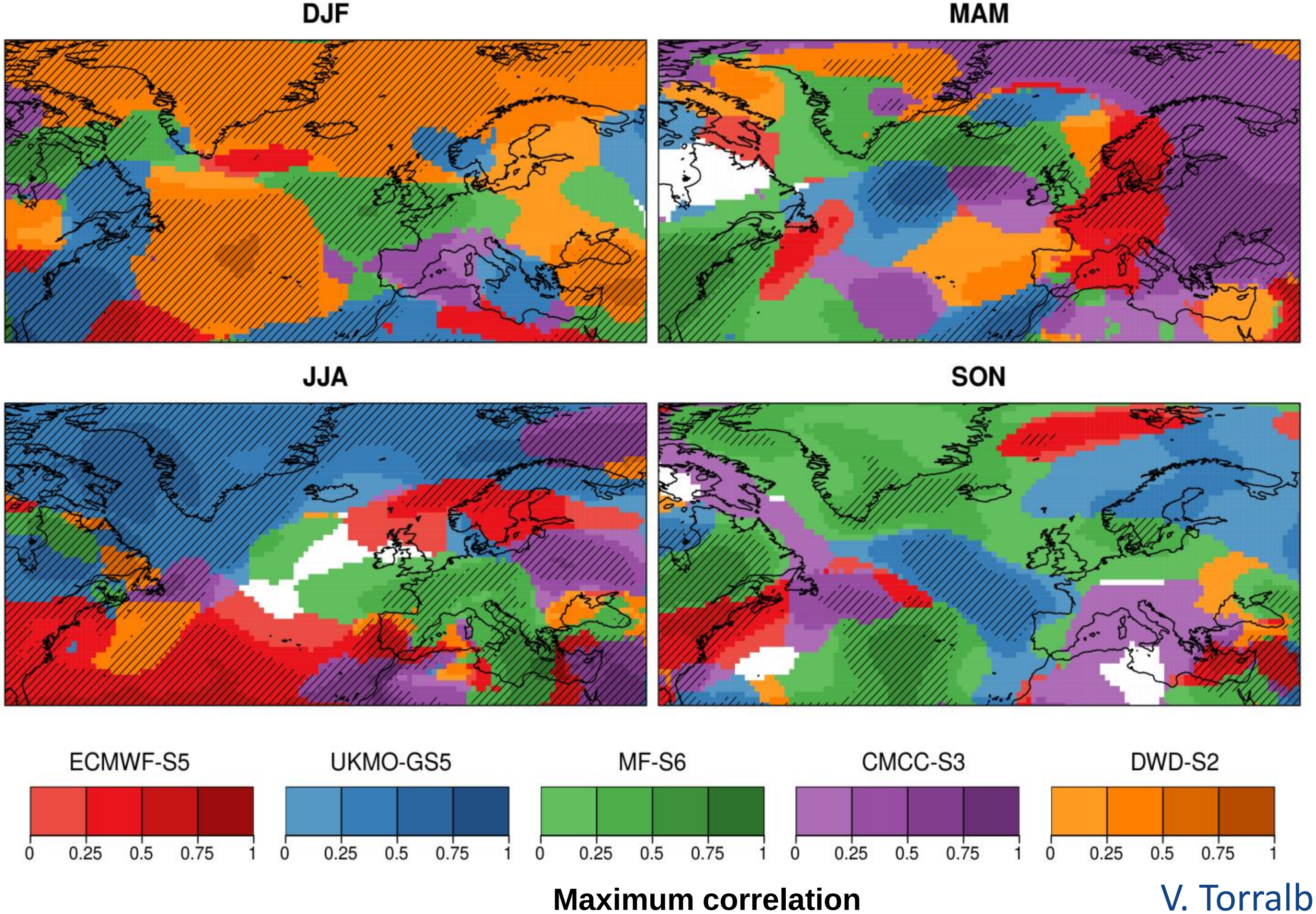
Hemri et al. (2019, Clim. Dyn.)

# Multi-model and forecast quality

The systematic evaluation and intercomparison of different seasonal forecast systems is essential for the generation of a robust forecast product that is delivered in an operational climate service. This is a simple way to combine information from different systems to guide users about the potential of different seasonal forecast systems.

Period: 1993-2016
Season: DJF
Start date: 1st Nov, Feb, May, Aug
Reference: ERA5
Variable : Sea level pressure

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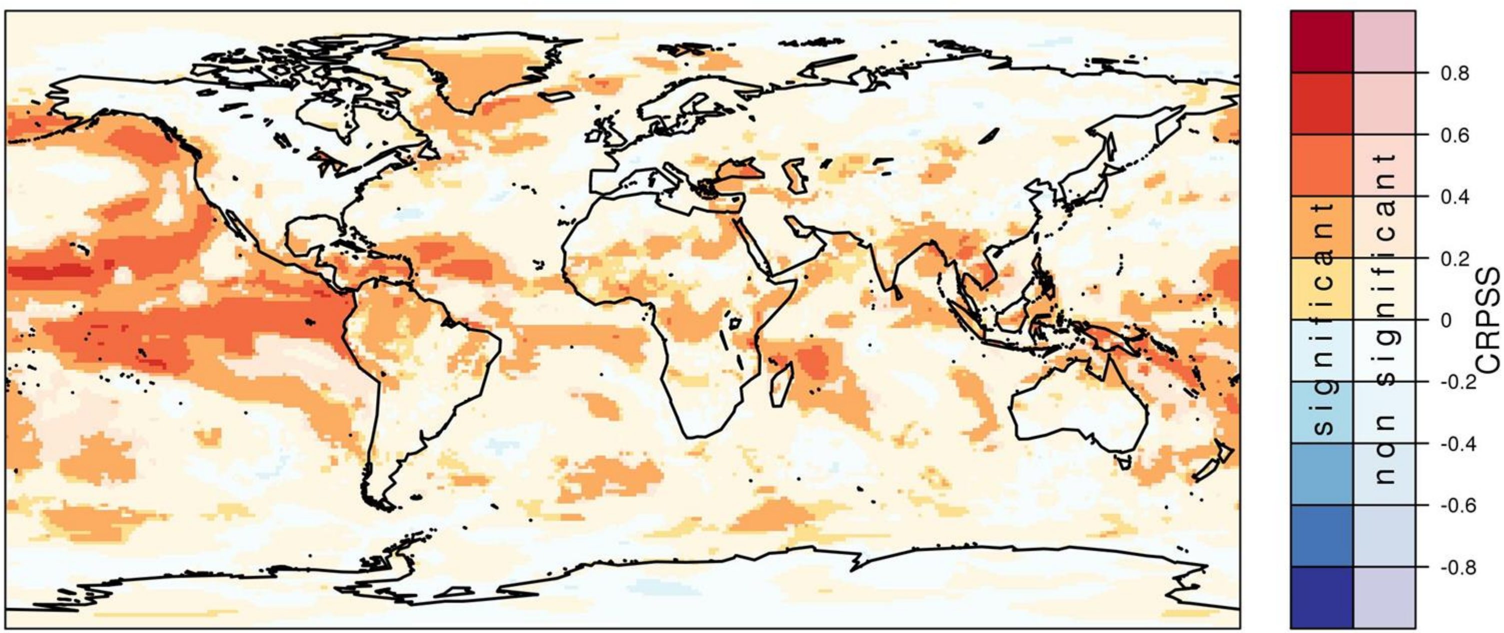
# Multi-model and forecast quality

CRPSS of JJA temperature from ECMWF SEAS 5, Météo-France System 5, MetOffice GloSea5, initialized in May, all systems recalibrated with CCR and weighted (RMSE) averaging of forecast PDF and verified against ERA Interim for 1993-2014.

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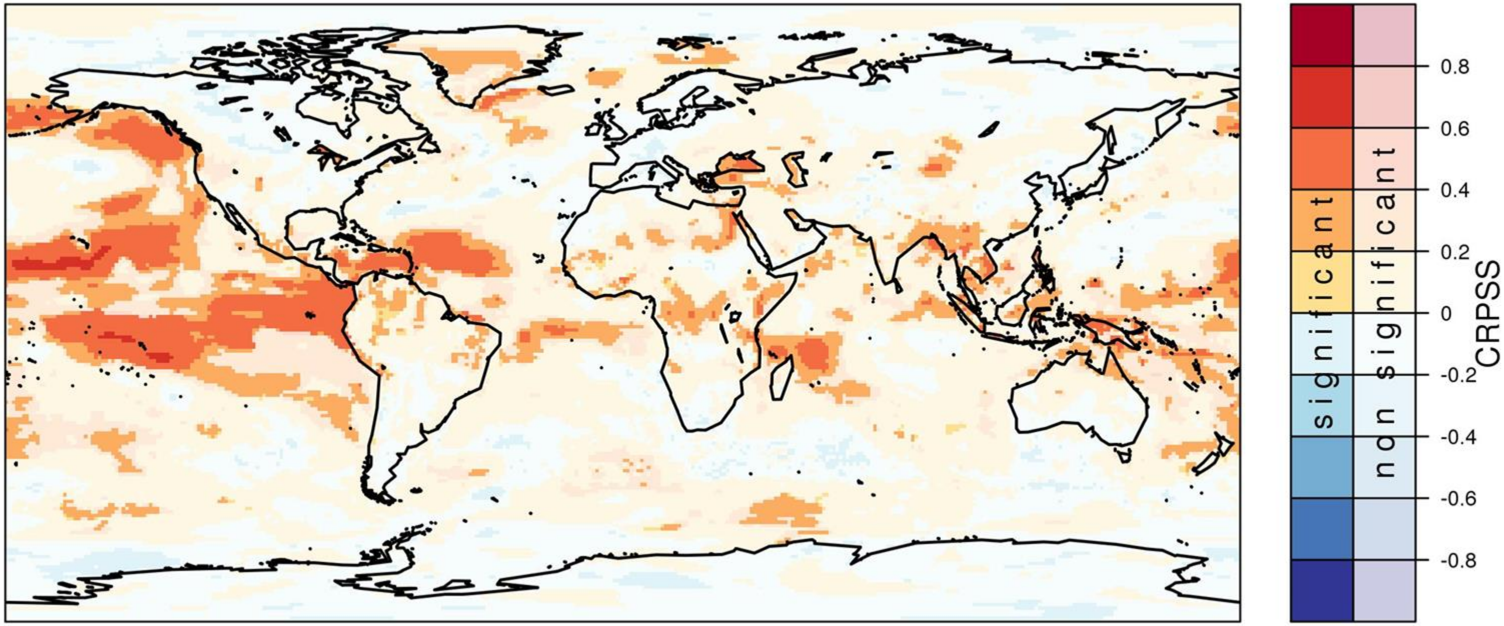


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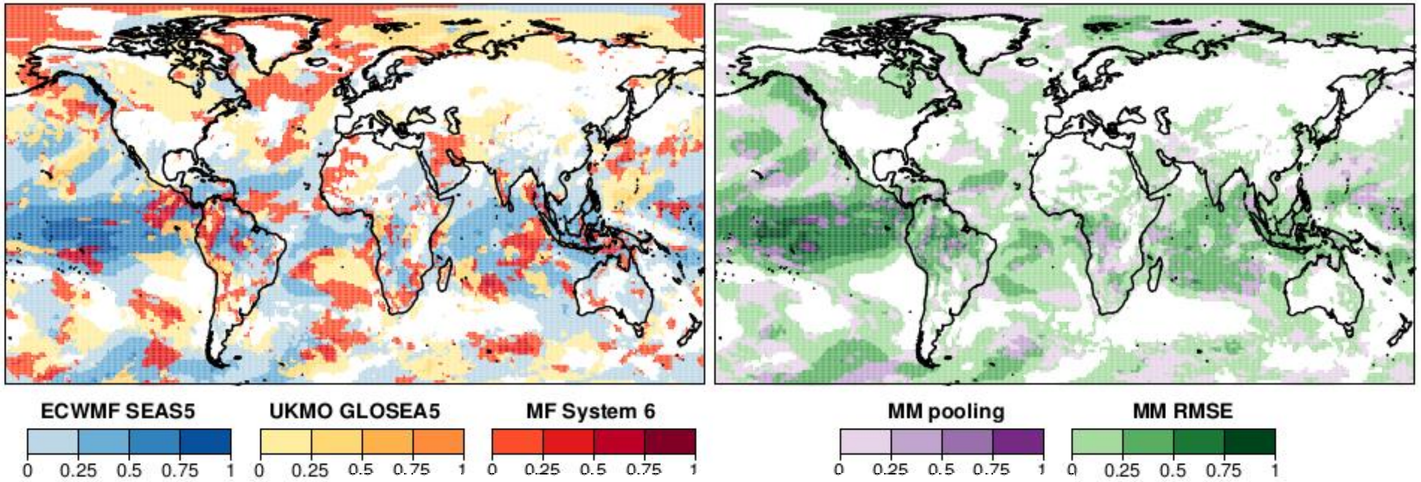
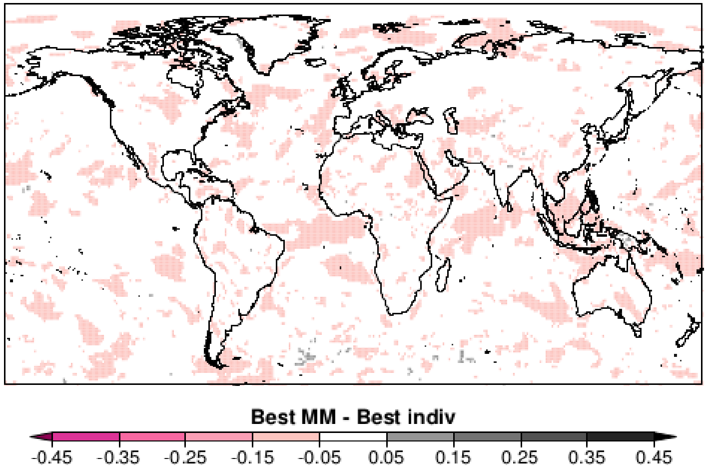
Hemri et al. (2019, Clim. Dyn.)

# Multi-model climate prediction

However, users do not always understand why multi-model is the preferable option.

CRPSS of DJF two-metre temperature for C3S forecasts initialized in November, all systems bias adjusted (MVA) compared to a simple and weighted multi-model (as inverse function of RMSE). Bottom gain of the best multi-model with respect to the best single system. Verified against ERA Interim for 1993-2015.

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# Always consider: climate information requirements

- Salience: *It refers to the relevance of information for an actor's decision choices*. Often interesting scientific questions are far from a real-world situation.
- Credibility: *It refers to whether an actor perceives information as meeting standards of scientific plausibility and technical adequacy*. Sources must be trustworthy and/or technically believable.
- Legitimacy: *It refers to whether an actor perceives the climate information process as unbiased and meeting standards of political and procedural fairness*. The information should be unbiased.

Power

Reputation

Values

Transparency

Standards

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Cash et al. (2003, PNAS)