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EXCELENCIA SEVERO OCHOA

Seasonal climate prediction: forecast quality and multi-model combination

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ICREA

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S2S4E Climate Services for Clean Energy

Copernicus Europe's eyes on Earth

Climate Change Service

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.

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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

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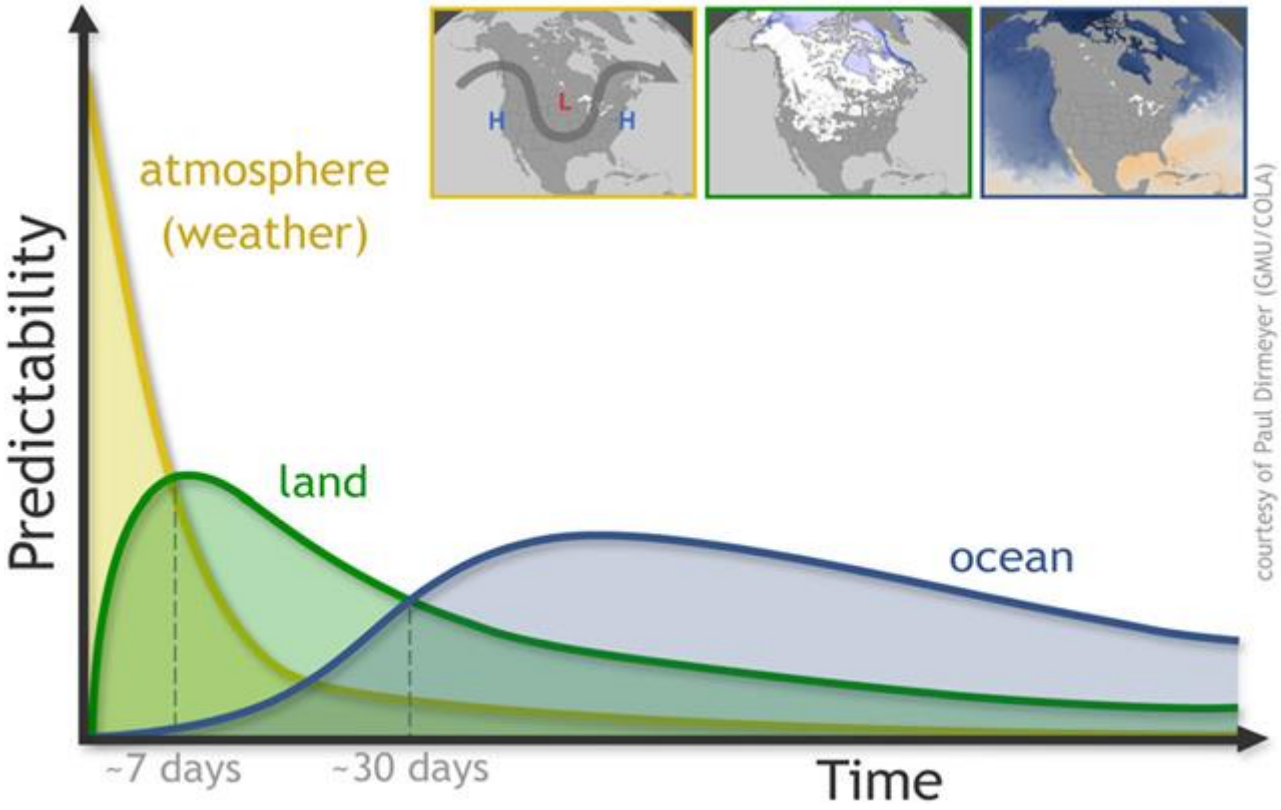
Predictability sources

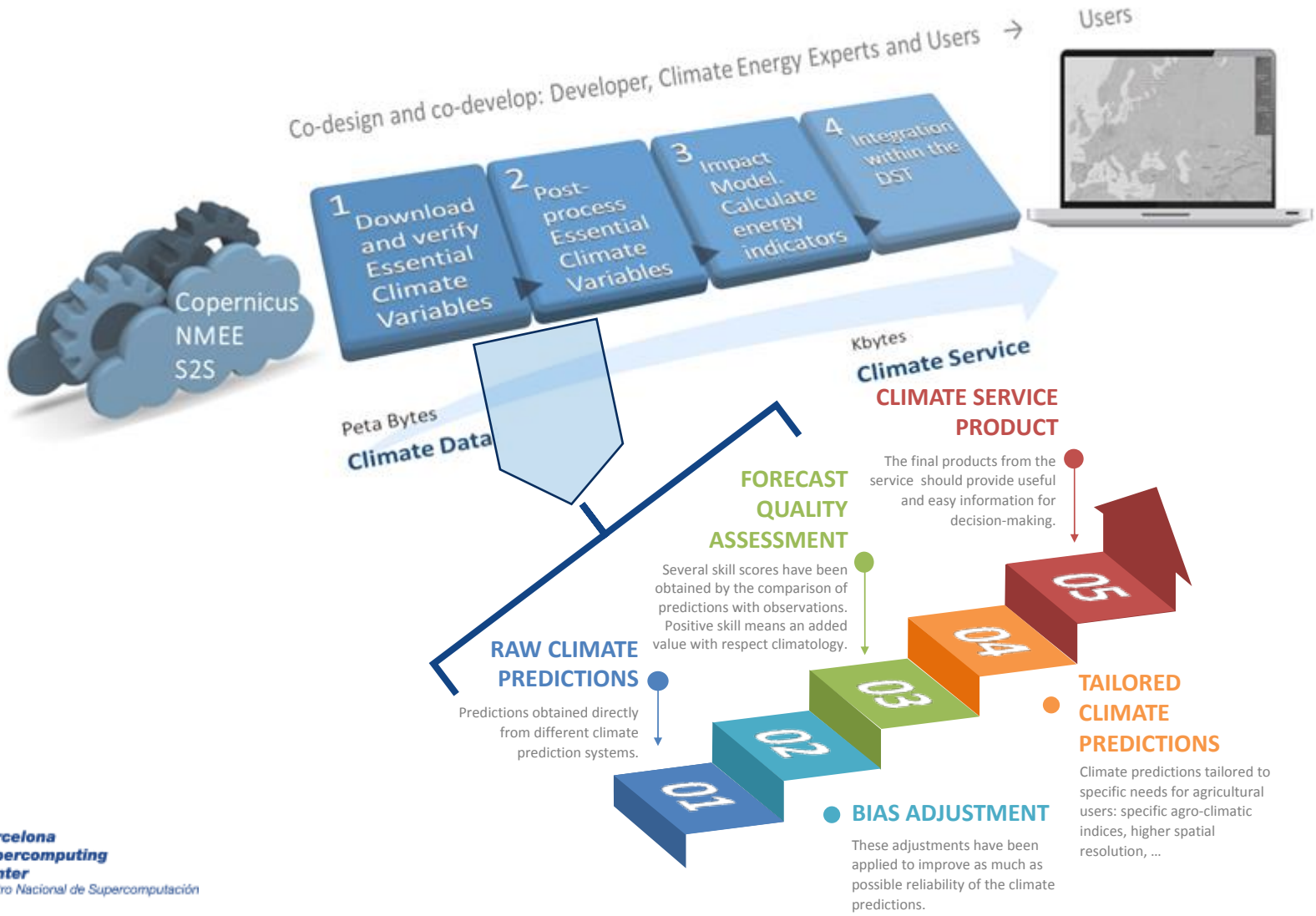
Different components of the climate system act as predictability sources depending on the time scale.

However, converting predictability into actual forecast ability (skill) is not a trivial task.

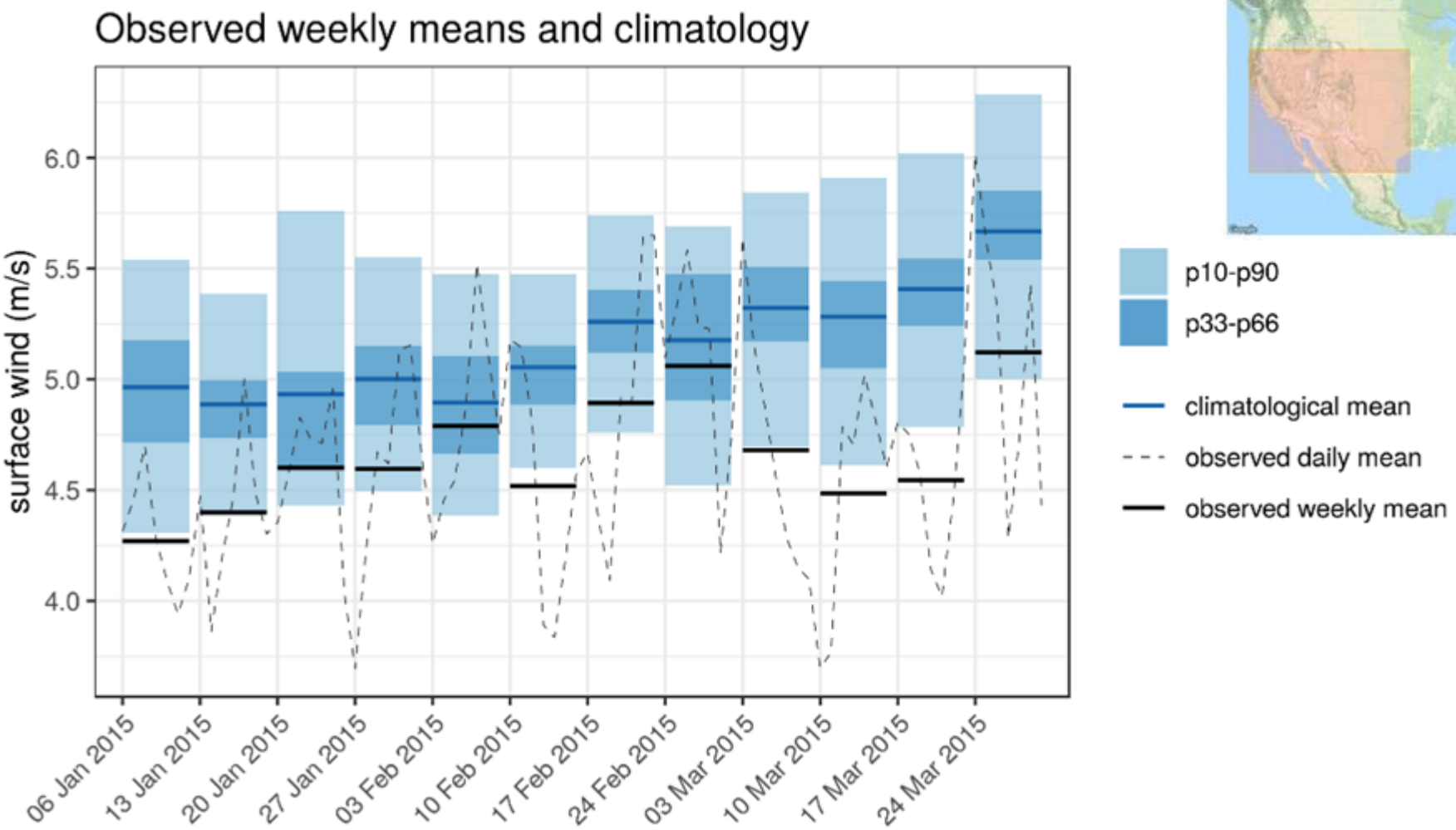


And the chain goes well beyond climate

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



Monitoring is key: what we want to predict



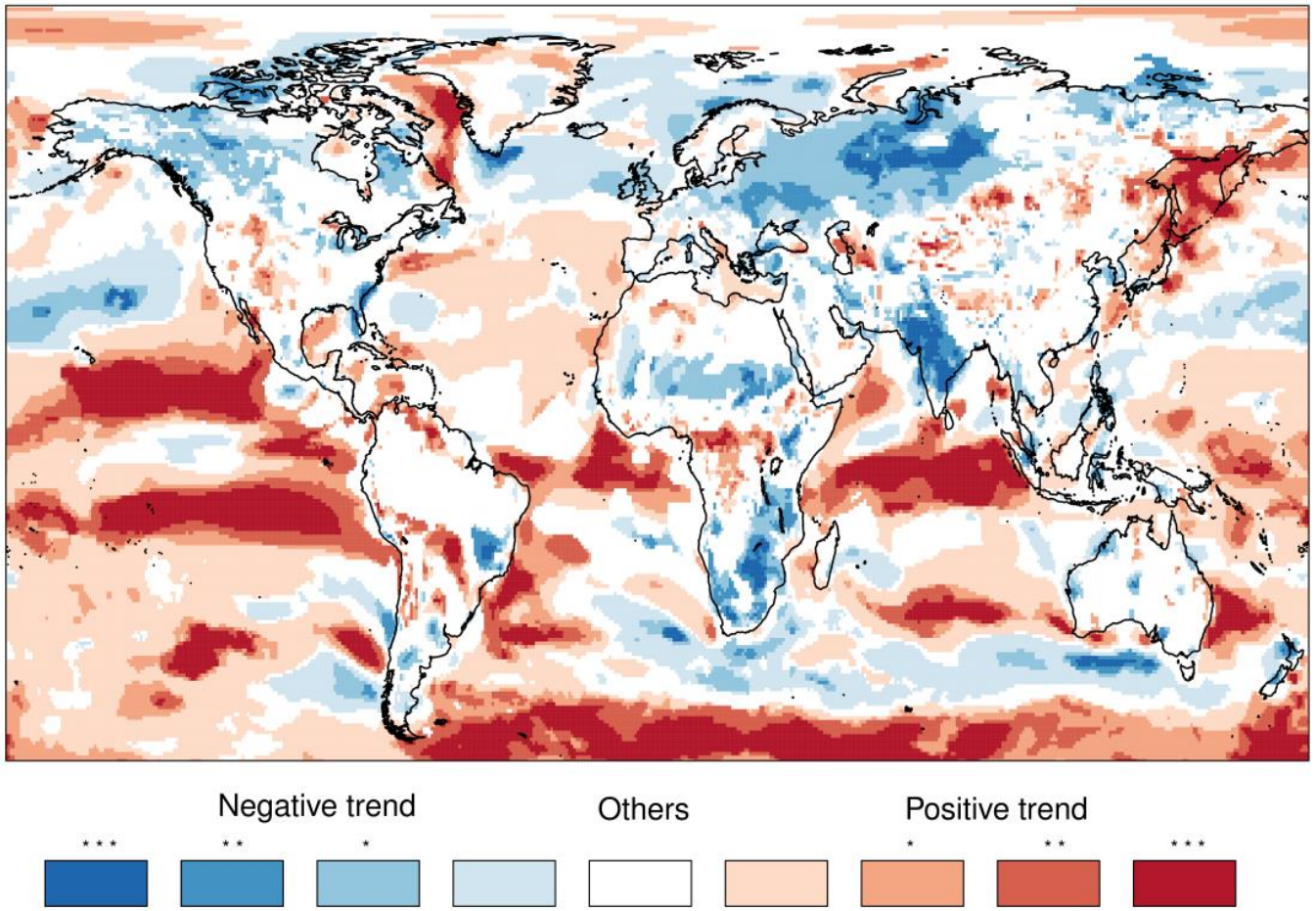
Products and their quality

The prediction process follows a series of steps:

- Formulate a prediction from a forecast system. The exact definition of the prediction is very important.
- Select the verification metrics of the prediction that allow us to adequately represent the attributes of interest and an observational reference.
- Choose a comparison standard 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 prediction.
- 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.

Observational uncertainty is a big issue

Coherence of the 10-metre wind speed trends in three reanalyses (ERA-Interim, JRA-55 and MERRA) over 1981-2015 during boreal winter.



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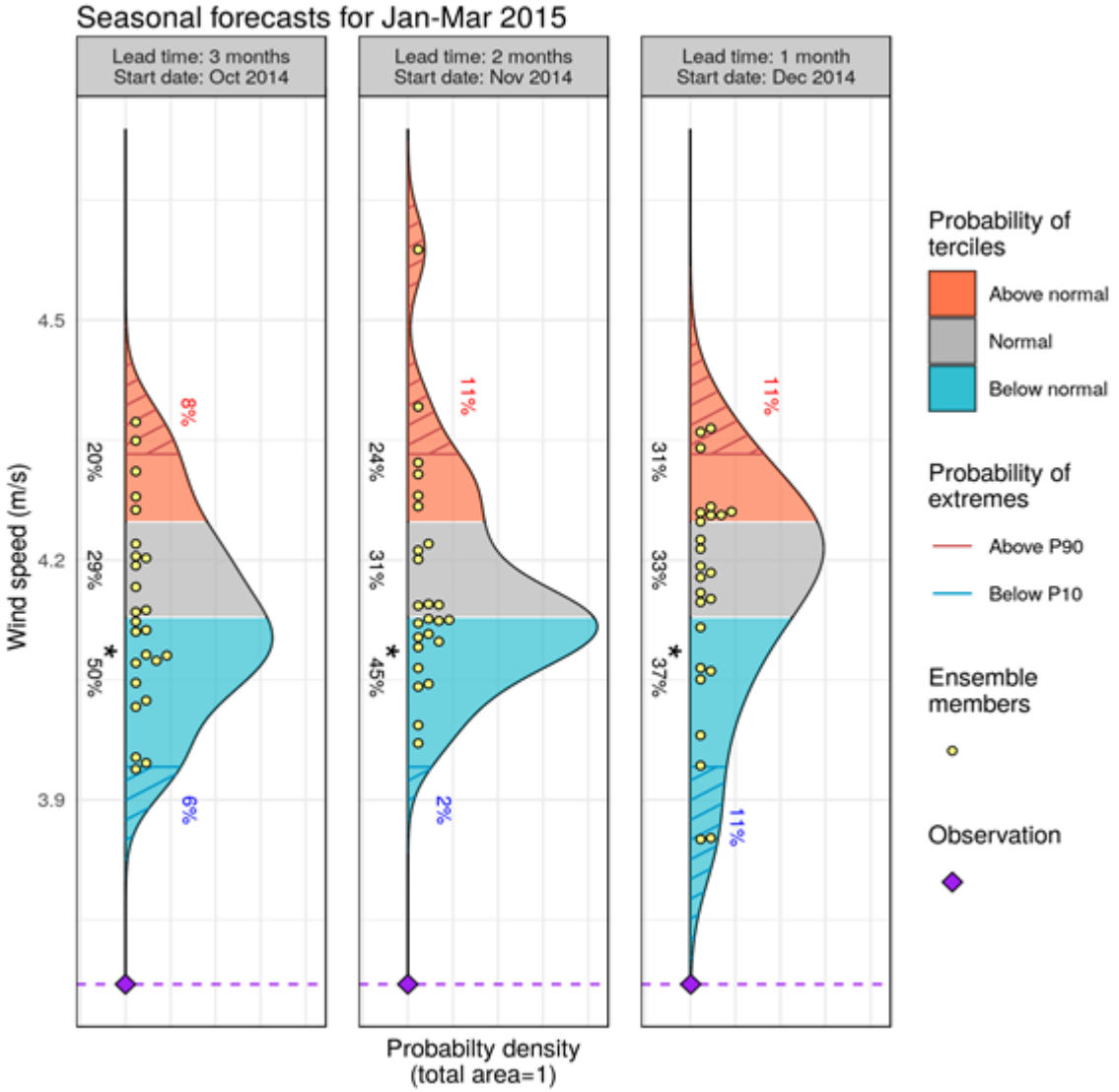
Torralba et al. (2017, ERL)

What does a prediction look like



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.

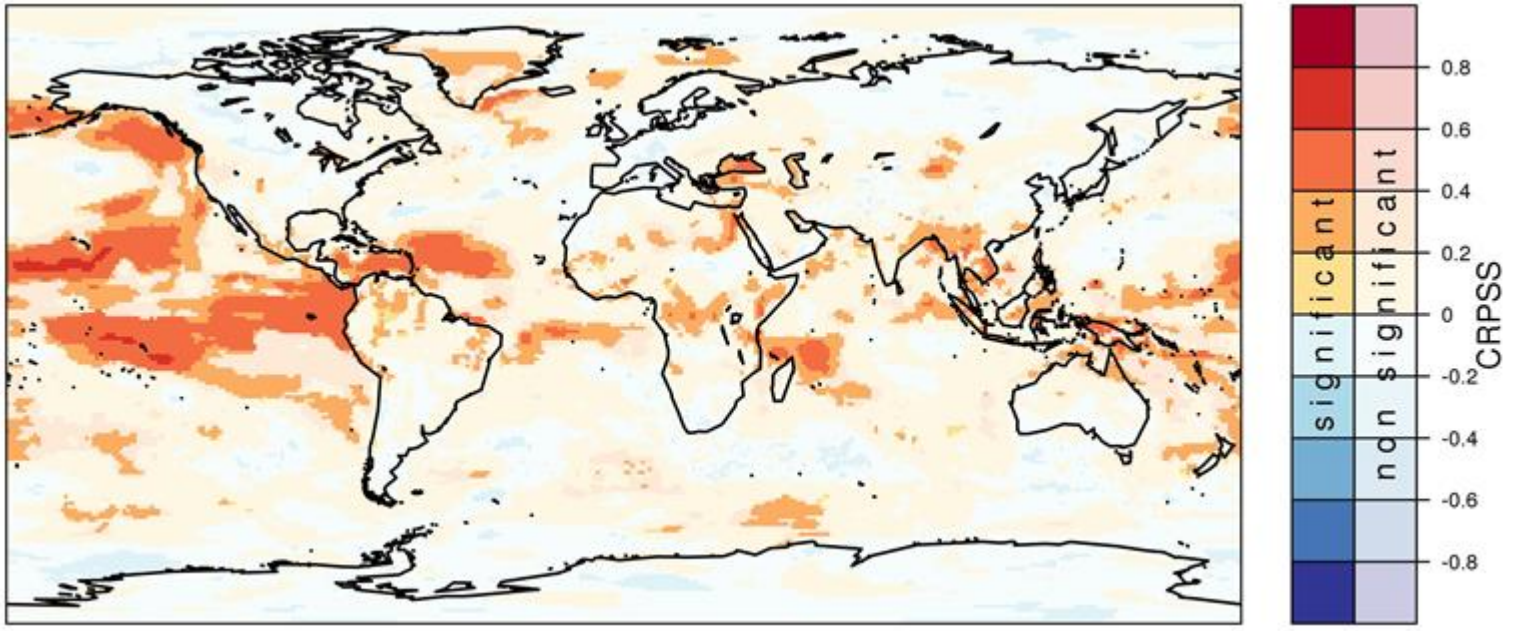
	Start Date		
	Oct	**Nov**	**Dec**
RPSS	0.35	0.39	0.35
CRPSS	0.14	0.11	0.14
Corr	0.55	0.54	0.51

Forecast quality, calibration, multi-model

- Forecast quality assessment:
  - Verification procedure of existing forecast systems based on scoring rules (e.g. RPS for multi-category probabilities, CRPS for ensembles)
  - Products, and not data, are verified; forecast products are scrutinised
- Calibration (or bias adjustment)
  - All bias correction 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.



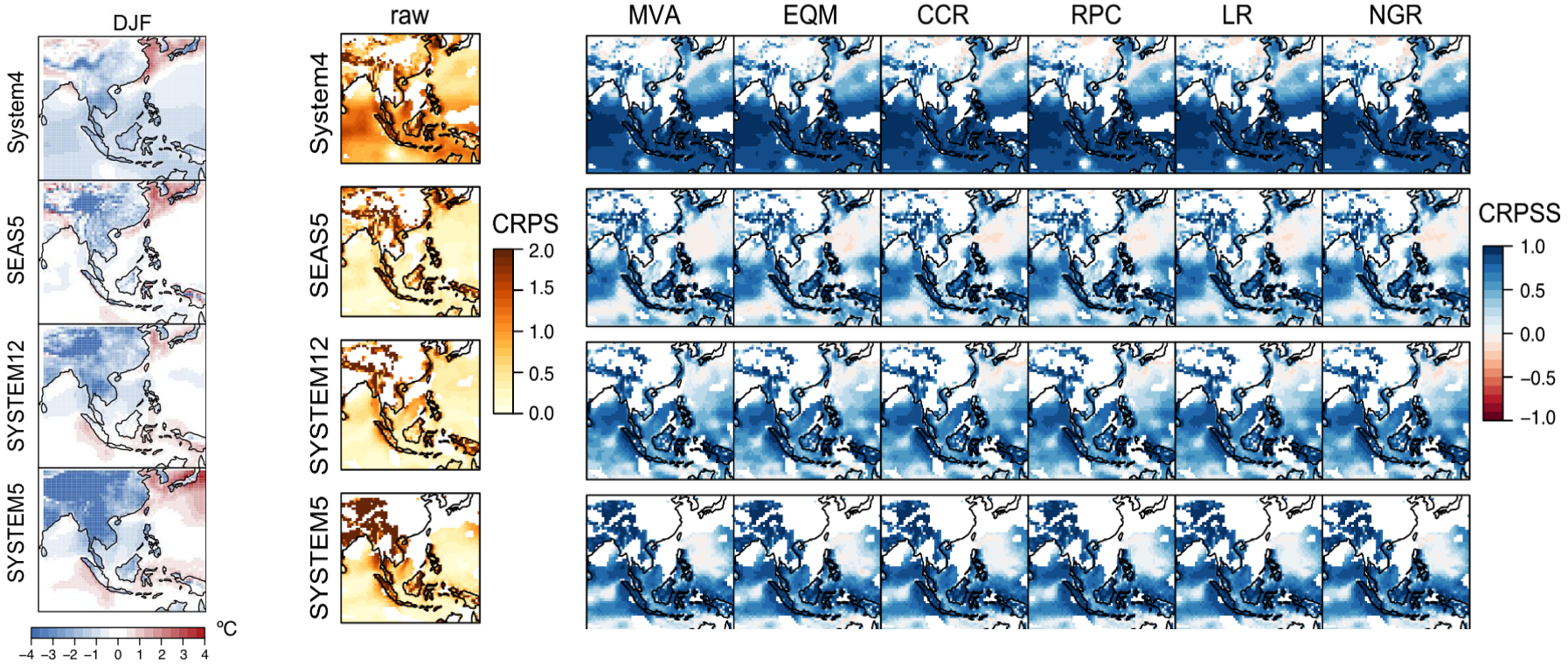
Better

than constant climatological forecast

Worse

Bias adjustment and forecast quality

CRPS of DJF temperature from several systems with different bias adjustment methods, bias adjusted and verified against ERA Interim for 1993-2014.



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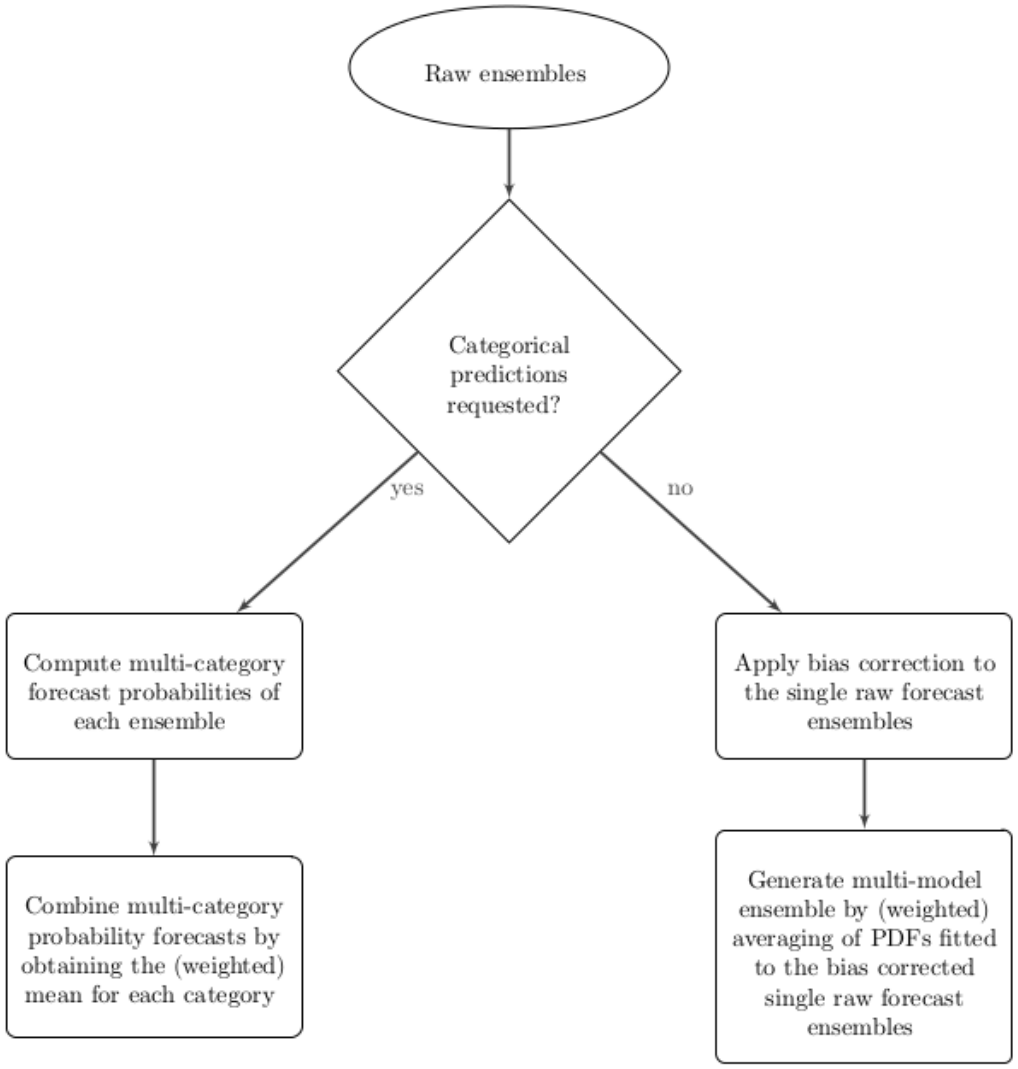
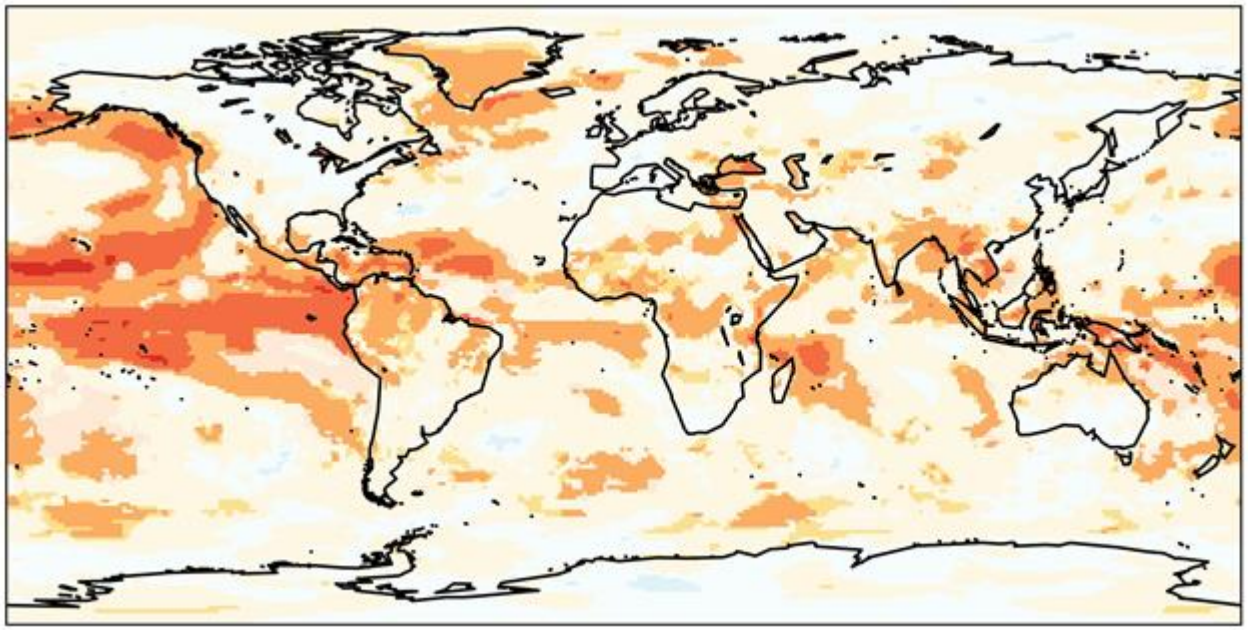
Manzanas et al. (2019, Climate Dynamics)

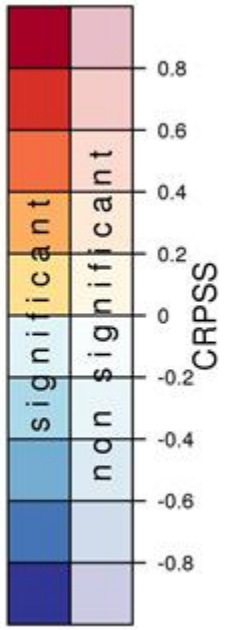
Multi-model predictions: how to



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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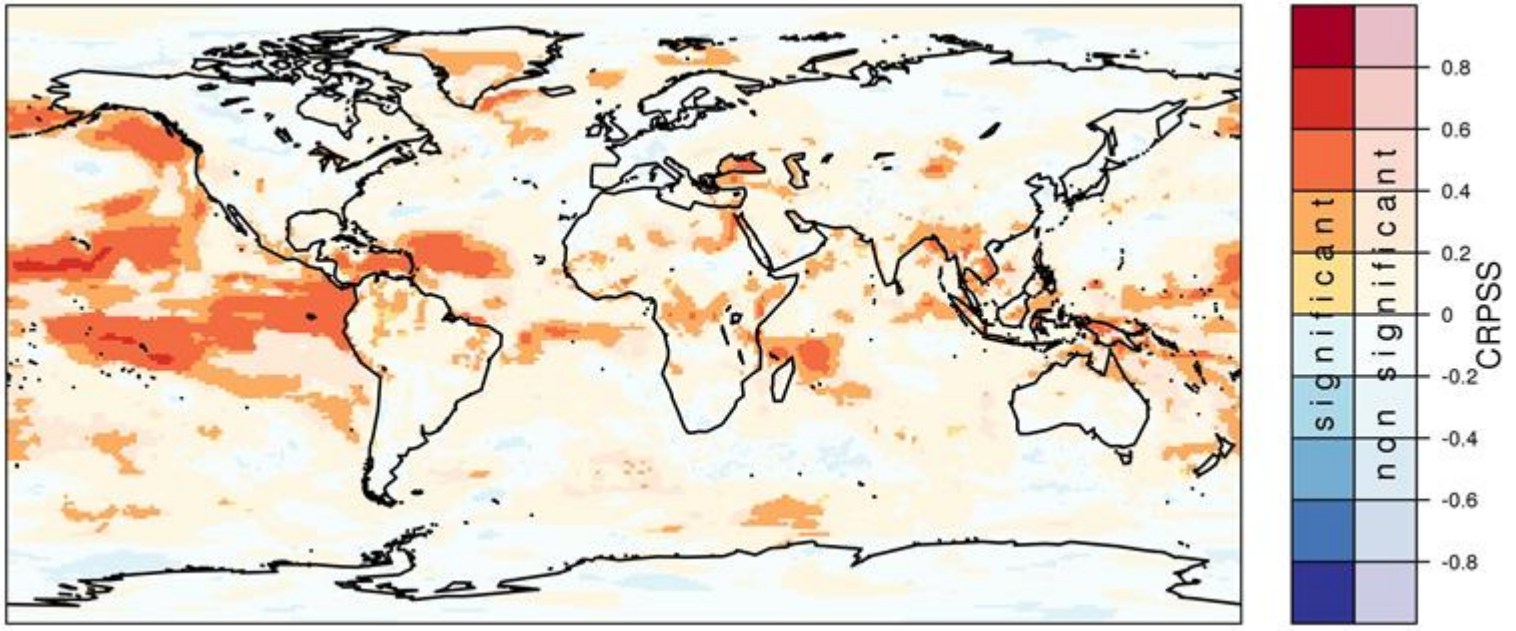

Better

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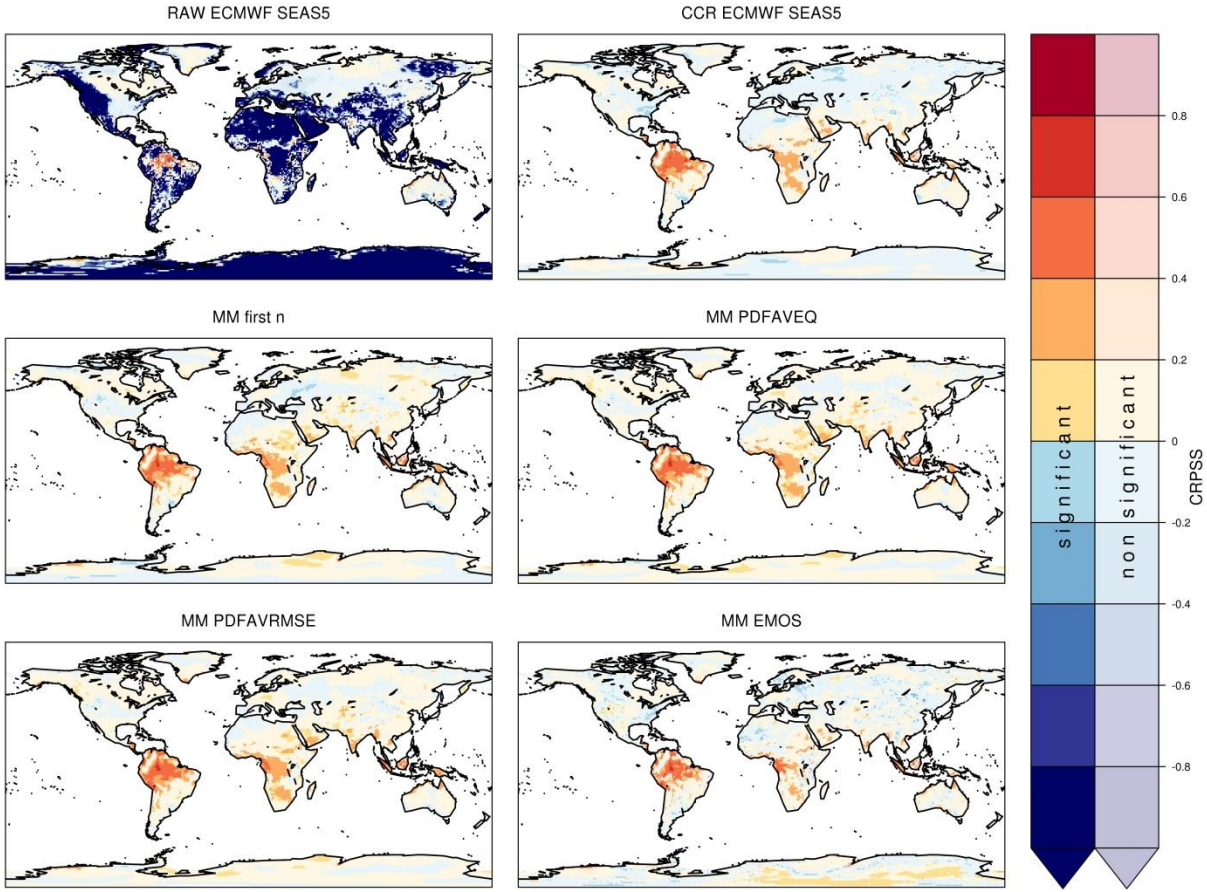
Multi-model and forecast quality

CRPSS of DJF temperature from ECMWF SEAS 5, Météo-France System 5, MetOffice GloSea5, initialized in November and verified against ERA Interim for 1993-2014.



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Hemri et al. (2019)

Illustrating prediction value

Gamification is useful to illustrate the challenges of using and the value of seasonal climate predictions:

- 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 three.

Climatology

RESILIENCE seasonal predictions

Expected wind speed:

- Above average
- Average
- Below average

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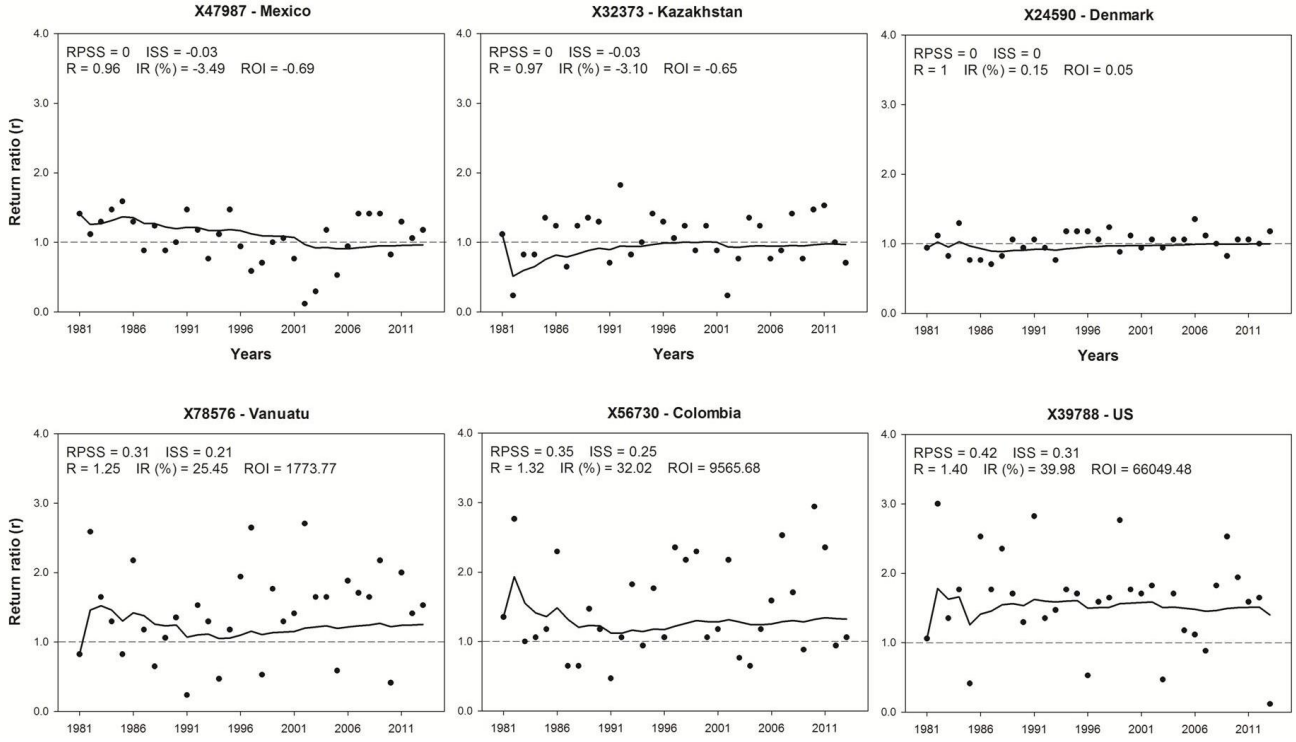
Illustrating prediction value

Examples of return ratio for 33 betting runs for different points where wind power plants are installed:

- Top row cases with RPSS=0, but ignorance skill score negative or zero.
- Bottom row cases with RPSS>0.
- Line for the geometric average of return ratios (interest rate).



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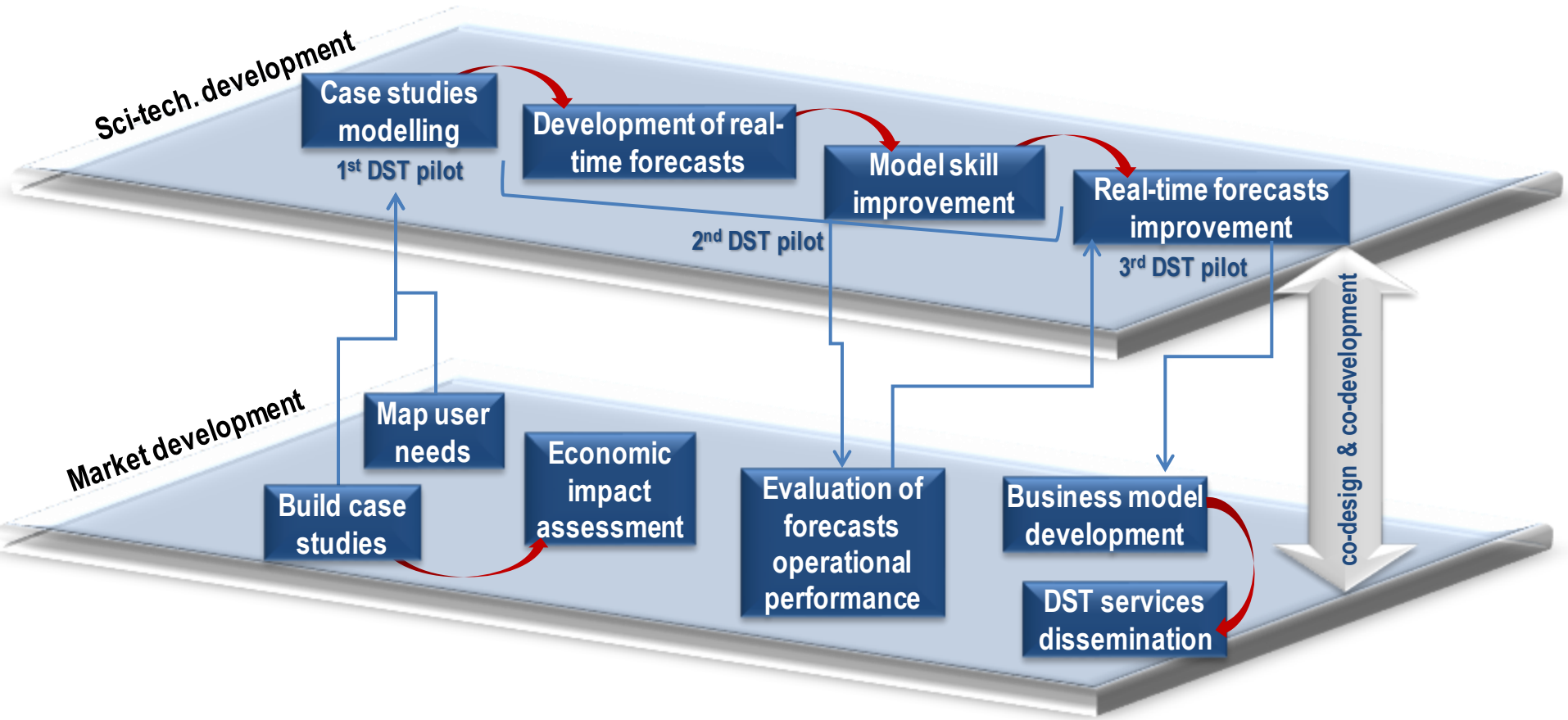
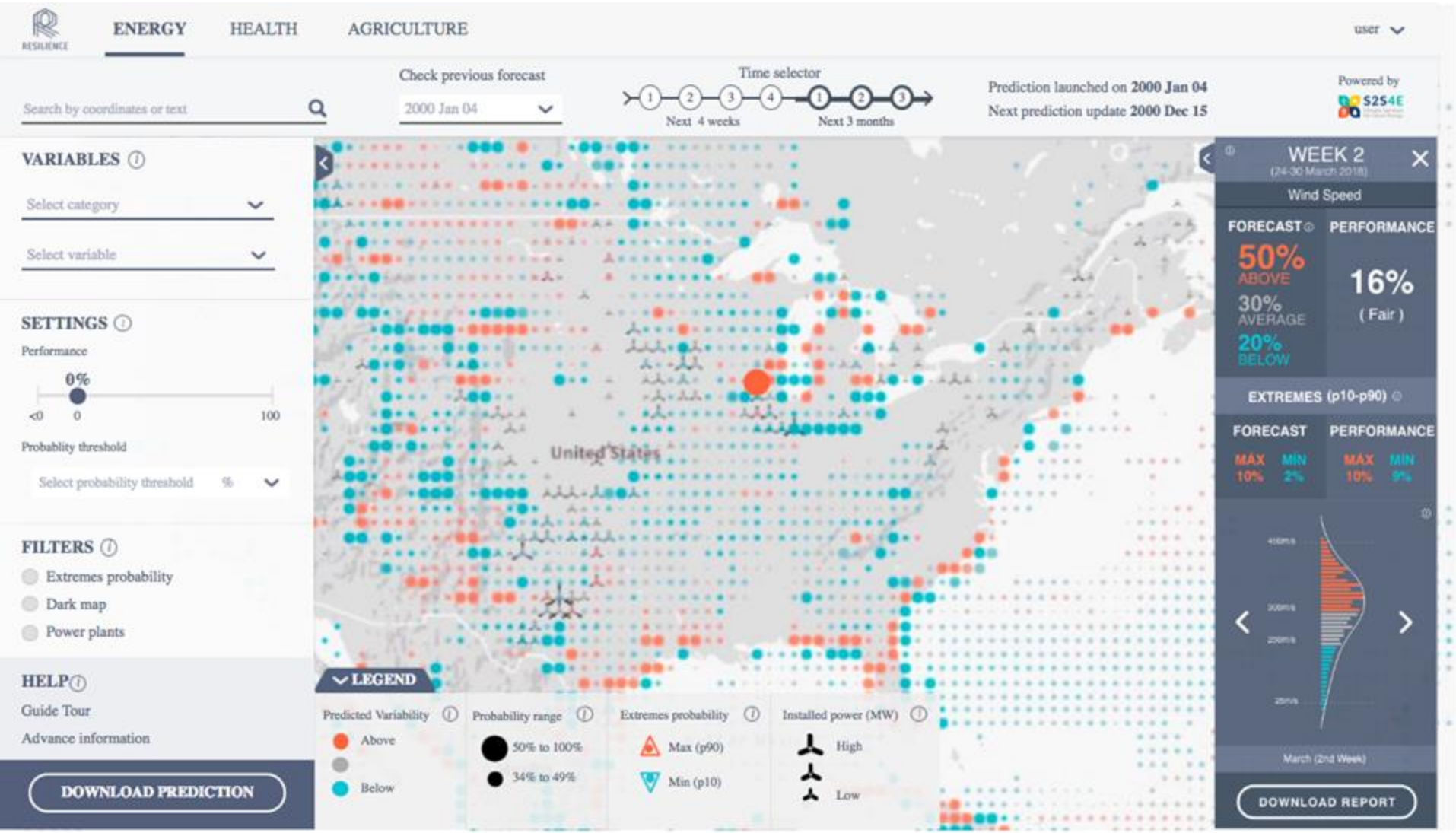
Terrado et al. (2019, BAMS)

Elements involved in the prototype development



Operational prototype: the DST



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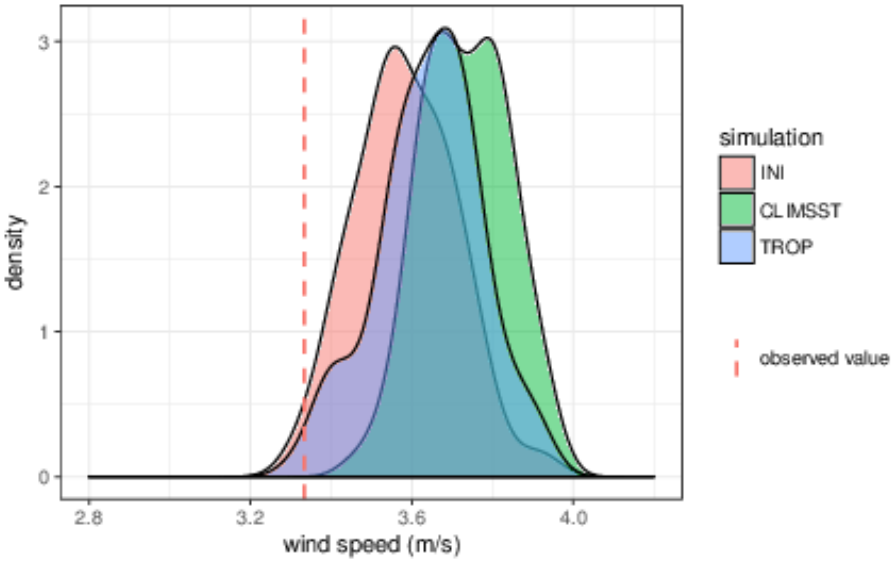
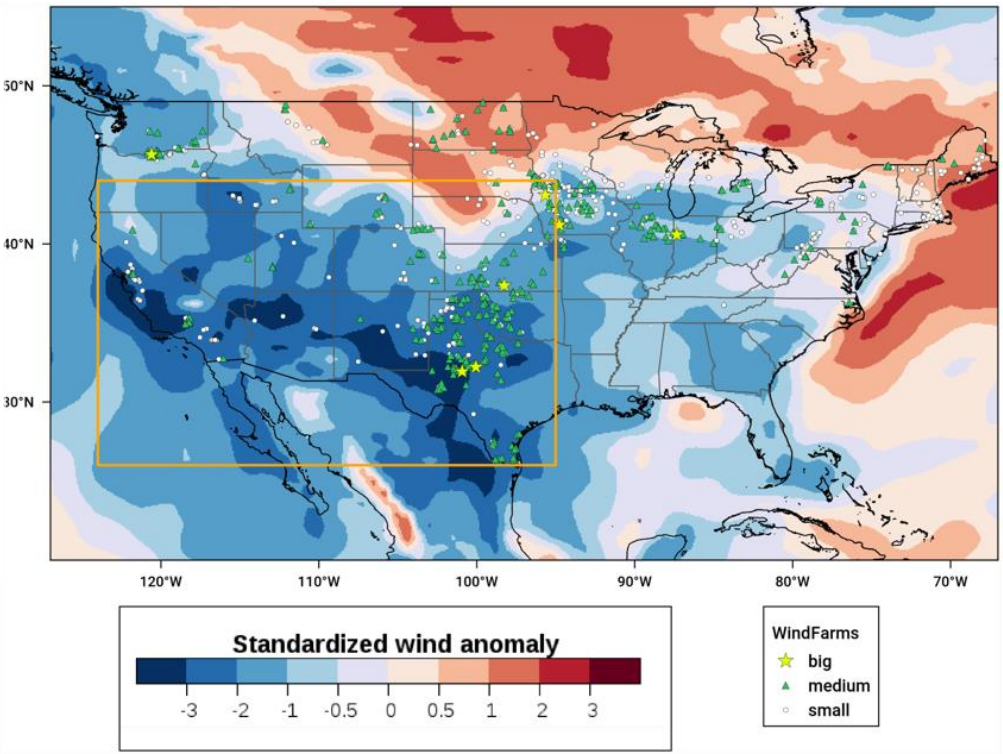
www.bsc.es/ESS/resilience

A twist to the idea: event attribution

During the first quarter of 2015 the United States experienced a widespread and extended episode of low surface wind speeds. This episode had a strong impact on wind power generation. Some wind farms did not generate enough cash for their steady payments, and the value of wind farm assets decreased.

Wind speed anomalies reflecting the wind drought over the United States for the first trimester of 2015, where the USA wind-farm fleet is also shown (Lledó et al., JGR 2018)





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Summary

- **Forecast quality assessment:**
  - **No prediction should be considered without its corresponding verification.**
  - **Products, and not data, are verified. Always define a product.**
- **Bias adjustment:**
  - **All bias adjustment methods effectively remove bias.**
  - **Simpler methods tend to work best, and the chosen method should be carefully assessed.**
  - **Correlation of the direct model output is not a good measure of the actual skill of a product.**
- **Multi-model combination**
  - **Multi-model combination is beneficial, although weighting the best systems is not a trivial exercise.**