18 November 2020

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EXCELENCIA SEVERO OCHOA

Forecast quality assessment for operational climate prediction

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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

S2S4E Climate Services for Clean Energy

EUCP European Climate Prediction system

ICREA

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 believable.

- Legitimacy: *It refers to whether an actor perceives the climate information process as unbiased and meeting standards of political and procedural fairness*.

Power

Reputation

Values

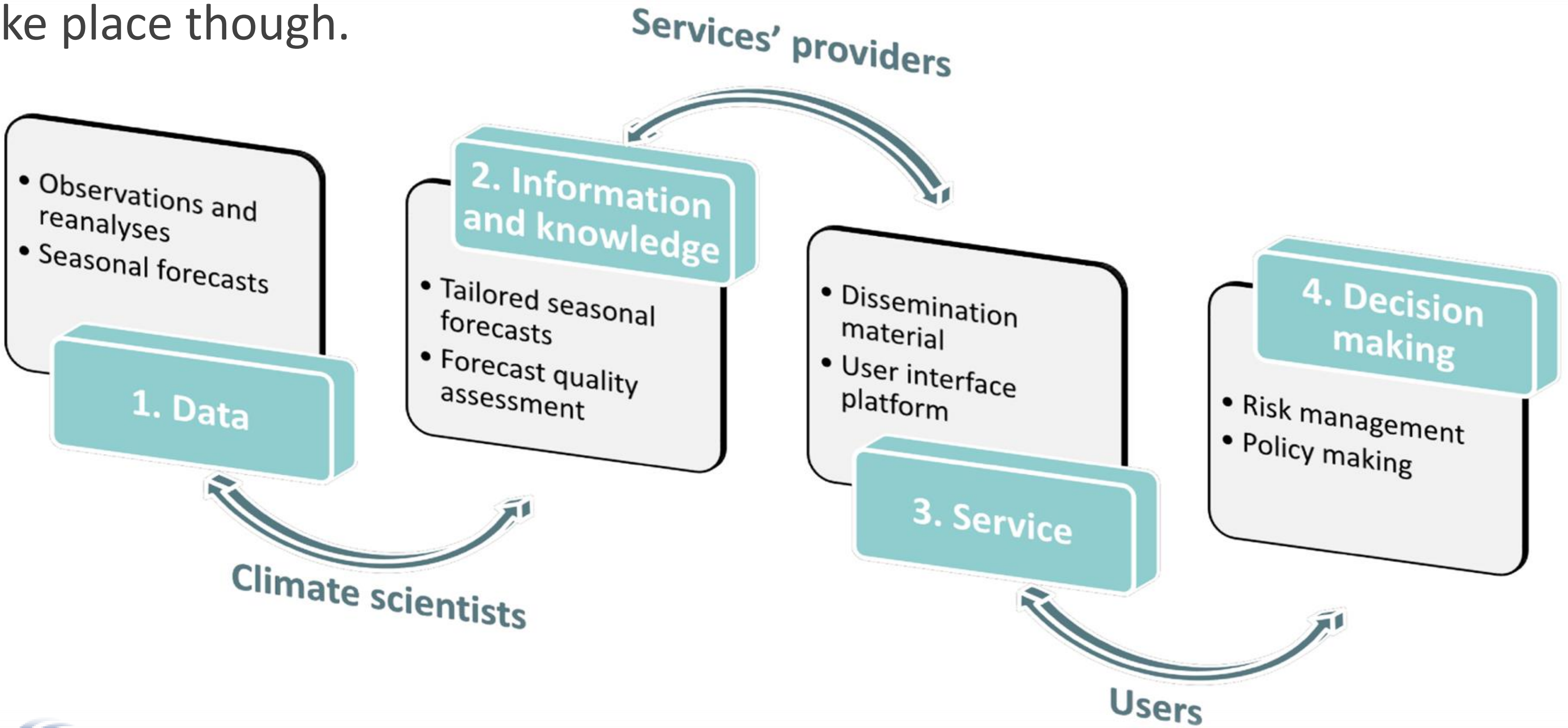
Transparency

Standards

Cash et al. (2003, PNAS)

The research-provider-service paradigm

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



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Forecast requirements identified by users

- Targeted …roducts need to become widely available, easy to access and underst… different professionals
- Need … how the information provided can be used and inte… …tions and activities.
- Added … …redictions needs to be better understood. The chai… …redictability source needs to be established.
- Need to reduce uncer… …ill. The skill is too low to base decisions on them, since t… …high.
- Better explanation of the link … …tions and climate change projections.
- The information needs to be reliable enoug…
- Maybe need for fine spatial resolutions or allo… …urban areas.

Forecast quality is an integral part of the service to the user because it is inseparable from the forecast product

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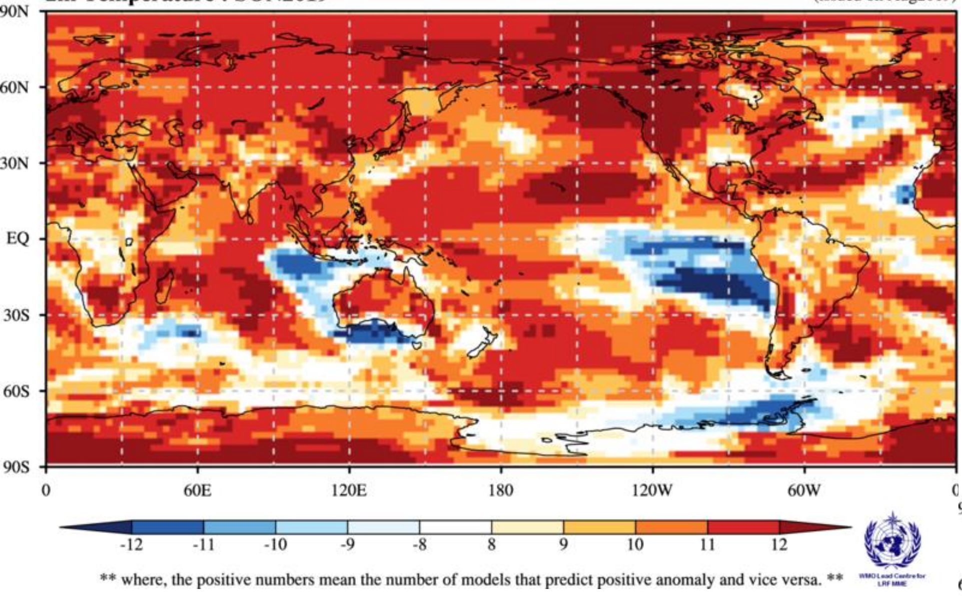
Extracted from project deliverables of EUCP (D6.4), PR… (D11.6) and EUPORIAS (D12.3). Additional sectoral comments in user en…agement by S2S4E, APPLICATE, MED-GOLD, HIATUS and VISCA.

Users look for climate forecasts online

Consistency Map
CPTEC,ECMWF,Exeter,Melbourne,Montreal,Moscow,Offenbach,Pretoria,Seoul,Tokyo,Toulouse,Washington

2m Temperature : SON2019 (issued on Aug2019)

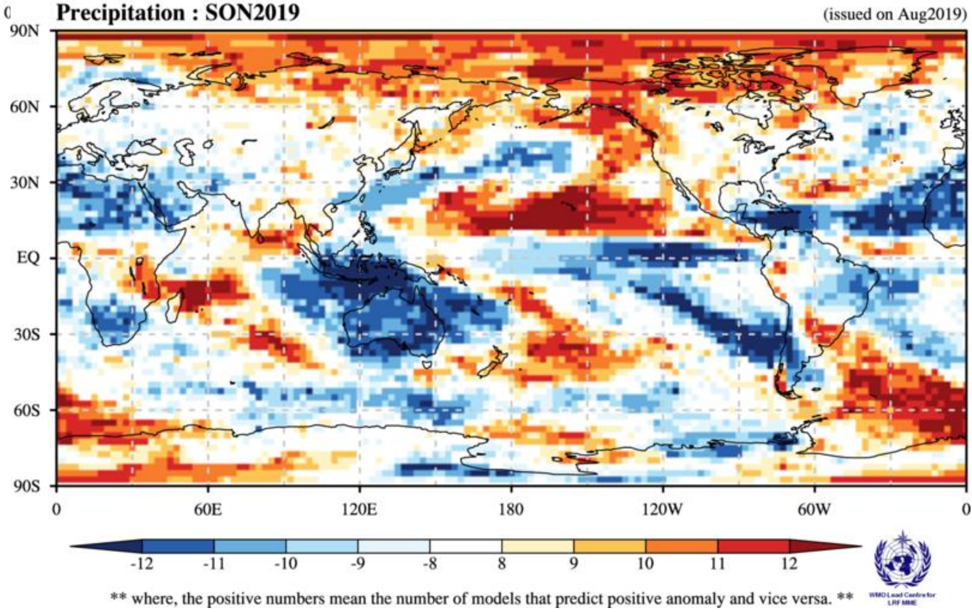


But some elements are missing:

- Quality assurance
- Traceability
- Interpretation
- Authority

Consistency Map
CPTEC,ECMWF,Exeter,Melbourne,Montreal,Moscow,Offenbach,Pretoria,Seoul,Tokyo,Toulouse,Washington

Precipitation : SON2019 (issued on Aug2019)



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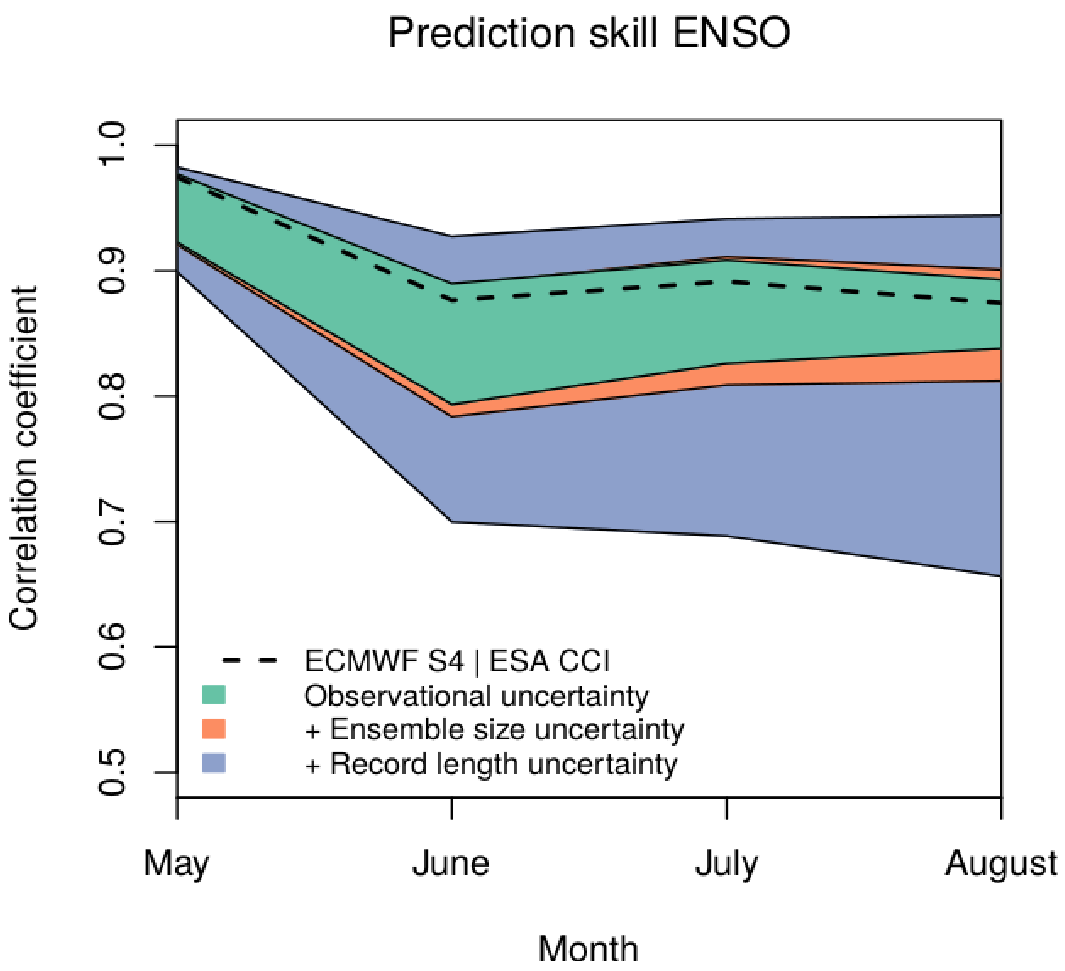
Some key elements for users

- Observational uncertainty: comparison between reanalyses in a forecast 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 its operational aspects are not solved yet.
- User indicators: indicators often 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.

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.



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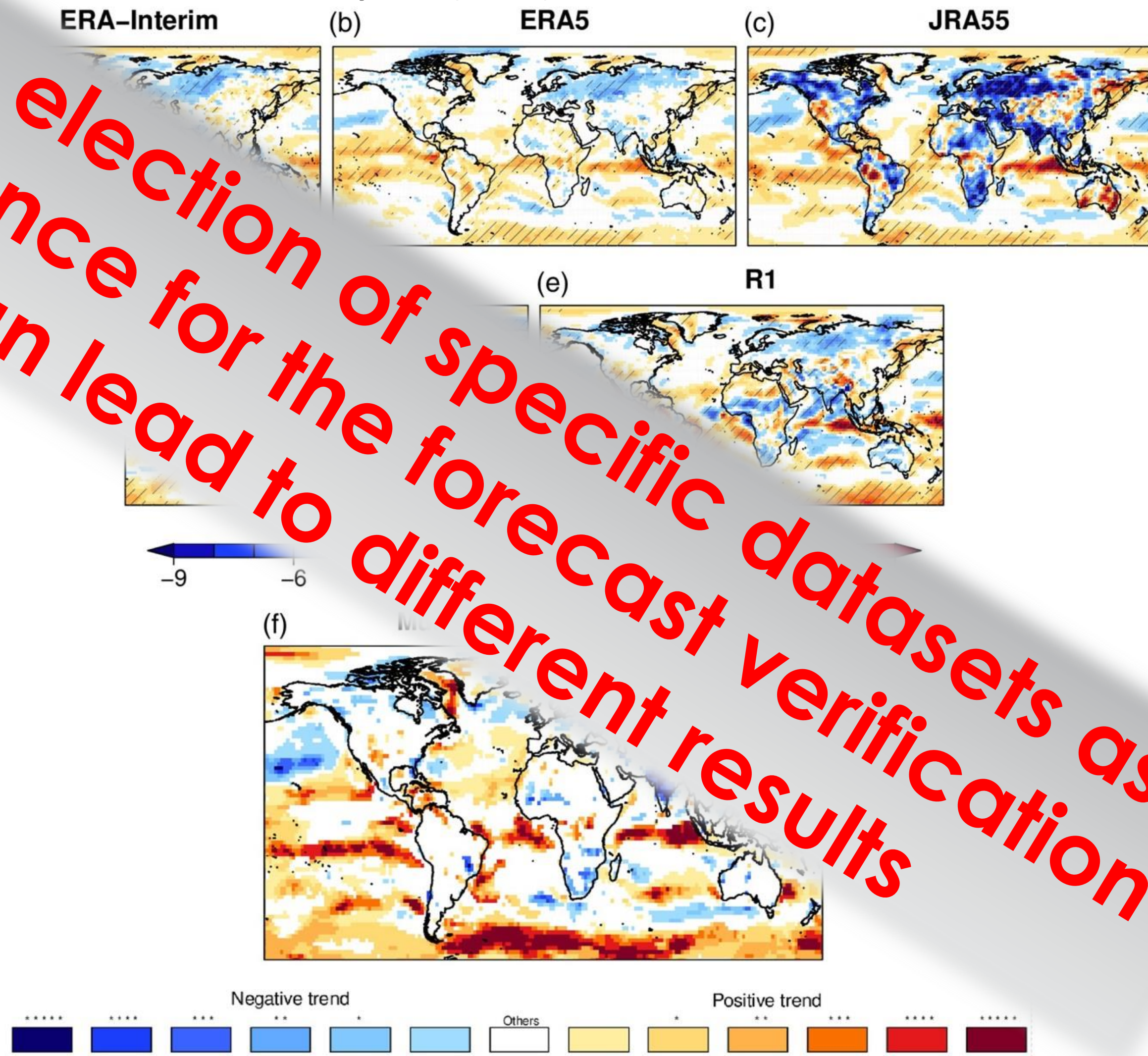
Bellprat et al. (2017, Rem. Sens. Env.)

Observational uncertainty is relevant to users

10-m wind speed trend (in percentage of the mean wind) for five reanalyses and agree[...] in the multi-reanalysis (MR) in DJF over 1981-2017.

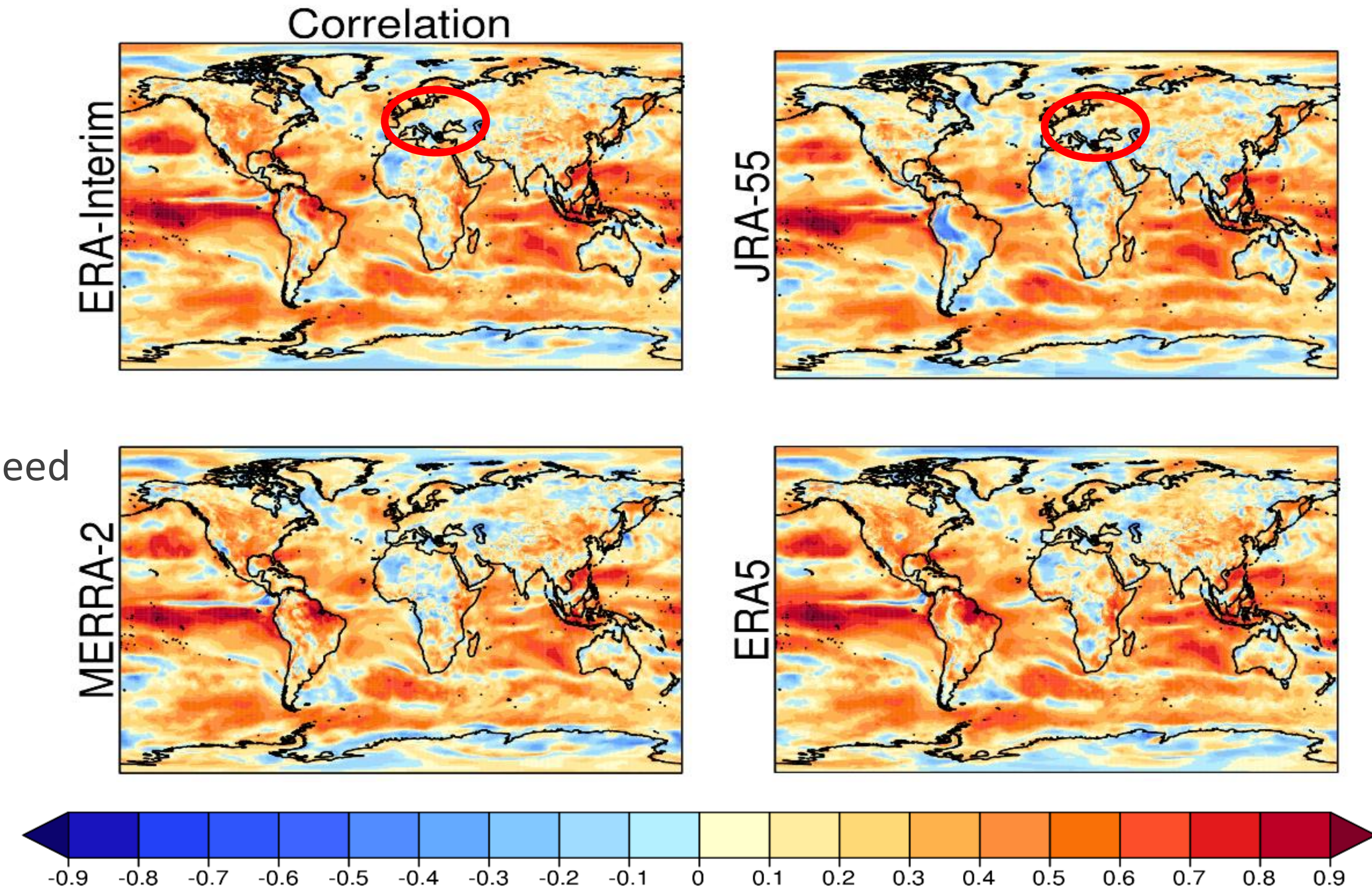


The election of specific datasets as reference for the forecast verification can lead to different results

Ramon et al. (2019, QJRMS)

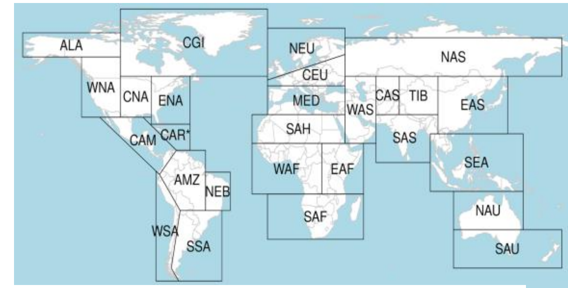
Observational uncertainty in verification

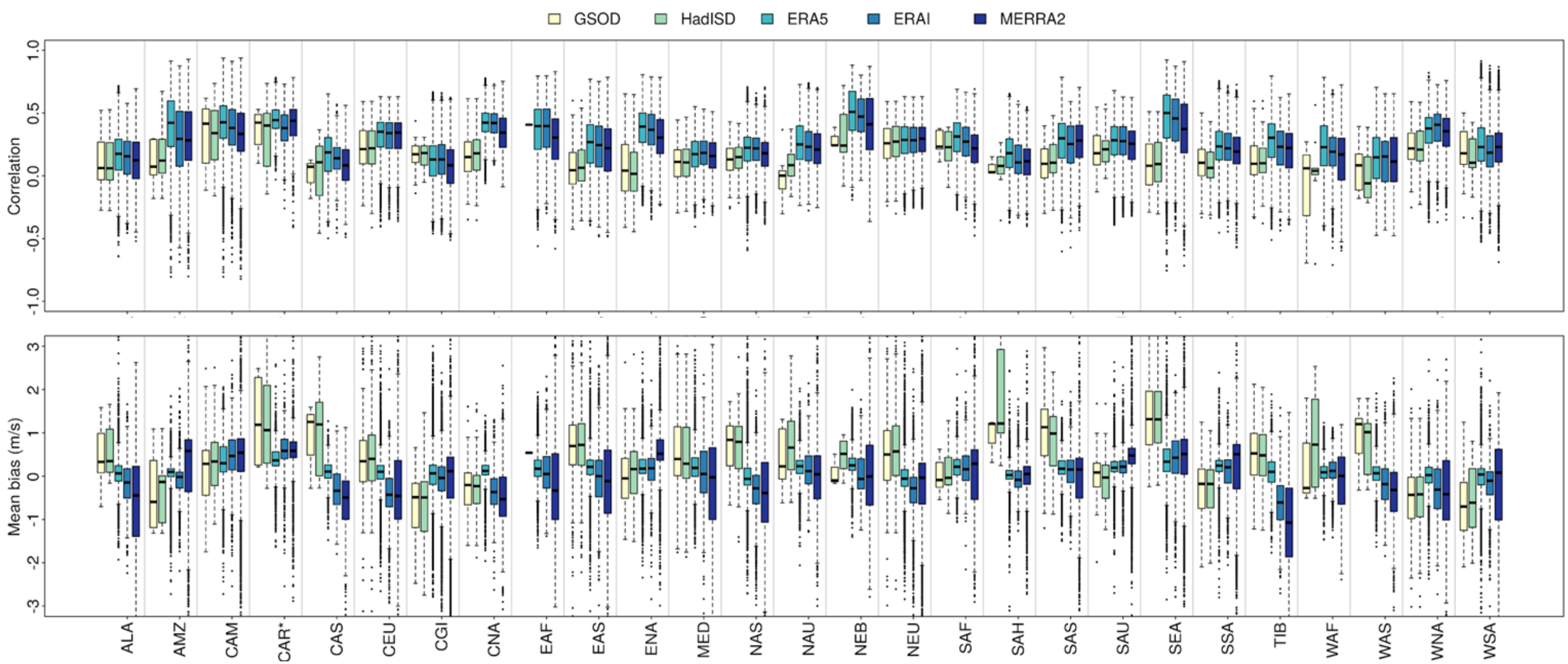
ECMWF System4
Period: 1981-2016
Season: DJF
Start date: 1st Nov
Variable: 10-m wind speed



Observational uncertainty in verification

Verification with two ground-based observational datasets and three reanalyses. The use of both types of datasets is very informative for wind energy users as they use them for the development of impact models and the long-term resource assessments.





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

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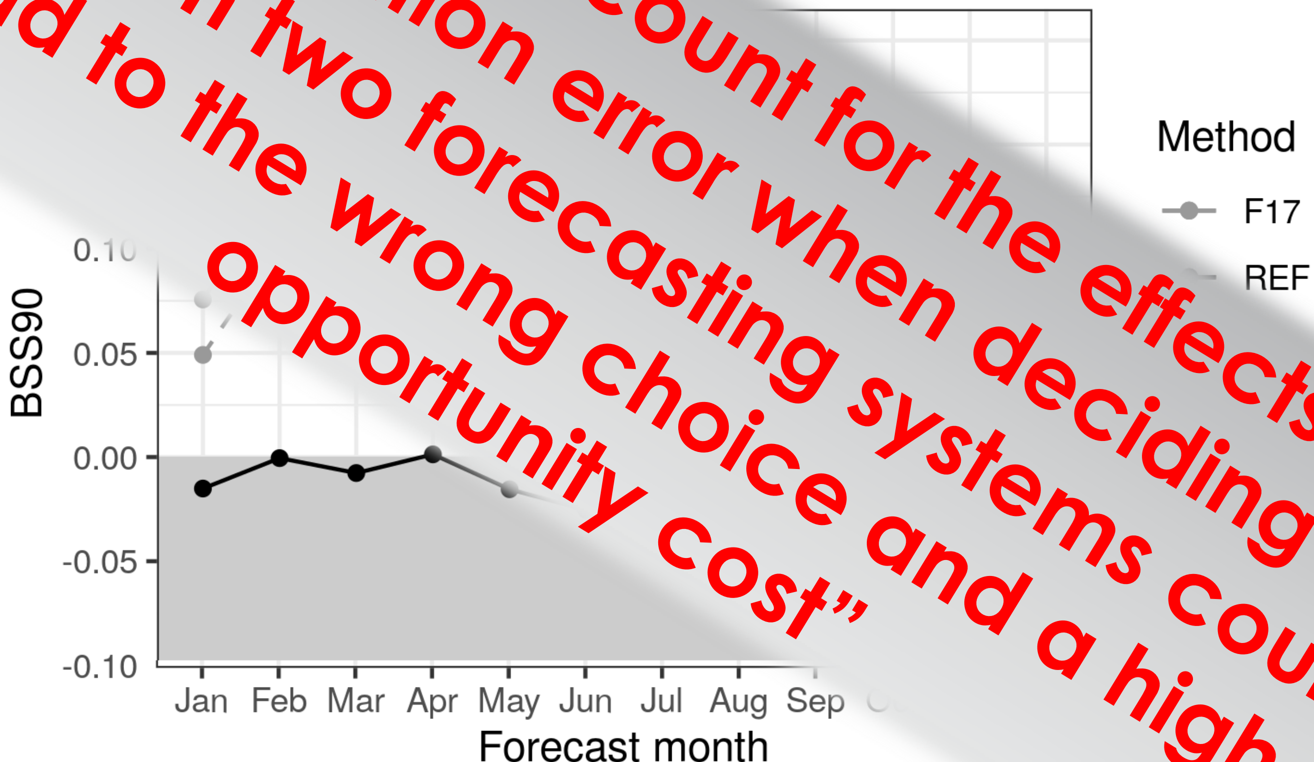
V. Torralba

Ob… ational uncertainty in verification

Brier sk… ind speed predictions above the climatological 90th perce… the reference forecast. Observational references from … high resolution (HRES) product with the Ferro (20… estimates in the presence of observational e…

“Failing to account for the effects of observation error when deciding between two forecasting systems could lead to the wrong choice and a high opportunity cost”



ECMWF SEAS5 Period: 1981-2016
Lead time: 1 month
Global coverage, 1,542 HadISD stations, which are the truth

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J. Ramon

A non-trivial climatology definition

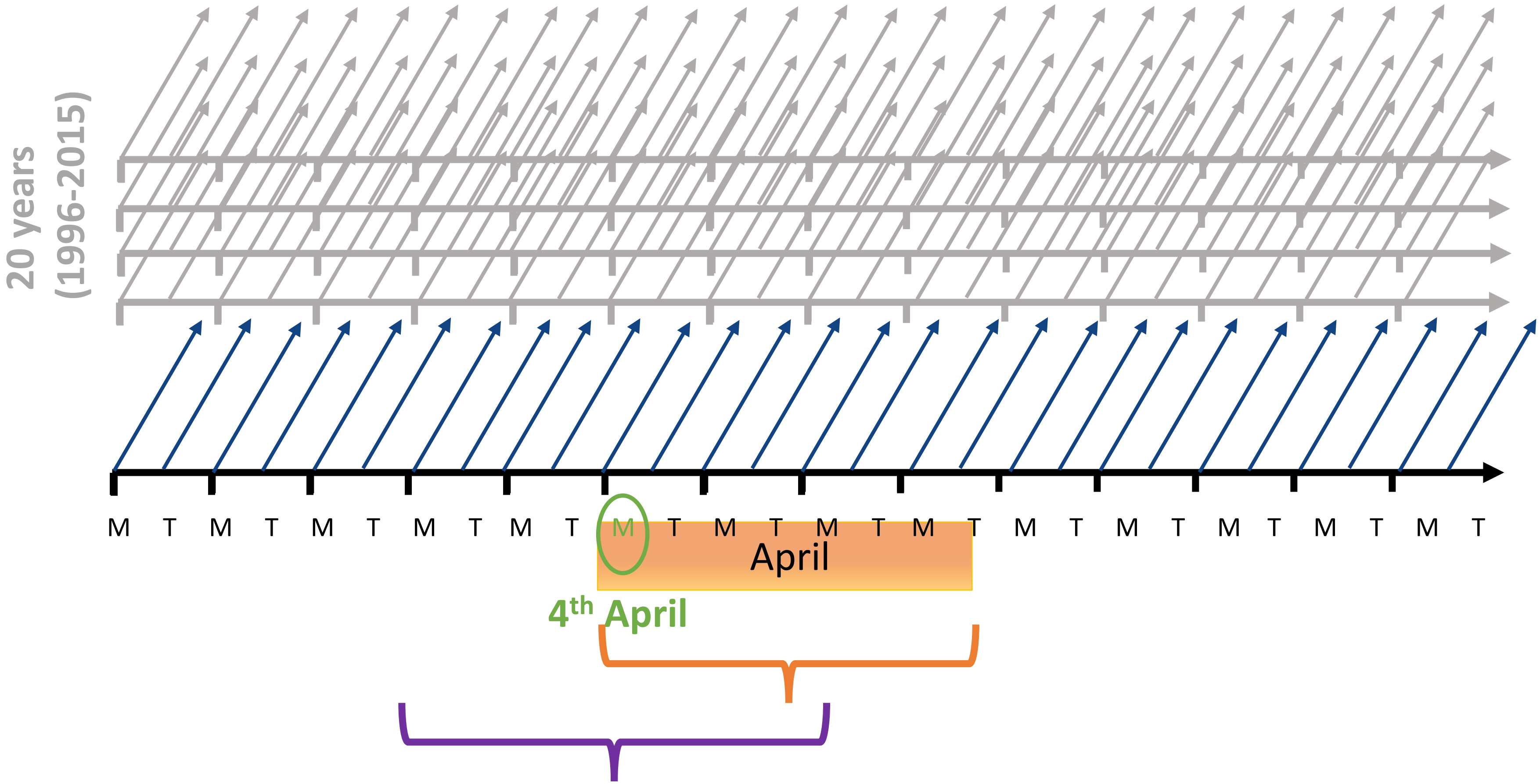
There is a large heterogeneity in the real-time subseasonal systems: different initialisations, hindcasts periods, etc.

Limited samples (even in the hindcasts) lead to : lack of robustness in forecast quality estimates, definition of the climatology, bias adjustment, etc.

			Forecast		Hindcasts			
Status on 2020-10-27	**Time range**	**Resolution**	**Ens. Size**	**Frequency**	**Re-forecasts**	**Rfc length**	**Rfc frequency**	**Rfc size**
BoM (ammc)	d 0-62	T47L17	3*11	2/week	fixed	1981-2013	6/month	3*11
CMA (babj)	d 0-60	T266L56	4	2/week	on the fly	past 15 years	2/week	4
CNR-ISAC (isac)	d 0-32	0.75x0.56 L54	41	weekly	fixed	1981-2010	every 5 days	5
CNRM (lfpw)	d 0-47	T255L91	25	weekly	fixed	1993-2017	every 7 days	10
ECCC (cwao)	d 0-32	39 km L45	21	weekly	on the fly	1998-2017	weekly	4
ECMWF (ecmf)	d 0-46	Tco639/319 L91	51	2/week	on the fly	past 20 years	2/week	11
HMCR (rums)	d 0-61	1.1x1.4 L28	20	weekly	on the fly	1985-2010	weekly	10
JMA (rjtd)	d 0-33	Tl479/Tl319L100	50	weekly	fixed*	1981-2010	2/month	13
KMA (rksl)	d 0-60	N216L85	4	daily	on the fly	1991-2016	4/month	3
NCEP (kwbc)	d 0-44	T126L64	16	daily	fixed	1999-2010	daily	4
UKMO (egrr)	d 0-60	N216L85	4	daily	on the fly	1993-2016	4/month	7

Manrique-Suñén et al. (MWR, 2020)

A non-trivial climatology definition



Weekly: 1 start date, 20 years
Monthly: All start dates in a calendar month, 8/9 start dates, 20 years
Monthly running window: Running window with 4 start dates before and after the target week, 9 start dates, 20 years

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A. Manrique

A non-trivial climatology definition

Other aspects to bear in mind include forecast timeliness, system updates, multi-model choices, etc.

kly: too noisy

ECMWF

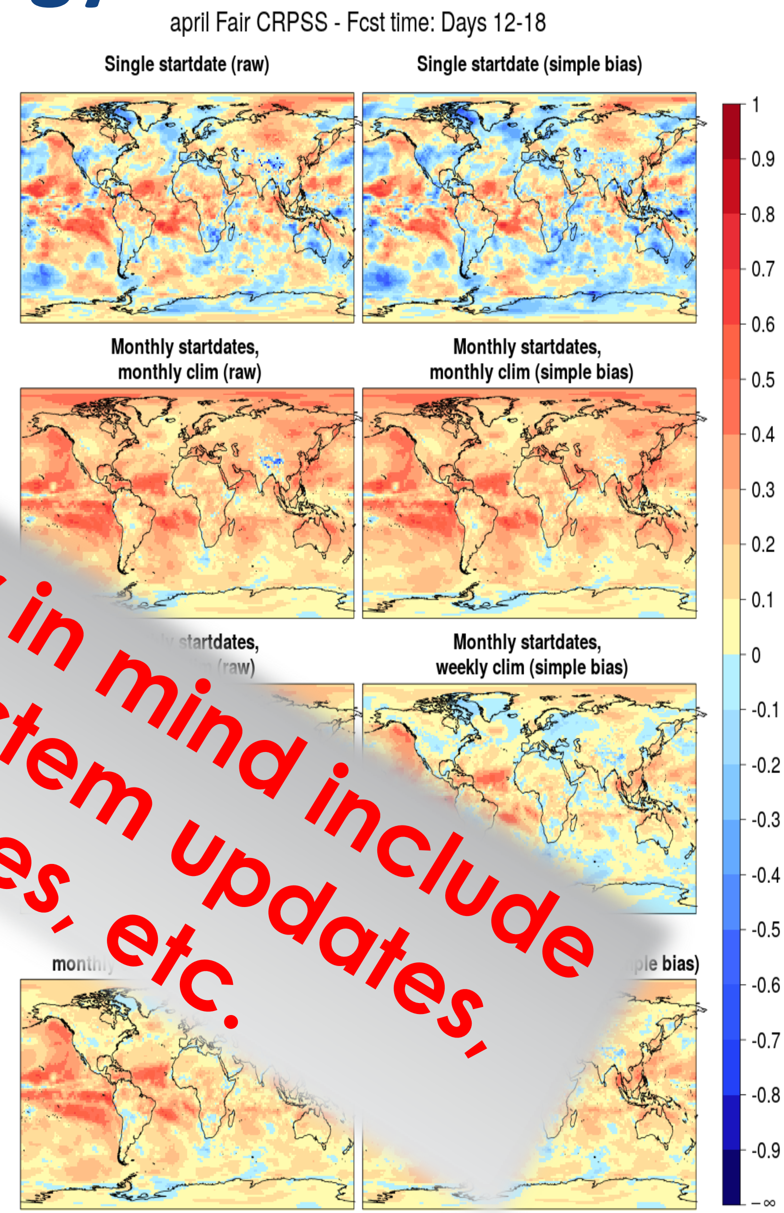
Period: 1

Reference: E

Variable: 2-m tem

Monthly runni
but weekly for th
adjustment: lower skill ,
too noisy for the adjustment

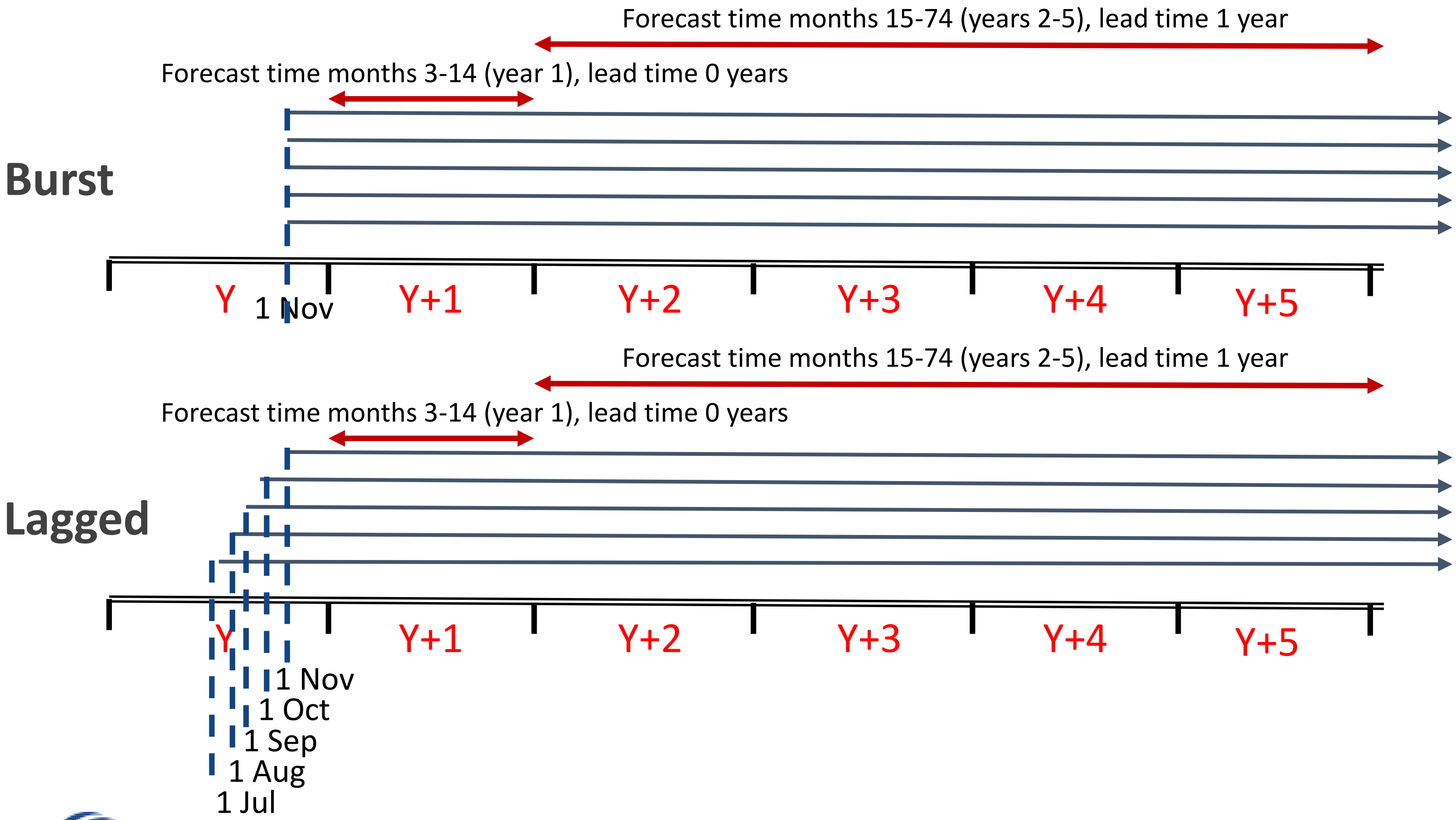
Monthly running window:
more credible estimates



Manrique-Suñén et al. (MWR, 2020)

Vocabularies

Vocabularies are part of the development of the evaluation and quality control (EQC) and a pre-requisite for the inclusion of decadal predictions in the climate data store (CDS) of the Copernicus Climate Change Service.



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Evaluation and quality control

The Cop… cus Climate Change Service is developing the evaluation and quality … QC) function of the climate data store to:

- Pr… verarching EQC service for the whole CDS
- … uality assessment of both datasets and prod…

Forecast quality assessment is a part of the evaluation and quality control function

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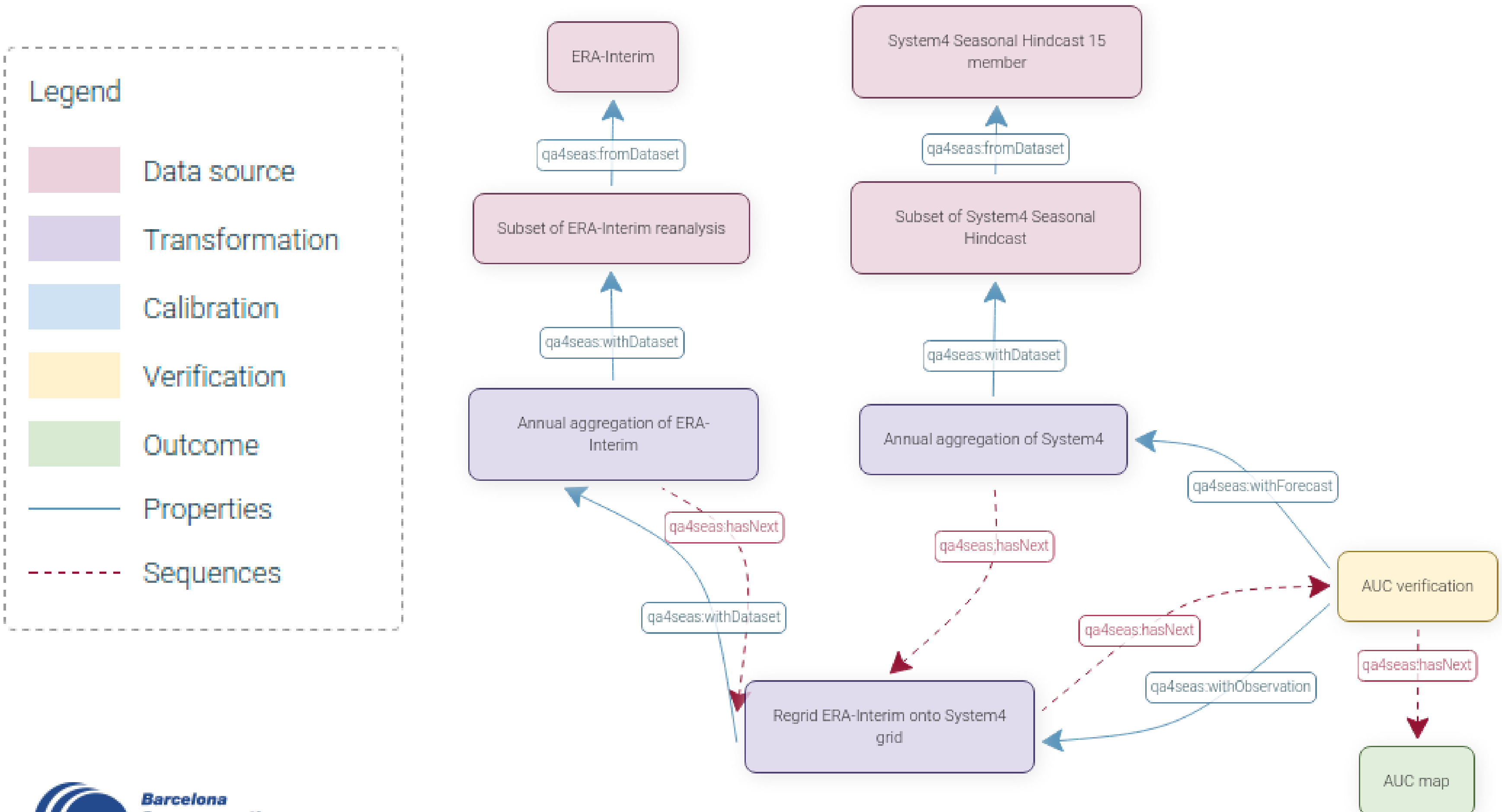
How traceable are both products and skill?

Generalised metadata provision and workflow provenance is required to ensure a minimum quality of the forecast-based climate information.



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J. Bedia

How traceable are both products and skill?

Well-documented packages safely developed are indispensable in an operational context.

The Comprehensive R Archive Network

- package shared in ftp and web servers around the world
- common standards for R users
  - easy installation
  - typical R documentation
  - typical warnings and error messages
- checks
  - to work on different OS
  - structure and documentation
  - package size
  - installation time
  - ...

Profiling tools

- ProfVis and Rprof
- scalability and parallelisation

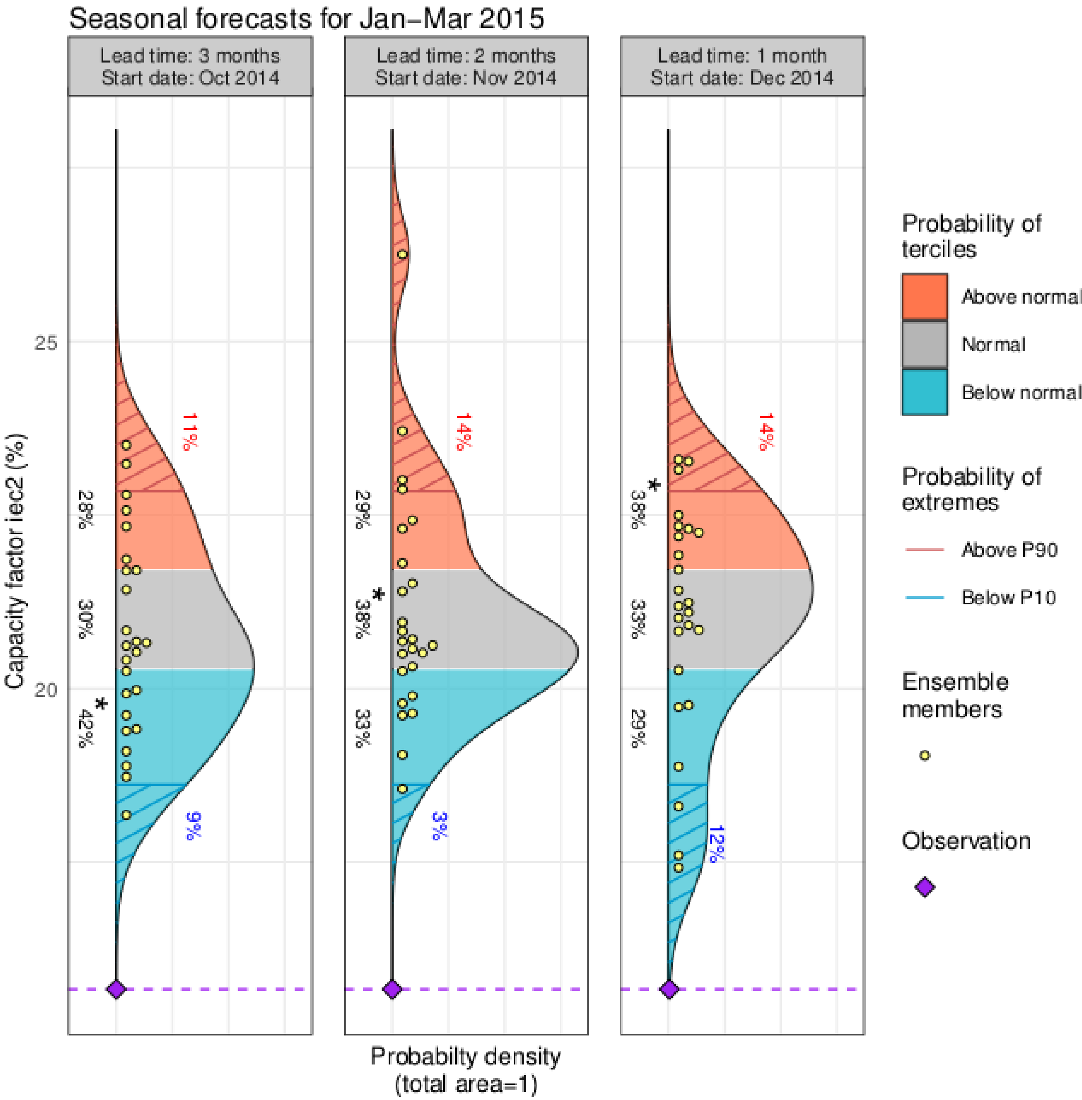
Version control system

- track changes
- issues discussion
- tag versions
- branching strategy
- unit testing
- continuous integration

Contributions and improvements

- open a new issue
- work in a new branch
- follow function standards
- review process
- merge into the master branch
- plan next release

Seasonal prediction of wind capacity factor



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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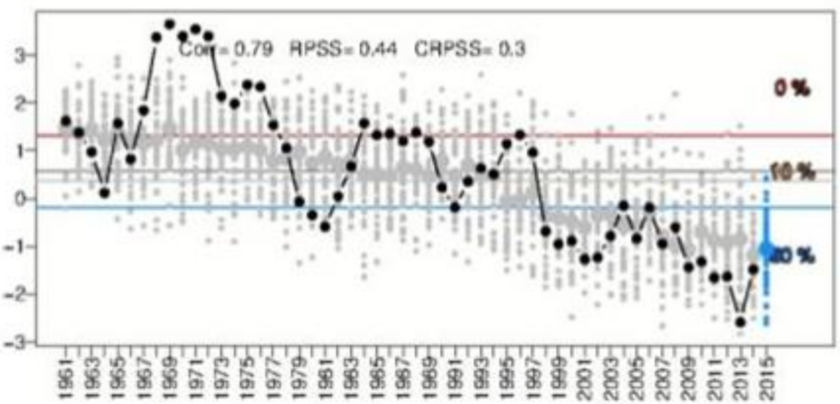
L. Lledó

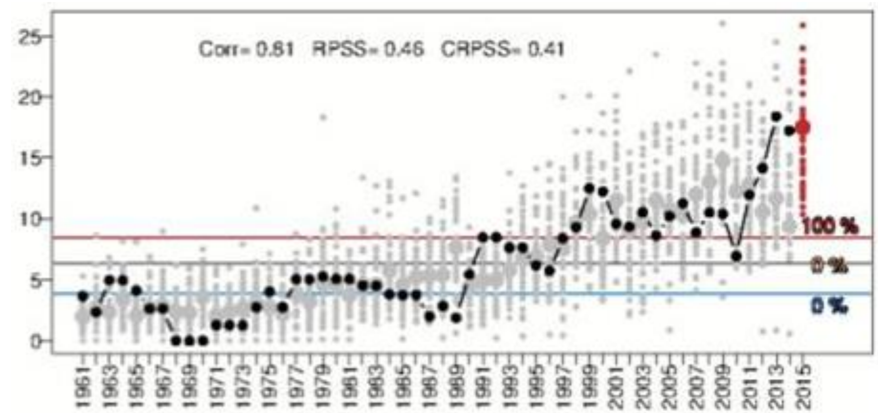
Decadal prediction of crop yield indices

WMO recognised global producing centres of decadal predictions contribute with the definition of standards for decadal predictions data and products, while C3S promotes the evaluation of the European multi-model and the illustration of the decadal prediction use in, among other sectors, the agricultural sector.

SPEI6



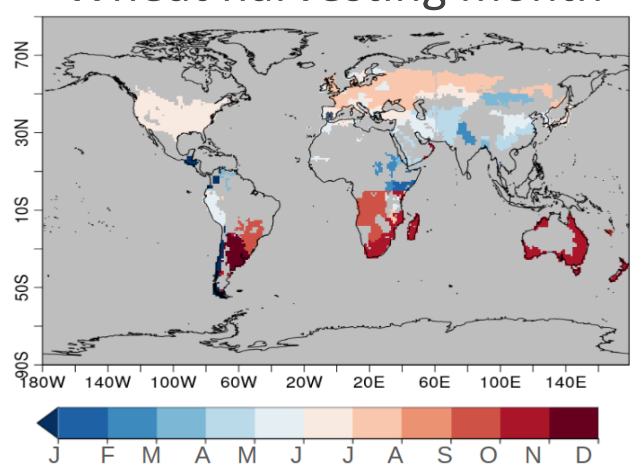
HMDI3



Indicators:

- Drought: Standardized Precipitation Evapotranspiration Index (SPEI6)
- Heat Stress: Heat Magnitude Day Index (HMDI3)

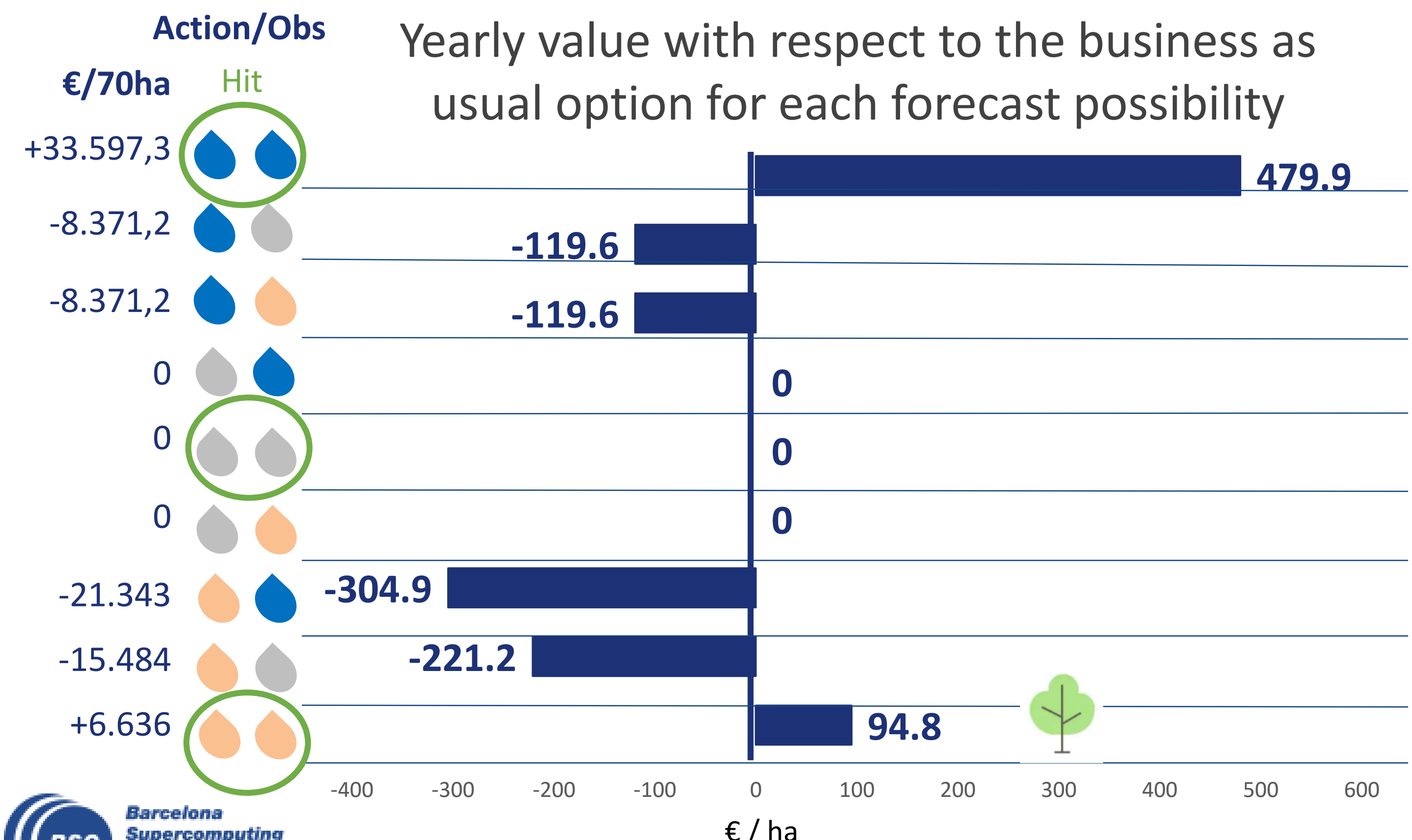
Wheat harvesting month



B. Solaraju

User value: wine making

A wine producer is using seasonal forecasts of spring rain (provided in January) to make decisions about with the objective of maximising the payoff of the production of a 70 ha lot. Forecast value is user specific and is the basis for the user-oriented forecast application.



Spring Rain (SP)	
Above Average	
Normal	
Below Average	
Plant Protection Costs	C_{pp}
Canopy Management Costs	C_{cm}
Yields	Y

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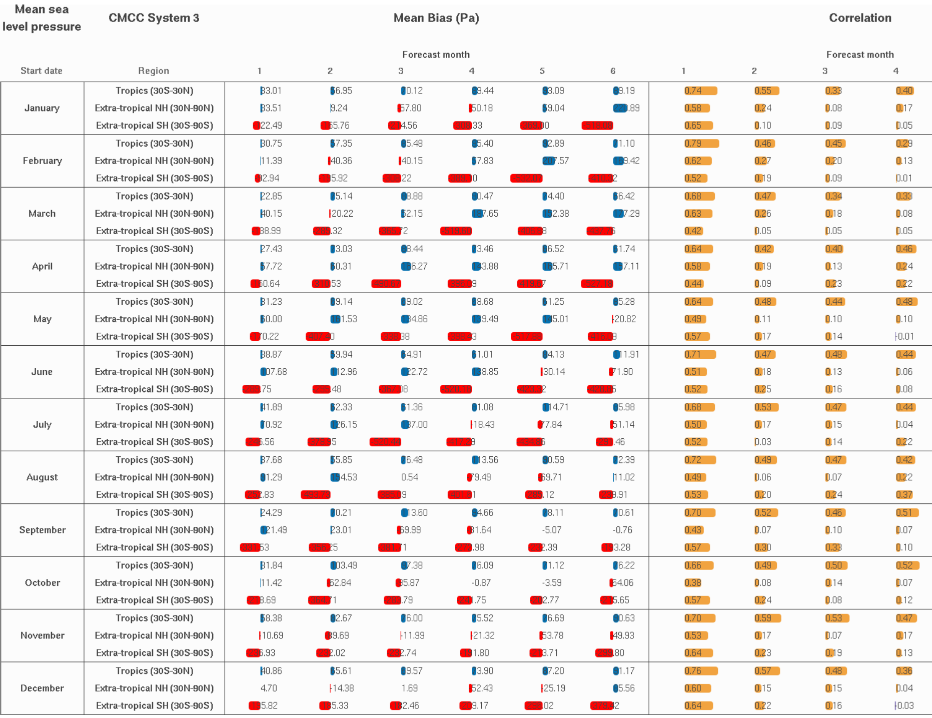
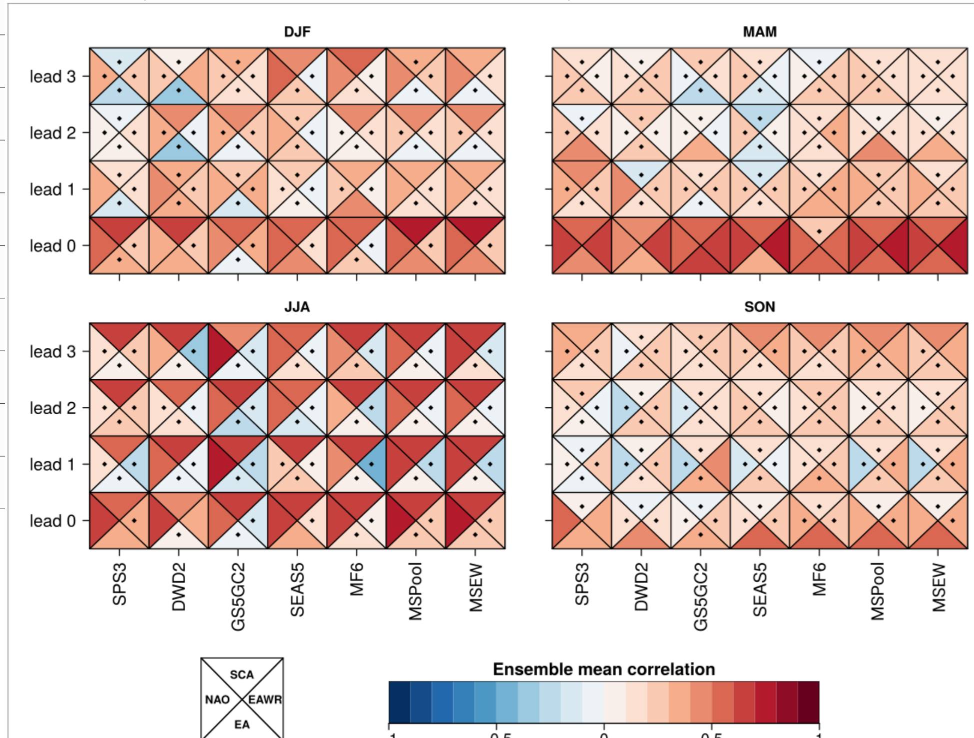
I. Vigo

Do not underestimate the power of an image

Scorecards and comprehensive displays of forecast quality measures become essential in a user-oriented service.



Forecast quality measures for the CMCC-CM3 operational seasonal forecast system from C3S.



Correlation for C3S seasonal forecasts of North Atlantic modes of variability.

N. Cortesi

opernicus Europe's eyes on Earth

Climate Change Service

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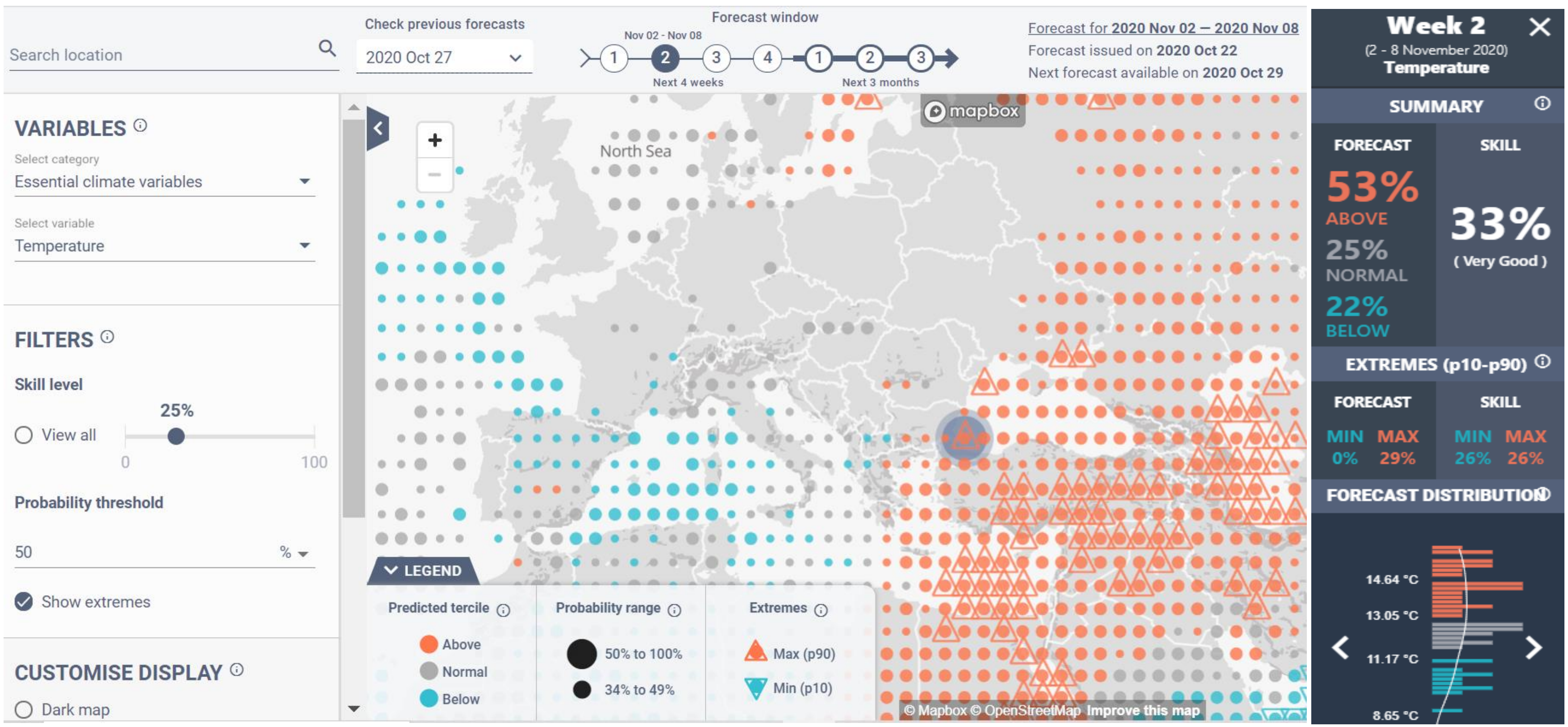
Lledó et al. (2020, ERL)

Prototypical climate services for energy

S2S4E is developing a decision support tool for the renewable energy sector based on Copernicus climate forecasts, S2S, and NCEP operational predictions co-designed with the industry for periodic updates on the state of relevant climate variables.



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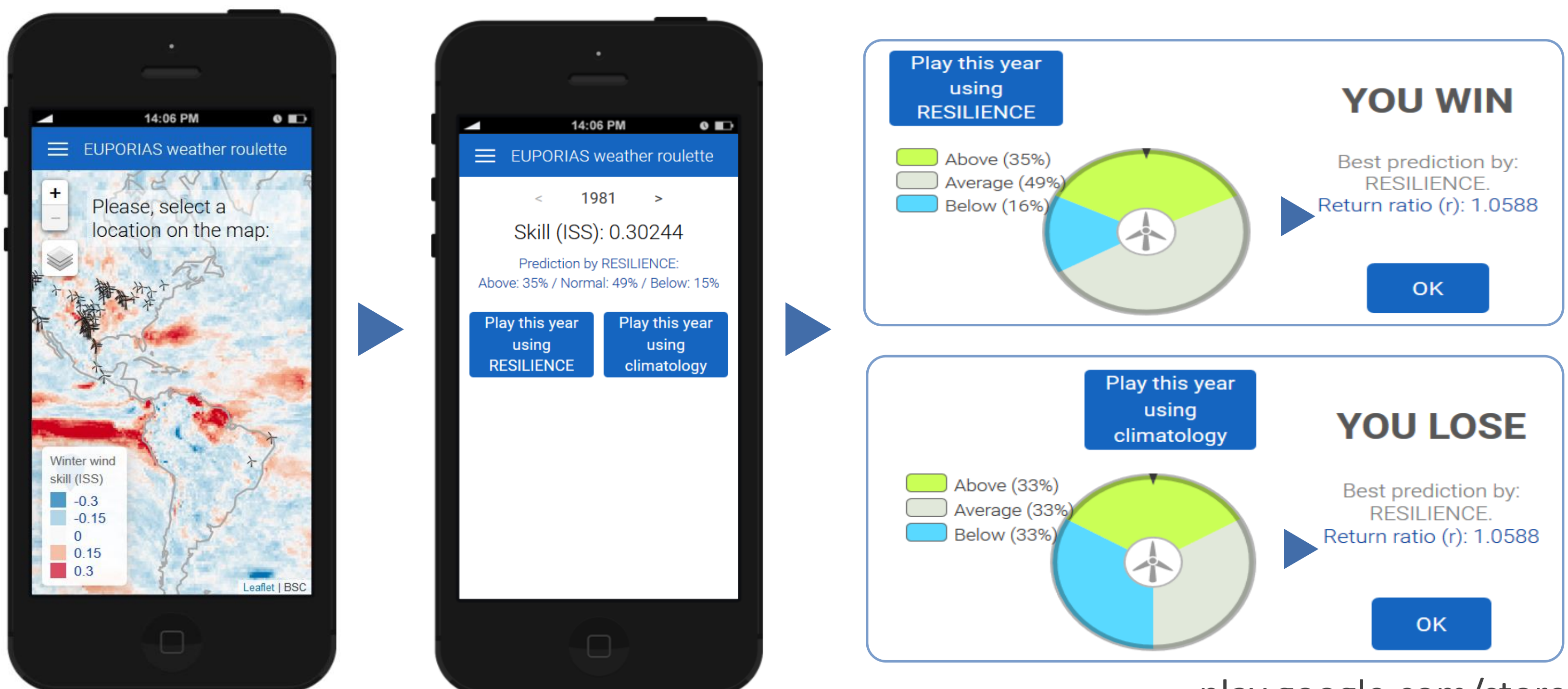
Subseasonal-to-Seasonal S2S Prediction Project

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

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

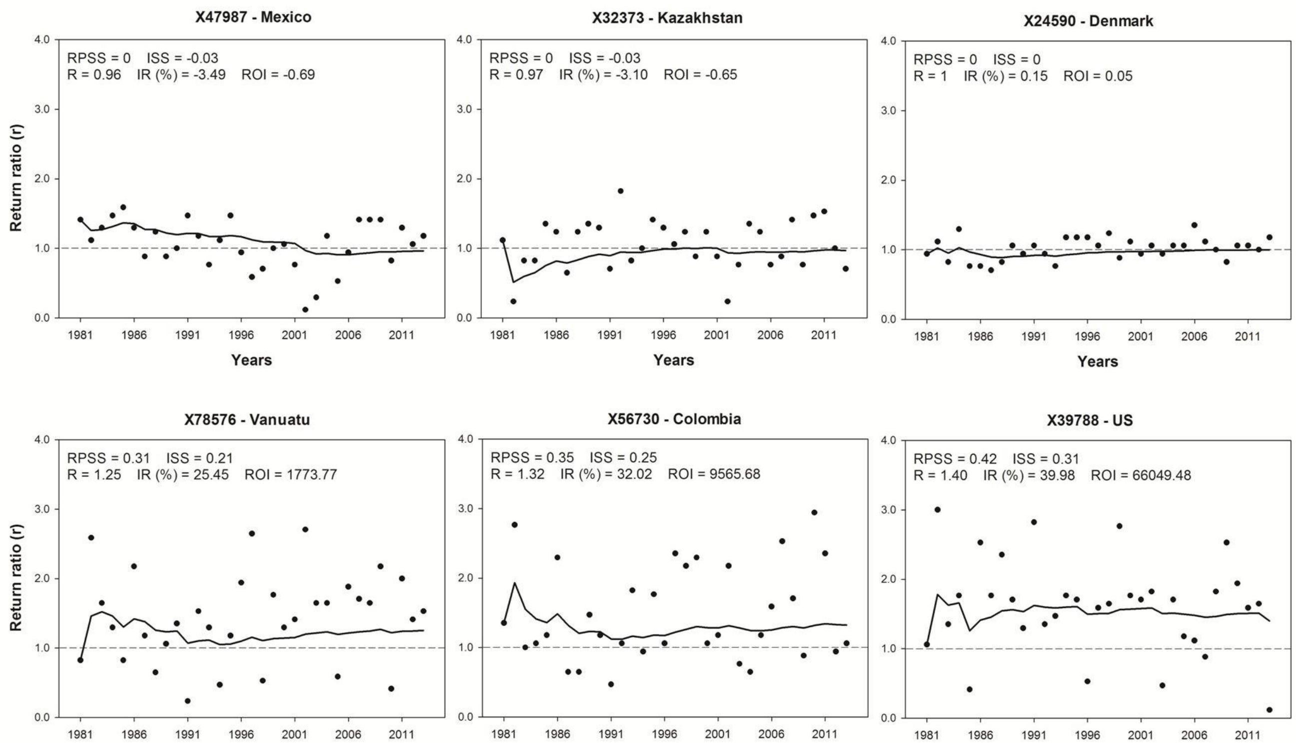
S2S4E
Climate Services for Clean Energy

Terrado et al. (2019, BAMS)

Illustrating the value of predictions

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

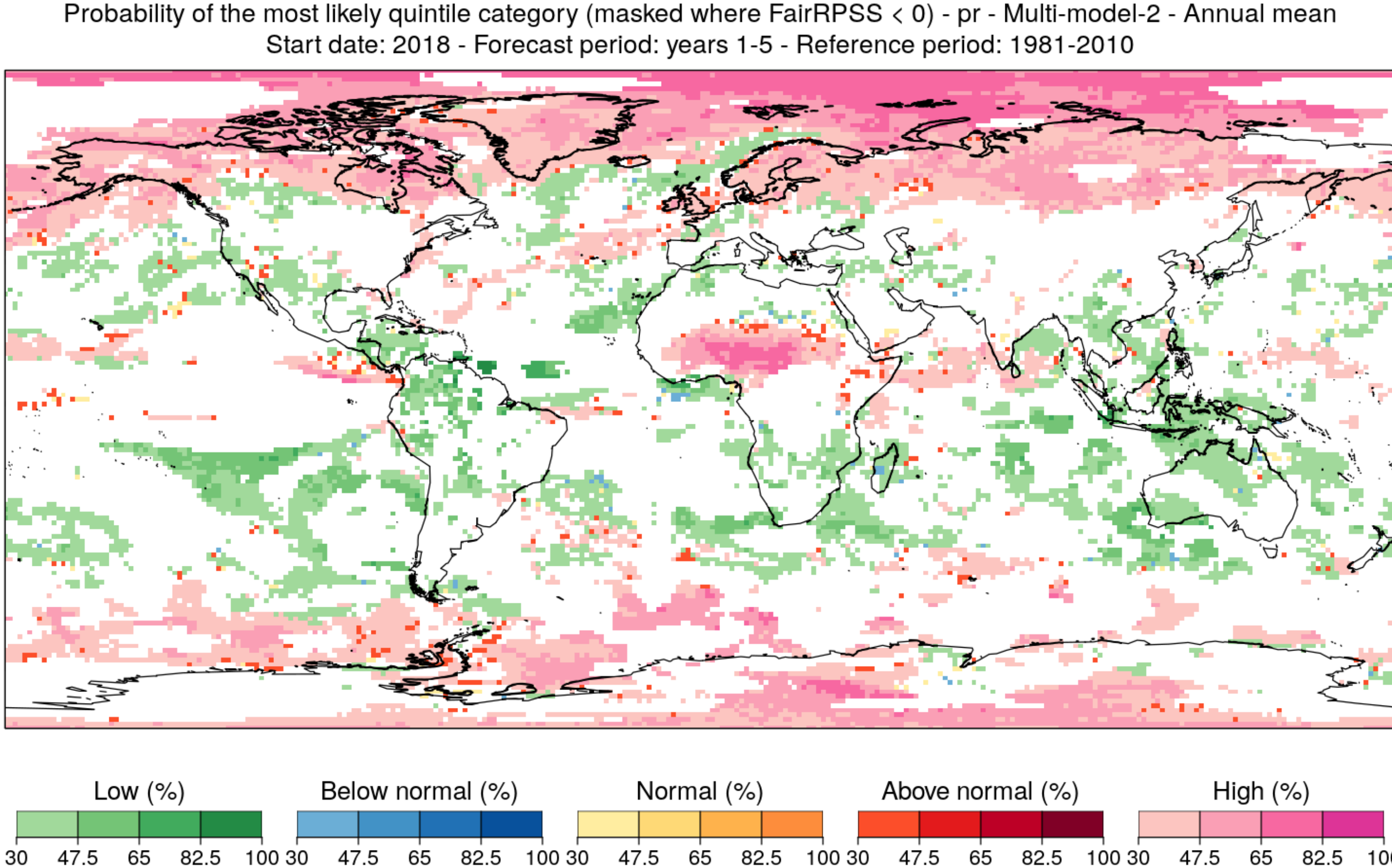
S2S4E
Climate Services for Clean Energy

Terrado et al. (2019, BAMS)

Multi-model climate predictions

Multi-model forecasts have been considered as an acceptable way to synthesise forecast information.

Decadal predictions of precipitation for forecast years 1-5 started near the end of 2018.



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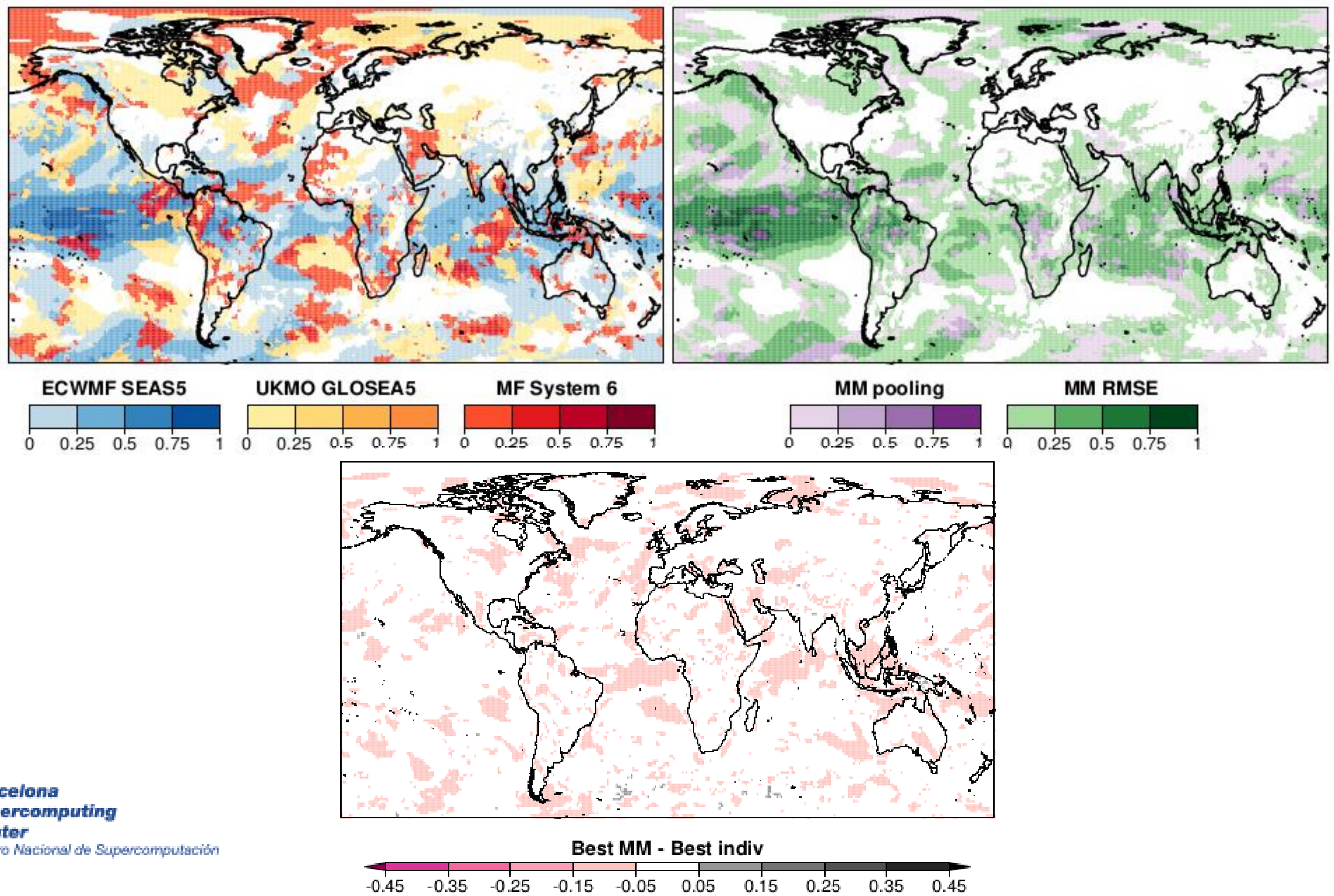
Copernicus Europe's eyes on Earth

Climate Change Service

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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V. Torralba

The non-exhaustive list of relevant elements

- Observational uncertainty: comparison between reanalyses in a forecast verification context.
- Definition of standard procedures: standards are less common than one would expect.
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