Earth Sciences Department

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WGSIP25's Centre Update:

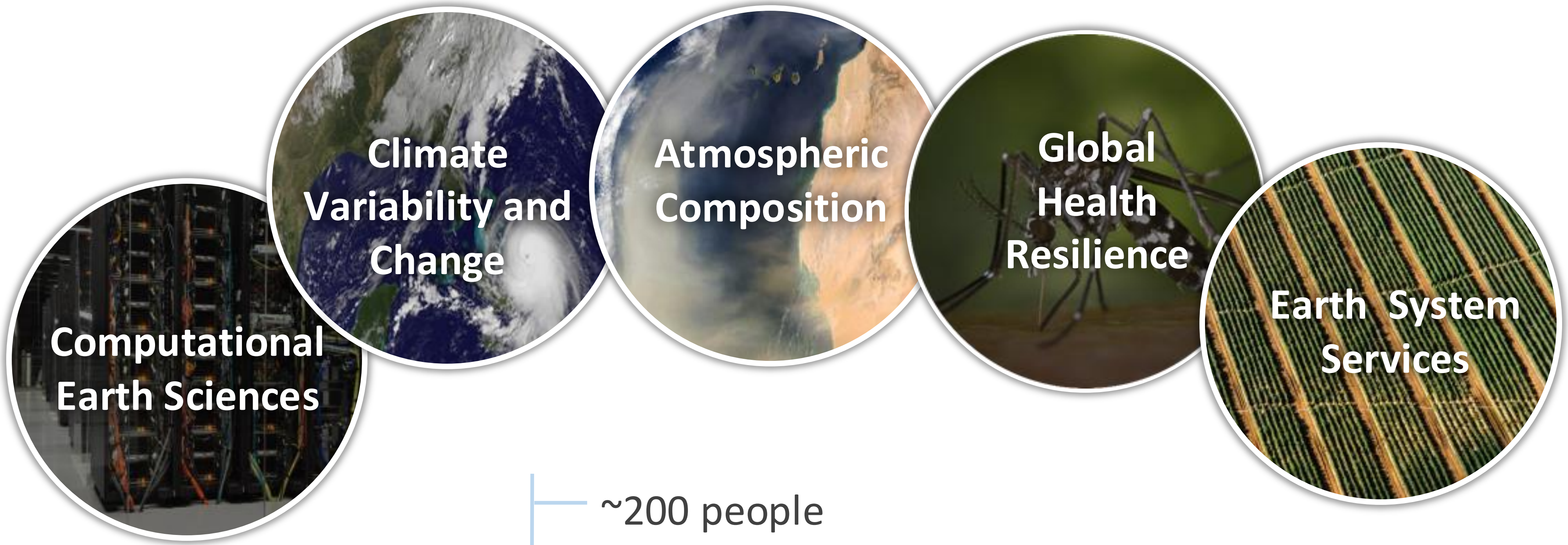
BSC

Ángel G. Muñoz
Head, Climate Services Team (CST)
Ramón y Cajal Fellow
Earth System Services (ESS) Group

Grant RYC2021-034691-I, funded by MCIN/AEI/10.13039/501100011033 and the European Union NextGenerationEU/PRTR

Earth Sciences Department

Environmental modelling and forecasting using process-based and artificial intelligence models, with a particular focus on weather, climate and air quality. This includes transferring solutions to support the main societal environmental challenges through data applications



- ~200 people
- Funding from EC, Copernicus, private sector, ESA, Spanish and regional governments
- Four ICREA, closer link to local universities

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Climate services across sectors

Temporal scale ↓

Sources	Description	Competences			Target
PAST OBSERVATIONS	Includes station data, gridded datasets or reanalysis	Tall towers dataset Observational uncertainty			SECTORS AND APPLICATIONS Wind Energy Agriculture Retail Health Herding Urban areas
SUB-SEASONAL FORECASTS	Fill the gap between weather and seasonal forecast	Assessment and verification	Indicators	Use cases and operational services	
SEASONAL FORECASTS	Takes advantage of slowly changing parts of the climate system				
DECADAL FORECASTS	Fill the gap between seasonal and long-term projections				
CLIMATE PROJECTIONS	Explore long-term climate change impacts			Seamless climate projections	

FOCUS-AFRICA
VITIGEOSS
E4 WARNING
EUCP European Climate Prediction system
PIISA
Destination Earth | EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS
S2S4E Climate Services for Clean Energy
eRise
MED-GOLD
ArcticXchange
iDAlert Infectious Disease decision-support tools and Alert systems
HARMONIZE
AI for Drought
LANCET COUNTDOWN: TRACKING PROGRESS ON HEALTH AND CLIMATE CHANGE
ASPECT
IMPETUS 4 CHANGE
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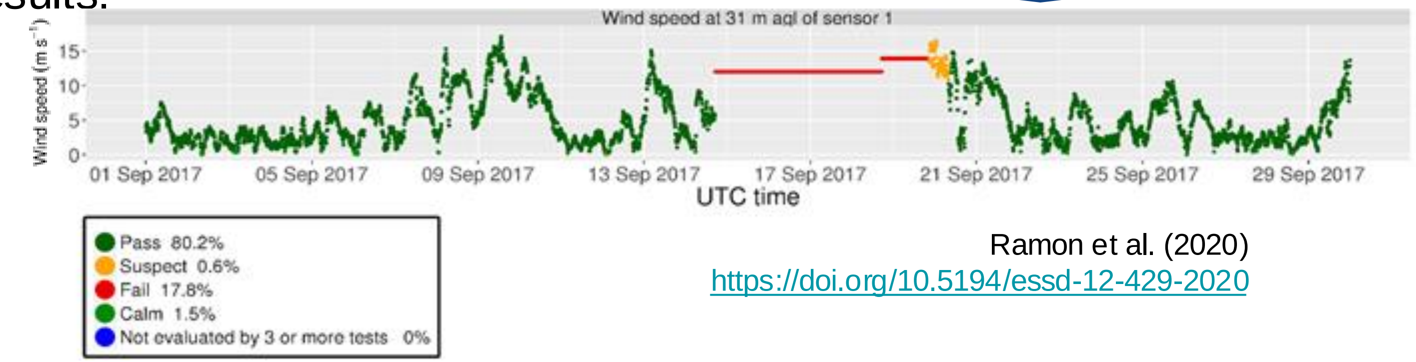
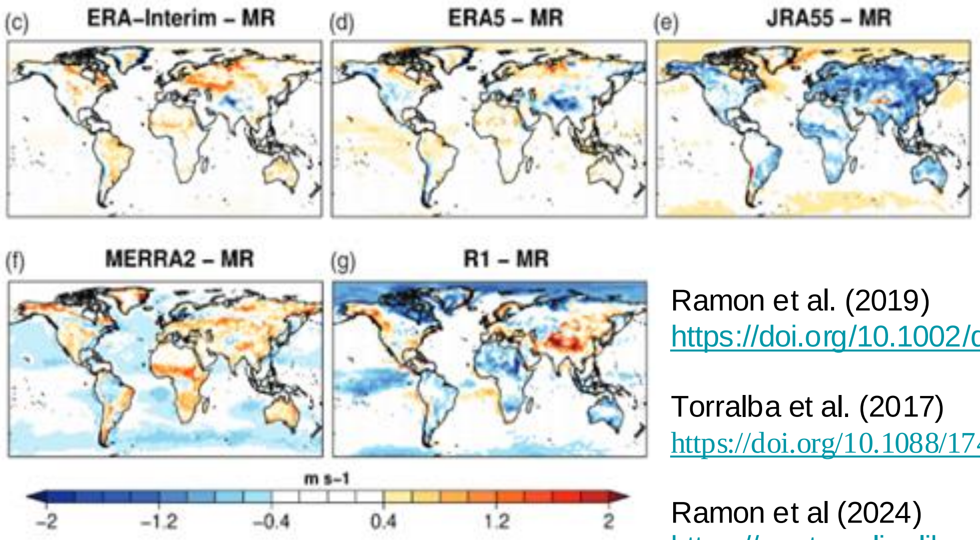
Observational uncertainty

Though observations are often used as a benchmark without any consideration of their quality, they can be subject to errors (e.g. instrumental or systematic errors) which may impact the results.

Quality Control of time series



Ramon et al. (2020)
https://doi.org/10.5194/essd-12-429-2020



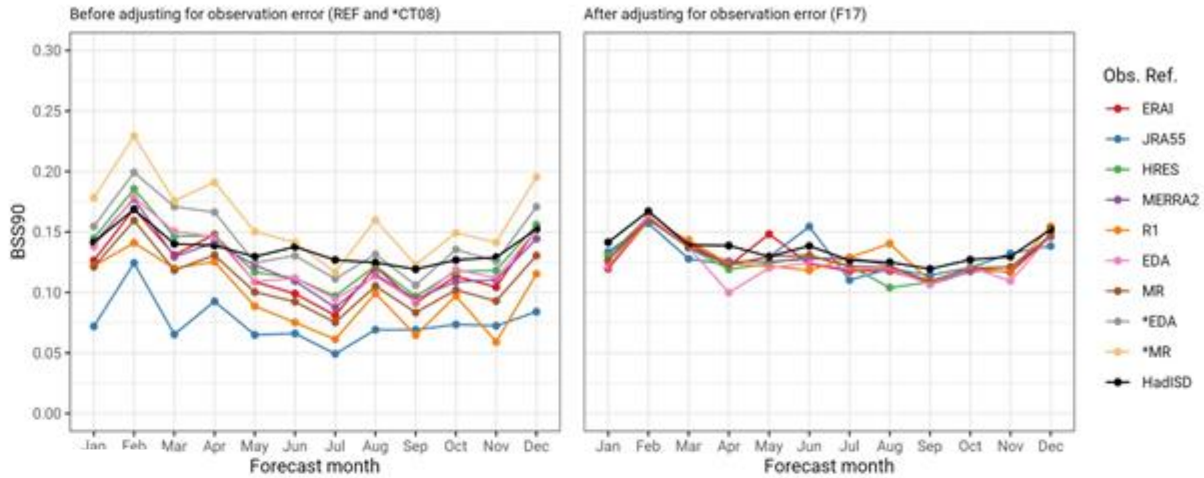
Ramon et al. (2019)
https://doi.org/10.1002/qj.3616

Torralba et al. (2017)
https://doi.org/10.1088/1748-9326/aa8a58

Ramon et al (2024)
https://rmets.onlinelibrary.wiley.com/doi/e
df/10.1002/qj.4628

Quantification of differences in wind speeds **between reanalyses**

Impact of observational uncertainty in forecast verification



Uncertainties in the observational reference: Implications in skill assessment and model ranking of seasonal predictions

Jaume Ramon[1] | Lloренç Lledó[1,2] | Christopher A.T. Ferro[3] | Francisco J. Doblas-Reyes[1,4]

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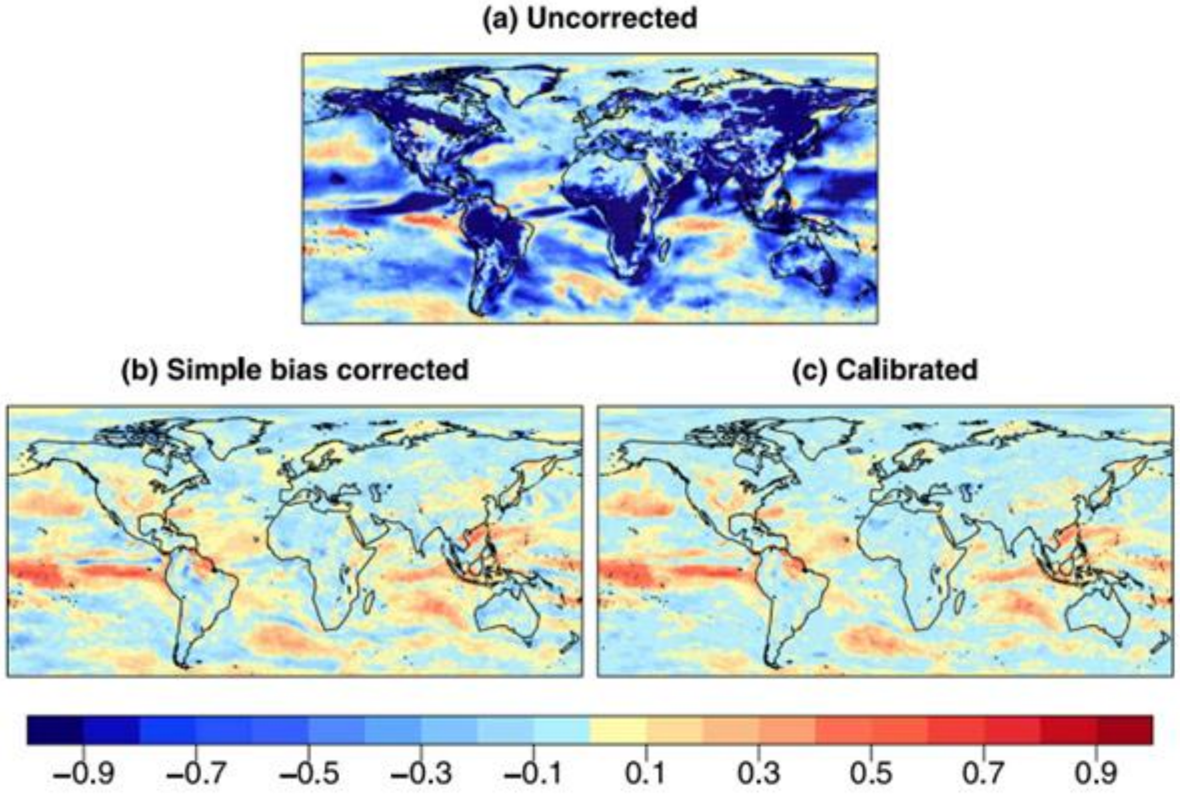
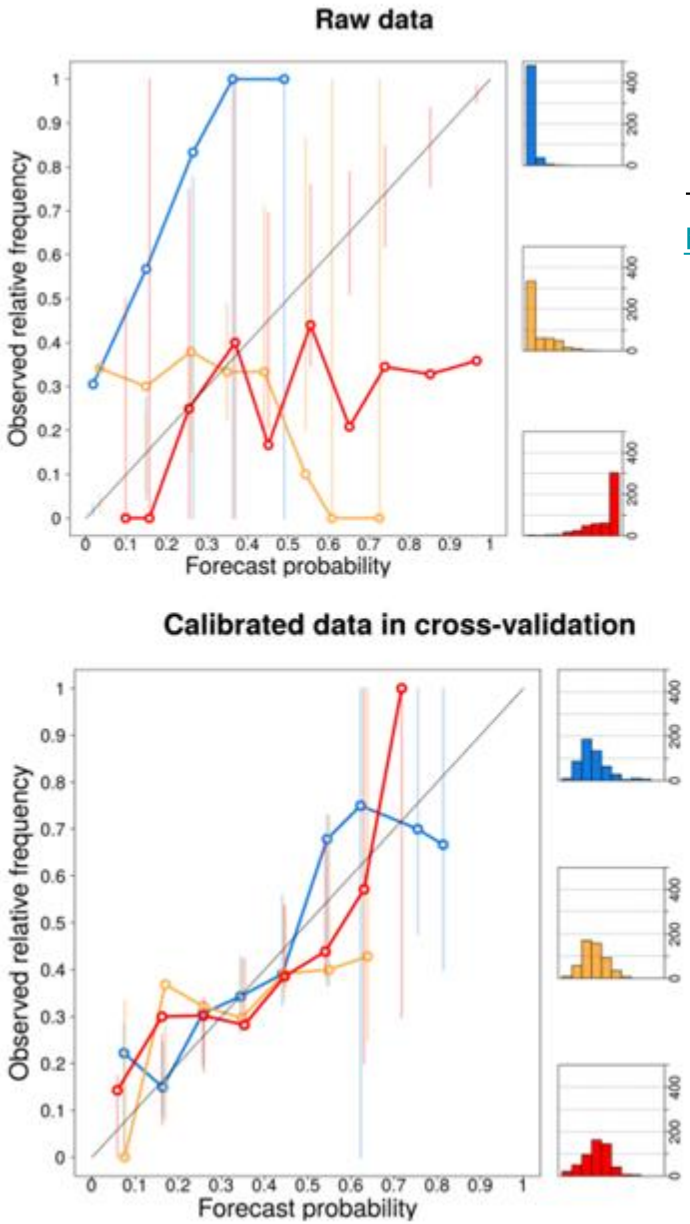
Bias adjustment and calibration

Through bias adjustment, we remove systematic errors and improve the reliability of climate predictions.



Fair RPSS for tercile events of winter 10-m wind speed forecasts



Torralba et al. (2017)
https://doi.org/10.1175/JAMC-D-16-0204.1

Reliability diagram exemplifying the difference between raw and calibrated seasonal predictions

Calibration function from the CSTools package

Pérez-Zanón et al. (2022)
https://doi.org/10.5194/gmd-15-6115-2022

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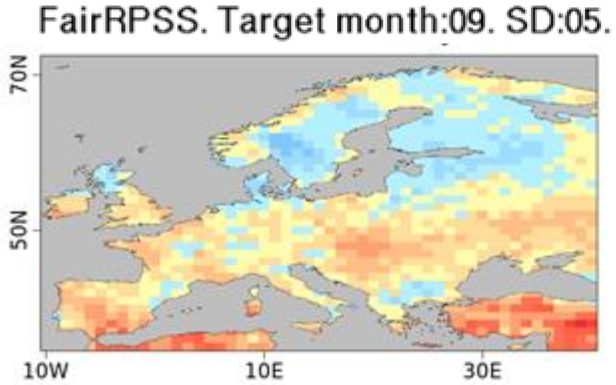
Forecast quality assessment

The forecast quality assessment (or forecast verification) is a necessary step to evaluate the performance of the predictions and should be provided with every forecast product.

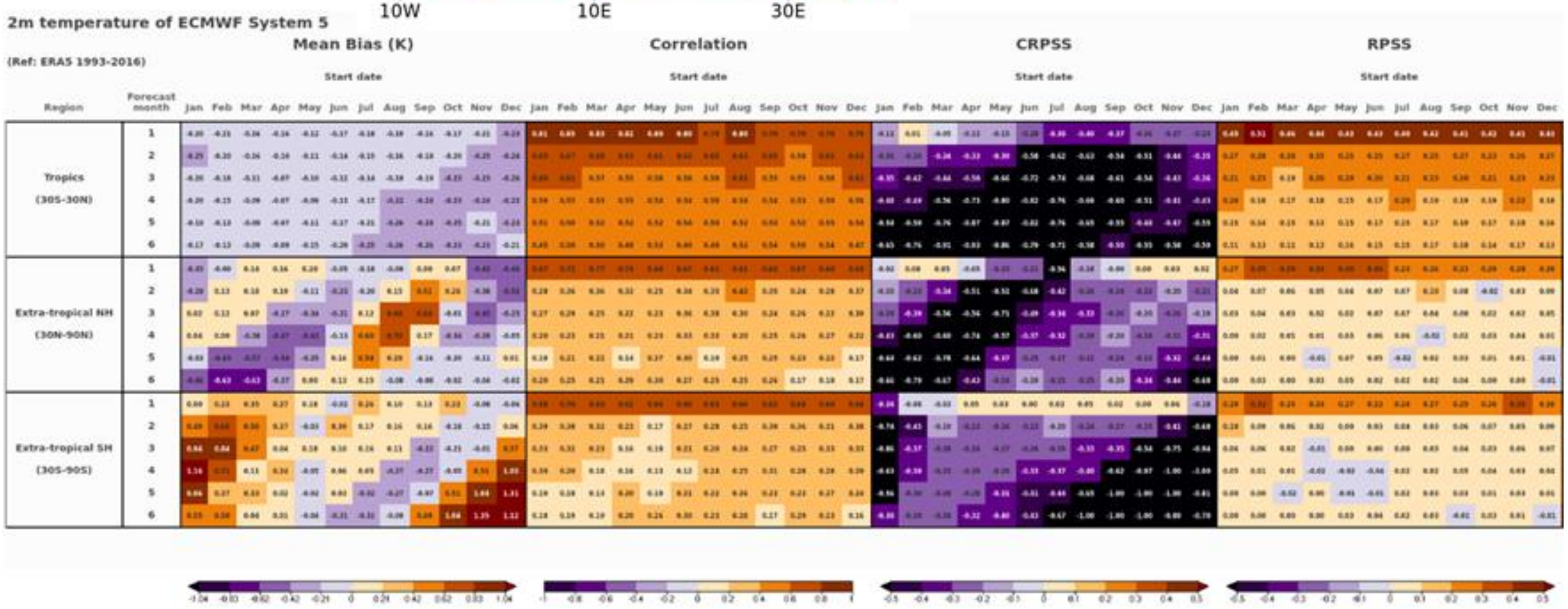
Analysis of probabilistic and deterministic metrics are performed. Given the probabilistic nature of the climate forecasts, **scores** and **skill scores** are commonly used.



FairRPSS for SPEI6 predictions of September (ref. Period 1985-2017), using hindcast data

Torralba et al. (2017)
https://doi.org/10.1175/JAMC-D-16-0204.1
Delgado et al. (2022)
https://doi.org/10.1175/JCLI-D-21-0811.1
Solaraju-Murali et al. (2019)
https://doi.org/10.1088/1748-9326/ab5043

Scorecards: Visualisation of verification metrics to measure the performance of models and estimate the reliability of climate predictions



Doblas-Reyes et al. (in preparation)

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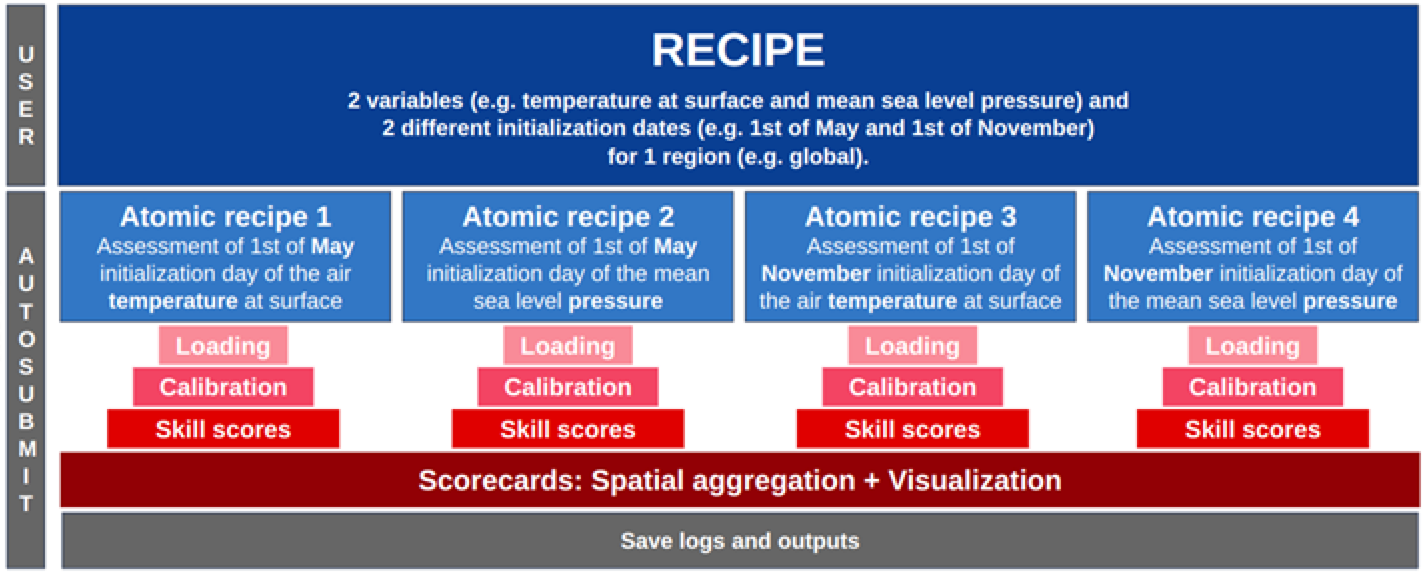
SUNSET: the SUbseasoNal-to-decadal climate forecast post-processiNg and asSEssmenT suite

SUNSET is a software suite developed collaboratively at the Barcelona Supercomputing Center, that aims post-process climate forecast outputs to provide climate services for sub-seasonal, seasonal and decadal time scales.

Its **modular design** allows the technicians and researchers flexibility in defining the required products, post-processing steps, outputs and visualization options. These computations can then be easily parallelized on HPC platforms, making use of the Autosubmit workflow manager.

The **SUNSET** repository:
https://earth.bsc.es/gitlab/es/sunset



Núria Pérez-Zanón, Victòria Agudetse, Lluis Palma, Carlos Delgado-Torres, Nadia Milders, Eren Duzenli, Alba Llabrés-Brustenga, Bruno de Paula Kinoshita, Pierre-Antoine Bretonnière, Albert Puiggròs, Ángel G. Muñoz

Pérez-Zanón et al., (2022, 2024); Pérez-Zanón et al., in

13th of June 2024 Belgium

Sub-seasonal climate forecast

	NEXT WEEK	IN 2 WEEKS	IN 3 WEEKS	IN 4 WEEKS
Precipitation	Normal	Below normal	Upper extreme	Lower extreme
Temperature	Below normal	Upper extreme	Above normal	Below normal

Seasonal climate forecast

	NEXT MONTH	IN 2 MONTHS	IN 3 MONTHS
Precipitation	Below normal	Above normal	Above normal
Temperature	Upper extreme	Above normal	Lower extreme

Timescales

Decadal climate forecast

	NEXT YEAR	IN 2 TO 5 YEARS
Precipitation	Below normal	Below normal
Temperature	Upper extreme	Upper extreme

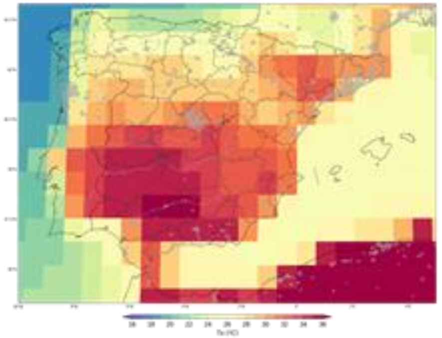
SUNSET

Exploring downscaling methods across timescales

Providing climate predictions with high resolution is very much needed for some applications, and here is where statistical downscaling comes to help.

The R package **CSDownscale** contains seven methods for downscaling climate data, either to a finer grid or to a point location.

Coarse scale model data



Interpolation
no need for training data
(observations are not used here)

Interpolation / CST_Interpolation
- Bilinear
- Bicubic
- Conservative
- Second order conservative
- Inverse distance weighting
- Large area fraction
- Nearest neighbour

regrid or point location

Observations needed

Bias-correction

Intbc / CST_Intbc
- Quantile mapping
- Simple bias correction
- EVMOS(variance inflation)
- mse_min
- crps_min
- rpc_based

Linear regression

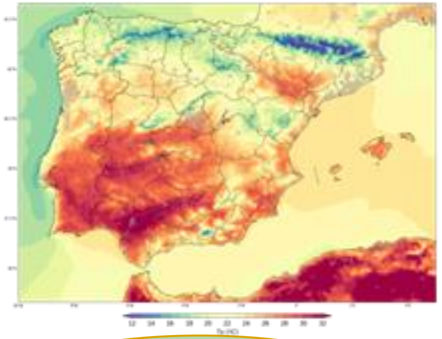
Intlr / CST_Intlr
- Basic
- Large-scale
- 9nn

Logistic regression

LogisticReg / CST_LogisticReg
- Ens_mean
- Ens_mean_sd
- Sorted_members

Analogs

Analogs / CST_Analogs



Fine scale model data

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Duzenli et al., sub judice

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Comparing Constraining Methods in NTCP

Near-Term Mediterranean Summer Temperature Climate Projections: A Comparison of Constraining Methods

Pep Cos,[a] Raül Marcos-Matamoros,[b,a] Markus Donat,[a,c]
Rashed Mahmood,[a,d] and Francisco J. Doblas-Reyes[a,c]

[a] *Earth Sciences Department, Barcelona Supercomputing Center, Barcelona, Spain*
[b] *Department of Applied Physics, University of Barcelona, Barcelona, Spain*
[c] *Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain*
[d] *Danish Meteorological Institute, Copenhagen, Denmark*

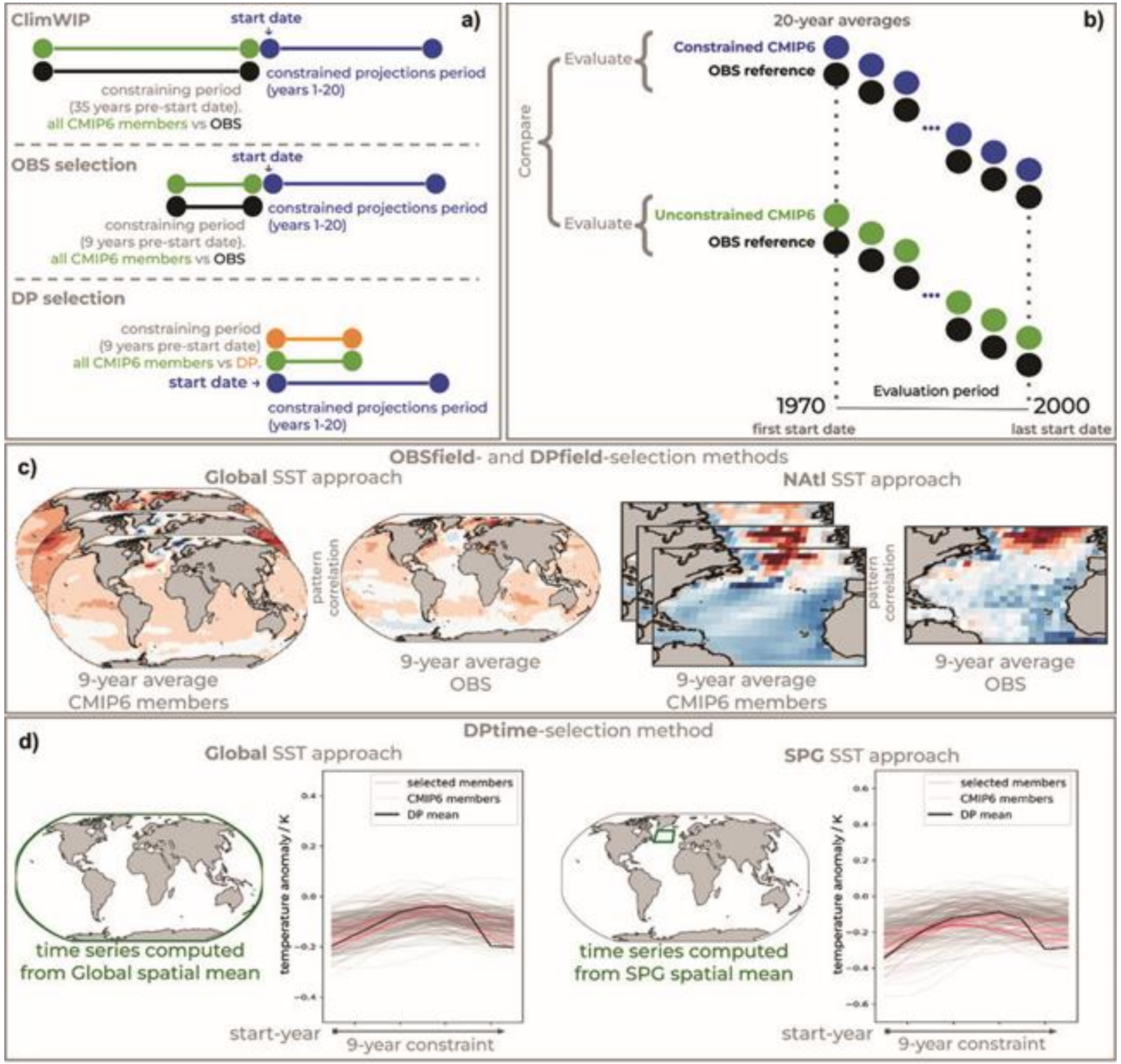

Fig. 1. Diagrams illustrating the main features of the constraining methodologies. (a) Constraining periods, start dates, and constrained projection diagrams for the ClimWIP, OBS, and DP selection methodologies (note that DPfield and DPtime use the same period for the constraint). (b) Process for the evaluation of the constrained and full CMIP6 ensembles against observational reference. (c) The OBSfield- and DPfield-selection methods can compute the SST pattern correlations over different target regions, which in this paper are either global (Glob) or the North Atlantic (NAtl). (d) The DPtime approach computes the mean absolute error between the reference time series and the rest of the CMIP6 ensemble, which are computed from either the Glob or the North Atlantic SPG area-averaged SSTs.

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Cos et al., 2024. JClim

Flow-dependent, cross-timescale physical diagnostics

1 NOVEMBER 2024 OLMO ET AL. 5525

Cross-Time-Scale Analysis of Year-Round Atmospheric Circulation Patterns and Their Impacts on Rainfall and Temperatures in the Iberian Peninsula

MATÍAS OLMO,[a] PEP COS,[a] ÁNGEL G. MUÑOZ,[a] VICENT ALTAVA-ORTIZ,[b] ANTONI BARRERA-ESCODA,[b] DIEGO CAMPOS,[a] ALBERT SORET,[a] AND FRANCISCO DOBLAS-REYES[a]

[a] Barcelona Supercomputing Center, Barcelona, Spain
[b] Meteorological Service of Catalonia, Barcelona, Spain

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Olmo et al., 2024. JClim

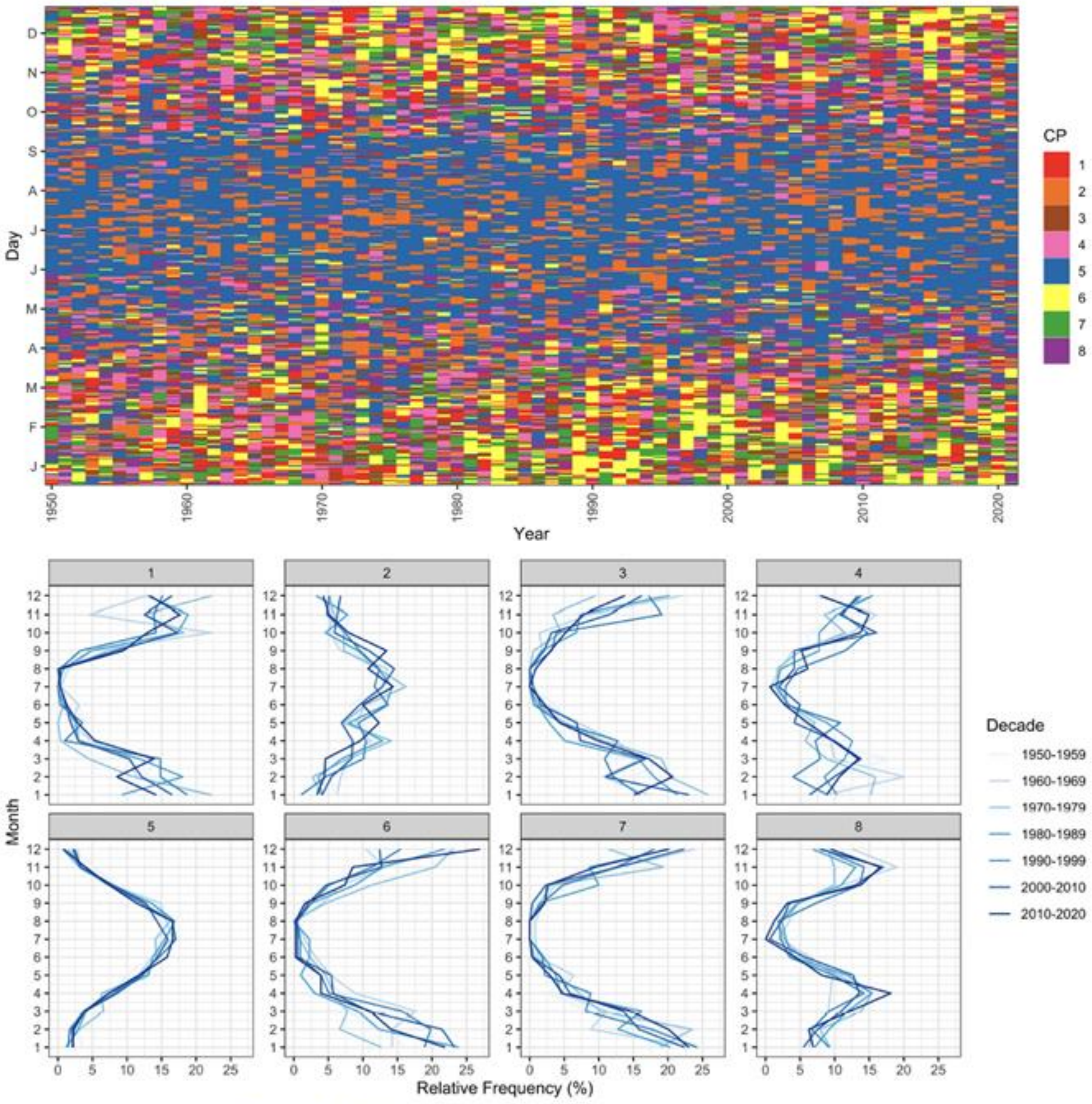
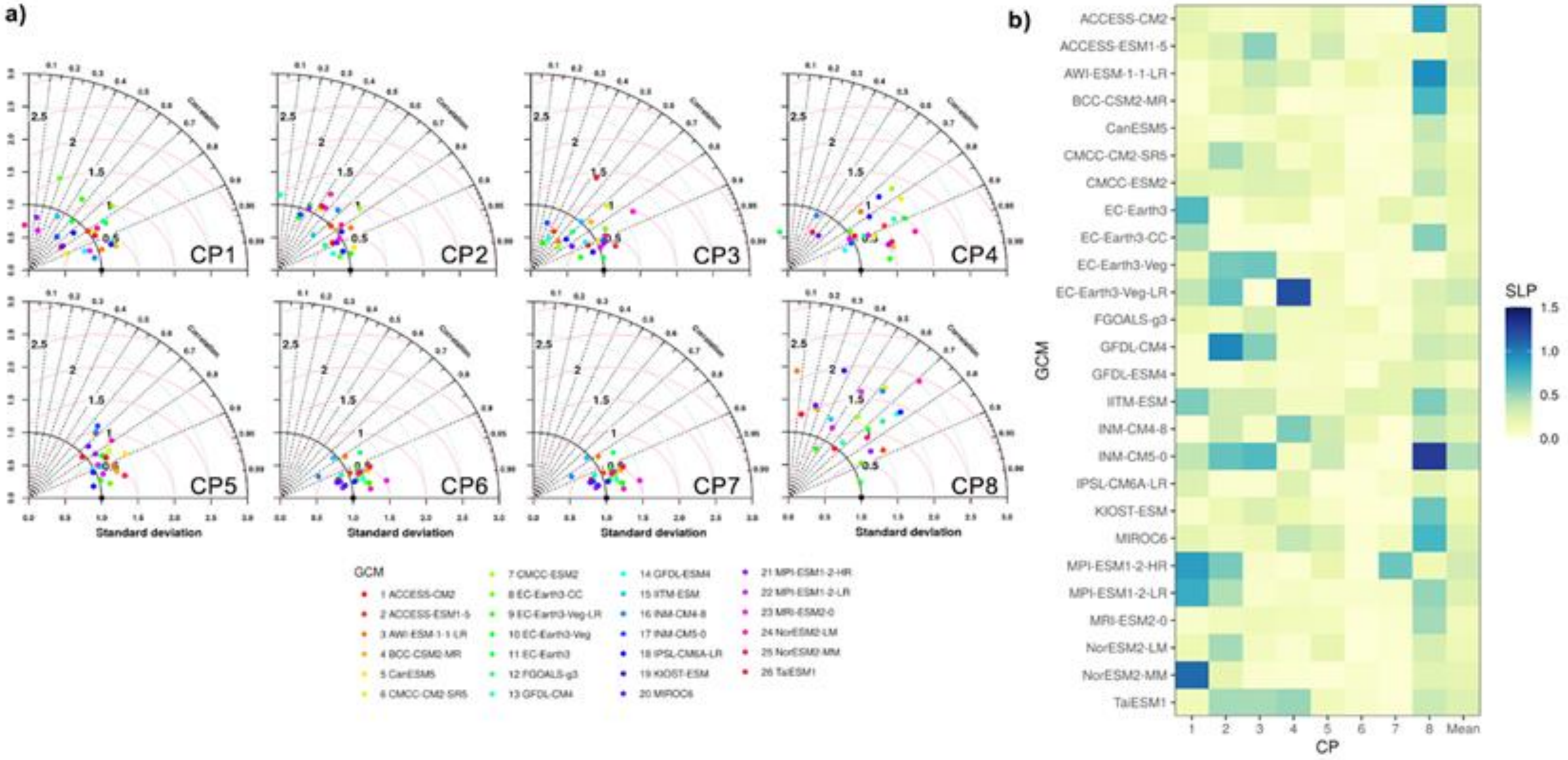


FIG. 7. (top) Klee diagrams (Muñoz et al. 2016) for the D2.8 classification. The *x* axis presents the years (1950–2022) and the *y* axis presents each day of the year. (bottom) The monthly frequencies of the CPs separated by decades (blue colors).

Flow-dependent, cross-timescale model diagnostics

Filtering CMIP6 models in the Euro-Mediterranean based on a circulation patterns approach

Olmo ME[1]*, Cos P[1], Campos D[1], Muñoz ÁG[1], Altava-Ortiz V[2], Barrera-Escoda A[2], Jury M[1,3], Loosveldt-Tomas S[1], Bretonniere PA[1], Doblas-Reyes F[1,4], Soret A[1].



Olmo et al., sub judice

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Representation of internal variability by models is key

On the role of model internal variability in reproducing synoptic circulation patterns in the Euro-Mediterranean

Matías Olmo[a] , Pep Cos[a] , Diego Campos[a] , Ángel G. Muñoz[a] , Margarida Samso[a] , Albert Soret[a] , Francisco Doblas-Reyes[a]

[a] *Barcelona Supercomputing Center, Barcelona, Spain*

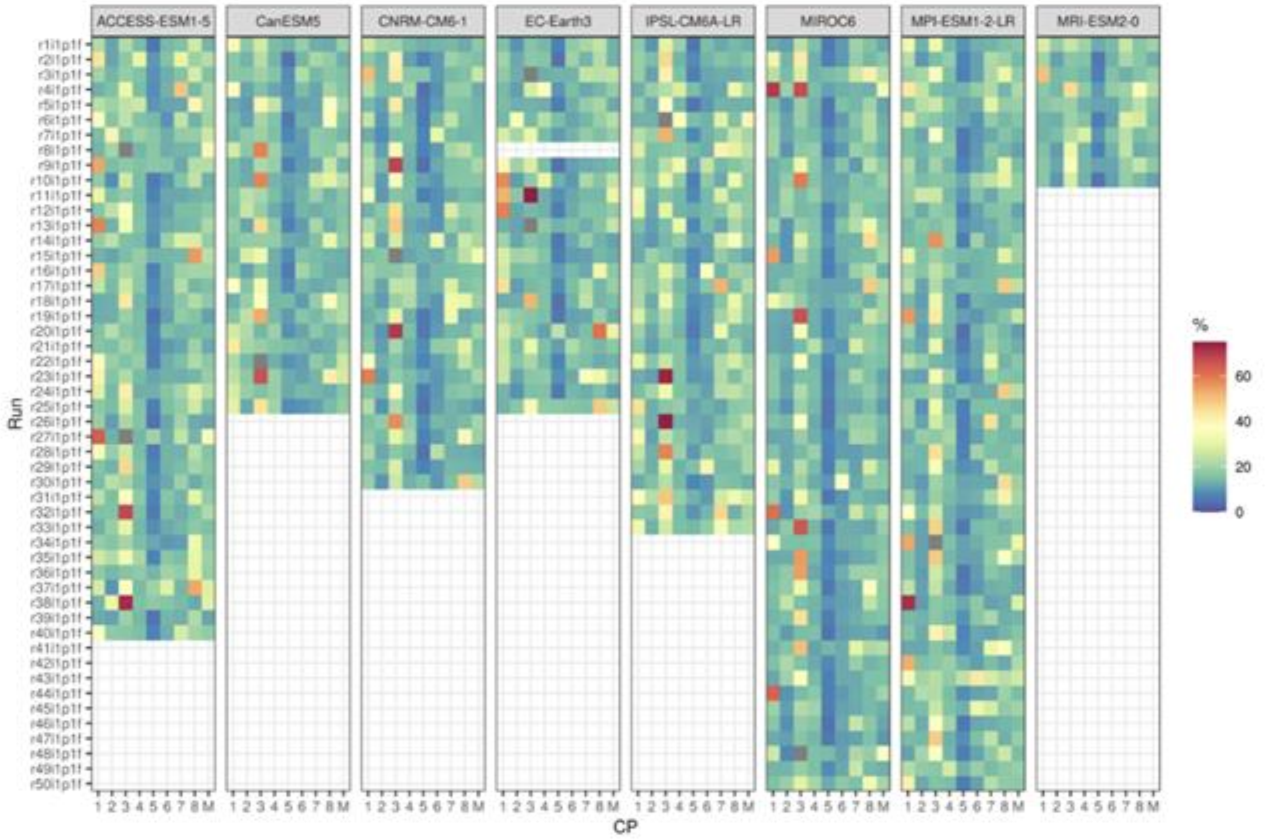

Fig. 4. ErrorCycle metric for each GCM run, expressed as a percentage of days with respect to the climatological frequency in the ERA5 reference. Results are presented for every CP, separately, and for the weighted mean of all CPs (M).

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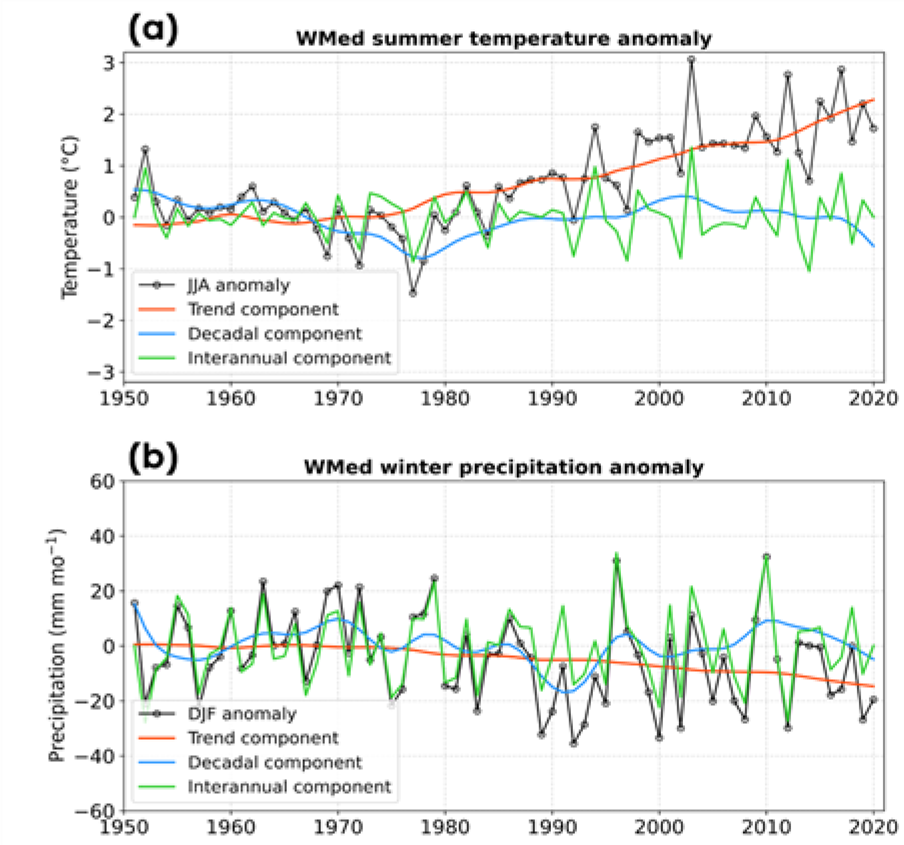
Muñoz et al (2017)
Olmo et al., sub judice

Diagnosing Observed and Modelled Trends via Timescale Decomposition



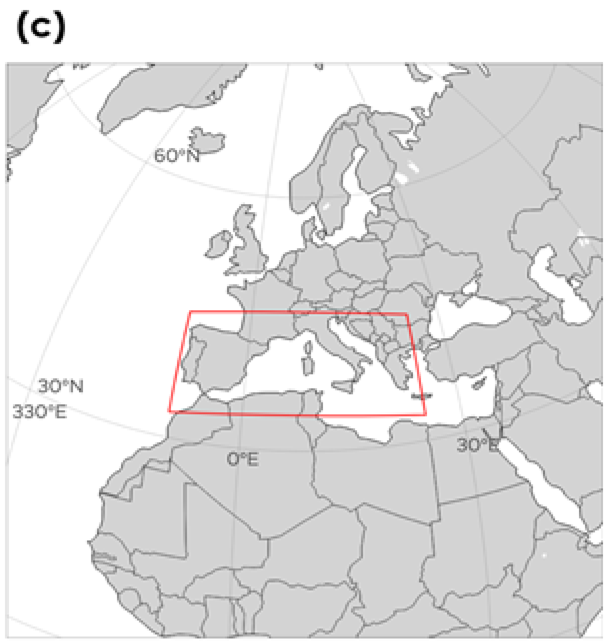


Figure 1. Timescale decomposition of the Western Mediterranean **(a)** winter precipitation anomalies, and **(b)** summer temperature anomalies. Long-term trends (red), decadal (blue), and interannual components (green) are shown. **(c)** Map of the area of study. The gray area (land-only) within the red box represents the defined Western Mediterranean (WMed).

Regional aspects of the recent observed trends in the Western Mediterranean: Insights from a Timescale Decomposition Analysis

D. A. Campos[1,2], M. E. Olmo[1], P. Cos[1,2], F. J. Doblas-Reyes[1,3], and Á. G. Muñoz[1]

[1] Earth Sciences Department, Barcelona Supercomputing Center, Barcelona, Spain.
[2] Facultat de Física, Universitat de Barcelona, Barcelona, Spain.
[3] Catalan Institution for Research and Advanced Studies, ICREA.

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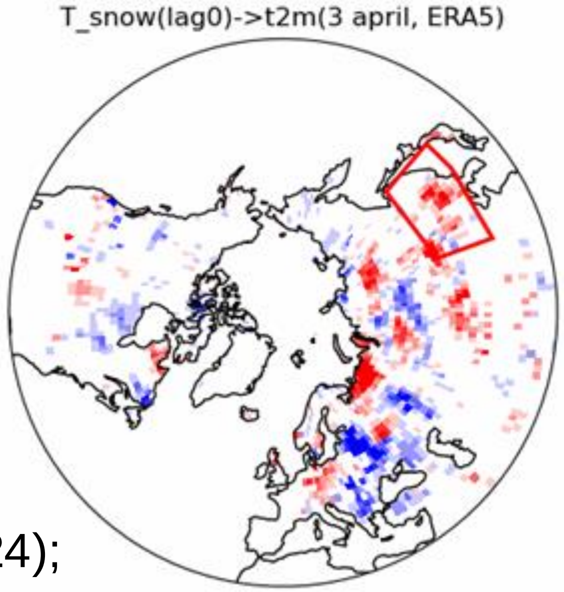
Campos et al., sub judice

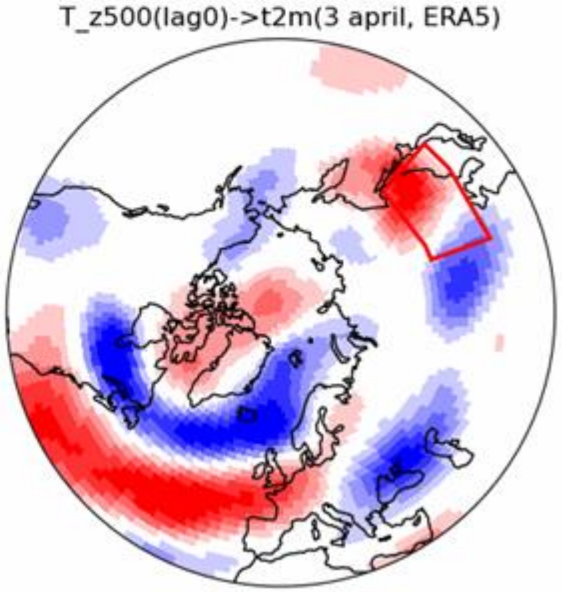
Causal ID of Sources of Predictability

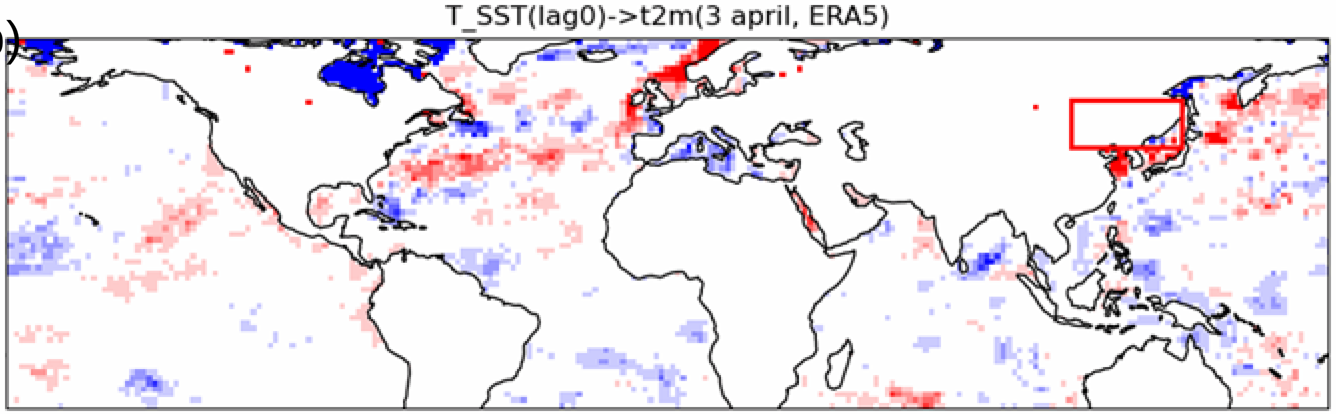
LK causality between (snow, z500 and sst), and t2m over the box

(colors indicate statistically significant, p<0.05)

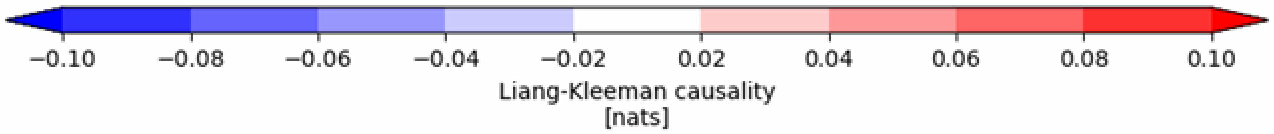
Ardilouze, Materia and Muñoz (2024);
Muñoz et al. (2023);
Ardilouze, Muñoz, Materia (in prep)
Muñoz (2024; in prep)







Causal and stable



Causal but unstable

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