

XXXVII Jornadas de la AME
Málaga, 27 de febrero 2026



boreas@bsc.es

Earth Sciences
Department



**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación

BOREAS: Combinando conocimientos de predicciones y proyecciones climáticas para incrementar la resiliencia del sector energético español frente a la variabilidad y el cambio climático.

BOREAS project: PID2022-140673OA-I00 funded by MICIU/AEI/10.13039/501100011033 and FEDER, EU

Paloma Trascasa-Castro, V. Torralba, S. Moreno, M. Olmo, C. Delgado-Torres, V. Agudetse, S. Octenjak, E. Baulenas, A. Batalla, A. Lacima-Nadolnik, P. Cos, N. Pérez-Zanón, A. Soret.



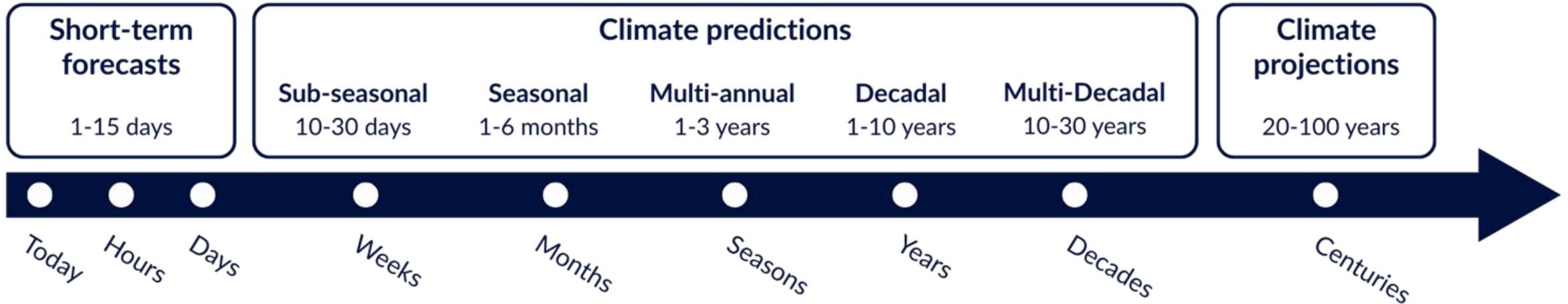
Understanding user needs through collaboration

- **Mapping** a comprehensive network of stakeholders within the energy sector: government, agencies, resource managers, data-related stakeholders, NGOs, private sector, academia, networks, media and investors.
- **User needs** and decision-making processes have been investigated and documented. They are based on:
 - Insights from previous projects, such as S2S4E (<https://s2s4e.eu/>),
 - Semi-structured interviews
 - **Workshop** conducted in BOREAS



Flyer (left panel) and pictures (right panel) for the joint workshop BOREAS-NEXTGEMS on the climate information at different timescales for the energy transition held in Madrid on the 24th of April 2025.

Decision-making at different time horizons



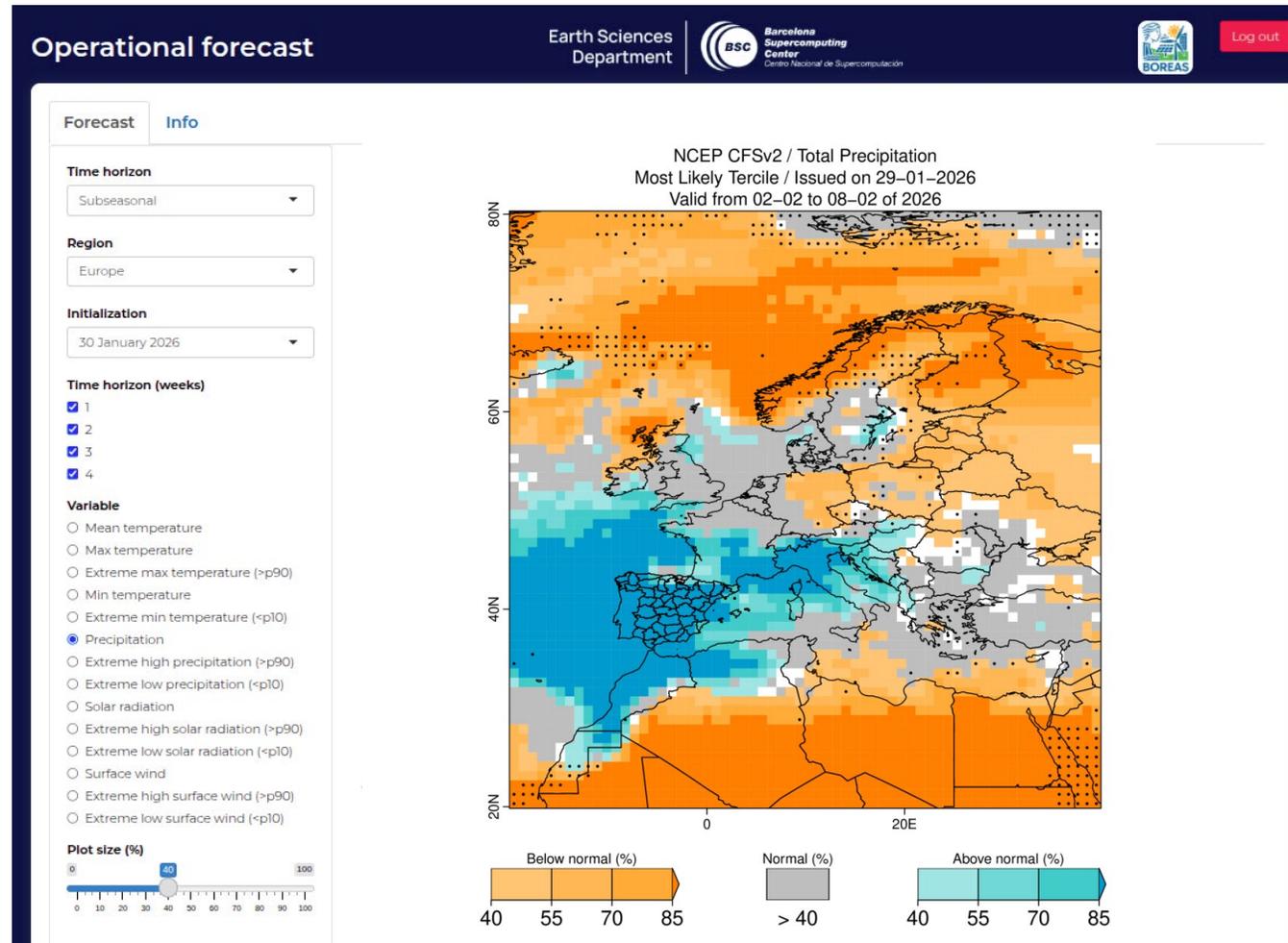
	Post-construction decisions	Post-construction decisions	Pre-construction decisions
Wind-Solar-Hydro generation	<p>Energy producers: commit energy sales for next day</p> <p>Grid operators: Market prices and grid balance</p> <p>Energy traders: Anticipate energy prices</p> <p>Plant operators: planning for cleaning and maintenance</p>	<p>Energy producers: Resource management strategies</p> <p>Energy traders: Resource effects on markets</p> <p>Plant operators: Planning for maintenance works (O&M)</p> <p>Plant investors: anticipate cash flow, optimize return on investments</p>	<p>Power plant developers: Site selection. Future risks assessment. Estimate annual energy production and its variability.</p> <p>Investors: Evaluate return on investments. Assess changes to energy mix</p> <p>Policy-makers: Define changes to energy mix</p> <p>River-basin managers: understand changes to better manage the river flow</p>

Operational S2S forecasts



Interactive web platform to visualise **subseasonal** and **seasonal** predictions

Please email us to get access to the web platform:
boreas@bsc.es

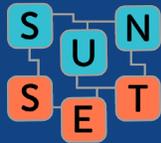


Operational S2S forecasts



Data and methods

The post-processing, calibration and visualisation of t has been performed with **SUNSET** (Subseasonal to decadal climate forecast post-processing and asSEssmenT suite). Pérez-Zanón *et al.* (2024).



Subseasonal forecast: NCEP CFSv2 (Saha, 2014), 48 forecast and 12 hindcast members. Reference period is 1999-2016. **Seasonal forecast:** ECMWF SEAS5 (Johnson *et al.* 2019), 51 forecast and 25 hindcast members. Reference period is 1999 to 2016.



What's available?

Most likely tercile maps of precipitation, temperature, surface winds and incoming solar radiation.

Probability of extremes (<p10 and >p90)

Statistical downscaling to 25 km, maps of Europe

Lack of skill (RPSS<0) displayed as dots

Coming soon

- Multi model forecasts:
 - Subseasonal with CFSv2 and ECMWF
 - Seasonal with all from C3S
- Key indicators: energy demand, solar and wind capacity factors

Forecast outlooks

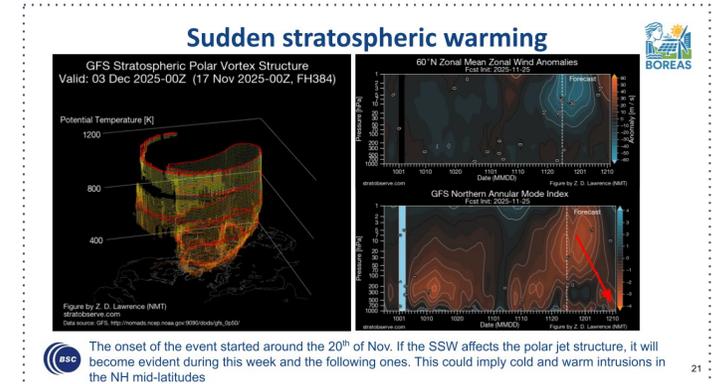
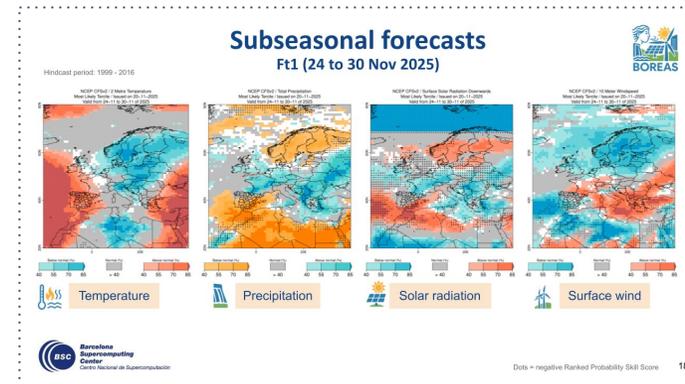
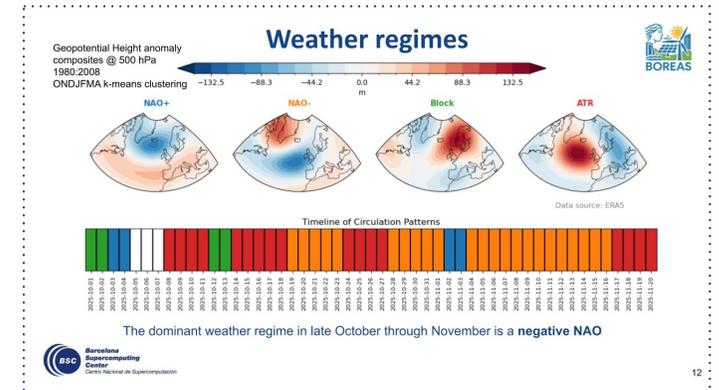
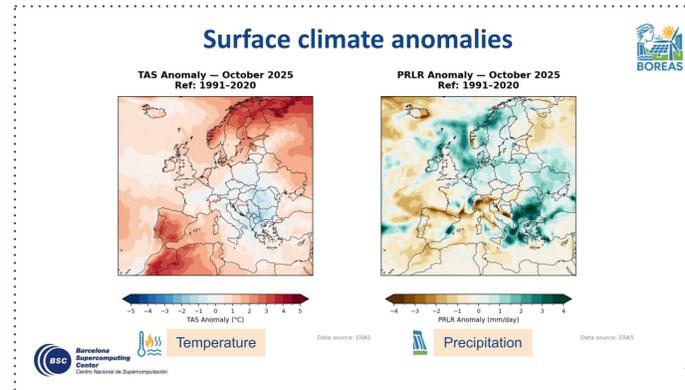
Online webinar (~ 50 p. on the first one)

Analysis of the recent state of the climate.

Anomalies, significant events, weather regimes analysis.

Discussion of subseasonal and seasonal forecasts.

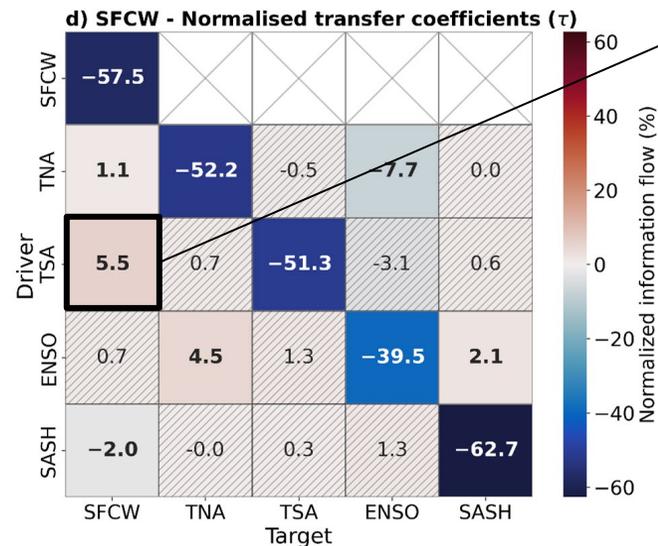
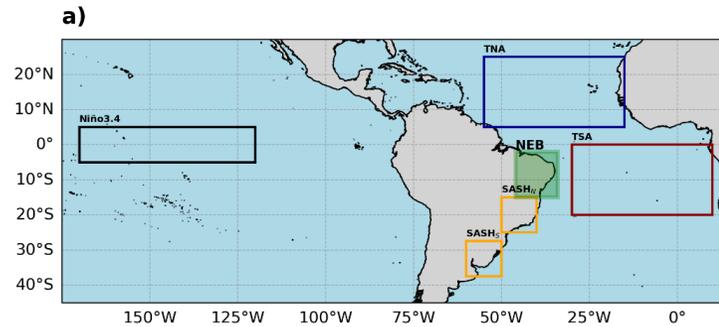
ENSO and European climate. Weather regimes, potential events with impacts on the energy sector.



Process-based evaluation

Northeast Brazil (NEB) is a climate-sensitive region and strategically important for Brazil's energy security, concentrating nearly 90% of the country's installed wind power capacity.

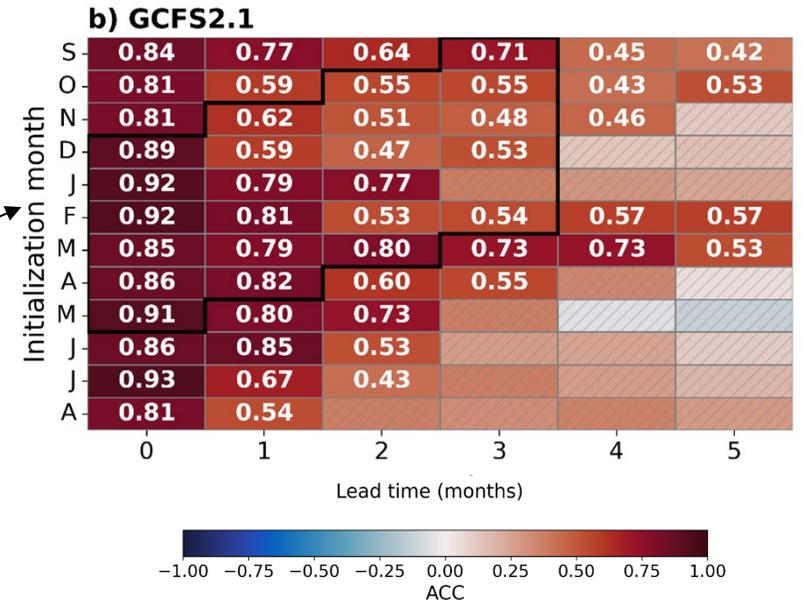
Driver identification analysis combining a classical Spearman correlation approach with a causality method based on the multivariate Liang-Kleeman information flow.



Bold values indicate statistical significance ($p < 0.05$); hatching indicates non-significance



ACC scorecard – TSA



Only statistically significant values shown ($p < 0.05$); hatching indicates non-significance

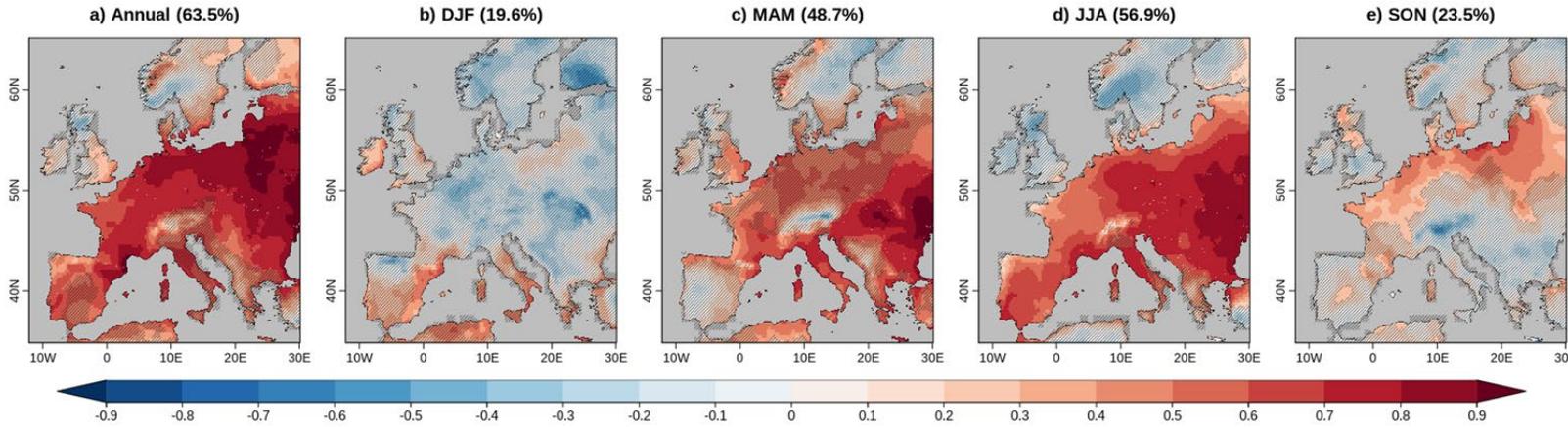
A decrease in predictive skill over TSA during SON (at short lead times), could be linked to the inability of some seasonal systems to accurately predict surface wind in NEB during austral summer.

Decadal - capacity factors

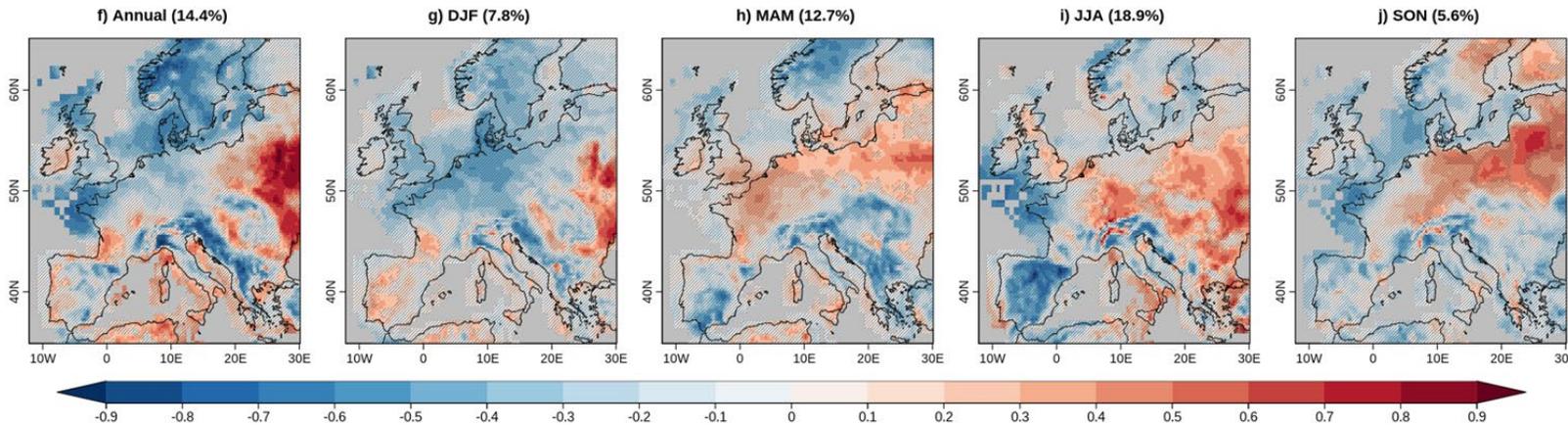


Anomaly correlation coefficient - Fyears 1-3

Solar PV potential



Wind capacity factor



Solar PVpot skill (a-e) is generally high, especially in summer and annual means

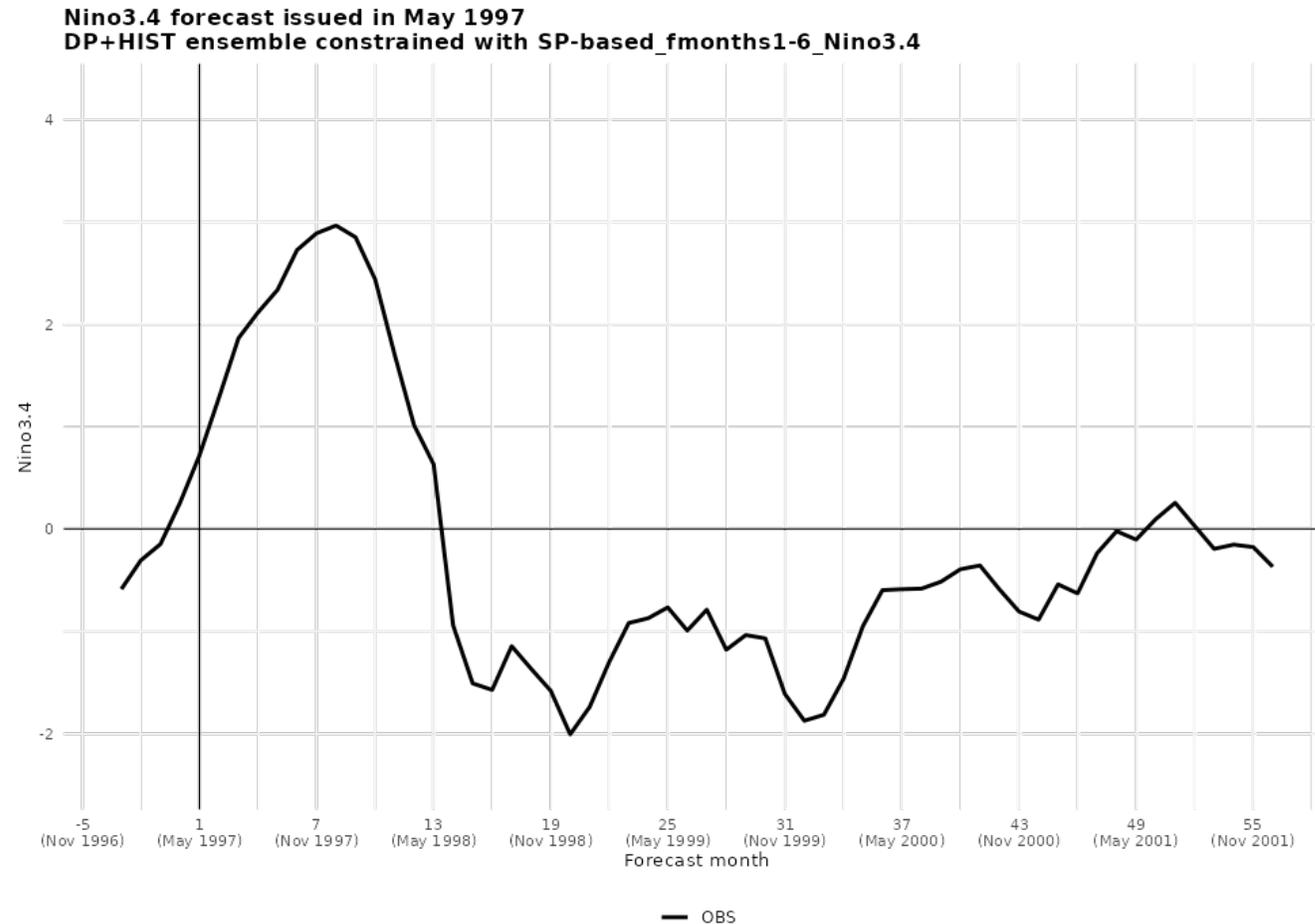
Wind CF skill (f-j) is heterogenous and with seasonal variations

Seamless seasonal-to-decadal predictions



Seamless ENSO forecast (May 1997)

Observed Niño3.4 index



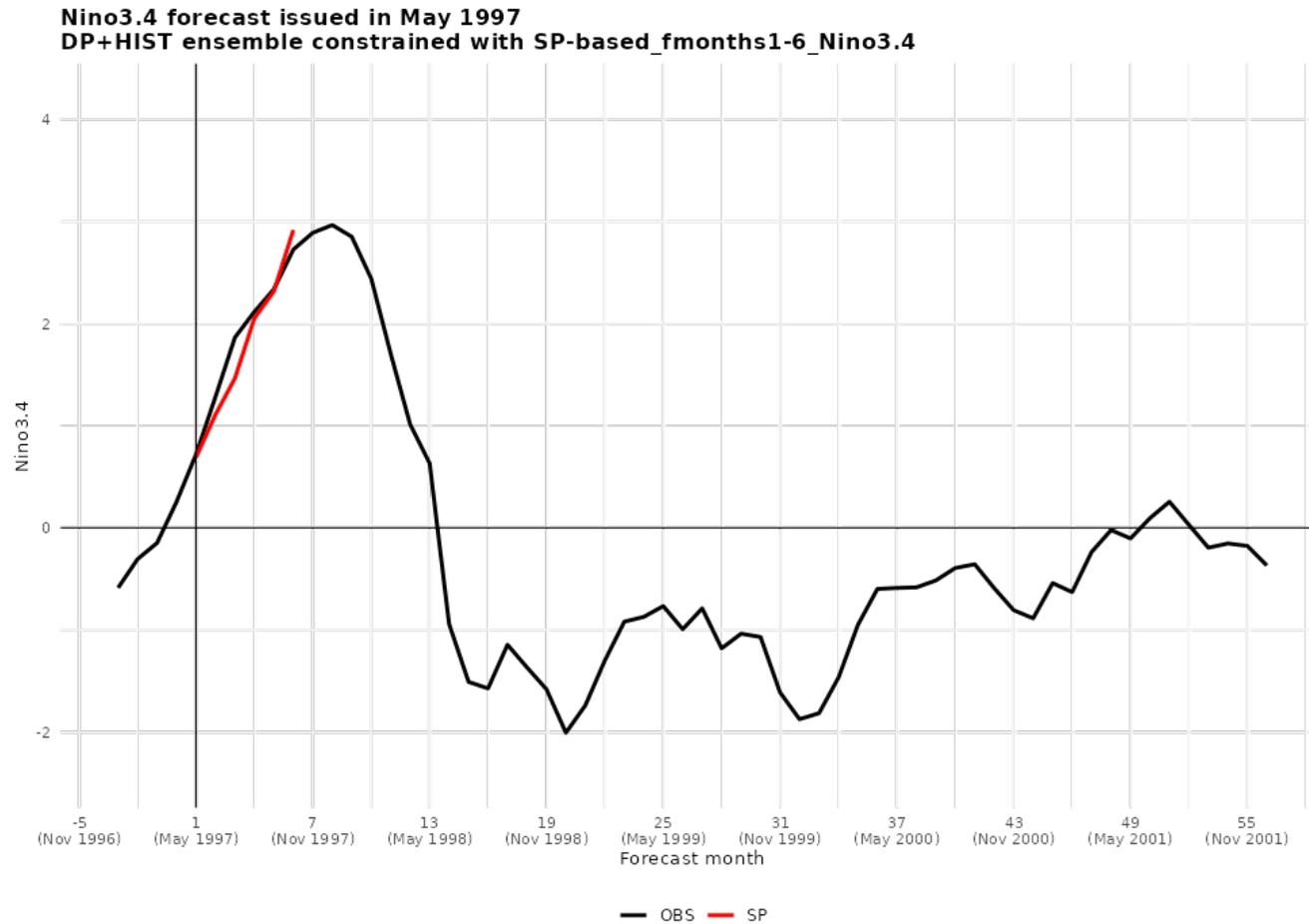
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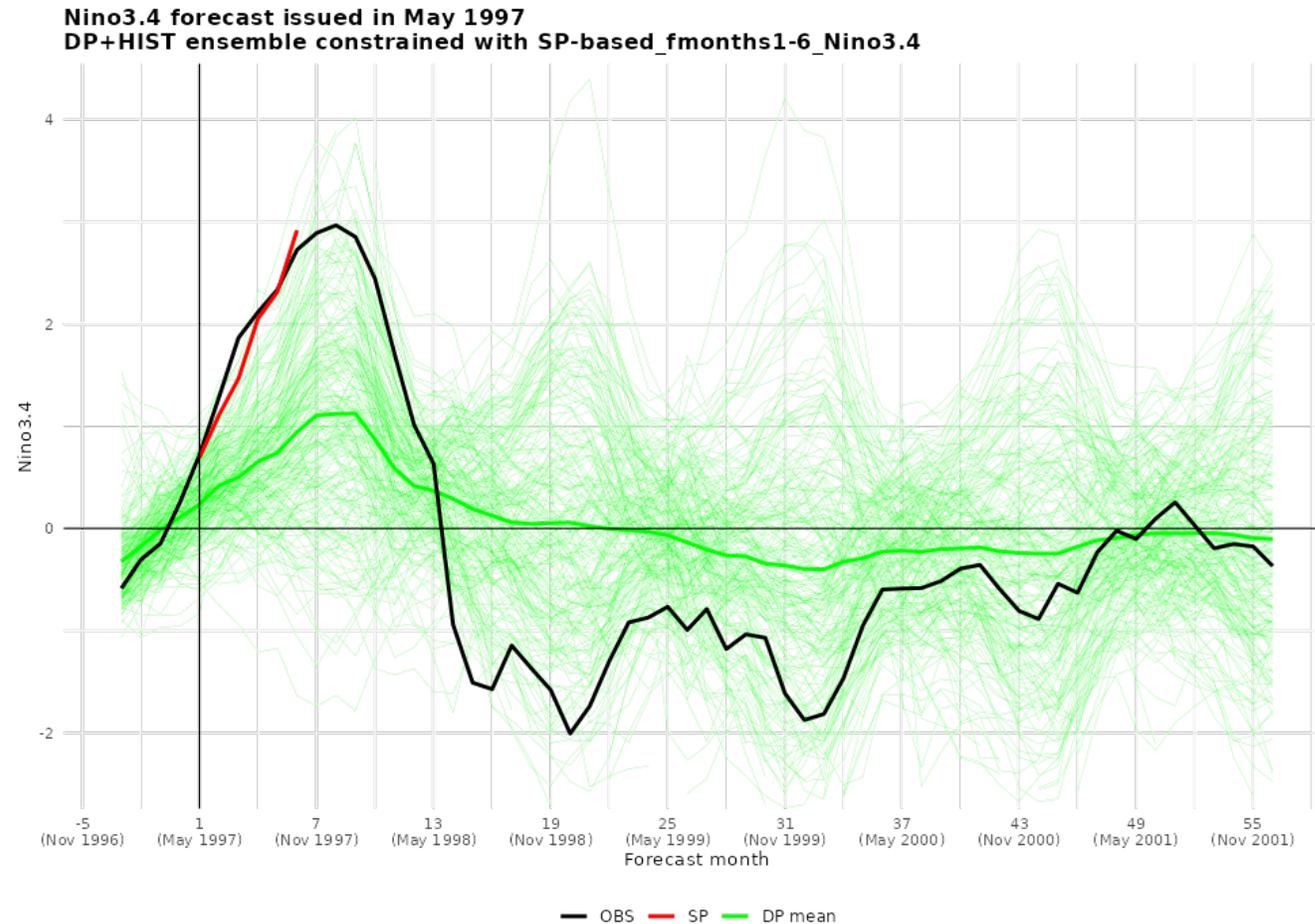


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Seamless seasonal-to-decadal predictions

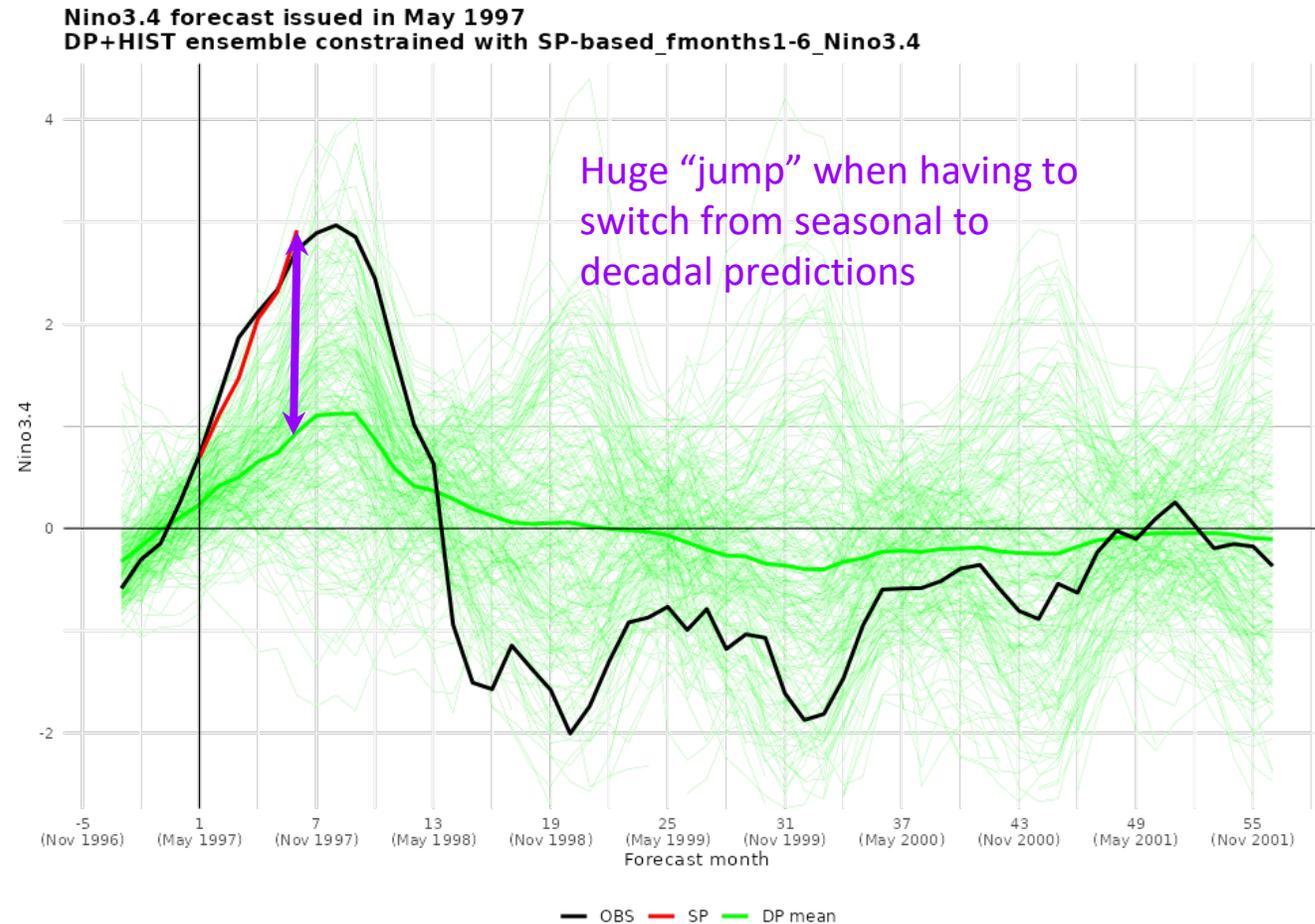


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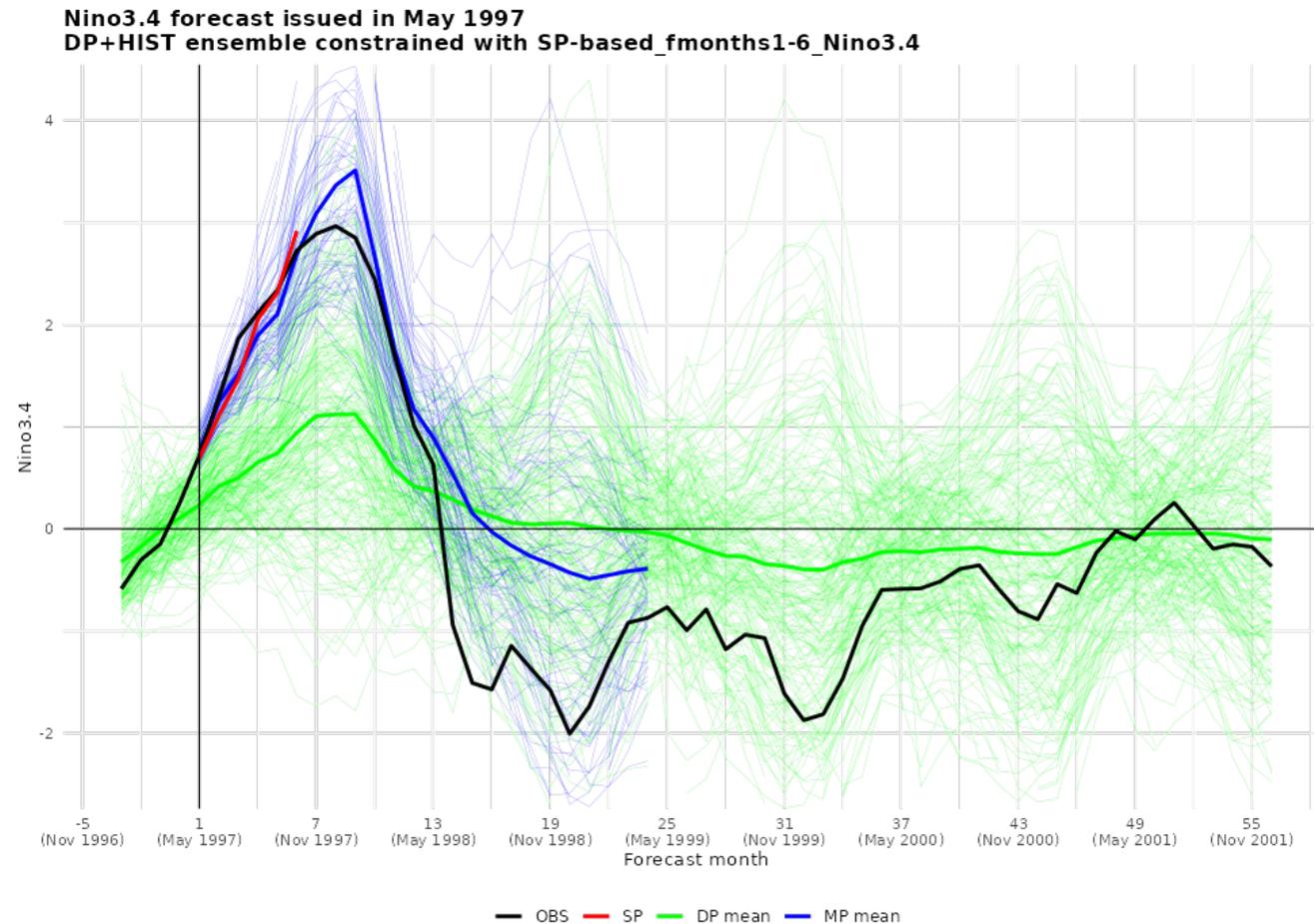
Seamless ENSO forecast (May 1997)

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Seasonal prediction initialised in May 1997

Decadal predictions initialised in January 1997

Extended seasonal predictions initialised in May 1997



Seamless seasonal-to-decadal predictions



Seamless ENSO forecast (May 1997)

Observed Niño3.4 index

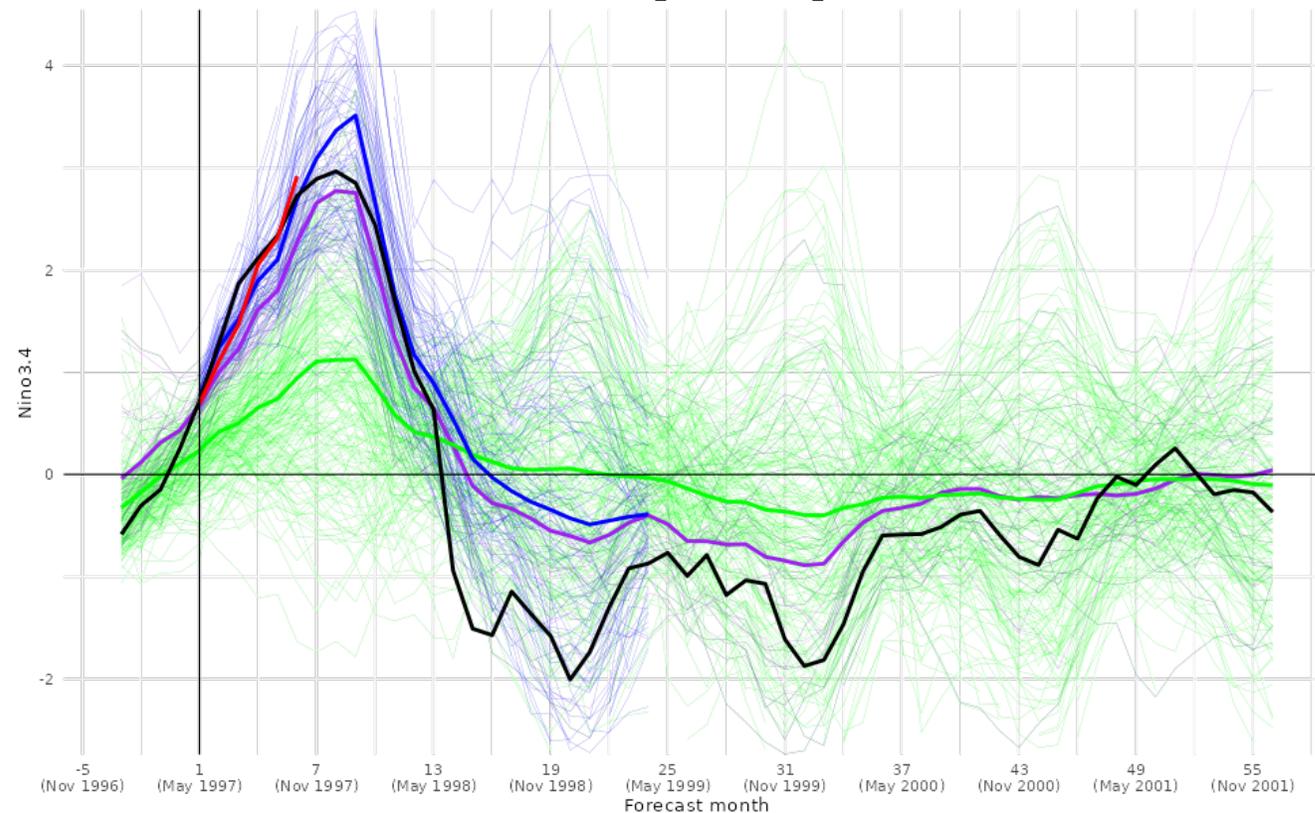
Seasonal prediction initialised in May 1997

Decadal predictions initialised in January 1997

Extended seasonal predictions initialised in May 1997

Constrained decadal predictions with seasonal

Niño3.4 forecast issued in May 1997
DP+HIST ensemble constrained with SP-based_fmonths1-6_Niño3.4

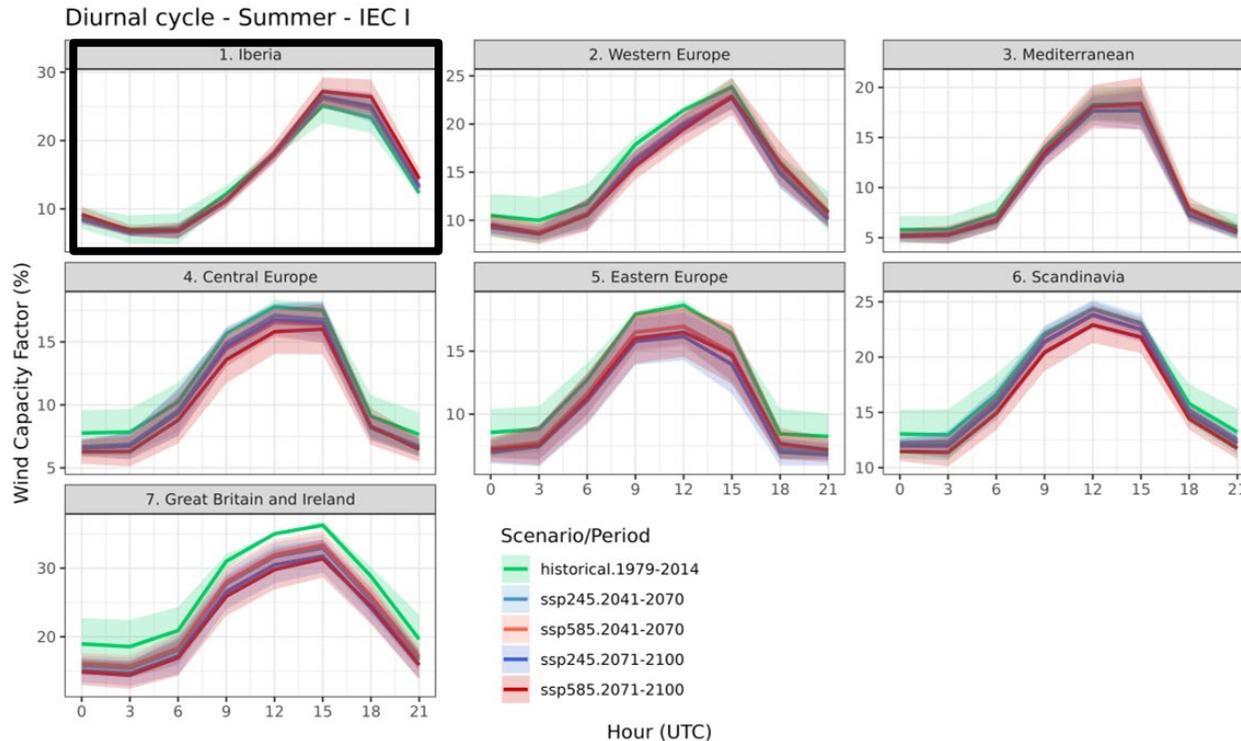


— OBS — SP — DP mean — MP mean — Best mean

Climate projections of energy production



Diurnal cycle of wind capacity factors in different regions



Analysis of CMIP6 projections of wind and energy indicators across Europe.

- Climate change will reduce WCF in summer over Europe, except for Iberia.
- NAO-WCF and NAO + might enhance wind resources in the future over Northern Europe.



Summary

BOREAS aims to increase the resilience of the Spanish energy sector under changing climate conditions by:

- ★ Providing operational subseasonal and seasonal forecasts, together with forecast outlooks.
- ★ Investigating drivers of climate conditions that favour renewable energy generation.
- ★ Blending of seasonal with decadal predictions to provide seamless forecasts with enhanced skill by subsampling.
- ★ Explore downscaling methods to improve the quality and usability of decadal predictions over Europe.
- ★ Investigate future changes in climate conditions that translate into changes in key energy indicators.

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Thanks for listening!

Contact us:

paloma.trascasa@bsc.es

boreas@bsc.es

albert.soret@bsc.es

veronica.torralba@bsc.es

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