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Pattern-based techniques:

why, how & applications for renewables

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Pattern-based methods bring us from data to knowledge

Climate data
Peta bytes

Information
Mega bytes

Knowledge
N neurons

Decision-making
1 bit

- Weather Regimes
- Euro-Atlantic Teleconnections

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Weather Regimes: unsupervised learning

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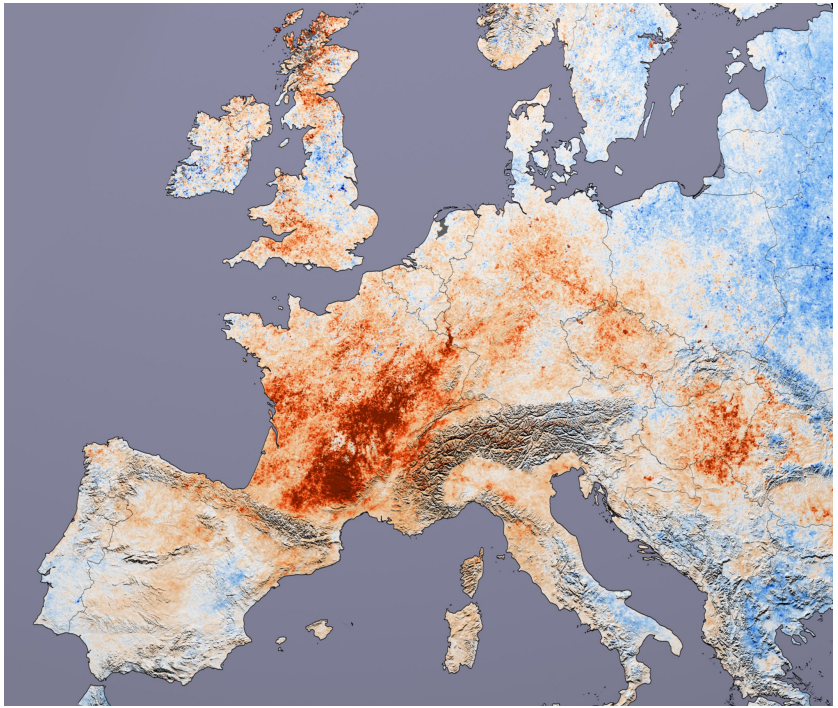
The European heat wave of summer 2003

~70.000 excess mortality in Europe



Which atmospheric circulation patterns can lead to these situations?

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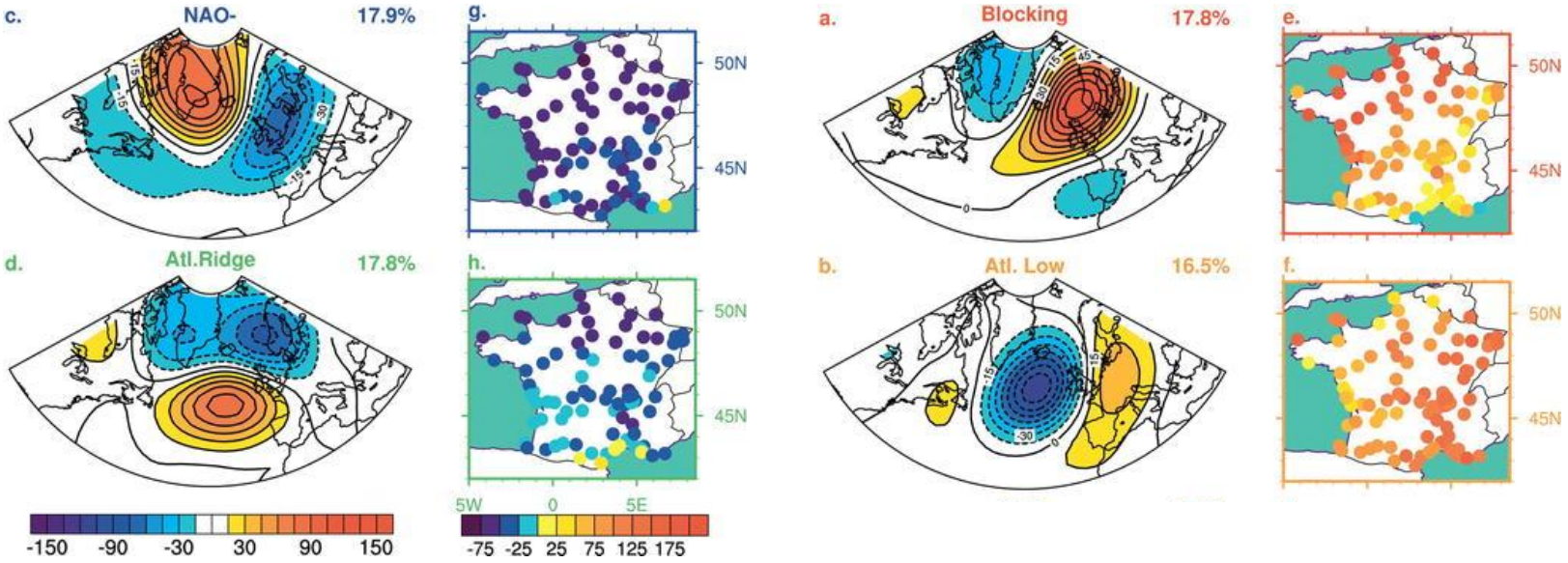
Weather Regimes

Classify each summer day into four groups of similar MSLP circulation



2 WRs that do not lead to heat waves in France

2 WRs that can lead to heat waves in France

Cassou et al. 2005

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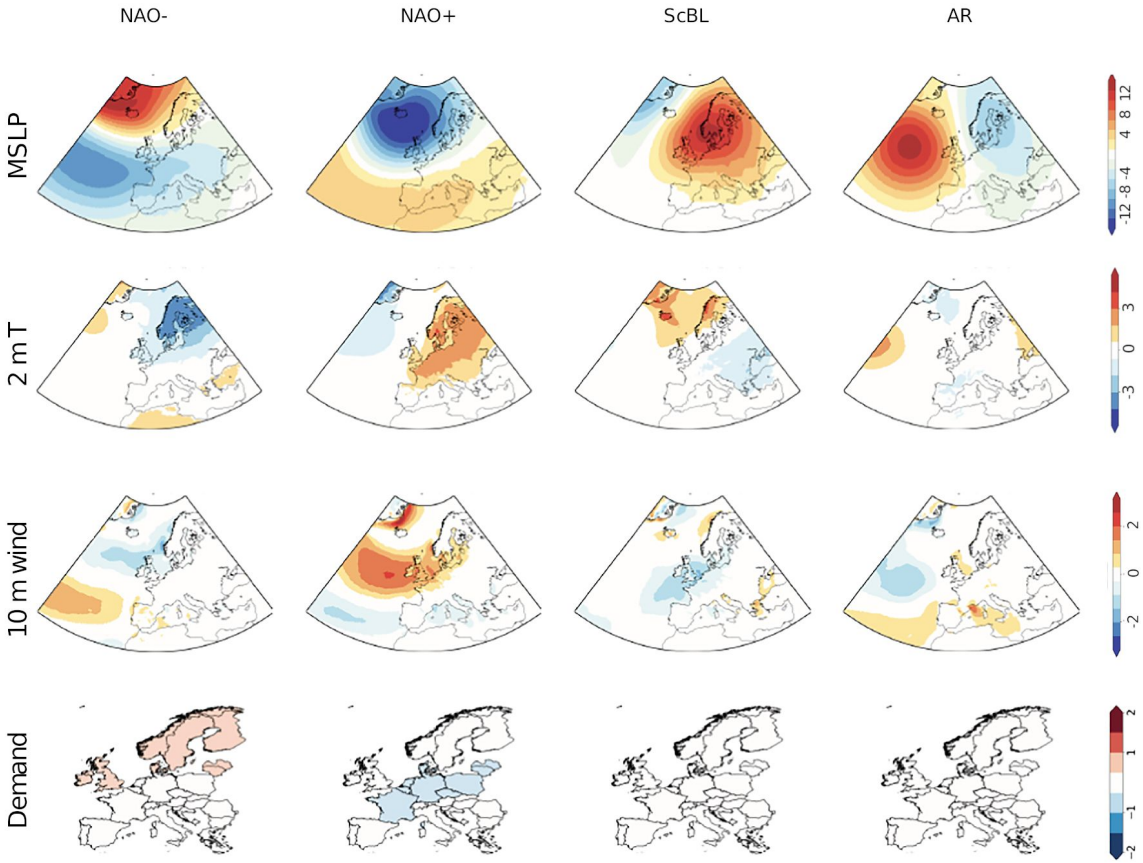
Weather Regime impacts on energy



Wich daily circulations lead to increased electricity demand?? or decreased wind power generation??

Check S2S4E D3.2

Bloomfield et al. 2019. **Characterizing the winter meteorological drivers of the European electricity system using targeted circulation types.**

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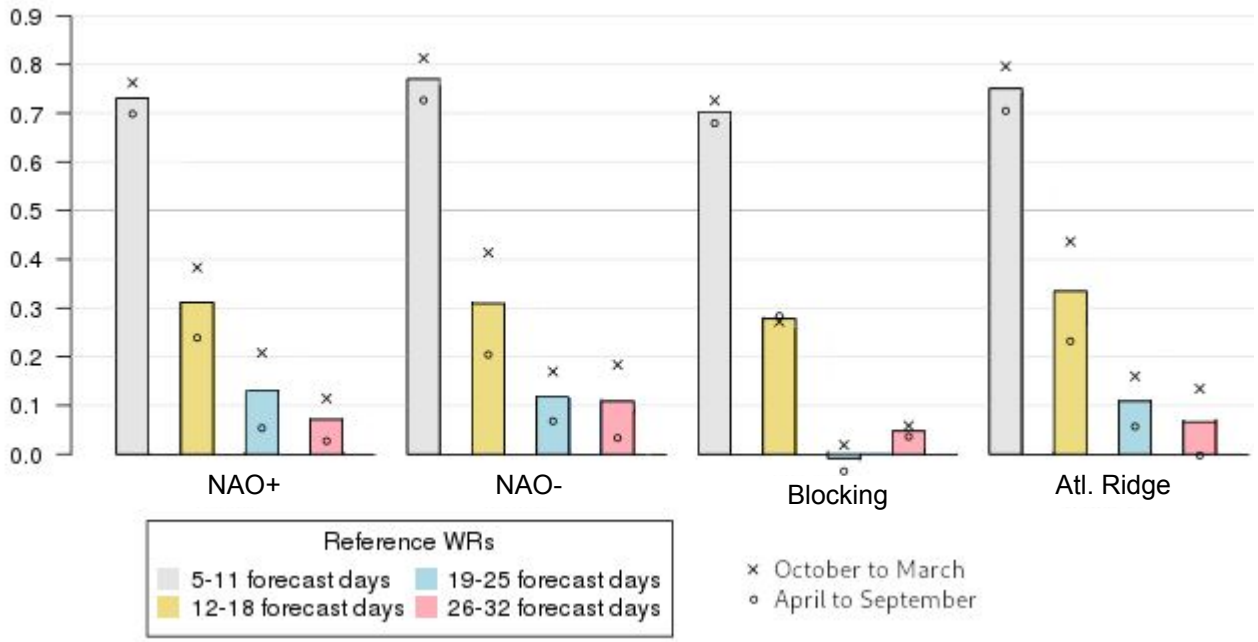
Weekly forecasts of weather regimes

Correlation between predicted and observed frequency



Cortesi et al. (Submitted)

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Euro–Atlantic Teleconnections: dimensionality reduction

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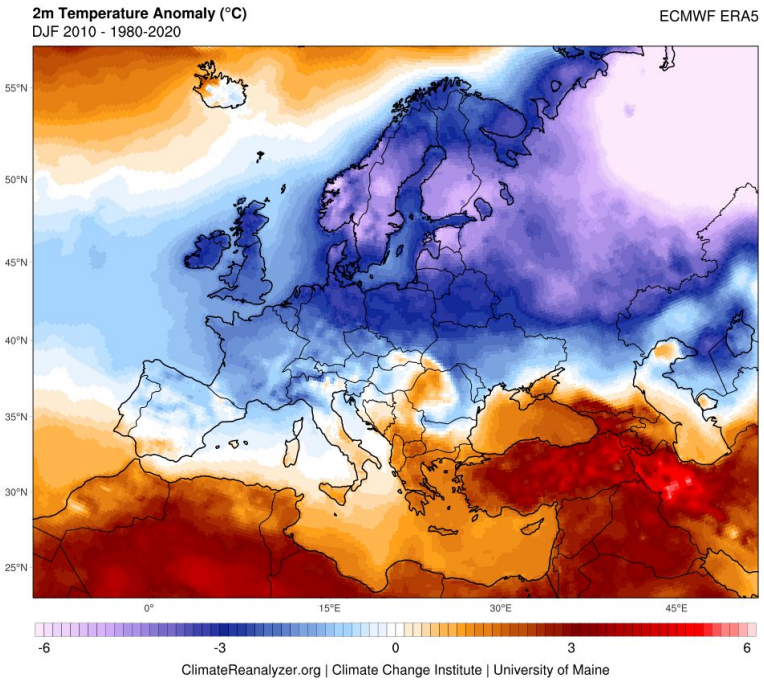
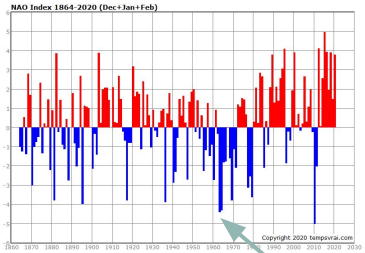
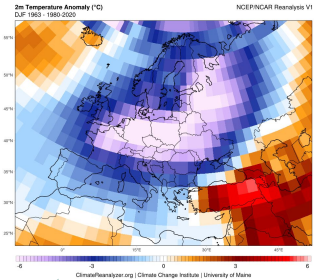
The cold and still 2009/10 winter

Energy demand increased up to 20%



- Sea level pressure difference between Iceland and Açores very weak (NAO⁻ pattern)
- Easterly flow brings cold continental air
- 1962/63 is an analogue year based on NAO index





1962/63

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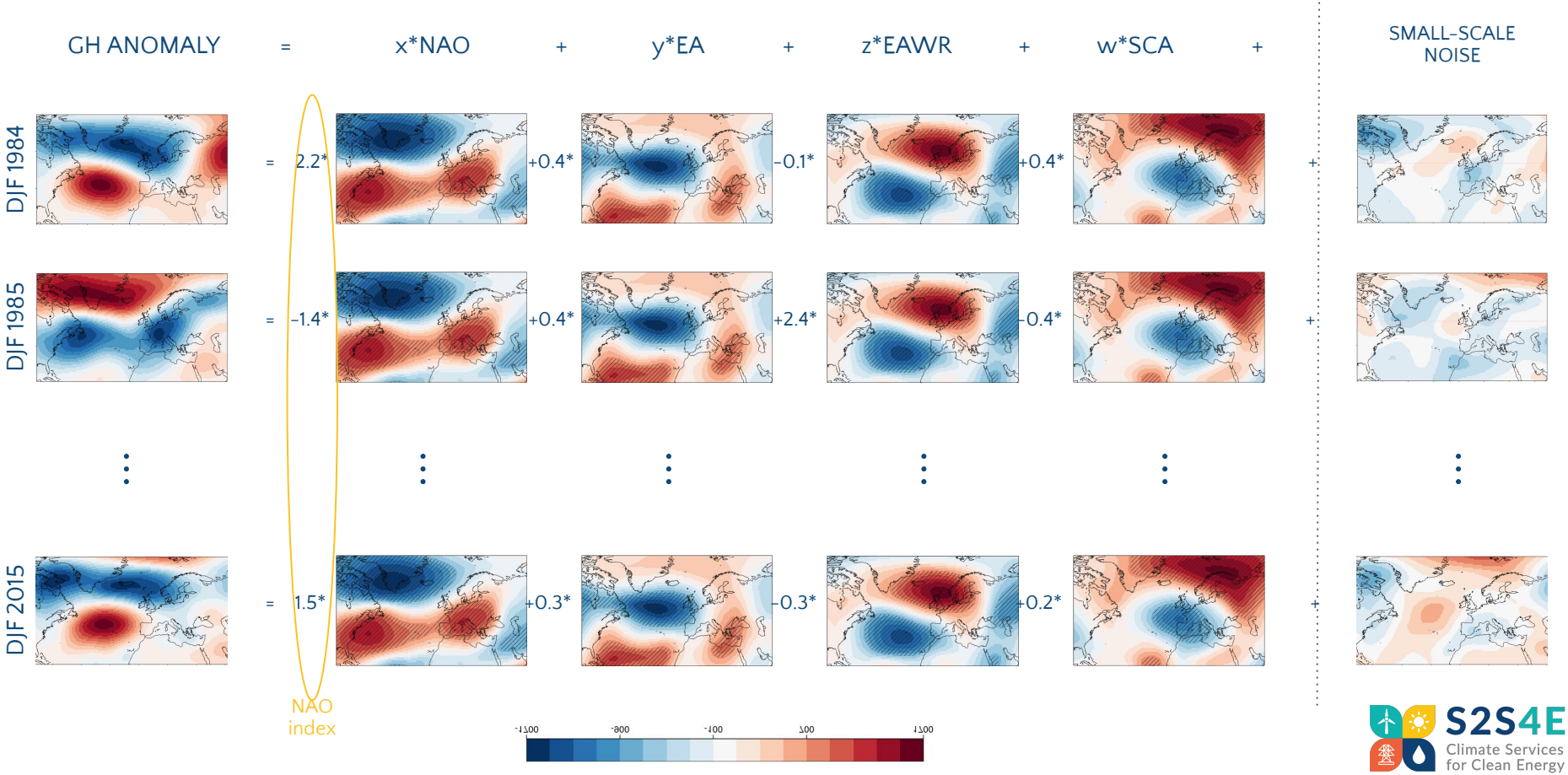
Euro-Atlantic Teleconnections



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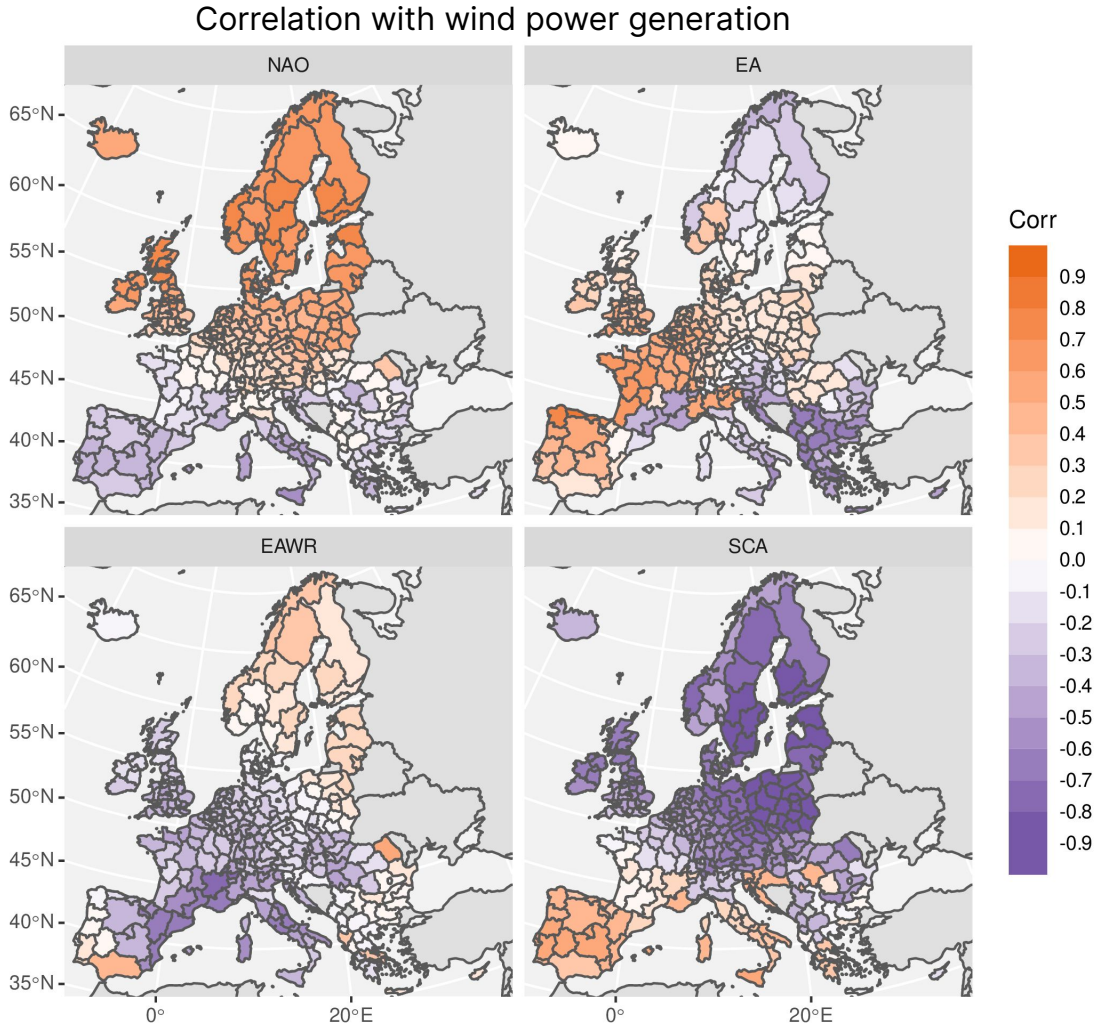
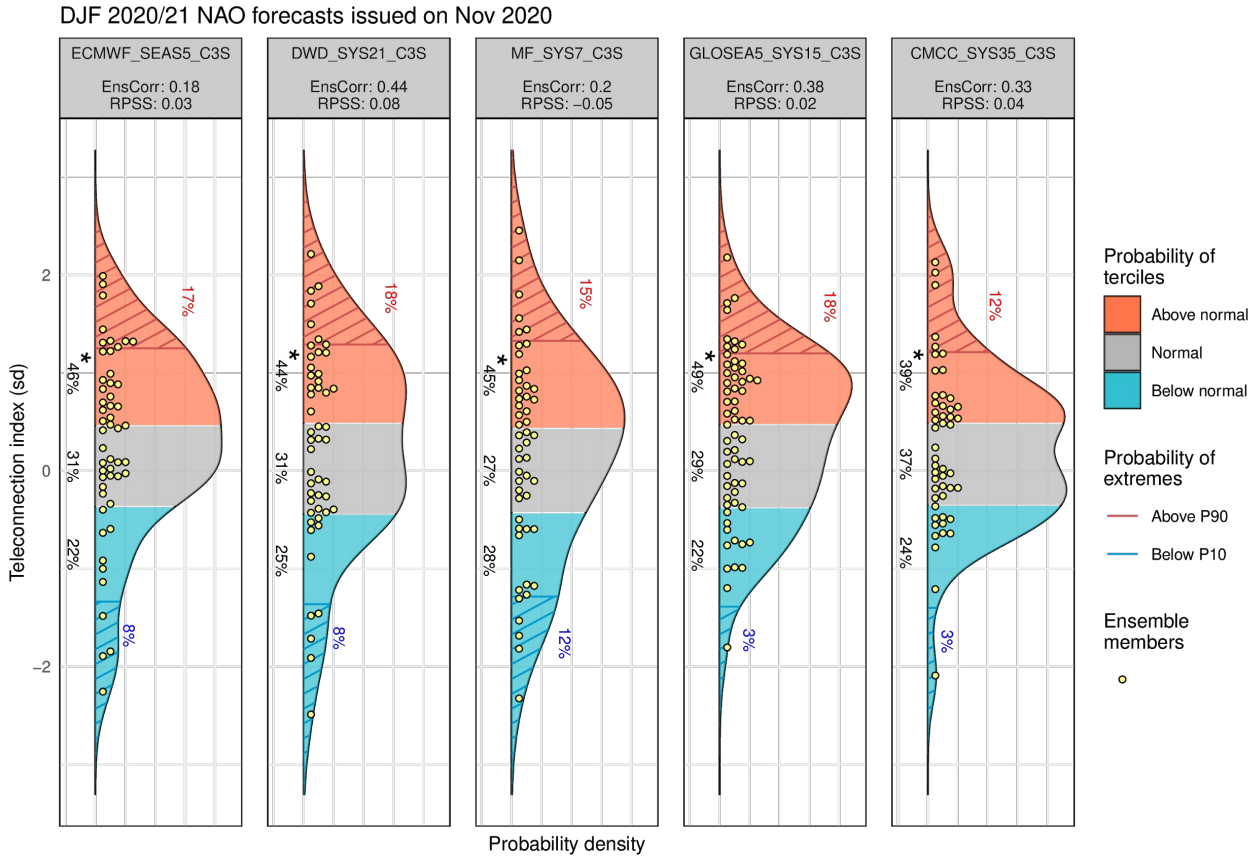
The impact of EATCs on wind CFs

Check S2S4E D3.2 for impacts on:
wind speed,
solar radiation,
precipitation....



Lledó et al. (in prep.)

NAO forecasts from 5 seasonal prediction systems



- Good consensus: enhanced probability of a positive NAO
- All systems indicate a 40–50% of probability
- Skill: positive but limited

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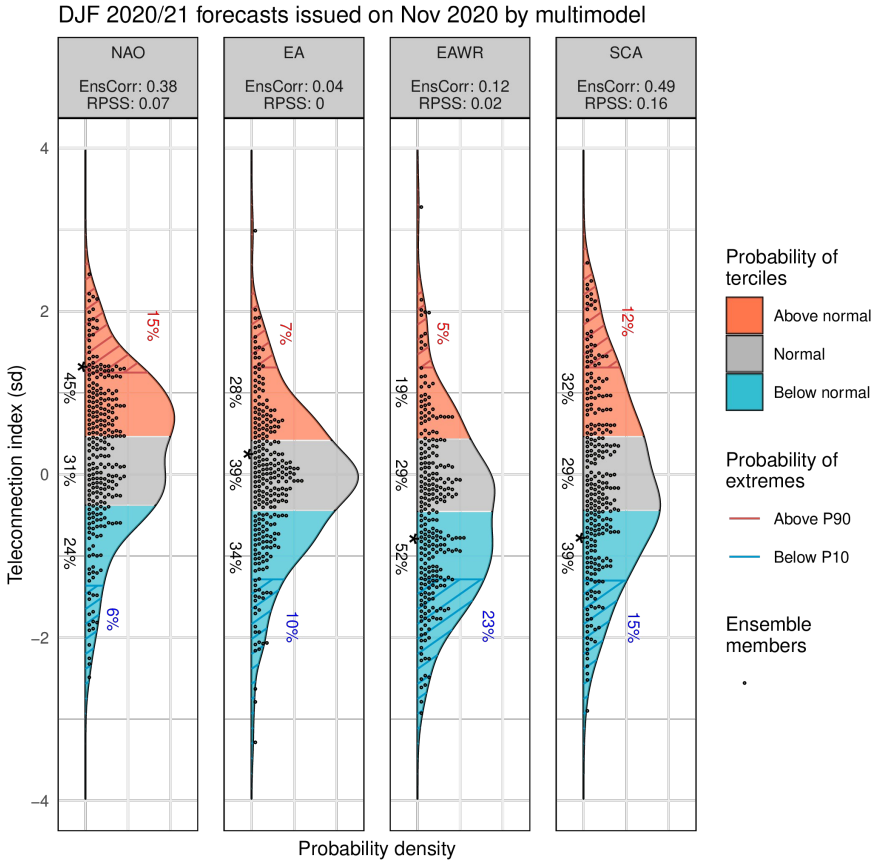
Multi-system predictions of 4 EATCs



- Combine info from several sources
- Skill almost as good a best system, and more robust.
- Extremes (PoE P10/P90) are better described with more members.
- Summary
  - Enhanced prob. of NAO+
  - Enhanced prob. of SCA-
  - High prob. of EAWR-

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Hybrid forecasts / Perfect prog / Bridging

Goal: reconstruct surface forecasts from pattern forecasts

Observed relationship

$$Impact \approx f(NAO, EA, EAWR, SCA)$$

Dynamical forecasts of EATCs

$$\widehat{NAO}, \widehat{EA}, \widehat{EAWR}, \widehat{SCA}$$

Hybrid forecasts of Impact

$$\widehat{Impact} := f(\widehat{NAO}, \widehat{EA}, \widehat{EAWR}, \widehat{SCA})$$

Wind Speed(t) ≈ a*NAO(t) + b*EA(t) + c*SCA(t) + d*EAWR(t)

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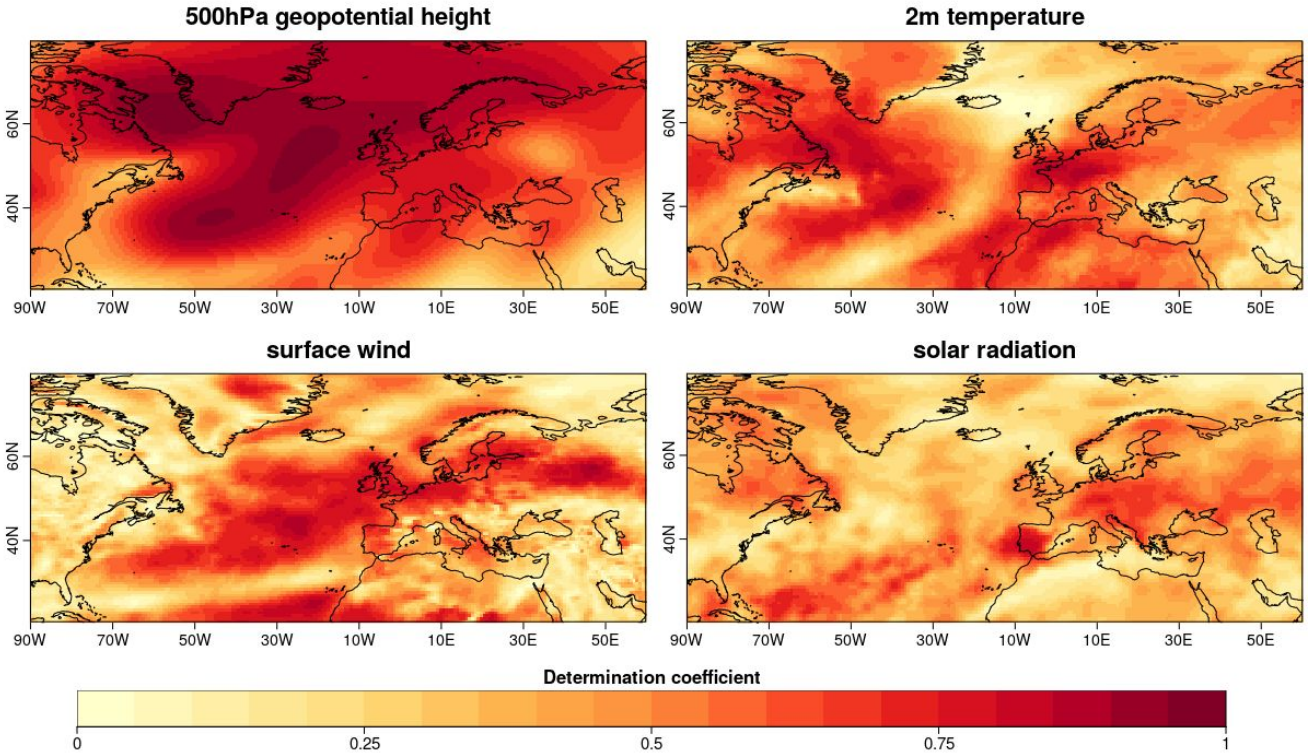
1st factor: accuracy of the approximation



Cionni et al. (in prep.)

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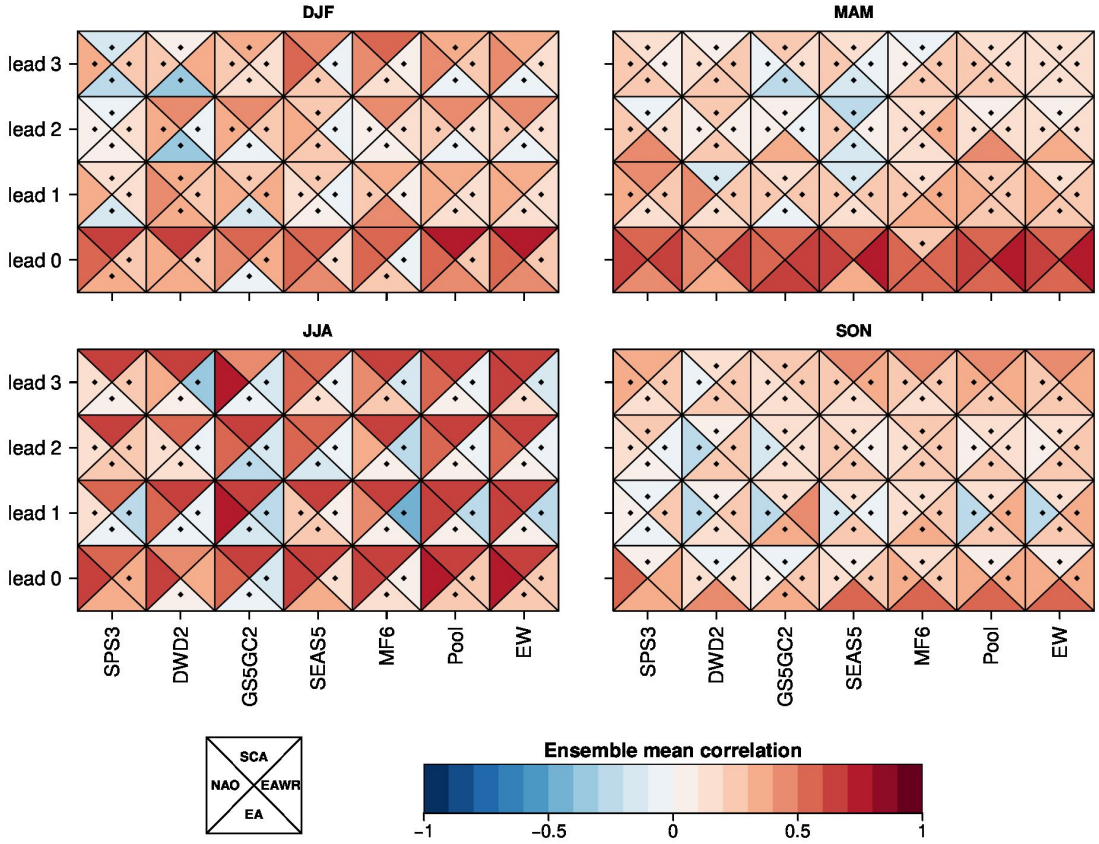
2nd factor: quality of EATCs forecasts



Lledó et al. (2020). **Seasonal prediction of Euro-Atlantic teleconnections from multiple systems.**

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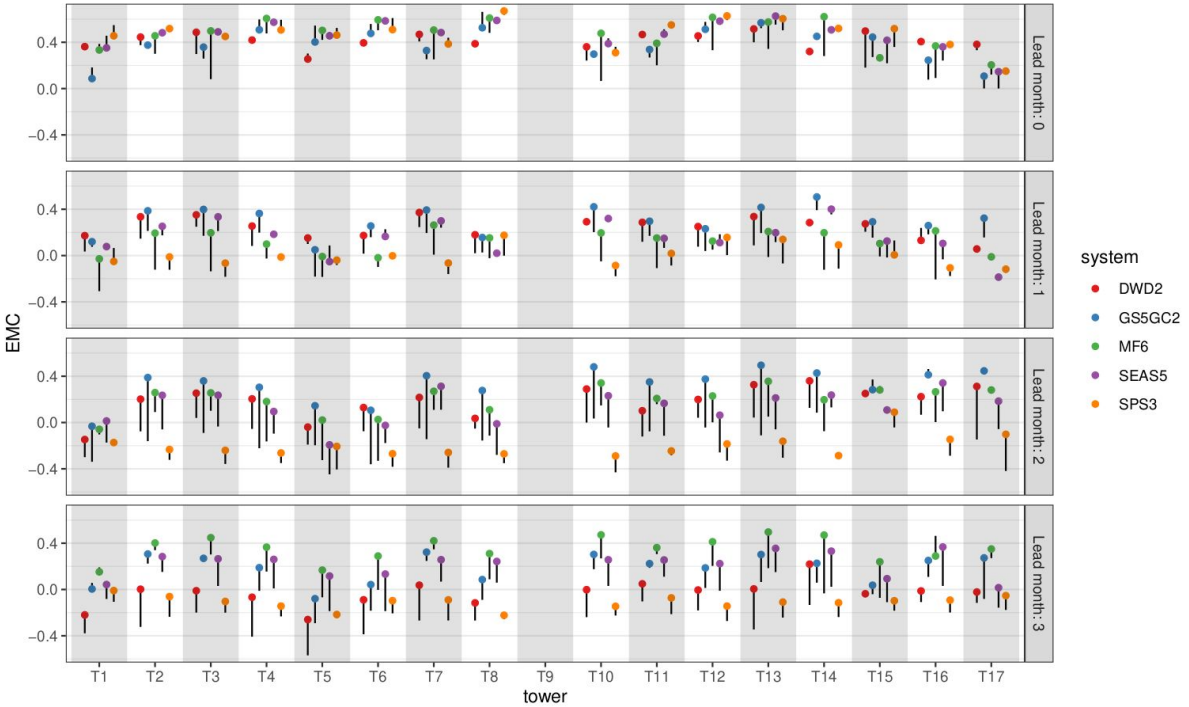
Use of observed data for downscaling

Train a statistical model between EATCs and wind speed at a tall tower:

Local Wind Speed(t) ≈ a*NAO(t) + b*EA(t) + c*SCA(t) + d*EAWR(t)



Ramon et al. (submitted to ERL)

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Conclusions

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Conclusions

1. **Pattern based techniques**
   allow analyzing huge amounts of daya and producing simplified knowledge, by grouping events by its patterns and putting them in context of historical records

2. **Forecasts of patterns**
   provide a summarized and alternative view to the point forecasts & allow simplified narratives and understanding

3. **Hybrid predictions**
   which combine forecasts of patterns and its impacts, can produce better results than dynamical forecasts

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Pattern-based techniques:

why, how & applications for renewables

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Pattern-based techniques

	Circulation data	***Goal***	***Data science method***	***Algorithm***
Weather Regimes	Daily MSLP	Make K groups with similar conditions	Unsupervised learning	K-mean clustering
Euro-Atlantic Teleconnections	Seasonal 500hPa GH	Approximate seasonal anomalies as a weighted sum of N fixed patterns	Dimensionality reduction	Rotated EOFs (Rotated PCA)

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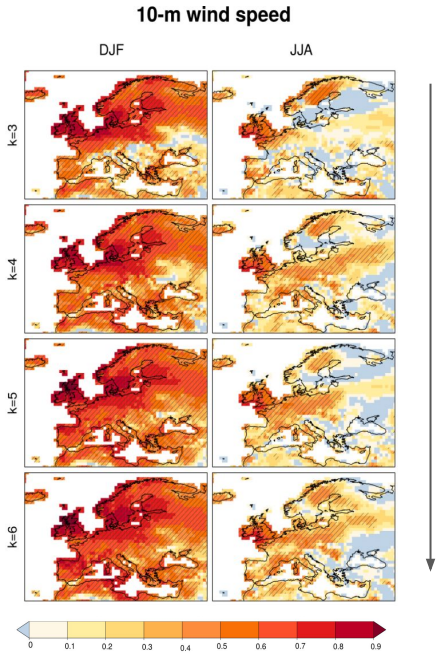
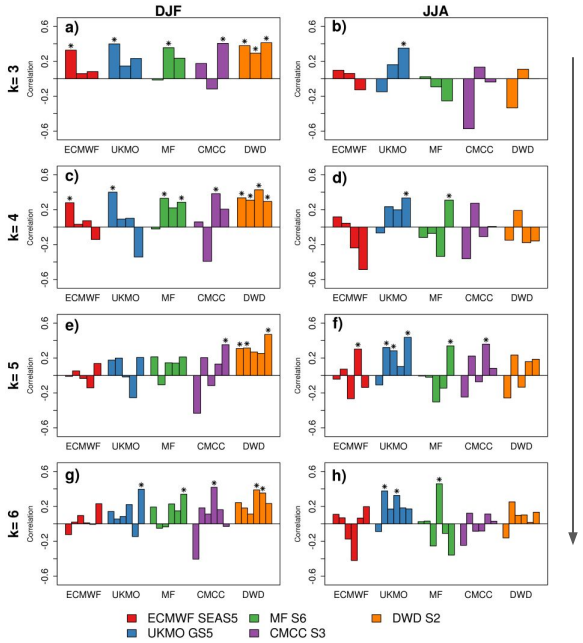
Reconstructions from weather regimes

Impact of #clusters

More clusters



Better reconstructions



Worst skill

Torralba et al. 2020. **Challenges in the selection of atmospheric circulation patterns for the wind energy sector.**

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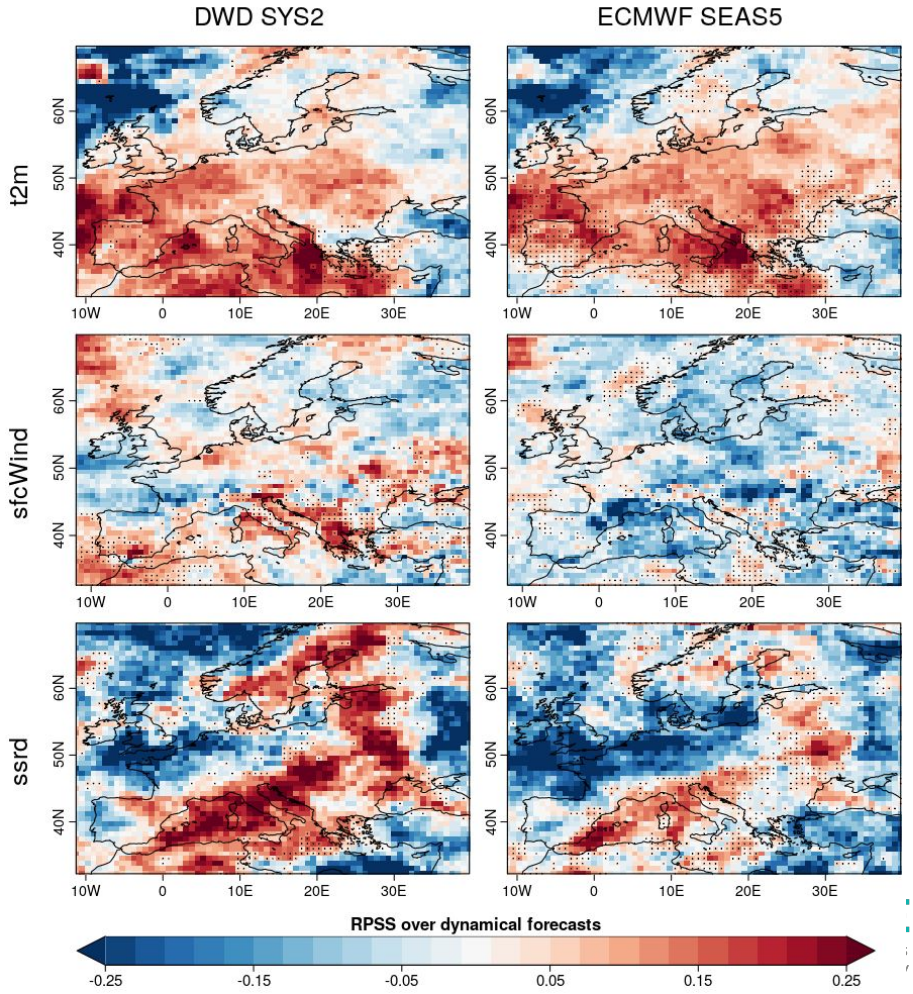
Hybrid forecasts: verification

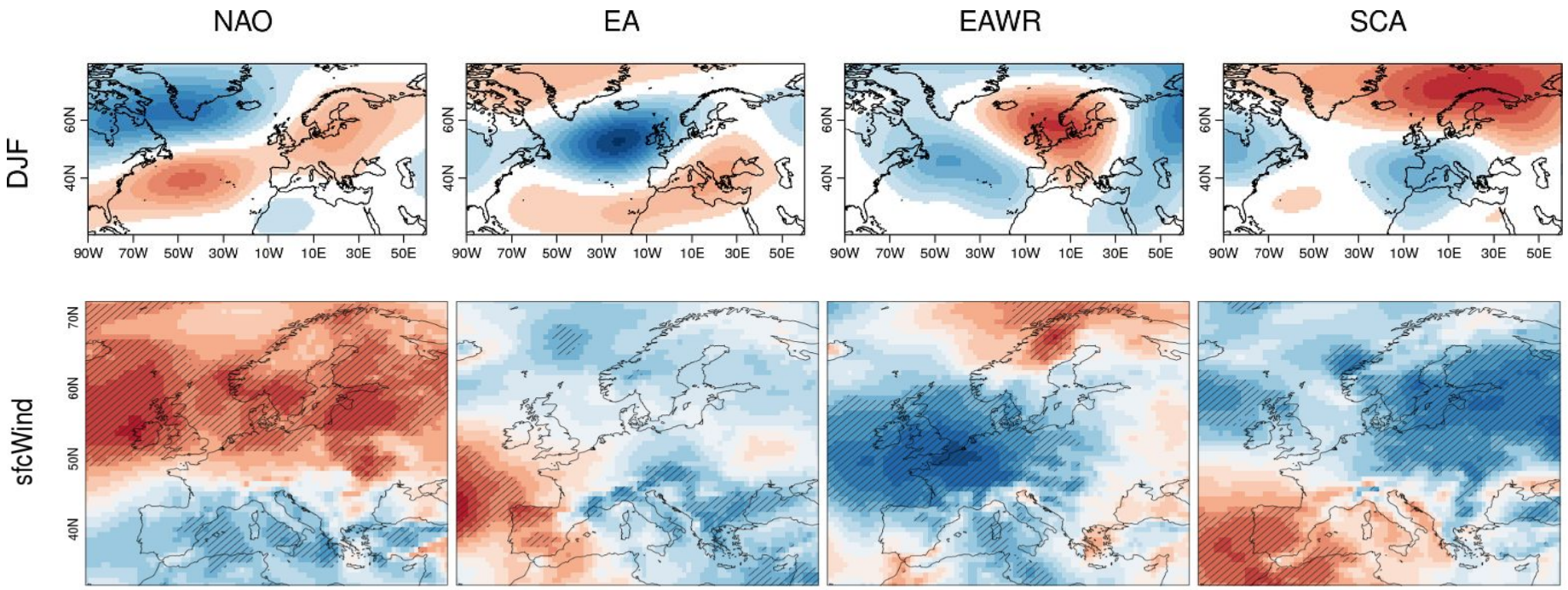
Methodology details

- *Probabilistic forecasts:* tercile probabilities (above-normal / normal / below-normal conditions)
- *Skill score*: RPSS
- *Baseline:* dynamic forecasts
- *Period*: 1993-2016
- *Season:* DJF
- *Lead time*: 1 month ahead
- *LOOCV*: No



Cionni et al. (in prep.)

Euro-Atlantic Teleconnection patterns for DJF



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