Spatial correlation structures of wind speed and irradiance in Europe as modelled in regional climate models and the ERA5 reanalysis

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Objective & Background

Comprehensive energy systems analysis requires well-modelled meteorological input data (esp. wind speed and solar irradiance). In particular, spatiotemporal variability needs to be well represented.

We analyze spatial correlation structures derived from anomalies in wind speed and irradiance, and systematically compare results from EURO-CORDEX climate simulations and ERA5 reanalysis.

By conditioning statistics of pattern correlation on the underlying global and regional models, we propose to identify their strengths and weaknesses with regards to the representation of variability in wind speed and solar irradiance.

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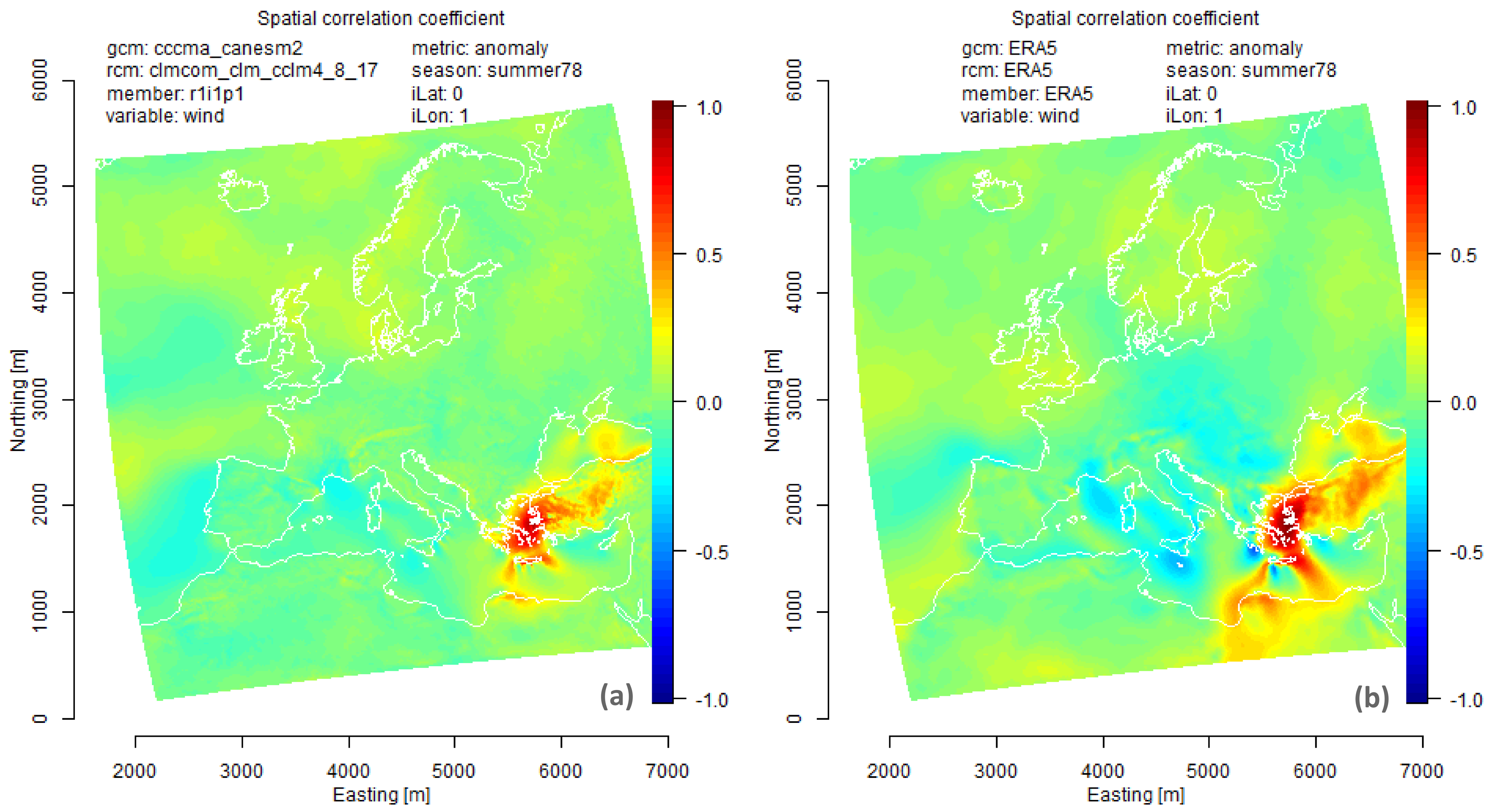
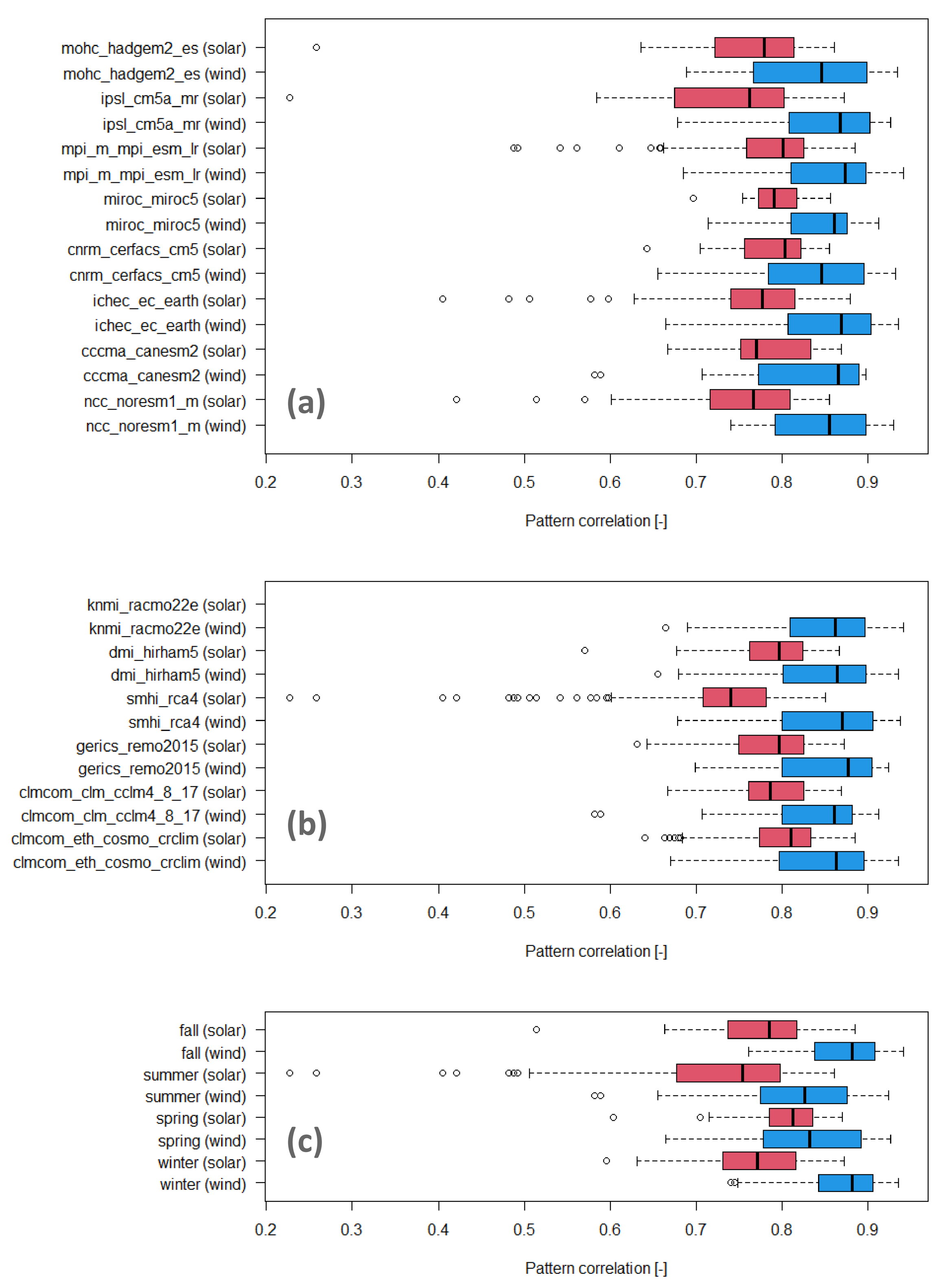


An example of wind speed anomaly correlation structures for a single reference point, derived from (a) arbitrarily selected CORDEX simulations (global model: cccma_canesm2; regional model: clmcom_clm_cclm4) and (b) ERA5 reanalysis (right panel). While the CORDEX output underestimates the spatial extent of correlation structures compared to ERA5 in this example - and specifically does not reproduce the small patches of negative correlations – it does capture the general character of the structures. The resulting pattern correlation amounts to 0.82.



Box-plot statistics characterizing the pattern correlation of anomalies in wind speed (blue) and solar irradiance (red) between EURO-CORDEX simulations and ERA5 reanalysis; conditioned on (a) global climate models, (b) regional climate models, and (c) seasons. Pattern correlation generally tends to be higher for wind than for solar, with indications of a specific regional climate model (smhi_rca4) mismatching the structures from ERA5 in several cases, especially during the summer.

Principal Findings

EURO-CORDEX simulations tend to better reproduce anomaly correlation structures in wind speed than in solar irradiance.

Between global models, there is little difference in case of wind, while some models feature a larger spread in case of solar, including low pattern correlations.

As for regional models, these low pattern correlation values are largely associated with the model SMHI-RCA4. Also, they are mostly sampled during the summer.

Discussion

This initial evaluation allows to help in the selection of global and regional models when compiling climate ensembles for use in energy systems analysis.

Calculating correlation structures for more reference points will improve the statistics and may uncover regional differences.

Using longer multi-decade time series and including future projections will enable the assessment of potential effects related to climate change.

Material and Methods

- Wind speed and solar irradiance from 10 years of historical EURO-CORDEX and ERA5 data from the Climate Data Store[1]
- 37 different EURO-CORDEX simulations, with 25 unique combinations of global and regional climate models
- 3 h temporal and 0.11° spatial resolution

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1. Anomaly calculations by subtracting the mean at every point in space and time from the respective time series
2. Deriving spatial correlation structures[2], i.e., maps of the correlation coefficient between each pixel's time series and a reference pixel's series (4 in total)
3. Quantifying similarities between ERA5 and each EURO-CORDEX simulation by computing pattern correlations[3]
4. Visualizing box-plot statistics of pattern correlations conditioned on climate models and season

References

[1] https://cds.climate.copernicus.eu
[2] Lohmann, 2018: https://doi.org/gfb5dq
[3] https://glossary.ametsoc.org/wiki/Pattern_correlation

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