

Assessing the Spatiotemporal Variability and Complementarity of Renewable Energy Resources across Europe

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Introduction

Europe's transition towards renewable energy sources is imperative for achieving sustainability and mitigating climate change. However, the intermittency of solar and wind power necessitates a detailed evaluation of their combined potential. This study uses long-term atmospheric reanalysis data to investigate the spatial-temporal variability in renewable resources.

Data and Methods

- ERA5 reanalysis data from 1950-2022
- Empirical Orthogonal Function (EOF) - characterizing the spatiotemporal patterns of variability in irradiance and wind speed up to multidecadal timescales
- Stability is estimated using the coefficient of variance of the capacity factor estimates (CF, i.e., electricity generation normalized to the installed capacity) and is compared with EOF patterns.

Preliminary Results

Distribution of spatial variability

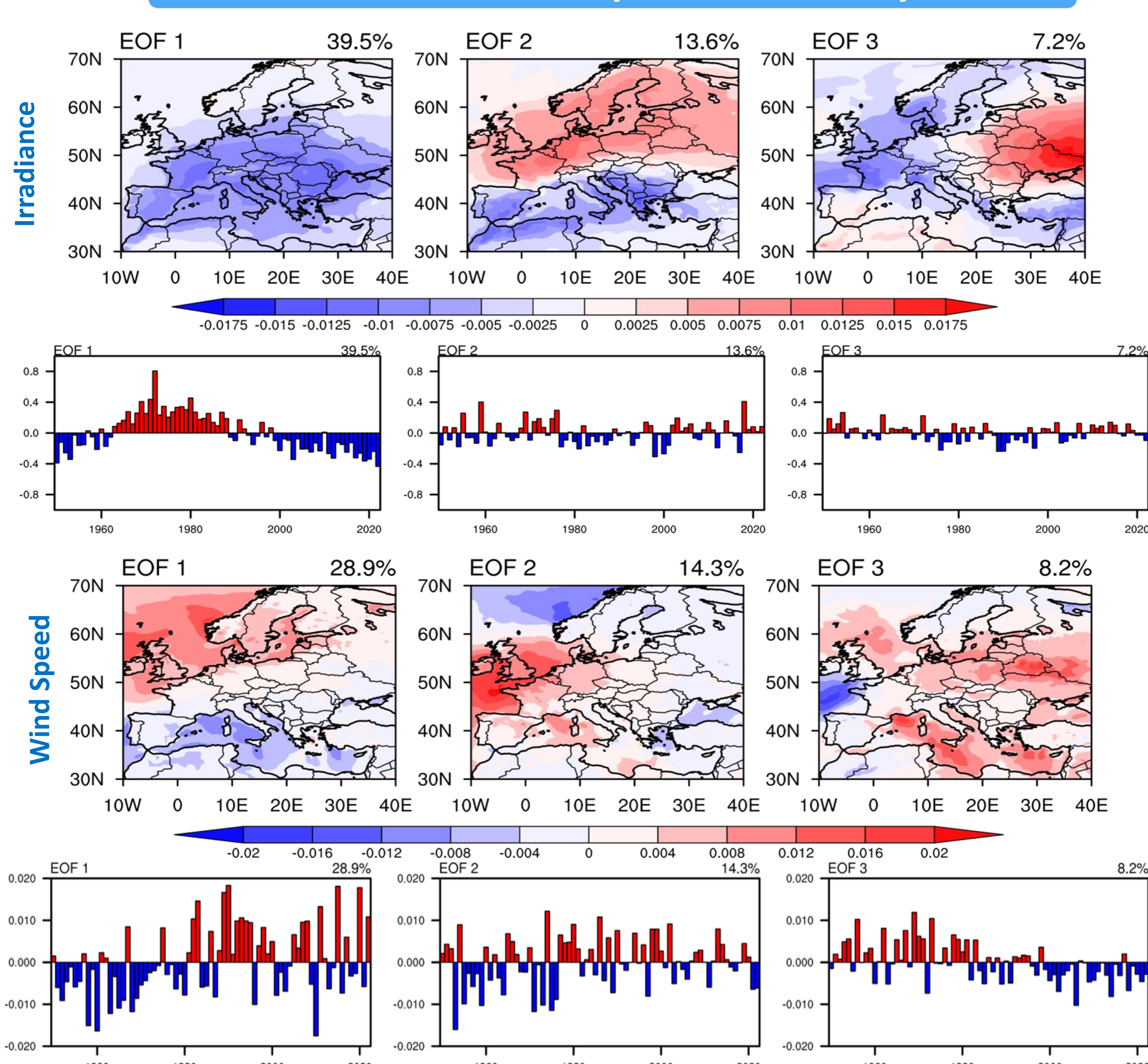


Figure 1 (a) Annual EOF of irradiance and wind speed over Europe

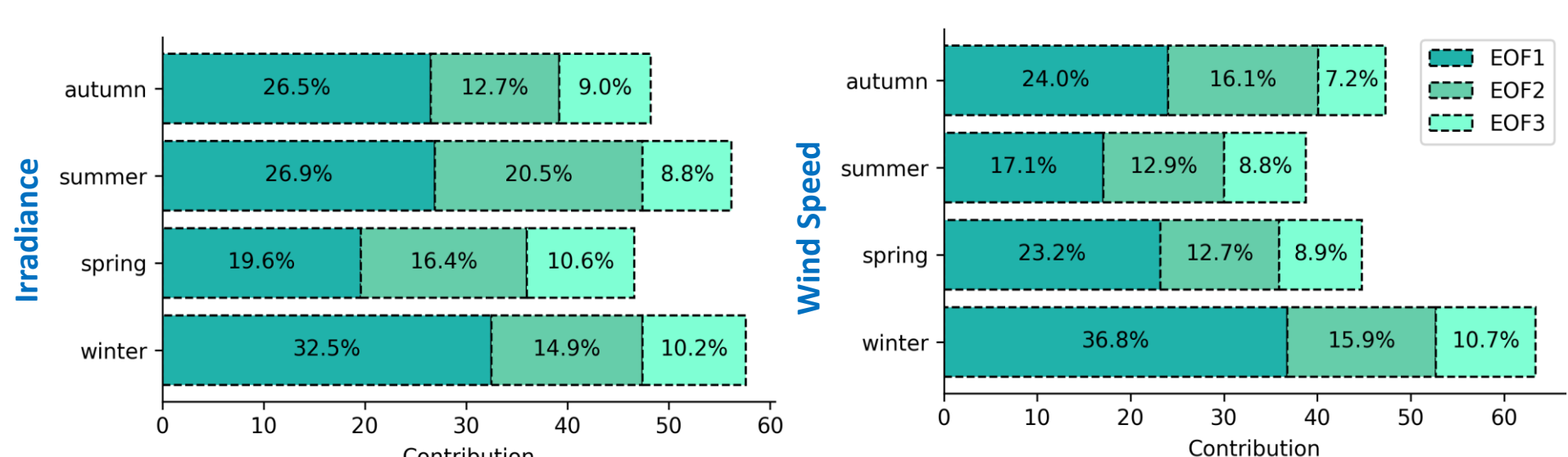


Figure 1 (b) Contribution rate of three EOF modes in seasons

Distribution of wind/solar stability

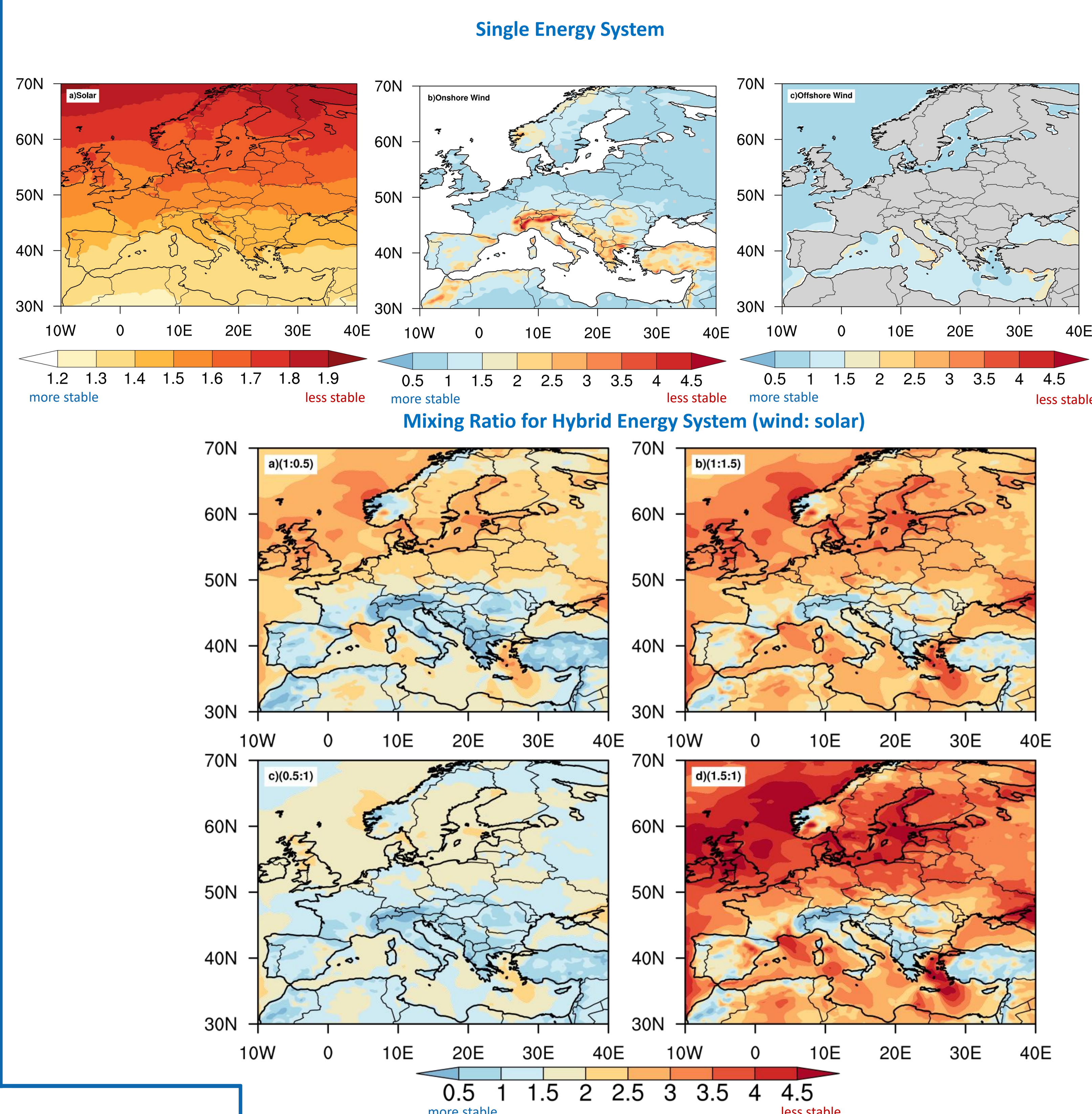


Figure 2 Spatial distribution of coefficient of variance of solar, Onshore and Offshore wind Power for single and hybrid energy

Capacity Factor vs Stability

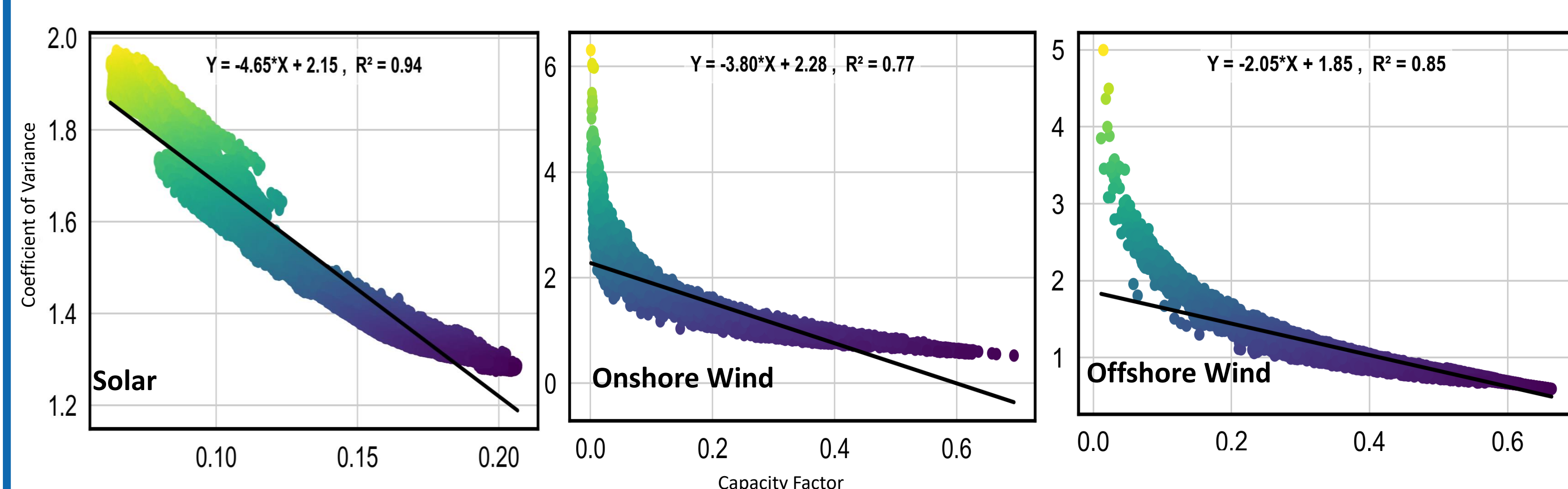


Figure 3 Relation between coefficient of variance and mean capacity factor of solar, onshore and offshore wind

Conclusion

- Southern Europe shows the lowest intermittency in solar power, Eastern and Northern Europe exhibit lower intermittency of onshore wind, and offshore wind potential is high over the Norwegian and Mediterranean Seas
- Future research will develop advanced hybrid energy models and expand the analysis using CMIP6 data until 2100
- Overall aim is to identify optimal strategies for siting future production installations and routing power cables.

Correlation of solar and wind power

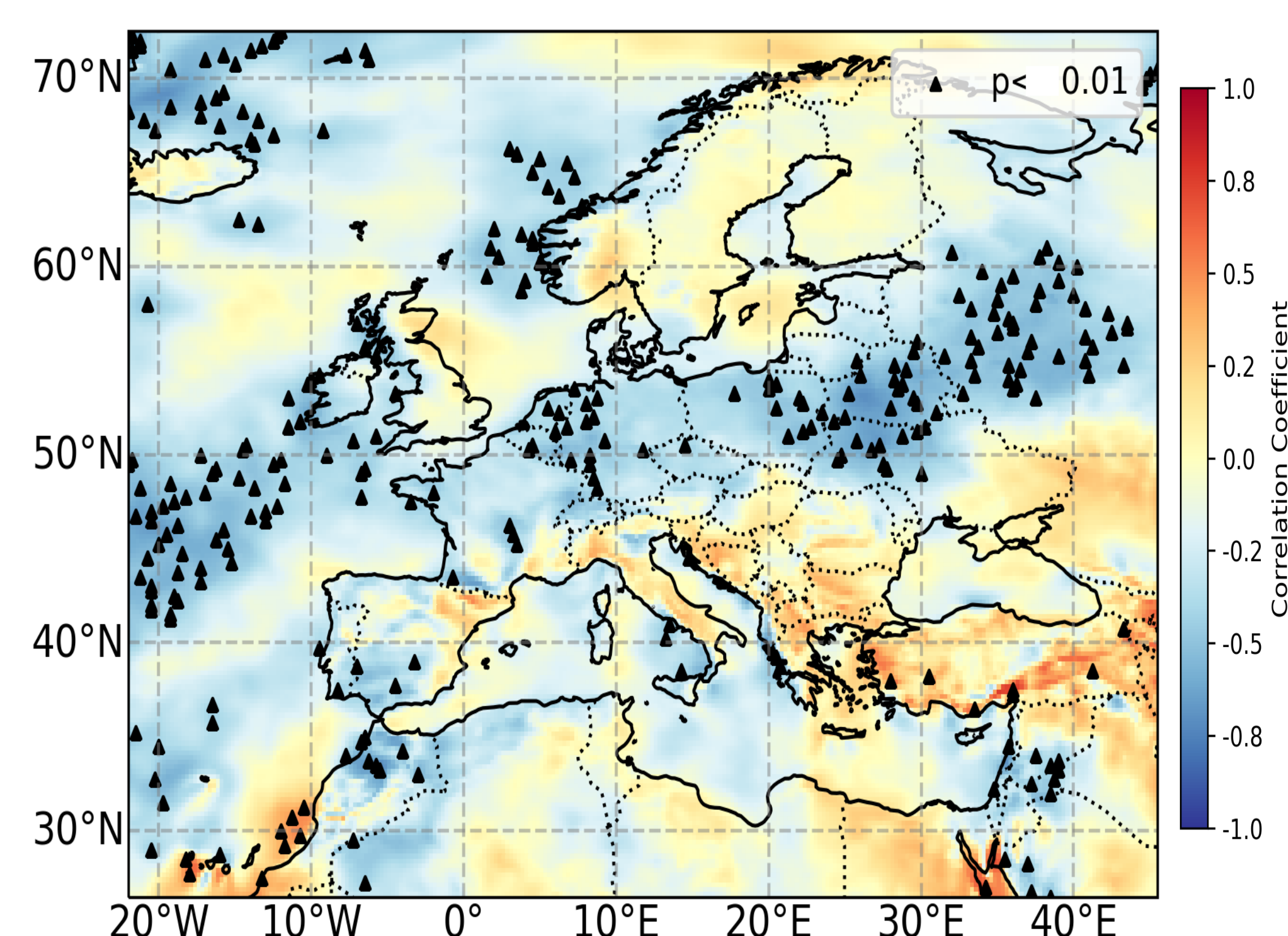


Figure 4 Annual correlation analysis between solar and wind capacity factor