Characterization of atmospheric conditions leading to compound low wind power production and high electricity consumption in France.

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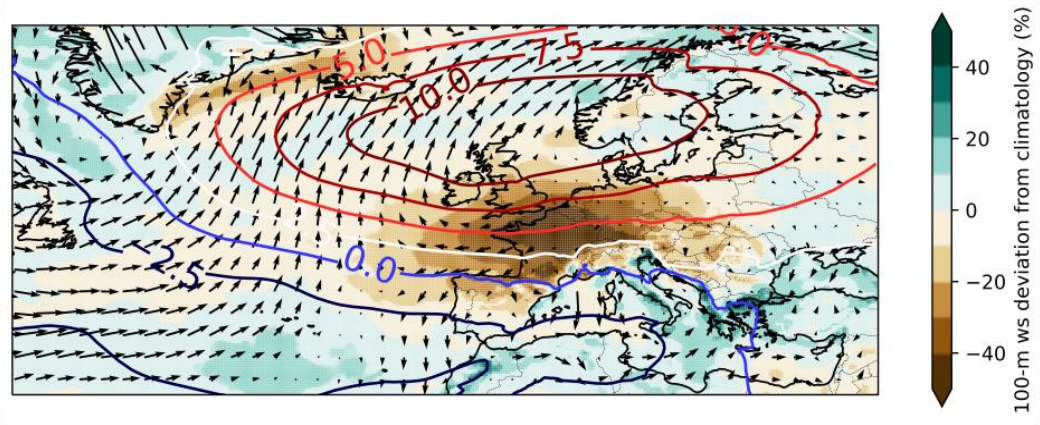
To reduce greenhouse gas emissions, the share of renewable energy is intended to increase in the European electricity system. France ambitions that 40% of its electricity will be supplied by renewable sources by 2030 [1], which will make the electricity production more sensitive to climatic fluctuations in the future. Using a bottom-up approach, the scope of this work is to characterize the atmospheric conditions leading to stress situations of low wind power production and high electricity consumption. We focus on the extended winter season from November to March, as high electricity consumption days occur primarily during this period. In particular, we are interested in low wind and cold temperature climate compound events ([2]) and how these extreme events have changed.

Based on daily wind speed at 100 m and surface temperature values, indices for both the wind power production and for the electricity consumption in France are calculated using the ERA5 [3] reanalysis over the 1980-2021 period. Capacity factors are reconstructed from the reanalysis wind speed data and the location, hub height, power and power curve of wind turbines based on the WindPower database [4]. These indices show good correlation to validated observations [5] of electricity consumption and wind power production over the 2012-2021 overlap period.

Days with simultaneous limited wind power production and high electricity consumption in France are identified using these indices, and the observed evolution of their frequency is analyzed. Then, the atmospheric conditions leading to such events are characterized in the ERA5 reanalysis. Composite maps exhibit a significant positive sea-level pressure anomaly over Scandinavia and the North Sea with cold temperatures and low wind conditions over Western Europe. Spatio-temporal patterns of preferred atmospheric conditions are further characterized using weather regimes classification. Perspectives of this work are to analyze the future evolution of these compound events and their climatic drivers to better help inform future adequacy studies.



ERA5 100-m wind speed deviation from NDJFM 100m-ws average (in colors), wind direction (arrows) and sea-level pressure anomaly compared to NDJFM sea-level pressure average (contours) during compound low wind power production and high electricity consumption from 1980 to 2021

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