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Spatio-temporal relationship of short-term renewable energy forecast errors

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Climate-neutral societies rely on large-scale renewable energy expansion. With increasing renewable energy capacities, the impact of renewable energy forecasts errors on energy systems magnifies which strengthens the need to better understand and describe them. Renewable energy forecast errors are particularly interesting when studied in their spatiotemporal domain: Uncorrelated or even negatively correlated forecast errors can get smoothed out reducing the regional impact of forecast errors whereas correlated renewable energy forecast errors can result into largescale deviations between plannable and dispatchable renewable energy which can affect the entire energy system. Despite its importance, an analysis of the spatio-temporal characteristics of short-term renewable energy forecast errors is still lacking. This study aims to close this gap by studying the spatio-temporal characteristics of short-term (1 to 3 days forecast lead time) renewable energy NWP (ECMWF IFS HRES) forecast errors in Europe. The spatio-temporal relationship is described by deriving characteristic correlation lengths for each site whereas the effect of smoothing is calculated through the analysis of spatially convoluted forecast errors. We show that solar and wind energy forecast errors have fundamentally different behavior subject to site characteristics and forecast lead times. Furthermore, we identify regions which are prone to forecast smoothing or accumulation. Lastly, we illustrate that accumulated forecast errors for actual renewable sites in Europe are uncorrelated over large distances, yet forecast error clusters can be identified for wind and solar energy. This is particularly crucial for the case of planned wind offshore farms as we show for the EU wind offshore expansion plans until 2030.