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Anticipating extreme wind and pv power forecast errors using ultra-large ensembles

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Though infrequent by definition, extreme error events in numerical weather predictions and the consequent power predictions for wind and solar plants have disproportionately costly effects on grid stability and energy markets. While probabalistic forecasts give some insight into the expected uncertainty of forecasts via ensemble spread, ensemble sizes are in practice small and give no good estimate of the likelihoods of more extreme, low probability events. Smaller ensembles also do not indicate whether such errors should more likely result in over- or undersupply events, which would inform the appropriate course of action to avert risk for grid operators and stakeholders. The Energy-Oriented Centre of Excellence for Computing Applications (EoCoE) is concerned with the extension of high-performance computing expertise to solve energy-related challenges in Europe. Within the EoCoE project, we generate ultra-large, thousand-member ensembles for extreme error test cases to evaluate how larger ensemble sizes can be useful in anticipating low probability events. Numerical weather predictions are calculated using Ensembles for Stochastic Integration of Atmospheric Systems (ESIAS), a new system at the Jülich Research Center that applies the Weather Research and Forecasting Model (WRF) and the particle-filtering technique for ensemble generation on the JUQUEEN supercomputer. The resulting meteorological data are converted to power forecasts using two power models applied at Fraunhofer IWES, a physical grid model for regional wind forecasts and a probablistic regional PV model for solar power production. The ultra-large ensembles yield probabilistic forecasts with smooth tails and resolved higher-order statistics that indicate the extreme error events of the test cases that conventional ensembles did not. We measure these statistical indicators for a contemporary, operational ensemble forecast group and likewise use random sampling of the ultra-large ensemble group to investigate how ensemble size affects statistical indicators and what ensemble sizes may be sufficient for anticipating future extreme error events. This work has important implications for the establishment of an operational extreme forecast error warning system, a key goal of the EoCoE project.