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Particle filtering and smoothing within an ultra large mesoscale ensemble for estimating wind energy

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This study aims to improve the short range predictability of wind at turbine hub height. By approaching today's computational limits, we realize a meteorological mesoscale ensemble with a size of up to 1000 members and perform multiple nesting with a target horizontal resolution of 1 km as finest. The system is tested on critical weather situations, which exhibited low-probability extreme-error events of the resulting power forecast.

Current wind power forecast systems rest on NWP ensemble models. However, only calibrated ensembles from meteorological institutions serve as input so far, which are restricted to limited spatial resolution (∼10-80 km) and limited members (∼50). Perturbations related to the specific needs of wind power production are as yet rare. Thus, single extreme error events which are not detected by such ensemble power forecasts occur frequently.

We therefore present a highly efficient ultra large ensemble setup of the Weather and forecasting Model (WRF) on an IBM Blue Gene HPC architecture. Within this environment, we focus on the investigation of different importance resampling particle filter (SIR-PF) techniques and its smoothing variant (SIR-PS). The SIR-PF and SIR-PS are not restricted to Gaussian noise assumptions as competitively ensemble data assimilation techniques. The increased member number makes the SIR-PF or SIR-PS finally applicable in an atmospheric system, since the ubiquitously phenomena of possible filter degeneracy, which is connected to the high dimensionality of the problem, is reduced.

Model uncertainties are represented by stochastic parametrization of sub-grid processes via stochastically perturbed parametrization tendencies (SPPT) and kinetic-energy backscatter backscatter scheme (SKEBS) as well as surface parameter perturbations. We use different ensemble systems from global models (ECMWF and GFS) as input and boundary conditions to capture different synoptic conditions.
The demanding computational effort is overcome by utilising the supercomputer JUQUEEN at the Forschungszentrum Juelich.