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Warning Electricity Grid Operators about Large Photovoltaic Forecast Errors

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With increasing share of photovoltaic (PV) in a power supply system there is an increasing demand for improved forecasts of regional production, requriring not only lower average error (like RMSE) but also additional information on predictability and the reliable prediction of extreme events. Due to around 40 GWp of installed PV capacity, German transmission system operators (TSOs) are facing large forecast errors which already reach the amount of the available balancing power.
We use numerical weather forecasts from an ensemble prediction system to simultaneously assess information about the expected feed-in and the corresponding spatial and temporal behavior of uncertainties for improved day-ahead forecasts of regional PV production in Germany and its four control zones.
Using recent historical data from a one-year period and regression methods for calibration we show how to implement a practically useful warning tool for TSOs which operationally marks periods with high uncertainties. Delivering highly reliable results (e.g. with a low false alarm rate) such a system would allow timely reactions to potentially unforeseen and therefore critical weather conditions.

To offer grid operators either an improved deterministic day-ahead forecast or an added value to the standard deterministic day-ahead forecasts of the regional PV production, we use the individual members from an Ensemble Prediction System, like the COSMO-DE-EPS operated by the German Weather Service DWD, as an input to our regional PV model. This already existing PV model transforms measured or predicted fields of irradiation and temperature into the yield from distributed PV plants, represented by a statistical set of orientations and power classes. The data used in this study spans the time period from 12/2014 to 10/2015, where the operational CDE-EPS 03 UTC modelrun offers a forecast horizon of up to 45 hours, covering the complete following day.
The resulting ensemble of regional PV power is calibrated with a quantile regression to represent a scenario or to match specific quantile probability levels of interest with respect to the corresponding regional power measurements published by the TSO. This final ensemble of calibrated PV scenarios or quantiles can then be used as a basis for further steps like the calculation of spread and correlation to errors of deterministic day-ahead forecasts.

Common statistical calculations and plots adequate for ensemble evaluation (like ‘continuous ranked probability score’ (CRPS), rank histogram, reliability diagram, etc.) show the success of the calibration. The distribution of the forecast error amplitude depends on the calibrated ensemble spread and works as a basis for a warning signal. Since we think a TSO would score the benefit of such a system mainly based on the experience of hits and false alarms, we investigated the use of scores like the ‘critical success index’ (CSI or also ‘threat score’). Such a score might be optimized through a variation of the warning threshold which is based on the ensemble spread. This optimization finally results in numbers for hits and false alarms for which the threshold is exceeded as well as in numbers for misses and correct rejections for which the ensemble spread is lower.
In an example processed for all of Germany, a simple calibration does not significantly change the number of hits and false alarms, but impressively improves the number of misses and correct rejections, respectively.

With our regional PV model we have processed complete ensembles of numerical weather predictions. Such an ensemble of power contains additional information about the related uncertainty. Combining this spread with a basic score and its straightforward optimization leads to the ability to detect periods of possibly high uncertainty, whose identification may form the basis of a warning system. Nevertheless, the selection of the optimal choice of weather ensemble and score to use in this context is still a work in progress, as is gathering feedback regarding the tool’s application.