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Statistical Analysis of NWP Prediction Errors and Their Consequences for Short-Time Photovoltaic Energy Forecasting; A Semi-Parametric Way to Prediction Quality Improvements

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We will compare prediction performance of several numerical weather prediction (NWP) models (two versions of WRF and MM5) in terms of forecast quality of both solar radiation itself (against a spatially distributed set of GHI measurement stations) and in terms of electric power produced at solar farms near the measurement sites.

First, we will show that the raw NWP output is not smooth enough and that the prediction performance can be improved substantially by spatial averaging. Improvements are easier to achieve for GHI. The power production (on tilted solar panel) poses an additional level of complexity. This is both in terms of systematic errors (related to specific NWP deficiencies and to imprecision of the tilted panel calculations as well as details of solar farm operation), but also in terms of the residual variability (and hence to the precision of estimates and their complete distribution, in general).

Next, we will derive a statistically motivated calibration of the NWP output in order to improve prediction quality. The methodology is based on the following three main ideas:

1. seeing the problem of power prediction based on NWP output as an instance (of highly non-standard) errors-in-variables problem known from several branches of statistics;
2. recognition of specific distributional features of the NWP prediction error (heteroscedasticity, but even more importantly changing its skewness in dependence on the level of true/unobserved GHI or power);
3. using a flexible, semi-parametric class of statistical models in order to address the ideas above in a formalized way.

We will demonstrate that the improvements achieved by this approach are both interpretable and appreciable in terms of practical quality of the forecasts.