Online Short-term Solar Power Forecasting

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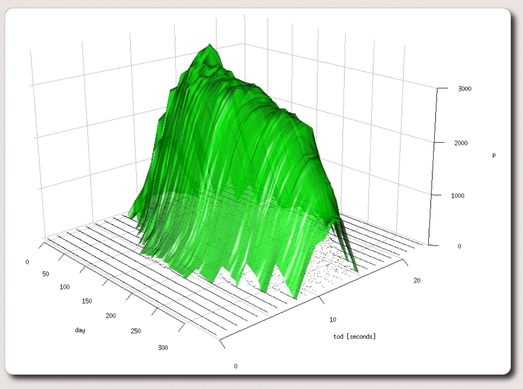
This poster presents two approaches to online forecasting of power production from PV systems. The methods are suited for online forecasting in many applications and here they are used to predict hourly values of solar power for horizons up to 32 hours.

Observed solar power and numerical weather predictions

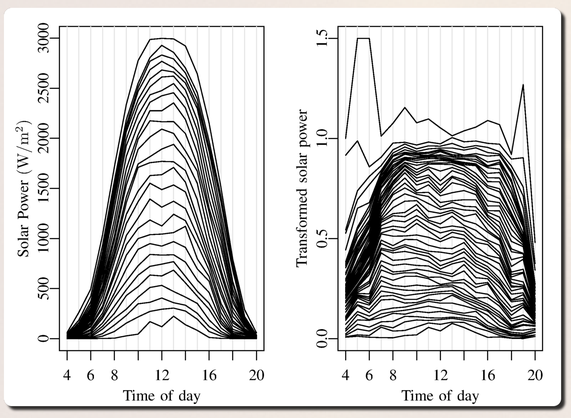
The data used is hourly observations of solar power from a single 4 kW-peak PV-system located on a rooftop in a small village in Denmark. The entire year of 2006 is covered. The numerical weather predictions (NWPs) are provided by the Danish Meteorological Institute (DMI) using the HIRLAM mesoscale NWP model. The NWPs have a calculation time of 4 hours and a time resolution of 3 hours.

Two-stage approach using a clear-sky model

One approach is to use a two-stage method in which a statistical normalization of the solar power is obtained using a clear sky model. The clear sky model is found using statistical smoothing techniques, which ensure that local phenomena are directly modelled from data, as opposed to applying a deterministically derived clear sky model. In the second stage forecasts of the normalized solar power are calculated using adaptive linear time series models.



The estimated clear sky solar power.

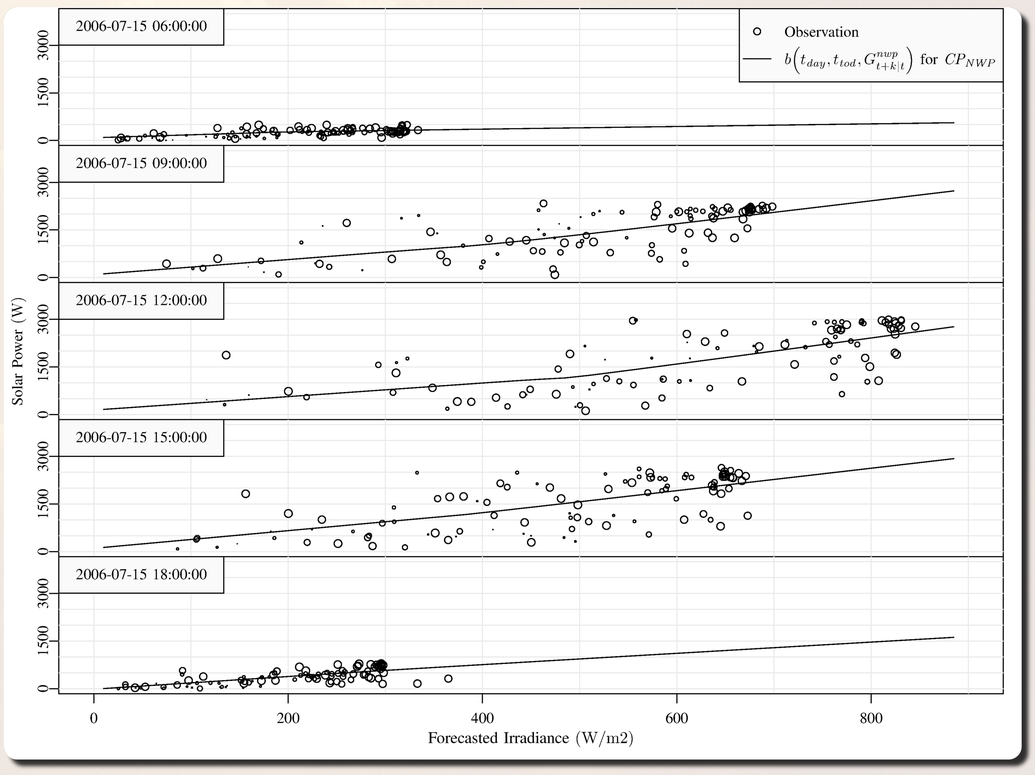


The 0%, 4%, … , 100% quantiles of the distribution of the solar power and the normalized solar power conditioned on the time of day. Values above 1.5 has been clipped, which was the case for 6 values.

Direct approach using conditional parametric models

A second approach is to use conditional parametric models with both autoregressive input and NWPs exogenous Input. The coefficients are conditional on the time of day and time of year. The models are applied with both past solar power observations and NWPs as inputs. Plots of the fitted forecasting function for k=24 hours are shown in the figure below.

It is seen how the slope of the function is lower in the morning, than in the middle of the day. This is naturally caused by the higher angle of incidence in the morning, which cause less horizontal radiation to be absorbed due to reflection. Likewise for the afternoon. Finally, non-linearity in the fitted function is seen.



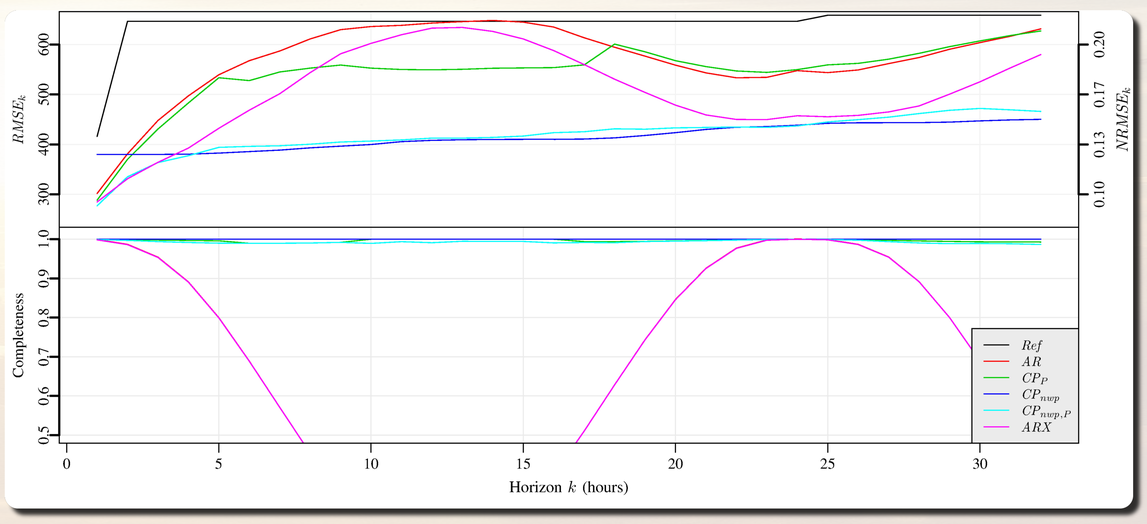
Examples of the function fitted for k=24 hours forecasting with the NWPs of global radiation at different times of the day on the 15'th of July 2010 for the conditional model with NWPs as input. For each observation the size of circle indicates the weighting of the observation. Thus observations with a larger circle have more influence on the fitted function.

Results

The performance is evaluated for each k hours horizon with the root mean square error (RMSE) and the completeness, the latter is the ratio of the total sum of solar power and the summed solar power for time points where the forecasts are not missing.

The following models are evaluated:

- *Ref* A reference persistence model
- *AR* Auto-regressive model forecasting the normalized solar power
- CP_P Conditional parametric model with solar power input
- CP_{nwp} Conditional parametric model with NWPs
- $CP_{nwp,P}$ Conditional parametric model with NWPs and solar power
- *ARX* Auto-regressive including NWPs as input



The upper plot is the RMSE for each horizon k for the forecasting models. The lower plot is the completeness for each horizon k.