Short-term Horizontal Irradiance forecasting with PV network

Boudewijn Elsinga1*, Ruut Brandsma2, Lou A.M. Ramaekers3, Bas Vet4, Santiago Peñate Vera3, Paul H. Raats3, Wilfred G.J.H.M van Sark1

Objective

• In situ determination of cloud transit time lag on reconstructed Global Horizontal Irradiance (GHI) and the use of this time lag for short-term irradiance forecasting.
• Forecast horizon 0 ~ 15 min. at resolution of input data: 15 sec.

Set up

• 169 Rooftop PV-systems (< 5 kWp) covering approx. 1600 km².
• AC Power Output measurements of 0.7 W and 2 sec resolution; 15 sec. interpolation used for GHI reconstruction (inverse PV-model).

Selection

• Example data from a distinct cloud system moving over Utrecht on 12-01-2014.
• For a target location, the time lag is determined with respect to all the other locations.
• Selection of r’s with high quality factor, e.g. Q > 0.75
• 3D plot staircase graph shows wind direction. Wind speed can be deduced from this as well.

Method

Determination of Time Lag \( r \)

The minimum of the absolute overlap between two GHI or \( \Delta \)GHI time series, dependent on relative temporal shift \( \delta t \) in observation window \( \tau \), see [1]:

\[
Y_{ij}^{\delta t} (\delta t, k) = \min \left( Y_{ij}^{\delta t} (\delta t, k), \Delta t \right) = \min \left[ \left( \Delta \text{GHI}_i (t) - \Delta \text{GHI}_j (t - \delta t) \right) \right]
\]

Robustness

Similarity of time series of locations \( i \) and \( j \) does not need to be perfect: this method allows for changing cloud structure or velocity, albeit modestly. The minimum of the overlap determines the time lag. Other characterization functions \( Y_{ij} \) may be used, e.g. covariance [2].

Quality factor

A found time lag \( r \) has a quality factor \( 0 \leq Q \leq 1 \), determined by the relative depth of the found minimum:

\[
Q_{ij}^{\delta t} = \frac{\min \left( Y_{ij}^{\delta t} (\delta t, k), \Delta t \right)}{\text{mean} \left( Y_{ij}^{\delta t} (\delta t, k), \Delta t \right)}
\]

For a target location, the \( \Delta \)GHI time series of peripheral locations with sufficient high quality factors \( Q \) are then shifted by their respective time lag \( \tau \) with respect to the target location. The sum of the shifted time series is then the forecast for the target location, assuming constant cloud speed and direction.

This method can also be applied to spatially interpolated data for forecast for PV-systems that are not monitored.

References


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