EGU22-9709
https://doi.org/10.5194/egusphere-egu22-9709
EGU General Assembly 2022

Nowcasting of Solar Power Production by a Deep Learning Methodology: Improving Forecasts for Solar Energy Sites during Sahara Dust Events using Highly Resoved Historic Time Series, Remote Sensing and Numeric Weather Prediction Models

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With the rapidly increasing use of solar power accurate predictions of the site-specific power production are needed to ensure grid stability, energy trading, (re)scheduling of maintenance, and energy transfer. Particularly in systems relying on many factors such as solar energy, extreme events can be a threat to the power grid stability and accurate nowcasts. Thus, warnings within a reasonable amount of time ahead for preparation are essential. In the MEDEA project, funded by the Austrian Climate Research Program, we aim at improving the definition and detection of extreme events relevant for renewable energies and using these findings to improve both weather and climate predictions of such extreme events.

In the presented case study, we investigate selected (extremes) cases of Sahara dust events in 2021 where various weather prediction models were unable to properly reproduce the amount of aerosols in Central Europe resulting in a discrepancy between actual solar power production compared to predictions being off by more than 5 GW. Here, several solar production forecasts gave impaired results based on raw NWP model output. To tackle such events and improve the predictability, a deep learning framework including an LSTM (long short-term memory; type of an artificial neural network) and random forest will be adopted for nowcasting with multiple heterogeneous data sources available. Relevant features include 3D-fields from different NWP models (AROME, WRF), satellite data and products (CAMS), point-interpolated radiation time series from remote sensing, and observation time-series (site observations, close meteorological sites). We investigate up to 6 hours ahead nowcasts at several Austrian solar power farms with an update frequency of 15 minutes.

Results obtained by the developed method yield, in general, high forecast-skills, where we elaborate on interesting cases studies from a meteorological point of view. Different combinations of inputs and processing-steps are part of the analysis. We compare obtained forecast results to available forecast methods, e.g., an analogs-based method, pvlib forecasts driven with AROME and AROME RUC.