EMS Annual Meeting Abstracts
Vol. 11, EMS2014-547, 2014
14th EMS / 10th ECAC

Using cloud fraction derived from all-sky camera to improve beam solar irradiance forecasting by time-series modeling

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Photovoltaic (PV) electricity is a variable energy source. Very short-term forecast (up to 30 minutes ahead) are crucial to optimize smart-grid systems, to manage PV electricity storage and to prevent non-interconnected territories network from a load shedding.
Solar energy variability is essentially due to stochastic cloud cover behavior. Deterministic weather models are unable to describe a cloud pattern over a given site within the next half-hour. Even cloud satellite observations do not offer a sufficient space and time resolution to study intra-hour irradiance variability.
A classical approach for very short term prediction is the time-series modeling such as ARMA (AutoRegressive Moving Average) model applied on irradiance data. However, all-sky cameras tracking cloud cover evolution from the ground provide pertinent information for such forecast. We propose in this work, the use of an ARMAX (Auto Regressive Moving Average with eXternal inputs) model to predict direct normal irradiance (DNI). We use as external input the cloud cover fraction derived from image of a total sky imager (TSI).
A 1-year time series of TSI images freely available from NREL with collocated DNI data have been processed. First half of the dataset is used to set the time-series models parameters, the second one is used to assess our forecasts. We tested three time horizons and quantified the performance by the RMSE of DNI against the persistence. ARMAX improves the persistence of 7.5, 11.1 and 12.7 % for the 10, 20 and 30 minutes time-horizon respectively, where ARMA improves it only of 3.1, 6.2 and 7.8 % respectively. These results demonstrate clearly the benefits of all-sky camera in such forecasting approaches. Further improvements can be done by allowing time-series models to detect cloud regime transition and by introducing additional cloud features as external inputs.