Assessing different module tilt and orientation assumptions for regional PV estimation

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Objective & Background

With the growing deployment of PV capacity across the globe, accurate modeling of regional-scale PV generation is expected to become more relevant for the operation of power grids as well as for integration studies evaluating the impacts of potential future pathways.

Several models have been proposed in the literature. These propose different degrees of modelling detail, data needs, and computational complexity. Here, the goal is to evaluate the assumptions made on the plane-of-array of PV modules for a given region. Generally, three types of assumptions were identified: i) a horizontal tilt; ii) a given tilt with a South orientation; or iii) a combination of tilts and orientations.

Method

A complete PV conversion workflow was implemented as described in Saint-Drenan et al.. It includes both irradiance processing (i.e., decomposition and transposition, when required) and PV conversion (optical and thermal losses), returning Capacity Factor (CF) values as these do not depend on a given PV capacity assumption.

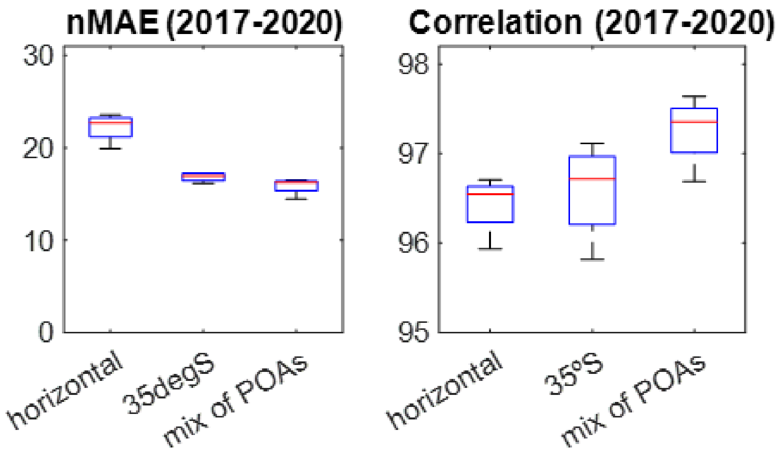
Weather data is obtained from the ERA5 reanalysis, notably global horizontal irradiance and air temperature at 2-m height. As reference data, solar generation and installed solar capacity is obtained from the Transparency Platform of the European Network of Transmission System Operators for Electricity. Since only annual records are available, PV capacity was assumed to evolve linearly through time.

- a horizontal tilt;
- a 35º tilt with South orientation;
- a tilt assuming normal distributions of $N(0.7\times\theta_{opt}{}^{1},10.8)$ and N(180,8) for the tilt and orientation, respectively. Here, θ_{opt} is the tilt which maximizes the annual CF for a given location

It is important to note that the third configuration was derived from the metadata extracted of thousands of installations both in France and Germany, as done in Saint Drenan et al..

Principal Findings

Only France was considered. The figure below shows that the simplest horizontal assumption performs worst in terms of the Mean Absolute Error (MAE) and the correlation, both normalized by the mean CF derived from ENTSO-E. When comparing an individual with a mix of tilted geometries, the difference in nMAE is not substantial; however, the more complex approach can better capture the seasonality of the data (an increase of 0.5 to 0.9 pp in correlation).



Discussion

Preliminary findings already show interesting differences between the various assumptions. At the time of the conference, a more exhaustive analysis will aim to better understand these results, notably by including considerations regarding accuracy-complexity trade-offs. Additionally, more countries are to be included in this analysis.

It is also of interest to note that these same models can be used for future climate projection studies, provided that the parameters and assumptions are adjusted.

[1]This was done by calculating the yield over the 2015-2019 period for a comprehensive range of tilt values for each pixel in the ERA5 grid

1. Saint-Drenan, Y.-M., Wald, L., Ranchin, T., Dubus, L., and Troccoli, A.: An approach for the estimation of the aggregated photovoltaic power generated in several European countries from meteorological data, Adv. Sci. Res., 15, 51–62, https://doi.org/10.5194/asr-15-51-2018, 2018.