Enhancing regional PV power estimation using physics-based models, solar irradiance data and deep learning

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Photovoltaic (PV) power generation is growing rapidly and is critical to mitigating the energy crisis. However, the safe integration of PV into the grid necessitates high-quality information about PV power generation in real-time and for forecasts. Transmission system operators (TSOs) usually have access to real-time measurements for the largest plants but lack information for smaller plants and rooftop PV generation. This lack of precise measurements is known as the lack of observability of PV power generation. Recently, various methods improved the estimation and forecast of PV power generation when measurements are lacking. Among them, physics-based probabilistic methods accurately estimate regional PV power generation (Saint-Drenan et al., 2019). These methods rely on meteorological data (satellite-derived irradiation and air temperature) and information on the spatial distribution of the PV installed capacity. However, two challenges arise as the number of rooftop PV systems is expected to increase strongly. First, accurate estimation of rooftop PV generation with physics-based models requires accurate information on its characteristics, which differ from large plants. Second, reference production data stemming from these rooftop installations is not accessible, even to operators such as TSOs. The lack of ground-truth PV power production data results in the impossibility of assessing the accuracy of PV forecasting methods. This work addresses the following question: can regional PV models improve the observability of PV generation when considering both unobservable PV plants and the high penetration of distributed PV generation? We first introduce new regional models to estimate PV power generation and compare them to existing approaches. We then leverage deep learning to accurately map the rooftop PV installed capacity from aerial imagery (Kasmi et al., 2022) and show how regional models benefit from more detailed information on the PV rooftop capacity. Finally, we compare these models to ground-truth data and show how PV power estimation and forecasting benefit from accurate data on rooftop PV installations.

1. Saint-Drenan, Y. M., Vogt, S., Killinger, S., Bright, J. M., Fritz, R., & Potthast, R. (2019). Bayesian parameterisation of a regional photovoltaic model–Application to forecasting. Solar Energy, 188, 760-774.
2. Kasmi, G., Dubus, L., Blanc, P., & Saint-Drenan, Y. M. (2022, September). Towards unsupervised assessment with open-source data of the accuracy of deep learning-based distributed PV mapping. In Workshop on Machine Learning for Earth Observation (MACLEAN), in Conjunction with the ECML/PKDD 2022.