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Deep learning for improved bias correction of satellite-derived SIS maps

Alberto Carpentieri[1,2], Martin Wild[2], Doris Folini[2], and Angela Meyer[1]
[1]Bern University of Applied Sciences, Bern, Switzerland (alberto.carpentieri@bfh.ch)
[2]Eidgenössische Technische Hochschule Zürich, Zürich, Switzerland

Accurate maps of surface incoming solar (SIS) radiation are a crucial prerequisite for producing precise solar radiation and photovoltaic power (PV) nowcasts useful to utility companies, grid operators and energy traders.

We present a new bias correction approach for satellite-retrieved SIS measurements using deep neural networks with time encoding features, achieving significantly reduced biases on high time resolution data. Moreover, we demonstrate the necessity and the benefits of automated bias correction prior to performing surface radiation and PV nowcasts.

We make use of SIS retrieved from the SEVIRI spectrometer onboard the geostationary Meteosat MSG satellite with the HelioMont (Stöckli, 2013) and HelioSat (Müller et al., 2015) algorithms by the CM SAF team. HelioMont comes at a spatial resolution of 0.02x0.02 degrees, while HelioSat provides a resolution of 0.05x0.05 degrees. For the bias correction, we employ high-quality long-term pyranometer measurements from 113 ground stations of one of the densest meteorological networks around the world, the SwissMetNet. The SIS radiations are retrieved at 30-minutes, 15-minutes and 10-minutes resolutions (HelioSat, HelioMont, and SwissMetNet, respectively) for the entire year 2018. We use 46 weeks as training set and 6 weeks as test set, wherein the latter consists of the 3 sunniest and 3 cloudiest weeks of 2018.

Our approach involves a multilayer perceptron (MLP) trained to correct the satellite SIS bias by exploiting the predictor variables (time encoding, location features and satellite SIS) and fitting them to predict the ground station SIS. By doing so, we demonstrate that our novel bias correction method can reduce the SIS mean absolute bias (MAB) of both HelioMont and HelioSat by more than 10%. Comparing our results with a standard linear regression (LR) model, we find that the MLP outperforms the LR approach on 112 and 111 SwissMetNet stations for HelioMont and HelioSat, respectively.

Moreover, we found that the bias magnitude is significantly correlated with the altitude of the considered location and with the time of year. The biases are largest in mountainous regions that tend to have a higher albedo due snow and ice. In fact, the Pearson correlation between the altitude and the average MAB is 0.76 and 0.80 for HelioMont and HelioSat, respectively.

References

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