i-EM

Intelligence in Energy Management

EMS21 conference - Session OSA2.3

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Hybrid nowcasting for solar power plants using satellite-data and Numerical Weather Predictions (NWP) for (Deep) Machine Learning methods

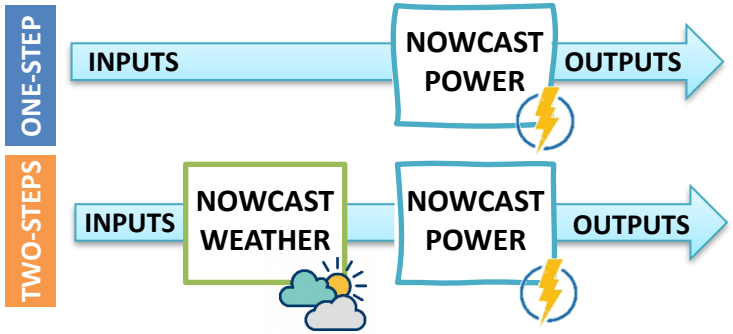
GOAL

Goal: nowcast prediction of solar power from +15 min to +3 hours ahead with 15 min time steps using satellite-derived data (and NWP).

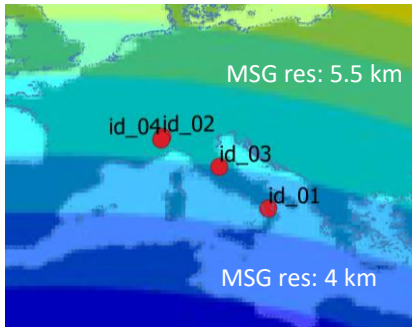
Research topics

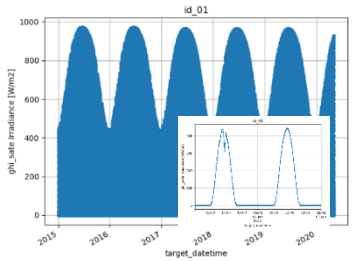
Topic 1. Compare results of a **two-steps** (nowcast weather -> nowcast power) versus **one-step** approach (directly nowcast power).
- PRO: one-step more flexible
- CONS: one-step less interpretable wrt two-steps ("black-box" analogy)

Topic 2. Compare results w/ and w/o using **NWP data** as input to models.
- PRO: NWP data can increase performance (especially after hour 2)
- CONS: NWP can be costly depending on required performance and timings

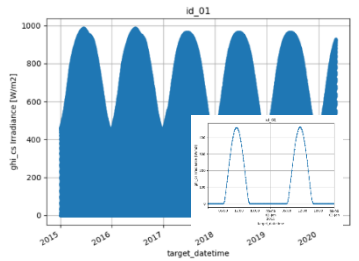


Data Acquisition and Preprocessing

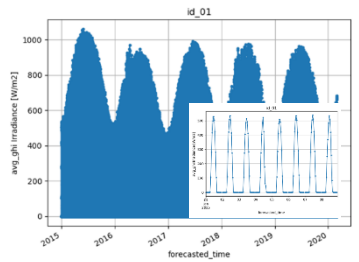




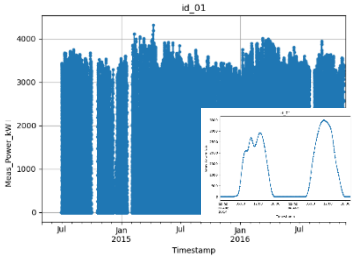
Ghi (global horizontal irradiance) and bni (beam normal irradiance) data from MSG (15 min)



Ghi (clearsky) data



Ghi and bni NWP data (1h -> 15min)



Power measured data (1h -> 15min)

Reliable weather data: 2015->2020
Reliable power data: July 2014-> Nov 2015

Analysis results and next steps

Data Processing

One-step

LongShortTermMemory Deep NN (LSTM-NN) to nowcast **power**

Inputs: ghi, bni(sate), ghi(cs), ghi, bni(NWP), sun position
Target: measured power
Output: power nowcast

Typical performance
3%->9%(nrmse),
2%->5% (nmae),
-0.4%->3% (nmbe);
(power averaged over the 13 steps on 6 months of valid data)

Two-steps

LongShortTermMemory Deep NN to nowcast **ghi** and **bni**

Inputs: ghi, bni(sate), ghi(cs), ghi, bni(NWP), sun position
Targets: ghi and bni (sate)
Output: ghi and bni (LSTM_nowcast)

Typical performance
66->78(rmse [W/m2]),
27->35 (mae [W/m2]),
(ghi averaged over the 13 steps on 1 year of valid data)

kNN, NN + QRF to nowcast power

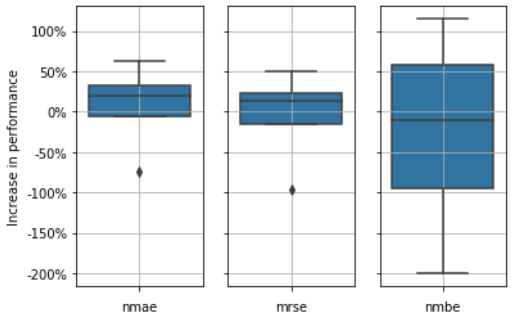
Inputs: [ghi and bni (LSTM_nowcast)] -> gti; gti(cs); sun position
Target: measured power
Output: power nowcast

Typical performance
3%->8%(nrmse), 2%->4% (nmae), -1.5%->3% (nmbe);
(power averaged over the 13 steps on 6 months of valid data)

Results

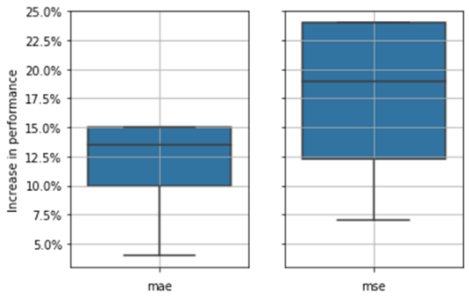
Research topic1:
One-step vs **Two-steps**

Two-steps usually outperforms onestep with increase of 20% (nmae), 10%(nmbe); nrmse results not conclusive



Research topic2:
w/ vs w/o NWP

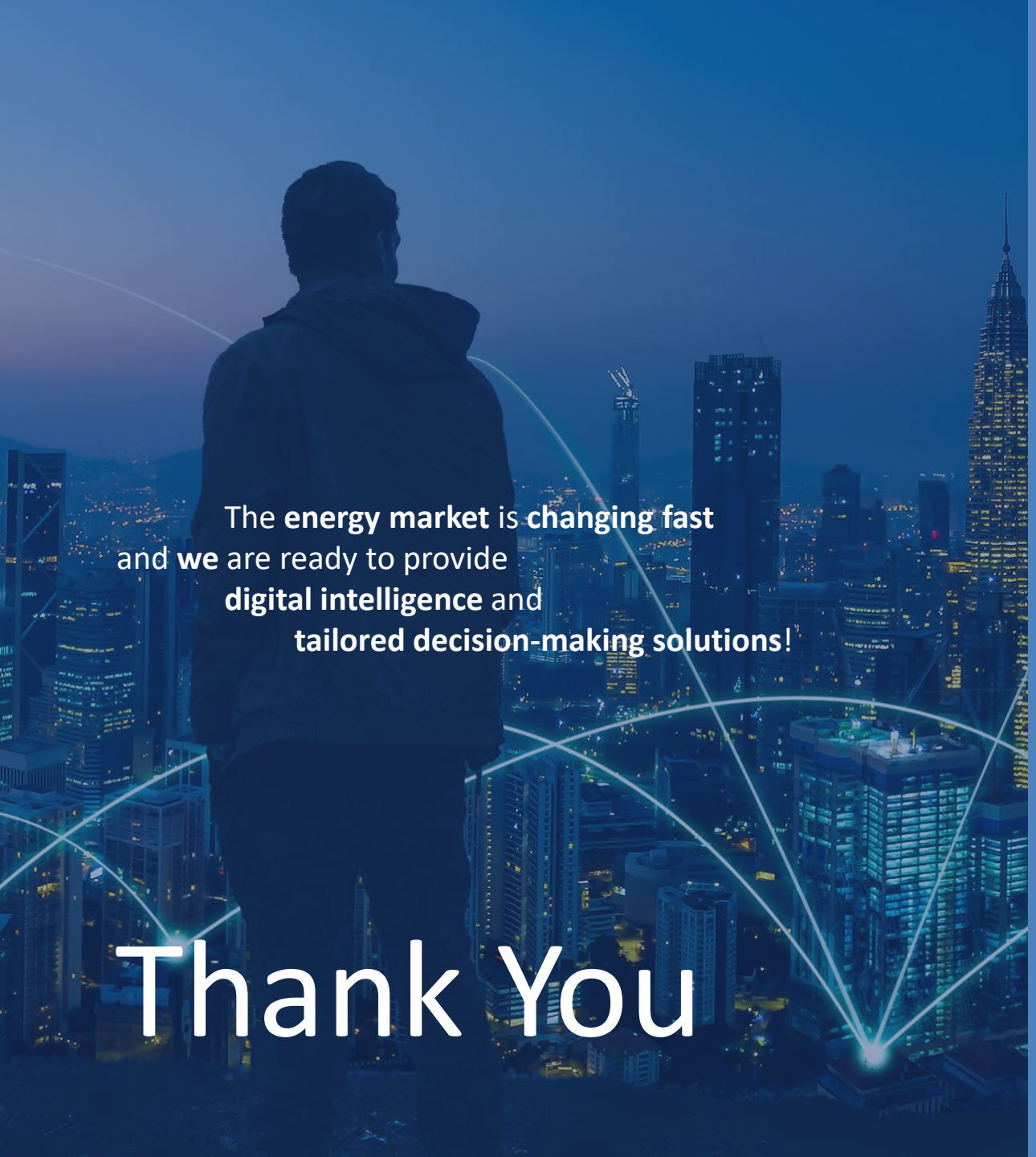
Performance on ghi nowcast increase between 7%->24%(mse) and 4%->15% (mae), averaged over the 13 steps on 1 year of valid data



Next steps

To obtain more robust results:

1. Enlarge datasample
   a) Time-period (one-step app. would benefit the most)
   b) Space (additional power plants to make more robust the final considerations)
2. Add bni_clearsky
3. Hypertune LSTM model



Thank You

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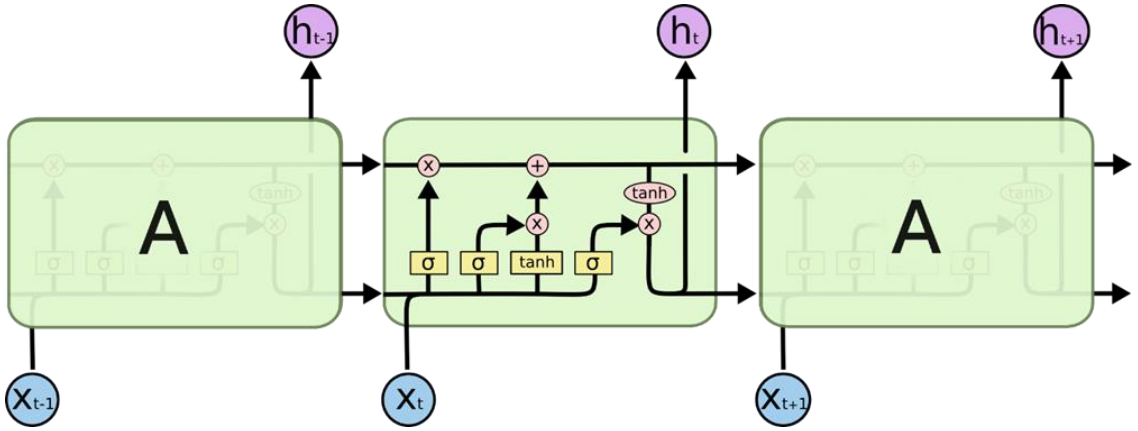
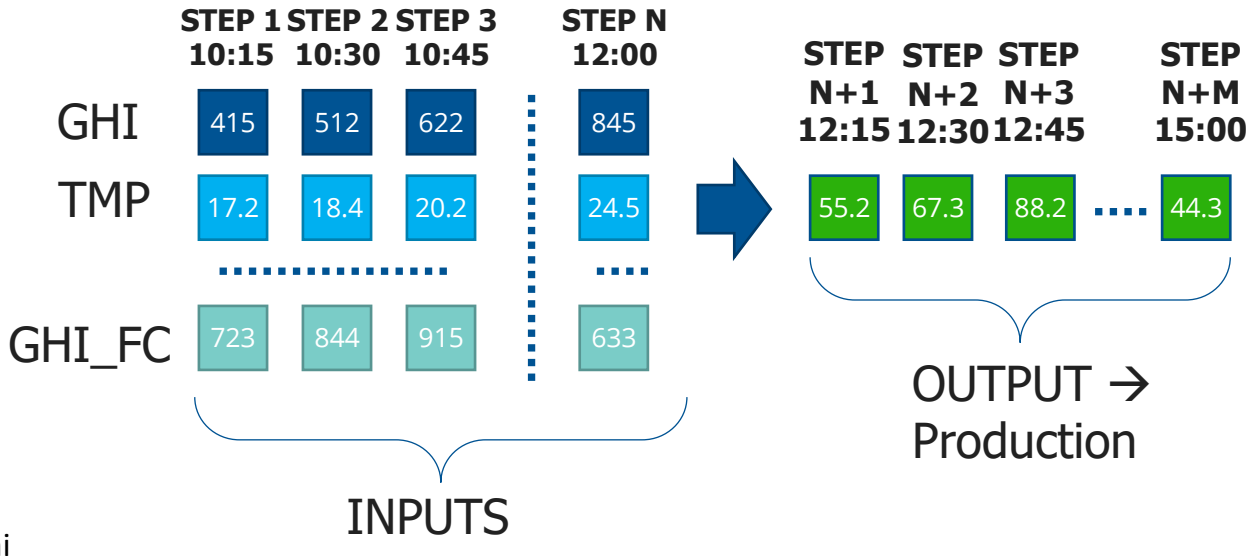
Backup

Focus on LSTM Neural Networks

Long Short Term Memory neural networks («LSTM») are a special kind of recurrent neural network («RNN»), that allows for the accounting of sequential dependencies in a time series taking care of the time-dependency.

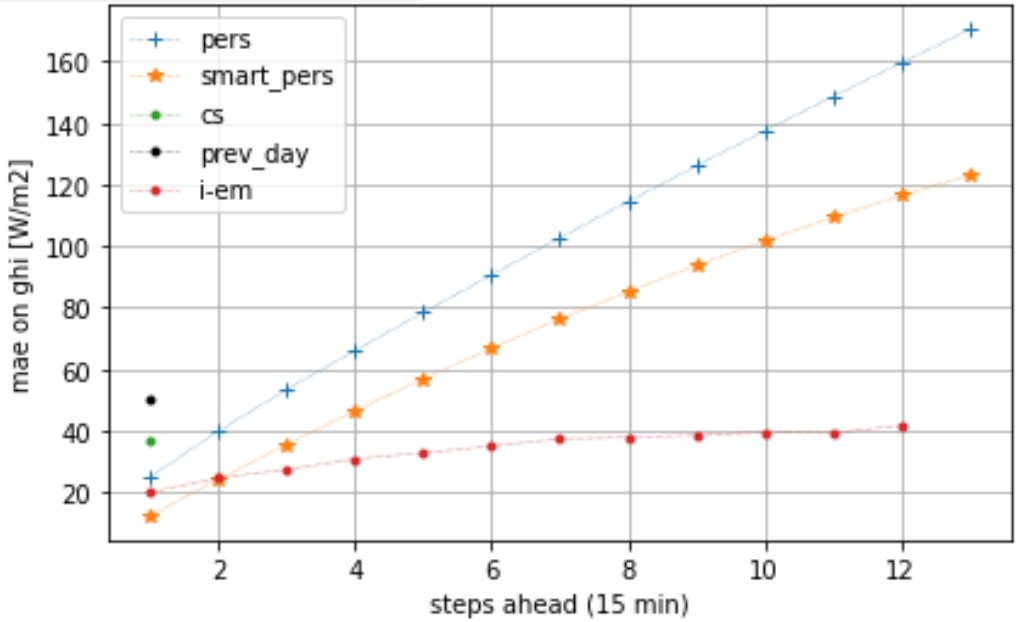
We used a LSTM algorithm that takes in input a certain number of observables steps and gives as output a certain number of output steps.



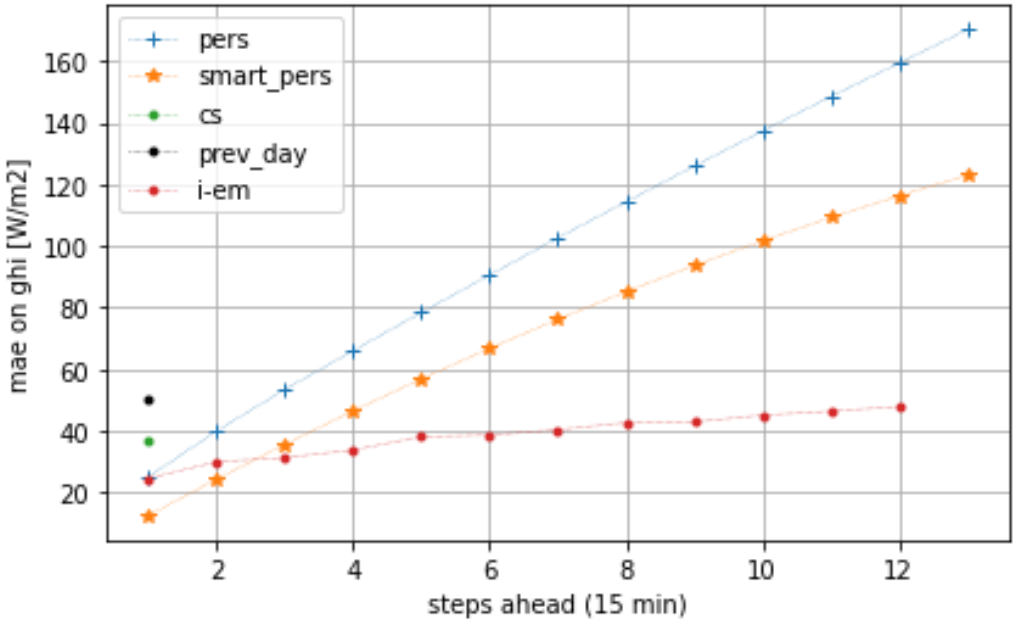


Comparison on results using (left) and not using NWP(right) as input

Mae results on id_1, ghi

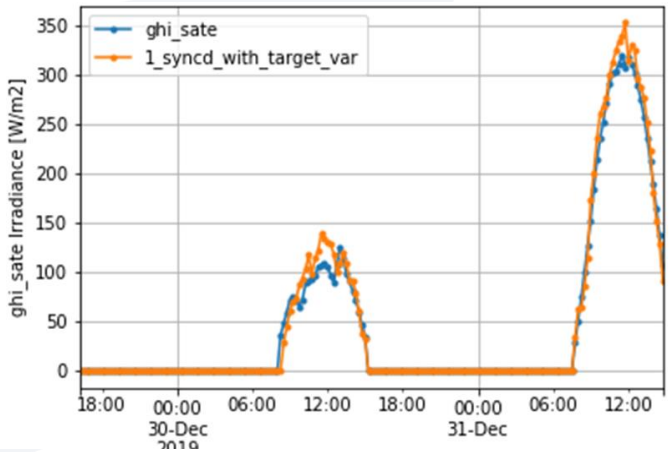


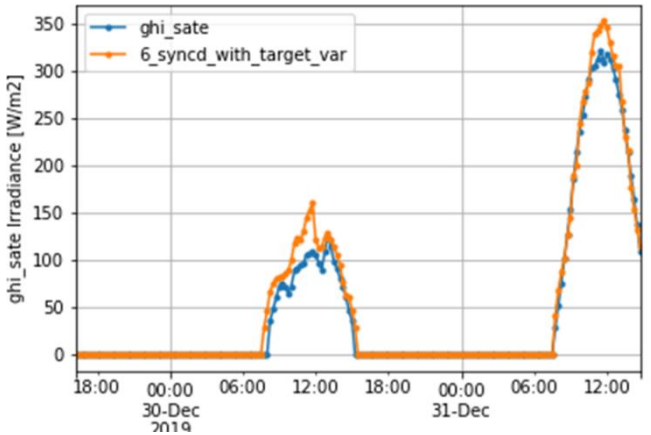
Mae results on id_1, ghi

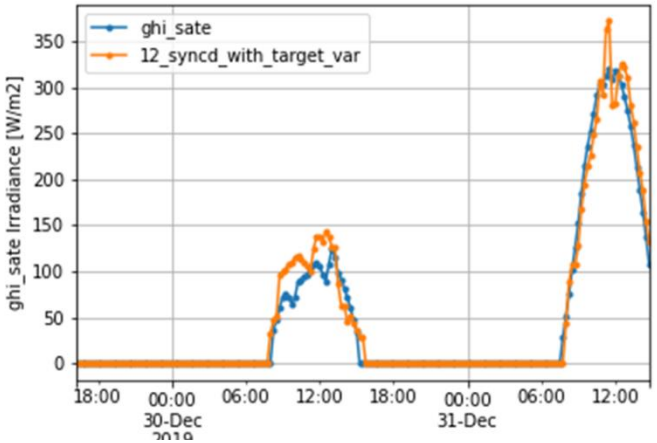


Nowcast solar power SafeStrategy: performances [ghi] id_02

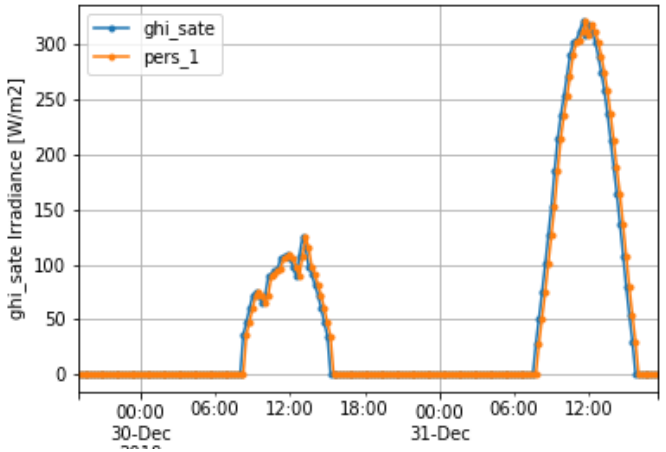
LSTM

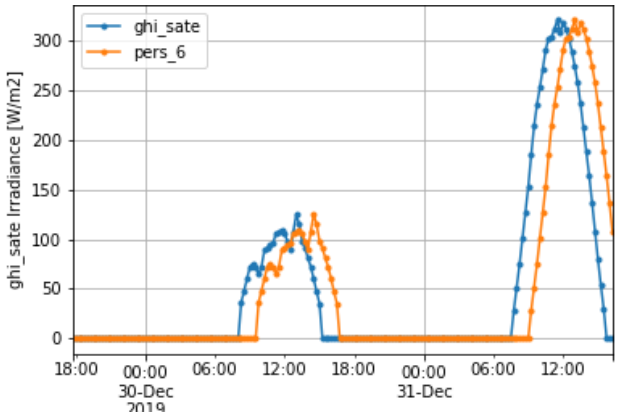


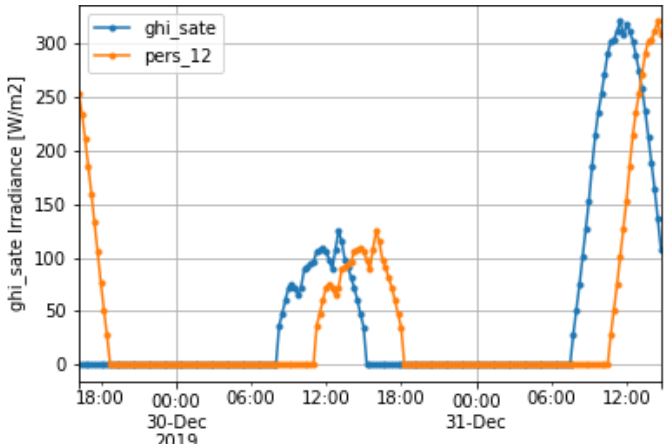




Persist







+15 min

+90 min

+180 min