PREDICTABILITY OF PV POWER GRID PERFORMANCE ON INSULAR SITES WITHOUT WEATHER STATIONS: USE OF ARTIFICIAL NEURAL NETWORKS*

C. Voyant[1,2], M. Muselli[2], C. Paoli[2], ML Nivet[2], P Poggi[2] and P. Haurant[2]
1- Hospital of Castelluccio, radiotherapy unit, B.P.85 20177 Ajaccio - France
2- University of Corsica/CNRS UMR SPE 6134, {Rte des Sanguinaires, 20000 Ajaccio/Campus Grimaldi, 20250 Corte} - France
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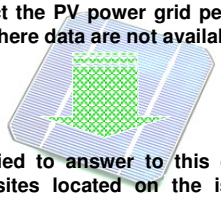
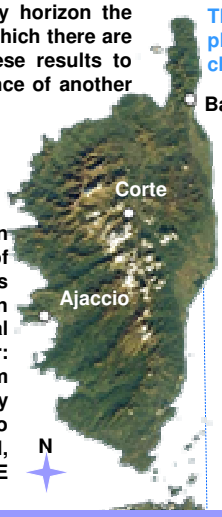
Presentation and Issue

Can we predict for daily and hourly horizon the global solar irradiation of a site for which there are a lot of data available and use these results to predict the PV power grid performance of another site where data are not available?



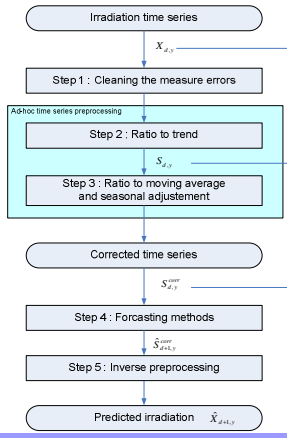
We tried to answer to this question with sites located on the island of Corsica (France). The island is characterized by a Mediterranean climate and a hilly terrain. The official meteorological network is very poor: only three sites being about 50 km apart are enable measurements by hourly and daily step: Ajaccio (41°55'N and 8°48'E), Bastia (42°33'N, 9°29'E) and Corte (42°30'N, 9°15'E average altitude of 486 meters)

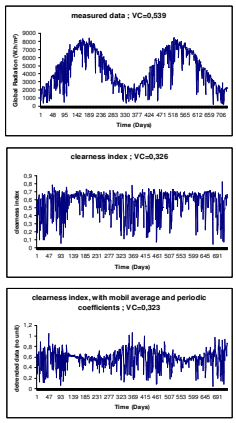


There are two approaches that allow quantifying solar radiation: the "physical modeling" based on physical process occurring in the atmosphere and influencing solar radiation, and the "statistic solar climatology" mainly based on time series analysis

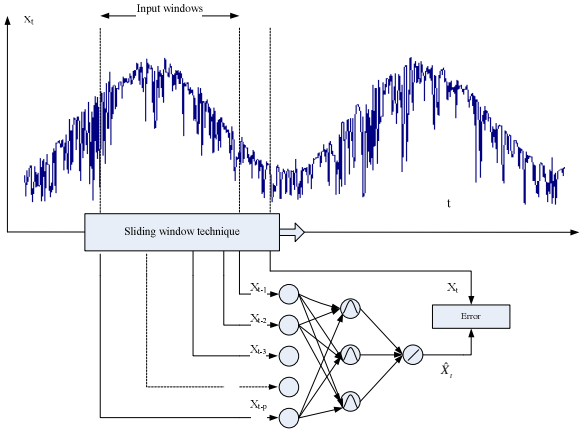
We have chosen to combine these two methods to improve the quality of prediction

We use the extraterrestrial global horizontal irradiance as stationarization setting and a connexionist modeling called Artificial Neural Network (ANN)

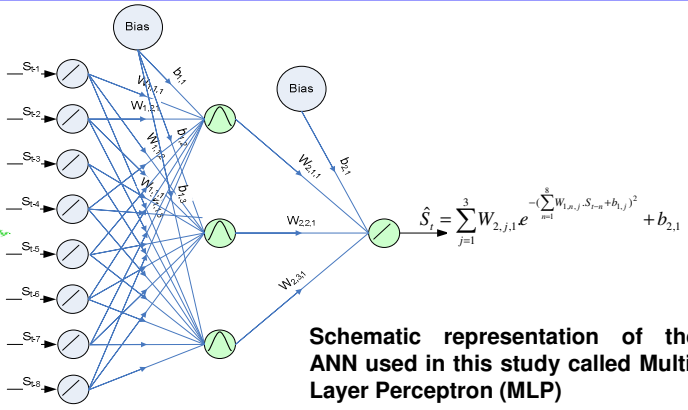




Neural network architecture and design



Detail



$$\hat{S}_t = \sum_{j=1}^{3} W_{2,j,1}\, e^{-\left(\sum_{n=1}^{8} W_{1,n,j}\cdot S_{t-n}+b_{1,j}\right)^2} + b_{2,1}$$

Schematic representation of the ANN used in this study called Multi-Layer Perceptron (MLP)

Application of the relocation for global horizontal radiation

Forecast Location	Techniques of Prediction	RMSE (Wh/m²) NRMSE (%)± IC95	CC
Bastia (year 1996)	Ajaccio (A)	1383 29.19±0,13	0.842
	Bastia (B)	1288 27.51±0,2	0.842
	Persistence (C)	1468 31.4	0.807
Corte (year 2007)	Ajaccio (A)	1213 25.88±0,17	0.887
	Corte (B)	1112 23.73±0,15	0.887
	Persistence (C)	1325 28.3	0.844

Daily D+1

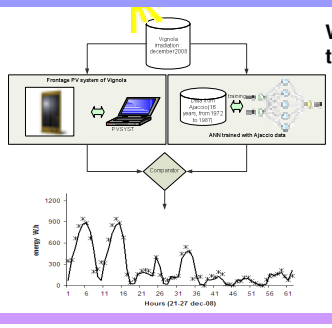
Three models of prediction: in the case A, we use the MLP trained with data from Ajaccio (16 years from 1972 to 1987). In the case B, we use the MLP trained with data from the selected place. We have 5 years of data in Corte (from 2002 to 2006) and also 5 years in Bastia (from 1991 to 1995). And in the case C, we use a "naïve" prediction method based on the persistence.

Hourly H+1

Forecast Location	Techniques of Prediction	RMSE (Wh/m²) NRMSE (%)± IC95	CC
Bastia (year 1996)	Ajaccio (A)	109.3 22.36±0.32	0.916
	Bastia (B)	109.1 22.32±0.32	0.916
	Persistence (C)	138.8 27.22	0.869
Corte (year 2007)	Ajaccio (A)	114.7 23.12±0.6	0.916
	Corte (B)	109.6 22.08±0.32	0.919
	Persistence (C)	135.1 26.50	0.889

Application of the relocation for a tilted PV process (one step prediction)

A frontage PV system has been installed recently in our laboratory (Ajaccio). It has a nominal power of 6.525 kW composed by respectively 1.8 kW and 4.725 kW amorphous and mono-crystal PV modules built in 6 independent power subsystems. PV power hourly predictions from ANN methodology described in this paper have been computed from one of this whole PV plant on a frontage side exposed to the south (azimuth null) and tilted at 80°. The ANN previously designed has been used to predict the energy produced by the PV plant of our laboratory. Its distance is about 10 km from the place where we obtained the data.



We get errors very suitable (nRMSE=27.9%, RMSE=99 Wh) compared to those obtained with the persistence (nRMSE=42.2%, RMSE=149.7 Wh).

Our forecast methodology allows studying sites with no meteorological station. The results show that the hourly horizon is well suited to this relocation. The daily horizon has yet to be studied in order to consider a generalization of the relocation and the versatility of ANN. The results found in this study show "hidden links" between the three sites. The results of the prediction of PV systems show that ANN and delocalized learning may be very useful, but we need to increase and to finalize the comparison between measurement and simulation.