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Photovoltaic production forecast : the significant role of the meteorological satellites

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Soleka RI is co-financed by the European Union and the Regional Council La Reunion
European Regional Development Fund (ERDF), helping to reduce the gap in development between the Community's regions

Background

Accurate surface solar radiation forecasting ensures the lowest cost and the highest security for a massive penetration of photovoltaic power into the electricity network.

For intra-day forecast horizon, future solar irradiance assessment consists in considering two main parameters :

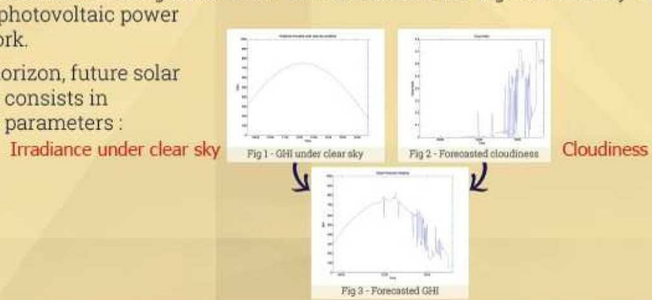


Fig 1 - GHI under clear sky

Fig 2 - Forecasted cloudiness

Fig 3 - Forecasted GHI

Clear sky irradiance can be modelled at any time with a relative high accuracy whereas cloudiness is a stochastic parameter difficult to assess with numerical weather prediction (NWP) models at intraday scale. Geostationary meteorological satellites are the most appropriate observation systems for monitoring cloud coverage every 15 minutes at kilometric spatial resolution. We present an overview of the benefits brought by such instruments to improve the solar irradiance forecast methods at intra-day horizon.

From satellite data to solar energy maps

Since the late 70's, images from visible channel of geostationary meteorological satellites are used to assess solar irradiance at ground level. This information permits to study the surface solar radiation behavior at large-scale with a greater accuracy than data obtained by interpolations of ground measurements. Two main types of satellite-to-irradiance models have been designed. Some examples of models currently used:

Models processing directly raw satellites images as input:

- *SUNY model* (Perez et al., 2002)
- *Heliosat-2 method* (Rigollier et al., 2004)

Models using external satellite-derived cloud products as input:

- *Pinker and Laszlo* (1992) use ISCCP database (Rossow and Schiffer, 1991)
- *SolarGIS* derives a cloud index from SAFNWC (Derrien and Le Gleau, 2005)
- *Heliosat-4* (Qu et al., 2012) uses cloud physical properties from APOLLO (Kriebel et al., 2003)

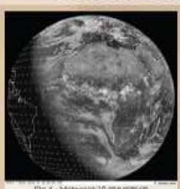


Fig 4 - Meteosat-10 (EUMETSAT)

Fig 5 - Meteosat-7 (EUMETSAT)

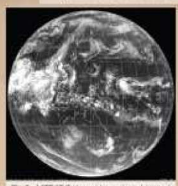
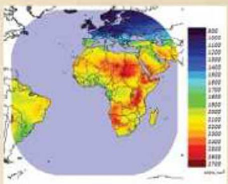


Fig 6 - MTSAT-2 (Japan Meteorological Agency)

Fig 7 - GOES-West (NOAA)

Fig 8 - GOES-East (NOAA)



Yearly Global Irradiation on Horizontal Plane (GHI) for the year 2010
Copyright Transvalor S.A., Produced in March 2011. Source Database HelioClim3v3

Figure 9 - HelioClim (SoDa Service)

Solar radiation databases

Satellite images processing permits to build solar databases offering large geographical coverage with a regular sampling in space (up to 1 kilometer) and time (up to 15 minutes). Global horizontal irradiation (GHI) and derived values can be found on line under the form of typical meteorological years or time-series originates from 1980. Such datasets support the design of solar atlases at a finer scale and help the calibration of GHI ground measurements.

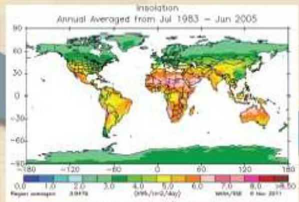


Figure 10 - NASA SMSE

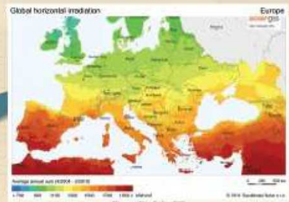


Figure 11 - SolarGIS

Cloud cover forecast

The analysis of consecutive satellite images allows the detection of cloud motion and then, the extrapolation of future cloud cover structure.

This method can forecast surface solar irradiance up to 6 hours ahead with a better accuracy than NWP models.

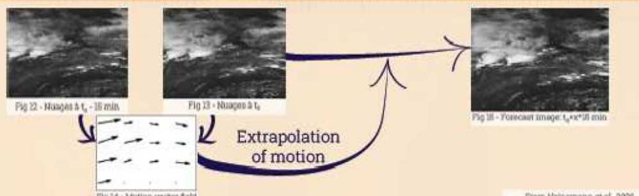


Fig 12 - Nuages à t_0 - 15 min

Fig 13 - Nuages à t_0

Fig 14 - Motion vector field

Fig 15 - Forecast image: t_0+x*15 min

From Heinemann et al. 2006

Conclusions

Earth observation from space provides an important added value for short-term solar energy forecasting by :

- Providing long-term observational datasets at global scale with fine and regular space-time sampling
- Predicting cloud cover evolution at meso-scale with better results than NWP models

Further improvements rely on :

- Refining satellite data processing algorithms
- Combining observations with additional data, model output statistics or NWP
- Benefiting of instruments enhancement (e.g. Meteosat Third Generation)

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