Ensemble forecast of solar radiation for EDF photovoltaic power generation

PhD Position at EDF R&D and INRIA

July 2013

1 Context and objectives

The variations in photovoltaic power generation essentially depend on downward solar radiation, and therefore of cloud cover. Operational forecasting of EDF photovoltaic production is currently based on meteorological forecasts of solar radiation (using simulations from Météo France or ECMWF) within the day and up to 14 days ahead. These forecasts are strongly limited by the high uncertainties of weather forecasts, especially at local scale. There is a crucial need for improvements of these forecasts. In addition, the uncertainty of these forecasts needs to be better estimated, since this information is almost as valuable as the forecasts themselves.

The ambitious objective of the PhD position is to build a forecasting system for solar radiation, in order to anticipate the photovoltaic power generation within the next 6 h–48 h and for the whole EDF generation pool. The envisioned method is to rely on ensembles of meteorological forecasts, as computed by WRF within the forecasting system or by a meteorological center. The ensemble of forecasts will be combined in order to (1) generate better solar-radiation forecasts at all production sites, (2) quantify the uncertainties of the forecasts. The results will be evaluated against point observations (e.g., from SIRTA, France) and satellite data (Heliosat). In the end, a prototype for an operational forecasting system will be tested for at least France and probably Europe, with fine resolution.

This work will rely on numerical simulations from meteorological models and on statistical methods. The leading strategy is to optimally combine of all information sources:

- several meteorological forecasts, from numerical models, which provide a variety of spatial distributions and time evolutions;

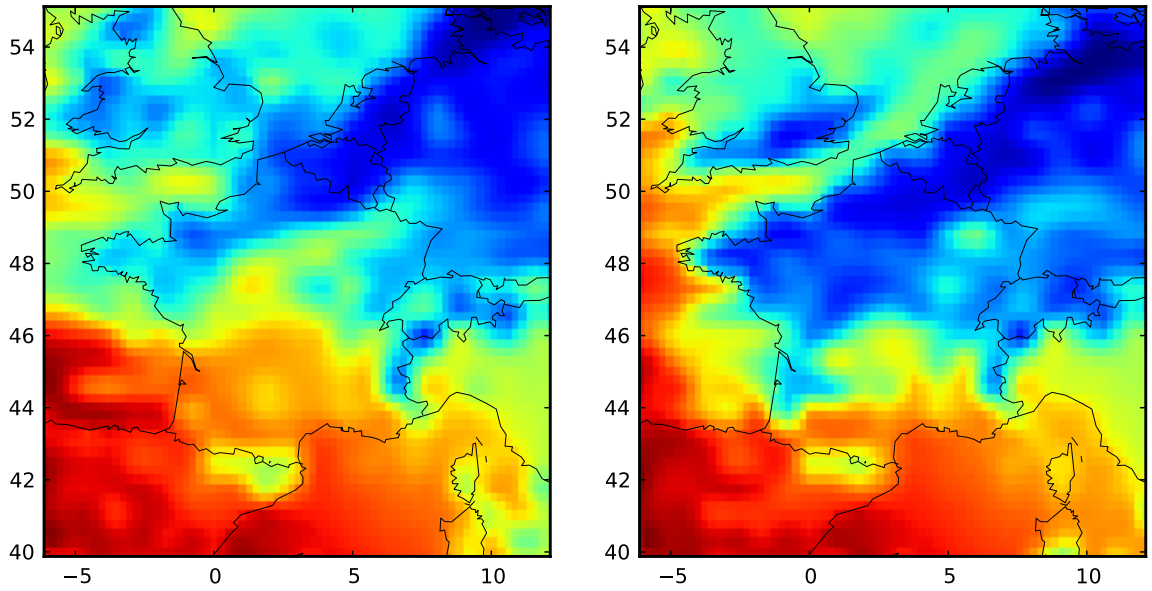

Figure 1: Solar radiation as computed by two ECMWF ensemble members, for a given date. The forecasts can show fairly different patterns.

- past observations available at the production sites;
- satellite data, to be assimilated, that can cover the whole target region.

2 Outline

The actual tasks of the PhD student will evolve as the difficulties and key issues are identified. However, one may anticipate the following tasks.

Ensemble simulations The performance of current meteorological models will be evaluated, using point observations and satellite observations of solar radiation. In particular, the data from AROME and ARPEGE (Météo France), ECMWF, NCEP and WRF (simulations to be carried out by the PhD student) will be studied. These models or associated ensembles can compute fairly different forecasts, as shown in Figure 1.

Ensemble aggregation Aggregation consists in combining an ensemble of forecasts in order to produce an improved forecast. Efficient methods, originating from supervised machine learning, have been applied with success for other environmental applications, but there is a need for further developments: (1) aggregation of spatial fields so as to maintain certain patterns in the solar radiation fields, (2) local aggregations, maybe in link with downscaling techniques, (3) optimal use of all observations, especially satellite observations which should be assimilated in the process. The objective is to take

advantage of the ensemble of simulations and the past observations in order to produce improved, robust and local forecasts.

Uncertainty quantification The uncertainty on the forecasts will be quantified using methods compatible with operational constraints. There are currently no methods that can produce at the same time robust forecasts and their uncertainties. This is however a crucial objective for an operational forecasting system of photovoltaic power generation. This issue is consequently an important question from both the theoretical and practical point of views.

3 Hosting team

The hosting laboratory is the Teaching and Research Center in Atmospheric Environment, CEREA. CEREA has expertise in physical modeling of atmospheric radiations (with models explicitly solving the radiative transfer equation), in the use of meteorological models at mesoscale, and in the development of ensemble methods to forecast tropospheric ozone and meteorological variables. In addition, the team develops software that is used by several operational organizations: data assimilation library Verdandi, local-scale meteorological model with Code_Saturne, air quality modeling system Polyphemus.

EDF is the main French electricity supplier, and is one of the world's leading electric utilities. EDF invests in renewable energies. Its branch EDF Energies Nouvelles gives priority to the development of wind energy and solar photovoltaics.

INRIA, the French national institute for research in computer science and control, operating under the dual authority of the Ministry of Research and the Ministry of Industry, is dedicated to fundamental and applied research in information and communication science and technology. The Institute also plays a major role in technology transfer by fostering training through research, diffusion of scientific and technical information, development, as well as providing expert advice and participating in international programs.

4 Further information and contact

Starting date: October 2013 (negotiable)
Duration: 3 years
Net pay: at least 1800 euros per month, possibly higher, depending on education background
Location:

- INRIA Paris-Rocquencourt (in Rocquencourt, close to Versailles, also accessible from Paris), in the project-team CLIME
- EDF R&D, in Chatou

Supervision: Vivien Mallet (INRIA), Maya Milliez (EDF R&D), Luc Musson-Genon (EDF R&D)
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