Analog nowcasting of solar irradiance from satellite images

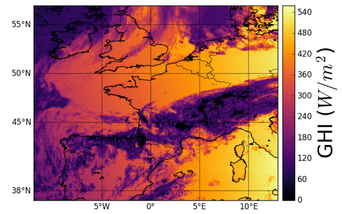
Alex Ayet[1,2] and Pierre Tandeo[3]

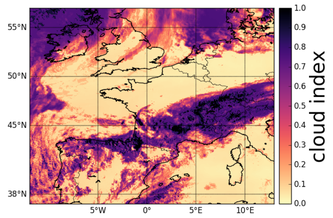
[1] Elum Energy, Paris [2] Département de physique, École Normale Supérieure, Paris
[3] Institut Mines-Télécom Atlantique, UMR 6285 LabSTICC, Université Bretagne Loire, Brest

Introduction

We implement a novel data-driven model for the nowcasting (up to 6h) of solar Global Horizontal Irradiance (GHI) at a particular location. We use 5 years of images from the EUMETSAT geostationary satellite, with a resolution of 1h and 0.5°. The physical model is emulated using a k-nearest neighbors algorithm on the satellite database (analogs), containing both the images to be compared to the current meteorological conditions and their successors at one hour of interval to produce a weighted ensemble of forecasts. This method requires no post processing, unlike Lagrangian methods, and tuning, unlike physical models, since the physics of the system is contained in the analogs database and in the chosen metric for the k-nearest neighbors algorithm [1,2]. It is also computationally efficient and suited for operational forecast. It is tested at the locations of European in-situ GHI measurement stations of the Baseline Surface Radiation Network.

Cloud Index





The cloud index c is defined as

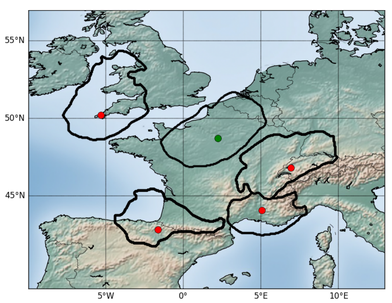
$$c(x,y,t) = \left[1 - \frac{\mathrm{GHI}(x,y,t)}{\mathrm{cs}(x,y,t)}\right]$$

where

$$\mathrm{cs}(x,y,t) = \max_{t' \in \mathbb{S}(t)} \mathrm{GHI}(x,y,t')$$

is the clear sky, with $\mathbb{S}(t)$ a 3-month interval around t with fixed hour.

Correlation mask



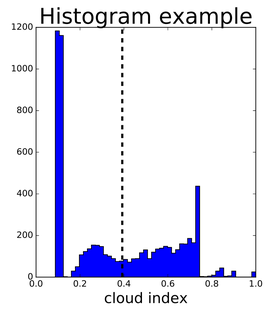
For a given site (x_s, y_s) , we consider only the region where

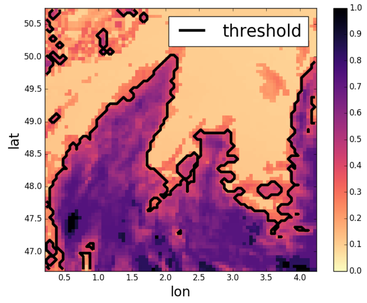
$$\frac{\overline{c(x_s,y_s,t)c(x,y,t)}}{\left(\overline{c(x_s,y_s,t)^2} \times \overline{c(x,y,t)^2}\right)^{1/2}}$$

is strong. The averages are temporal within a 3-month interval.

Features

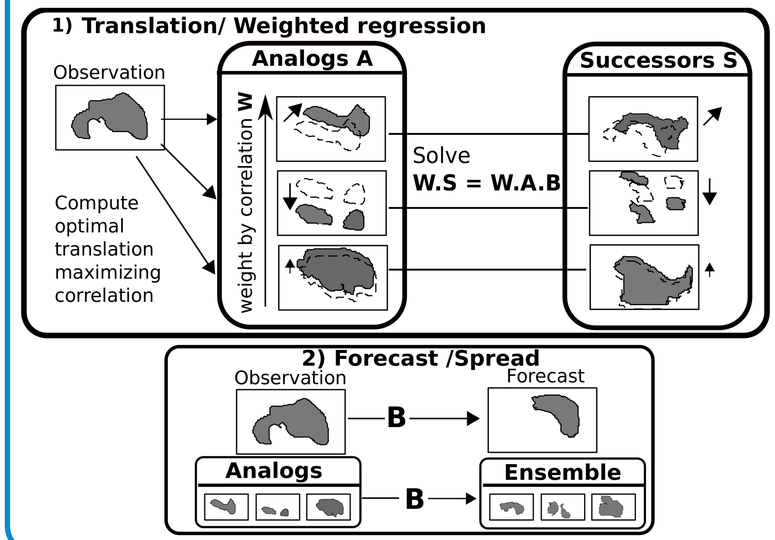
We use a **two modes Gaussian mixture model** to get a threshold.



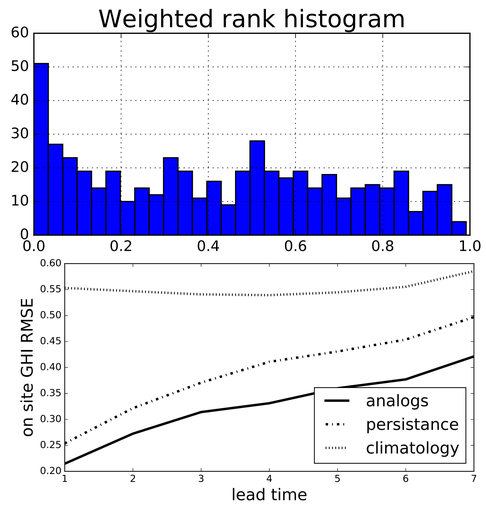


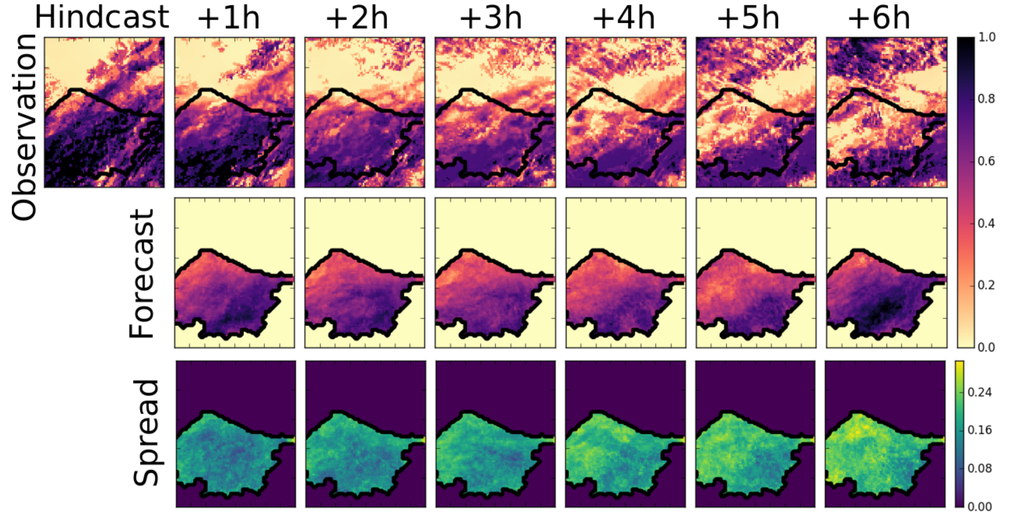
The considered features for the analogs are:
- the **cloud fraction**: pixels where c is over the threshold
- the **cloud spread**: cloud area over cloud convex hull area
- the **clear sky** and **cloud mean intensity**

Forecast procedure



Results





References

[1] A. Atencia and I. Zawadzki. A comparison of two techniques for generating nowcasting ensembles. part ii: Analogs selection and comparison of techniques. *Mon. Weather Rev.*, 143(7):2890–2908, 2015.

[2] L. Panziera, U. Germann, M. Gabella, and P. V. Mandapaka. Nora – nowcasting of orographic rainfall by means of analogues. *Q. J. R. Meteorol. Soc.*, 137(661):2106–2123, 2011.