nowcRadiation seamless-nowcasting solar radiation using satellite and high resolution numerical model output

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Mauri Martínez Sánchez
Alfons Callado Pallarès

AEMet-γSREPS Predictability Group

RED ELÉCTRICA DE ESPAÑA

ENC 2019 European Nowcasting Conference

GOBIERNO DE ESPAÑA
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA
AEMet Agencia Estatal de Meteorología

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nowcRadiation

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Introduction

What is nowcRadiation?

nowcRadiation is a project developed by AEMet (the Spanish Meteorological Agency) for the Spanish transmission system operator, Red Eléctrica de España, to improve hourly Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI) forecasts in Spanish solar power plants.

Red Eléctrica de España (REE) was interested in use the sofware package of SAFNWC/MSG to forecast the dependence on clouds of Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI) in solar plants.

What is nowcRadiation?

It is an interdepartamental project:

1. The former *Innovation Area* of *the Development and Applications Department*
2. *Satellite Application Facility for support to Nowcasting (SAFNWC)*
   nowcRadiation uses some products from Meteosat Second Generation (MSG)
3. Numerical Weather Prediction Section output of HARMONIE-AROME model.
4. AEMet Radiometric Network Observations of Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI) stations of AEMet network.
5. Systems Tecnical suport of software and hardware

Aim project

The project's target was to design, validate and make operational a tool that every fifteen/thirty minutes provides a four-hour forecast of Direct Normal and Global Horizontal Irradiances, with a time resolution of fifteen minutes. It uses information from the satellite based on SAF's products (Satellite Aplication Facilities, EUMESAT) and forecasting from the model HARMONIE-AROME

SAF $\rightarrow$ EXIM	Distribución SAF + HARMONIE-AROME	HARMONIE-AROME
1ª hora	2ª y 3ª hora	4ª hora

During the first hour of forecast the software uses satellite data (SAF de Nowcasting), data from the NWP model HARMONIE-AROME are utilized from four hours on, both forecast are employed following a transition function in intervening hours.

Satellite Products

Cloud Type (CT): provide a detailed cloud analysis [1]

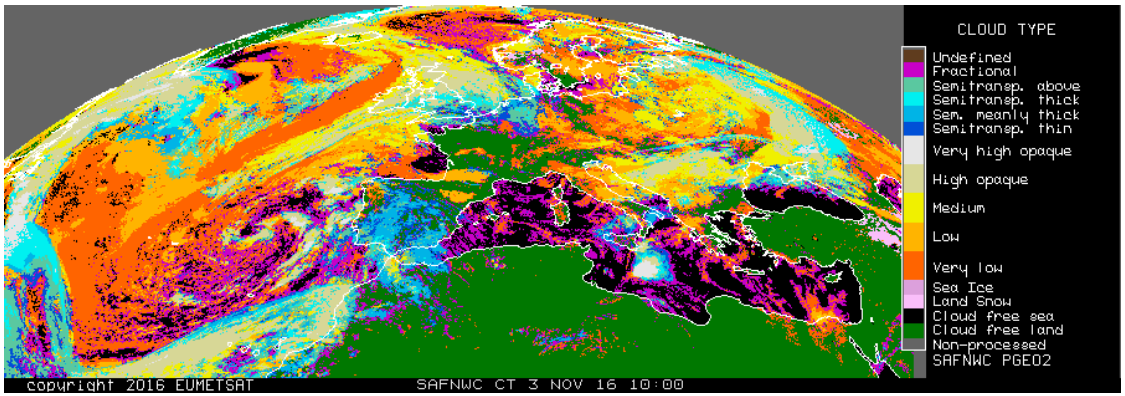


Figure 1: Cloud Type (CT)

Satellite Products

Extrapolated Imagery (EXIM) [2] applies kinematic extrapolation using motion vectors (AMWs) for displacing SEVIRI pixels of selected NWCSAF products.

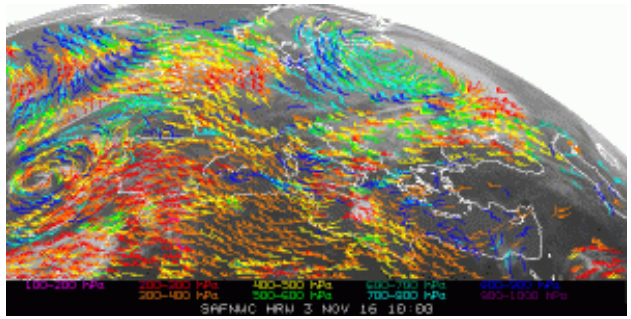
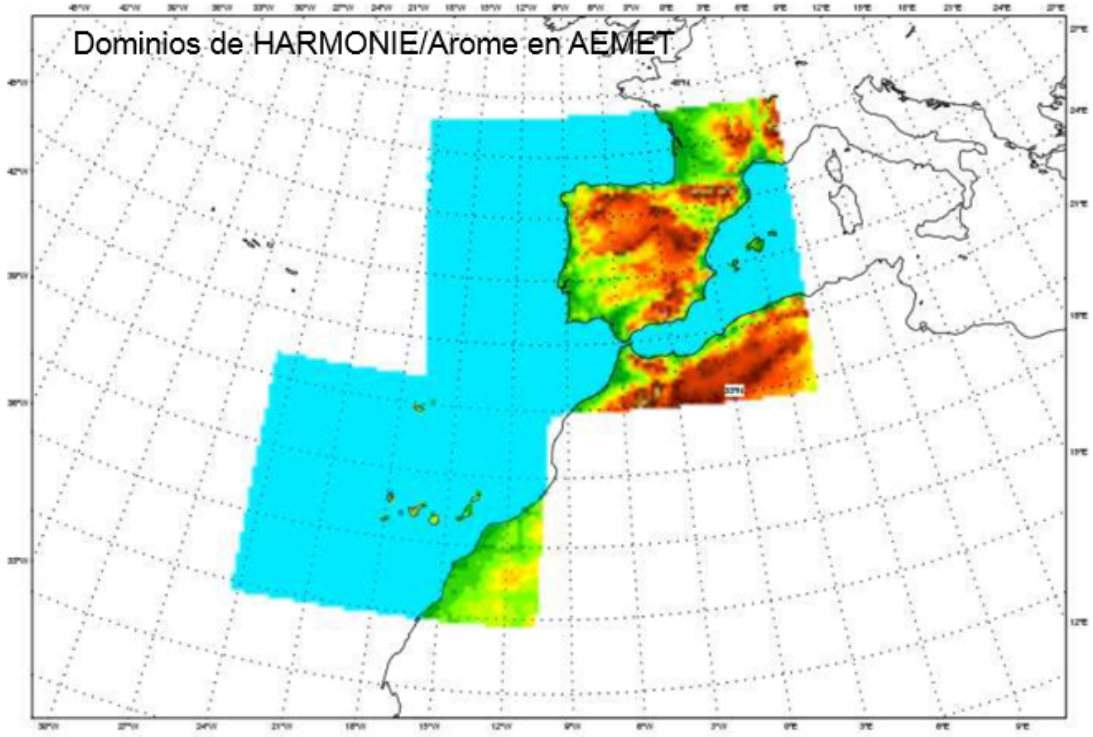


Figure 2: High Resolution Winds (HRW) [3]

HARMONIE-AROME v40h1.1

- 2.5 km
- integrated 8 times per day
- forecast lenght 48 hours
- 2 geographical domains (Iberian Penisula and Canary Island)



Transition Function

The seamless vision for forecasting

We are entering a new era in technological innovation and in use and integration of different sources of information for the wellbeing of society M. Jarraud WMO (2015)

Transition Function GHI

Range of expected values:

- Satellite cloudly areas and midlatitudes: 15 - 30% [4]
- Mesoscale Models 24-hour forecast: 10 - 50% [5]

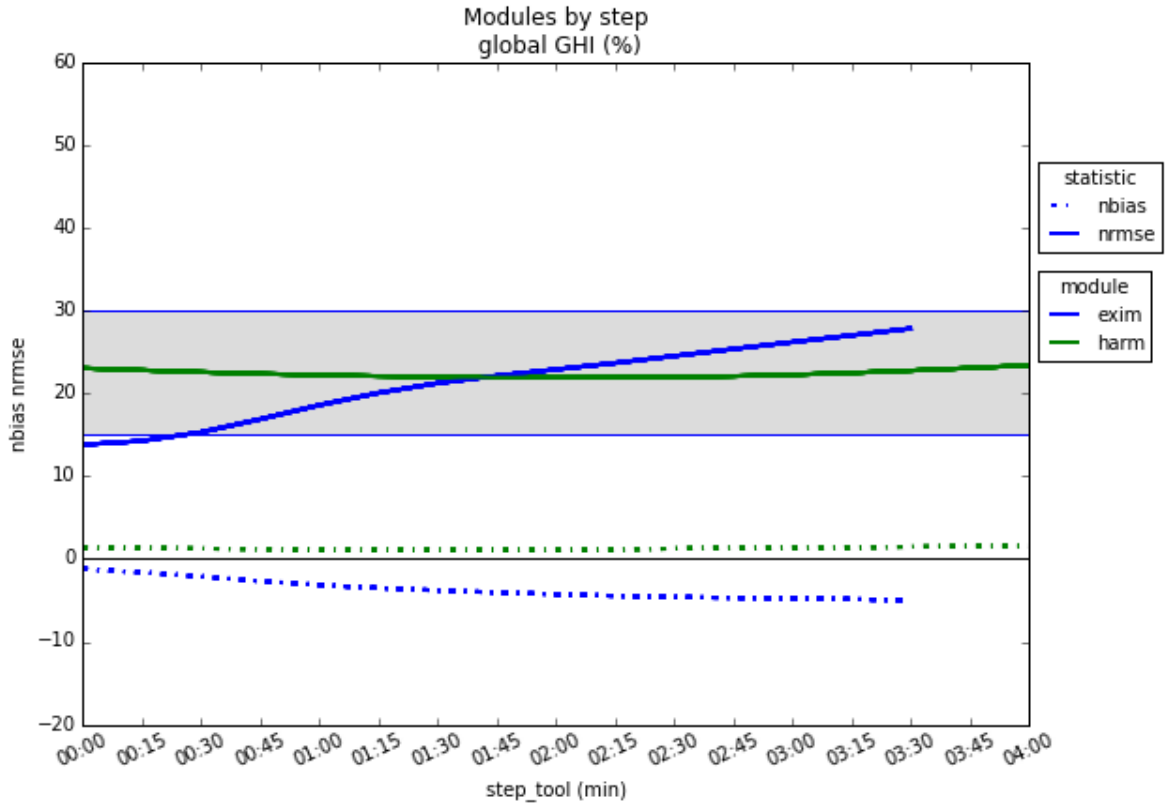


Figure 3: Graphic representation of hourly accumulated foreast nRMSE and nBIAS errors from satellite module (blue line) and NWP-model (green line)

Transition Function DNI

Range of expected values:

- Satellite cloudly areas and midlatitudes: 25 - 45% [4]
- Mesoscale Models 24-hour forecast: 30 - 100% [5]

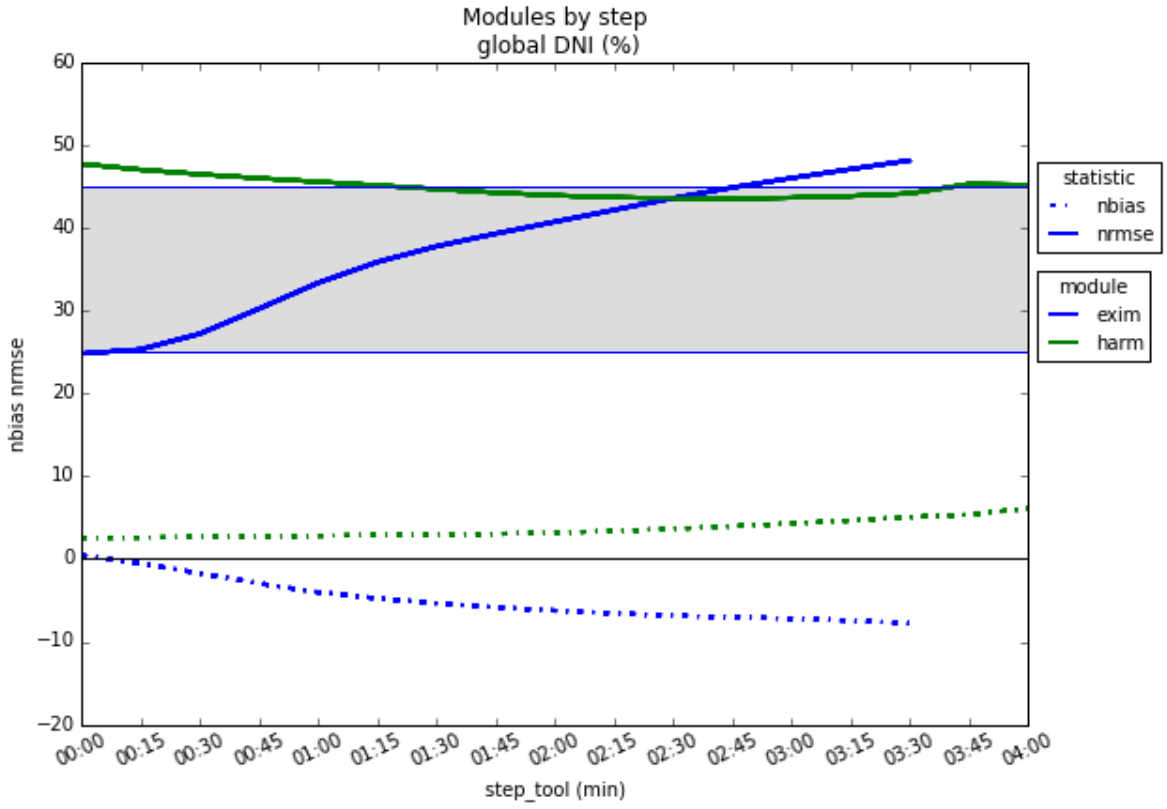


Figure 4: Graphic representation of hourly accumulated foreast nRMSE and nBIAS errors from satellite module (blue line) and NWP-model (green line)

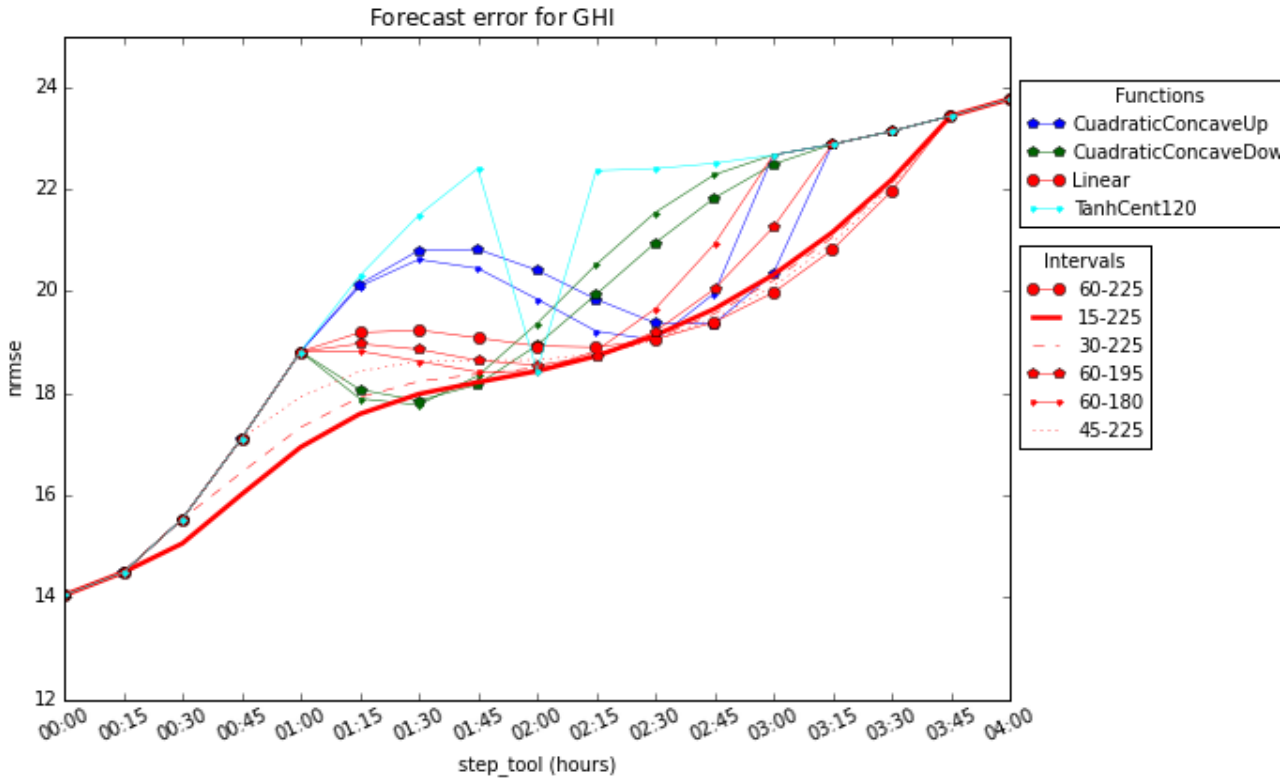
Data Set

- Semi-operationtal conditions
- Spatial locations: Arenosillo, Badajoz, Córdoba, Lleida, Madrid, Murcia, Santander, Tenerife y Palma de Mallorca
- Time Frame:
  - 1st December 2016 - 15th June 2017 Peninsula and Baleares
  - 1st February 2017 - 15th June 2017 Tenerife
- Radiation values filtered for solar height larger than 8º

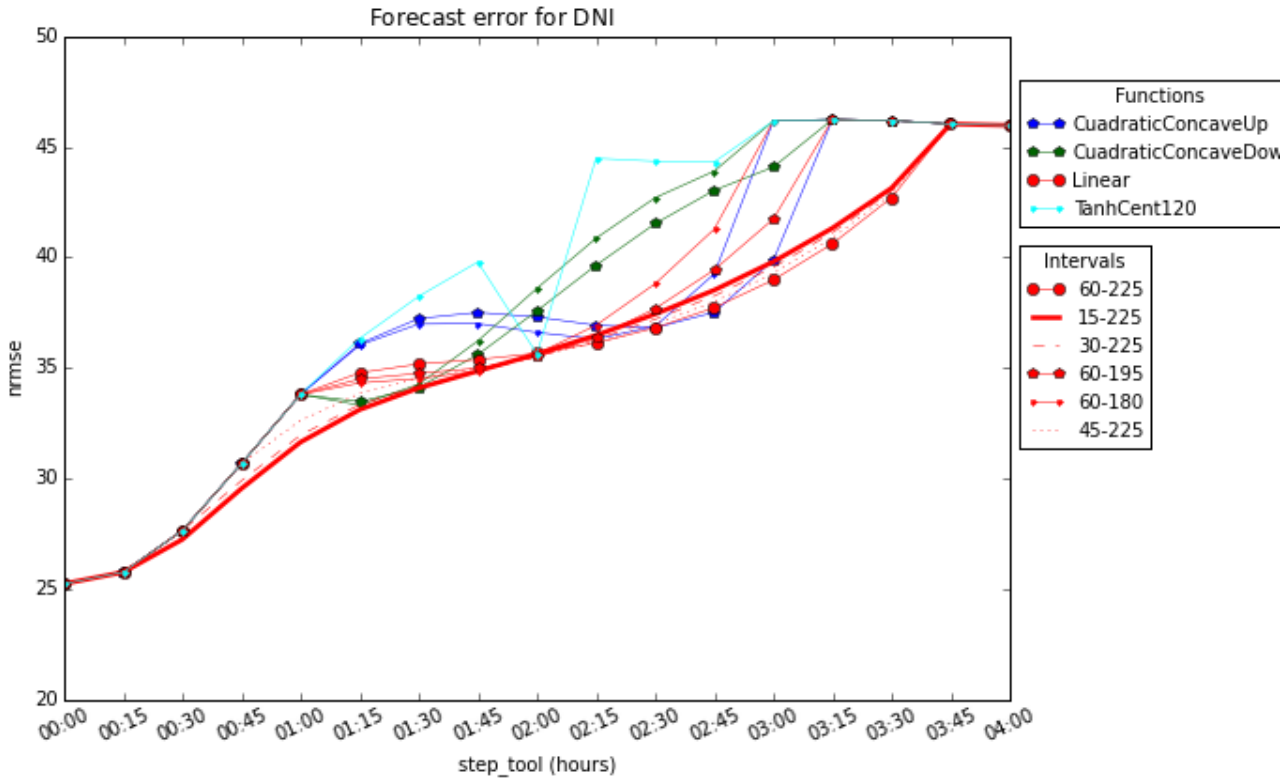
4 type of functions:

1. linear
2. quadratic function concave up and down.
3. hyperbolic tangent centered on 120 minutes lead time

Representation of studied functions GHI

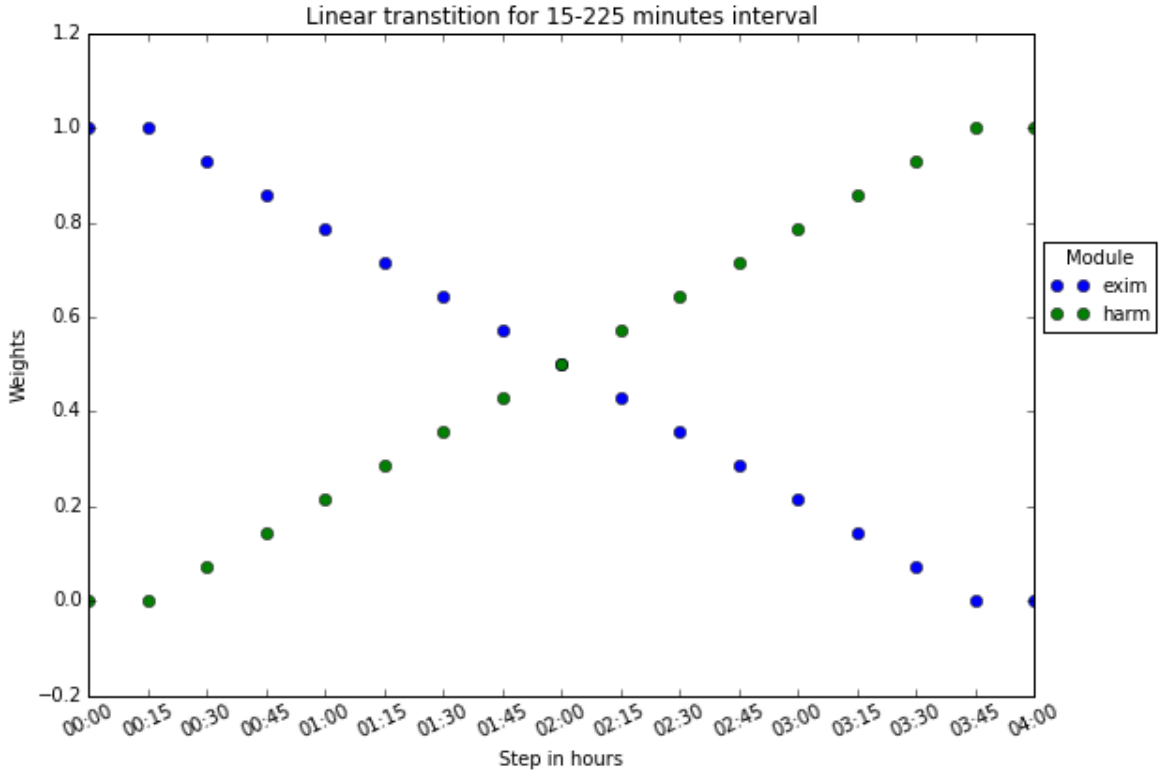


Representation of studied function DNI

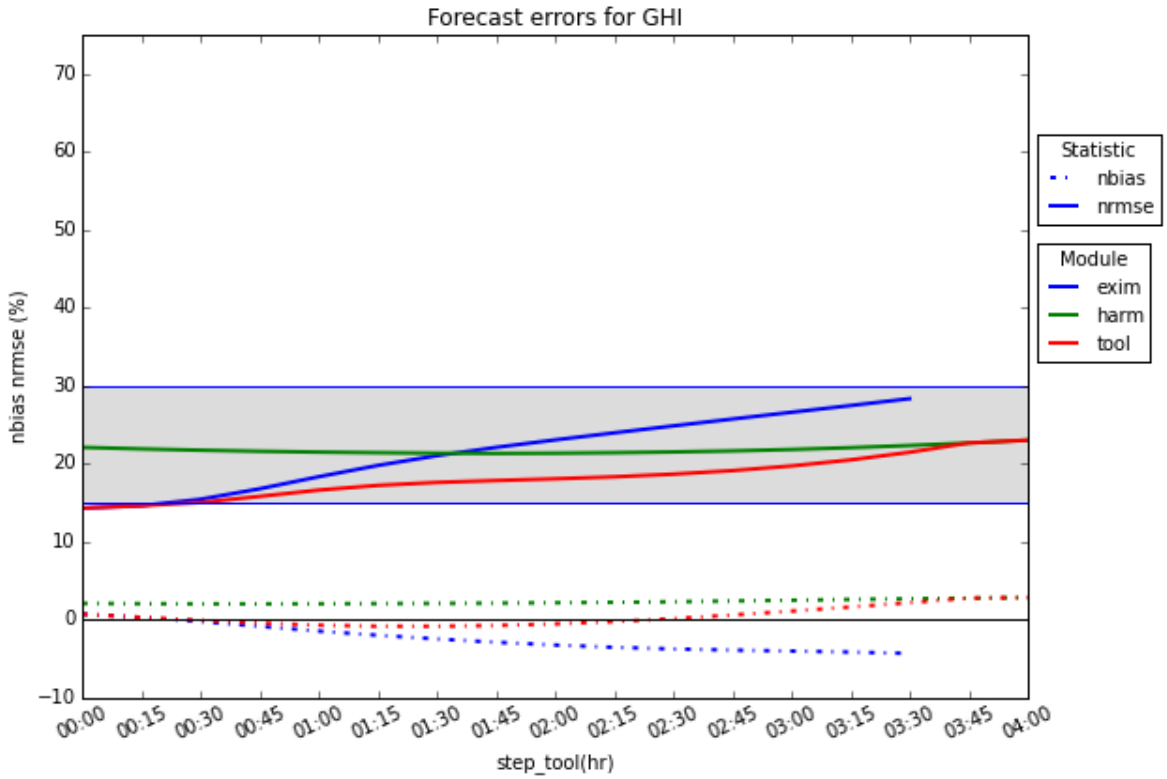


nowcRadiation - the transition function

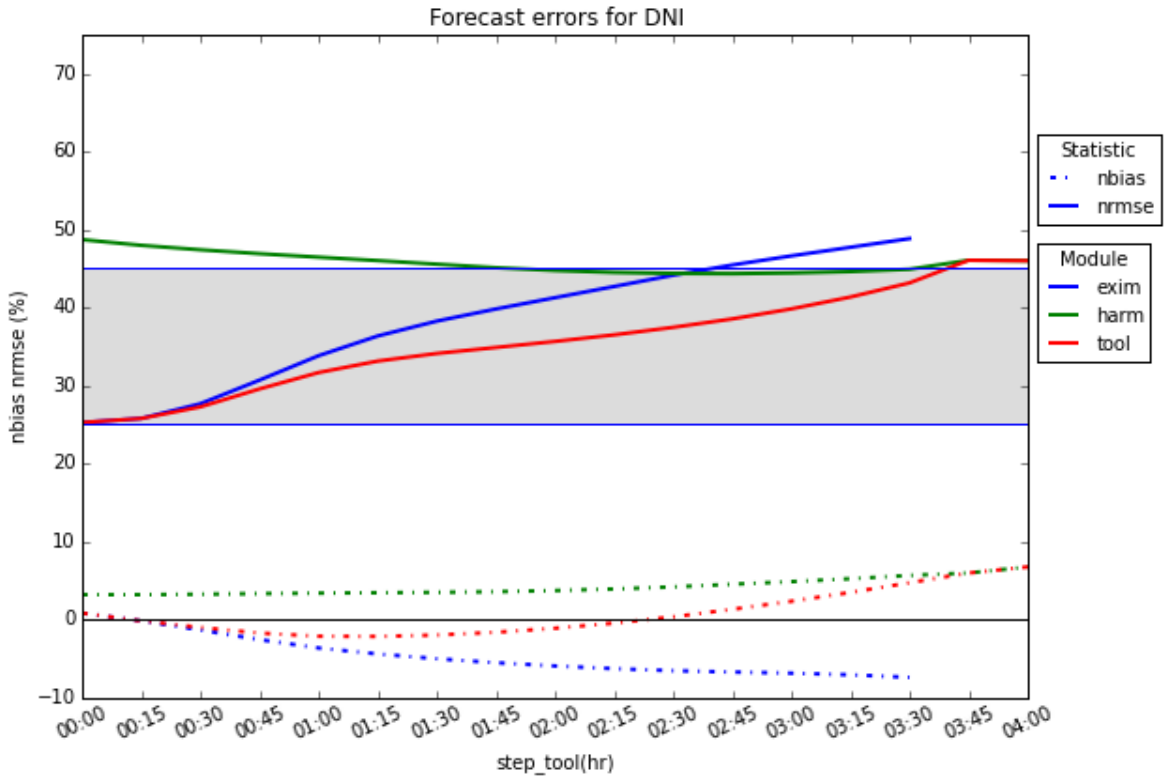
$$\text{Rad_forecast}_{\text{step}} = \text{weight_exim}_{\text{step}} \times \text{Rad_exim}_{\text{step}} + \text{weight_harm}_{\text{step}} \times \text{Rad_harm}_{\text{step}}$$



Linear function applied between lead times 15' - 225' GHI



Linear function applied between lead times 15' - 225' DNI

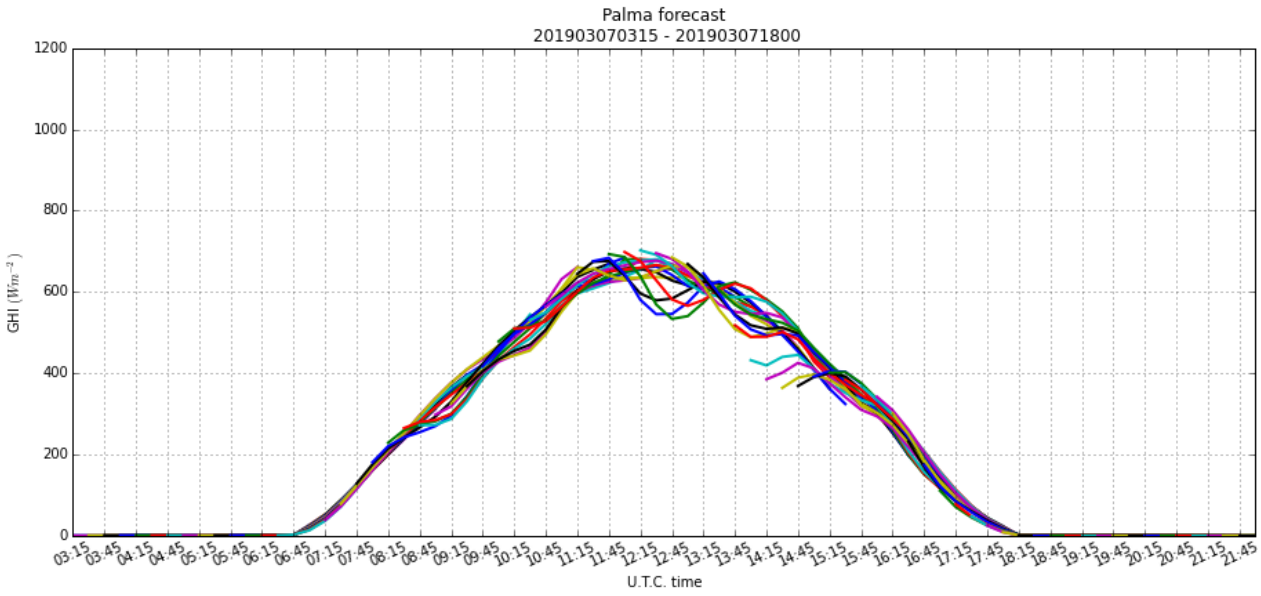


nowcRadiation

nowcRadiation

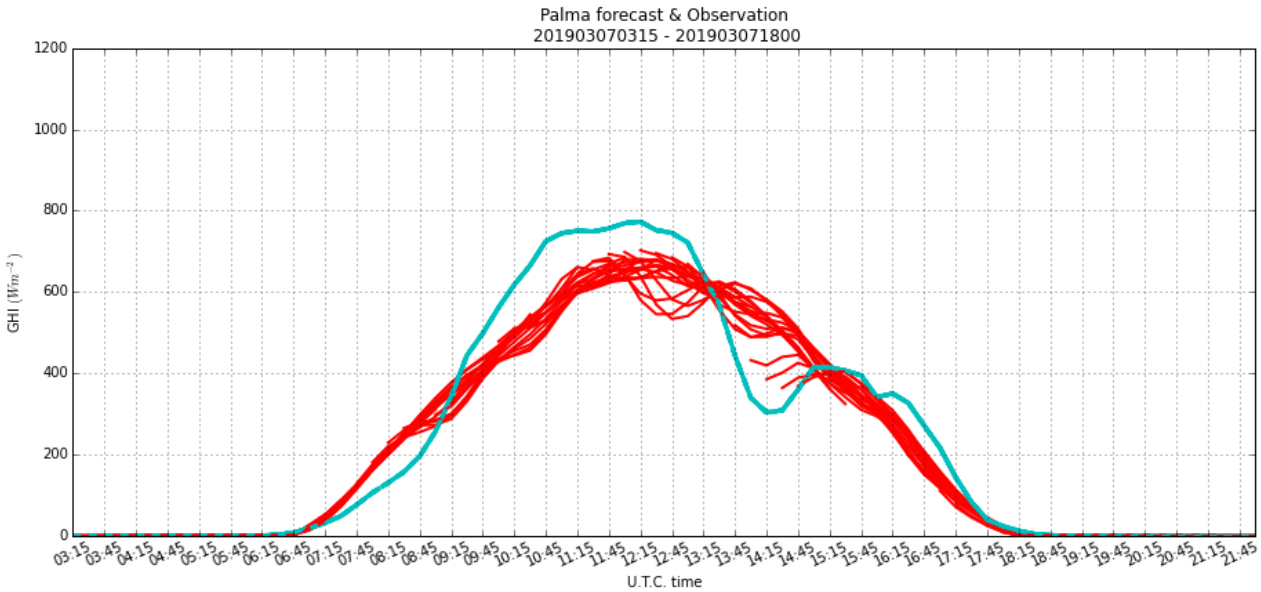
AEMet nowcRadiation software is integrated every fifteen minutes and provides a four-hour forecast of hourly accumulated Normal Direct and Global Horizontal Irradiances with lead times of fifteen minutes.

nowcRadiation forecast GHI

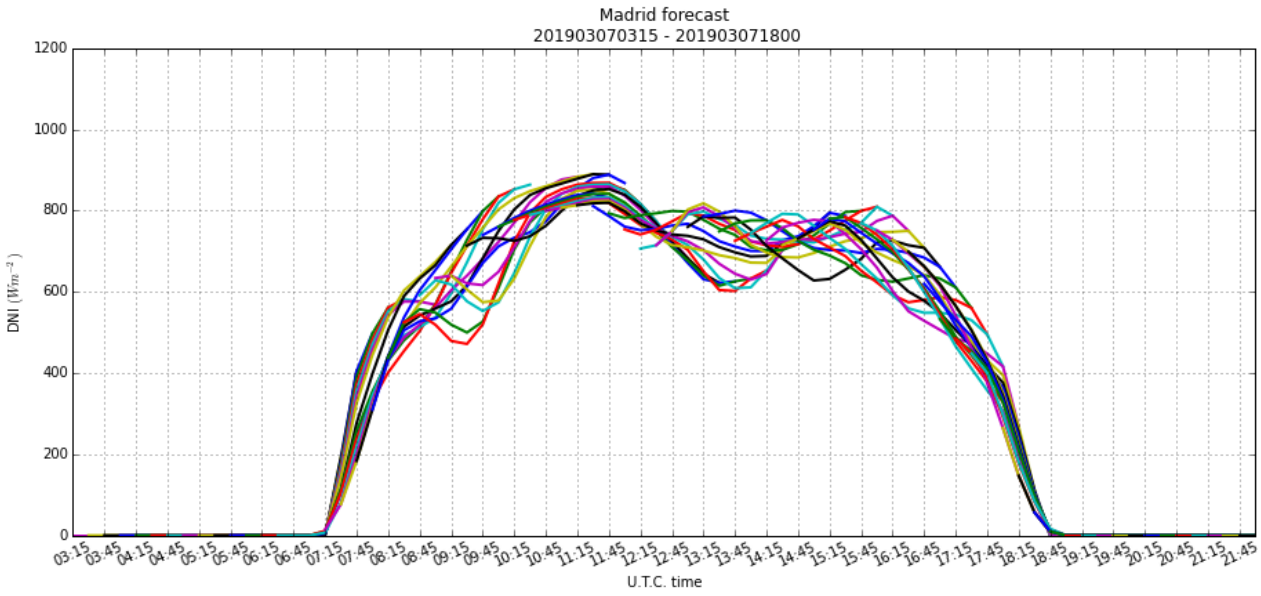


nowcRadiation forecast and observation GHI

Small lead times track clouds!

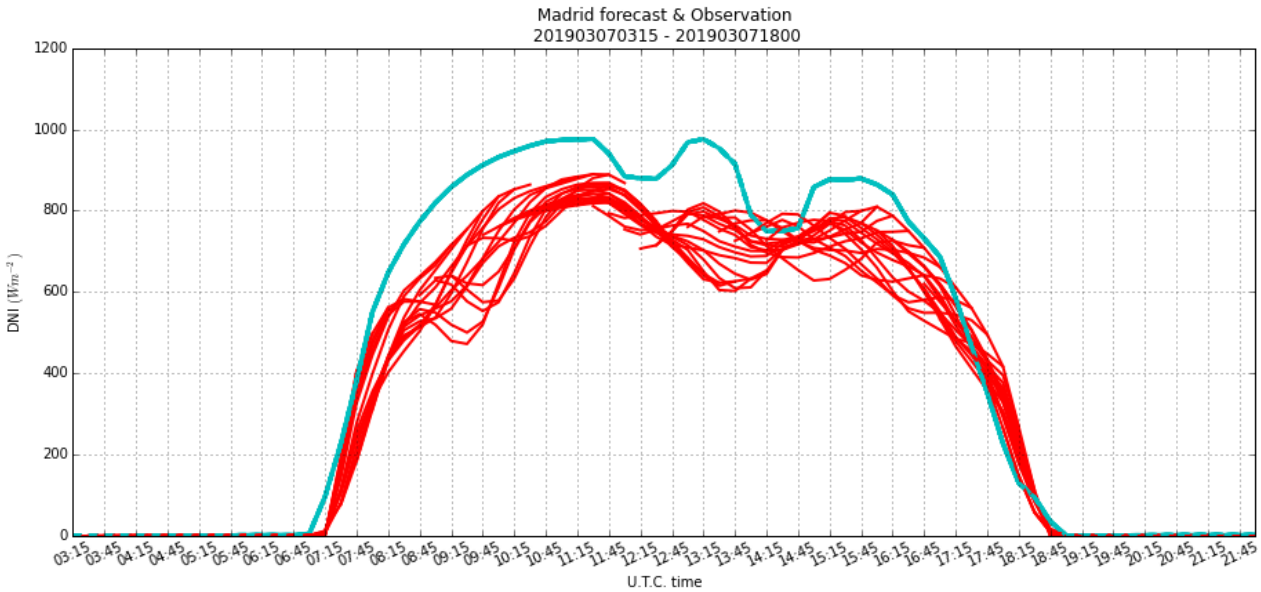


nowcRadiation forecast DNI



nowcRadiation forecast and observation DNI

Small lead times track clouds!



REE

- Fifteen minutes output
- Available since 1st June 2018
- 45 spatial locations
- lead times each hour

Seasonal behaviour

Data Set

- Operating conditions
- Locations : Arenosillo, Badajoz, Canarias (Maspalomas), Córdoba, Lleida, Madrid, Murcia, Santander, Tenerife, y Palma de Mallorca
- Time Frame: 3rd June 2018 - 8th April 2019
- Radiation filtered values for solar heigh larger than 8^{o}
- Radiation filtered values between 0 and 1270 W/m^2

Seasonal behaviour

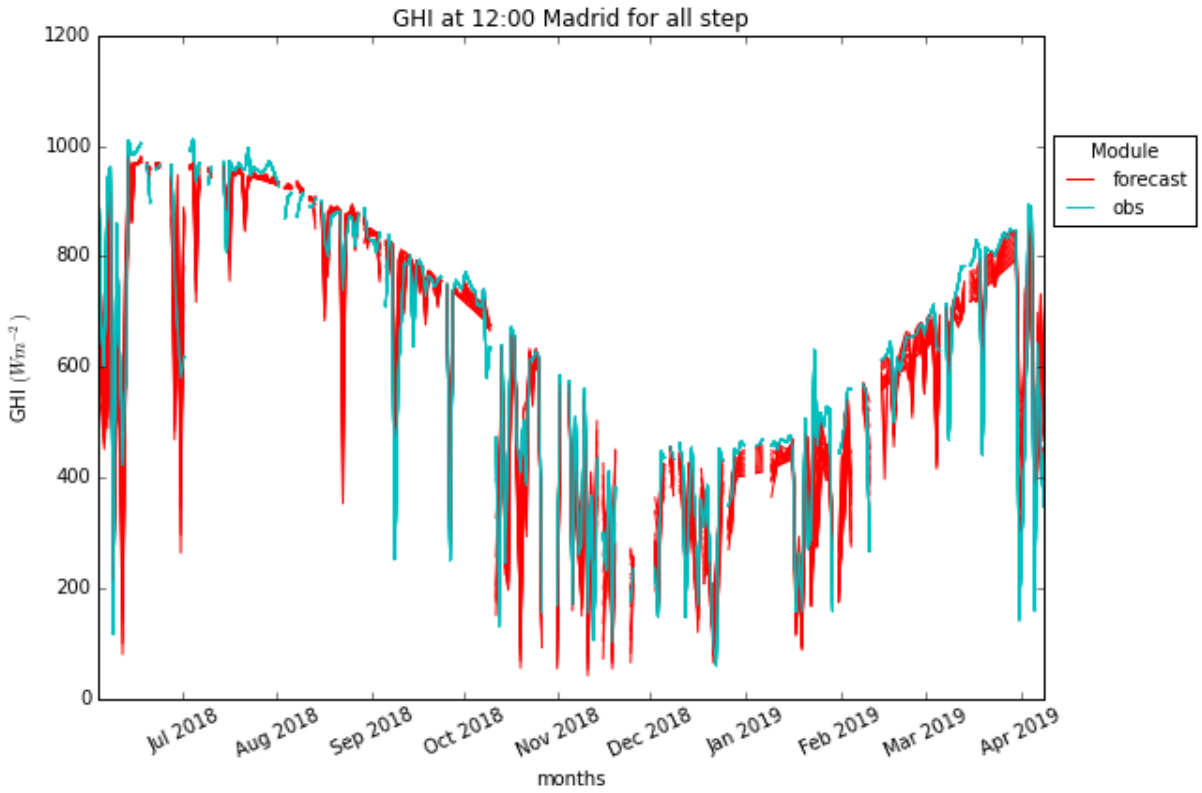


Figure 5: Seasonal behaviour of GHI at 12:00 UTC for all steps

normalized monthly errors GHI

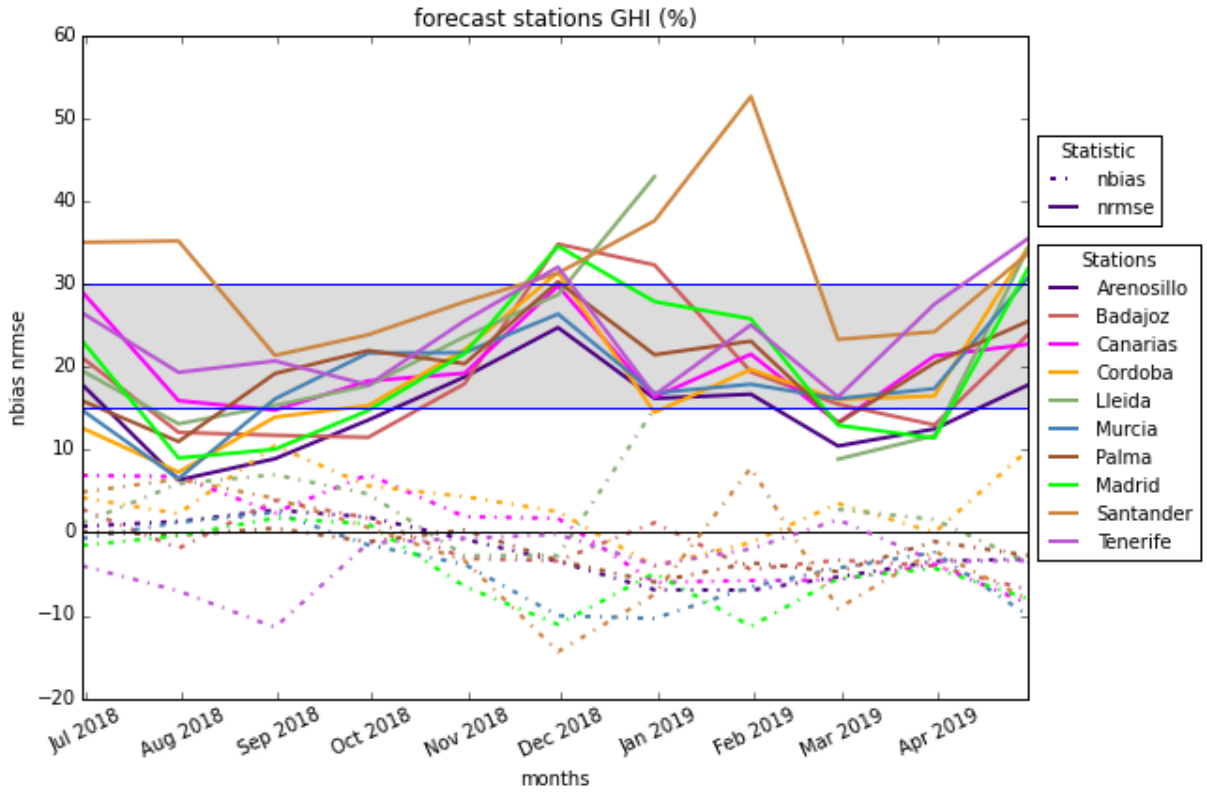


Figure 6: nrmse and nbias by month GHI

Seasonal behaviour

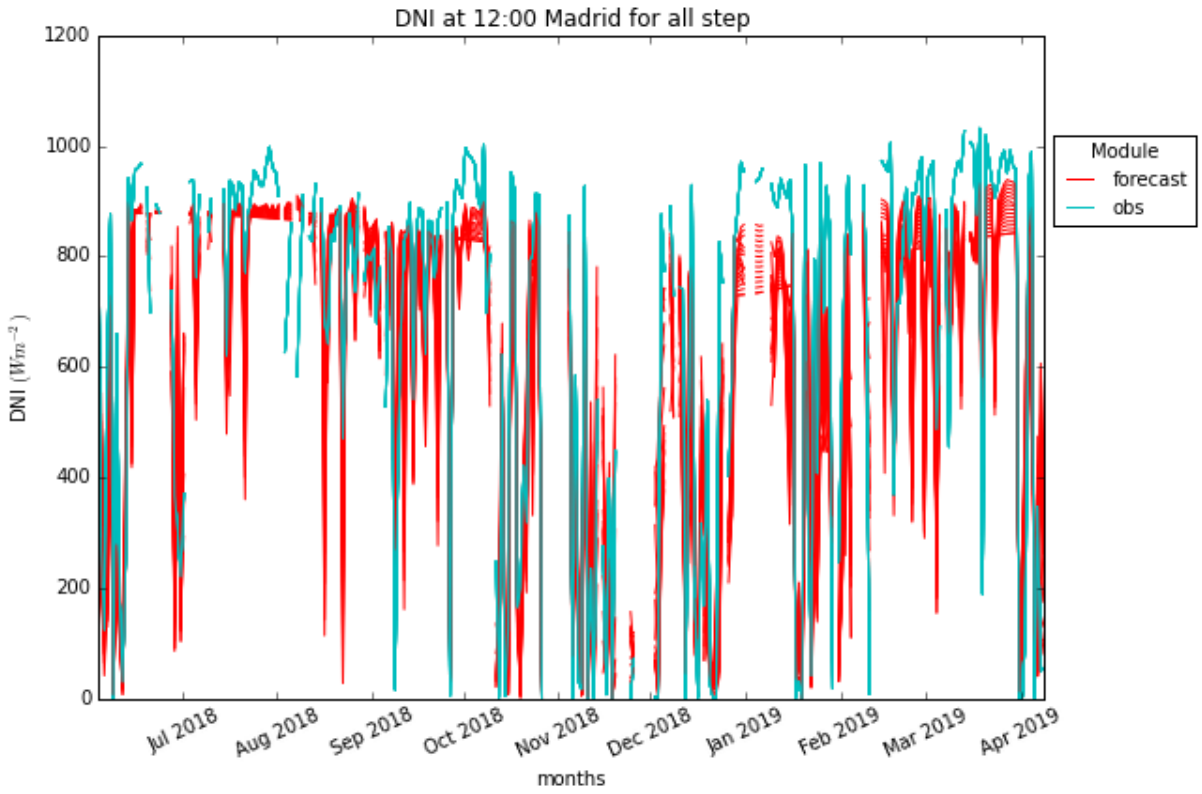


Figure 7: Seasonal behaviour of DNI at 12:00 UTC for all steps

normalized monthly errors DNI

Mesoscale Models 24-hour forecast: 30 - 100% [5]

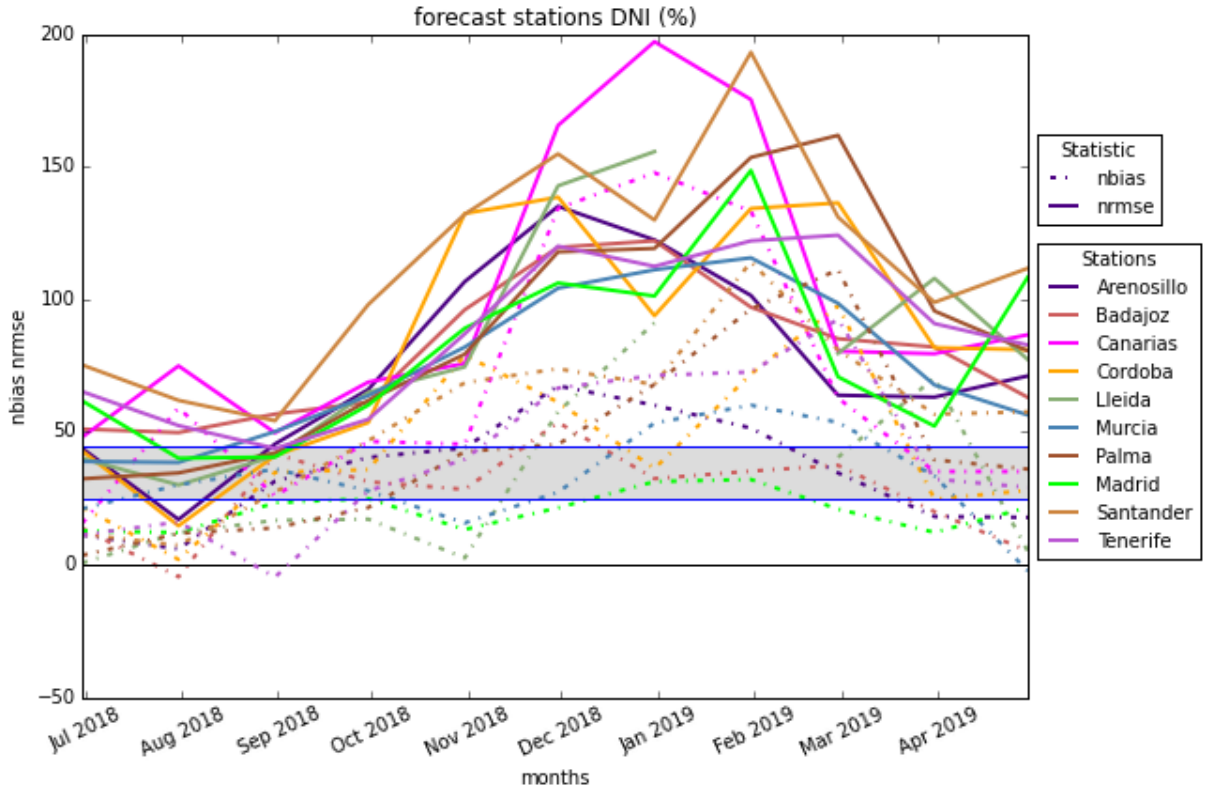


Figure 8: nrmse and nbias by month DNI

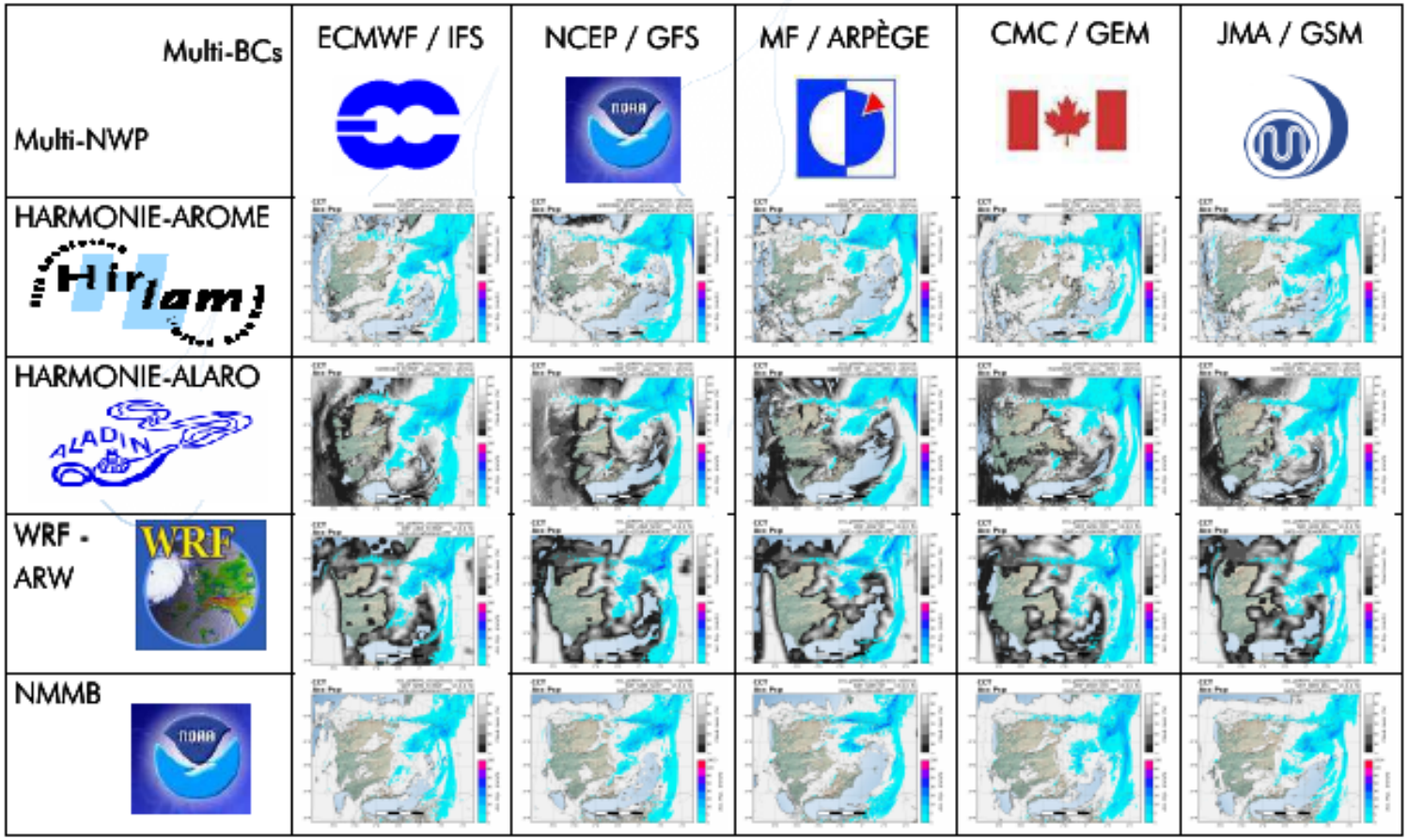
Further information

Information about → nowcRadiation

- *Predicción inmediata y a muy corto plazo de la radiación solar a partir de datos de satélite y modelos numéricos*
  Rodríguez-Martínez, A. Martínez-Sánchez, M.
  http://www.iic.uam.es/energias/prediccion-radiacion-solar-corto-plazo/
- *EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017* (04-07 Septiembre 2017) Dublin, Ireland *European Conference for Applied Meteorology and Climatology. Sesion Operational Systems and Applications - Energy Meteorolgy*
  Abstract: https://meetingorganizer.copernicus.org/EMS2017/EMS2017-128.pdf
  Poster: https://presentations.copernicus.org/EMS2017-128_presentation.pdf
- *40th EWGLAM & 25th SRNWP Meetings (2018)*
  Poster: https://repositorio.aemet.es/handle/20.500.11765/9842
- *6 Simposio Nacional de Predicción Memorial Antonio Mestre*
  Presentation: https://repositorio.aemet.es/handle/20.500.11765/10349

Future Work

AEMet-γSREPS characteristics



AEMet-γSREPS characteristics

- 2.5 km 20-member convection-permitting LAM-EPS
- Multi-boundary conditions from 5 Global NWP models
- Multi-model with 4 non-hydrostatic NWP models
- Forecasts over Iberian Peninsula and Canary Island

Probabilistic Forecast Result from AEMet-γSREPS

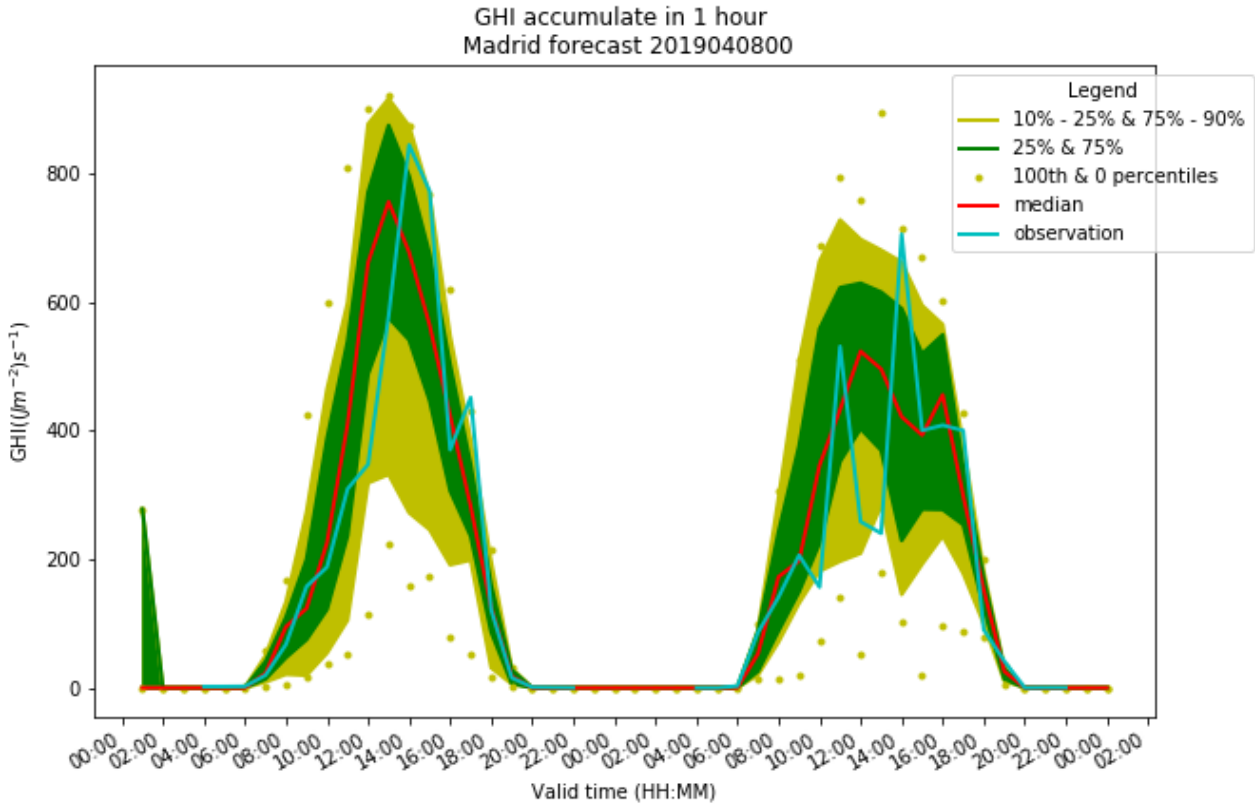


Figure 9: 1 hour accumulated GHI

Probabilistic Forecast Result from AEMet-γSREPS

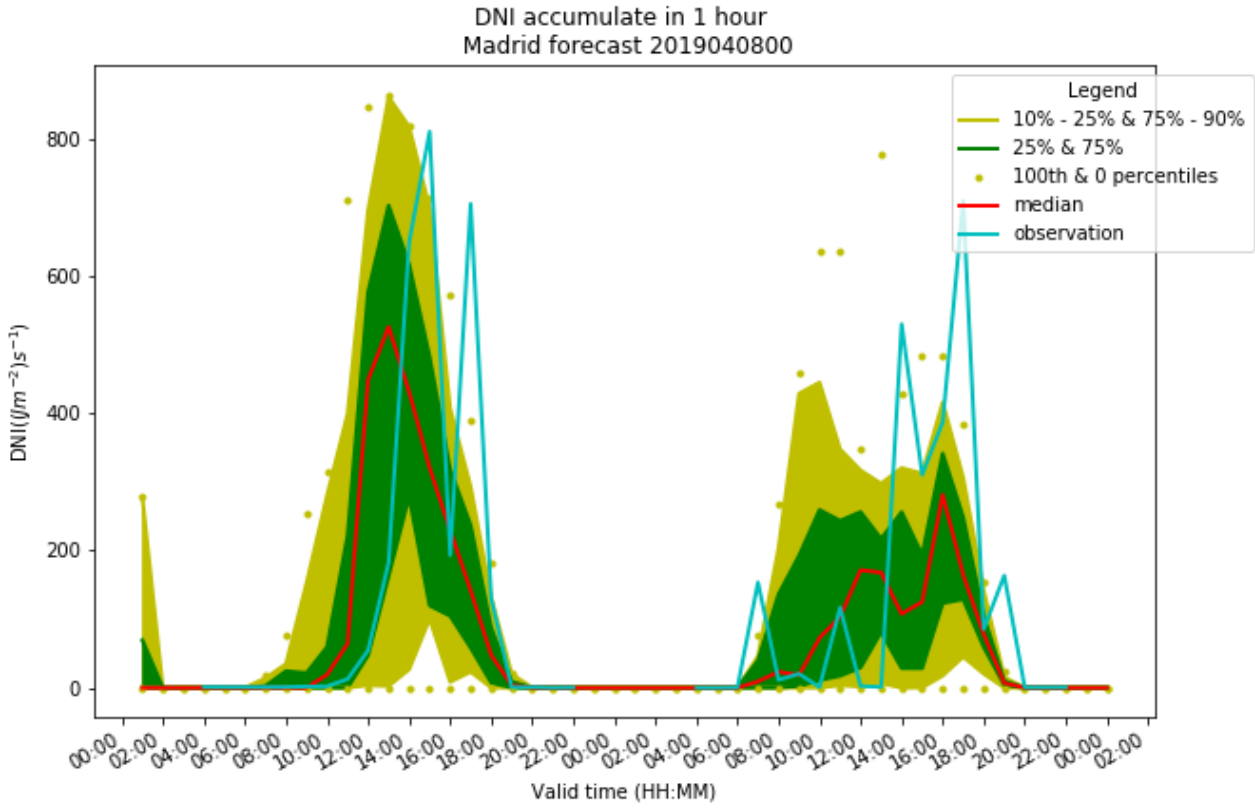


Figure 10: 1 hour accumulated DNI

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- *Algorithm Theorical Bases Document for the Extrapolated Imagery*, EUMETSAT, 2013
- *Algorithm Theorical Basis Document for High Resolution Winds*, EUMETSAT, 2013
- *Semi-Empirical Satellite Models in: Solar Resource Assesment and Forecasting*, Perez R.T. and Cebecauer M. Suri, Elsevier, 2013
- *Evaluation of the WRF model solar irradiance forecasts in Andalusia (southern Spain)* Lara-Fanego, J.A. Ruiz-Arias, D. Pozo-Vazquez, F.J. Santos-Alamillos, and J. Tovar-Pescador, Sol. Energy, 86, 2200-2217, doi:10.1016/j.solener.2011.02.014 2012

Thank you very much for your attention!