Simulation of Direct normal Irradiance (DNI) in Portugal with the Meso-NH Model. Several Case Studies

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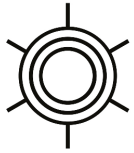

CÁTEDRA ENERGIAS RENOVÁVEIS

ICT
Instituto de Ciências da Terra

Meso-NH
mesoscale non-hydrostatic model

9th Meso-NH User's Meeting
12-13 Oct 2017, CNRM, Toulouse

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METEO FRANCE

Motivation

- Direct normal irradiance (DNI) is important for the efficiency of concentration solar energy technologies such as solar power plants systems (CST).

- Alentejo region (southern Portugal) has exceptional conditions for solar energy assessment.

- DNI-A project: To measure and evaluate DNI in Alentejo with regards to its interaction with the atmosphere and implications for regional mapping of DNI.

- Objective: To evaluate the performance of the (recently corrected) radiative scheme used by Meso-NH in short-term forecasts of DNI in Alentejo.

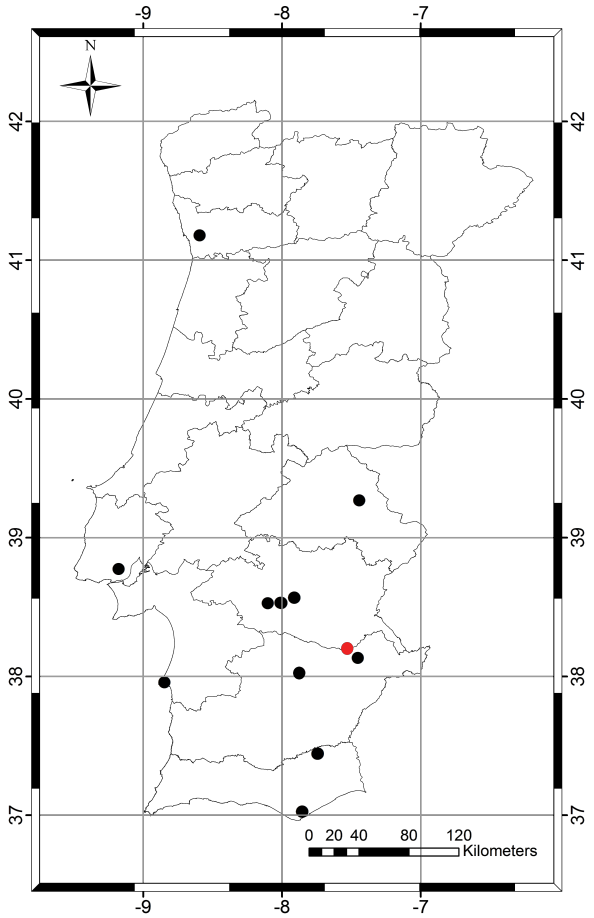
Methodology

	Period	Experiment	Validation station
Case 1	21 to 23 July 2014	ALEX IOP alex2014.cge.uevora.pt	Alqueva Lake
Case 2	4 to 5 June 2015	OBELIX I	Évora
Case 3	4 to 5 July 2016	OBELIX II	Mitra

SOLYS 2 Sun Tracker


2 pyranometers (GHI and DHI)

1 Pyrheliometer (DNI)



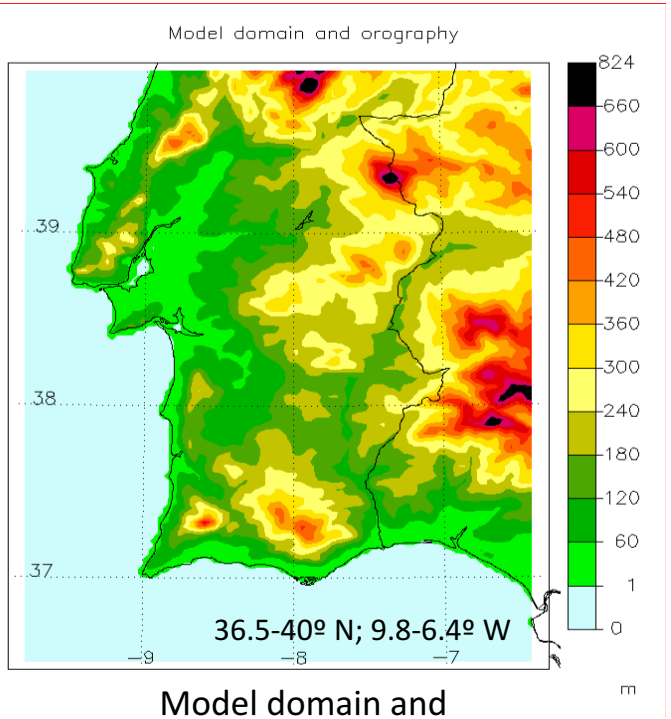
Network of the current operational DNI observations in Portugal as part of the DNI-A project

Centered hourly means were used against simulations.

Model Setup

The following physics schemes were activated:
Surface: SURFEX
Radiation: ECMWF
Turbulence: 1D
Clouds microphysics: ICE3
Deep convection: No
Shallow convection: Eddy-Diffusivity-Kain-Fritsch (EDKF)
Surface databases:
Land cover: Ecoclimap
Orography: SRTM;
Texture: Clay and Sand databases derived from FAO
The model was initialized and forced by 6-hourly ECMWF analysis.

Variable	Designation	Units
Direct irradiance on flat surface	DIRFLASWD	W/m^2
Diffuse irradiance on flat surface	SCAFLASWD	W/m^2
Zenith angle	ZENITH	º



Model domain and orography.

$$DNI_{meso} = \frac{DIRFLASWD}{\cos(ZENITH)}$$

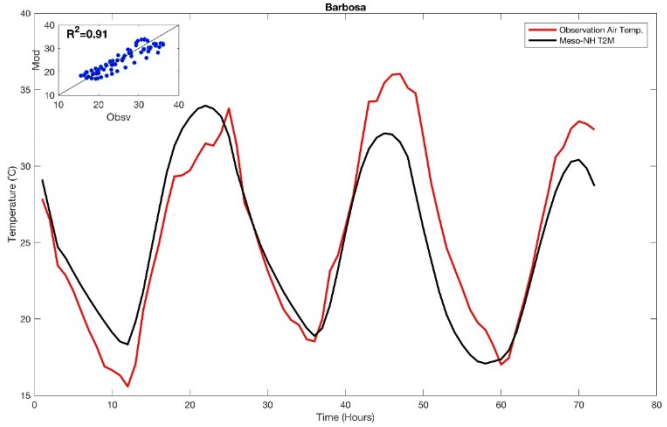
$$GFLASWD_{meso} = DIRFLASWD + \mathrm{SCAFLASWD}$$

- In all cases, simulations performed on a horizontal grid of 3 x 3 km^2 and a stretched vertical grid with the first level at 20 m.
- **Sum of all 6 spectral bands is used: 185-4000 nm**.
- Hourly data with spatio-temporal averages were simulated for each hourly instant.
- *Predictions of DNI from the radiative scheme of the Meso-NH (Version 5.3) were assessed.*

Validation: Near Surface Thermodynamic Variables

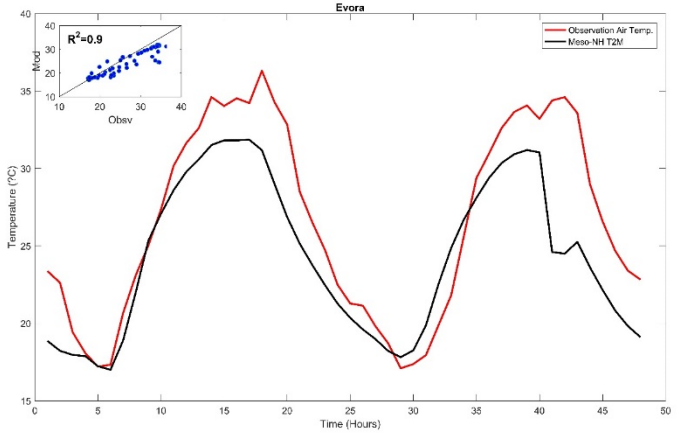
Case 1(Alqueva)

R^2=0.91



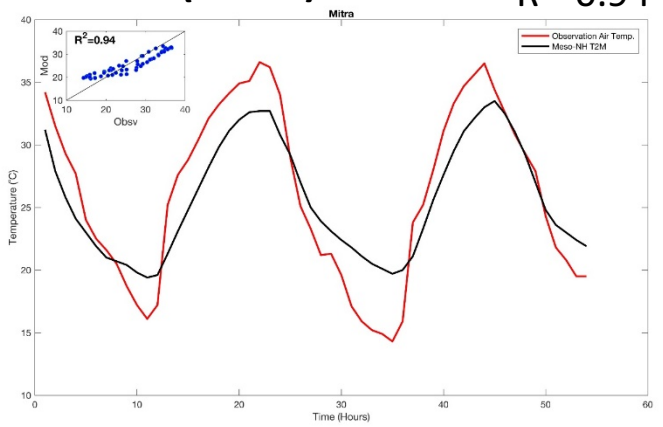
Case 2 (Évora)

R^2=0.90

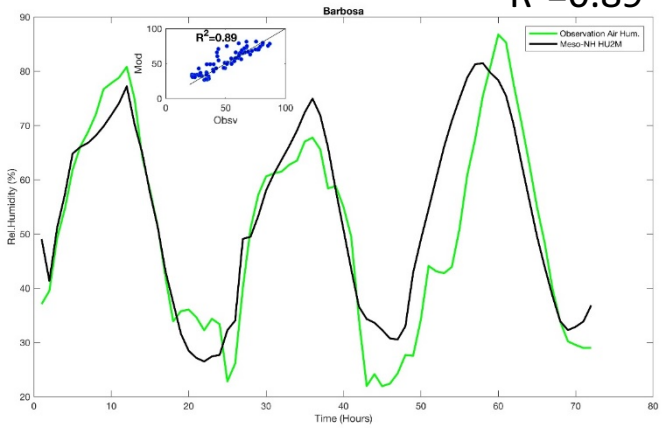


Case 3 (Mitra)

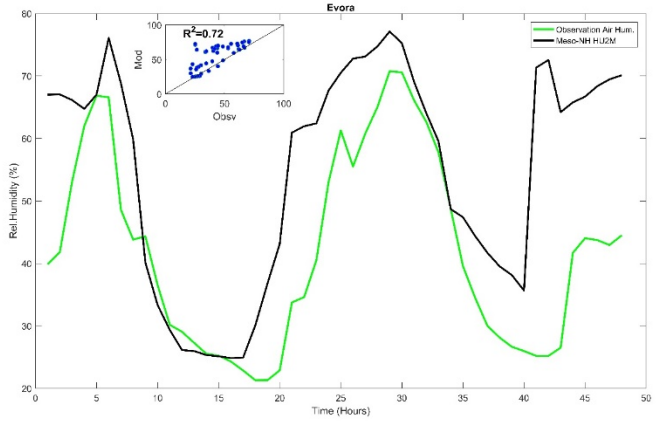
R^2=0.94



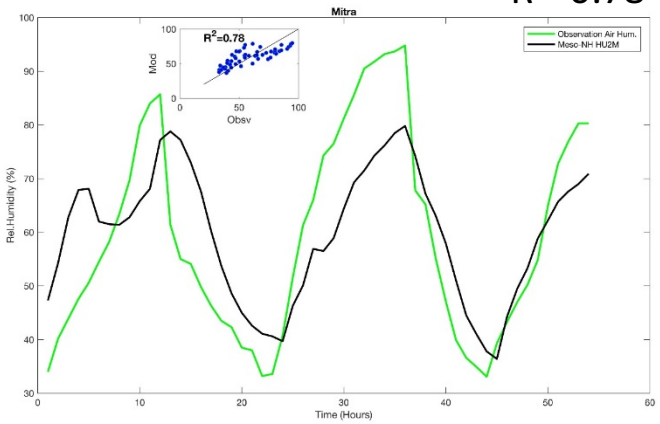
R^2=0.89



R^2=0.72



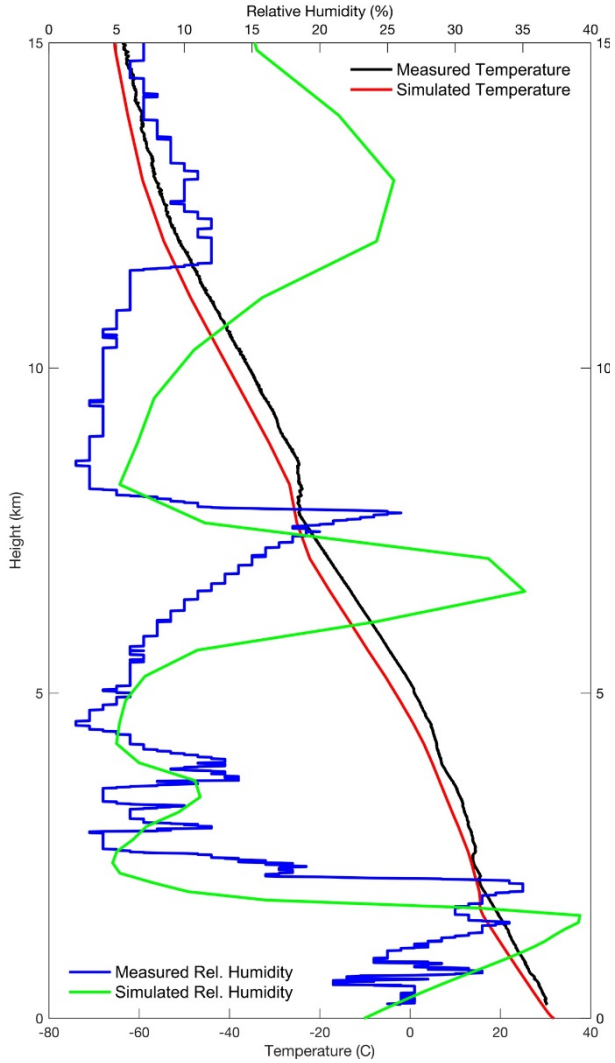
R^2=0.78



● Meso-NH ● Observed temperature ● Observed relative humidity

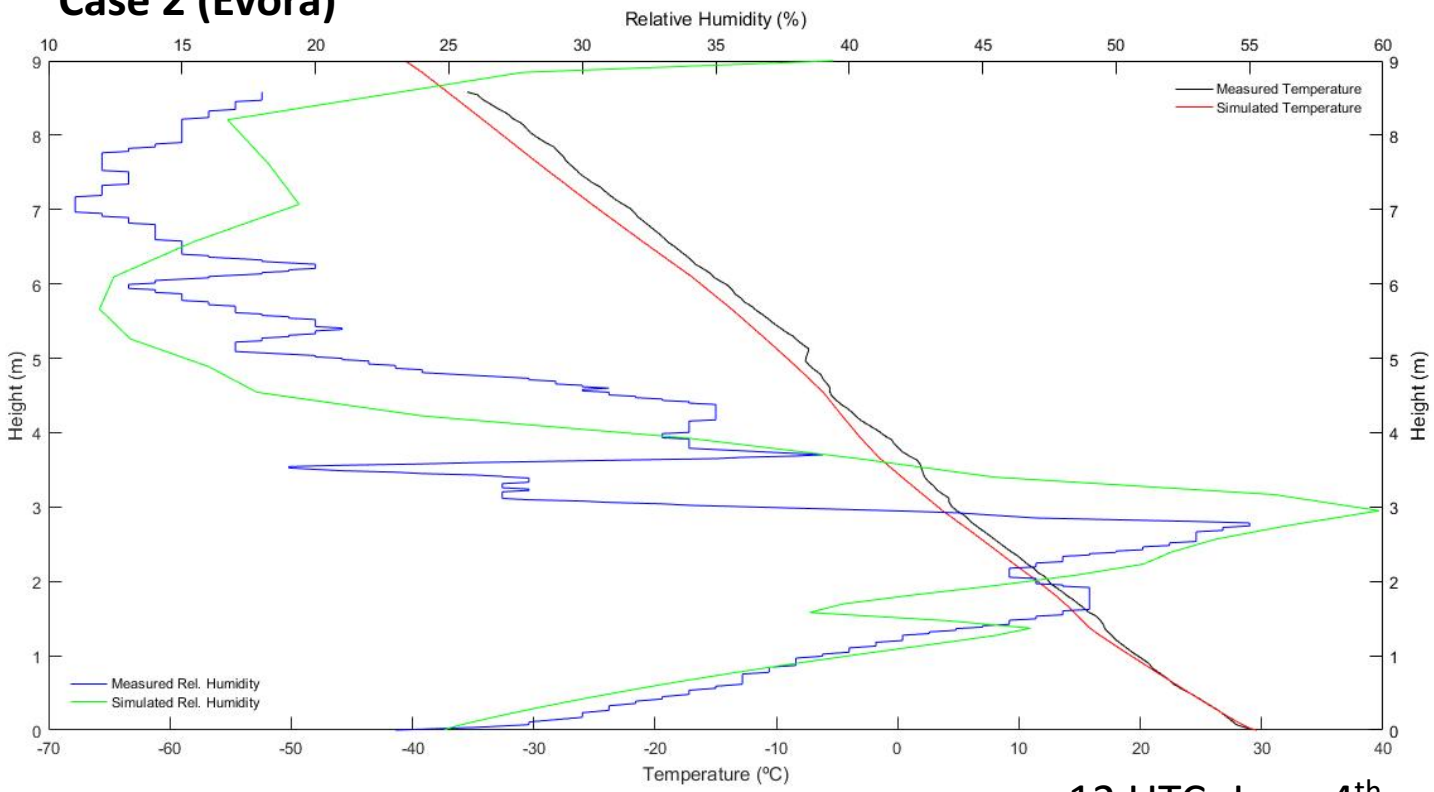
Validation: Vertical Profiles

Case 1(Alqueva)



12 UTC, July 22nd

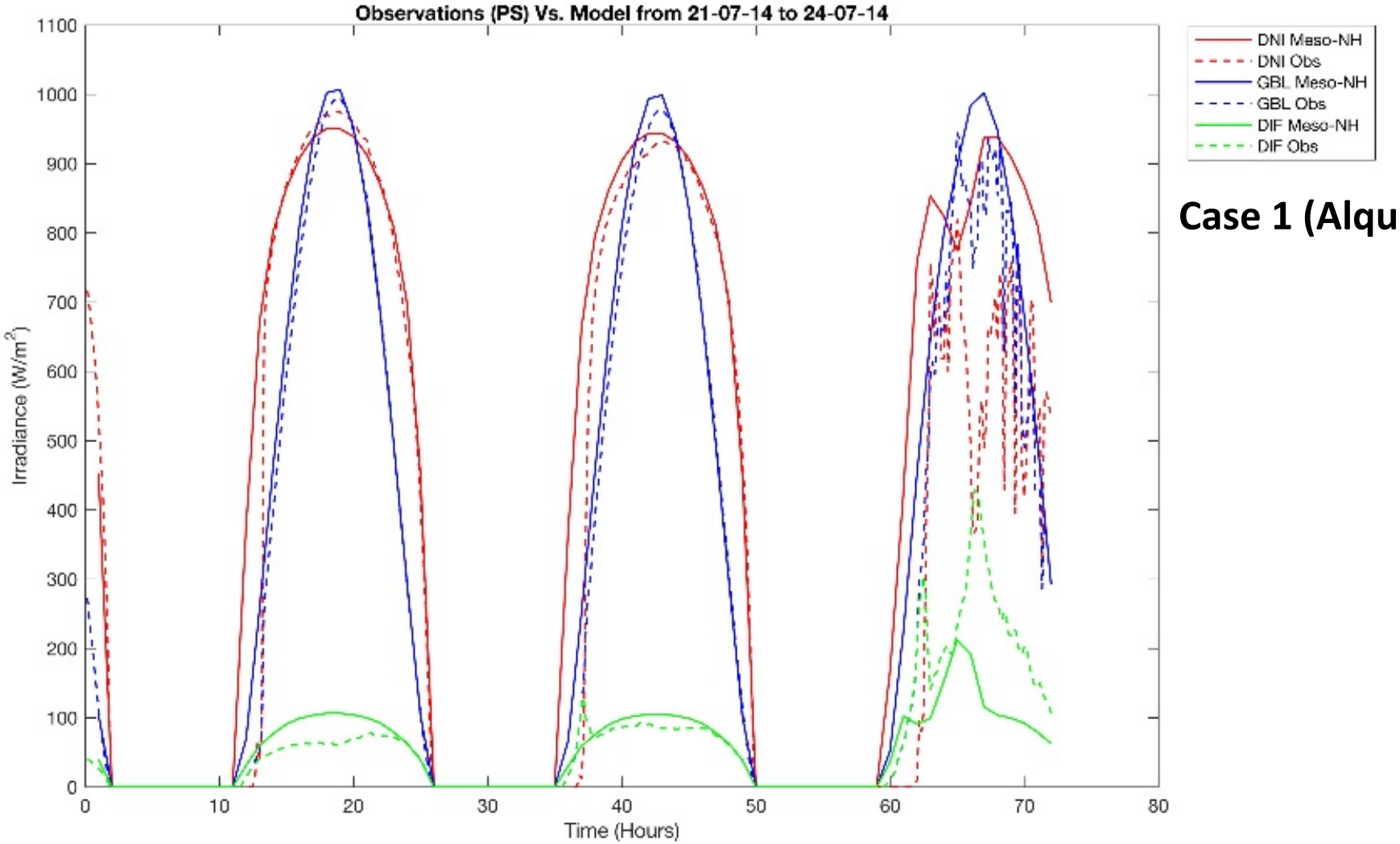
Case 2 (Évora)



12 UTC, June 4th

- Observed temperature
- Simulated temperature
- Observed relative humidity
- Simulated relative humidity

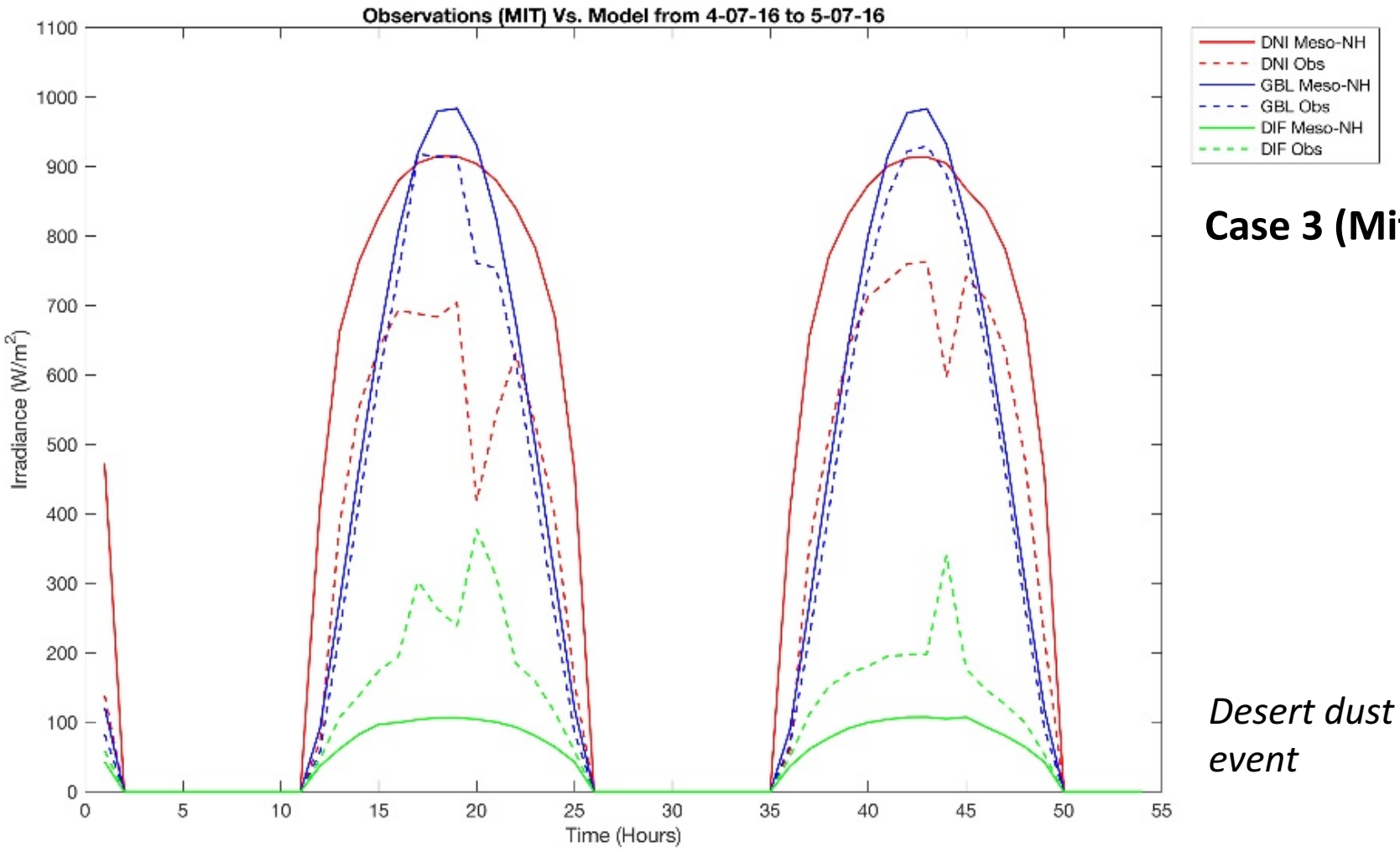
Results: Short wave radiative fluxes at the surface



Case 1 (Alqueva)

Model correction performed by Quentin Libois

Results: Short wave radiative fluxes at the surface

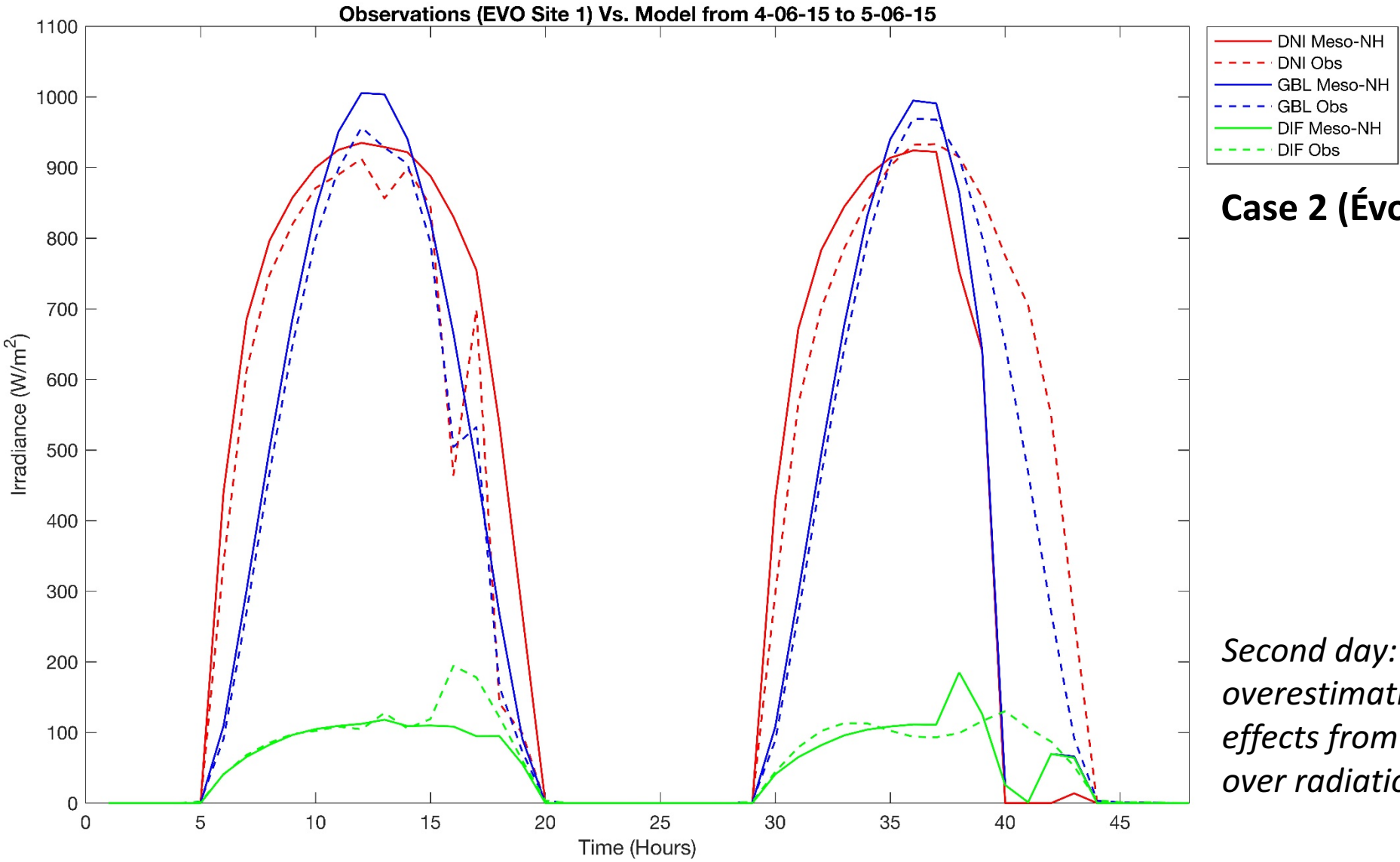


Case 3 (Mitra)

Desert dust event

Model correction performed by Quentin Libois

Results: Short wave radiative fluxes at the surface

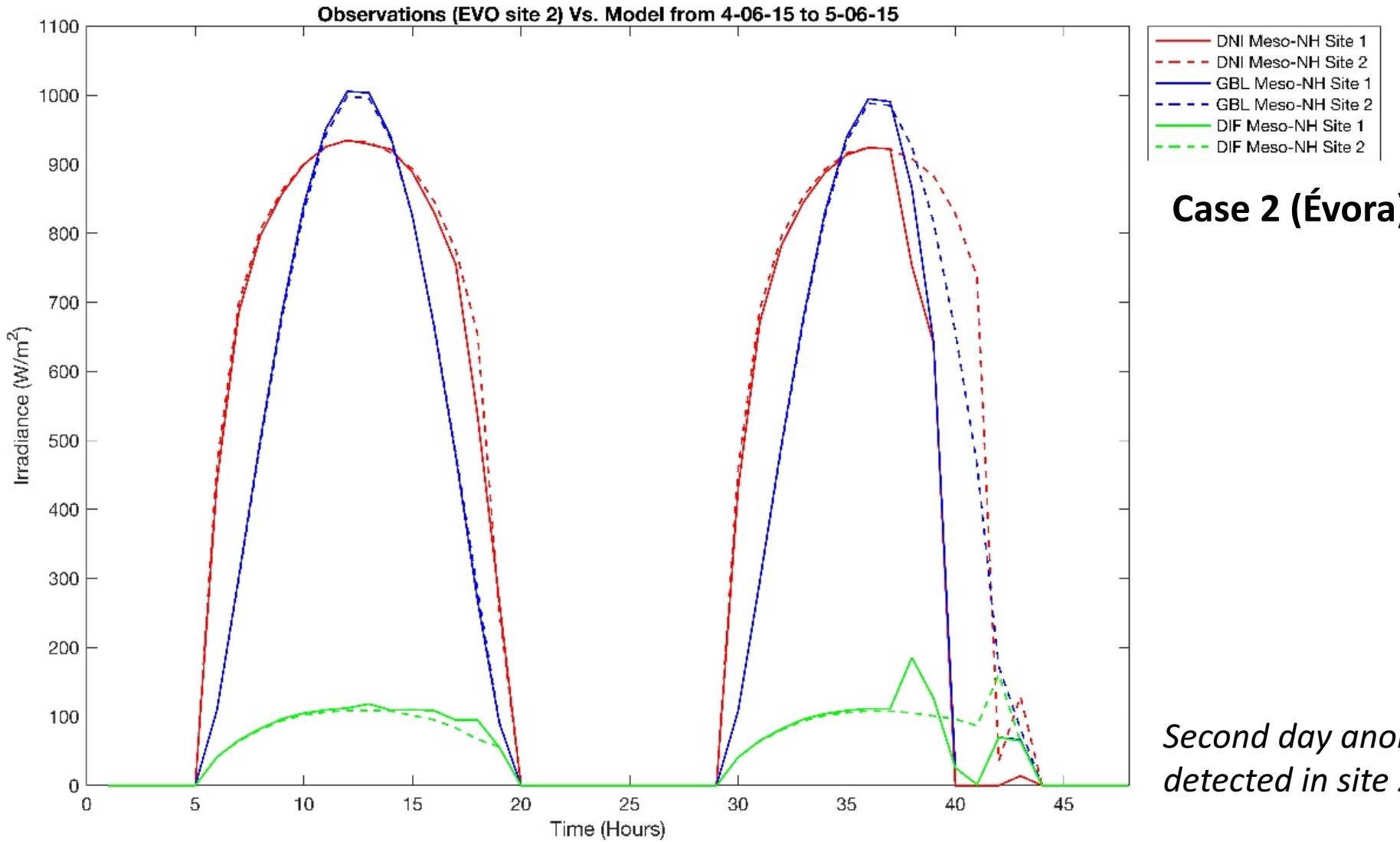


Case 2 (Évora)

Second day: overestimation of cloud effects from thick clouds over radiation

Model correction performed by Quentin Libois

Results: Short wave radiative fluxes at the surface

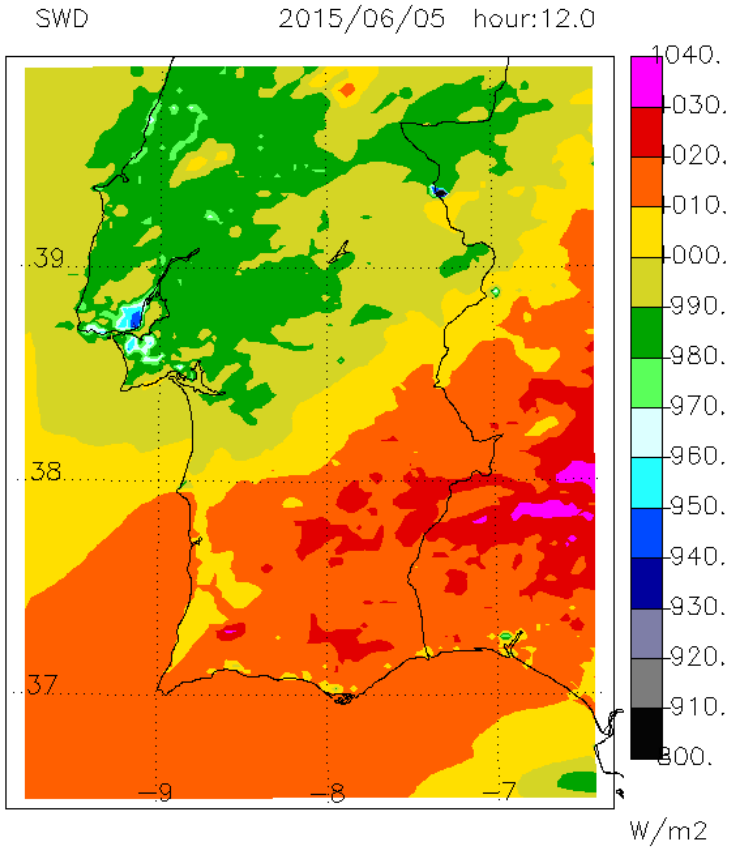


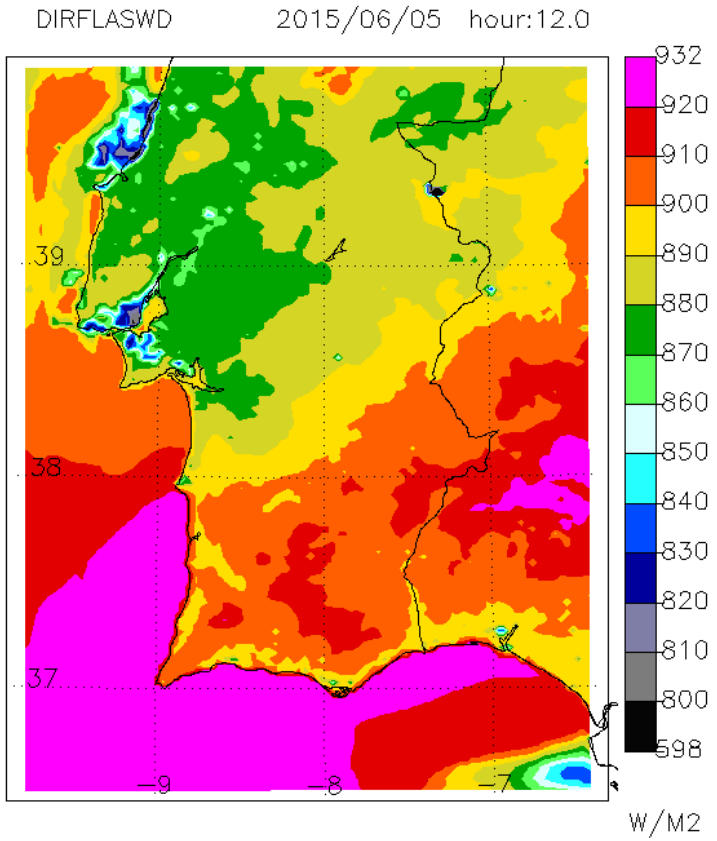
Case 2 (Évora)

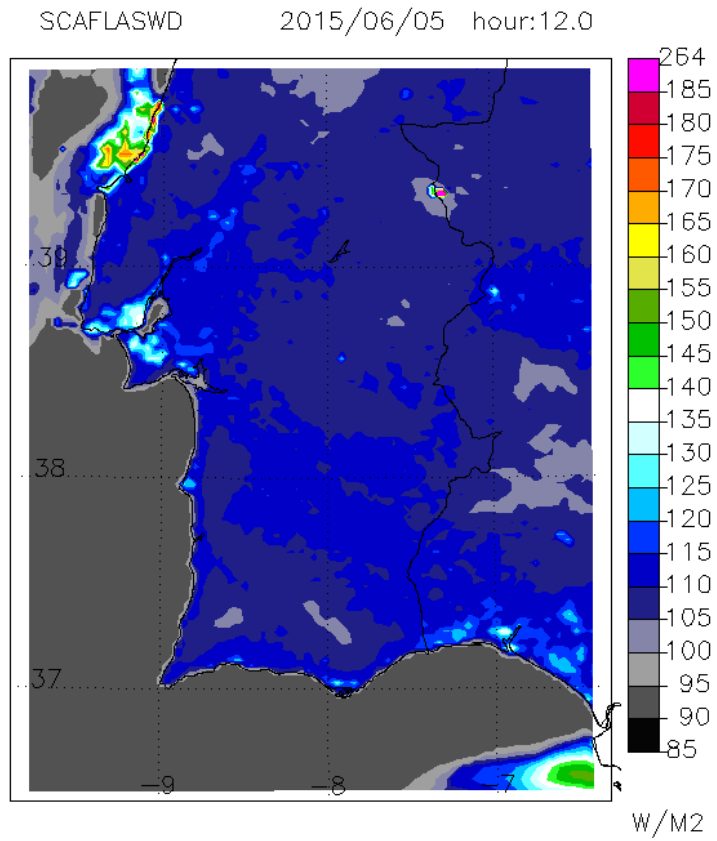
Second day anomaly not detected in site 2

Model correction performed by Quentin Libois

Results: Surface charts of radiation fluxes



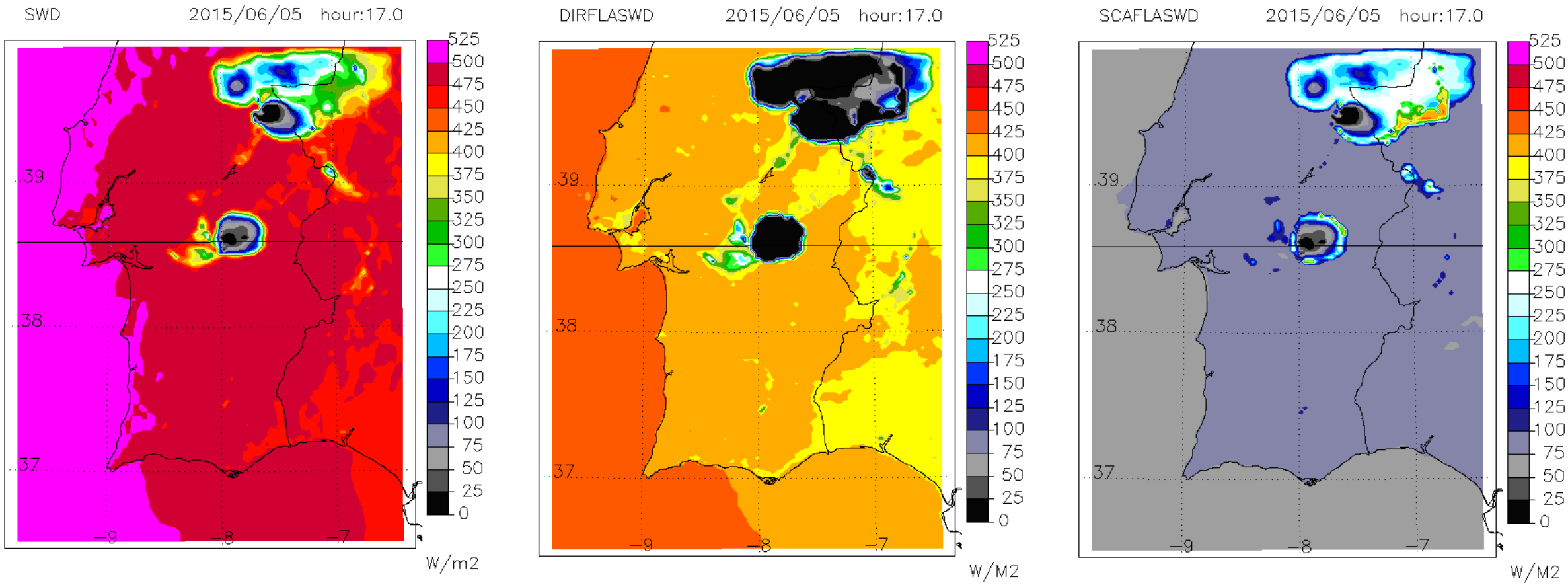




Model correction performed by Quentin Libois

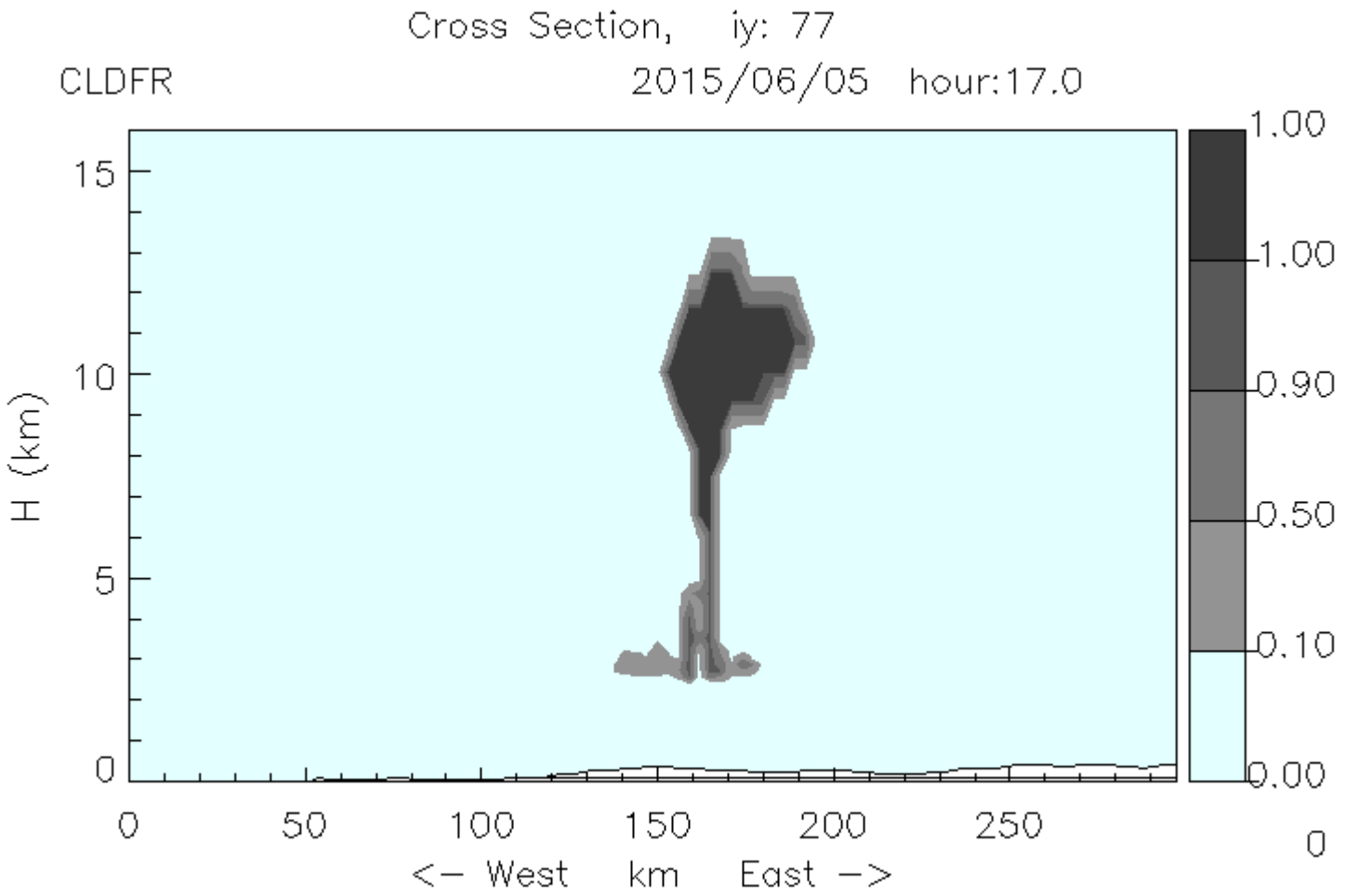
Results: Surface charts of radiation fluxes

Deep convection case



Model correction performed by Quentin Libois

Results: Cloud fraction cross section



Zeros in simulated diffuse and global correspond to points below very deep clouds (2-13 km)

Model correction performed by Quentin Libois

Summary and Future Work

- Results from the Meso-NH (recently corrected) radiative scheme, used in the presented cases over the Alentejo region, show that:

i. During clear sky conditions, solar radiation is well simulated;

ii. During aerosol events, model should be improved with realistic profiles;

iii. At 3 km resolution, model does not represent well clouds, but displays realistic values for shallow clouds;

iv. Model over estimates the effect of deep clouds in solar radiation at surface;

- The Meso-NH can be a valuable tool for the assessment and mapping of DNI at surface. For that matter, longer time series and more available measuring stations should be used for a more robust analysis.

Acknowledgements

MERCI!

ACKNOWLEDGMENTS
The work was supported by COMPETE 2020 through the ICT project (UID / GEO / 04683/2013) with the reference POCI-01-0145-FEDER-007690 and also by the DNI-A (ALT20-03-0145-FEDER-000011) and ALOP (ALT20-03-0145-FEDER-000004) projects.

ALENTEJO 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional