RICTA 2015 Elche

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GOBIERNO DE ESPAÑA | MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE | AEMet Agencia Estatal de Meteorología

IMPACT OF ATMOSPHERIC AEROSOLS ON SOLAR RADIATION FORECASTS

AEMET
Grupo de Modelos de Radiación

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2) Methodology

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4) Conclusions and work in progress

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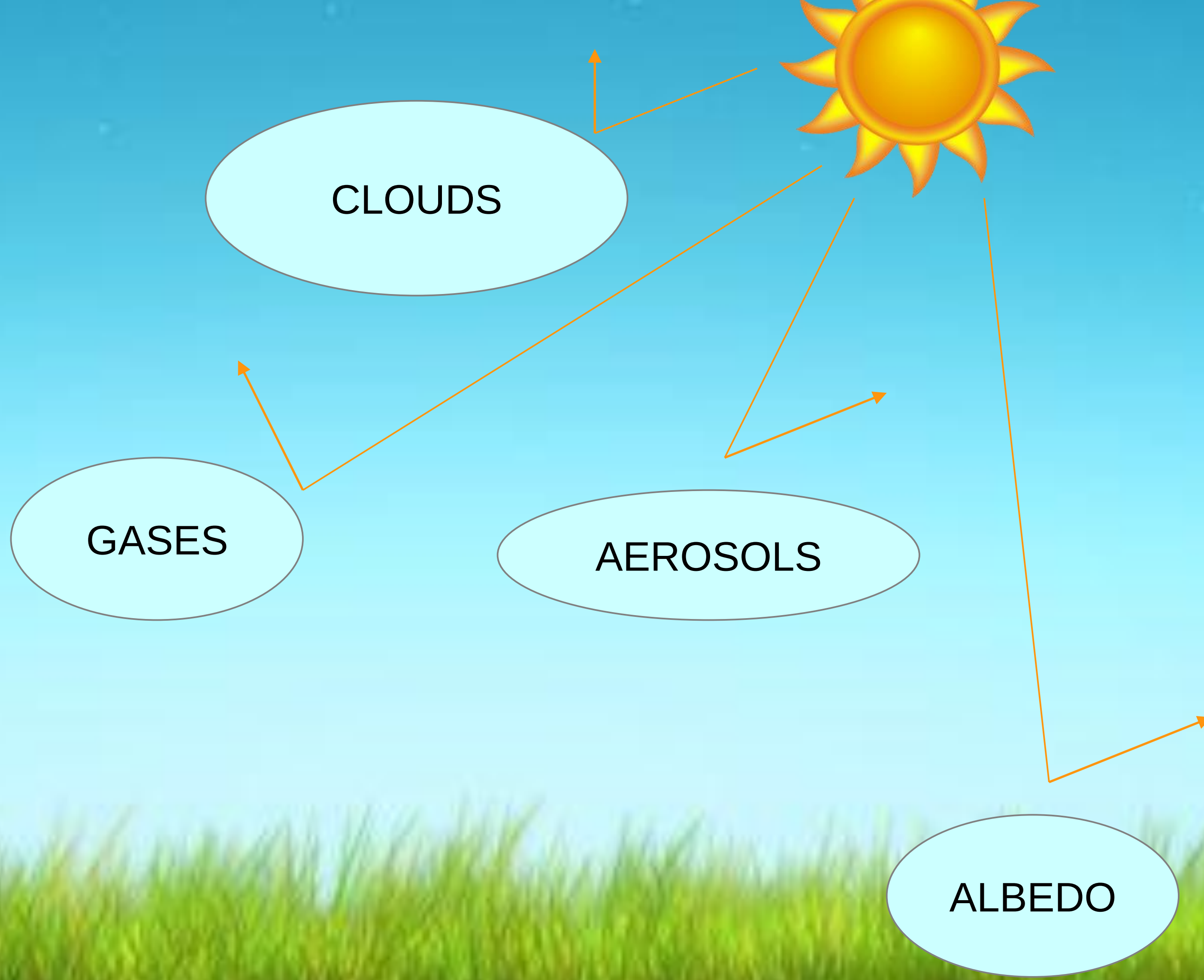
Why?

Meteorological forecast models do not incorporate predictions of atmospheric aerosols yet (only use climatological values)

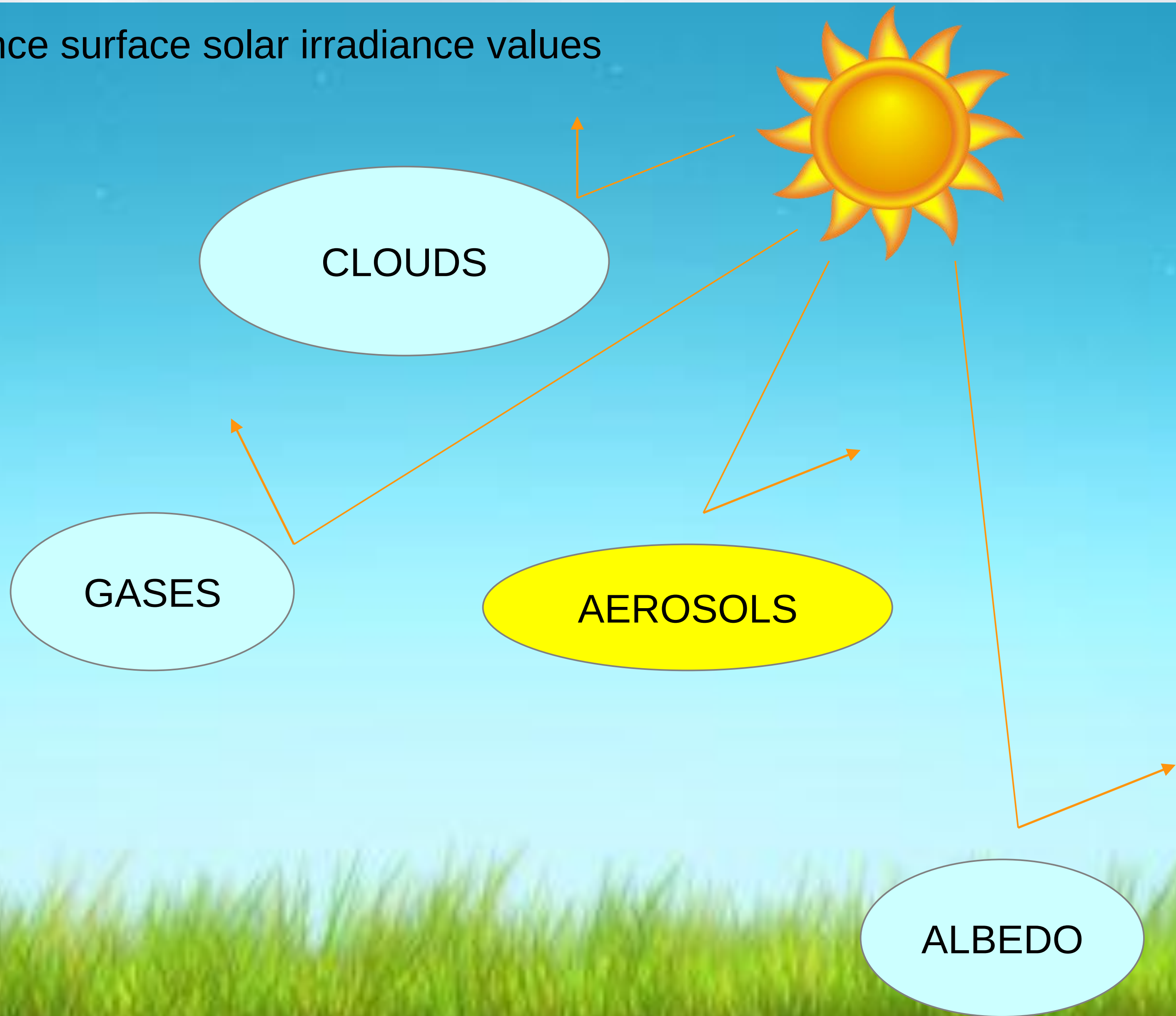
- Scientific interest
  - → This information would improve the forecast of meteorological variables
  - → It is essential for irradiance calculations
- Industrial interest
  - → Irradiance forecasts highly demanded by the solar industry

Other option : radiative transfer models

Factors which influence surface solar irradiance values



Factors which influence surface solar irradiance values



Main components of solar irradiance :

Direct Normal Irradiance (DNI) - amount of solar radiation from the direction of sun

Diffuse Sky Radiation - Diffuse sky radiation is solar radiation reaching the Earth's surface after having been scattered by molecules or suspensoids in the atmosphere (clouds and aerosols)

Global Horizontal Irradiance (GHI) – sum of the Diffuse Horizontal Irradiance (DHI) and the Direct Normal Irradiance (DNI) in the horizontal direction (perpendicular to the ground)

$$GHI = DHI + DNI * \cos(Z)$$

Z = zenith angle

Thermosolar power plants	Photovoltaic power plants
DNI	GHI
CLOUDS + AEROSOLS	CLOUDS

According to some studies:

Aerosol loading is the most critical parameter in the Mediterranean and northern Africa, causing 30% of total DNI extinction reaching even 100% on dust outbreak events (Wittmann et al, 2008).

Wittmann, M., Breitkreuz, H., Schroedter-Homscheidt, M., Eck, M. Case studies on the use of solar irradiance forecast for optimized operation strategies of solar thermal power plants. IEEE J-STARS 1(1), 18-27.(2008)

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Our group is developing tools for calculating irradiance forecasts using :

1. Observational data from the AERONET network to select clear days

2. The 1D radiative transfer model libRadtran

3. Inputs: Forecast meteorological variables from models of the European Centre for Medium-Range Numerical Weather Prediction (ECMWF), aerosol forecasts from the MACC project model.

4. Validation with observational data from the Red Radiométrica Nacional

Factors which influence surface solar irradiance values

CLOUDS

Forecasts from the ECMWF

GASES

libRadtran atmospheric profile
Water vapour: precipitable water ECMWF

AEROSOLS

State of art: AOD550 forecasts from the MACC project
5 aerosol types: dust, sulphate, sea salt, organic matter and black carbon

ALBEDO

Constant value: 0,2

Constant parameters:

- Altitude of the station
- Atmospheric gases profile (including ozone)
- Albedo

Forecasted parameters:

- Precipitable water (water vapour)
- AOD550 for 5 aerosol types: dust, sulphate, sea salt, organic matter and black carbon

Other aerosol parameters relevant for DNI:

- Angström parameters α and β: NOT AVAILABLE IN FORECASTS

Area of study :

Iberian Peninsula

Sites :

Murcia, Badajoz, Valladolid and Zaragoza

Time period :

Year 2013

3 hours / day : 9 UTC, 12 UTC, 15 UTC

Forecasts from 0 UTC on the same day

Clear days selected according to AERONET data availability (no data indicate cloud).

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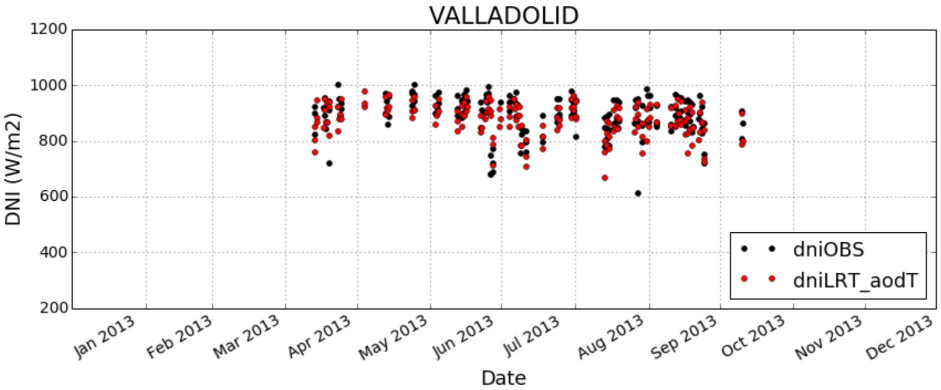
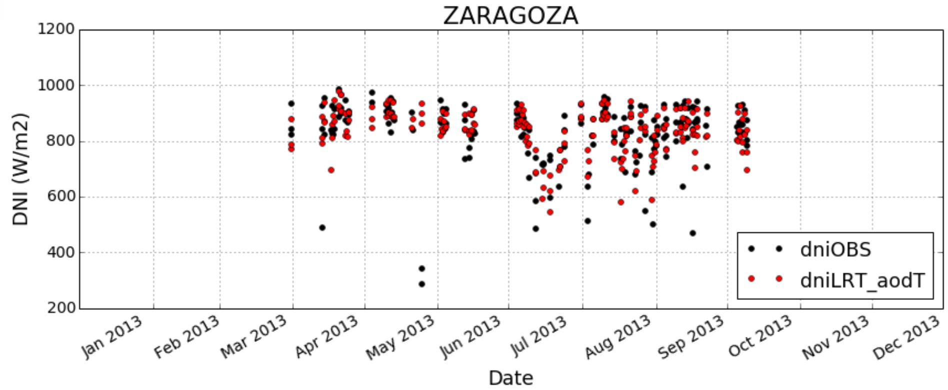
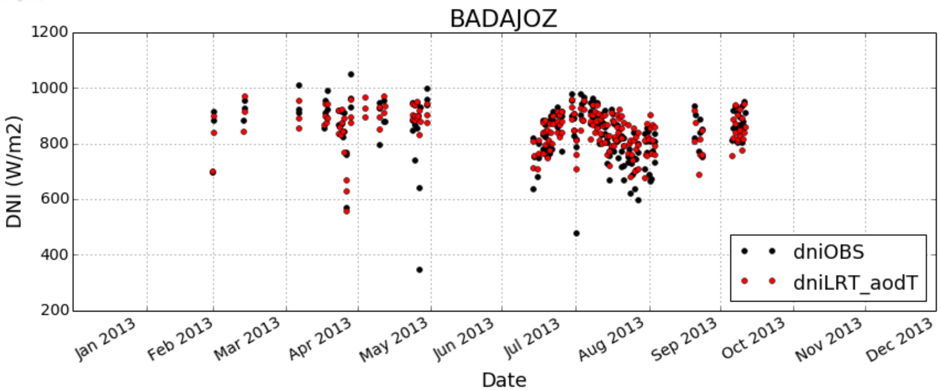
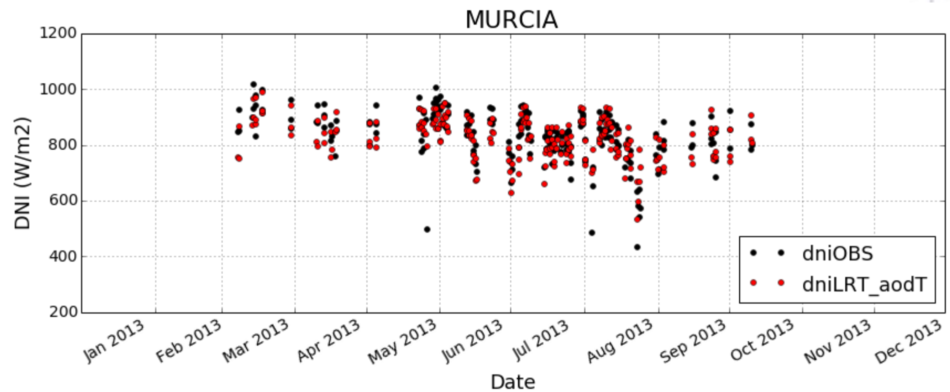
3 – Results : Annual evolution

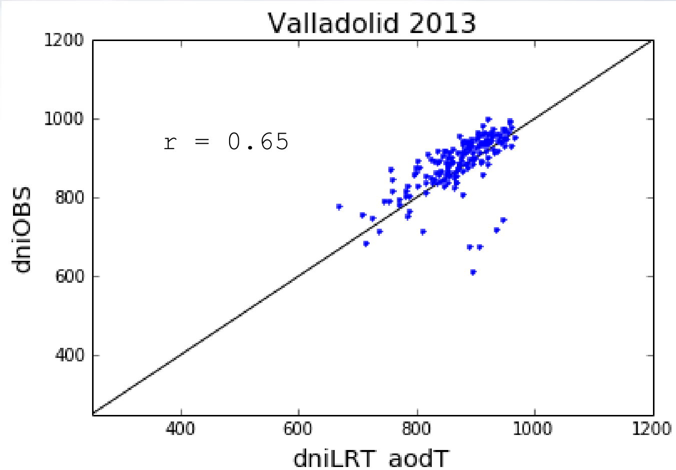


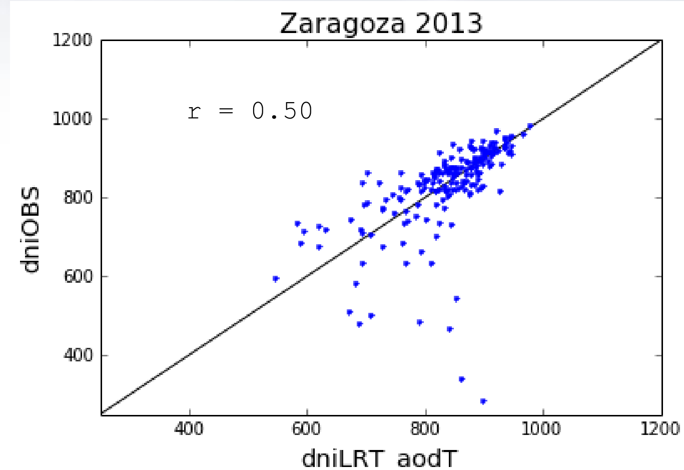


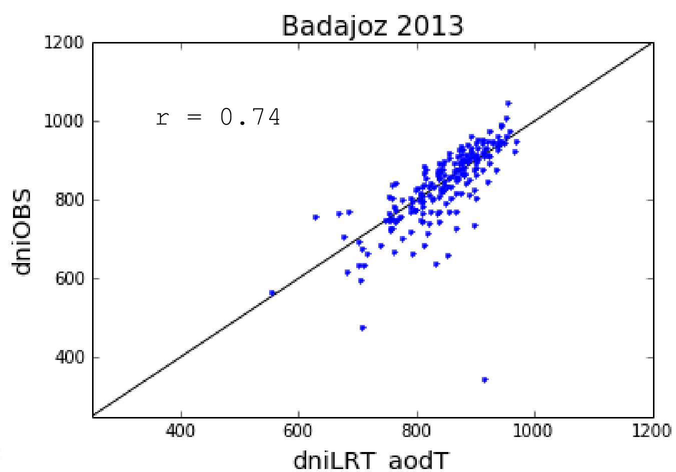


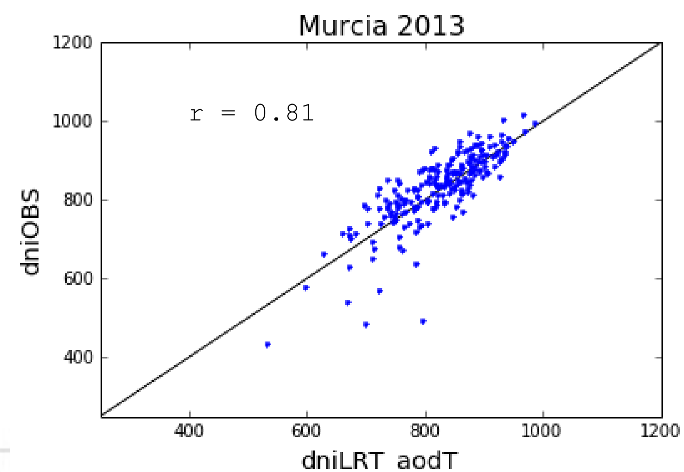


3 – Results: Scatter Plots









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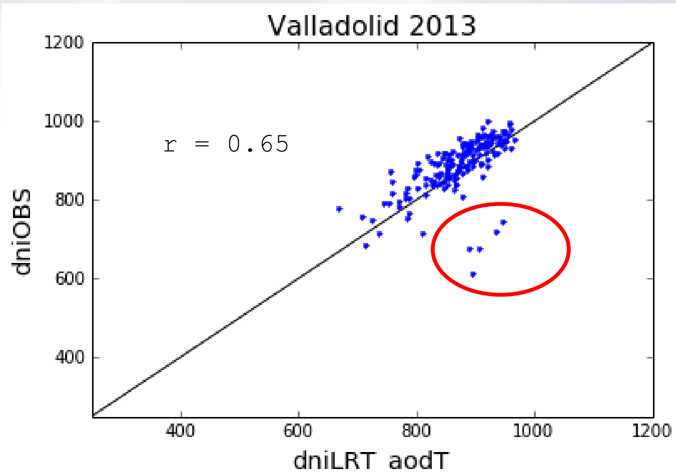
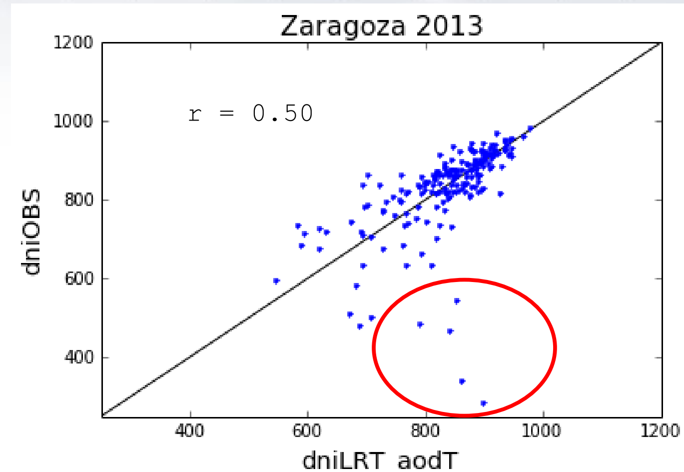
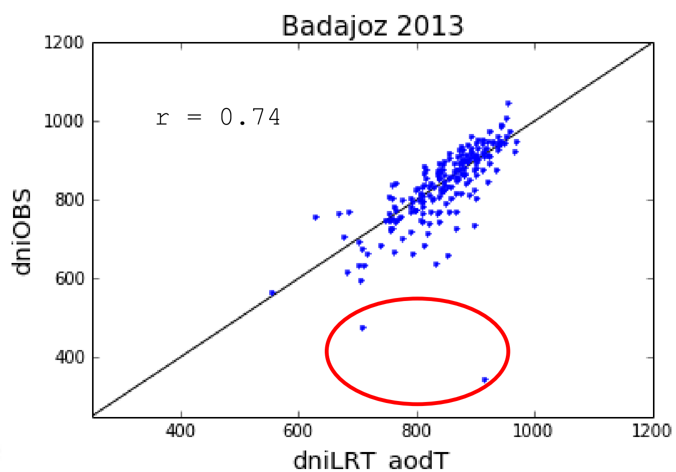
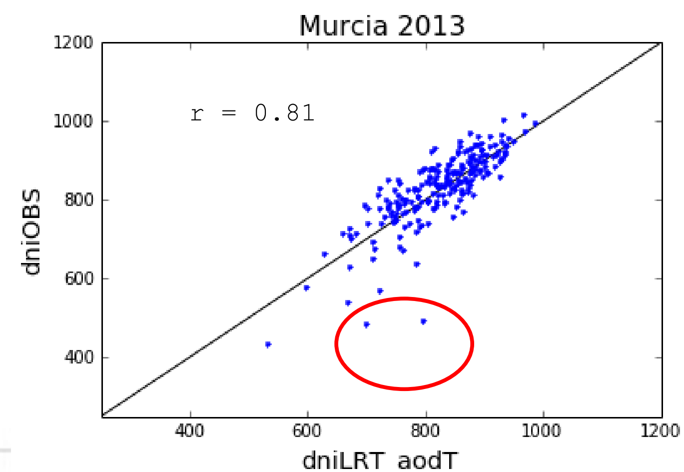








low clouds

3 – Results: Scores

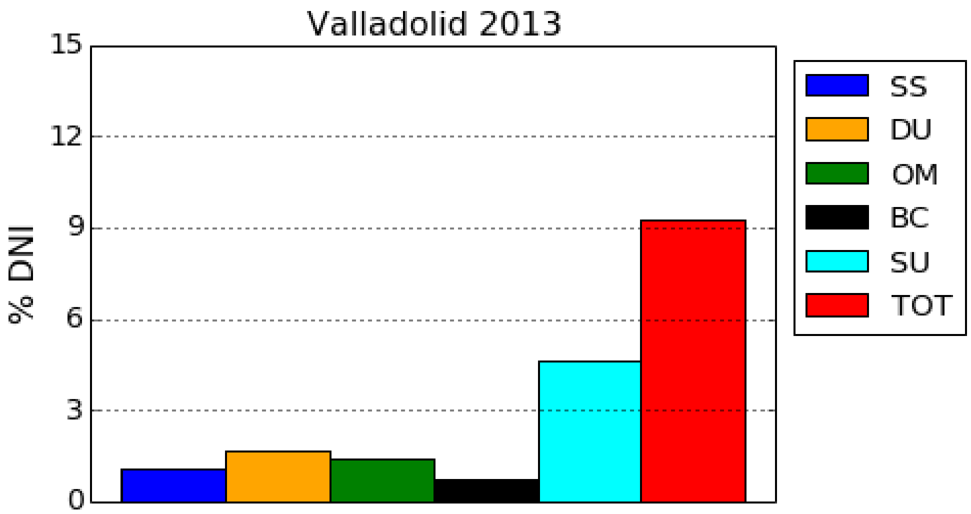
VALLADOLID	LRT + MACC	ECMWF
Bias	-17.4	-44.4
Mean Abs Err	37.1	65.3
RMSE	55.2	97.7
r	0.65	0.48

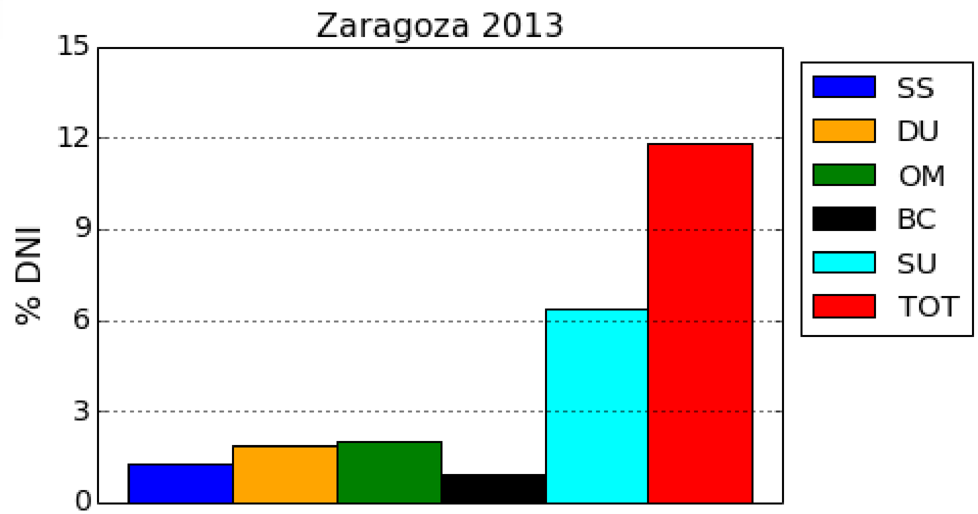
ZARAGOZA	LRT + MACC	ECMWF
Bias	6.5	-23.4
Mean Abs Err	53.4	75.9
RMSE	104.7	129.0
r	0.50	0.37

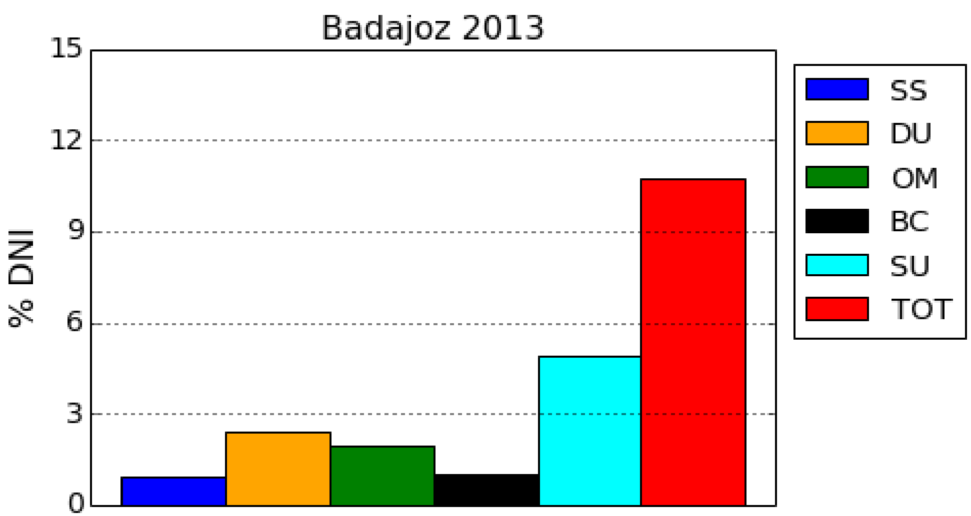
BADAJOZ	LRT + MACC	ECMWF
Bias	7.2	-5.3
Mean Abs Err	39.2	65.6
RMSE	65.3	102.0
r	0.74	0.37

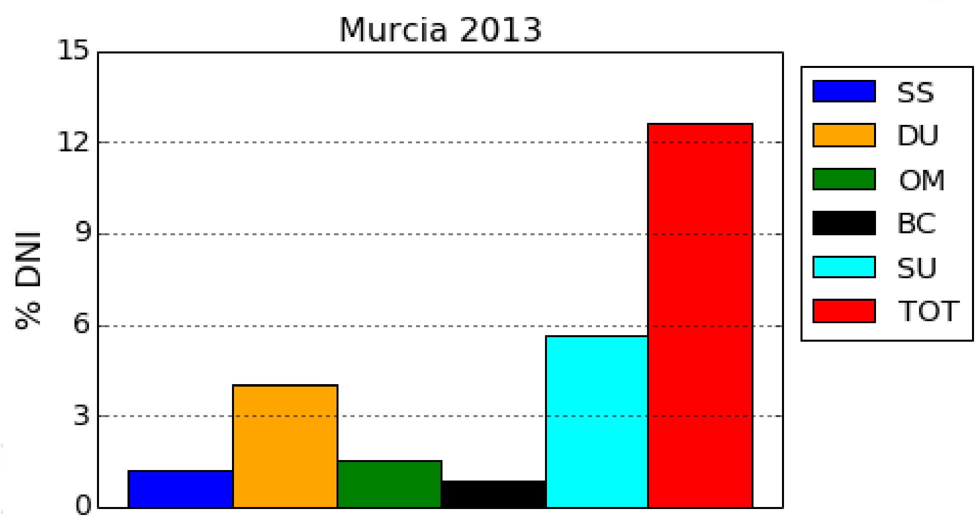
MURCIA	LRT + MACC	ECMWF
Bias	-10.8	-40.1
Mean Abs Err	40.0	74.0
RMSE	53.9	103.3
r	0.81	0.42

2013 annual average $(DNI_{noAOD}-DNI_{AOD}) / DNI_{noAOD}$

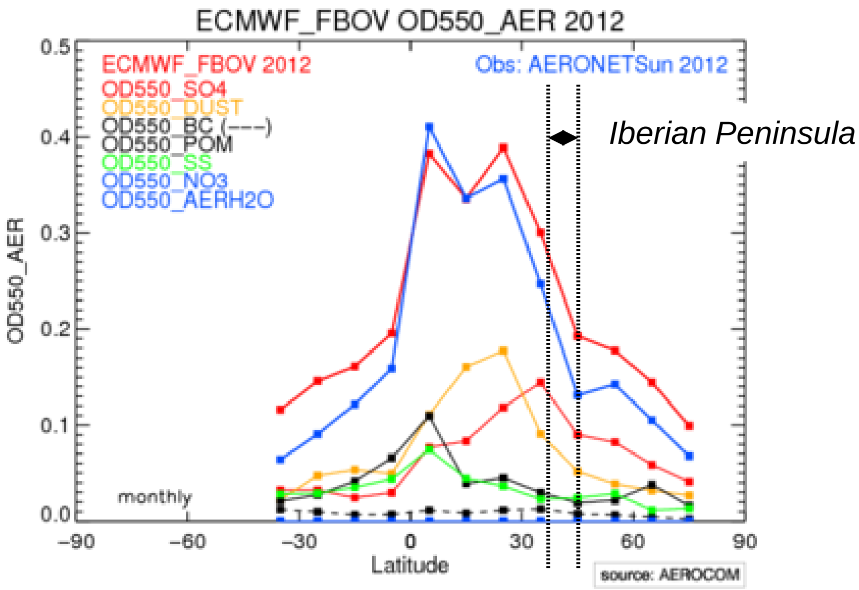








MACC results : the type of aerosol with the highest contribution to AOD is sulphate, although it might be a bit overestimated



Red : MACC reanalysis
Blue : Aeronet
Orange : Sulphate from MACC reanalysis

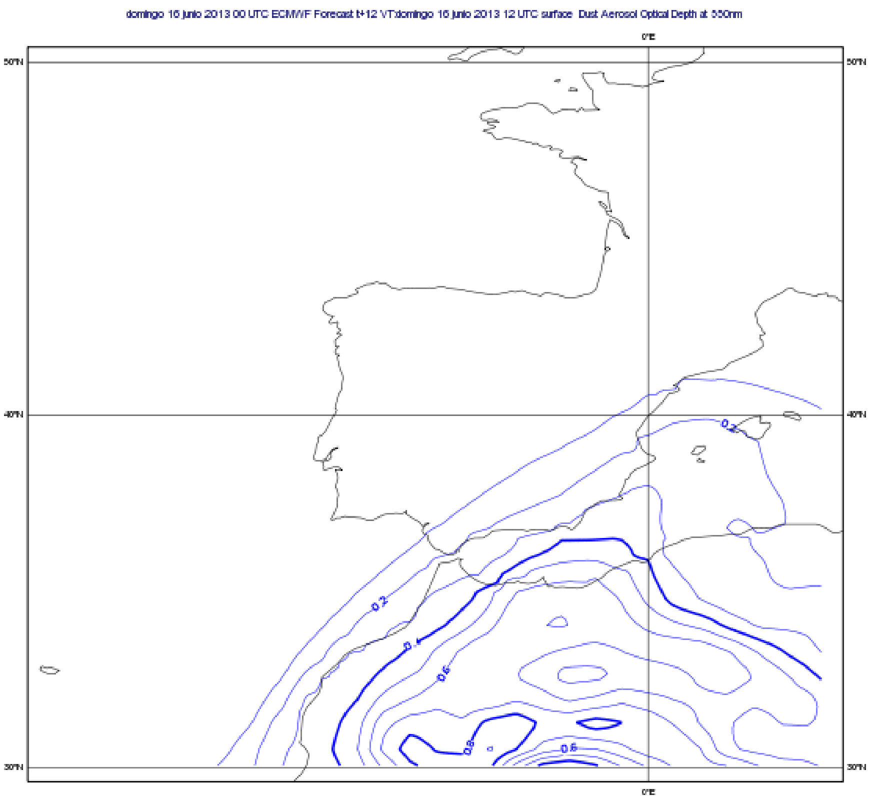
Murcia 2013

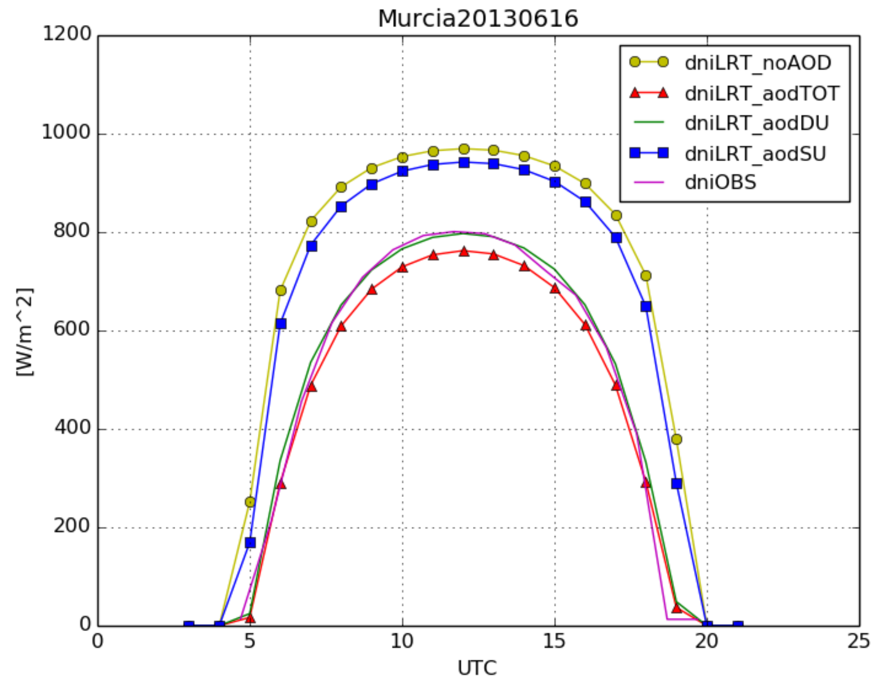
8 days with DNI < 800 W/m2

Date	NAF (SDS-WAS)	MACC
16/06/2013	✓	
30/06/2013	X	Dust + sulphate
01/07/2013	✓	
04/07/2013	✓	
15/07/2013	✓	
04/08/2013	✓	
23/08/2013	✓	
24/08/2013	✓	

3 - Results

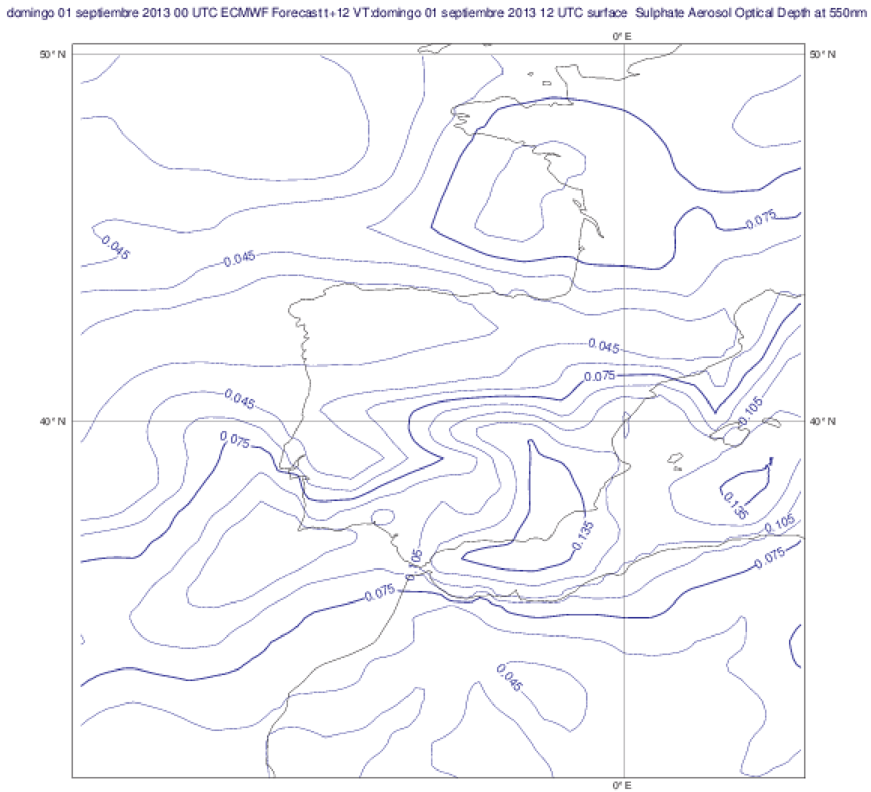
Dust event : 16/06/2013

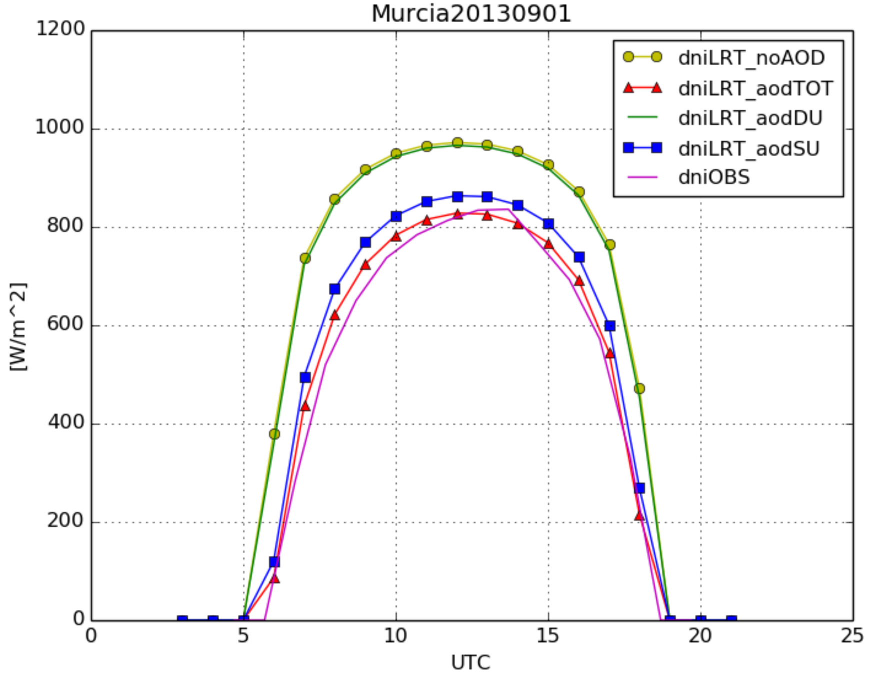




DNI drop : 20,8 %

Sulphate event : 01/09/2013





DNI drop : 20,0 %

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Conclusions :

- Improvements in radiation forecasts have been made using libRadtran 1D + MACC aerosol forecasts with respect to the ECMWF meteorological model (considering an aerosol climatology) for clear days.

- According to MACC forecasts, in the Iberian Peninsula dust contributes significantly to the fall of the DNI under African intrusion situations. However, the aerosol type which contributes most on an annual scale is sulphate.

4 – Conclusions and work in progress

Work in progress...

Improve the selection of clear situations: Criterium based on predictions of cloudiness of ECMWF

Constant parameters : albedo and gases profile

Cloudy days : Try libRadtran with ECMWF cloud cover forecasts + typical cloud parameters

REFERENCES

Wittmann, M., Breitkreuz, H., Schroedter-Homscheidt, M., Eck, M. Case studies on the use of solar irradiance forecast for optimized operation strategies of solar thermal power plants. IEEE J-STARS 1(1), 18-27.(2008)

Validation report of the MACC reanalysis of global atmospheric composition. Period 2003-2012. MACC-II Deliverable D_83.5.

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The Red Radiométrica Nacional, managed by AEMET, provided observational data.

THANK YOU FOR YOUR ATTENTION