

Land surface albedo and downwelling shortwave surface flux from MSG/SEVIRI in the EUMETSAT LSA-SAF project

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CNRM/GAME – Météo-France/CNRS

LPVE 2014 – 28-30 January 2014

Outline

- **LSA-SAF program**
- **Surface albedo**
- **Downwelling surface shortwave flux**
- **Conclusions and future work**

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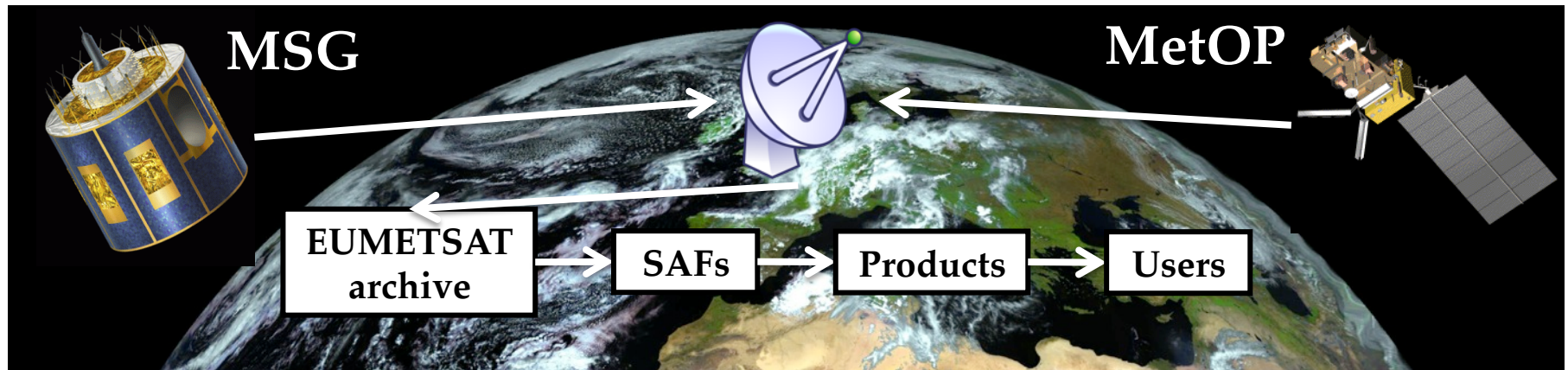
The LSA-SAF: Introduction

➤ LSA-SAF: Land Surface Analysis - Satellite Application Facility

The EUMETSAT
Network of
Satellite Application
Facilities



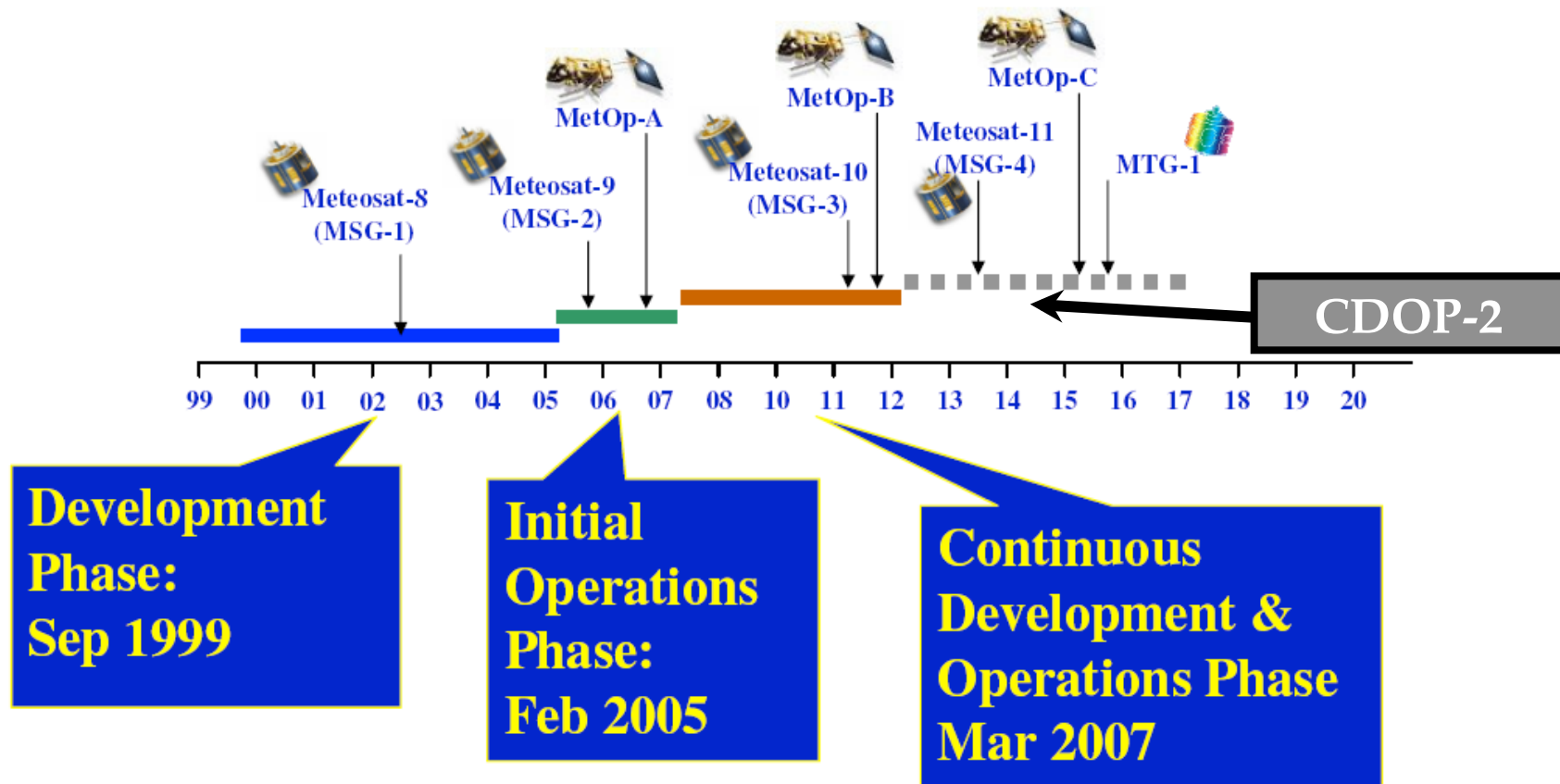
Generation of land surface products from EUMETSAT geostationary (MSG) and polar (MetOp) satellite data



The EUMETSAT
Network of
Satellite Application
Facilities



The LSA-SAF: Chronology



- **CDOP-2:** continuation and improvement of operational production of surface parameters from EUMETSAT satellite data

The LSA-SAF: Products

- **Surface products from MSG/SEVIRI:** fires, vegetation, snow, albedo, surface temperature, radiative fluxes, evapotranspiration

<http://landsaf.meteo.pt/>

MSG/SEVIRI based products	
Wild Fires	
Fire Radiative Power - PIXEL	
Fire Radiative Power - GRID	
Fire Risk Map	
Fire Detection and Monitoring	
Vegetation Parameters	
Fraction of Vegetation Cover	
Leaf Area Index	
Fraction of Absorbed Photosynthetic Active Radiation	
Snow Cover	
Snow Cover (daily)	
Snow Cover (15 mins)	
Other	
Bi-Directional Reflectance Factor	
Land Surface Emissivity	
Albedo	
Surface Albedo	
MSG Ten Day Surface Albedo	
Land Surface Temperature	
Land Surface Temperature (15 mins)	
Down-welling Surface Fluxes	
Down-welling Surface Short-wave Radiation Flux	
Down-welling Surface Long-wave Radiation Flux	
Daily Downward Surface Shortwave Flux	
Daily Downward Surface Longwave Flux	
Evapotranspiration	
Evapotranspiration (30 mins)	
Daily Evapotranspiration	

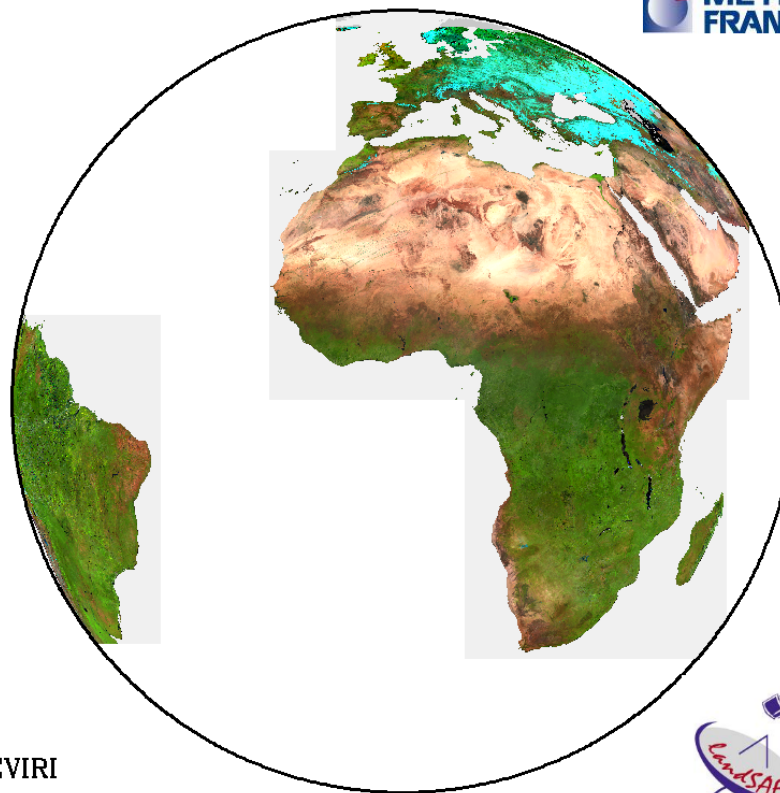
The LSA-SAF: Products

- **Surface products from MSG/SEVIRI:** fires, vegetation, snow, albedo, surface temperature, radiative fluxes, evapotranspiration

15.02.2006

- **Surface albedo:**

AL-SP-DH Colour Composite
R: 1.6 μ m, G: 0.8 μ m, B: 0.6 μ m



Meteosat-8/SEVIRI



MSG/SEVIRI based products

Wild Fires

- Fire Radiative Power - PIXEL
- Fire Radiative Power - GRID
- Fire Risk Map
- Fire Detection and Monitoring

Vegetation Parameters

- Fraction of Vegetation Cover
- Leaf Area Index
- Fraction of Absorbed Photosynthetic Active Radiation

Snow Cover

- Snow Cover (daily)
- Snow Cover (15 mins)

Other

- Bi-Directional Reflectance Factor
- Land Surface Emissivity

Albedo

- Surface Albedo
- MSG Ten Day Surface Albedo

Land Surface Temperature

- Land Surface Temperature (15 mins)

Down-welling Surface Fluxes

- Down-welling Surface Short-wave Radiation Flux
- Down-welling Surface Long-wave Radiation Flux
- Daily Downward Surface Shortwave Flux
- Daily Downward Surface Longwave Flux

Evapotranspiration

- Evapotranspiration (30 mins)
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The LSA-SAF: Products

- **Surface products from MSG/SEVIRI:** fires, vegetation, snow, albedo, surface temperature, radiative fluxes, evapotranspiration

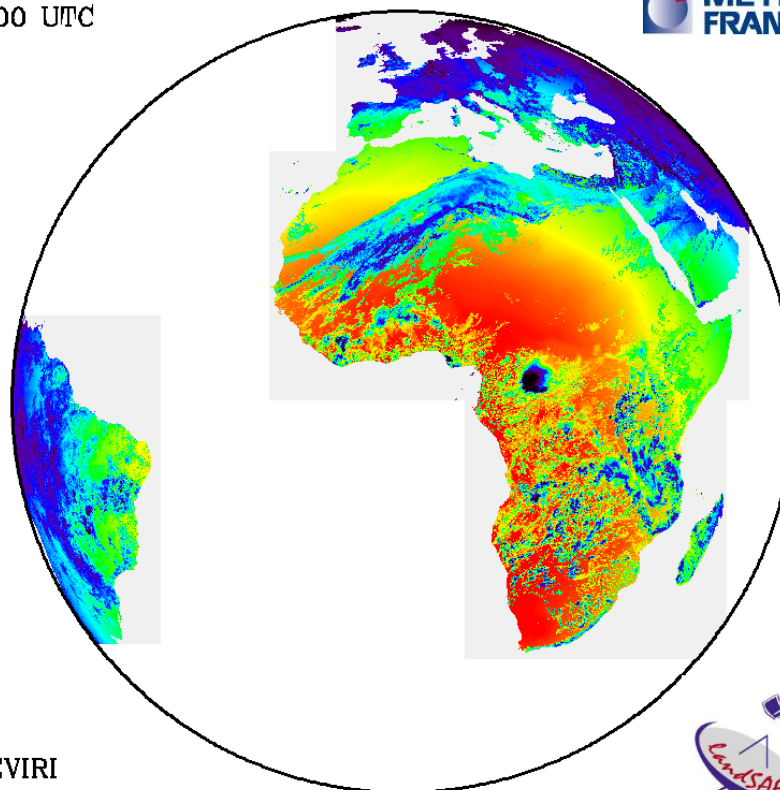
- **Shortwave flux (DSSF):**

15.02.2006 12:00 UTC

DSSF in W/m^2

1000
800
600
400
200
0

Meteosat-8/SEVIRI



MSG/SEVIRI based products

Wild Fires

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- Fire Radiative Power - GRID
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- Evapotranspiration (30 mins)
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Outline

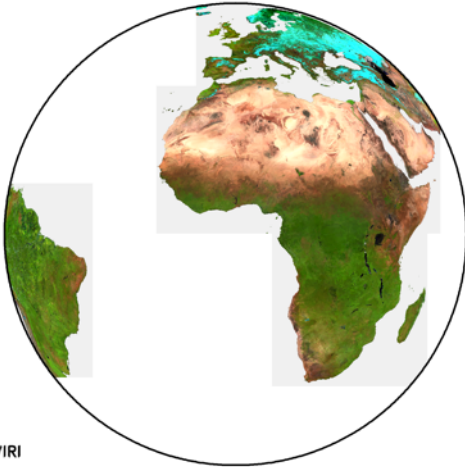
- LSA-SAF program
- **Surface albedo**
- Downwelling surface shortwave flux
- Conclusions and future work

LSA-SAF albedo: Characteristics

Color composite of 3 spectral albedos

01.03.2006

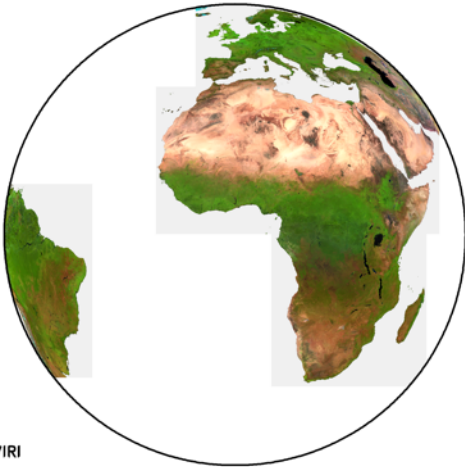
AL-SP-DH Colour Composite
R: 1.6 μ m, G: 0.8 μ m, B: 0.6 μ m



Meteosat-8/SEVIRI

01.07.2006

AL-SP-DH Colour Composite
R: 1.6 μ m, G: 0.8 μ m, B: 0.6 μ m



Meteosat-8/SEVIRI

- **Spatial resolution:** 3 km at the equator
- **Projection:** MSG/SEVIRI native
- **Several albedo products:**
 - **Temporal:** daily and 10-day
 - **Spectral:** 0.6 μ m, 0.8 μ m, and 1.6 μ m
 - **Angular:** DH et BH
 - **Broadband:** VIS, NIR, SW
- **Uncertainties!**

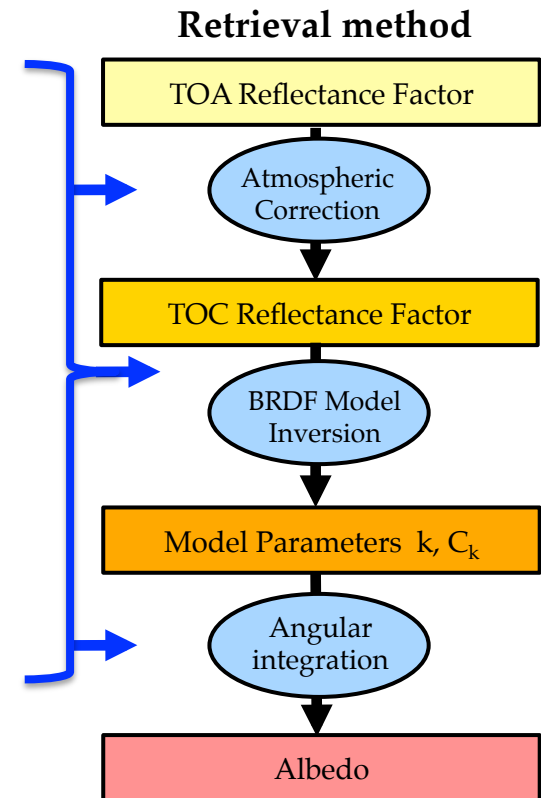
Accuracy:

- **Daily albedo:** 10-20% bias for VIS (due to aerosols) and 5% for SW and NIR
- **10-day albedo:** maximum bias of 10%

LSA-SAF albedo: Inputs and retrieval method

Inputs

- **Radiances** at 0.6 μm , 0.8 μm , 1.6 μm (SEVIRI)
- Solar and satellite **zenith angles** (SEVIRI)
- **Cloud mask** (NWC-SAF)
- **Water vapor** column and pressure (ECMWF)
- **Ozone** content (ECMWF)



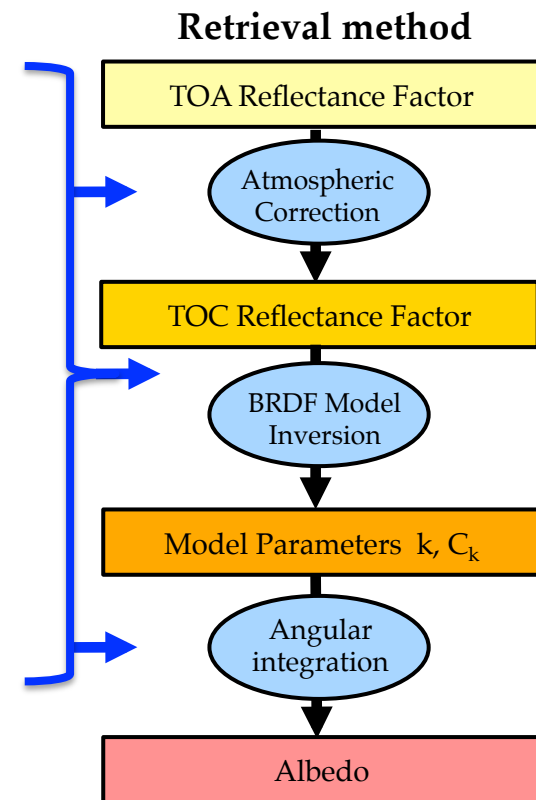
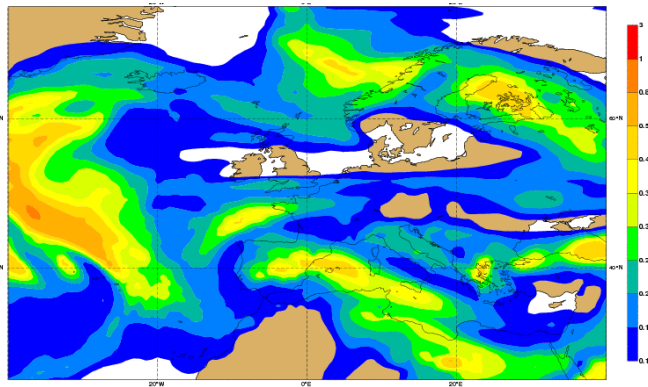
[Geiger et al.,
IEEE TGRS, 2008]

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- **Aerosol optical thickness**
 - ✧ *OP. chain: climatology / MACC ch.: MACC-II*

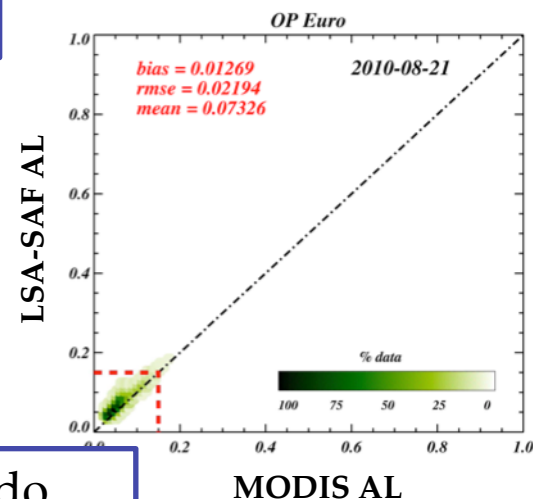
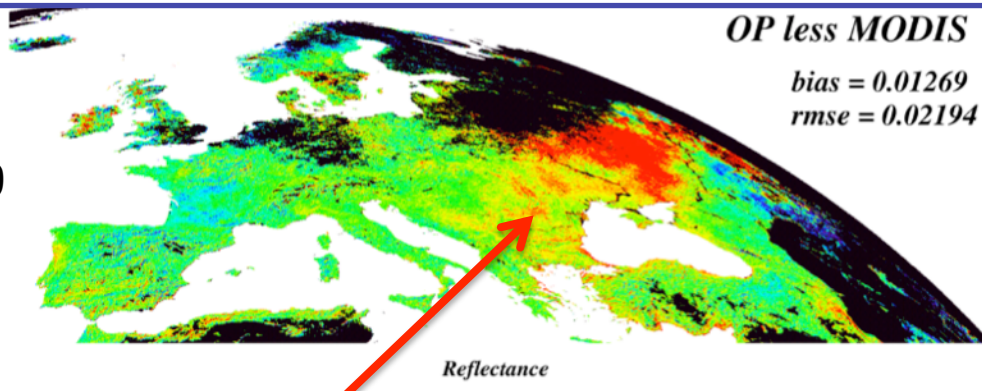
AOD at 550 nm on Feb 28th at 15h, 2013



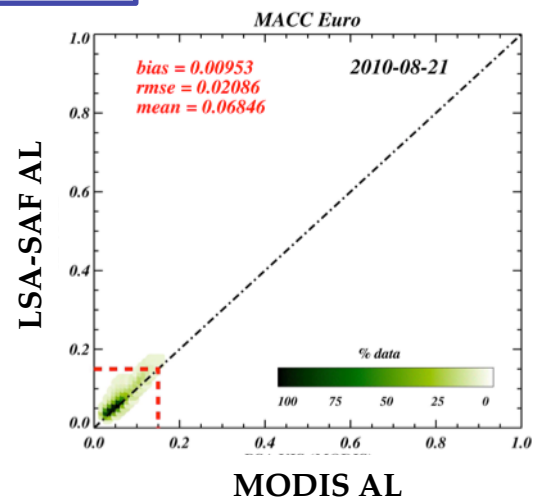
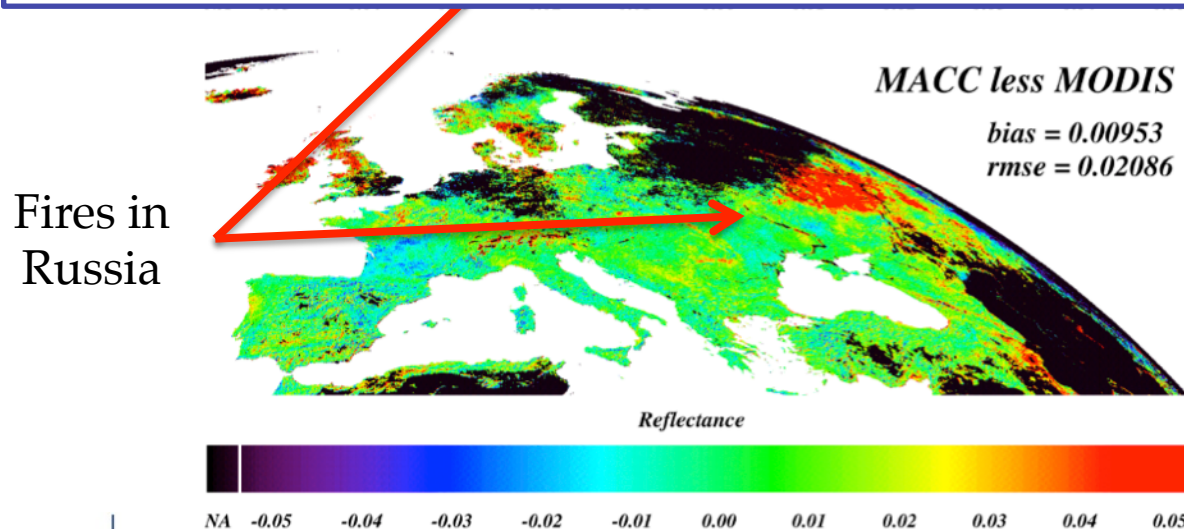
[Geiger et al.,
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LSA-SAF albedo: Assessment

Difference between OP LSA-SAF and MODIS VIS albedo



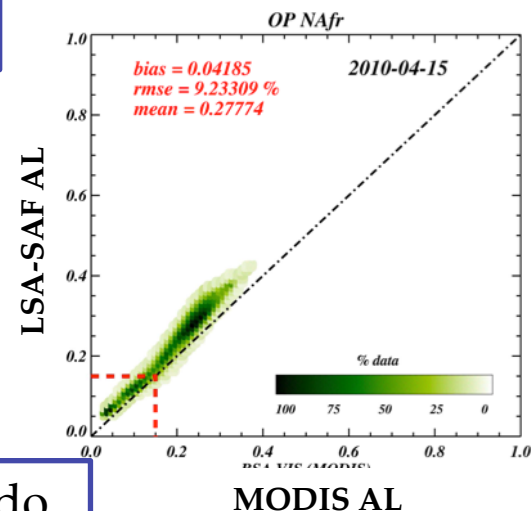
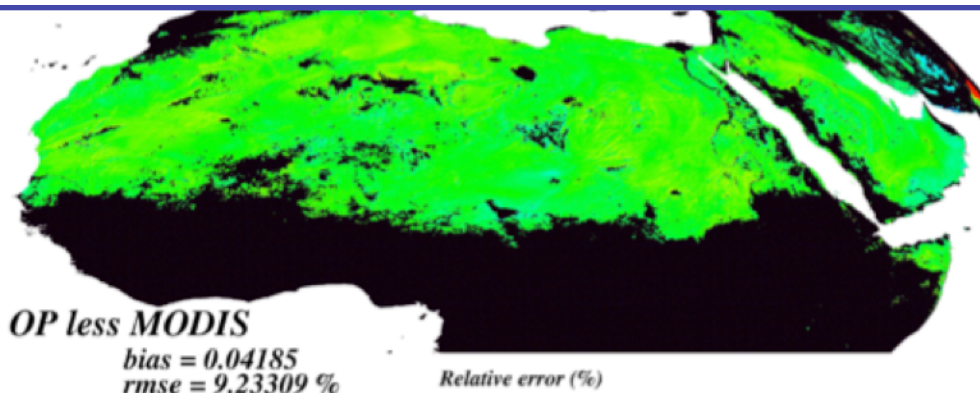
Difference between MACC LSA-SAF and MODIS VIS albedo



LSA-SAF albedo: Assessment

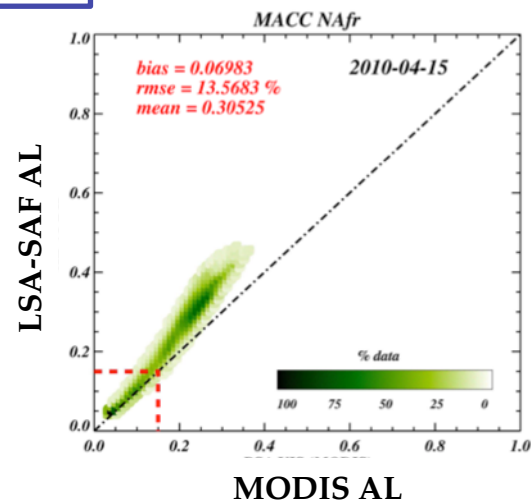
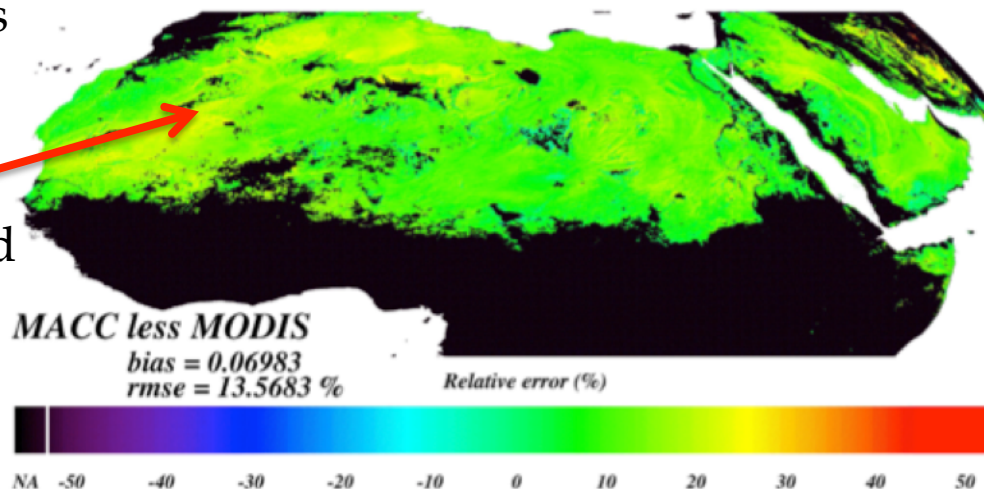
Difference between OP LSA-SAF and MODIS VIS albedo

15-04-2010



Difference between MACC LSA-SAF and MODIS VIS albedo

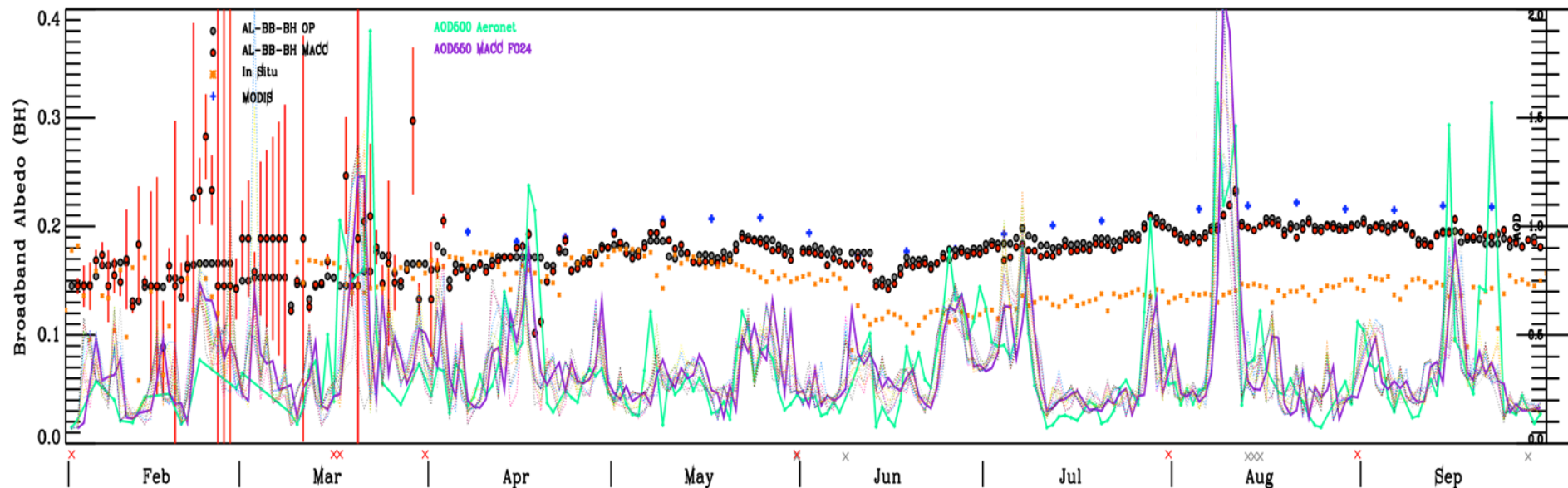
Differences in AOD product used by MODIS and MACC-II



LSA-SAF albedo: Assessment

- Temporal series compared to MODIS and in situ measurements

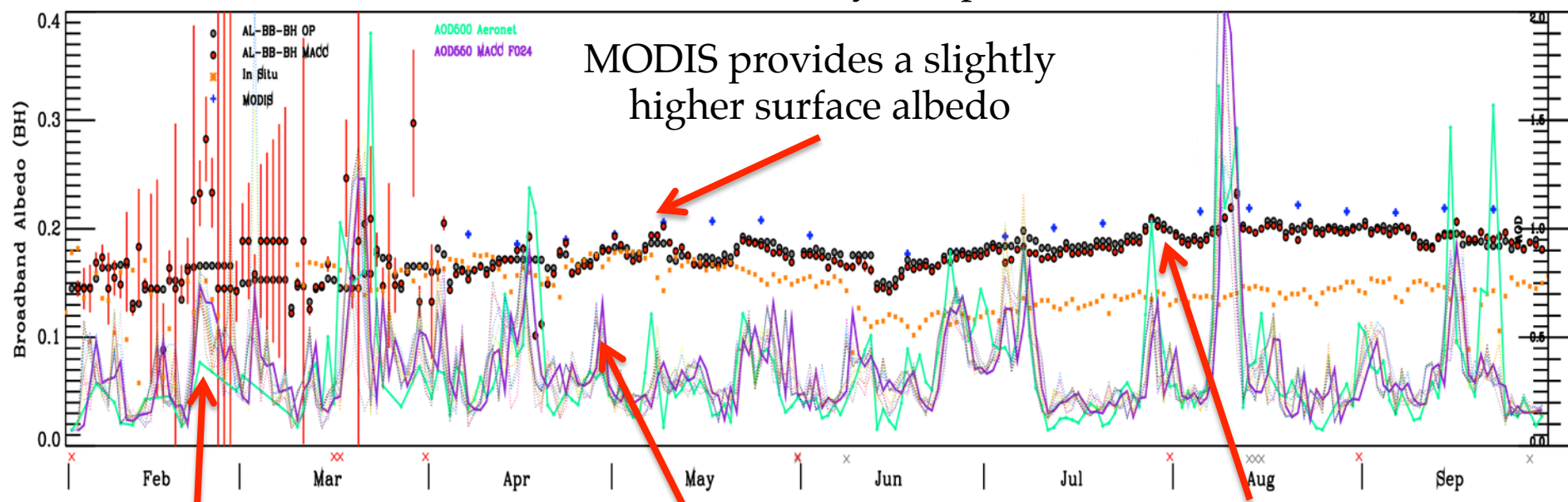
Evora station from February to September 2010



LSA-SAF albedo: Assessment

- Temporal series compared to MODIS and in situ measurements

Evora station from February to September 2010



High albedo
uncertainties due to
cloudy conditions

Moderate agreement
between MACC-II and
AERONET data

Spatial representativeness of
tower measurements with regard
satellite products?

LSA-SAF albedo: Spatial representativeness

➤ Station at Evora, Portugal

✧ Crops and sparse vegetation



Tower at Evora station



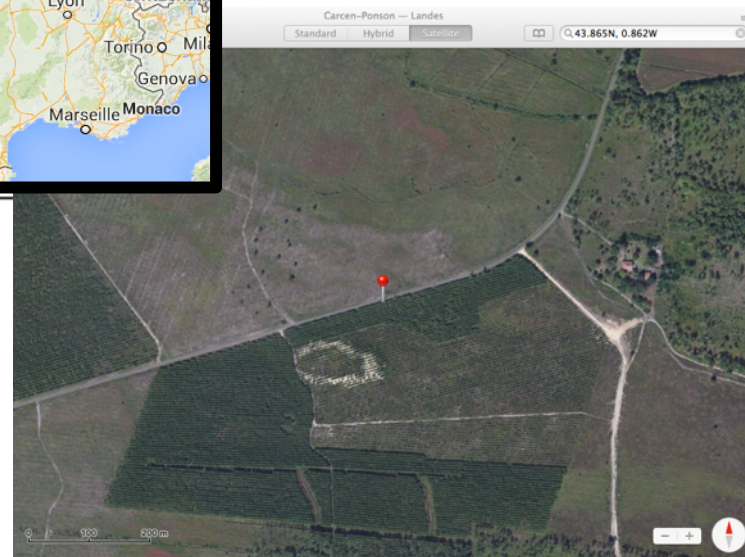
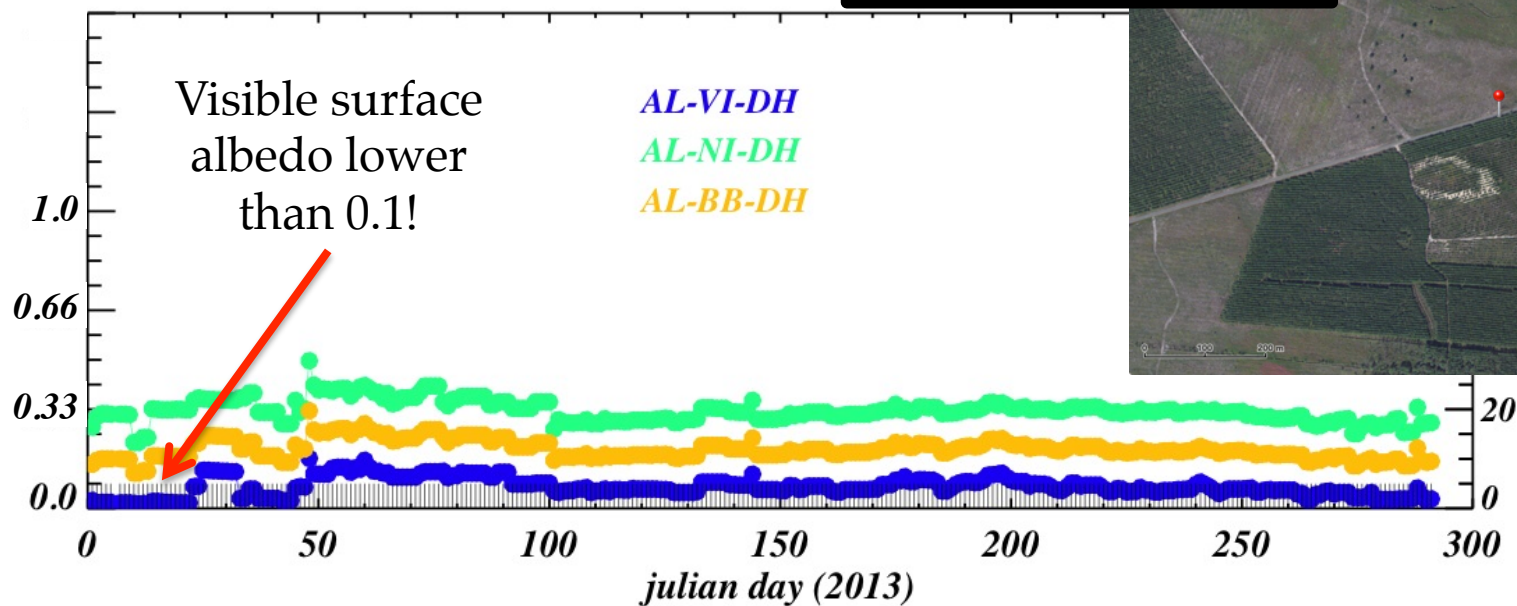
Satellite view of Evora station

Different land cover units are observed from tower and satellite observations!

LSA-SAF albedo: Assessment

- Case study:
 - ✧ Surface albedo in the Landes forest

SFr



LSA-SAF albedo: Assessment

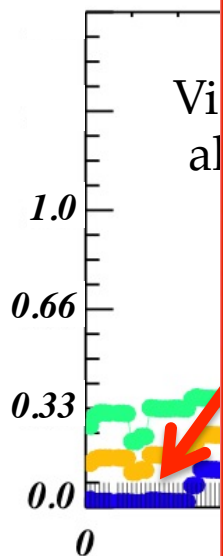
➤ Ca



Field campaign, September 2013

✧ SVC hyperspectral sensor

✧ Wet soil albedo lower than 0.1!

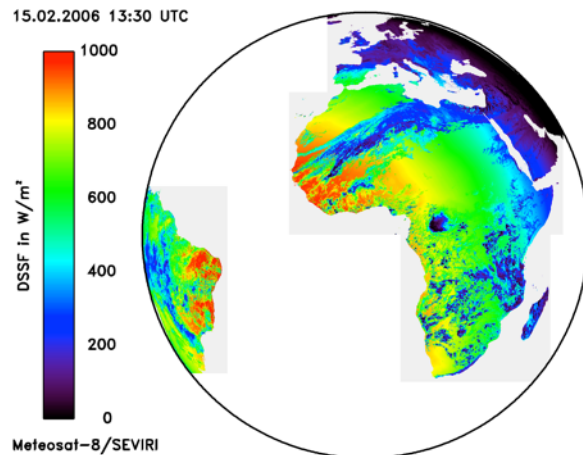


Outline

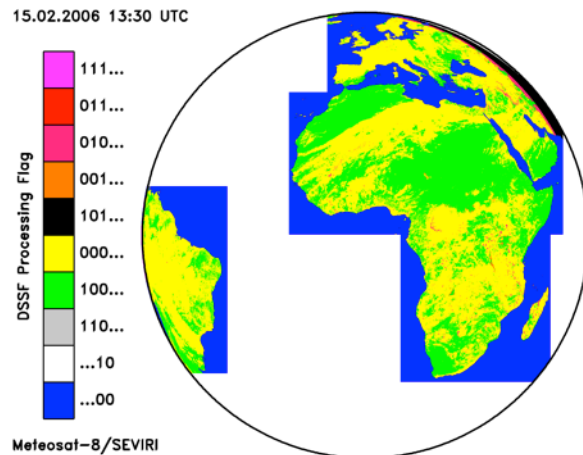
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- **Downwelling surface shortwave flux**
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LSA-SAF shortwave radiation: Characteristics

LSA-SAF product DSSF



LSA-SAF flag DSSF



- **Spatial resolution:** 3 km at the equator
- **Projection:** MSG/SEVIRI native
- **Several DSSF products:**
 - **Temporal:** instantaneous and daily
- **Inputs:** similar to albedo product
 - ✧ **Static aerosol conditions!**

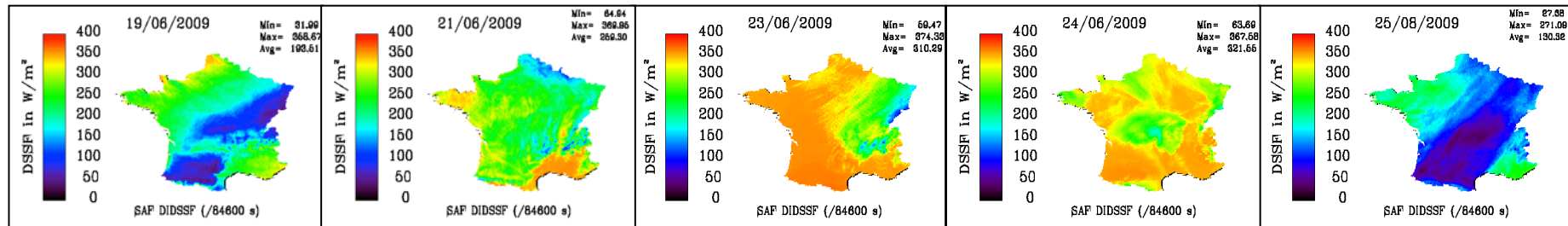
Accuracy:

- **Instantaneous DSSF:** bias of $\pm 5-10\%$
- **New method:** aeroMix
 - ✧ Dynamic AOD and aerosol type (MACC-II)
 - ✧ Consideration of aerosol mixtures

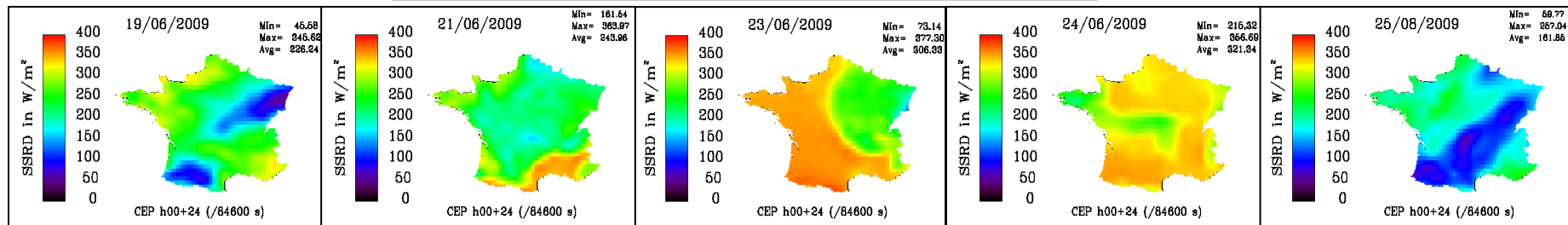
LSA-SAF shortwave radiation: Assessment

- Evaluation with meteorological model outputs
 - ✧ Integrated forecast system (IFS) from the ECMWF

LSA-SAF (satellite) product DSSF

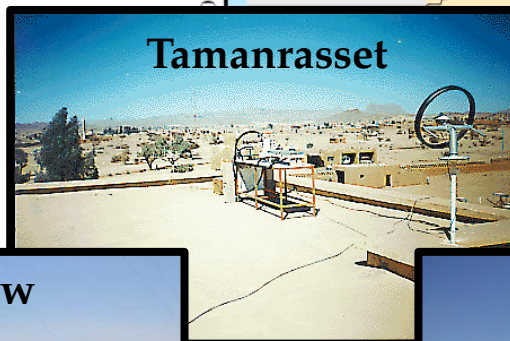
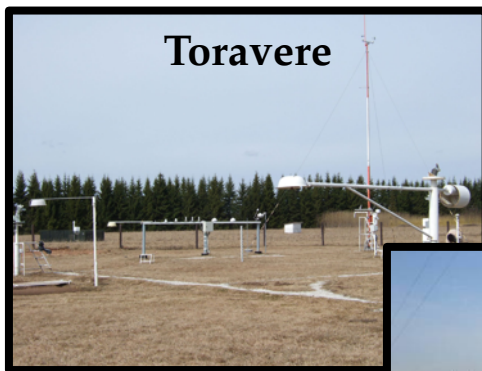
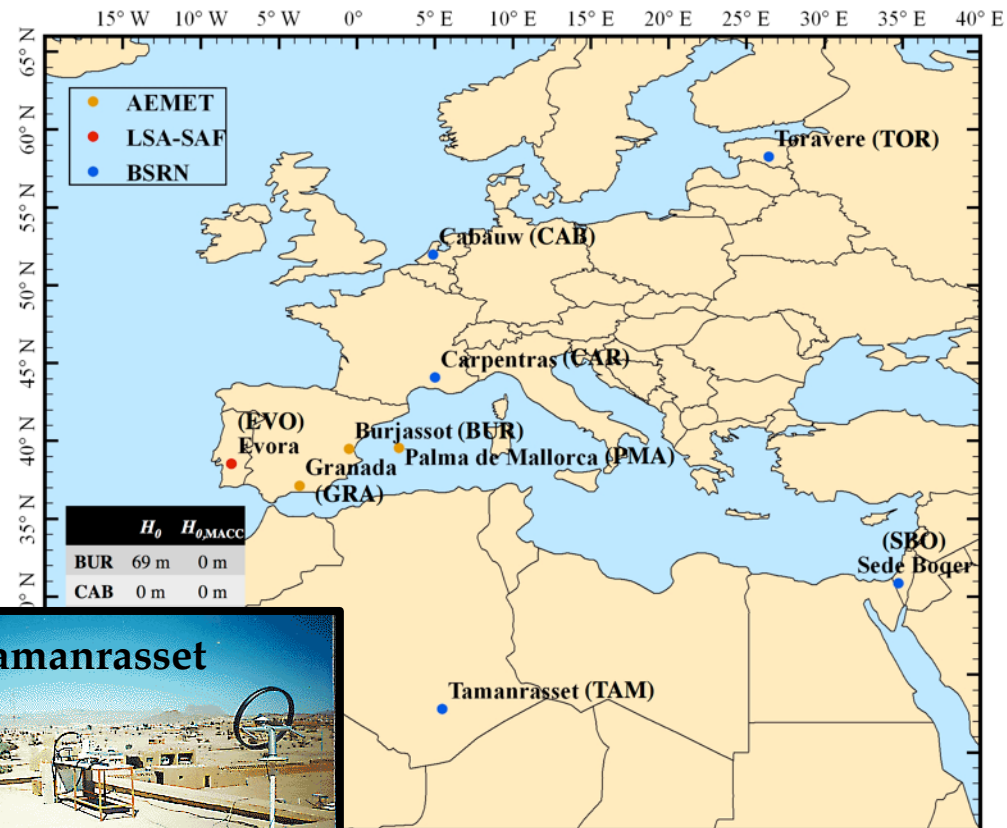


ECMWF (model) product DSR



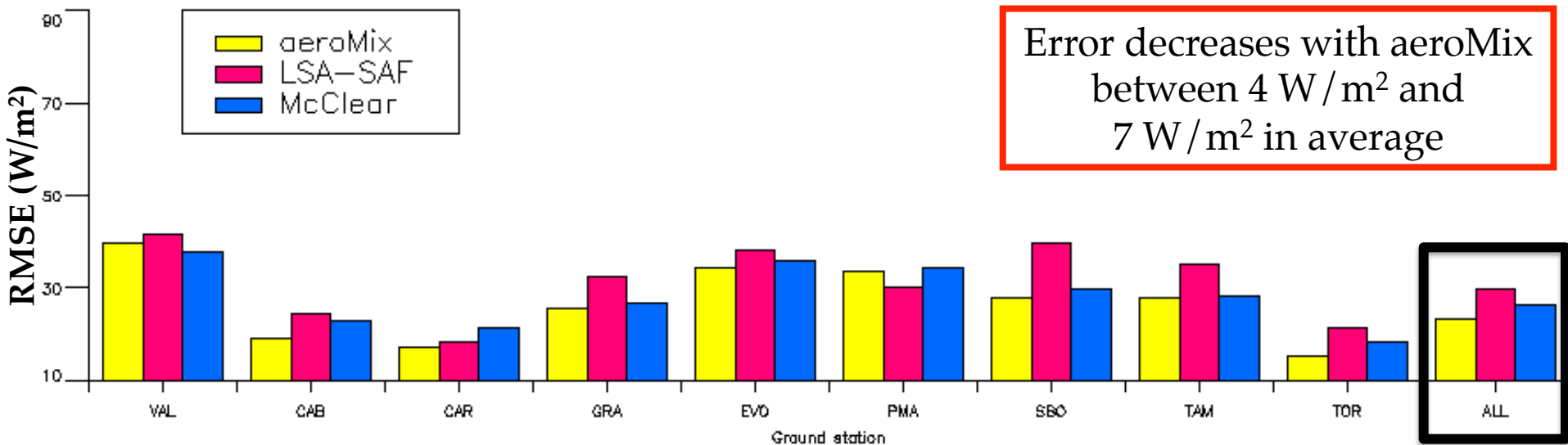
LSA-SAF shortwave radiation: Assessment

- In situ measurements:
 - Year 2011
 - 9 ground stations from
 - ✧ **BSRN** network
 - ✧ **AEMET** network
 - ✧ **LSA-SAF** network



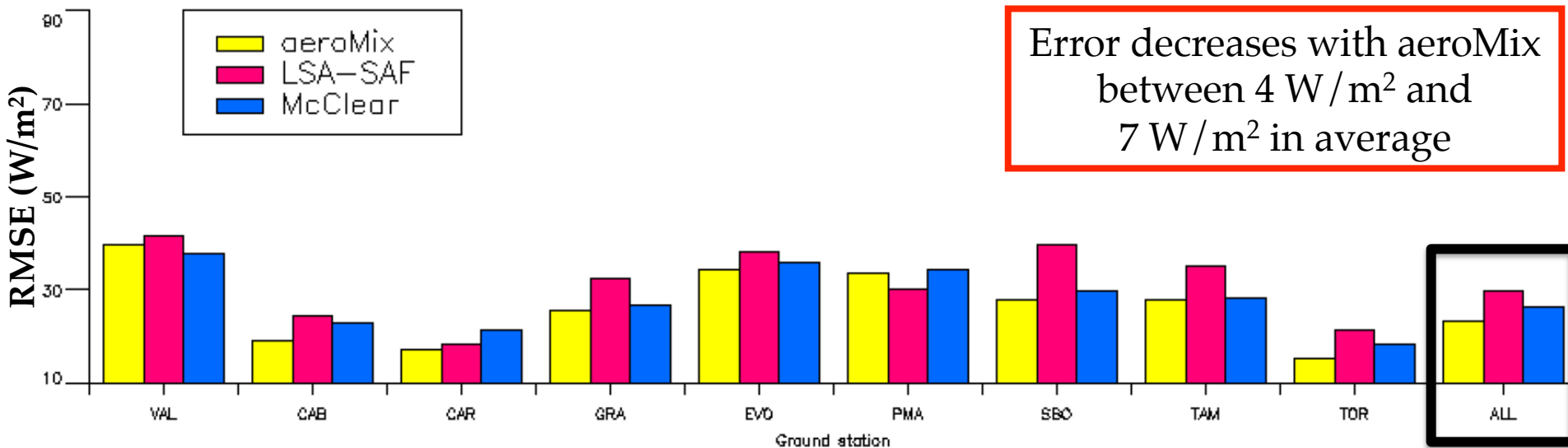
LSA-SAF shortwave radiation: Assessment

➤ Error for estimated DSSF:



LSA-SAF shortwave radiation: Assessment

➤ Error for estimated DSSF:



➤ Use of in situ measurements as input data to run aeroMix

Input data	RMSE of estimated DSSF in Carpentras
AERONET for AOD, H ₂ O, and O ₃	11.0 W/m ²
ECMWF for AOD, H ₂ O, and O ₃	17.3 W/m ²

Still significant inaccuracies coming from operational inputs!

Outline

- LSA-SAF program
- Surface albedo
- Downwelling surface shortwave flux
- **Conclusions and future work**

Conclusions and future work

- ✧ Validation of surface products leads to their improvement
 - Importance of in situ measurements for validation
 - ✧ Large spatial coverage and long temporal series
 - ✧ **Crucial issue for surface albedo: Spatial representativeness!**
 - Importance of other satellite and model products
 - ✧ Inter-comparison issues!
 - Importance of aerosol effects for VIS albedo and SW radiation
 - ✧ **Crucial issue: Need of high quality aerosol data!**
- ✧ Continuous algorithm improvement in CDOP-2
- ✧ Global coverage using polar MetOp satellites
- ✧ Preparation for the arrival of MTG

Thank you for your attention!

Publications

Albedo:

D. Carrer et al., "Evaluating operational MSG/SEVIRI land surface albedo products from LSA-SAF with ground measurements and MODIS", *IEEE Transactions on Geoscience and Remote Sensing*, 2010

B. Geiger, "Land Surface Albedo derived on a daily basis from Meteosat Second Generation Observations", *IEEE Transactions on Geoscience and Remote Sensing*, 46, 3841–3856, 2008

Product User Manual and Validation Report

DSSF:

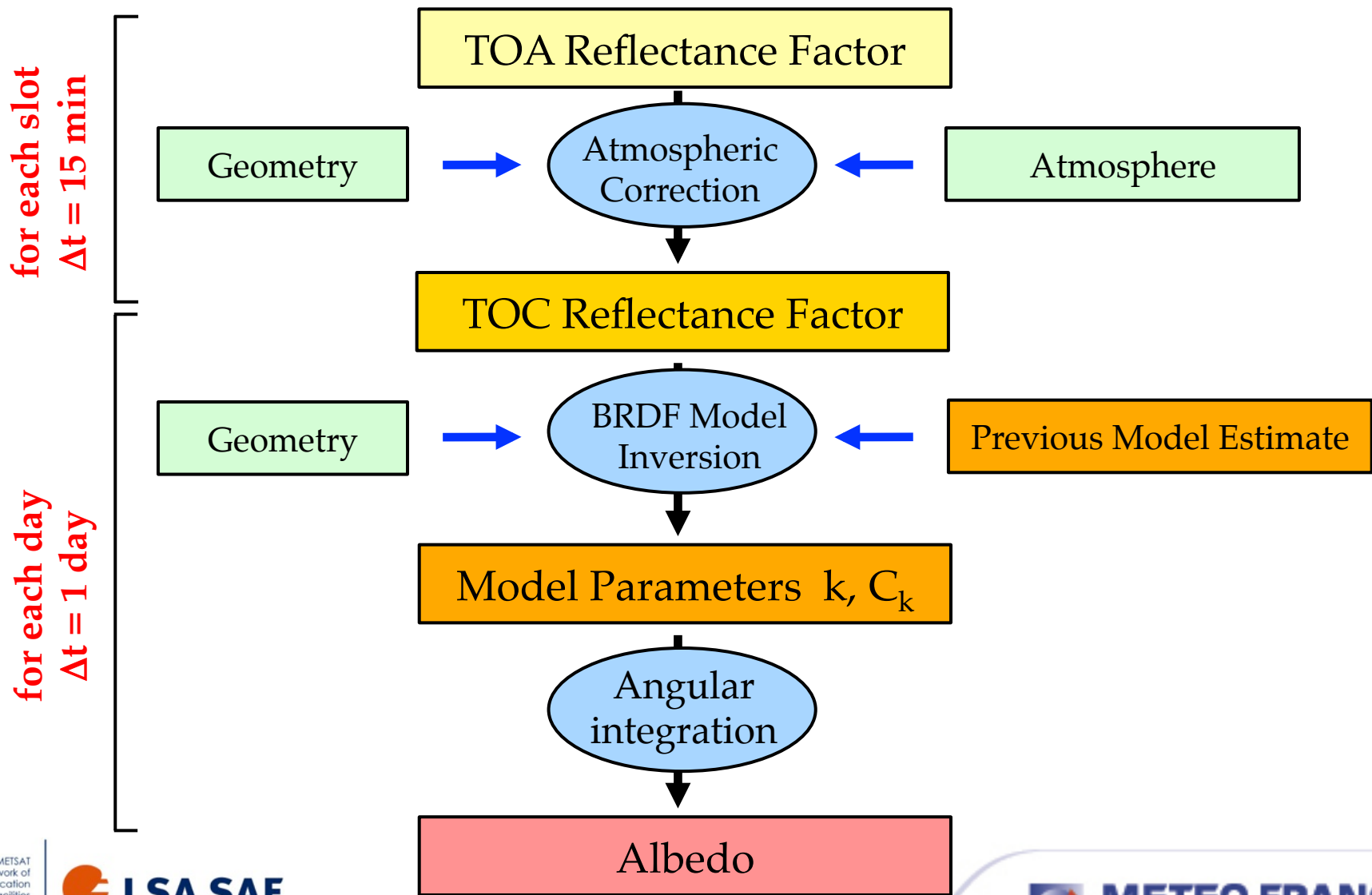
Geiger, B, C. Meurey, D. Lajas, L. Franchistéguy, D. Carrer, and J.-L. Roujean, 2008: Near real-time provision of downwelling shortwave radiation estimates derived from satellite observations, Royal Meteorological Society, 15, 411-420.

LPVE 2014 – 28-30 January 2014



METEO FRANCE
Toujours un temps d'avance

LSA-SAF surface albedo: Retrieval method



LSA-SAF surface albedo: Accuracy

- **Daily albedo:** bias of 10-20% in the VIS (mainly due to the presence of aerosols) and of 5% in the SW and NIR
- **10-day albedo:** maximum bias of 10%

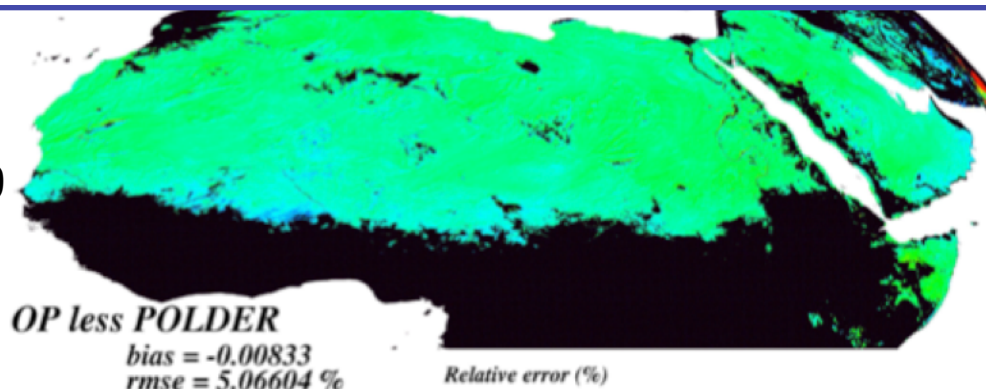
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- Product User Manual and Validation Report

LSA-SAF surface albedo: Assessment

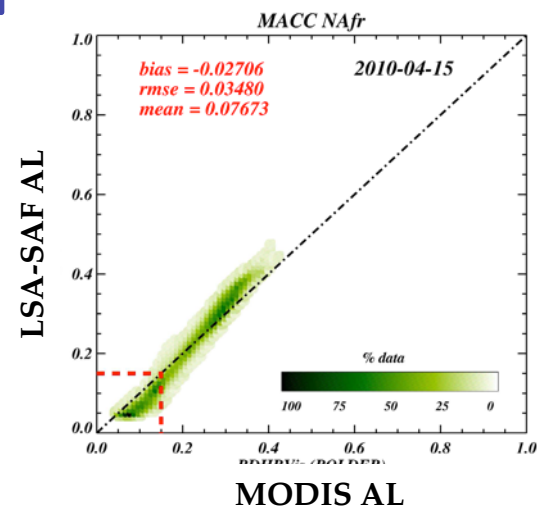
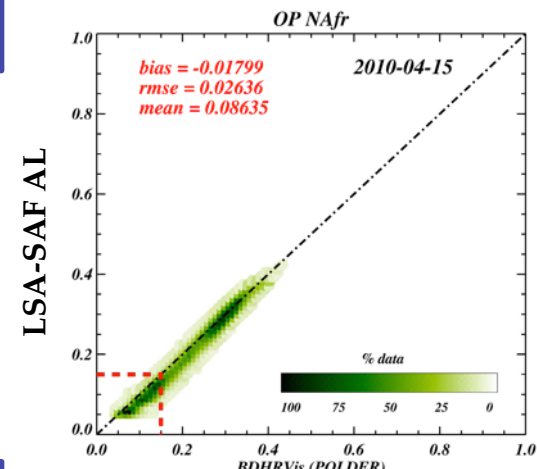
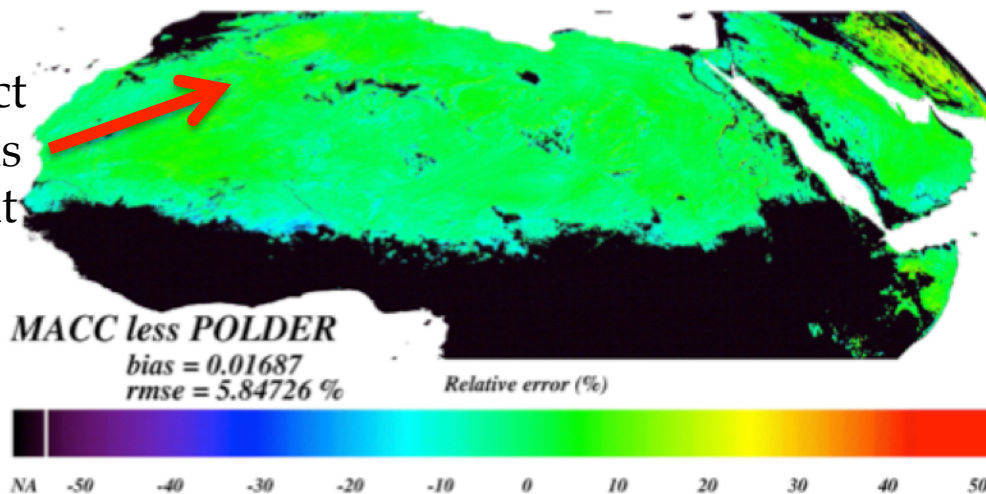
VIS LSA-SAF albedo (climatol. AER) – **POLDER** albedo

15-04-2010

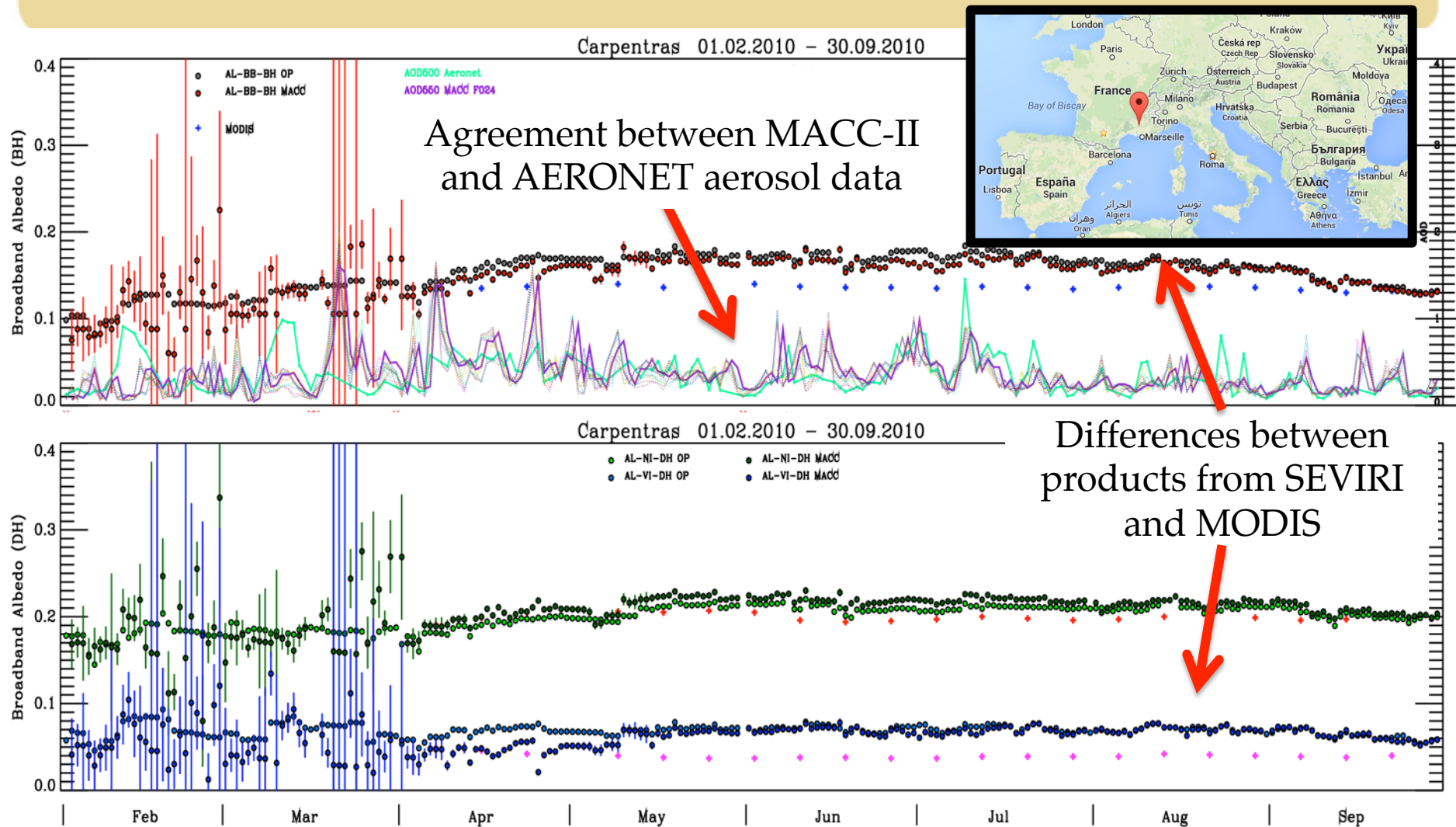


VIS LSA-SAF albedo (MACC-II AER) – **POLDER** albedo

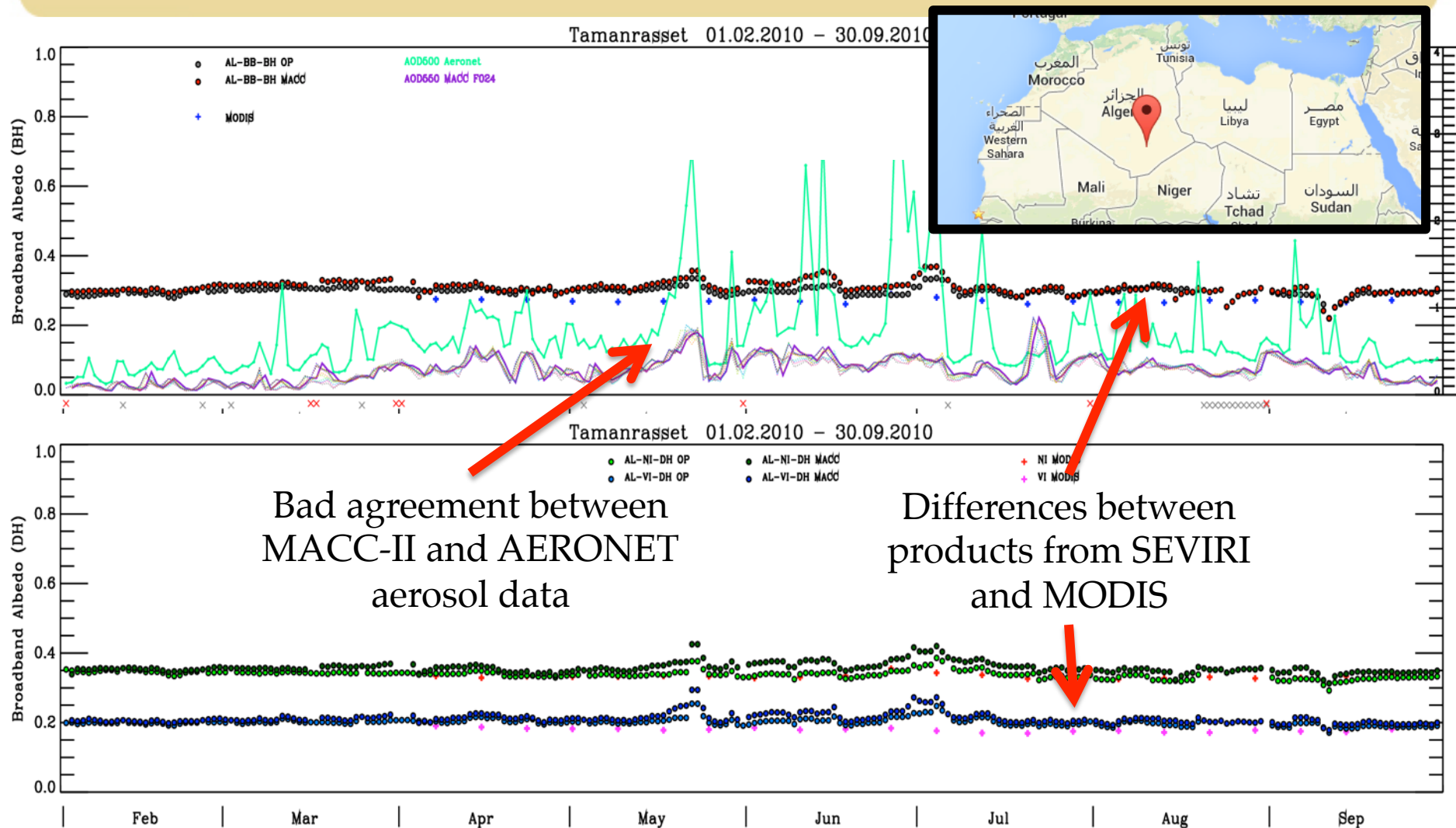
POLDER
does correct
for aerosols
over bright
targets



LSA-SAF surface albedo: Assessment



LSA-SAF surface albedo: Assessment



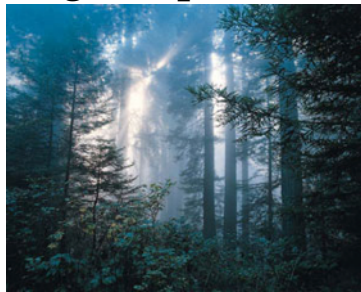
Shortwave radiation: Recent improvements

➤ New method **aeroMix**

- ✧ **Clear sky conditions only.**
- ✧ **Aerosol content and type (mixtures!)** are taken into account
- ✧ **Operational implementation** using **ECMWF outputs** for gases and aerosols (MACC-II)

DSSF is
calculated
taking into
account
aerosols
coming from

Organic particles



Black carbon



Desert dust



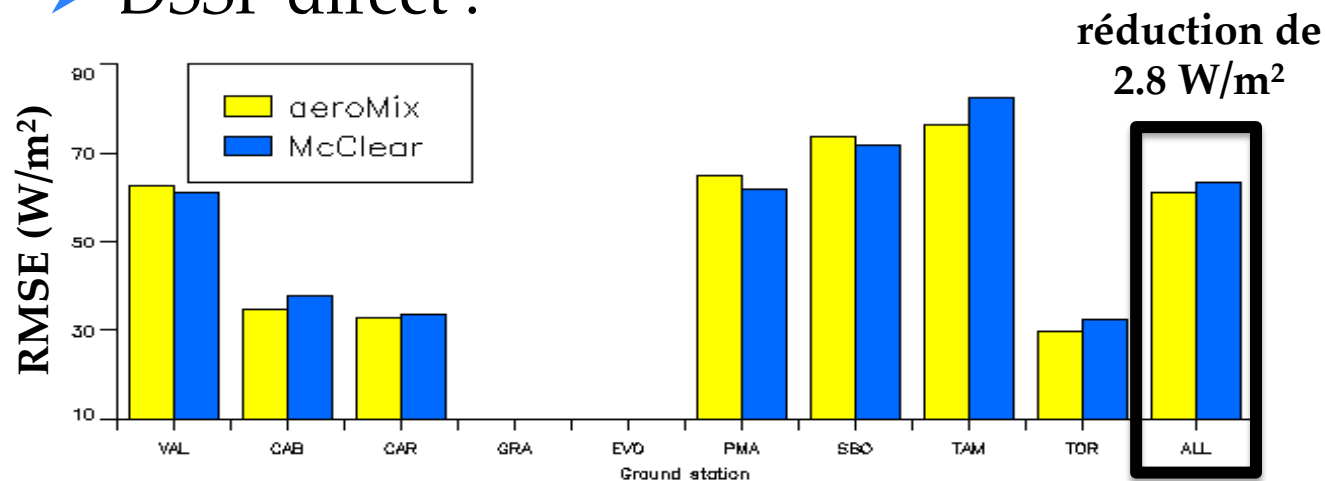
Sulphates



Sea salt

Résultats : validation avec données « in situ »

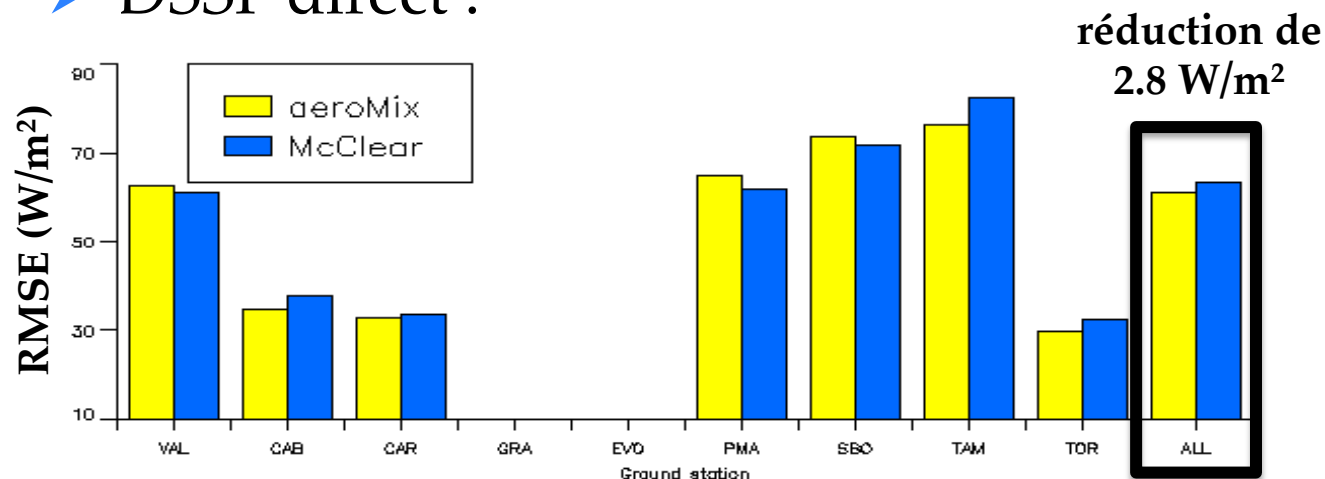
➤ DSSF direct :



Résultats très similaires entre « aeroMix » et « McClea »

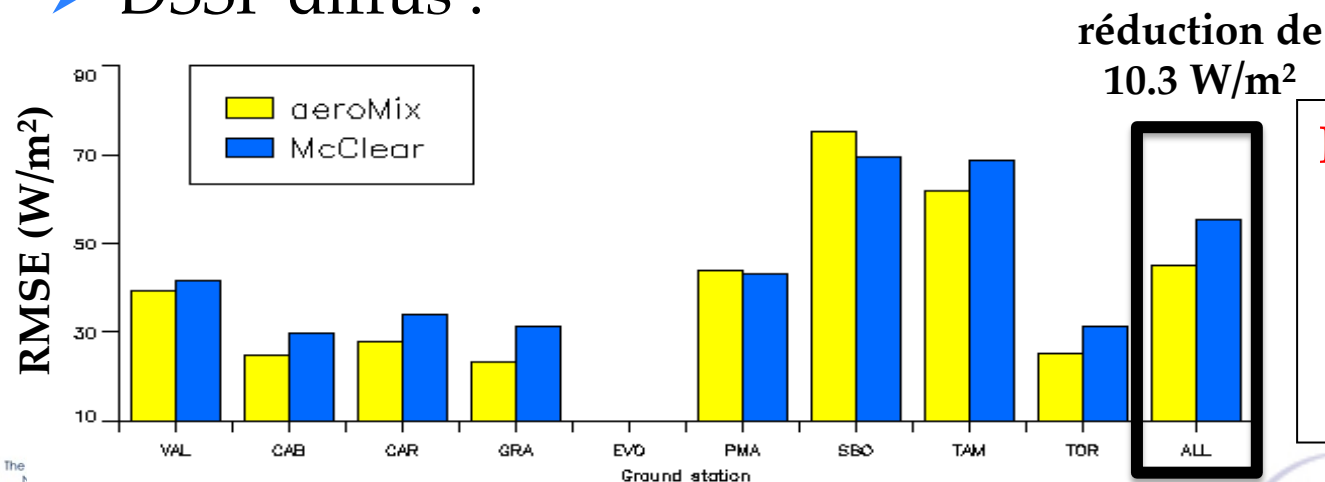
Résultats : validation avec données « in situ »

➤ DSSF direct :



Résultats très similaires entre « aeroMix » et « McClear »

➤ DSSF diffus :



Meilleure estimation du DSSF diffus par « aeroMix » grâce à la considération de mélanges d'aérosols