MACCS

AN OPERATIONAL ATMOSPHERIC CORRECTION TOOL FOR SENTINEL-2 AND LANDSAT TIME SERIES

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PROCESSING MULTI-TEMPORAL SERIES

MACCS (Multi-Mission Atmospheric Correction and Cloud Screening)

is an operational software which generates Level-2A products

from time series of L1C products from optical remote sensing satellites.

Level-1C products: Top Of Atmosphere orthorectified reflectance

Level-2A products: orthorectified surface reflectance images after atmospheric correction along with mask of clouds, cloud shadows, water and snow

MACCS has been designed to process temporal series of products

at high resolution, high revisit and under constant viewing angles

MACCS uses the temporal dimension to improve the knowledge of the area imaged. MACCS is based on recursive and multi-temporal methods which make the distinction between

- Elements which vary slowly i.e. the landscape itself (surface reflectance)
- Elements which vary quickly such as clouds, cloud shadows and aerosols
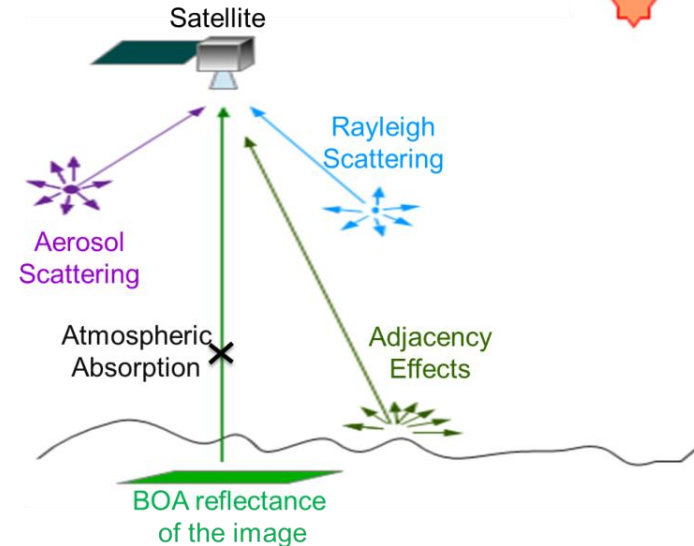
PROCESSING MULTI-TEMPORAL SERIES

Brief explanation of algorithms implemented in MACCS:

- Mask estimation:
  - ✓ Cloud cover using multi-temporal method (rapid increase of the blue band reflectance) and cirrus band (if available)
  - ✓ Cloud shadows using detected cloud location and multi-temporal method (sudden darkening)
  - ✓ Water using SRTM and multi-temporal method
  - ✓ Snow using SWIR bands (if available)
  - ✓ Relief shadows using MNT and viewing and solar angles

- Estimation of
  - ✓ Water vapor using water vapor band (if available) or weather analysis data
  - ✓ Aerosol optical thickness (AOT) combining multi-temporal and multi-spectral (Dark Dense Vegetation) methods

PROCESSING MULTI-TEMPORAL SERIES

Brief explanation of algorithms implemented in MACCS:

- Correction of atmospheric effects:
    - ✓ Atmospheric absorption (especially water vapor, ozone, oxygen and carbon dioxide)
    - ✓ Scattering by air molecules (Rayleigh)
    - ✓ Scattering by aerosols
    - ✓ Adjacency effects

- Correction of lightening variations due to relief using MNT and considering a bidirectional reflectance distribution function.

PROCESSING MULTI-TEMPORAL SERIES

MACCS software is actually able to process othorectified TOA products issued from several missions:

- Sentinel-2
- Landsat 5, 7 and 8
- Venµs
- Formosat-2
- Spot4/Take5 & Spot5/Take5
  Simulation of ESA SENTINEL-2 mission time series

In order to increase repetitivity over a region, MACCS allows to process time series of products issued from different sensors having similar bands (e.g. Landsat8/Sentinel-2)

OPERATIONAL USE OF MACCS

MACCS is used operationally by the following projects:

- Sentinel-2 Simplified Level-2 Processor at ESA-ESTEC

- Sentinel-2 Technical Expertise Center at CNES

- Venµs Image Processing center in France and in Israel

- ESA project Sentinel-2 for Agriculture (Sen2-Agri)

- THEIA processing center at CNES
  THEIA: a French national multi-agency organization which promotes the
  use of satellite data by scientific community and public policy actors.

OPERATIONAL USE OF MACCS

The THEIA land data center produces and distributes L2A products from:

- Landsat5&7
  2009-2011 over France
  ~ 7 000 images

- Landsat8 in real-time
  2013-present over France
  ~ 6 000 images

  available on http://theia.cnes.fr

- Spot4-Take5
  45 sites every 5 days
  during 6 months in 2013
  ~ 800 images

- Spot5-Take5
  150 sites
  during 6 months in 2015
  ~ 3 000 images

  available for non-commercial use
  on http://spot-take5.org

- Sentinel-2A&B in real-time
  on five million square kilometers

  soon
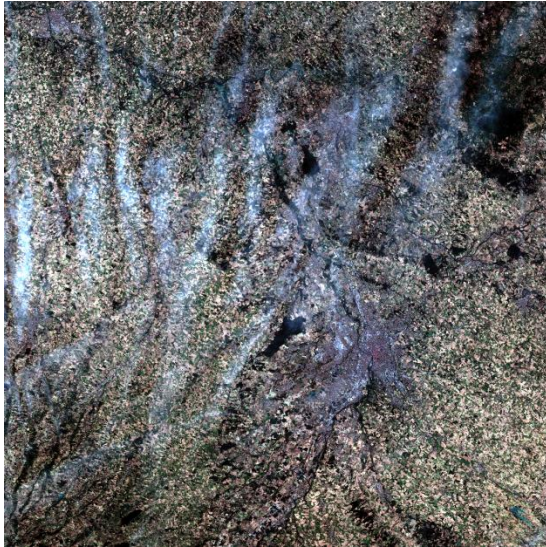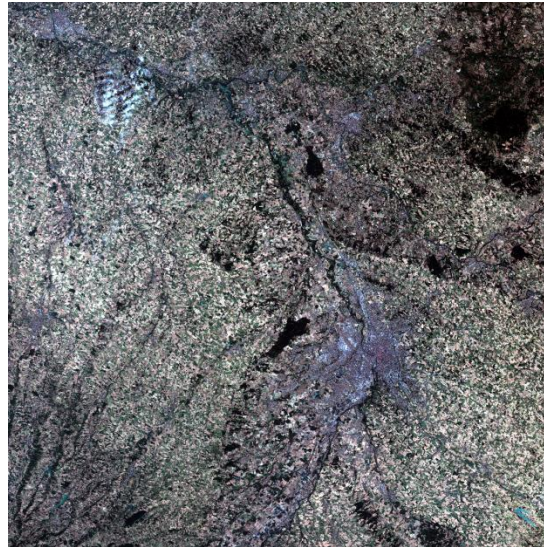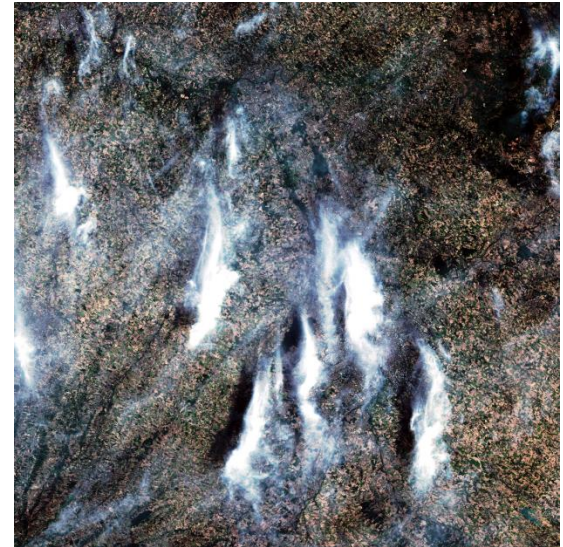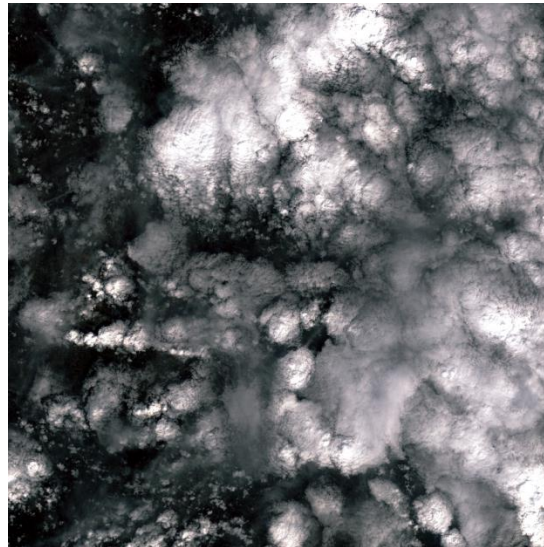
06/07/2015

16/07/2015

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05/08/2015

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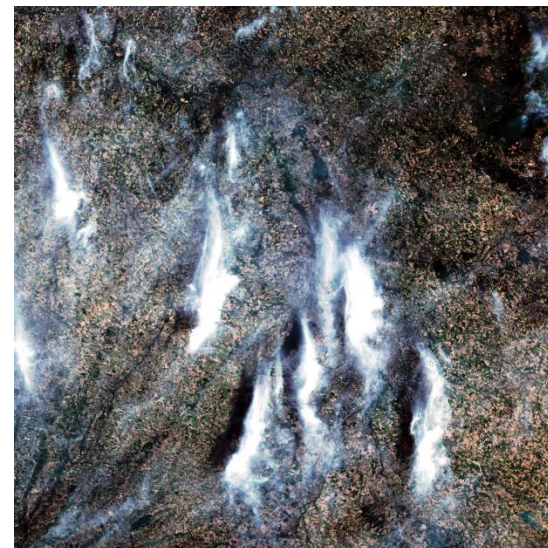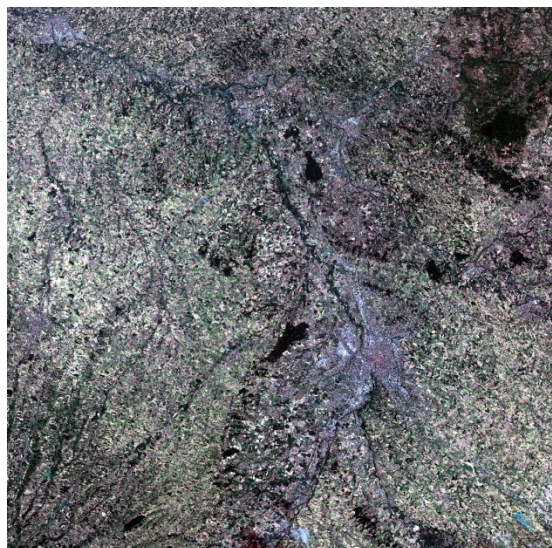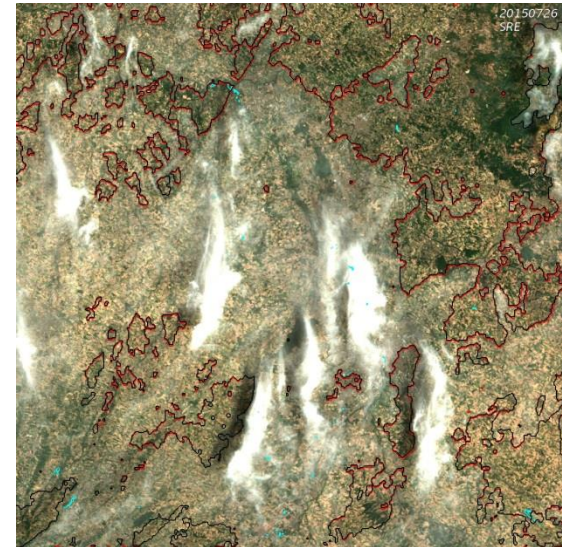

16/07/2015

26/07/2015

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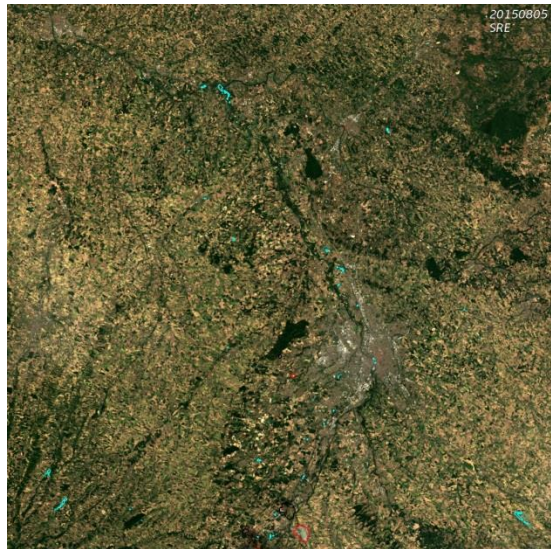**Images with a high percentage of clouds (90%) are not processed by MACCS**
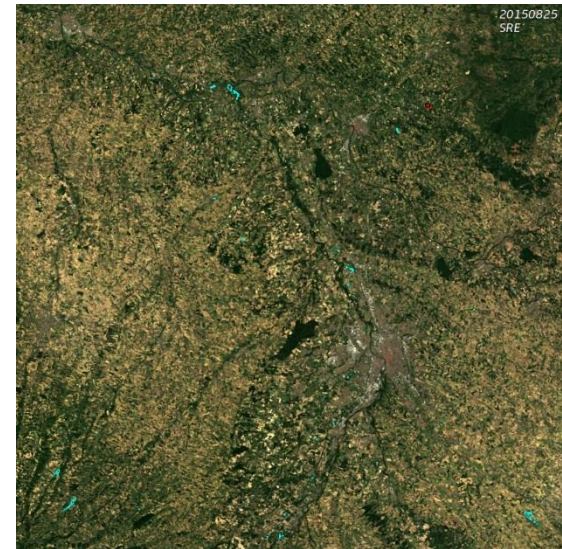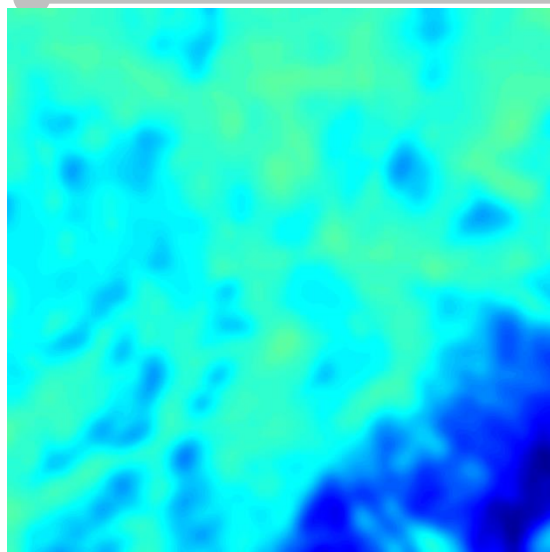15/08/2015
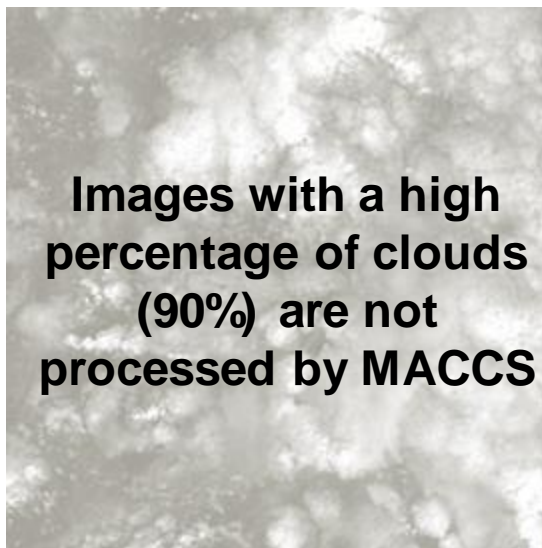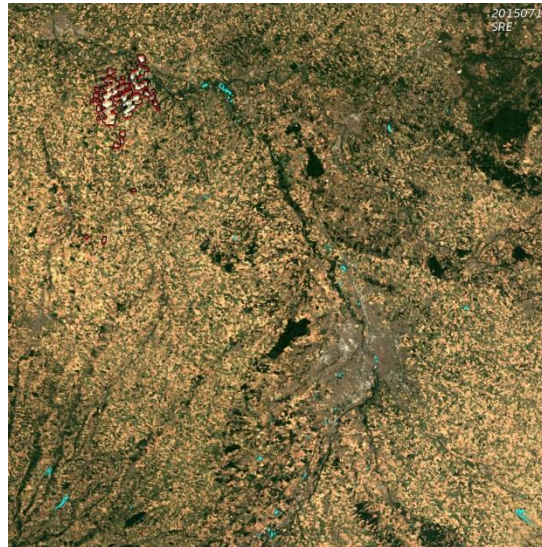
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L2A products over Toulouse area.

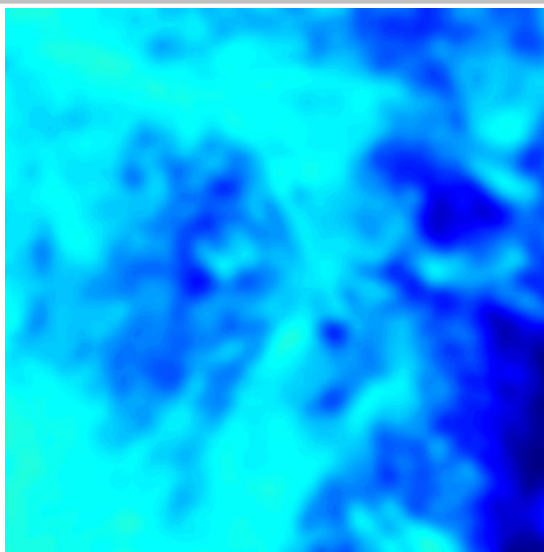**Detected clouds are circled in red shadows in black and water in blue.**
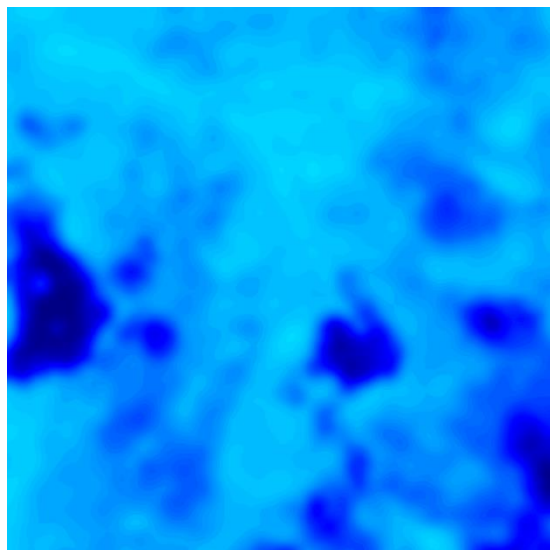
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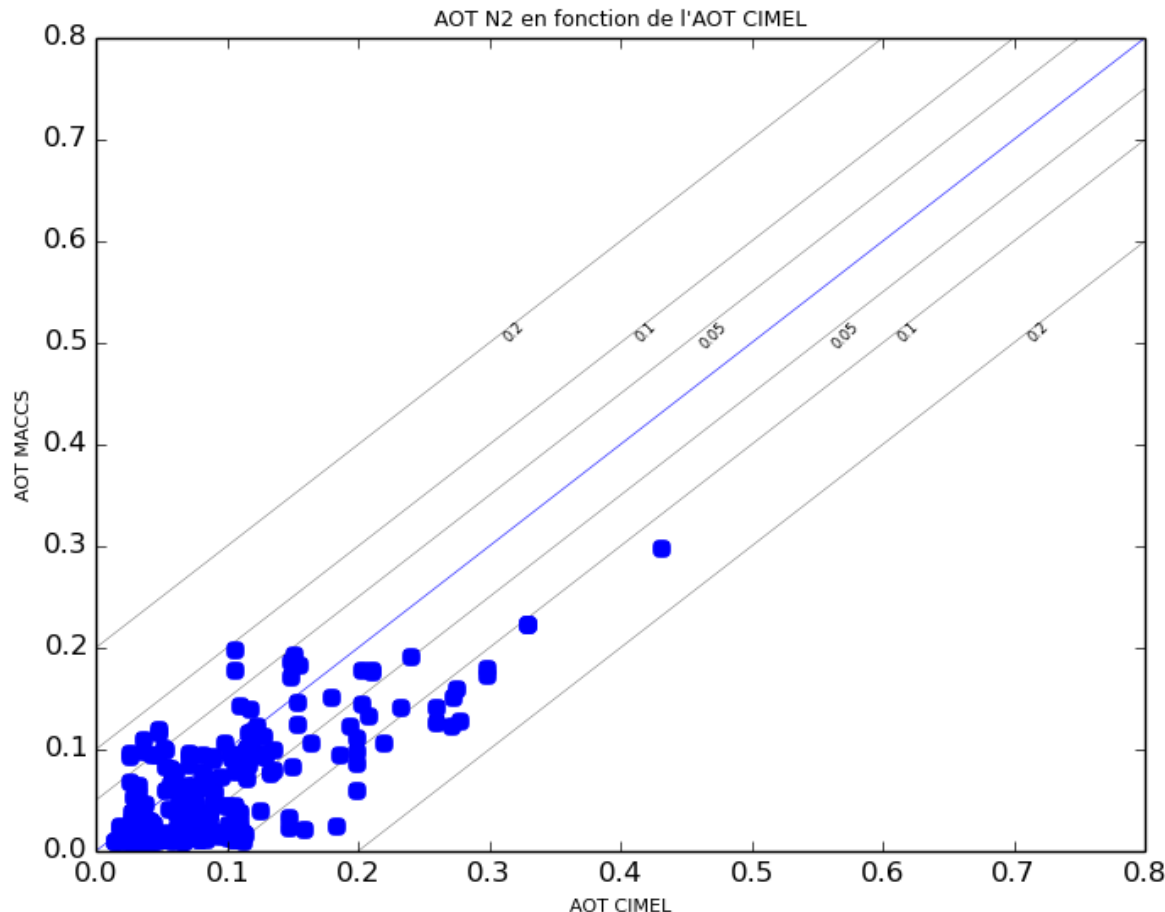0   0,3   0,6
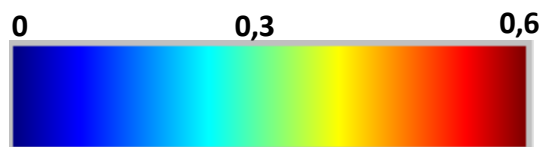
**AOT estimation
over Toulouse area**
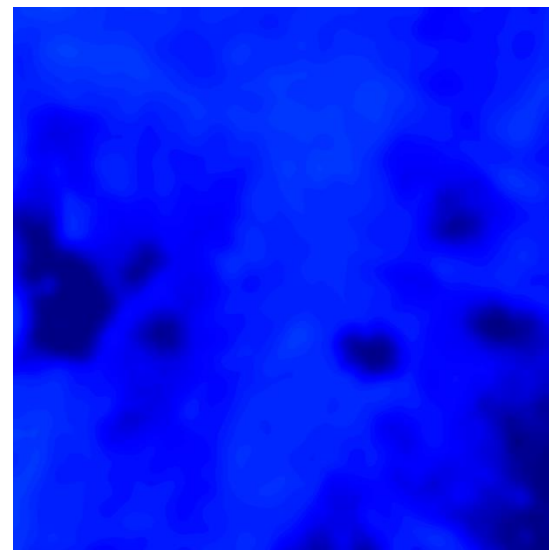
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AOT validation with in-situ measurements done by the AERONET network

Aerosol optical properties are the major unknown for atmospheric correction

➢ AOT estimation performance is a driver of atmospheric correction accuracy

AOT N2 en fonction de l'AOT CIMEL

LANDSAT8 L2A products distributed by THEIA and processed using MACCS

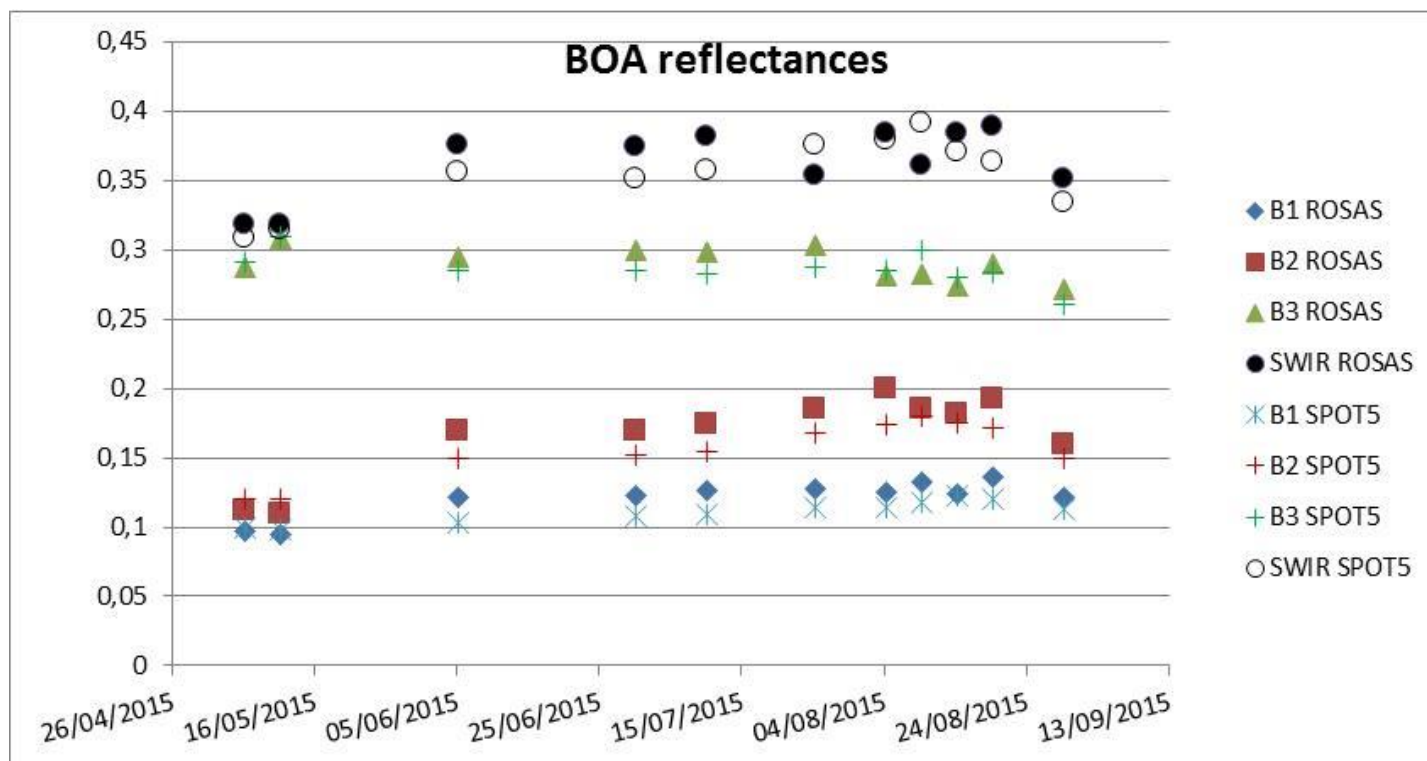18 AERONET sites with AOT ground measurements 236 L2A/AERONET matchups

Global RMS : 0.055

Good overall agreement between Aeronet AOT and Landsat-8 AOT estimated by MACCS

L2A reflectance comparison with in-situ measurements done by ROSAS at CNES Lacrau instrumented site

SPOT5 L2A products distributed by THEIA and processed using MACCS

Band	B1 (Green)	B2 (Red)	B3 (NIR)	SWIR
Mean [BOA reflectance (ROSAS)/BOA reflectance(SPOT5)]	**1,089**	**1,071**	**1,014**	**1,023**
Standard deviation	**0,071**	**0,076**	**0,036**	**0,047**

References on MACCS algorithms:

- ✓ Hagolle, O.; Huc, M.; Villa Pascual, D.; Dedieu, G. A Multi-Temporal and Multi-Spectral Method to Estimate Aerosol Optical Thickness over Land, for the Atmospheric Correction of FormoSat-2, LandSat, VENuS and Sentinel-2 Images. Remote Sens. 2015, 7, 2668-2691

- ✓ Hagolle, O.; Huc, M.; Villa Pascual, D.; Dedieu, G. A multi-temporal method for cloud detection, applied to FORMOSAT-2, VENuS, LANDSAT and SENTINEL-2 images. Remote Sens. Environ. 2010, 114, 1747–1755

- ✓ Hagolle, O.; Dedieu, G.; Mougenot, B.; Debaecker, V.; Duchemin, B.; Meygret, A. Correction of aerosol effects on multi-temporal images acquired with constant viewing angles: Application to Formosat-2 images. Remote Sens. Environ. 2008, 112, 1689–1701