MUSCATE : Operational Production Atmospheric Corrections and Monthly Composites Sentinel-2

Marc Leroy¹, Olivier Hagolle², Mireille Huc², Mohamed Kadiri², Gérard Dedieu², Joëlle Donadieu¹, Philippe Pacholczyk¹, Céline L'Helguen¹, Béatrice Petrucci¹, Selma Cherchali¹

1  CNES, Toulouse
2  CESBIO, Toulouse
MUSCATE is a multi-satellite, multi-sensor processing centre for multi-temporal data.

Set up by CNES and CESBIO, in the framework of the THEIA Land Data Centre (www.theia-land.fr)

THEIA is a partnership between national French institutions dedicated to land surface monitoring.

The THEIA Land Data Centre includes a joint Space Data Infrastructure and a network of Science Expertise Centres at national scale.
MUSCATE: ready to use products coming from time series of images acquired over large territories, includes atmospheric corrections and time compositing

What we have now is a prototype version of MUSCATE

- It has already produced data from Landsat 8 and from the SPOT 4 (Take5) experiment.
- Available on the THEIA portal (www.theia-land.fr)
- It will produce soon Spot data from the Spot World Heritage Program.

A fully automatized, operational version of MUSCATE is under way

It is designed to process systematically Sentinel-2 and Landsat data when Sentinel-2 is operational
Spot World Heritage Programme

- Objective: free availability for non-commercial use of orthorectified multispectral Spot 1 – 5 images of more than 5 years old
  - Partnership agreement between CNES and Airbus Defence and Space

- Raw images will be first processed to the orthorectified level before they are made available to users.

- Start by CNES of the processing of a first batch of 100,000 images with MUSCATE

- CNES is meanwhile inviting the international institutional community to contribute to order large image batches while covering the processing costs

- Access to the SWH database through the THEIA portal (www.theia-land.fr)
MUSCATE produces

- **Level 1C**: geometric corrections (Spot Take 5, Spot World Heritage)
- **Level 2A**: cloud screening + atmospheric corr. (Spot Take 5, Landsat, Sentinel-2)
- **Level 3A**: time compositing (Spot Take 5, Sentinel-2)

**Level 1C:**
Top of Atmosphere reflectances calibrated & orthorectified

**Level 2A:**
Single date surface reflectances after cloud screening and atmospheric correction

**Level 3A:**
N days time composite of surface reflectances,
Cloud screening use multispectral and multitemporal methods
See Hagolle et al., RSE, 2010
ATMOSPHERIC CORRECTIONS

- Scattering correction
  Performed using Look-Up Tables based on SOS radiative transfer code
  AOT estimates combine 2 criteria
  - Multi-temporal criterion based on the relative stability of surface reflectance vs time
  - Multi spectral criterion (DDV method)
  AOT estimates performed at 200m resolution

- Adjacency effect accounted

- Slope illumination correction

Details in Hagolle et al, RSE, 2008
Objective:
Produce one nearly cloud free image per month, from Level 2A data.

Utility:
- Data volume
- Regular time sampling
- Reduction of data gaps
Level 3A algorithm

Compute, for each pixel, a **weighted average** of the surface reflectance of the cloud free observations, obtained within a **$N$ day distance** from the central date of the level 3A product.

The weighted average gives more weight to:
- cloud free images
- pixels far from clouds
- images with a low aerosol content
- images acquired near the level 3A product date
Level 3A results

Level 3A products for 45 Take 5 sites around the world
Quality of level 3A products depends on the weight and the duration $N$.

Three quality criteria:
- Measurement of the artefacts presence index
- Percentage of residual data gaps
- Difference between level 3A reflectance and level 2A product acquired near the central date
- Results: histograms
Prototype production so far

- **Spot Take 5**
  - L1C, L2A, L3A, 45 sites, 4 months, 3000 images
  - processing took one week

- **Landsat 8**
  - L2A, France, April – Decembre 2013, 900 images
  - processing took 3 days

- Data available on [www.theia-land.fr](http://www.theia-land.fr) (except L3A Spot Take 5, which will be available soon there)

Prototype production to come

- Landsat 8, Landsat 5-7, Spot World Heritage
An operational version of MUSCATE is under way

MUSCATE is built as a flexible and adjustable center to facilitate integration of new treatments.

Timeline

- Call for Tender: January 2014
- Company selection: March 2014
- Kick-off: 14 May 2014
- End of development (target): 15 November 2015
PRODUCTION REQUIREMENTS

Sentinel-2:
- Surface area: that of Europe (6 M km²)
- Exact areas processed still TBD
- Timeliness for Level 2A products
  - ≤ 2.5 calendar days for 90% of products
- Reprocessing
  - 5 months of data reprocessed in one month

Landsat 8:
- Surface area: France & ROM-COM
- Delivery every day of Level-2 product from Level 1C
- Reprocessing
  - 5 months of data reprocessed in one month

Also, Landsat 5 & 7 and Spot World Heritage capabilities

CONCLUSION

- Operational MUSCATE should be ready for Sentinel-2
- SpotTake 5 and Landsat products already available on www.theia-land.fr
- First Spot World Heritage data processed soon

- MUSCATE part of ESA Collaborative Ground Segment on Land
- A role in EU Support Action to Copernicus Core Services?