

The French Theia Land data center products based on Sentinel-2 data

Olivier Hagolle and all THEIA team at CNES and CESBIO



October, 2016



PEPS : French collaborative ground segment

Sentinel Mirror site

- ▶ PEPS : french acronym for Sentinel Products Exploitation Platform
- ▶ <https://peps.cnes.fr> : Service opened in September 2015
- ▶ Up to now, mostly a mirror site for all sentinel data, globally
- ▶ Much faster than scihub... probably because much less users (~ 1000)
- ▶ Free and open data policy

Cloud processing

- ▶ Three modes being tested (Opening Autumn 2016)
 - "Pre-wired" processing
 - User selects a S1 product and orthorectifies it, downloads result
 - "Expert" processing
 - User provides his Docker container with application
 - "A la carte" processing
 - Implementation of Australian Datacube + Jupyter console
- ▶ Compatibility with CNES security rules is part of the test

THEIA : French Land Data Center

- Partnership of 11 French Public institutes, established in Dec. 2012



- <https://www.theia-land.fr/>

- Aim : help French (and other) users of remote sensing data, for :
 - Data access (SPOT, PLEIADES, LANDSAT, Sentinel-2)
 - Advanced products (Ortho-rectification, Mosaics, Atmospheric correction, Cloud masks, land cover...)
 - Training, regional meetings, federation of research efforts
- Free and open data policy, as far as possible
 - no more constraints than those set by input data provider



First Achievements

Geosud

Yearly publication of high resolution ($\sim 5m$) summer coverage for France

- ▶ <http://ids.equipex-geosud.fr/>
- ▶ Open to French public users

First Achievements

Geosud

Yearly publication of high resolution ($\sim 5m$) summer coverage for France

- ▶ <http://ids.equipex-geosud.fr/>
- ▶ Open to French public users

Pleiades

Access to Pleiades data bought by any French public institution

- ▶ <http://geosud.ign.fr/>
- ▶ Open to French public users

First Achievements

Geosud

Yearly publication of high resolution ($\sim 5m$) summer coverage for France

- ▶ <http://ids.equipex-geosud.fr/>
- ▶ Open to French public users

Pleiades

Access to Pleiades data bought by any French public institution

- ▶ <http://geosud.ign.fr/>
- ▶ Open to French public users

Spot World Heritage

Reprocessing (L1C) and distribution of archive SPOT data

- ▶ More than 100 000 images already distributed
- ▶ <https://theia.cnes.fr/>
- ▶ Not for commercial use

First Achievements

Sentinel-2 preparation

- ▶ SPOT (Take5) data (SPOT4 2013, SPOT5 2015)
 - 195 time series, acquired every 5th day, during 5 months
 - CNES-ESA funding, more than 1000 users
 - <http://spot-take5.org/>
 - free and open for any user

First Achievements

Sentinel-2 preparation

- ▶ SPOT (Take5) data (SPOT4 2013, SPOT5 2015)
 - 195 time series, acquired every 5th day, during 5 months
 - CNES-ESA funding, more than 1000 users
 - <http://spot-take5.org/>
 - free and open for any user
- ▶ Landsat data acquired above France and overseas territories since 2009
 - <https://theia-landsat.cnes.fr> provisionnally, then <https://theia.cnes.fr>
 - L1C and L2A products
 - free and open

Sentinel-2 : L2A production

MACCS processor

- ▶ Development of MACCS started 10 years ago for Venµs
 - Use of time series for cloud/shadow detection and atmospheric correction
 - Surface reflectance variations slower than atmospheric effects variation
 - Good results => Applied to SPOT (Take5), LANDSAT 8 and Sentinel-2
 - Continuous enhancement on-going (research at CESBIO, dev. at CNES)

Sentinel-2 : L2A production

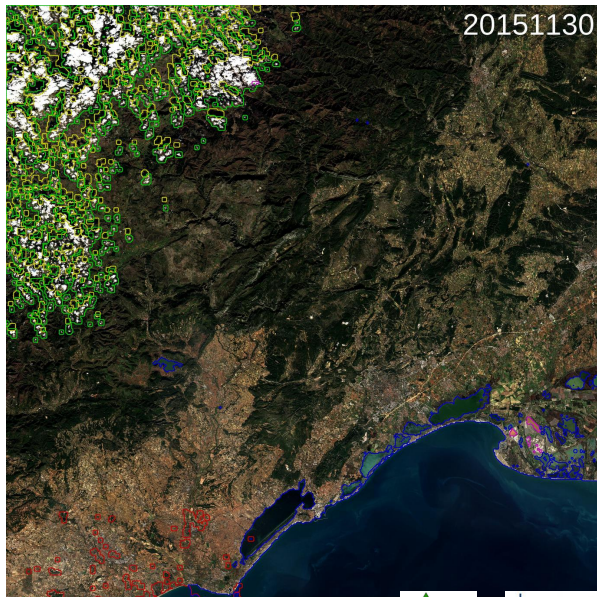
MACCS processor

- ▶ Development of MACCS started 10 years ago for Venµs
 - Use of time series for cloud/shadow detection and atmospheric correction
 - Surface reflectance variations slower than atmospheric effects variation
 - Good results => Applied to SPOT (Take5), LANDSAT 8 and Sentinel-2
 - Continuous enhancement on-going (research at CESBIO, dev. at CNES)

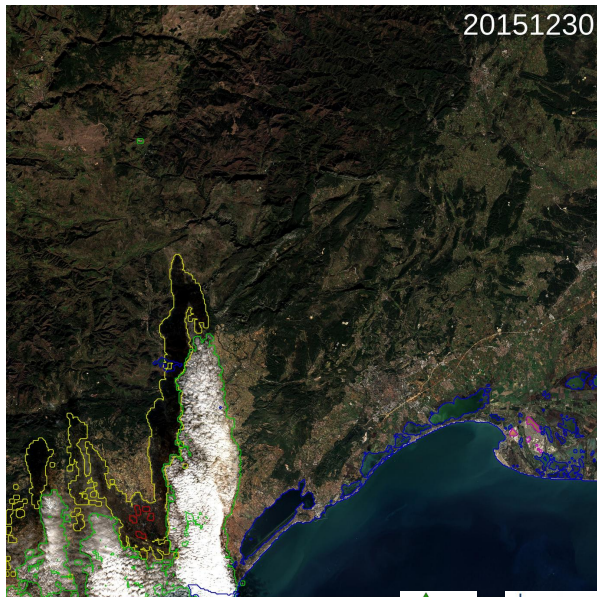
MUSCATE ground segment

- ▶ 2012-2014 : prototype ground segment (SPOT (Take5), Landsat8)
 - MACCS requires to process data in chronological order
- ▶ 2014-2016 : development of operational processor
 - Fully automatic system, just drop the data on a directory
 - Much better monitoring of production status
- ▶ 2016 : Start of Sentinel-2 production over 5M km2
 - Data over France already available <https://theia.cnes.fr>
- ▶ Implemented within CNES computing center

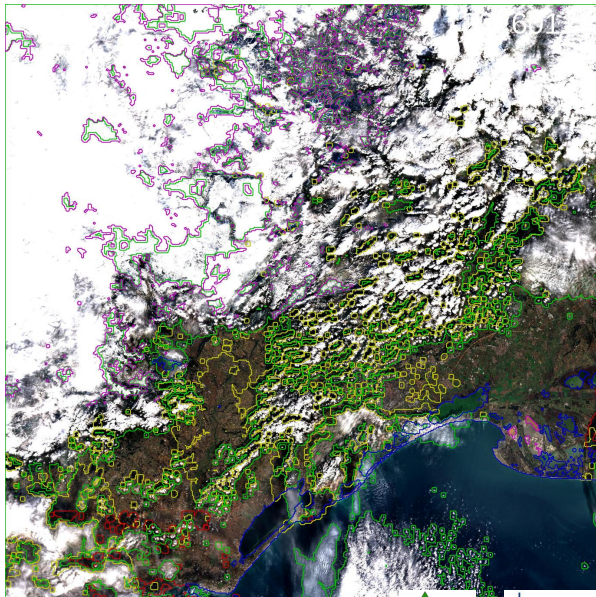
Sentinel-2 L2A time series, Tile 31TEJ



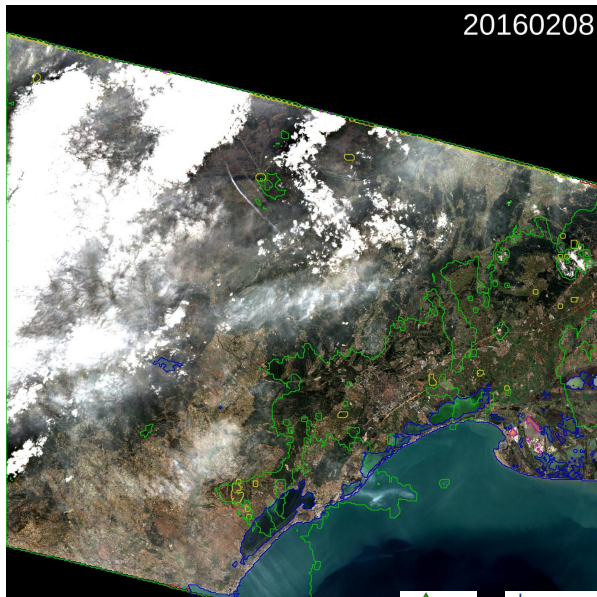
Sentinel-2 L2A time series, Tile 31TEJ



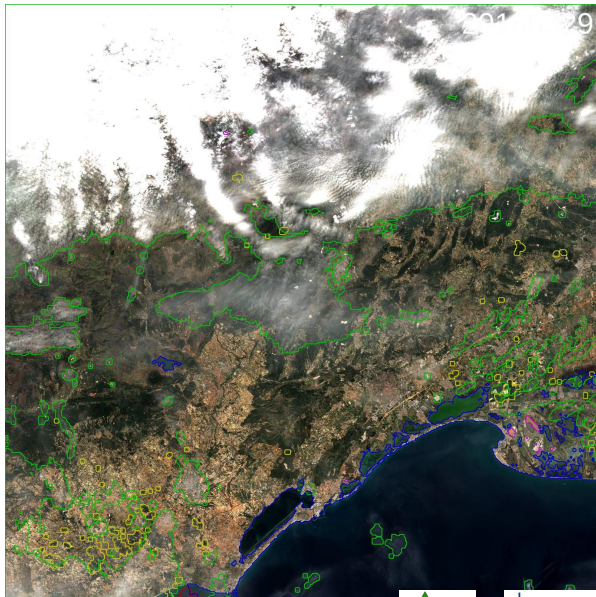
Sentinel-2 L2A time series, Tile 31TEJ



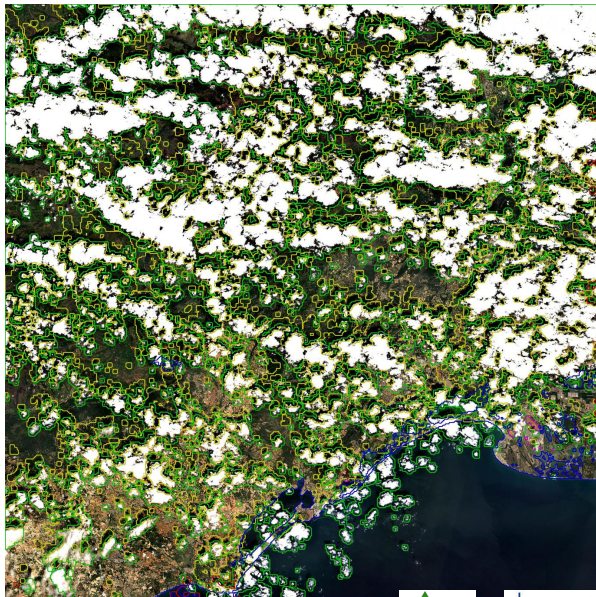
Sentinel-2 L2A time series, Tile 31TEJ



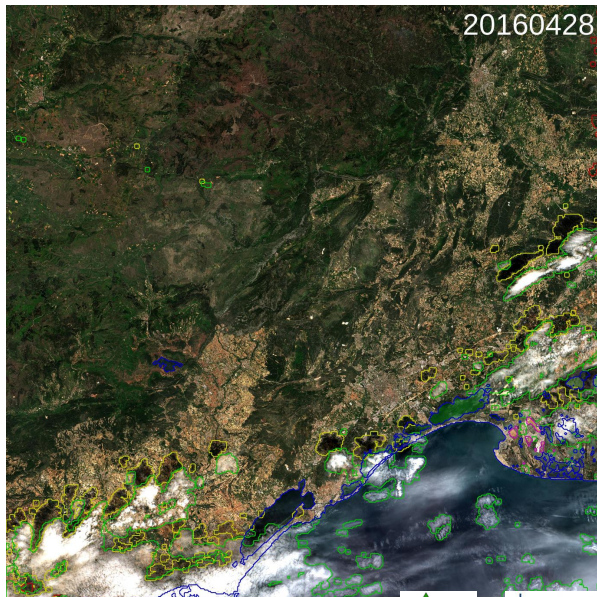
Sentinel-2 L2A time series, Tile 31TEJ



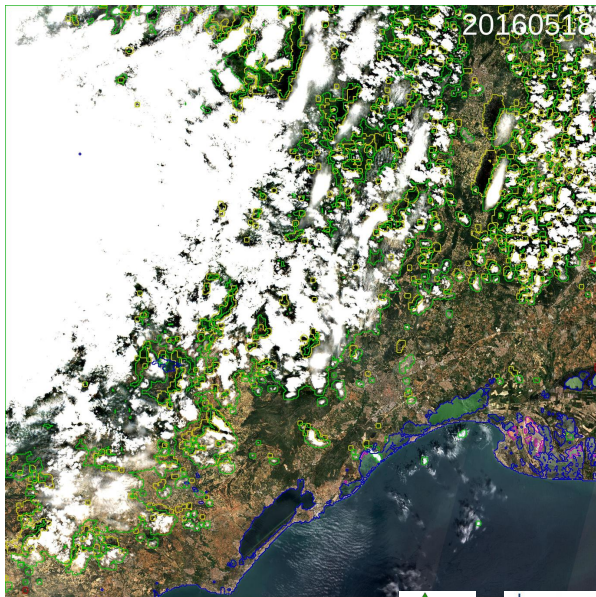
Sentinel-2 L2A time series, Tile 31TEJ



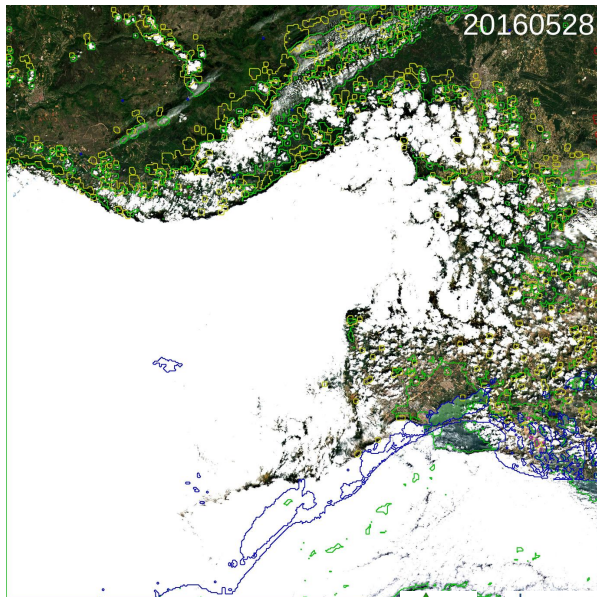
Sentinel-2 L2A time series, Tile 31TEJ



Sentinel-2 L2A time series, Tile 31TEJ



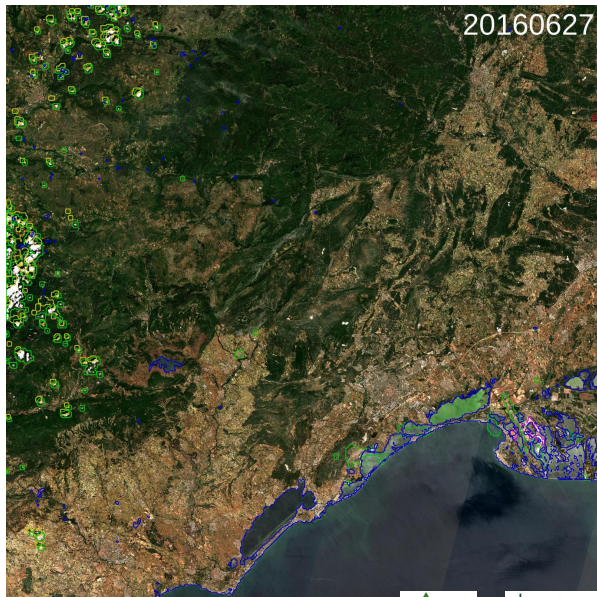
Sentinel-2 L2A time series, Tile 31TEJ



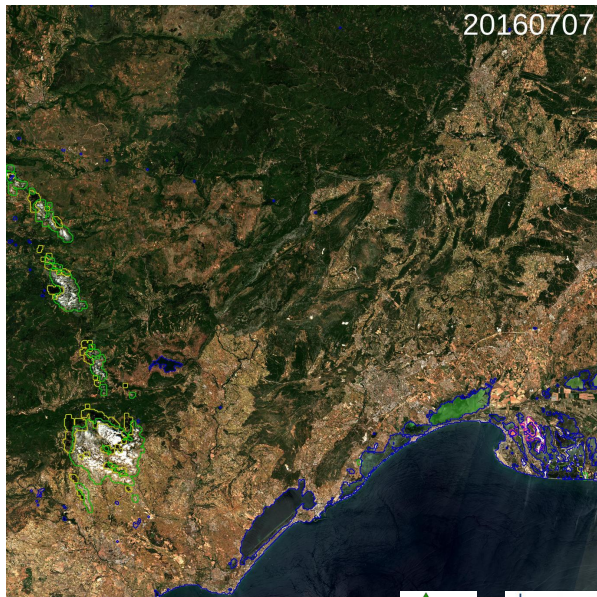
Sentinel-2 L2A time series, Tile 31TEJ



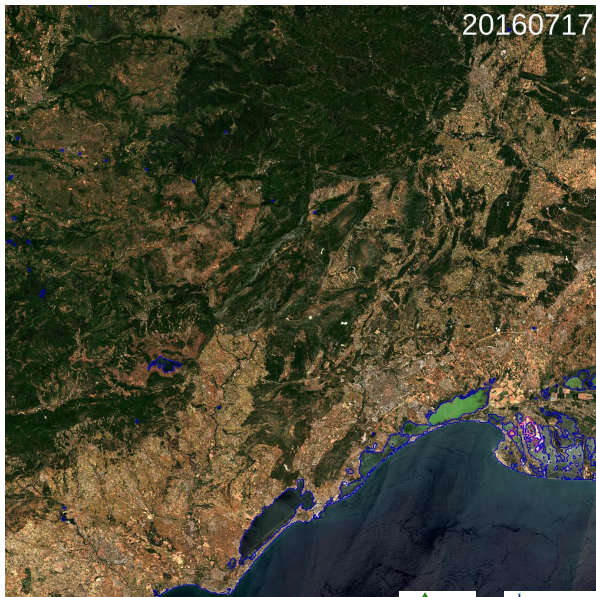
Sentinel-2 L2A time series, Tile 31TEJ



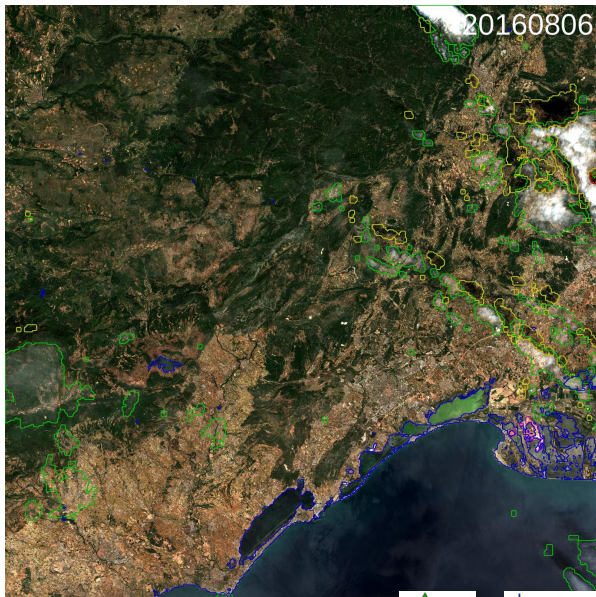
Sentinel-2 L2A time series, Tile 31TEJ



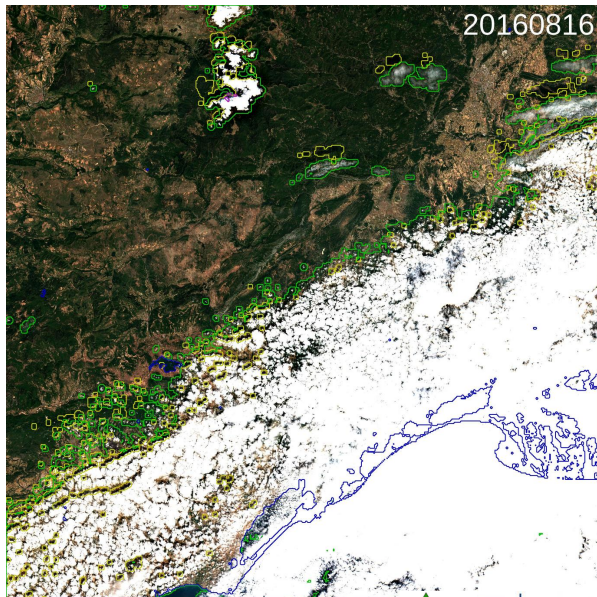
Sentinel-2 L2A time series, Tile 31TEJ



Sentinel-2 L2A time series, Tile 31TEJ



Sentinel-2 L2A time series, Tile 31TEJ



Sentinel-2 L2A validation vs Aeronet for France

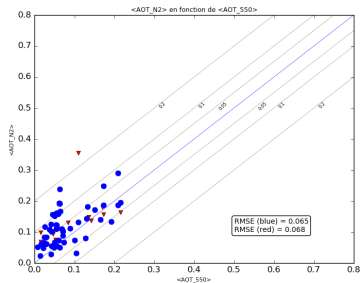


Figure : Aerosol Optical Thickness

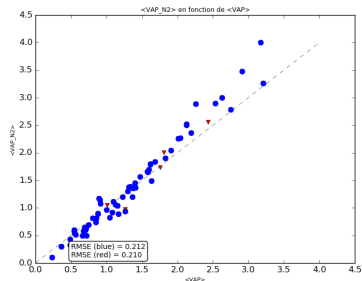
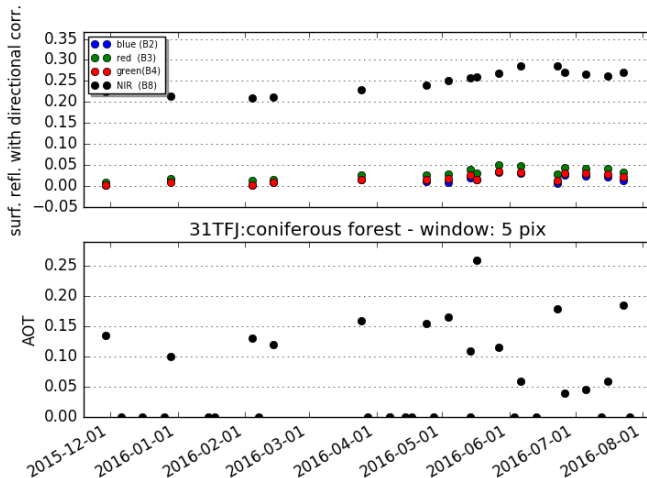
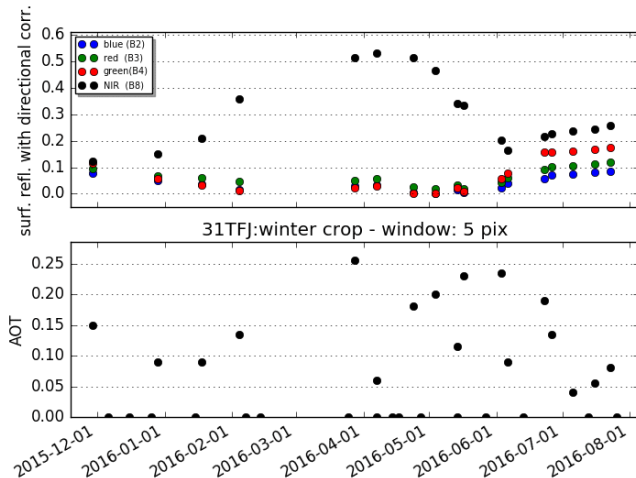


Figure : Water vapour

Quality of time series



Quality of time series



MACCS further plans

MACCS status

- ▶ MACCS is an efficient and robust processor
 - based on multi-temporal methods
 - Not yet open source
 - Better fit to distribute products than to be distributed as code
 - Mainly because of constraint to process data in chronological order
 - Not multi-platform and as easy to use as ESA's Sen2cor
 - However, included in ESA's Sen2Agri system released next May :
<http://www.sen2agri.org>

MACCS further plans

MACCS status

- ▶ MACCS is an efficient and robust processor
 - based on multi-temporal methods
 - Not yet open source
 - Better fit to distribute products than to be distributed as code
 - Mainly because of constraint to process data in chronological order
 - Not multi-platform and as easy to use as ESA's Sen2cor
 - However, included in ESA's Sen2Agri system released next May :
<http://www.sen2agri.org>

Next Steps

- ▶ CNES and DLR join efforts for a MACCS-ATCOR Joint Algorithm (MAJA)
 - Based on MACCS, but including ATCOR better methods
 - Mono-temporal cloud detection to complement MACCS Multi-temporal
 - Better water vapor estimates
 - Cirrus cloud correction
 - ...

MACCS further plans

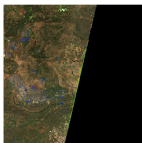
Global production

- ▶ MAJA proposed to ESA and EU for global production
 - But there are other runners (Sen2cor, Brockmann Consult, GFZ)
 - Comparison exercise to start soon (one year duration)
 - ESA unlikely to start production before 2018

Sentinel-2 Level 3A: Monthly cloud free syntheses

- ▶ CESBIO developed a Level 3A product for Venus
 - Extended to Sentinel-2, operational software developed within Sen2Agri
 - Needs Sentinel-2 A & B satellites to provide cloud free images
 - Will be implemented in Theia in 2017
 - Easy to use product but information loss compared to L2A

L2A



20160321

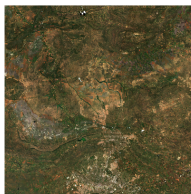


20160328



20160407

L3A



20160401

Theia Expertise Centers

Scientific call for methods/applications

► ~ 20 proposals received. Most mature ones :

- Surface reflectance Sentinel-2
- Fully automatic land cover maps Sentinel-1,2
- Water body height Jason, Sentinel-3
- High resolution snow cover Sentinel-2
- Biomass and forest cover change Sentinel-1, JERS-2
- Irrigated surfaces Sentinel-1,2
- Biophysical variables Sentinel-2
- Soil Moisture SMOS
- Soil properties Sentinel-2

Theia Expertise Centers

How it works ?

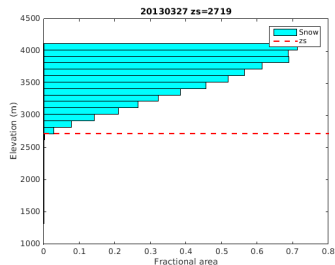
- ▶ Each “Expertise center” groups 1 to 8 laboratories
- ▶ Each Theia partner can then support studies, implementation, production...
 - CNES funds **Surface reflectance**, **Snow cover**, **Land Cover**, Soil Moisture, Water body height
 - INRA funds **Land Cover**, Biophysical Variables, Soil properties
 - CNRS funds Soil Moisture, **Snow cover**
 - Biophysical variables included in Sen2Agri and SNAP

Snow cover monitoring with Sentinel-2/LANDSAT-8

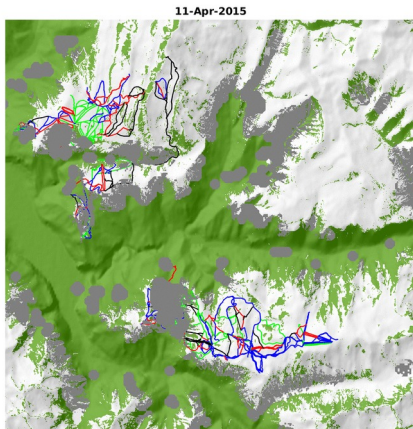
Snow cover monitoring with Sentinel-2/LANDSAT-8

Method

- ▶ Method developed at CESBIO/CNES (S.Gascoin, M.Grizonnet)
 - Difficulty : Snow-Cloud separation
 - Easier with SWIR bands, but confusions when partial snow cover
 - Uses L2A product, cloud mask
 - Two steps process :
 - First conservative snow threshold => Minimum altitude h_{min}
 - Less conservative threshold for pixels above $h_{min} - 100m$
 - L3A in preparation : mainly gap filling



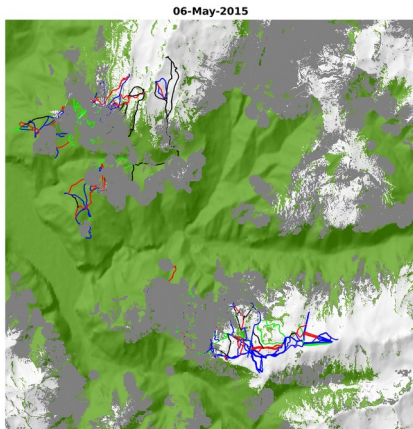
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S.Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

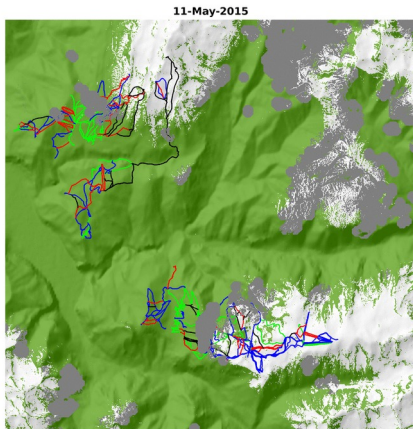
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S. Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

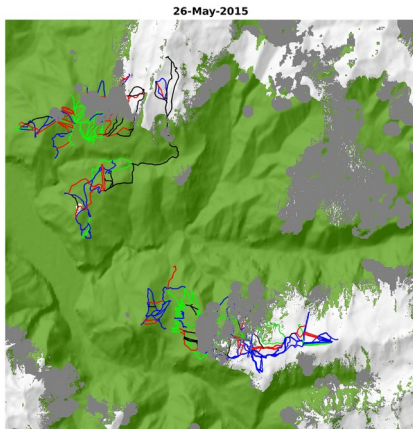
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S.Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

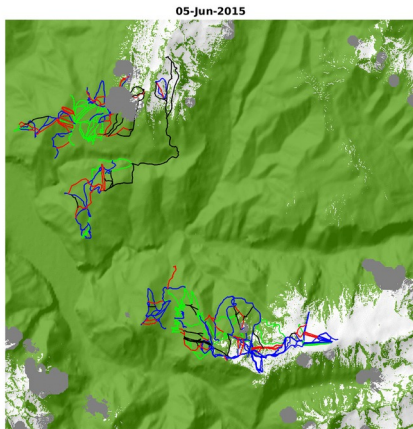
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S.Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

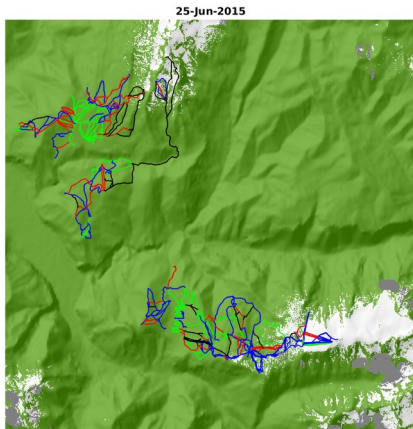
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S. Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

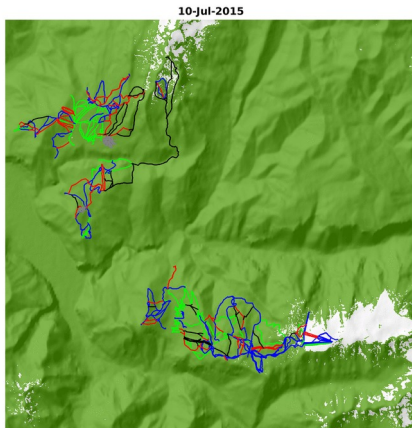
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S.Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

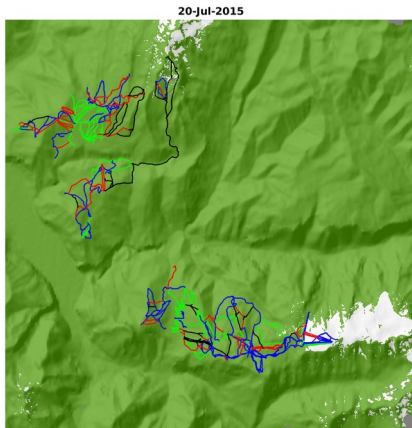
Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S.Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

Snow cover monitoring with SPOT5 (Take5)



- ▶ North : Alpe d'Huez
 - Winter ski resort
- ▶ South : Deux Alpes
 - Winter and Summer ski resort

S.Gascoin, CESBIO, "Let It Snow" processor
Snow in white, clouds in grey, ski tracks in color

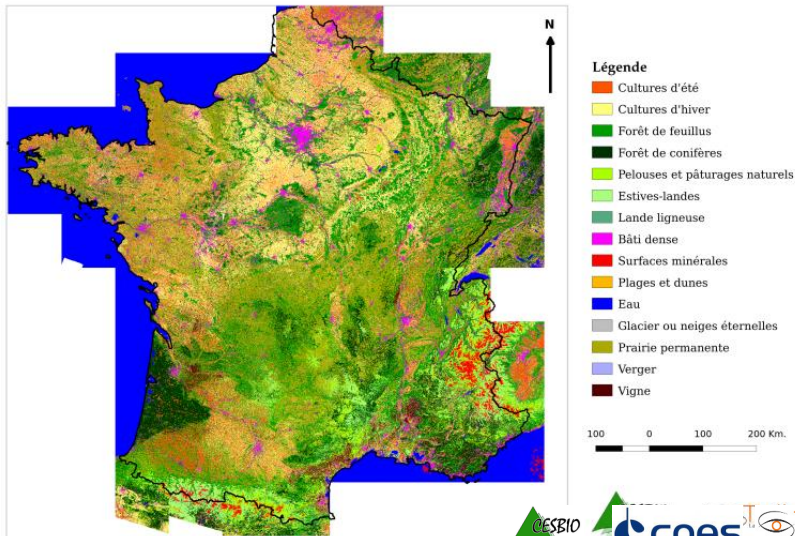
Snow cover monitoring with Sentinel-2/LANDSAT-8

Status

- ▶ Open source software based on Orfeo ToolBox
<http://tully.ups-tlse.fr/grizonnet/let-it-snow>
- ▶ An ATBD is available with the software
- ▶ Needs Theia L2A products as input
 - but might be adapted to work with ESA's SEN2COR for instance
- ▶ On-going implementation within THEIA/MUSCATE
- ▶ Operational production over a selection of relevant tiles within THEIA S2 tiles
- ▶ Expected distribution start end of 2016/beginning 2017

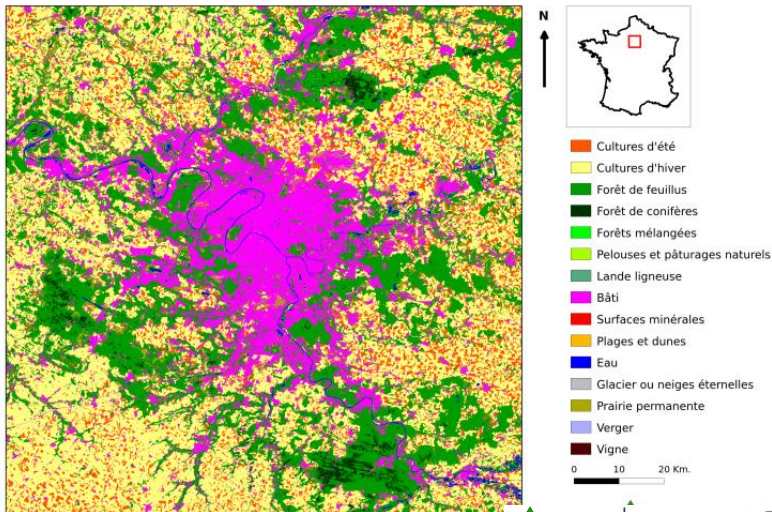
Fully automatic Land Cover over France with LANDSAT 8 data

Occupation du sol - France 2014



Fully automatic Land Cover over France with LANDSAT 8 data

Occupation du sol - France 2014



Conclusions

- ▶ A large federating effort within French public institutes
 - Trying to help users get access to remote sensing products without spending all their time in lengthy pre-processing
 - Addresses scientific labs as well as administrations and small businesses
- ▶ Regarding Sentinel-2
 - Processing and distribution of high quality Sentinel-2 L2A products, over 10 times France's area
 - First Sentinel-2 higher level products about to be released (snow, land cover...)
- ▶ Still a pity to stop processing data at French borders
- ▶ Theia's processing should at least consider Europe
 - But money issues or...time issues to bid to European calls.
 - Most of our codes provided as open source

Thank you !

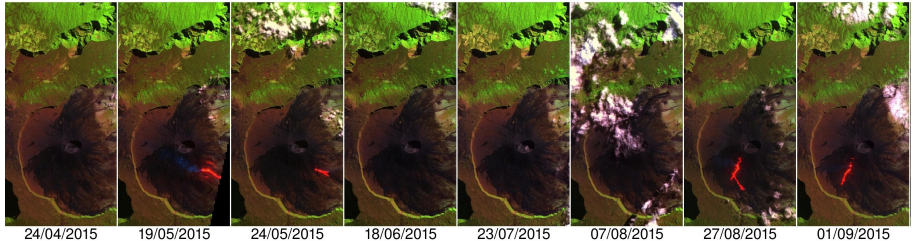


Figure : Eruptions of Piton de La Fournaise, Reunion, France

[More news on CESBIO multitemp blog](#)