SPOT4 (Take 5) first validation and application results

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October 2nd, 2013

Outline

Validation results

- Ortho-rectification
- Cloud masks
  - Lessons learned about observed nebulosity
- Aerosols and Atmospheric correction

New product

- Level 3A development and first tests on SPOT4 (Take5) data
  - to define Sentinel-2 L3A product at THEIA

Some applications

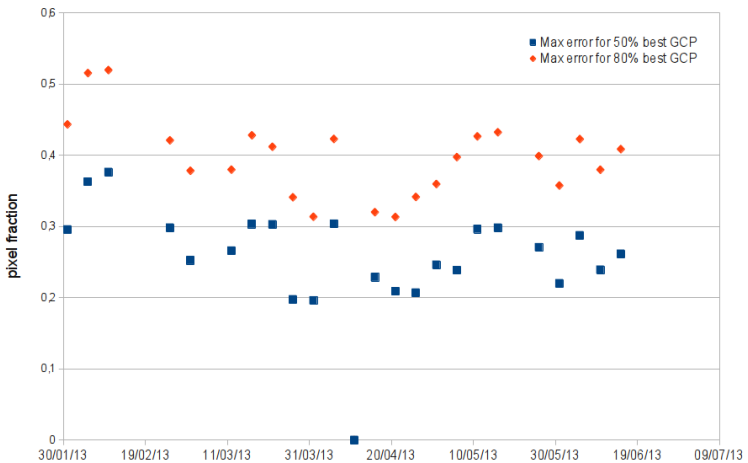
- Large area Land cover maps with automatic supervision
- Fast test on SudMiPy site, to be generalized to several sites

L1C Ortho-rectification

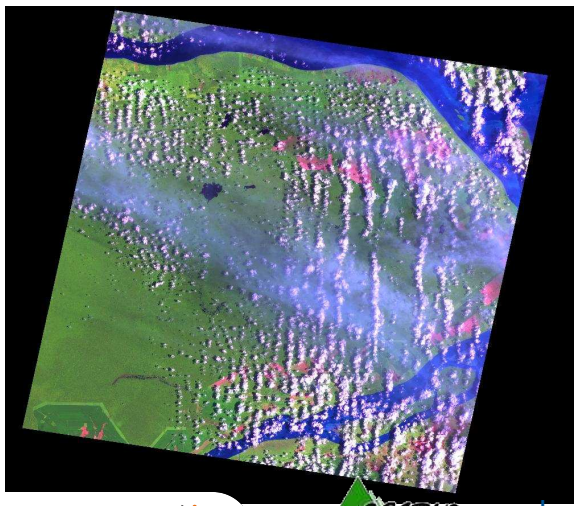
Ortho-rectification

- Old SPOT4 had poor location performances (errors up to 1500m)
- Landsat 5 or 7 used as reference for automatic GCP extraction
  - Next version : Geo-Sud RapidEye images in France, and LANDSAT 8 elsewhere
- Good overall registration performances : 80% of measures within 0.5 pixel
- 4 sites with poor performances, up to 10 pixels
  - Cloudy sites with uniform equatorial forests in flat areas
  - Sumatra (JRC), Borneo (JRC), Gabon (ESA), Congo(ESA))

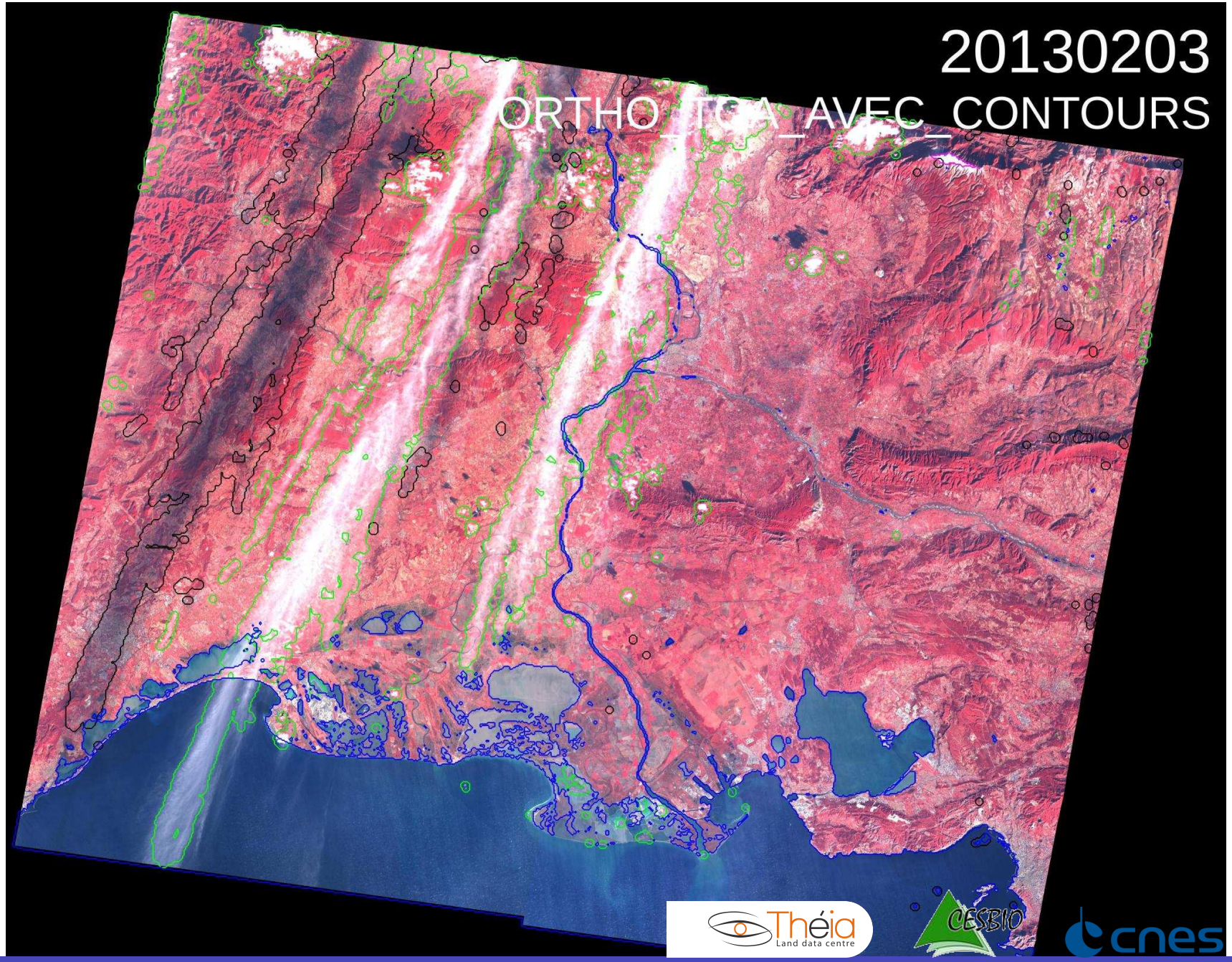
Morocco



Sumatra



L2A Masks : Clouds, Shadows, Water, Snow



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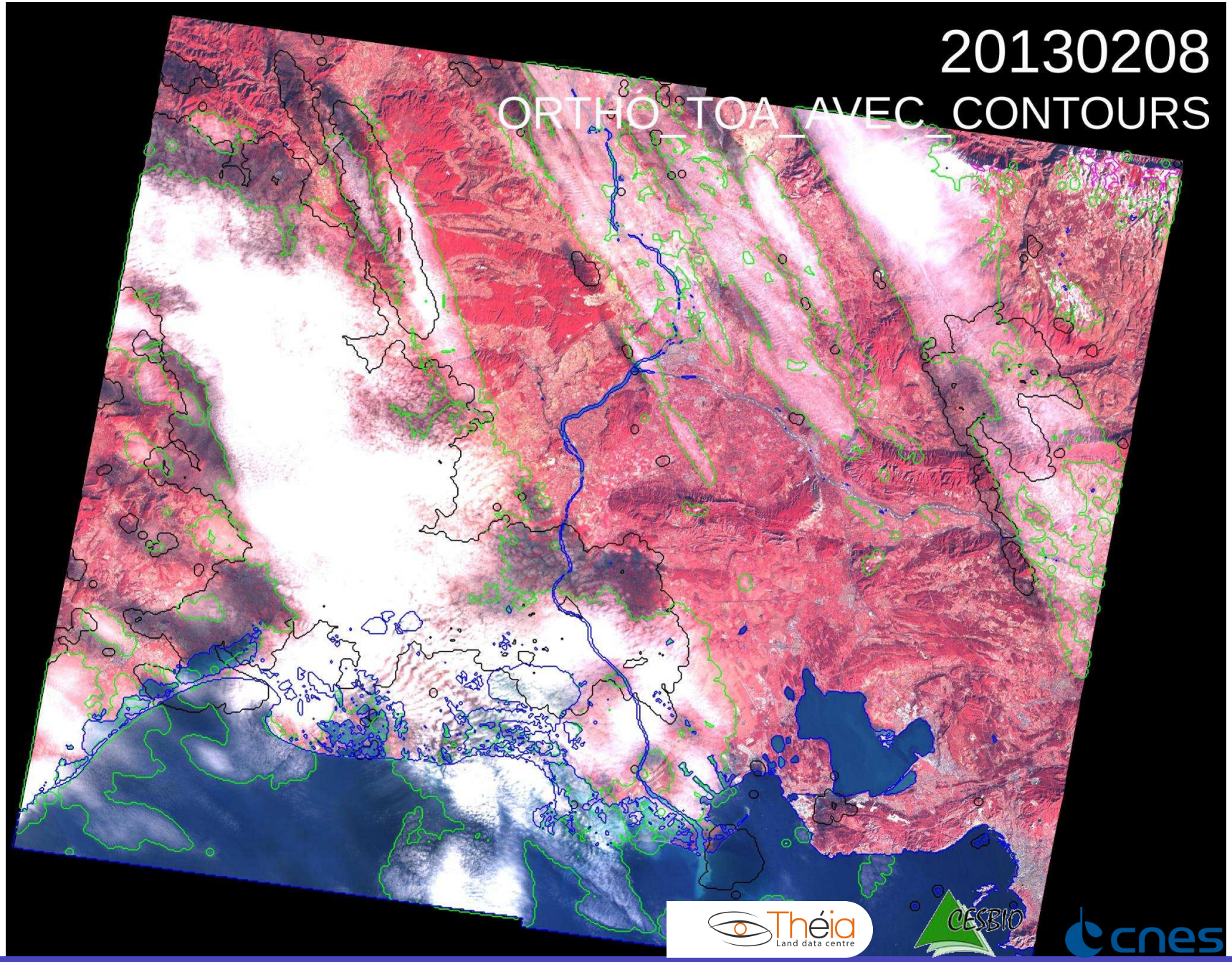

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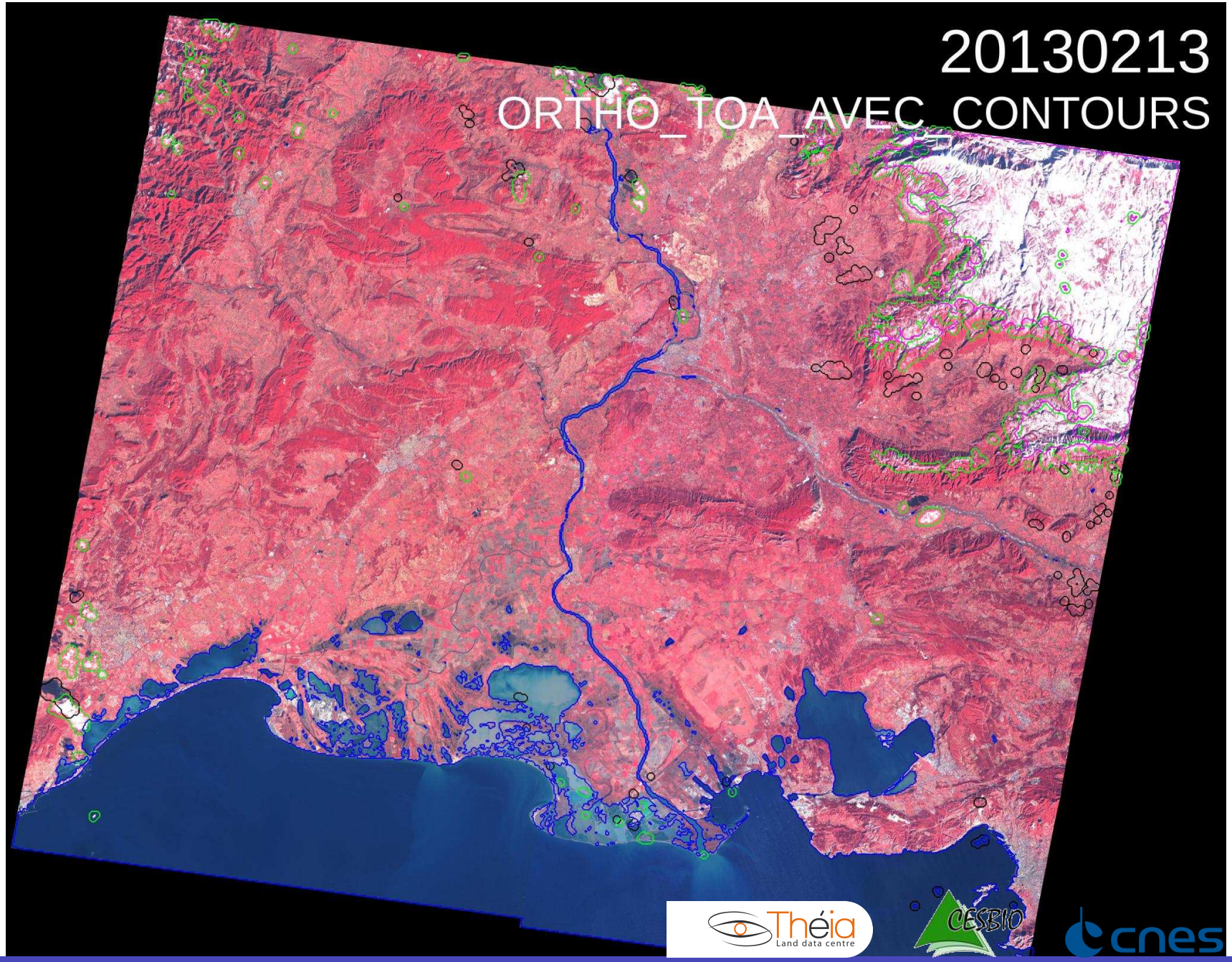
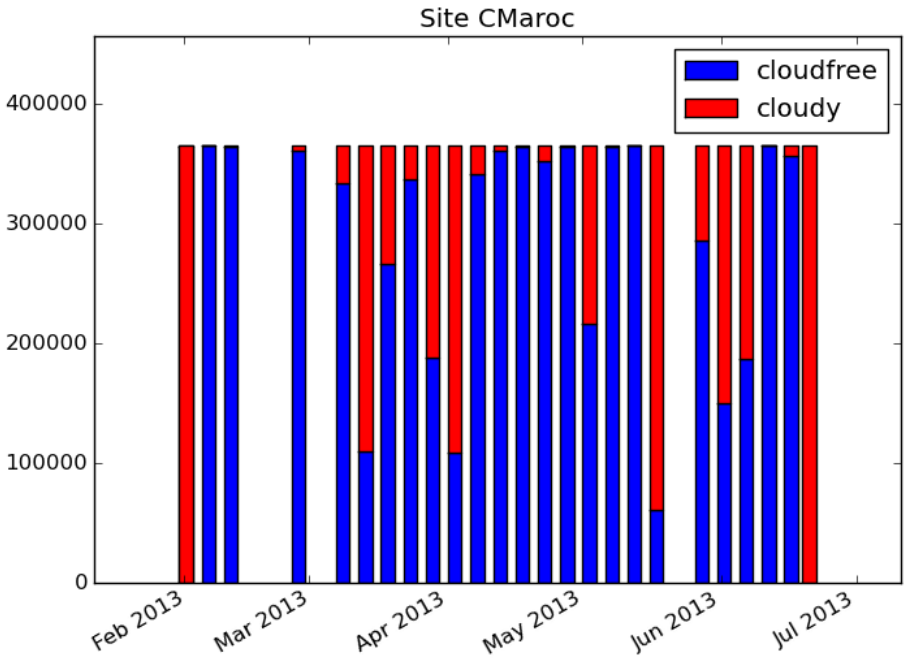
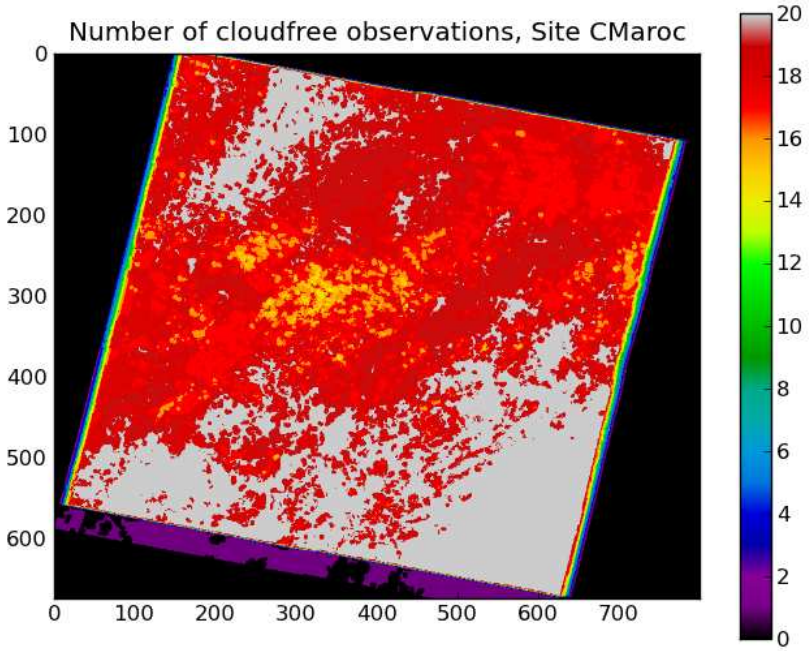


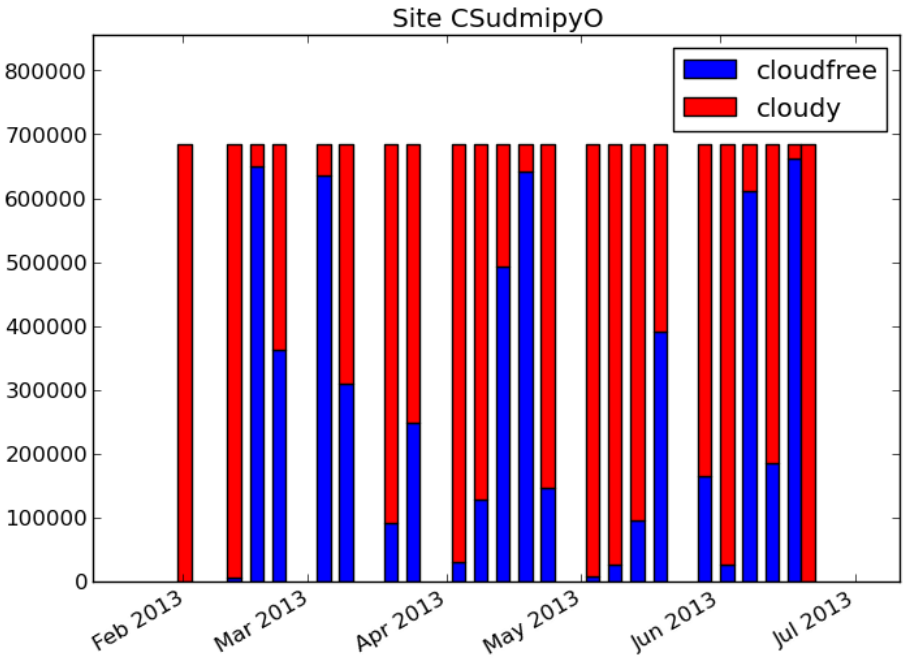
Cloud Free Observations

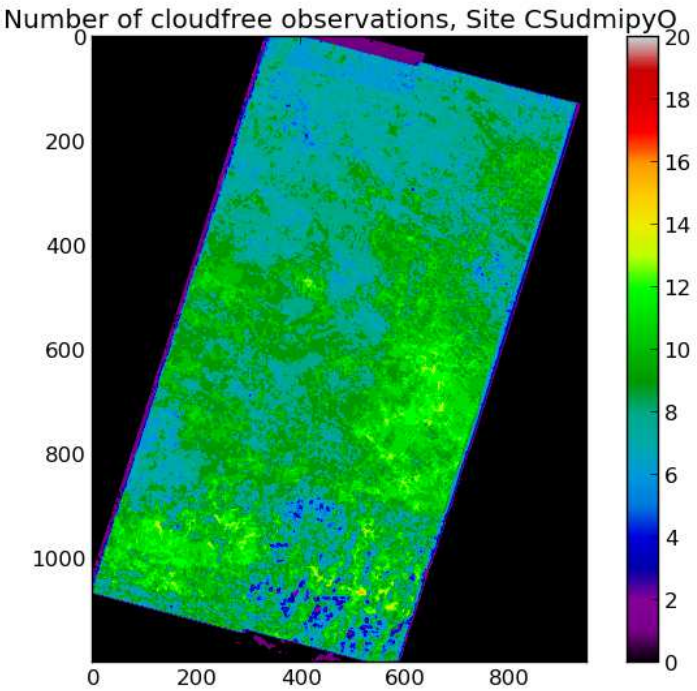




Morocco Tensift

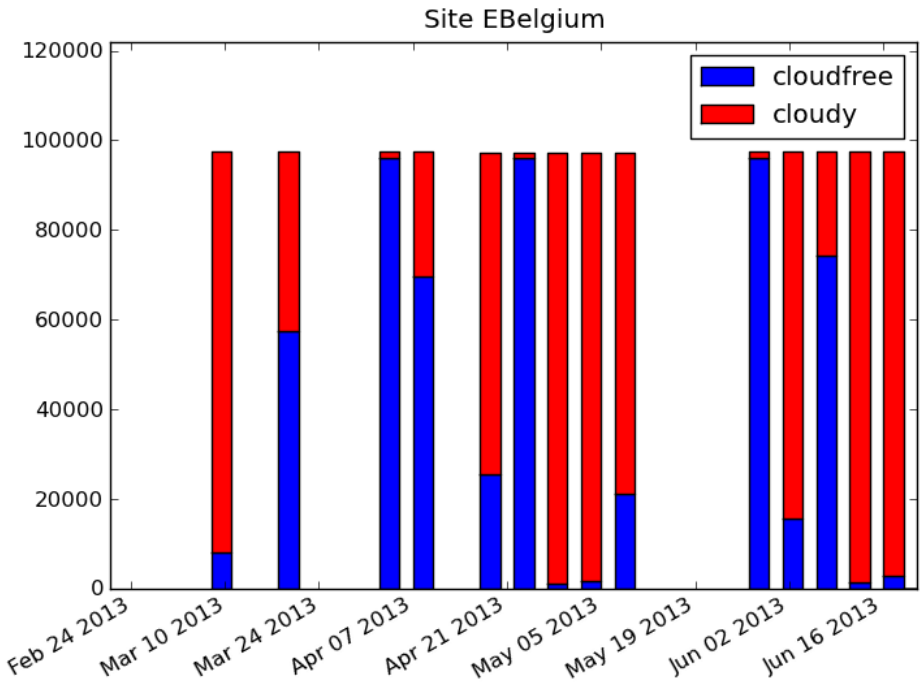
Cloud Free Observations

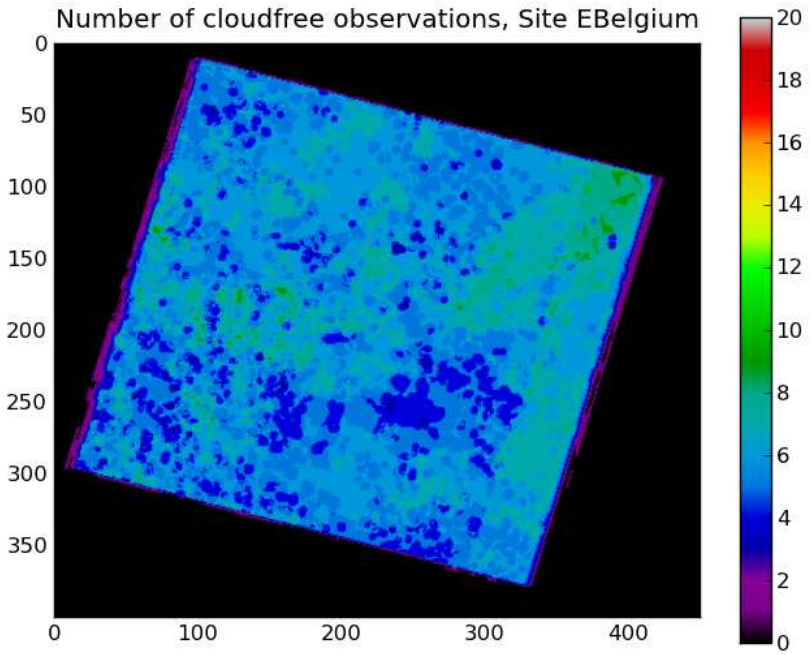




France Midi-Pyrénées

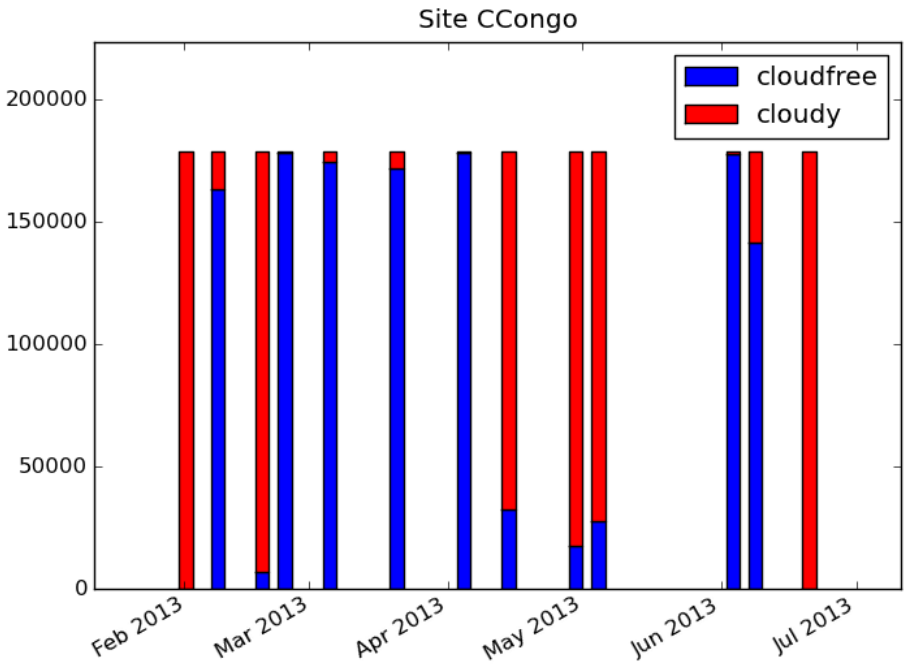
Cloud Free Observations

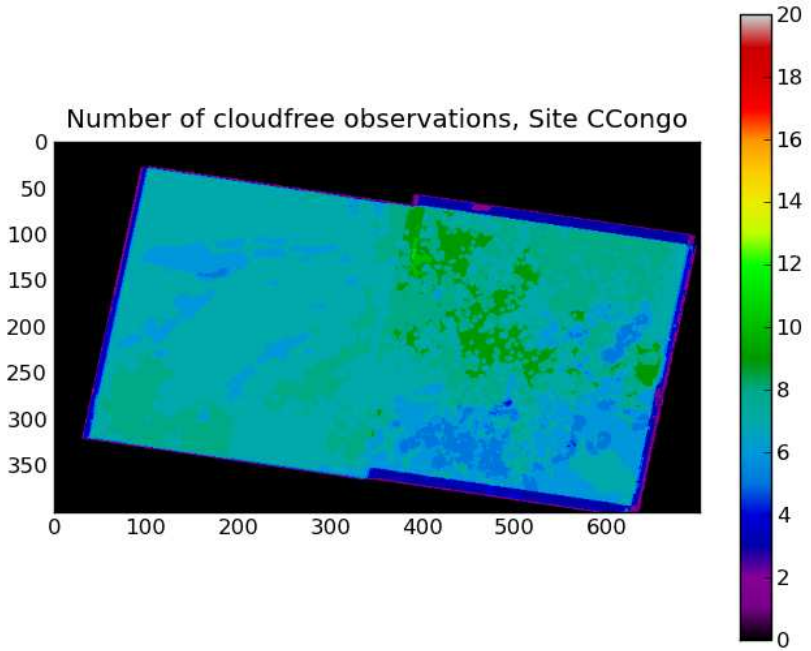




Belgium

Cloud Free Observations





Congo (1)

Lessons learned

Cloud Free Observations

- Very nice time series over a lot of sites :
  - Morocco, Provence, Paraguay, Angola, Maricopa, Congo...
- Not far from 1 clear observation/month for most sites
  - Despite bad weather in Europe
    - Except in Belgium, Alsace, Aquitaine, or even Tunisia
  - And with exceptions in Equatorial regions
- Big sites always have clouds
  - Necessity to develop methods which are robust to data gaps
  - Composite products should be useful (Level 3A)

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Message

- With 10 days repetitivity, SPOT4(Take5) would have failed in Western Europe
- Necessity to launch S2-B shortly after S2-A
- Next S2 generation should consider increased repetitivity

Atmospheric correction

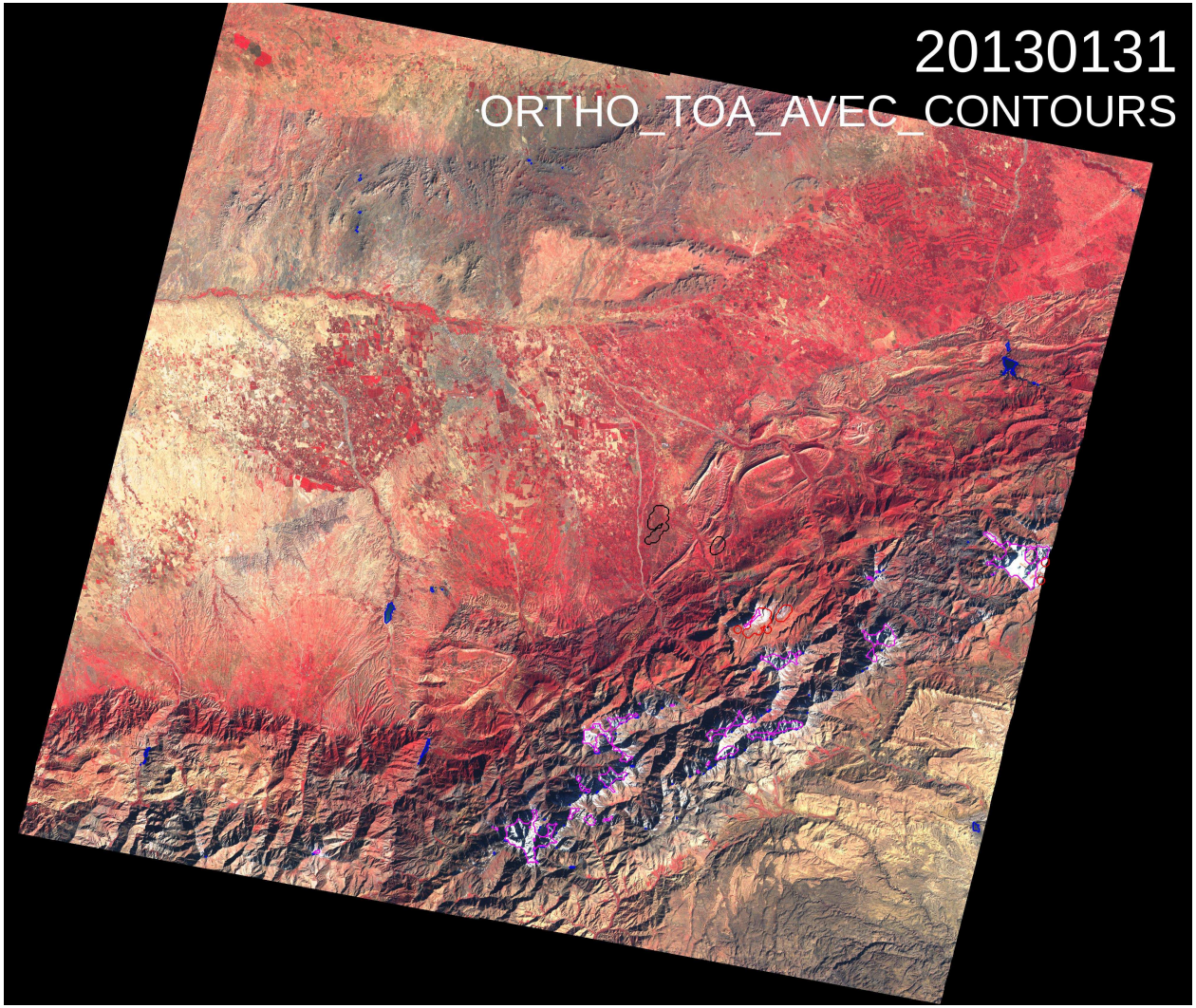
Atmospheric correction

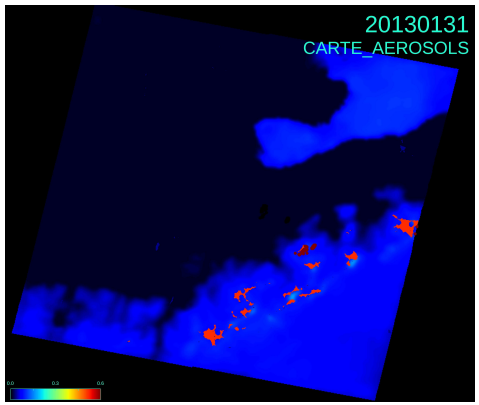
- takes into account :
  - Absorption
  - Scattering by molecules and aerosols
  - Aerosol parameters are estimated
  - Adjacency effects
  - Illumination effects due to topography

Aerosol estimation method (MACCS)

- No blue band in SPOT satellites
- Use of a multi-temporal method to estimate aerosol content
  - two successive L2A images should be similar (at 200 m resolution)
- Aerosol model is constant per site

Aerosol maps with SPOT4(Take5)





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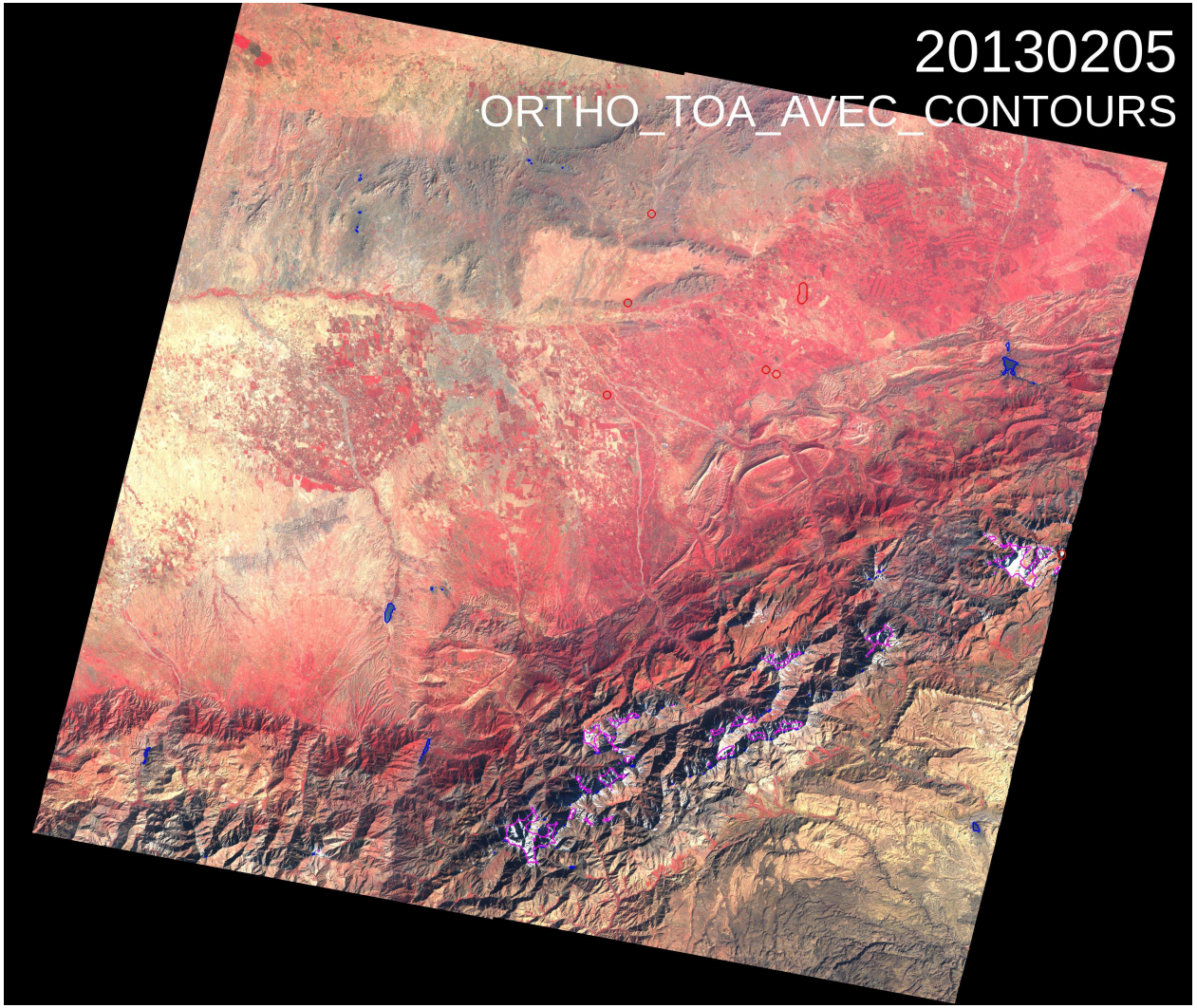

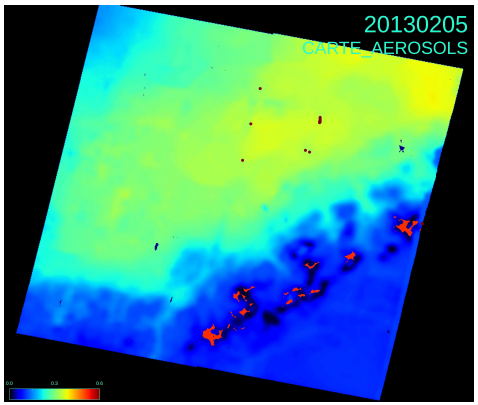

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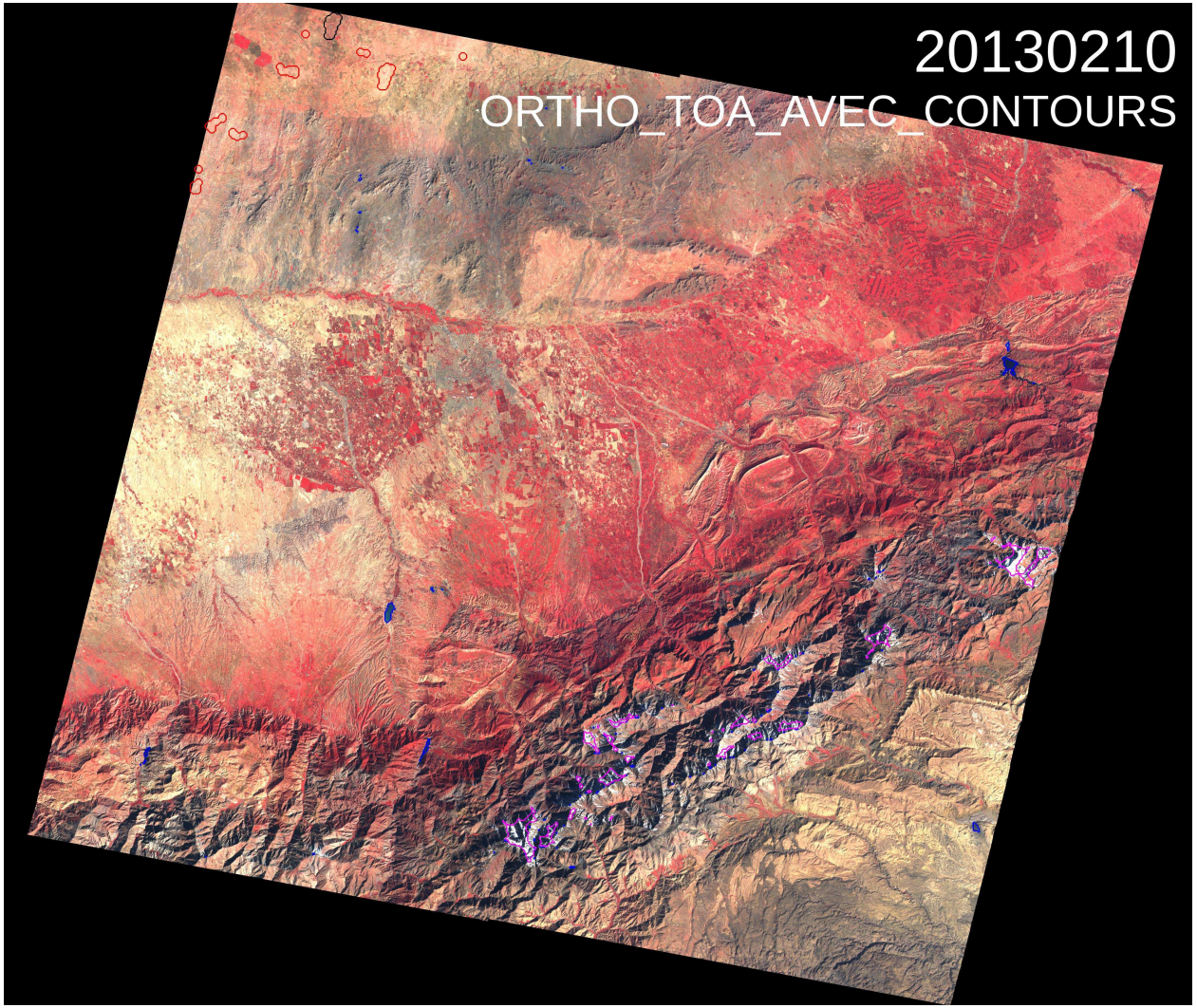

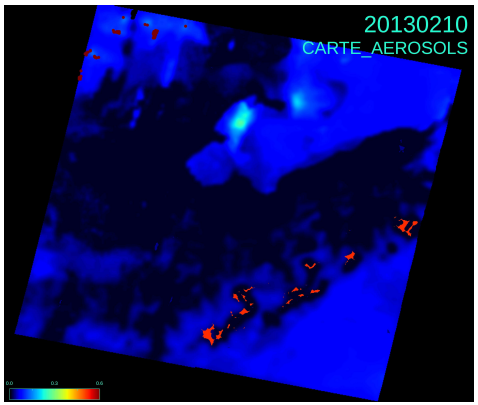

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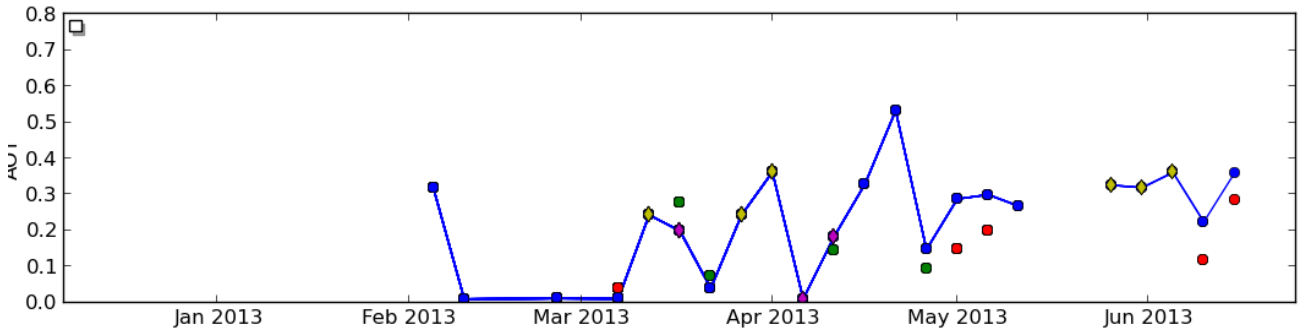
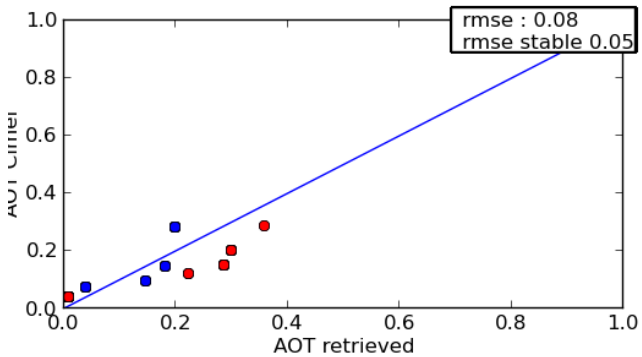
Atmospheric correction

Aerosol Validation

- Aerosol validation sites with a cimel nearby
  - Europe : Arcachon, Carpentras,Seysses,Le Fauga,Palaiseau,Paris,Kyiv
  - Africa : Saada, Ouarzazate (Morocco), Ben salem(Tunisia)
  - USA : Wallops, Cart Site
  - Asia : Gwangjiu, Korea





Saada

Atmospheric correction

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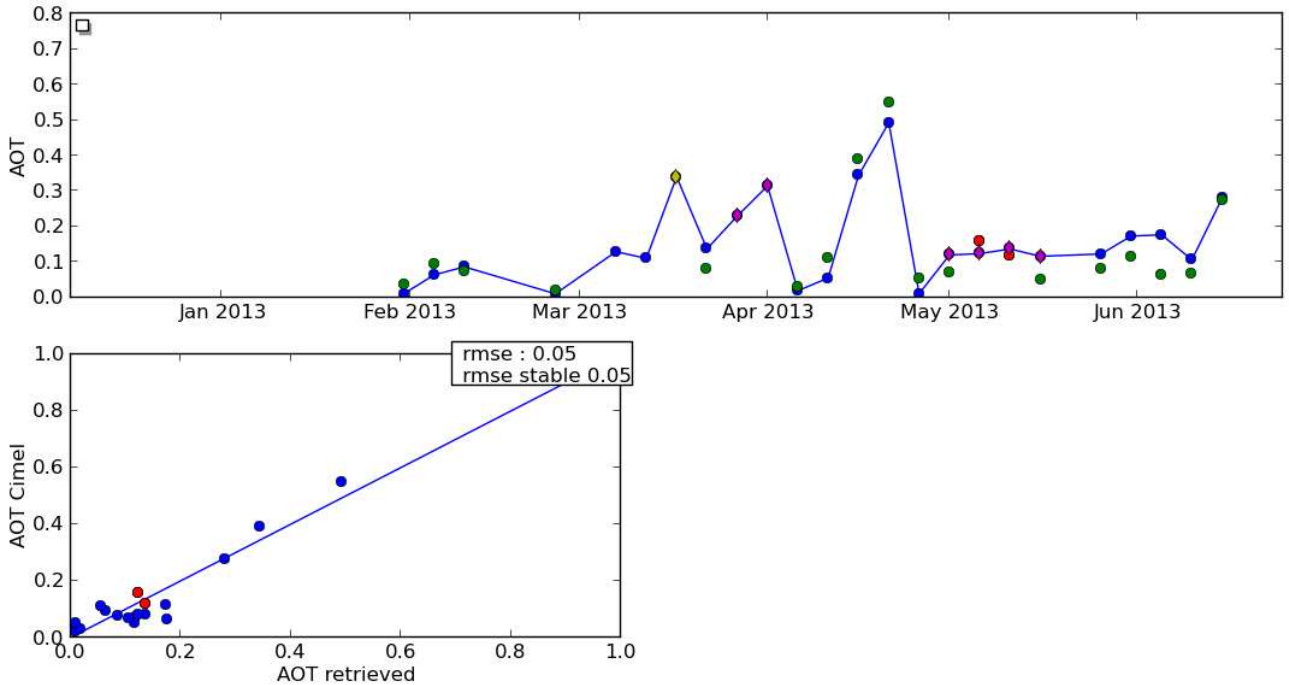
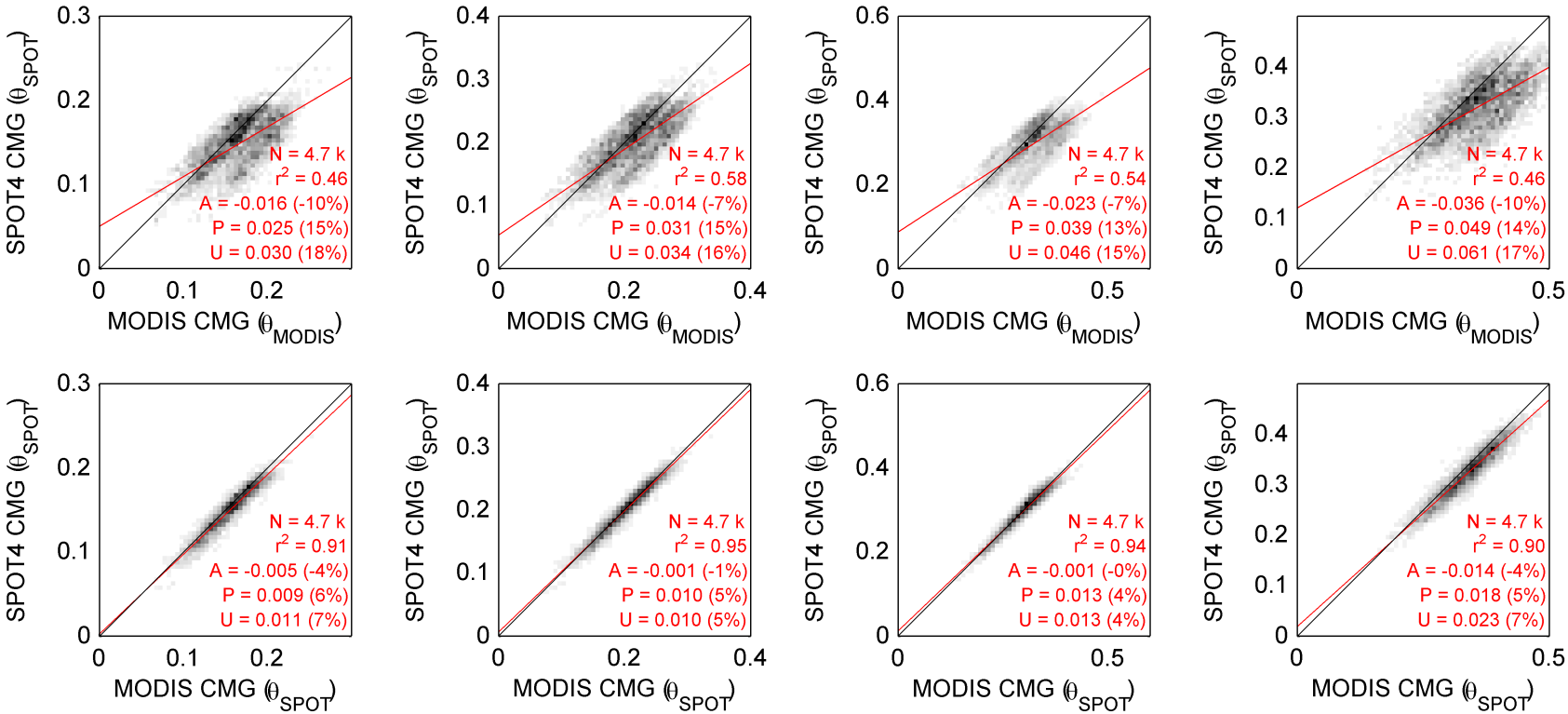


Ouarzazate

Surface Reflectance validation

- NASA compared MODIS and Take5 Surface reflectances for cloud free pixels
  - On Maricopa site, at 5 km resolution, using 25 dates
  - A directional effect correction is necessary (Vermote 2009)
  - Excellent agreement that validates Cloud Masks and atmospheric corrections
  - (M.Claverie,E.Vermote J.Masek)

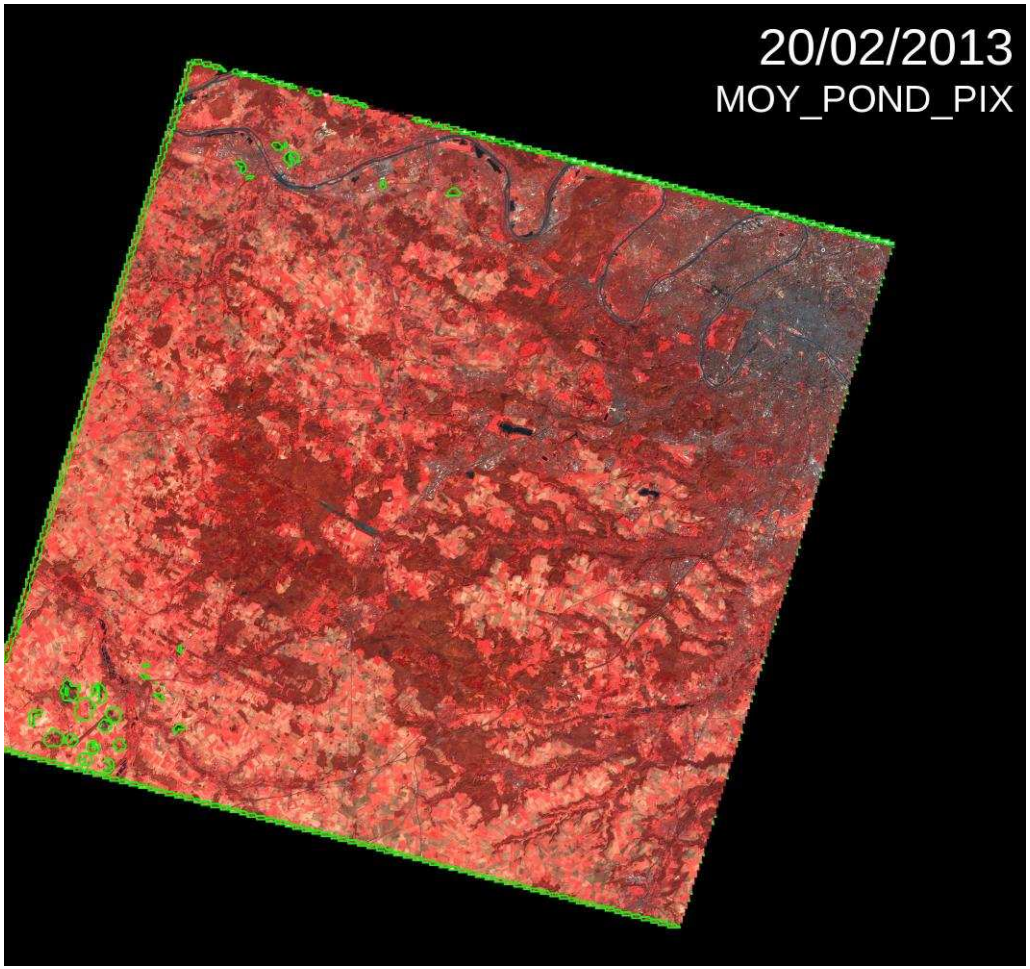


Level 3A

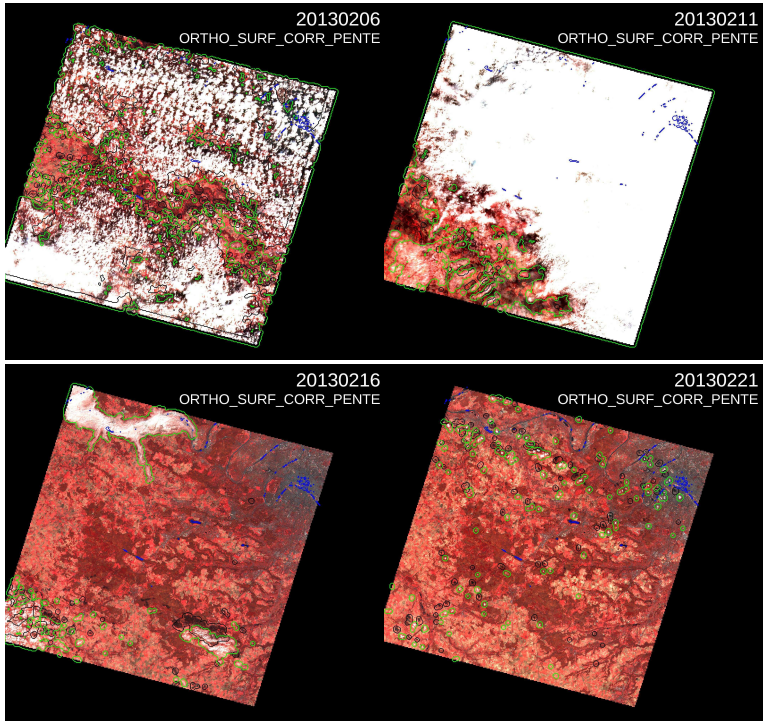
- Monthly (or fortnightly) composite of cloud free surface reflectances
  - Based on level 2A products, acquired within N days from the composite date
  - Weighted average of cloud free pixels
    - More weight to low cloud cover images
    - Less weight close to a cloud
    - Less weight when high aerosol content
- SPOT4 (Take5) is perfect for testing these methods in view of F2
  - 45 sites with different conditions
  - 4 large overlapping sites to test directional correction
- Funded by CNES THEIA budget

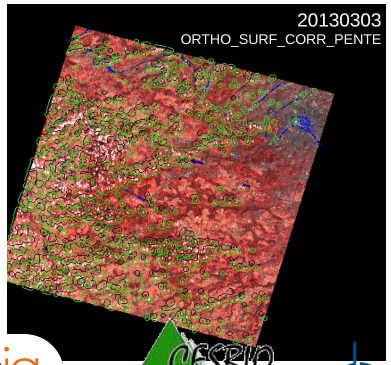
- Example of L3A time series from Versailles SPOT4 (Take5) site

L3A February



L2A





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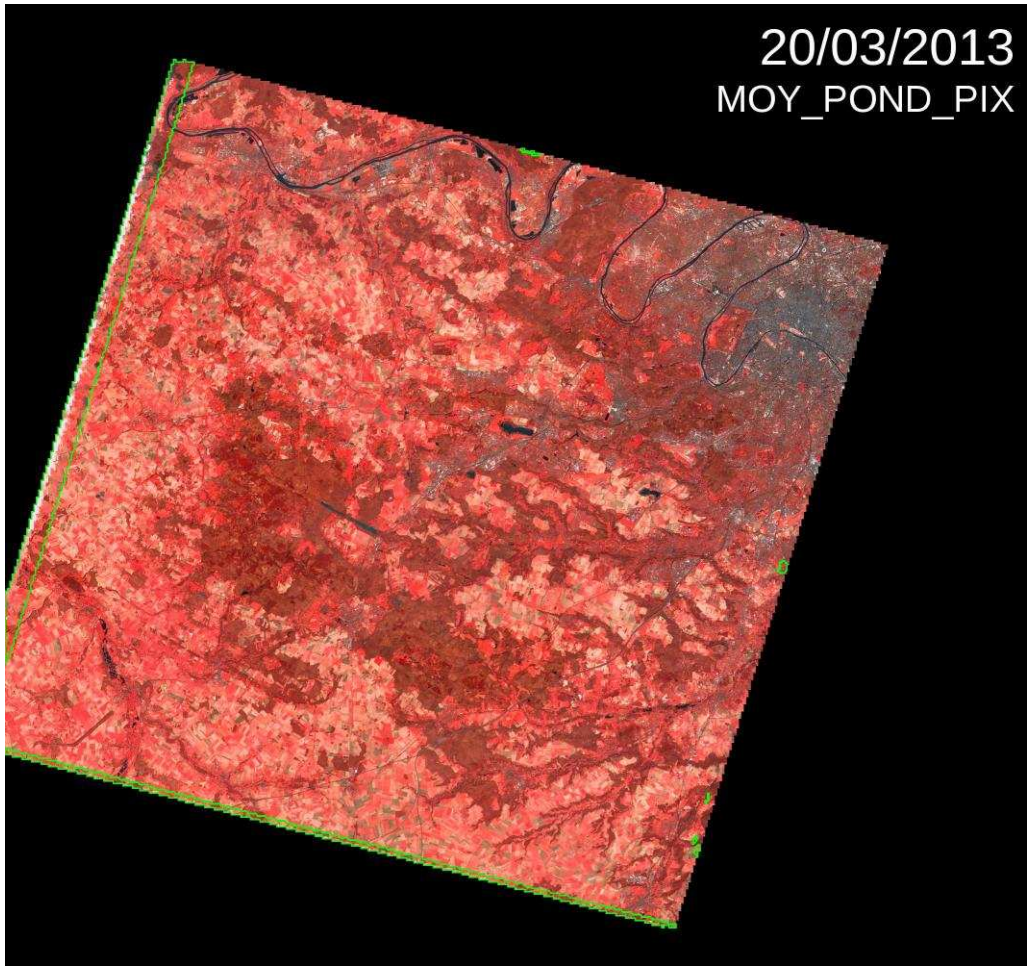
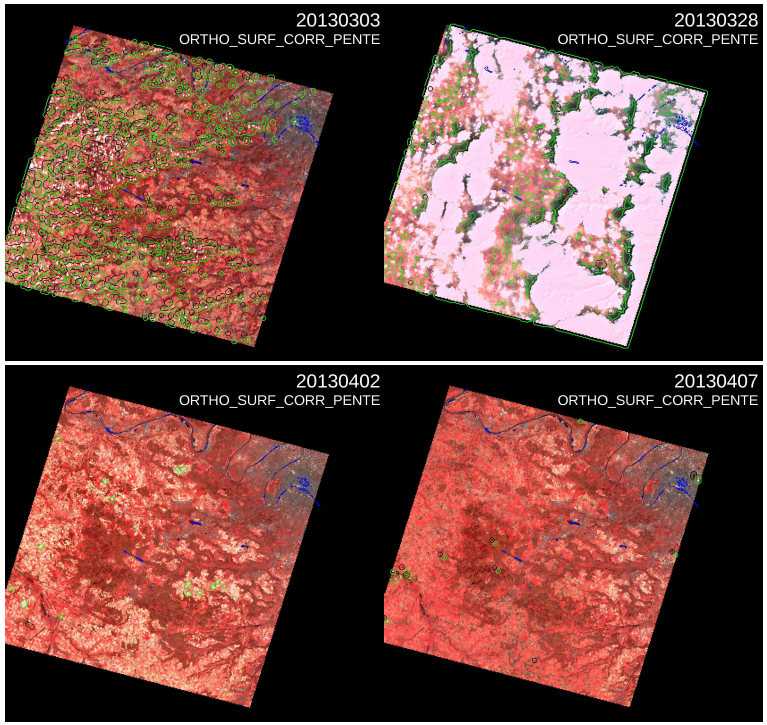
- Example of L3A time series from Versailles SPOT4 (Take5) site

L3A March

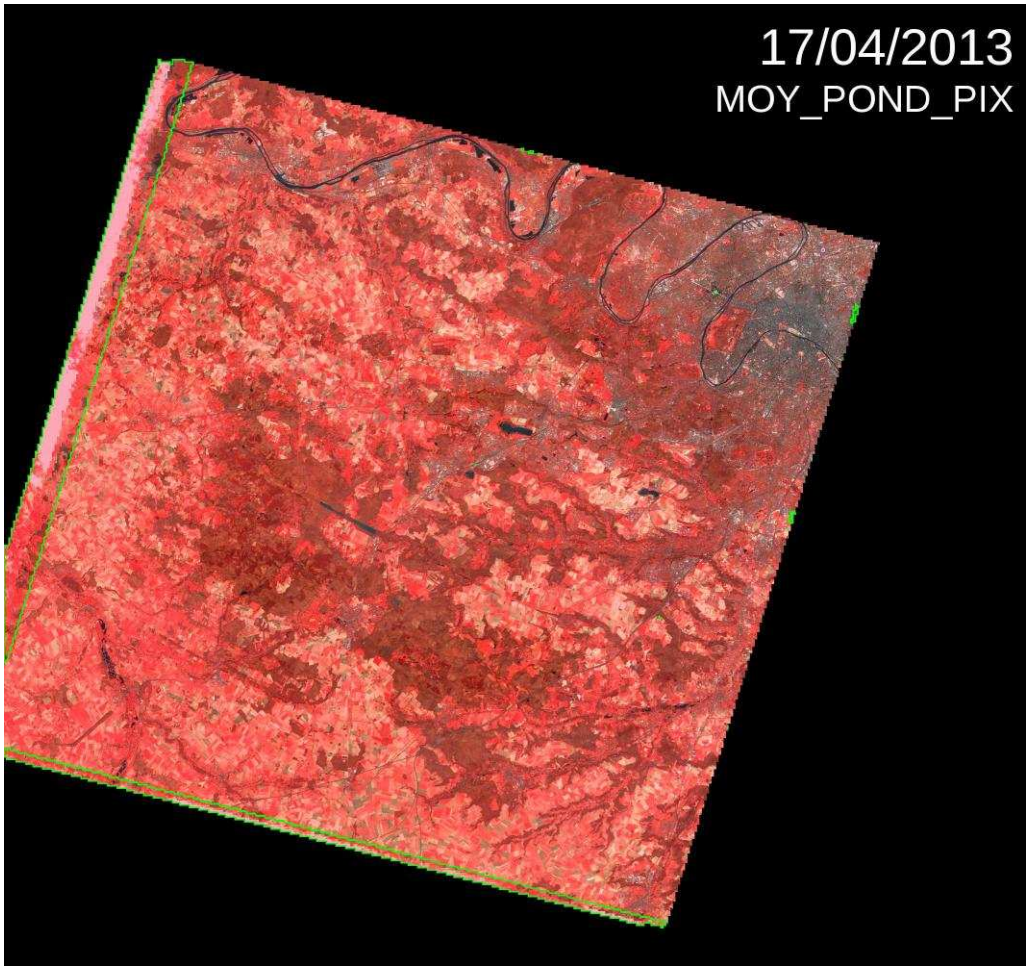


L2A

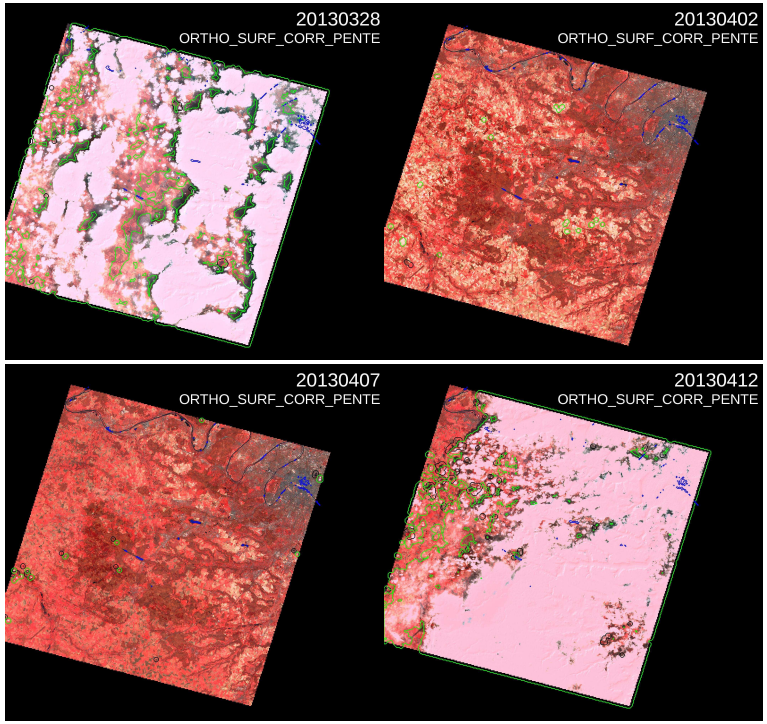


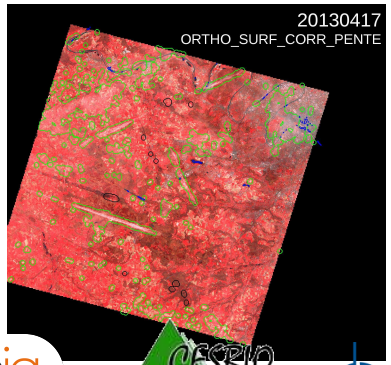
- Example of L3A time series from Versailles SPOT4 (Take5) site

L3A April



L2A





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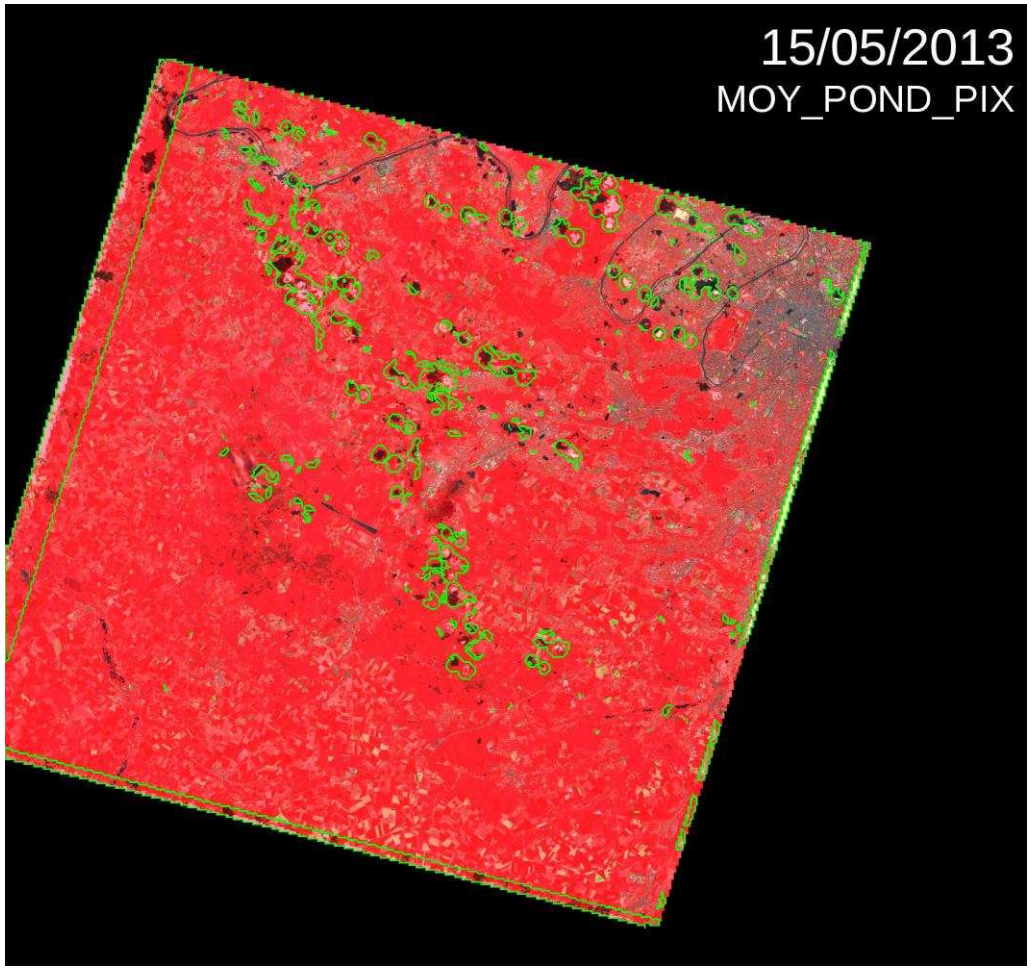
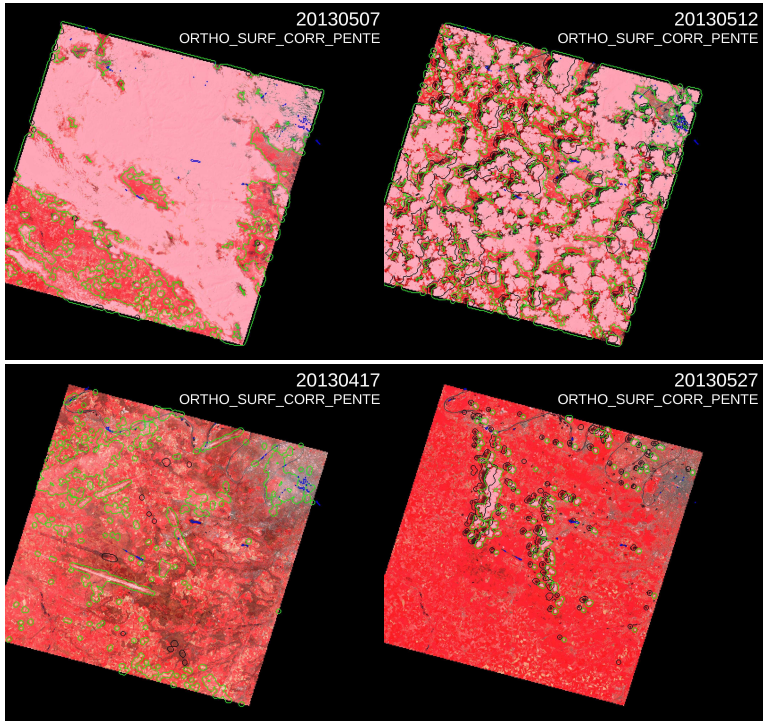
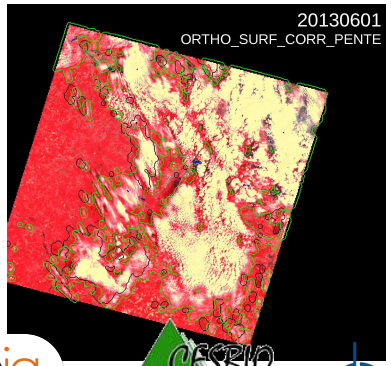
L3A May



L2A





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Level 3A

- Success in providing monthly (almost) cloud free images
- Sensitivity to cloud mask errors and cloud shadows errors
  - Relatively rare, and even better with Sentinel-2
  - Possibility to add an outlier detection
    - will require long compositing period
- Some inaccuracy in terms of dates, when most images are cloudy
  - Ex Versailles : May L3A based on data obtained End of June
- Future improvements
  - filling of residual gaps via interpolation
  - directional correction to account for Large S2 field of view (overlapping tracks)
- Future distribution of sample L3A products to get feedback

Land Cover : Approaches

Supervised automatic classification

- Fast production of a land cover map over Midi Pyrénées sites
- Experiment decided last Wednesday to show results at Take5 day
- => results produced on Friday !
- SVM, Random Forests, Boosting from Orfeo Tool Box (OTB)
- 9 dates, 4 bands, 12500×9500 pixels
- The L2A images to be classified weight 7.7 GB

Reference : existing DBs

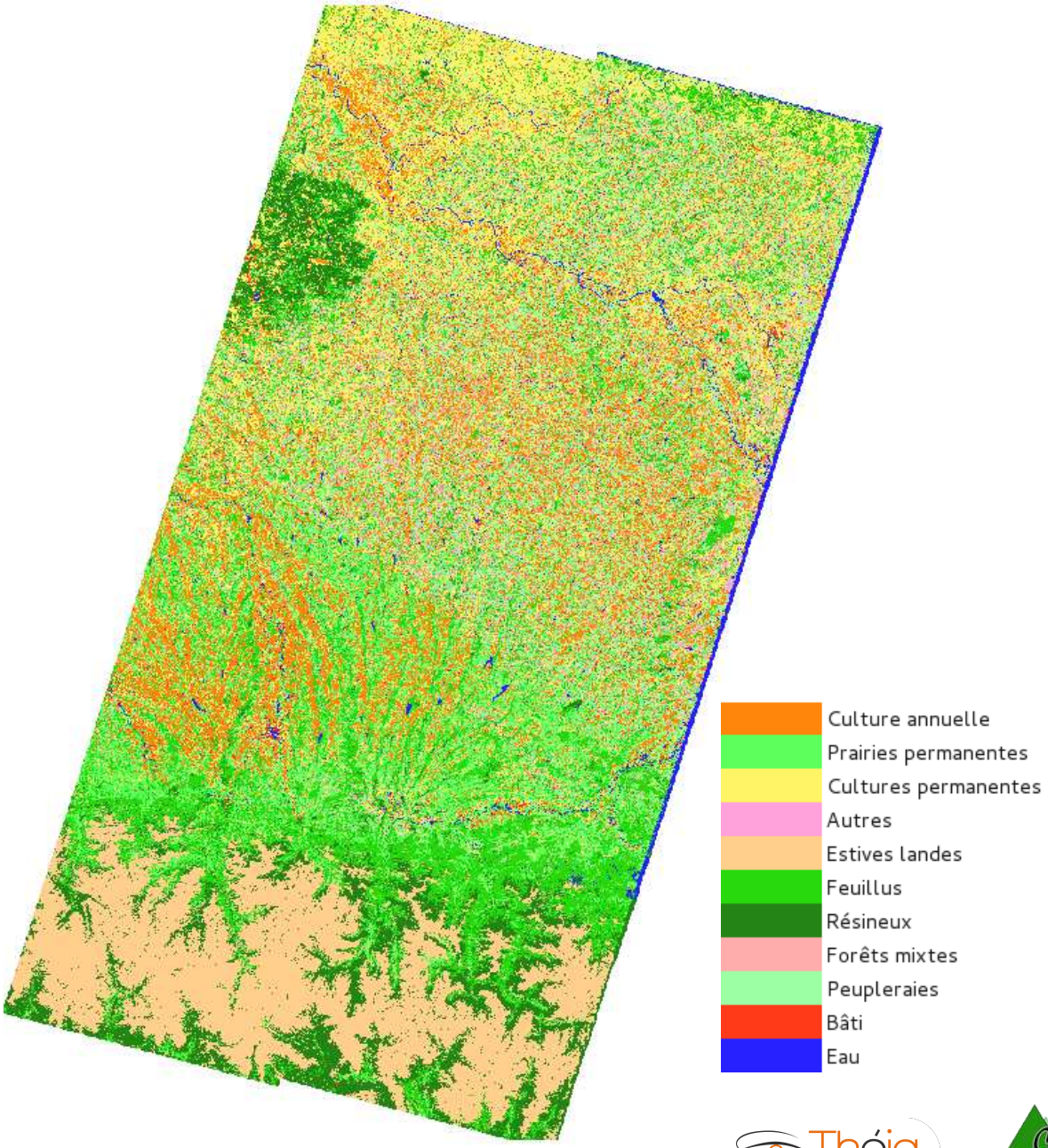
- Fusion of
  - BD-Topo (built up)
  - BD-Carthage (water)
  - IFN (forest),
  - RPG 2011 ! (Agriculture)
- Many data but also many errors

Reference : Field campaigns

- Accurate ground truth, but few samples
- Some samples obtained by photo-interpretation
- Small, very localised area covered

Image

Classification



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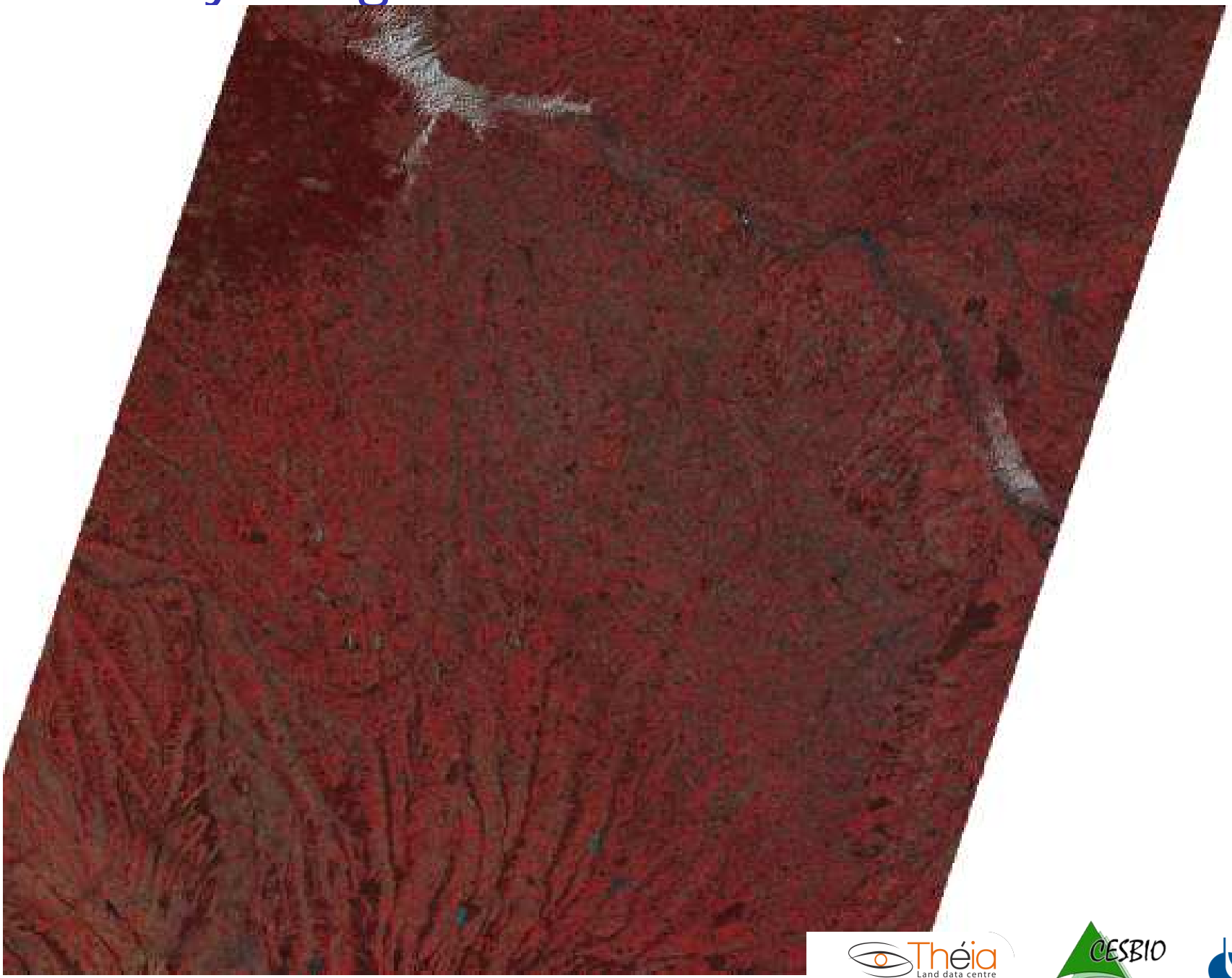
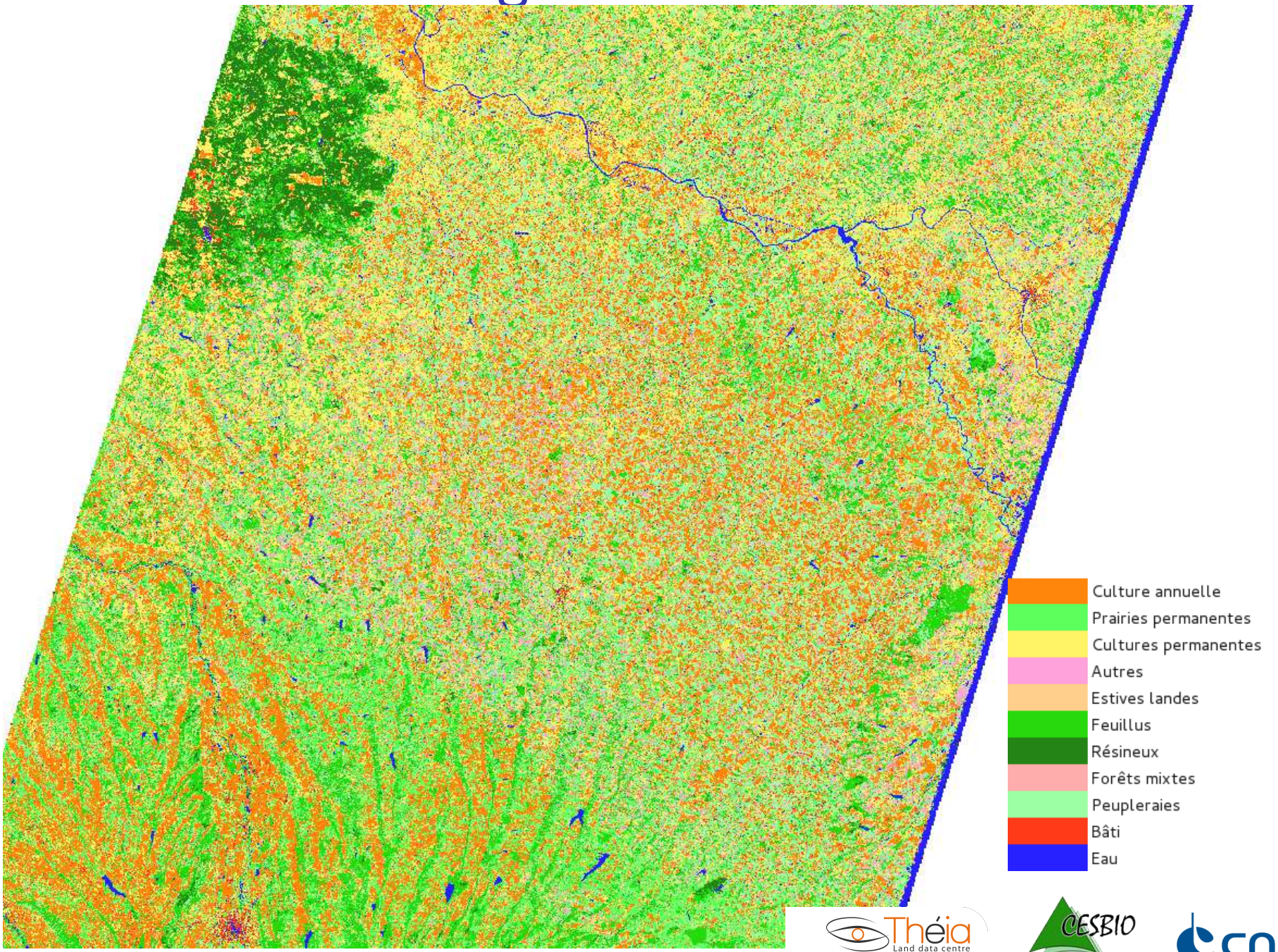
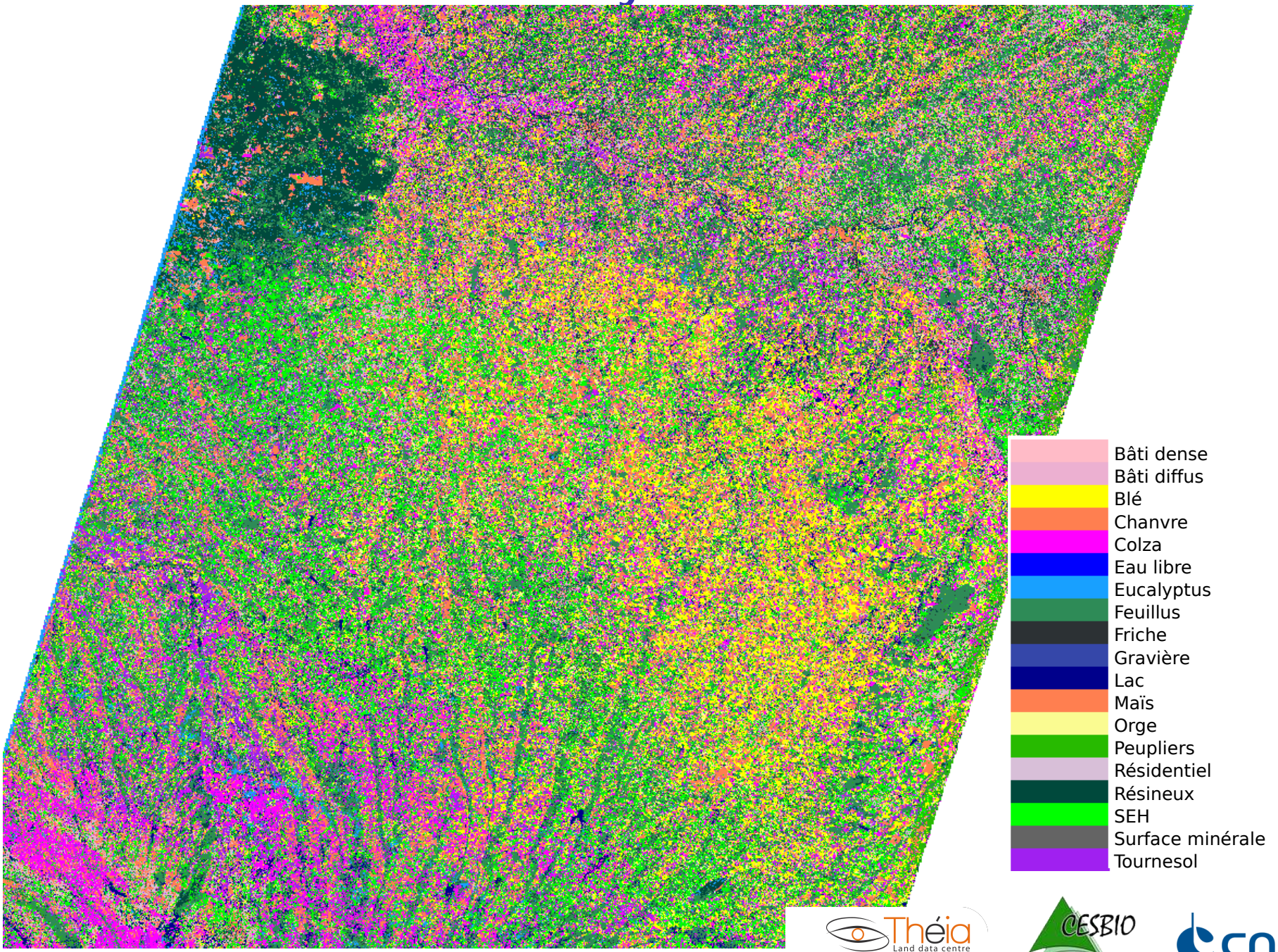
February Image



Reference : Existing databases



Reference : Field Surveys



Land Cover : Conclusions

About the processing chains

- Quick and efficient "Take5 day" operation
  - CESBIO expertise on reference data preparation
  - Efficient (time) and robust (quality) tools based on OTB
  - This work is only starting

About SPOT4 (Take5) data

- Data contains most of the necessary information
  - Although 5 months is a little short (confusions meadows-winter crops)
  - Use of Landsat 8 to obtain summer images

About reference data

- RPG of year N is not available before the end of year N+1
- Reference data quality is crucial
  - 90% with field surveys (1000 concentrated samples)
  - 70% with of-the-shelf DBs (50 000 scattered samples)
- Influence of the spatial spread of the sample
  - We found rapeseed on the mountains when using field surveys

Summary

L1C L2A Validation

- Good validation results for Level 1C and Level 2A
  - Partial validation so far, to be continued
  - Reprocessing needed because of geometric issues
    - Ortho-rectification did not work on 4 Equatorial forest sites
    - Replace LANDSAT 5,7 by better ortho reference images
  - Up to now, same Level 2A parameters for all sites
    - Next version with aerosol models adapted to the sites
- New version expected in November

Higher level products

- Interesting results for Level 3A :
  - Future distribution of sample data, Feedback from users expected
- Land Cover Maps
  - Operational and efficient libraries (OTB)
  - Main difficulties related to in situ data base collection
  - Much more accurate results Next Year...