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Bennett Laboratory
Logan, Utah , USA

17 – 19 June 2019

VENµS:

Mission specificities, products features and in-orbit absolute calibration

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CENTRE NATIONAL D'ETUDES SPATIALES

Arthur Dick

Physics of Optical Measurements
Instrumental Systems
CNES

And also:
P. Gamet, S. Marcq (CNES)
G. Dedieu, O. Hagolle (CESBIO)

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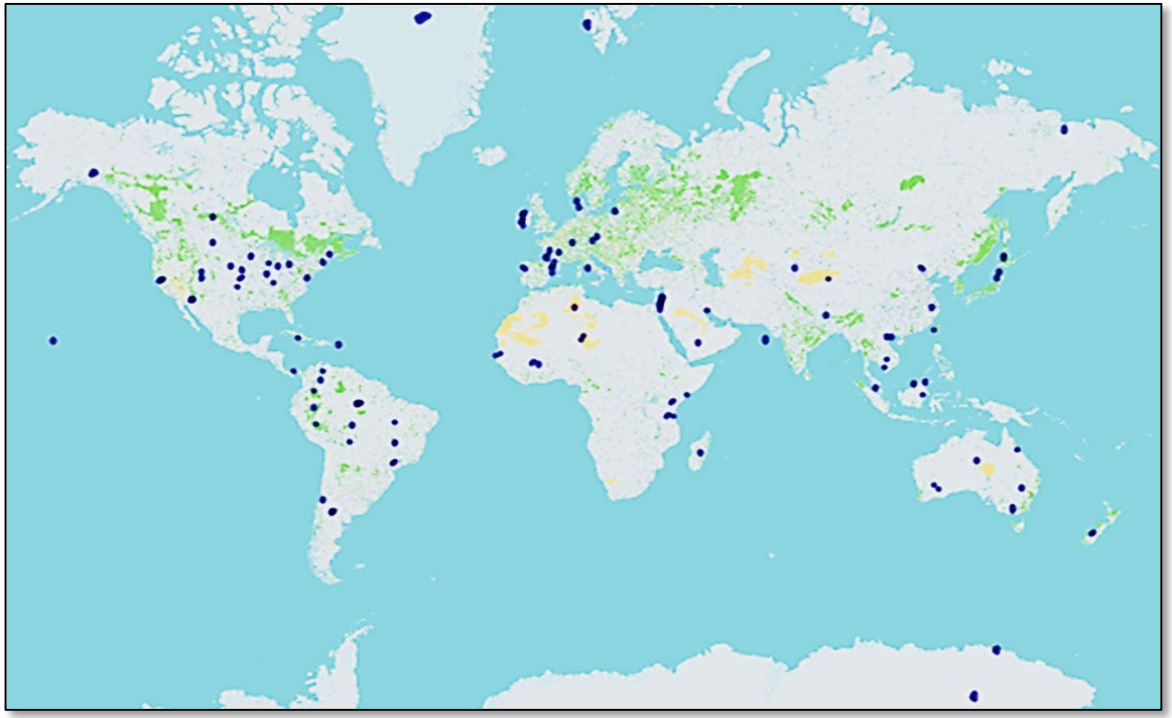
Outline

- VENμS mission
- VENμS products
- Stray-light correction
- Absolute calibration: methods and results
- Cross-calibration with Sentinel-2: SNO
- Conclusion

VENµS mission overview



Location of the 110 sites selected following an international call for proposals

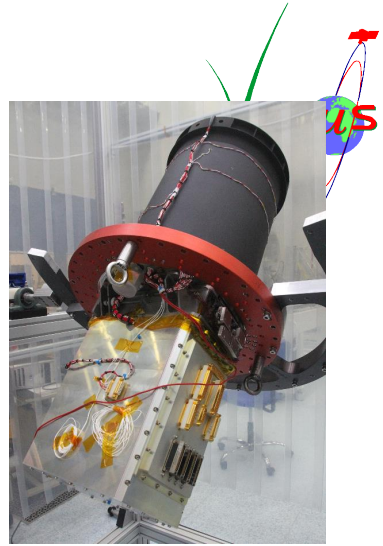
- French – Israeli mission
- Study of vegetation, 2.5 years mission
- 110 selected scientific sites *(123 sites since few weeks)*
- 12 spectral bands in VNIR
- 2 days revisit, GSD 5.3m
- Tilting capability: +/- 30 deg
- Swath 27 km

- Successfully launched Aug. 1, 2017
- Products on ***www.theia-land.fr***

VENµS mission overview

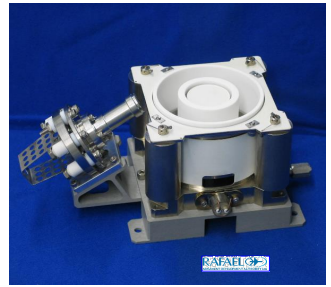
Scientific mission

Radiometer
12 spectral bands in VNIR

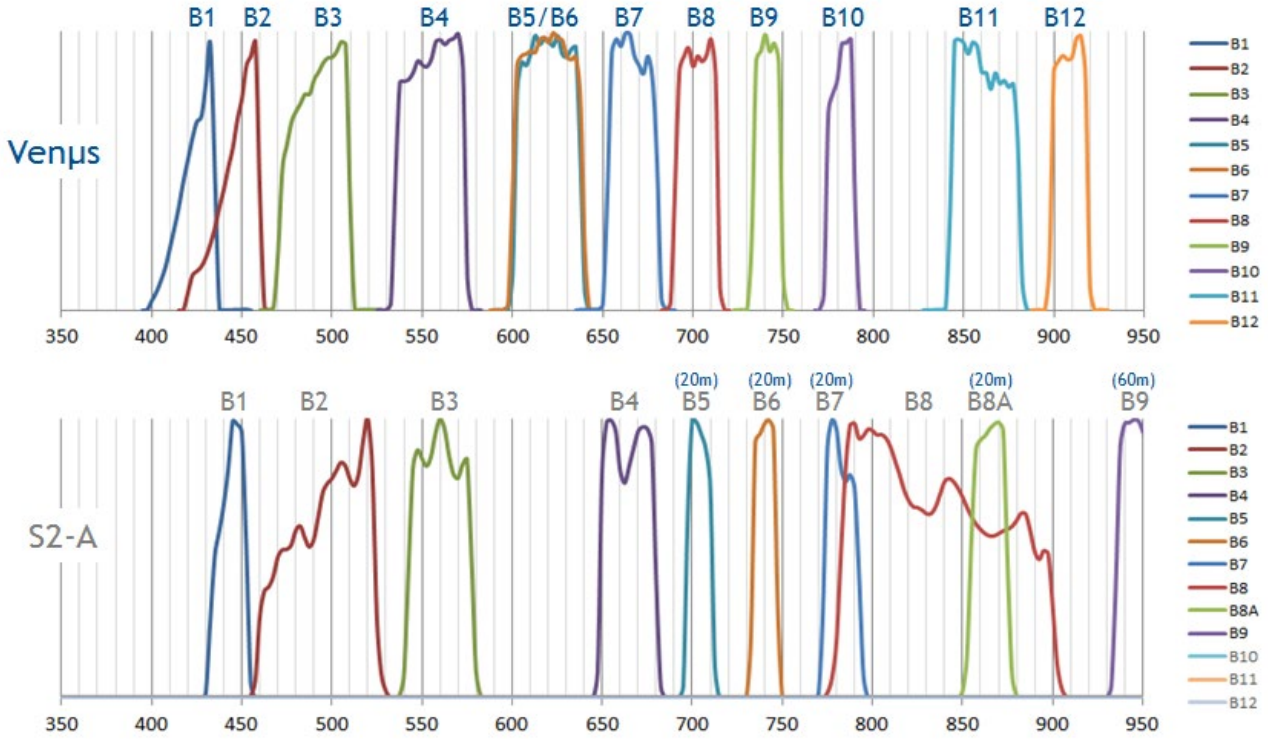


Technological mission

IHET
Israeli Hall Effect Thruster



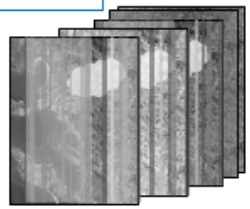
VENµS spectral bands



- 12 spectral bands in VNIR
- Stereoscopic bands B5 & B6 for clouds detection
- No cirrus detection band (no SWIR bands)

VENμS products

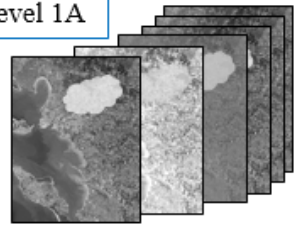
Level 0



Raw data of the 12 spectral bands

Radiometric calibration

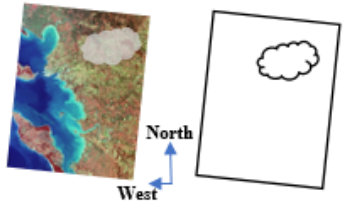
Level 1A



Radiometric calibration of each spectral band

Geometric calibration

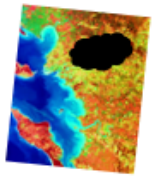
Level 1



Cartographic projection
Top-of-atm. reflectance

Atmospheric correction

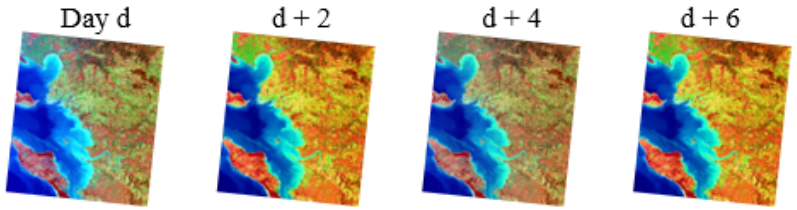
Level 2



Surface reflectance after cloud masking and atmospheric correction

Computation of time series

Level 3



Multi-date. No cloud, no aerosol

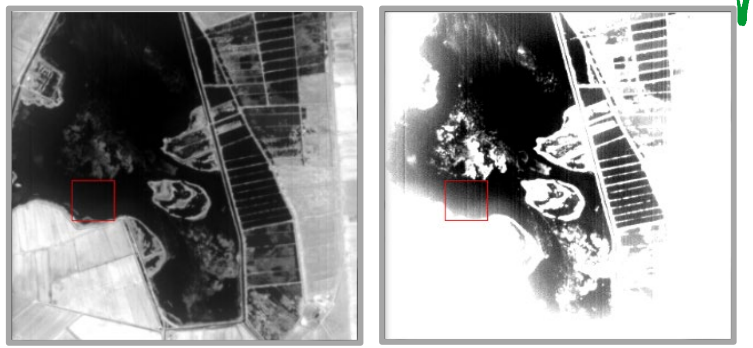
Access to changes at surface level

Stray-light correction

T1: Local ghosts

Caused by scattering of surfaces of the instrument and multiple reflections on detectors, filters or lenses

→ generates a low intensity but large blurring effect on the edges of high radiance targets

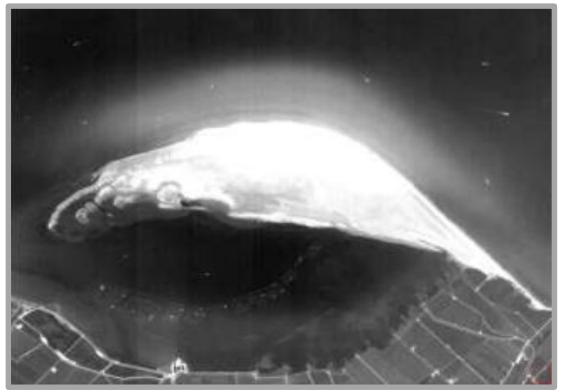


T1 stray-light on B12 (Maccarese sea shore, Italy)

T2: Cross-talk ghosts

Caused by reflections of light from a band to another band of the same tri-detector

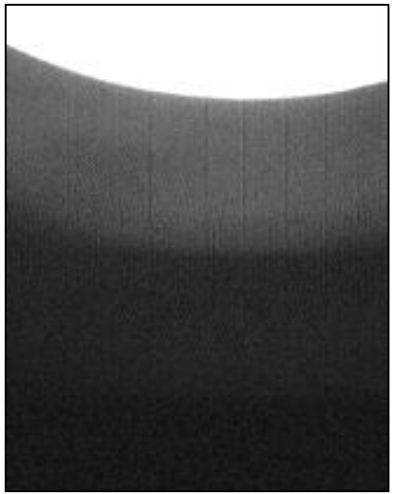
→ generates a blurring replication of the landscape +/- 150 pixels above/below



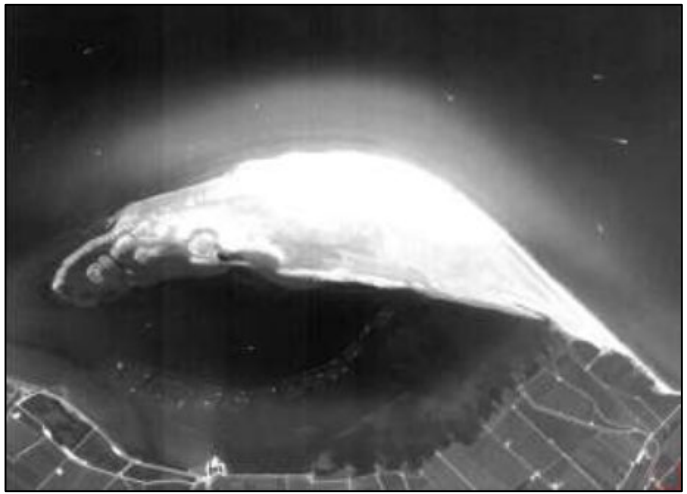
T2 stray-light on B1 (Ebro Delta, Spain)

Stray-light correction

Several examples of stray-light correction from B2 spectral band (before correction)



The Moon

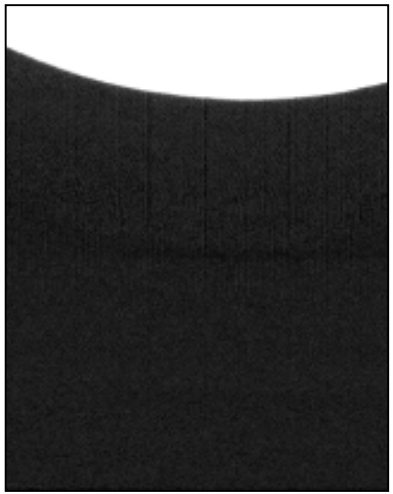


Delta Ebro beach and sea shore

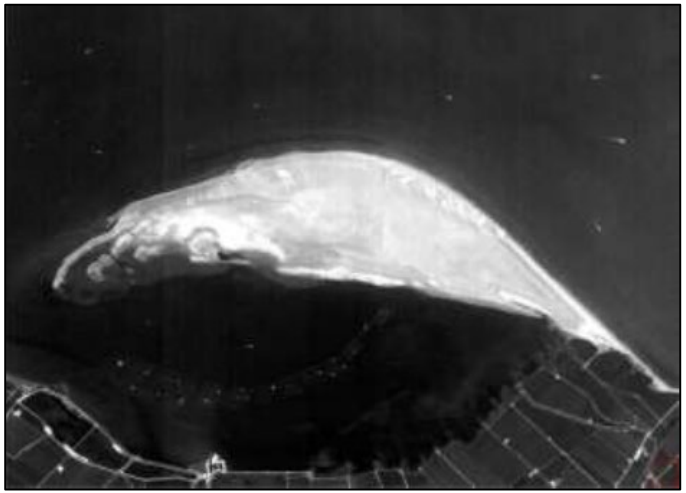
Clouds over Pacific ocean

Stray-light correction

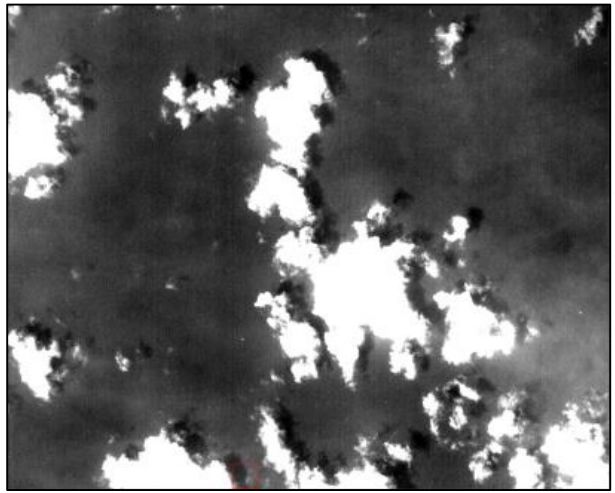
Several examples of stray-light correction from B2 spectral band (after correction)



The Moon



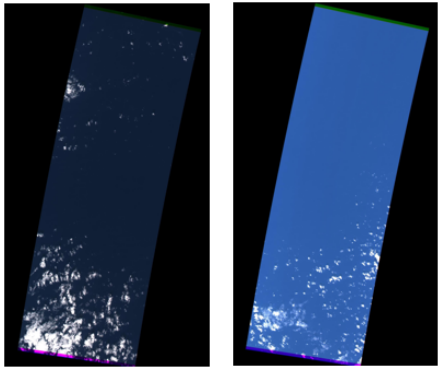
Delta Ebro beach and sea shore

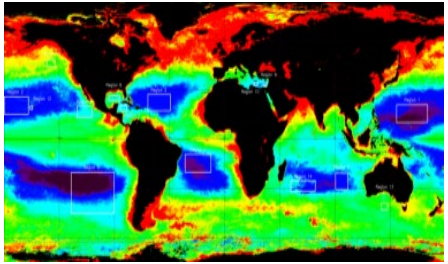


Clouds over Pacific ocean

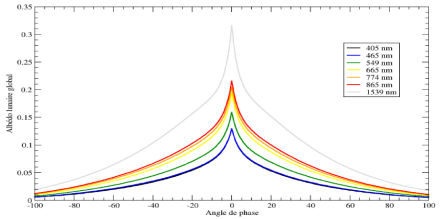
Absolute calibration: vicarious methods

Rayleigh
Molecular scattering over ocean sites

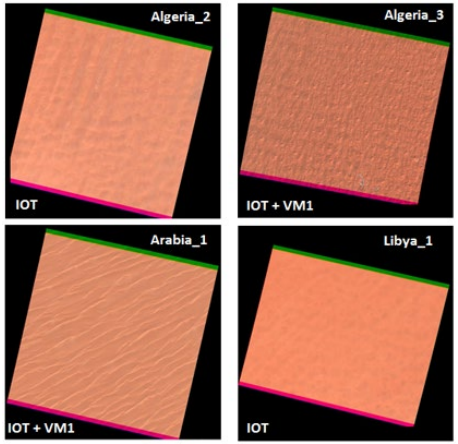


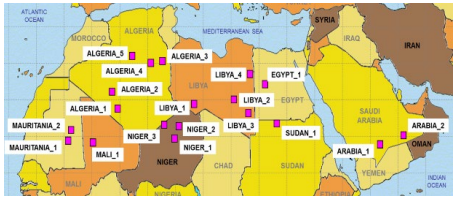


The Moon
ROLO model

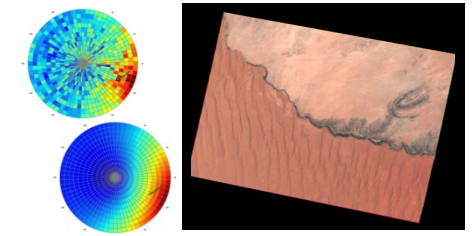


Desert sites
Cross-calibration with MERIS and Sentinel-2





In-situ measurements
from RADCALNET photometer in Gobabeb, Namibia



Absolute calibration: results

➢ Reference

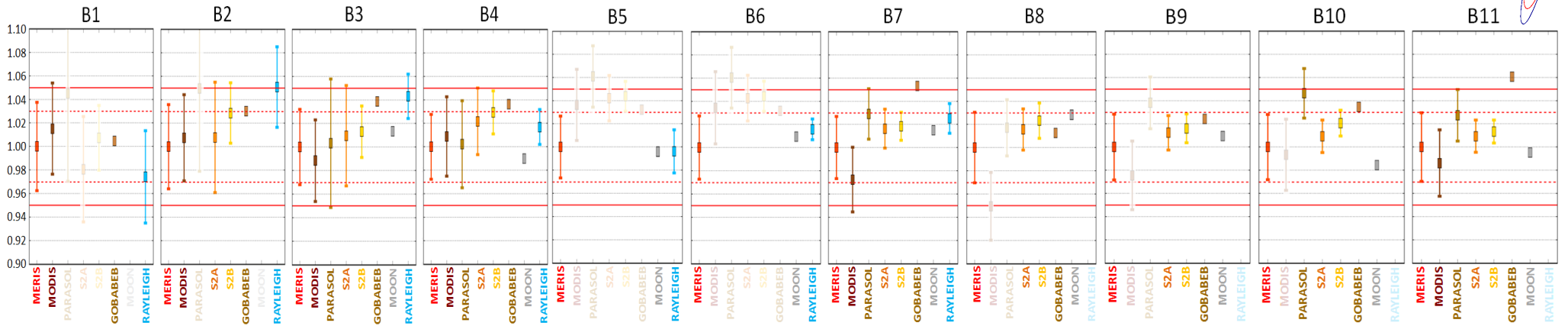
- For bands B1 to B11: cross-calibration on desert sites with MERIS
- For band B12 : absolute calibration on moon acquisition

➢ Reasons

- MERIS
  - → Reference for the calibration of many sensors
  - → Errors due to spectral interpolation are minimized (high number of spectral bands)
- B12
  - → Water vapor band
  - → Moon calibration method is not affected by the atmosphere
  - → *However: existing bias to be removed, investigations in progress*

Absolute calibration: results

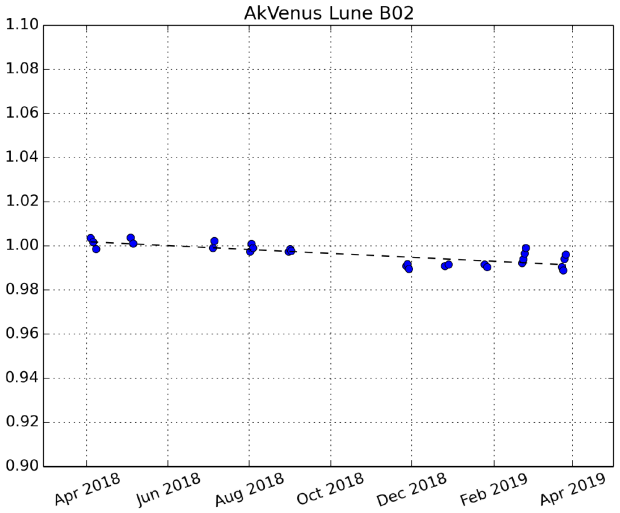
Absolute calibration performance after commissioning phase (march 2018)

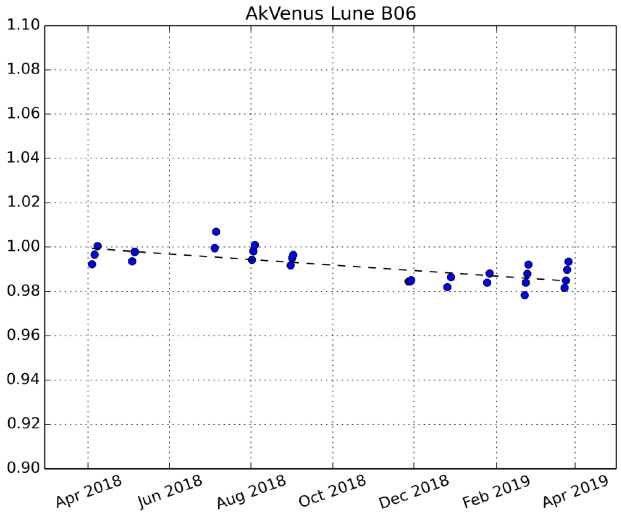


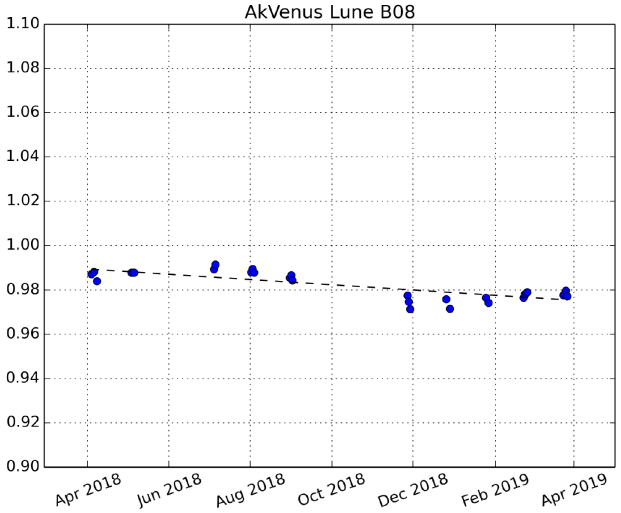
- B1 to B3 : calibration results within the 5% requirement
- B4 to B11 : within the 3% goal requirement
- B12 : about 3 % (performance derived from the precision of the Moon calibration method)

Absolute calibration: results

Absolute calibration evolution: the Moon method



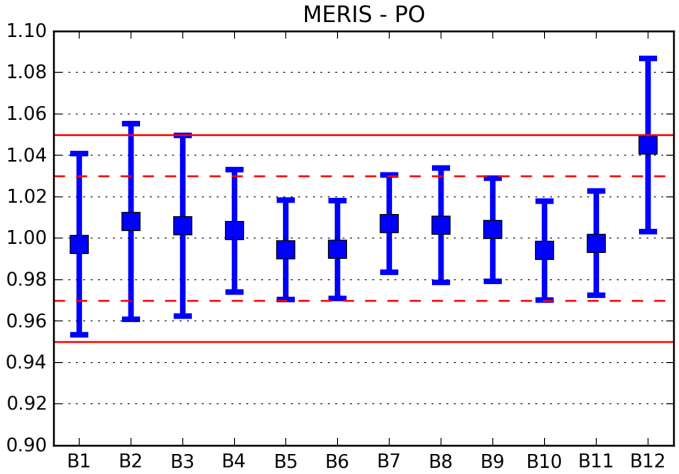


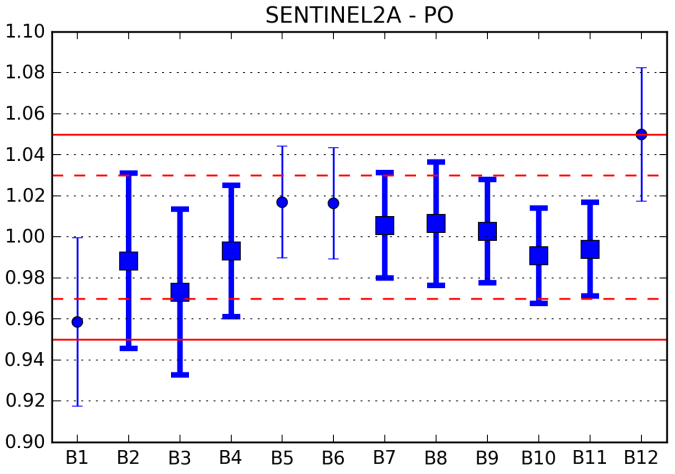


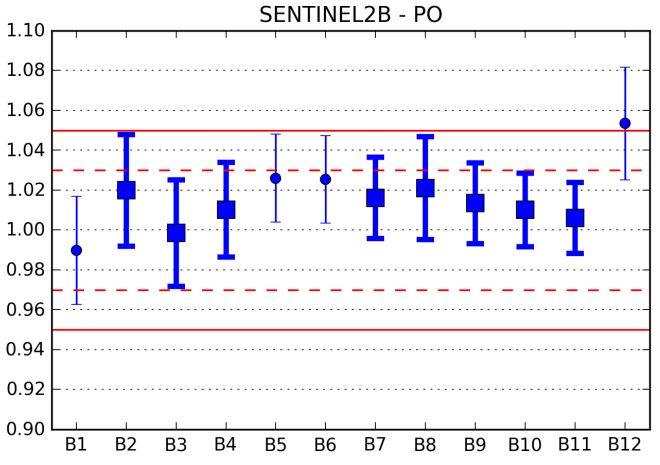
- The Moon method to estimate the temporal deviation of absolute calibration
- Same trend for all spectral bands
- Accurate monitoring of absolute calibration temporal deviation (about 2% in one year) with Moon acquisitions
- 2 updates of absolute calibration coefficient : 01/07/2018 and 01/01/2019

Absolute calibration: results

Absolute calibration evolution: desert sites

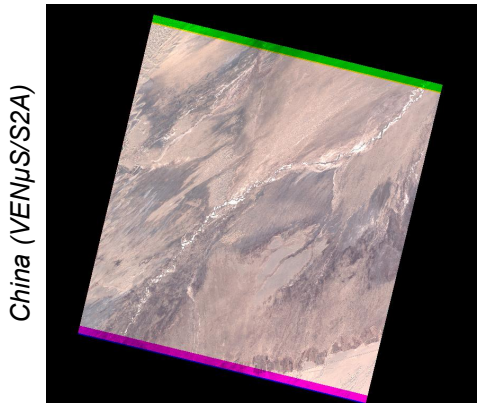


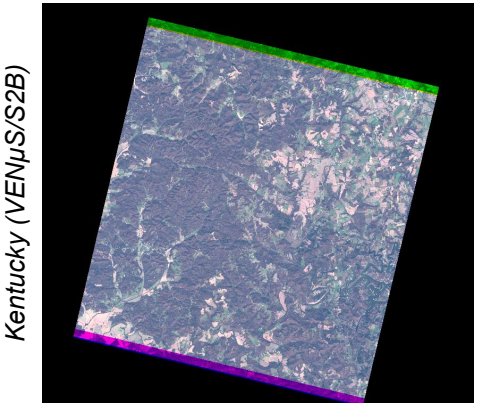


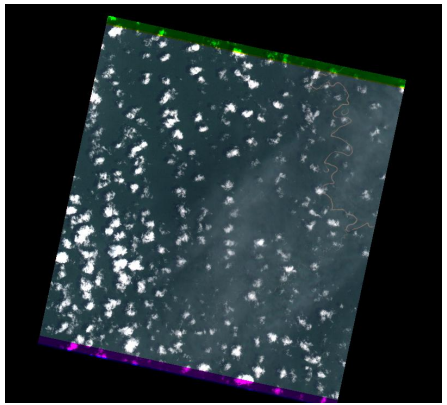


- B1 to B3 : calibration results within the 5% requirement
- B4 to B11 : within the 3% goal requirement
- B12 : about 3 % (precision of the Moon calibration method) → ongoing improvement to remove bias

Cross-calibration with Sentinel-2: Simultaneous Nadir Observations (SNO)





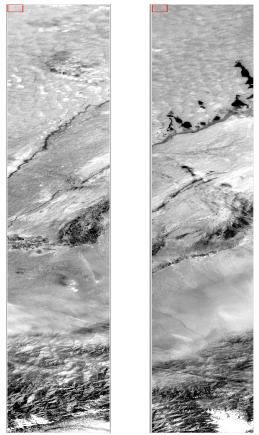


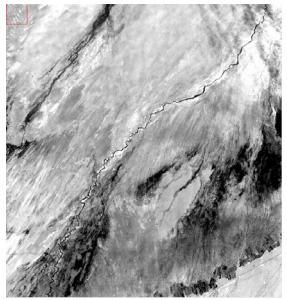
- 3 sites acquired by VENμS and S2 at almost same time and with almost same acquisition geometry
  - Δ time ~ 3 min
  - Δ zenithal viewing angle < 1° (nadir)
  - Δ zenithal solar angle < 0,5°

- Plenty of acquisitions could not be used
  - Phasing between VENμS and S2
  - Operational issues on VENμS or S2
  - Clouds

Cross-calibration with Sentinel-2: Simultaneous Nadir Observations (SNO)

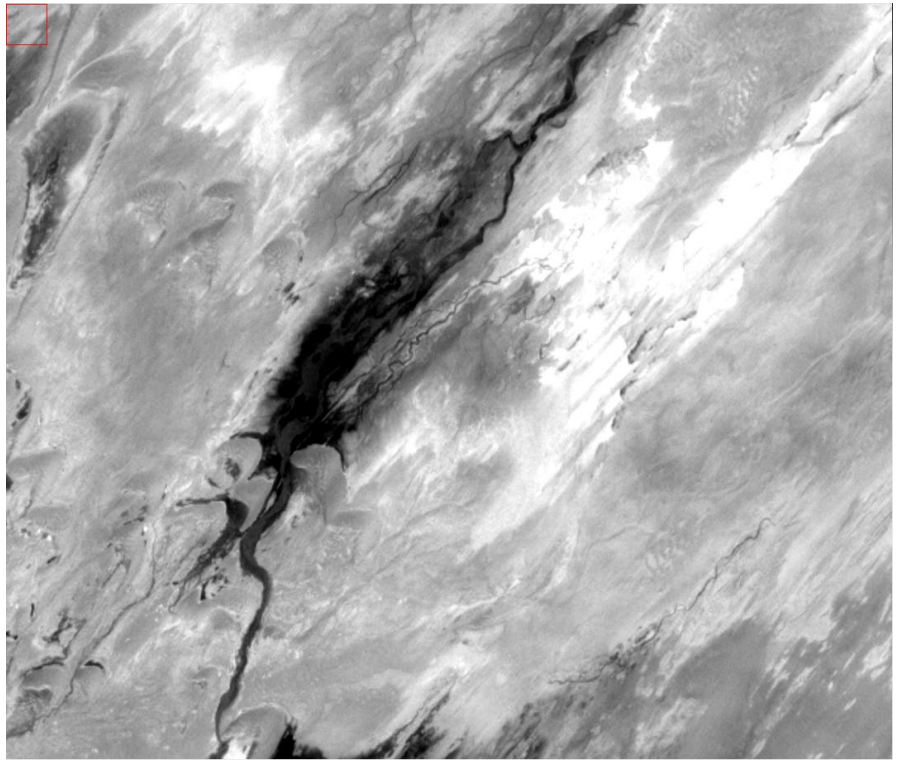
2 detectors of S2 equalized image B3 (in LSB)





VENµS equalized image B4 (in LSB)

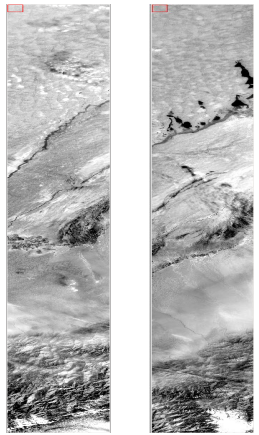
- Resampling S2 image into VENµS resolution
- Registration
- Extraction in S2 acquisition (300 km swath) of the VENµS footprint acquisition (27 km swath)

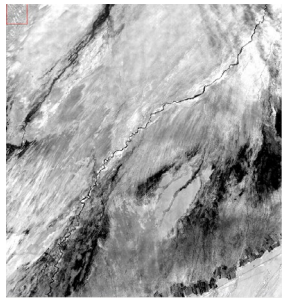


Extract of VENµS image (B4)

Cross-calibration with Sentinel-2: Simultaneous Nadir Observations (SNO)

2 detectors of S2 equalized image B3 (in LSB)





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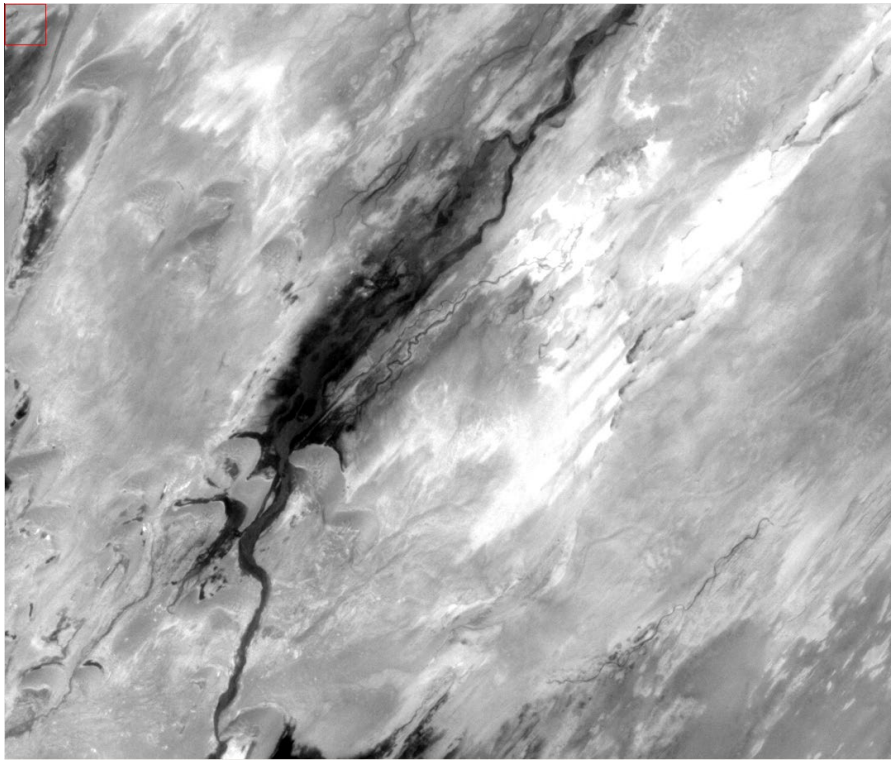
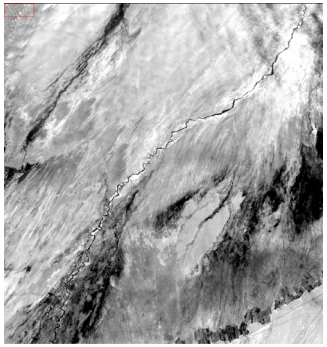
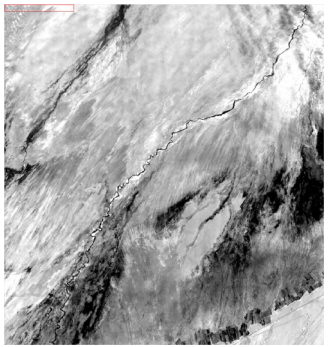


Extract of S2 image (B3)

Cross-calibration with Sentinel-2: Simultaneous Nadir Observations (SNO)



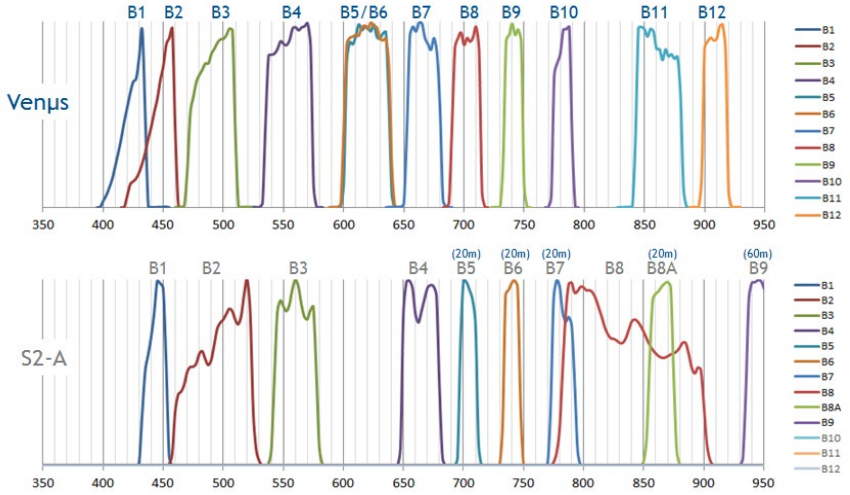
S2 image



VENµS image

- Conversion into reflectance image
- Zoom out
- 1-sigma filtering to remove pixels where important radiometric changes are observed

For each band association and for each pixel, comparison of measured reflectance between S2 and VENµS



Band association (VENµS/S2):

(B1/B1), B2/B1, B3/B2, B4/B3, (B5/B4), (B6/B4), B7/B4, B8/B5, B9/B6, B10/B7, B11/B8a, (B12/B8a)

Cross-calibration with Sentinel-2: Simultaneous Nadir Observations (SNO)

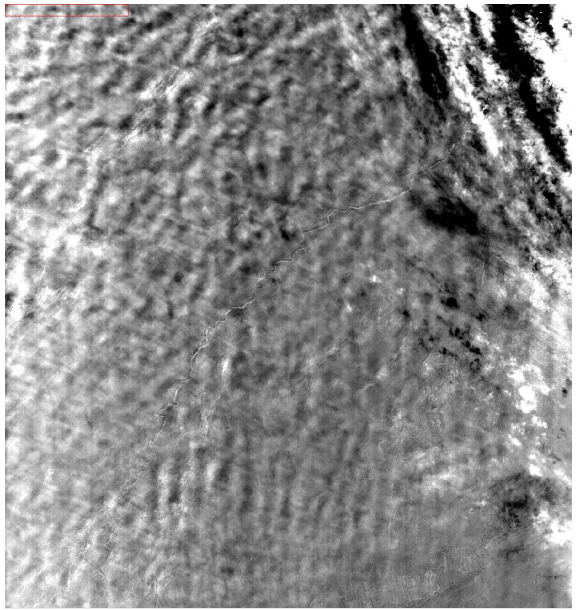
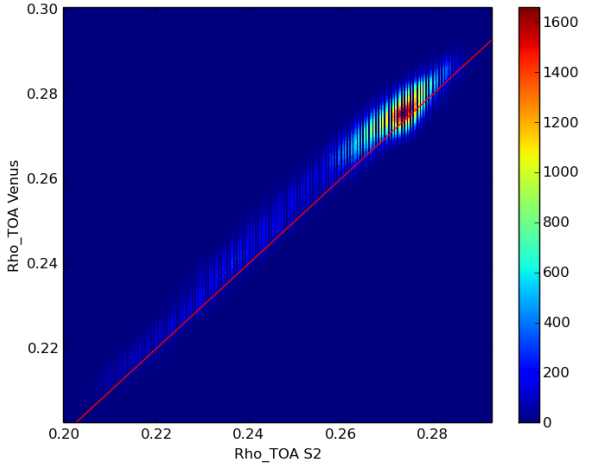


Image of reflectance ratio between VENμS and S2

Image of filtered pixels

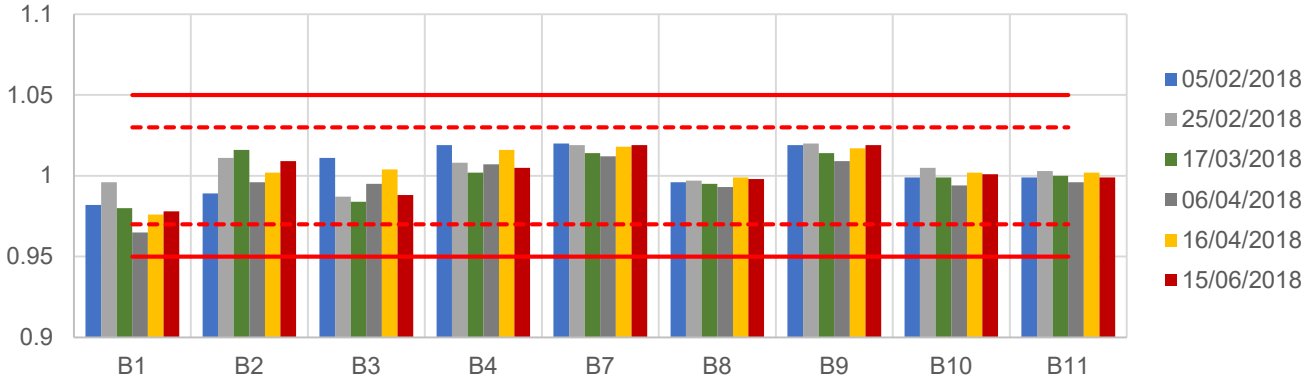


Histogram of VENμS TOA reflectance (B4) as a function of S2 TOA reflectance (B3) and y=x in red

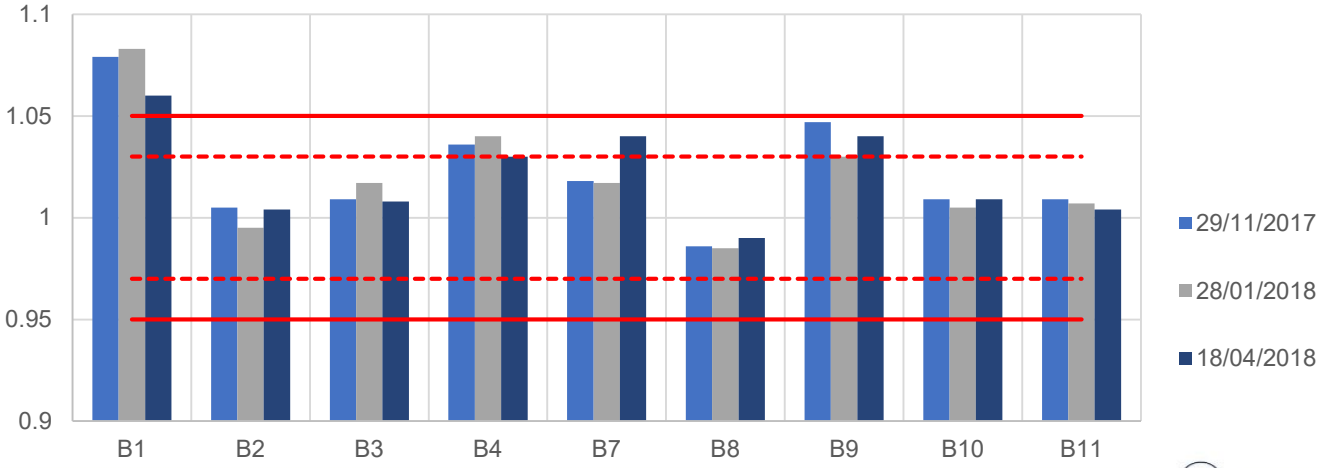
Absolute calibration coefficient is the slope

Cross-calibration with Sentinel-2: Simultaneous Nadir Observations (SNO)

China



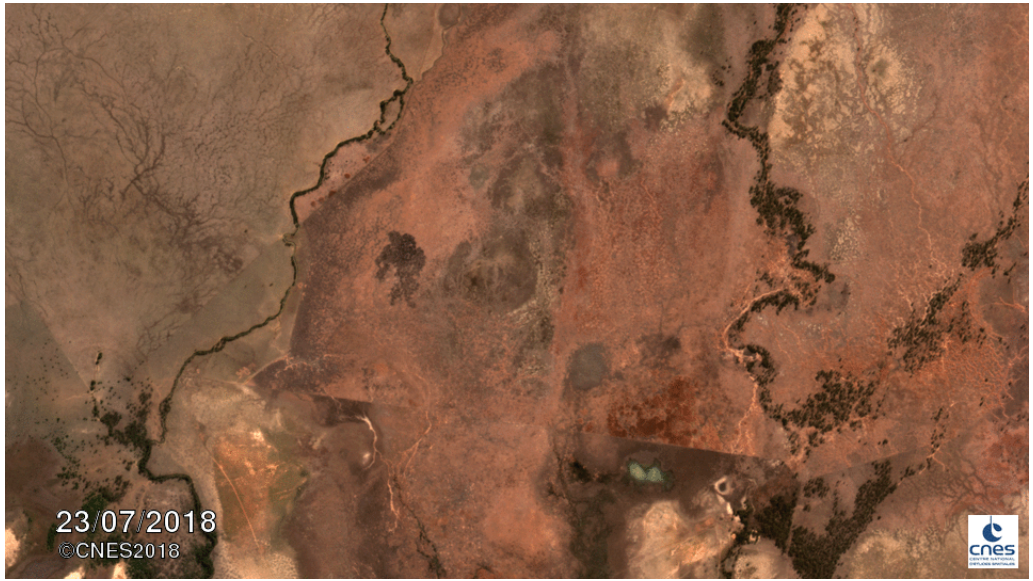
Kentucky



- Results seem stable in time and in location and consistent with other methods
- Spectral bias for VENμS bands B1, B5, B6 and B12 which have not associated band in S2 → *ongoing improvement*

Conclusions

- Overall image quality is good, and the products match scientific expectations, except for some « difficult » sites
- Stray-light correction performance is highly satisfactory
- Moon acquisitions are really important to monitor the temporal deviation of the absolute calibration
- Cross-calibration with SNO is a promising method
- 2 days revisit and 5 m resolution provide crucial information in specific cases
- Ongoing reprocessing with updated configuration (improvement of geometric performance and clouds detection)



Time series over MACQ site (Australia)

Products freely available : ***www.theia-land.fr***

Thank you for your attention !