Improved Confidence on the PLEIADES In-flight Absolute Calibration Through the Merging of Different Vicarious Calibration Methods

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from SPOT to PLEIADES

- SWATHS:
  - SPOT1-4: 60 km, 2 instruments, East/West tilt +/- 27°, 10m PA, 20m XS
  - SPOT5: 20 km, 1 instrument, agile Satellite, 2.5m PA, 10m XS
  - PLEIADES: 20 km, 1 instrument, 70 cm PA, 2.80 XS

Timeline:
- 1986-2012
ISTANBUL (Extrait)
The PLEIADES system

System with a very high level of agility!

Dubai: the highest tower of the world

Manhattan
The PLEIADES system

Monument Valley
when Pleiades points the sky ...

Jupiter and its moon
two other planets ...
Moon  (spatial resolution: 380m)
The PLEIADES system (spectral bands)
PLEIADES Absolution calibration

Goal: absolute radiometric calibration < 5%

Methods:

African deserts  La Crau  Oceans  Antarctica  Moon
The PLEIADES absolute calibration

To reach this goal:

5 types of natural targets with 5 spectral behaviors
Examples of average spectrum:

![Graph showing TOA reflectance vs. Wavelength (nm)]
The PLEIADES absolute calibration

Desert and Dome calibration methods are cross-calibration methods, using “reference” sensors.

Rayleigh method is an absolute calibration method based on the rayleigh scattering above oceans (used only for the spectral bands from the blue to the red).

La Crau is a site where an automatic station is settled, provided simultaneous measurements with satellite data (absolute calibration).

The Moon is used mainly for multi-temporal calibration, but can be also used for cross-calibration, inter-band calibration.

→ To cross-check the results and the sites is very important to validate and improve the calibration of the sensors.
PLEIADES Absolution calibration: our dreams

What we would like to obtain...

Very good consistency of the results for each spectral band of the sensor

![Graph showing the consistency of the results for each spectral band of the sensor. The x-axis represents the acquisition date, ranging from 14/09/2011 to 06/05/2013, and the y-axis represents the ratio of Ak/Ak_ground. There are multiple data points scattered across the graph, indicating the consistency of the results over time.](image-url)
PLEIADES Absolution calibration: *the real life!*

What we obtain at the beginning of the calibration phase...
Dispersion of the results depending of the methods, sites and spectral bands

Where is the truth???
PLEIADES Absolution calibration
How to improve confidence on the results

First step: determine where the truth is

Second step: understand why some methods/sites show bias

→ The sites don’t have the same spectral properties:
   Take advantage of them !!!

Third step: confirm the previous conclusions with another method
First step: determine where the truth is

Second step: understand why some methods/sites show bias

Third step: confirm the previous conclusions with another method

How: spectral comparison of the Top Of Atmosphere reflectances between PLEIADES and our reference sensor (ENVISAT/MERIS)

![Graph showing Top Of Atmosphere Reflectance versus Wavelength (µm)]

- **Dome**: ozone absorption band
- **Desert**: inflexion point of the sand
First hypothesis: Oceans and Dome give the correct calibration results

Comparison of TOA reflectance over dome sites between PLEIADES (with application of the 1st hypothesis) and MERIS.

Hypothesis not correct. The TOA reflectance in green couldn’t be higher than the blue and red one.

→ Need to find the error(s) in the dome and oceans processings
PLEIADES Absolution calibration
How to improve confidence on the results

**Second step:** understand why some methods/sites show bias

Analysis of errors in the cross-calibration based on dome sites

**Conclusion:** the solar irradiance used for the dome processings was not enough precise! This error was sufficient to create this bias of 7% for Dome sites.
PLEIADES Absolution calibration
How to improve confidence on the results

After correction of the solar irradiance:
Good consistency of the results for desert and dome cross-calibration methods

![Graph showing Ak/Ak_ground values over time](image-url)
PLEIADES Absolution calibration
How to improve confidence on the results

Second step: understand why some methods/sites show biais
Analysis of errors in the cross-calibration based on ocean sites

Calibration on ocean sites = modelisation of the rayleigh scattering

This method modelises the radiance received by the instrument in the equivalent wavelength of the considered spectral band

Different errors/uncertainties are possible:
- this method is not enough precise due to spectral rejection of the PLEIADES spectral responses
- the PLEIADES spectral responses are measured only in 6 points of the field of view on ground. We don’t know precisely the spectral variation between these points.
  \[ 1 \text{nm} \rightarrow 1\% \text{ in the calibration results} \]

→ These two points could explain the biais observed for the oceans sites.
The PLEIADES system (spectral bands)
Third step: confirm the previous conclusions with another methods

How: Inter-band calibration based on Moon acquisition

Differences between Moon results and other methods

→ Good consistency between Moon, Desert and Domes.

Confirmation that there is a bias within the calibration over oceans.
CONCLUSIONS:
Quite difficult to assess calibration results better than 5%

To improve confidence on the results, we need
- Different sites (snow, desert, Moon, ocean…)
- Different methods: absolute calibration, cross-calibration, inter-band calibration
- Different reference sensors for cross-calibration

Why:
To be able to answer to the question:
Where does the observed phenomena come from ? (sites, methods, data…)

To confirm analysis:
Once the phenomena is understood, it is necessary to confirm it by another method/site/reference sensor.
Where to get some PLEIADES images?

- [http://smsc.cnes.fr/PLEIADES/premieres_images.htm](http://smsc.cnes.fr/PLEIADES/premieres_images.htm)
- [http://image-cnes.fr/tag/pleiades/](http://image-cnes.fr/tag/pleiades/)