The CNES Intercalibration Method over Desert Sites

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CONTENT

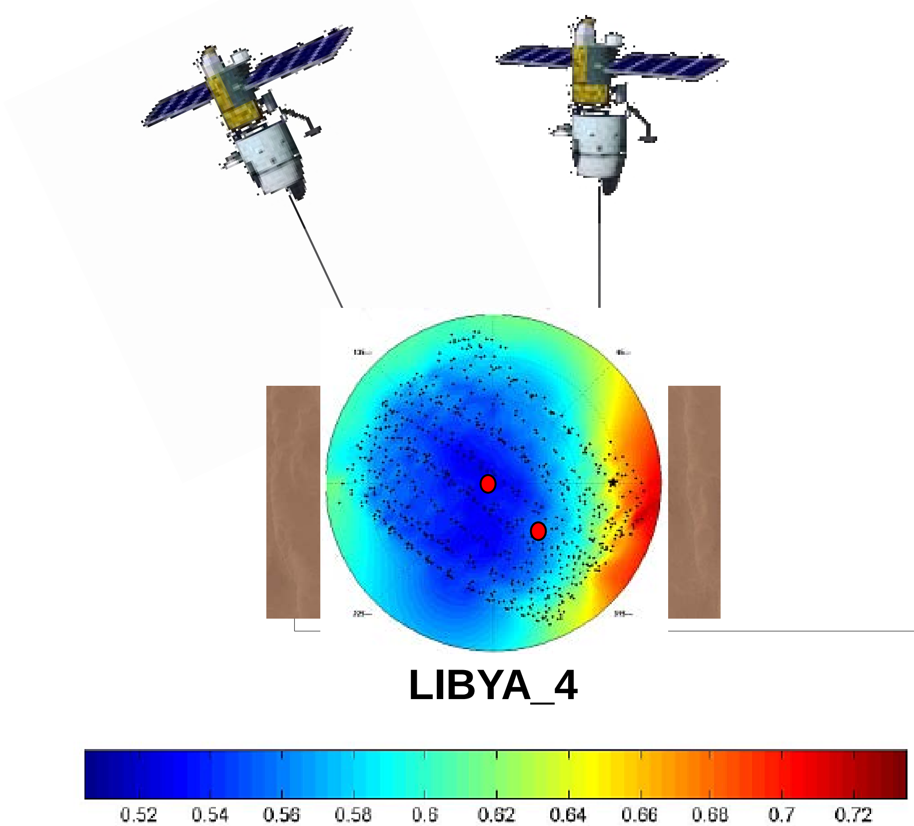
- Context
- Approach description
- Matchup Strategy
- Atmospheric corrections
- Interpolation strategy
- Improvement

Context

Why is it difficult to inter-calibrate two sensors over desert sites:

SENSOR 2
Acquisition date:
04/10/2012-11:30:28

SENSOR 1
Acquisition date:
04/07/2012-11:16:24



Different Acquisition Date

Is the same site (position, spectral and bidirectional behaviour) between S1 and S2 ?

What about the atmosphere content ?
How to take into account the difference in AOT ?

Different Acquisition Time

The sun position is not the same
How to take into account the difference of the atmosphere contribution ?
[$\theta s(S1) = 12.90°$ - $\theta s(S2) = 27.25°$]

Different viewing conditions

[$\theta v(S1)=0°$ - $\theta v(S2)=25°$]
is $\rho_{\theta i,\ \theta v, \Delta\varphi}(S1) = \rho_{\theta i,\ \theta v, \Delta\varphi}(S2)$?

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Context

How to take into account these difficulties:

<u>Different Acquisition Date</u>

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Context

How to take into account these difficulties:

<u>Different Acquisition Date</u>

Is the same site (position, spectral and bidirectional behaviour) between S1 and S2 ?

→ Libya_4 have been chosen for its time stability and homogeneity

What about the atmosphere content ?
How to take into account the difference in AOT ?

→ No information about AOT
Use of statistics to overcome this issue (SADE)

<u>Different Acquisition Time</u>

The sun position is not the same
How to take into account the difference of the atmosphere contribution ?
[$\theta s(S1)= 12.90\,°$ - $\theta s(S2)= 27.25\,°$]

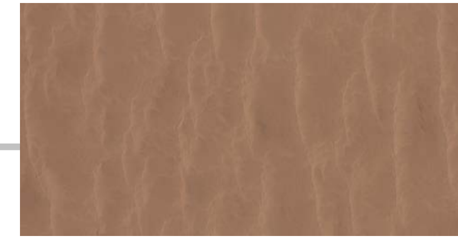
<u>Different viewing conditions</u>

[$\theta v(S1)=0°$ - $\theta v(S2)=25°$]
is $\rho_{\theta i,\ \theta v, \Delta\varphi}(S1)= \rho_{\theta i,\ \theta v, \Delta\varphi}(S2)$?

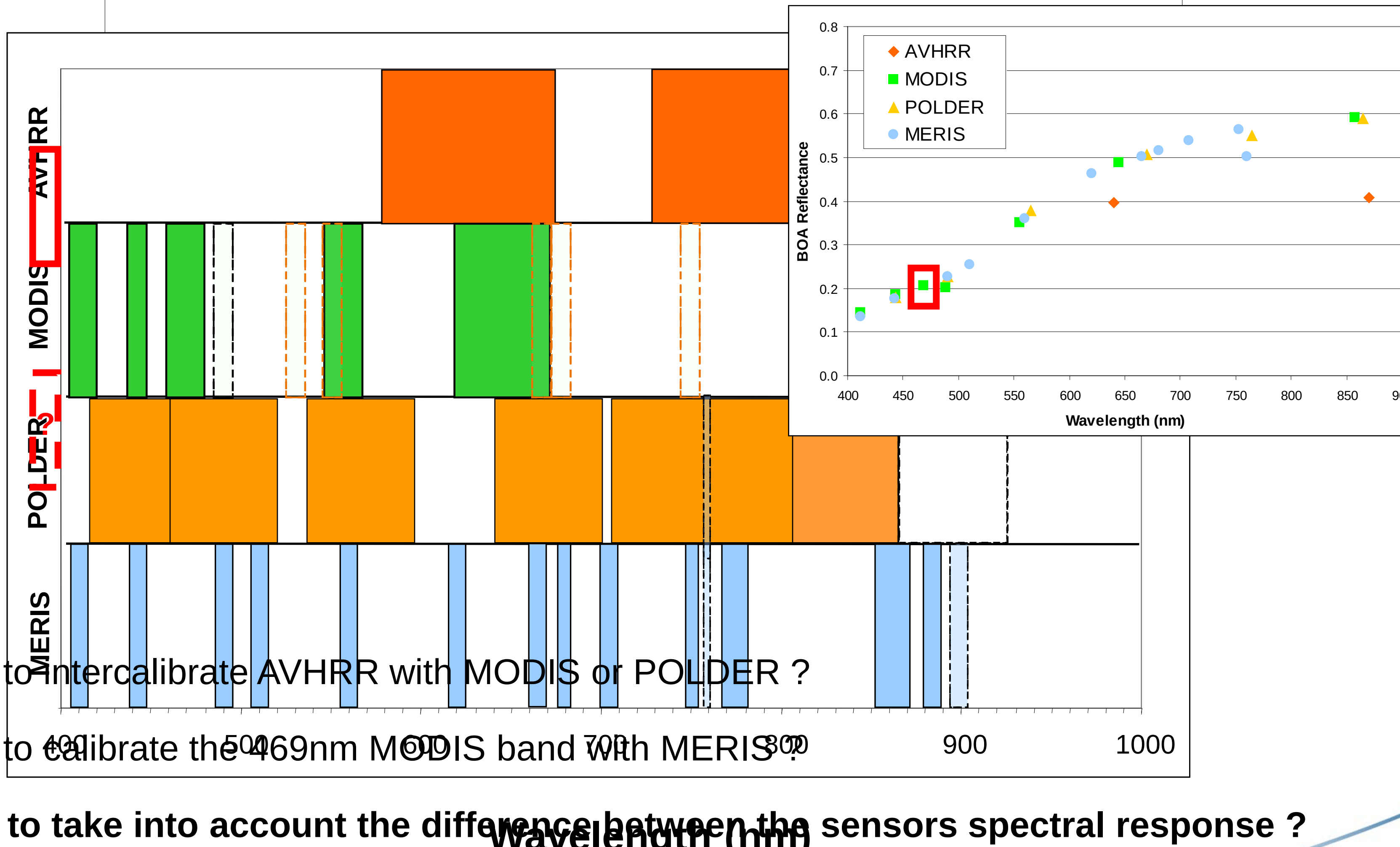
→ Matching conditions between S1 and S2 to limit the bidirectional effects of the site

Processing to compute the S1 into the geometry of the acquisition S2

Context



What about the sensors ?



How to intercalibrate AVHRR with MODIS or POLDER ?

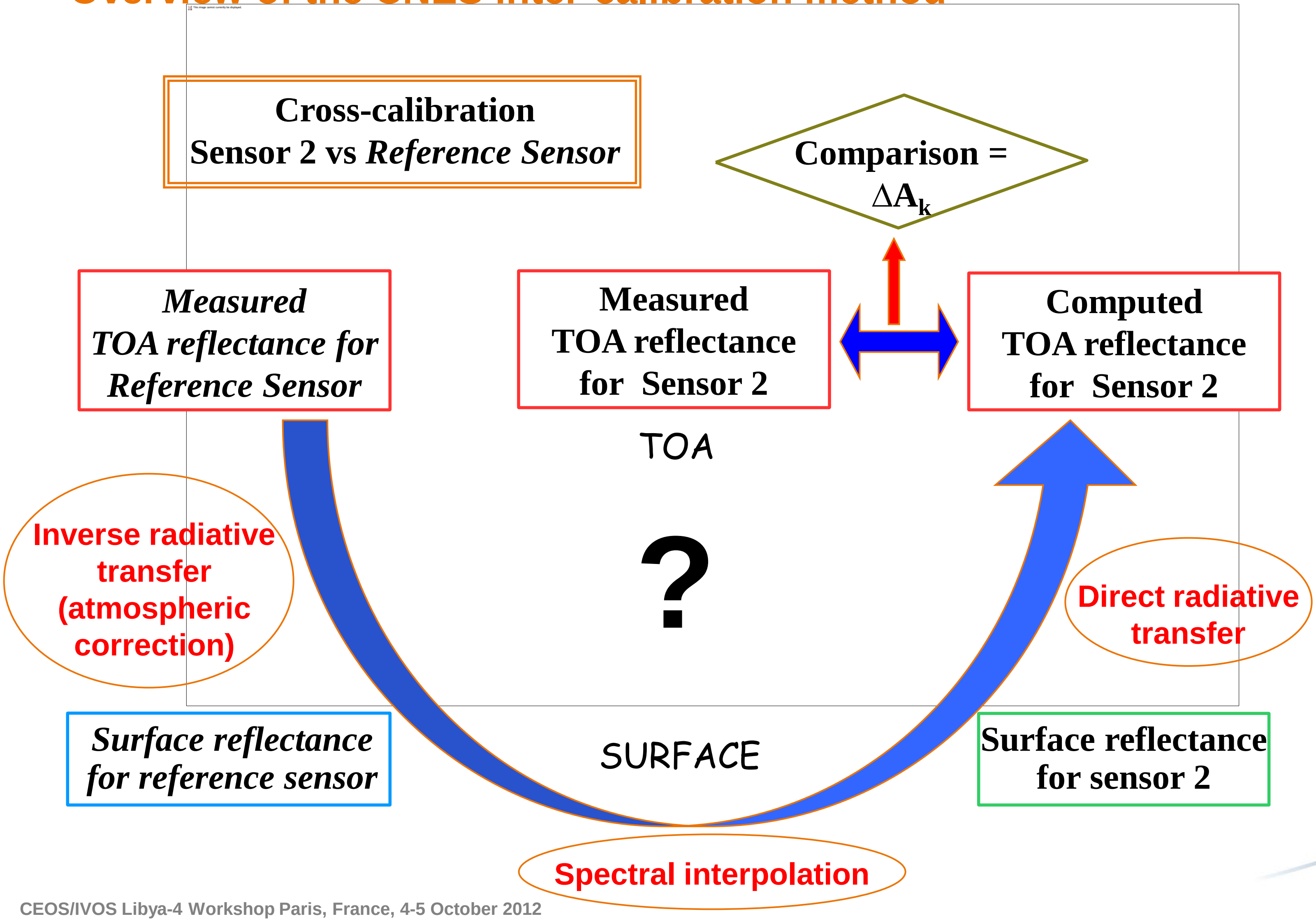
How to calibrate the 469nm MODIS band with MERIS ?

How to take into account the difference between the sensors spectral response ?

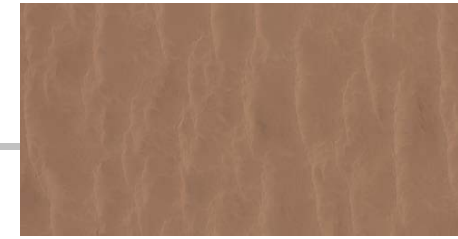
→ Use of interpolation functions

Method

Overview of the CNES inter-calibration method

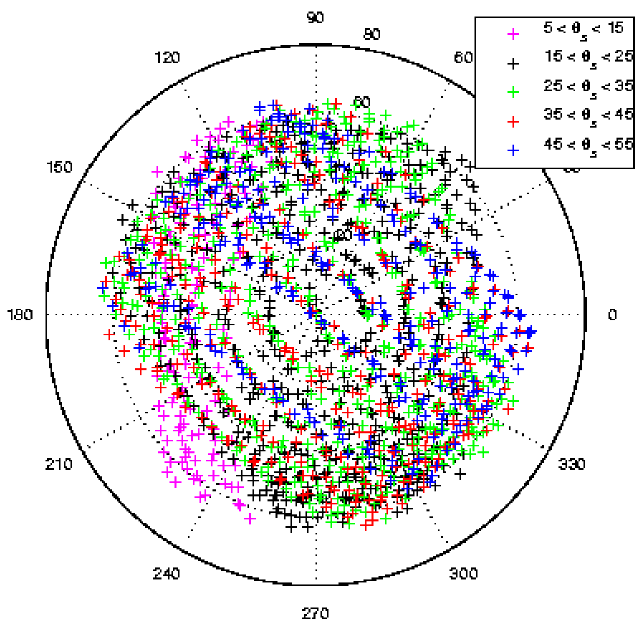


Method

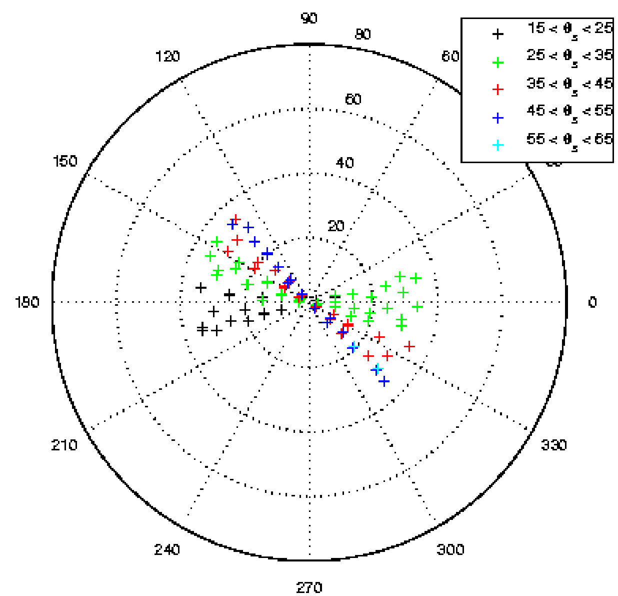


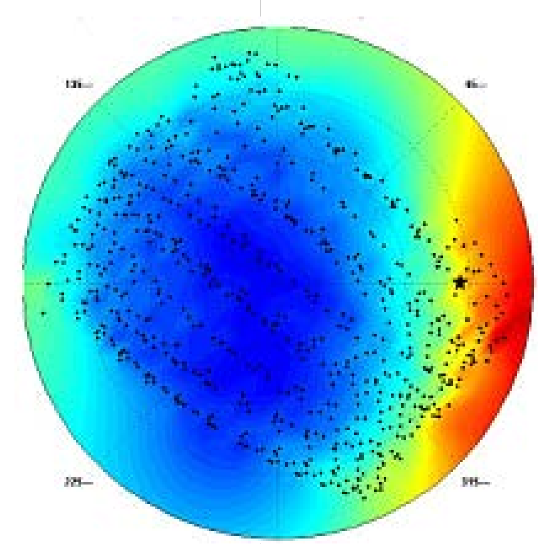
Geometrical coupling

Measured TOA reflectance for Sensor 2



Measured TOA reflectance for Reference Sensor





→ Necessary to perform the intercalibration with measurements acquired in the same directions (solar and viewing)

Method

Geometrical coupling conditions:

$$\left|\theta_s^{CAL} - \theta_s^{REF}\right| < 2°$$
$$\left|\theta_v^{CAL} - \theta_v^{REF}\right| < 2°$$
$$\left\|\varphi_s^{CAL} - \varphi_v^{CAL}\right| - \left|\varphi_s^{REF} - \varphi_v^{REF}\right\| < 5°$$

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$$\left|\theta_v^{CAL} - \theta_v^{REF}\right| < 5°$$
$$\left\|\varphi_s^{CAL} - \varphi_v^{CAL}\right| - \left|\varphi_s^{REF} - \varphi_v^{REF}\right\| < 10°$$

Objectif: compromise between number of matched measurements and the need to avoid errors in the inter-calibration due to the bidirectional behaviour of the reflectance of the site

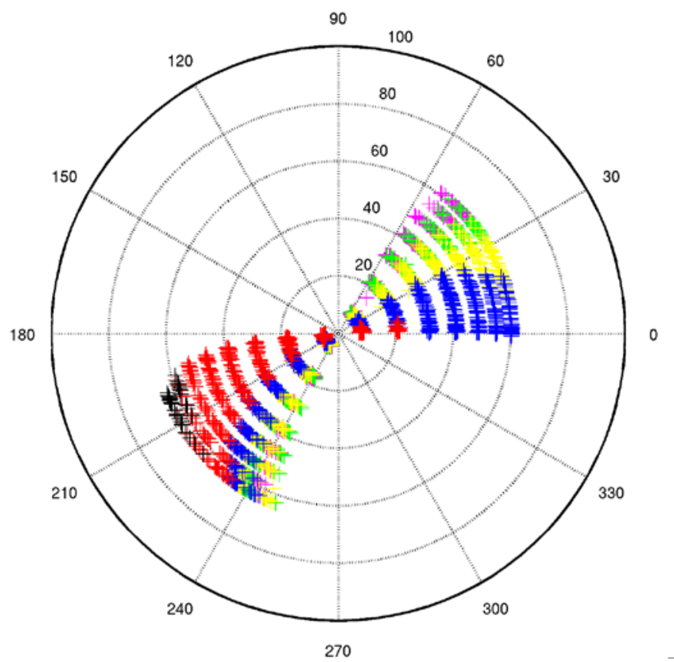
→ These equations implies that the BRDF is symmetric with respect to the principal plane

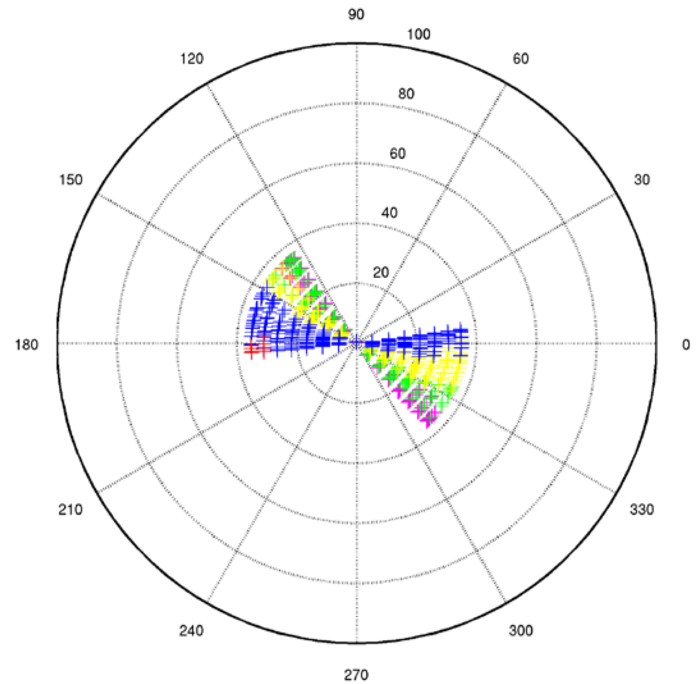
The second solution to increase matching measurements is to apply the reciprocity principle

Method

Geometrical coupling conditions
Example with the inter-calibration of MODIS / MERIS

No matching





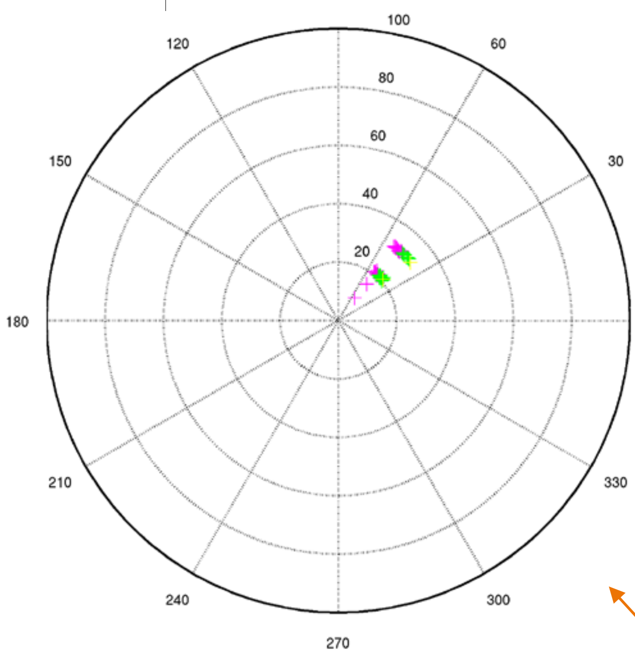
MODIS SADE dataset (1920 measurements)

MERIS SADE dataset (1255 measurements)

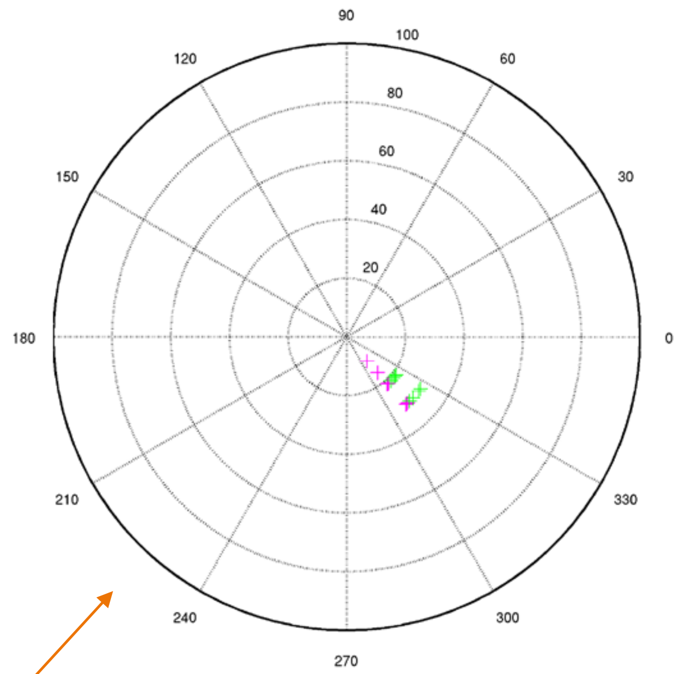
Method

Geometrical coupling conditions
Example with the inter-calibration of MODIS / MERIS

Coupling conditions: (θs<2- θv<2-∆φ<5) without reciprocity



MODIS SADE dataset



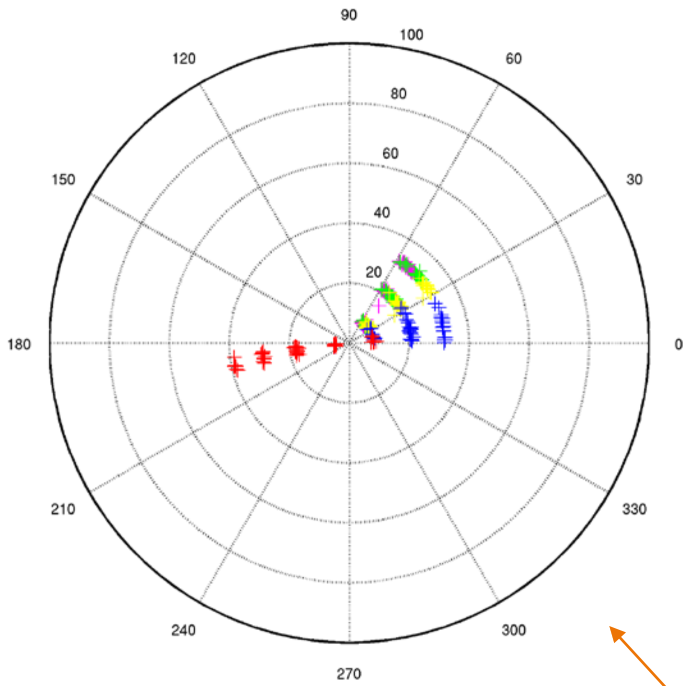
MERIS SADE dataset

99 pairs

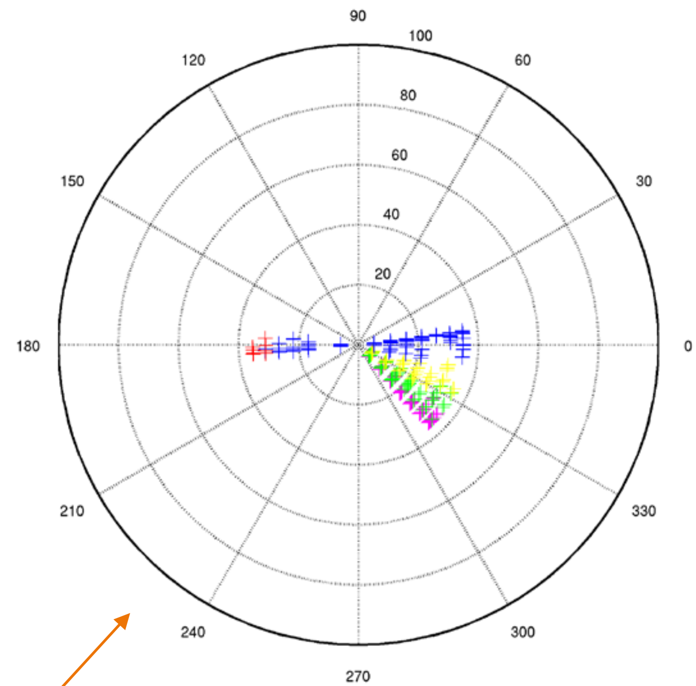
Method

Geometrical coupling conditions
Example with the inter-calibration of MODIS / MERIS

Coupling conditions: ($\theta s<5$- $\theta v<5$-$\Delta\varphi<10$) without reciprocity



MODIS SADE dataset



MERIS SADE dataset

1925 pairs

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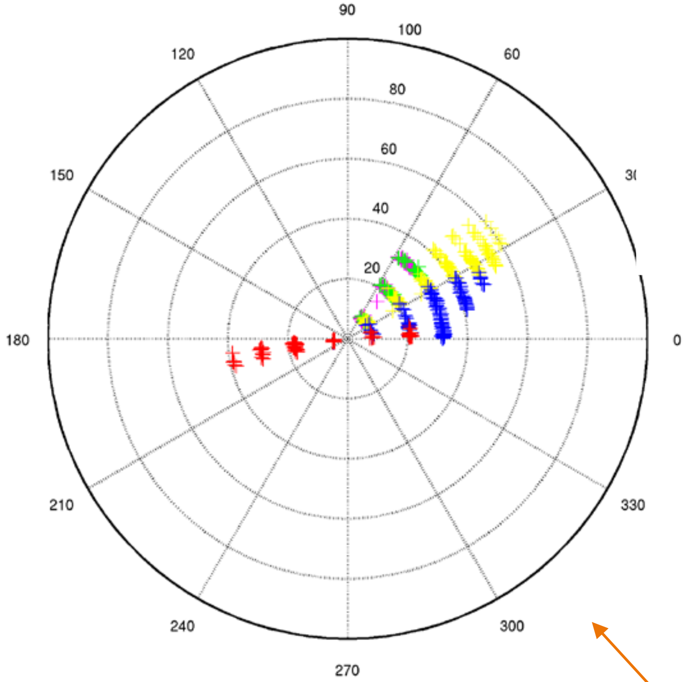
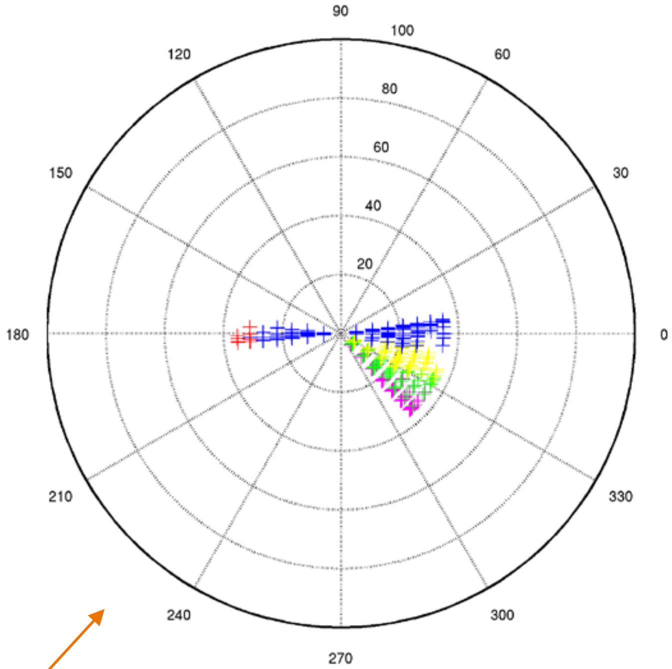
Method

Geometrical coupling conditions
Example with the inter-calibration of MODIS / MERIS

Coupling conditions: (θs<5- θv<5-∆φ<10) with reciprocity





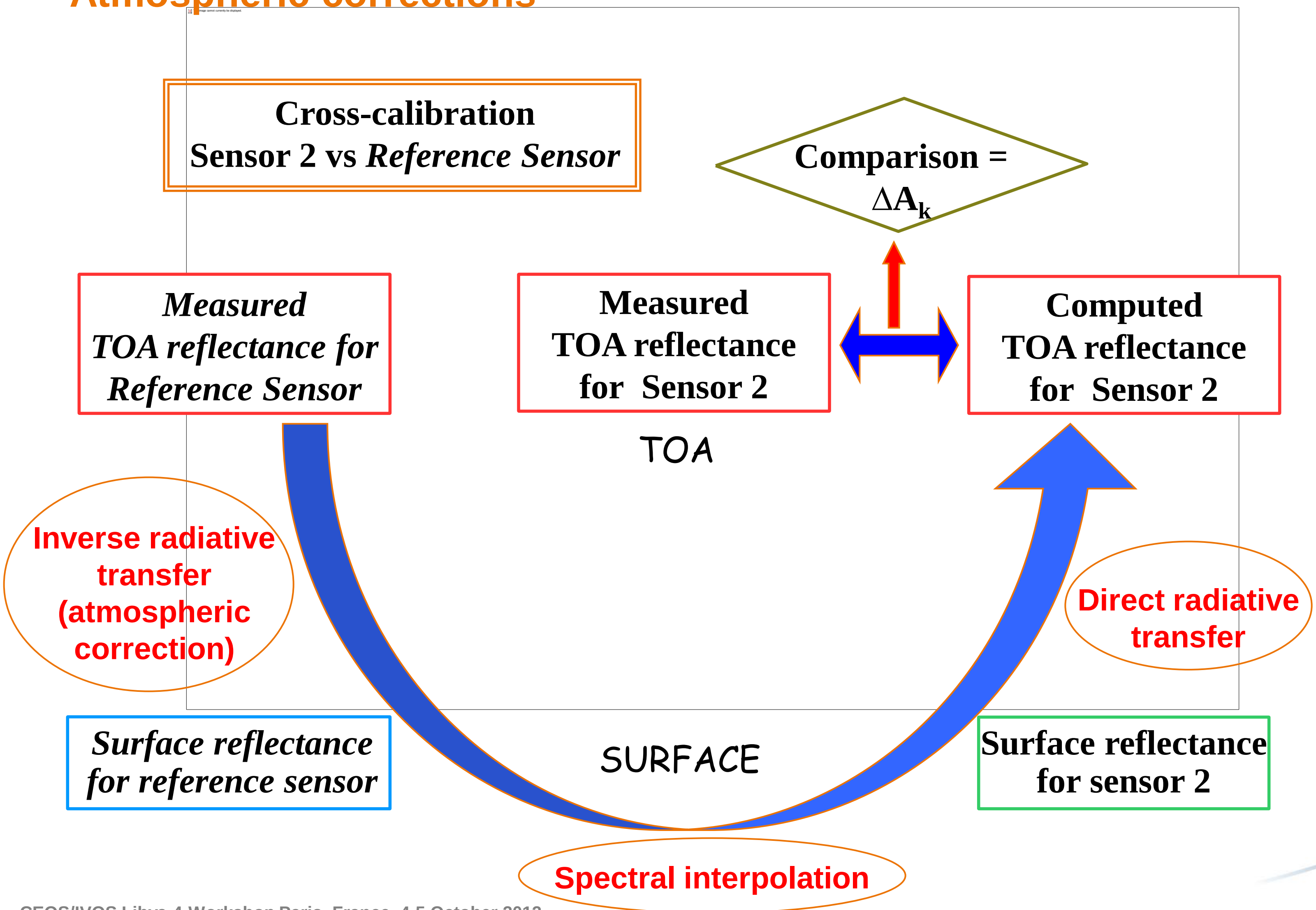
MODIS SADE dataset

MERIS SADE dataset

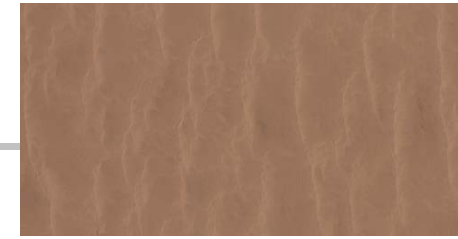
4762 pairs

Method

Atmospheric corrections



Method



Atmospheric corrections

-Inverse radiative transfer
→ To derive the BOA reflectance for the reference sensor

-Direct radiative transfer
→ A direct computation to obtain the simulated TOA reflectance of the reference sensor in the sensor spectral bands to calibrate

-Use of SMAC to calculate the atmospheric coefficients for the two sensors

-H20 and Pressure content from NCEP (US weather service)

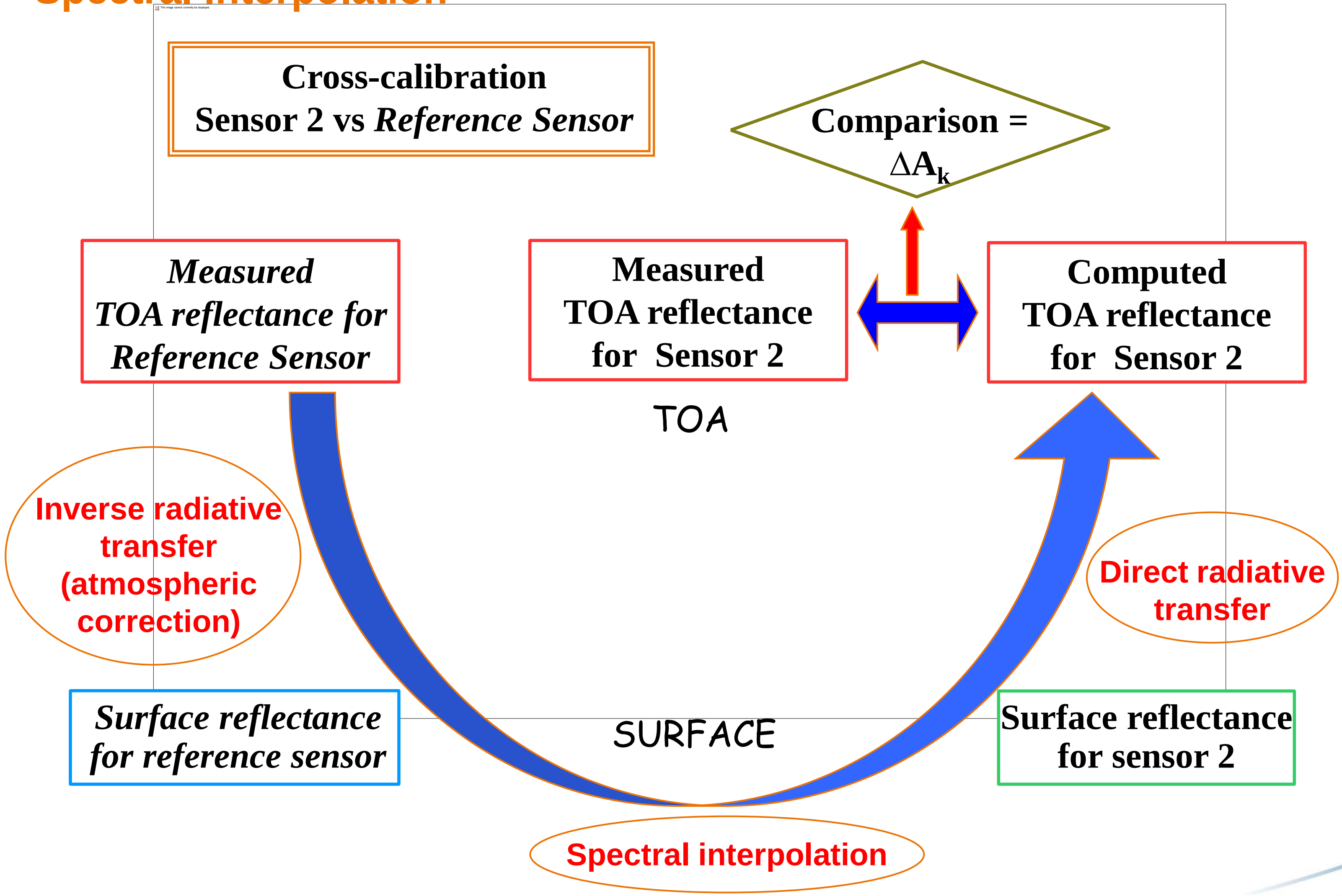
-O3 from TOMS (OMI satellites)

-Aerosol: AOT = 0.2 at 550nm associated to a desertic aerosol model

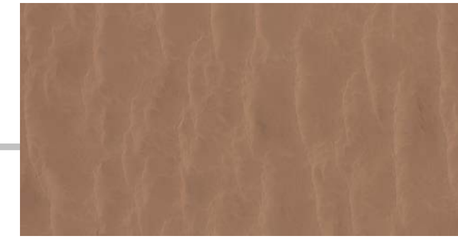
->This assumption (use for the direct and inverse atmospheric contribution) does not introduce a mean bias but just day to day variations

Method

Spectral Interpolation



Method

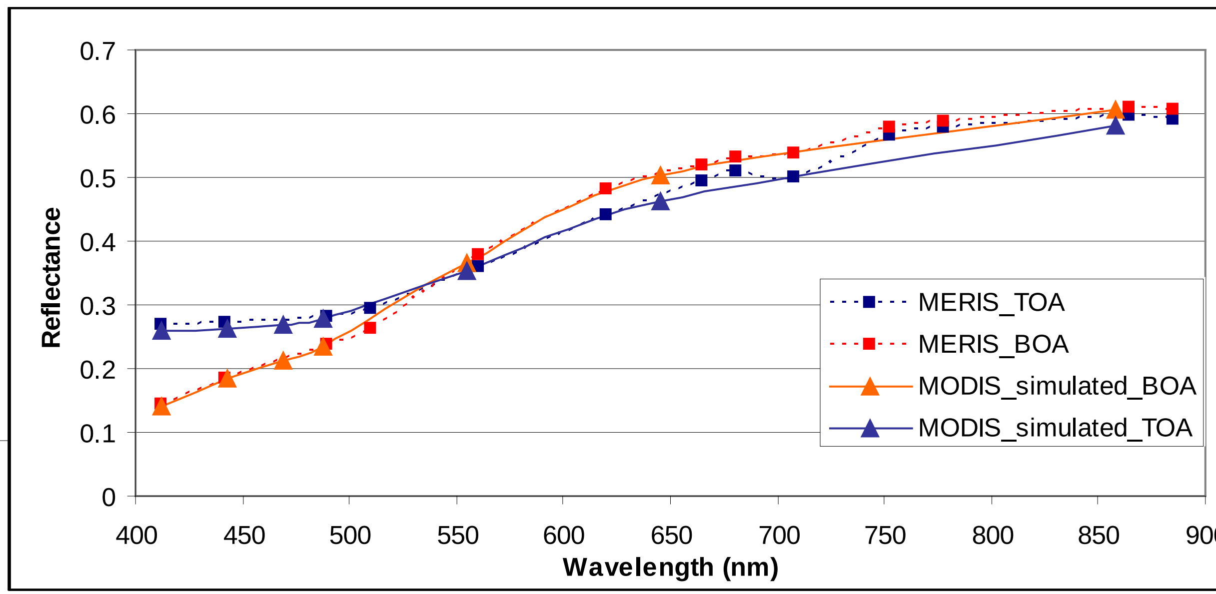


Spectral Interpolation

Goal: to convert the BOA reflectance of the reference sensor to the spectral bands of the sensor to calibrate

→ Use of a Spline function (smooth curve between spectral bands)

Example of the calibration of MODIS versus MERIS



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Method

Spectral Interpolation

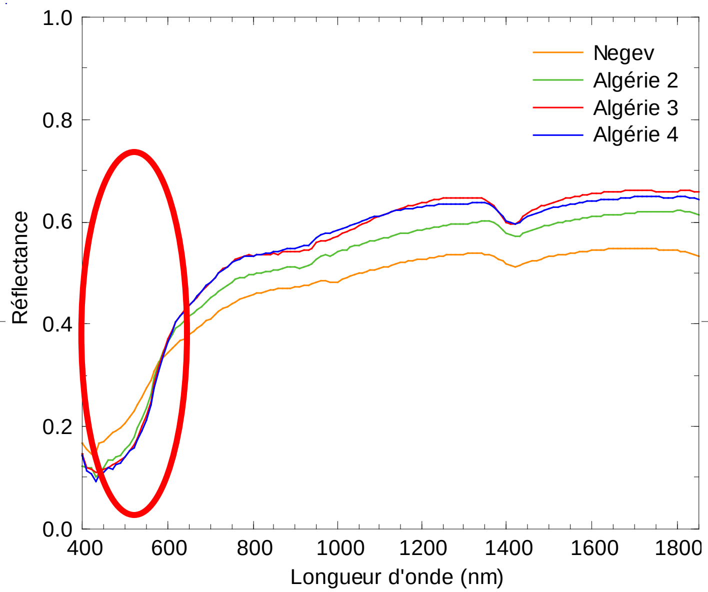
Goal: to convert the BOA reflectance of the reference sensor to the spectral bands of the sensor to calibrate

→ Use of a Spline function (smooth curve between spectral bands)

Be careful to the choice of the reference sensor regarding the spectral band to model (CAL sensor) !!!

The final accuracy is strongly linked to this adequacy

Sand reflectance measured in laboratory (ONERA)



Method

Intercalibration coefficient computation

$$A_{k,CAL\_REF}(t) = \frac{1}{n} \sum_{n\_pairs} A_{k,CAL\_REF}(t) = \frac{1}{n} \sum_{n\_pairs} \frac{\rho_{k,CAL}}{\rho_{k,REF}}$$

→ **Ratio is computed for each pairs of measurements of the two sensors and average over the all set of matched measurements**

→ **Defectuous measurements due to saturation or abnormal behavior are discarded.**

The accuracy of this method depends on two main aspects:

- **the reference sensor (spectral band coverage)**
- **the spatial geometrical sampling for the two sensors**
- **the number of matched measurements**

When conditions are optimum, accuracy ~ 1% between 2 sensors, or some bands of these 2 sensors

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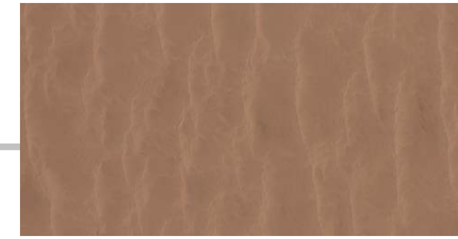
Improvement



• BRDF consideration for the geometrical coupling step

A fixed geometrical window has 2 drawbacks:

→ limit the number of measurements for low VZA whereas the bidirectional behavior of desert sites shows a very small variation

→ could lead to large errors near hot spot

→ **On-going ! (see next presentation)**

• Spectral interpolation step

To add an a priori on surface spectrum to help the spectral interpolation

→ on-ground measurement

→ satellite-based measurements (Hyperion or Sciamachy)

• Spectral domain: extension to SWIR bands

• Cross-calibration GEO-LEO