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**Title** : **Recommendation for the calibration for Sentinels: S2 and S3**

**Abstract** : This document describes the recommendations for the calibration of Sentinel 2 and Sentinel 3 sensors.

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# GLOSSARY

The Glossary contains definitions of acronyms, abbreviations and terms used throughout the document.

| | |
|---|---|
| AATSR | Advanced Along-Track Scanning Radiometer ( |
| BOUSSOLE | BOUée pour l'acquiSition de Séries Optiques à Long termE |
| BRDF | Bi-directional Reflectance Distribution Function |
| BRF | Bi-directional Reflectance Function |
| Cal/Val | Calibration and Validation |
| CEOS | Committee on Earth Observation Satellites |
| CNES | Centre National d'Etudes Spatiales |
| ENVISAT | ENVIronment SATellite |
| EO | Earth Observation |
| ESA | European Space Agency |
| ETM | Landsat Enhanced Thematic Mapper |
| IR | Infrared |
| ITT | Invitation To Tender |
| IVOS | Infrared and Visible Optical Sensors |
| LES | Land Equipped Site |
| LNES | Land Non Equipped Site |
| LPV | Land Product Validation |
| MAVT | MERIS & AATSR Validation Team |
| MERIS | Medium Resolution Imaging Spectrometer |
| MOBY | Marine Optical Buoy |
| MODTRAN | MODerate resolution atmospheric TRANsmission |
| MSI | Multi spectral instrument |
| MWIR | Medium-Wavelength Infrared |
| NIR | Near InfraRed |
| PMP | Project Management Plan |
| POLDER | POLarization and Directionality of the Earth's Reflectances |
| RMS | Root Mean Square |
| RTC | Radiative Transfer Code |
| SADE | Structure d'Accueil pour les Données d'Etalonnage |
| SAM | Standard aerosol models |
| Sentinel | Family of ESA spacecrafts |
| SES | Sea Equipped Site |
| SNES | Sea Non Equipped Site |
| SOW | Statement Of Work |
| SWIR | Short Wave Infrared |
| SZA | Solar Zenith Angle |
| TBD | To be Defined |
| TEB | Thermal Emissive Band |
| TOA | Top Of Atmosphere |
| VIS | Visible |
| VOS | Visible Optical Sensors |
| WGCV | Working Group on Calibration and Validation |
| WP | Work Package |

# AMENDMENT POLICY

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

**AMENDMENT RECORD SHEET**

| ISSUE | DATE | DCI No | REASON |
|---|---|---|---|
| A | 15 April 2009 | N/A | Initial Issue |
| B | | | |

# 1. INTRODUCTION

## 1.1 Overview of the project: purpose and scope

This study is part of the ESA strategy for ensuring the quality (calibration, validation and operational quality) of data developed for current and future missions within the Explorers and GMES framework.

The scope of the project is to select, identify and characterise reference test sites that will be used for the calibration and characterisation of different sensor types. The characteristics of the sites that will be provided at the end of this study will be incorporated in the Cal/Val portal.

The project is composed of four tasks.

- The first task (WP100) aims at identifying the needs per sensors in terms of external (vicarious) calibration.
- The second task (WP200) aims at identifying and, characterising remote test sites that can be used for external calibration according to the needs previously described in WP 100.
- The third task (WP300) will perform the synthesis adapted to Sentinels satellites. The output of this task will help ESA in the definition of the strategy for external calibration of Sentinel instruments.
- The fourth task aims at giving ESA the support for the integration of identified sites into the ESA Cal/Val portal.

Task 100 and 200 are achieved and documented. This document corresponds to WP 300.

## 1.2 Objectives of the WP 300: Performing of a synthesis adapted to Sentinels satellite

The objective of this WP is double:

- Definition of a strategy which will allow ESA to become a leading player for the instrument / product quality performance and particularly for the vicarious / external calibration activities.
- Recommendations on calibration aspects for the sensors of the family of the Sentinel missions.

### Strategy definition

In this context, we suggest that the Agency makes available EO data in a structured way and for several purposes:

- For inter-comparison between sites. Images acquired in a short-time period and by a same sensor over a set of calibration test sites will be made available by the Agency allowing users comparisons. The sensor is considered here as a “reference” sensor, i.e. for which its temporal calibration drift is totally controlled. MERIS can be considered as a “reference” due its performance. Considering its high similarity with MERIS, we can suppose that the MERIS-like sensor onboard the future Sentinel-3 will also be used as a "reference" sensor.

- For cross-calibration between sensors. A database of reference images acquired over a selection of sites could be developed allowing cross-sensors calibration. In a similar way, CNES has developed SADE (Structure d'Accueil des Données d'Etalonnage, Cabot, 1997, RD.20); It is an architecture which ensures the link between long-term series of satellite acquisitions over 20 desert sites (extended now to oceanic, snowy and cloudy sites and to glitter measurements) and calibration results. EO data are systematically collected (SPOT, SeaWiFs, VGT, AVHRR, MERIS …) with a high priority to POLDER in the past and now PARASOL. PARASOL acquisitions are particularly appropriate to retrieve BRDF. They also offer a large range of illumination-viewing configurations which is of particular interest to assess cross-sensor calibration. Up to now, this database is restricted for CNES purposes. The development of a SADE-like database will be discussed and studied in the framework of this WP.

- Another point where ESA may play a relevant role in the future is the certification of calibration test sites. Indeed, CEOS has already prepared a first list of calibration sites knowing that this list needs to be refined. Certainly, an international approach shall be developed to provide a certification / label in order to reference and qualify calibration sites. In this context, ESA could play a significant role to support this initiative.

### Recommendations for the Sentinel missions

From the results obtained in the previous tasks, an analysis of the ESA requirements will be performed for several periods. Typically, the total costs to equip and maintain a site and to acquire auxiliary data will be provided for a short period (1-3 years), a medium period (3-7 years) and a long period (> 7 years).

- For the radar instrument of Sentinel-1 and more generally for microwave radiometers, the technical recommendations have been attached to the report in output of the WP120.

- For Sentinel-2 instrument (Optical High Resolution sensors), the traditional approach using equipped land test sites seems o be a standard. We will investigate the potentiality of using the test sites during the life of Sentinel-2 and if in-situ campaigns or maintenance of instrumentation are required.

- For Sentinel-3 optical Medium Resolution sensors, we will take advantage of the experience gained during the ENVISAT lifetime combining MERIS and AATSR. There is a clear need to define a strategy to conduct cross-sensors calibration. This is a requirement to ensure the continuity of EO between ENVISAT and Sentinel-3. The need and the possibility to cross-calibrate Sentinel-2 and -3 sensors also exist.

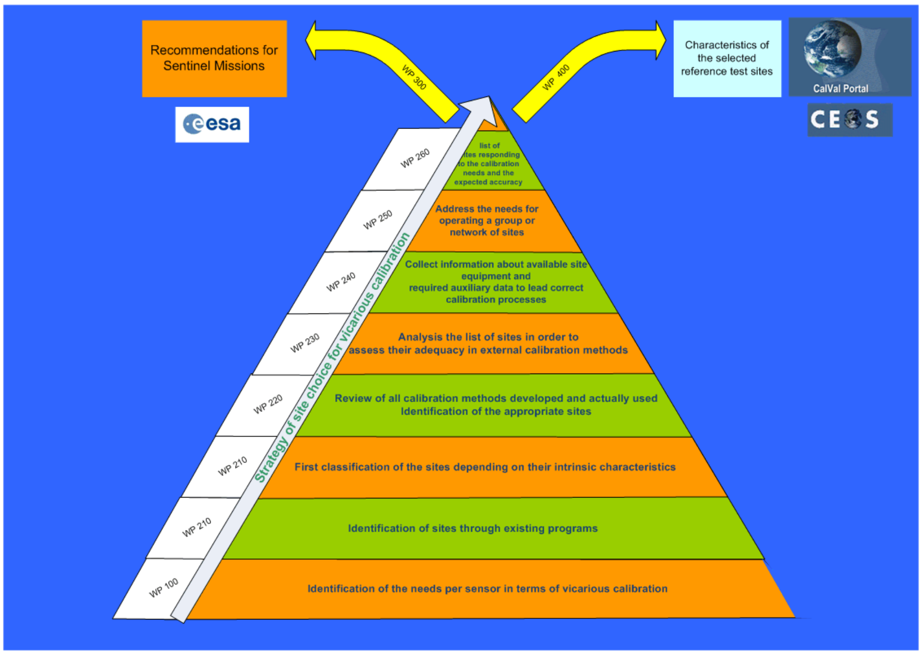



**Figure 1: Project activities for defining the vicarious calibration strategy used for S2/S3 sensors.**

## 1.3 Structure of the document

This document is structured as follows:

- Chapter 2 is a synthesis of WP200,
- Chapter 3 provides with the description of Sentinel 2 and Sentinel 3,
- Chapter 4 provides with the recommendation for S2 calibration,
- Chapter 5 provides with the recommendation for S3 calibration.
- Chapter 6 provides with the recommendation for the two Sentinel sensors calibration
- Chapter 7 provides with the recommendation for spectral calibration
- Chapter 8 describes the proof of concept for vicarious calibration of S2 and S3

# 2. CONCLUSION OF WP200

## 2.1 Sites and instrumentations

The activity lead in WP200 aimed at identifying and characterising the reference test sites used for vicarious calibration of sensors belonging to the sensor class 2 or 3. The approach was a progressing task which aims at identifying and, characterising remote test sites that can be used for external calibration according to the radiometric requirements in WP 100.

The sites that have been at least used one time for vicarious calibration have been identified. This has created a list containing a lot of sites (39 LES, 46 LNES, 9 SES, 20 SNES, Tables 36, 37 and 38 of WP220) which have been discriminated not only by their characteristics but also by the usage done from different calibration groups. The criteria to characterise the sites have been set and a classification of the sites versus their location, altitude, spatial homogeneity, equipment etc has been done. It follows that, regards to the vicarious methods, some sites or group of sites are more often used because they are well characterised, they are used for a long time etc.

An evaluation of the absolute calibration accuracy on well characterised site has been done (WP 260) with La Crau and White Sands as representatives of LES and MOBY and AAOT as representatives of SES. The site properties to reach the specifications have been highlighted for both types of sites:

- For LES,
    - At least the adjacency effects for class 3 sensors if the site is non homogeneous,
- For LES and SES,
    - the aerosol scattering properties

An evaluation of Intercalibration (inter band and inter sensor) over LNES and SNES has been done. Auxiliary data is needed:

- For LNES,
    - Site BRDF and aerosol scattering properties for class 2 sensor
- For SNES,
    - Aerosol scattering properties for class 2 sensors

Recommendations have been done to better characterise the sites in terms of spatial homogeneity, BRDF, aerosols properties, and associated equipments.

## 2.2 The site data base

Site data base built in WP 230 contains information which allows to provide sites with a quality label, characterising its adequacy in external calibration methods. Its objective was to identify sites that minimize the source of errors in the calibration process.

- The cloud coverage
- Precipitation
- Atmospheric water vapour and ozone
- Aerosol content
- Spatially uniform

- Stable over time
- Anisotropy
- Spectral variability

For Sentinel 2, the database is just used to assess the quality of the sites regarding to the criteria listed above. For Sentinel 3, over SNES, auxiliary data could rely on the monthly MERIS Level 3 data of chlorophyll content for estimating the water leaving reflectance and aerosol model.

## 2.3 The methodology

The methodology was described in WP220. The next step from the CEOS should be, starting from this document and the abundant literature, to stamp an official guide on the best practice at least for the equipped sites. It should be relevant as well to define a protocol to indicate the different sources of error and their amplitude at the different levels of the processing chain of the calibration coefficients.

## 2.4 Summary of the recommendations for the radiometric calibration

### 2.4.1 Class 3 sensor

The goal to achieve a 5 to 6 percent accuracy from vicarious calibration method can certainly be reached by several means:

The traditional land site approach goes first. The clear handicap is the coast of a campaign. A given campaign is primarily designed and supported for a given sensor. Actually, there is a high probability than another sensor over flights the site during the time period of the campaign.  Therefore, it will be relevant:

(i) That a group which organized a campaign informs the community.

(ii) Then, following a data policy, the in situ data can be made available in a common data base.

(iii) The data can be only use if the calibration protocol is documented.

Complementary to the traditional approach, it is recommended to improve the characterization of the aerosols. The AERONET approach with the CIMEL instrument can contribute.

The characteristic of the BRDF of the site may vary as well. Therefore, it is recommended to measure as often that possible the site BRDF. An automatic radiometer, with multi view measurements, is a potential solution.

If a class 2 sensor, with high performance in terms of radiometric calibration (likely based on an internal calibration device) is available during the life time of the class 2 sensor, then an inter sensor calibration may cover the need. It can be over water or over land.

### 2.4.2 Class 2 sensor

If we go to better than 3 percent accuracy, the task is challenging and should combine different methods.

The vicarious calibration over water can achieve the goal in the visible but the price to pay is high:

(i) A perfect measurement of the water leaving radiance will cover only few $m^2$ while the pixel size is of the order of the $km^2$ (or tenth of the $km^2$). It should be really simultaneous to the satellite time of overpass.

(ii) The aerosol contribution should be precisely predicted which suppose to have measurement of the extinction but also of the scattering properties.

We can not say that the two conditions are mutually exclusive (condition (i) correspond to the open ocean with measurements from a buoy and condition (ii) need a stable platform which can not be a buoy.

Reaching the 3 percent objective also results from a self consistency: the BRDF of the water leaving reflectance are modelled consistently with the level 2 algorithm. Radiometric calibration in the open ocean may reefer to the likely presence of the maritime model and therefore reduced the characterization of the aerosols to the AOT. Extinction measurements are possible from a cruise which can also measured the water leaving radiance.

In principle, a vicarious calibration over land bright sites may work as well. By the site should present a very good spatial homogeneity and should be sampled accordingly. BRDF correction will degrade the results. But, over all aspect, we lost the consistency with the oceanic environment and the way to model 1. Even if at the end the potentiality to reach the goal in terms of radiometric calibration, any bias will be recover in the level 2 process.

If we believe in the land sites, it is more likely in the NIR. The sites are more homogeneous and lambertian than in the visible. The key element is the aerosol scattering properties and mainly the single scattering albedo.

A sunglint inter band calibration can ensure the link between the SES calibration in the visible and the LES in the NIR. Such an inter band calibration can only work if the aerosol properties are measured both in extinction (AOT) and in scattering (mainly the forward scattering).

## 2.5 Summary of the recommendations for the vicarious spectral calibration

The spectral calibration aims to quantify a possible shift of the central wavelength.

The first recommendation covers the medium resolution spectrometer for which a portion of the solar spectrum is measured. The Fraunhofer absorption lines are the references. The instrument needs to have a spectral flexibility in order to offer the best spectral resolution around these lines.

For instruments with a $O_2$ spectral band, the recommendation is to achieve a spectral adjustment through the pressure product.

The two above spectral calibration do not need an accurate radiometric calibration. They are differential methods which rely on a specific spectral feature well define in relative not in absolute.

For class 3 sensors, it is more likely a spectral adjustment which ensures the quality of the level 2 products. A possible protocol is to reconstruct with a medium resolution spectrometer (let us say MERIS) the TOA signal of a S3 sensor (let us say ETM+). We first need to inter calibrate the two sensors (the S2 recomposed in S3, and the actual S2) over a calibration land site. Then we run the L2 process to compare over the same landscape, with various coloured targets, the L2 products. A shift on the central wavelength on the reference sensor is applied to obtain the best fit.

# 3. THE MAIN CHARACTERISTICS OF S2 AND S3

## 3.1 The S2 instrument(s)

Sentinel-2 is a GMES land mission scheduled to be launched in 2012. Its objective would be a systematic coverage of the earth's land surface (from -56° to +83° latitude) to produce cloud-free imagery typically every 15 to 30 days over Europe.

The Sentinel-2 wide-swath high-resolution multispectral system will provide enhanced continuity to the SPOT-and Landsat-type observations -with improved revisit time, coverage area, spectral bands, swath width, radiometric and geometric image quality.

At term, a constellation of 2 operational will allow a **5 day geometric revisit.** The revisit time is 10 days with 1 satellite.

Systematic **acquisitions** of data located **between -56° latitude and +84° latitude** are done, including:

The EU islands (whatever their size) located between -56° latitude and +84° latitude,

Any island located at less than 20 km from the continental coastline and located between -56° latitude and +84° latitude,

All other major islands (greater than 100 km2 size), located between -56° latitude and +84° latitude,

The inland waters (rivers, lakes, closed seas) located between - 56° latitude and +84° latitude,

The Mediterranean Sea.

### 3.1.1 Spectral bands

Sentinel-2 is equipped with a 13 channel multi spectral imager (MSI) at a high spatial resolution (4 channels at 10 m, 6 channels at 20 m and 3 channels at 60 m resolution). Table 1 described the spectral bands.

**Table 1: Spectral bands for Sentinel-2. ESA MRD S2, RD.30**

| Band | Center λ (nm)` | Spectral Width Δλ (nm) | Spatial Resolution (m) | Purpose |
|---|---|---|---|---|
| 1 | 443 | 20 | 60 | Atmospheric Correction |
| 2 | 490 | 65 | 10 | Sensitive to Vegetation Aerosol Scattering |
| 3 | 560 | 35 | 10 | Green peak, sensitive to total chlorophyll in vegetation |
| 4 | 665 | 30 | 10 | Max Chlorophyll absorption |
| 5 | 705 | 15 | 20 | Position of red edge consolidation of atmospheric correction, /fluorescence retrieval of aerosol |
| 6 | 740 | 15 | 20 | Position of red edge atmospheric correction, retrieval of aerosol |
| 7 | 775 | 20 | 20 | LAI ,edge of NIR plateau |
| 8 (or81) | 842 | 115 | 10 | LAI |

| Band | Center λ (nm)` | Spectral Width Δλ (nm) | Spatial Resolution (m) | Purpose |
|---|---|---|---|---|
| 8a (or 82) | 865 | 20 | 20 | NIR plateau, sensitive to total chlorophyll biomass, LAI and protein; water vapour absorption reference; retrieval of aerosol load and type |
| 9 | 940 | 20 | 60 | Water Vapour absorption atmospheric correction |
| 10 | 1375 | 20 | 60 | Detection of thin cirrus for atmospheric correction |
| 11 | 1610 | 90 | 20 | Sensitive to lignin, starch and forest above ground biomass Snow/ice/cloud separation |
| 12 | 2190 | 180 | 20 | Assessment of Mediterranean vegetation conditions.<br>Distinction of clay soils for the monitoring of soil erosion.<br>Distinction between live biomass, dead biomass and soil, e.g. for burn scars mapping. |

### 3.1.2 Radiometric requirements

Table 3 and Table 2 provide with the radiometric specifications. Radiometric accuracy at TOA has to be not worse than 3% (goal) to 5% (threshold). For inter-band radiometric calibration 3% accuracy is also required.

**Table 2: Sentinel-2 radiometric specifications (ESA, 2008, RD.31)**

| Parameter | Value |
|---|---|
| Absolute Radiometric Accuracy | The absolute radiometric accuracy will be better than **5 %** (goal 3%) for the set of bands specified in Table 3 over the reduced dynamic range (goal: full dynamic range). |

The requirements for Signal-to-Noise Ratio (SNR) and minimum, reference and maximum radiance levels for each spectral band are presented in Table 3.

**Table 3: Radiometric performances of Sentinel-2 MSI instrument**

| Band # | | Center $\lambda$center nm | Spectral width $\Delta\lambda$ nm | $L_{min}$ | $L_{ref}$ | $L_{high}$ | $L_{max}$ | SNR @ $L_{ref}$ | SNR @ $L_{high}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | W.m$^{-2}$.sr$^{-1}$.µm$^{-1}$ | | | | | |
| B | 1 | 443 | 20 | 15.97 | 129.11 | n/a | 587.87 | 129 | n/a |
| B | 2 | 490 | 65 | 11.70 | 128.00 | n/a | 615.48 | 154 | n/a |
| B | 3 | 560 | 35 | 6.49 | 128.00 | n/a | 559.01 | 168 | n/a |
| B | 4 | 665 | 30 | 3.31 | 108.00 | n/a | 484.13 | 142 | n/a |
| B | 5 | 705 | 15 | 2.61 | 74.60 | n/a | 449.55 | 117 | n/a |
| B | 6 | 740 | 15 | 2.06 | 68.23 | n/a | 412.92 | 89 | n/a |
| B | 7 | 783 | 20 | 1.67 | 66.70 | n/a | 387.08 | 105 | n/a |
| B | 8 | 842 | 115 | 0.95 | 103.00 | n/a | 307.80 | 174 | n/a |
| B | 8a | 865 | 20 | 0.95 | 52.39 | n/a | 307.80 | 72 | n/a |
| B | 9 | 945 | 20 | 0.51 | 8.77 | n/a | 232.91 | 114 | n/a |
| B | 10 | 1375 | 30 | 0.06 | 6.00 | n/a | 83.00 | 50 | n/a |
| B | 11 | 1610 | 90 | 0.40 | 4.00 | 32.00 | 69.78 | 100 | 504 |
| B | 12 | 2190 | 180 | 0.10 | 1.70 | 11.00 | 24.60 | 100 | 475 |

The spectral information is given through Figure 2 and Figure 3. Three spectral domains have to be considered:

(i) The visible and NIR without absorption (B1, B2, B3, B4, B5, B6, B7, B82). For these spectral bands, the traditional methods for S2 sensors apply.

(ii) Bands with a high gaseous absorption (B81, B9, B10). If required, the treatment of the gaseous absorption is specific.

(iii) The calibration of the MIR bands (certainly at 2.2 µm) may require specific radiometers both for the surface and for the atmosphere.

By the diversity of spectral bands in the visible region, S2 will offer the opportunity to conduct ocean colour studies. For this application, the level of accuracy will be high.

**Figure 2: Spectral responses of S2 in the MIR**

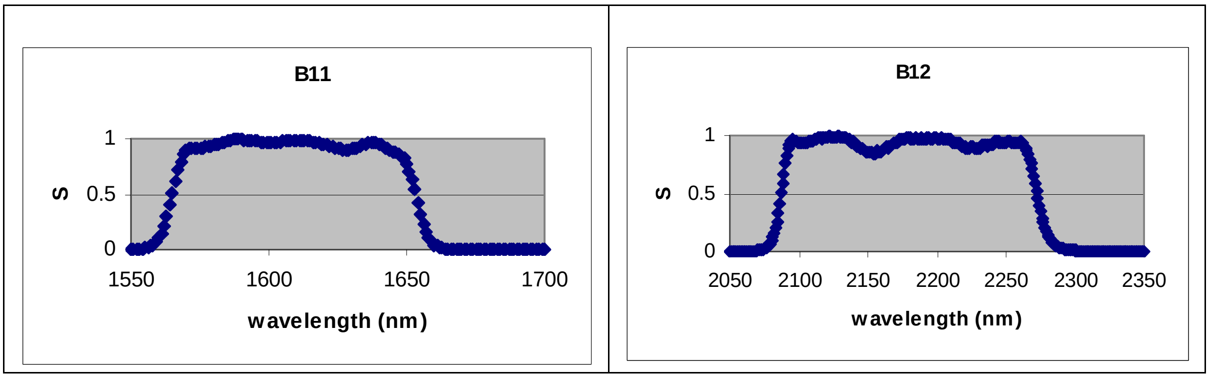
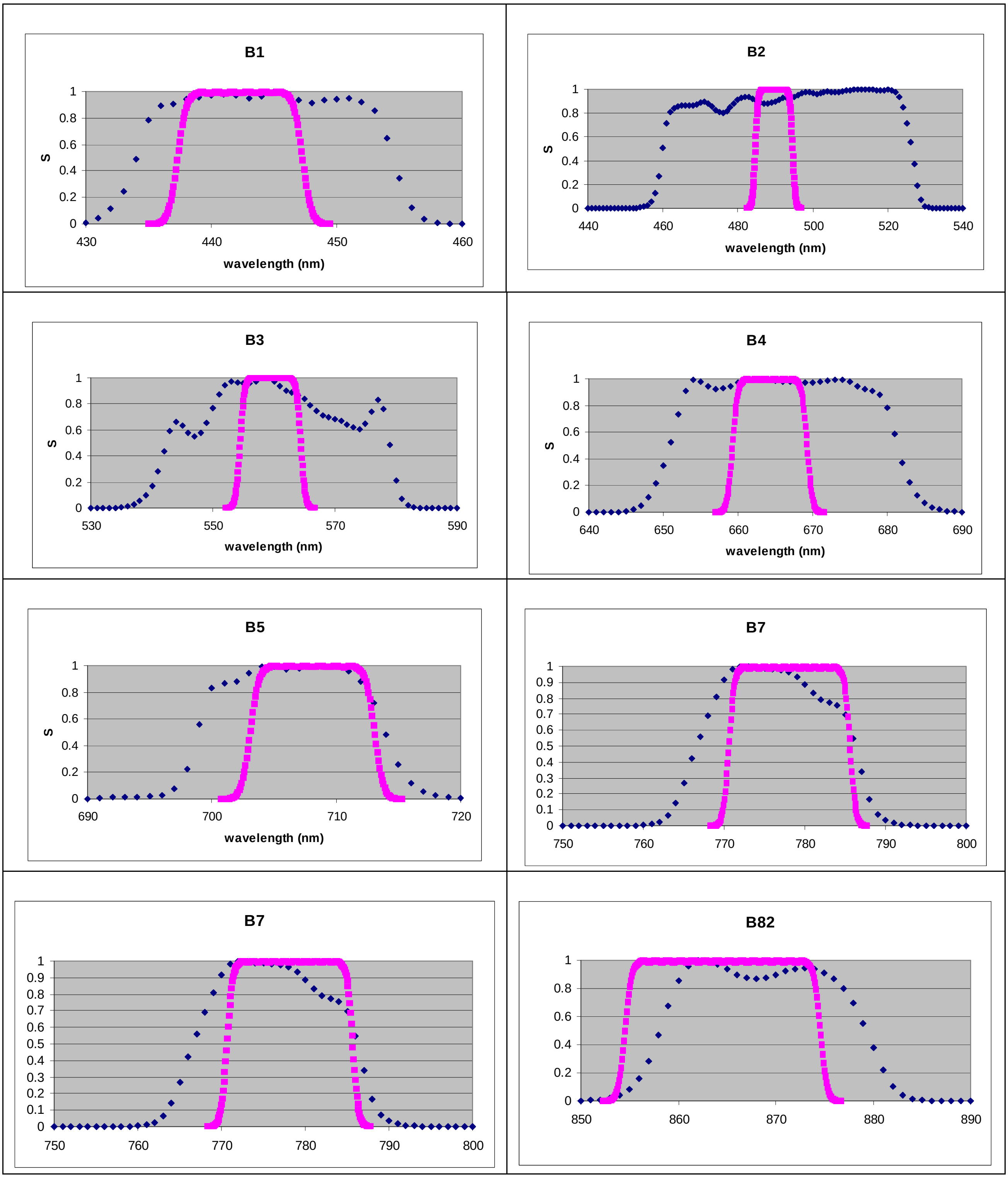


**Figure 3: Spectral responses of S2 in the visible and NIR (blue diamonds) and corresponding MERIS bands (pink square)**



## 3.2 The S3 instrument(s)

Table 4 gives the spectral configuration of the two S3 instruments. We are just concern here by the calibration in the solar spectrum. In the thermal domain, including 3.74 µm, we rely on the onboard calibration.

**Table 4: OLCI and SLSTR instruments: spectral setting and spatial resolution**

| S3 channel | Central Wavelength | | Width | | Ground resolution* (km) | |
|---|---|---|---|---|---|---|
| | OLCI | SLSTR | OLCI | SLSTR | OLCI | SLSTR |
| | Nm | µm | nm | nm | Nadir / west | Best /worst for Nadir view ; constant value of backward view |
| O 1 | 400 | | 15 | | 0.27 / 0.75 | |
| O 2 | 412.5 | | 10 | | 0.27 / 0.75 | |
| O 3 | 442.5 | | 10 | | 0.27 / 0.75 | |
| O 4 | 490 | | 10 | | 0.27 / 0.75 | |
| S 1 | | 0.555 | | 20 | | 0.5 / 1.5 ; 0.8 |
| O 5 | 510 | | 10 | | 0.27 / 0.75 | |
| O 6 | 560 | | 10 | | 0.27 / 0.75 | |
| O 7 | 620 | | 10 | | 0.27 / 0.75 | |
| S 2 | | 0.659 | | 20 | | 0.5 / 1.5 ; 0.8 |
| O 8 | 665 | | 10 | | 0.27 / 0.75 | |
| O 9 | 681.25 | | 7.5 | | 0.27 / 0.75 | |
| O 10 | 708.75 | | 10 | | 0.27 / 0.75 | |
| O 11 | 753.75 | | 7.5 | | 0.27 / 0.75 | |
| O 12 | 761.25 | | 2.5 | | 0.27 / 0.75 | |
| O 13 | 764.375 | | 3.75 | | 0.27 / 0.75 | |
| S 3 | | 0.865 | | 20 | | 0.5 / 1.5 ; 0.8 |
| O 14 | 773.75 | | 5 | | 0.27 / 0.75 | |
| O 15 | 781.25 | | 10 | | 0.27 / 0.75 | |
| O 16 | 862.5 | | 15 | | 0.27 / 0.75 | |
| O 17 | 872.5 | | 5 | | 0.27 / 0.75 | |
| O 18 | 885 | | 10 | | 0.27 / 0.75 | |
| O 19 | 900 | | 10 | | 0.27 / 0.75 | |
| O 20 | 940 | | 20 | | 0.27 / 0.75 | |
| O 21 | 1020 | | 40 | | 0.27 / 0.75 | |
| S 4 | | 1.375 | | 15 | | 0.5 / 1.5 ; 0.8 |
| S 5 | | 1.61 | | 60 | | 0.5 / 1.5 ; 0.8 |
| S 6 | | 2.25 | | 50 | | 0.5 / 1.5 ; 0.8 |
| S 7 | | 3.74 | | 380 | | 0.5 / 1.5 ; 0.8 (TBC) |
| S 8 | | 10.85 | | 900 | | 1 / 3 ; 1.6 |
| S 9 | | 12 | | 1000 | | 1 / 3; 1.6 |

### 3.2.1 OLCI and comparison with MERIS

Table 5 reports the correspondence in spectral bands between OLCI and MERIS. Any radiometric calibration approaches developed for MERIS will apply to OLCI. The spectral flexibility of OCLI allows as well to conduct a spectral calibration based on the Fraunhofer lines and/or on the $O_2$ bands.

**Table 5: OLCI and MERIS spectral bands**

| Channel OCLI | Central wavelength (nm) | Width (nm) | Channel MERIS | Central wavelength (nm) | Width (nm) |
|---|---|---|---|---|---|
| 1 | 400 | 15 | | | |
| 2 | 412.5 | 10 | 1 | 412.5 | 10 |
| 3 | 442.5 | 10 | 2 | 442.5 | 10 |
| 4 | 490 | 10 | 3 | 490 | 10 |
| 5 | 510 | 10 | 4 | 510 | 10 |
| 6 | 560 | 10 | 5 | 560 | 10 |
| 7 | 620 | 10 | 6 | 620 | 10 |
| 8 | 665 | 10 | 7 | 665 | 10 |
| 9 | 681.25 | 7.5 | 8 | 681.25 | 7.5 |
| 10 | 708.75 | 10 | 9 | 708.75 | 10 |
| 11 | 753.75 | 7.5 | 10 | 753.75 | 7.5 |
| 12 | 761.25 | 2.5 | 11 | 761.75 | 3.75 |
| 13 | 764.375 | 3.75 | | | |
| 14 | 773.75 | 5 | 12 | 778 | 15 |
| 15 | 781.25 | 10 | | | |
| 16 | 862.5 | 15 | 13 | 865 | 15 |
| 17 | 872.5 | 5 | | | |
| 18 | 885 | 10 | 14 | 885 | 10 |
| 19 | 900 | 10 | 15 | 900 | 10 |
| 20 | 940 | 20 | | | |
| 21 | 1020 | 40 | | | |

For OLCI compare to MERIS, the whole field-of-view is shifted across-track by 12.2 degrees away from the Sun to minimise the sun glint impact. The impacts on the different calibration methods are:

(iv) To better control the surface BRDF for the largest VZA both over land and over water.

(v) To better control the aerosol scattering properties for the largest VZA both over land and over water.

(vi) The choice to reduce the sunglint contamination will increase the probability to collect data in the backscattering region. In this region we combine more uncertainties for the surface BRDF (hot spot) and for the aerosol phase function.

(vii) The sun glint inter band calibration will be *de factor* less favourable.

At the end, to reach the same level of accuracy, the vicarious calibration of OLCI will be more demanding than for MERIS.

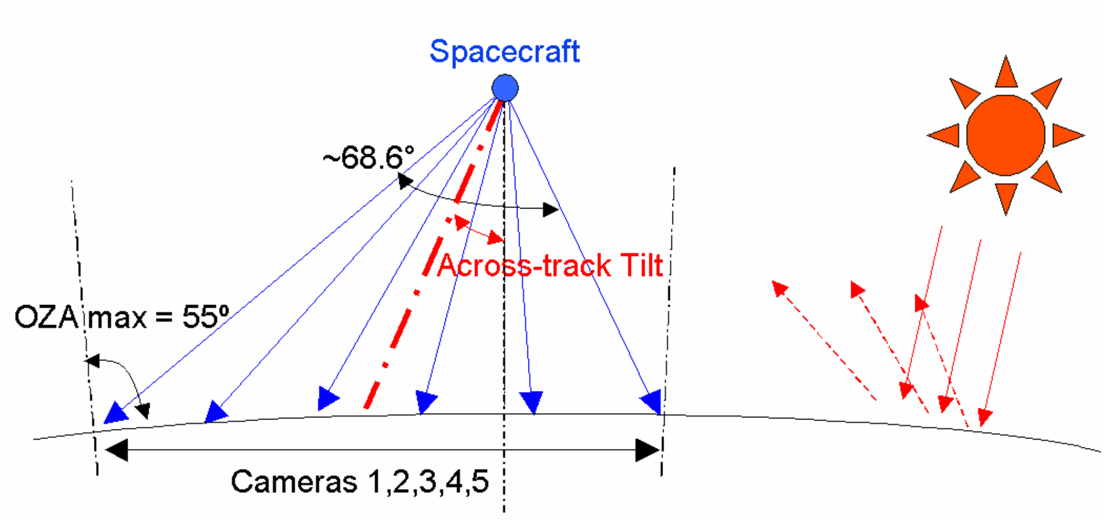



**Figure 4: OLCI scanning mode**

### 3.2.2 SLSTR versus AATSR

The 3 first bands of SLSTR fits quite well with corresponding OCLI bands. Some minor spectral adjustments are needed. MIR bands in the atmospheric windows at 1.61 µm and 2.25 µm fall in the standard calibration procedures. The specific “cirrus cloud” bands at 1.37 µm can not be calibrated except by high aircraft measurements associated to estimates of the water vapour above the aircraft.

# 4. VICARIOUS RADIOMETRIC CALIBRATION OF S2

## 4.1 The L1 products

Sentinel – 2 products are defined in Table 6 (MRD, 2008, RD.30):

**Table 6: Product definition**

| Product Level | Definition |
|---|---|
| Level 1b | Top-Of-Atmosphere (TOA) radiometric measurements, not re-sampled, **radiometrically corrected and calibrated**, spectrally characterised.<br>Quality controlled and ortho-geolocated, annotated with satellite position and pointing, landmarks and preliminary pixel classification (e.g. land/water/cloud masks).<br>**The Level 1b product consists of TOA radiance ($W.m^{-2}.sr^{-1}.\mu m^{-1}$).**<br>Image correlation, if involved to meet the spatial co-registration requirements, will be performed using a selectable re-sampling method including at least the dichotomic resampling based correlation. |
| Level 1c | Level 1b data ortho-rectified, re-sampled to a specified grid.<br>Image re-sampling will be performed using one of the following methods:<br>▪ Windowed truncated Shannon interpolation (also called Hamming window re-sampling),<br>▪ High-order B-spline interpolation,<br>▪ Bi-cubic convolution interpolation. |

## 4.2 LES calibration

### 4.2.1 The traditional LES calibration

What can be the specific recommendation for S2?

(i) Use the same strategy for the gaseous correction than for the L2 algorithms.

(ii) Use a field portable spectrometer to cover the spectrum from 0.4 µm to 2.5 µm.

### 4.2.2 Sharing the data

The LES calibration is quite costly. Then, following the rules of the different Space Agencies, it is generally not possible for a given Agency to support a research group which do not belong to its state members.

The CEOS should be the forum to propose to exchange data for vicarious calibration purposes with:

(i) A site to put in the different pieces of information. The calval portal is an opportunity.

(ii) A monthly bulletin to inform in advance about the field campaigns.

(iii) An agreement on the content of in situ database (content, format,…).

(iv) The generation of a satellite data base over test sites.

(v) A maintained web site for this in situ and satellite sensors data base (Again the calval portal?).

**Recom 1: Use CEOS as mean of exchange of information and data (bulletin; cal/val portal, forum ..)**

### 4.2.3 Sharing a network of radiometers

The AERONET network has proved its efficiency for aerosol study. The new CIMEL instrument, with a detector to cover the MIR, is suitable for the S2 spectral range. The ROSAS scanning protocol is a starting point for a common agreement. The existing instrument has a rotating wheel carrying 9 filters: 380, 440, 550, 670, 870, 937, 1020 and 1600 nm. 380 nm was selected for a “Rayleigh” calibration in radiance but 440 nm gives even better results. Therefore 380 nm can be removed and can be replaced by a filter at 2.2 µm. 1020 nm is needed as a common filter between the two detectors. 937 nm is for the water vapour. Alternatively, it can be replaced by a filter around 740 nm.

**Recom 2: Assess the interest of a radiometer network development in terms of instrument, filters, cost issues, local maintenance etc**

### 4.2.4 Sharing a processing chain

If we go to a network of radiometers, there is a need to develop a processing chain:

(i) To calibrate in irradiance and in radiance the radiometer.

(ii) To process the AOT and the sky radiance in order to define the aerosol inherent optical properties.

(iii) To process a radiative transfer code to predict the TOA radiance.

**Recom 3: Assess the development of a processing chain for managing a network of radiometers, including processing of new bands**

## 4.3 SES calibration

### 4.3.1 Motivation

If the LES calibration is the standard, it is useful to validate the calibration coefficients at low level of signal mainly for ocean colour applications.

### 4.3.2 Protocol

The ocean colour AERONET is the tool to perform this vicarious calibration. They are limitations in the spectral bands: the above water leaving radiance is only measured at 412 nm, 443 nm, 490 nm and 560 nm. In the NIR (B7 and B82), the water body is dark. The TOA signal is atmospheric. The method will be detailed for S3.

## 4.4 LNES inter temporal calibration and inter band calibration

The desert sites are the option first to validate the degradation model. We start to use the TOA reflectance corrected from the gaseous absorption. Then, we apply a Rayleigh correction based on the surface pressure value attached in the auxiliary file.

We need a BRDF model for nadir view versus the SZA. We recommend to use the PARASOL database, available at POSTEL site.

All the above methods will require a spectral adjustment. The desert sites present a stable spectral response to be used for an inter calibration exercise.

**Recom 4: Use POLDER/PARASOL BRDF database for BRDF modelling**

## 4.5 The specificity of the gaseous absorption bands

For spectral bands with a high gaseous absorption (B81, B9, B10) the treatment of the gaseous absorption is specific. The absorbing gas is the water vapour. For B81 and B9, the water vapour transmittance can be applied as a multiplicative factor of the TOA reflectance evaluates without any gaseous absorption as for the other bands. For example, the B82 TOA reflectance is multiplied by the $H_2O$ transmittance to get the B81 TOA reflectance.

The $H_2O$ transmittance in B81 and B9 needs as inputs the total water vapour content. It can be a meteorological data. Alternatively, with the CIMEL AERONET, there is a water vapour product derived from the extinction measurement at 940 nm.

For B10, the surface is not apparent because the water vapour absorption is too strong. A full modelling of the TOA signal requires to know the vertical distribution of the water vapour (thanks to radio sondages) and the vertical distribution of the aerosols (dynamism model, lidar?).

One possibility is to use the sunglint. At the tropic during the equinox, the sun is closed to the zenith. The sunglint can be strong enough to see the surface even in B10. Combining B81, B81, B9, B10 and B9, we can investigate the consistency of the signal in all these bands. B82 and B10 are the reference bands without water vapour absorption. The other bands should be consistent.

**Recom 5: Assess the accuracy of water vapour origin in $H_20$ transmittance**

**Recom 6: Foreseen a campaign for B10 calibration, including radiosounding**

**Recom 7: Define a protocol to acquire data over sunglint for B10 calibration**

# 5. VICARIOUS RADIOMETRIC CALIBRATION OF S3

## 5.1 The L1 product

Vicarious calibration will use the TOA reflectance. By simplification, on this TOA reflectance, the smile effect (which will certainly be present at least for OLCI) will be neglected. For historical reasons, the L1 product is still a radiance. Can we think about replacing a radiance by a reflectance? A reflectance corrected from the smile? If not, for vicarious calibration purpose, a simple tool should be made publicly available at the beginning of the mission to transform the TOA radiance into TOA reflectance with a smile correction if needed.

Then, where to apply the calibration procedure? It is relevant to believe than the L2 gaseous correction follows the best state of the art. Over water, a sunglint correction is applied. The recommendation is to perform the calibration procedure after the correction of the gaseous correction; and over ocean, after the L2 correction of the sunglint. Again, a simple tool should be made publicly available at the beginning of the mission to do these corrections.

The vicarious calibration applies on clear sky pixels. Can we rely on the L1 flags? The merged L1N product will be certainly an opportunity to built reliable flags because once can combine the two instruments. The L1N, through a re projection of the two instruments should be the tool to perform an intercomparison of the two instruments at least for the three similar spectral bands.

If we do not use the L1N to perform the calibration, it will be useful to .have access to the level 2 flags, at least those which enable to identify the clear sky pixels. Again, a simple tool should be made publicly available at the beginning of the mission to generate those flags.

## 5.2 Over LES

The accuracy on the pixel geolocalisation is a key element. It is certainly not relevant to recommend to do field campaigns for S3. It does not mean that we can not take the opportunity of using LES. If class 2 campaigns are organized and if we have access to these data, it is an opportunity. The problem remains the pixel size for S3. The site needs to be large (to include several pixels) and homogeneous. La Crau is a poor candidate.

The presence of a ROSAS radiometer will be another opportunity. But ROSAS or any automat can only sample the surface on few $m^2$, while we are talking about pixel size of $km^2$. In §6, we will indicate how to combine S2 and S3 in an attempt to combine both to correct for the spatial heterogeneity. .

We certainly need to consider differently SLSTR from OLCI. The bright land sites are the primary target for the solar spectral bands of SLSTR. The nadir view of SLSTR will be used for calibration.

**Recom 8: Check the site homogeneity**

**Recom 9: Use intersensor calibration method**

## 5.3 Over SES

In the visible we both need a good characterization of the water and of the atmosphere optical properties. If we account for the pixel size of OLCI, in the visible, we need homogeneous waters which correspond more likely to the open ocean than to the coastal waters. On the other hand, we need to characterize the aerosols, not only through extinction measurements but also with sky radiance measurements. It is quite difficult to find stable platforms in the open ocean. The ideal situation is a buoy in the case 1 ocean for marine measurements and an atmospheric radiometer set not to far from the buoy. The association MOBY and AERONET in Lanai is an option to be validated.

An alternative option is to use a radiometer to measure the water leaving radiance and to combine with atmospheric measurements. The use of commercial ships is an option. The vicarious calibration of POLDER and MERIS by Deschamps et al, 2004 (RD.29) using the SIMBAD radiometer is an example. The RAMSES TRIOS instrument onboard of ferries is another option.

In the NIR, the signal is driven by the aerosol scattering. Case 1 waters around small islands equipped with a CIMEL are a good option. The atmospheric data processing can be similar to the atmospheric data processing suggest in §4.2.5, including the prediction of the TOA signal with a RTC.

**Recom 10: Validate the MOBY candidate for absolute calibration in the visible.**

**Recom 11: Assess the deployment of SIMBAD or RAMSES TRIO instruments on boat**

**Recom 12: Install sunphotometers on small islands located in case 1 waters. Assess the list suggested in WP 260: Ascension Island, Azores, Barbados, Bermuda, Lampedusa, Maldives, San Nicolas, and Tahiti.**

## 5.4 Over LNES

We follow the strategy reported in §4.4. The additional thing is the inter calibration between OLCI and SLSTR in its 3 first bands. This methodology has been successfully applied to MERIS and AATSR. The nadir view of SLSTR will be used for calibration.

**Recom 13: use the protocol defined for inter temporal calibration over LNES**

## 5.5 Over SNES

### 5.5.1 The NIR adjustment

It may apply to OLCI bands O10, O11, O13 to band 18 over case 1 waters. The water body is dark. From the L1 radiance, we extract the aerosol path radiance. This aerosol path radiance is assumed to follow a log-log spectral dependence. The calibration is O10 is the reference and the calibration in the other bands is adjusted to follow the above law.

**Recom 14: Check the aerosol spectral dependence in NIR calibration over SNES**

### 5.5.2 The so-called Rayleigh calibration

The may apply to OLCI between band O1 to band O6 and to SLSTR band S1. We can start with:

(i) The oceanic sites selected by CNES.

(ii) The water leaving reflectance (associated to chlorophyll content) provides by the MERIS level 3 products and an associated monthly climatology.

(iii) The aerosol model provides by the MERIS level 3 product and an associated monthly climatology.

(iv) A threshold at 865 nm to select the good atmospheric visibilities.

Based on the above pieces of information, we predict the TOA signal in the visible and compared it to the sensor output. The NIR adjustment can be made a priori but the absolute calibration in the NIR can be a flexible parameter.

By consistency, the prediction of the signal is based on:

(i) The auxiliary data of S3 (barometric pressure, ozone content, wind speed).

(ii) The same reference model for the water.

(iii) The same reference model for the atmosphere (gaseous absorption, Rayleigh and aerosols).

(iv) Same formalism for the TOA signal than for the L2 algorithm.

For a given case, the prediction of the signal can be multiple: different aerosol types, different aerosol optical thicknesses,… Each assumption provides a set of calibration coefficients.

The CNES approach relies on the inter band calibration between the NIR and the visible (Vermote and Kaufman, 1995, RD.28) in order to transport an estimate of the aerosol contribution from 865 nm to the visible bands. We can follow this approach which is certainly better than another common approach to state of the validity of the calibration at 865 nm.

The above approach relies on the selection of an aerosol type. A selection criterion can be made on a statistical basis: what is the best aerosol type which gives the less dispersion on the retrieval of the calibration coefficients.

**Recom 15: Introduce a minimisation criterion in the Rayleigh calibration based on aerosol model**

### 5.5.3 Sun glint inter band calibration

Because the two above methods for OLCI deal with the inter calibration, it is relevant to have an inter calibration procedure. The sun glint is one candidate even if less sunglint occurrence is expected for OLCI thanks to the instrument tilt.

One example of sunglint is reported for a MERIS image. If strong sunglint exists for MERIS (and should still exist for OLCI), it is needed to better identified the sunglint. Clearly with MERIS, the sunglint is flagged as cloud which should not be. We raise again the question on the level 1, here the quality of the flags.


**Figure 5 : RGB MERIS, Pacific Ocean, day 2005/05/17, long: -144.01W, lat: 22.42N**

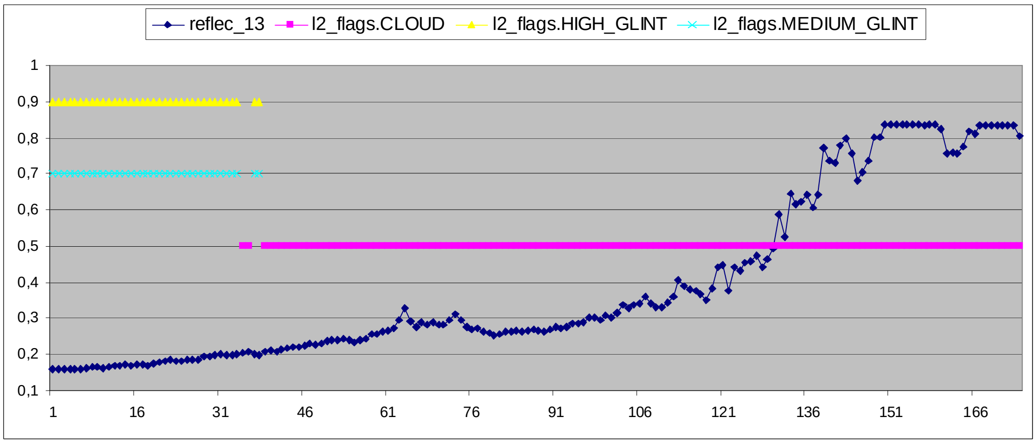



**Figure 6: TOA B13 reflectance (blue diamond) and flags: Medium glint (cyan cross), high glint (yellow diamond) and cloud flag (pink point)**

The obvious limitation to this method is the knowledge of aerosol model. The vicinity of an AERONET site is an alternative to measure the optical properties of the aerosols.

**Recom 16: Improve flag sunglint**

**Recom 17: Use AERONET data to estimate aerosol optical properties in sunglint interband calibration in areas located near coast**

### 5.5.4 Inter calibration of SLSTR and of OLCI

As for over land, in the nadir view of SLSTR, we can cross calibrate the three first bands of SLSTR versus OLCI.

## 5.6 Synergy in the calibration of the two S3 instruments

### 5.6.1 The flags

As we already noticed, the flags we can set by combining OLCI and SLSTR can be a plus in the detection of clear sky condition, the basic requirement for all the calibration approaches.

For inter calibration over LNES, the thermal can be used to detect dust storm episodes we also need to exclude.

**Recom 18: Define the flags using OLCI and SLSTR**

### 5.6.2 The water vapour absorption

The water vapour band of OLCI may help to compute the water vapour absorption of the S3 and S5 SLSTR bands.

**Recom 19: Compute SLSTR water vapour absorption using OLCI estimation**

### 5.6.3 The dual view of SLSTR

Above the ocean, when we are in sunglint conditions for OLCI and the nadir view of SLSTR, we have the forward view of SLSTR outside the sunglint. Thanks to S2 and S3, we can derive the aerosol model.

Back to the sunglint, we can introduce this aerosol model in the prediction of the TOA signal for the inter band calibration.

**Recom 20: Use SLSTR forward view to estimate an aerosol model for interband calibration in the sunglint**

# 6. INTER SENSORS RADIOMETRIC CALIBRATION S2 VERSUS S3

The inter calibration of S2 and S3 sensors over test sites (land and water) is easy to achieve and therefore recommended based on the *a priori* better performances of S3 (OLCI).

## 6.1 The S2 spatial resolution for S3 calibration

### 6.1.1 Over land

Let us imagine that a LES is equipped with a ROSAS instrument. This instrument characterizes the atmosphere. The IOP of the aerosols present a spatial homogeneity which can be used for a macro pixel of S3.

ROSAS will characterize few S2 pixels (2*2?). Thanks to the in situ atmospheric measurements, we can accurately derive the surface reflectance for the S2 image over the LES. The ROSAS S2 reflectance can be duplicated to site thanks to the S2 surface reflectance image by simple ratio. After a spectral adjustment, we can predict the mean surface reflectance on the S3 macro pixel (4*4, TBC).

The TOA S3 signal will use this surface reflectance and the atmospheric measurement to predict the S3 TOA radiance.

NB: the quasi simultaneity between S3 and S2 is a plus. The main requirement is to have a corrective factor between the ROSAS “pixel” and the S3 macro pixel.

**Recom 21: Develop a method to predict S3 reflectance from S2 measurements**

### 6.1.2 Over water

The same approach than over land can be used but only for quasi simultaneous measurements. In the NIR, S2 directly indicates the spatial homogeneity of the aerosols. In the visible, the same weighting technique to extend the surface characterization for the water leaving radiance can be adopted. But it is unlikely to have a simultaneity between S2 and S3.

**Recom 22: Develop a method to predict S3 reflectance from S2 measurements**

## 6.2 The S3 spectral resolution for S2 calibration

The comparison in Figure 3 on the spectral responses between S2 and MERIS (also OLCI) indicates a good spectral correspondence. The S2 spectral bands are quite narrow compare to the former class 3 sensors (SPOT-HRV, Landsat ETM+,…).

A spectral adjustment is needed between ground based reflectance measurements (except if a high resolution spectrometer is used). Measurements need to be re sampled in the satellite bands. May be OLCI can be used to produce a library of the spectral reflectance for the test site in order to perform this spectral adjustment.

**Recom 23: Use OLCI to produce a library of the spectral reflectance for the test site in order to perform this spectral adjustment**

# 7. VICARIOUS SPECTRAL CALIBRATION

## 7.1 S3/OLCI

### 7.1.1 Fraunhofer lines

The spectral flexibility of OLCI allows to cover some Fraunhofer lines and to conduct a similar vicarious spectral calibration than for MERIS. The on board reference panel should be used.

**Recom 24: Conduct a similar vicarious calibration for OLCI than the one use for MERIS**

### 7.1.2 Sensor inter calibration

The atmospheric sensors (high resolution spectrometers) should be the reference for the spectral calibration of OLCI in the strong absorption line such as the oxygen around 761 nm.

**Recom 25: Use atmospheric sensors as reference for spectral calibration**

## 7.2 Sensor inter calibration between OLCI and S2

### 7.2.1 Over water

Over the open ocean (in the middle of the Pacific Ocean) the water colour is deep blue and even violet, the Rayleigh atmospheric scattering as well. The meteorological visibilities are good. Let us assumed than OLCI and S3 are well calibrated (or well inter calibrated over bright land targets). A cross radiometric calibration over the open ocean between OLCI and S2 is conducted as least for the 3 first spectral bands of S2. Any discrepancy between S2 and S3 can be explained by a spectral adjustment of S2.

**Recom 26: Cross calibration of S2 B1, B2 and B3 and OLCI O3, O4 and O6 over SNES**

### 7.2.2 Over land

OLCI is the reference instrument and the “red edge” is covered by several spectral bands. Red edge indices can be used to compare OLCI and S2. Agreement between the two instruments can be reached after a spectral adjustment of S2.

Large and homogeneous biomes need to be selected such as the Amazonian forest or large agricultural fields.

**Recom 27: Comparison of red edge for OLCI and S2**

**Recom 28: Choose forest and agricultural LNES sites for red edge comparison**

# 8. PROOF OF CONCEPT FOR RADIOMETRIC CALIBRATION

## 8.1 Summary of the S2 and S3 recommendations

Table 7 is a summary of recommendations for radiometric calibration. The sensor response degradation model can be evaluated (built) on LNES particularly desert sites for all type of sensors.

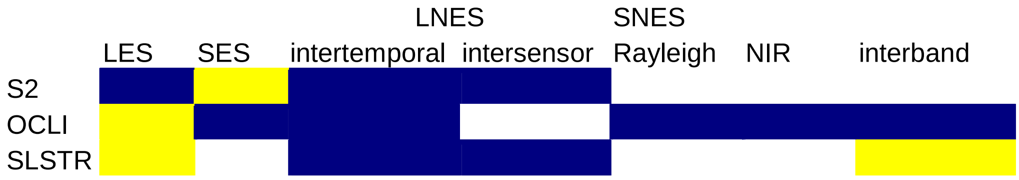
The inter sensor calibration starts from a reference sensor (here OLCI) and can be applied to S2 and SLSTR.

The standard procedure for S2 is on LES. The standard procedure for ocean colour sensor is on SES.

The SES does not offer enough warranty and therefore need to be completed by various methods over case 1 waters. The presence of AERONET atmospheric measurements is a plus.

The interband calibration of SLSTR over the sunglint can be a plus mainly for the MIR bands.

**Table 7: Mandatory (blue) and recommended (yellow) vicarious calibration methods**




## 8.2 Radiometric calibration of ETM+ over La Crau using ROSAS

### 8.2.1 The standard CNES protocol

The ROSAS instrument and the calibration procedure are described in Santer et al, 2009,RD.27. The calibration procedure is summarized in Table 8.

**Table 8: ROSAS calibration procedure**

| | **input** | **tool** |
|---|---|---|
| Gaseous absorption | ECMWF data | 6S computations |
| Molecules | ECMWF barometric pressure | Rayleigh theory |
| Aerosol characterization | ROSAS extinction measurements | AOT<br>Mie theory for IOP |
| Surface reflectance | Surface leaving radiance<br>AOT and sky radiance | Approximation to compute the irradiance at surface |
| Surface BRDF | ROSAS and Roujean BRDF model | Best fit of BRDF model |
| Surface reflectance in the sensor geometry | BRDF model and surface reflectance measurements | Mean reflectance after BRDF correction |
| TOA reflectance | All above | SOS RTC and 6S |

What are the weak points of the procedure?

(i) Over bright sites, the main parameter is the mean surface reflectance of the pixel in the sun to sensor path. ROSAS measured radiance. The conversion radiance to reflectance requires an extinction measurement and the prediction of the diffuse irradiance at surface. This last term is approximated.

(ii) ROSAS measures the surface leaving radiance at the satellite time of over path under 750 different views. To normalize this direction to the satellite view direction, we need a surface BRDF model. This model is the best fit between the 750 measurements and an analytical reflectance model. A reference BRDF model is needed.

(iii) The aerosol model is a power law associated to the measured Angstroem coefficient. The refractive index is quite arbitrary set o m=1.44-j*0.005. The Mie theory is used to define the aerosol IOPs.

### 8.2.2 Using WOPAER

WOPAER is a software package, developed under an ESA contract, which uses as input the sky radiance measured by the CIMEL instrument in AERONET, and by an inversion technique provides the aerosol phase function and the single scattering albedo (RD.24).

With WOPAER, we first covers point (iii). Then, knowing the Rayleigh, the AOT and the aerosol IOPs, a reasonable guess for the surface reflectance, we can compute (with the SOS code) the diffuse irradiance at surface (point (i)).

### 8.2.3 Site surface BRDF model

ROSAS collected a large data base of BRDF measurements. The analyse of this data base should allow to define a BRDF model

## 8.3 Radiometric calibration of MERIS over the AERONET "ocean colour" sites

### 8.3.1 The standard protocol

The instrument and the calibration procedure are described in Zibordi et al, 2004, RD.23. The calibration procedure is summarized in Table 9. The data are available on the ocean colour AERONET web site.

**Table 9: Calibration procedure**

| task | input | tool |
|---|---|---|
| Gaseous absorption | Auxiliary MERIS data | MERIS correction |
| Sun glint | Auxiliary MERIS wind speed | Wave slope distribution model |
| Molecules | Auxiliary MERIS barometric pressure | Rayleigh theory |
| Aerosol characterization | CIMEL extinction measurements | AOT<br>Mie theory for IOP |
| Normalized water leaving radiance | Surface leaving radiance<br>Atmospheric radiance<br>Irradiance at surface | Sky dome reflection correction. |
| | Chlorophyll a content | Morel model |

| task | input | tool |
|---|---|---|
| TOA reflectance | All above | RTC and 6S |

### 8.3.2 Using WOPAER

The motivations are the same than for the LES:

(i) A better estimate of the aerosol IOPs mainly for the calibration in the NIR

(ii) A complementary estimate of downwelling irradiance at the surface.

Additionally, the computation of the downwelling radiance may help in the correction of the sky dome reflection.

## 8.4 Radiometric calibration of MERIS over SNES

### 8.4.1 The standard CNES protocol for the so-called Rayleigh method

#### 8.4.1.1 MERIS data base

From defined oceanic sites, MERIS images will be processed through the calval portal using an existing data extraction procedure. The calval extraction procedure is the following:

(i) generate an MERIS data base for the site on the calval portal

(ii) select the MERIS scenes on quick look images.

(iii) Export a text file.

The text file will be process on a 50*50 pixels window to:

(i) Convert radiance into reflectance

(ii) Flag clouds, including cirrus clouds

(iii) average the reflectance and provide quality index

#### 8.4.1.2 MERIS level 3 climatology

On the selected site, L3 MERIS will provide, on a monthly basis, the Chla content and the surface reflectance

#### 8.4.1.3 TOA reflectance and associated LUTs

The 6S formulation will be used to compute the TOA signal. Pre computations with the SOS code will provide :

(i) the molecular scattering functions.

(ii) the aerosol scattering functions.

The general procedure was described in §5.5.2.

### 8.4.2 Using the AERONET network for NIR calibration

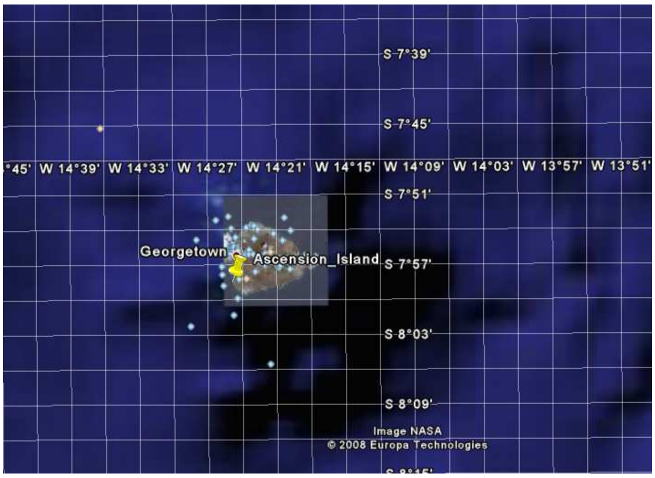
Over NIR dark case 1 waters, first we apply the spectral alignment of the aerosol reflectance as described in §5.5.1.

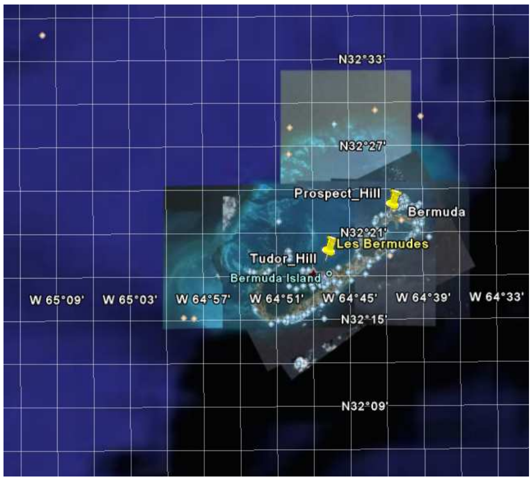
AERONET and WOPAER are the mean to correctly describe the aerosol IOPs and therefore to correctly predict the TOA signal. 7 AERONET sites are selected and listed in Table 10. AERONET site uses Google Earth to display the location of the AERONET sites.

**Table 10: Selected AERONET stations: localisation and period of data acquisition**

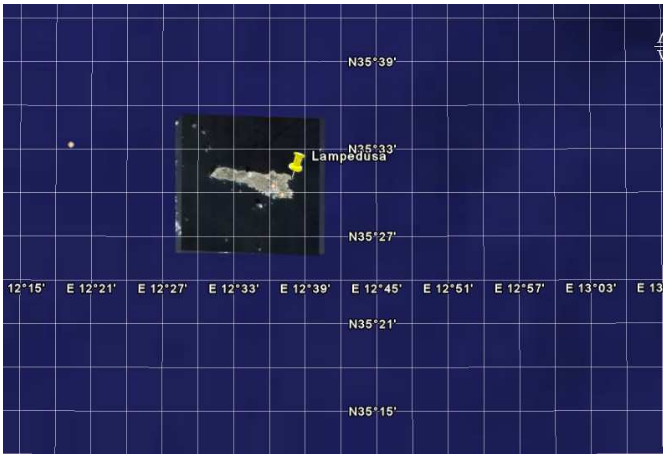
| Name | Lon | Lat |
|---|---|---|
| Ascension_Island | -14.41 | -7.976 |
| Azores | -28.63 | 38.53 |
| Barbados | -59.50 | 13.167 |
| Bermuda | -64.70 | 32.37 |
| Lampedusa | 12.63 | 35.517 |
| MALE | 73.53 | 4.192 |
| San_Nicolas | -119.49 | 33.257 |
| Tahiti | -149.61 | -17.577 |

**Table 11: Pre selection of the AERONET stations for the NIR calibration**

<table>
<tr><th>Ascension Island</th><th>Bermudes Island</th></tr>
<tr><td>


</td><td>


</td></tr>
</table>

<table>
<tr><th>Lampedusa Island (Italy)</th><th>Azores</th></tr>
<tr><td>


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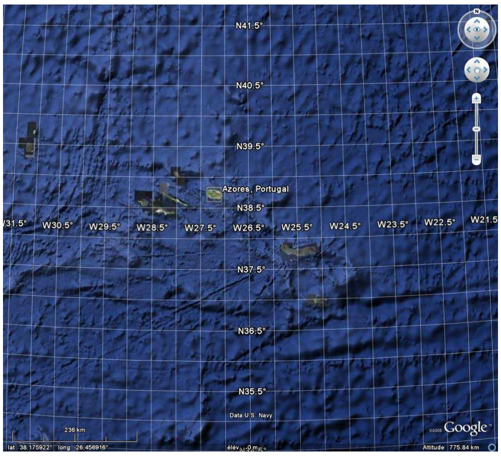
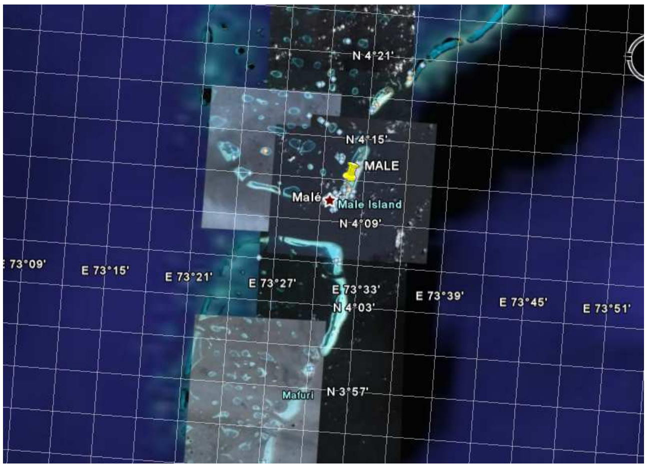
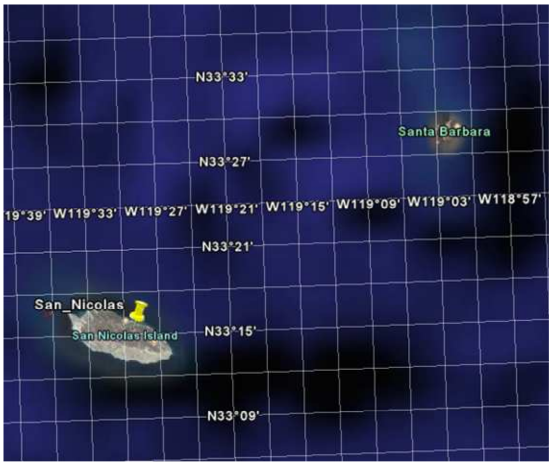
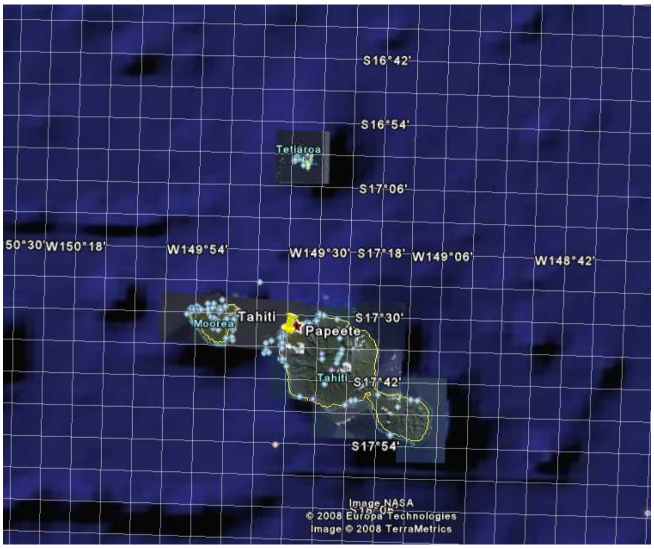


</td></tr>
<tr><th>Maldives Island</th><th>San Nicolas Island (Catalina Islands, USA)</th></tr>
<tr><td>


</td><td>


</td></tr>
<tr><th>Tahiti Island (France)</th><th>Barbades</th></tr>
<tr><td>


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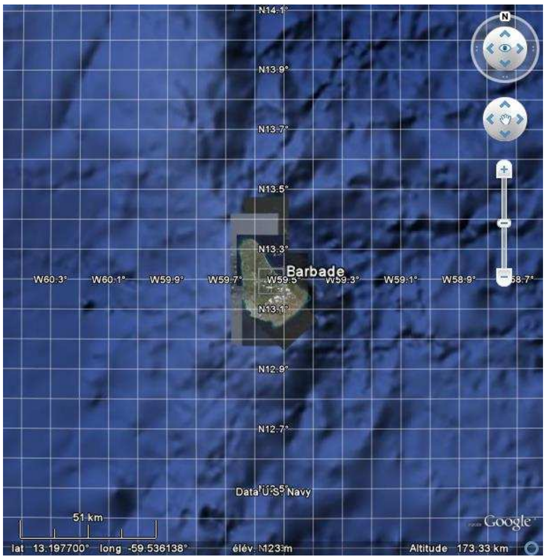

</td></tr>
</table>

## 8.5 LNES

### 8.5.1 Inter temporal calibration of MERIS over desert sites

The Lybian site is an opportunity to set the procedure described in the WP200.

This Lybian site is a calval portal site.

The calval extraction procedure can be used.

We need to define the criterion for data rejection.

We need to define on short time series a BRDF model for MERIS.

We want to derive a degradation model for 13 MERIS bands.

### 8.5.2 Inter sensor calibration of MERIS and a class 3 sensor over desert sites

An attempt to do inter sensor calibration over the Lybian site was done with AVNIR. This exercise can be redone with a better procedure.

## 8.6 Inter band calibration of MERIS over sunglint

### 8.6.1 The standard protocol

We can use the data and the tools realized for the Rayleigh calibration in §8.4.1. Simply we select high sunglint areas.

### 8.6.2 Using AATSR

Over the same sites, we collect AATSR images in simultaneity with MERIS images. A simple inversion routine to determine the aerosol model will be developed on the forward view of AATSR which is out the sunglint spot. This routine is a double loop on the aerosol type and AOT to predict the TOA signal. The best retrieval of AATSR B2 and B3 gives the aerosol model.

This aerosol model is used in the sunglint procedure for MERIS.

### 8.6.3 Using AERONET

The data based on the 7 AERONET sites of §8.4.3 can be used with an accurate description of the aerosol IOPs in simultaneity with sunglint on the MERIS images.

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