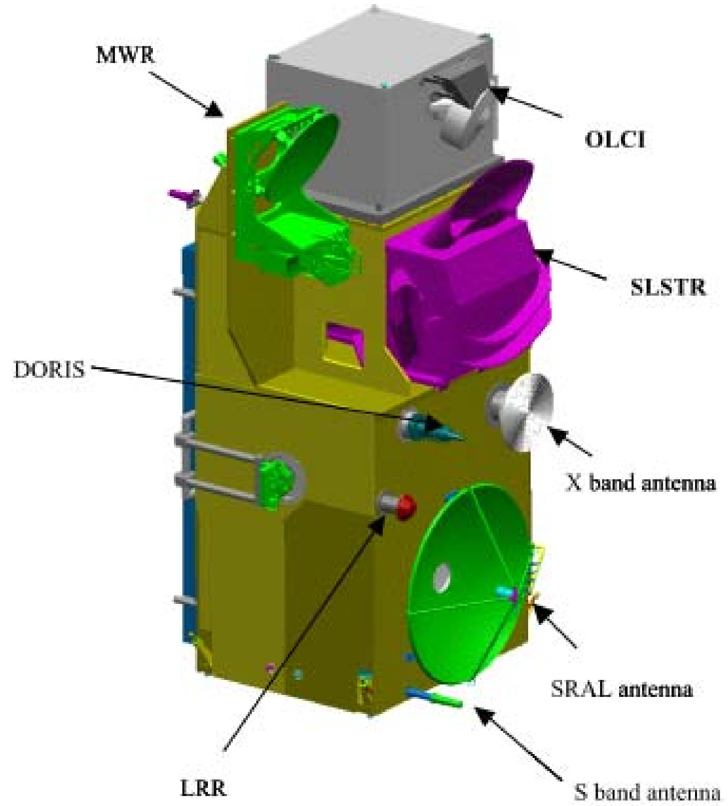
OLCI calibration and characterisation

Sentinel-3



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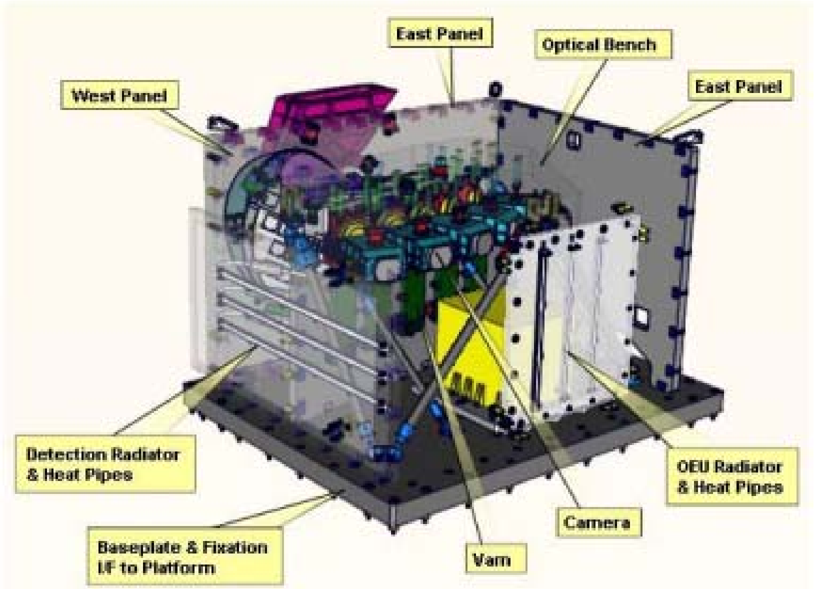
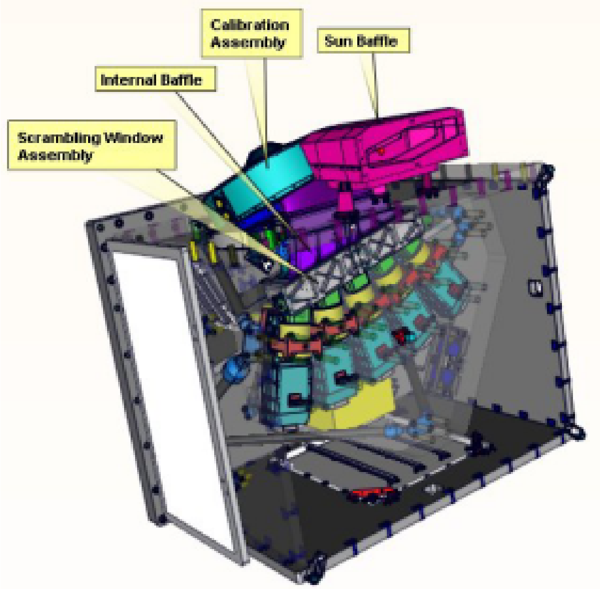
Overview

- ❖ OLCI, successor to MERIS
- ❖ Overall calibration strategy
  - Radiometric model
  - Calibration processing chain
    - ✓ In-flight measurements
    - ✓ On-ground characterisation
    - ✓ Analysis and modelling
- ❖ Lessons learnt from MERIS
  - Calibration sequences
  - Calibration data & processing
  - On-ground Characterisation
- ❖ Conclusion

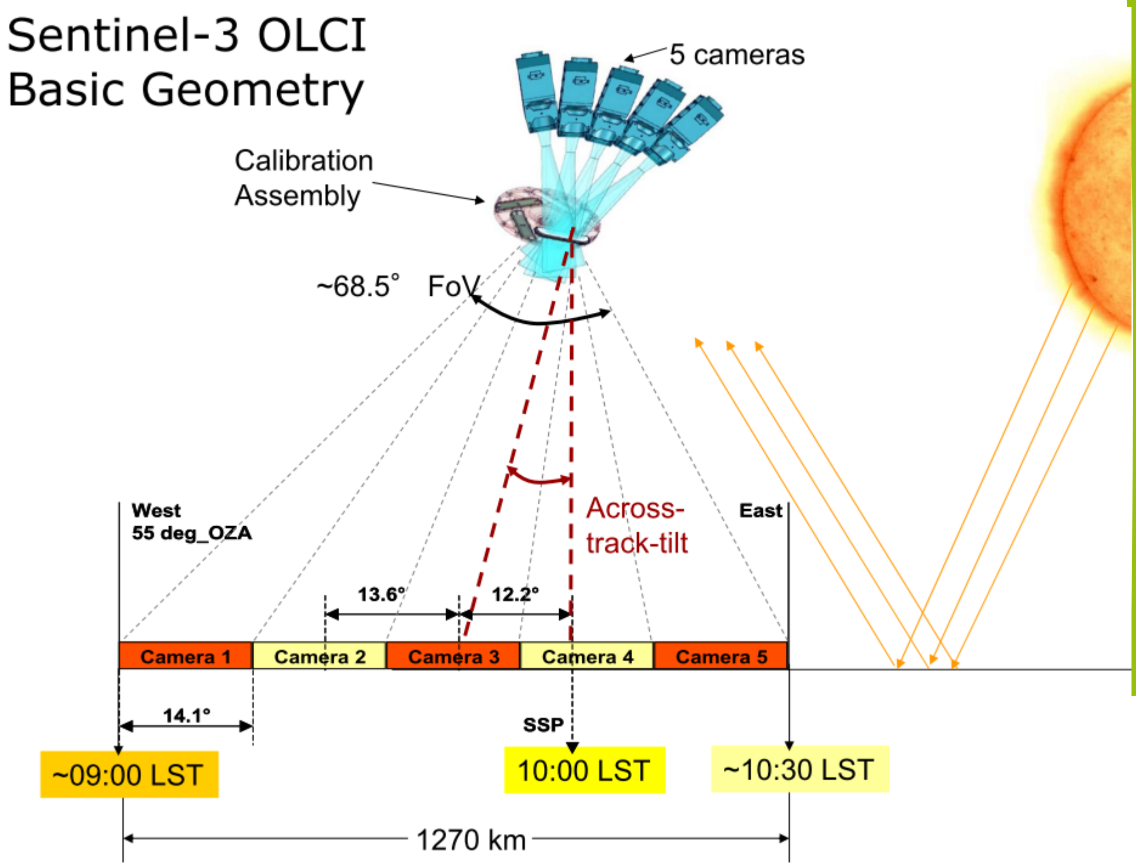




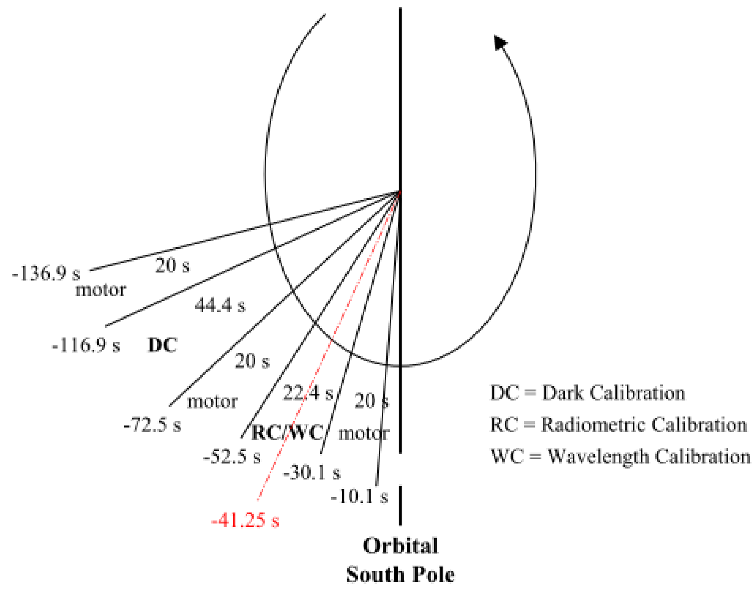
OLCI, successor to MERIS

- Push-broom imaging spectrometer, 5 fan-arranged cameras
- Radiometric calibration based on on-board diffuser(s)
- Spectral calibration using dedicated on-board diffuser

+ 12 degrees westward tilt to avoid Sun glint and increase swath to 1250km
+ number of bands increased to 21
+ technological improvements…



Overall Calibration Strategy



On-ground characterisation

+

In-flight calibration measurements

+

Processing, analysis and modelling

=

Self standing absolute calibration for the EO processing chain

Radiometric model

$$X_{b,k,m,t} = NL_{b,m}\left[\begin{matrix} A^0_{b,k,m} \cdot \left(L_{b,k,m,t} + SL_{b,k,m,t}(L_{*,*,*,*})\right) + \\ Sm_{b,k,m,t}(L_{*,k,m,*} + SL_{*,k,m,*}(L_{*,*,*,*})) + \\ g_C(T_t^{CCD}) \cdot C^0_{b,k,m} \end{matrix}\right] + \varepsilon$$

Where:

- b = band, k / m = pixel / camera, t = time, (* = whole/partial domain)
- $X_{b,k,m,t}$ is the OLCI raw sample
- $NL_{b,m}$ is a non-linear function
- $T^{CCD}(t)$ is the temperature of the CCDs
- $g_C(T^{CCD})$ is a dimensionless temperature correction function
- $A^0_{b,k,m}$ the "absolute radiometric gain" in counts/radiance unit
- $L_{b,k,m,t}$ the spectral radiance distribution in front of OLCI
- $Sm_{b,k,m,t}$ the smear signal, due to continuous sensing of light by OLCI
- $C^0_{b,k,m}$ the calibrated dark signal (possibly including an on-board compensation)
- $SL_{b,k,m,t}$ a linear operator representing the stray light contribution to the signal
- ε is a random process representative of the noise and measurement errors.

Radiometric model applies to Calibration measurements

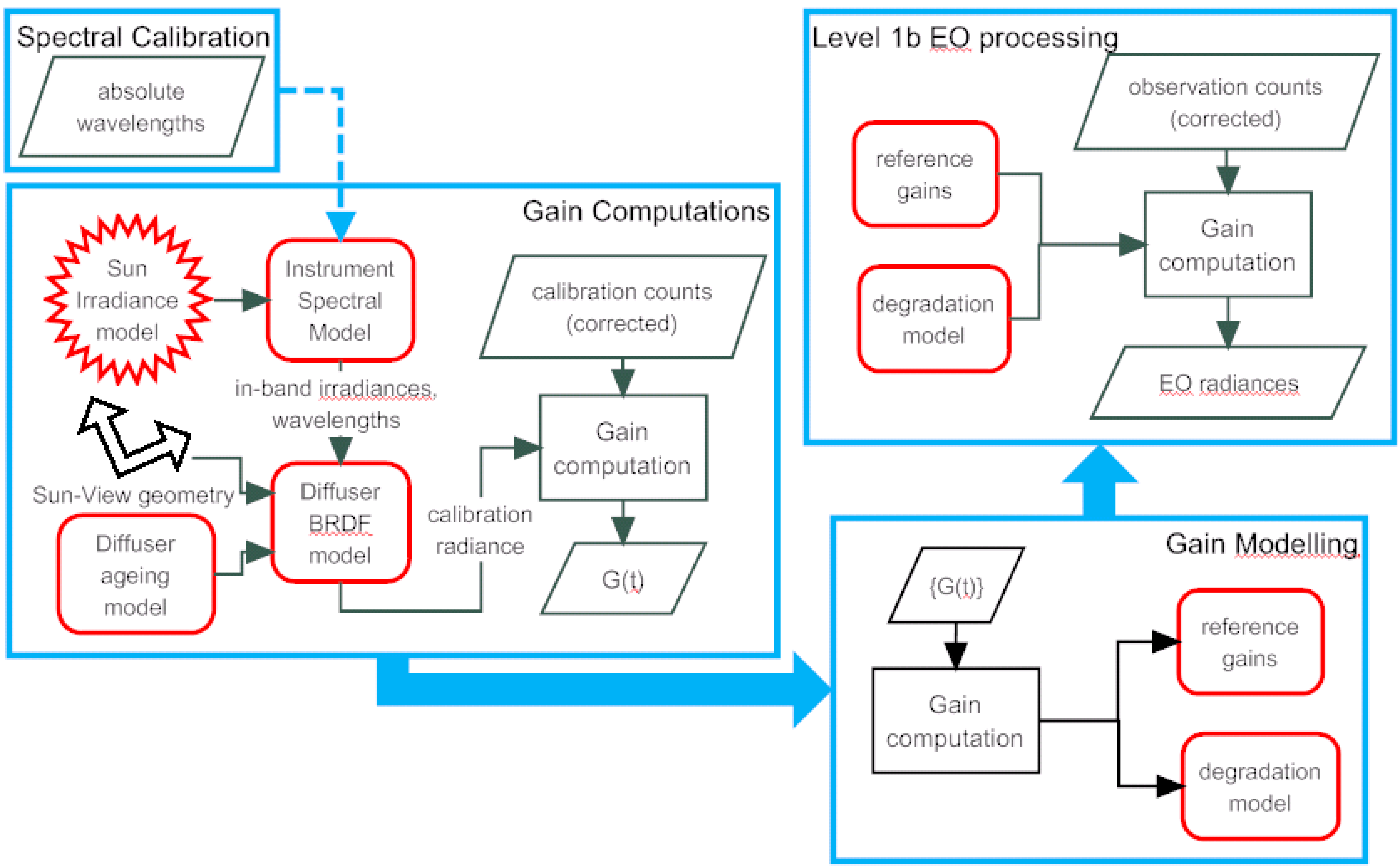
$$X^{Cal}_{b,k,m,t} = NL_{b,m}\begin{bmatrix} A^{0}_{b,k,m}\cdot\left(L^{Cal}_{b,k,m,t} + SL_{b,k,m,t}(L^{Cal}_{*,*,*,*})\right) + \\ Sm_{b,k,m,t}(L^{Cal}_{*,k,m,*} + SL_{*,k,m,*}(L^{Cal}_{*,*,*,*})) + \\ g_C(T^{CCD}_t)\cdot C^{0}_{b,k,m} \end{bmatrix} + \varepsilon$$

$$A^{0}_{b,k,m} = \left\langle \frac{NL^{-1}_{b,m}\left(X^{Cal}_{b,k,m,t}\right) - Sm_{b,k,m,t}(L^{Cal}_{*,k,m,*} + SL^{Cal}_{b,k,m,t}) - g_C(T^{CCD}_t)\cdot C^{0}_{b,k,m}}{\left(L^{Cal}_{b,k,m,t} + SL^{Cal}_{b,k,m,t}\right)} \right\rangle_{t\in\{cal\}}$$

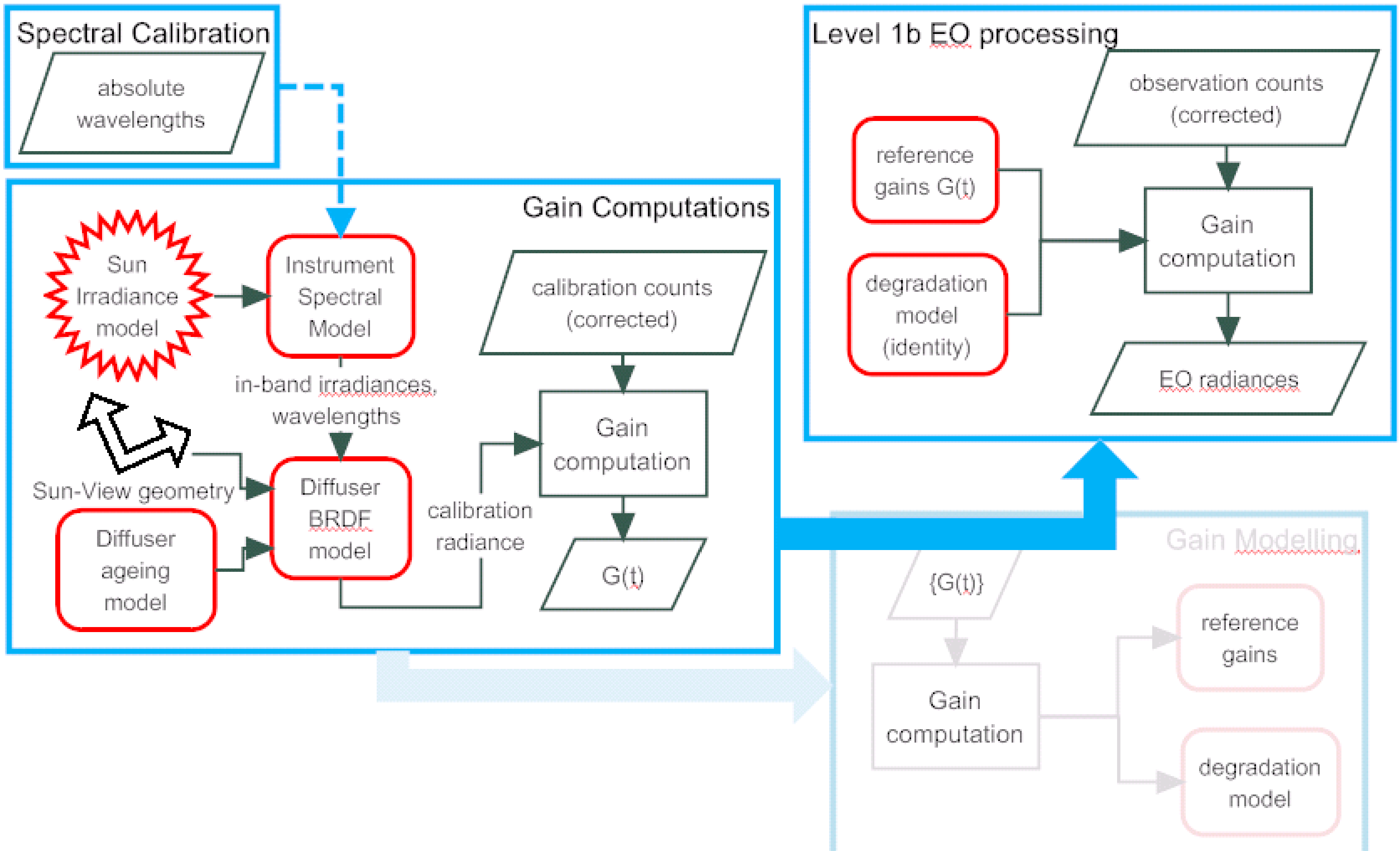
With:

- X^{Cal} from Sun diffuser measurements
- C^0 from dedicated measurements (with shutter)
- Sm from dedicated band (virtual, lit only during CCD frame transfer)
- L from characterised diffuser BRDF + in-flight geometry + E_0 at OLCI bands
- SL from L + characterised/modelled convolution kernels
- gC from characterisation
- NL^{-1} from characterisation

Calibration chain summary

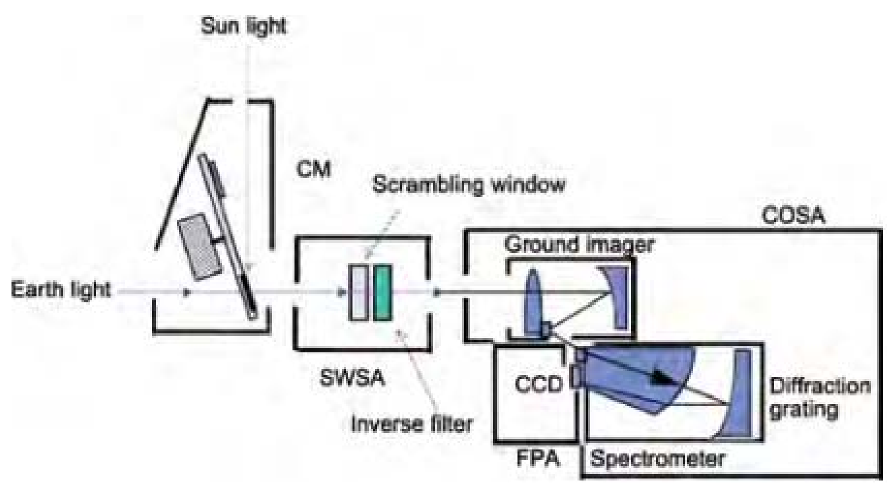


Calibration chain summary (short term)



In-flight measurements

- **Shutter: dark offset (calibration zero),**
  before every diffuser acquisition (systematic) or along-orbit (infrequent)
- **Radiometric diffuser: calibration gains**
- **Reference radiometric diffuser: ageing of nominal diffuser**
- **Spectral diffuser: spectral calibration at 3 wavelengths**
- **Specific observations in support to spectral calibration**
  (Fraunhofer lines on diffuser, O2 absorption over Earth) → additional wavelengths



On-ground characterisation: Key Inputs

Main inputs for radiometric calibration:

- **Spectral data: central wavelengths, spectral response curves → in-band equivalent irradiance**
- **Diffusers characterisation: BRDF and orientation**
- **Integral non-linearity**
- **Instrument pointing vectors**
- **Stray light operators**

- **Compute radiance at instrument entrance during radiometric calibration from in-flight geometry**

Processing, analysis and modelling

- From spectral calibrations: correction of spectral model, impact on central wavelengths and in-band irradiances, if required
- From radiometric diffuser: calibration gains
- From reference diffuser comparison with nominal (ageing sequences): modelling of diffusers ageing (browning)
- Analysis of calibration gains time series (mid and long term): derivation of instrument degradation model, smoothing transitions

➢ Back to Calibration of EO data through auxiliary files

Lessons learnt from MERIS 1/3

1) Calibration sequences

In addition to "classical" sequences (radiometric, ageing and spectral diffuser), the following have been included:

- **Orbital stability (along-orbit dark level stability)**
- **Fraunhofer lines observations on radiometric diffuser (no spectral relaxation: 1 orbit allows observing 6 lines, while 3 orbits were necessary with MERIS)**
- **Earth observations of O_2 atmospheric absorption using dedicated band setting (+ corresponding radiometric calibration)**

> **All the MERIS spectral campaigns are pre-defined on-board OLCI**

Lessons learnt from MERIS 2/3

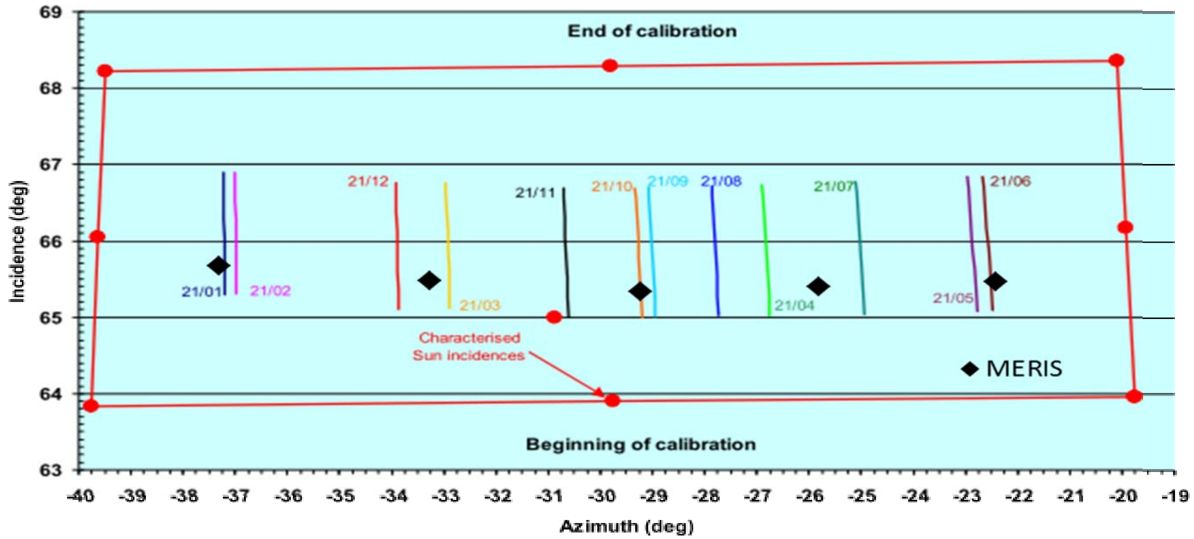
2) Calibration acquisitions and processing

- All calibration measurements are sent to ground and processed on a frame by frame basis (i.e. without the temporal averaging of MERIS)
  - → inputs to uncertainties, SNR evaluations, BRDF model assessment, diffuser speckle, sensitivity to geometry …
- All calibration acquisitions are packed without spectral relaxation (i.e. in micro-bands, or sub-bands)
  - → better processing, finer analysis
- Much more detailed stray-light modelling for both Radiometric Calibration and Earth Observation: full spatial 2D for Ground Imager and full across-track/spectral 2D for the spectrometer.
- accurate navigation/<u>attitude</u> from on-board system

Lessons learnt from MERIS 3/3

3) On-ground Characterisation

- ❖ Improved spectral characterisation → spectral model
- ❖ Improved diffuser BRDF characterisation domain



- ❖ Much more detailed stray-light modelling for both Radiometric Calibration and Earth Observation: full spatial 2D for Ground Imager and full across-track/spectral 2D for the spectrometer.

Conclusion

Thanks to commonality between the two instruments:

- **a successful calibration strategy is re-used,**
- **refined according to lessons learnt,**
- **embedded in an operational environment**

should guarantee success

Surprising instrumental behaviours cannot be excluded

- **Validation from vicarious is mandatory (and adjustment if required)**
- **calibration team must be prepared to revise everything**

Thank you for your attention