Status of MERIS Calibration for 4th reprocessing

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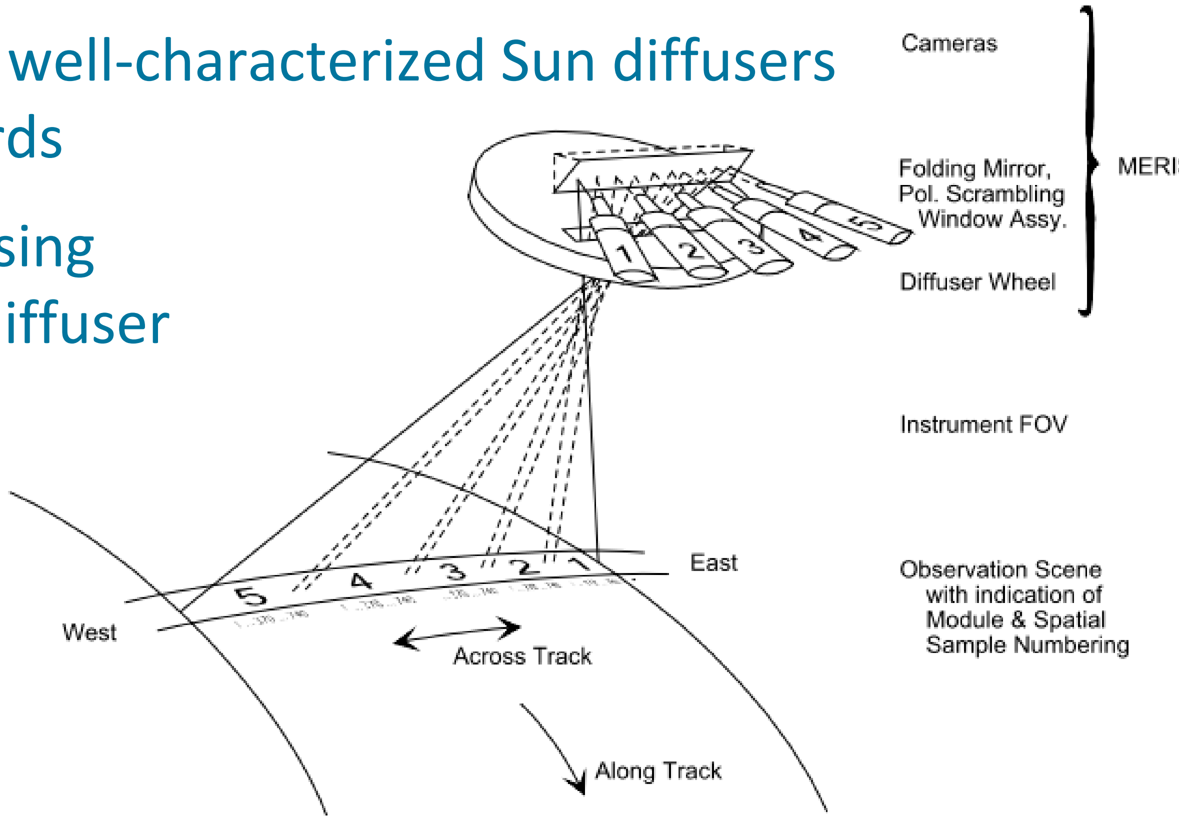
Overview

- Instrument overview
- In-flight calibration hardware
- Overall calibration strategy
  - 3rd reprocessing radiometric validation results
- Calibration processing chain
  - Radiometric model
  - Processing chain
  - Why a temporal model?
  - Gain modelling
- Some results from whole mission reanalysis
  - Reference diffuser stability
  - Impact on gain drift determination
- Conclusion

Instrument overview

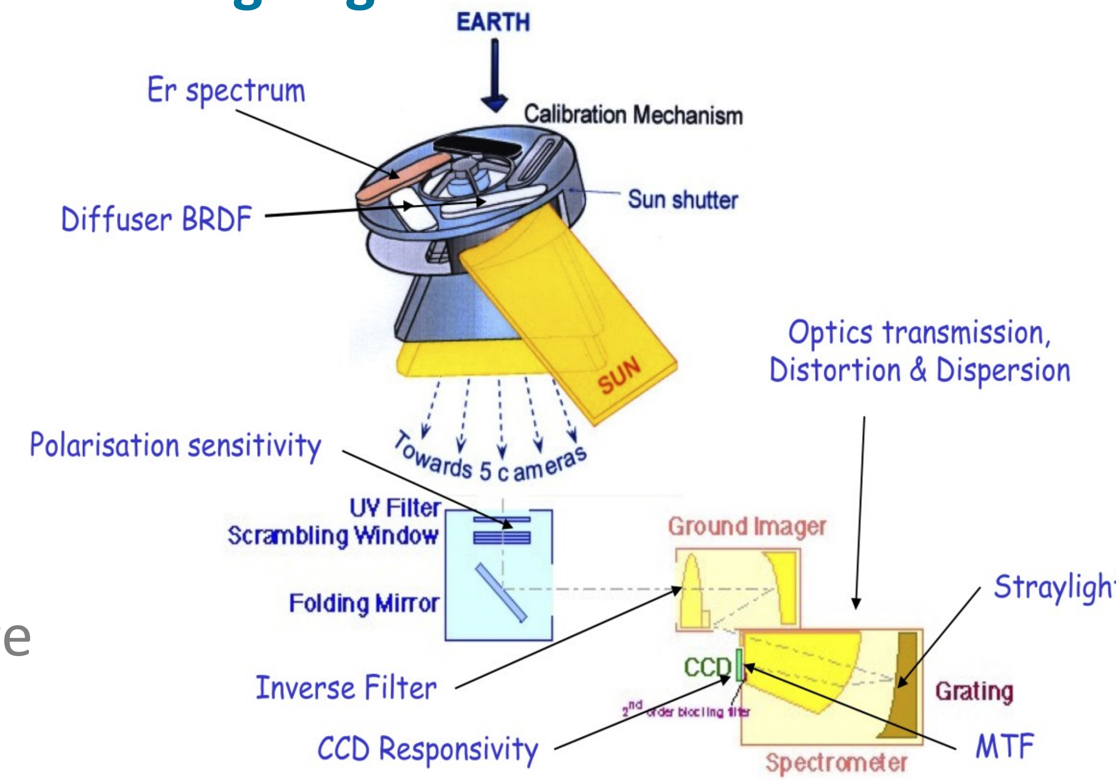
- Push-broom imaging spectrometer, 5 fan-arranged cameras
- CCD sensing with [390,1040] nm spectral range
- Up to 45 programmable µchannels relaxed into 15 channels
- **Self-calibrating** using well-characterized Sun diffusers as secondary standards
- Spectral calibration using dedicated on-board diffuser



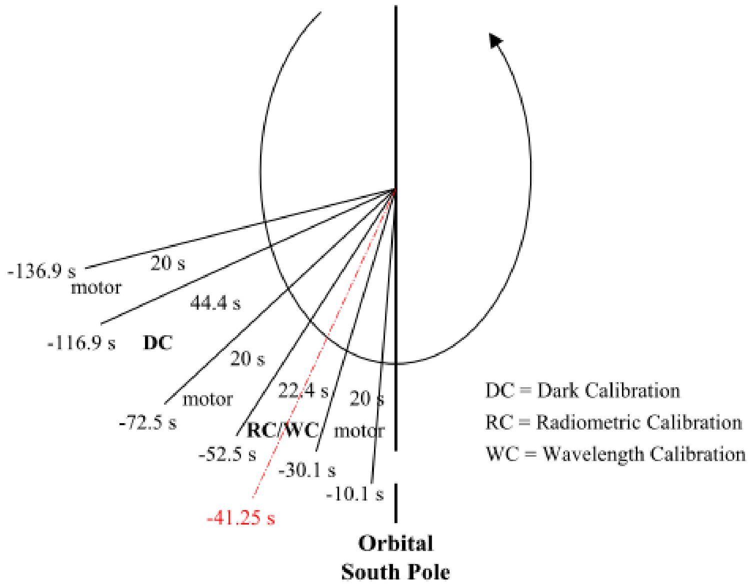
In-flight Calibration hardware

Calibration wheel with 5 positions:

- Shutter: dark offset (**calibration zero**), before every diffuser acquisition
- Radiometric diffuser: **calibration gains** (every 2 weeks)
- Reference radiometric diffuser: **ageing of nominal diffuser** (every 3 months)
- Spectral diffuser: spectral calibration at 2 wavelengths (every 3 months @520nm, every 6 months @ 408nm)
- All calibrations near orbital South pole, where Sun aligns with baffle



Overall Calibration Strategy



On-ground characterisation

+

In-flight calibration measurements

+

Processing, analysis and modelling

=

Self standing absolute calibration for the EO processing chain

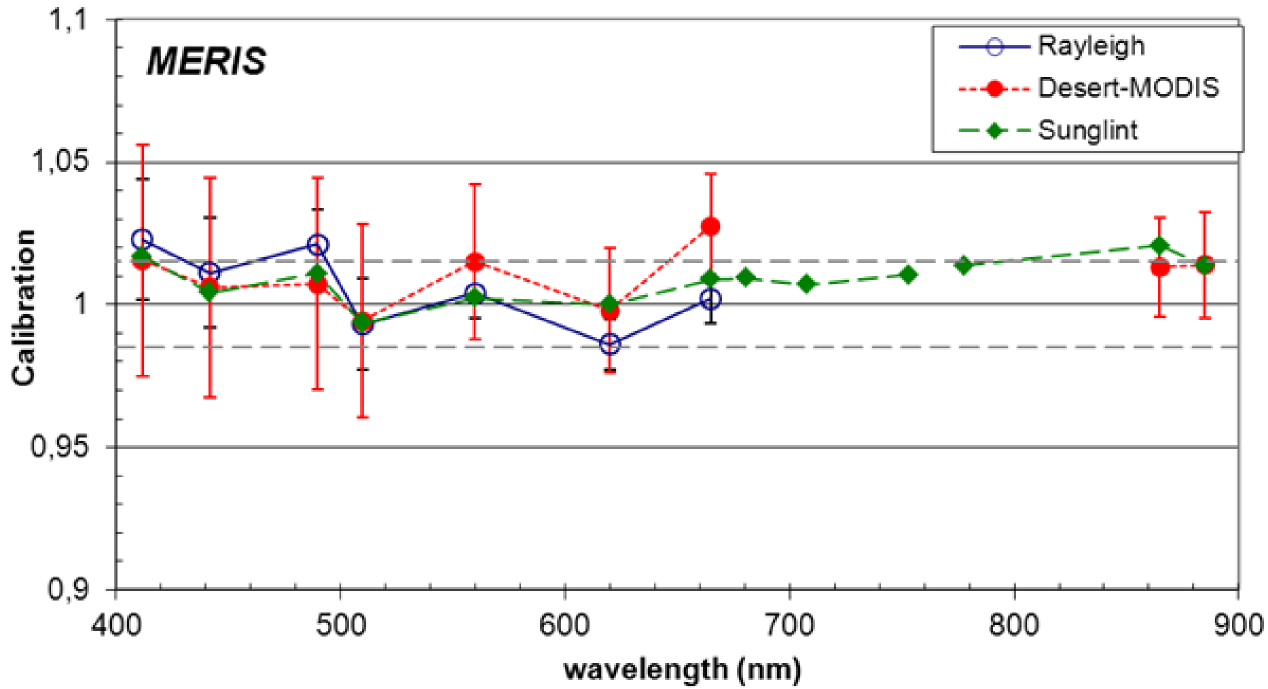
Validated by vicarious methods

3rd RP Radiometry Validation results

(from B. Fougnie, CNES, MERIS QWG, June 2013)

General comparison of all results from various methods

- ✦ Good consistency between all results for all methods
- ✦ Very good accordance for
  - » 412-443-490-510 within 1% between the 3 methods
  - » 753-778-865-885 within 0.5% between the 2 methods



Radiometric model

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

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

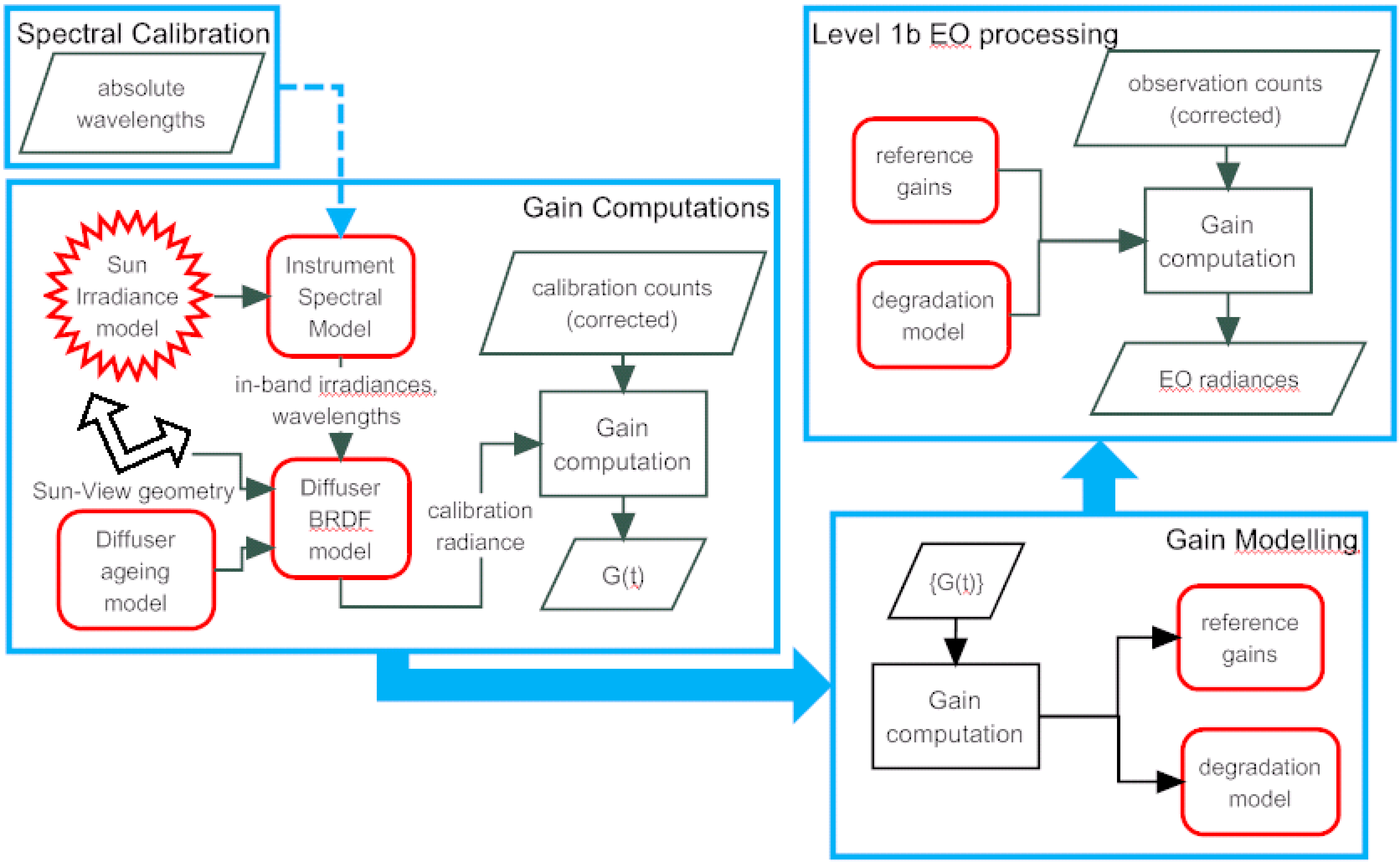
$$X^{Cal}_{b,k,m,t} = NL_{b,m}\left[\begin{array}{c} A^{0}_{b,k,m}\cdot\left(L^{Cal}_{b,k,m,t} + SL_{b,k,m,t}(L^{Cal}_{*,*,*,*})\right) + \\ Sm_{b,k,m,t}(L^{Cal}_{*,k,m,*} + SL_{*,k,m,*}(L^{Cal}_{*,*,*,*})) + \\ g_C(T^{CCD}_t)\cdot C^{0}_{b,k,m} \end{array}\right] + \varepsilon$$

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

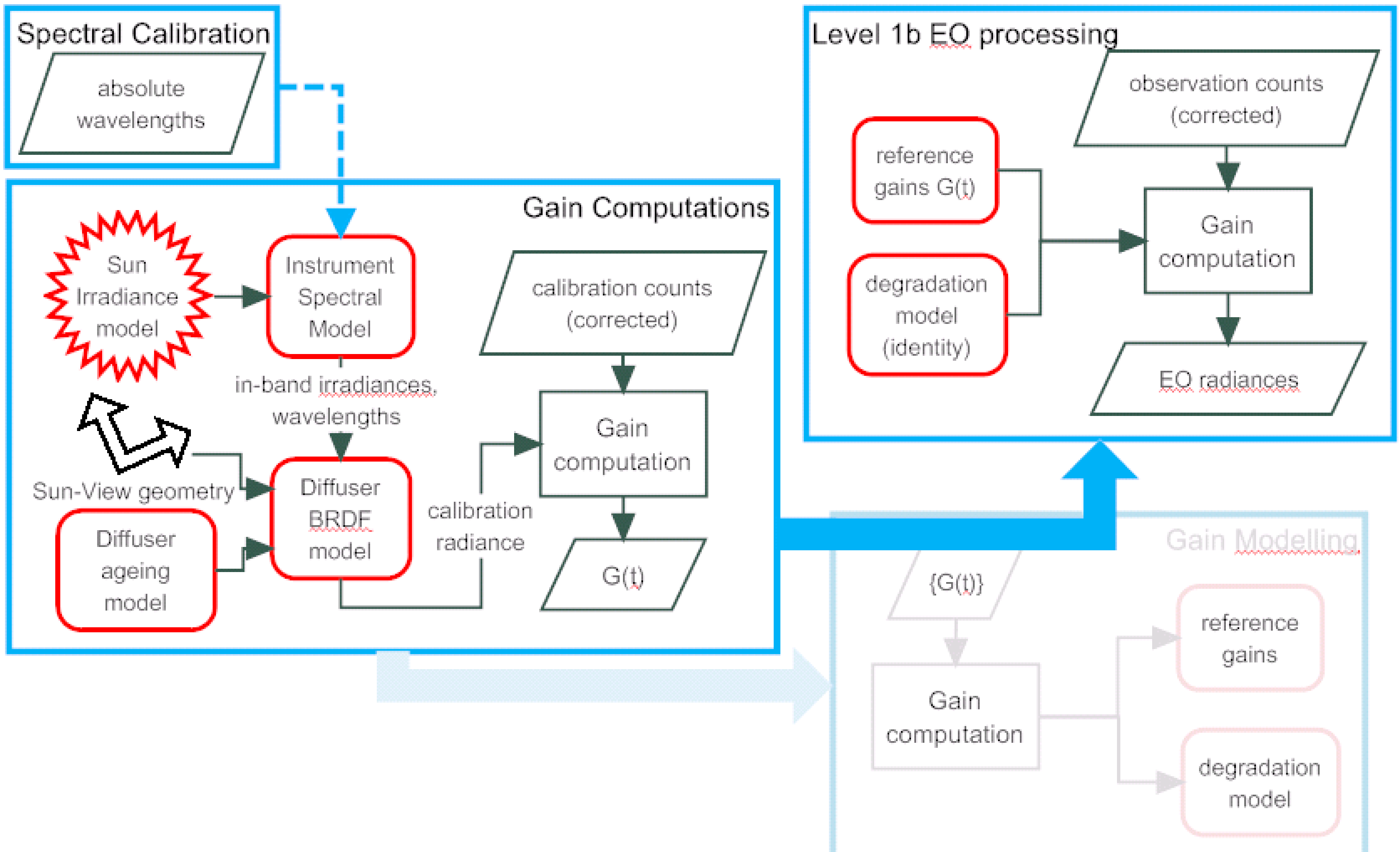
With:

- 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^{cal} from characterised/modelled diffuser BRDF + in-flight geometry + E_0 at MERIS bands & pixels (from Spectral characterisation/model)
- SL from L + characterised/modelled convolution kernels
- gC from characterisation
- NL^{-1} from characterisation

Calibration chain summary

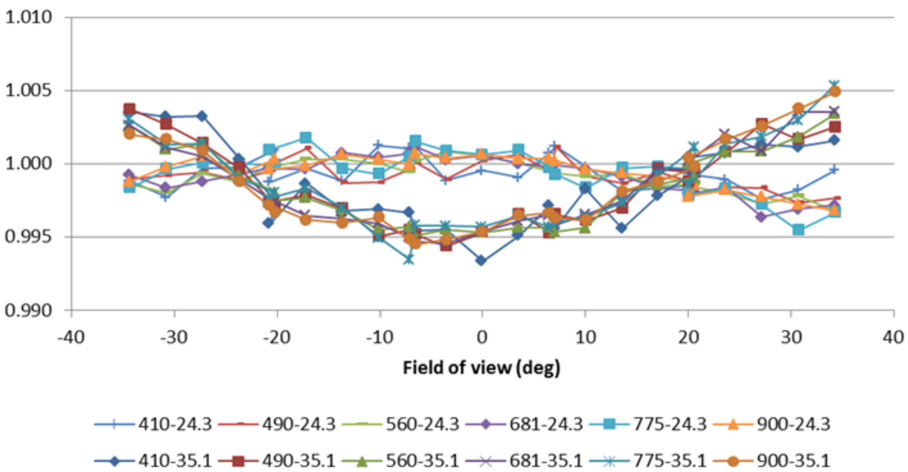


Calibration chain summary (short term)

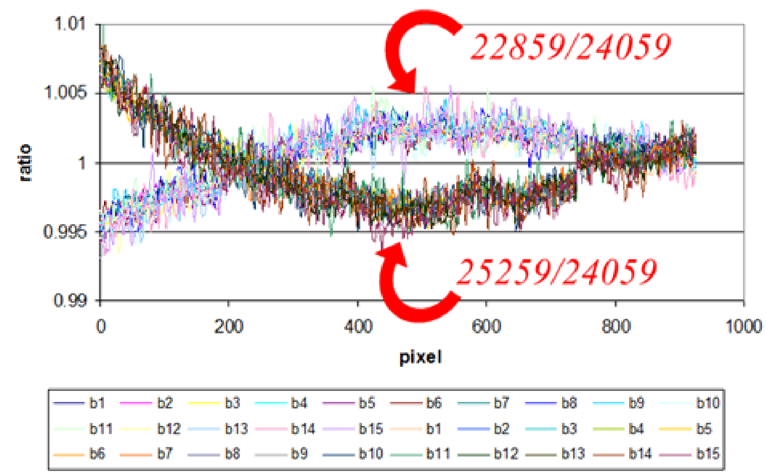


Why using a Gain model

- Allows smooth long-term trends correction
- BRDF model does not fully capture dependency with Sun azimuth (±0.5%)



On-ground:
BRDF model residuals for 2 extreme SAA



In-flight:
Relative gain variations: extreme SAA gains over central one

➔ **Selecting "best" SAA ensures better accuracy.**

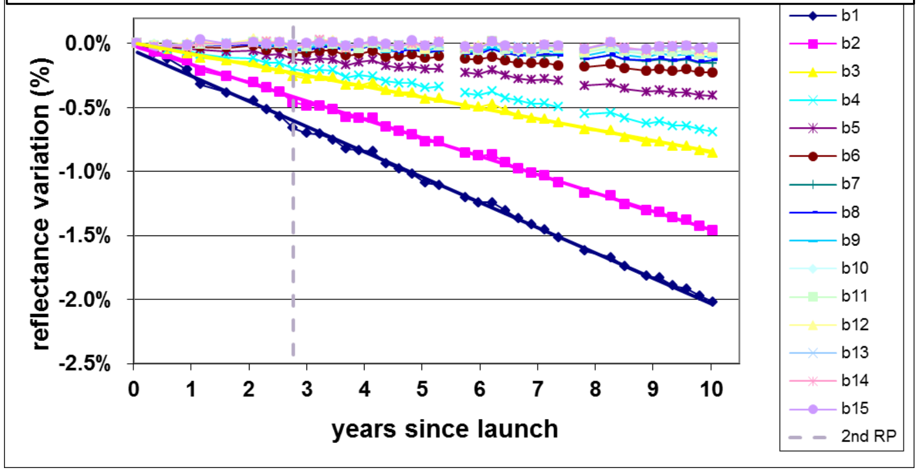
Principle of Gain modelling

- Model is basically $G(t) = G(t_0) \cdot f(t-t_0)$
- Correcting Diffuser 1 (<u>and 2!</u>) for ageing allows to measure consistent gains from both diffusers
- Gain long-term drift (Instrument Degradation) captured from D1 (more data, good spread in SAA domain)
- Validated on D2
- Gain at reference time can be derived from D1 or D2
  - D1 pros: minimize speckle
  - D2 pros: minimize discrepancies at camera interfaces
- Stability with time and view angle verified over Antarctica

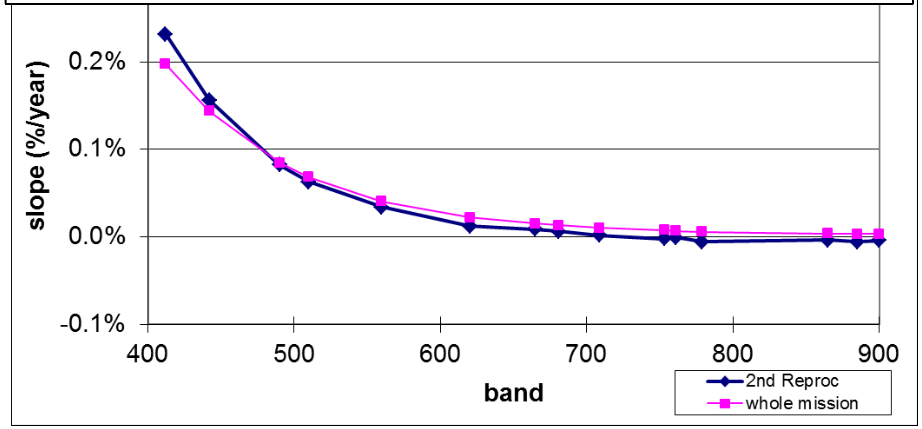
Some results, 1

- Ageing correction is essential for accurate gain drift modelling
- Assumption: ageing proportional to cumulated exposure (D2 exposed ~10 times less)
- Ageing measured by evolution of D1/D2 ratio, shows up to ~2% variation (in the blue)

Time evolution of average d1 darkening (rel. to d2)



Yearly darkening rate vs. band: from first ~3 yrs (blue) and whole mission (red)

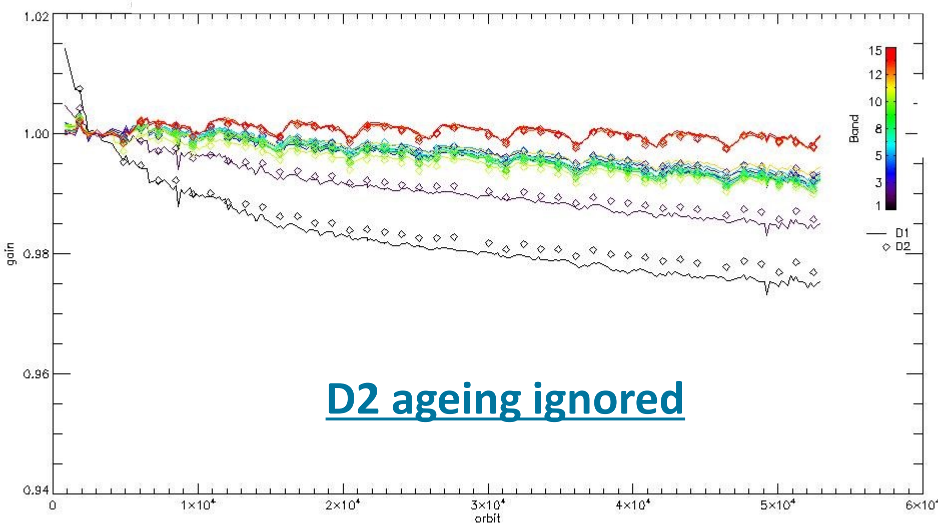


➔ D2 ageing no longer negligible

Some results, 2

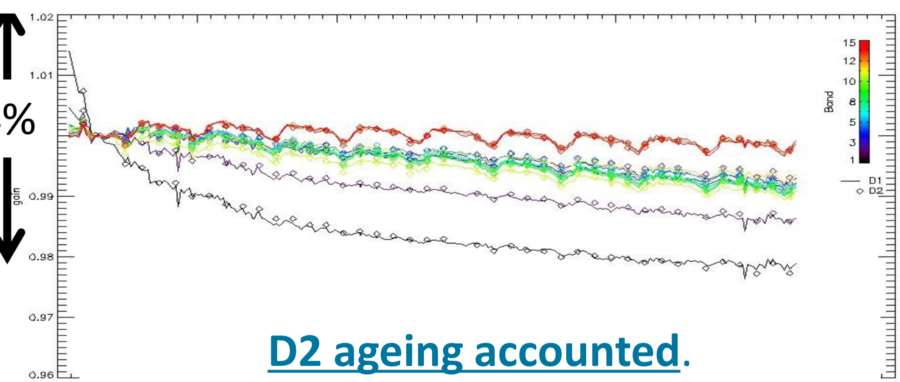
- **Neglecting D2 ageing has a small absolute impact (<0.2%) but degrades overall consistency: D1 and D2 do not "see" the same instrument degradation anymore: example of camera 2.**

Raw time evolution of ageing corrected gains, from D1 (solid) and D2 (symbols)



D2 ageing ignored

4%



D2 ageing accounted.
(vertical scaled shrunk to fit left figure)

← 10 years →

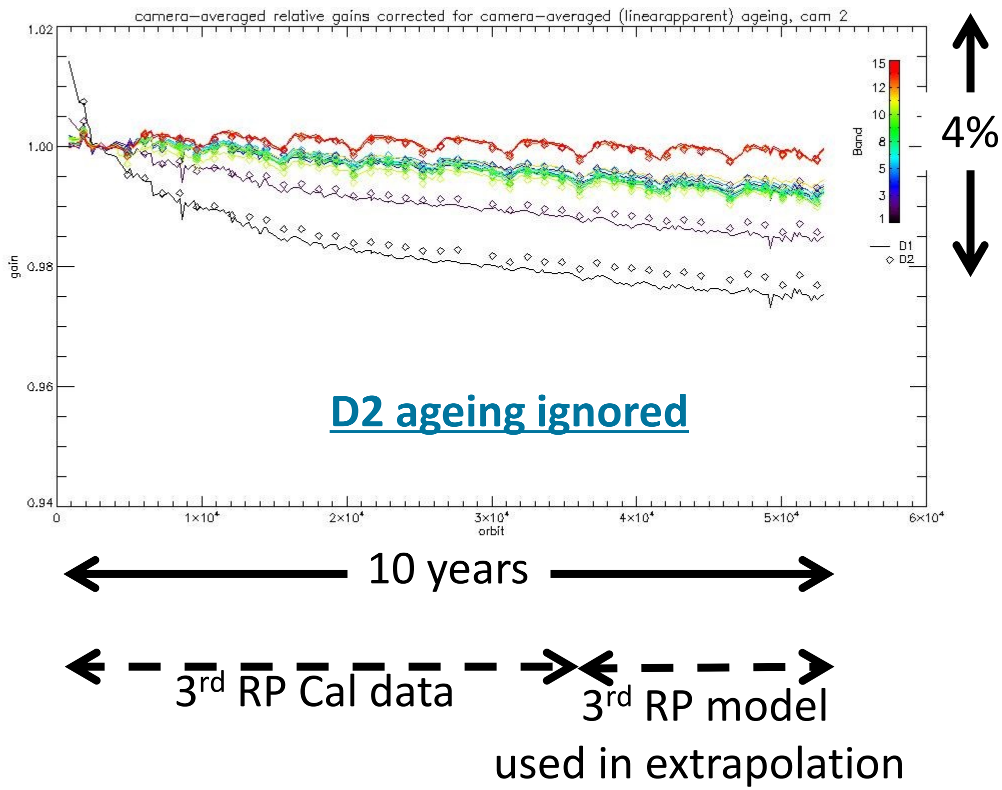
← 3rd RP Cal data →

Some results, 3

Still work in progress, sorry!

Here you should see an illustration of the impact of ageing revision 4th RP model, in particular over the 3rd RP extrapolation period.

Coming soon…



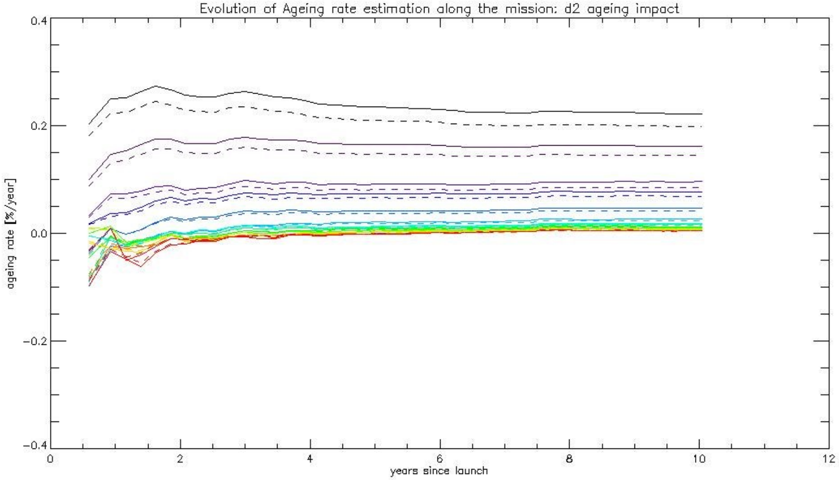
Conclusion

Well characterized on-board diffusers are extremely accurate calibration "sources".

As for any space borne item ageing is a concern and shall be closely monitored.

A reference diffuser has proven to be a reliable monitoring device

- **unfrequently exposed diffusers seem to degrade fairly linearly**
- **time sampling is important to minimize geometry effects**
- **But accurate ageing rate determination requires time**



Thank you for your attention