The Sentinel-3(A) Mission:

Mission Radiometric Calibration Status

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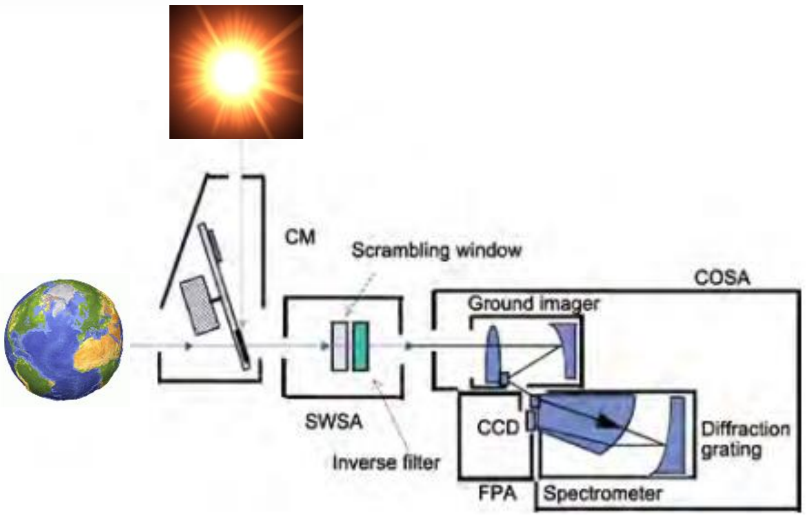
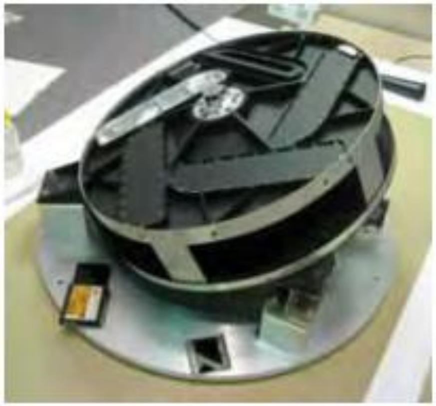
CEOS-IVOS WG Meeting, ESTEC 28-29.3.2018

On-Board Calibration OLCI



Calibration wheel with 5 positions:

- Shutter: dark offset (calibration zero)
- Radiometric diffuser: calibration gains
- Reference radiometric diffuser: ageing of nominal diffuser
- Spectral diffuser: spectral calibration at 3 wavelengths
- Earth Observation aperture



+ Specific observations in support to spectral calibration

- Fraunhofer lines on diffuser,
- Fraunhofer lines + O2 absorption over Earth

→ additional wavelengths

Radiometric Gains from RC data

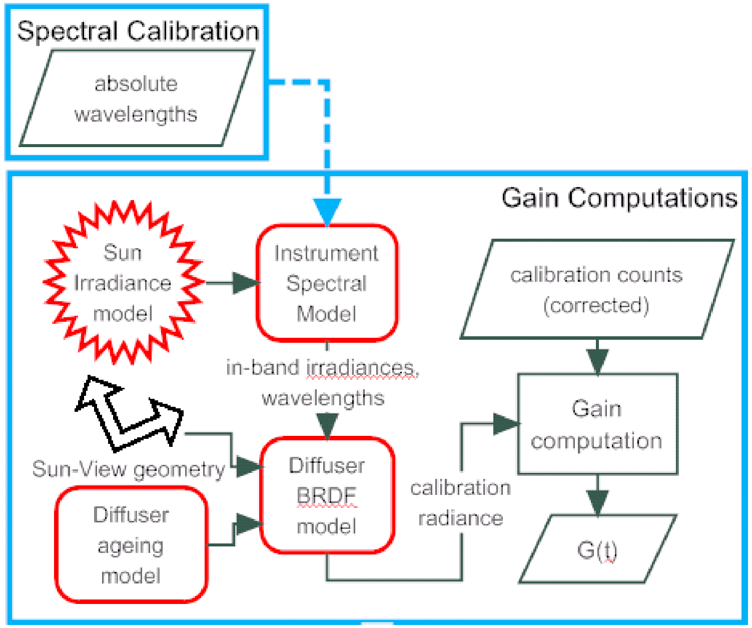
From counts, corrected for non-linearity dark and smear: X_C,

+

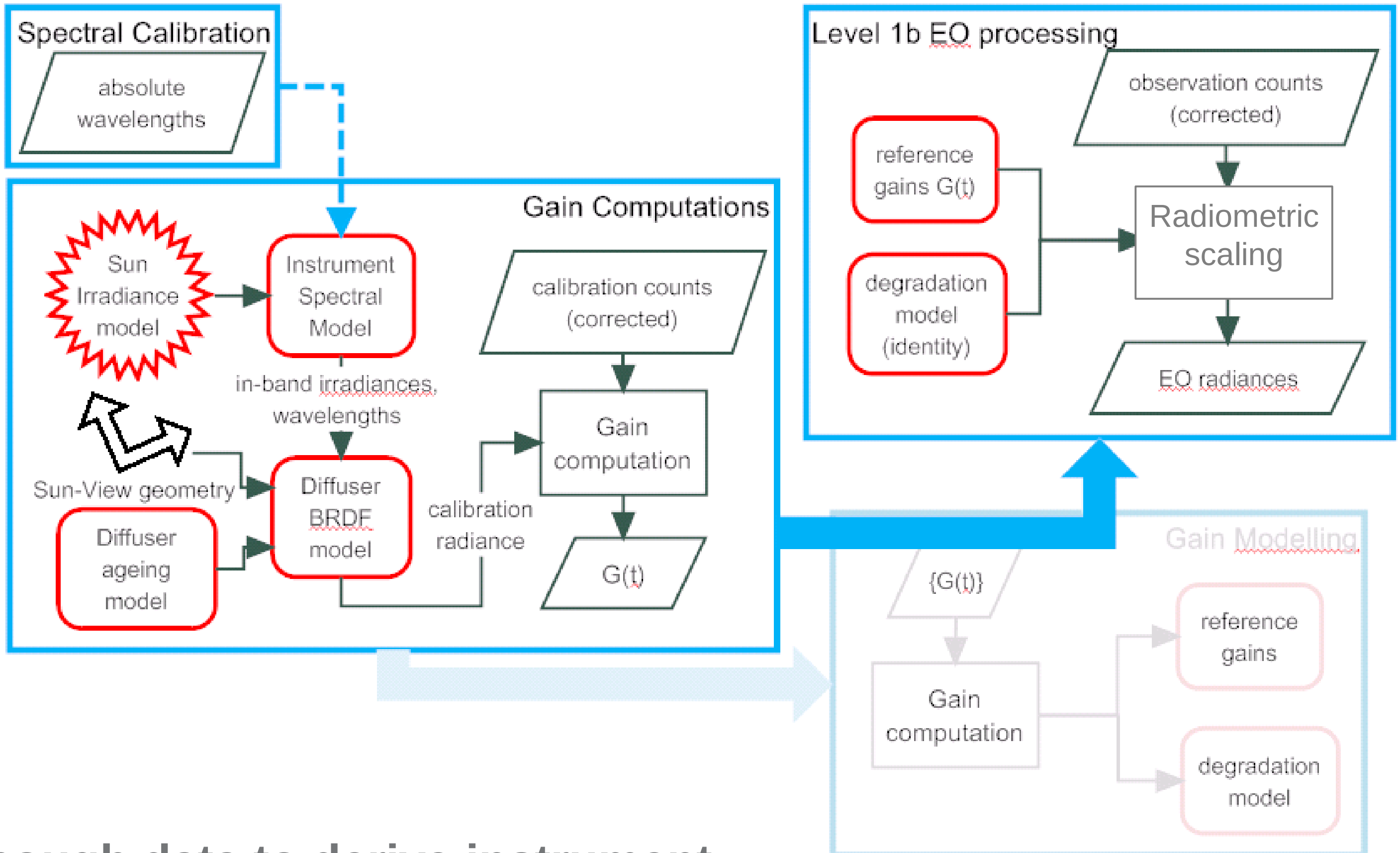
input radiance L_{cal} computed from Sun irradiance, diffuser BRDF and Sun/view geometry,

Instantaneous gains are computed:

$$G = \frac{X_C}{L_{cal}}$$

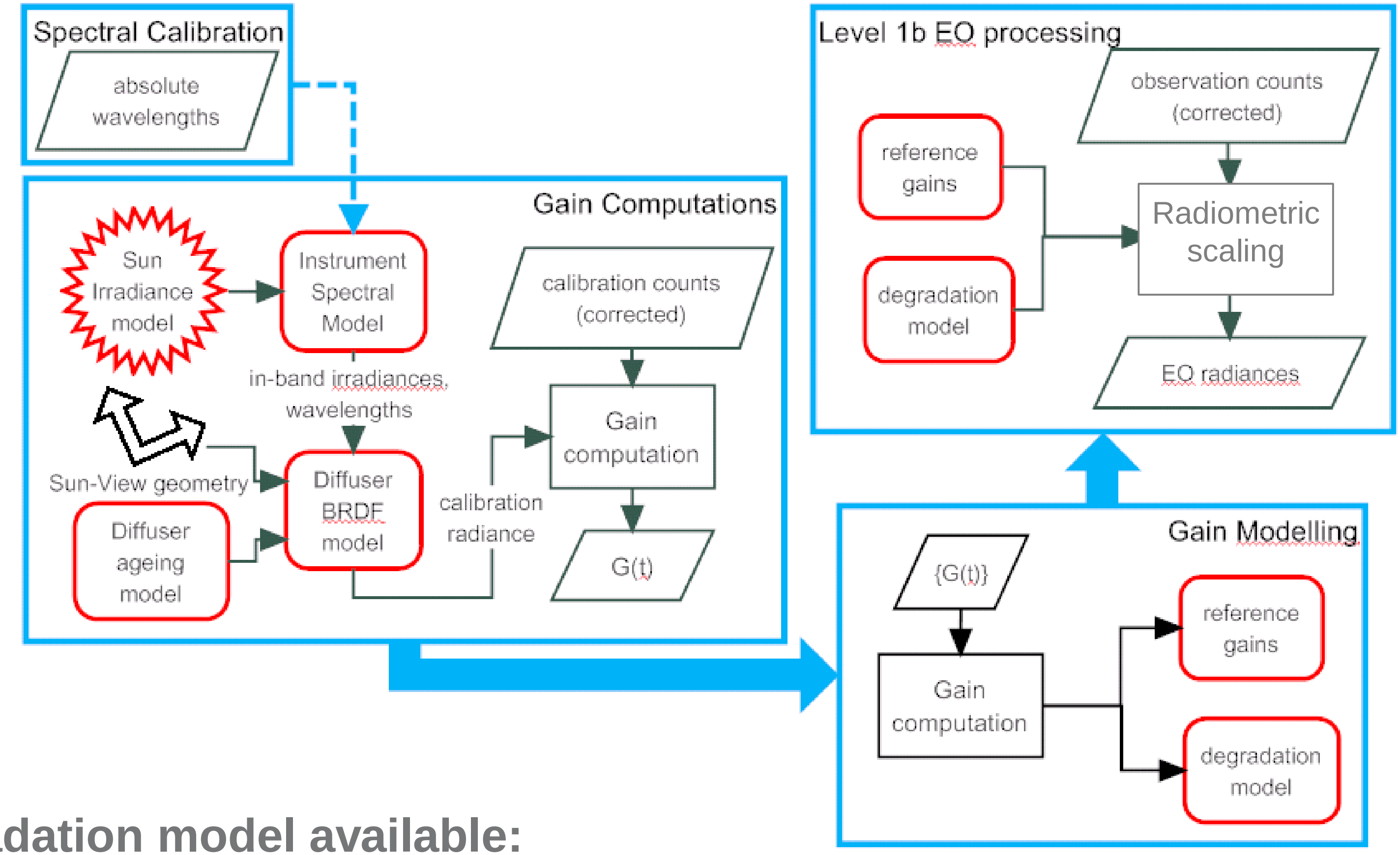


Radiometric Calibration: Step one: Early mission shortcut



Not enough data to derive instrument degradation, use instantaneous gains

Radiometric Calibration : Step 2: Radiometric Model



Degradation model available:

Use gain at reference date + trending correction

- **1st version → REP_005 (S3VT) at L2 Release July 2017**
- **2nd version (incl. ageing correction) → REP_006 in Sept 2017**

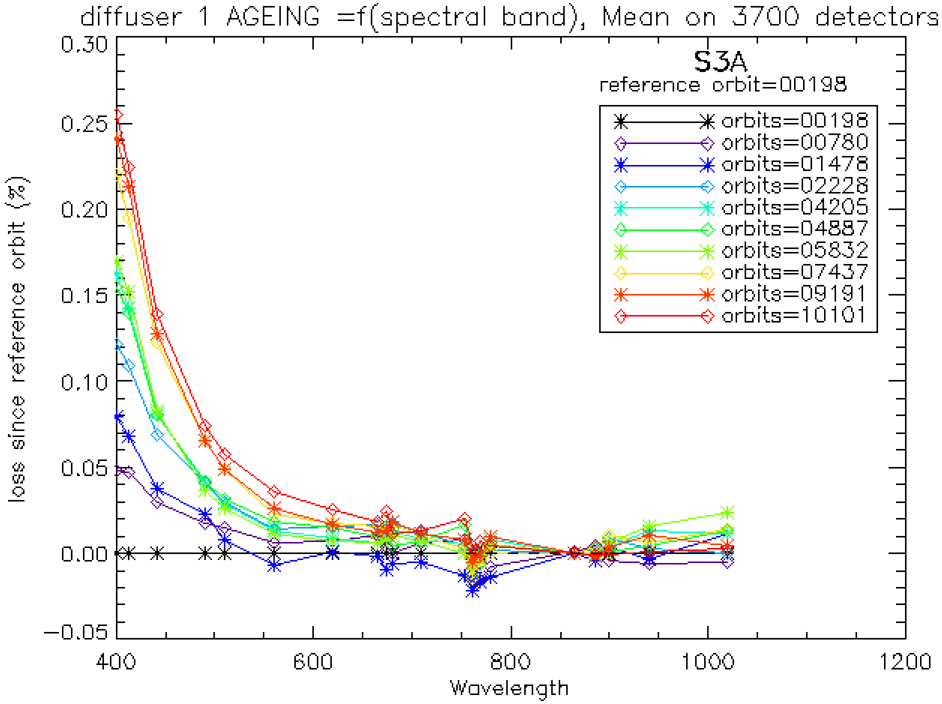
Radiometric stability pre-requisite: quantify diffuser ageing

10 ageing sequences so far

(RC with nominal diffuser followed by reference on next orbit)

→ 9 ageing assessments

- Expected spectral behaviour: strong decrease with λ
- Expected magnitude: ≤ 0.25% after 2 years
- Unmeasurable above 600 nm
- Intrinsic variability ~0.03%

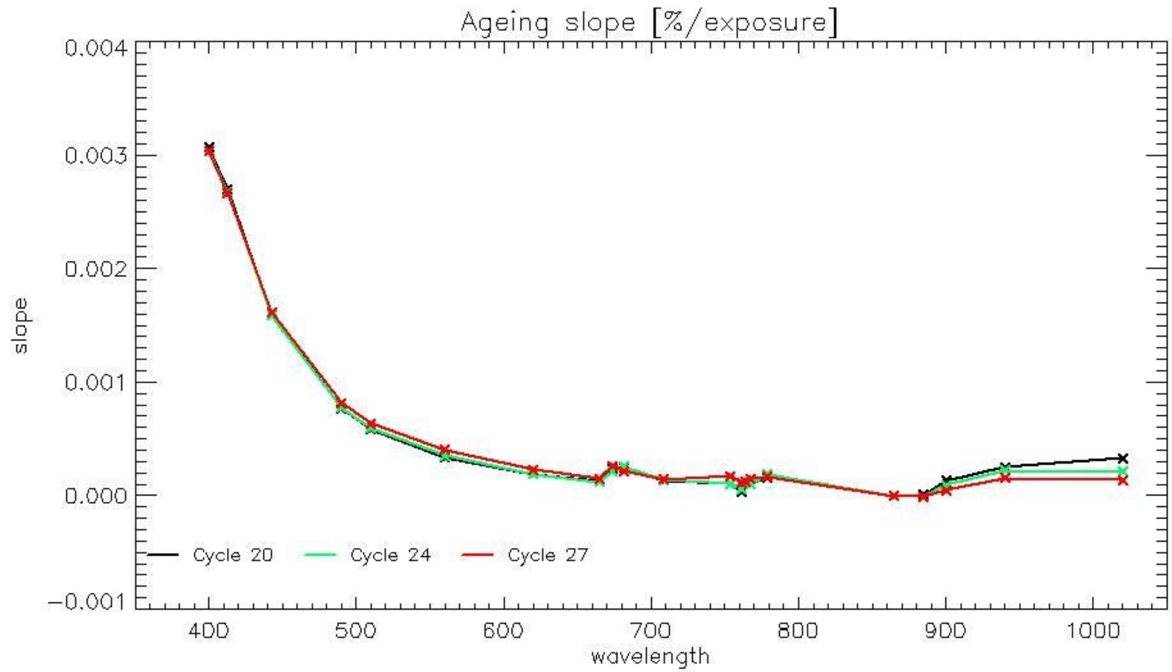


Modelled:

BRDF(t,l) = BRDF(t_0,l)*ageing_rate(l)*cumulated_exposure(t)

Correction for (Oa1 to Oa5) in further RC data use

Radiometric stability
Repeatability of diffuser ageing assessment



Very good stability of the ageing slope assessment for the last 3 acquisitions.

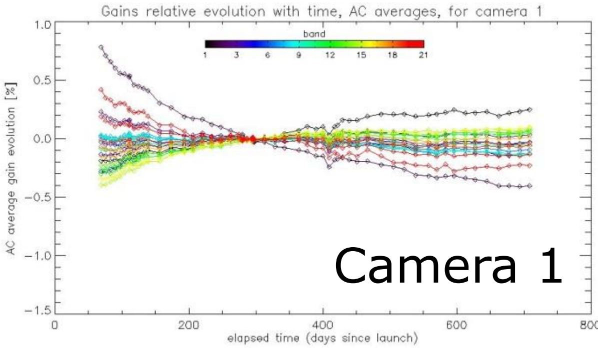
- Excellent where significant (channels Oa01 to Oa05)
- Slope in the NIR tends to disappear (no ageing impact expected there)

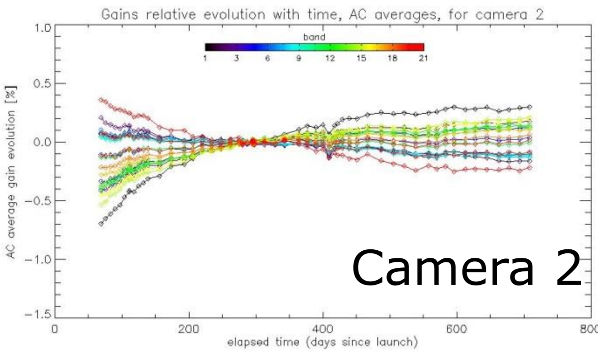
SENTINEL 3 Mission Performance Centre

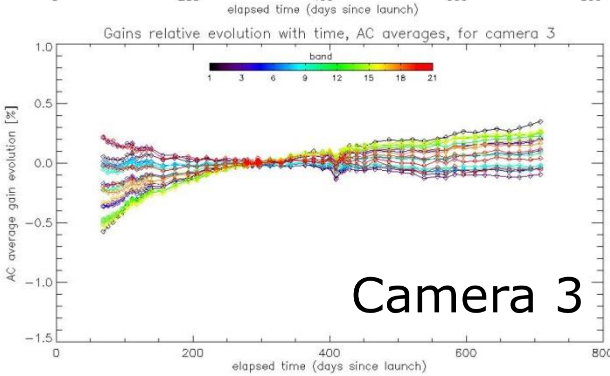
Radiometric stability

EUMETSAT esa

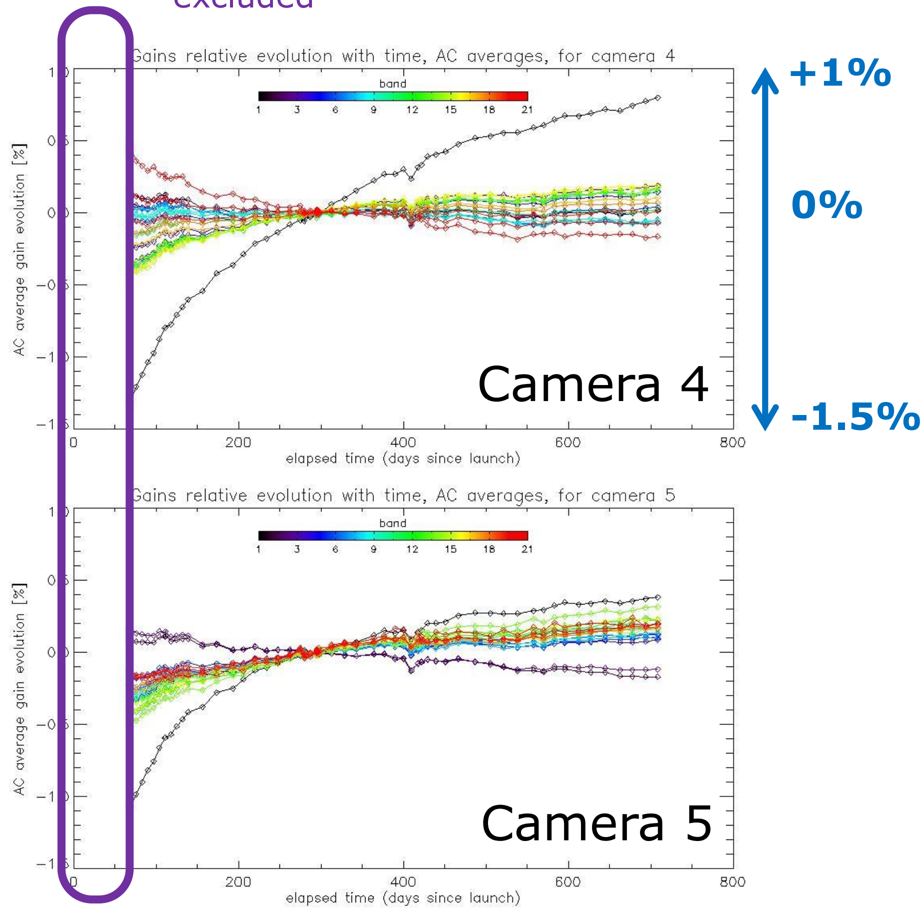
Evolution relative to 22/11/2016, whole usable dataset (25/04/16 → present), ageing corrected



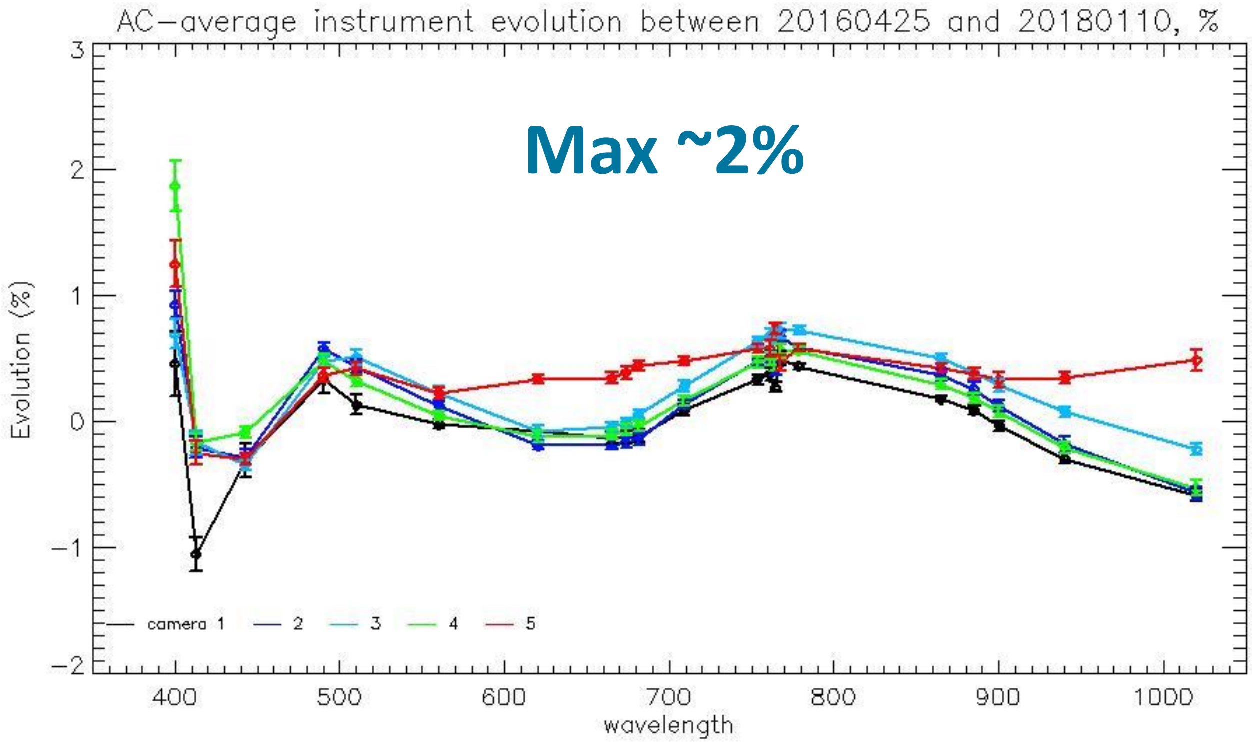




Bad geometry period (Star Trackers issue) + 1 RC before channel reprogramming excluded



Radiometric evolution
21 months overall drift



Camera-averaged instrument evolution versus wavelength between 26/04/2016 to 10/01/2018 (channel programming change to most recent calibration)

→ Spectral shape similar to that of the spectrometers correcting filter…

Radiometric Model
Summary of modelling steps

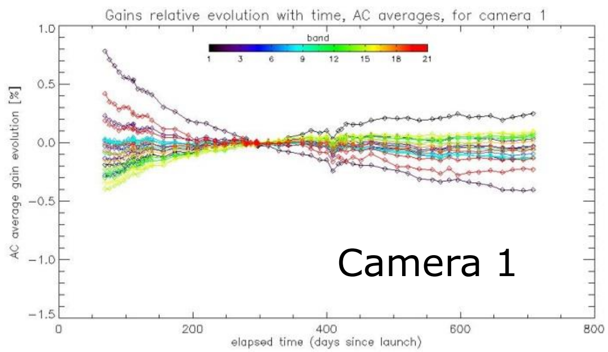
Step 1: ageing model

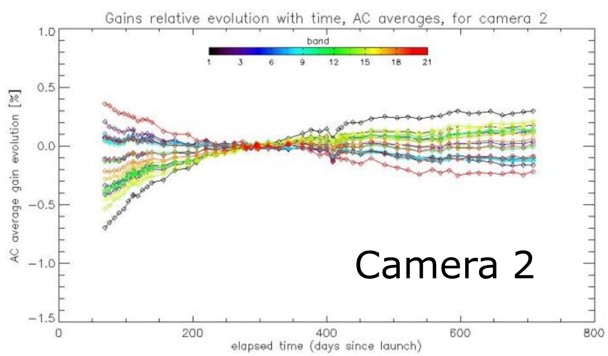
a. Ageing assessed from nominal over reference diffusers results (ground BRDF models) versus cumulated exposure time

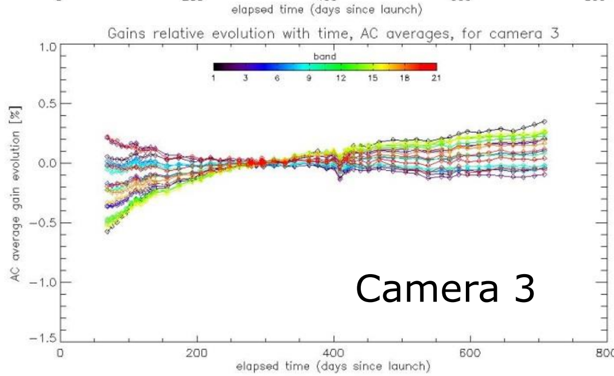
Step 2: long term trend model and reference gain

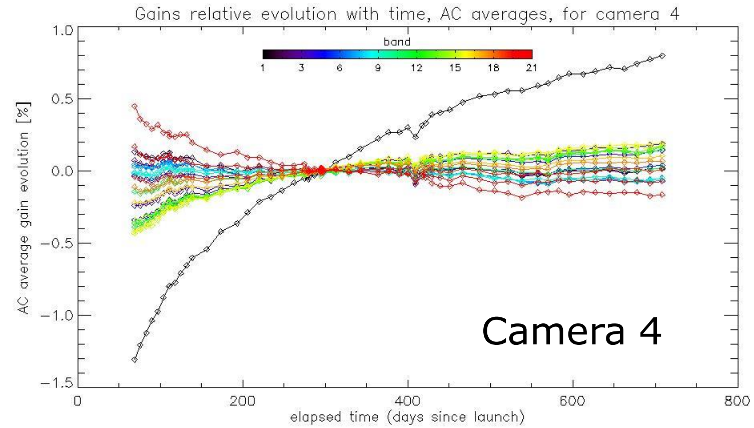
a. From instrument settings change (25/04/2016) on
b. Nominal diffuser Gains from *in-flight BRDF model*
c. Fitted on decreasing bounded exponential model, after normalisation to a reference date, *for each band and pixel*
d. Reference gain is time average of trend corrected data
e. Validated against data (training + newer)

Radiometric Model
Training and Validation Dataset





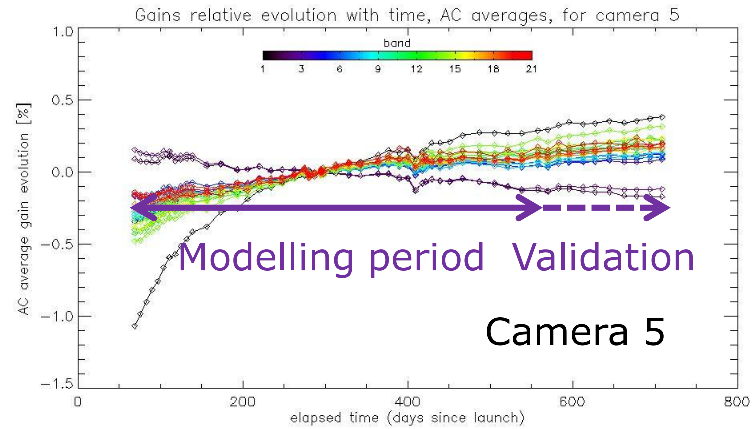




+1%

0%

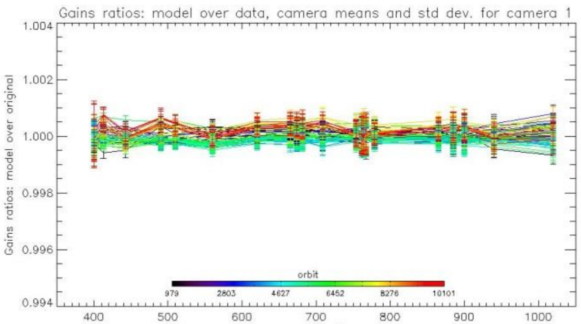
-1.5%

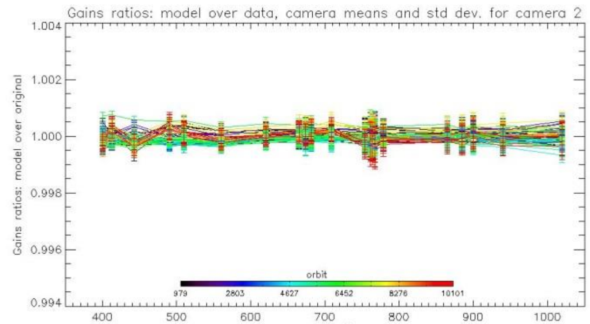


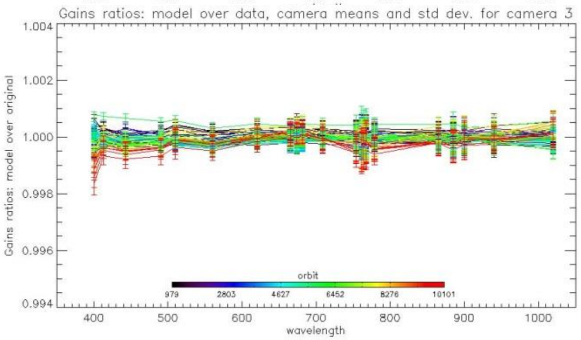
→ 1st Gain Model trained on raw data

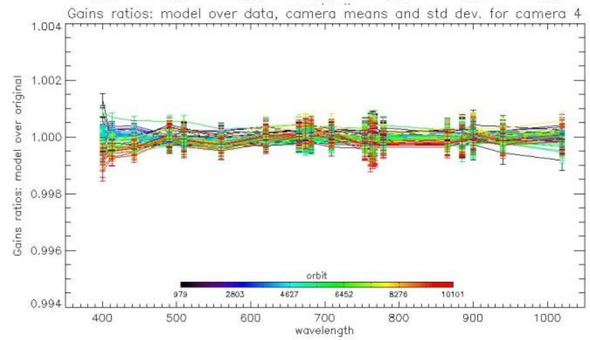
→ 2nd Gain Model trained on Ageing Corrected data

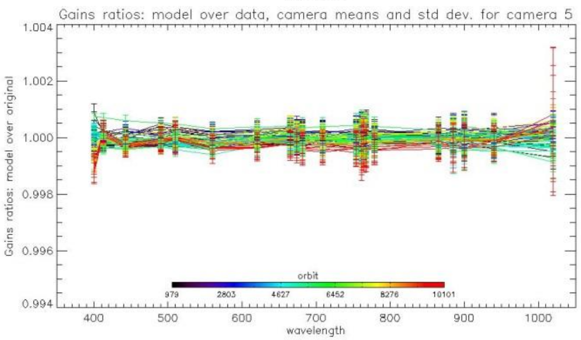
Radiometric model: Model performance









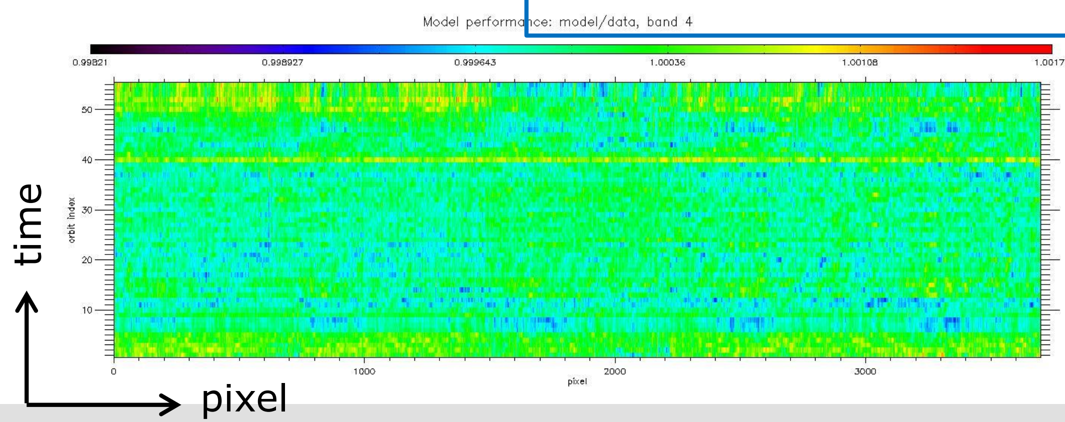


Data/model, including validation calibrations within 0.1% (1σ)

← Profiles (averages and RMS), all bands, for each camera

2D plot for band 4 vs. pixel and time: no obvious spatial structures

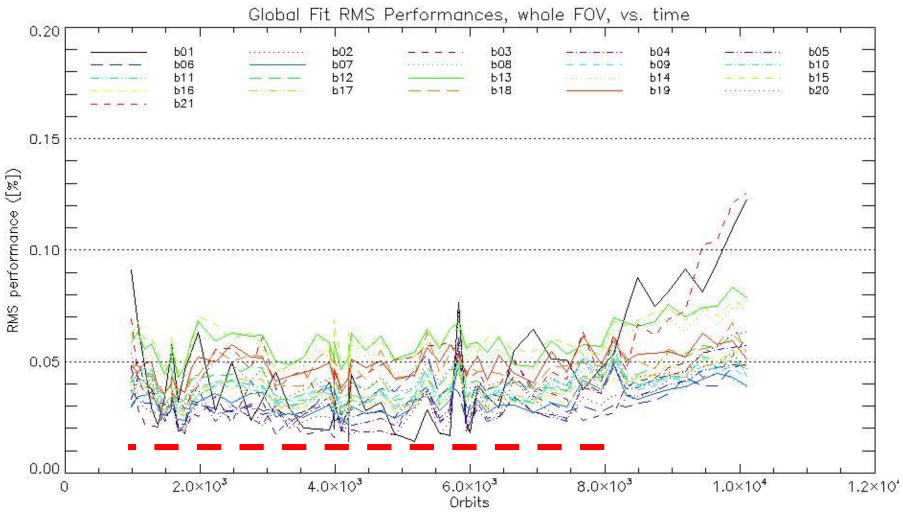
↓

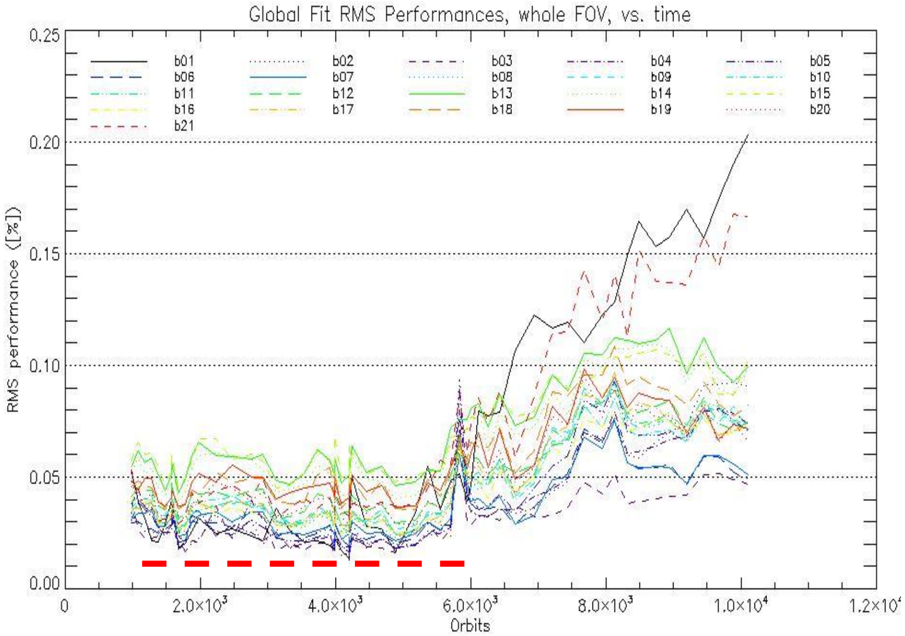


Radiometric evolution model: Comparison with L2 Release version

Model performance = RMS relative difference (%), FOV averaged at each orbit and for each channel.

_ _ _ _ training period





NEW **OLD**

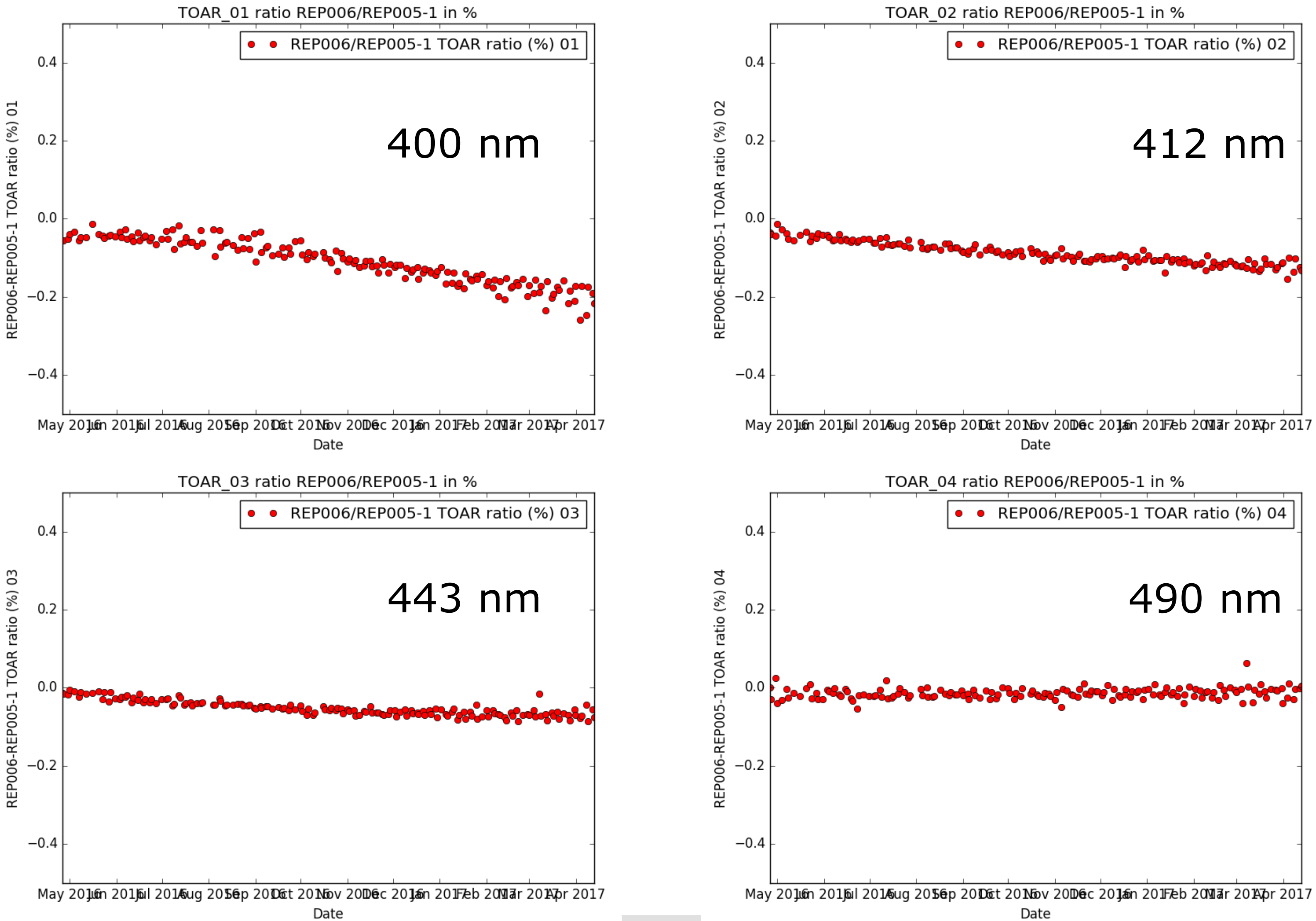
Improved or equal global performance for all bands,

except very first orbit for Oa1 and Oa21

Will also need to be revised in mid-term

Impact of new Gain Model on data

TOA ratios RP6 / RP5 at SVC sites **(%)**

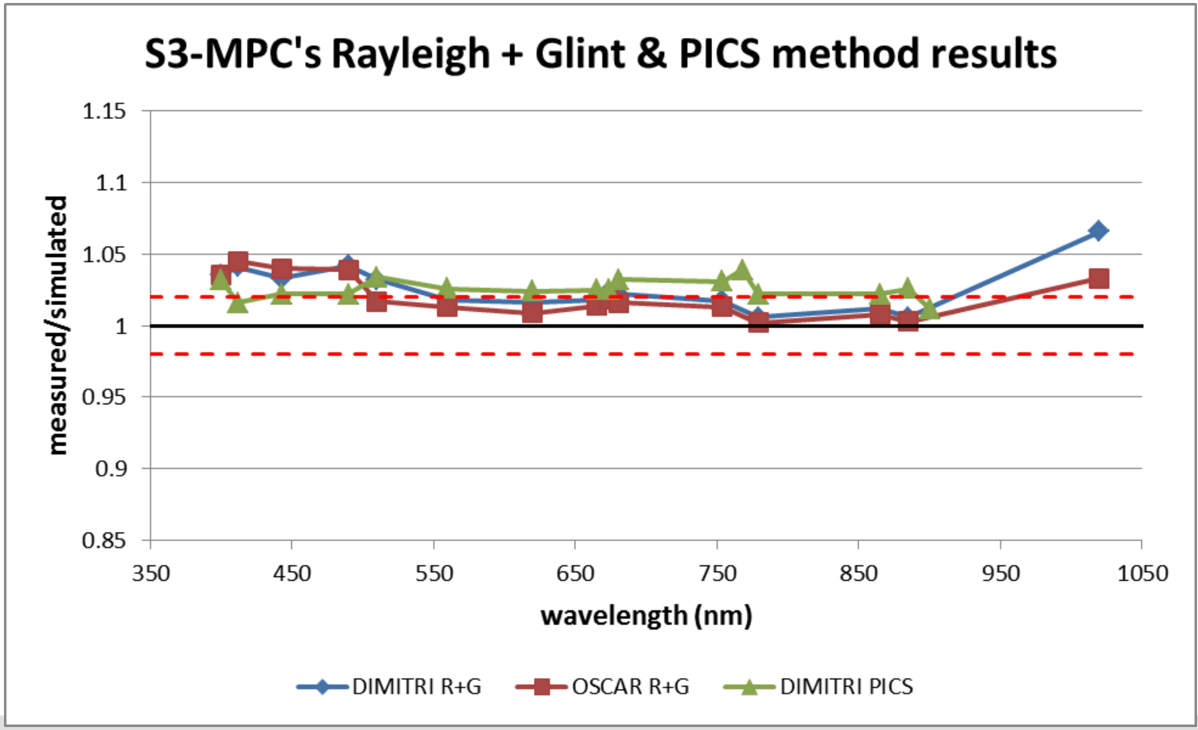


Absolute performance (radiometric validation)

Radiometric Validation:

- desert (PICS), absolute, VisNIR
- Rayleigh, "absolute" (assumes 865 ok), Vis
- Glint, interband, red→NIR, normalised to Rayleigh at 665

⇨ Excess of brightness 2-3%,
↗ toward the blue (4%)
(ignoring 1020…)



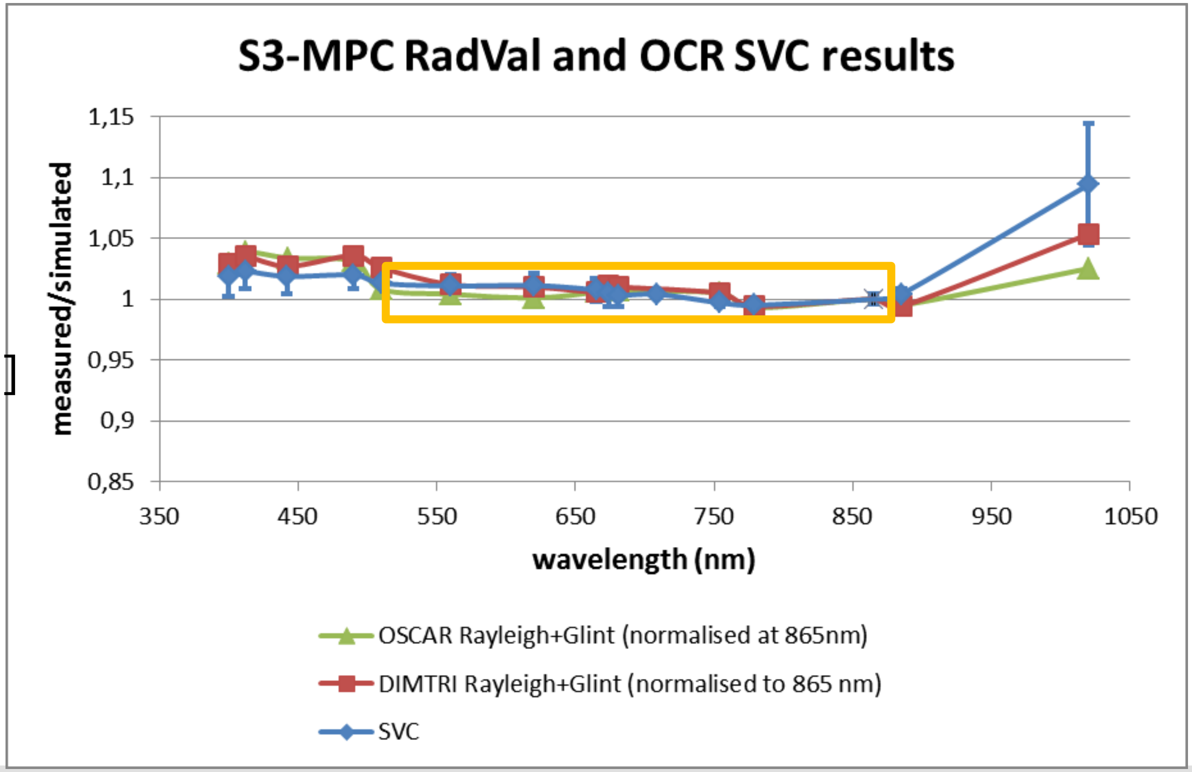
Interband performance (radiometric validation + OCR SVC)

Radiometric Validation over water (Rayleigh + Glint, normalised to 865 nm)

How does it compare with Ocean Colour SVC over waters ?

Pretty well: same inter-band from 865 to 510 nm, but Rayleigh seems to overestimate the excess in the blue…

Inter-band within:
- All: 1% in [560, 885] (in spec!)
- SVC: 2% in [400-885]
- Rayleigh: 3,5% in [400, 510]



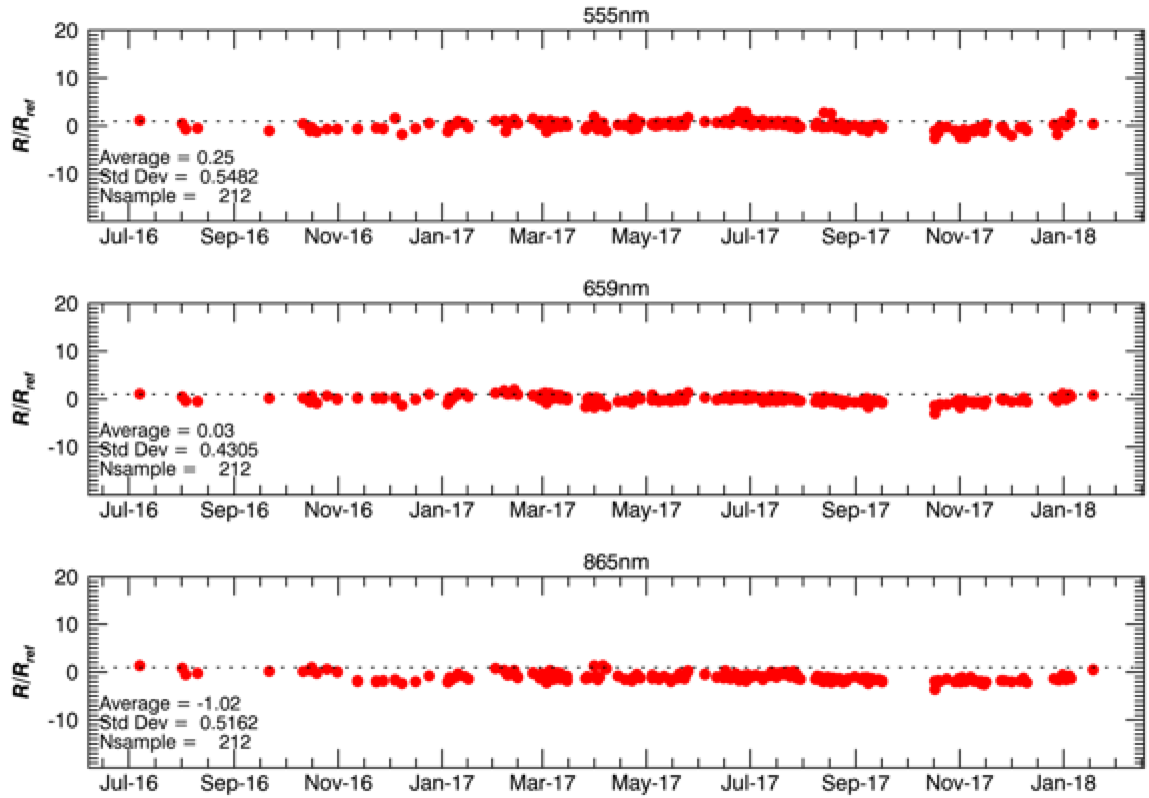
SLSTR vs OLCI, Nadir

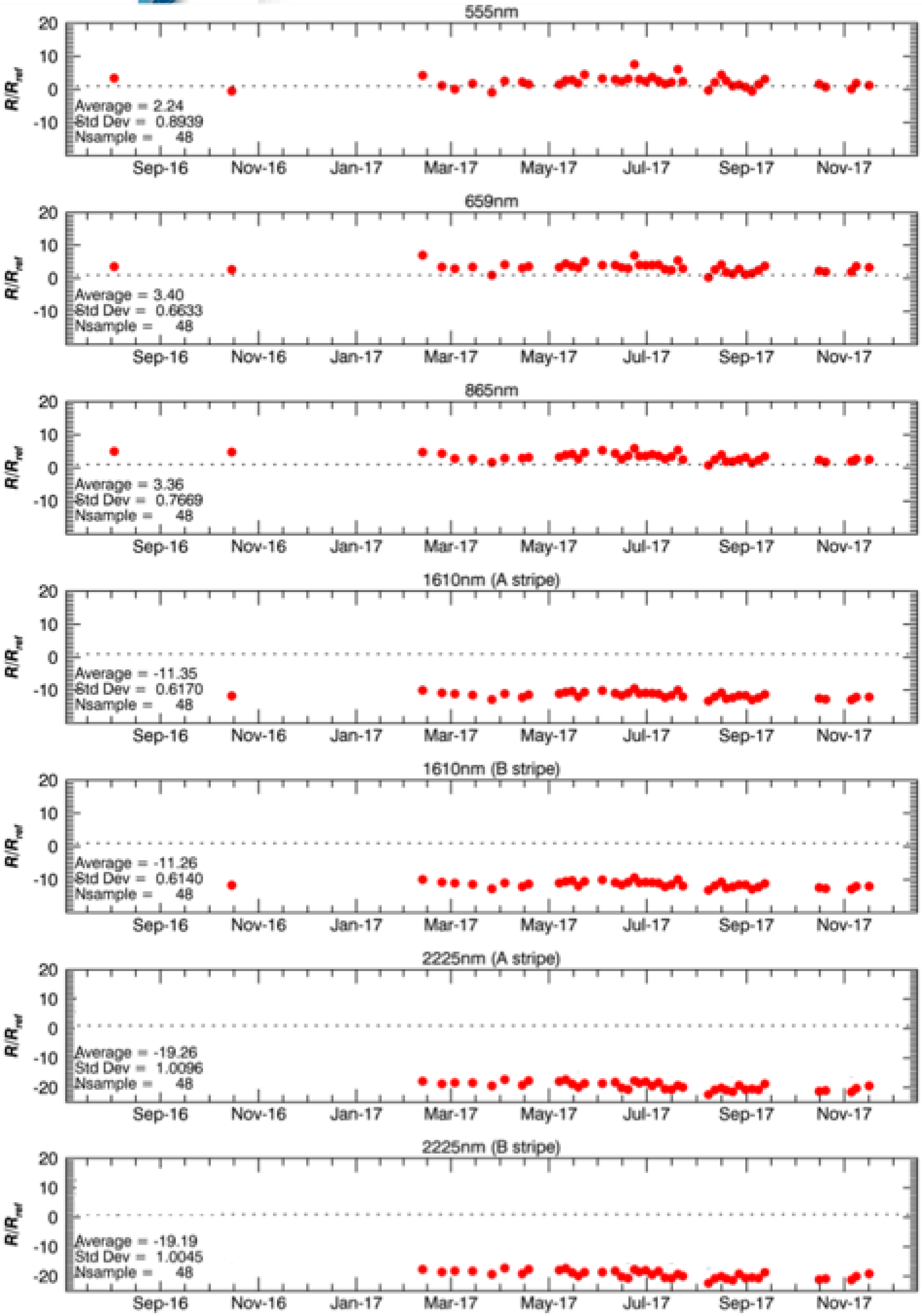
Combined results for all desert sites processed to date

Match-ups constrained to observations where nadir VZA <25 degrees

Corrections for spectral variations, atmosphere + site spectral profile are needed

	Average Rel.Diff. (%)	Stddev
S1	0.25	0.55
S2	0.03	0.43
S3	-1.02	0.52





SLSTR vs MODIS Aqua

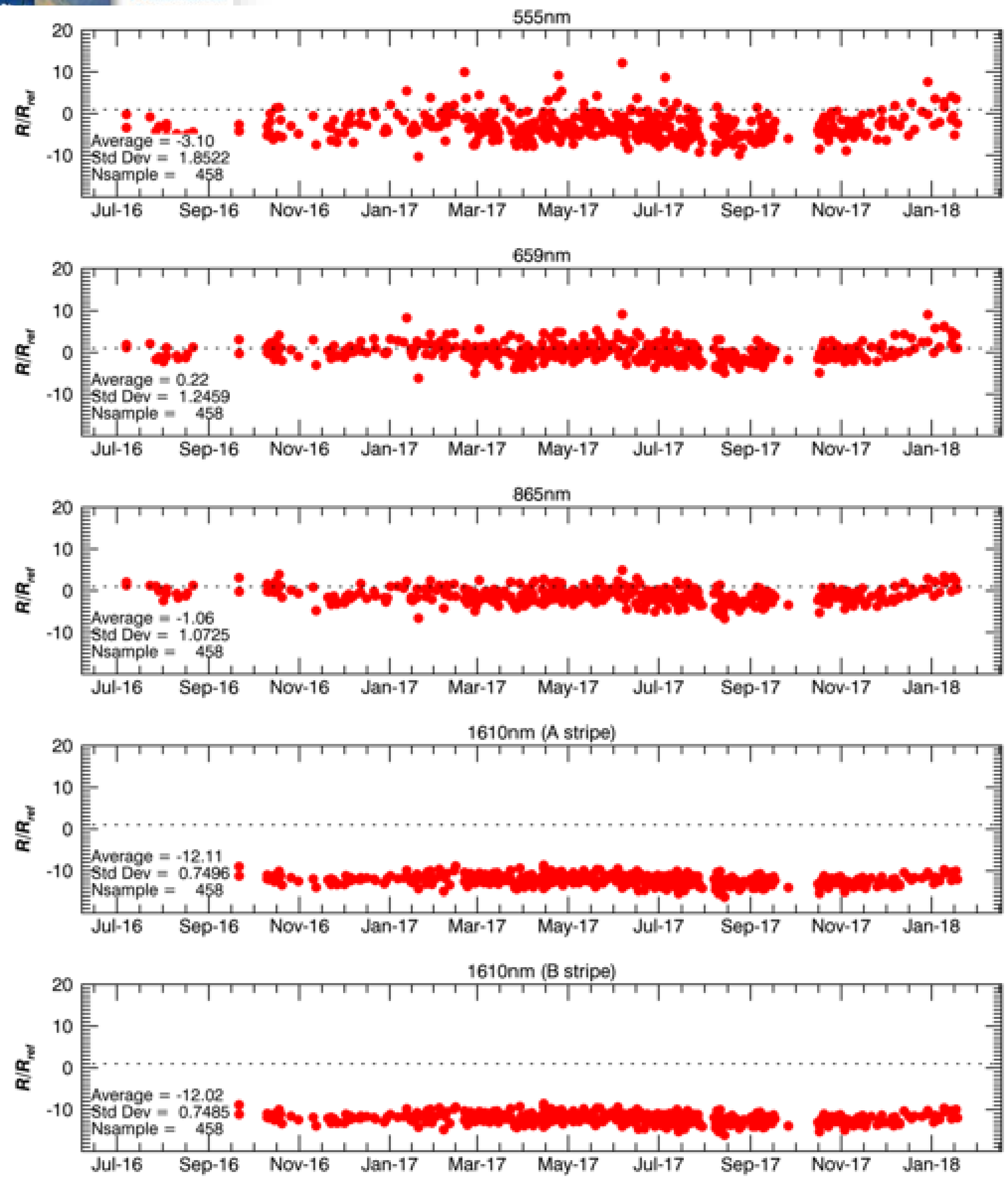
Data for Libya-4 only

Match-ups constrained to observations where nadir VZA <25 degrees

Geometric corrections and
Corrections for spectral variations

	Average Rel.Diff. (%)	Stddev
S1	2.24	0.89
S2	3.40	0.66
S3	3.36	0.77
S5a	-11.4	0.62
S5b	-11.3	0.61
S6a	-19.3	1.00
S6b	-19.2	1.00

SLSTR vs AATSR Nadir



Combined results for all desert sites processed to date

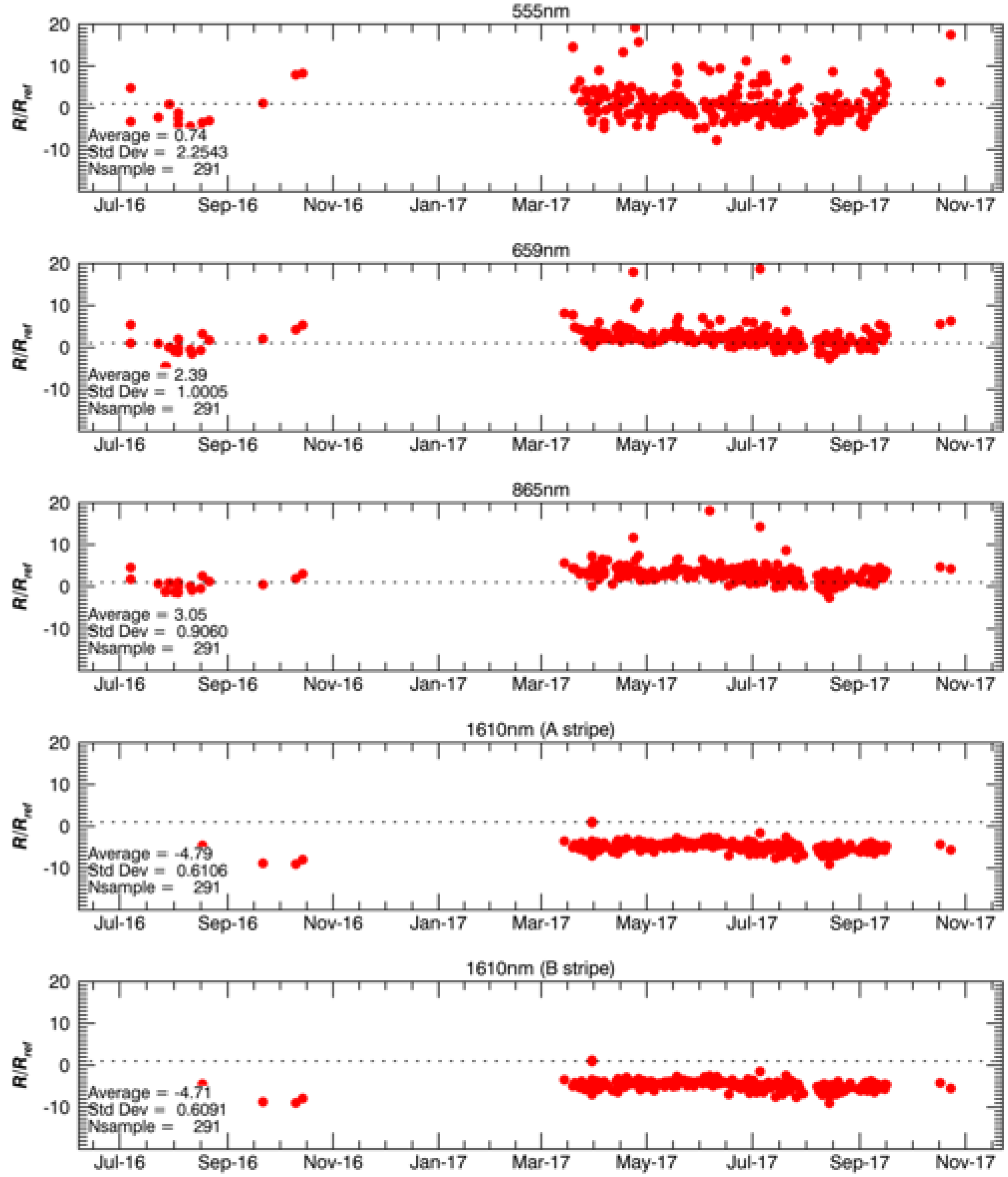
Match-ups constrained to VZA <25 degrees

SWIR A and B stripes show excellent agreement – mean difference < 0.1%

Geometric corrections are needed to account for different overpass times

	Average Rel.Diff. (%)	Stddev
S1	-3.10	1.85
S2	0.22	1.24
S3	-1.06	1.07
S5a	-12.11	0.75
S5b	-12.02	0.75

SLSTR vs AATSR Oblique



Combined results for all desert sites processed to date

Match-ups constrained to VZA <25 degrees

SWIR A and B stripes show excellent agreement – mean difference < 0.1%

Geometric corrections are needed to account for different overpass times

	Average Rel.Diff. (%)	Stddev
S1	0.74	2.25
S2	2.39	1.00
S3	3.05	0.90
S5a	**-4.79**	0.61
S5b	**-4.71**	0.61

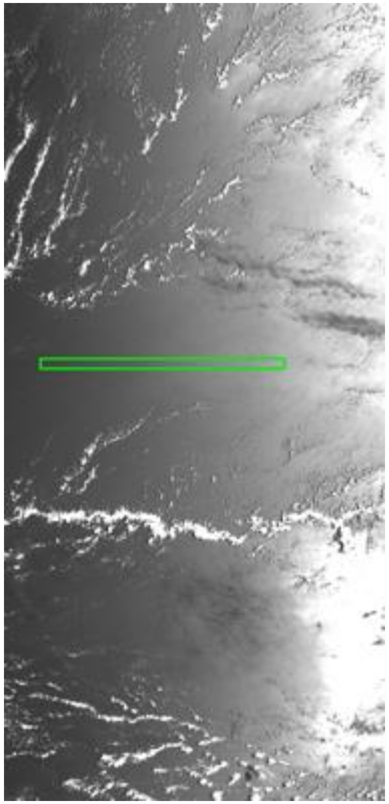
Relative Differences (%)

Channel	a) Comparisons over Deserts				b) Comparisons over Sun-glints	
	SLSTR/OLCI Nadir	SLSTR/MODIS-A Nadir	SLSTR/AATSR Nadir	SLSTR/AATSR Oblique	SLSTR/model Nadir	SLSTR/model Oblique
S1	0.25% (0.5)	2.24% (0.9)	-3.10% (1.9)	0.74 (2.25)		
S2	0.03% (0.4)	3.40% (0.7)	0.22% (1.2)	2.39 (1.00)		
S3	-1.02% (0.5)	3.36% (0.8)	-1.06% (1.0)	3.05 (0.90)		
S5a		-11.35% (0.6)	-12.11% (0.7)	-4.79 (0.61)		
S5b		-11.26% (0.6)	-12.02% (0.7)	-4.71 (0.61)		
S6a		-19.26% (1.0)				
S6b		-19.19% (1.0)				

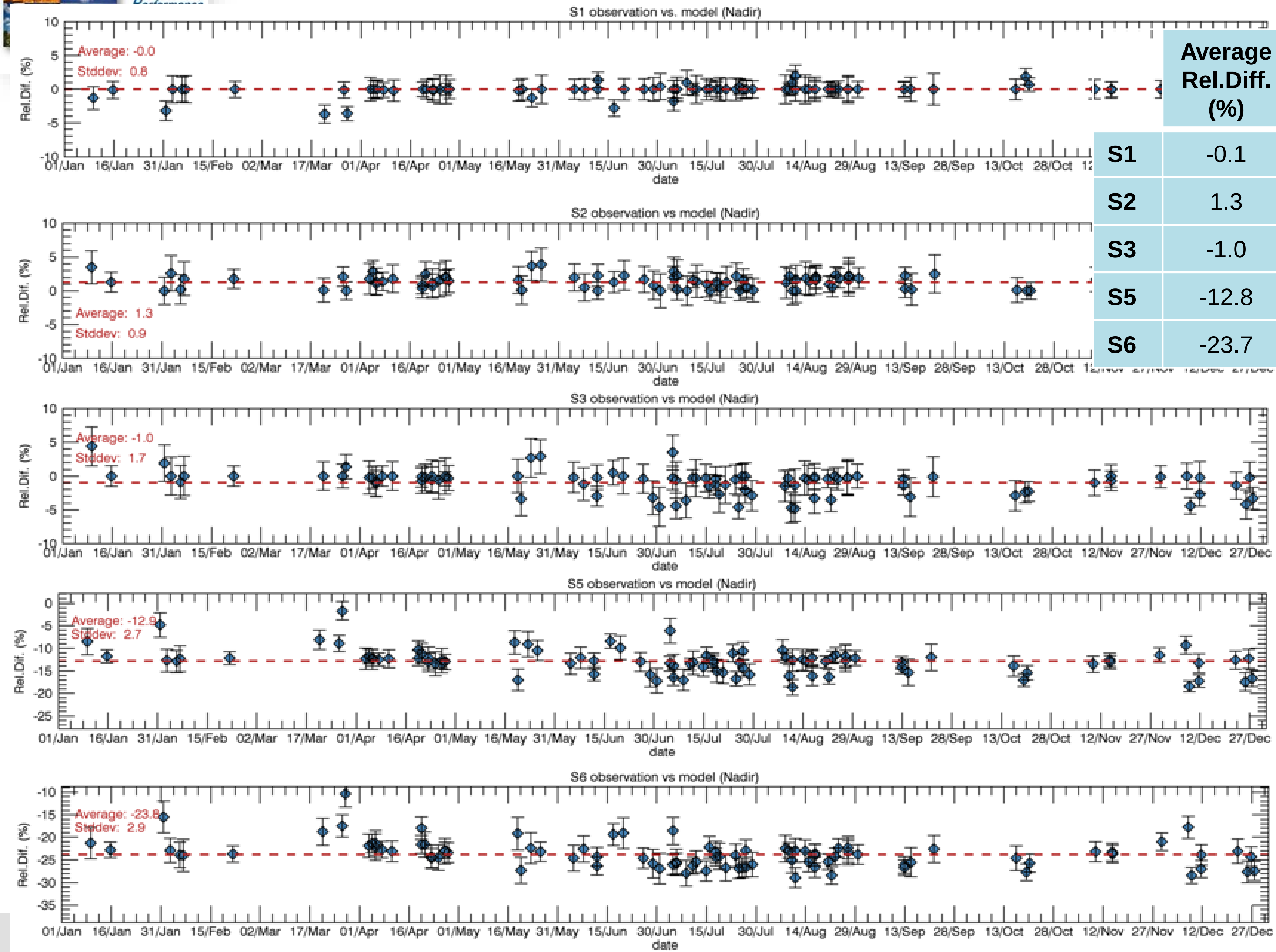
Sun-glint calibration method

- **Radiative transfer code**
  - Based in the Oxford-RAL Aerosols and Clouds (ORAC) retrieval algorithm.
  - On the approach of Cox & Munk (1954)

- **Targets are Sun-glints:**
  - Level-1 products
  - over the North and South Pacific Ocean
  - Nadir and Oblique
  - Size 100km x 5km

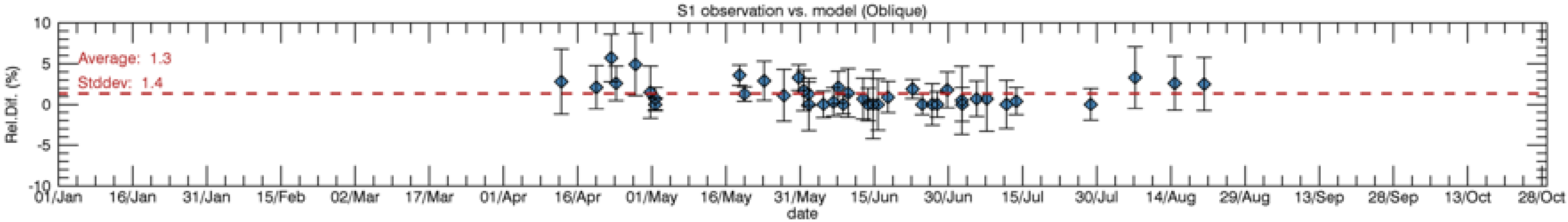


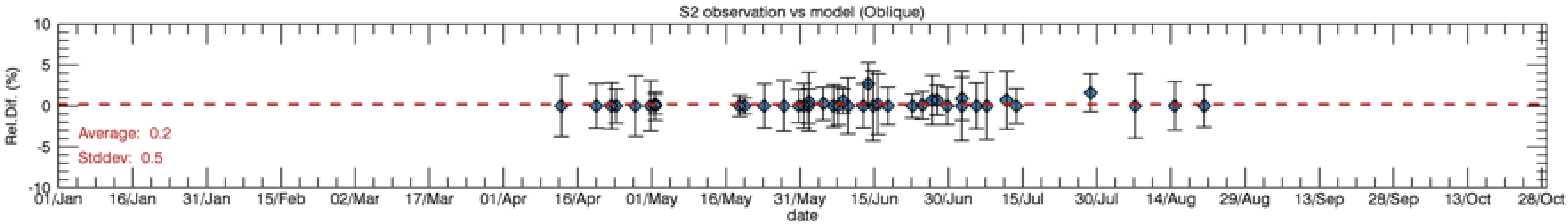
Sunglint models: SLSTR nadir

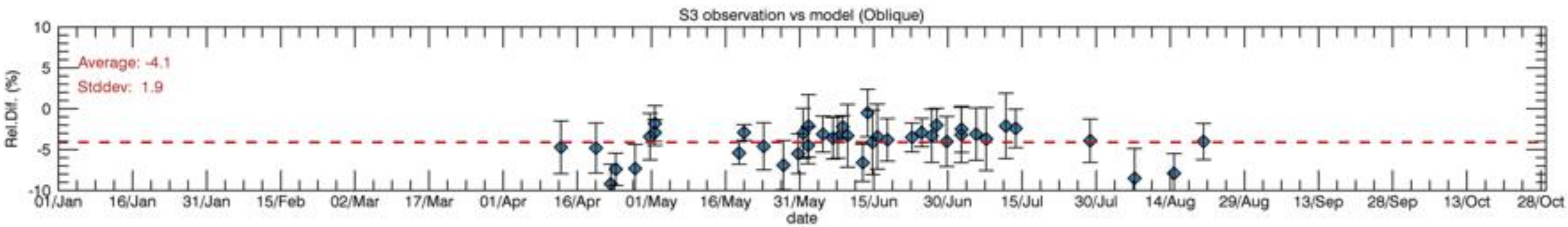


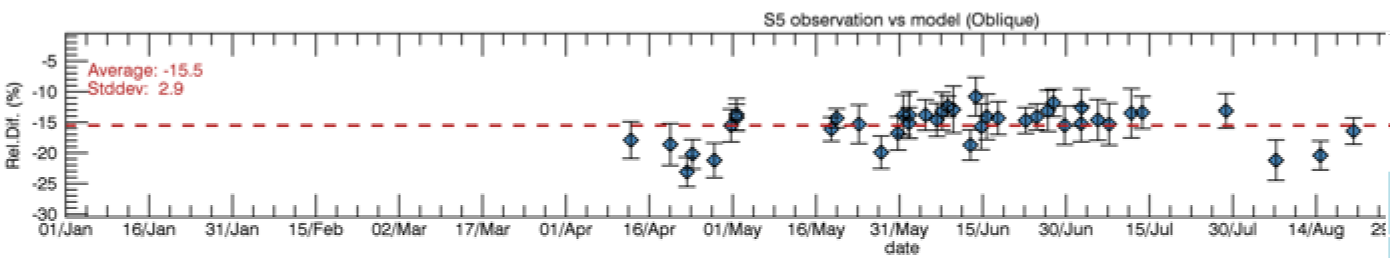
	Average Rel.Diff. (%)	Stddev
S1	-0.1	0.8
S2	1.3	0.8
S3	-1.0	1.5
S5	-12.8	2.6
S6	-23.7	3.0

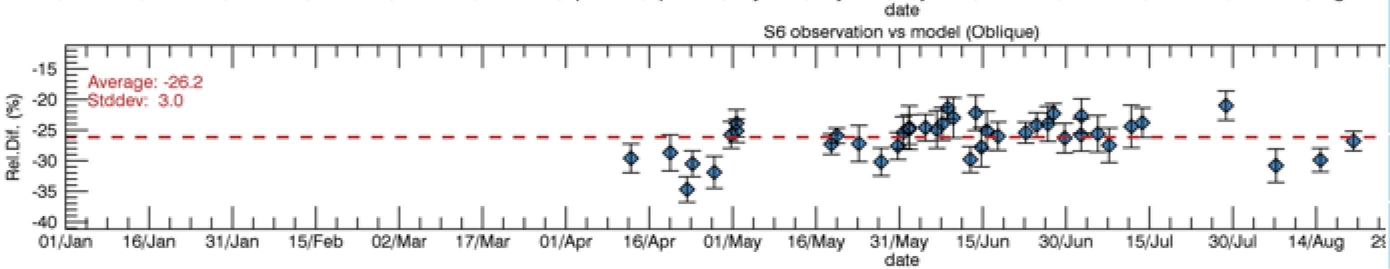
Sunglint models: SLSTR oblique











	Average Rel.Diff. (%)	Stddev
S1	1.3	1.4
S2	0.2	0.5
S3	-4.1	1.9
S5	**-15.5**	2.9
S6	**-26.2**	3.0

Relative Differences (%)

Channel	a) Comparisons over Deserts				b) Comparisons over Sun-glints	
	SLSTR/OLCI Nadir	SLSTR/MODIS-A Nadir	SLSTR/AATSR Nadir	SLSTR/AATSR Oblique	SLSTR/model Nadir	SLSTR/model Oblique
S1	0.25% (0.5)	2.24% (0.9)	-3.10% (1.9)	0.74 (2.25)	0.0 (0.8)	1.3 (1.4)
S2	0.03% (0.4)	3.40% (0.7)	0.22% (1.2)	2.39 (1.00)	1.3 (0.9)	0.2 (0.5)
S3	-1.02% (0.5)	3.36% (0.8)	-1.06% (1.0)	3.05 (0.90)	-1.0 (1.7)	-4.1 (1.9)
S5a		-11.35% (0.6)	-12.11% (0.7)	-4.79 (0.61)	-12.90% (2.7)	-15.50% (2.7)
S5b		-11.26% (0.6)	-12.02% (0.7)	-4.71 (0.61)	…	…
S6a		-19.26% (1.0)			-23.80% (3.0)	-26.20% (3.0)
S6b		-19.19% (1.0)			…	…

VIS/SWIR Calibration Summary

- SLSTR agrees with OLCI and AATSR for S1-S3

- Discrepancy in Oblique view comparisons using Desert sites
  Query geometric matching approach for Desert Sites (Azimuth angles).

- First recommendation to adjust S5 and S6 radiometric calibration to improve alignment to AATSR/MODIS, radiative transfer models, and observations:

	Nadir View	Oblique View
S5 correction by	12%	15%
S6 correction by	20%	26%

Finally…

3B to come on 25th of April
Thank You