EOSense

Statistically based approach for estimation of sensor performance indicators

Status and way forward

QA4EO WP2160

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PRINCIPLES

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Basic principles

- Currently radiometric calibration and data quality relies largely on infrequently acquired on-board data (Sentinel-2 has a calibration cycle every month) or through vicarious calibration using specific sites that may have environmental limitations (Dome-C during its winter, cloud cover over Libya 4). So opportunities are limited.

OUR APPROACH

- All images collected contain useful information for assessing changes in radiometry and data quality, this provides very high temporal sampling of parameters of interest.

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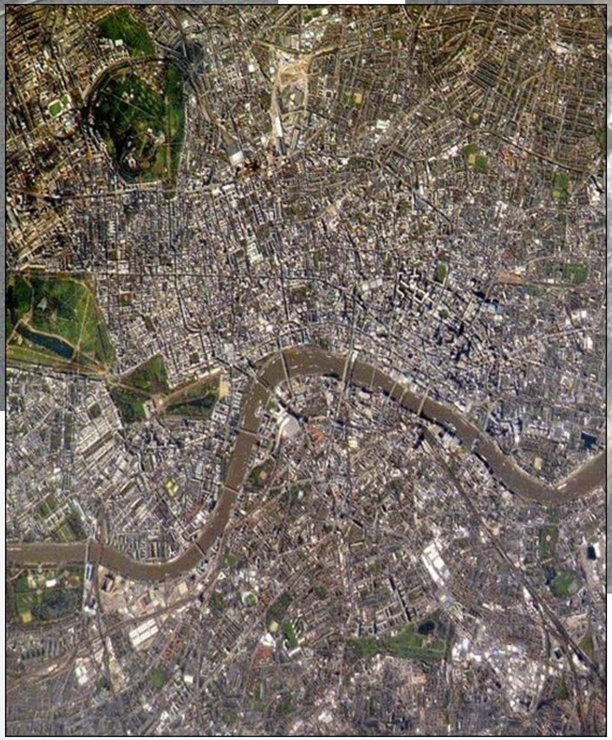
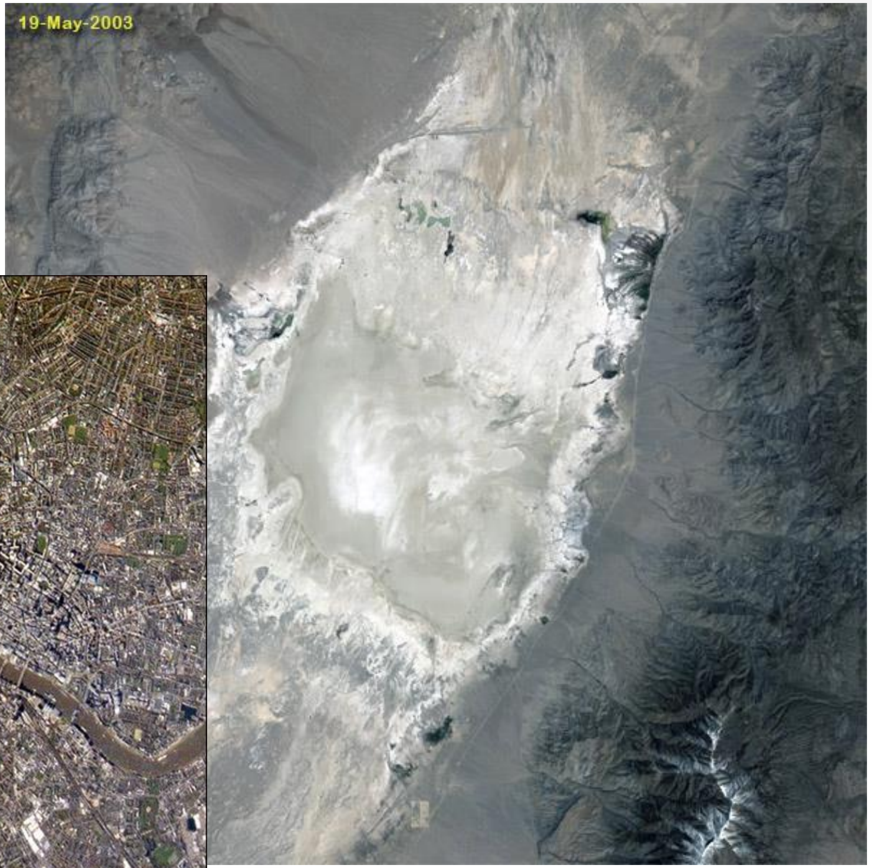
Types of images we use, essentially everything





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Advantages of using normal images

- By using normal images, we have a much higher sampling interval, every 41 seconds for Sentinel-2 rather than every month using on-board devices. We can therefore monitor and update our results with a much higher frequency than many on-board devices and vicarious methods which use specific sites, that can only be accessed infrequently.
- By using normal images, in theory we can identify issues as they occur and either flag issues or update coefficients automatically (for example, detector non-uniformity, where a single detector responsivity changes dramatically in a short period of time)
- We also avoid "dead" periods where a specific site cannot be used, such as the polar sites in Antarctica and Greenland that for precision work can only be used effectively for one to two months per year.

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PROBA-V

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PROBA-V basic information

Parameter	Vegetation (SPOT series)	VGT-P (Vegetation on PROBA-V)
Mass of instrument	152 kg	33 kg (with margin)
Volume	1.0 m x 1.0 m x 0.7 m	0.81 m x 0.2 m x 0.35 m
Swath	2250 km	2285 km
GSD at nadir	1165 m	100 m (VNIR), 200 m (SWIR)
GSD at edge of the swath	1700 m	360 (VNIR), 690 (SWIR)
MTF at GSD	0.3	0.3
Spectral bands Blue Red NIR SWIR	 450 nm, FWHM: 42 nm 645 nm, FWHM: 70 nm 834 nm, FWHM: 121 nm 1665 nm, FWHM: 89 nm	 460 nm, FWHM: 42 nm CWL 658 nm, FWHM: 82 nm 834 nm, FWHM: 121 nm 1610 nm, FWHM: 89 nm

3 cameras, 12 bit with variable along track integration time

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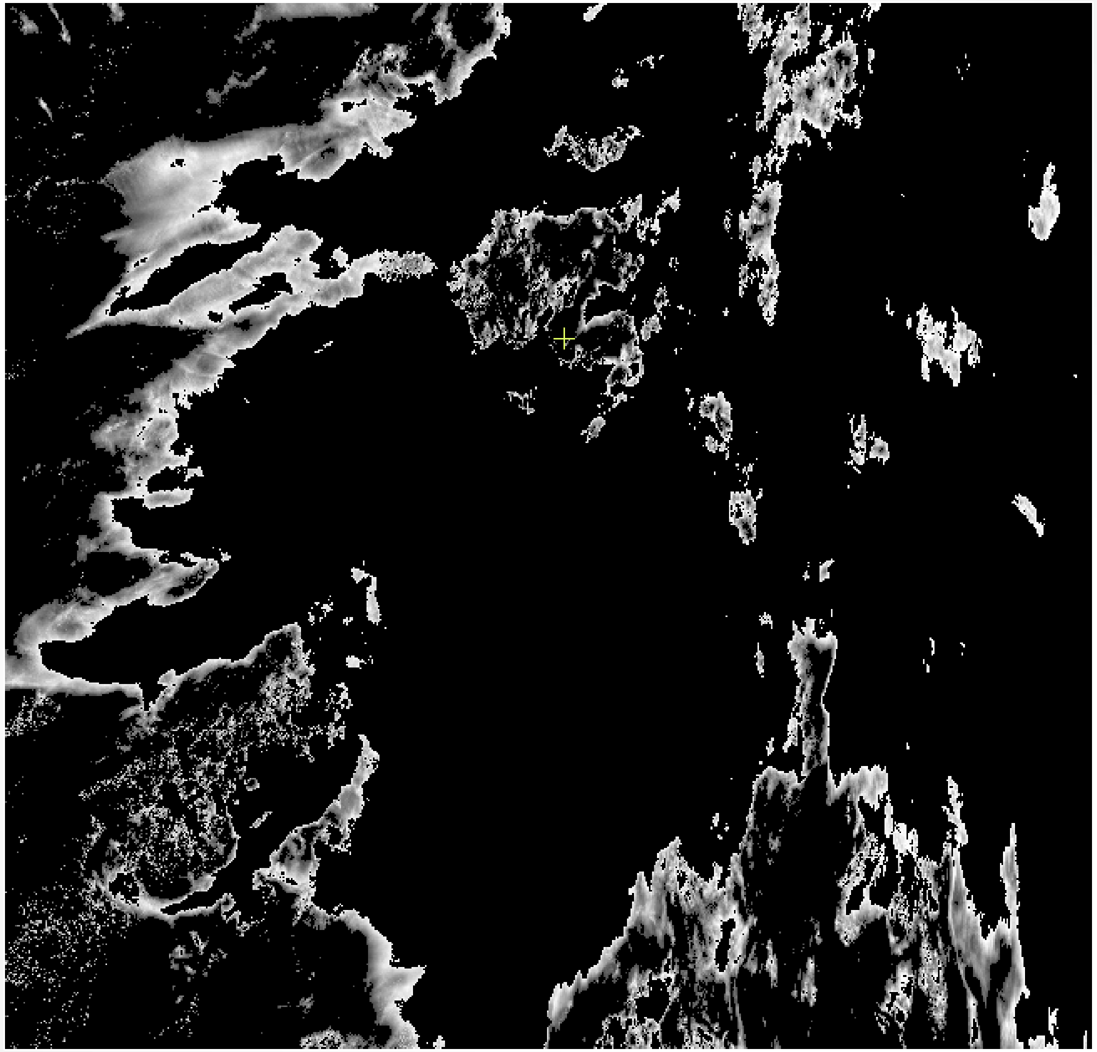
Reading the data and artefacts

- The reading procedure was straight-forward the back conversion from TOA reflectance to radiance **was not**, documentation on this would be beneficial.
- Missing/Saturated data is an issue.
- Artefacts were found that had a serious impact on how we extract data quality information.



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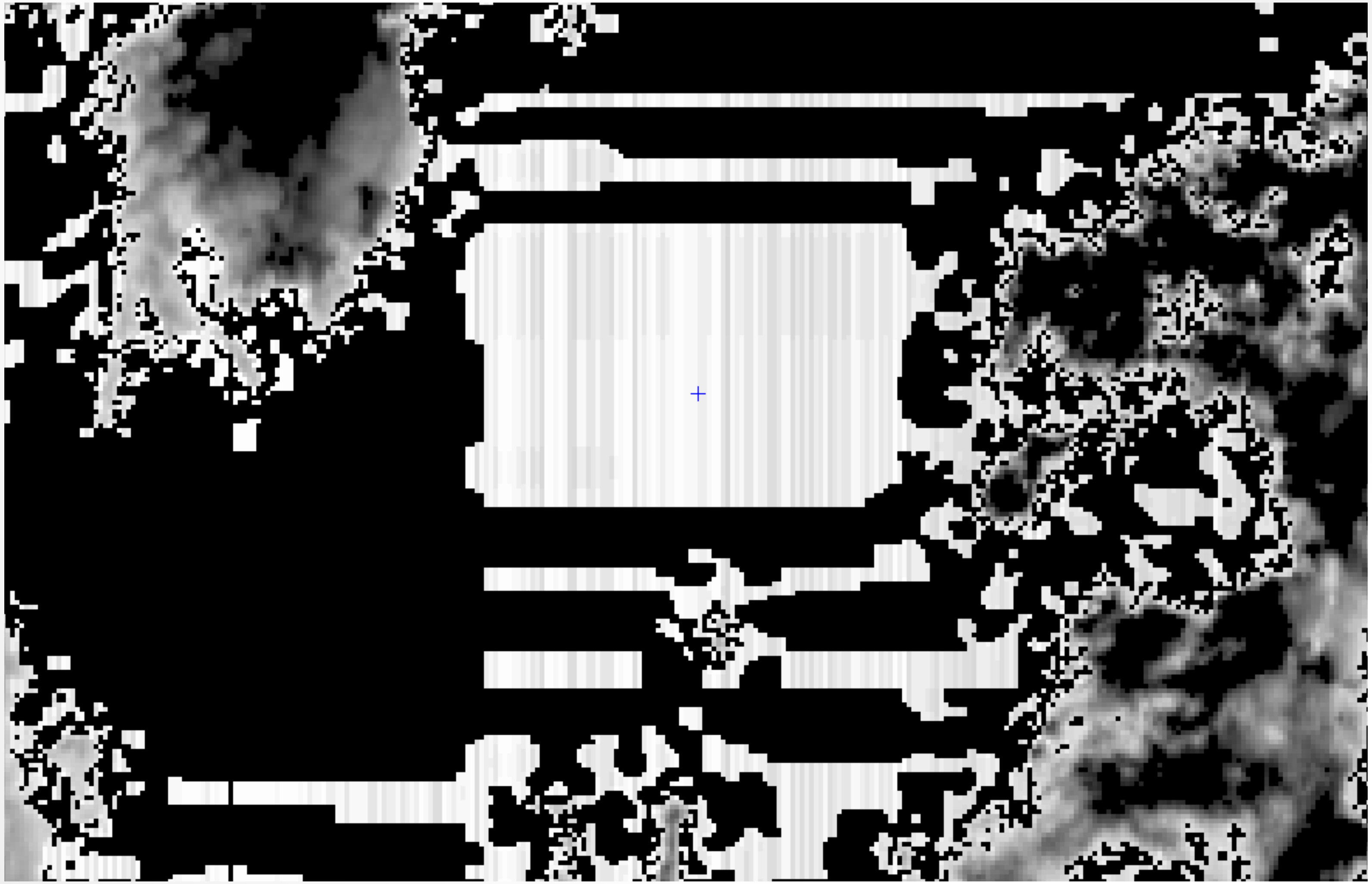
Reading the data and artefacts

- The integration time changes during the acquisition of an imaging strip.
- Close to the boundaries we have found striping artefacts, which resemble saturation effects.
- These artefacts affect the statistics derived from the imagery used in the data quality analyses.



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AREAS BEING INVESTIGATED

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Areas being investigated (all in-orbit) using normal images

- Signal to Noise Ratio assessment
- Relative gain determination
- Non-linearity assessment

Methods have been under development and testing for several years and with the larger amounts of data now processed we are getting significant results for both Sentinel-2 MSI, Sentinel-3 OLCI and SLSTR.

In this presentation we will show the preliminary results from PROBA-V but referencing some examples from other sensors

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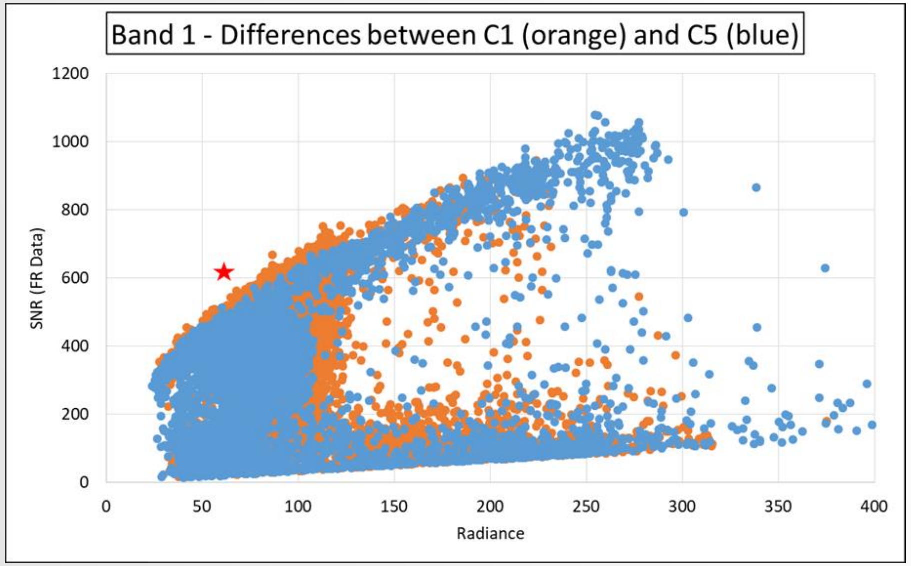
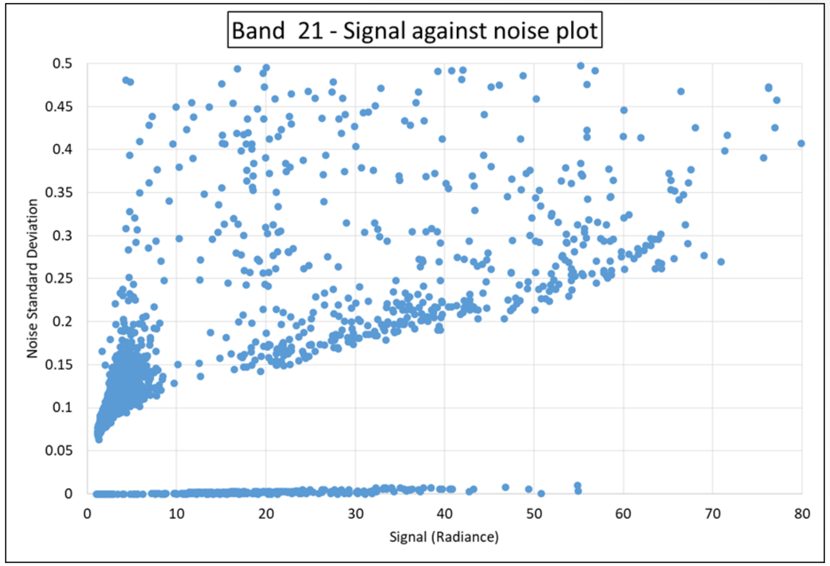
SNR data clouds (OLCI vs PROBA-V)

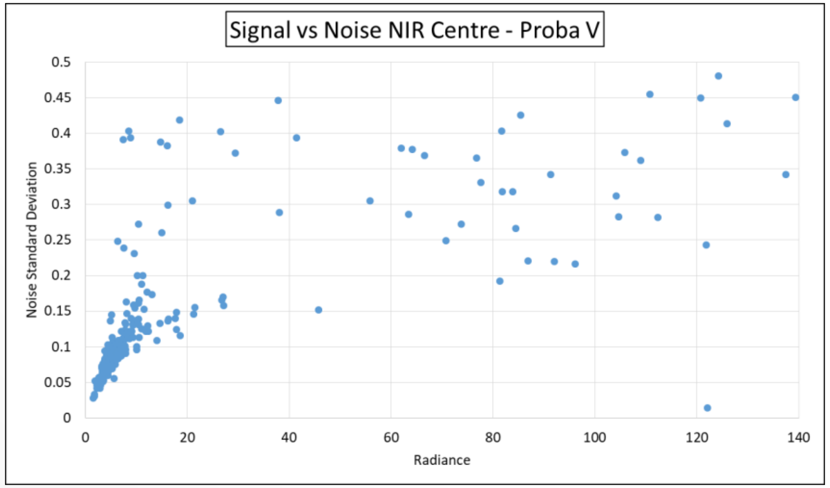


OLCI



For Proba-V (bottom right) most data is in a small radiance range, hence its difficult at this time to be precise on the SNR at a target radiance of around 100W.

Lots of SNR data points are rejected due to image artefacts



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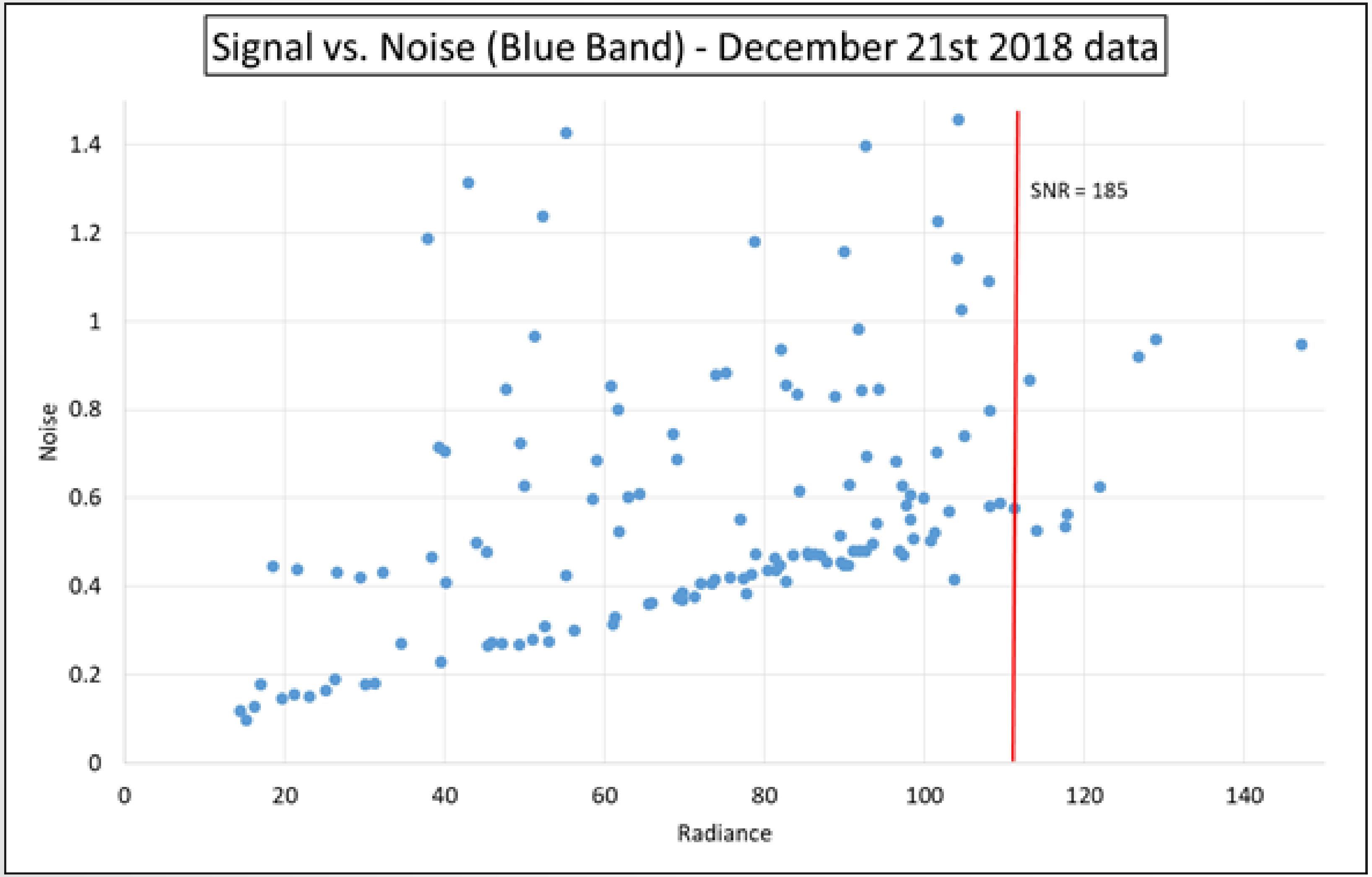
PROBA-V Blue band Noise estimate



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Relative Gain

- What is relative gain
  - When a detector array is manufactured each detector in the (let us assume) silicon substrate has slightly different behaviour, including
    - Different bias values when there is no signal
    - Some non-linearity in response
    - Different overall response to the same signal level (gain values)

So to get a stripe free image from a group of detectors in a linear array we need to equalise all the detectors, so we get the same response to the same radiant energy on the detector surface.

This is the relative gain correction.

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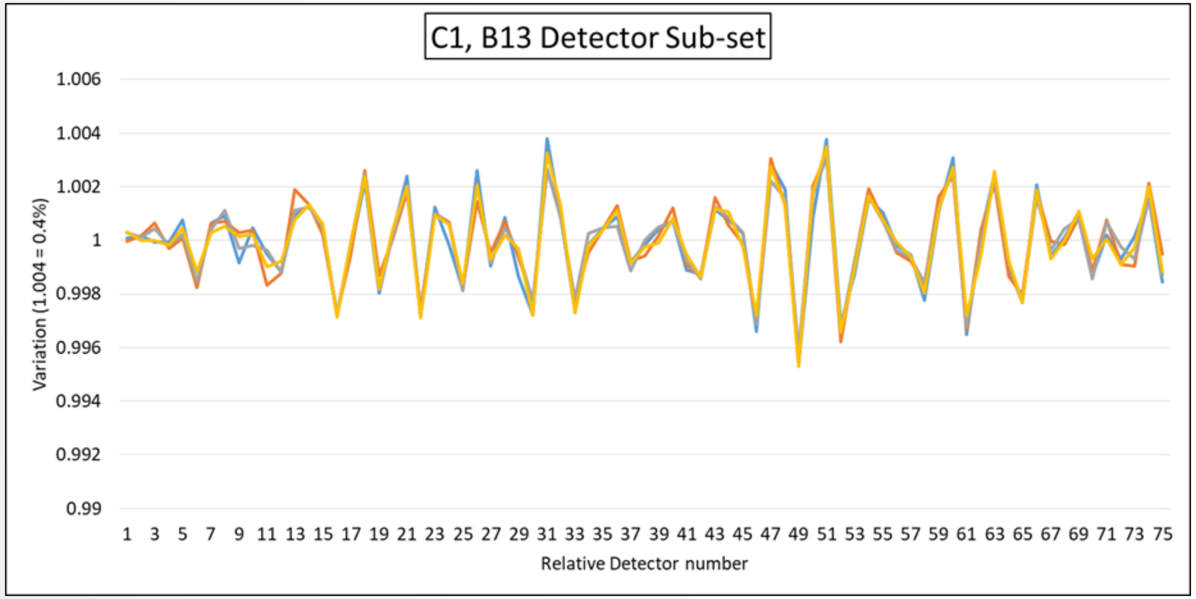
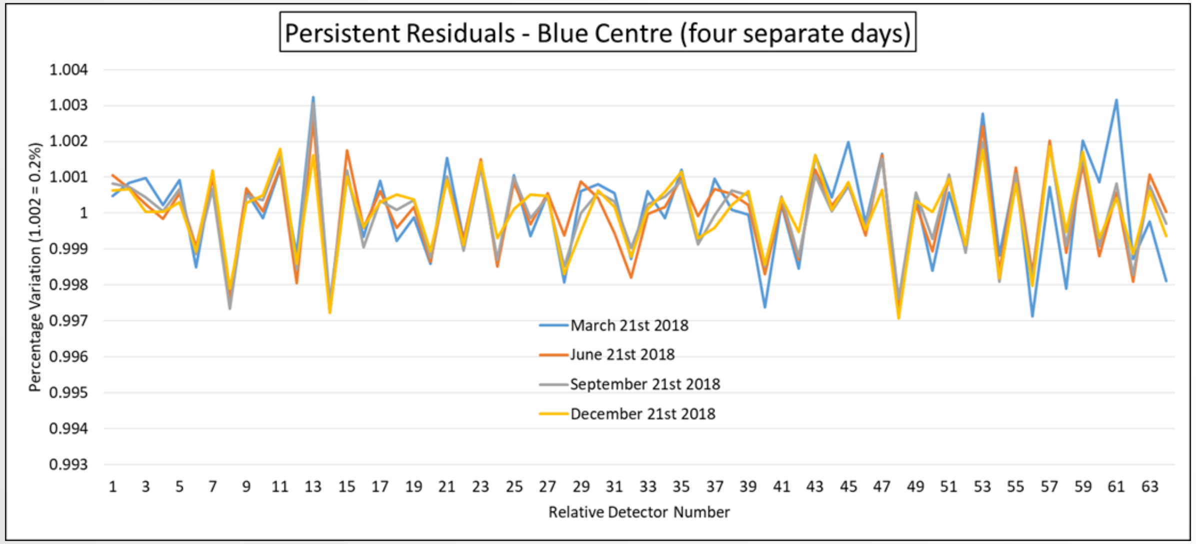
Relative gain comparison



OLCI Band 13



PROBA-V Band 1

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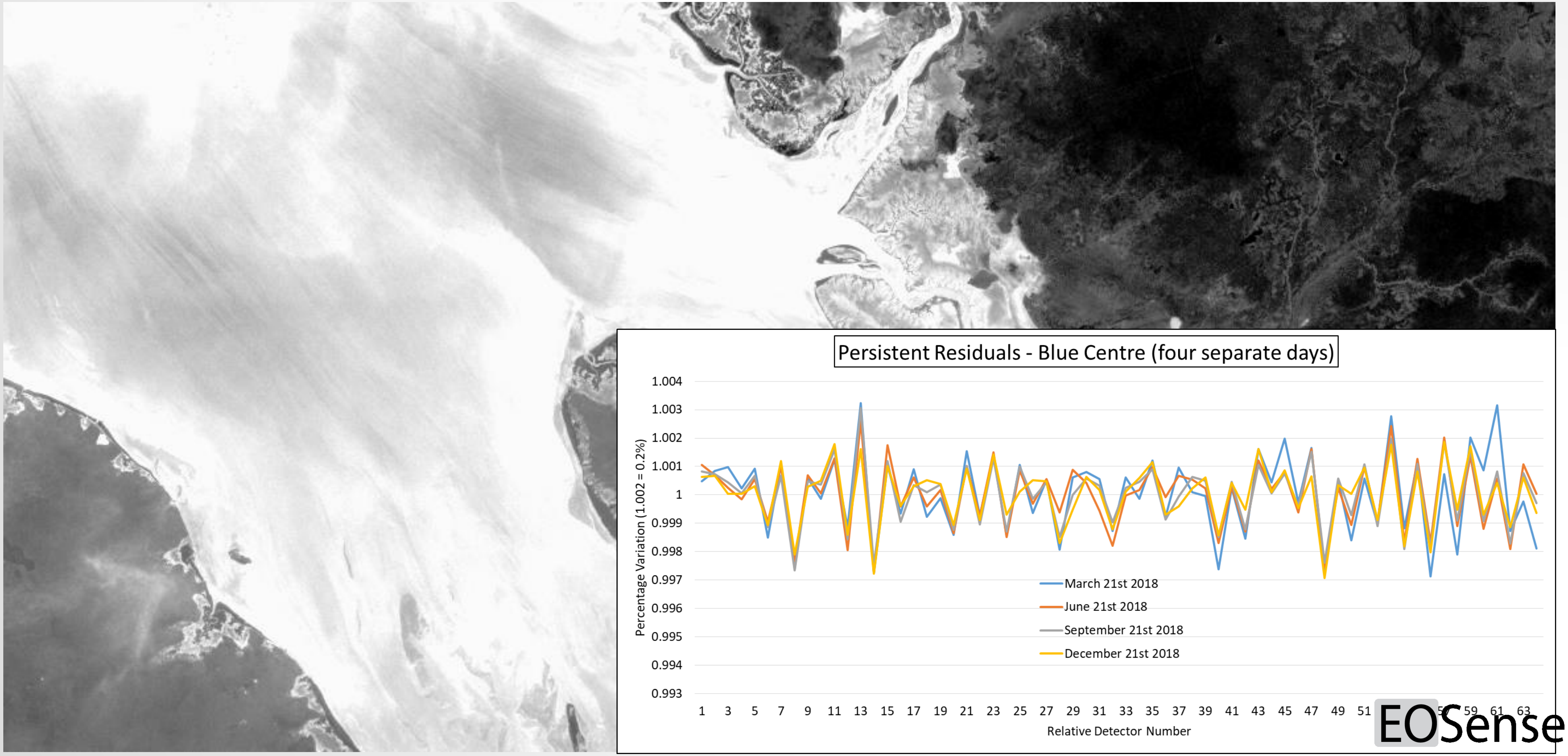
PROBA-V (when it goes well)

- Image blue band



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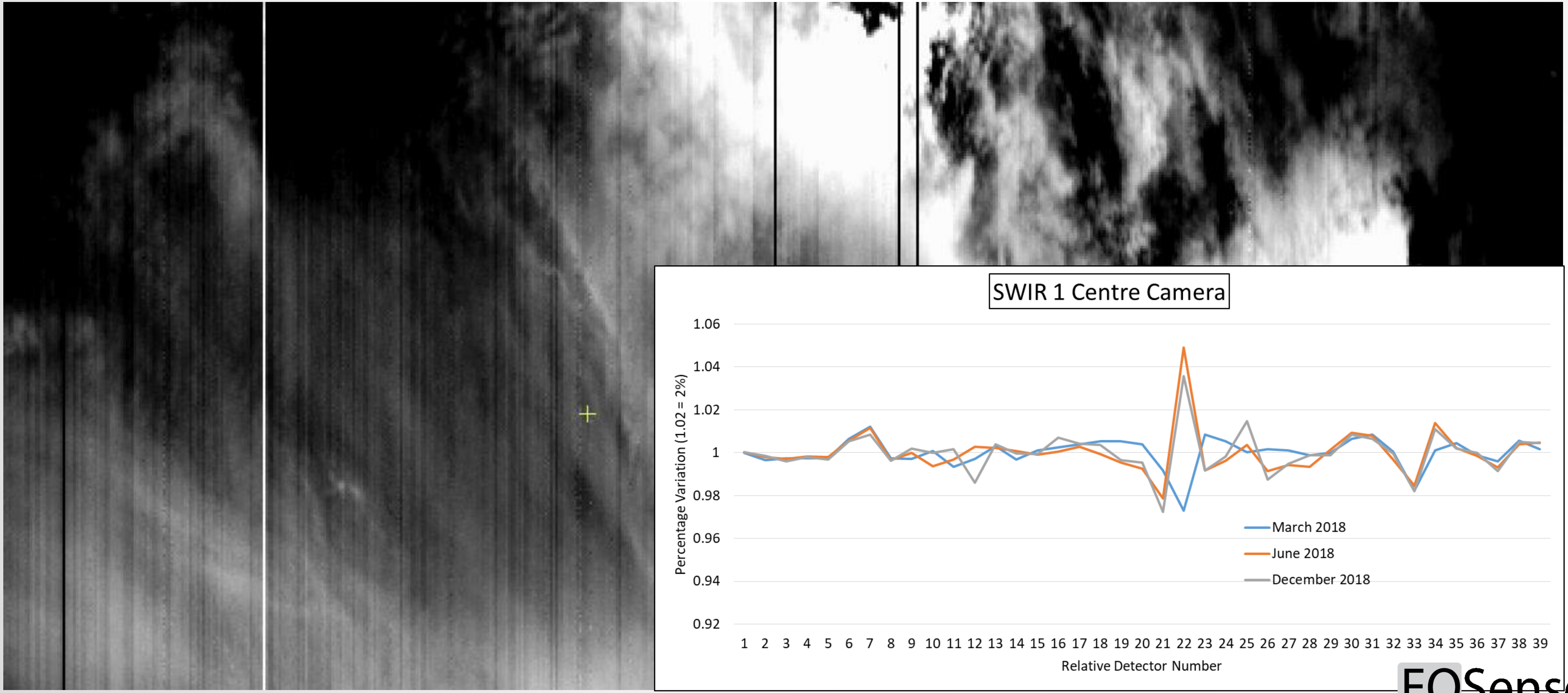
PROBA-V (or not so well)

- Image SWIR band



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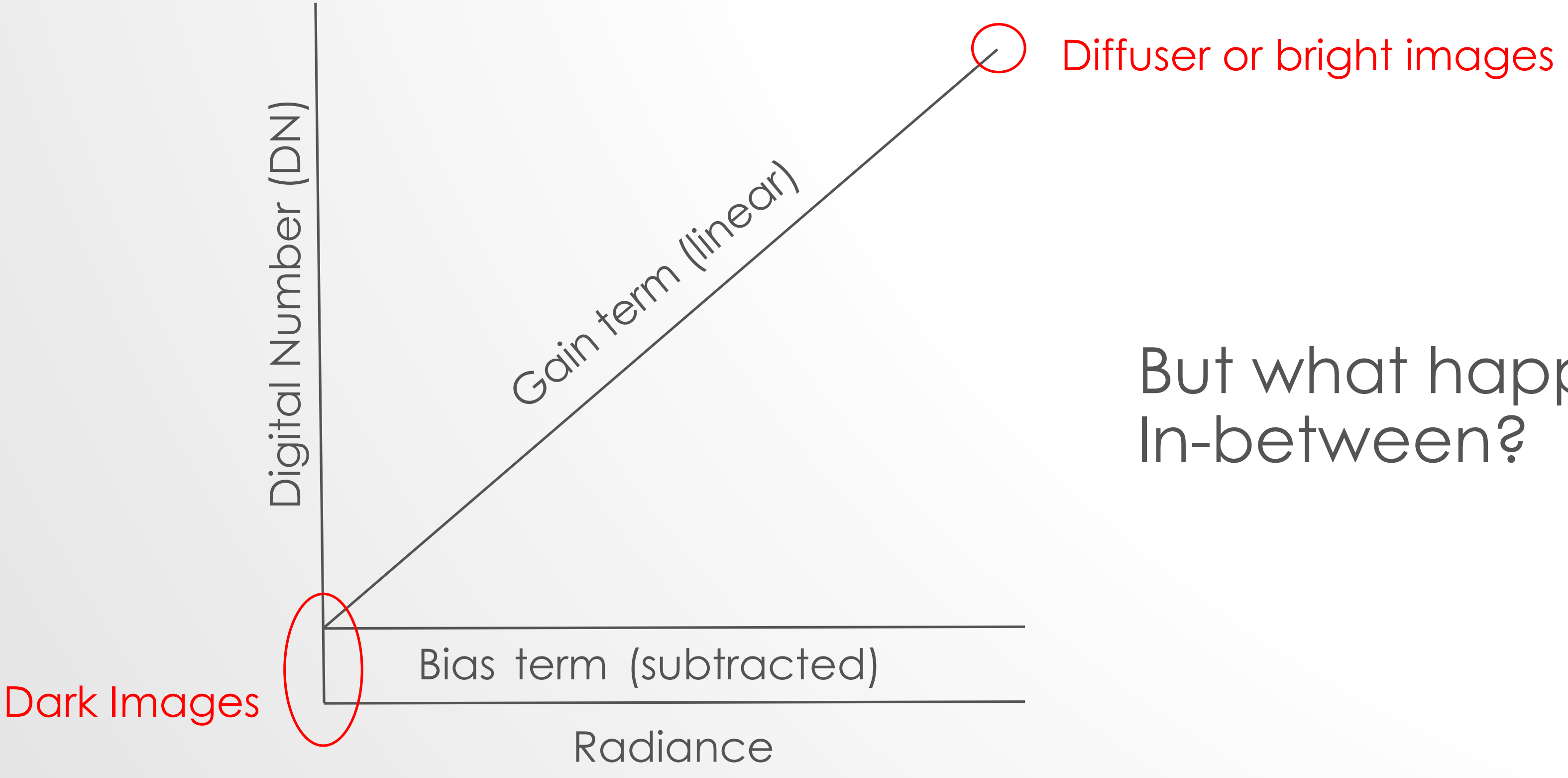
Non-linearity

- Not easily validated in space, we can get the bias term from dark images and we can get the upper bound from diffuser images or a bright vicarious target (snow)



But what happens In-between?

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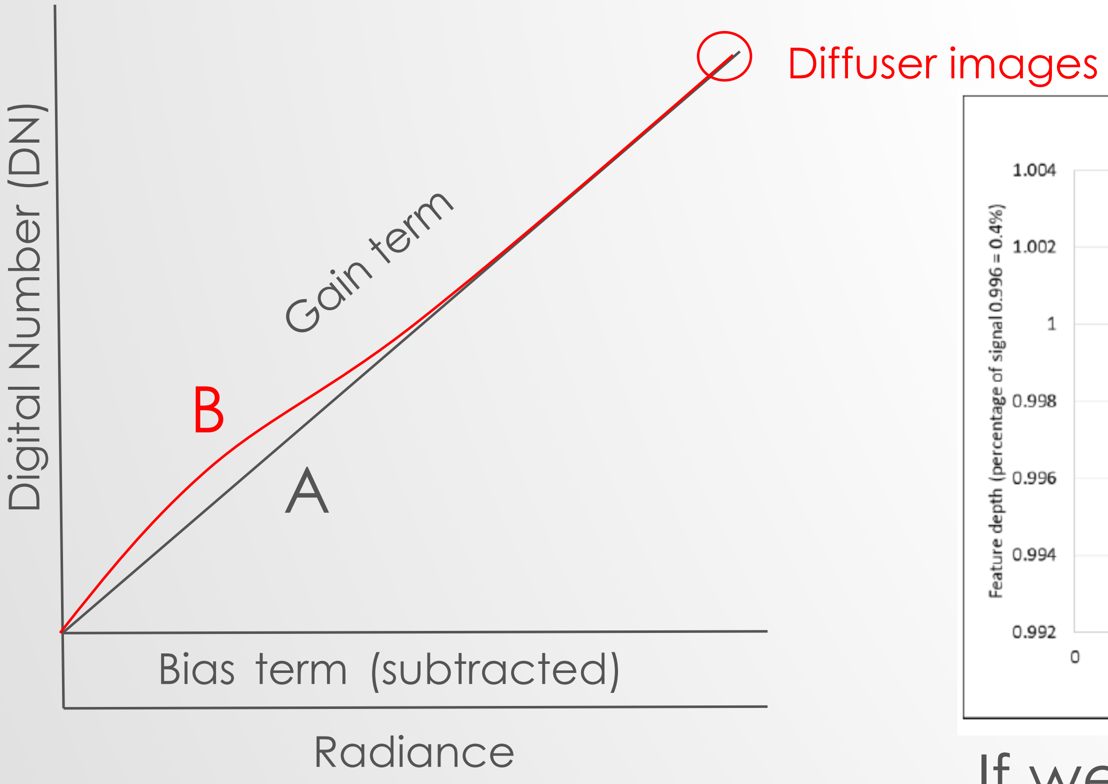
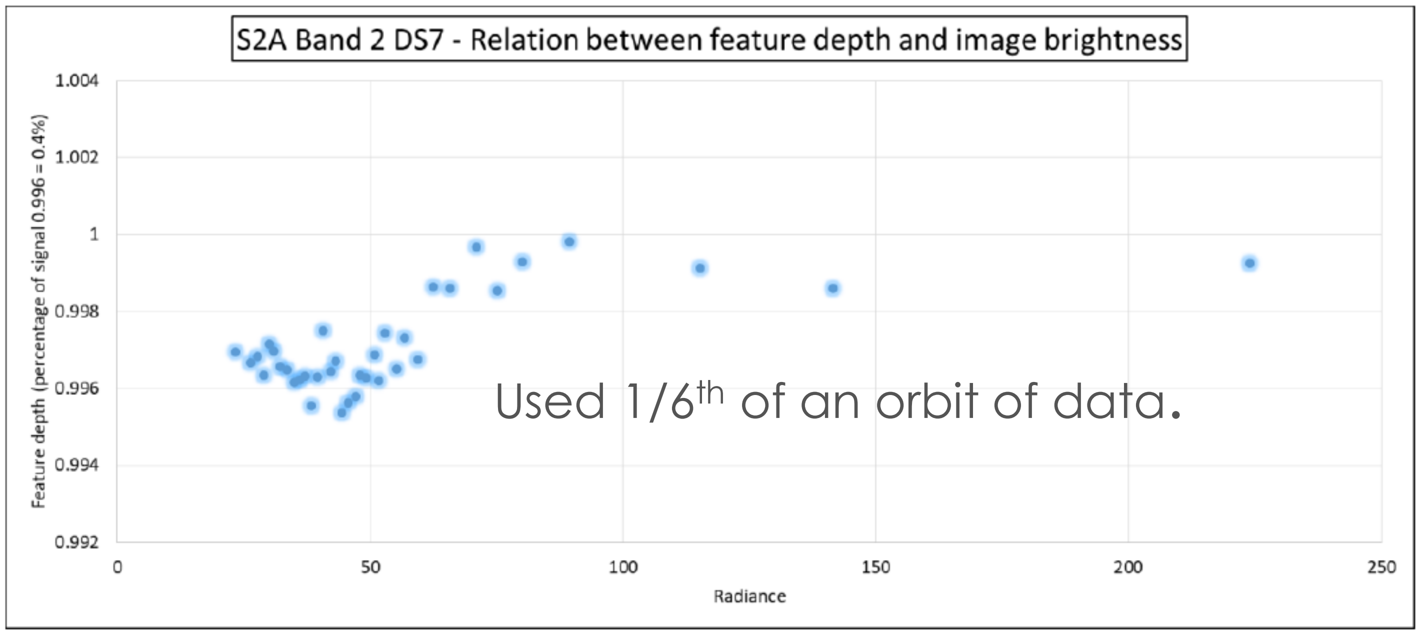
Example of non-linearity in S2A





Assuming our non-linearity correction is not perfect (B)

If we ratio the values A/B we get a distinct pattern of behaviour which shows the correction required to remove the persistent residuals

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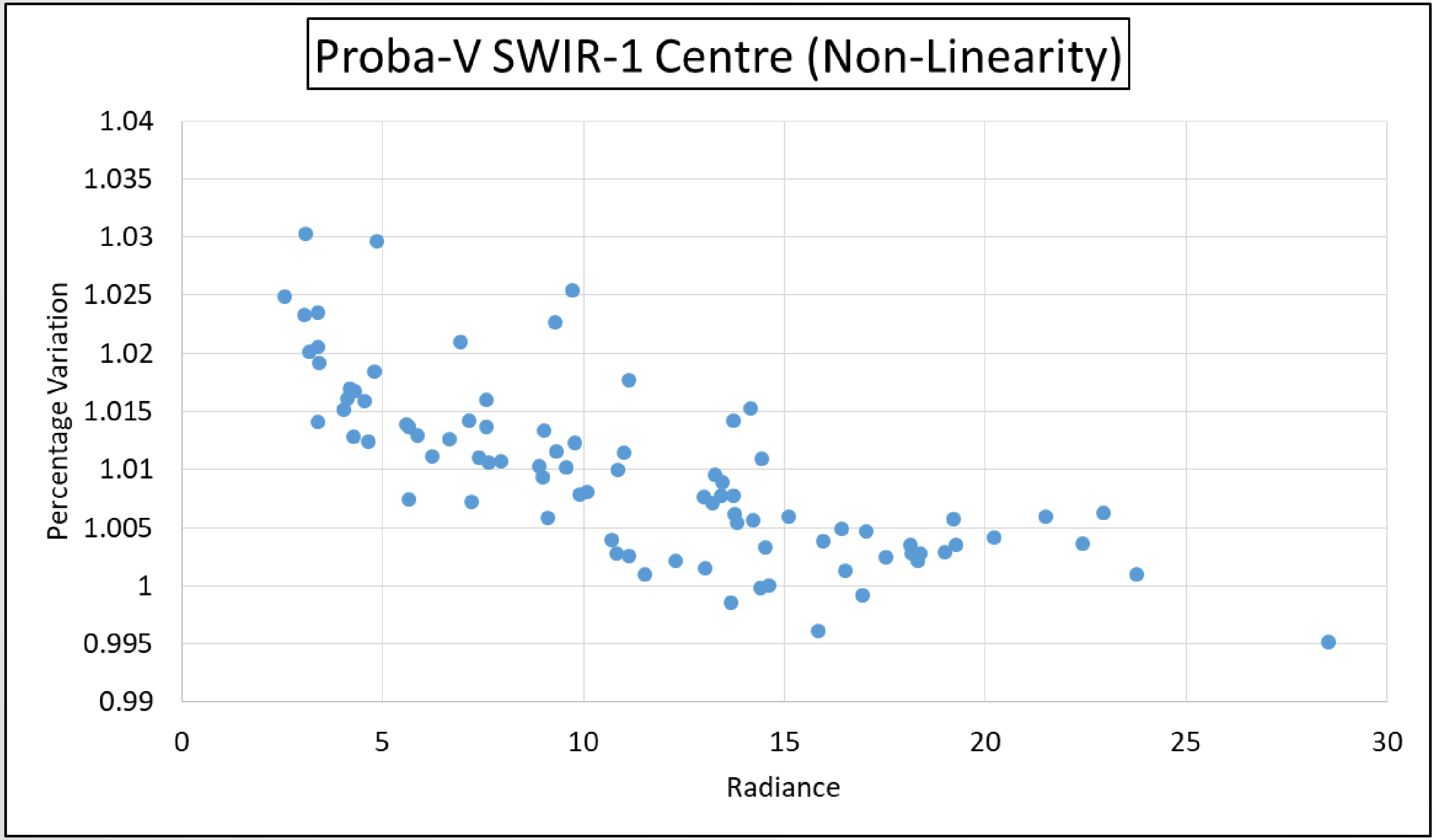
PROBA-V non-linearity



The residual magnitude varies with radiance from 2.5% of the signal to less than 0.5% of the signal over a 10W radiance range.

Note that the values tend to converge on to a residual magnitude of zero (that is the "1" line in the plot).

So observations using very bright targets can not see these features.

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Conclusions

- The PROBA-V data has some features we need to deal to prevent image artefacts affecting the automated procedures.
- Overall the SNR has proven difficult to extract, although with more data we should be able to develop reasonable SNR profiles.
- The relative gain estimation shows the presence of persistent residuals, but with quite low magnitudes in the VNIR bands, especially the red band. SWIR values are rather high (several percent). Non-linearity is being explored as a possible cause.
- There is a general instability in sensor response at the detector level that needs understanding before a full set of corrections can be applied to PROBA-V to reduce relative gain variations.

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