

## Statistically based approach for estimation of sensor performance indicators

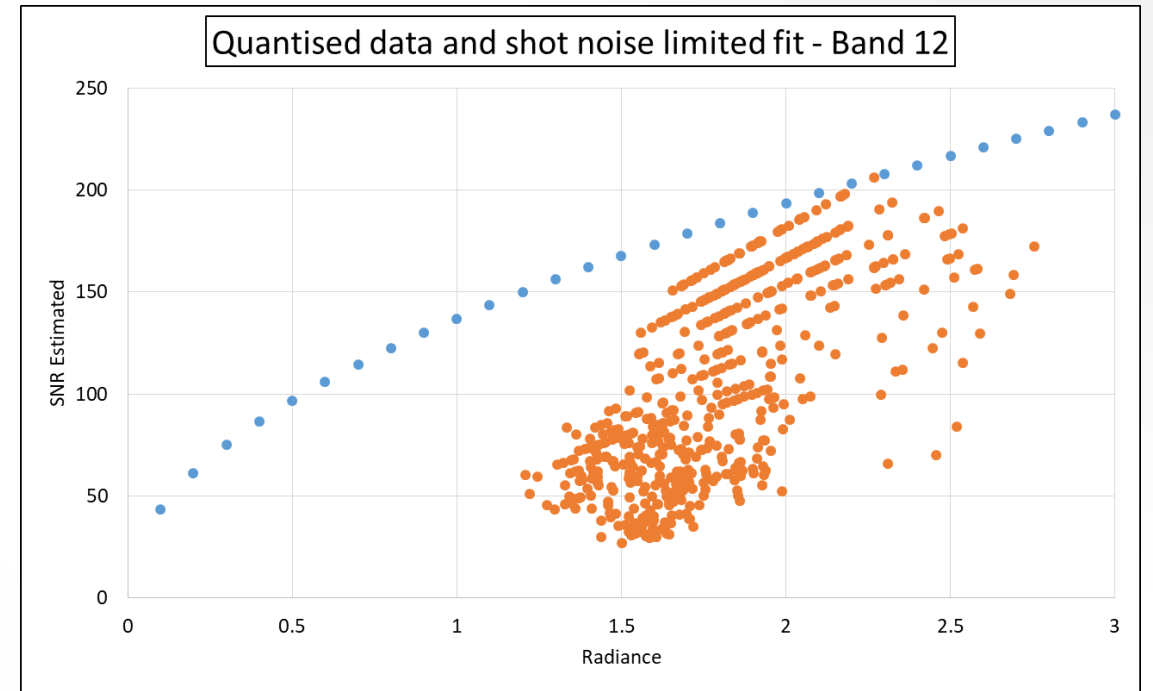
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Project - 025	Presentation		ESA
2 <sup>nd</sup> Dec. 2020			

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# SIGNAL QUANTISATION – SENTINEL 2

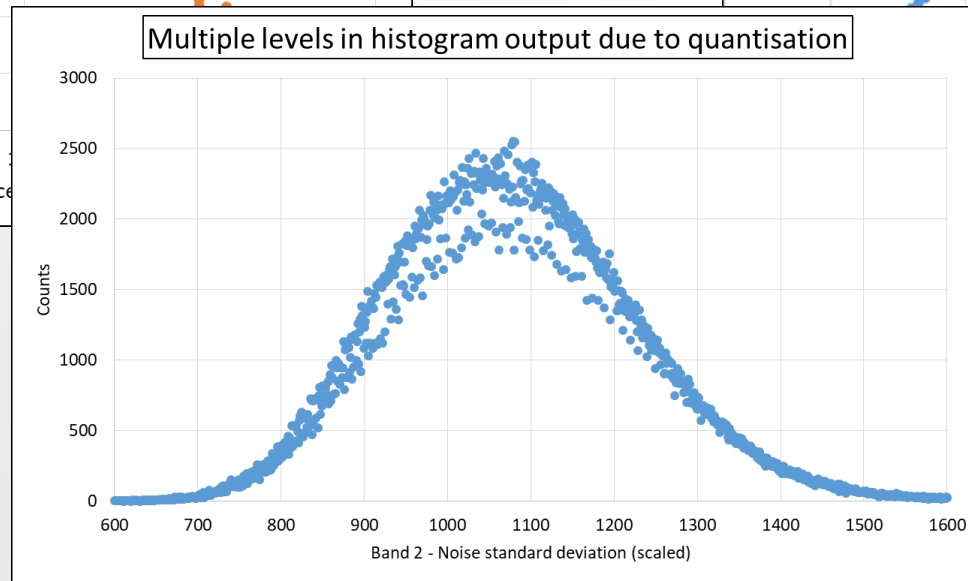
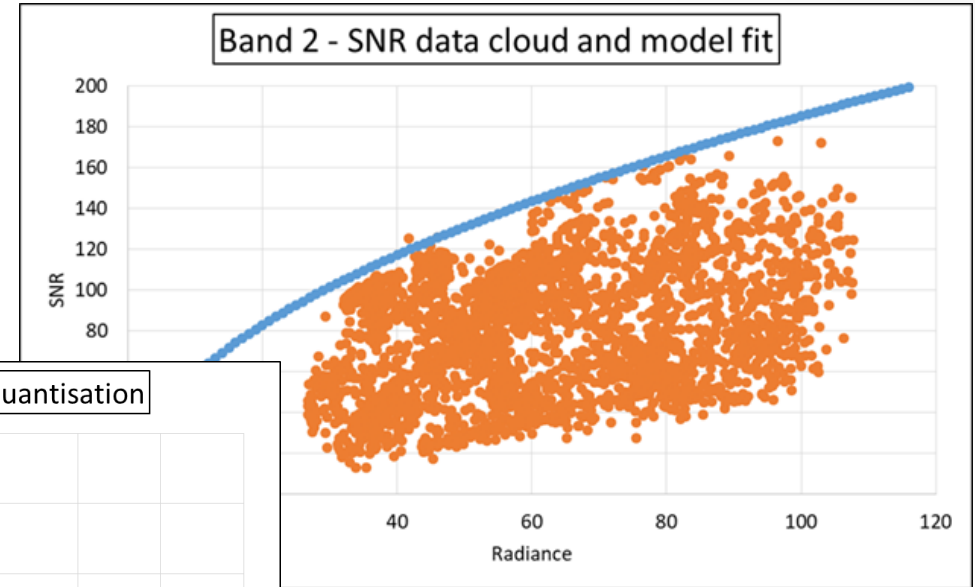
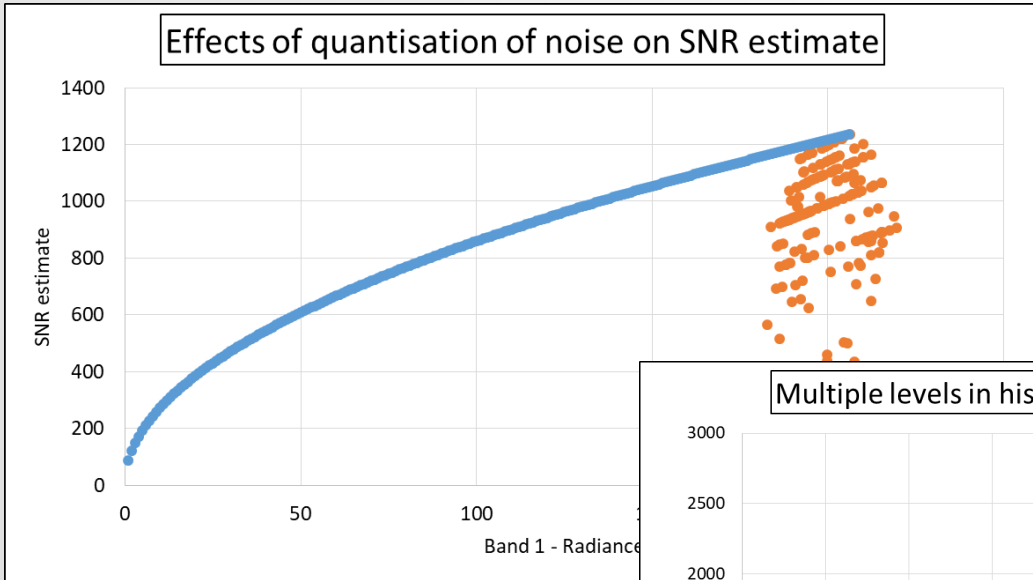


Quantisation effects in SNR (Band 12 – Dome C)  
the radiance range is tiny for this band.

Quantisation effects in imagery (Band 1 – Dome C)

# SIGNAL QUANTISATION – SENTINEL 2

- Quantisation issues only observed in Sentinel-2 affects all algorithms, SNR, relative gain and focus.



Multiple image Data (Dome-C) for band 1

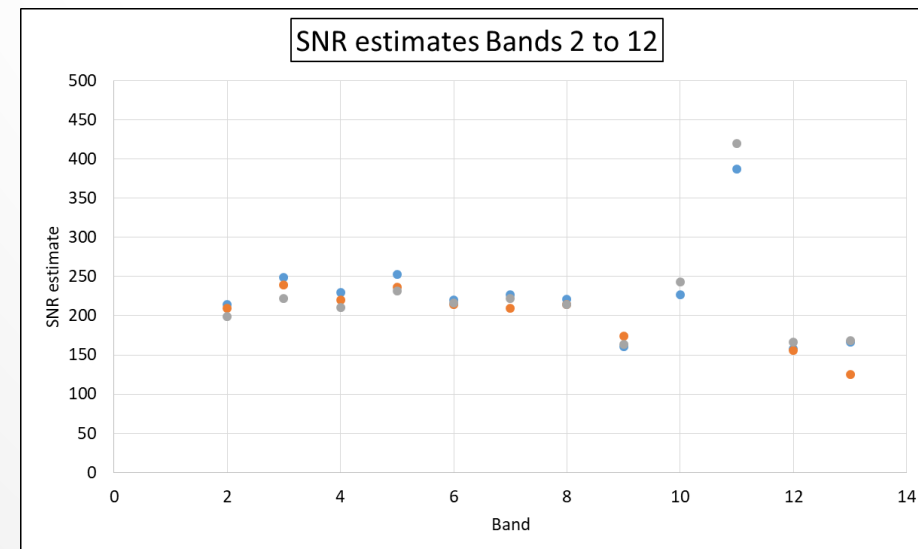
Multiple image Data for band 2

Single image statistic band 2 (Dome-C)

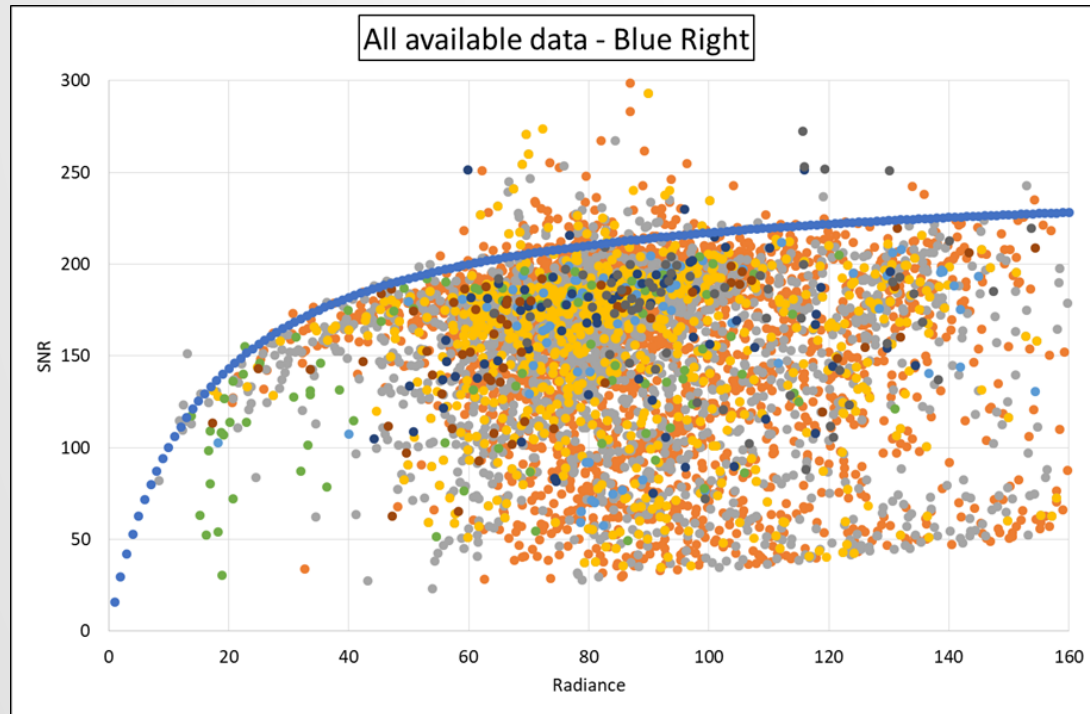
# SNR ESTIMATION – SENTINEL 2

Band	Target Radiance	SNR predicted*	EOSense (Heterogeneous)	Dome-C (Homogeneous)	Comments
1	129	1361	992	1081 quantised	Poor distribution, needs more data.
2	128	214	210	199	Good distribution
3	128	249	239	222	Good distribution
4	108	230	220 (revised)	211	Moderate distribution
5	74.5	253	236	232	Weak distribution, needs more data.
6	68	220	236 (193 lower)	216	Weak distribution, needs more data.
7	67	227	238 (182 lower)	222	Weak distribution, needs more data.
8	103	221	214	214	Weak distribution, needs more data.
8A	52.5	161	174 (revised)	163	Moderate distribution
9	9	227	90 (approximate as data shows severe quantisation)	243 Quantised	Very poor distribution, no valid result
10	6	387	No estimate	420 Quantised	Very poor distribution, no valid result
11	4	158	156	166 Quantised	Limited data points but enough in lower radiance range
12	1.5	166	125	168 Quantised	Very low values, very rough approximation

- EOSense estimates in line with ESA estimates in literature using shot noise limited model.
- Dome-C values a little lower, but closer in cases where the automated algorithm had “difficult” data clouds.
- New approach to improve “difficult” data clouds in January 2021 which will show a marked improvement using less data.

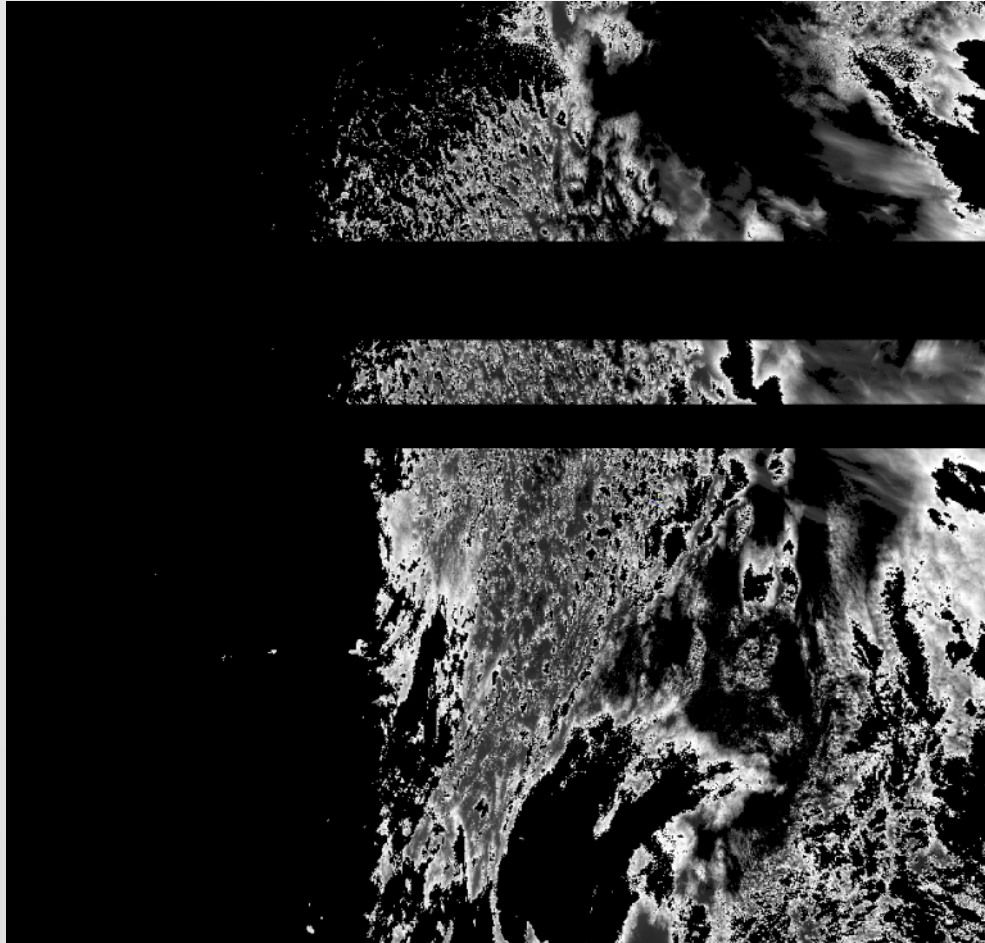


# SNR ESTIMATION – PROBA-V



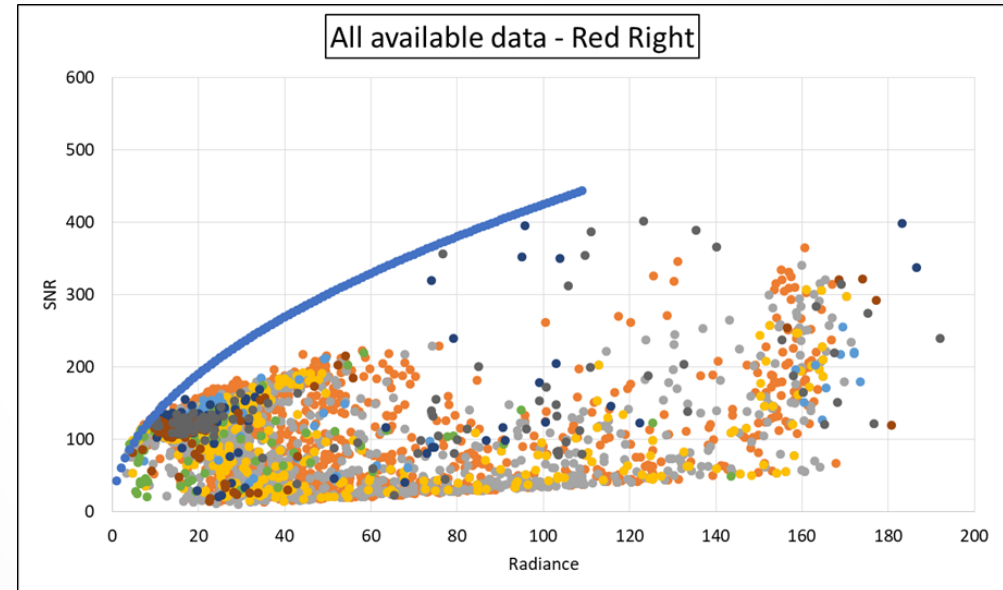
For Proba-V the shot noise limited model did not fit. Instead we noted for the blue band an almost linear relationship between increasing signal and noise. Lots of outliers due to missing or low data quantities in the statistics.

# SNR ESTIMATION – PROBA-V



Missing or corrupt data an issue

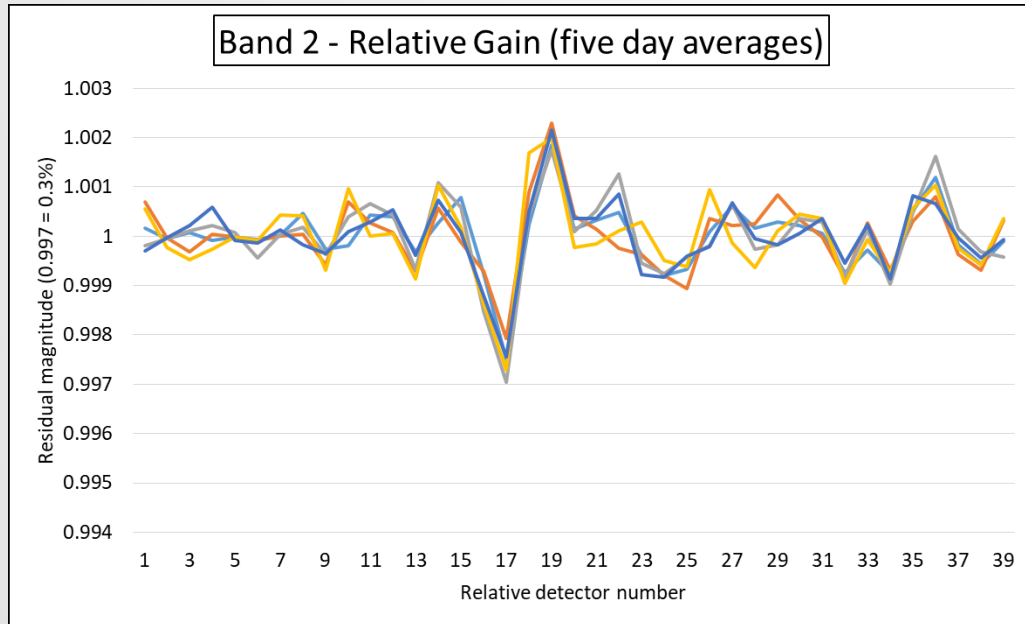
Shot noise limited curves give poor fit



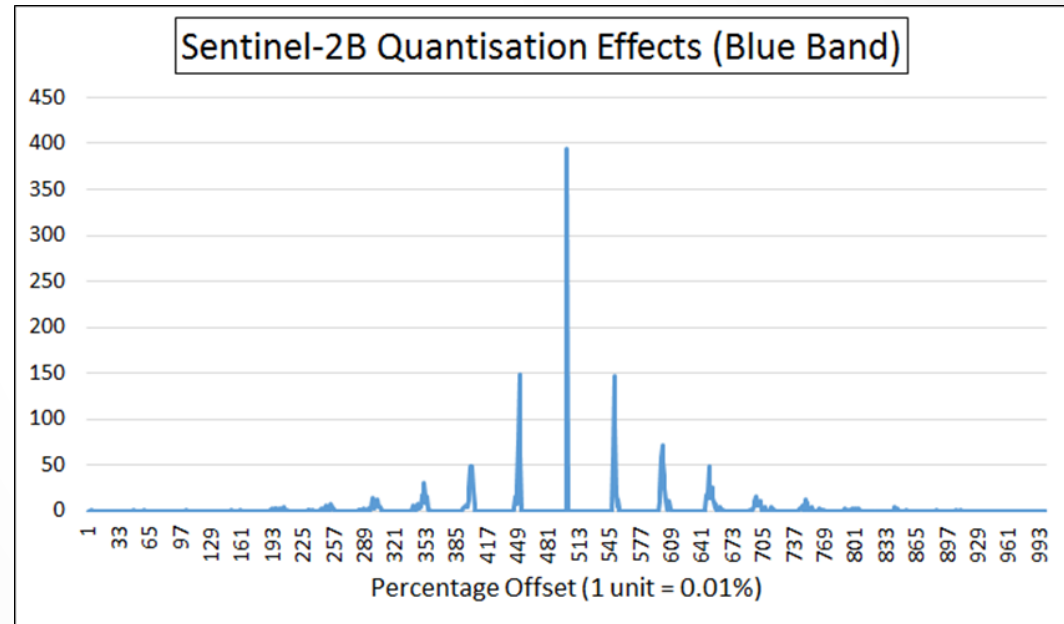
Band	VITO estimate	Lower estimate SNR	Upper estimate SNR
Blue	155-1	213-1 (Linear to noise)	213-1 (linear to noise)
Red	430-1	270-1 (forced fit)	470-1 (best shot noise)
NIR	529-1	500-1 (log fit to noise)	527-1 (linear fit to SNR)
SWIR	380-1	> 200-1 (data upper limits)	> 200-1 (data upper limits)

All snow scenes were saturated or poor quality

# RELATIVE GAIN / NON-LINEARITY – SENTINEL 2



Each line is a separate five day average. X-axis is detector number showing 39 detectors, y-axis is the relative gain residual (0.998 = 0.2%).

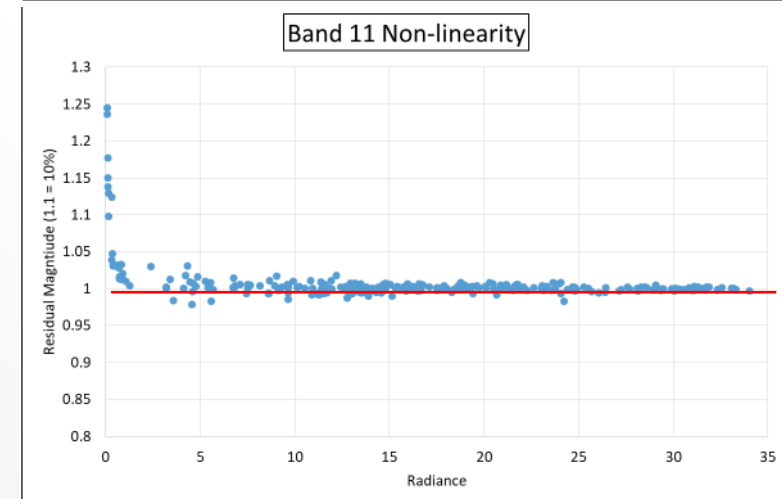
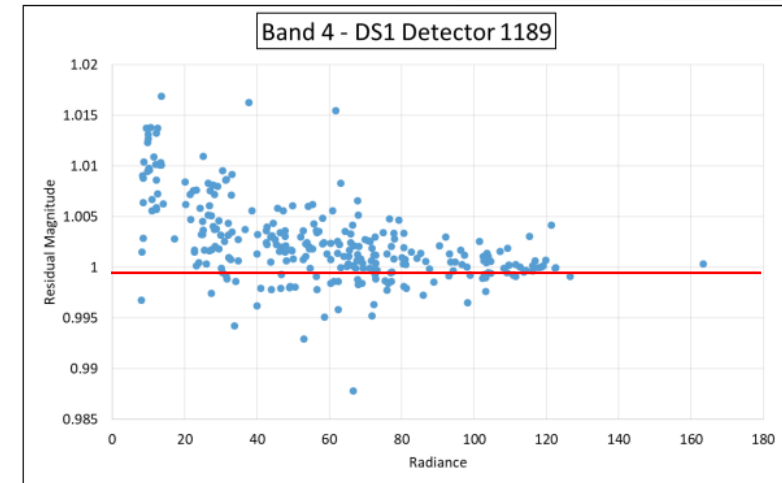
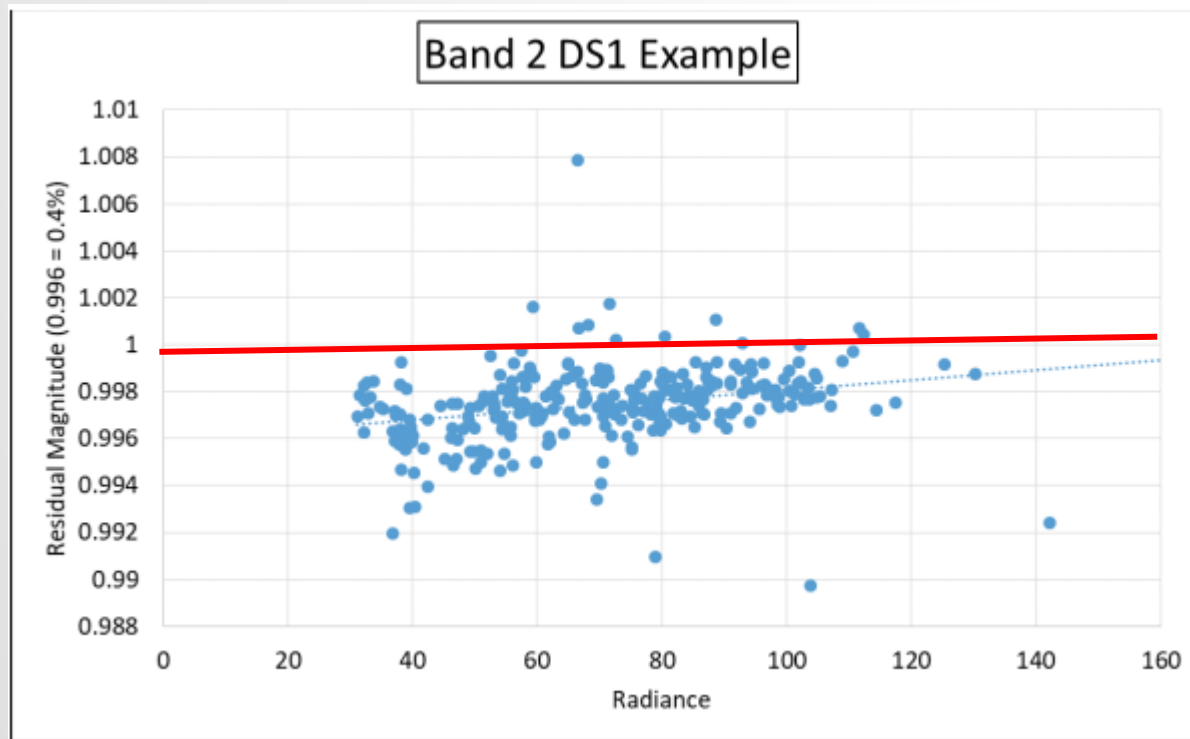


The histogram peak in theory shows detector to detector offsets. However, for Sentinel-2 the peak is always at 500 which means no offset (so perfectly calibrated) this is not reality. Peaks are about 0.5% apart. So it would need a shift of  $> 0.25\%$  in the signal level.



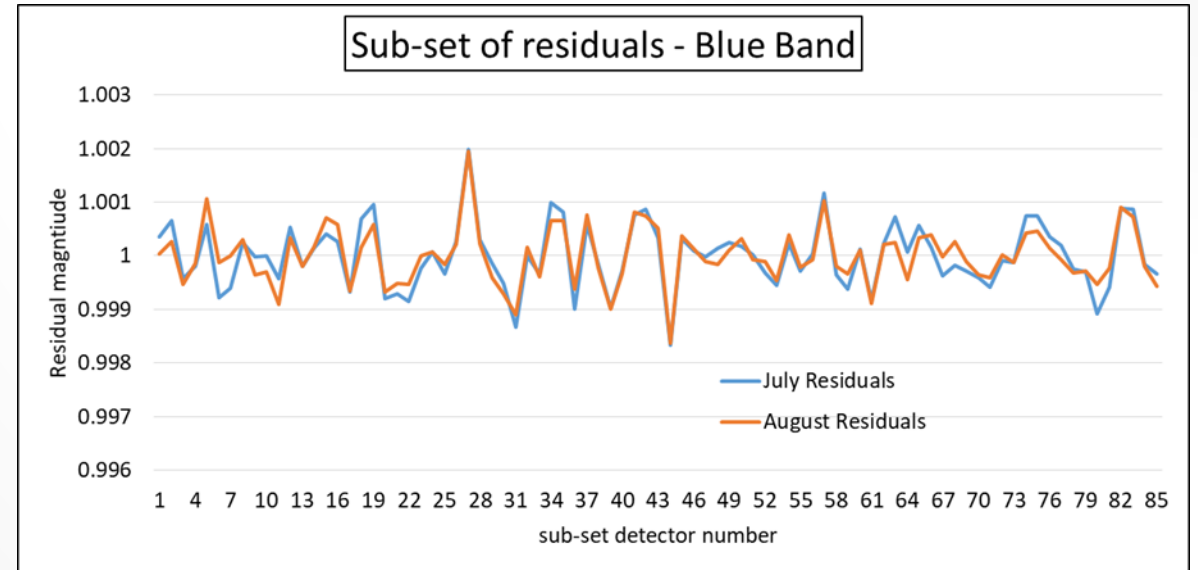
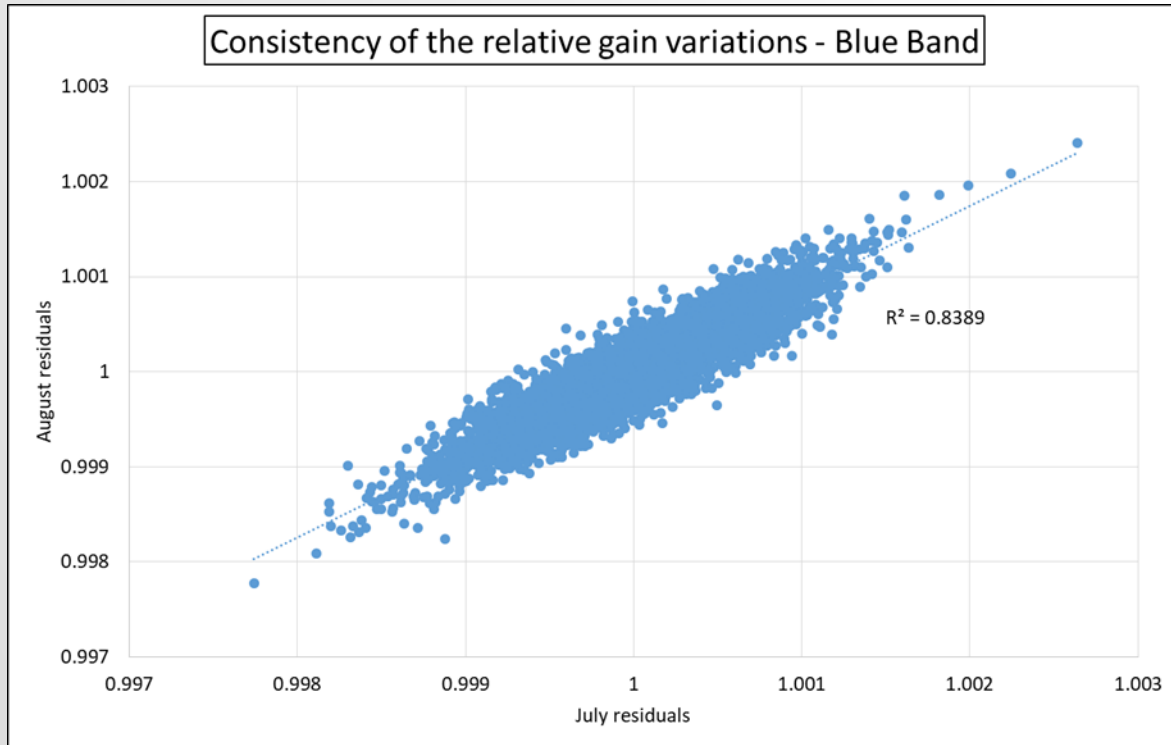
# RELATIVE GAIN / NON-LINEARITY – SENTINEL 2

- Relative gain shifts seem related to non-adjusted non-linearity effects due to additive (bias) and multiplicative (gain) errors.



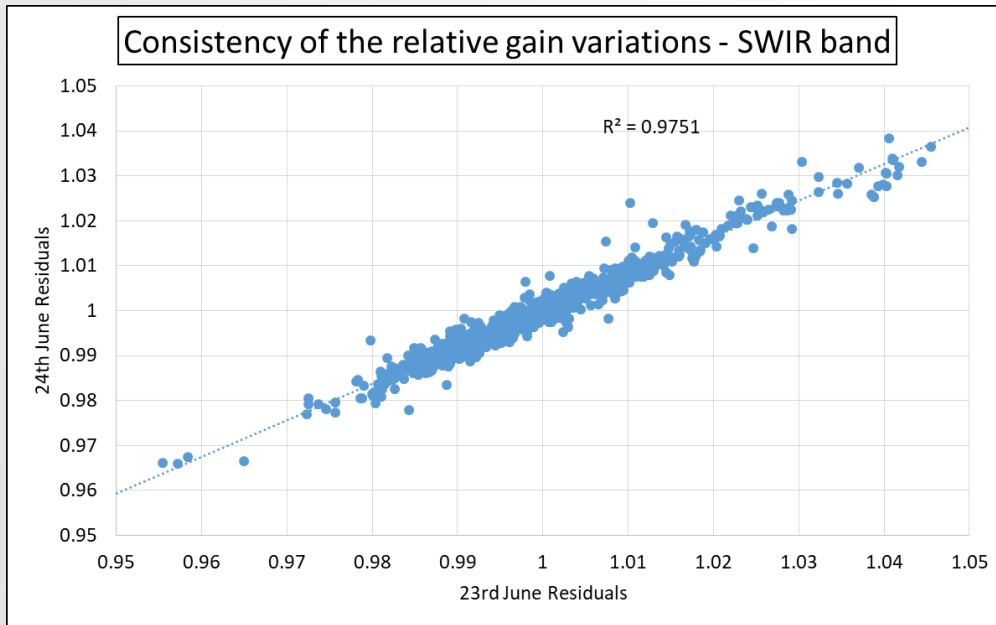
# PROBA-V

- Working on understanding the causes of non-linearity and detector behaviour.

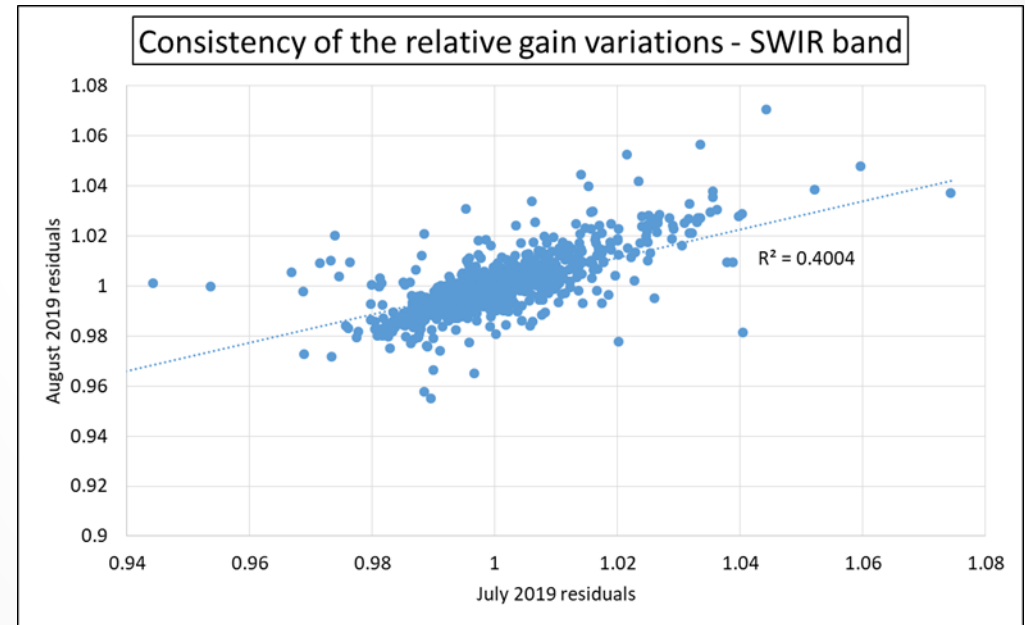


# PROBA-V

- Working on understanding the causes of non-linearity and detector behaviour.



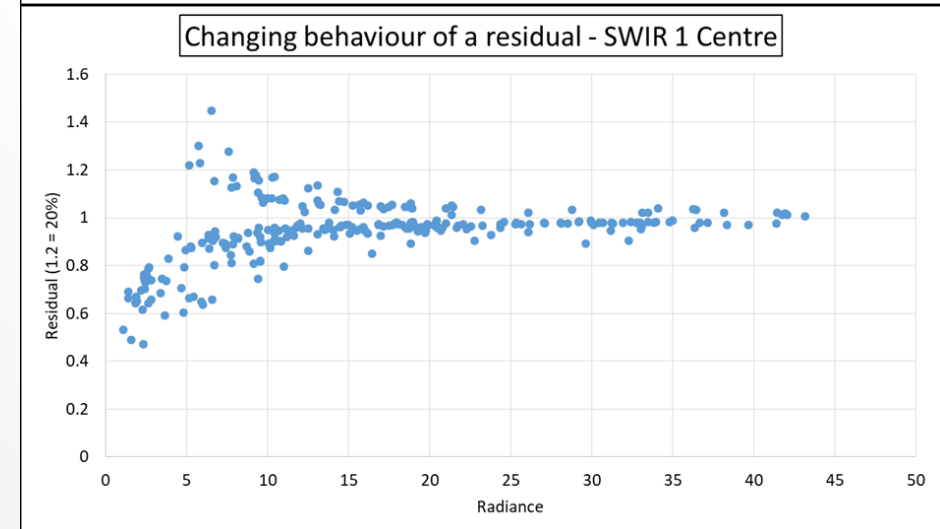
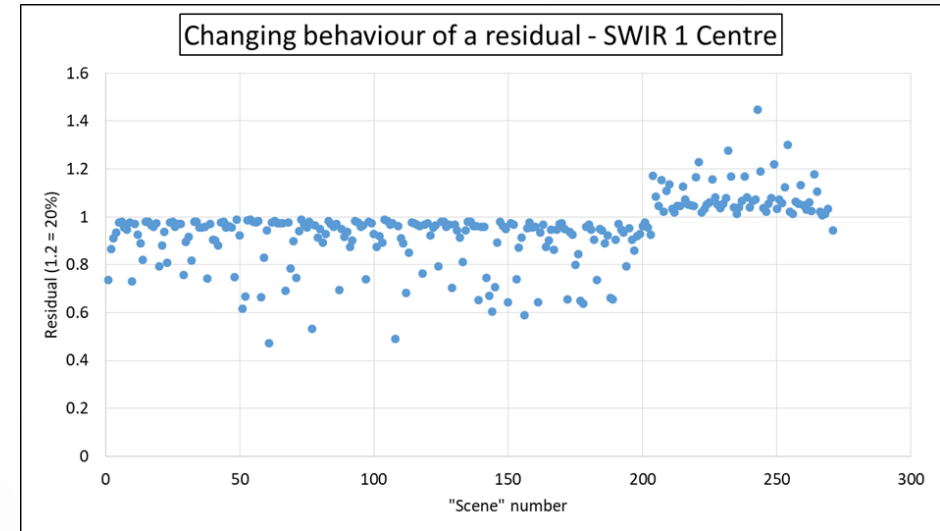
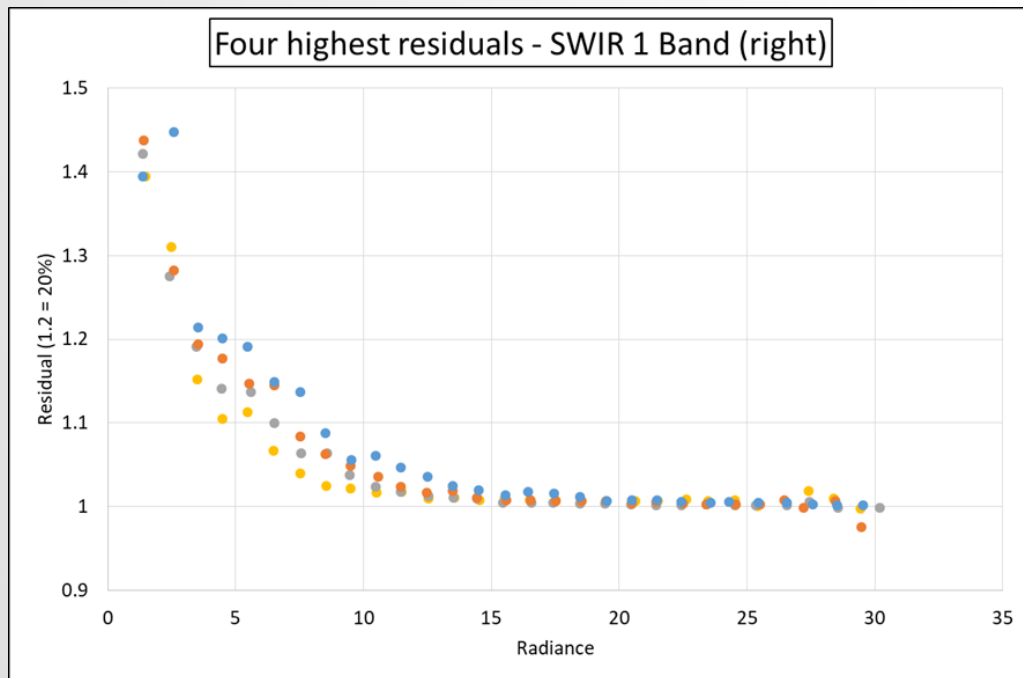
Day to day



Month to Month

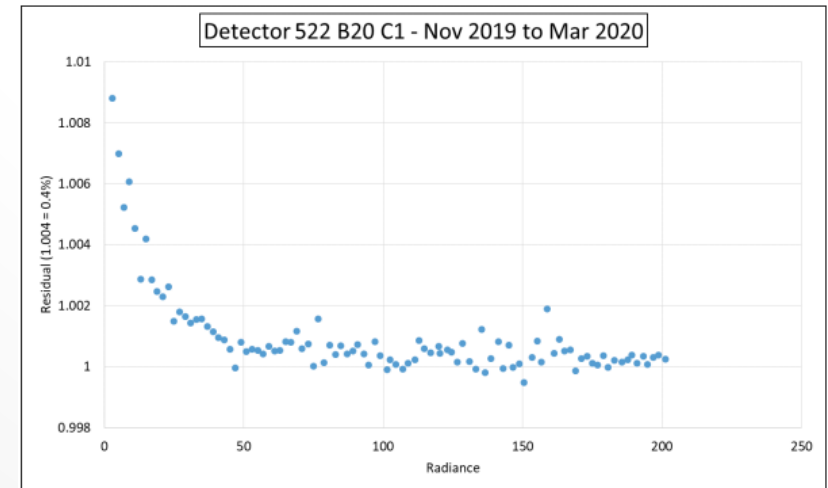
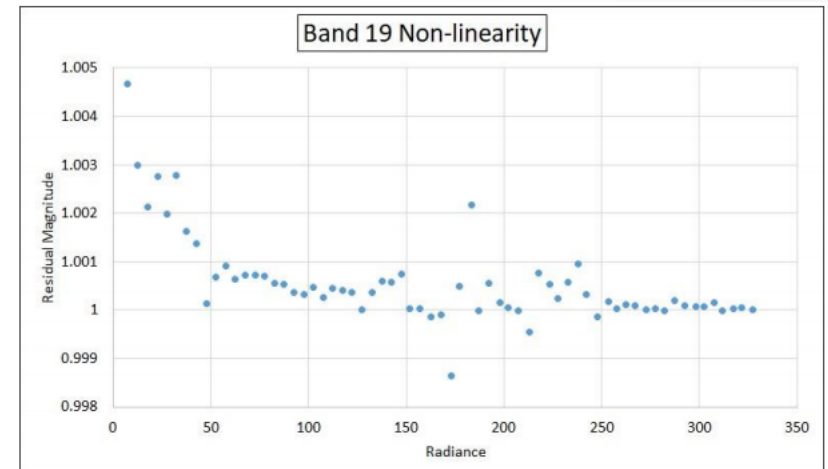
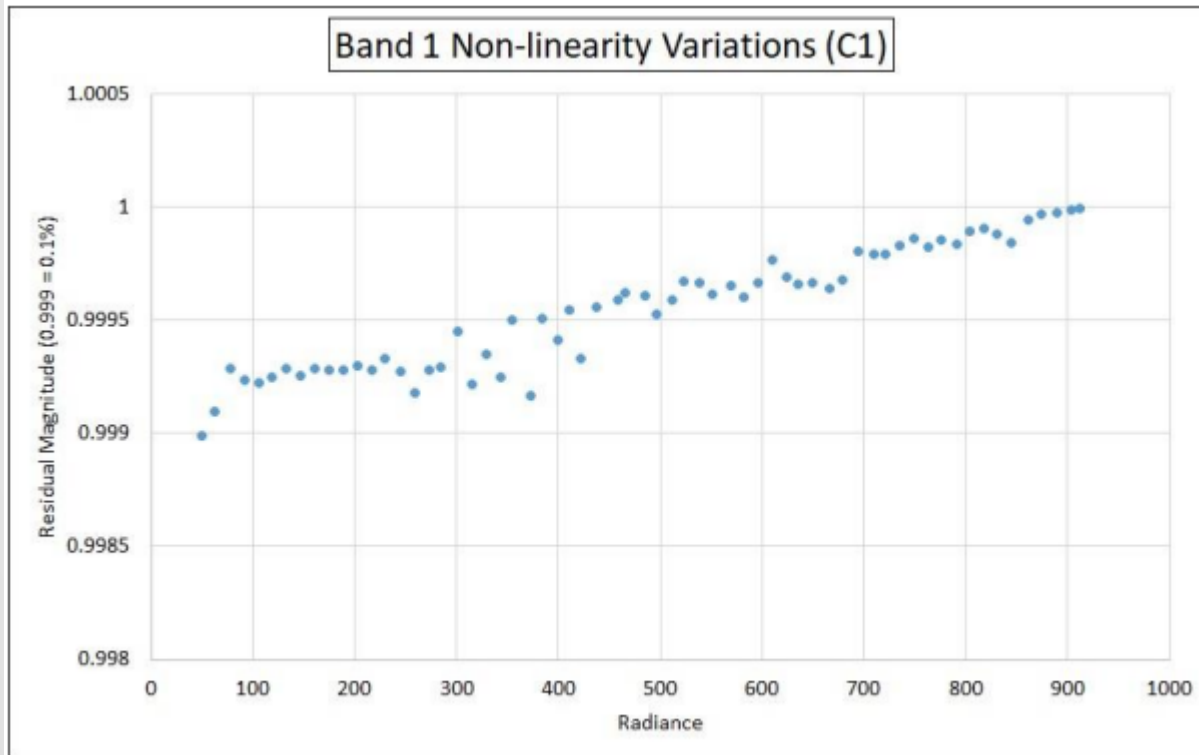
# PROBA-V SWIR BAND

- Bias flips between different states causes large additive features.



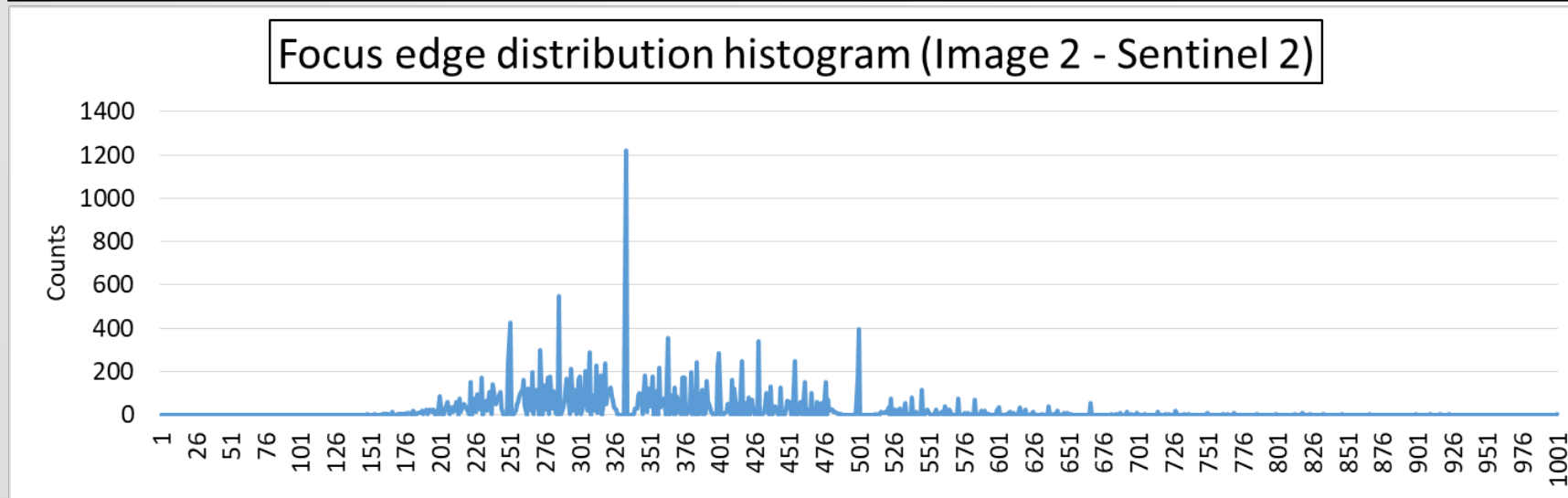
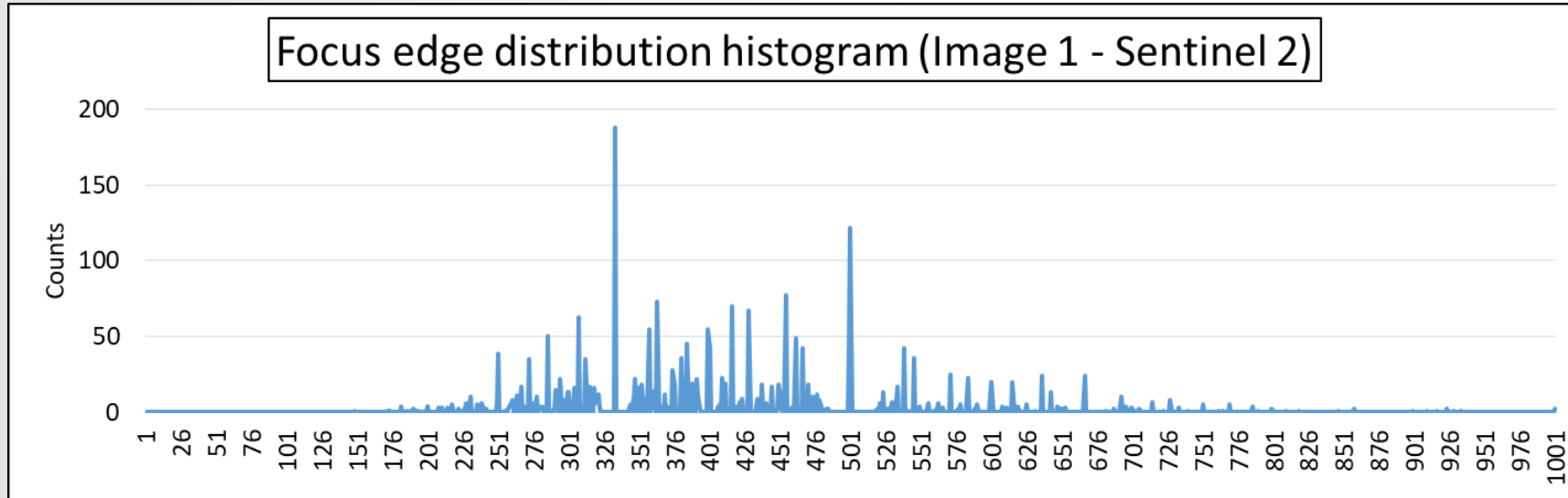
# OLCI

- Has similar behaviour to S2, with shorter wavelengths showing small multiplicative offsets, while longer wavelengths show large additive offsets mainly affecting the lower radiance range. This is the same for Proba-V.



# FOCUS – SENTINEL 2

- Quantisation effects in two histograms



Algorithm uses edges and texture to determine focus.

However quantisation means that specific edges recur on a regular basis in quantised magnitudes producing spikes at specific values

# SUMMARY

- Techniques work well on very different sensors from small high resolution satellites to S2 MSI and S3 OLCI and Proba-V spatial resolution.
- Methods show a lot about the causes of some of the errors, I say errors as they are repeatable and can be corrected.
- Methods show that model assumptions may not be true and that using a single source of information for data quality assessment may give inaccurate estimates if based on those assumptions.
- Sentinel-2 shows issues related to signal quantisation not seen on any other sensor. Is this related to the compression or some truncation step?