EOSense

INNOVATIVE METHODS FOR INFLIGHT CALIBRATION

IDEAS-QA4EO Cal/Val Workshop#4

28th February – 2nd March 2023 – Potsdam (Germany)

Project	Project		
	EOSense WP-2160		Version 3

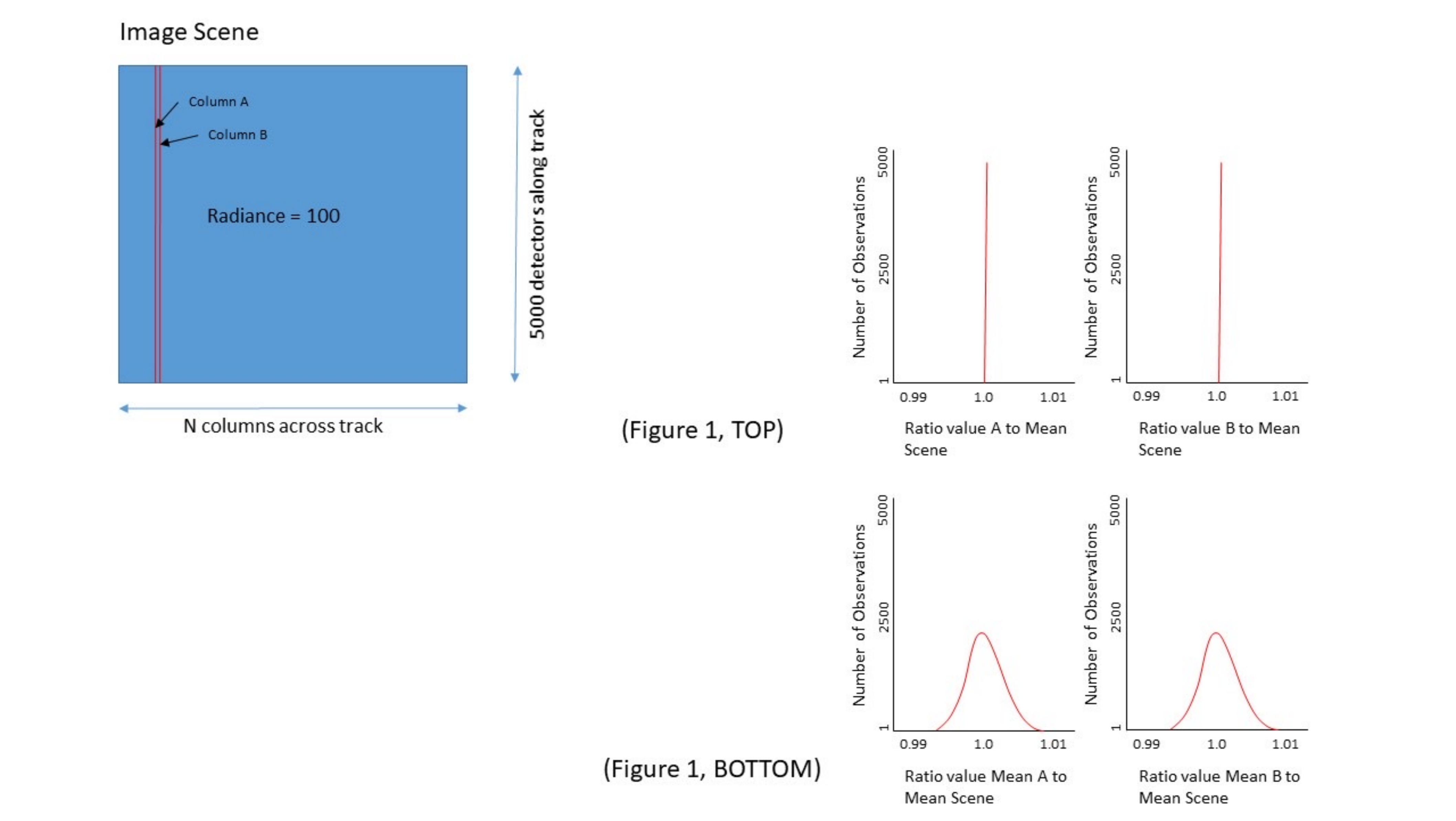
CURRENT PROGRESS AND TODAYS PRESENTATION

- A software package to process Proba-V data and the follow-on small satellite system data has been developed and delivered. This extracts,
  - SNR information
  - Relative gain information
  - Non-linear behaviour between detectors.
- The software is provisional and still under development, but hopefully will be used during the commissioning period.
- Today I wish to discuss in detail how the relative gain algorithm operates (about time some of you may say).

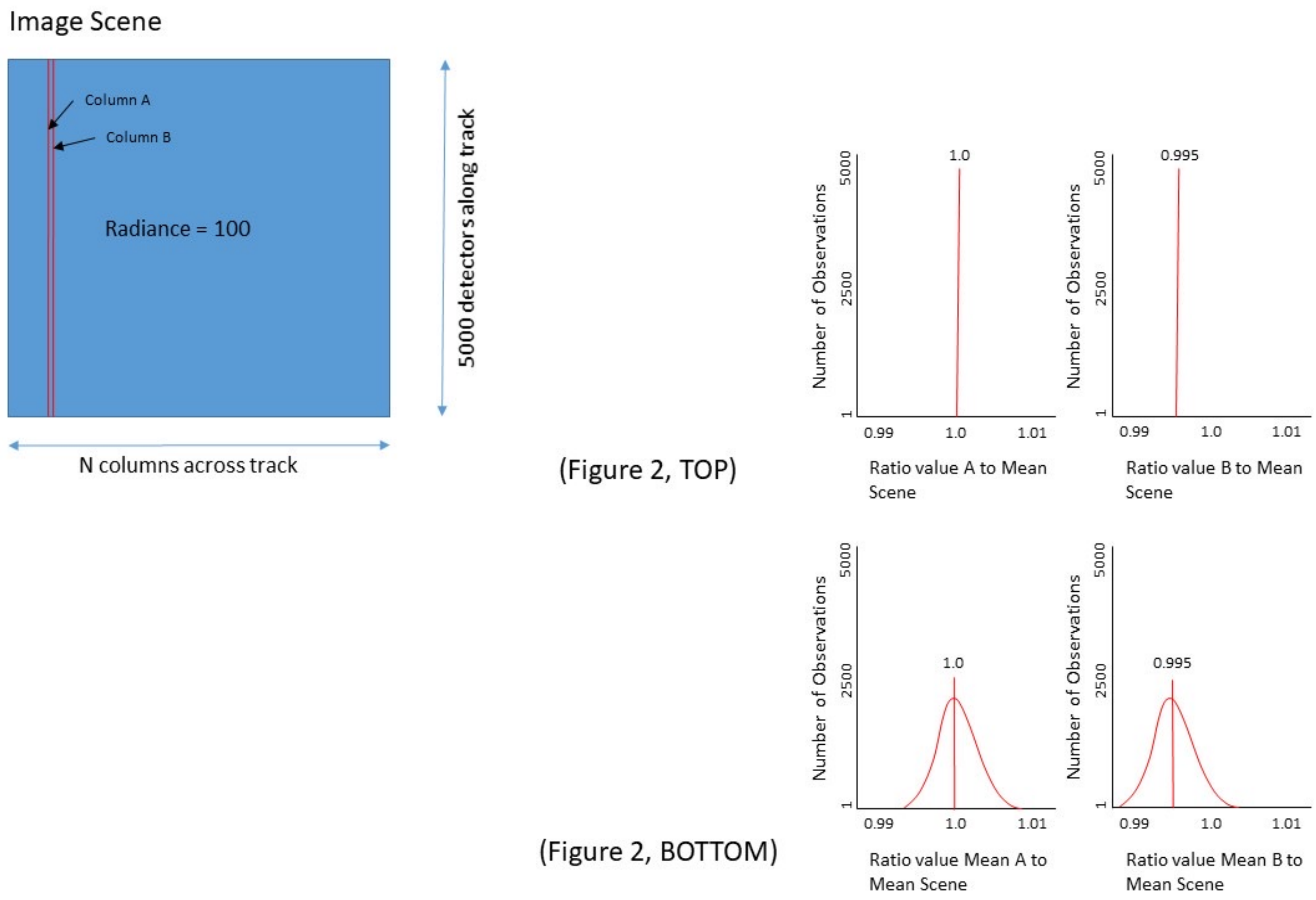
RELATIVE GAIN OBJECTIVES

- To derive equalisation coefficients using normal images rather than homogeneous surfaces (snow, on-board diffusers etc.)
- To use the simplest possible algorithm that requires no specific calibration images and is not affected by the type of surface or presence of cloud.
- To use those derived coefficients to correct for very small additive and multiplicative errors.

BASIC PRINCIPLES - HOMOGENEOUS SCENE WITH NOISE RATIO OF COLUMN VALUES TO SCENE MEAN

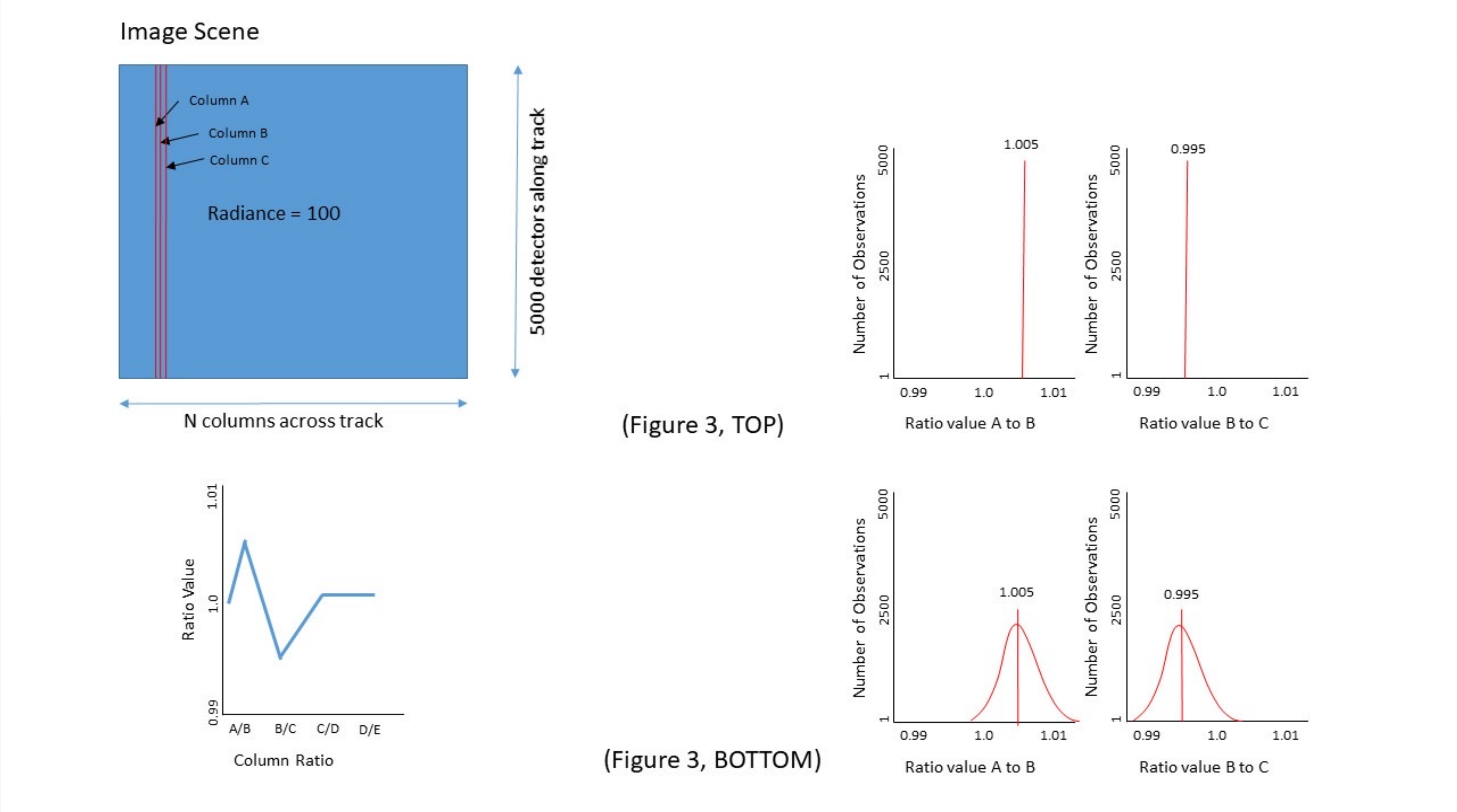


HOMOGENEOUS SCENE WITH NOISE AND A CALIBRATION ERROR
RATIOS OF COLUMN VALUES TO SCENE MEAN



HOMOGENEOUS SCENE WITH NOISE AND A CALIBRATION ERROR RATIOS BETWEEN COLUMN PIXELS

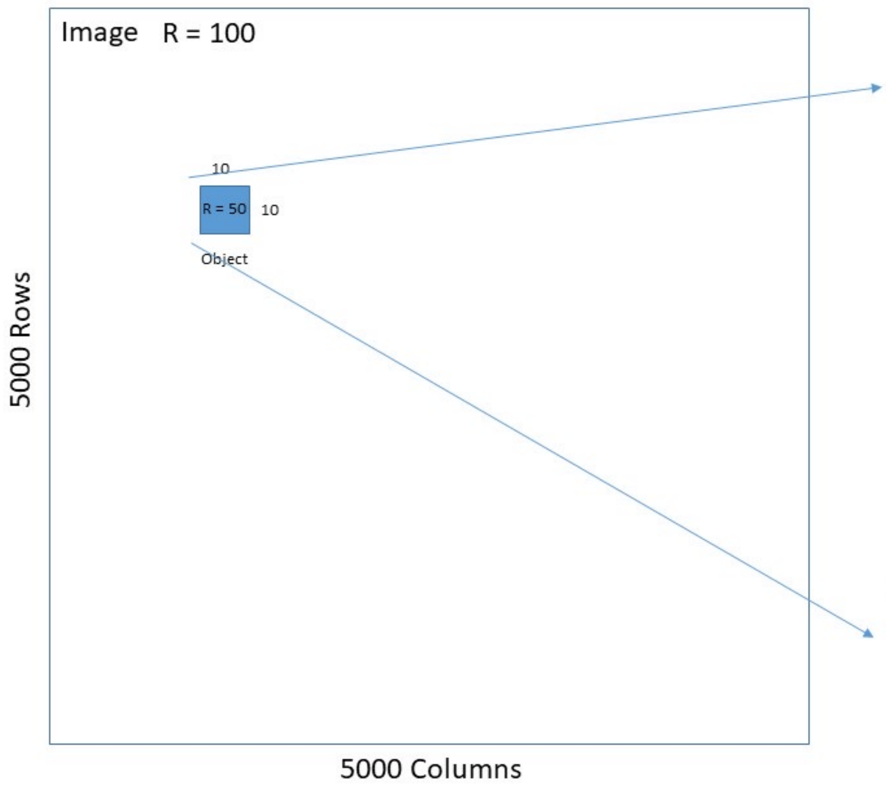
Assumption : There is a high spatial correlation between neighbouring pixels



(Figure 3, TOP)

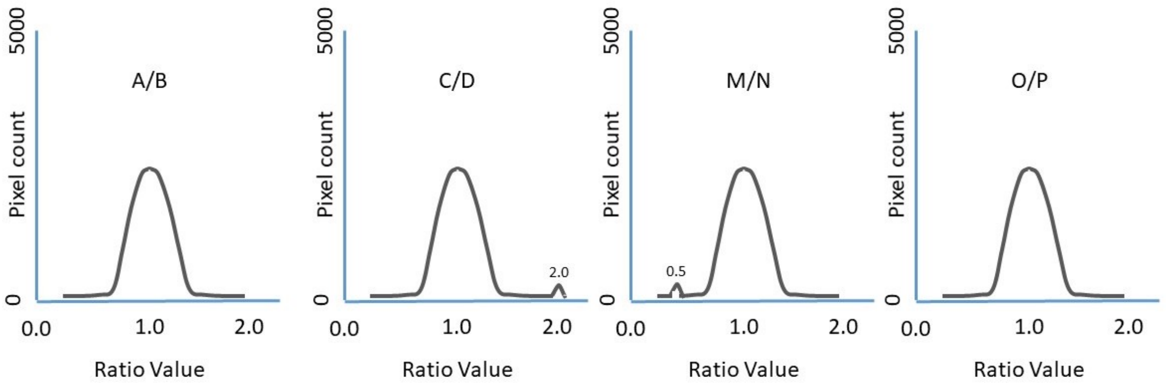
(Figure 3, BOTTOM)

HETEROGENEOUS DATA NO CALIBRATION ERROR
RATIO OF PIXEL TO PIXEL VALUES (AVERAGE PER COLUMN)

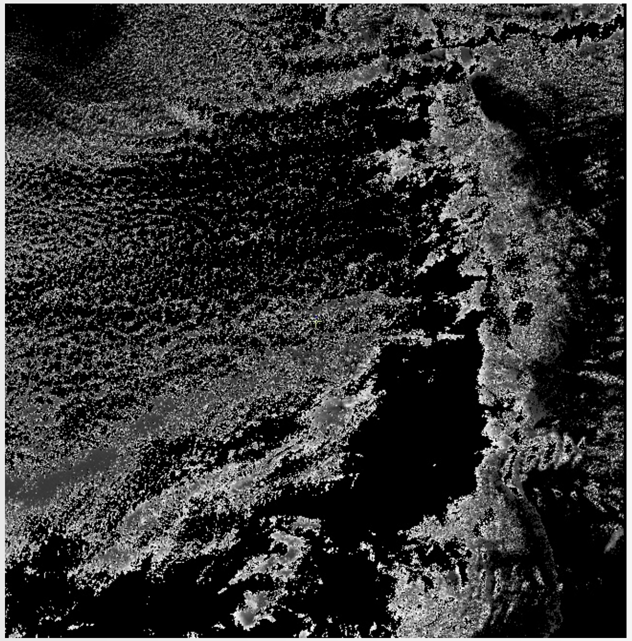


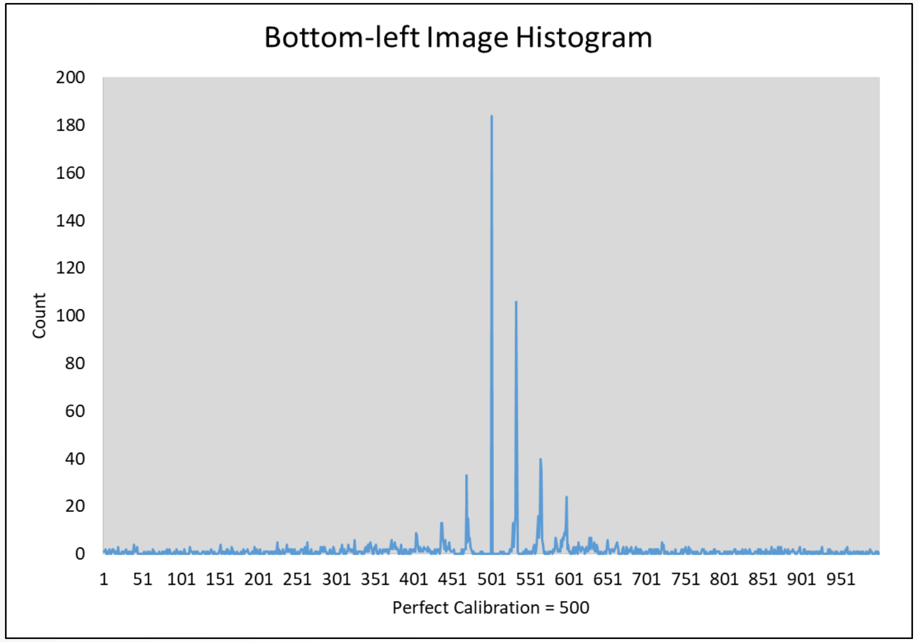
Columns

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



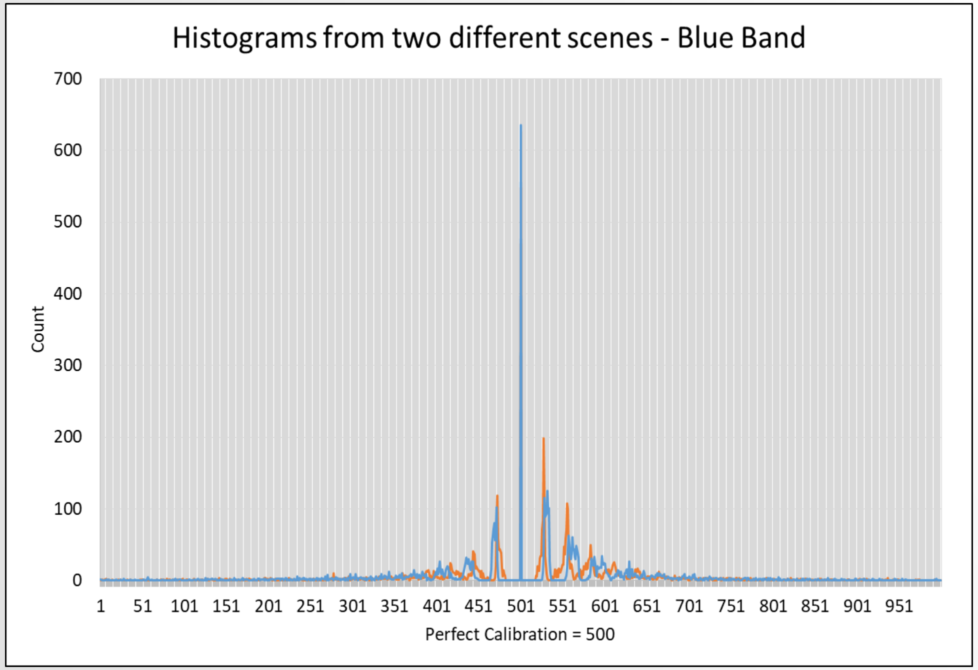
REAL OUTPUT FROM PROBA-V



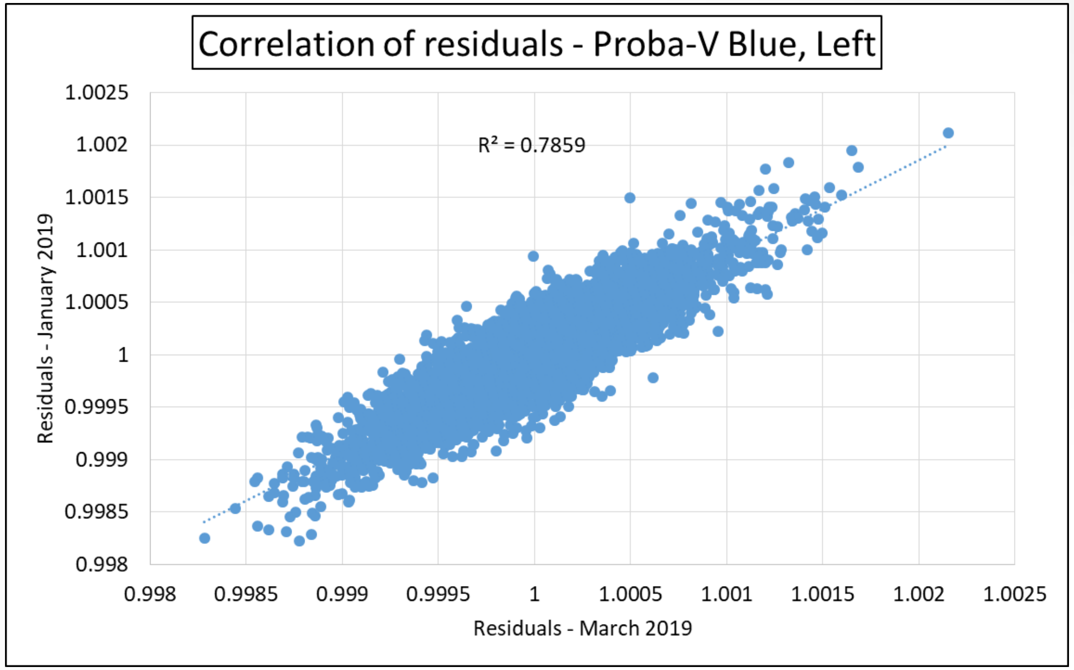


The image left has missing data, clouds and surface pixels. The histogram is that from comparing two columns pixel by pixel and binning the results. Note the quantisation of the values, but also the asymmetry.

CONSISTENCY ACROSS SCENES



The histogram derived from ratioing two columns of data is consistent in this case.



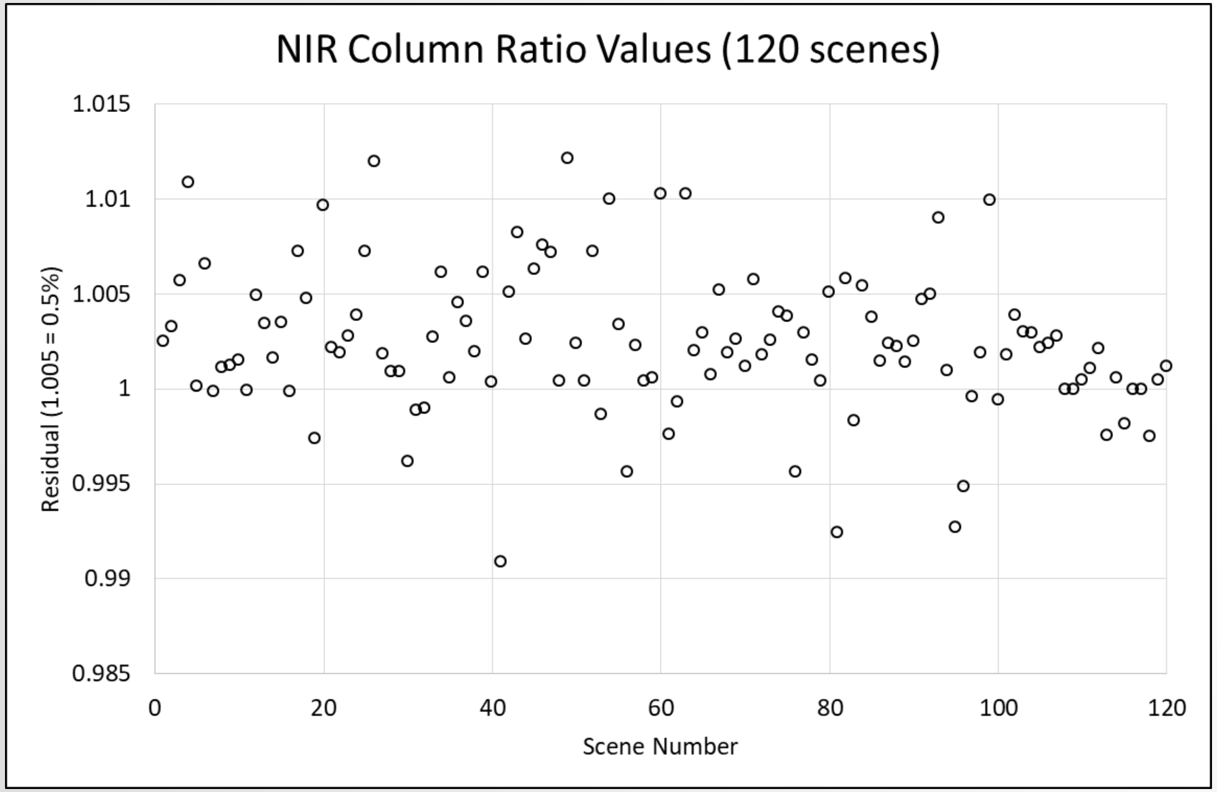
Looking across all columns in a scene and comparing to another time period, we see long term consistency

EXTENSION TO NON-LINEARITY

- We noted that the residuals varied in magnitude from one time period to another. Suggested a relationship with brightness.
- So took same data and average brightness and binned by brightness.
- Found shorter wavelength bands of S3-OLCI, S2-MSI and PROBA-V showed more or less multiplicative effects.
- Found that longer wavelength bands of S3-OLCI, S2-MSI and Proba-V all showed an asymptotic effect, which suggests an additive component.
- The additive term can be assessed and corrected by simple modelling.

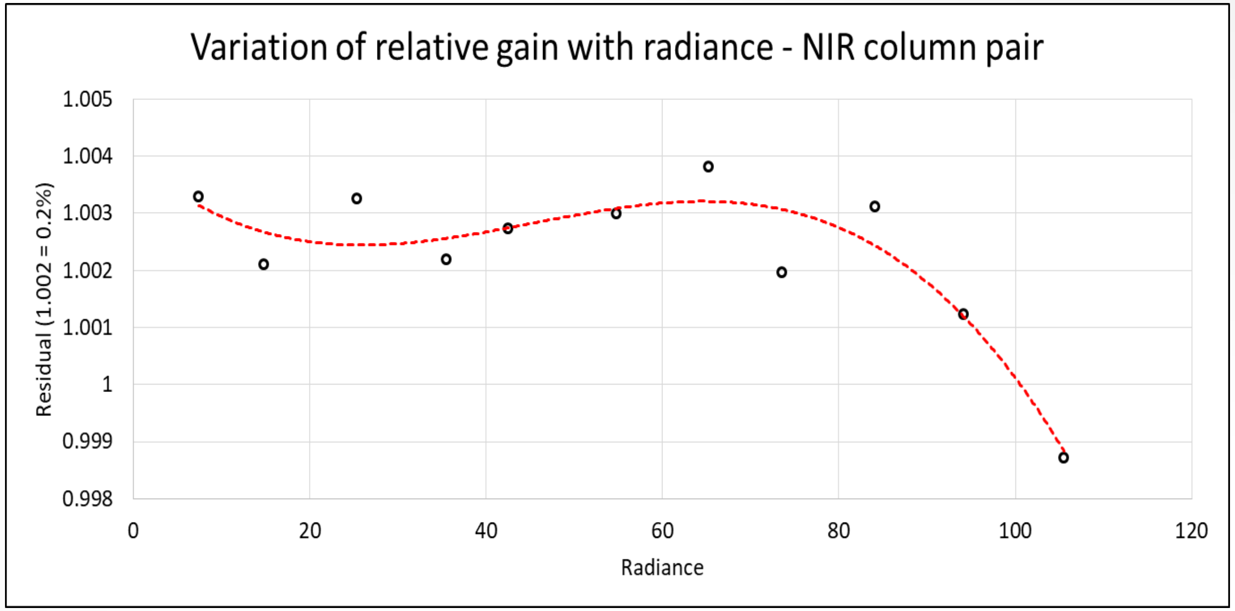
SHORTER WAVELENGTH BANDS

(temporal plot)



Residuals for single column pairing 120 scenes is 4.5 orbits (1/3rd day)

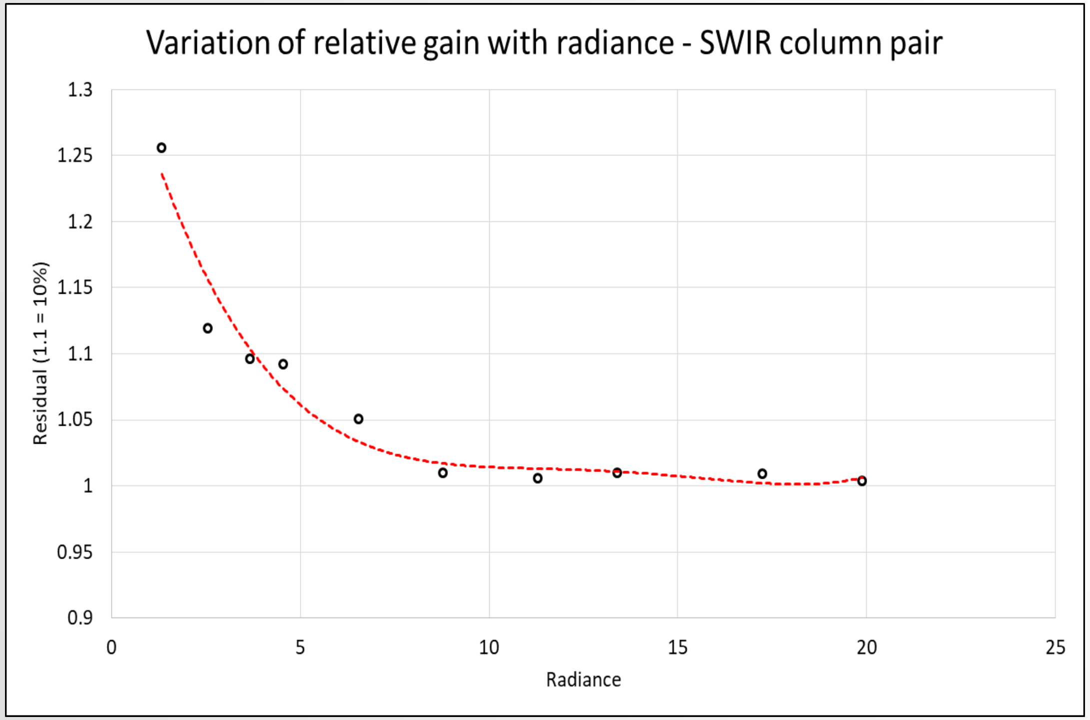
(radiance binned plot)



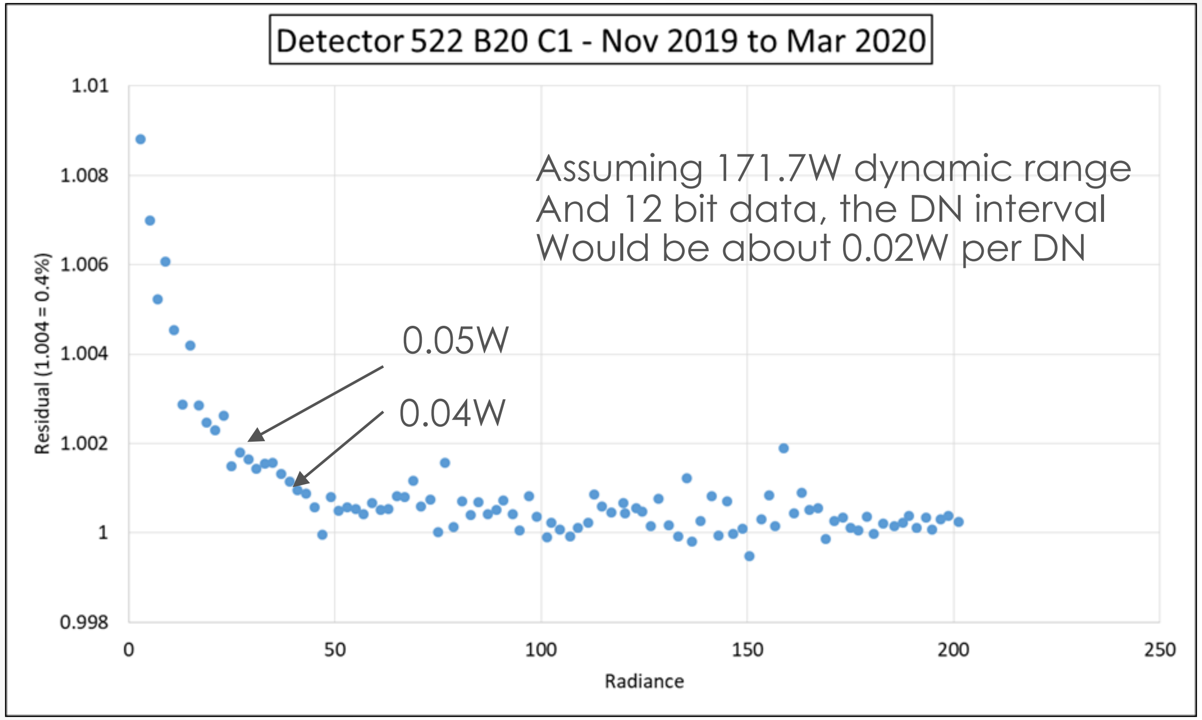
Binned values by radiance, show consistency (except at high radiance due to low number of data points)

LONGER WAVELENGTH BANDS

(radiance binned plots)



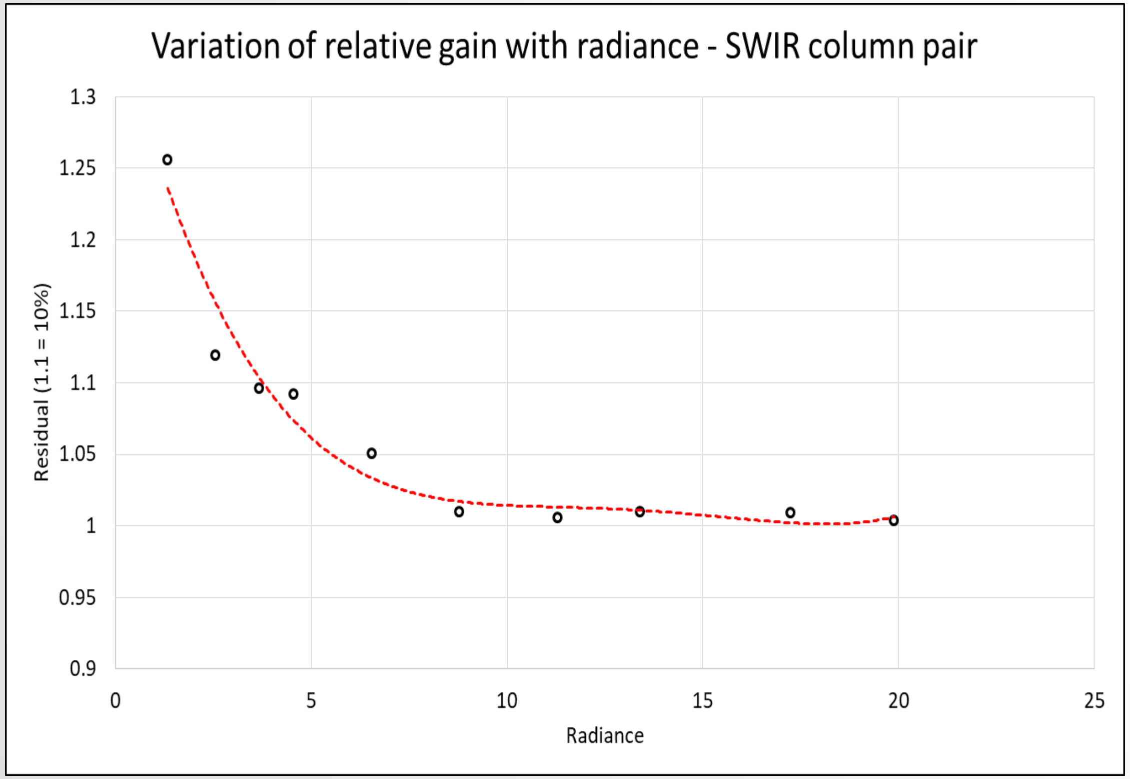
Proba-V example (SWIR)

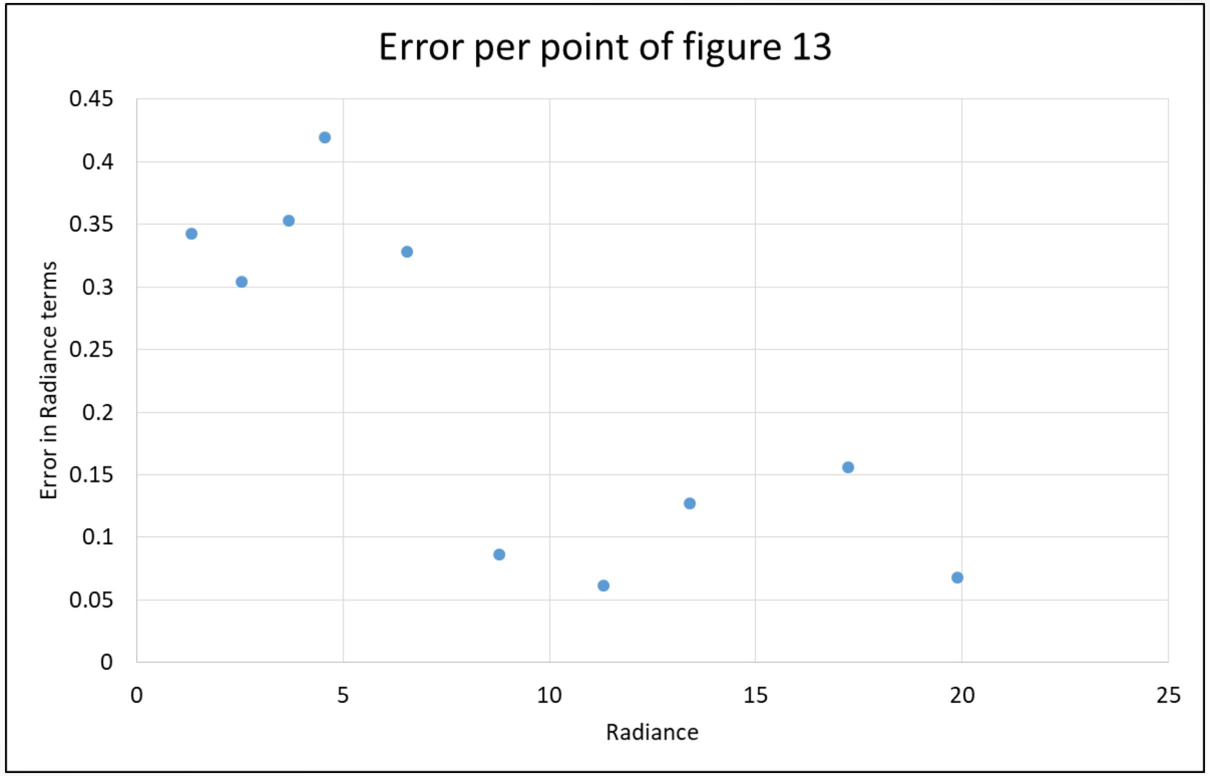


S3-OLCI example (SWIR)

LONGER WAVELENGTH ERROR CALCULATION

(radiance binned plots)





Since we know the signal (radiance) and the error percentage, its simple to calculate the error in radiance terms for each point.

STEPS

- For each column pair of each scene, ratio the first pixel of column 1 with the first pixel of column 2, then the second pixel for column 1 with the second of column 2.
- Collect the statistics for the whole column pair in a distribution and find the mean of the distribution (good approximation of what we need), ignore central peak in average if quantised.
- Do the same for all the columns and generate average output residuals for every column pair. Multiply each average output residual by its neighbour (we used logs so added each, but the principle is the same).
- Run a Savitsky-Golay filter on output from previous step to get a smoother version of the output, divide the original version by this smoothed version to get the high frequency residuals we need.
- Do it for multiple images, the higher the number the lower the final uncertainty. Collect in a database and get the average values across multiple images.
- For multiplicative corrections, multiply the first residual value against the second column radiometric coefficients, etc.
- For additive corrections, there is a simple modelling step (can be automated) and then apply correction in the same manner, detector by detector but additive this time.

ADVANTAGES

- Simple to use.
- No specific calibration sites
- Observation conditions are not important as its based on statistics, not single images.
- Derives information in the difficult to observe range of background earth brightness.
- Continuous observation providing rapid updates.
- **<u>NOTE – Use radiance data that has not been resampled across detectors, otherwise you start to destroy the relationships.</u>**

FUTURE STEPS

- Continue the development of the software product in collaboration with VITO, so as to provide consistent, reliable, data quality monitoring.
- Further development of the analysis algorithms, as currently there are additional potential uses of the information derived from the processing.