



Pre-processing & its impact on the quality of small satellite images

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pinkmatter
space • earth • intelligence

State of the market

- ❖ Many startups
- ❖ A lot of vision and lofty goals
- ❖ Much funding

Where is the data?

- Do-Everything-Yourself approach
- Startups must focus on core contributions
- Data quality and repeatability problematic
- Negative perception from commercial marketplaces
- Lack of scientific trust in data

The EO Revolution is Yet to Hit Top Speed Despite its Obvious Potential

The inaugural EO Summit in London in June brought together Earth Observation leaders along with finance and insurance executives to get the pulse on the evolving satellite imagery and sensing market.

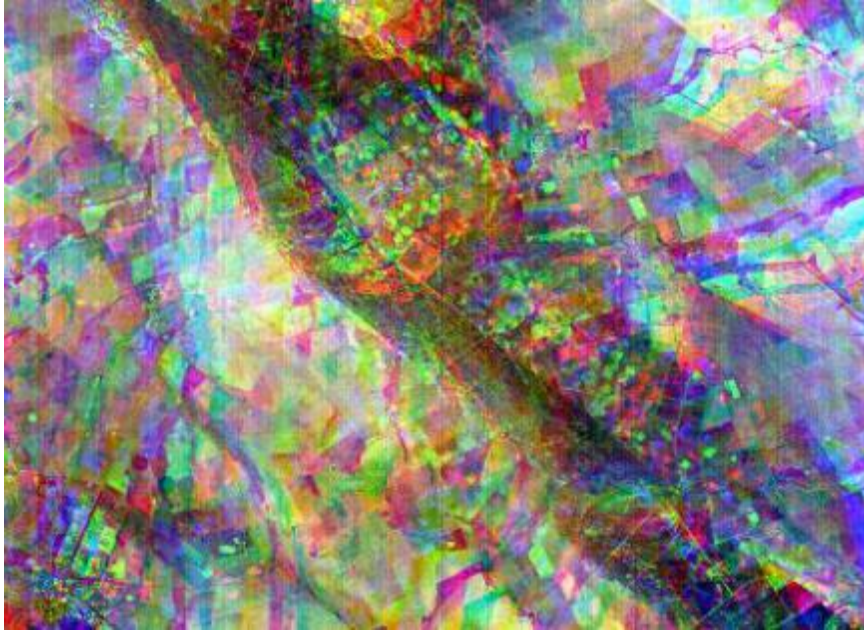


MARK HOLMES • JUNE 25, 2024

Jarkko Antila, CEO of Kuva Space, said the commercial part of the market is still in an early phase, with the defense market underpinning the EO market so far. **While supply chains for the defense part of the market have been developed, the commercial market is a different story.**

What is pre-processing?

All satellites require pre-processing of their raw data to be usable in downstream applications



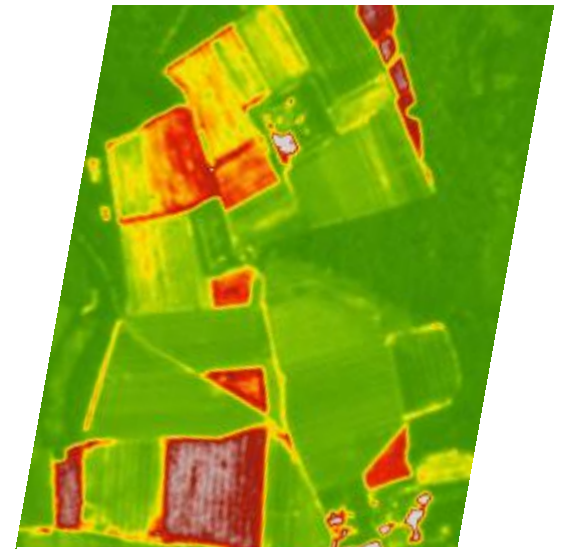
Unprocessed raw image



Calibrated and corrected product

- Satellite sensor calibration
- Radiometric and geometric image correction

Pre-processing



Downstream analytics applications

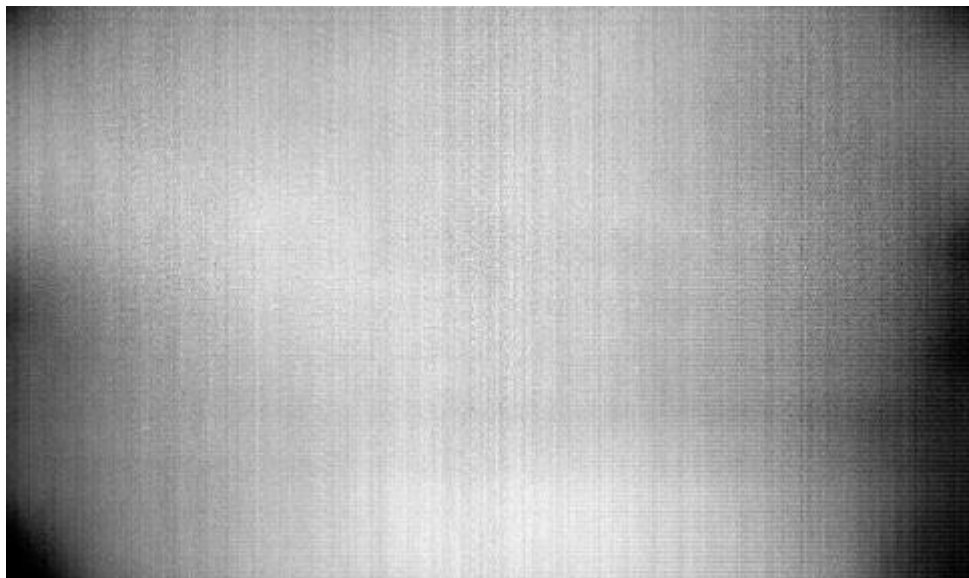
Downstream

Why is pre-processing necessary?

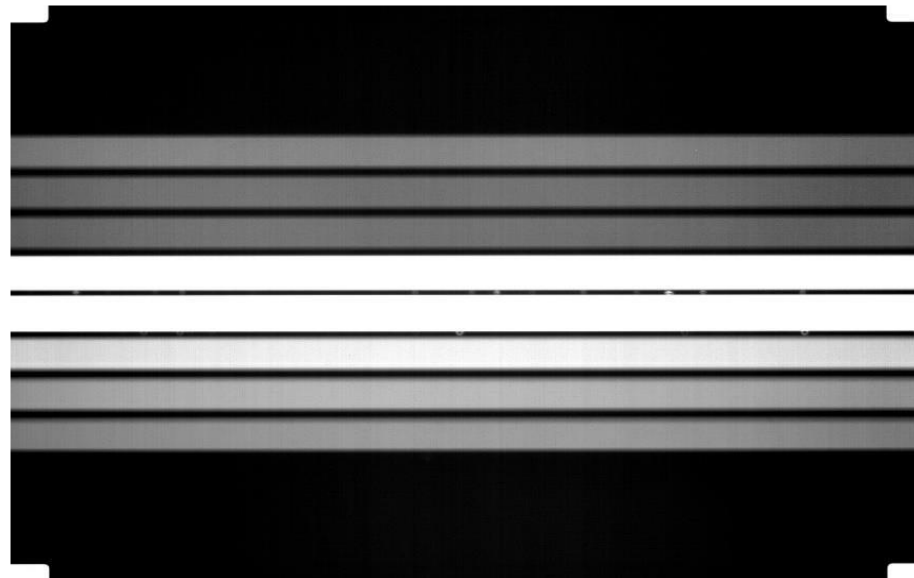
	Static	Dynamic
Radiometric	<ul style="list-style-type: none">• Non-uniform detector responses• Vignetting and optical butting• Optical aberrations• Sensor degradation (continuous)	<ul style="list-style-type: none">• Thermal readout noise• Banding (inconsistent exposure)
Geometric	<ul style="list-style-type: none">• Detector alignment (spatial)• Spectral filter locations• Field-of-view and bore-sight alignment• Band offsets and alignment	<ul style="list-style-type: none">• Inaccurate attitude determination• Vibrations and jitter• Clock drift (ADCS & OBC)• (Terrain and look angles)

Calibration with lab data - radiometric

Dark view acquisition in the
lab before launch

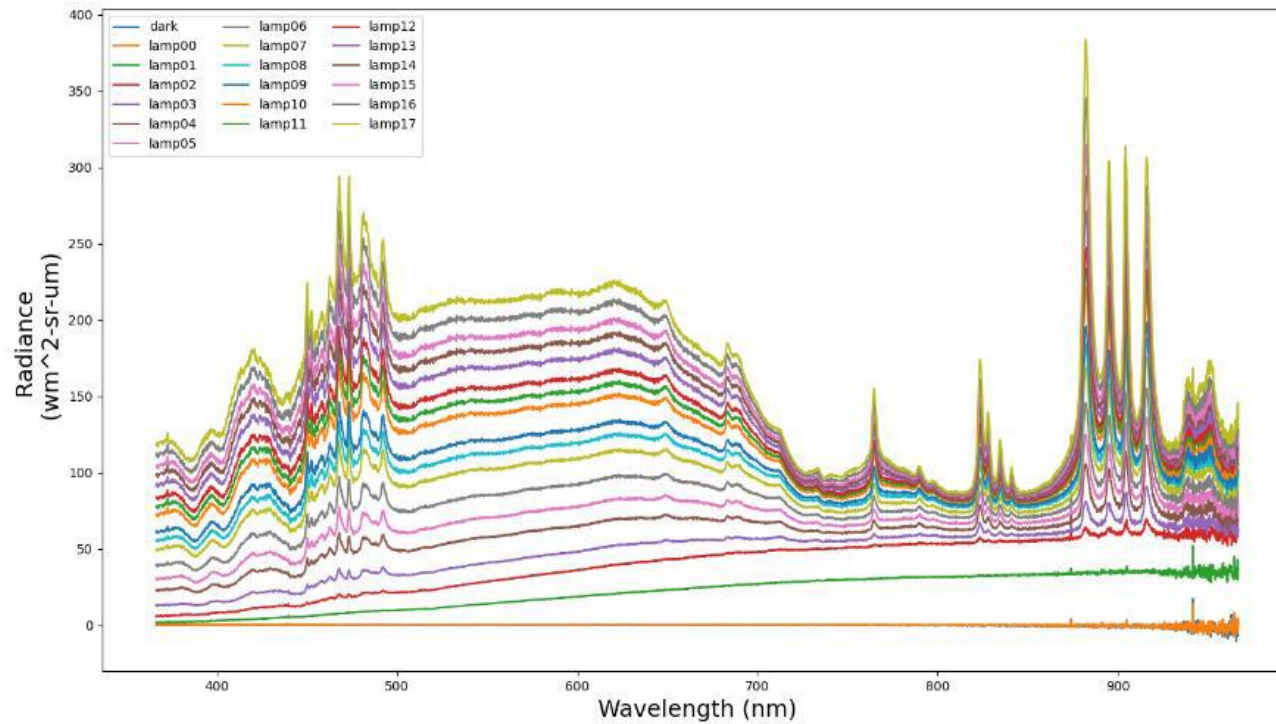


Flat field image with bandpass
filters installed

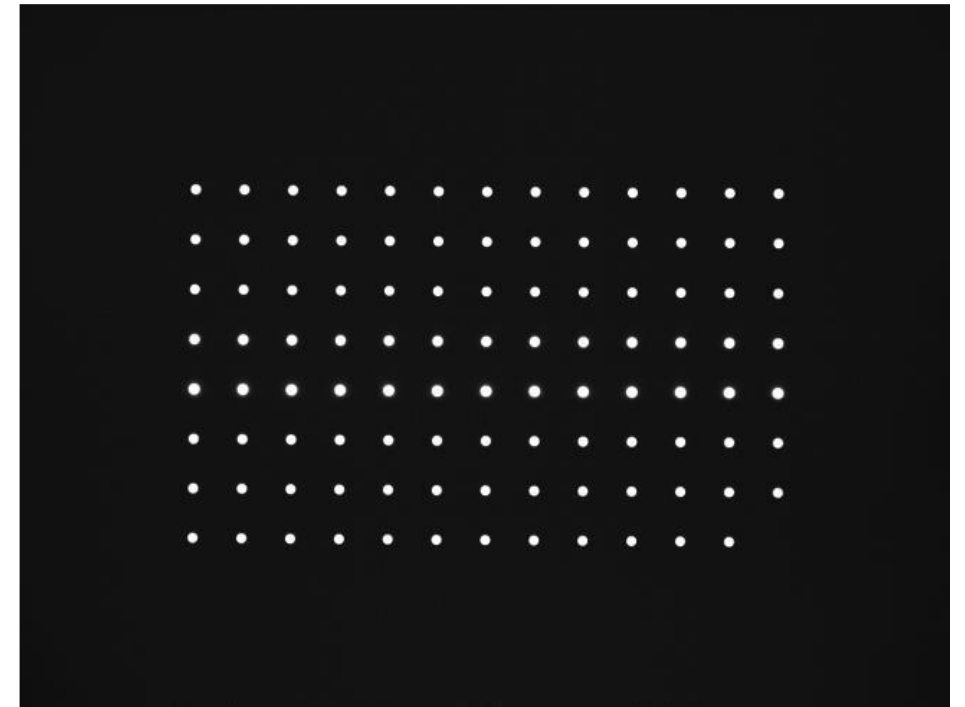


Calibration with lab data

Spectral radiance levels measured at various illuminations for a range of wavelengths



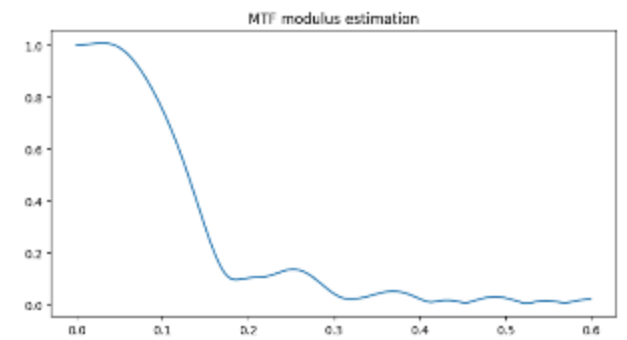
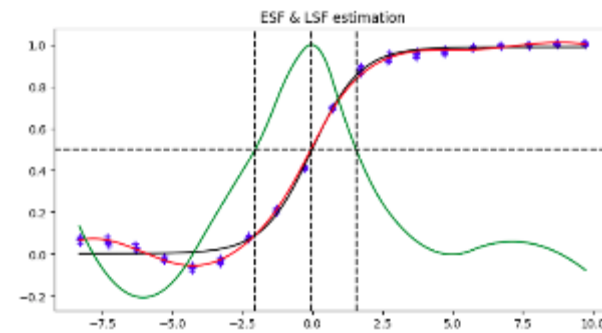
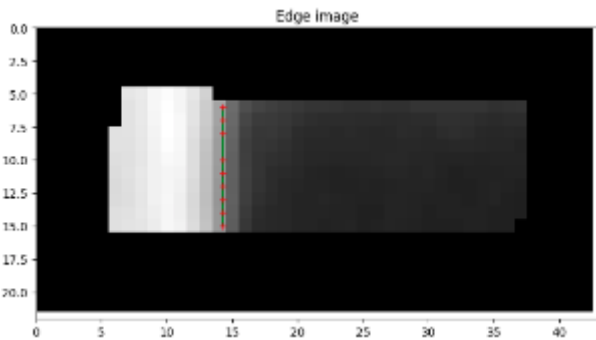
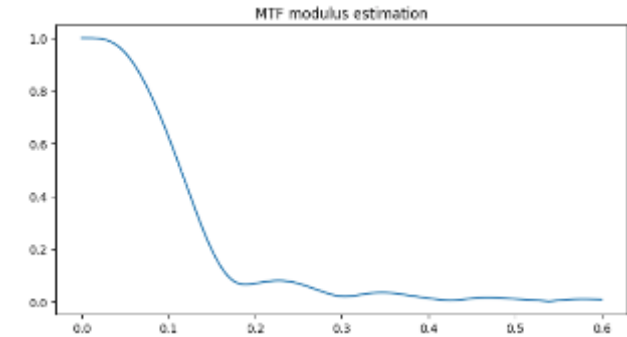
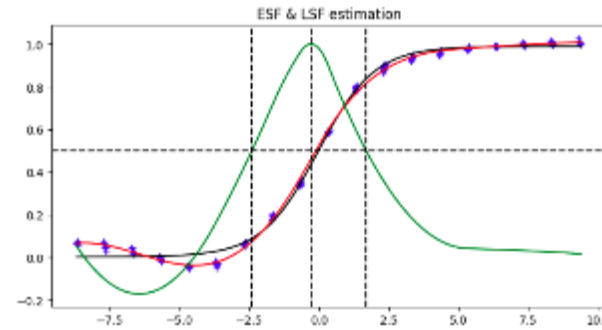
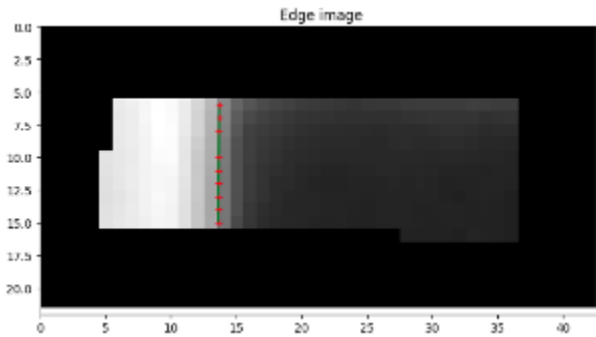
Collimator images to determine lens characteristics



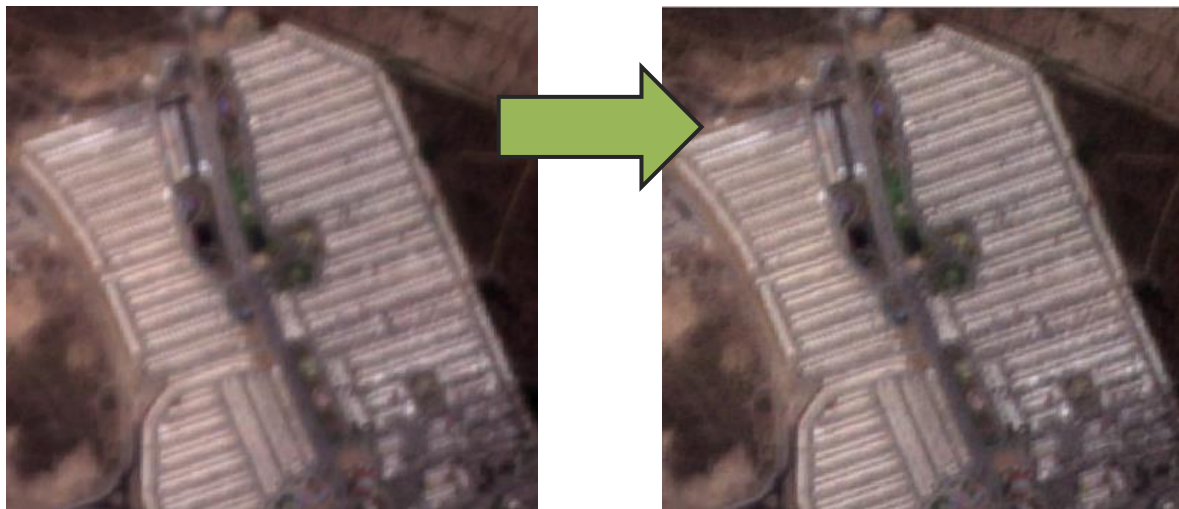
MTF compensation

The MTF was improved a modest 2% in this example with a simple sharpening

Sharpened



Using sharpening to compensate for MTF

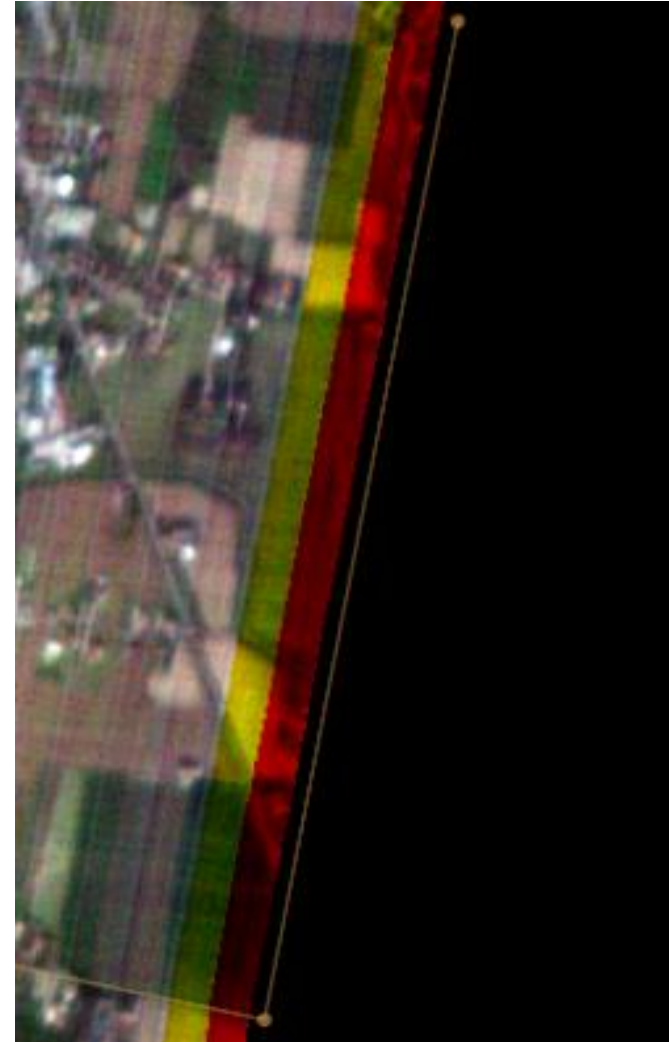


Some sharpening to optimize MTF response



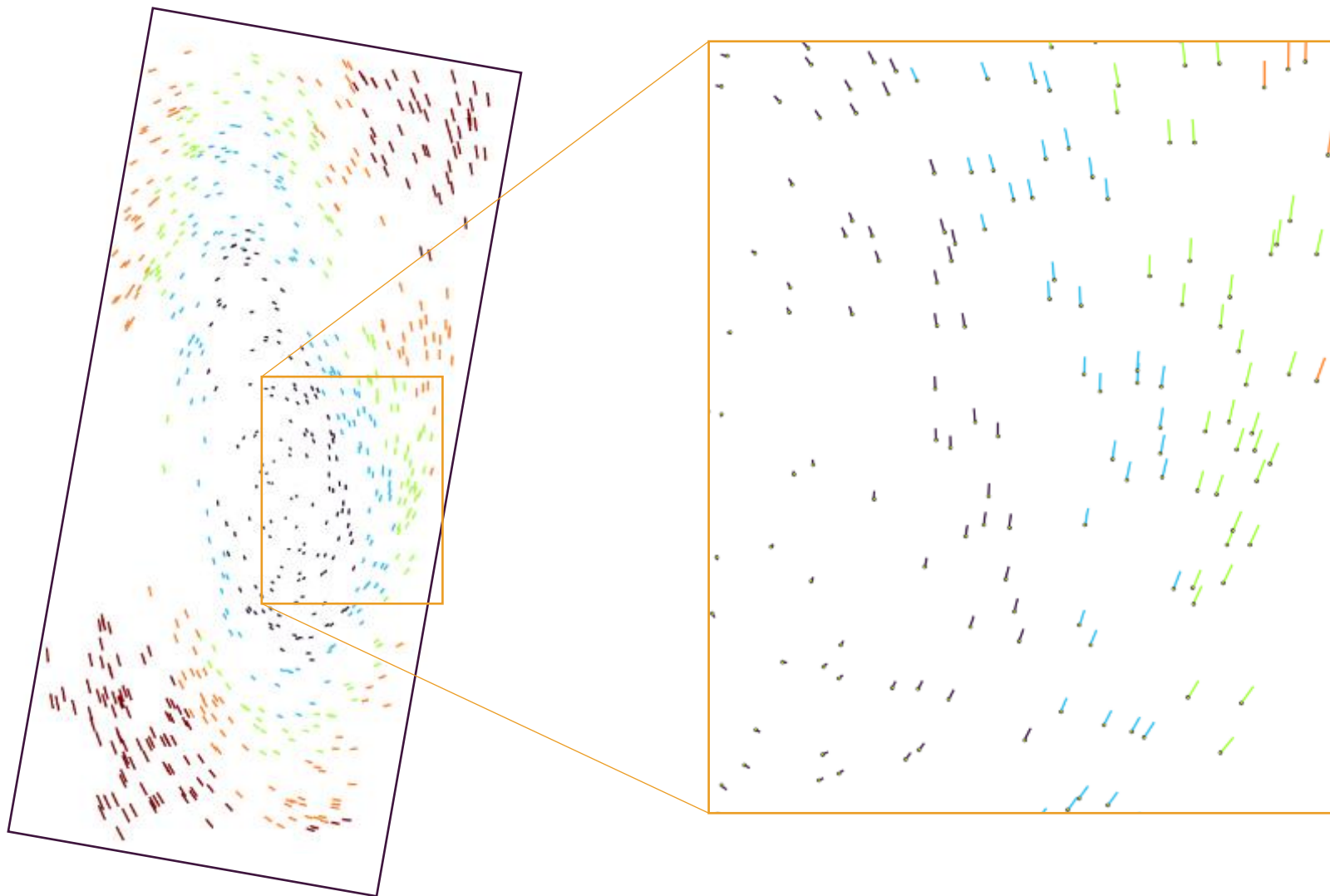
Too much sharpening introduces artefacts and destroys radiometry

Jitter analysis



Sample shown without radiometric correction

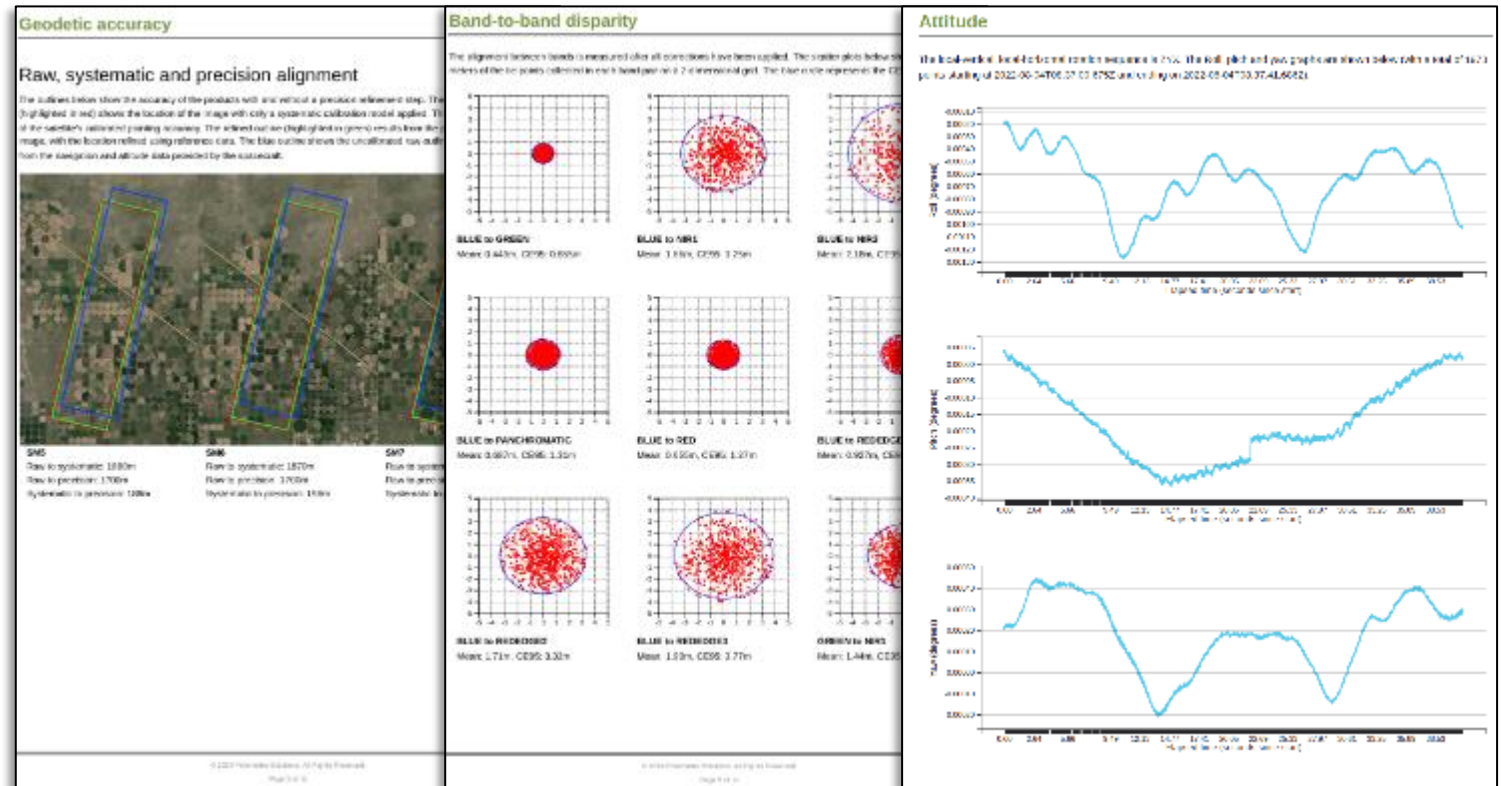
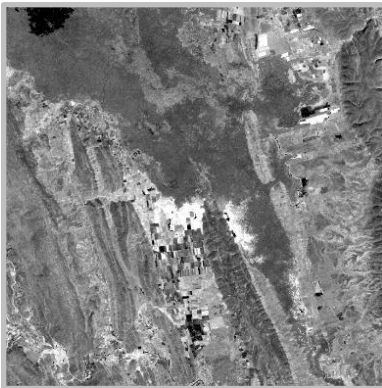
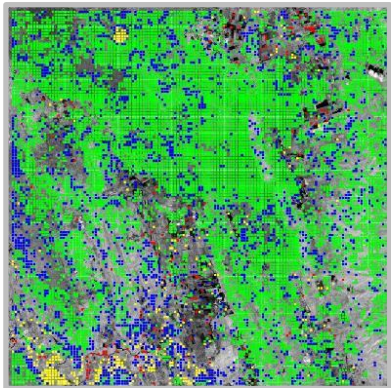
Jitter compensation



Measure the quality of each product

- Quantify the accuracy of individual products
- Track quality over time
- Automated

The Geodetic Accuracy of each sample can be measured against reference datasets



Radiometric accuracy

TOA comparison of RCN site for Sentinel-2 and SampleSat
(compensated for time-difference)



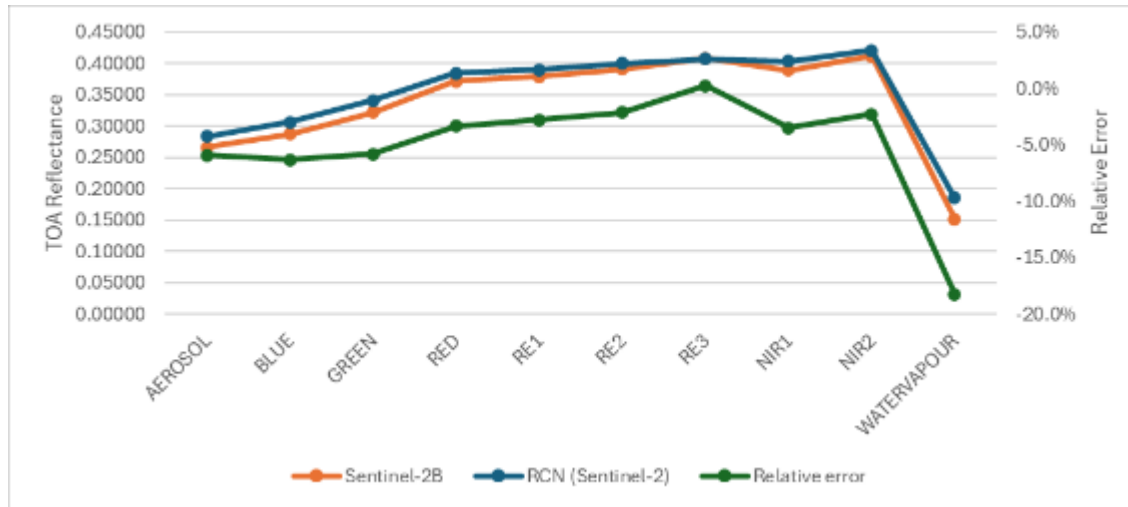
TOA comparison of a scene between Sentinel-2 and SampleSat
(different times, but similar profile)



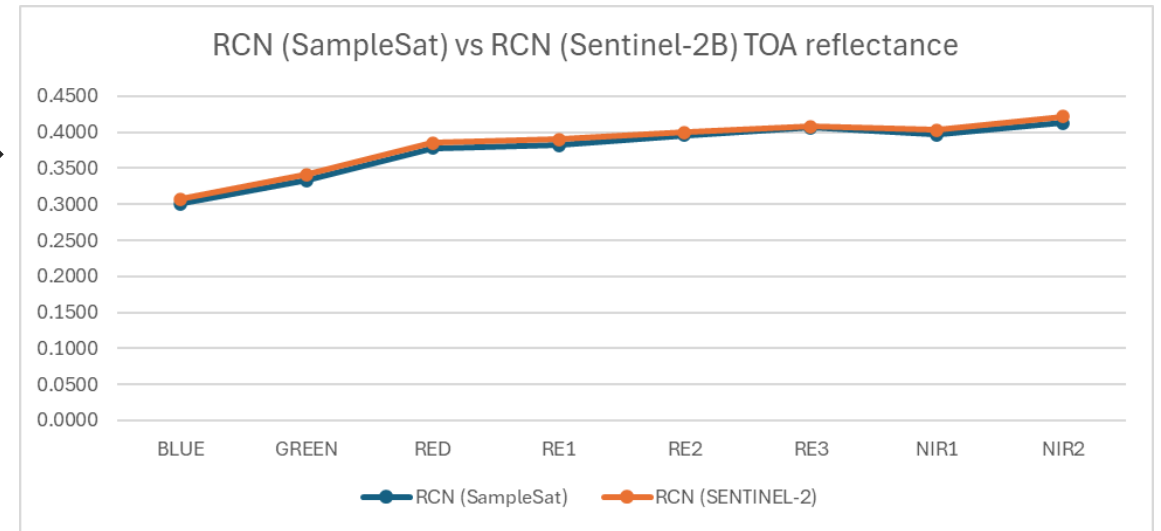
Measured accuracy of Sentinel-2 against RCN



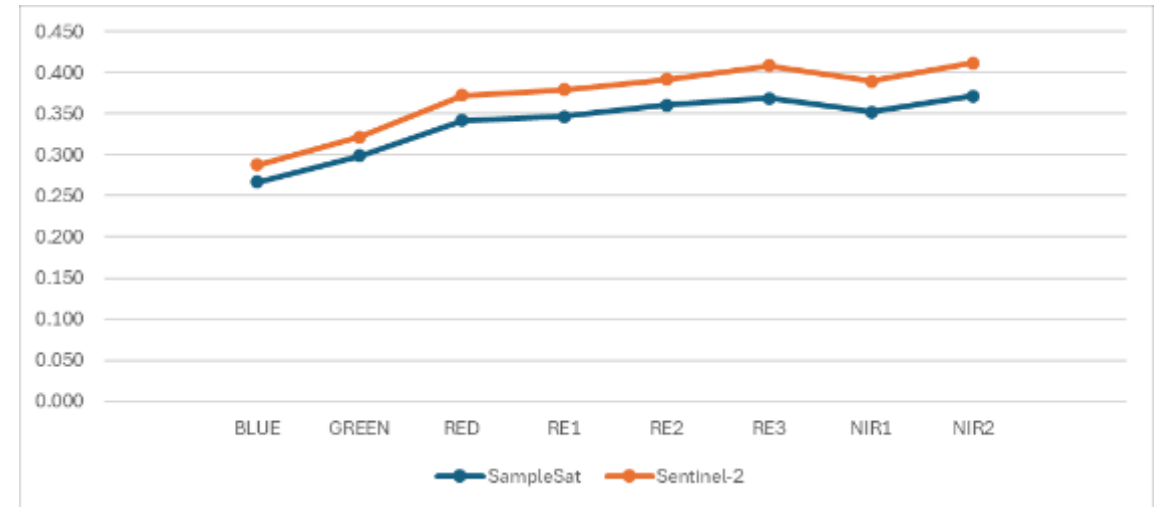
Sentinel-2 relative error (vicarious)



Absolute accuracy comparison (TOA, vicarious)



Top-of-atmosphere relative response



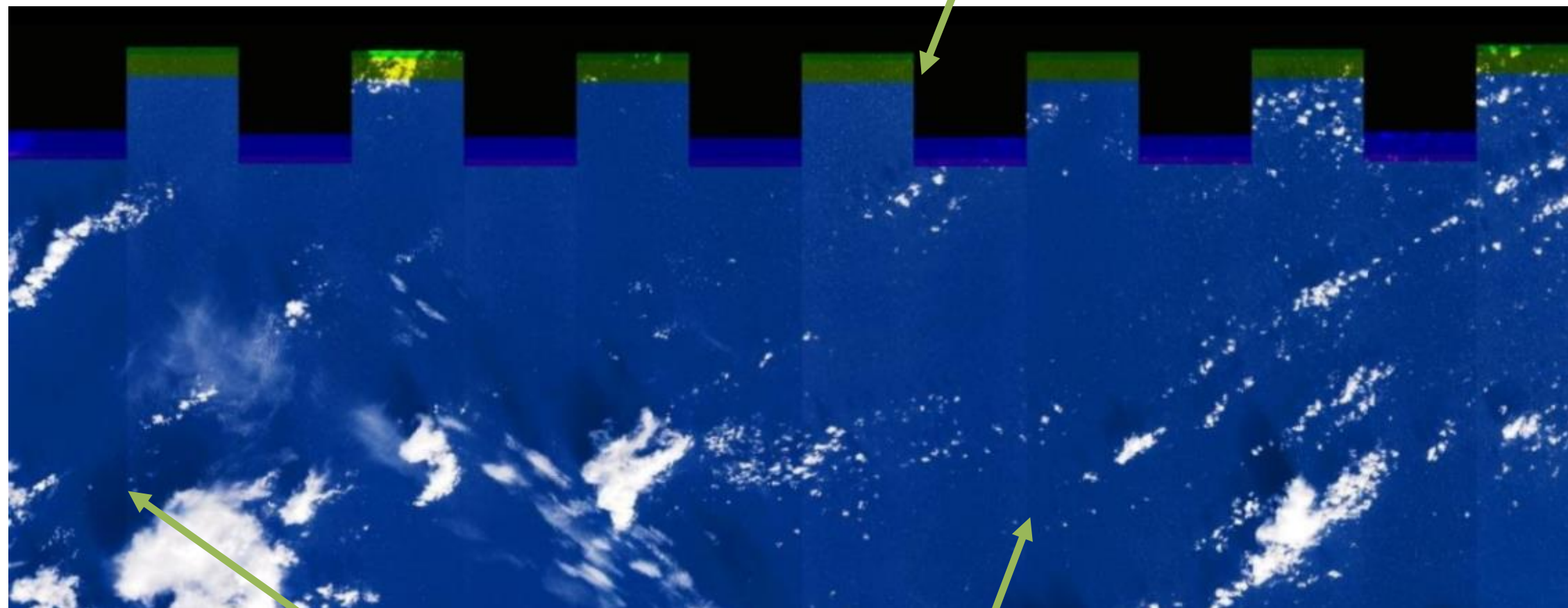
Is this a 'NewSpace' problem?

Calibration not unique to New Space

New Space need:

- Additional refinements above and beyond calibration per product
- Quality can approach classic space
- Corrections must not compromise the scientific utility of imagery
- Instead of teams of scientists manually performing calibration and processing, develop ways to automate constellations

Glimpse behind Landsat 9 OLI



Complex spatial modelling
compensates for band-alignment

Slightly outdated sensor calibration
causes visible artefacts

SmallSat imagery is not reaching the market

- Quality expectations, imagery not yet commercially or scientifically viable
- Include pre-processing in planning & budget
- SmallSats require dynamic corrections
- Corrections must be applied responsibly to maintain the utility of the data





**“If you want to go fast, go alone.
If you want to go far, go together”
- African Proverb**

