Automated methods for the quality control of data from the DMCii satellite constellation.

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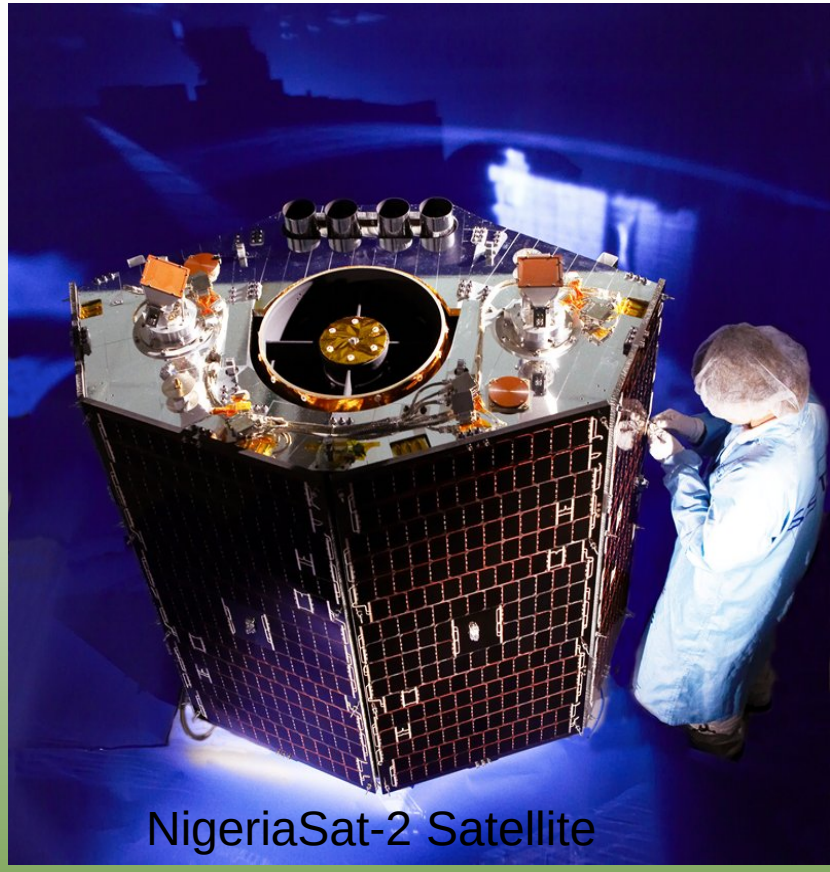
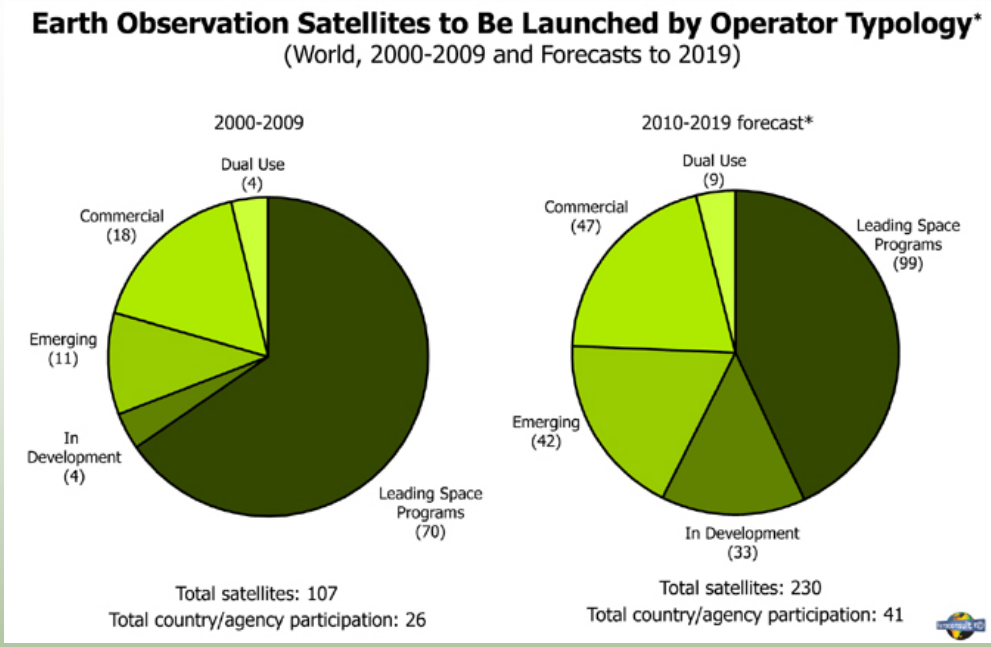
Small Satellites

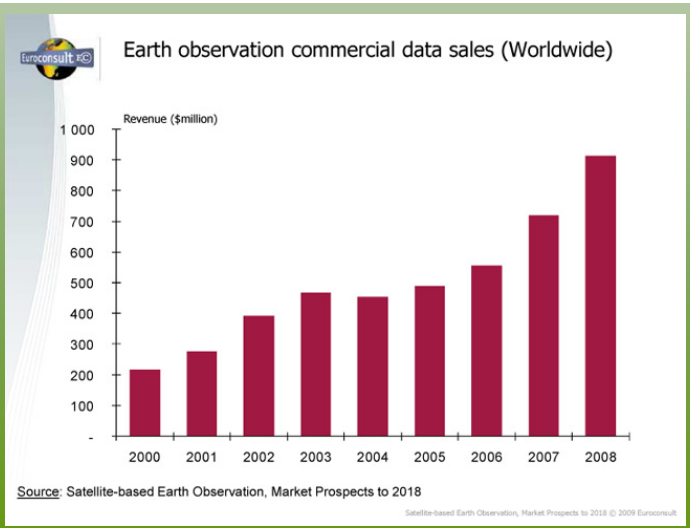
- Current satellites about 100 kg up to 300 kg
- No onboard calibration equipment
- So how can we monitor the calibration and data quality?


NigeriaSat-2 Satellite

Satellite Constellations

- Currently there are a growing number of space nations, with ambitious space programs (Nigeria being a good example)
- DMCii has co-operative agreements to manage commercial programs with these nations and also to manage its own growing number of satellite systems.
- The amount of data generated by these systems is continuously growing and it is not feasible to manually control data quality.



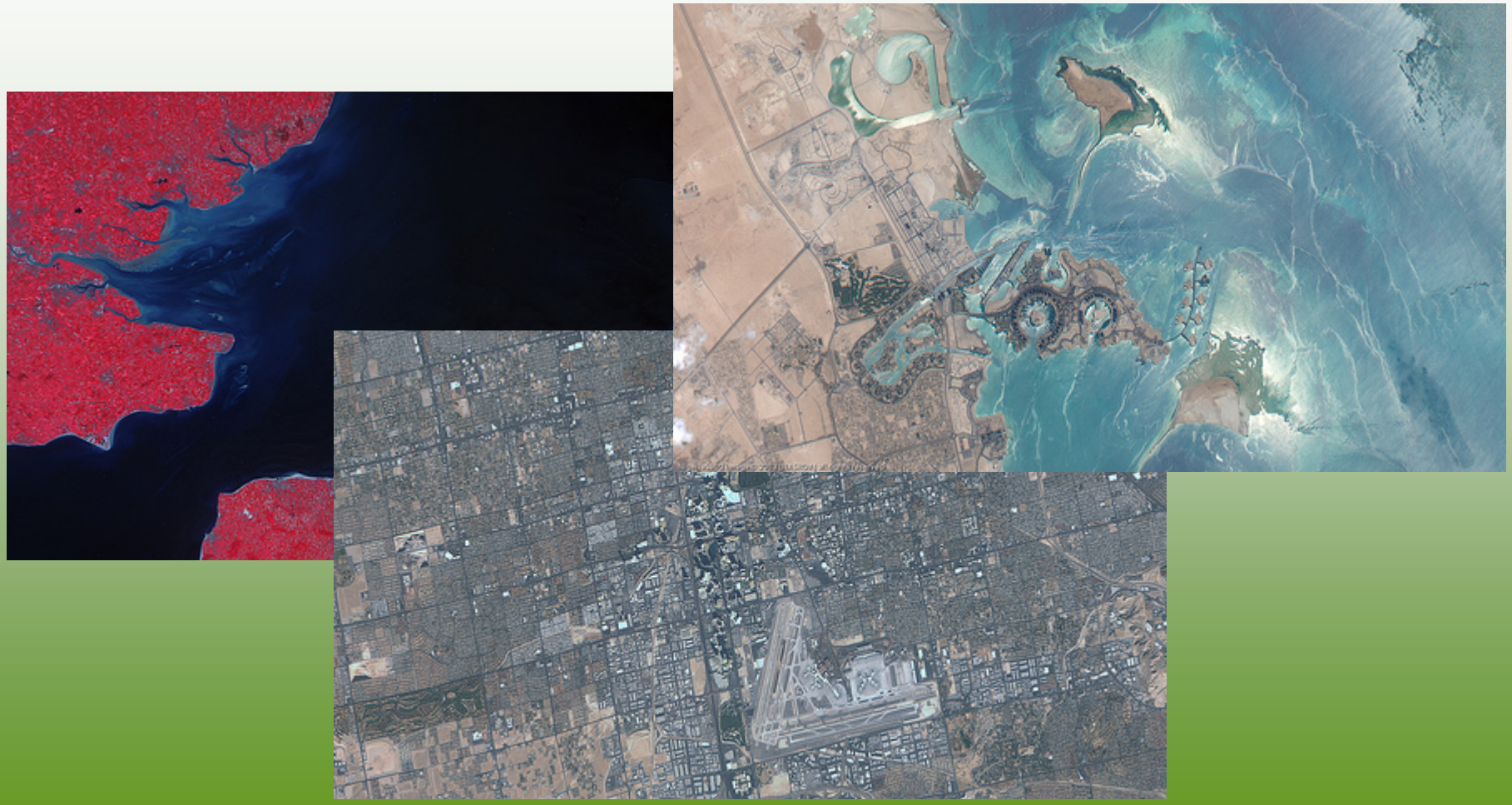


What would you (I) like ?

- Artefact free data
  - Changes in sensor behaviour captured before they become apparent.
- “Real-Time” satellite monitoring
  - Monitor a range of system parameters and provide them real time to operators, managers and end-users.
- Satellites that “look after themselves”
  - Monitor various instrument parameters
  - Update themselves (calibration drift)
  - Email when things get serious.
- Avoid time-consuming calibration campaigns
  - Costly campaigns and later analysis
  - Use satellite resource that could be used for customers

What do we need in terms of data ?

- Ordinary images, collected over any target type



Areas already examined…

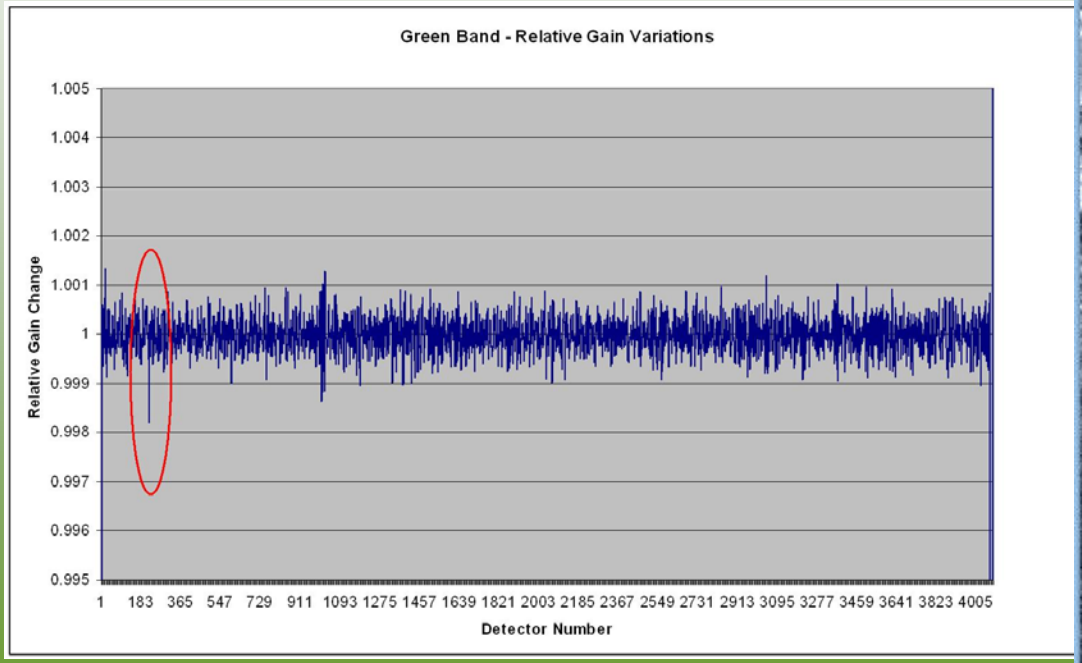
- Individual detector drift
  - Dark Current and detector gain
- Relative Calibration changes
  - Groups of detectors
  - Different readouts
- Signal to Noise Ratio
  - Estimation and temporal changes
- Single image artefacts
  - Zipper effects
- Absolute Calibration drift

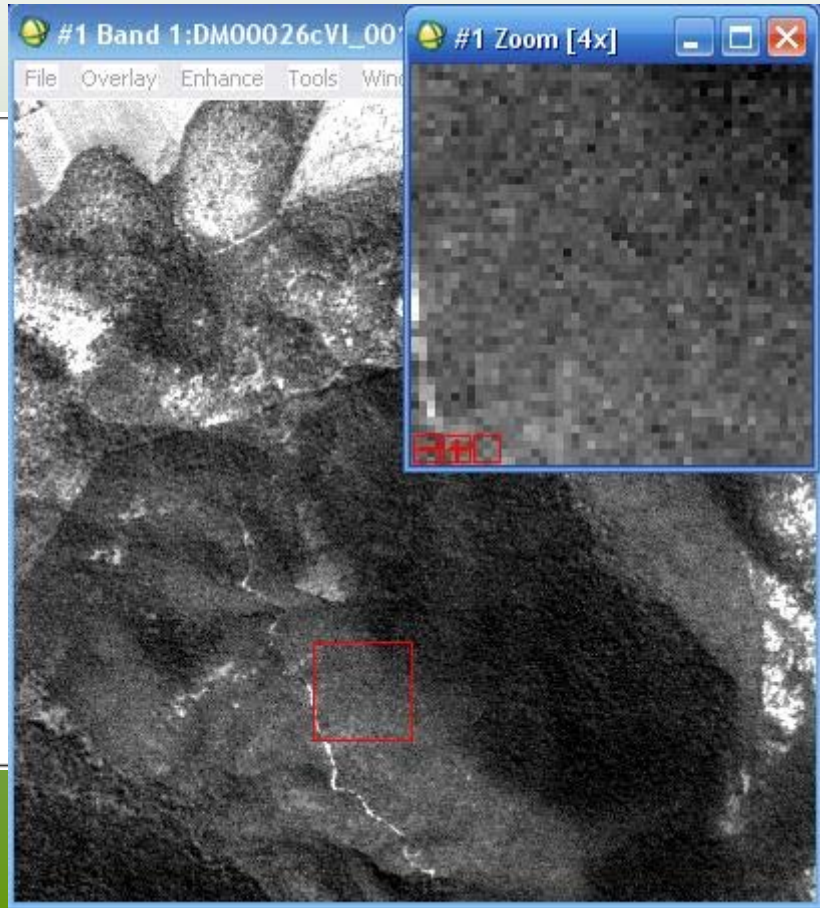
Individual Detector Drift

- No matter how good the calibration of linear CCD's there tends to be drift with time, producing striping effects.
- Corrected in the past using white (snow) scenes which we consider uniform, but are only approximate flat-fields.

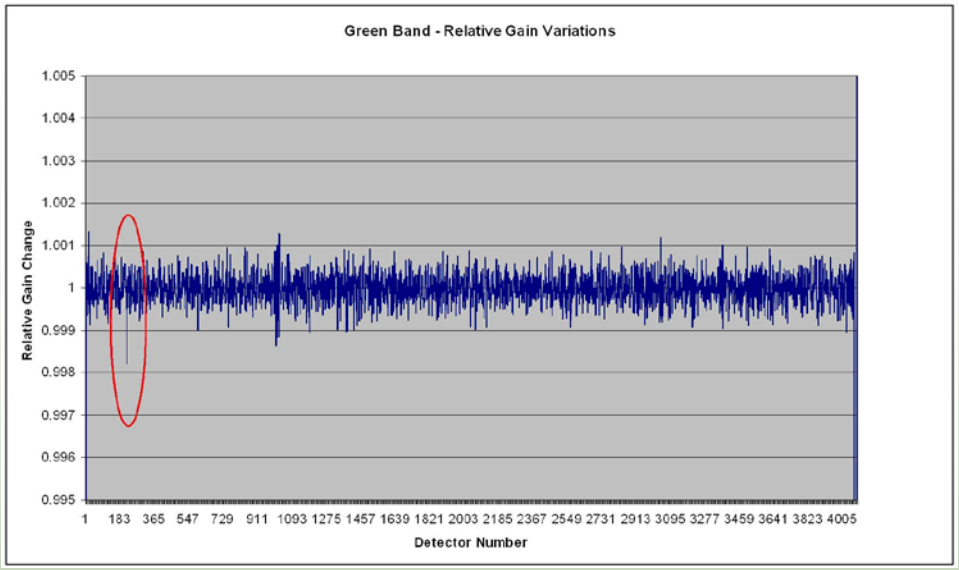
Individual Detector Drift

- Uses heterogeneous images and automatically generates a map of the deviations of individual detectors from expected performance.
- If this exceeds a threshold, the coefficients are modified without human intervention





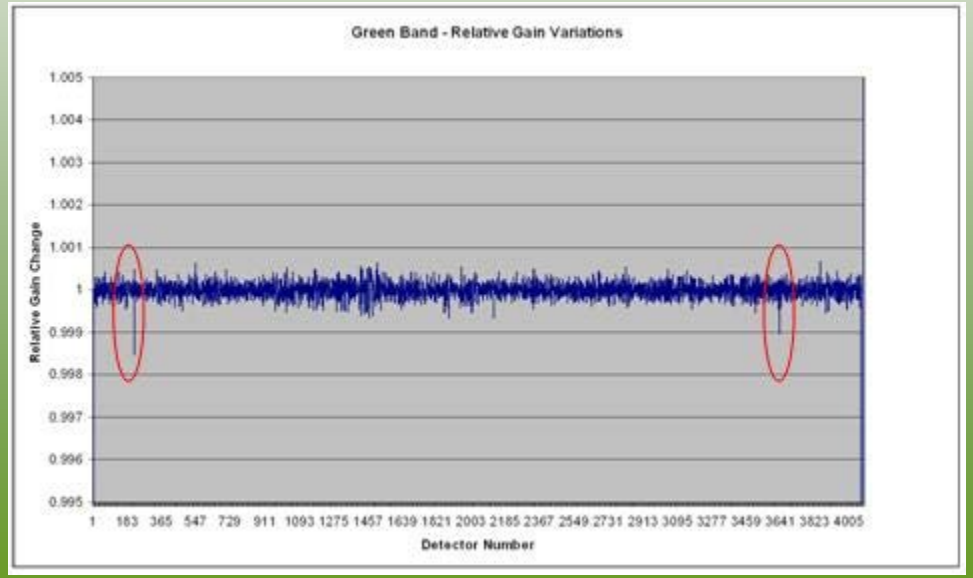
Automated Single Detector



Coefficient number 222 modified by 0.2% for 10 N2 scenes

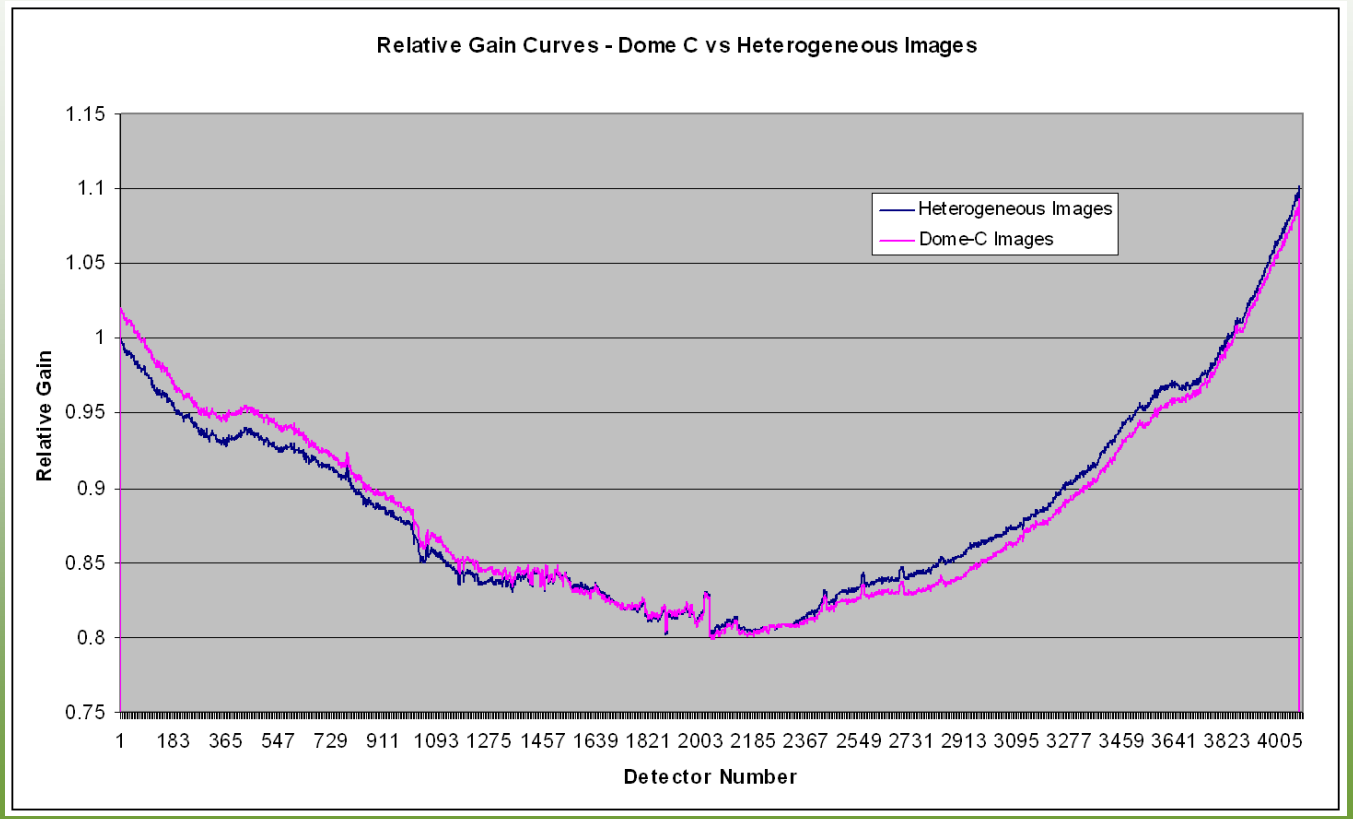
40,000 lines of data

Increased scenes reduces the background clutter and reveals underlying features



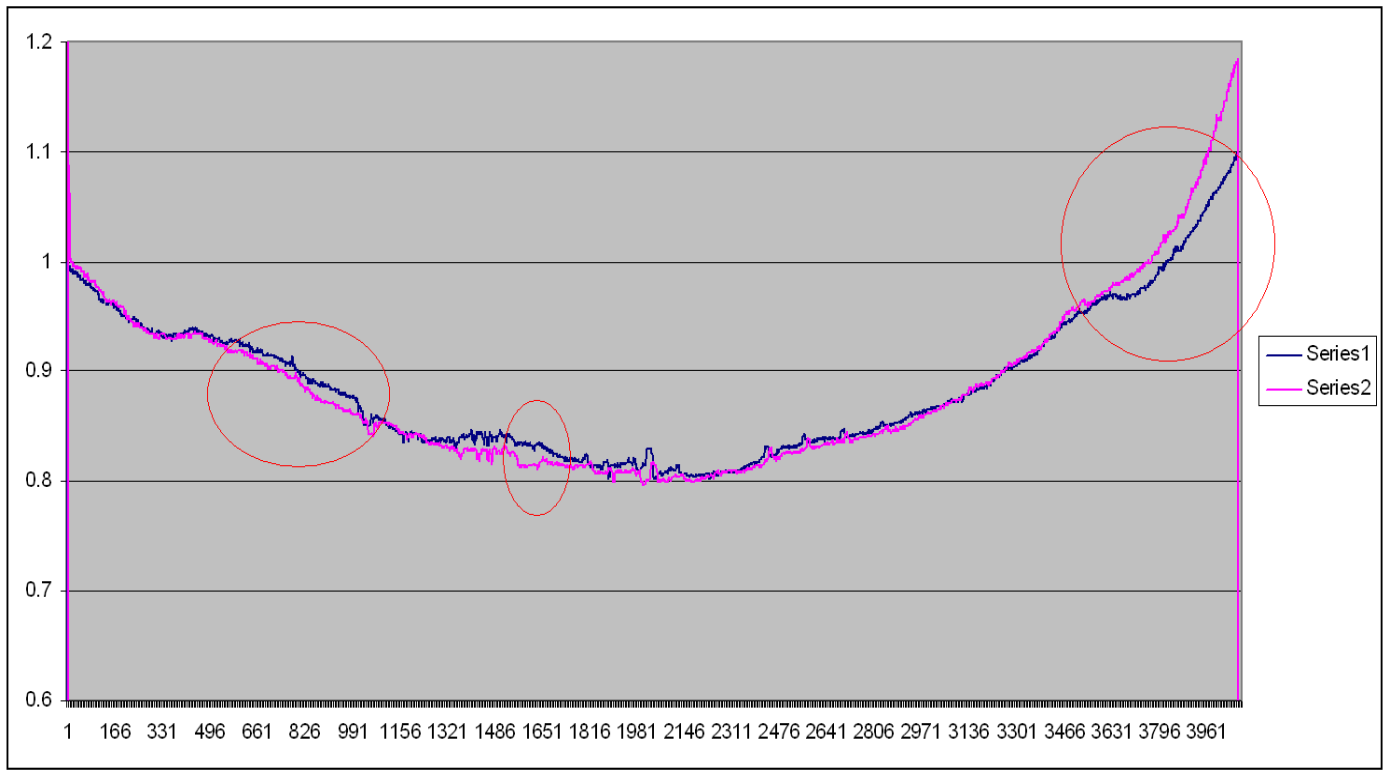
Relative Calibration Changes

- One can monitor changes in groups of detectors.
  - Temporal changes, CCD boundaries, external influences



Relative Calibration Changes

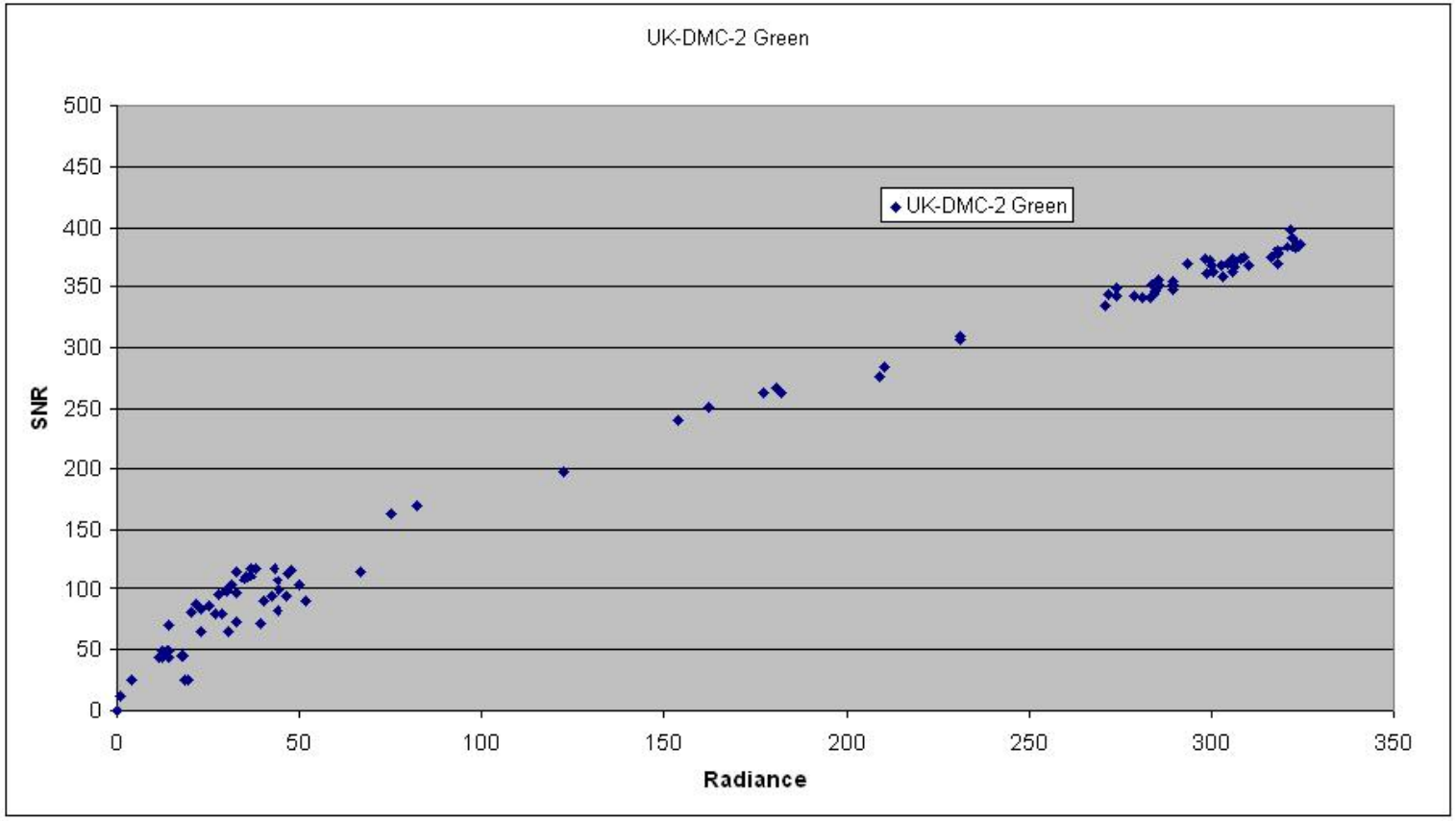
- One can monitor changes in groups of detectors.
  - Pre-launch calibration errors



Series 1 is from heterogeneous images, Series 2 is pre-launch

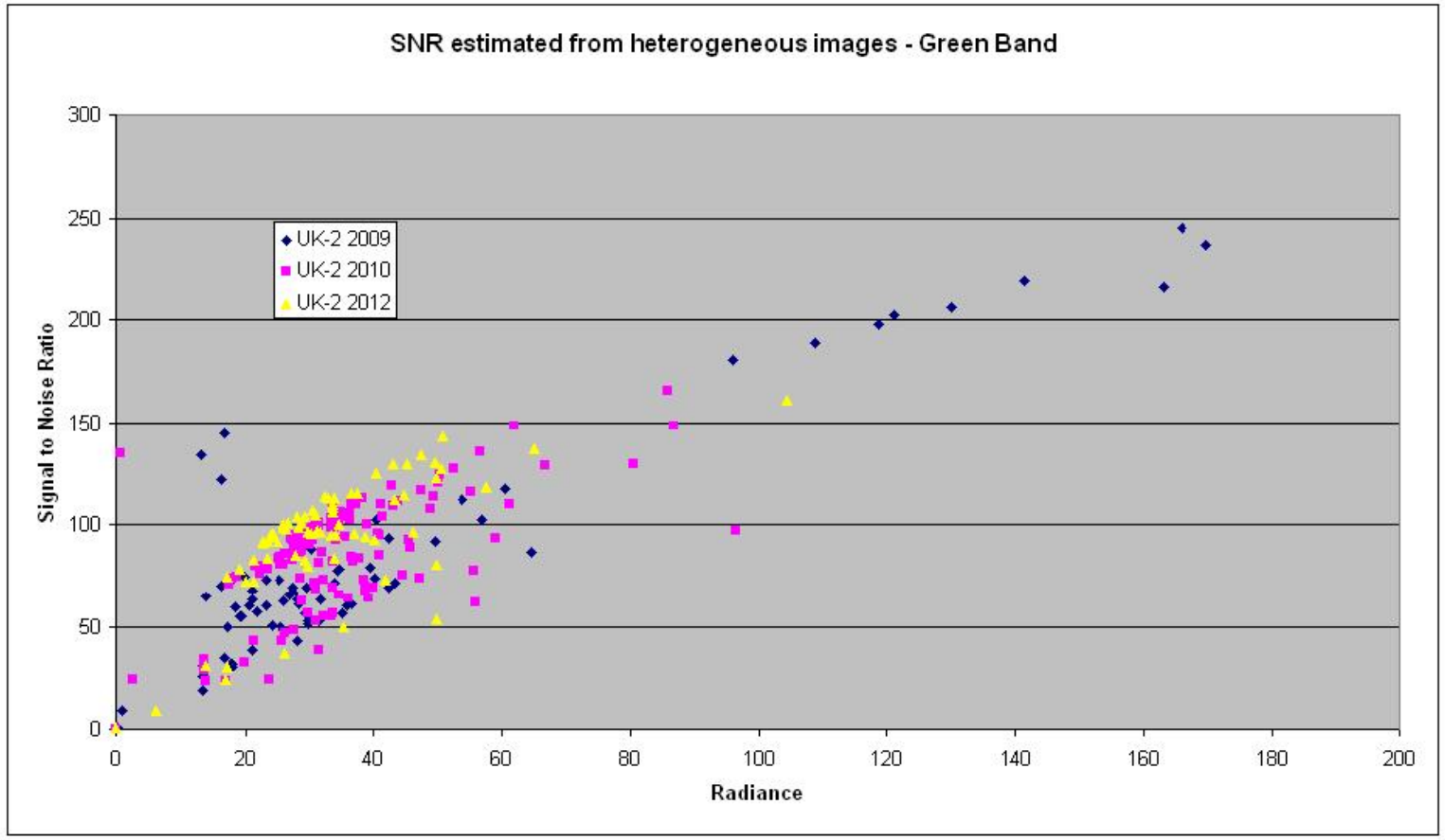
Full SNR Profiles can be determined

- The upper edge defines the SNR



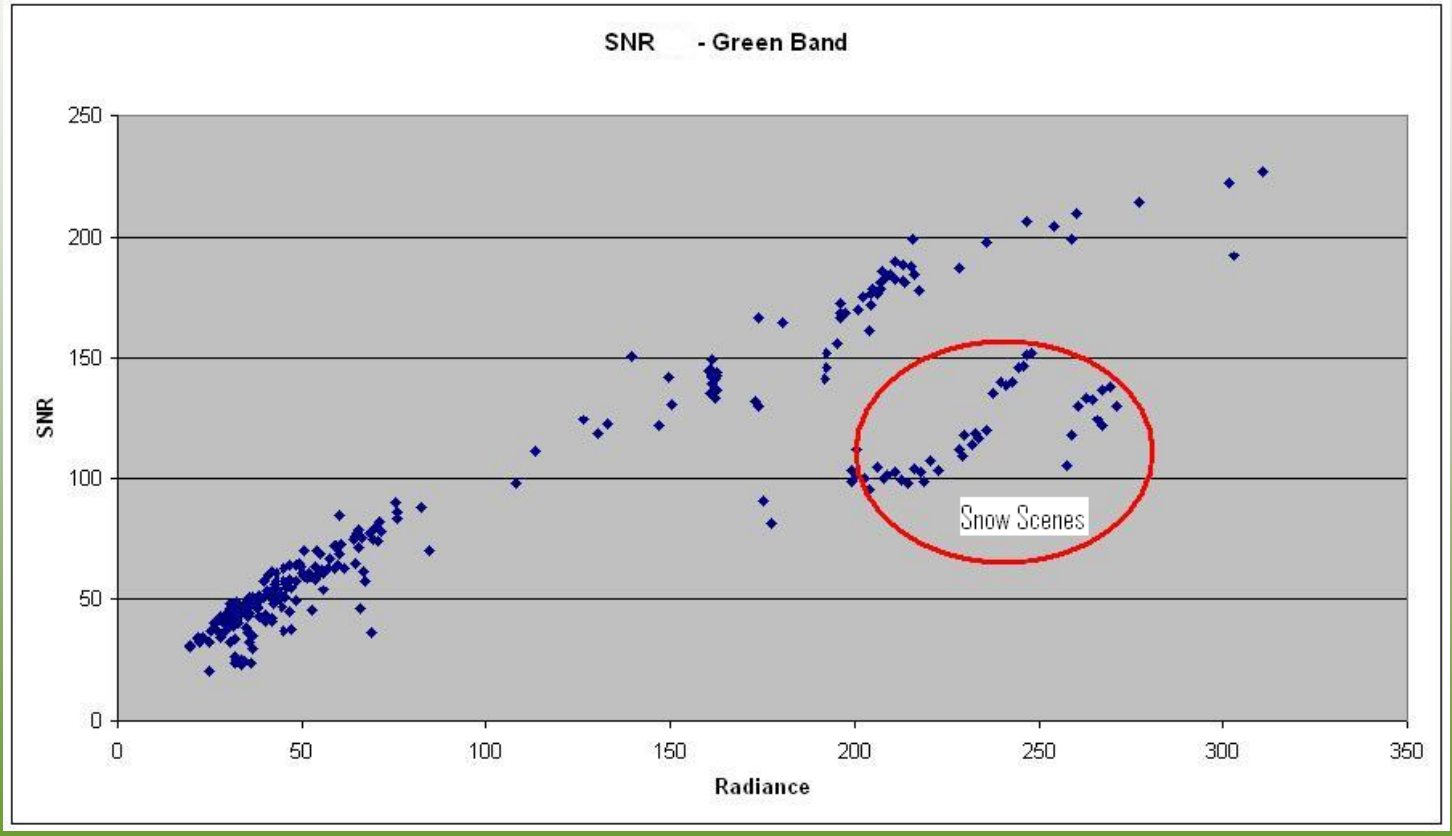
Signal to Noise Ratio (SNR) estimation

- Uses heterogeneous images (approximately 30 to 50% accepted)
- Operational version will exclude dark images used in calibration
- 2012 SNR is better than previous years.



Signal to Noise Ratio

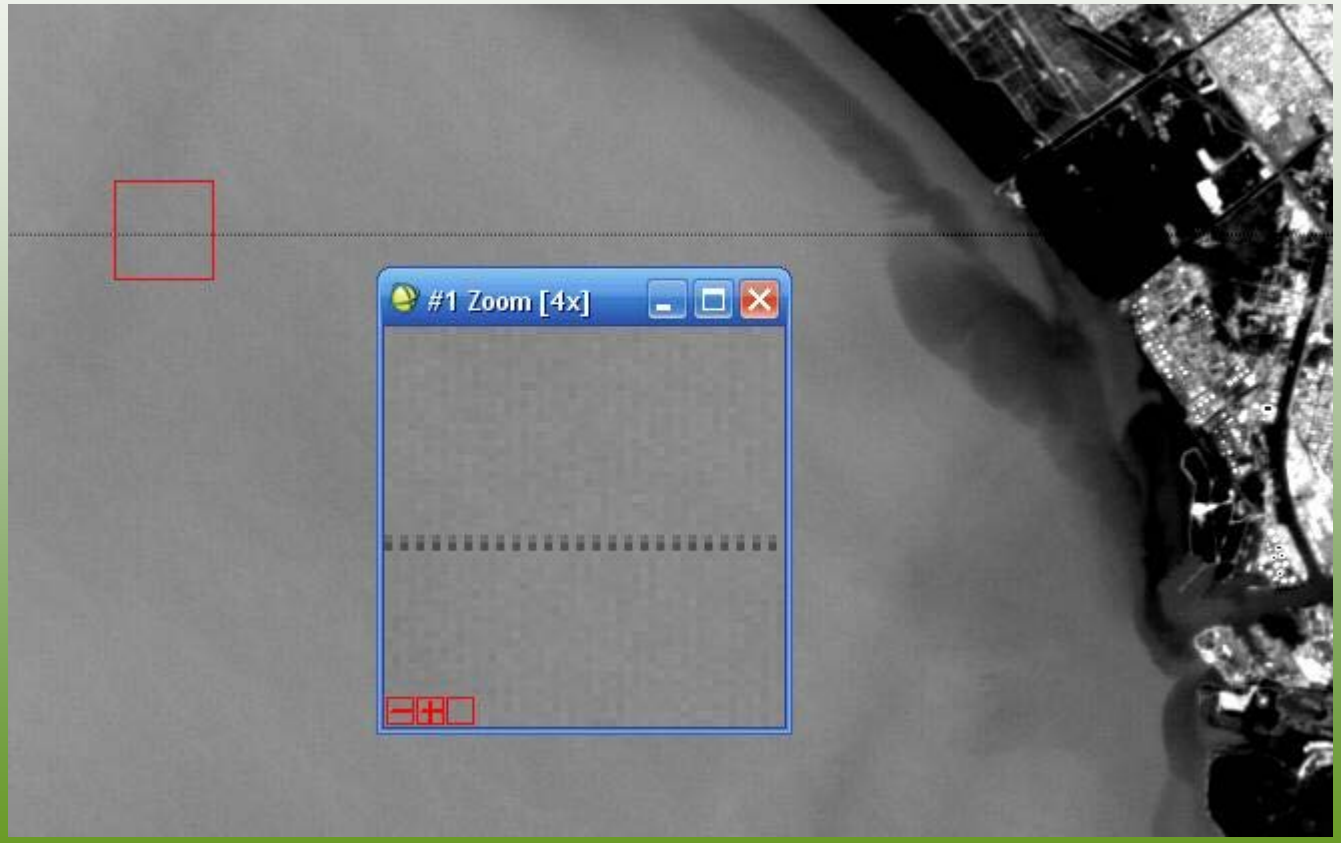
- Are white targets suitable?
- Depends on the resolution of your sensor…



Single Image Artefacts - Zipper effects

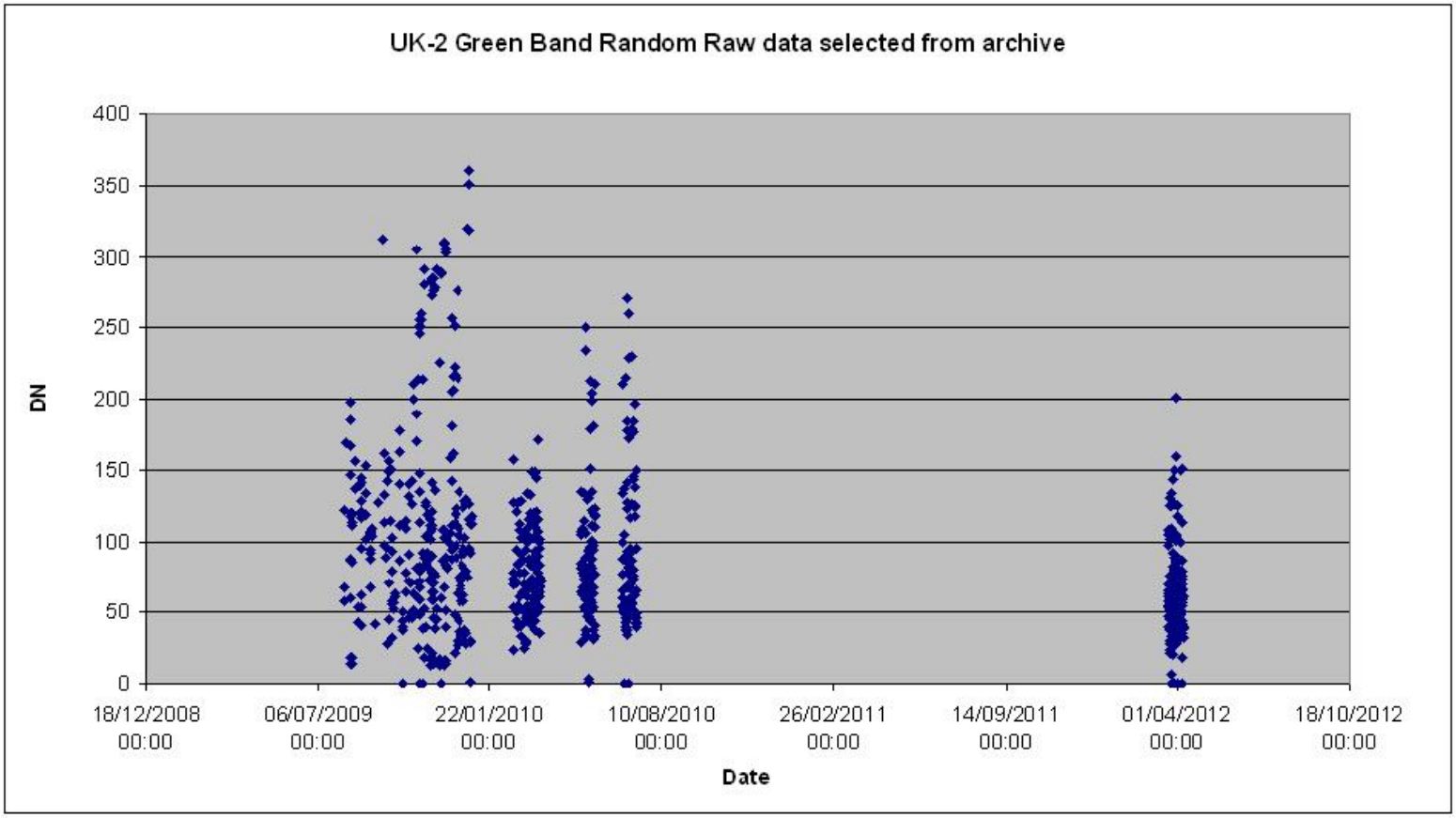
- Due to particle hits in the reference dark pixels. Causes odd or even to go high so affects dark current subtracted.

- Relatively rare, more prevalent over SAA



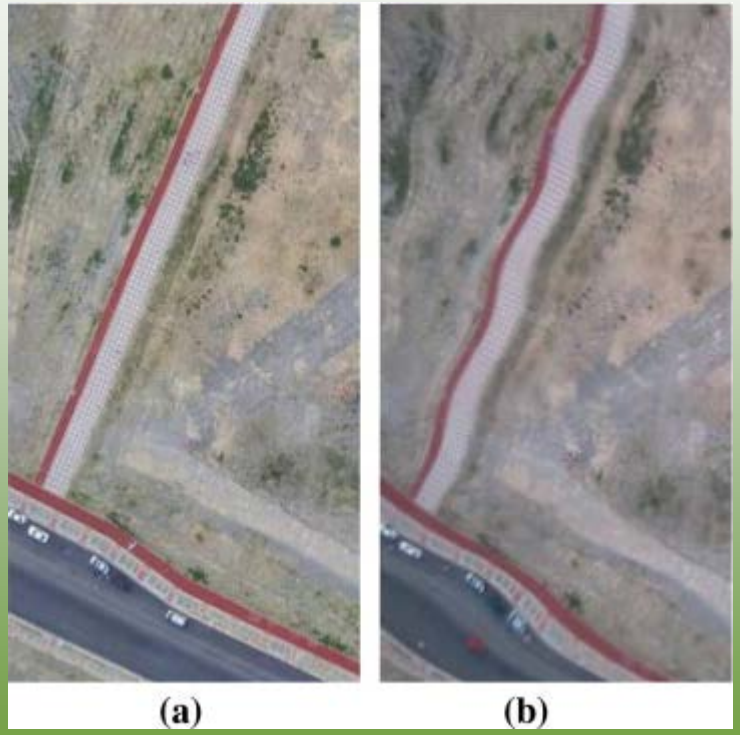
Absolute Calibration

- Basic analysis using all data…can we determine trends ?
  - Too early to tell…some promising trends observed



Additional areas – Microvibration

- With the move to higher resolution sensors we need to be able to effectively monitor micro-vibration effects in our imagery.

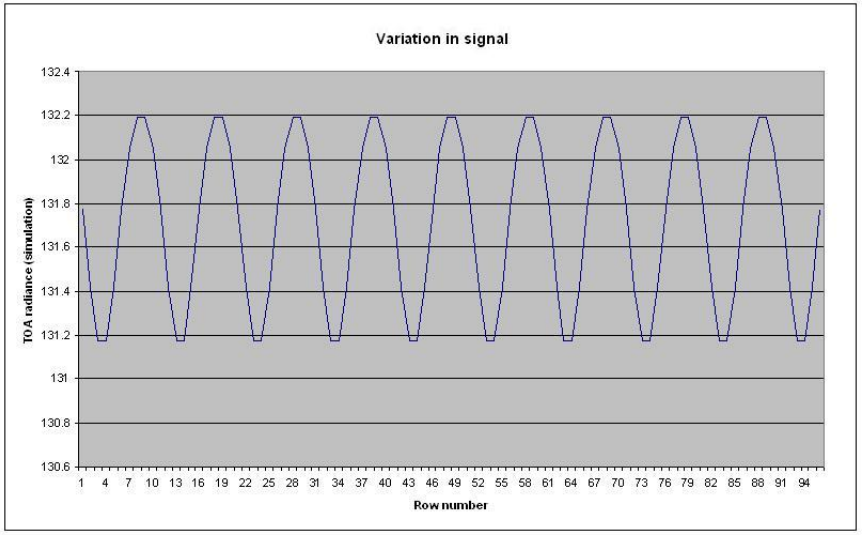


NOT our data..!!

Feasibility of employing a smartphone as the payload in a photogrammetric UAV system.
ISPRS Journal of Photogrammetry and Remote Sensing
Volume 79, May 2013, Pages 1–18

Additional Areas

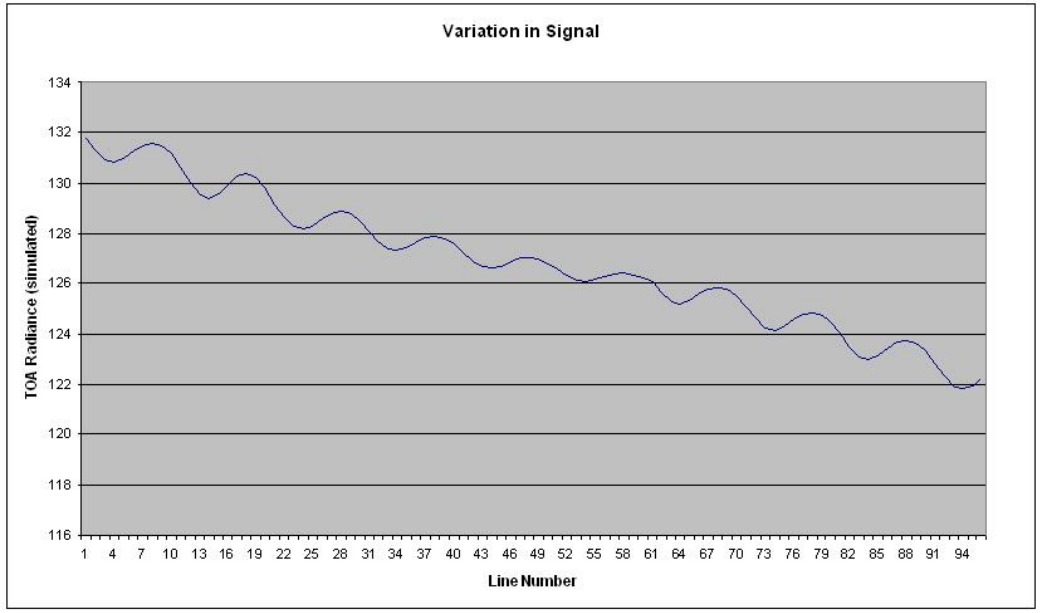
- Using calibration specific images we have developed a very sensitive method for determining the presence of micro-vibration and attitude variations outside the bandwidth of the AOCS.



- In this case we are looking for 0.1 pixel oscillation with a 10 pixel period.

Additional Areas

- The method is sensitive to both low frequency attitude variations and high frequency attitude variations. In other words we can extract the high frequency component from spacecraft drift.



Summary - 1

- Due to the large and rapidly increasing amount of data from the growing number of satellite systems, we believe the only way forward is to develop automatic methods of quality control.

- The aim is to use where possible the normal images collected for customers, rather than using capacity from our satellite systems on extensive calibration campaigns.

Summary - 2

- Many elements of the automated system are complete the final integration of these methods into a full processing chain is under development.

- The developed system will allow almost complete “self-calibration” of our sensors within defined limits (target is 5% absolute in radiometry)

- Methods are being developed to provide real-time on the satellite sensor status both internally and externally to end-users of the data. (QA4EO).