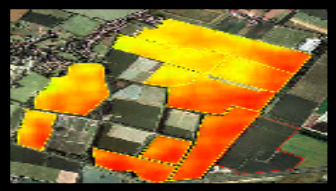

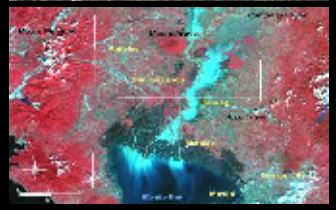

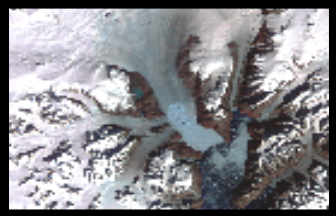

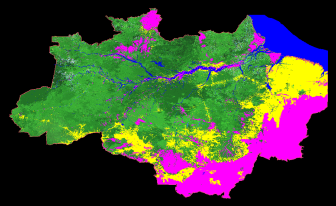

Improved Radiometric Calibration of the Disaster Monitoring Constellation using a "Gold" standard satellite - preliminary results

Steve Mackin
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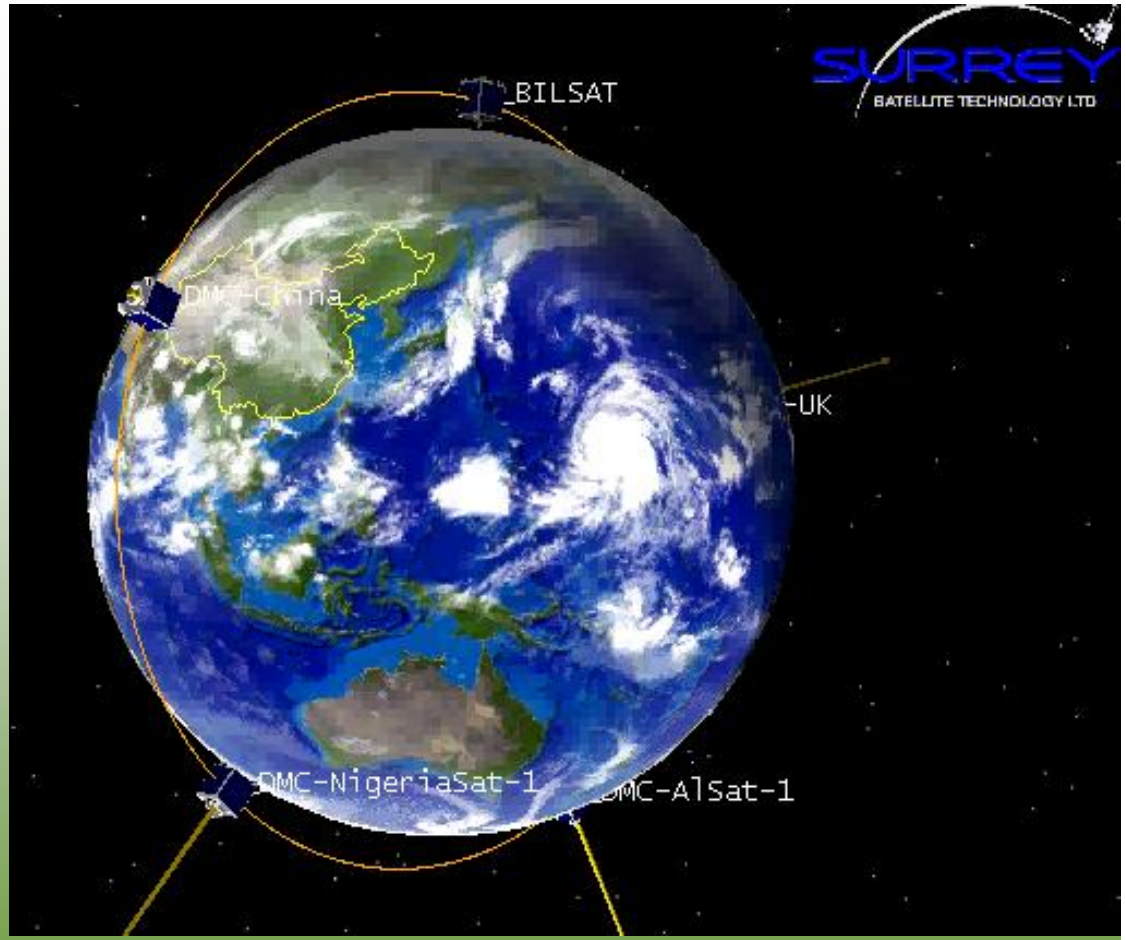
dmc International Imaging

Presentation

- DMC Constellation overview
- Problems of vicarious calibration
- New Approach – Cross calibration
  - Vicarious calibration
  - Transfer calibration
  - Cross-calibration
- Summary and conclusions

DMC Constellation

- Four satellites in Constellation
- 32m GSD, 640km wide swath
- Green, Red and NIR bands



Problems of Vicarious Calibration

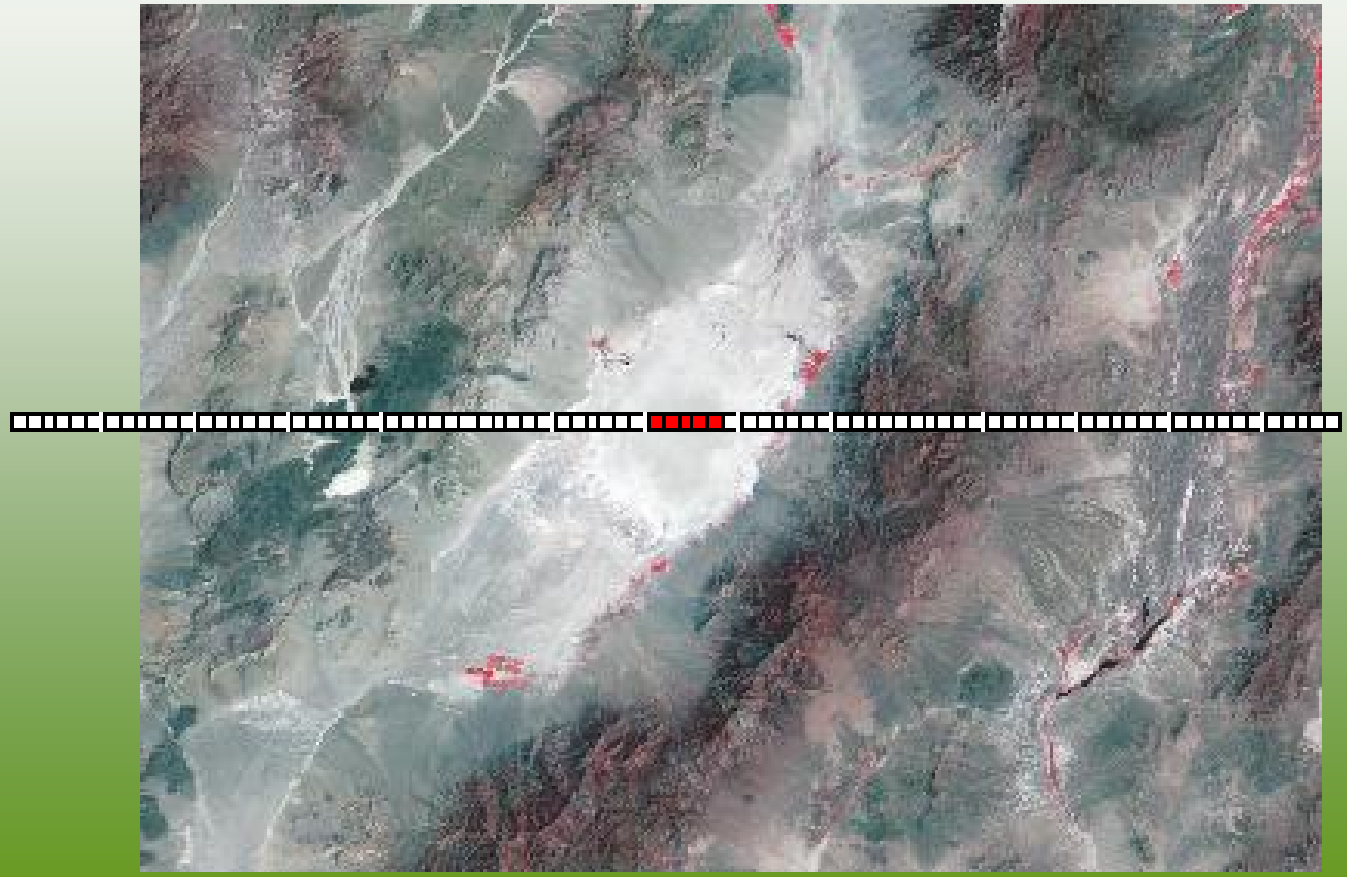
- Logistics and costs
  - Many satellites each requiring several acquisitions
    - Organisational issues (timing, availability)
    - Costs (ground teams and processing)
  - Growing number of satellites each year
- Technically
  - Variable number of acquisitions gives variable quality
  - Larger than desired relative (satellite to satellite) calibration variability
    - Affects customer applications (precision farming using the whole constellation)

New Approach

- Three elements
  - Absolute calibration
    - Uses a single satellite “Gold” standard
    - More acquisitions (more confidence)
    - Lower costs as single satellite
  - Transfer calibration
    - Uses Dome-C in Antarctica to transfer from a few detectors to whole array
  - Cross-calibration
    - Intersections over Dome-C (half an image overlap – 320km) time separation of 30 minutes to one hour with stable atmosphere

Absolute Calibration - Approach

- Railroad Valley using the reflectance method (6 – 10 acquisitions)
- Nine columns (pixels) calibrated



Absolute Calibration - Approach

- Analysed image variation over ASTER test site and a much larger area. The system noise seems to be the larger source of variability (after comparing several data sets)
- Used 9 x 10 pixel box (instead of 9 x 2 for ASTER site). This reduced the uncertainty due to system noise.

193	187	195	192	196	188	195	190	200	193
195	189	201	190	196	191	198	190	199	194
192	189	196	190	200	187	199	190	195	193
195	190	197	190	198	191	199	194	197	192
190	189	199	190	194	192	198	196	199	194
191	187	199	191	197	191	198	192	198	192
188	183	198	191	196	192	194	192	198	192
196	191	198	190	195	191	197	189	197	194
196	195	200	192	196	197	198	193	197	191
197	195	198	194	197	192	198	193	198	193
198	193	198	190	201	193	196	193	198	193

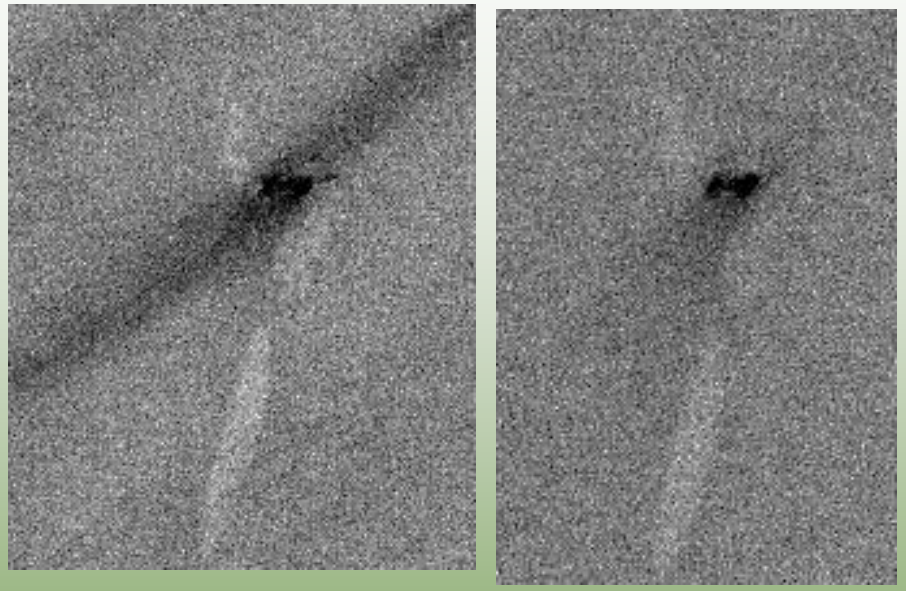
Absolute Calibration – Uncertainties

- Uncertainties as defined in the literature (2.7% r.m.s) for the absolute from UofA.

- Additional uncertainty from system noise both over RRV and over Dome-C
  - When the RRV derived coefficients for a single absolute calibration are applied to the same white image, there is variability across the nine pixels used
    - Green : 0.31%, Red 0.37%, NIR, 0.4%
  - This is combined in the transfer uncertainty (in next section)

Transfer Calibration

- Transfer uses stable site in Antarctica at Dome-C
  - For each absolute acquisition all nine pixels used to generate nine radiances
  - Use mean value of nine pixels
  - Repeat for other absolute acquisitions
  - Get range of radiance values (one for each absolute image), since single white image used for transfer this is a measure of uncertainty



Dome-C base, note the surface Disturbance. Image from Nigeriasat-1

Transfer Calibration - Uncertainties

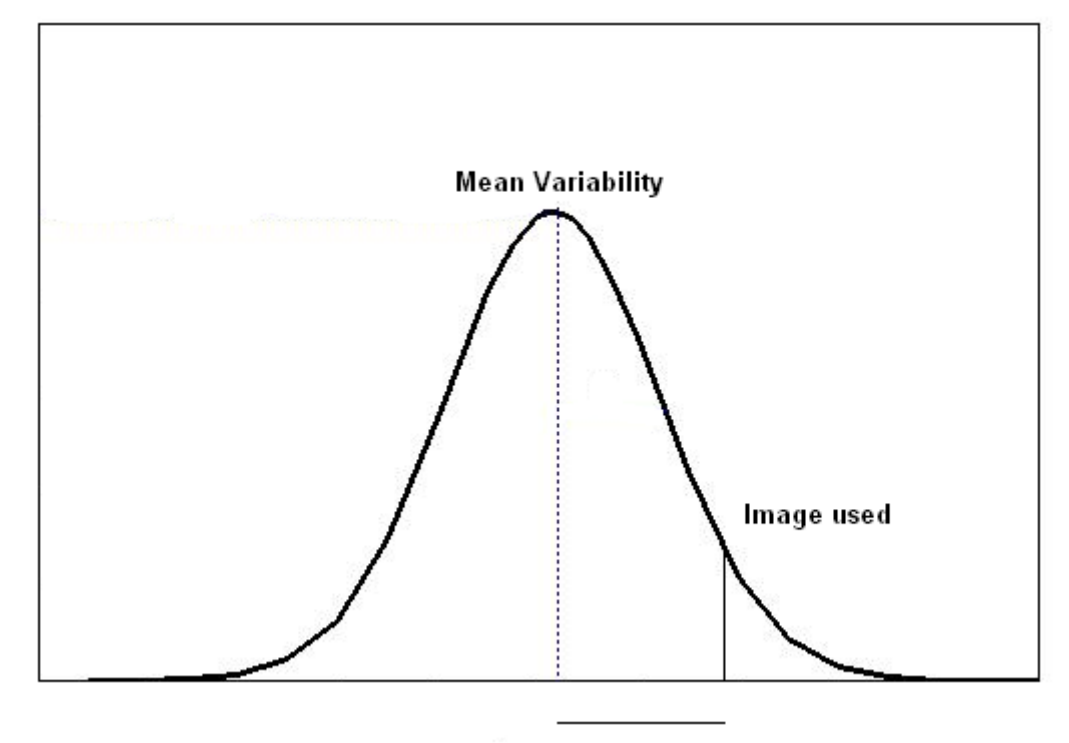
- The uncertainties are related to the variation in the mean radiance using a “standard” white image. With no uncertainty the mean radiance derived from each absolute image would be the same
- Combines uncertainties from all sources (system noise, surface variability).
  - Green : 2.419%, Red : 2.87%, NIR : 3.37%
- This gives final absolute calibration coefficients when combined with the UofA uncertainty

  - **Green : 3.625%, Red : 3.94%, NIR : 4.318%**

Cross-Calibration

- Uses Dome-C site. Images have between one half and full overlap.
- Time separation of 30 minutes to one hour, yawed across principal plane.
- Preparation Steps include
  - Identification of image pairs (UK-DMC-1 and Nigeriasat-1 had 19 image pairs)
  - Cloud screening to select best for final cross calibration
  - Correction for solar zenith differences
  - Variability determination by ratioing values using new Nigeriasat-1 calibration and old UK-DMC-1 calibration.

Cross-Calibration – Variability Correction



Correction made to final calibration radiance based on where the image used lies in comparison to all the other images used in the process

Cross-Calibration

- Cross-calibration steps include,
  - Selection of best cloud free pair
  - Correction for solar zenith differences
  - Correction for variability, if the pair is at the edge of the distribution it is corrected to the mean for the 19 image pairs
  - Calculation of new TOA radiances for UK-DMC-1 based on TOA radiances from Nigeriasat-1
  - Recalculation of calibration gain values

Cross-Calibration

- Uncertainties
  - This is tested by applying the new calibration to the UK-DMC-1 satellite and comparing the differences with Nigeriasat-1 satellite using the 19 image pairs.
  - Variability is a measure of the uncertainty
  - Green : 0.46%, Red : 0.47%, NIR : 0.65%
  - Combining these uncertainties with those from the absolute calibration of Nigeriasat-1 gives absolute uncertainties for UK-DMC-1 of
  - Green : 3.65%, Red : 3.97%, NIR : 4.36%

Calibration – Summary and Conclusions

- The use of a “Gold” standard satellite reduces cost and management for constellation use
- Provided absolute values with better than 5% uncertainty.
- Cross-calibration was very effective with inter-satellite variability less than 1% for all spectral bands
- Absolute uncertainty for all constellation members is less than 5%.

Are we right ?

- CEOS WGCV Intercomparison has just finished over the Dome-C site
  - Sensors from all the major agencies
    - SPOT
    - Landsat
    - DMC
    - etc…
  - Same target near Dome-C
  - Data collected in December 2008 and January 2009
- So watch this space…

Thank You!

- www.dmcii.com
- www.sstl.co.uk

Sustainable Earth Observation