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

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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.

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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.
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