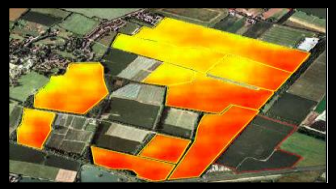

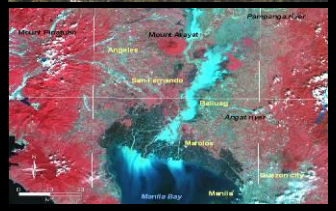

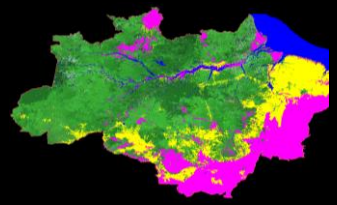

Cross-Calibration trending of the 2nd Generation Disaster Monitoring Constellation SLIM-6-22 and Landsat 7 ETM+ sensors over the Libya 4 CEOS reference pseudo-invariant test site

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Gyanesh Chander (SGT/USGS)
Laura Brindle (DMCii)

dmc International Imaging

Aims

- Evaluate a non-instrumented CEOS endorsed “invariant” site for the cross-calibration of sensors.
- Determine the relative calibration accuracy between the UK-DMC-2 Satellite sensor and Landsat 7 ETM
- Develop the methodology to allow tracking of multiple satellite systems (Landsat, SPOT, Sentinel-2) for the cross-calibration.

Libya 4 – Test Site

- Challenging due to the presence of Dunes (BRDF)
- Has been used by SPOT initially and by Landsat satellites
- http://calval.cr.usgs.gov/sites_catalog_template.php?site=lib4

Assumptions (first pass)

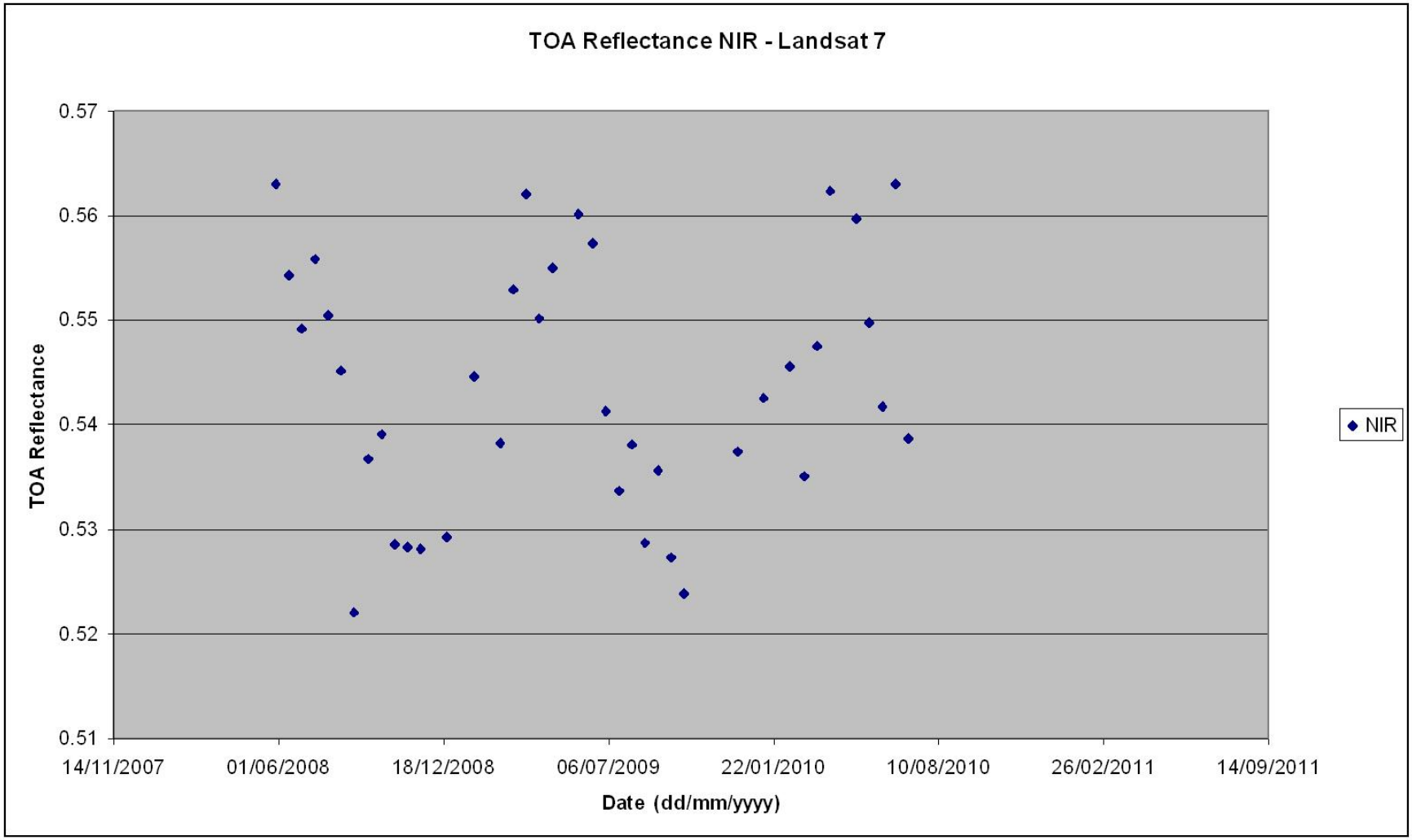
- Atmosphere is a random variable around the true value
  - Produces scatter but no trend
- Instrument is stable in the short term but may have long term drift
- Surface is “invariant”
  - Tested by using multiple sites of different type
- No significant BRDF component apart from seasonal trend

Landsat 7 ETM

- Descending node, but same local overpass time as the UK-DMC-2 satellite within a few minutes over the Libya 4 site.
- Images taken on a regular basis over several years, some days coincide with the UK-DMC-2 satellite.
- Landsat has a fixed repeat track and has a consistent nadir view to the target of interest

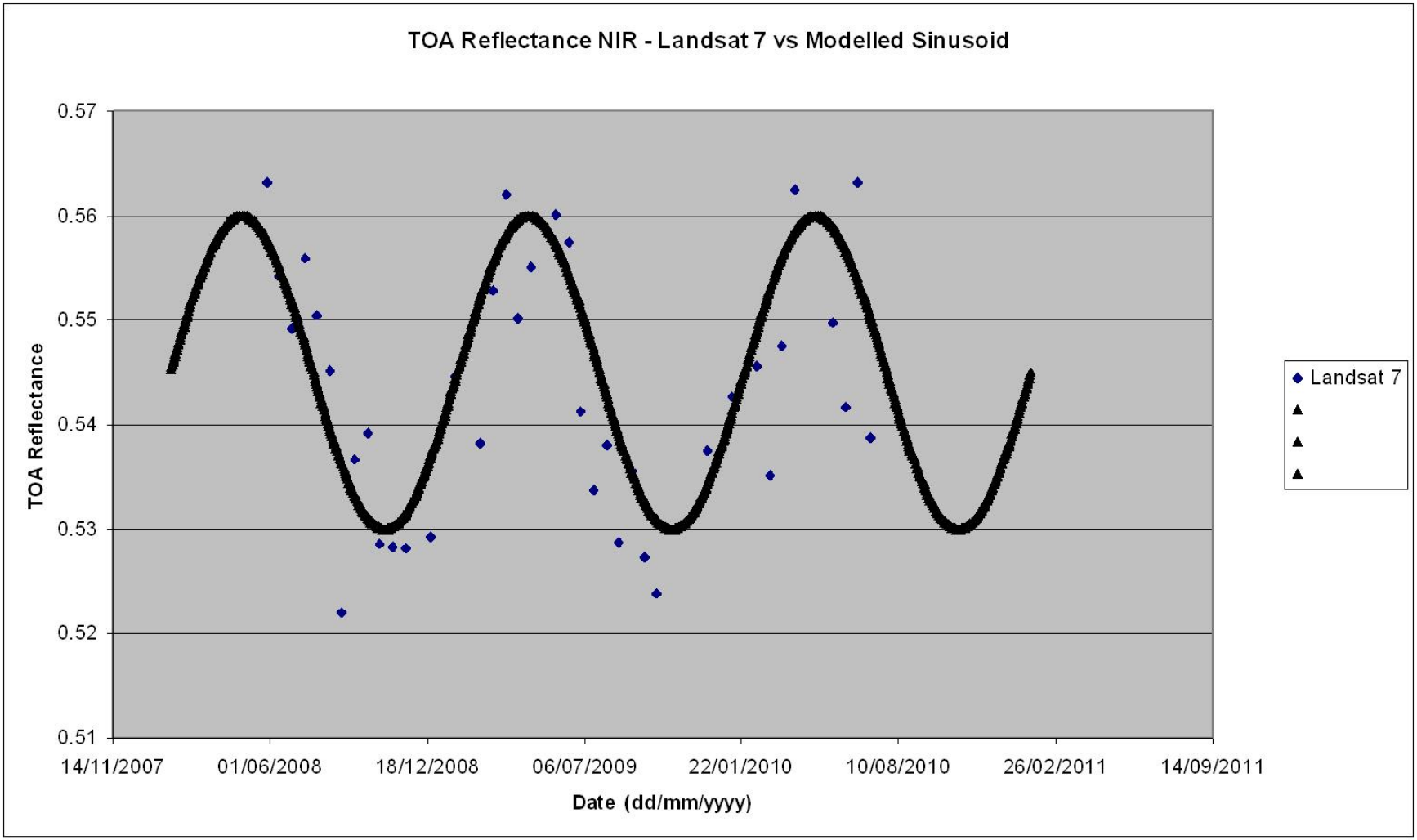
Landsat Seasonal Trend and Atmospheric noise

- Plot of Landsat, show NIR band
  - Note the seasonal variation



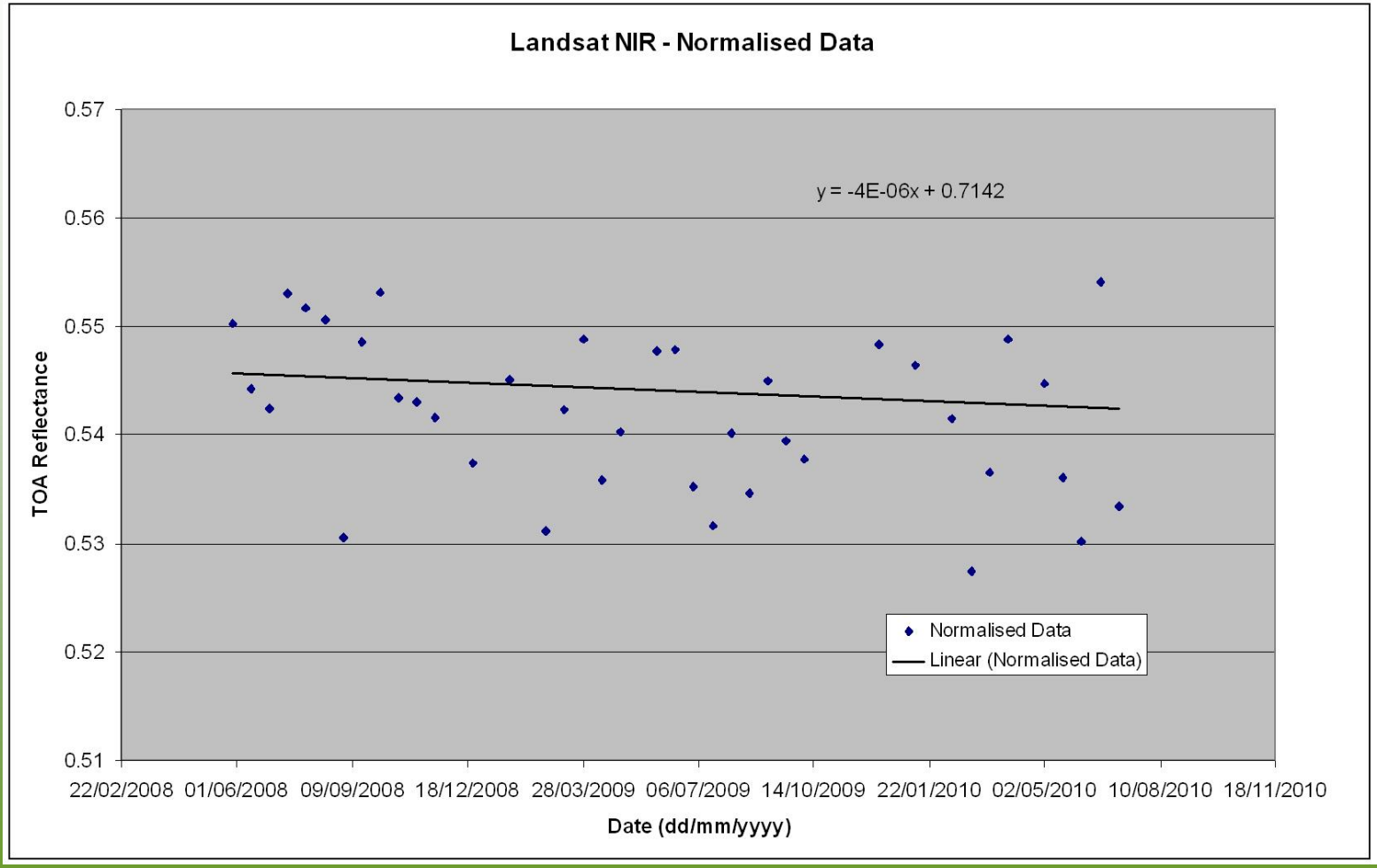
Landsat Seasonal Trend and Atmospheric noise

- Plot of Landsat, show NIR band
  - Overall trend fitted with simple sinusoid



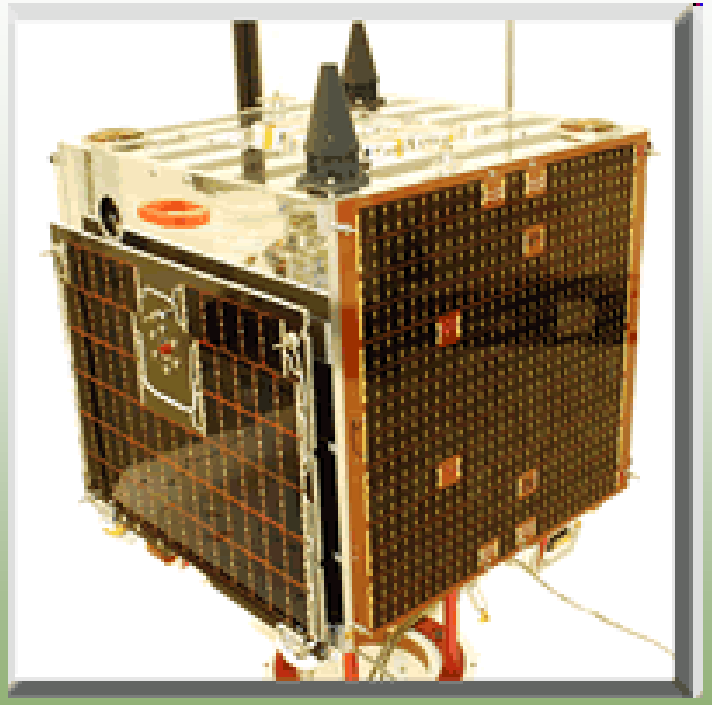
Landsat Seasonal Trend and Atmospheric noise

- Plot of Landsat, show NIR band
  - Residual points show trend and scatter



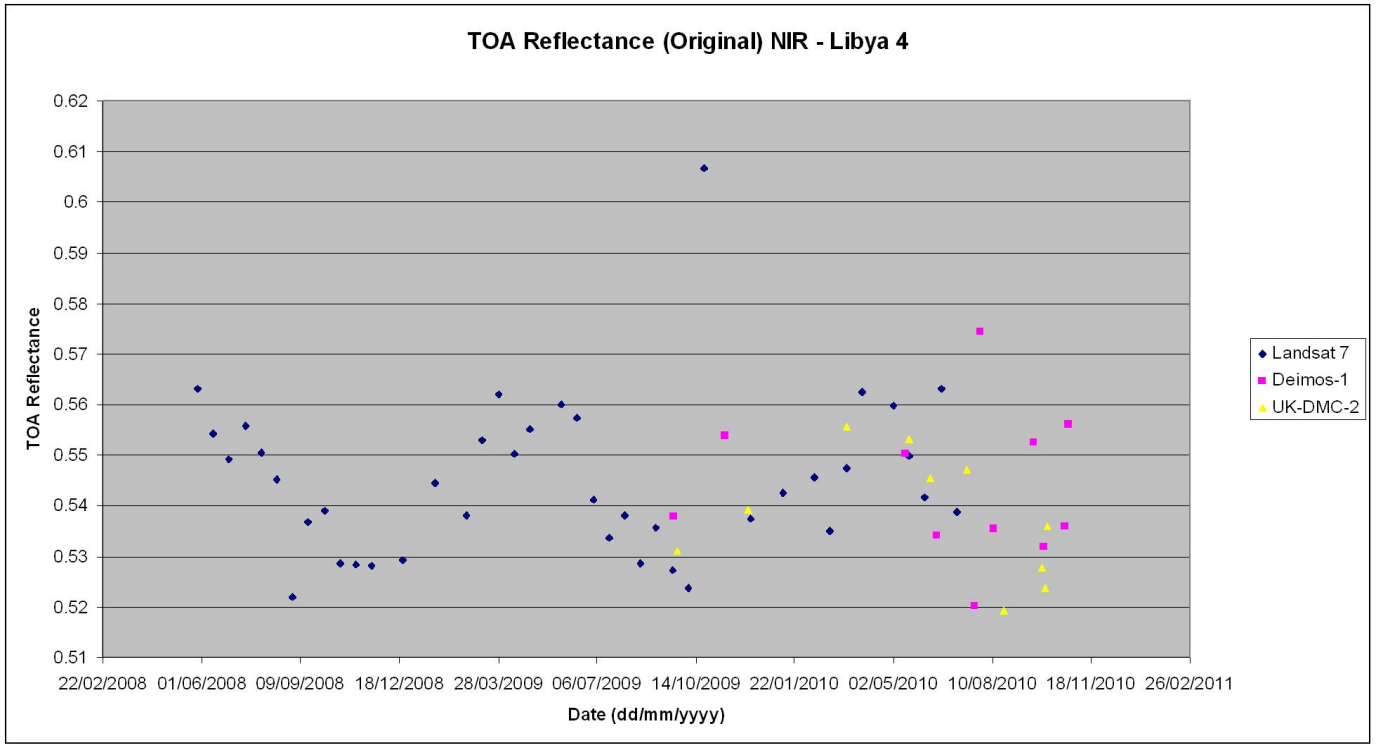
UK-DMC-2

- 22m GSD imager
- Ascending node, but same local overpass time as Landsat ETM within a few minutes over the Libya 4 site
- Images taken very regularly sometimes separated by only 2-3 days, some overlaps in time with Landsat 7.
- Imager can have non-nadir views hence a more complex BRDF correction.



Initial Comparison (NIR)

- Problems of offsets and scatter
  - Possibilities
    - Atmospheric
    - Surface Scattering (BRDF)
    - Other component

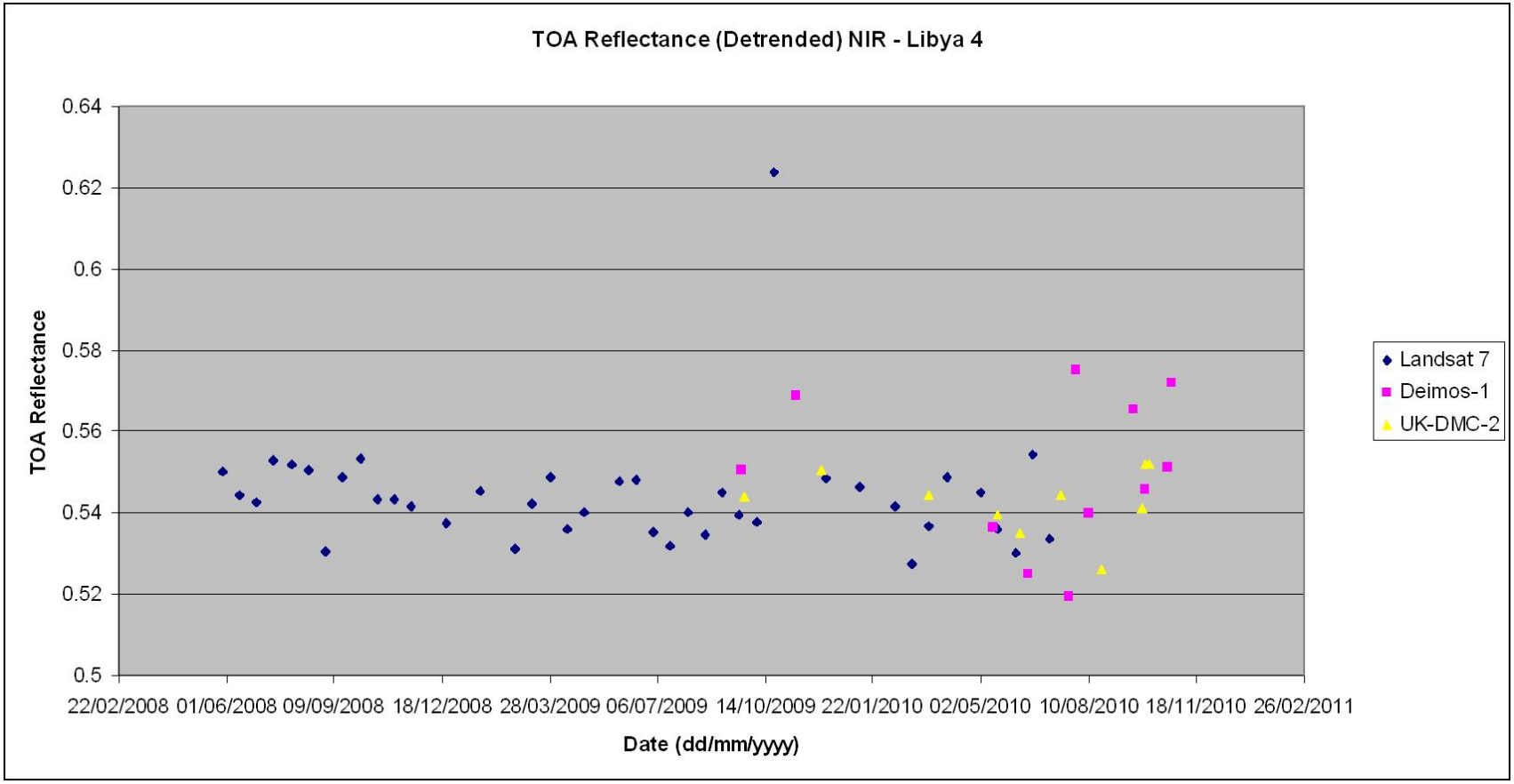


Potentially Confusing Components

- Seasonal Variation
- Different banks on UK-DMC-2 imager (offsets)
- View Angle (atmosphere and BRDF)
- Relative Azimuth (Landsat descending, UK-DMC-2 ascending)

Remove Seasonal

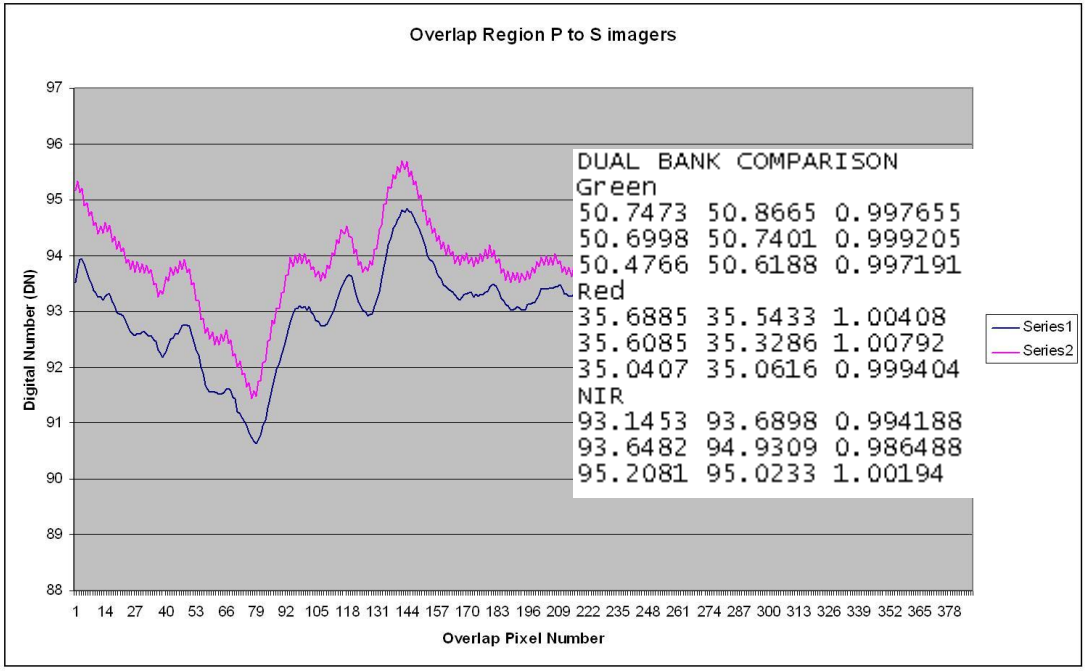
- Detrended data



Check bank to bank overlap

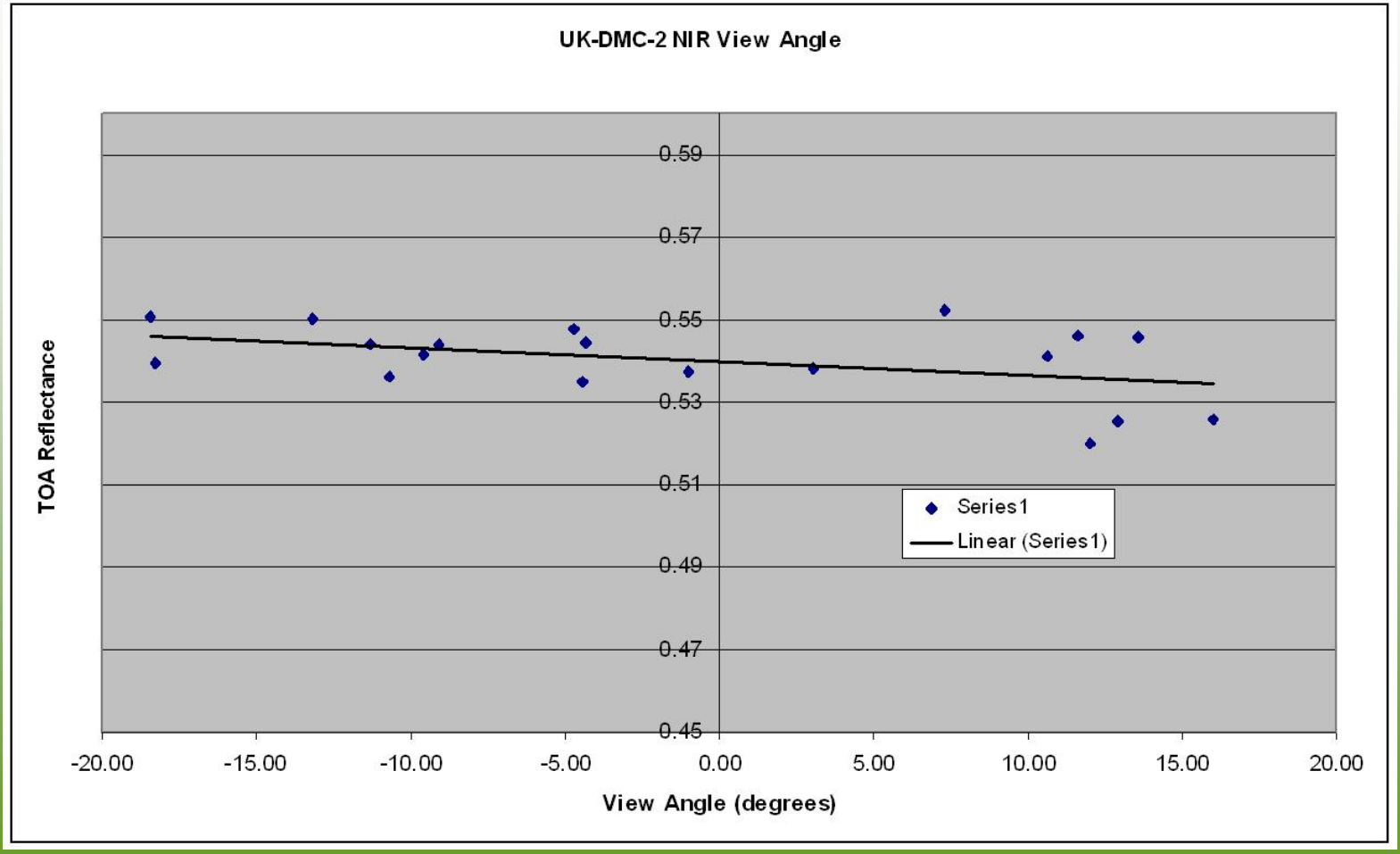
U2000813	0.998415	1.00816	1.01198
U2000730	0.993673	1.00179	0.998893
U200071f	1	1	1.00234
U200065f	0.993225	1.00396	1.00356
U20009fc	0.998749	1.00954	1.01289
U20008c1	0.992711	1.00613	1.00432
	0.996129	1.00493	1.005664

Libya 4 Images



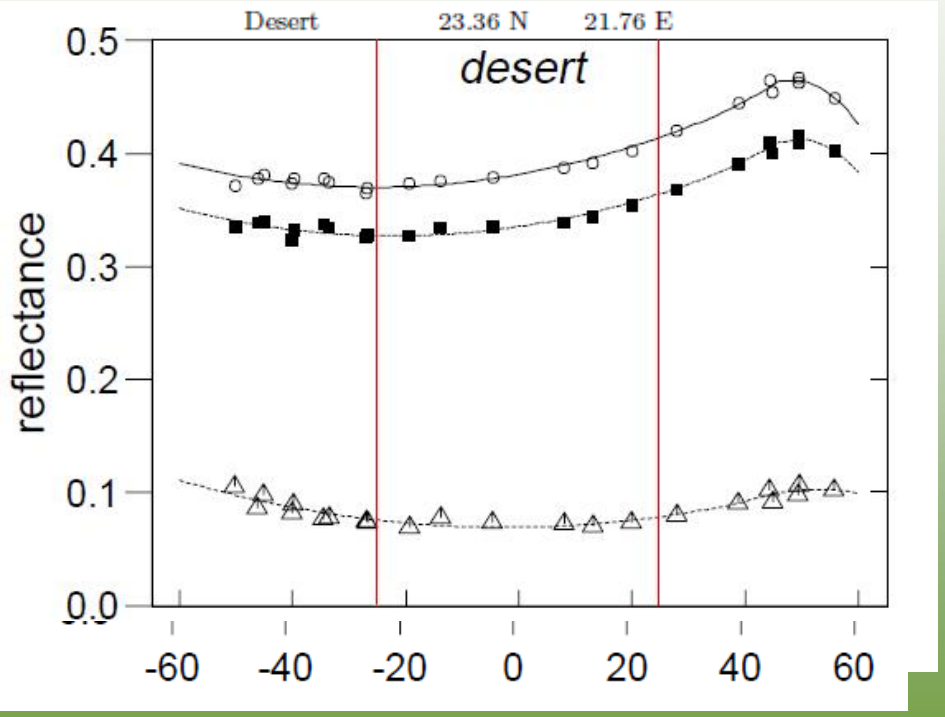
Plot View Angle

- Detrended data used

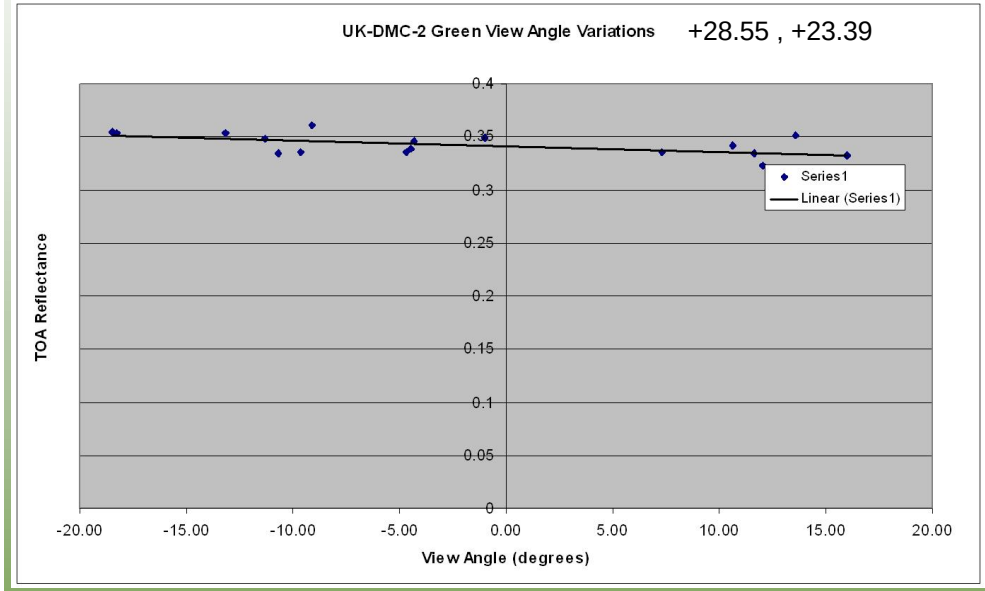


Correct for View Angle using simple linear correction

- Simple linear chosen as functional form still evades as not enough data points to determine true form
- Does not match POLDER data



Based on Polder data

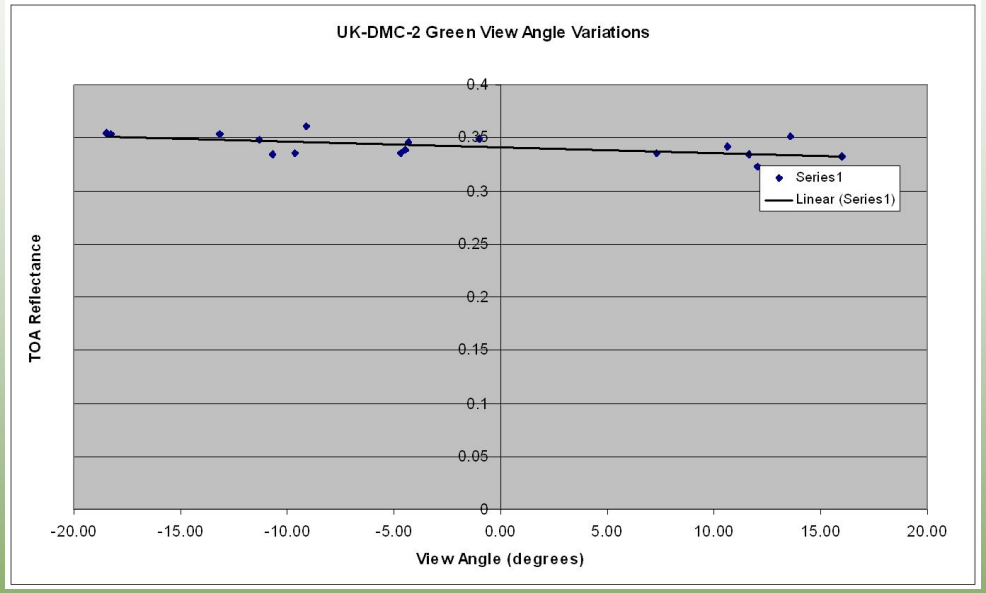


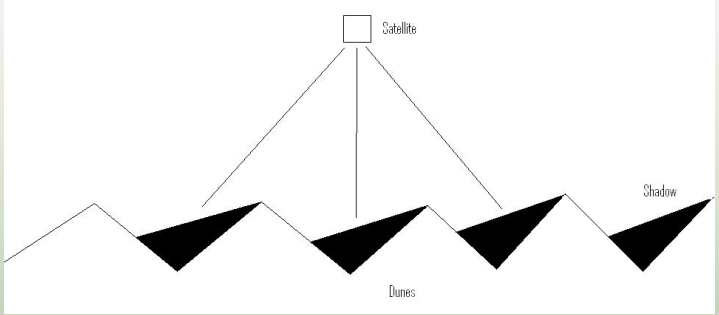
Based on UK-DMC-2 data

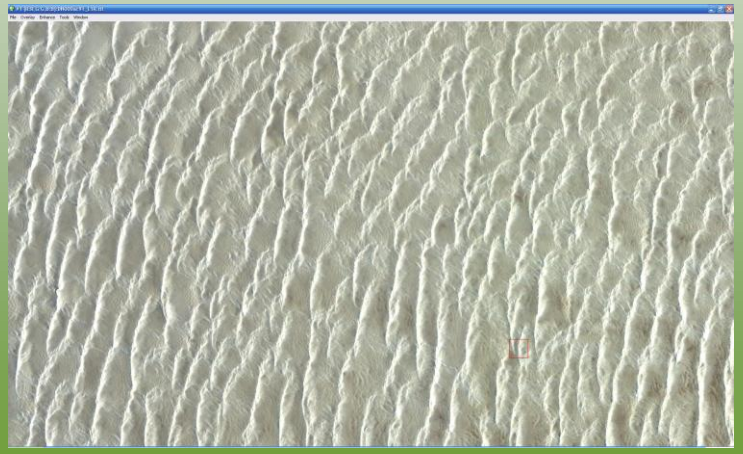
Principal and perpendicular planes, at 443 nm (triangles), 670 nm (filled squares) and 865 nm (circles).

Correct for View Angle

- Why is the correction the opposite of that expected ?
  - The supposition is that it is due to dune shadowing



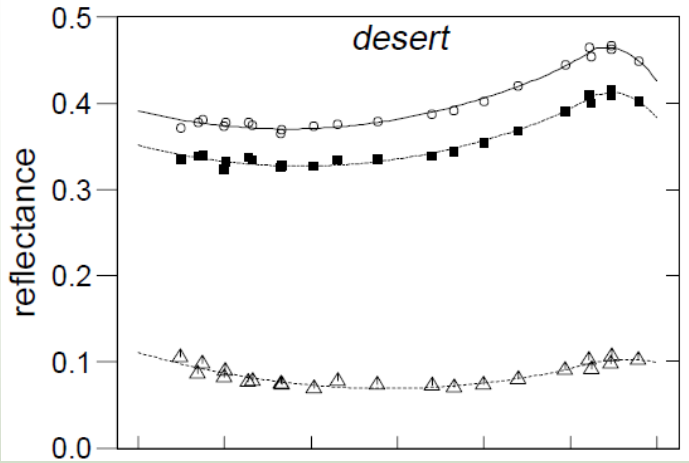




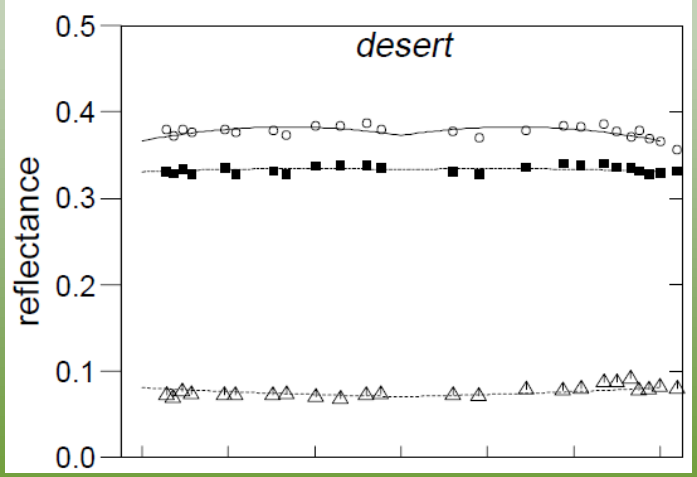
Relative Azimuth

- Will have some relevance even for Nadir imagery from Landsat 7, as it will affect TOA reflectance value for a specific date due to Dune field orientation (will impact magnitude of seasonal oscillation)

- More important when differing view angles. Going from Principal plane to perpendicular to Principal plane we get big differences in BRDF of desert sites



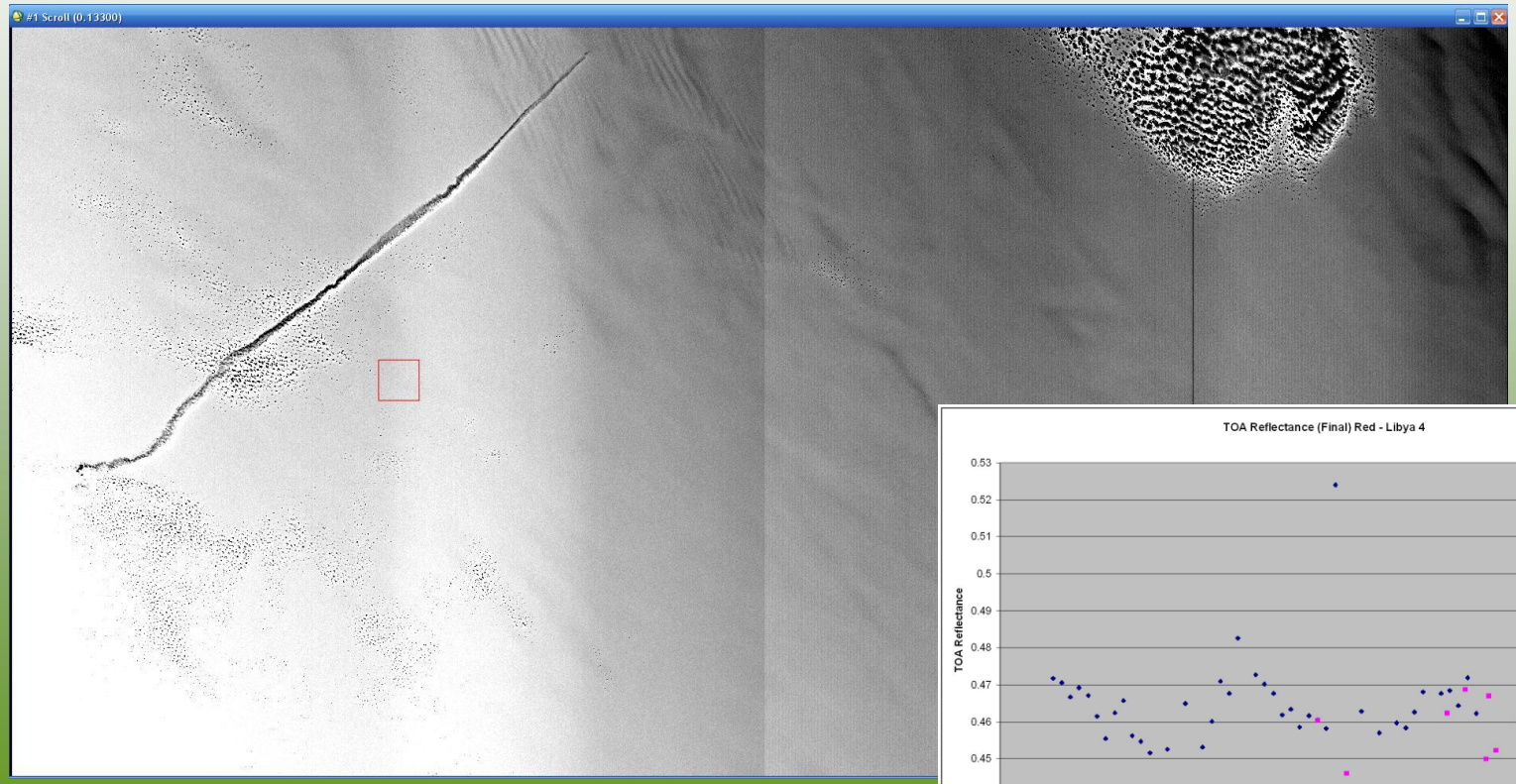
Principal Plane Observation



Perpendicular observation

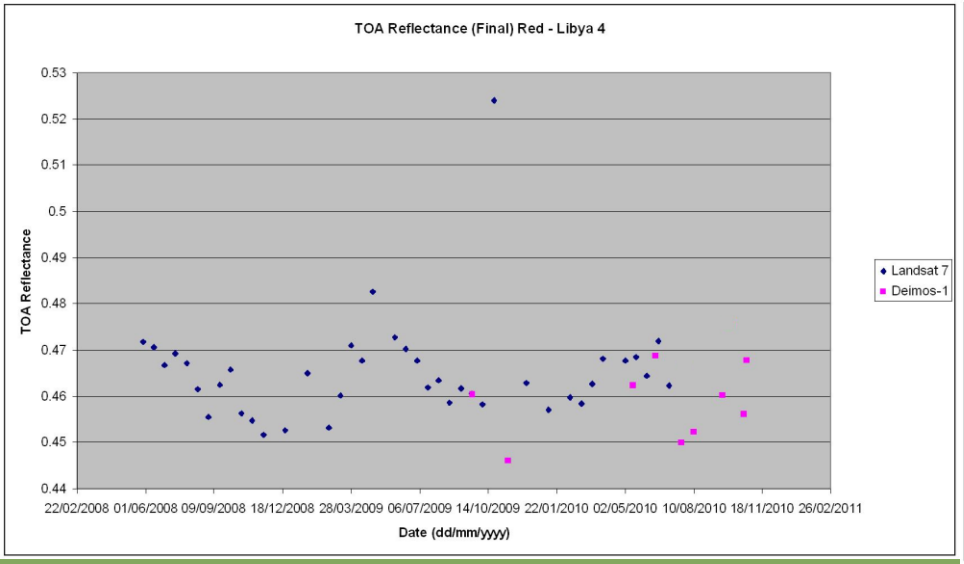
Additional Factor DMC

- What happens if other areas of the calibration have not been completed first. Tested this with data that had not had the column equalisation step as Antarctic data (post-launch) had not been collected at that point

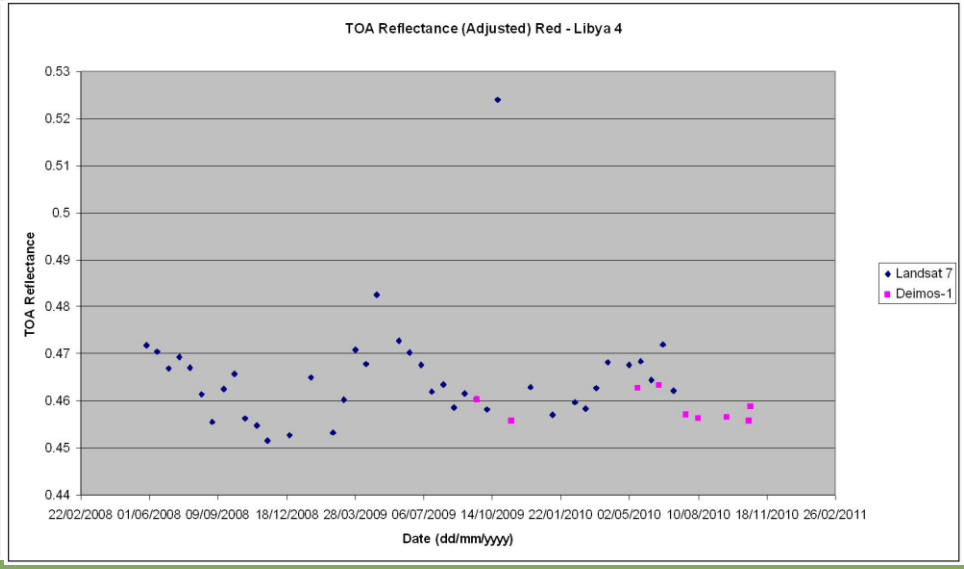


Additional Factor DMC - Corrected

- After equalisation the scatter is removed as using different view angles sampled different bits of the swath which had various artefacts



Before equalisation



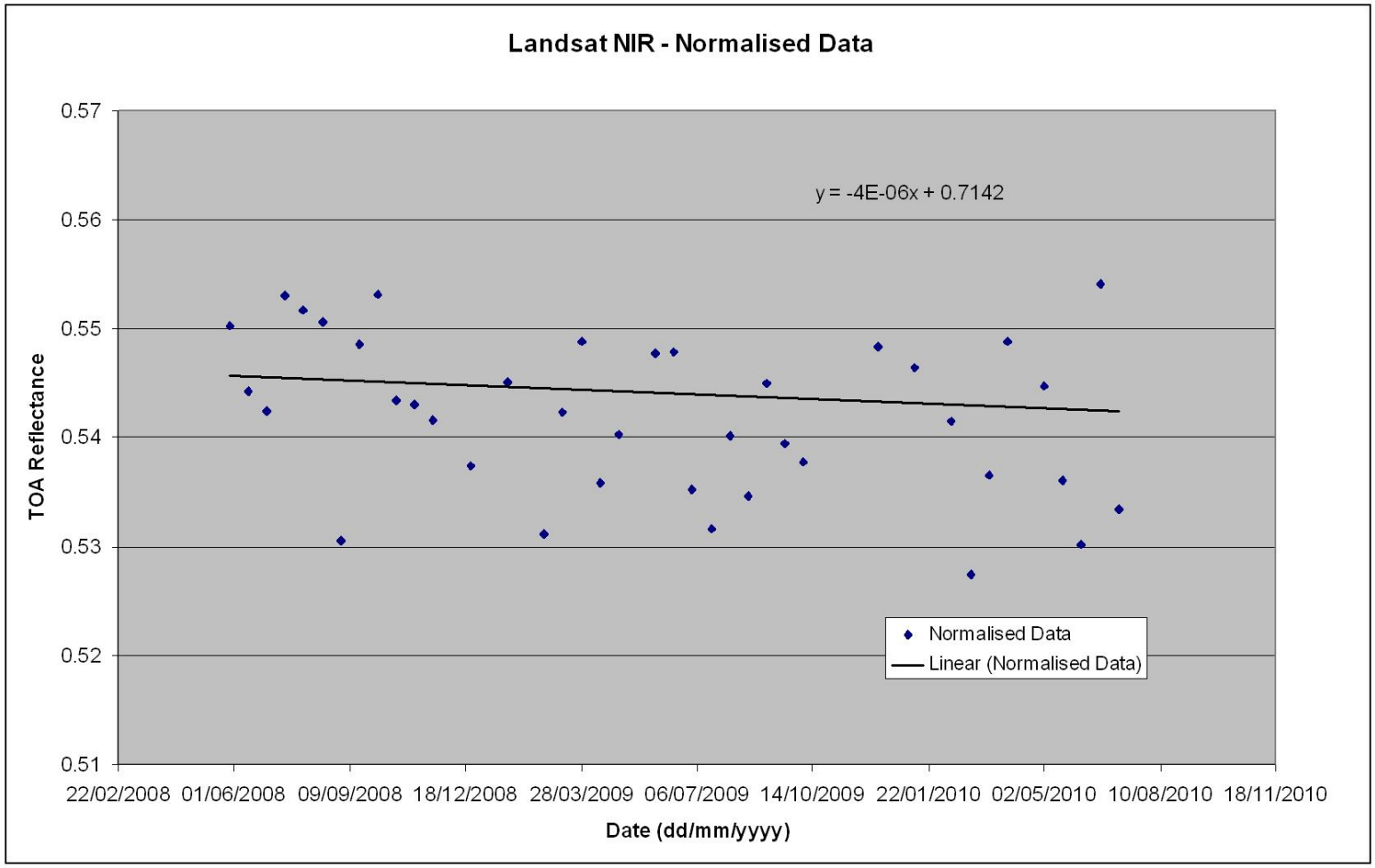
After equalisation

Discussion

- For non-instrumented sites need to build up own BRDF profile
- Still ignoring atmospheric effects through different path lengths
- Still ignoring azimuth angles, need to include
- Can estimate the stability of the results after removal of seasonal trends (assume the mean value of trend is the target value)

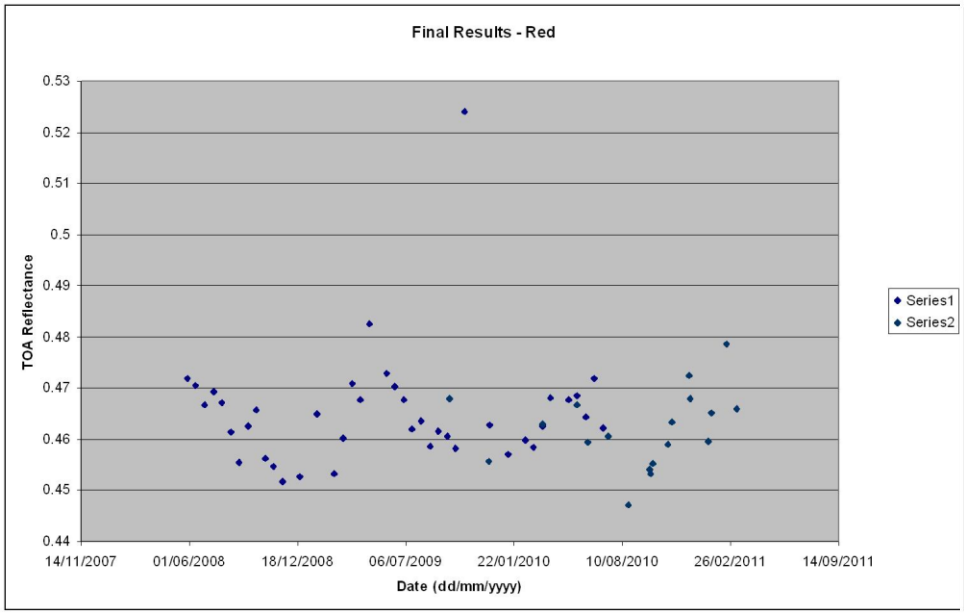
Discussion (Point 4)

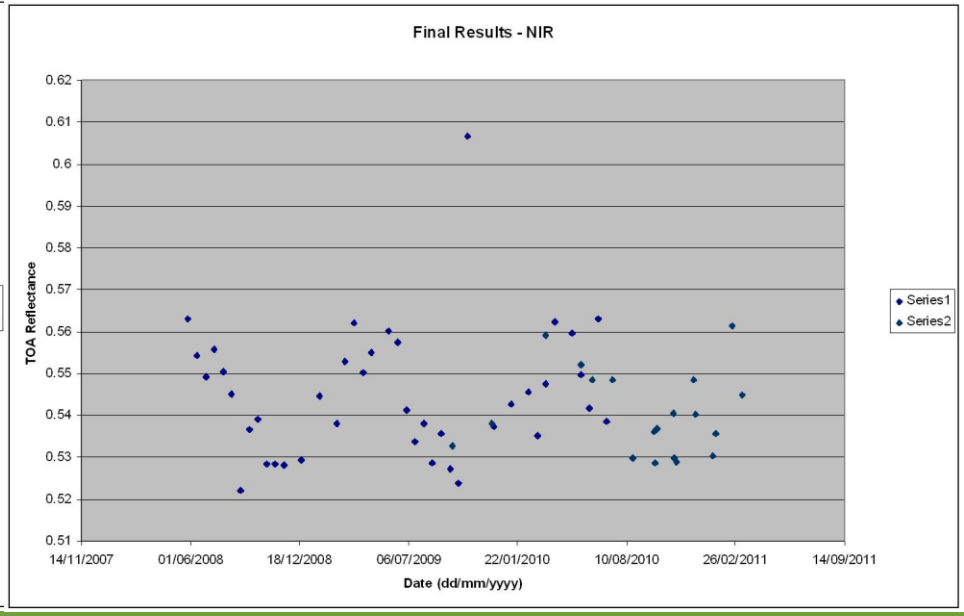
- Scatter shows uncertainty after removal of seasonal trend. This may be atmospheric or due to imaging geometry effects



Final Results

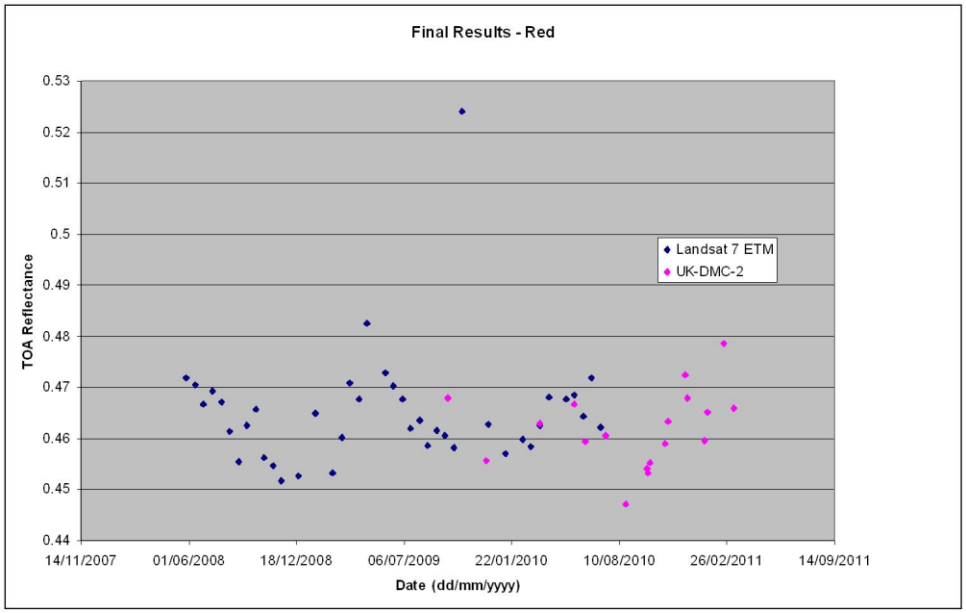
- Landsat seasonal trend continues in the red and NIR bands

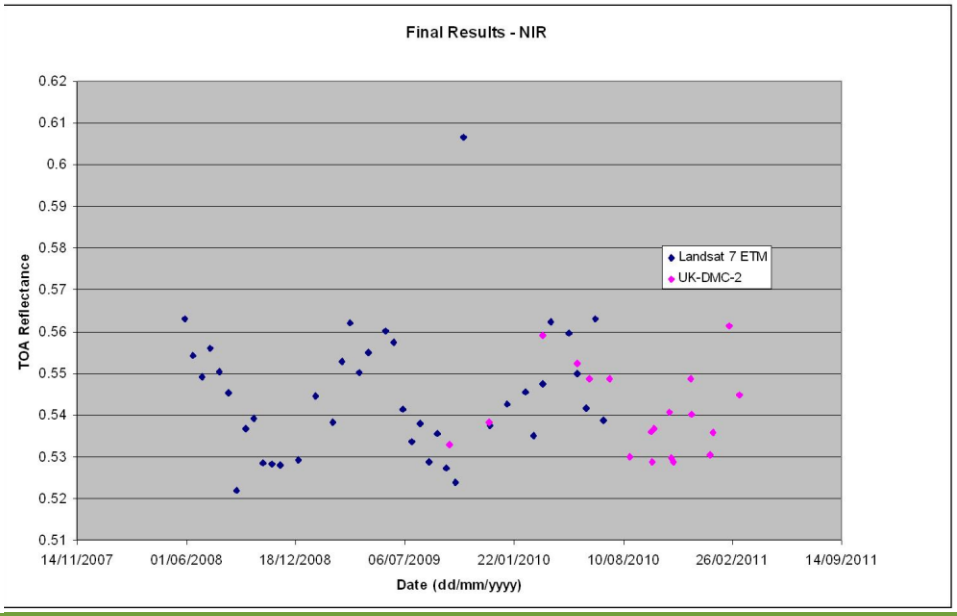




Final Results

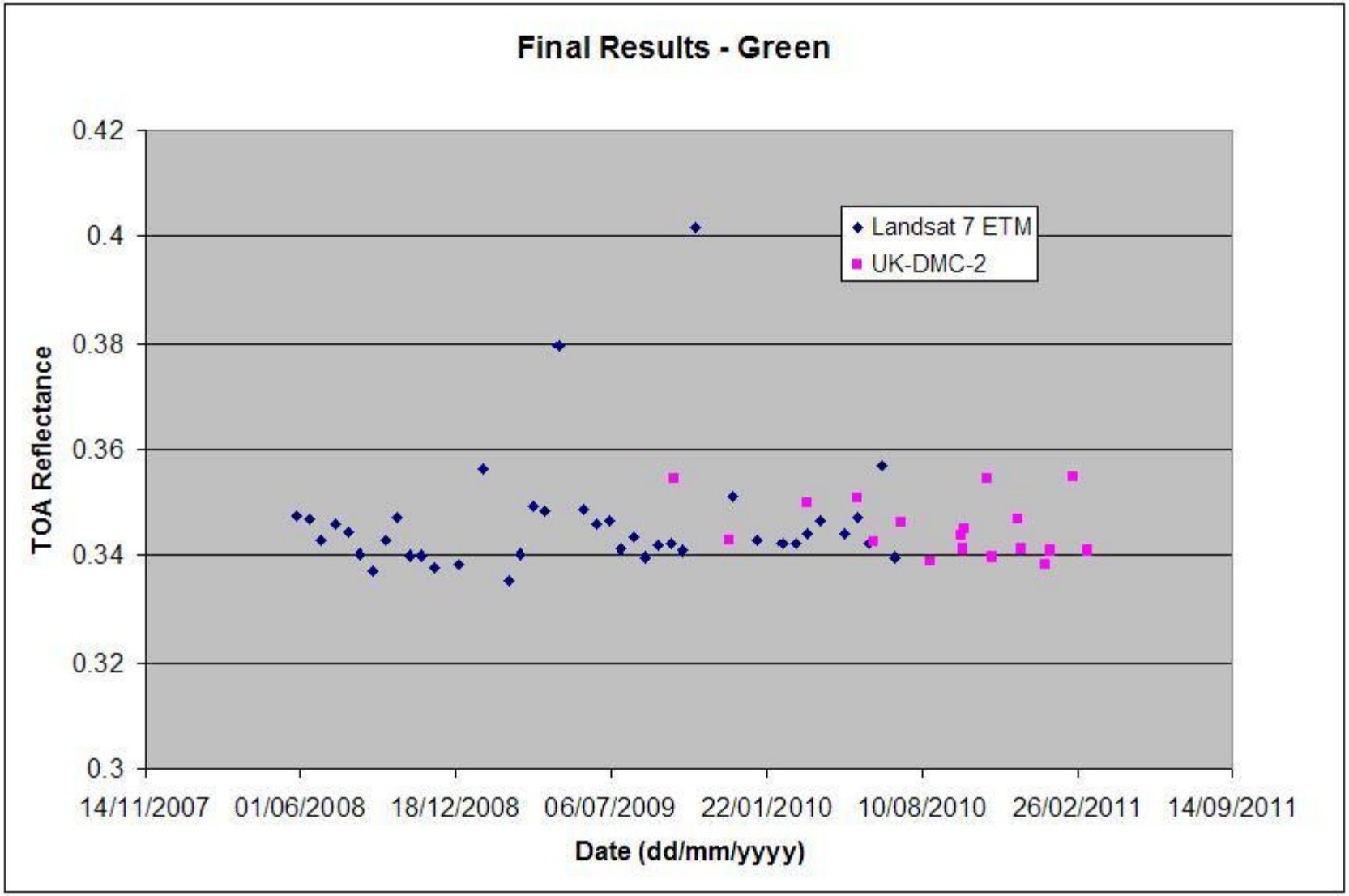
- Except that the values shown are the “Combined” Landsat and UK-DMC-2 values





Final Results

- Green Band



Future Work

- Add other sites to avoid non-invariant behaviour.
- Add more sensors to avoid biases due to a single sensor comparison
- Model atmospheric effects to try and estimate and reduce scatter
- Include azimuth and other parameters to reduce scatter further, as still slightly greater than Landsat 7

Conclusions

- CEOS endorsed invariant sites can be used effectively for cross-calibration. Data updated with coefficients based on last years data are tracking Landsat 7 ETM very well.

- Lack of instrumentation and information on the site characteristics makes it more challenging, but not impossible
  - Better BRDF would help (derived from space)
  - Atmospheric sensors would help, if not numerical models could be used as a first approximation

- Preliminary results suggest that tracking of Landsat 7 ETM is possible to within 1 to 2% using cross-calibration with the second generation SLIM-6 sensors.

- There is more work to do to evaluate other effects (relative azimuth, etc.)

- Thank You…!!!

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