dmc
International Imaging

Libya 4 – Measurement and Modelling

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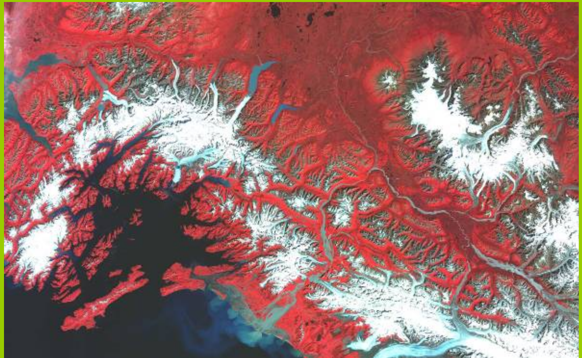


Introduction

- As part of the cross-calibration process we need (as a company) to both
  - Reduce the uncertainties of our calibration
  - Reduce the time taken to perform a calibration (during commissioning)

- So for Libya 4, this means to reduce the uncertainty due to surface variability, surface effects (BRDF) and atmospheric effects.

- This also means we need to minimise the number of observations required to get a low uncertainty on our cross-calibration from long time series of tens or hundreds of observations to less than ten.

Basic Ideas

- For the Libya 4 site generate a surface model. Covering the geometry of the site components (dunes for example), the BRDF or ARF of the surface material (sand for example). With accurate widths and heights of the objects and absolute surface reflectance.
- Tie in a solar geometry with variable zenith and azimuth and a sensor geometry including view zenith and azimuth.
- Tie in atmosphere via a radiative transfer code and generate TOA radiances for different solar and sensor geometries, probably based on an interpolated LUT from several runs of a radiative transfer code with a standard model initially.

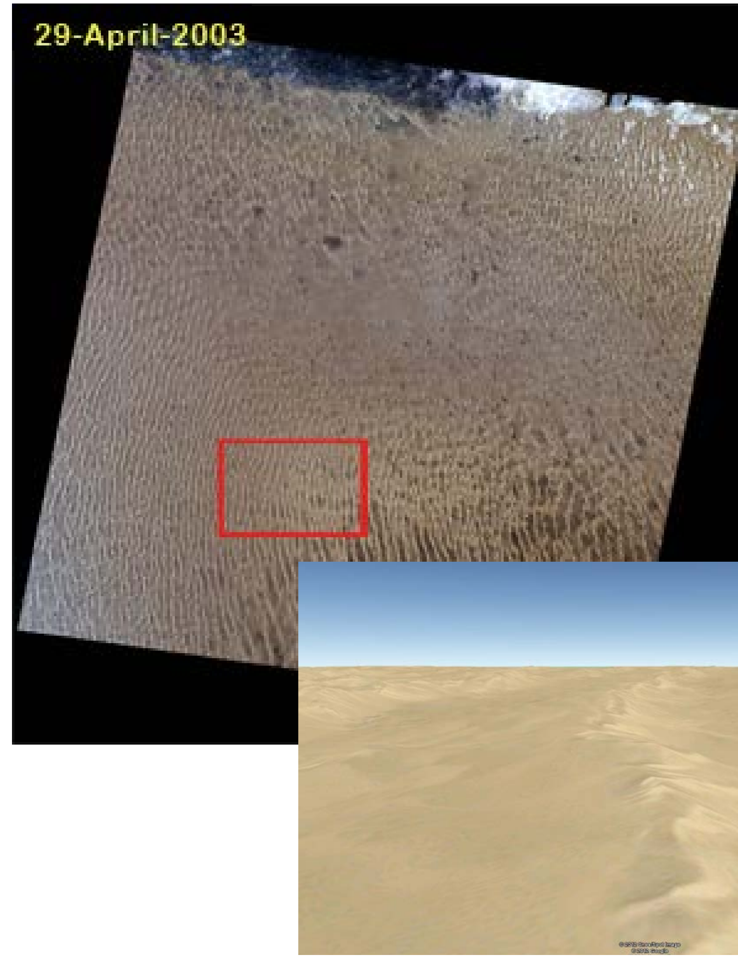
Aims

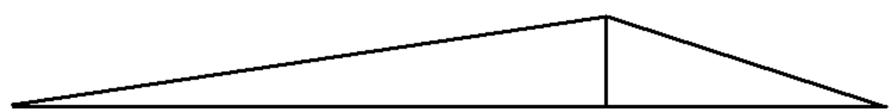
- Use model to asses the importance of each characteristic in determining the TOA radiance.

- Use model to retrieve “corrected” TOA radiance, by inverting model elements to get back to the fundamental values. Allows a more accurate cross-calibration of multiple sensors with different bands and spatial scales.

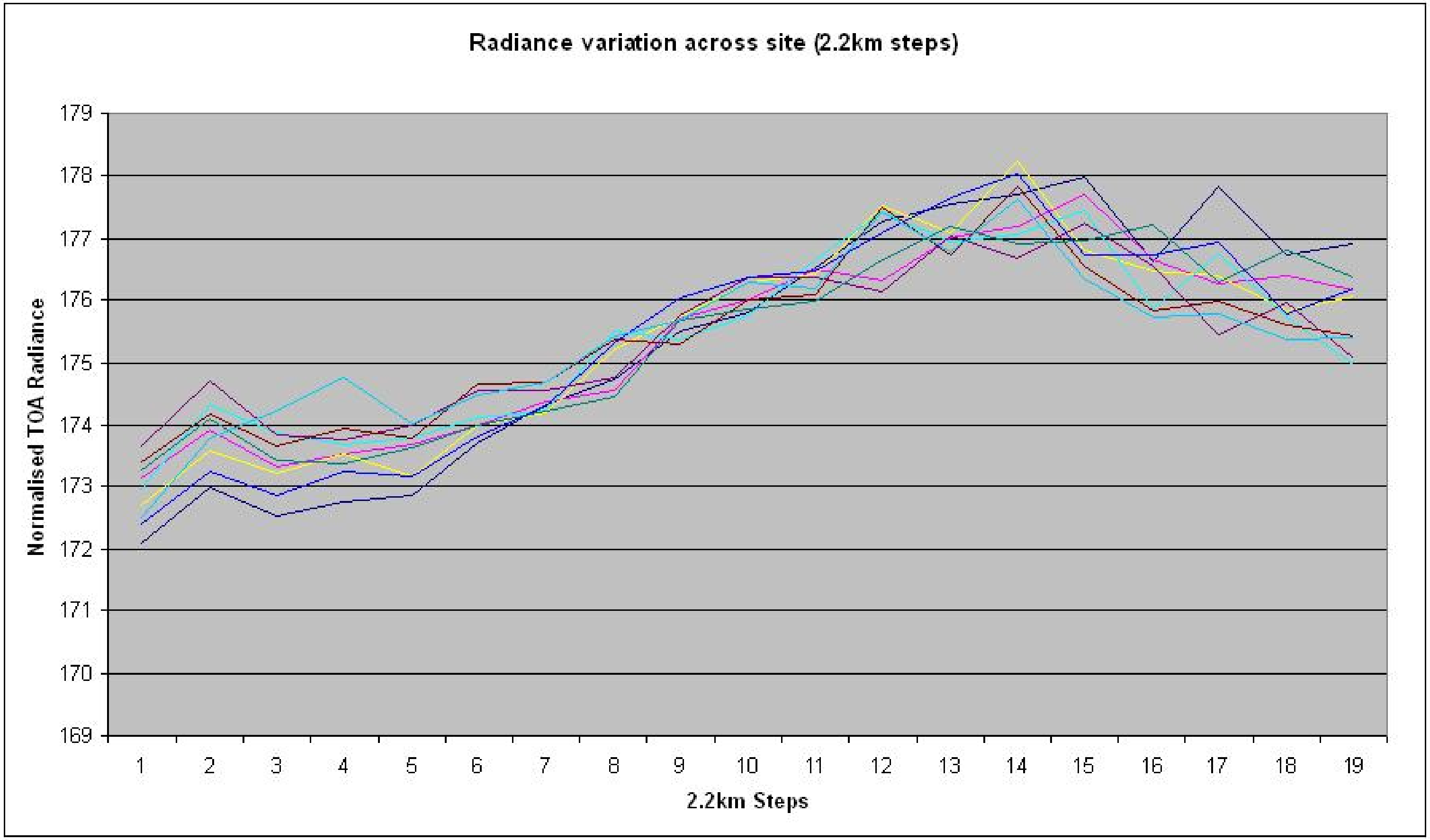
Libya 4

- Stable (?) area of sand dunes, dunes seem to be asymmetric, aligned N-S.
- No ground or atmospheric measurements
- Atmospheric variation treated as noise component currently
- Site is not instrumented and consists of sand-dunes, so strong BRDF component.
  - Nadir viewing
  - Off-pointing viewing





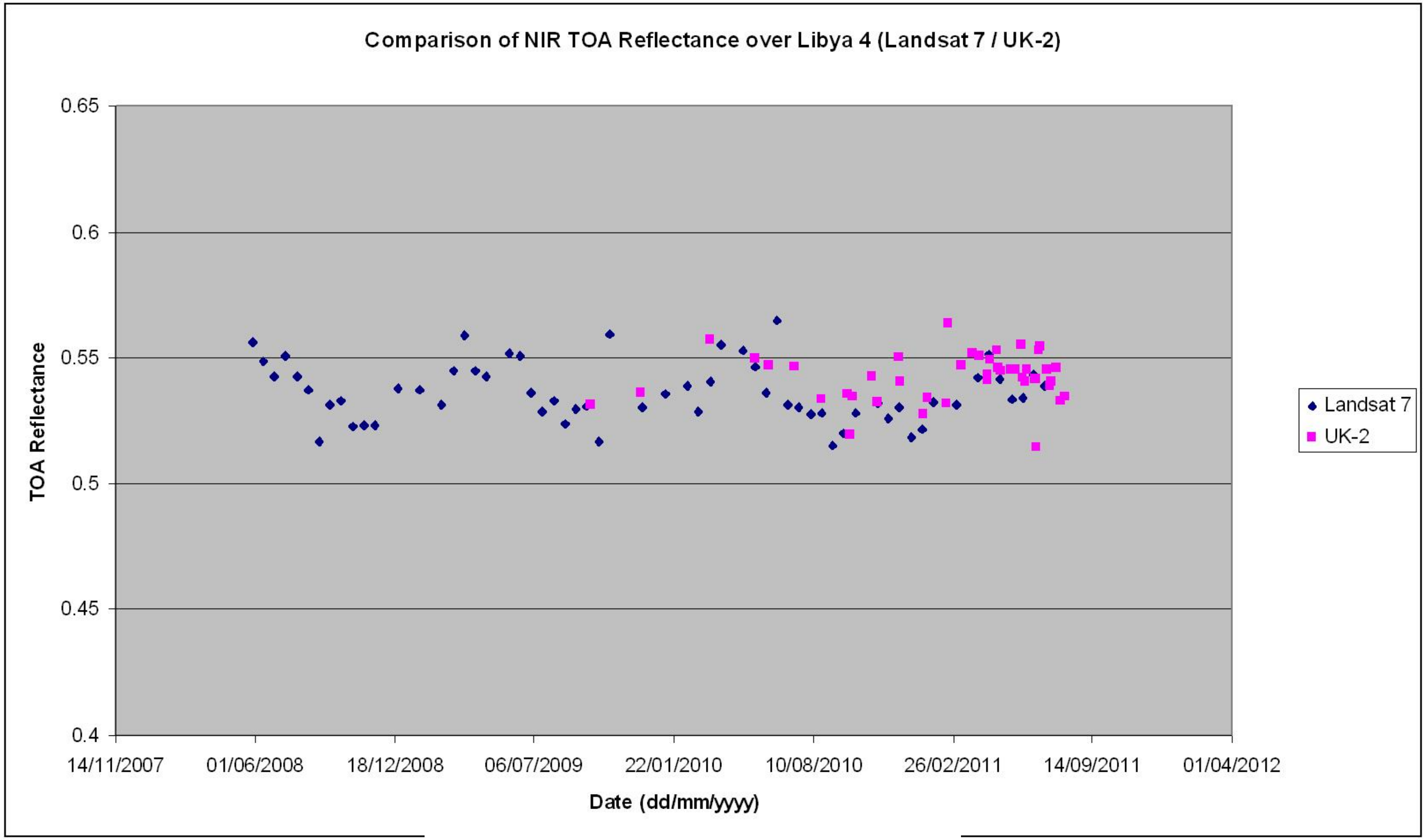
Libya 4 – Variability across site



- Site seems stable but not uniform in terms of its reflectance (2.2km wide x 20km long strips)

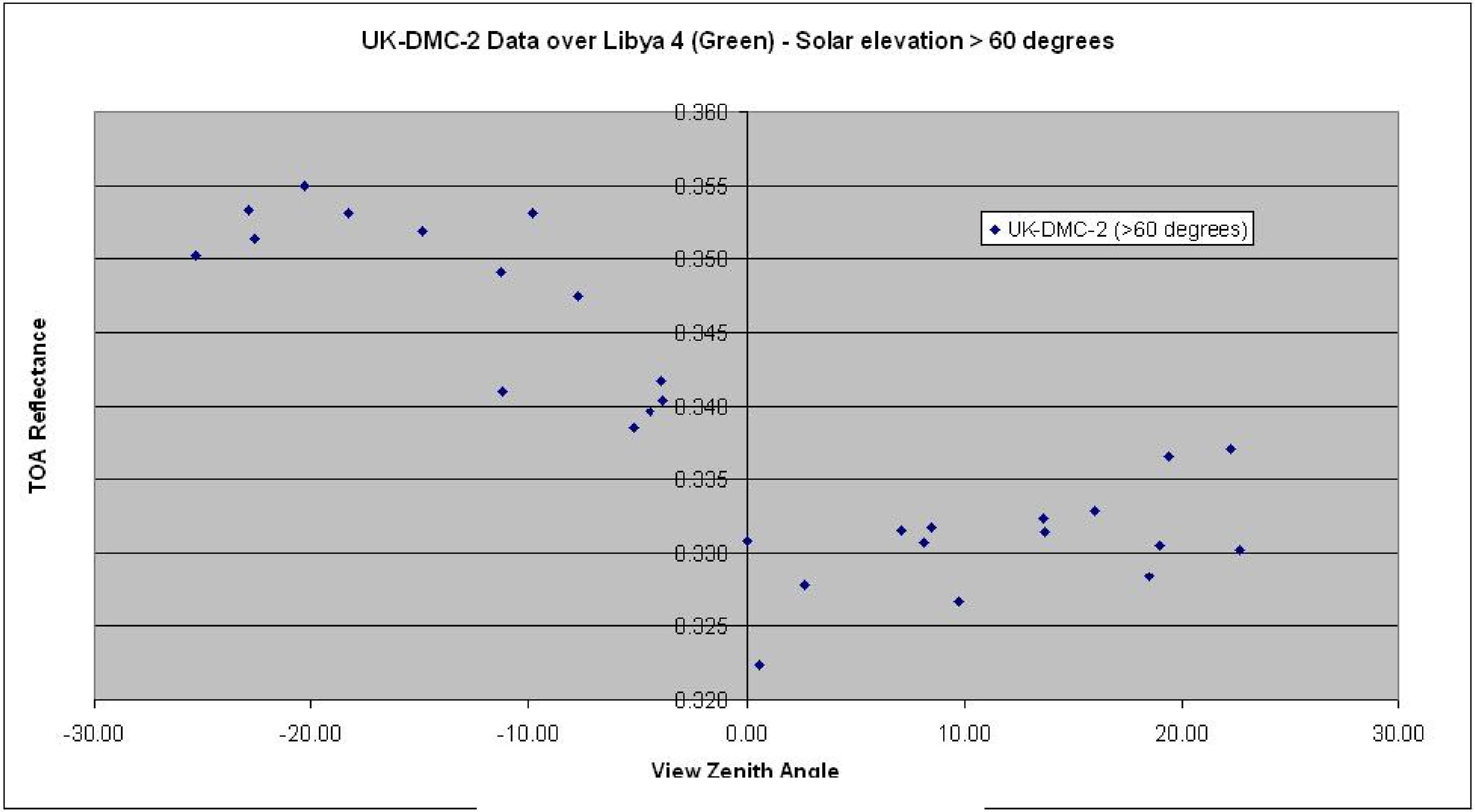
Cross-Calibration – Nadir Viewing

- Used in cross-calibration, in this case UK-DMC-2 against Landsat 7 ETM+.



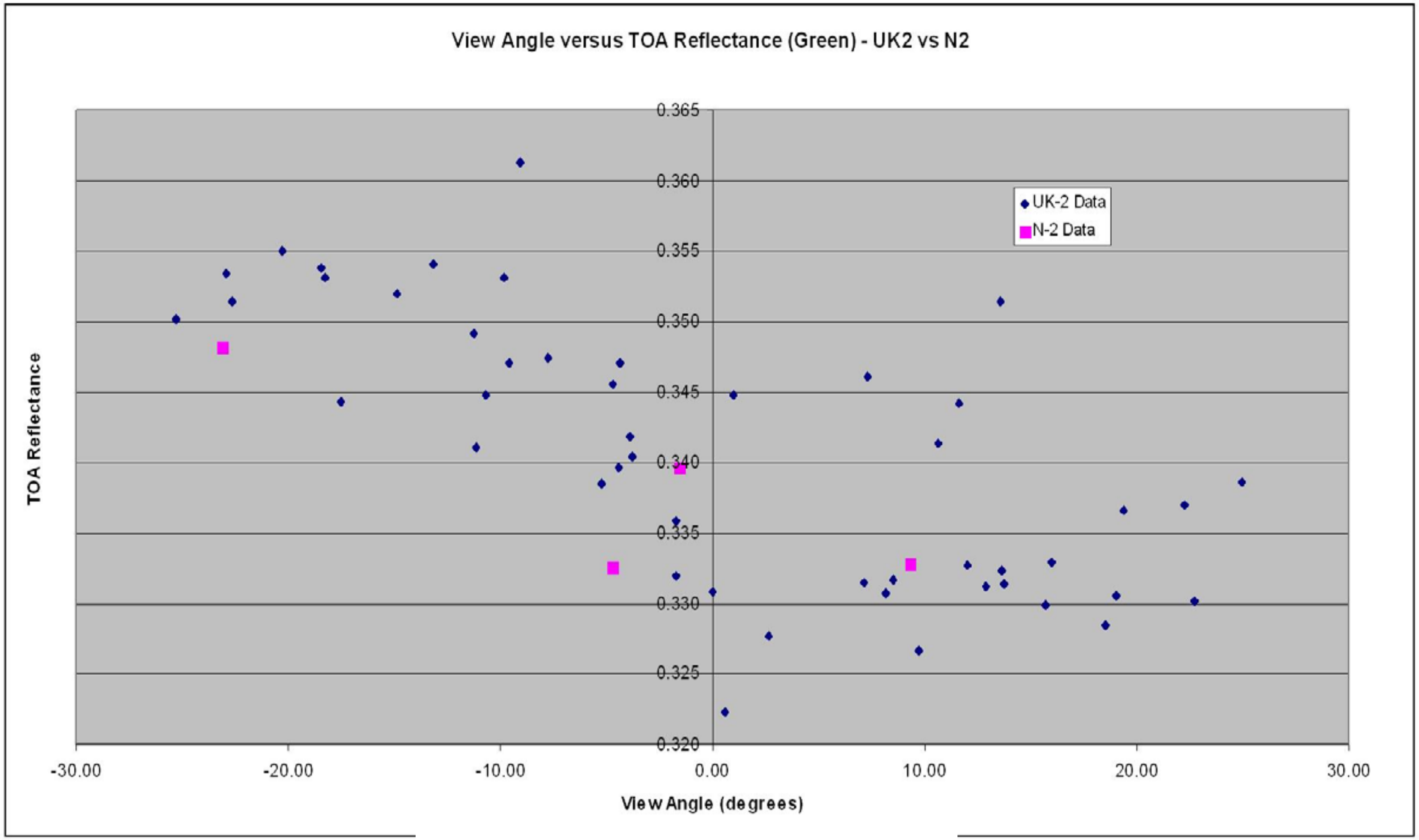
Cross-Calibration – Off Pointing

- View angle effects due to drifting ground track of UK-DMC-2



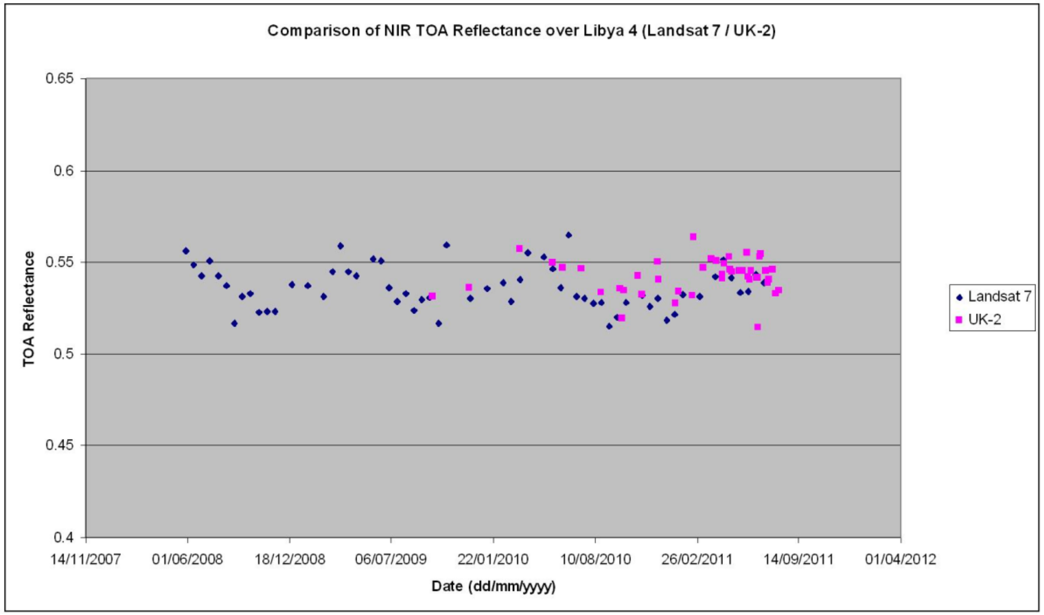
Consistent off-pointing (multiple sensors)

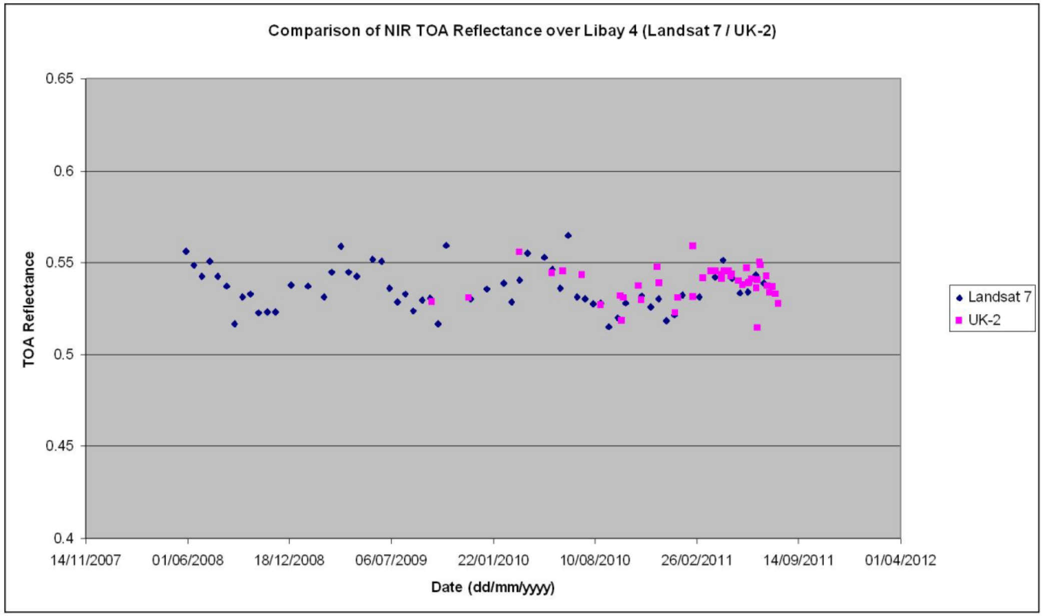
- We see the view angle effects with multiple sensors, here four N2 observations are plotted against UK-DMC-2 data



Cross-Calibration against L7

- Knowing we have view angle effects we can apply a simple correction to reduce them.
- But its not the whole story…!!!





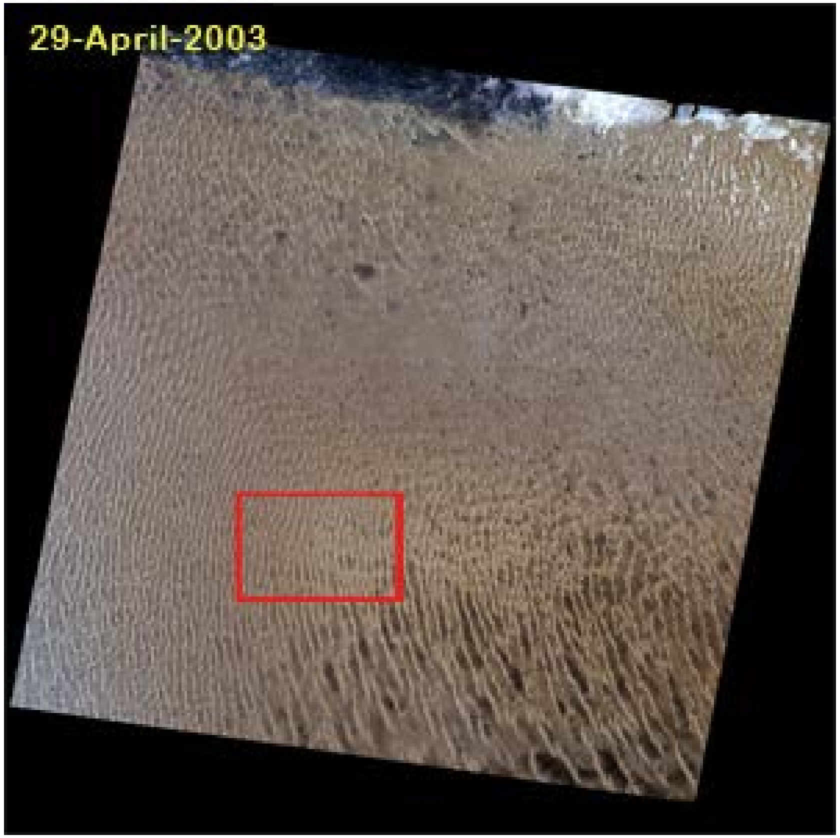
Model Step 1 – Surface Geometry

Assume N-S dunes. Used imagery to assess asymmetry, used ground photos and ASTER and SRTM DEM’s to assess dune to dune variation in relation to dune width.

- Slope widths and height, gives slope angles

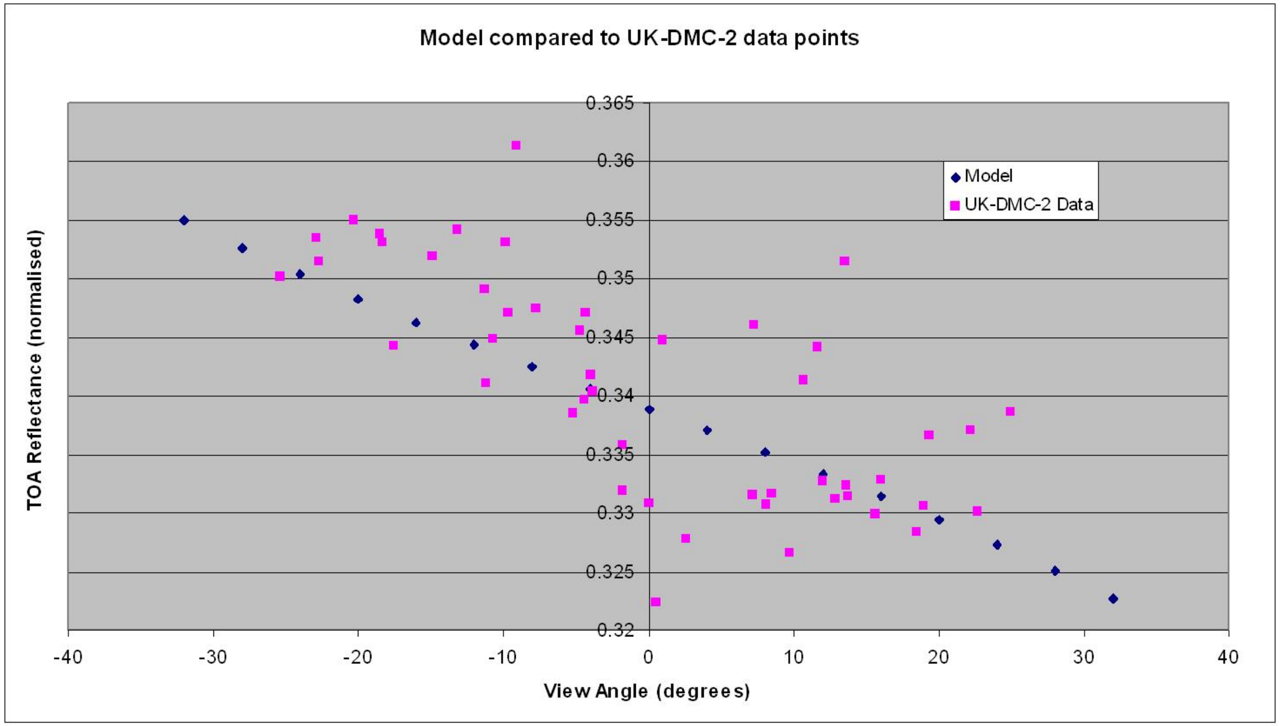
– Other parameters

- Solar elevation (zenith) angle
- Solar azimuth angle
- Sensor view zenith angle
- Sensor view azimuth is assumed to be +- 90 degrees.
- Atmospheric absorption/scattering (off-angle) based on MODTRAN



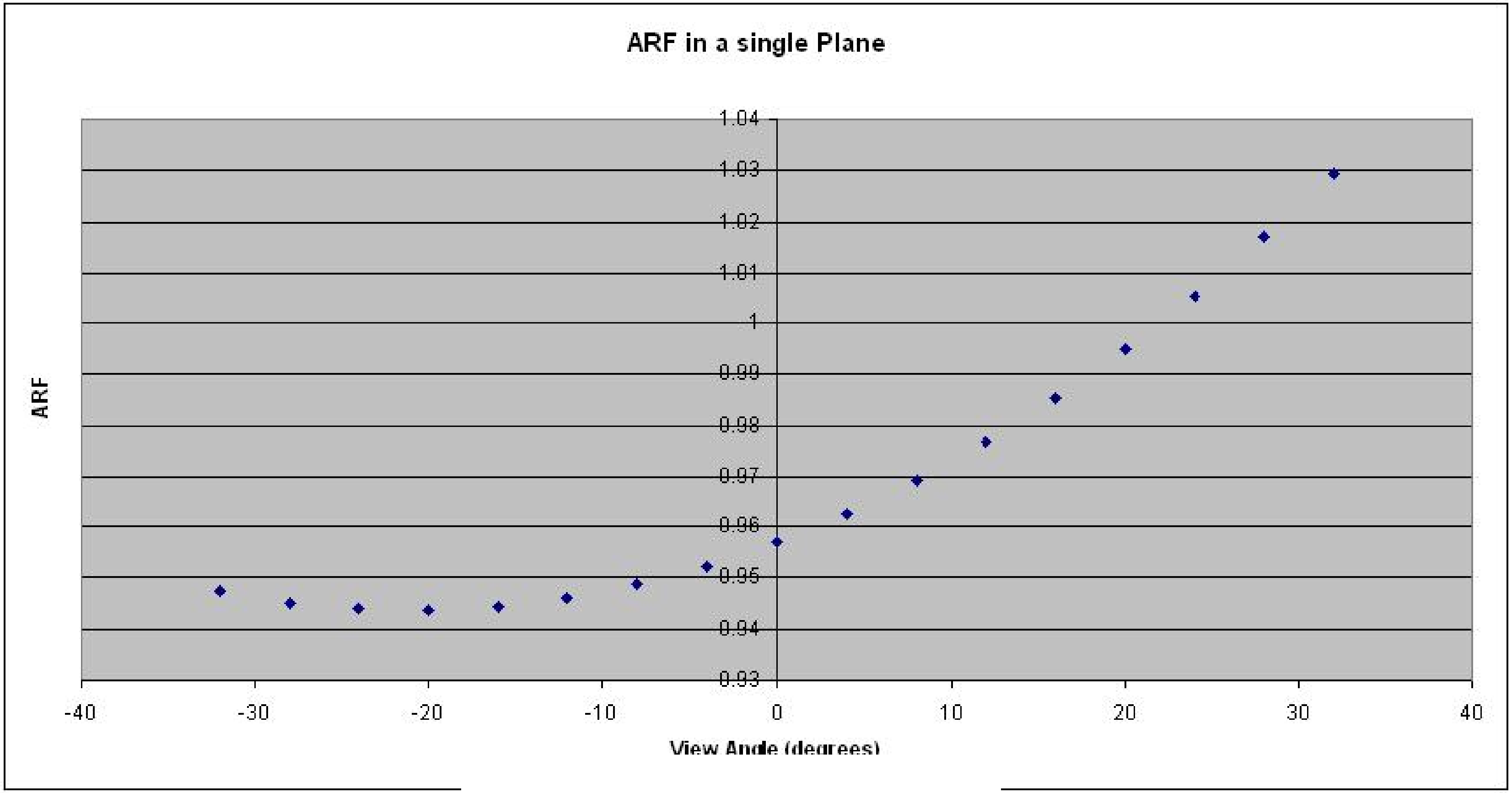
Model Step 1 - Geometry

- Lambertian surface, N-S trending dunes

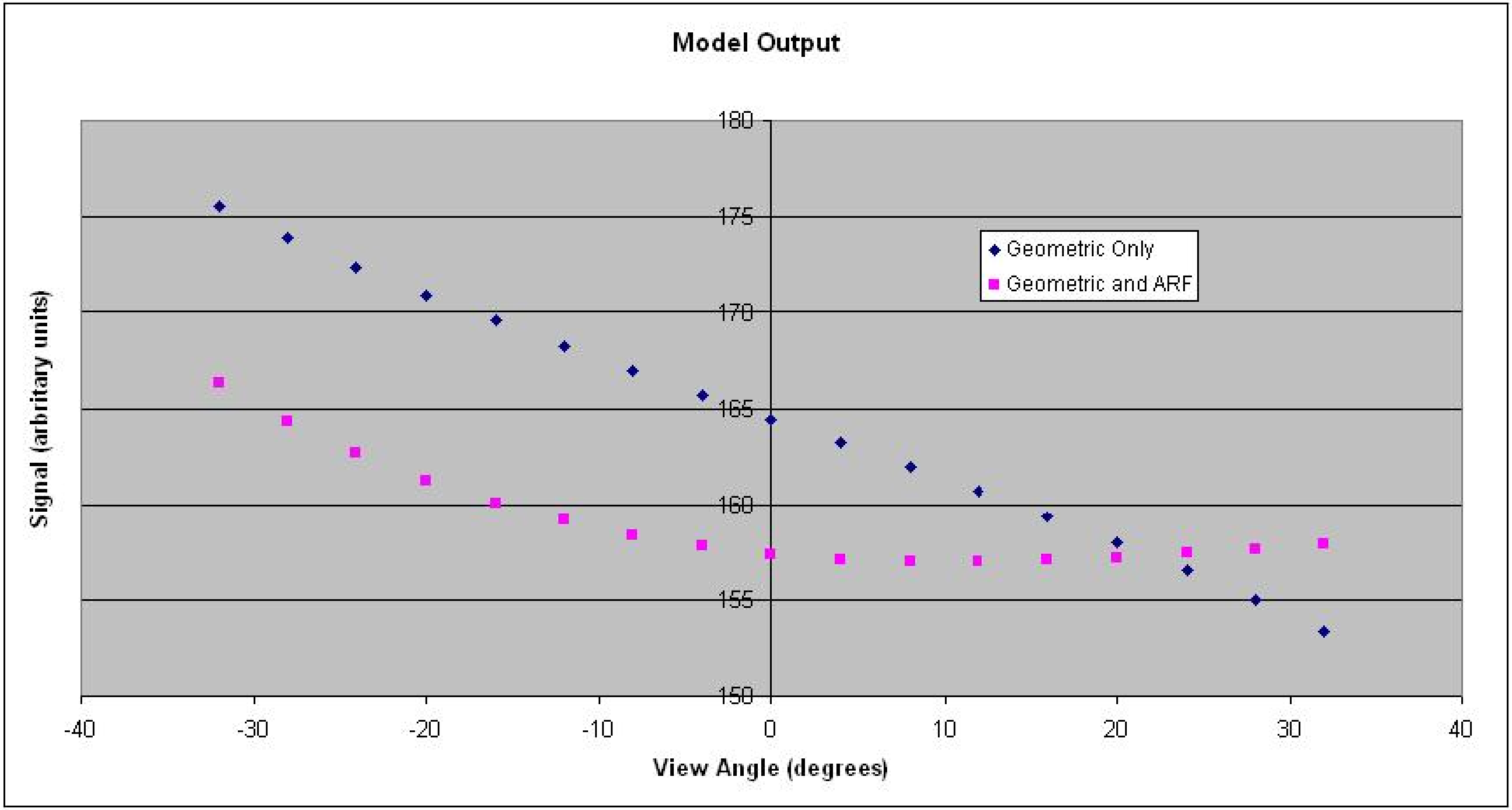


Model Step 2 - BRDF

- Literature review provided limited information on sand BRDF (this model assumes forward scattering). Used very simple normalised "slice"

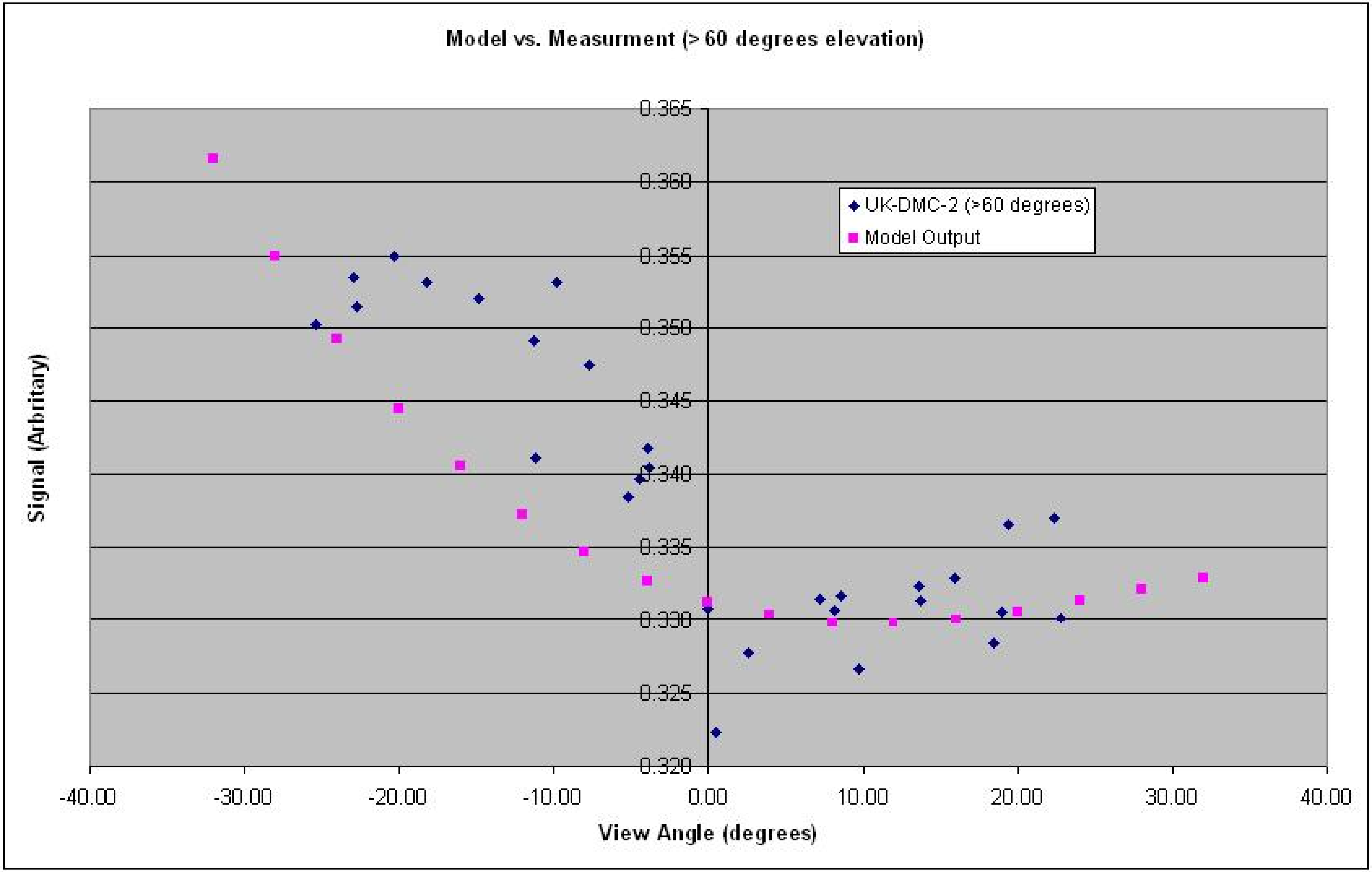


Combined Geometry and BRDF



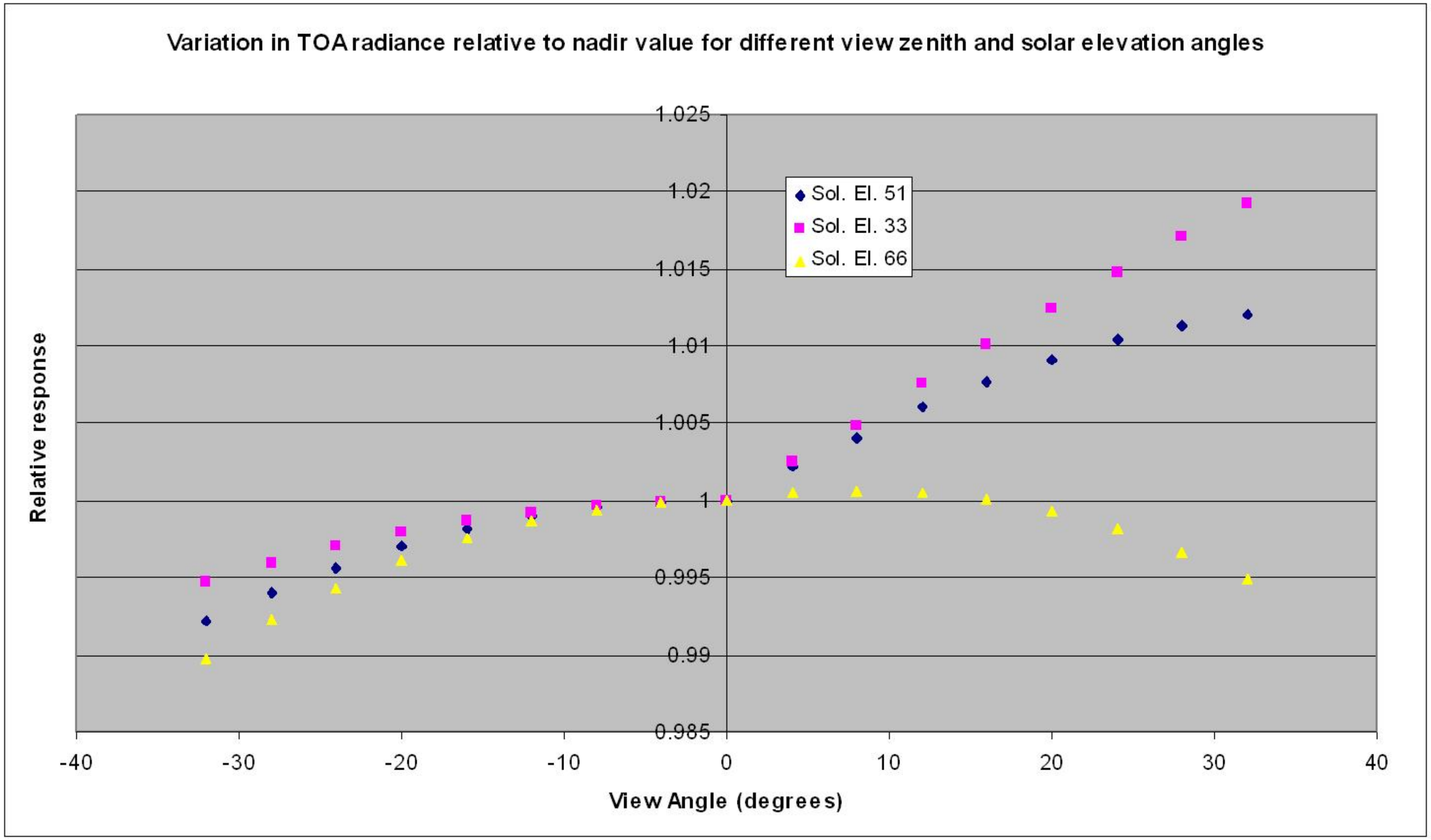
- Curve shape sensitive to dune height and asymmetry, solar elevation and forward scattering magnitude

Comparison against real data



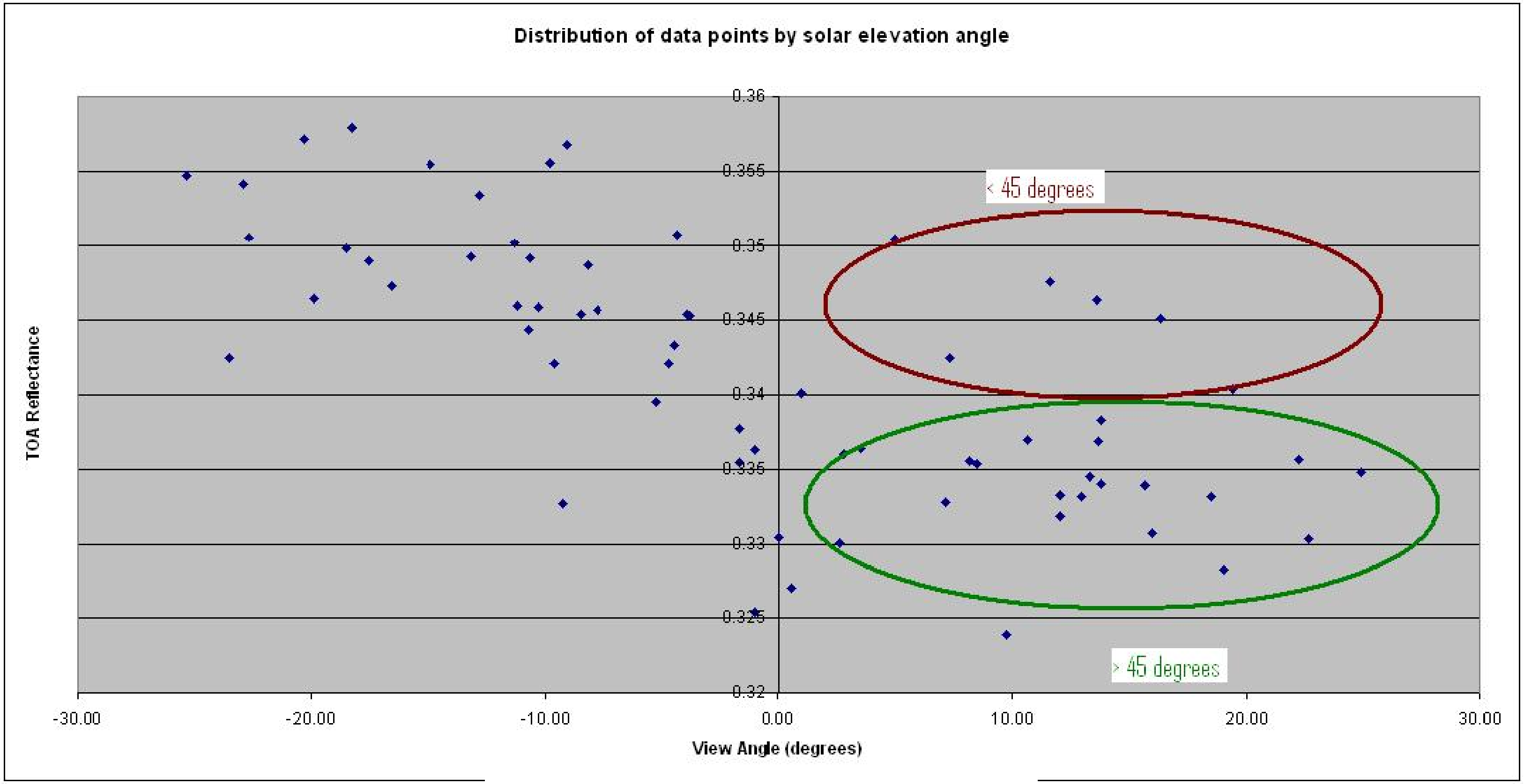
Model Step 3 - Atmosphere

- Path Length effects
  - MODTRAN runs with same atmosphere but different view zenith angles and solar elevation angles.



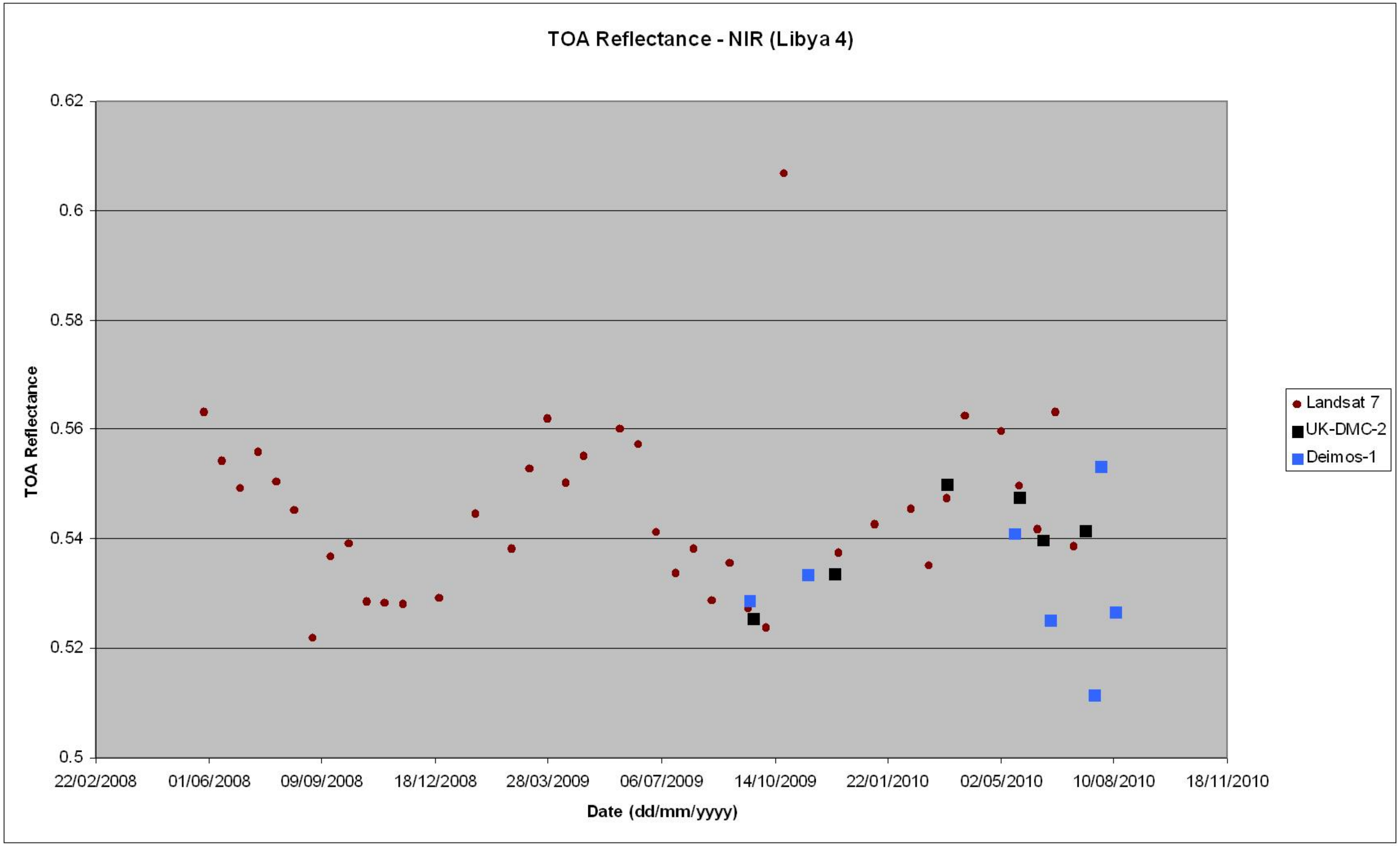
Variation of data with solar elev.

- Points cluster when looking towards sun, but are not separable looking away from sun, now strongly suspect BRDF as source



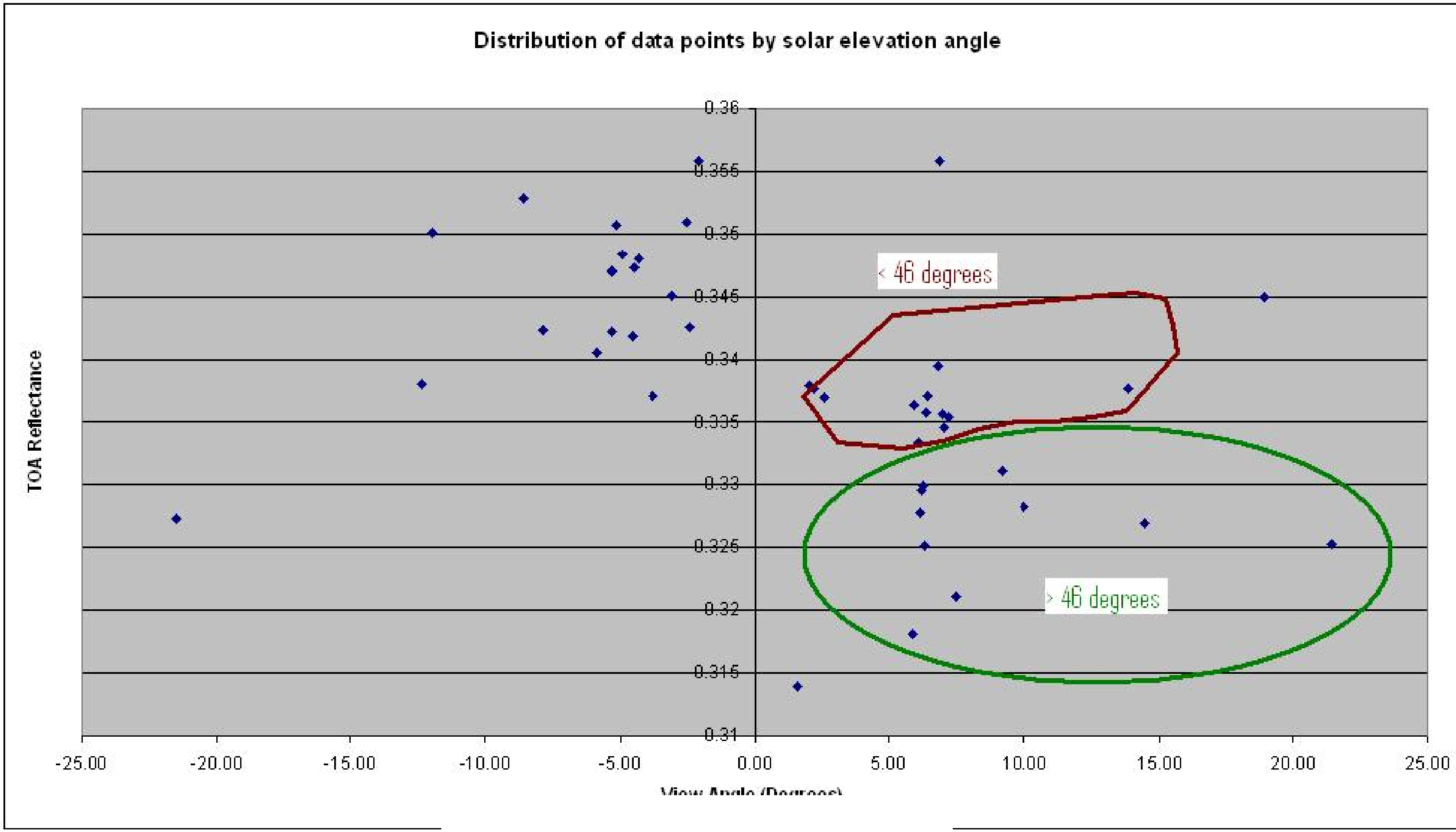
Scatter in data due to BRDF ?

- Deimos-1 always showed more scatter compared to UK-DMC-2.



Scatter due to BRDF ?

- Reason being in part that they have much higher proportion of low solar elevation data.



Conclusions

- There is a distinct structure to the data from multiple view angles across the Libya 4 site.
- The general dune geometry and BRDF of the sand seem responsible for a large proportion of the signal variation seen in the data.
- Atmospheric effects even assuming a stable atmosphere do contribute, especially at large view angles.
- The method of simple modelling used is insufficient to fully capture the variation seen in the data.
- However, we (DMCii) consider modelling as the best way forward to achieve our goals of reduced uncertainty and reduced commissioning time.

Recommendations

- Need to carry out better evaluation of the geometry of the dune field (accurate DEM)
- Need accurate BRDF that approximates well to the desert sand of the area to generate a look up table for the view and solar geometry during an observation.
- Need a better model...!!! (ray-tracing)
- Need to find a way to incorporate key atmospheric variations for non-instrumented sites (MODIS, meteorological model data?)