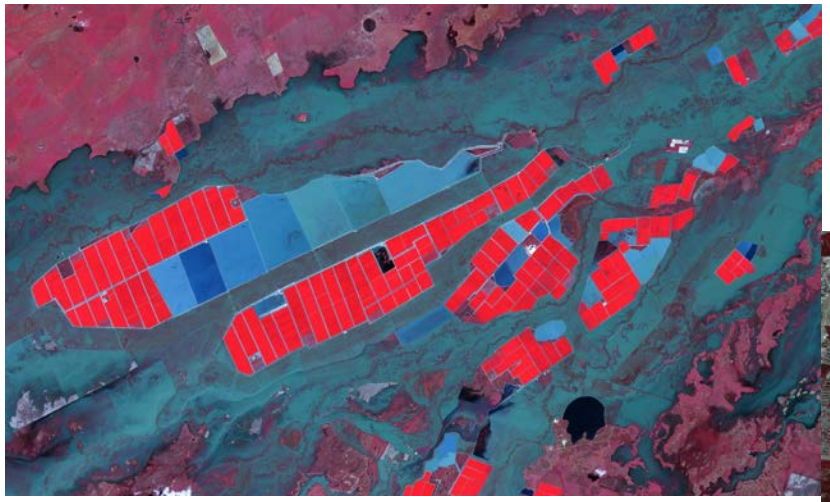
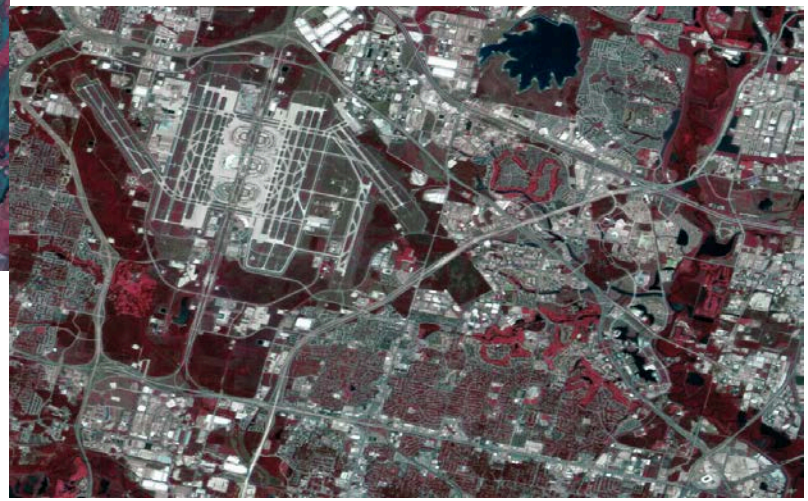
Reducing the uncertainty in radiometric cross-calibration over the Libya 4 site – Measurement and Modelling





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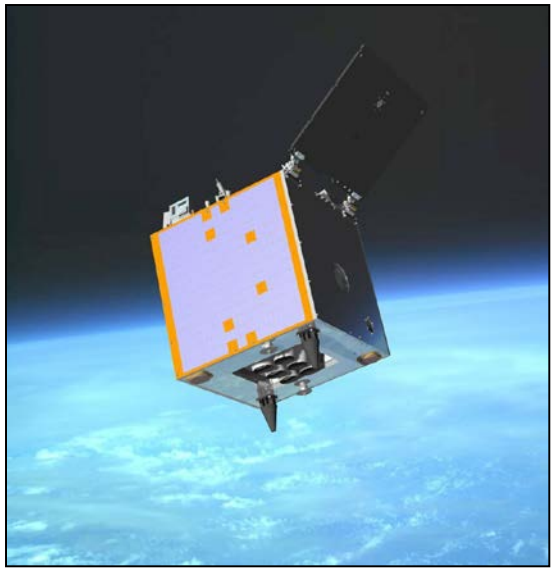
Overview

- Introduction to 22m satellites
- Outline calibration method
- Expand on Libya 4 Cross-Calibration and it's limitations
- Future Developments
- Results

Introduction to 22m Satellites

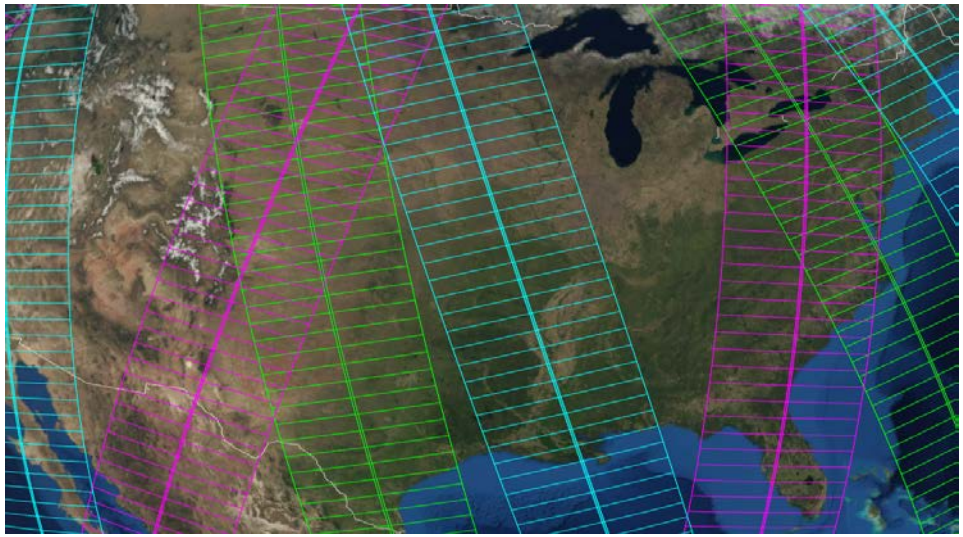
- 3 in constellation – UK-DMC2, Deimos-1 and Nigeriasat-X
- SSTL-100 platform
- 22m GSD
- ~3 Day repeat
- Pushbroom
- 640km Swath
- Landsat compatible Red, Green and Near Infra-red bands
- Drifting ground tracks
- 2 imaging banks



Spectral Band	Spectral Bandwidth
Green	0.52 – 0.60 µm
Red	0.63 – 0.69 µm
NIR	0.63 – 0.69 µm

Introduction to 22m Satellites

- Working together in imaging campaigns they must be very closely calibrated to ensure accuracy for our customers



- Figure shows UK-DMC2 in blue, Deimos-1 in green and Nigeriasat-X in pink.
- Nigeriasat-X is descending while the others are ascending

Calibration Method

- Dark Images
  - Pacific Ocean at Night
  - Determine calibration bias
  - Remove artefacts
- White Images
  - Dome C
  - Equalisation
  - Determine calibration gain
  - Cross-Calibration
- Libya 4 Cross-Calibration

Libya 4 Cross Calibration

- Absolute calibration
- Dune field, homogenous and stable
- Used to validate and refine the calibration result
- Collect images most available opportunities
- Monitor trends and changes in patterns

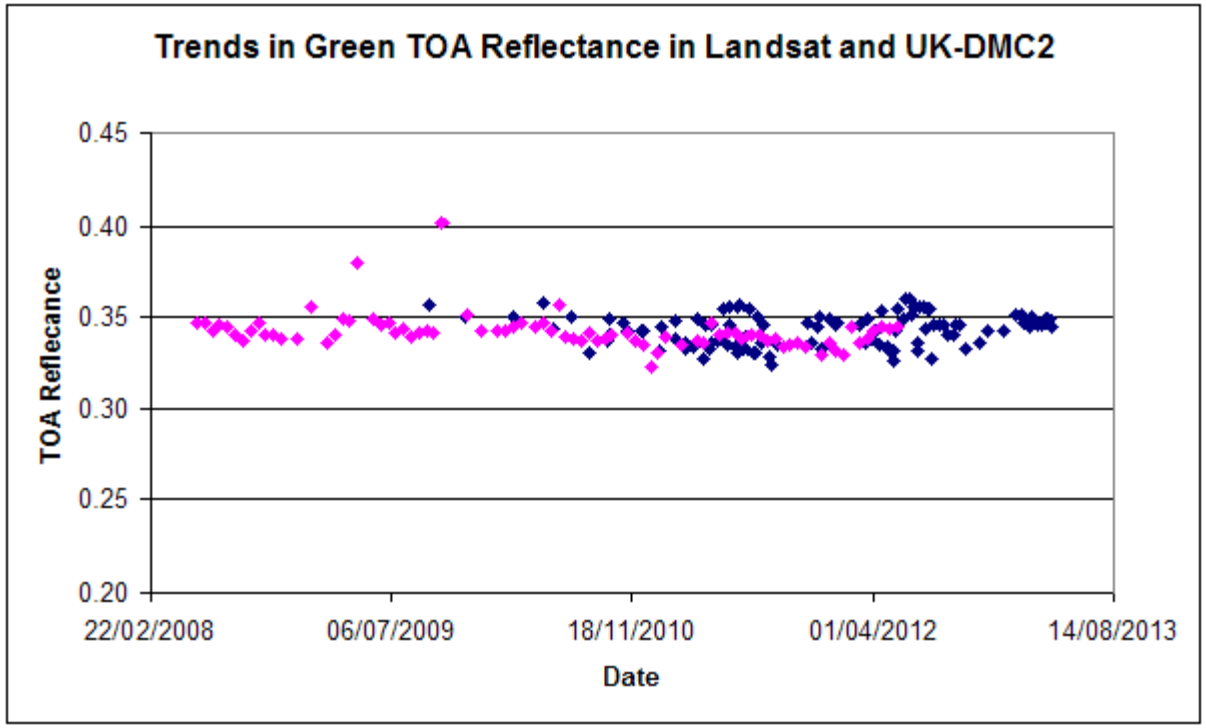
Libya 4 limitations

- Atmospheric components - Ozone, water vapour and aerosols. Exacerbated by different pass times.
- Seasonal Solar Zenith Angle BRDF effects
- View Angle BRDF effects
- Geometry of the dunes

Methodology

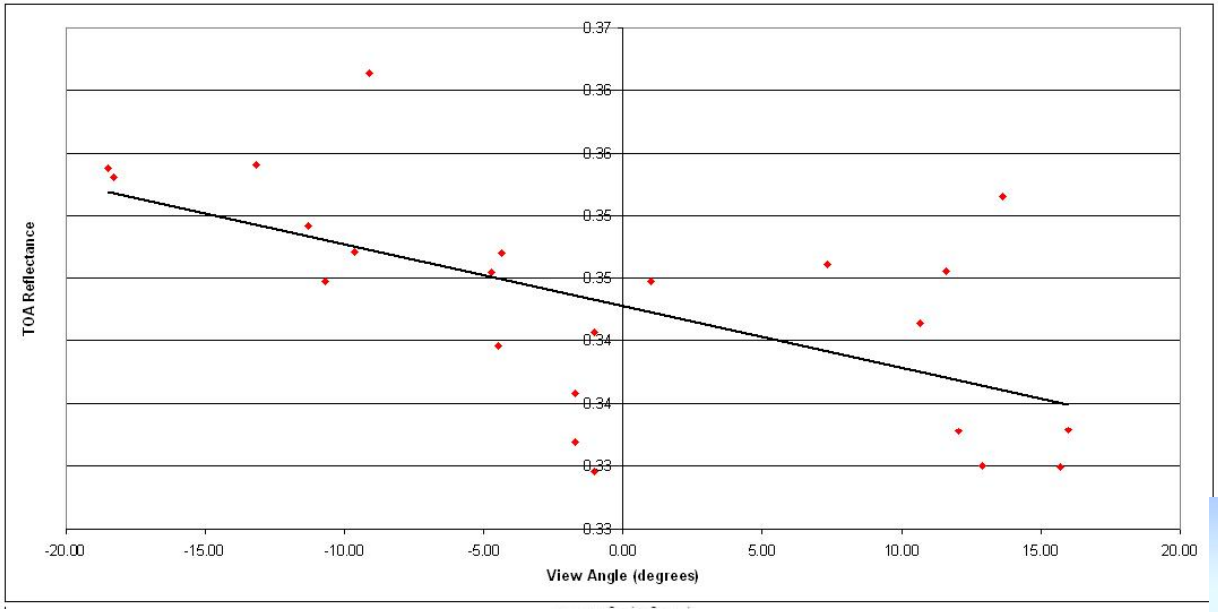
- Cross calibrate against any well calibrated reference sensor
- Currently using Landsat-7 as the data is widely distributed
- Planning to use Landsat-8 when available
- Landsat views at ~Nadir whilst DMC satellites have a drifting ground track and hence variable view angle to the surface per image. This must be corrected in order to directly compare to Landsat

View Angle Effects



Scatter shown in the UK-DMC2 data (blue) is greater than in Landsat-7 data (pink) primarily due to different view angle.

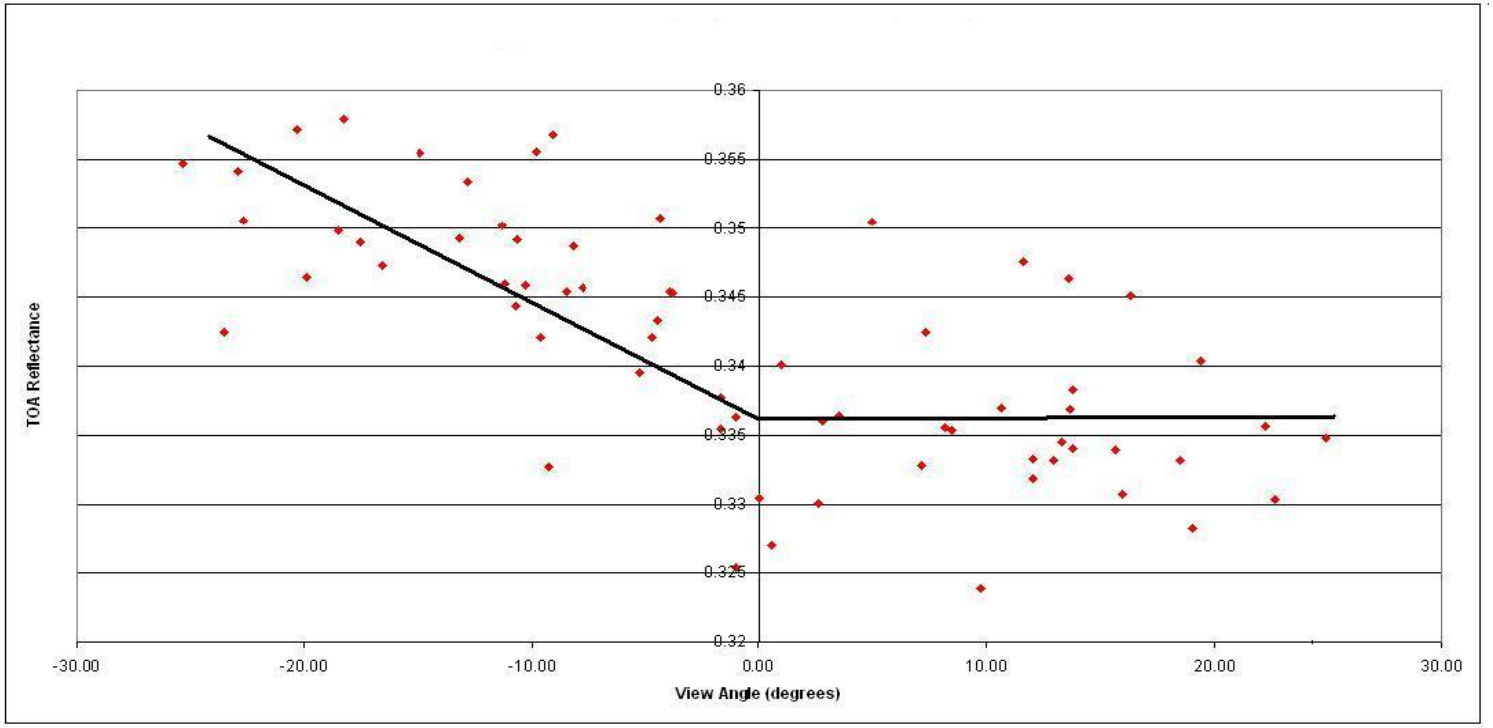
View Angle Profile 1



Facing away from sun Facing towards sun

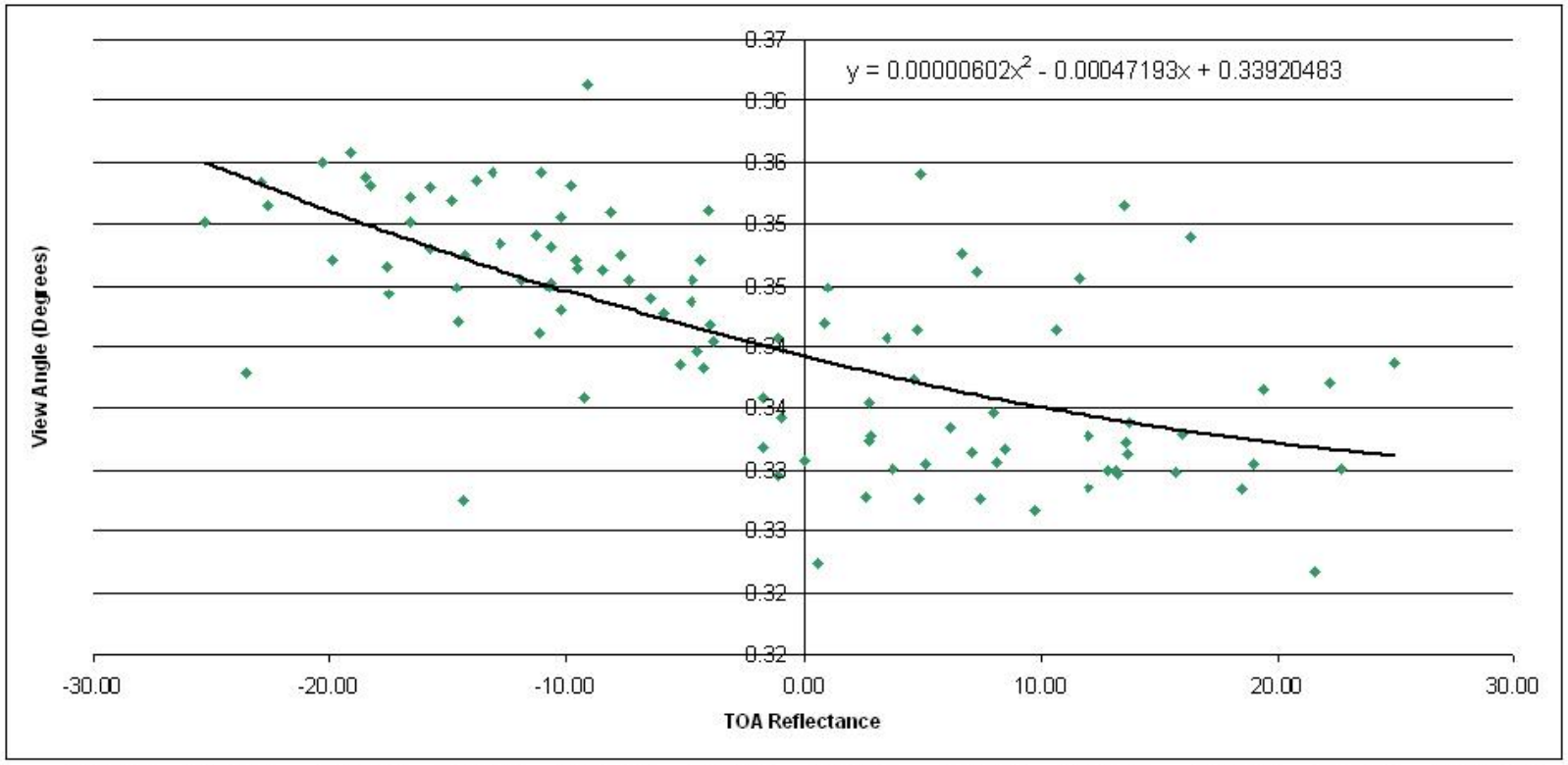
At first with limited data points the only fit we were able to establish was a linear relationship

View Angle Profile 2



As we collected more data with time, a distinct shape emerged that showed a separate linear relationship per bank

View Angle Profile 3



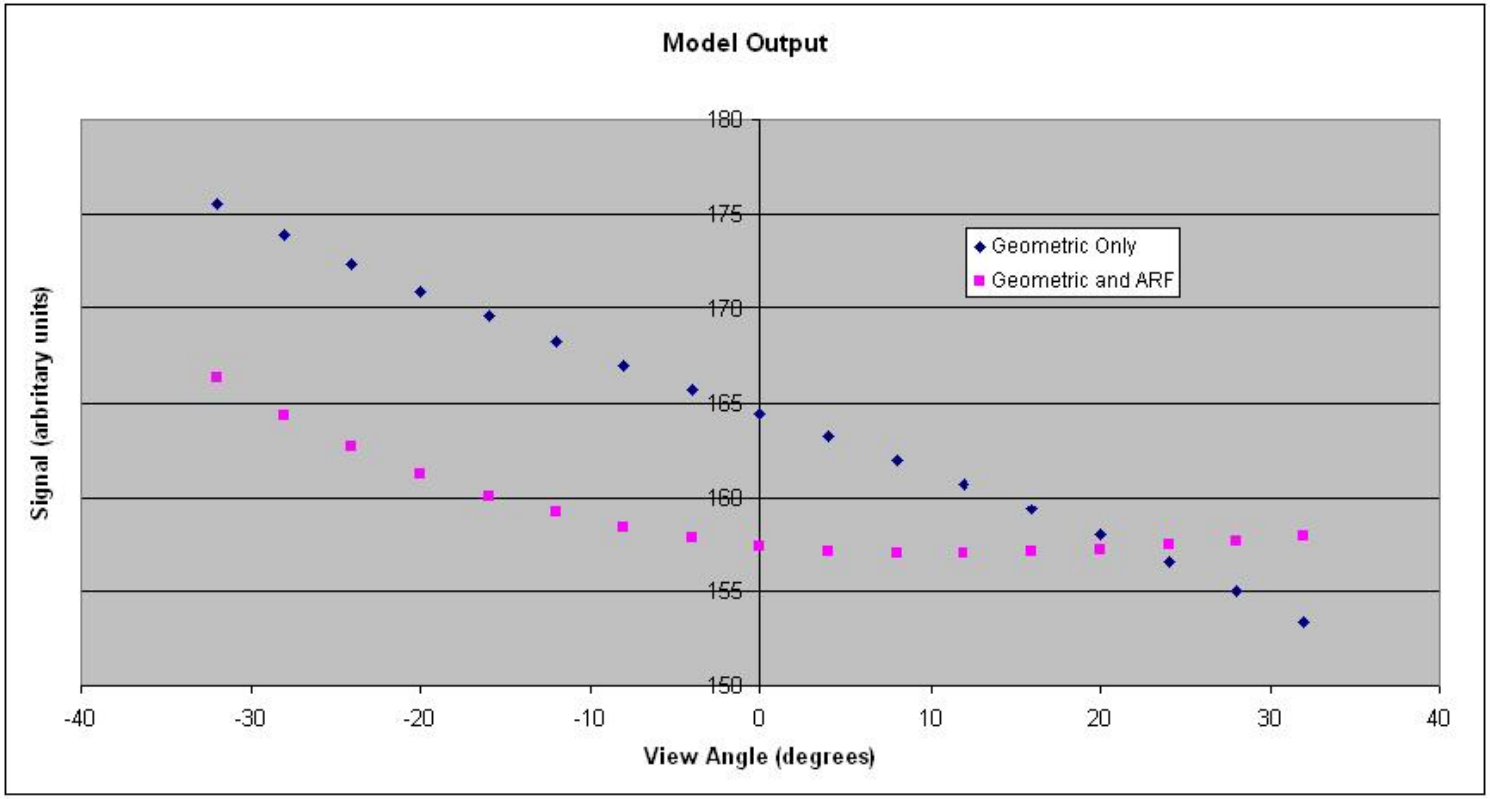
Now we have over 100 data points the shape has changed again and the best result is given when using a second order polynomial

Alternatives to our empirical fit?

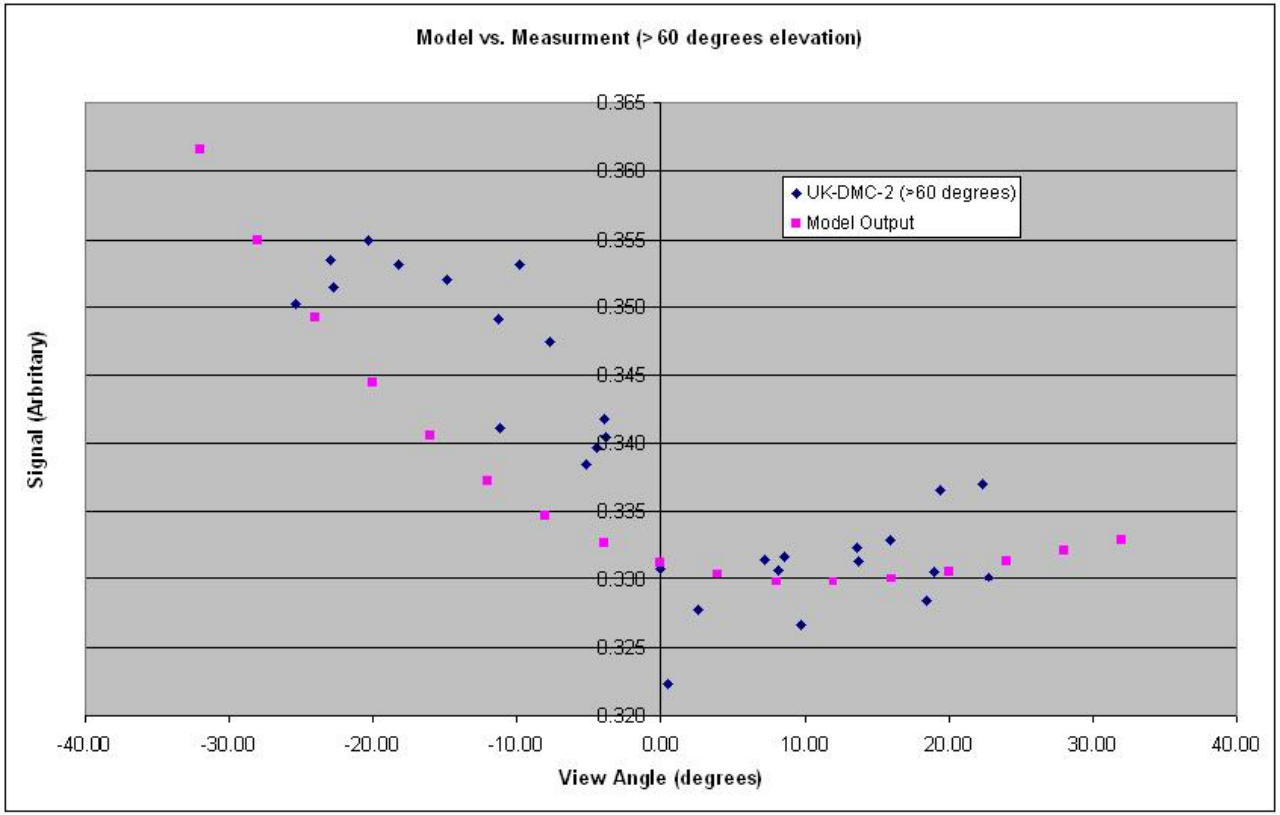
- Polynomial equation is an improvement on our first attempts at an empirical solution to remove view angle effects
- Looking into Snyder BRDF model provided by CNES and to cross compare against empirical model results
- Full physical model of the surface including
  - Geometric modelling of the dune facets
  - Modelling of BRDF of the sand

Basic geometric model

- Initial steps were to treat the dune field of Libya 4 as a set of facets, with no BRDF component (surface or atmosphere)
- Secondly we included BRDF of the sand based on measurements made by CNES in Libya



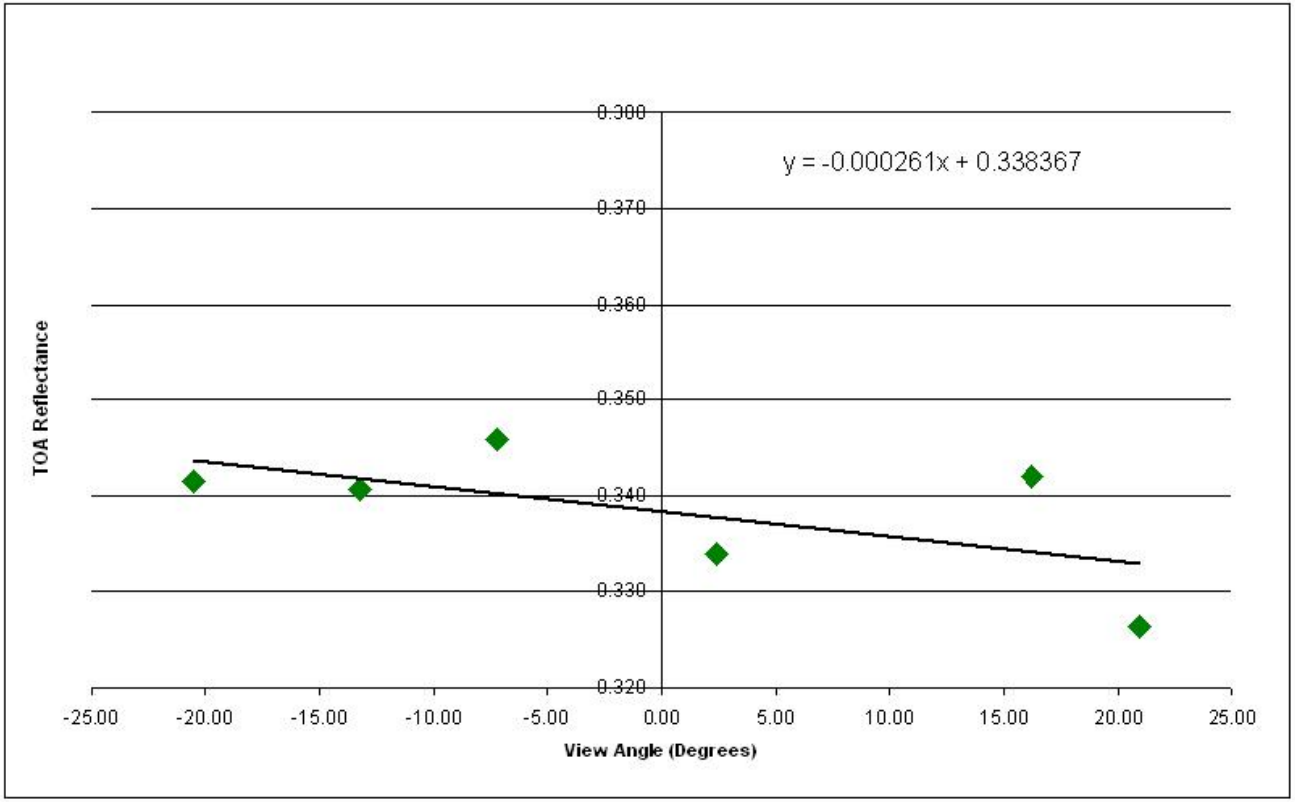
Comparison against our data



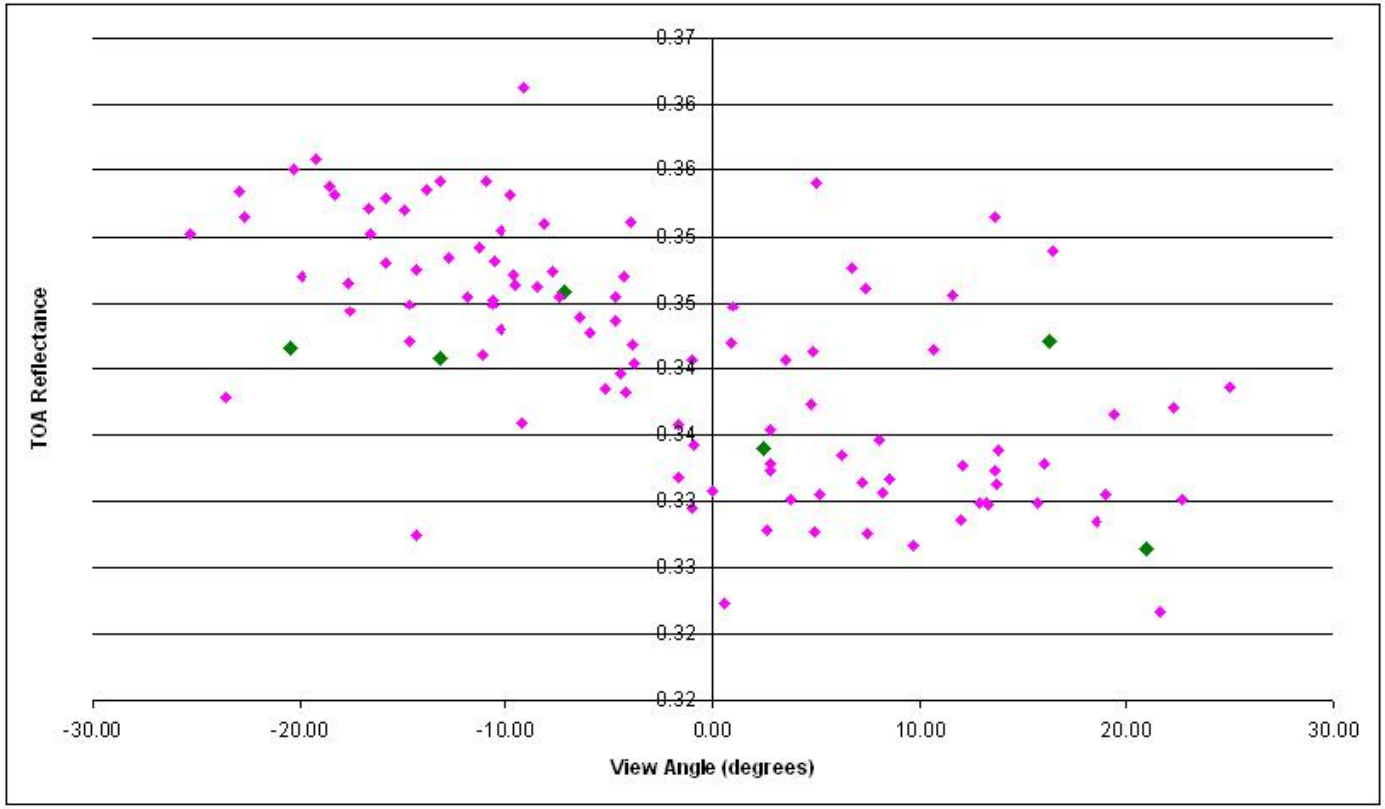
•Only images with >60 degrees elevation used as lower angles cause scatter, this is being investigated

Further Developments

Modelling especially useful for newer satellites when we only have a small amount of data points e.g. Nigeriasat-X



Further Developments



Using the UKDMC-2 polynomial equation as an empirical model we were able to improve upon the initial calibration results generated using the linear relationship of the NX results

Further Developments

- An improved model would reduce the uncertainty when cross comparing different sensors over the site given their different overpass times and view angles

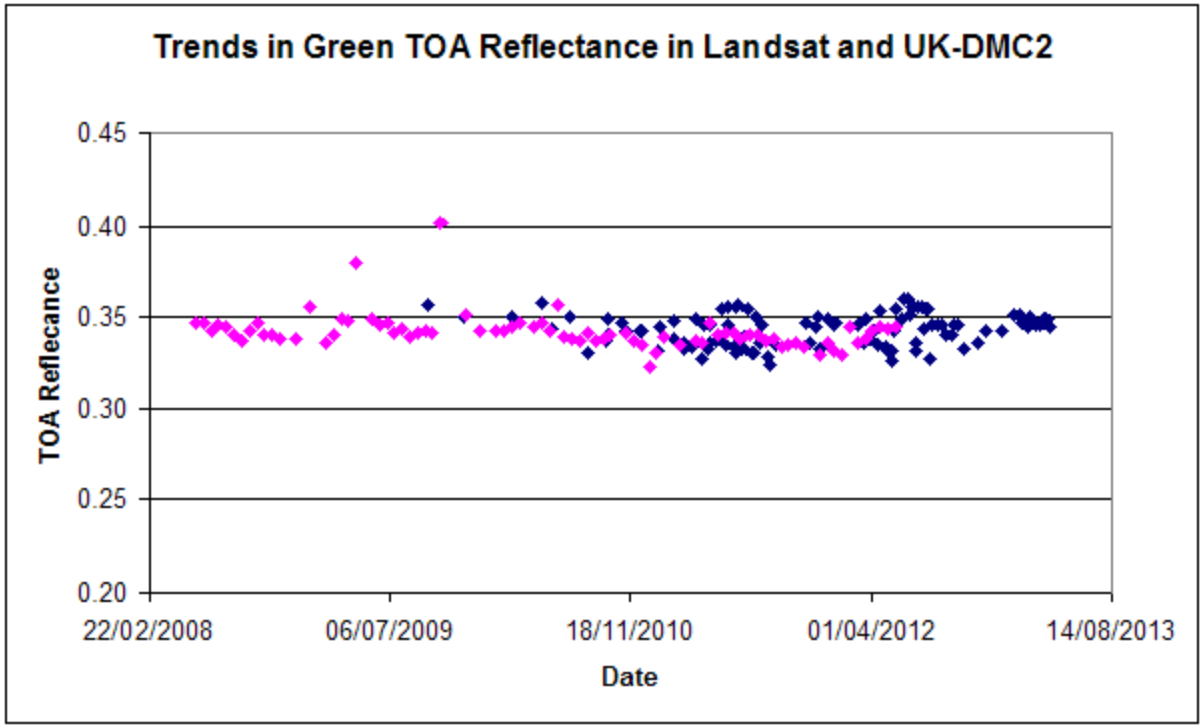
- Additionally we can include atmospheric information derived from other sensors/meteorological models to account for the atmospheric component

Calibration Results Summary

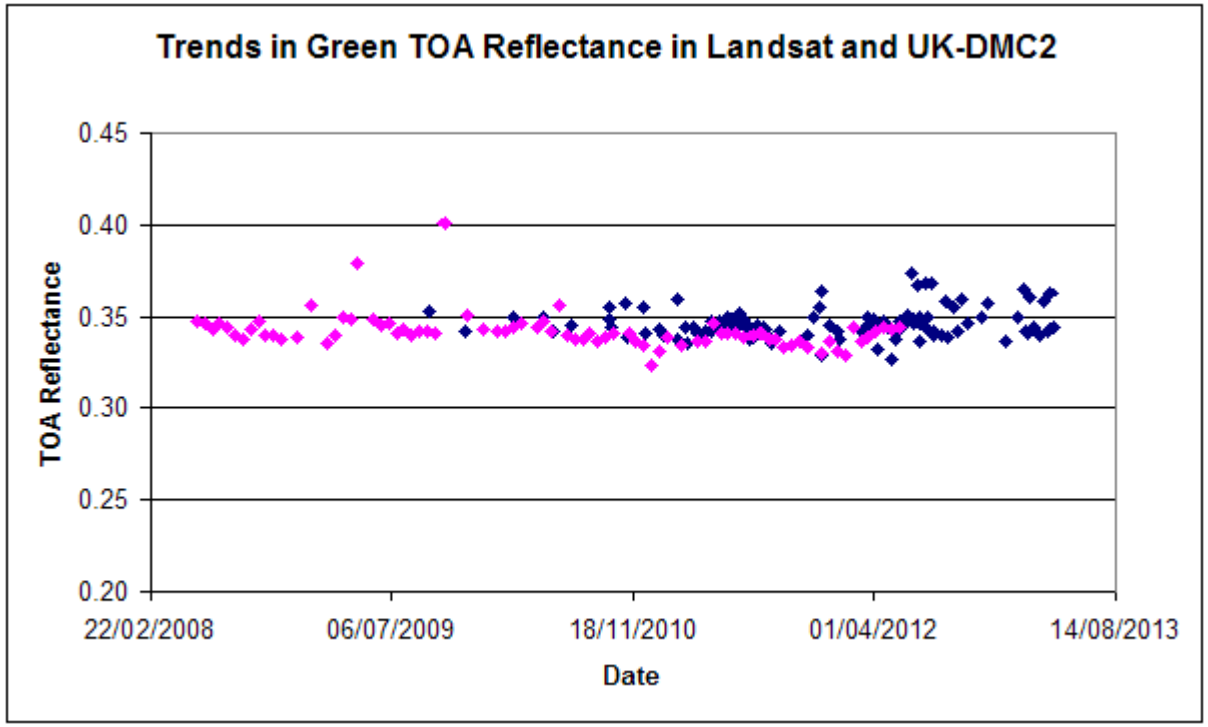
Mean TOA Reflectance Vs Landsat	Green	Red	NIR
UKDMC-2	-0.62274 +/- 0.44	-0.78877 +/- 0.89	0.28753 +/- 1.21
Nigeriasat-X	-0.95864 +/- 0.45	-0.32346 +/- 1.13	-0.11269 +/- 1.72
Deimos-1	-0.62399 +/- 0.52	-0.35624 +/- 0.58	0.915778112 +/- 0.72

- The overall results suggest that the sensors are very stable with absolute calibrations that are 5% or better in all bands
- NIR shows the largest spread for all sensors

Before Model Correction



After Model Correction



Scatter in the UK-DMC2 data (blue) has been reduced by applying our empirical model. This can be further reduced by correcting for atmospheric effects.