CEOS Inter-comparison over Dome-C (2008-2009)

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CEOS Inter-comparison

- Inter-comparison took place from December 2009 to January 2009
- Many sensors of varying spatial and spectral resolutions over four sites near the Dome-C base
- Nadir views provided as radiance or TOA Reflectance

Dome-C

- Situated at 75°S 123°E
- 3.2km above sea level, thin atmosphere
- Temperatures below zero all year round
- Very flat
- Areal extent for several hundred kilometres
- Franco-Italian instrumented base
  - Ozone monitor, Sun Photometer, daily radiosondes

Project Aims

- To evaluate key parameters that may have significant impact on estimation of TOA reflectance for inter-comparisons

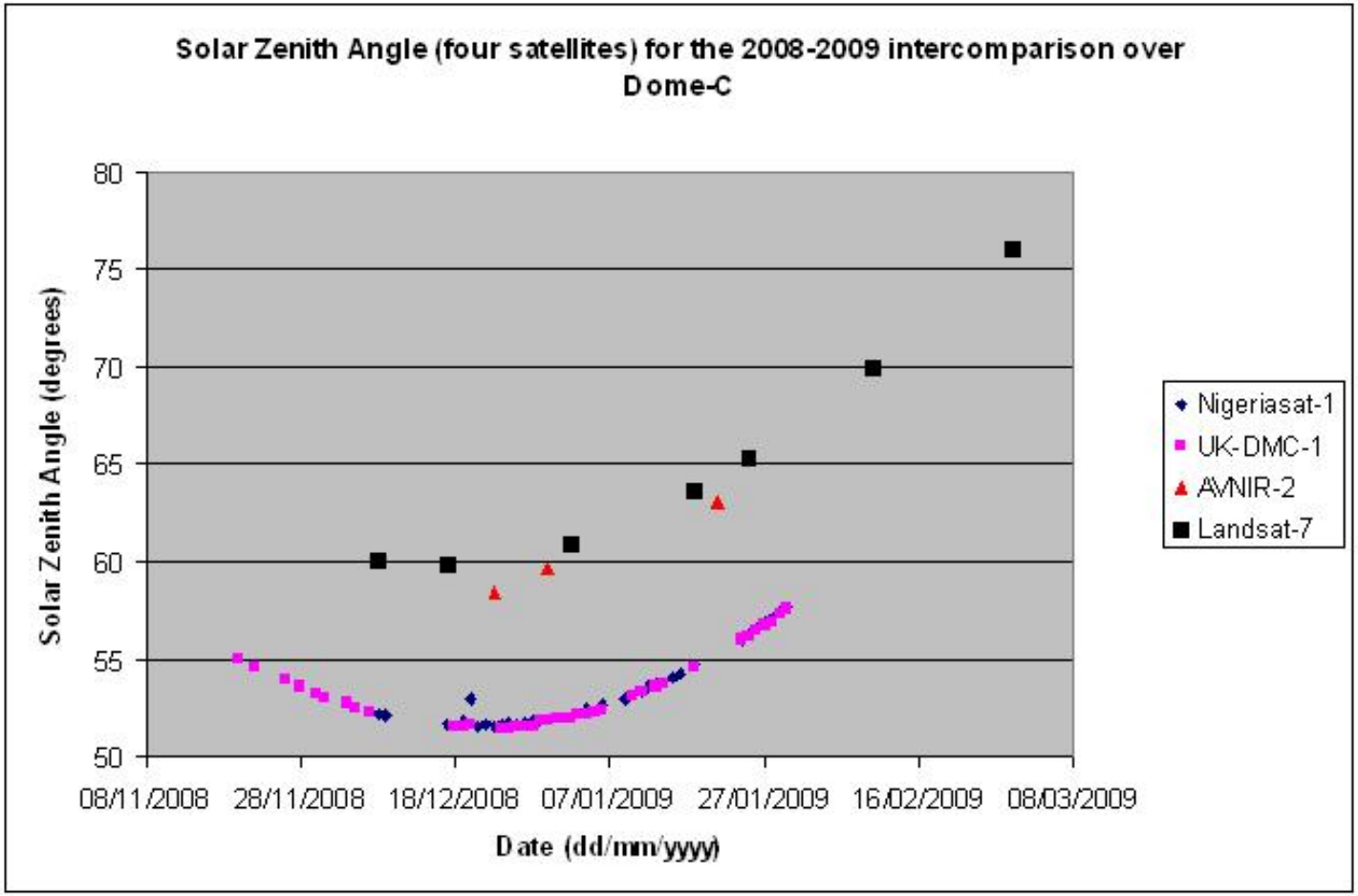
- To correct for them (where possible) to allow unbiased inter-comparisons between different satellite systems

Main Parameters

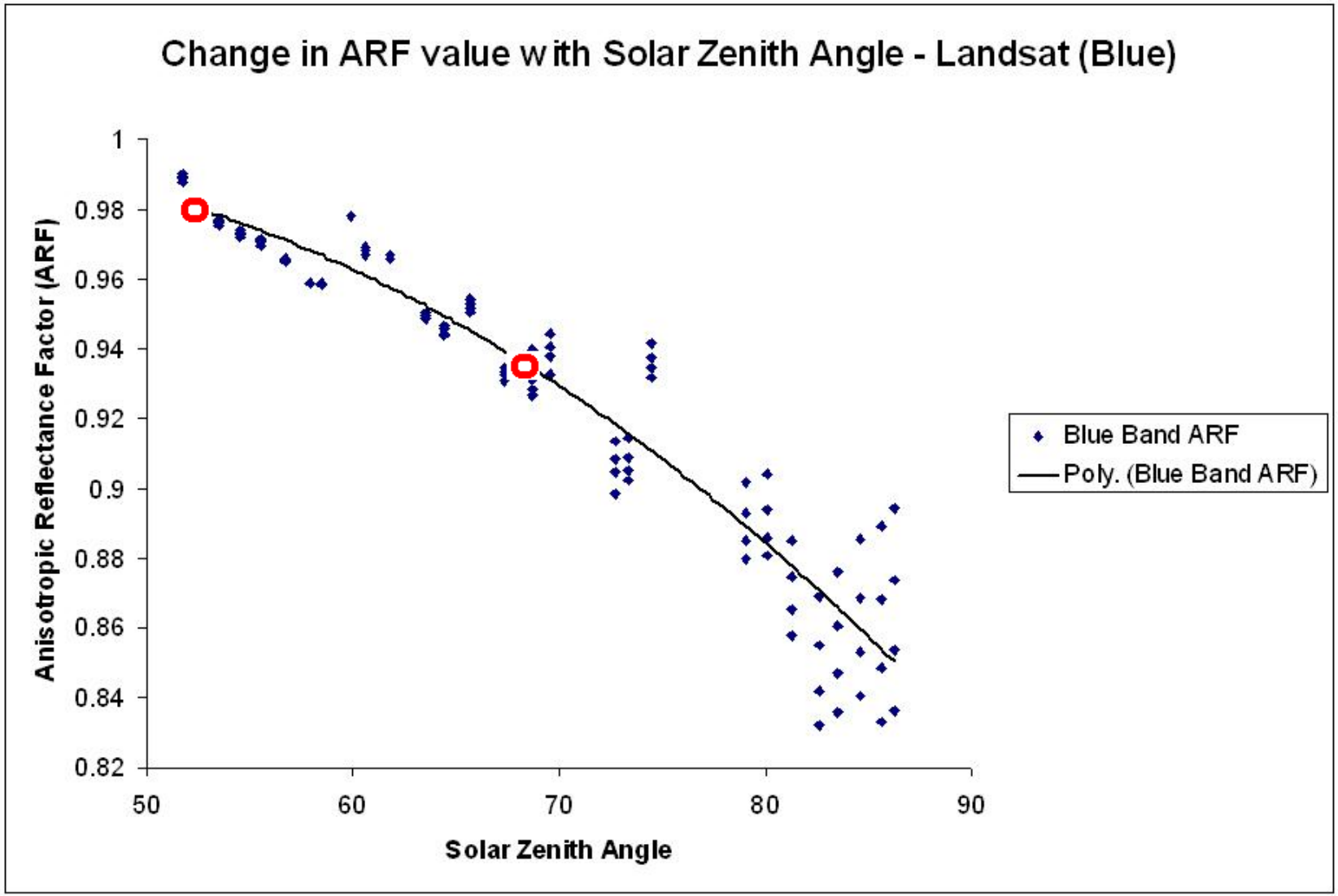
- BRDF of the snow surface (based on work by University of Washington at site in 2003-2005)
- Atmospheric effects (based on instrumentation on site)
  - Ozone
  - Aerosols
  - Water vapour
- Surface Variability between acquisitions (based on imaging data alone)

BRDF

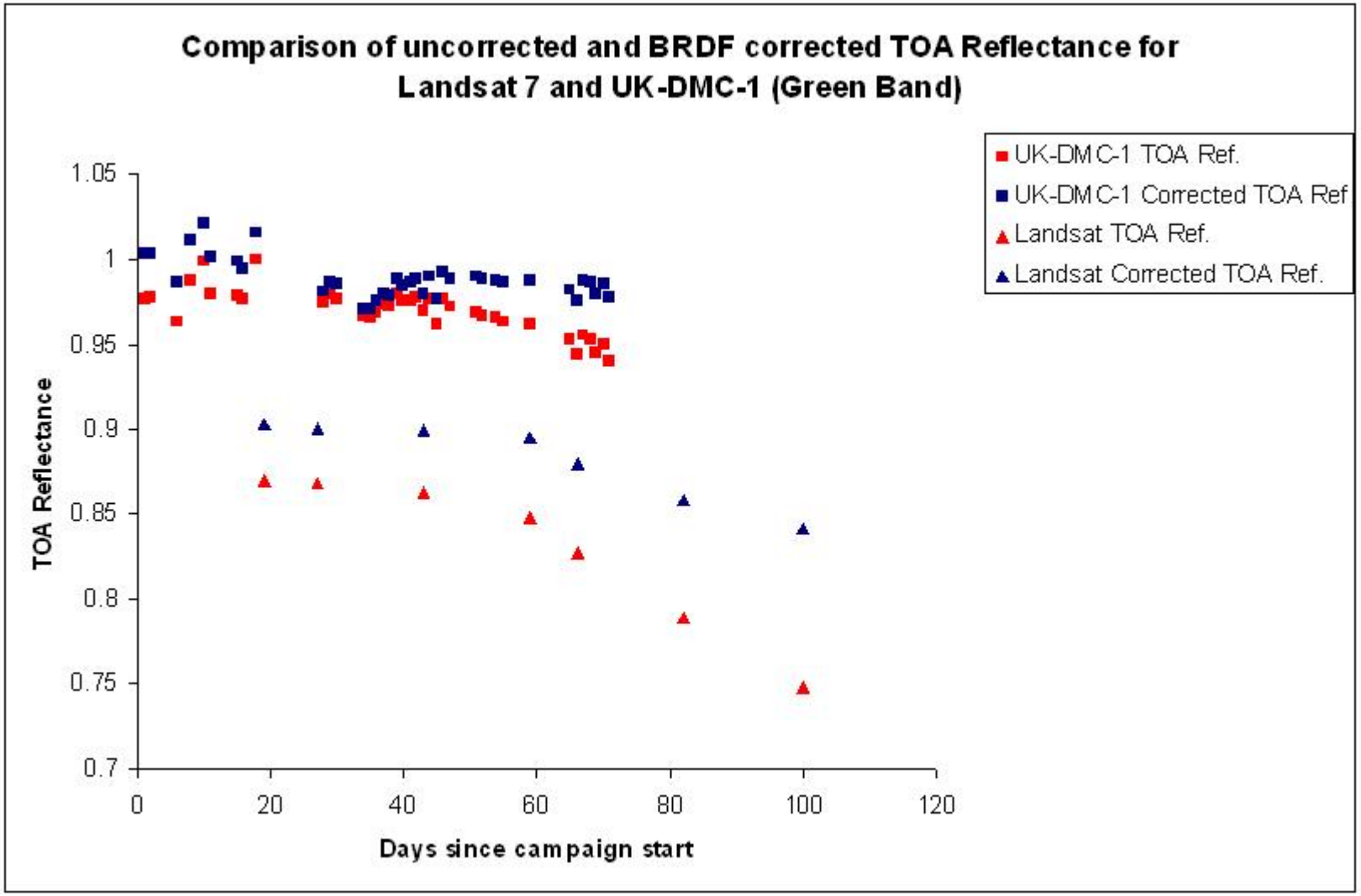
- For BRDF everyone thinks “View Angle” that is its only an issue if we change view angle
- Nadir views, but with different solar zenith angles, so we have to compensate for this to get an unbiased estimate



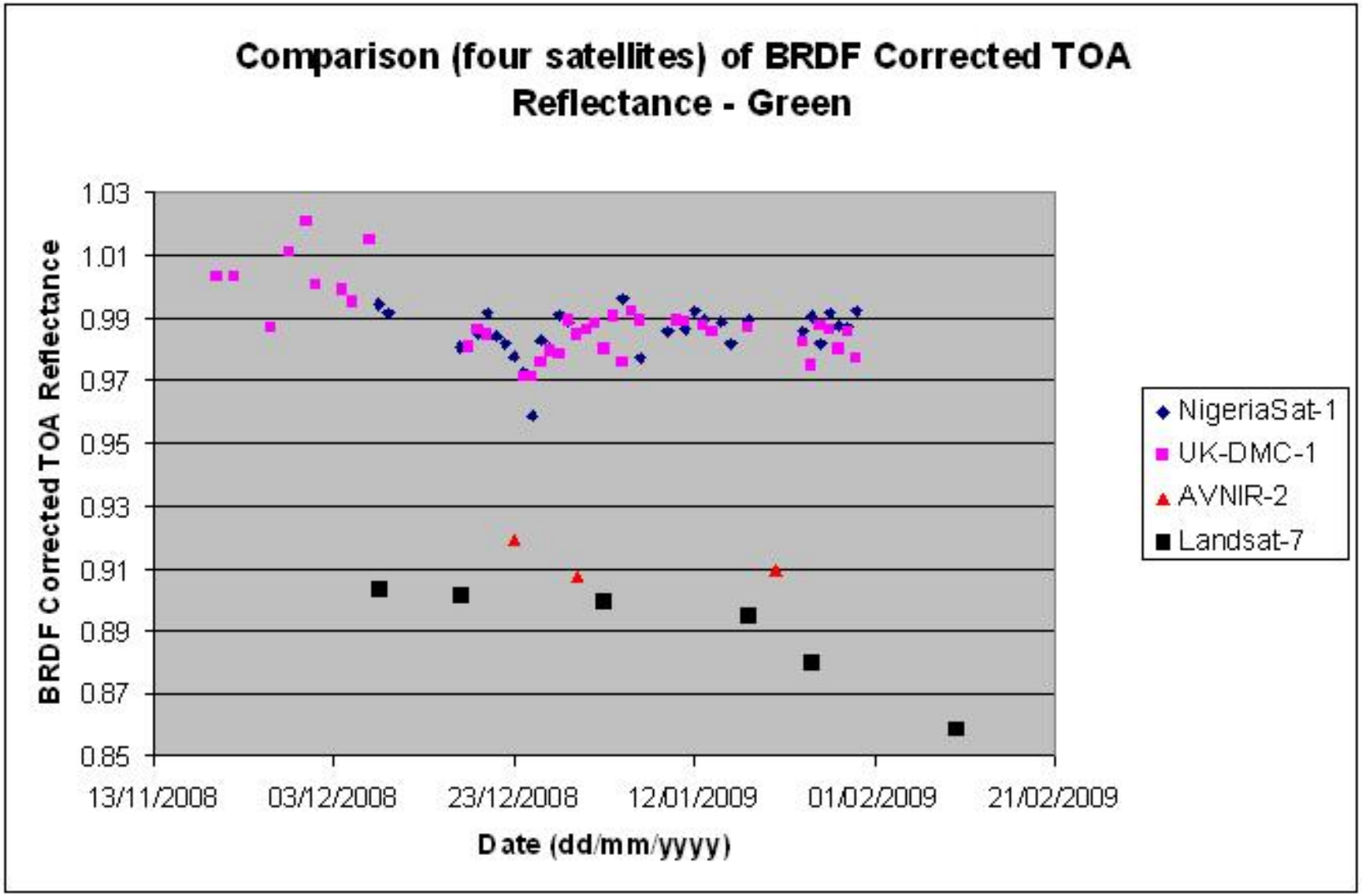
BRDF


Change in ARF value with Solar Zenith Angle - Landsat (Blue)
Anisotropic Reflectance Factor (ARF)
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
50
60
70
80
90
Solar Zenith Angle
Blue Band ARF
Poly. (Blue Band ARF)

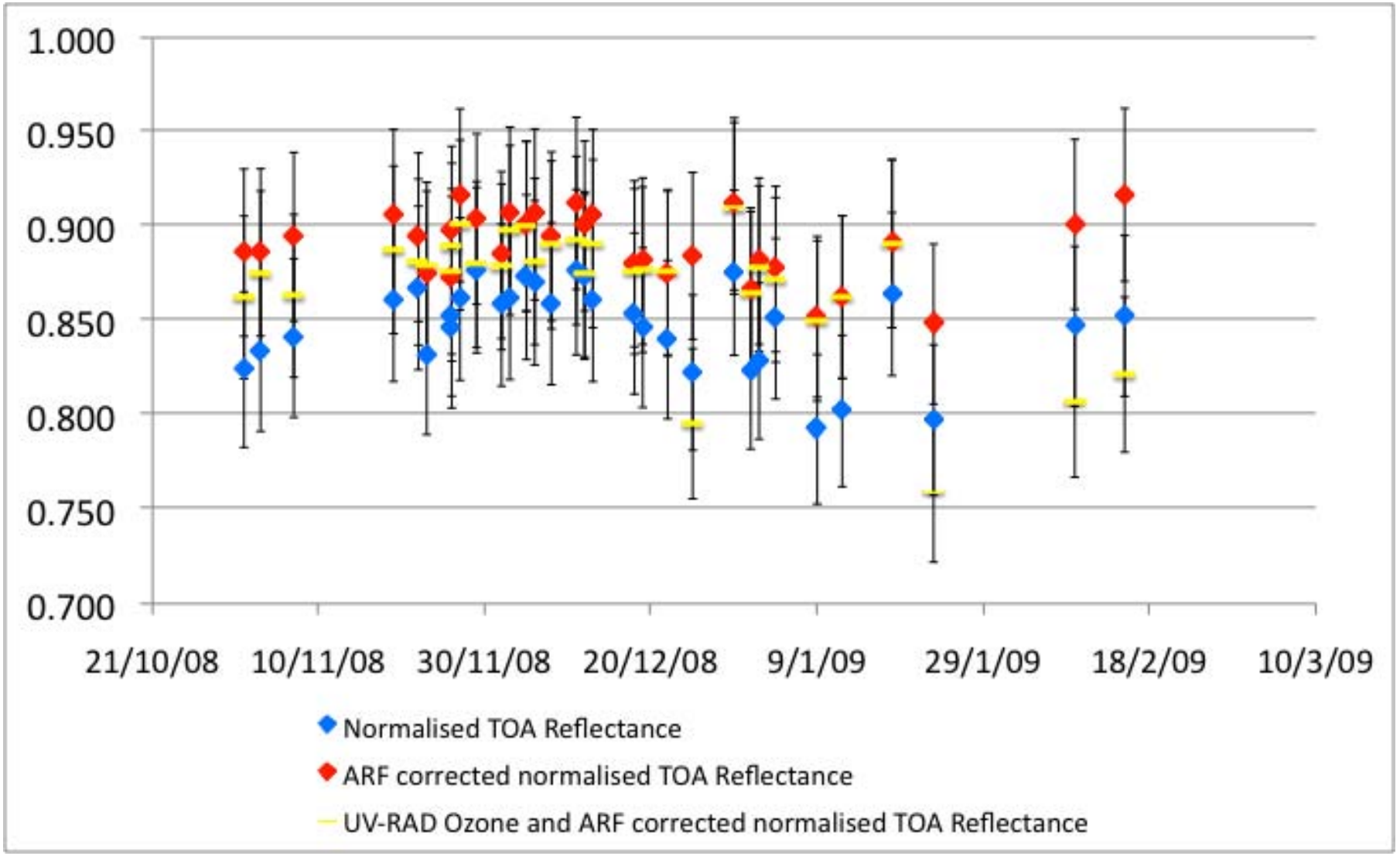
BRDF

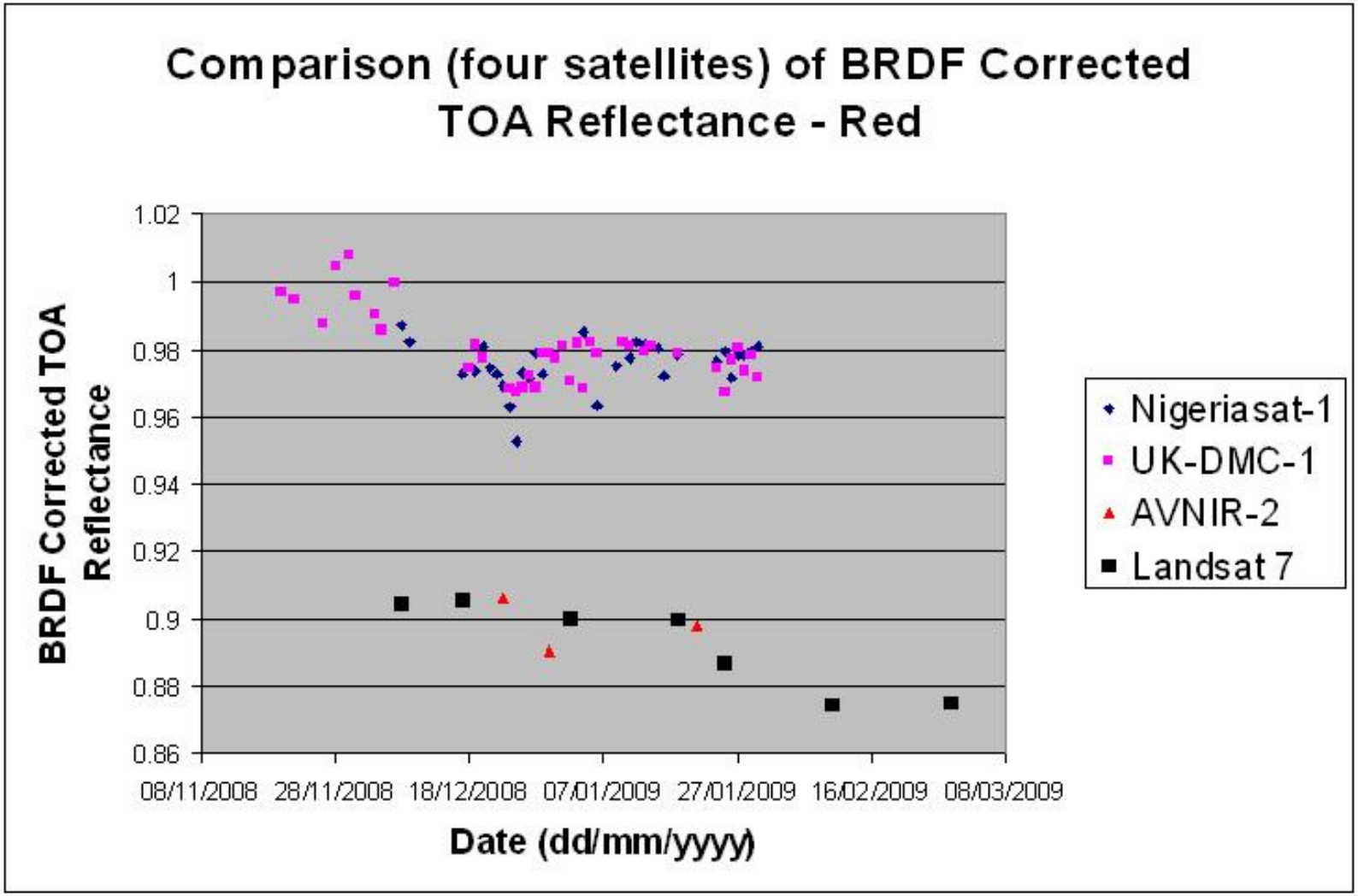

Comparison of uncorrected and BRDF corrected TOA Reflectance for Landsat 7 and UK-DMC-1 (Green Band)
UK-DMC-1 TOA Ref.
UK-DMC-1 Corrected TOA Ref
Landsat TOA Ref.
Landsat Corrected TOA Ref.
TOA Reflectance
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0
20
40
60
80
100
120
Days since campaign start

Results

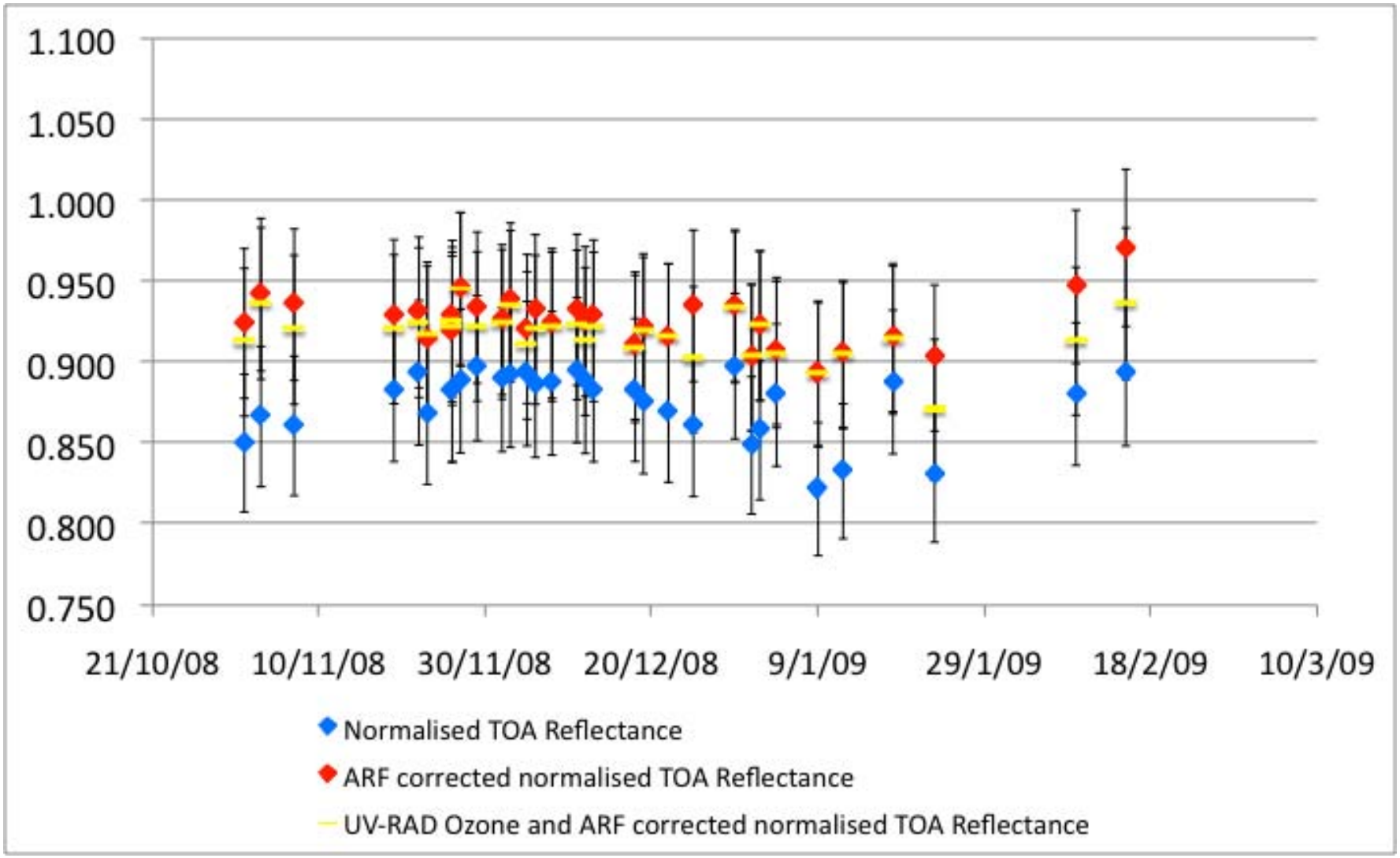

Comparison (four satellites) of BRDF Corrected TOA Reflectance - Green
BRDF Corrected TOA Reflectance
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0.85
13/11/2008
03/12/2008
23/12/2008
12/01/2009
01/02/2009
21/02/2009
Date (dd/mm/yyyy)
NigeriaSat-1
UK-DMC-1
AVNIR-2
Landsat-7

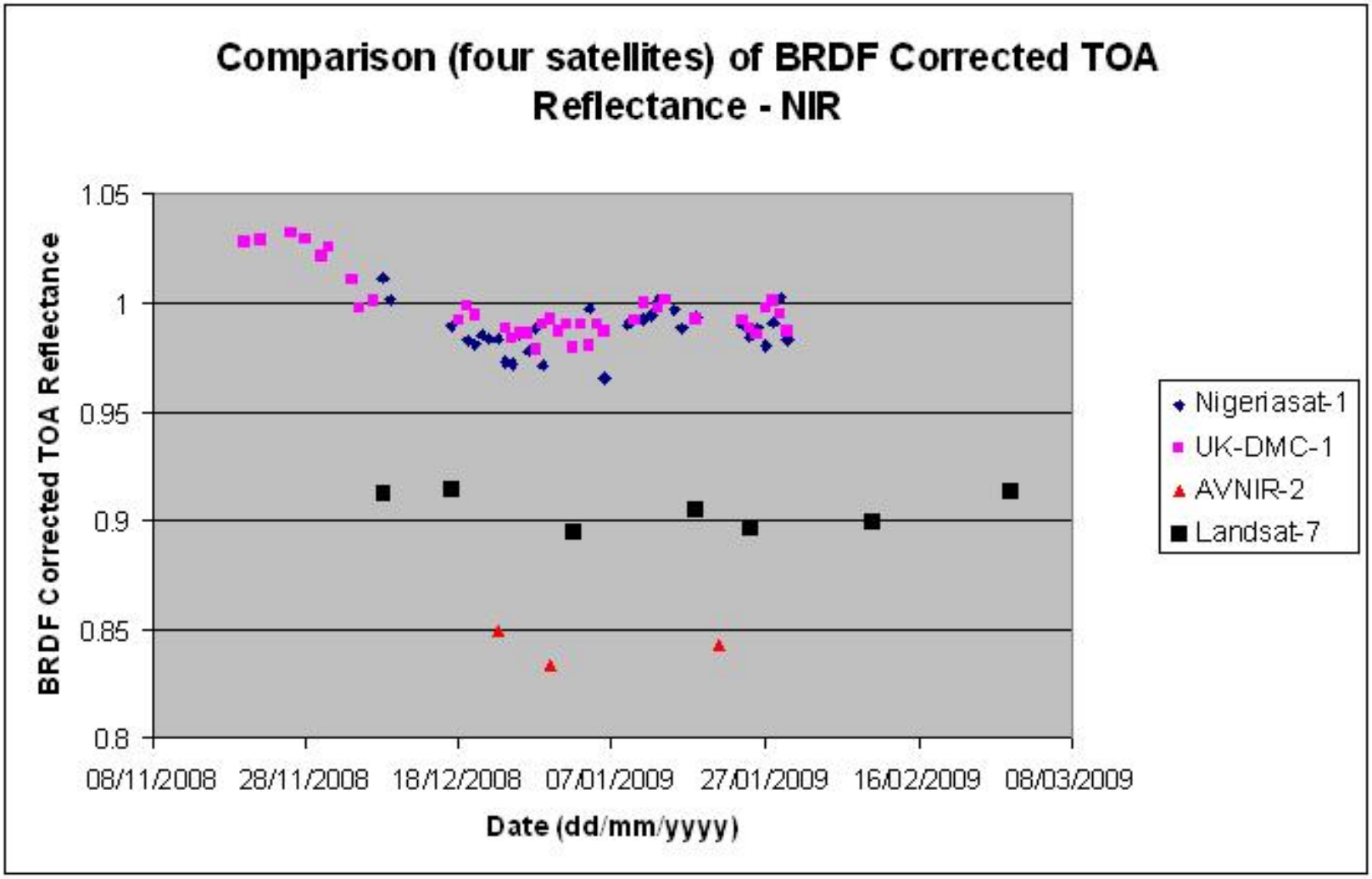
MERIS 560nm


1.000
0.950
0.900
0.850
0.800
0.750
0.700
21/10/08
10/11/08
30/11/08
20/12/08
9/1/09
29/1/09
18/2/09
10/3/09
Normalised TOA Reflectance
ARF corrected normalised TOA Reflectance
UV-RAD Ozone and ARF corrected normalised TOA Reflectance

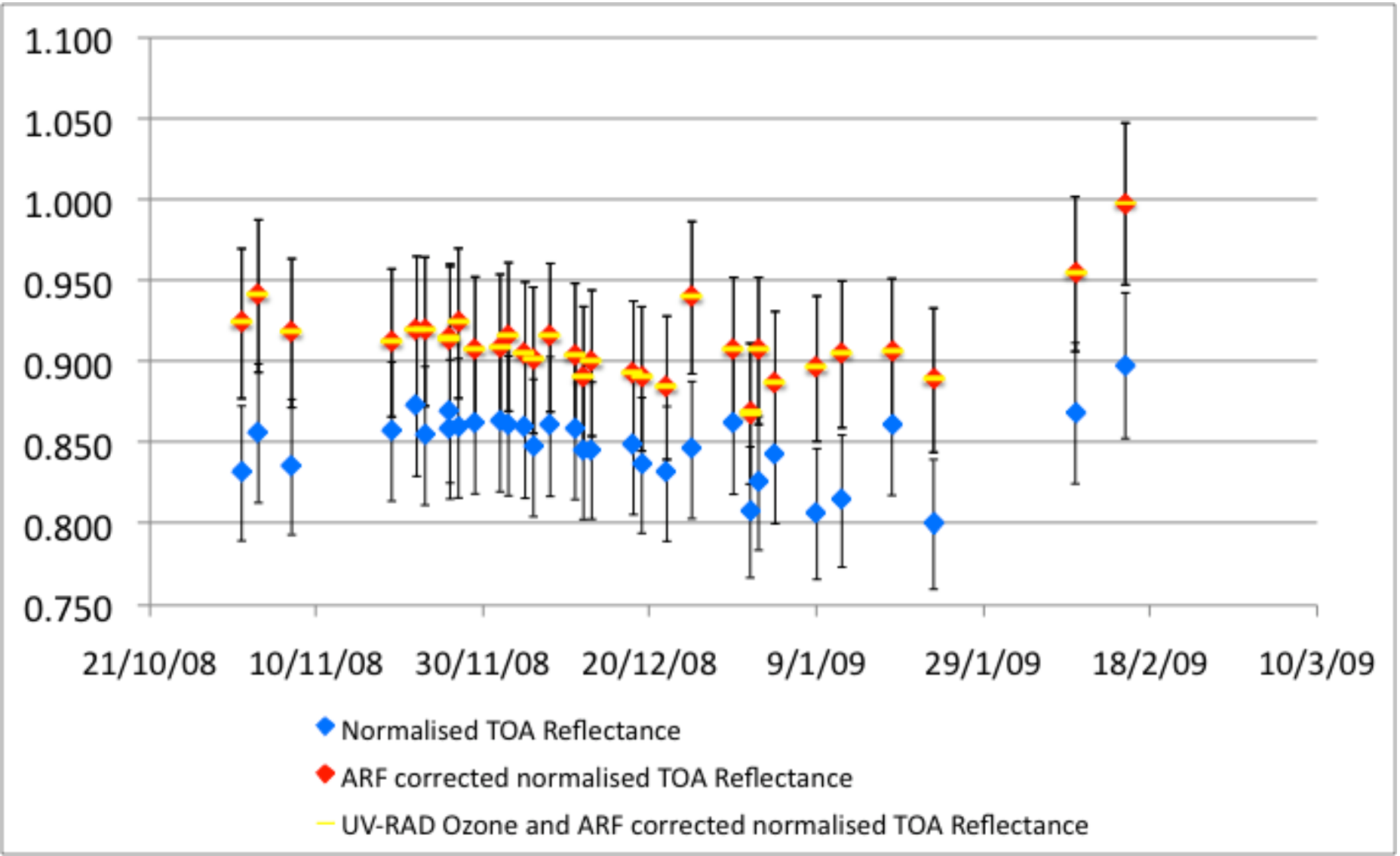

Comparison (four satellites) of BRDF Corrected TOA Reflectance - Red
BRDF Corrected TOA Reflectance
1.02
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
08/11/2008
28/11/2008
18/12/2008
07/01/2009
27/01/2009
16/02/2009
08/03/2009
Date (dd/mm/yyyy)
Nigeriasat-1
UK-DMC-1
AVNIR-2
Landsat 7

MERIS – 665nm

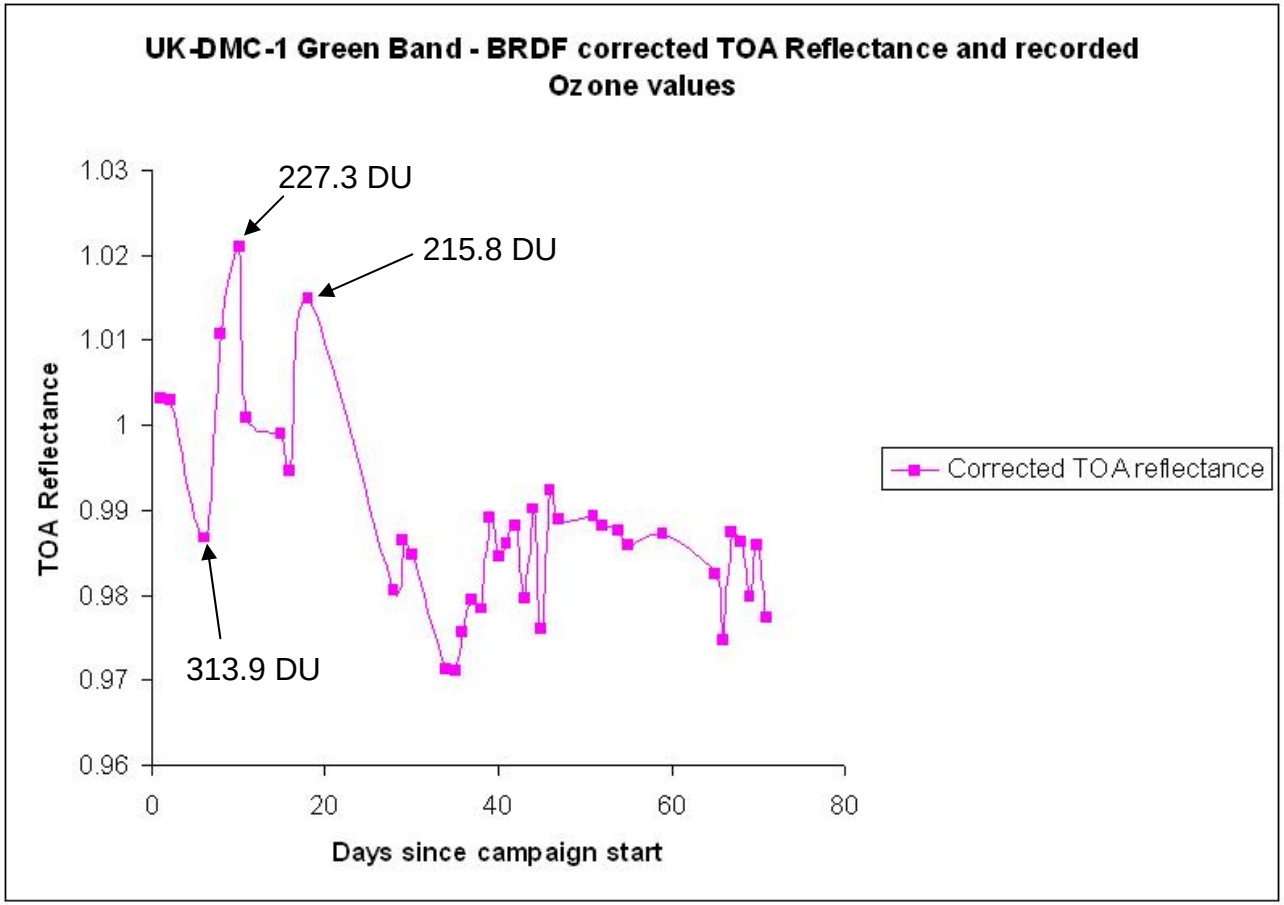

1.100
1.050
1.000
0.950
0.900
0.850
0.800
0.750
21/10/08
10/11/08
30/11/08
20/12/08
9/1/09
29/1/09
18/2/09
10/3/09
Normalised TOA Reflectance
ARF corrected normalised TOA Reflectance
UV-RAD Ozone and ARF corrected normalised TOA Reflectance


Comparison (four satellites) of BRDF Corrected TOA Reflectance - NIR
BRDF Corrected TOA Reflectance
1.05
1
0.95
0.9
0.85
0.8
08/11/2008
28/11/2008
18/12/2008
07/01/2009
27/01/2009
16/02/2009
08/03/2009
Date (dd/mm/yyyy)
Nigeriasat-1
UK-DMC-1
AVNIR-2
Landsat-7

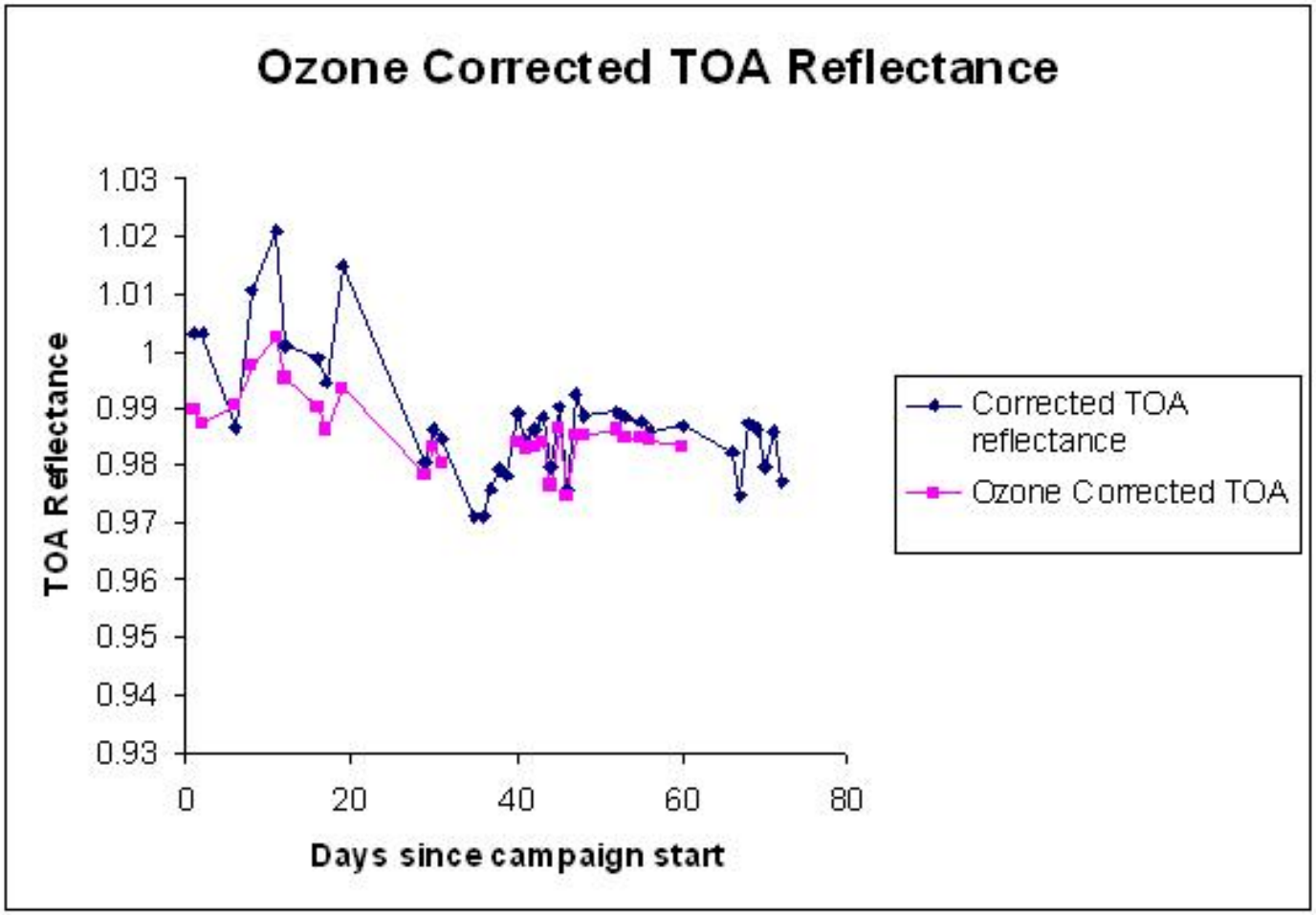
MERIS – 865nm (NIR)



Ozone


UK-DMC-1 Green Band - BRDF corrected TOA Reflectance and recorded Ozone values
227.3 DU
215.8 DU
313.9 DU
TOA Reflectance
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0
20
40
60
80
Days since campaign start
Corrected TOA reflectance

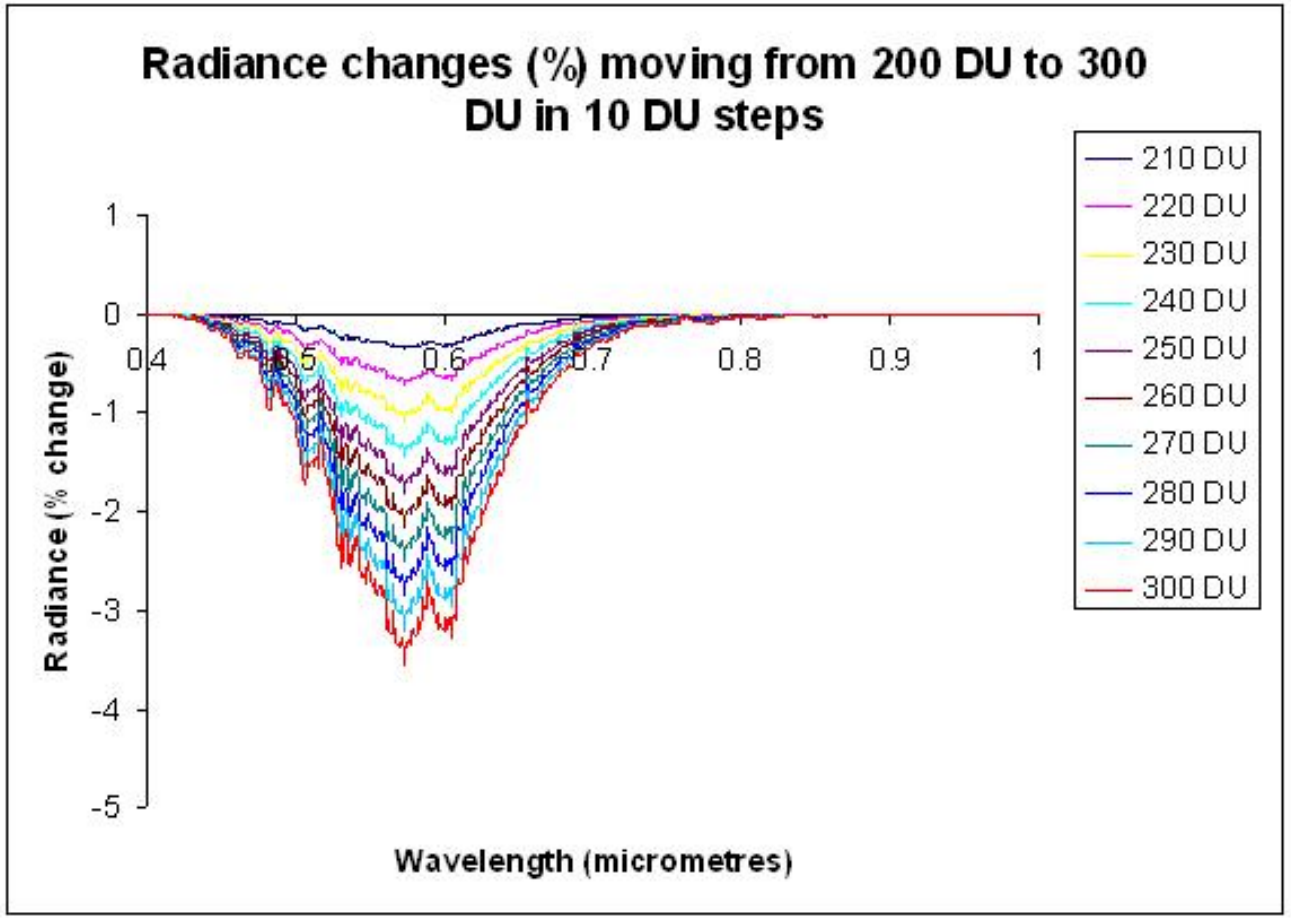
Ozone



- The overall correction for some points is of the order of 2% (in radiance or reflectance terms (green band)
- Large reduction in the variability of the TOA Reflectance
- Some small residuals seem to be present

Ozone

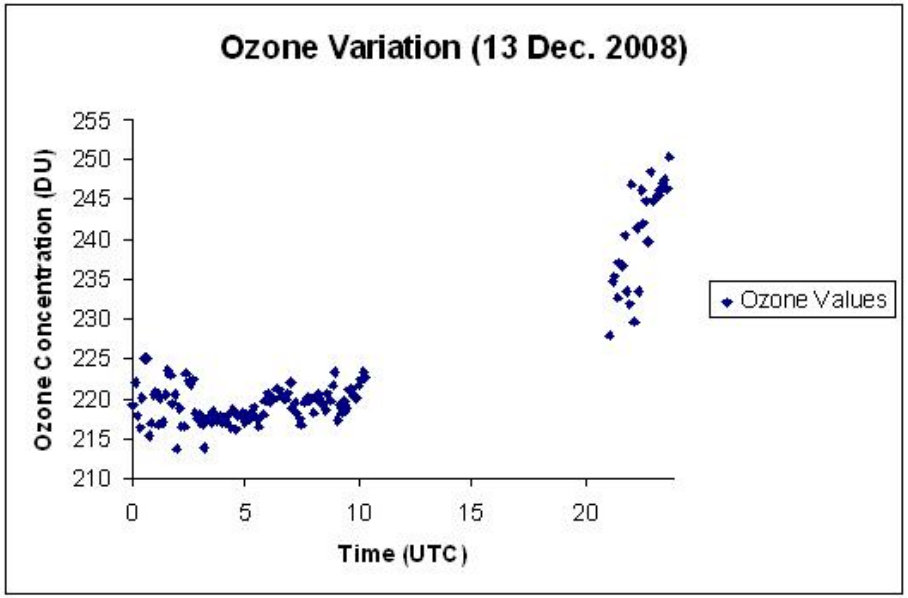
- Ozone absorption in the VNIR

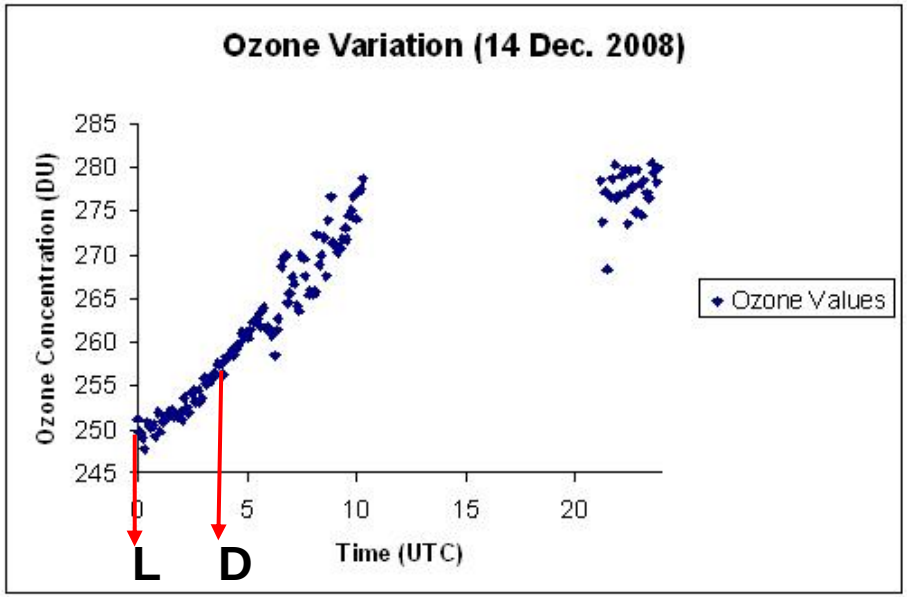


Known as the Chappius absorptions, the peak absorption is near the green / red boundary

Ozone values cover a range from about 210 DU to over 310 DU in the data collected during the CEOS intercomparison.

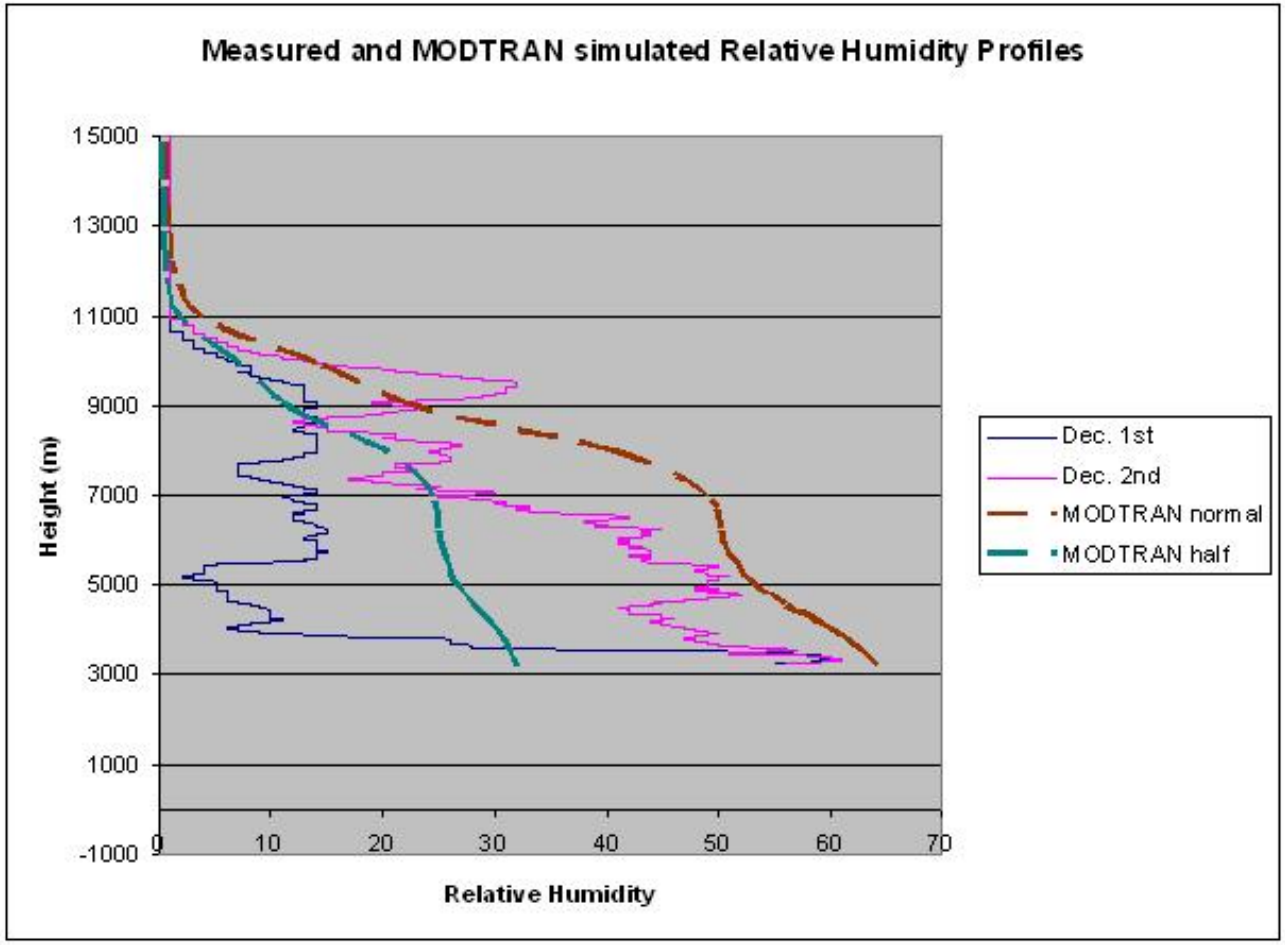
Ozone Variability





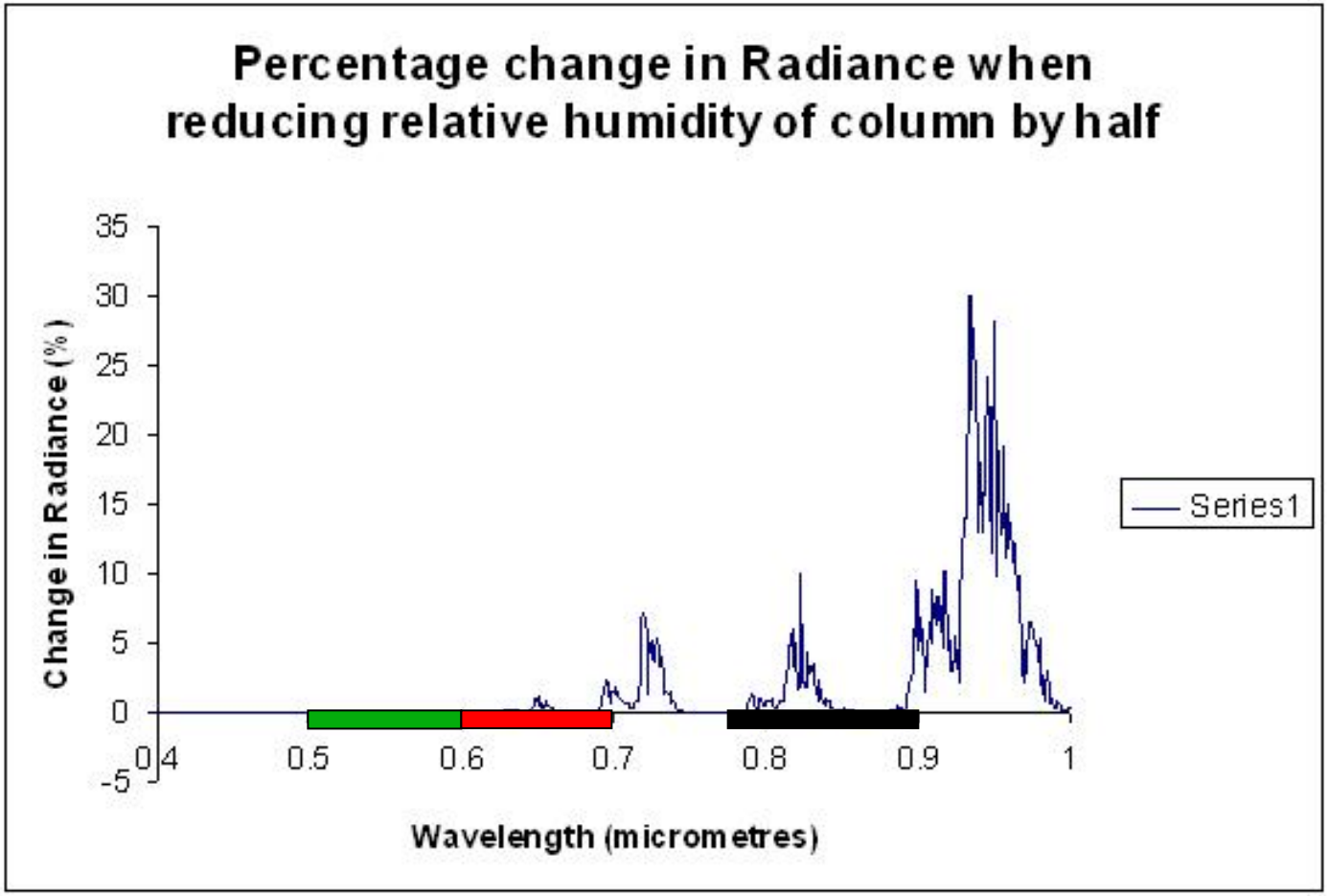
- Ozone can vary dramatically from day to day, so two acquisitions separated by one day could have an ozone difference of 50 DU equivalent to a radiance change of 1.75% at 600nm
- Even within a single day the recorded ozone can vary greatly. Note on the lower figure the L and D for Landsat and DMC overpasses (0.25% radiance difference at 600nm).
- Ozone profile temporally is not consistent.
- Some days missing from records.

Water Vapour



- Two radiosonde relative humidity profiles (Dec. 1st and 2nd are compared to MODTRAN simulations with the “normal” relative humidity profile and that with half of the water in the column

Water Vapour



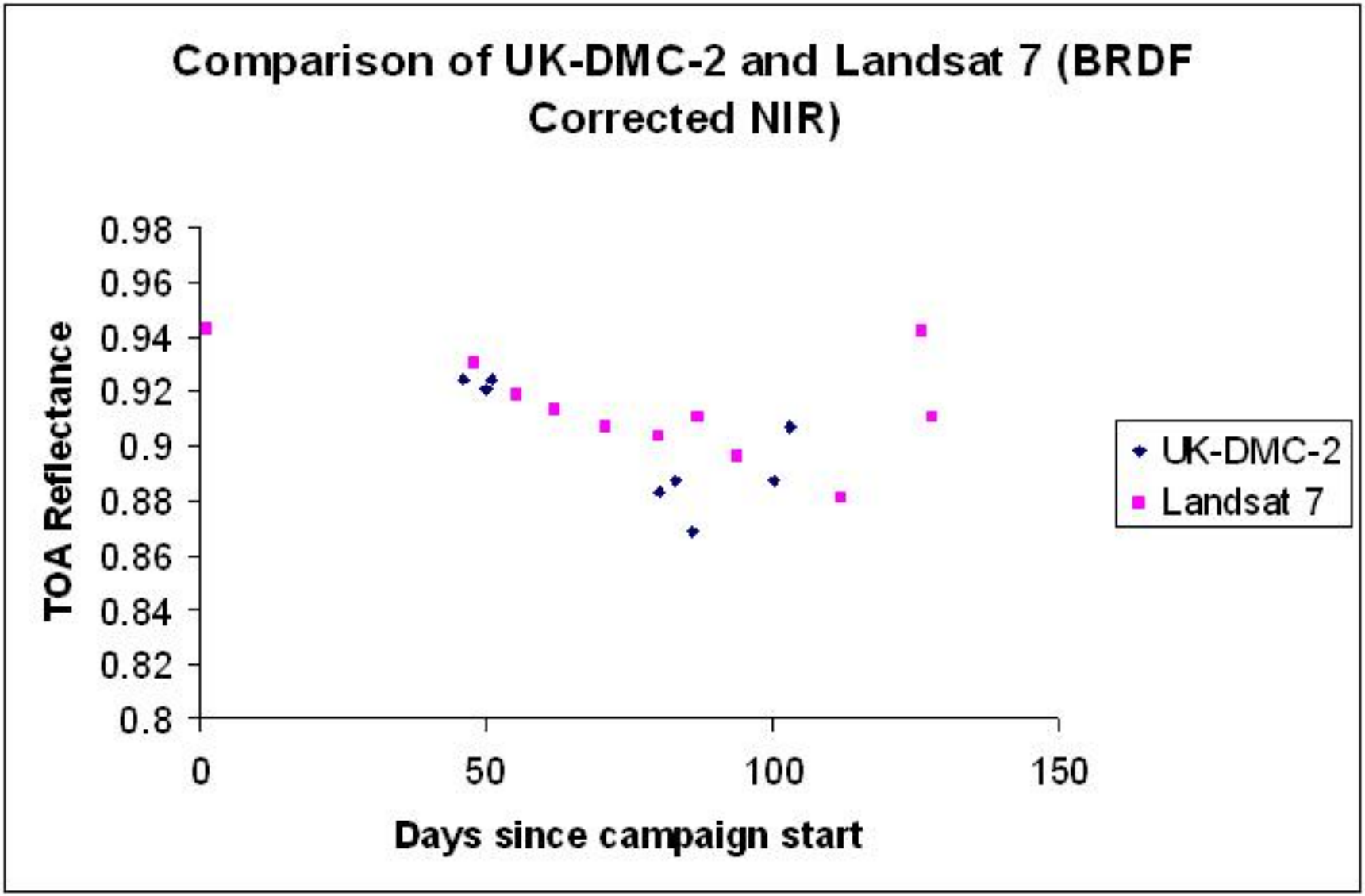
Water vapour effects have a larger impact in the NIR spectral band (black bar in diagram) with smaller effects in the red.

No real effects in the green spectral band.

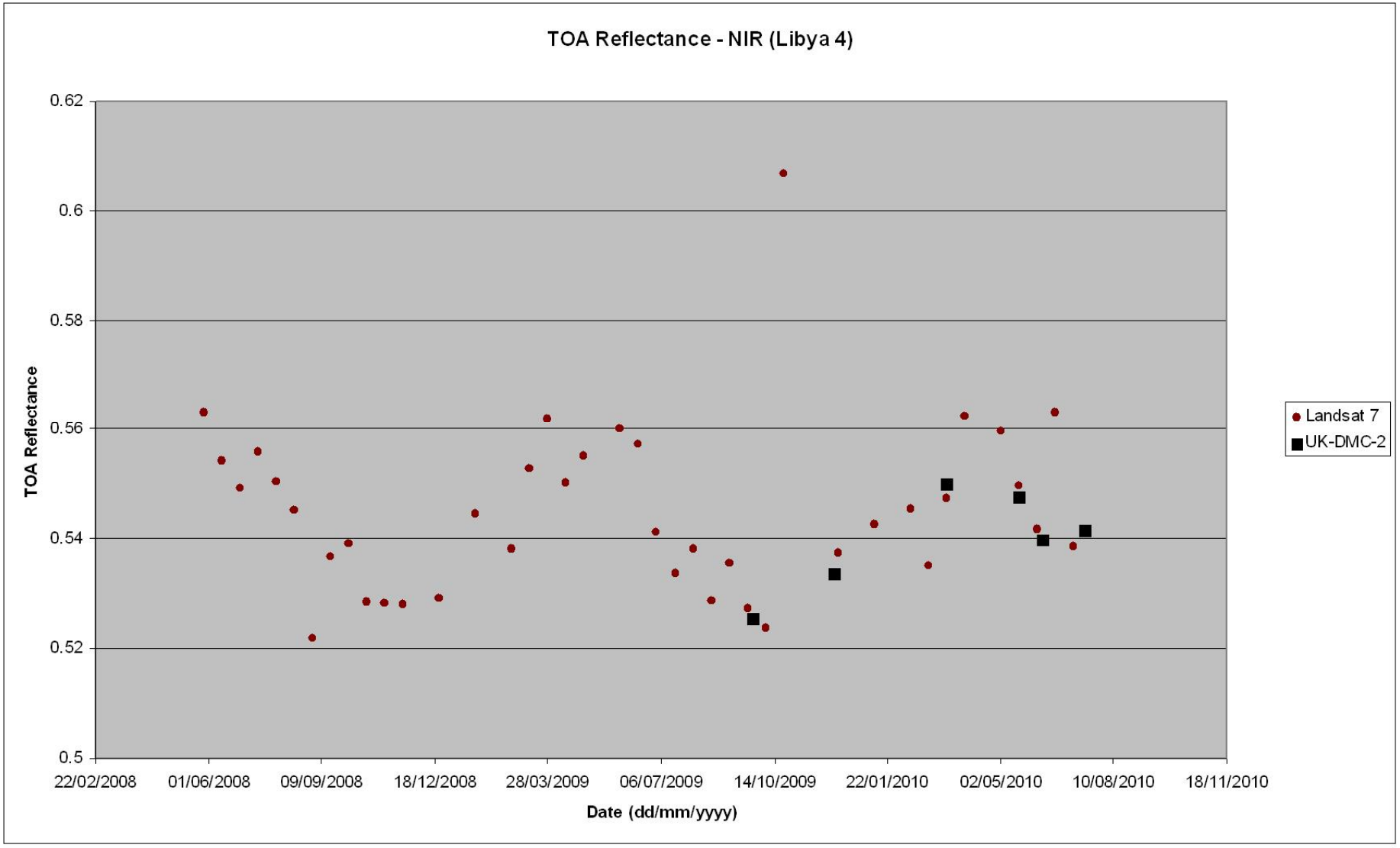
Surface Variability

Figure 3.12: View from an airplane near Siple Dome, West Antarctica (82°S, 150°W), November 1994. The surface elevation is about 500 m. The streaks which appear dark in this photograph were later identified (on an oversnow traverse by snowmobile) as surface frost; viewed from the opposite direction they instead appear brighter than the intervening regions of snow. (The frost therefore probably has little effect on the albedo.) Photo by Nadine Nereson.

Comparison 2010 Dome - C



Comparison 2010 Libya 4



Comments Dome-C

- BRDF model not perfect, especially at low sun angles
- Overestimates correction in SWIR
- Ozone correction not perfect as underestimates the correction
- No water vapour correction applied, but should be considered due to large day to day changes
- No aerosol correction applied, as lack of calibrated data from sun-photometer
- Surface is not invariant on scale of a few days

Conclusions

- BRDF correction when sensors have significant differences in site overpass times are required
- Ozone correction can be significant even over non-polar targets
- Other atmospheric corrections are essentially “noise” which may be reduced by suitable correction from instrumented sites and only have major impact when few acquisitions are made