Results of Dome-C Comparison

- For Medium Resolution Sensors

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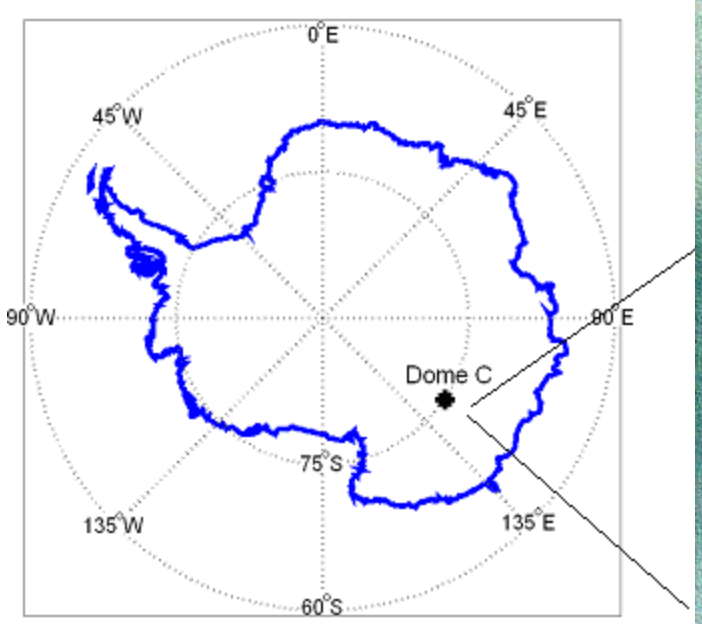
Outline

- Dome C Site
- Site Characterization
- Sensor Calibration Inter-comparisons at Dome C Site
- Other Efforts and Progress
- Summary

Location of the Antarctic Dome C Site

(75°06'S, 123°21'E)



EO-1 Hyperion observations with 30 m resolution

Dome C (75.10°S, 123.39°E)

Dome 1 (78.59°S, 120.26°E)

Dome 2 (75.74°S, 113.74°E)

Dome 3 (77.38°S, 128.72°E)

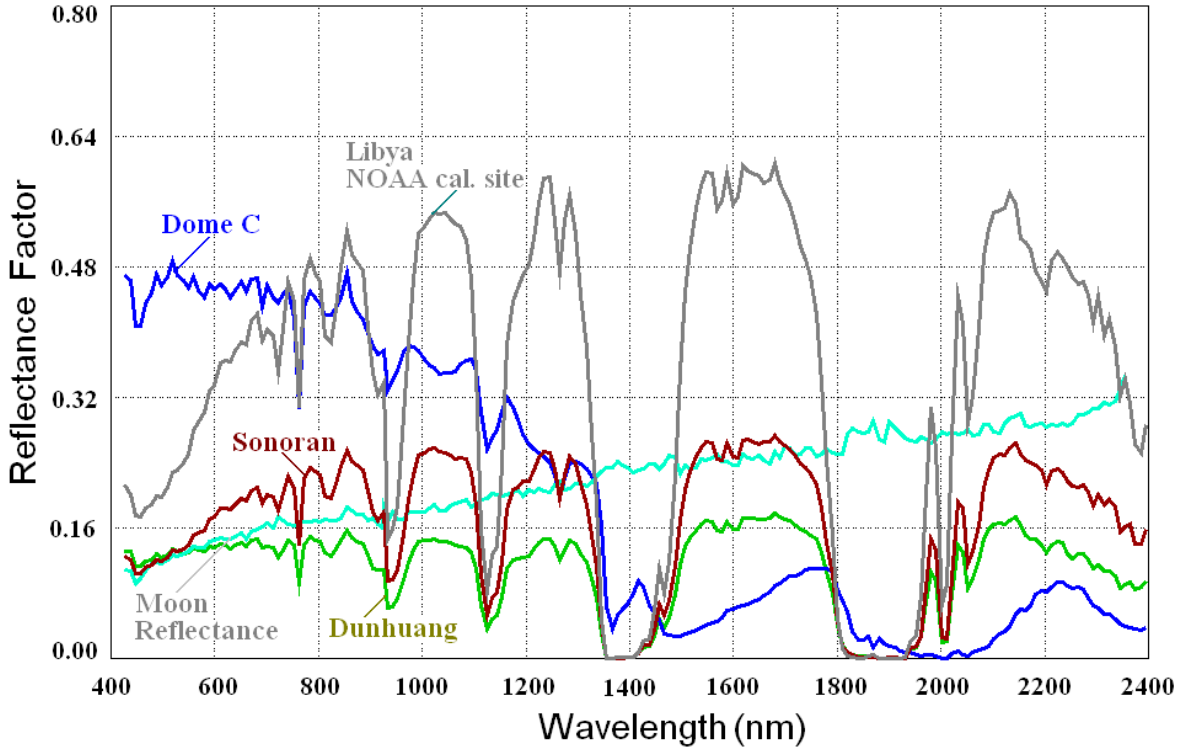
One of the CEOS Endorsed Reference Standard Sites

High elevation (3.3 KM), thin and relatively constant atmosphere, clear sky most of the time

Automated Weather Station (AWS)

Spectral Characterization of Dome C Site

- Dome C spectra is relatively flat in the 0.5-0.7um spectral region
- Libyan desert has sharp spectral slope
- Dunhuang is more sensitive to clouds due to low reflectance

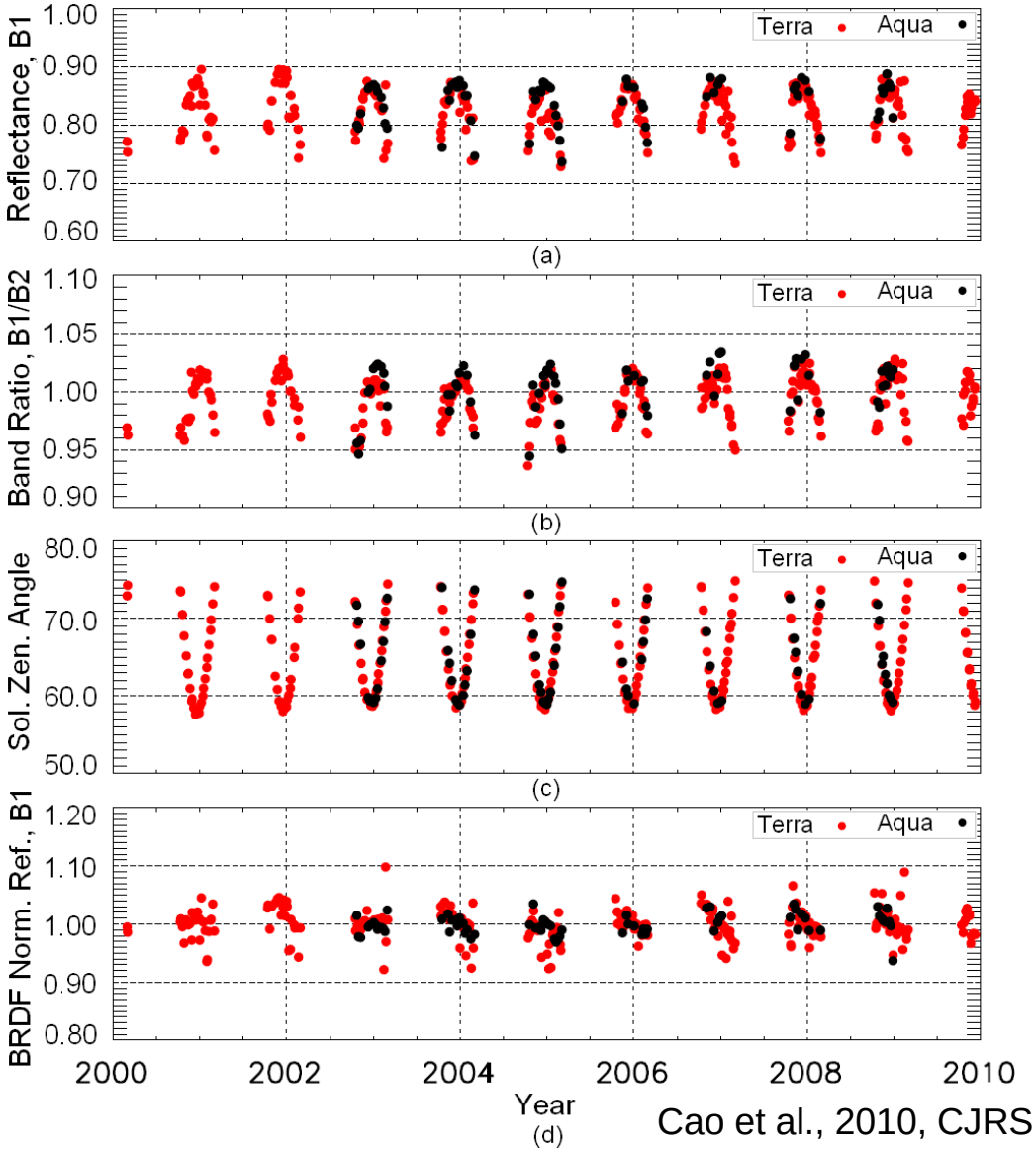


Cao et al., 2010, CJRS

Spectrally favorable for VIS and NIR channel calibration

MODIS Observations at the Dome C Site

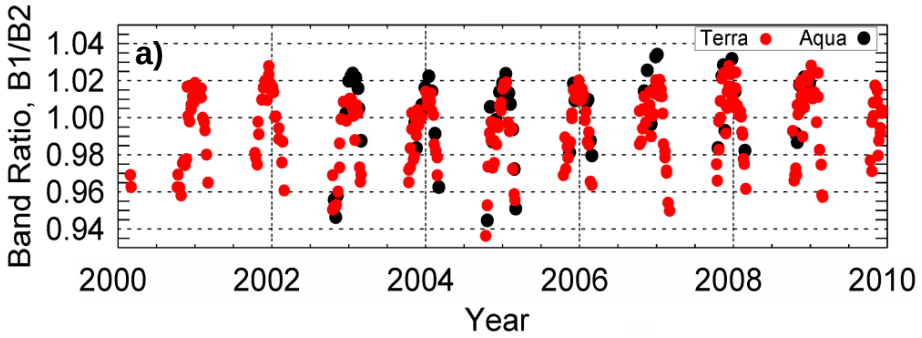
- Terra MODIS launched in 1999 and Aqua MODIS in 2002
- MODIS observations show snow BRDF effects but the site is relatively stable at 2% level.
- Band ratio shows solar zenith angle dependency, suggesting that the BRDF of the two bands (0.6 and 0.8um) are not the same.
- Slight increase in the band ratio around 2007 from both Terra and Aqua MODIS (further studies are needed).

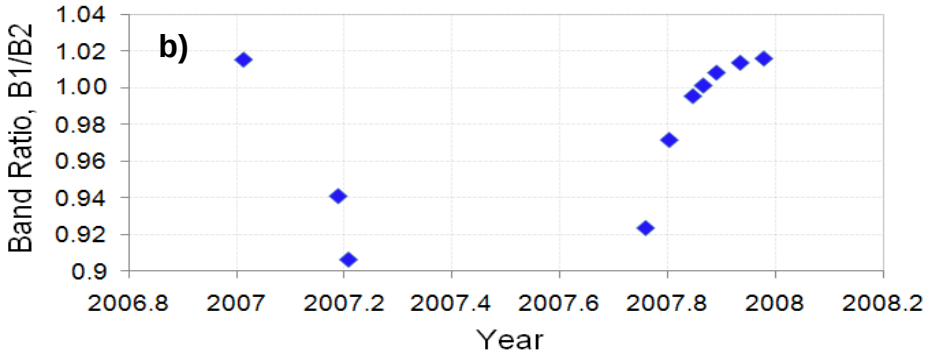


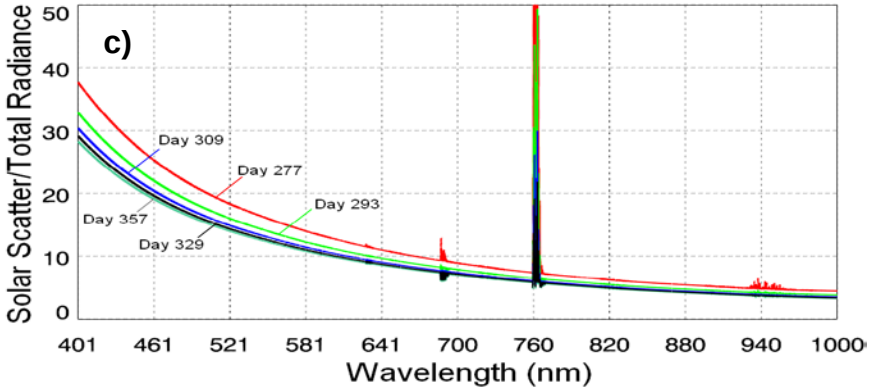
Cao et al., 2010, CJRS

Wavelength Dependant BRDF Effect

- TOA BRDF effect is wavelength dependant for the Antarctic snow (Figure a. Band ratio from MODIS observations).
- This effect was confirmed using MODTRAN simulations (Figure b. Band ratio from MODTRAN).
- The seasonal trend in band ratio in Figure a is primarily due to the wavelength and solar zenith angle dependency of Rayleigh scattering (Figure c. Solar scattering from MODTRAN simulation).







Ozone Effect

- Ozone over Dome C shows high variability up to ~14% (Figure 1).
- Ozone transmittance shows direct correlation with AVHRR reflectance with the coefficient of determination of 0.68 (Figure2).
- Recommendation: broad bands such as AVHRR Band 1 over Dome C is highly affected by atmospheric ozone and needs to be taken into account to reduce the uncertainty in reflectance time series.

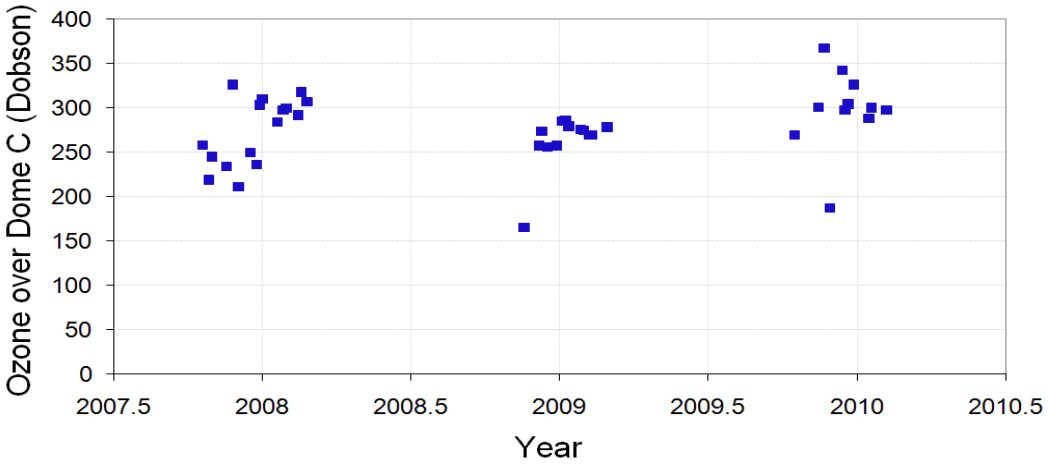


Figure 1. Ozone variability over Dome C

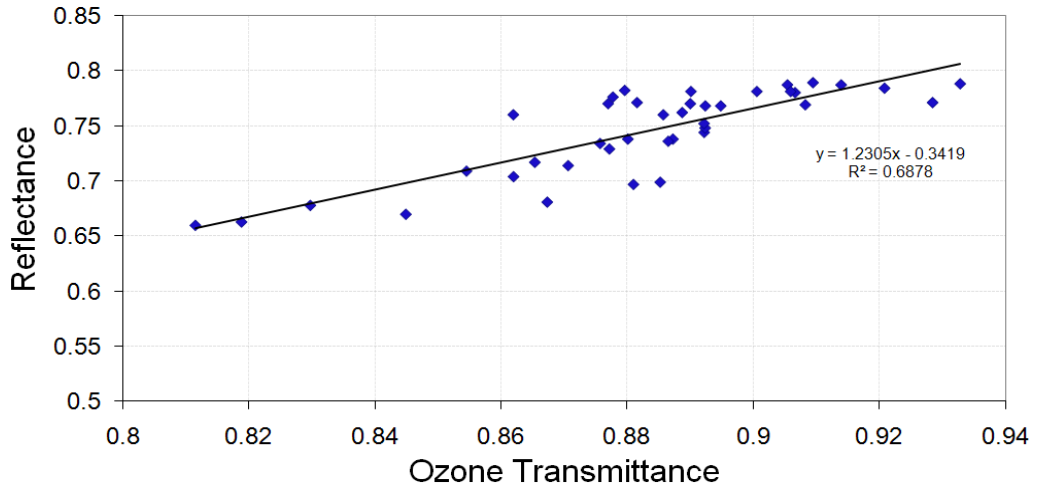
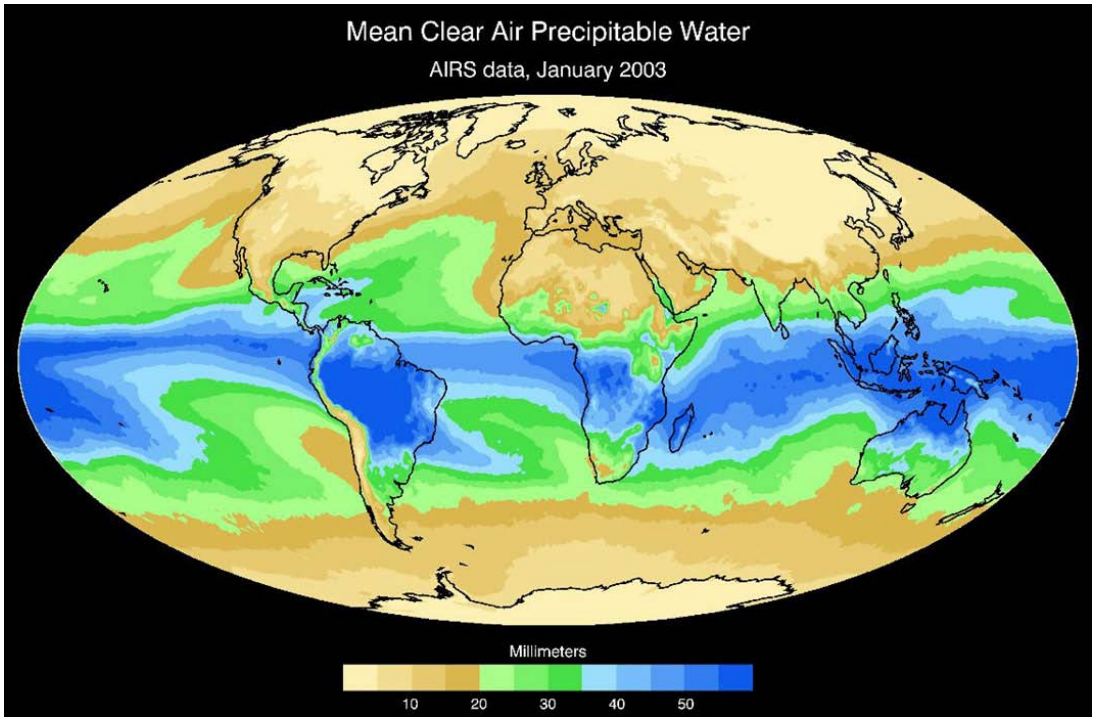


Figure 2. Reflectance vs. Ozone Transmittance for AVHRR band 1

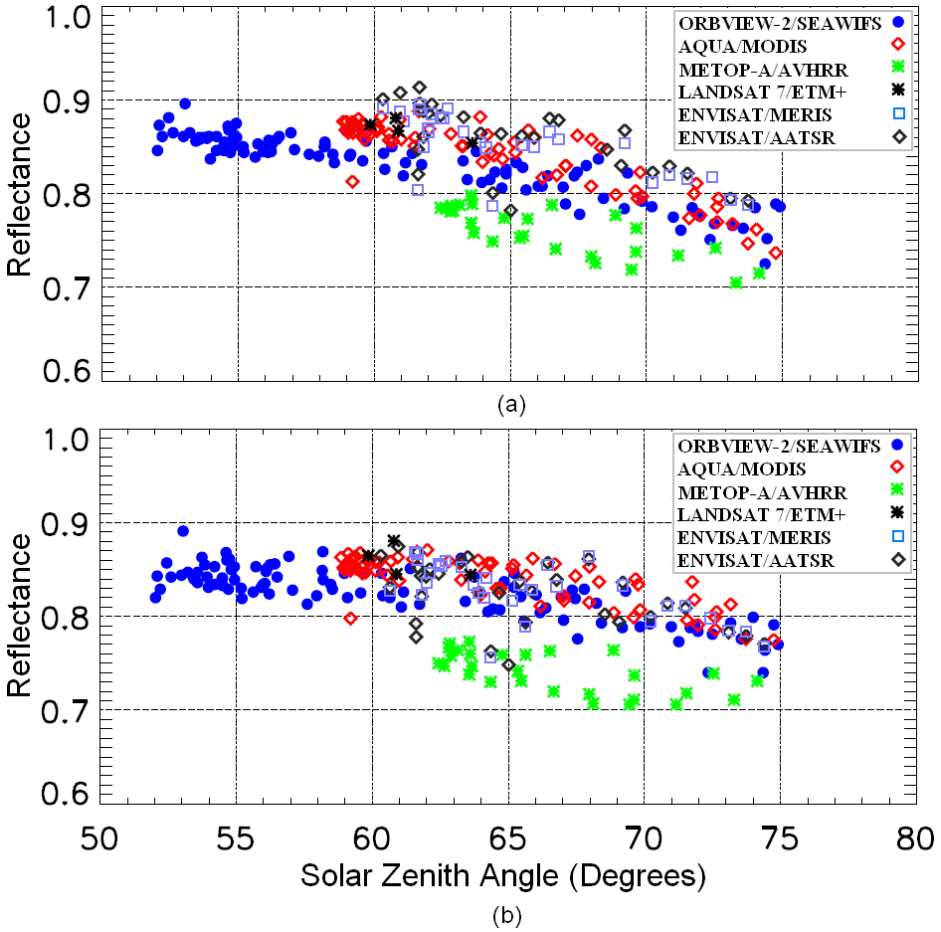
Water Vapor Effect

- It is known that the water vapor is low at the Dome C but reliable data are not easy to get because retrieval at Dome C is very challenging;
- Qualitatively, the specific humidity at Dome C is lower than that at the Desert sites because of the low temperature at Dome C;
- On the other hand, the relative humidity may show different results but it is not as useful as specific humidity.



Comparison of Six Radiometers Reflectance at the Dome C

- MODIS is used as the community reference standard for the comparison (example: 86.73% +/- 1.49% for band 1)
- Both MERIS and Landsat ETM+ agree well with MODIS
- AATSR has large spread due to contamination in the optics
- SeaWiFS differs from MODIS probably due to the 20 deg tilt
- AVHRR is ~9% lower



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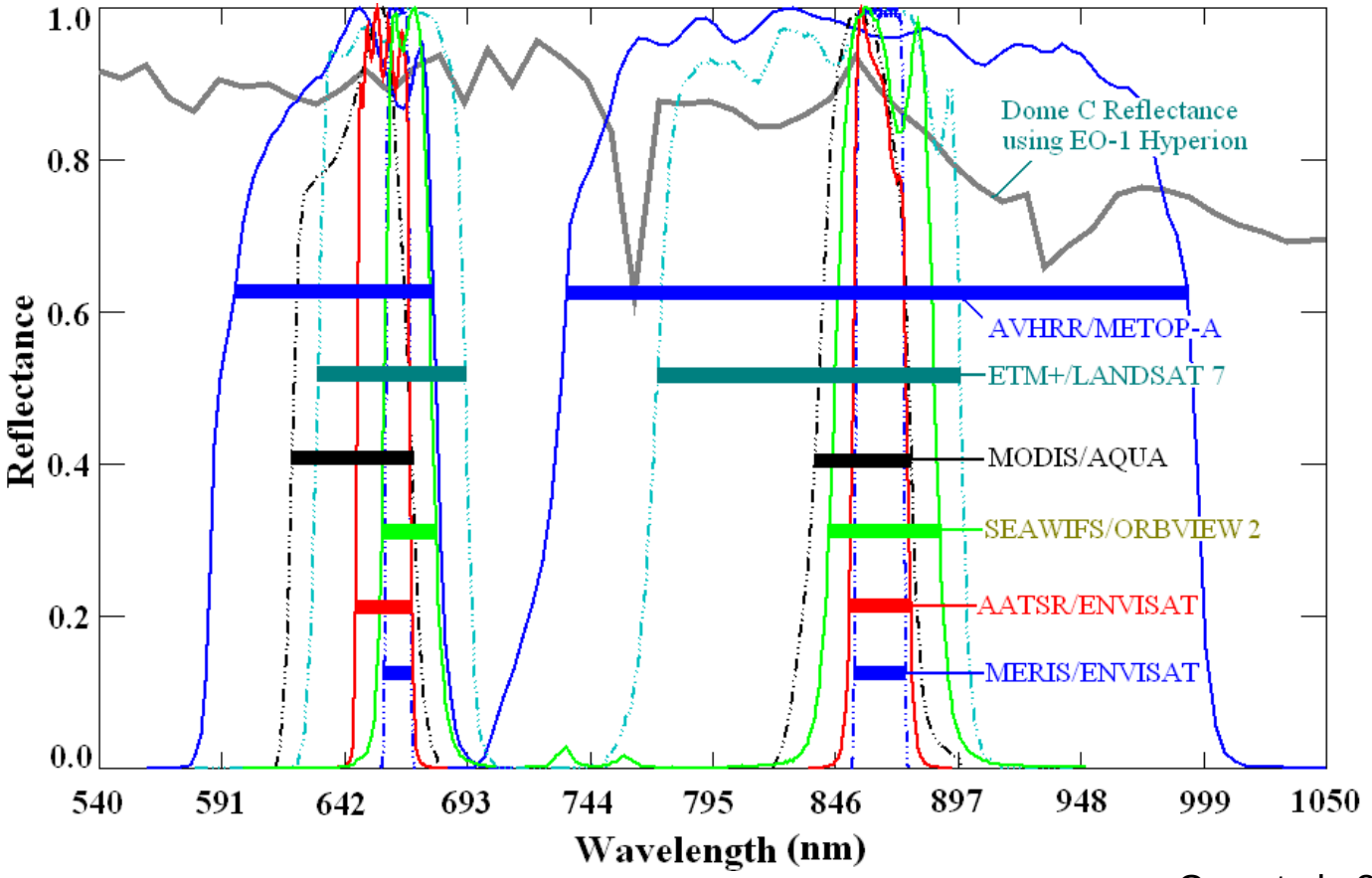
Comparison of Six Radiometers Spectral Response Function



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Spectral response differences have to be taken into account in the comparisons

Comparison of Reflectance Biases at the Dome C

		MODIS 0.64 μm (ρ= 86.73% +/- 1.49% @60 sza)		MODIS 0.86 μm (ρ= 85.48% +/- 1.44% @60 sza)	
	@SZA	Observed Bias	Theoretical Bias	Observed Bias	Theoretical Bias
OrbView/SeaWiFS	59°	-2.74%±1.32%	1.95%	-2.09%±1.57%	-1.46%
METOP-A/AVHRR	62°	-8.74%±1.60%	-0.43%	-10.14%±1.58%	-8.21%
Envisat/MERIS	62°	0.74% ±2.28%	0.66%	-1.22% ±2.28%	0.20%
ENVISAT/AATSR	62°	1.76% ±2.83%	1.07%	-1.90% ±2.92%	0.43%
Landsat 7/ETM+	60°	1.03% ±0.52%	1.17%	1.35% ±1.24%	-3.22%
EO-1/Hyperion	60°	+2.63 ± 0.48%	n/a	+4.35± 0.18%	n/a

See JCRS 2010 paper for details on uncertainty assessment

Dome C Site Used for HIRS Anomaly Study

- NOAA-19/HIRS observation shows inconsistent reflectance trend compared to Metop-A (Figure 1) and other sensors;
- Investigation reveals that the BRDF pattern for NOAA-19/HIRS is out of family;
- Root cause: space view count discrepancies between pre and post launch;
- Correction can be made by changing the calibration offset.
- This suggests that Dome C site is useful for calibration anomaly investigations.

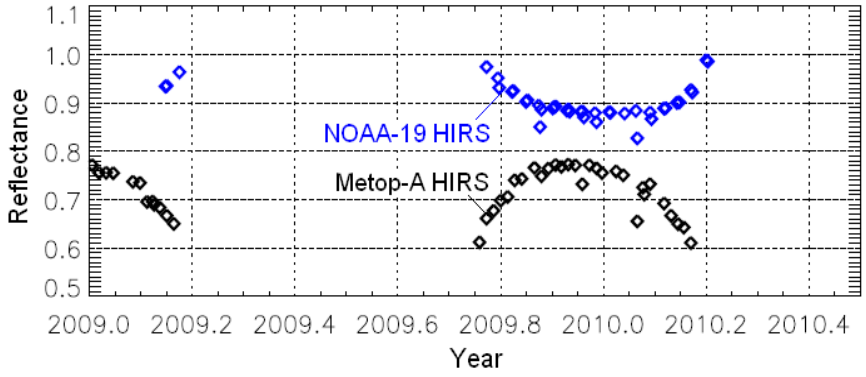


Figure 1. Visible band reflectance trend for HIRS on NOAA-19 and Metop-A (before correction)

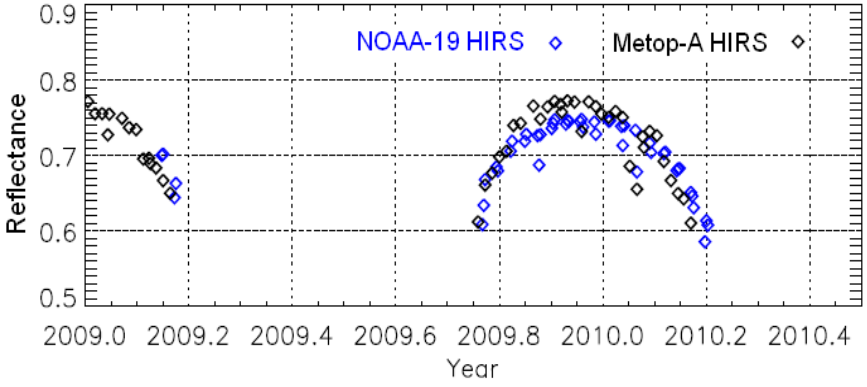


Figure 2. Reflectance trend observed after correcting the calibration offset for HIRS in NOAA-19 (after correction)

Dome C Site Used for MODIS Calibration

- The Dome C has been used to monitor **MODIS calibration stability and consistency** (GRSL in 2008 for thermal emissive bands; JARS paper in 2009 for both reflective solar and thermal emissive bands).
- CEOS comparison data over four sites within the Dome C region, Dome C (75.1017^{o}S, 123.3950^{o}E), Dome 1 (78.5933^{o}S, 120.2648^{o}E), Dome 2 (75.7431^{o}S, 113.7356^{o}E), and Dome 3 (77.3825^{o}S, 128.7150^{o}E), during the period from 1 December 2008 to 31 January 2009 are analyzed (preliminary results presented at the SPIE Europe Remote Sensing in September 2009).
- Dome C site has been used for Aqua MODIS and AIRS calibration consistency over time (ongoing effort).

Other Progress

- The Dome C paper has been accepted for publication by CJRS
- Results of inter-comparison between Dome C and Sonoran desert site presented at the SPIE in August 2010
- Results of Inter-comparison between Dome C and Dunhuang desert site presented at the SPIE Asia-Pacific in October 2010
- Preliminary analysis on HJ-1A/HSI data over Dome C completed

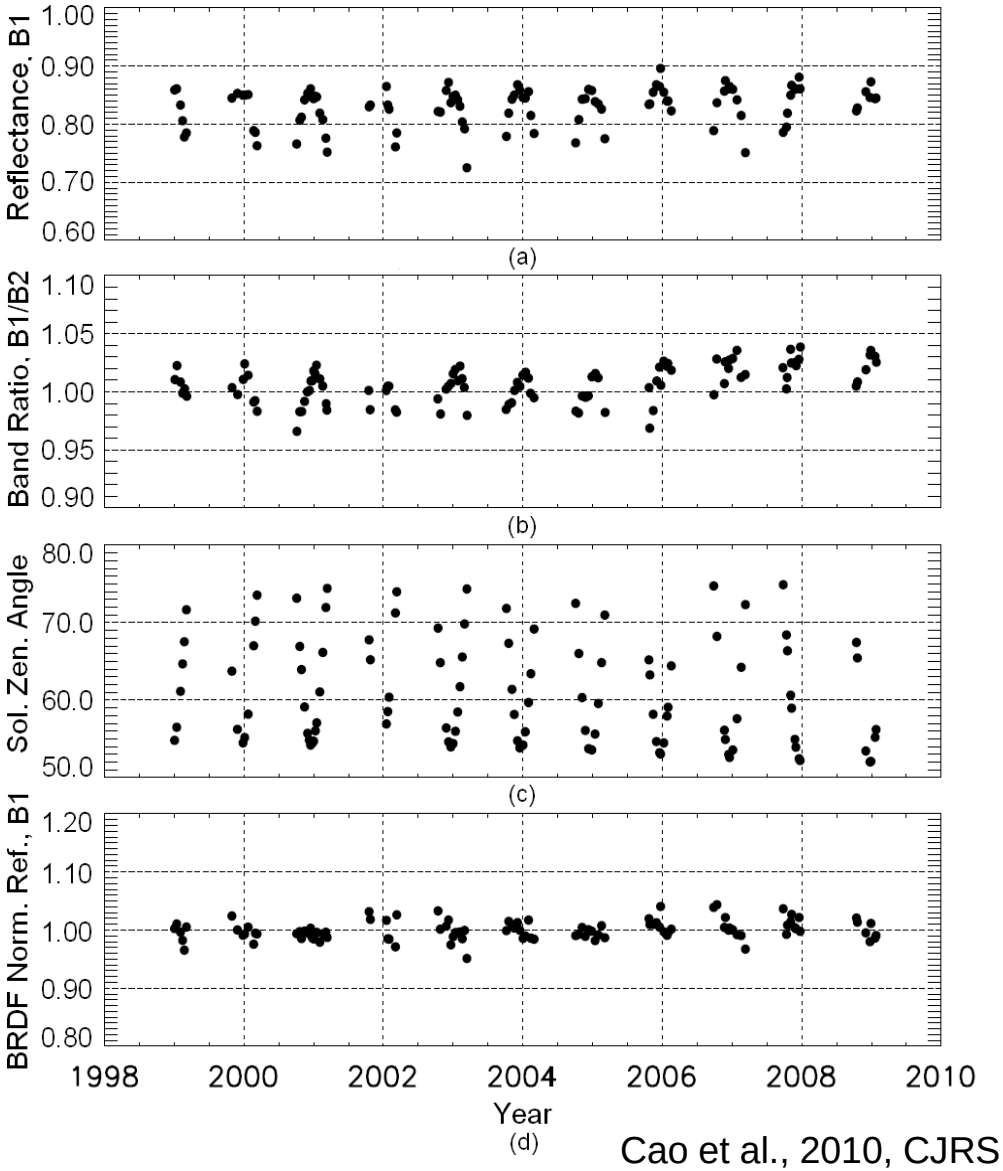
Summary

- Dome C is relatively stable based on MODIS and SeaWiFS observations; although some small short-term climate anomalies might exist;
- Dominant atmospheric effects include Rayleigh scattering and Ozone absorption and these effects can be modeled;
- Dome C is spectrally favorable for the visible/near infrared channel calibration;
- Spatially uniform is excellent (1% level);
- Inter-comparisons show that most of the radiometers agree within 2% in reflectance.

- Backup slide

SeaWiFS Observations at the Dome C

- SeaWiFS is probably the most stable instrument due to its dedicated lunar calibration
- However, the SeaWiFS orbit drifts over time, changing the observation time and solar zenith angle
- SeaWiFS doesn't have true nadir observations (tilted 20 deg.)



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