

## **CEOS Action 2009: DA-09-01a\_7**

### **Dome C Project Progress Update**

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With contributions from CEOS/WGCV and  
CEOS/WGCV/IVOS members

# DA-09-01a\_7

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1. *Conduct a multi-sensor comparison to evaluate the size of any biases using the Dome C site as a reference standard. This will serve as a pilot for future regular CEOS comparisons over this and other reference sites to ensure data interoperability and to underpin the LSI constellation. The results of the comparison will allow an assessment to be made of the site's suitability for climate quality calibration.*
2. *Develop the theoretical basis and standard procedure as part of the QA4EO guidelines for future cross comparisons.*
3. *Present results and put information on the Cal/Val portal*

## Dome C Data Analysis

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- SeaWiFS
- MODIS/Terra/Aqua
- AVHRR/N18, MetOP, N19
- Hyperion
- ASTER
- See IVOS report by N. Fox for a complete list

## Sample data made available on the web

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- Temporary website established: URL  
*<http://www.star.nesdis.noaa.gov/smcd/CEOS/WGCVProjects/DomeC/DomeCStudy.html>*;
- About 30 MetOP/AVHRR data sets made available on the web in NetCDF format, with sample IDL code;
- Procedure for analyzing longterm stability made available;
- Conference presentations and reports.

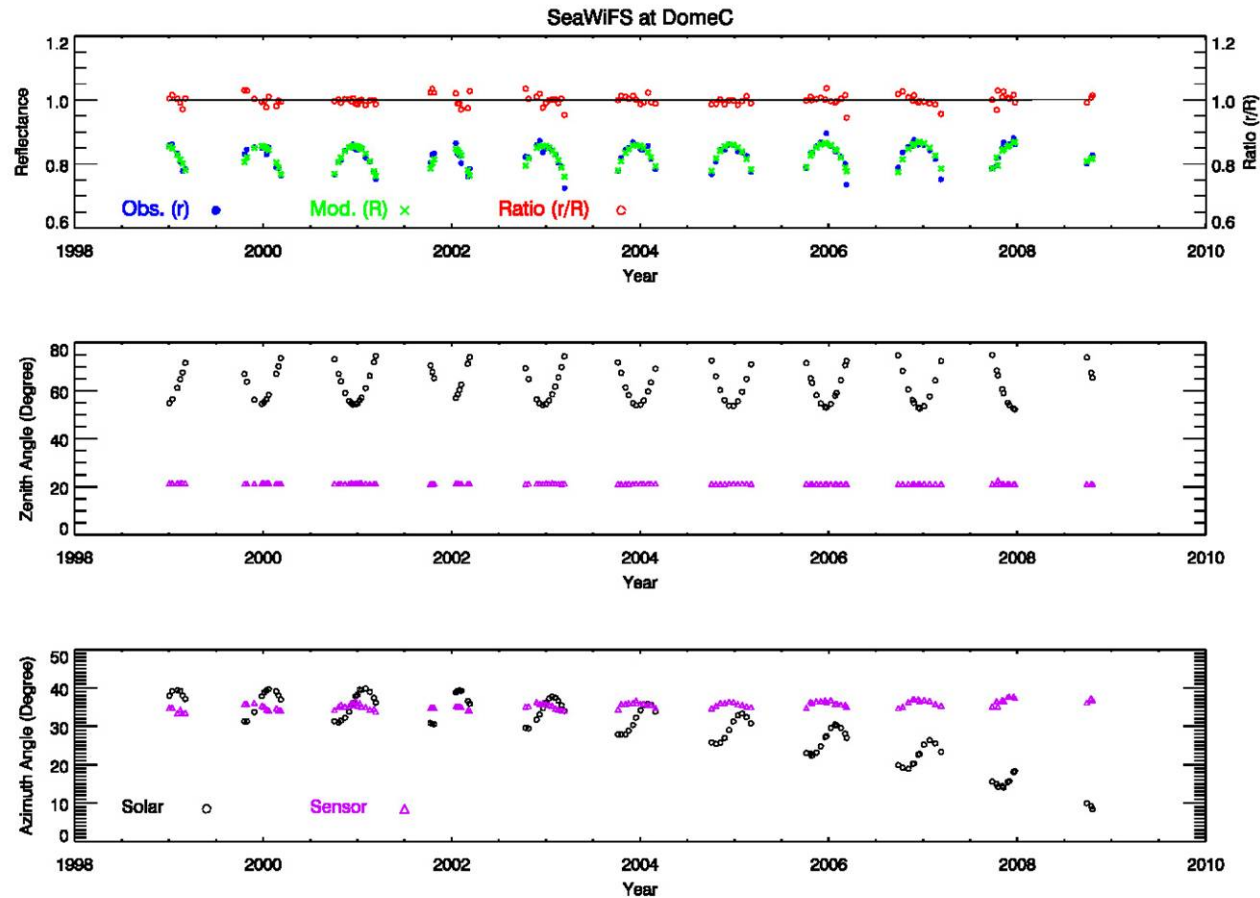
# Progress

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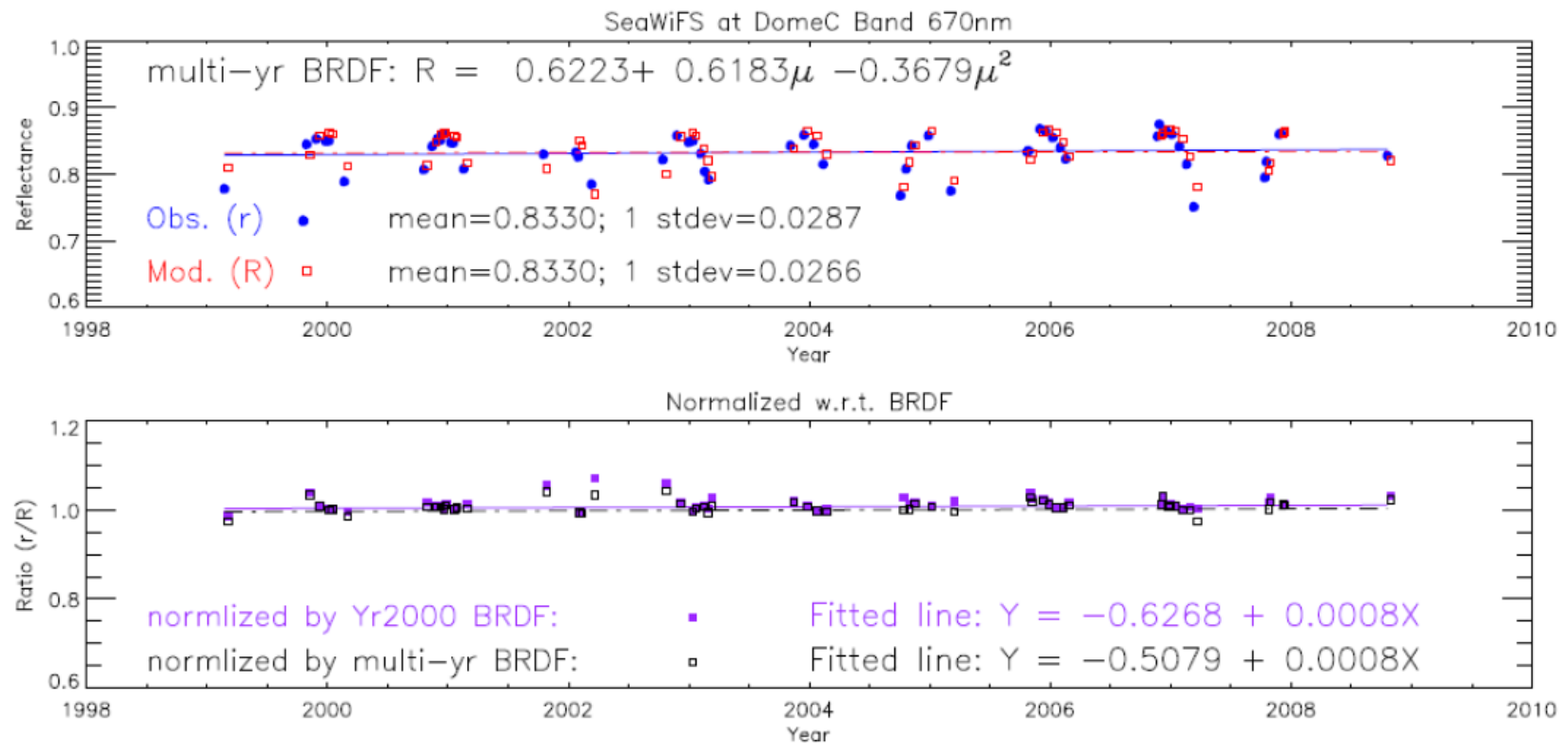
- Characterization of the Dome C site is performed using SeaWiFS observations, since SeaWiFS is extremely stable with its dedicated lunar calibration.
- The radiometric responses of SeaWiFS, MODIS (proxy for VIIRS), and AVHRR at the Dome C site are analyzed and compared.
- Simultaneous Nadir Overpass (SNO) observations between MODIS and AVHRR over the Antarctica are used for independent verification and potential radiometric transfer between satellites.
- Hyperion observations at Dome C are used to resolve issues related to the spectral response function differences.

# SeaWiFS Dome C BRDF Effects

- The Warren model is used to account for the BRDF effects.
- After BRDF correction, the seasonal oscillation is significantly reduced, with residual uncertainty of  $\pm 1.4\%$  (1 sigma).

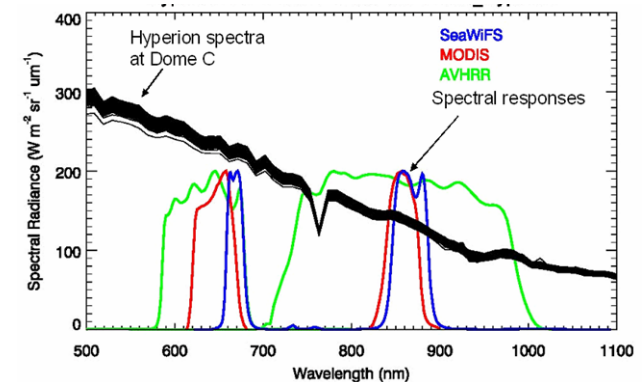
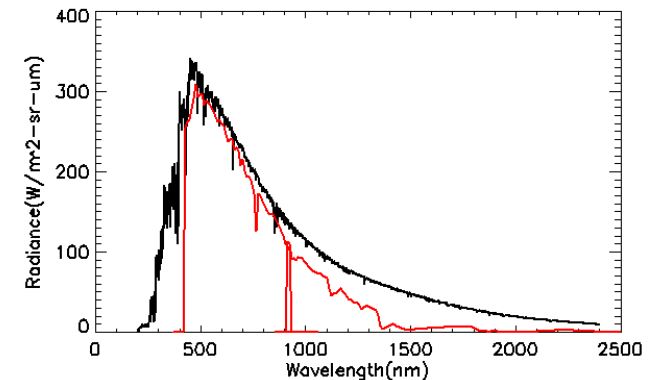


# BRDF Correction



# Hyperion Observations at Dome C

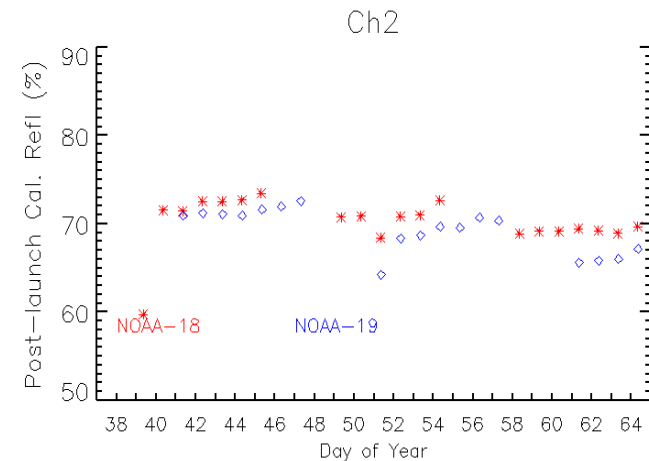
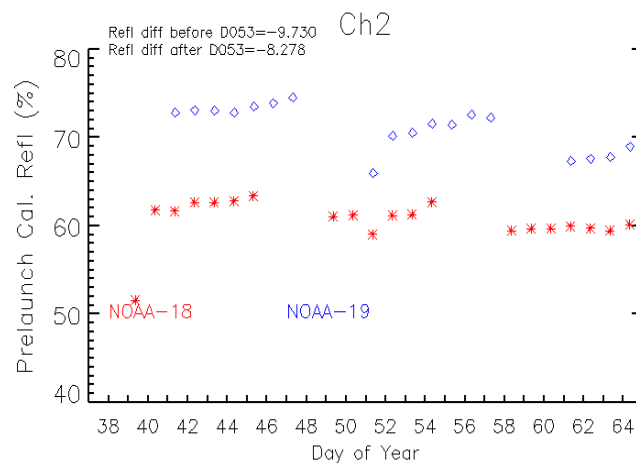
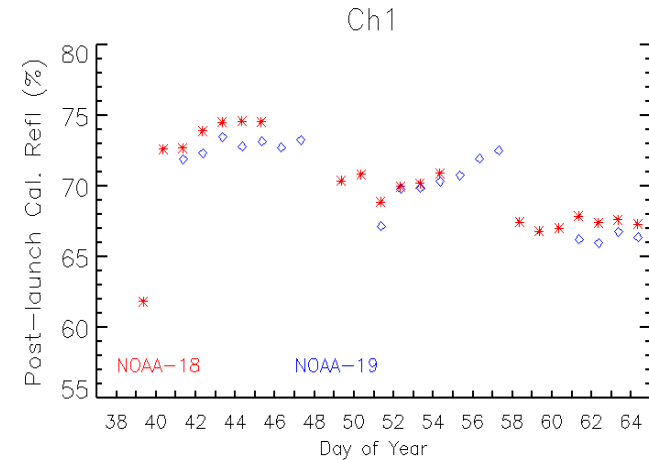
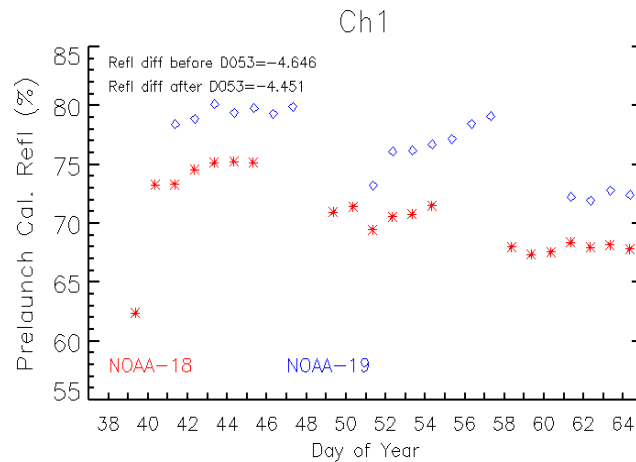
- To address the issue of spectral response difference induced biases, Hyperion observations are acquired in collaboration with NASA;
- AVHRR and MODIS spectral response functions are convolved with Hyperion spectral radiances;
- Reflectance ratio analysis shows that the spectral response difference does not have major effect on the 0.6 $\mu$ m band.





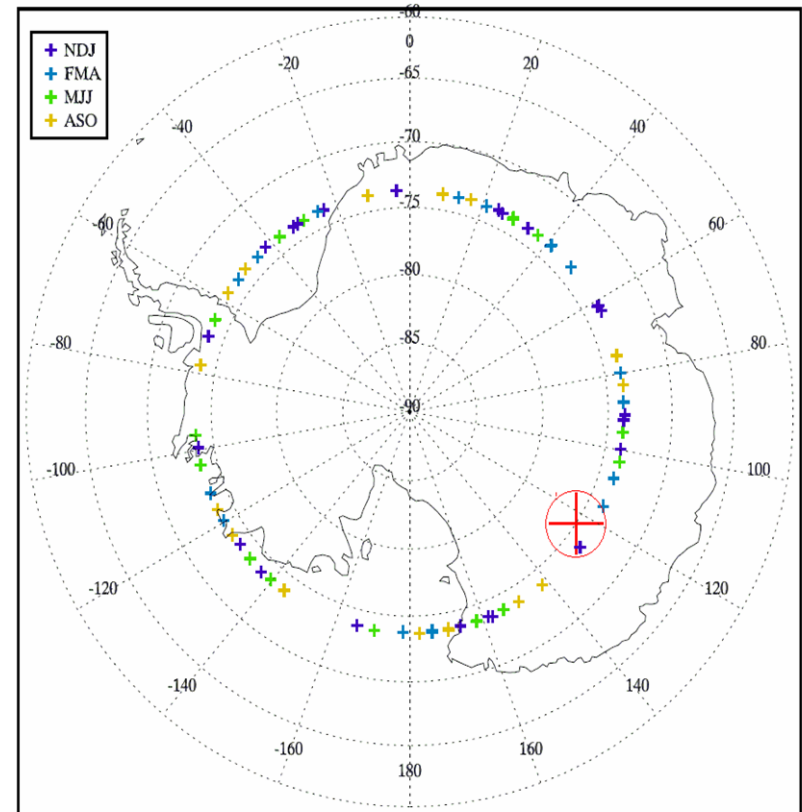
# Dome C Site Used for NOAA-19 AVHRR On-orbit Verification

Nadir observations of Dome C, Pre- and Post-launch (Libyan)  
calibration w/o BRDF correction



## Simultaneous Nadir Overpass (SNO) at Dome C

- SNO has been applied to many applications for the inter-calibration of polar-orbiting radiometers in recent years;
- Inter-calibration uncertainty on the order of 1% has been demonstrated for some channels (Cao, et al., JGR, 2008);
- However, SNO is for relative instead of absolute calibration;
- Dome C can potentially be used for absolute calibration, which significantly complements the SNO method.



SNOs between MetOP and Aqua  
occur at Dome C occasionally

## Dome C Study Preliminary Findings

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- SeaWiFS study of Dome C show excellent stability of both the instrument and the site.
- The Warren model was found to be very useful for correcting the BRDF effect.
- MODIS and SeaWiFS at 0.6  $\mu\text{m}$  are found to agree at 1% level (note the view angle differences)
- Further work will focus on high resolution sensors under the IVOS subgroup.

# Summary

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- Preliminary studies show that Dome C is an excellent site for absolute, relative, and inter-satellite calibration;
- The site appears to be stable long-term and has little aerosol or water vapor effects. This greatly reduces the uncertainties in the vicarious calibration. ;
- The study of MODIS, SeaWiFS, and AVHRR/MetOP at Dome C has revealed small calibration biases between them;
- Further work should lead to very accurate absolute calibration at Dome C. When combined with the SNO method, it will allow us to establish accurate calibration links for a constellation of satellites;
- Further explore the potential for calibrating microwave instruments at Dome C (MW and SAR subgroups) .

- Backup slides

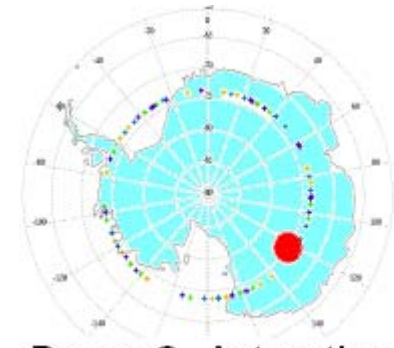
# Background

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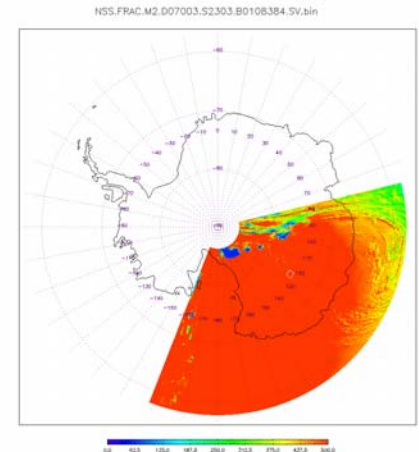
- Establishing common radiometric reference sites for the inter-calibration of satellite radiometers is an effective strategy to bring consistency to a constellation of satellites.
- In a joint effort by scientists from NOAA, NASA, CNES, and other CEOS space agencies, the Antarctic Dome C radiometric standard site is being established for the inter-comparison of visible bands of satellite radiometers (Cao, et al., 2008).
- Dome C is recognized as one of the eight “Landnet” calibration sites worldwide endorsed by the CEOS (Committee on Earth Observation Satellites)/WGCV (Working Group on Cal/Val).

# Why Antarctic Dome C?

- Dome C is an exceptional site due to its thin atmosphere and climate stability;
- Relatively uniform and flat snow surface, elevation > 3 kilometers;
- Clear most of the time, and less affected by clouds due to high reflection (less contrast);
- Low uncertainties from atmospheric variability and radiative transfer calculations: dry atmosphere with low aerosol loading. Low wind speed;
- Frequent satellite overpass, and occasional Simultaneous Nadir Overpass provide opportunities for highly accurate calibration transfer between satellites;
- Extensive previous studies (Warren, Hudson, Masonis, U. of Washington);
- International site for all space agencies, a.k.a., CEOS agencies;
- Also an exceptional site for Astronomers.



Dome C, Antarctica



# Disadvantages

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- Only available in the winter months (best between Dec. 1 to Jan 31, according to Patrice Henry of CNES), thus only good for infrequent inter-comparisons,
- BRDF (Bi-directional Reflectance Distribution Function) effects is apparent,
- Boundary layer (~30 meters) exists,
- Limited ground measurements (Hudson, et al, 2006),
- High solar zenith angles (50-75 deg).



## References

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- Cao, C., S. Ungar, P. Lecomte, N. Fox, X. Xiong, P. Henry, et al., 2008b, Toward consistent satellite calibration and validation for GEOSS interoperability, IGARSS 2008, Boston, MA.
- Wu, A., X. Xiong, and C. Cao, 2008, Examination of calibration performance of multiple POS sensors using measurements over the Dome C site in Antarctica, Proc. SPIE, Vol. 7106, 71060W (2008); DOI:10.1117/12.80033.
- Hudson, S., S. Warren, R. Brandt, T. Grenfell, D. Six, 2006, Spectral bidirectional reflectance of Antarctic snow, Measurements and parameterization, Journal of Geophysical Research, Vol. 111, D18106, doi:10.1029/2006JD007290.