Towards a Consensus AVHRR Reflectance Calibration

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Outline

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- Approach
- Results/Accomplishments
- Validation Strategy/Results
- Algorithm/Product Maturity
- Issues/Risks & Work-Off Plans
- Schedule
- Research-to-Operations or Delivery Plan
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Overview

- Goal(s)

  The AVHRR data record now spans 30 years. The ability to derive long-term time series of many critical ECV's demand accurate post-launch calibration of the reflectance channels. This project aims to build upon past research and develop a new reflectance calibration for the entire record (*for the first time*). Part of this effort is the hosting of a workshop to help identify consensus approaches. Analysis shows current long-term calibrations differ by 5% in 0.63μm and 10 % in 0.86 μm.

- Source Data
  - NOAA and EUMETSAT's Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data from 1978 to the present.
  - MODIS observations during SNO events and over selected targets.

Overview

- Deliverables
  - Complete the PATMOS-x AVHRR historical reflectance calibration and apply to every AVHRR (1978-2009)
  - Host workshop(s) to elicit feedback on how to improve the accuracy of this effort based on past experience.
  - Reprocess the AVHRR record through PATMOS-x with a new calibration and make the data available.
- ECVs addressed
  - 0.63 and 0.86 μm top-of-atmosphere reflectance
  - Cloud properties
  - Aerosol optical depth
  - Atmospherically corrected NDVI

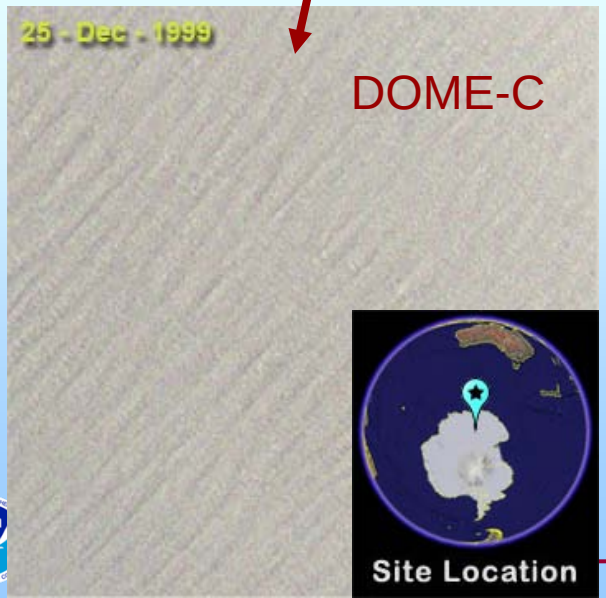
Overview

- Current/expected user communities (especially non-research sectors, e.g., Health, Defense, etc.)
  - PATMOS-x users (PATMOS-x is a NESDIS AVHRR cloud climatology data set).
  - EUMETSAT CM-SAF and their users.
  - NCDC's internal use of PATMOS-x to generate climate records and their users (Ken Knapp and Tom Zhao).
  - This may potentially influence ISCCP which is undergoing a recalibration.

Approach

Our PATMOS-x AVHRR reflectance calibration is based on 4 different sources of data. Method has been applied to all sensors.

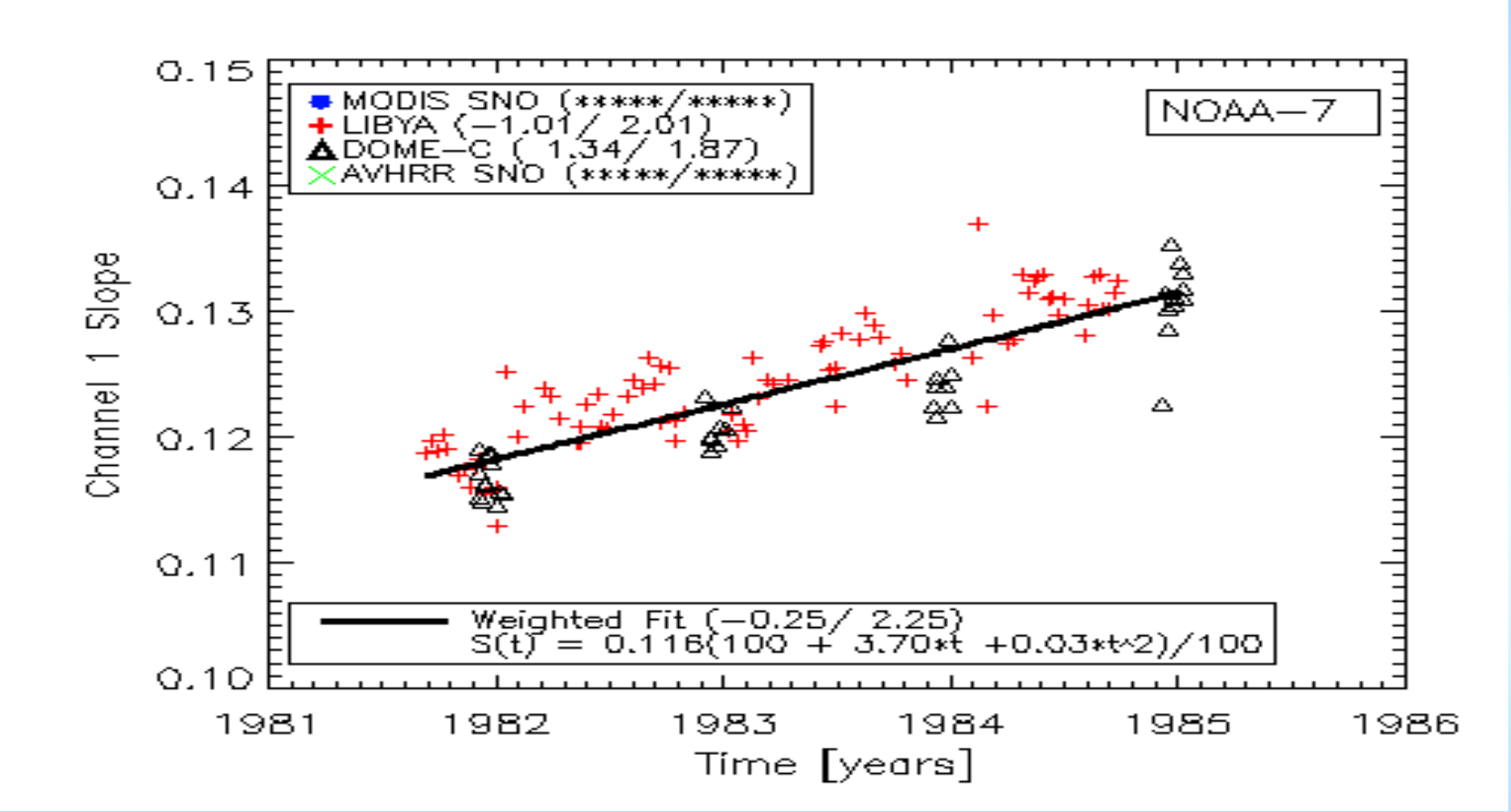
1. MODIS to AVHRR SNO (2000-2009)
2. AVHRR to AVHRR SNO (1980-2009)
3. Libyan Desert MODIS-derived Reference
4. DOME-C MODIS-derived Reference



Images courtesy of CEOS and STAR websites

Results/Accomplishments

Application to a pre-MODIS sensor (NOAA-7: 1981-1985)



Blue Points – Calibration slopes generated from MODIS to AVHRR simultaneous nadir overpasses.

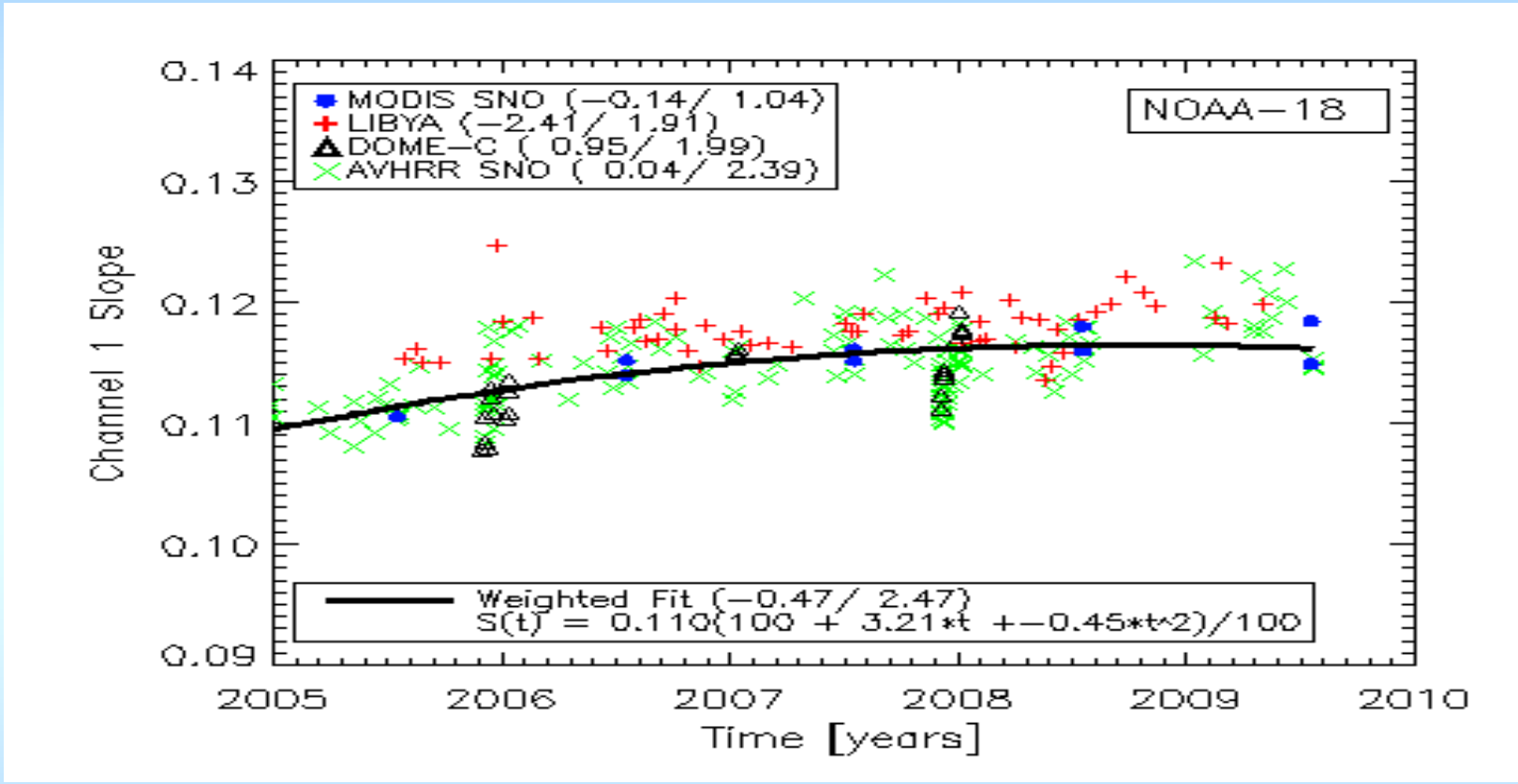
Black Points – Calibration slopes generated from AVHRR observations of DOME-C (Antarctica) using a MODIS-derived reflectance model.

Red Points – Calibration slopes generated from AVHRR observations of the Libyan Desert using a MODIS-derived reflectance model.

Green Points – Calibrations slopes from other AVHRR sensors transferred using AVHRR to AVHRR simultaneous nadir overpasses.

Results/Accomplishments

Application to a MODIS era sensor (NOAA-18: 2005-2009)



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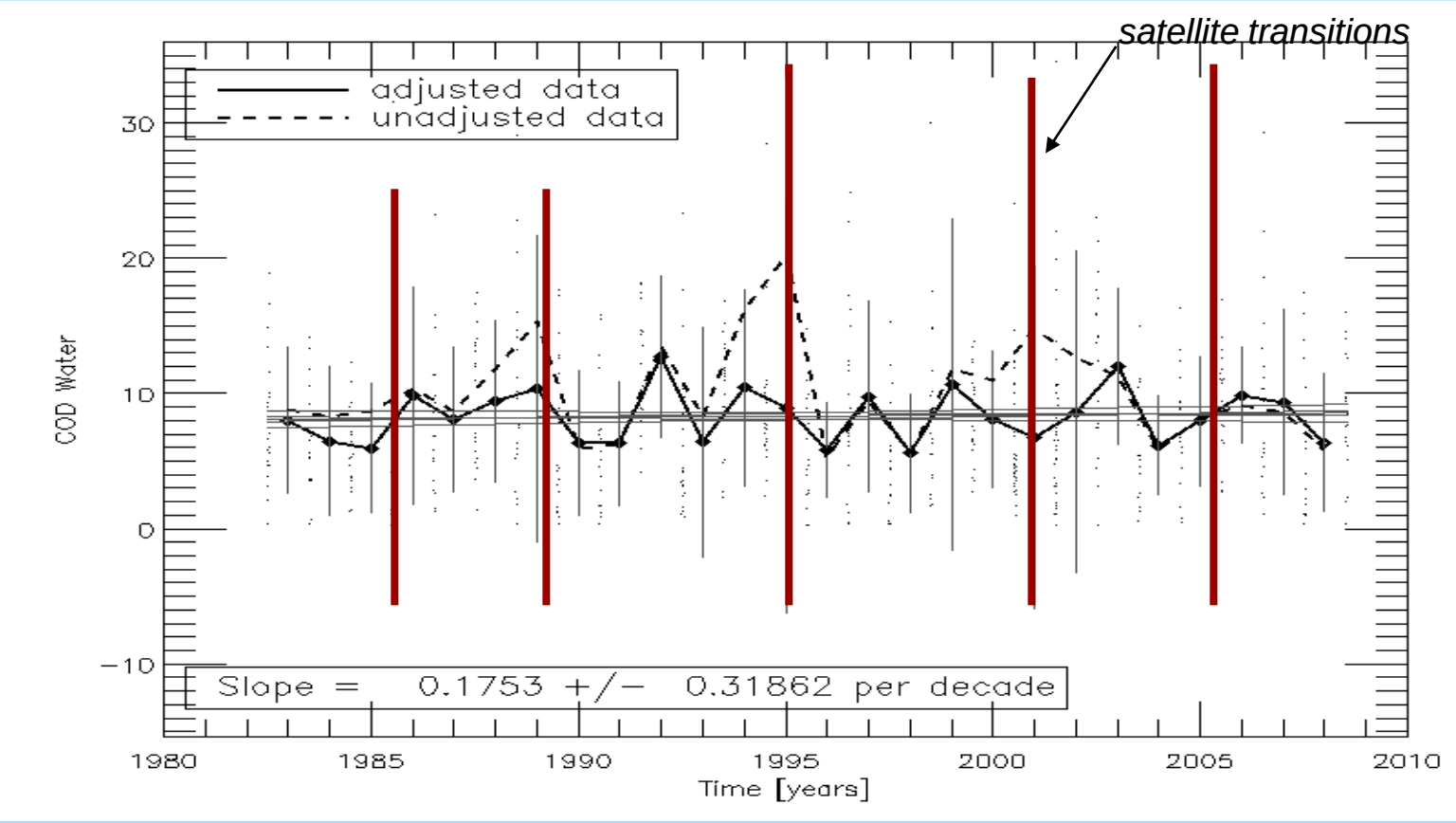
Validation Strategy/Results

- Given the goal of tying the calibration to MODIS, the methodology is self-validating since guarantees agreement with MODIS.
- Use of the AVHRR SNO data automatically validates the AVHRR to AVHRR consistency for those satellites in operation at the same time.
- Analysis of ECV's that are sensitive to the reflectance calibration offers a way to validate satellite to satellite consistency (*see following slide for an example*).

Validation Strategy/Results

Analysis of our time-series of cloud properties (i.e. optical depth) shows that our reflectance calibration does not introduce artifacts at the transition from one satellite to the next. (*jumps are smaller than natural annual variation*).



Adjusted = time series adjusted to a constant observation time of 14:00 local
This data is from a region off the coast of California dominated by stratus.

Product Maturity

Maturity	Sensor Use	Algorithm stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none
2	Research Mission	Some changes expected	Research grade (extensive)	ATBD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use.	Limited or ongoing
3	Research Missions	Minimal changes expected	Research grade (extensive); Meets international standards	Public ATBD; Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
4	Operational Mission	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public ATBD; Draft Operational Algorithm Description (OAD); Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Public ATBD, Operational Algorithm Description (OAD) and Validation Plan; Peer-reviewed algorithm, product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators
6	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators

Issues/Risks & Work- Off Plans

- Water Vapor Correction Uncertainty
  - 0.86 micron channel contains significant amount of water vapor relative to analogous MODIS channel.
  - The NCEP Reanalysis water vapor fields used to account for the MODIS/AVHRR differences may be in error over the Libyan Desert Site.
  - Switch to ERA40/Interim Reanalysis is in progress and sensitivity studies will be done soon.
- Gaps in AVHRR GAC archive
  - Large gaps in the AVHRR/1 data limit the number of AVHRR-AVHRR SNO opportunities. This is an open issue for all users of GAC data.

Schedule

• July 2008 – Generate AVHRR count data-base over SNO events and over selected targets (DOME-c and LIBYA).

•October 2008 – Develop first version of PATMOS-x AVHRR reflectance calibration.

• November 2008 – Hold first Workshop in Washington D.C. (Workshop was expanded to include HIRS).

• July 2009 – Develop second and complete version

• September 2009 – Reprocess AVHRR GAC record to test calibration

• November 2009 – Submit two papers

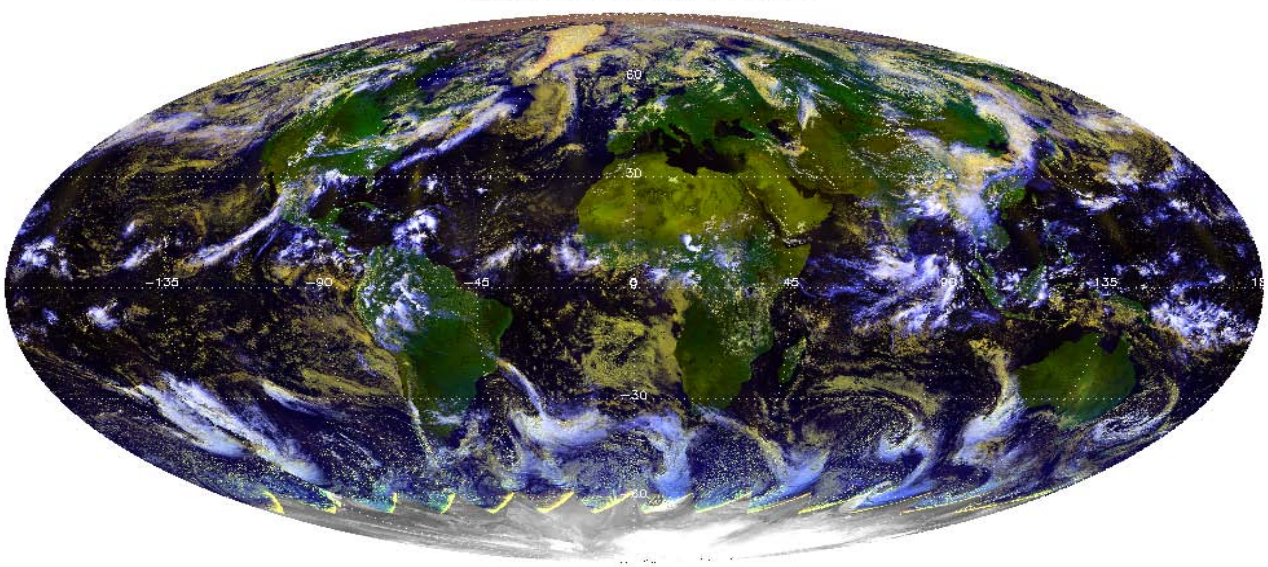
• December 2009 – Period of Performance ends.

Research- to- Operations or Delivery Plan

- Publish final calibration coefficients.

- Deliver to users CM-SAF, NCDC and others.

- Generate 10 km resolution AVHRR reflectance data base via PATMOS-x for distributing calibrated 0.63 and 0.86 μm reflectances to the community. Image below is an example of this data.



False Color Image
Red=0.63μm, Green = 0.86μm, Blue = 11μm (reversed)

Resources

- Number of personnel employed for project
  - One FTE (split among two persons).
- Key equipment or observatories used
  - AVHRR archive at CIMSS (a copy of CLASS archive)
  - CIMSS workstation coupled with 16 Tb of storage.
- Key collaborating projects or personnel
  - CEOS calibration working group chaired by Changyong Cao of NOAA/NESDIS
  - Fred Wu's AVHRR calibration activities.

Resources

- NOAA points-of-contact or collaborators, as applicable
  - Fred Wu, NESDIS/STAR
  - Ken Knapp, NESDIS/NCDC
  - Tom Zhao, NESDIS/NCDC
  - PATMOS-x collaborators (Laszlo, Pavolonis …)
- Target NOAA Data Center
  - CLASS should be eventual home of recalibrated AVHRR data via the PATMOS-x data set.

Additional Material

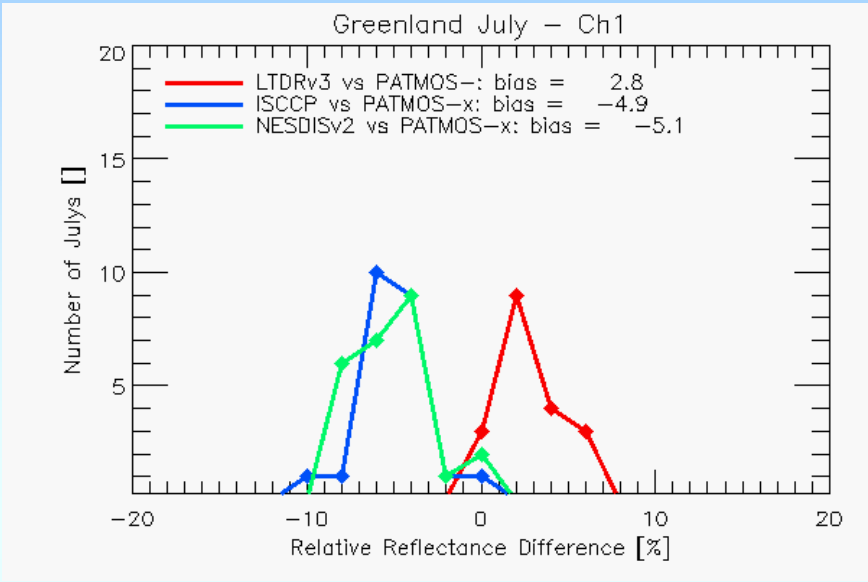
Current State of Consensus

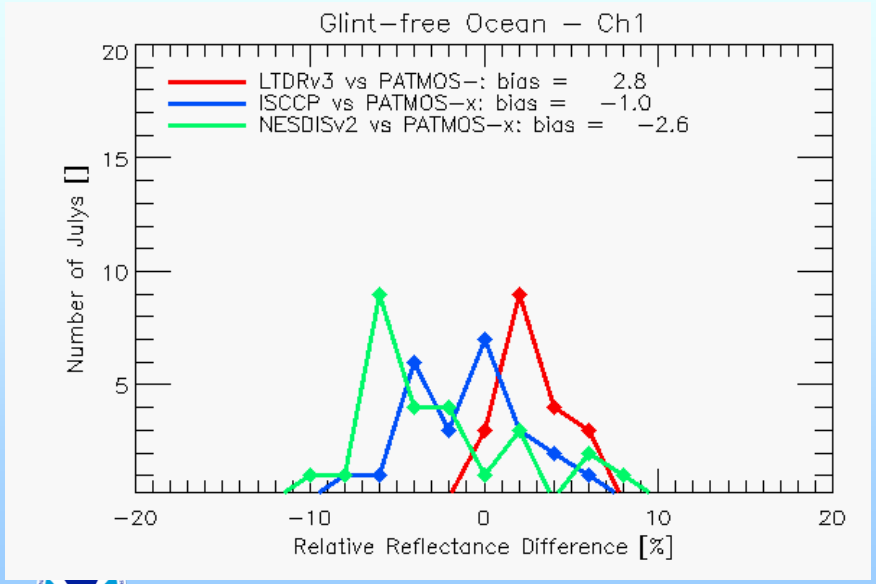
Comparison of Ch 1 for PATMOS-x, LTDR, NESDISv2 and ISCCP for 1981-2007

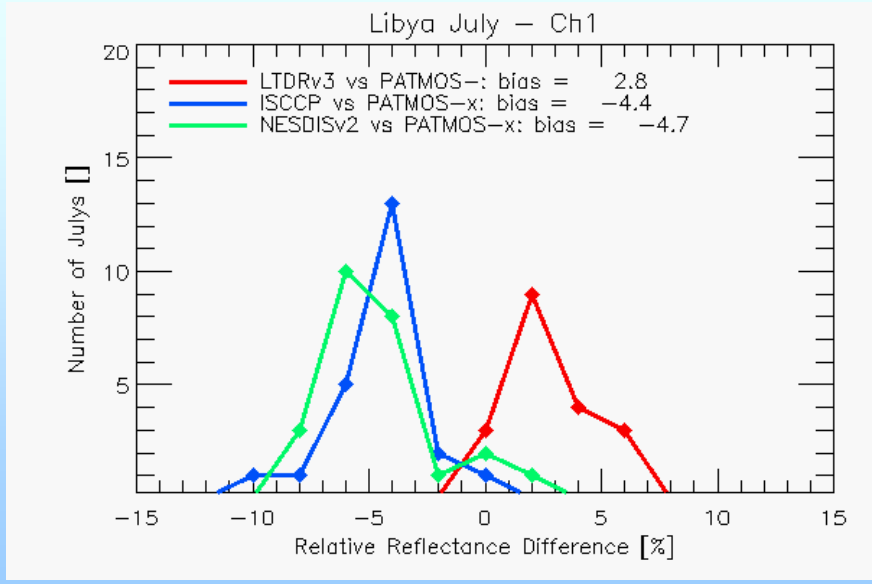
Relative Reflectance Difference = 100%*(Y-X)/X

where:

X = PATMOS-x
Y = LTDR or ISCCP or NESDISv2







Current State of Consensus

Comparison of Ch 2 for PATMOS-x, LTDR and NESDISv2 for 1981-2007

Relative Reflectance Difference = 100%*(Y-X)/X

where:

X = PATMOS-x
Y = LTDR or ISCCP or NESDISv2