National Environmental Satellite, Data, and Information Service

# Global Space-based Inter-Calibration System (GSICS)

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# What is GSICS?

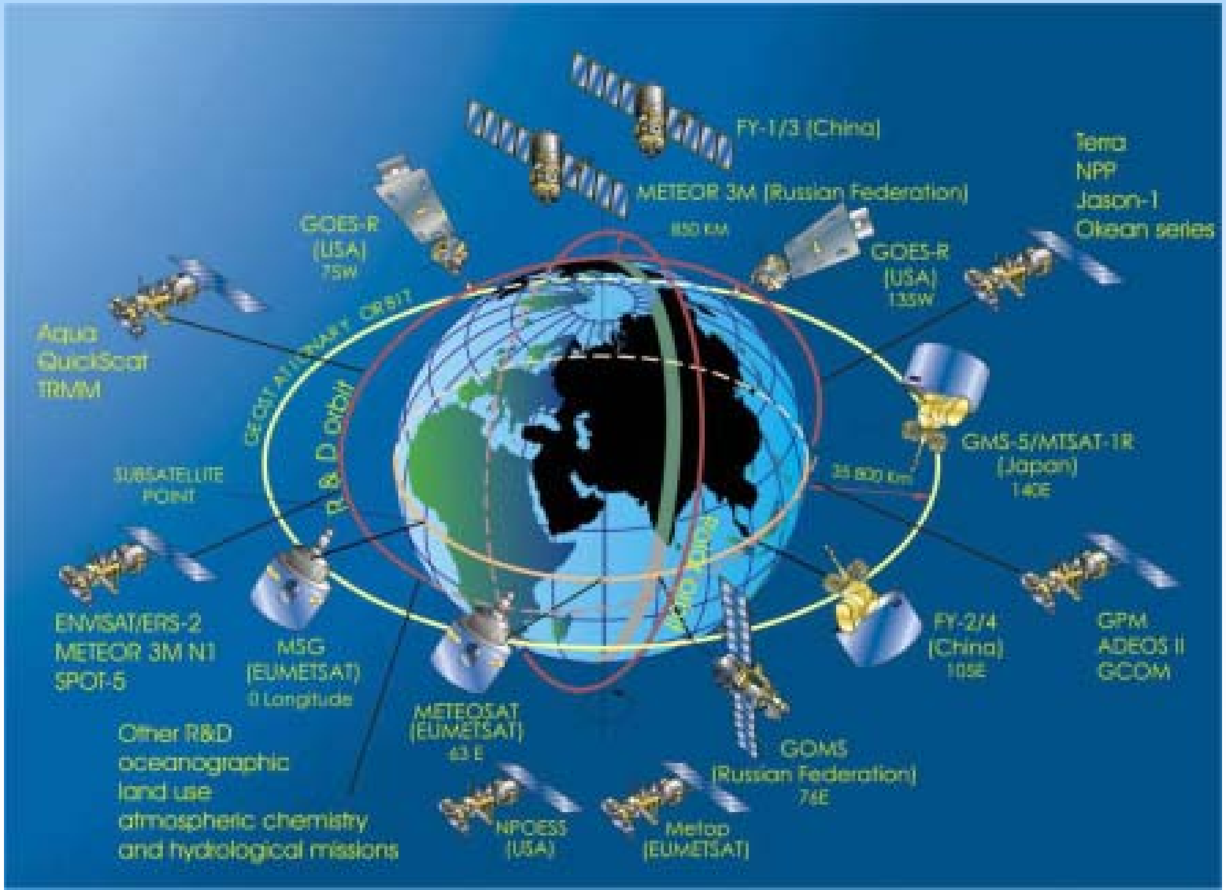
- Global Space-based Inter-Calibration System (GSICS)
- WMO sponsored
- Goal - Enhance calibration and validation of satellite observations and to intercalibrate critical components global observing system

# Motivation

- Applications are becoming more demanding
- Demanding applications require accurate, well calibrated & characterized measurements
- Reduce measurement uncertainty
- Growing global observing system

# GEOSS

- GEOSS – international coordinated effort to share Earth observations to provide a level of information about the Earth not previously achieved.



# Nine Societal Benefits

- Improve Weather Forecasting
- Reduce Loss of Life and Property from Disasters
- Protect and Monitor Our Ocean Resource
- Understand, Assess, Predict, Mitigate and Adapt to Climate Variability and Change
- Support Sustainable Agriculture and Forestry and Combat Land Degradation
- Understand the Effect of Environmental Factors on Human Health and Well-Being
- Develop the Capacity to Make Ecological Forecasts
- Protect and Monitor Water Resources
- Monitor and Manage Energy Resources

# Science Requirements for GEOSS to meet the 9 societal benefits:

- Satellite Intercalibration & Sensor characterization
- Data Fusion & Integrated Products, including CDRs
- Data Assimilation & Modeling

# GSICS formulation

- The GCOS Climate Monitoring Principles (GCMPs) were extended to address the problems associated with developing long-term climate data records from satellite observations
  - Stable orbits
  - Continuity and adequate overlap of satellite observations
  - **Improved calibration and validation**

- CGMS tasked the WMO Space Programme to build an international consensus and consortium for a global space-based inter-calibration system for the World Weather Watch (WWW)/Global Observing System (GOS).

# GSICS Chronology

- GSICS Conceptual Paper approved at CGMS 23  (11/05)
- GSICS Executive Panel (10/06)
- GSICS Implementation Plan and Program formally endorsed at CGMS 24  (11/06)
- CEOS in their response to the GCOS Implementation Plan endorses GSICS (11/06)
- First GRWG  (1/07)

# GSICS Formulation Team

- Mitch Goldberg – NOAA/NESDIS (Chair)
- Raju Datla - NIST
- Gerald Frazer – NIST
- Donald Hinsman – WMO (Space Program Director)
- Jérôme Lafeuille - WMO
- Xu Jianmin (CMA)
- Toshiyuki Kurino (JMA)
- John LeMarshall - JC Sat. Data Assimilation
- Paul Menzel –NOAA/NESDIS
- Tillmann Mohr – WMO
- George Ohring (NESDIS, consultant)
- Hank Revercomb – Univ. of Wisconsin
- Johannes Schmetz – Eumetsat
- Jörg Schulz – DWD, CM SAF
- William Smith – Hampton University
- Steve Ungar – CEOS, Chairman WG Cal/Val

# GSICS Objectives

- To improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of satellite sensors.
- To provide for the ability to re-calibrate archived satellite data using the GSICS intercalibration system to enable the creation of stable long-term climate data sets
- To ensure instruments meet specification, pre-launch tests are traceable to SI standards
- On-orbit satellite instrument observations are well calibrated by means of careful analysis of instrument performance, satellite intercalibration, and validation with reference sites

# Why intercalibration?

- To integrate observations and products from different satellite systems, the measurements must be inter-calibrated.
- Needed for Multisensor Climate Data Records
- NWP  requires very accurate and well characterized measurements for direct radiance assimilation
- Blending environmental products requires minimizing systematic biases from different sensors

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# Building Blocks for Satellite Intercalibration

- Collocation
  - Determination and distribution of locations for simultaneous observations by different sensors (space-based and in-situ)
  - Collocation with benchmark measurements
- Data collection
  - Archive, metadata - easily accessible
- Coordinated operational data analyses
  - Processing centers for assembling collocated data
  - Expert teams
- Assessments
  - communication including recommendations
  - Vicarious coefficient updates for “drifting” sensors

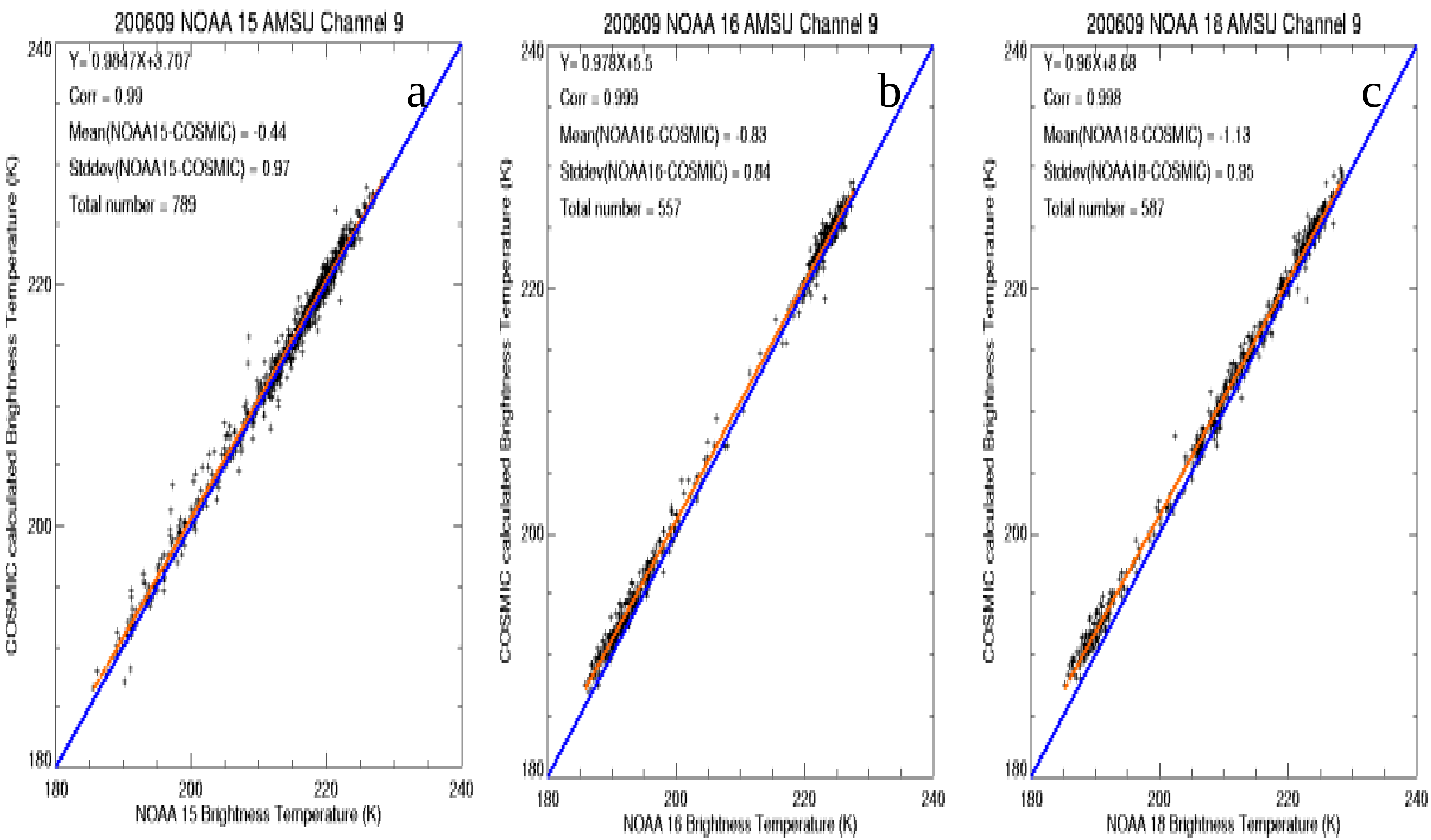
# Other key building blocks for accurate measurements and intercalibration

- Extensive pre-launch characterization of all instruments traceable to SI standards

- Benchmark instruments in space with appropriate accuracy, spectral coverage and resolution to act as a standard for inter-calibration

- Independent observations (calibration/validation sites – ground based, aircraft)

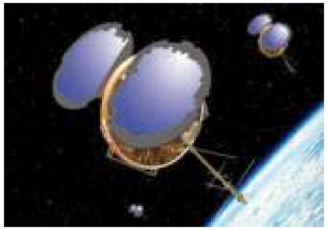
# Can we use GPS RO data to calibrate other instruments ?



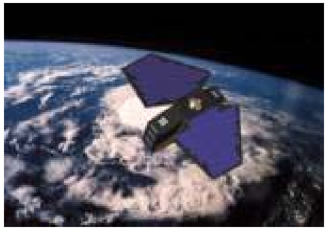

N15, N16 and N18 AMSU calibration against COSMIC



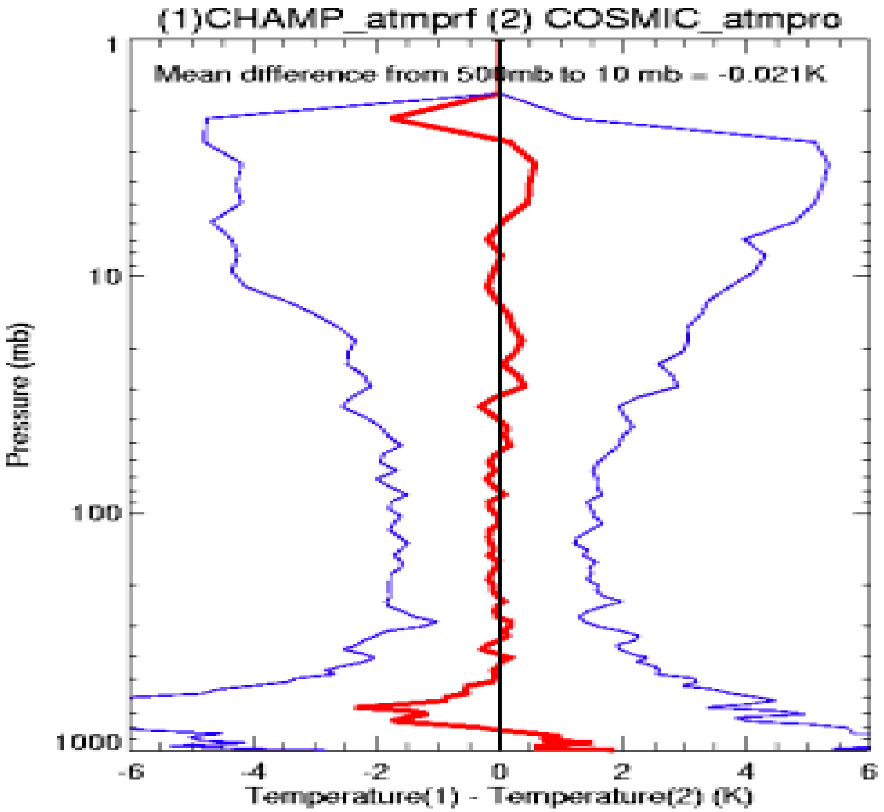
*Shu-peng Ben Ho, UCAR/COSMIC*

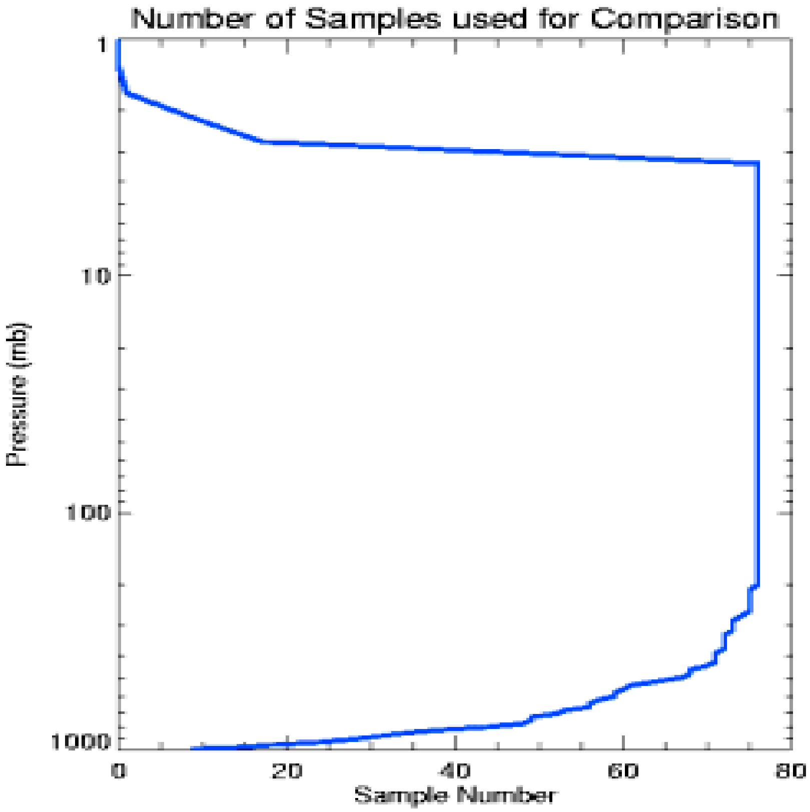


# Difficulty II: to find measurements with long term stability



## Mean bias CHAMP-COSMIC temp from 500mb to 5 mb =-0.021K



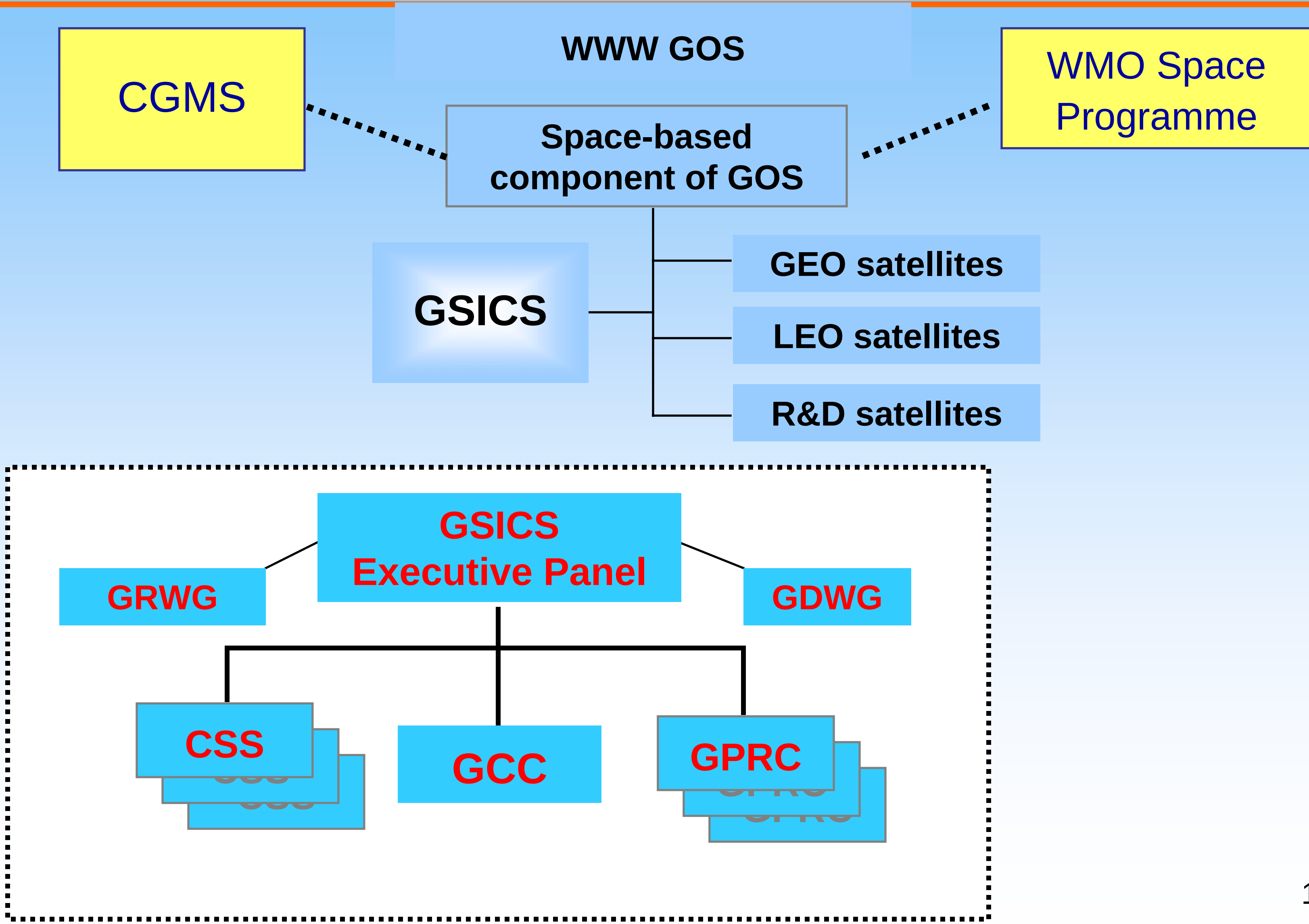




**COSMIC (launched in 2006) vs. CHAMP (launched in 2000) atm tmp**



*Shu-peng Ben Ho, UCAR/COSMIC*

# GSICS organization



# GSICS Components

- GSICS Executive Panel – reps from each satellite agency
  - Priorities, objectives and agreements
- GSICS Coordination Center (GCC) - NESDIS
  - Transmit intercalibration opportunities to GPRCs
  - Collect data from the GPRCs and provide access
  - Quarterly reports on performance
- GSICS Processing and Research Centers (GPRCs)
  - Satellite agencies
  - Activities:
    - Pre-launch calibration
    - Intersatellite calibration
    - Supporting research

# *Calibration Support Segments (CSS)*

- The GSICS Calibration Support Segments (CSS) will be carried out by participating satellite agencies, national standards laboratories, major NWP centers, and national research laboratories. CSS activities are:
- **Earth-based reference sites,** such as stable desert areas, long-term specially equipped ground sites, and special field campaigns, will be used to monitor satellite instrument performance.
- **Extra-terrestrial calibration sources,** such as the sun, the moon, and the stars, will provide stable calibration targets for on-orbit monitoring of instrument calibration
- **Model simulations** will allow comparisons of radiances computed from NWP analyses of atmospheric conditions with those observed by satellite instruments
- **Benchmark measurements** of the highest accuracy by special satellite and ground-based instruments will help nail down satellite instrument calibrations

# Nominated GSICS participants

| Current representatives Organization | Executive Panel | GRWG | GDWG |
|---|---|---|---|
| **CMA** | Naimeng LU | Peng ZHANG | Thiguo RONG |
| **EUMETSAT** | Johannes SCHMETZ | Leo VAN DE BERG<br>Marianne KOENIG | Volker GAERTNER (Chair) |
| **JMA** | Toshiyuki KURINO | Takanori MATSUMOTO | Yoshihiko TAHARA |
| **NOAA** | Mitch GOLDBERG | Fuzhong WENG<br>Changyong CAO<br>Jeff PRIVETTE<br>Fred Wu (chair) | Bruce BARKSTROM<br>Aleksander JELENAK |
| **KMA** | | Professor Sohn | |
| **CNES** | Renault Didier | Patric Henry | |

# First GSICS Exec. Panel Meeting

- Held in WMO headquarter, in Geneva, Switzerland on 11-13 October 2006.
- Representatives from NOAA, EUMETSAT, JMA, CNES and WMO
- Each agency reported on their meteorological satellite programme, cal/val activities and GSICS related priorities and contributions
- Developed Terms of Reference

# 2007 Activities

- Annual Operating Plan
- Two GRWG meetings
- GDWG to discuss data management issue
- Commission  GSICS Website and routine LEO to LEO intersatellite calibration, with performance reports at NESDIS
- Intercomparisons of AIRS and IASI

# 2008 Activities

- Commission intercalibration of MTSAT, MSG and GOES with IASI and AIRS.
  - Routine intercomparisons between MSG (SEVIRI) and AIRS/IASI at EUMETSAT
  - Routine intercomparisons between GOES and AIRS/IASI at NESDIS
  - Routine intercomparisons between MTSAT and AIRS/IASI at JMA

# GRWG-1

- GRWG 1 shall focus on infrared measurements and address in priority:
  - Review methodologies currently applied for Geo to Leo collocations
  - Define an agreed GEO to LEO collocation methodology for IR sensors
    - collocation criteria (viewing angle, time window)
    - sampling strategy (target size and numbers, geographical coverage, target selection bright/dark clear/cloudy, temporal frequency )
    - matching technique to account for different fields of views and spectral response
    - statistical processing (bias, or regression, spectral shift, quality index)
  - Methodology for spectral convolution (comparison of IR band radiances with hyperspectral measurements)

- Expected output is:
  - Agreed initial GEO-LEO methodology,
  - Identification of software tools to be exchanged
  - Definition of a methodology to compare GEO IR radiances with AIRS and IASI radiances

# GRWG-2

- To be convened in June 2007, place TBD
- Main focus on calibration of reflective channels, noting that the co-location criteria won’t be the same as for IR because of directional effects, aerosols, atmospheric backscattering, and hot spots.
- Expected output :
  - Methodology for GEO-MODIS comparison for visible channels
  - Radiative transfer requirements for simulations from reference sites

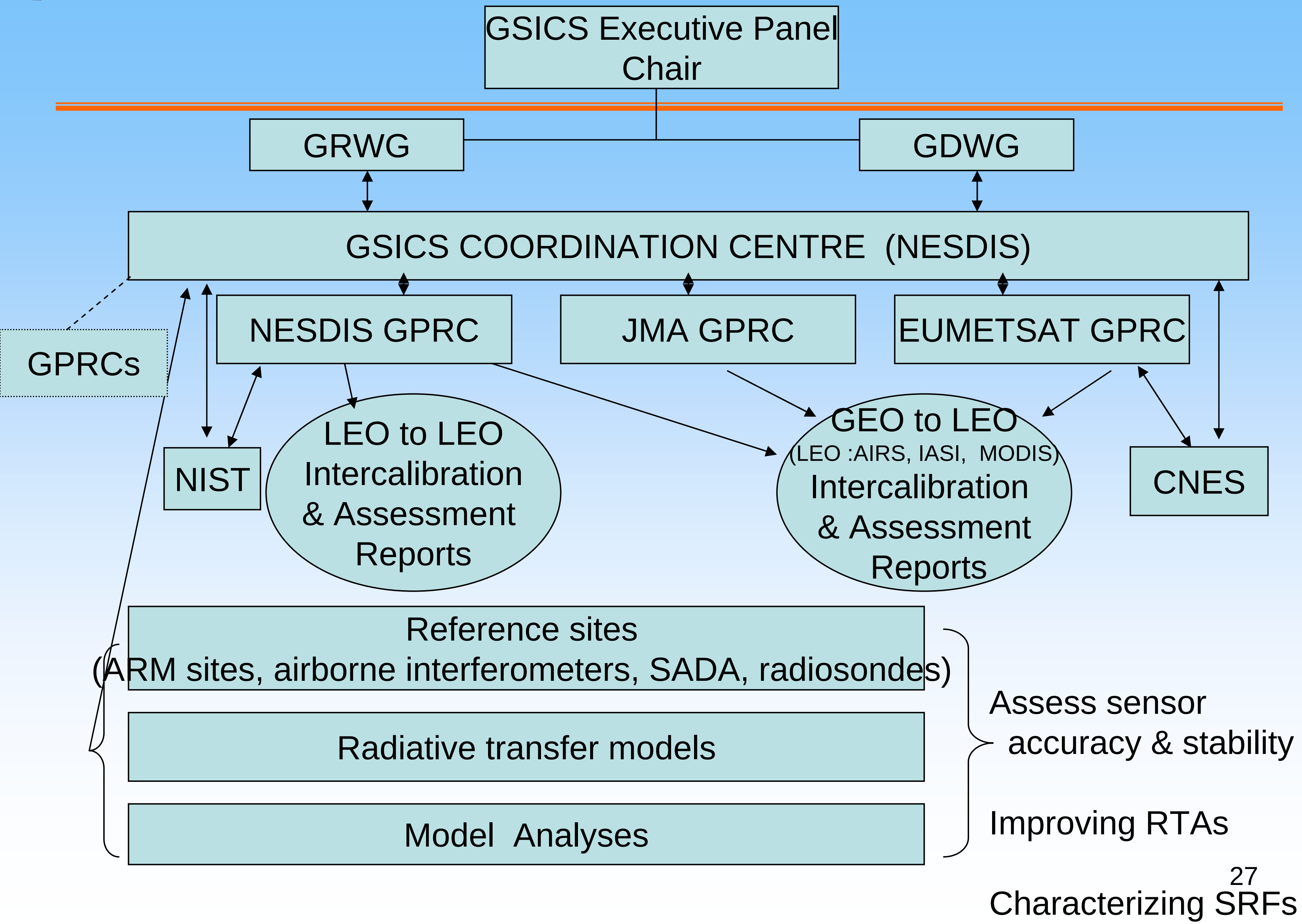
# GDWG-1

- To be convened in June 2007?, (co-located with GRWG)
- Expected output:
  - Definition of best practices for data management
  - Definition of formats and operational procedures for data exchange

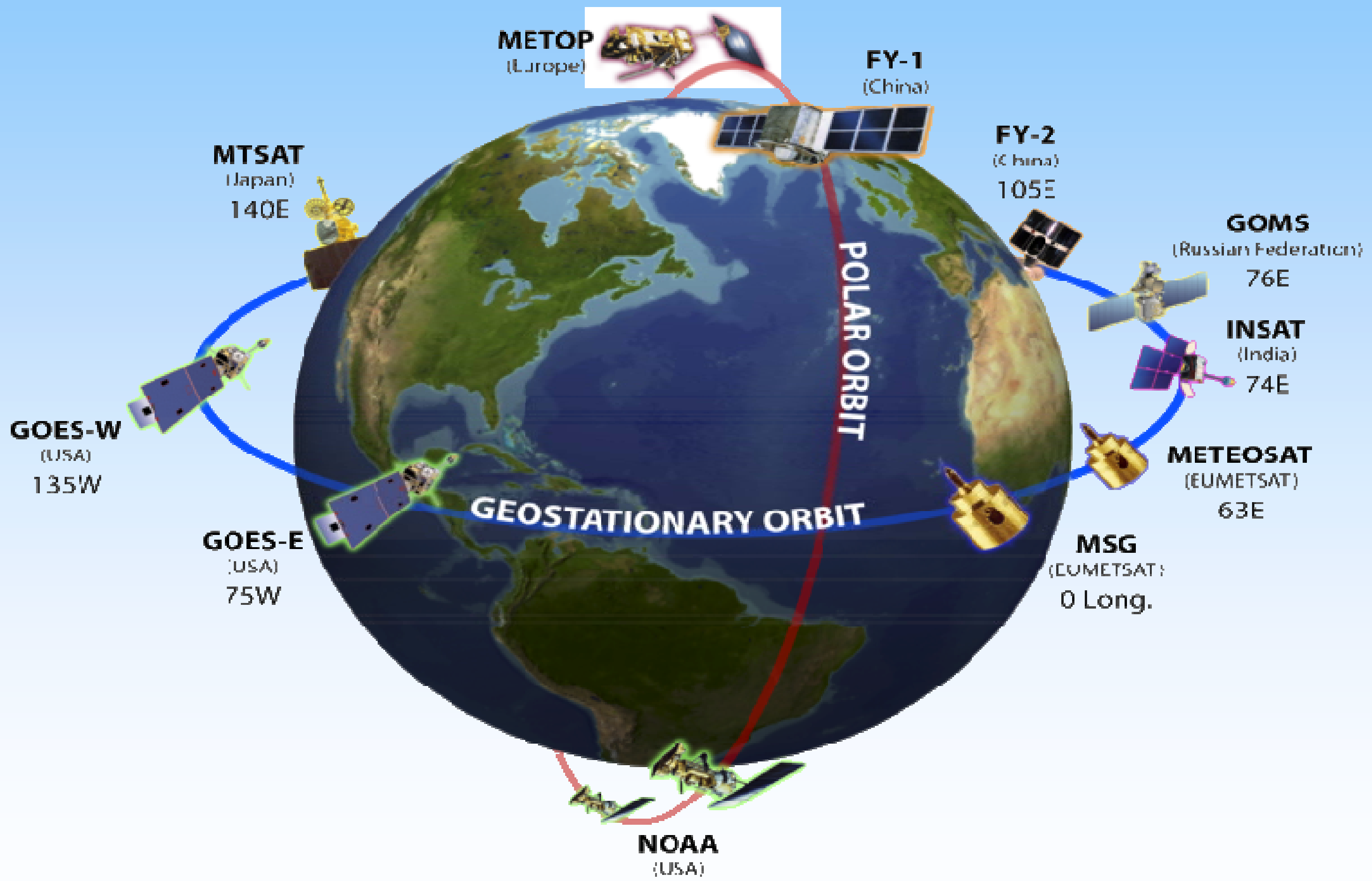
# GSICS Outcome

- Coordinated international intersatellite calibration program
- Exchange of critical datasets for cal/val
- Best practices/requirements for monitoring observing system performance (with CEOS WGCV)
- Best practices/requirements for prelaunch characterisation (with CEOS WGCV)
- Establish requirements for cal/val (with CEOS WGCV)
- Advocate for benchmark systems
- Quarterly reports of observing system performance and recommended solutions
- Improved sensor characterisation
- High quality radiances for NWP & CDRs

**From Exec Meeting Oct 06**

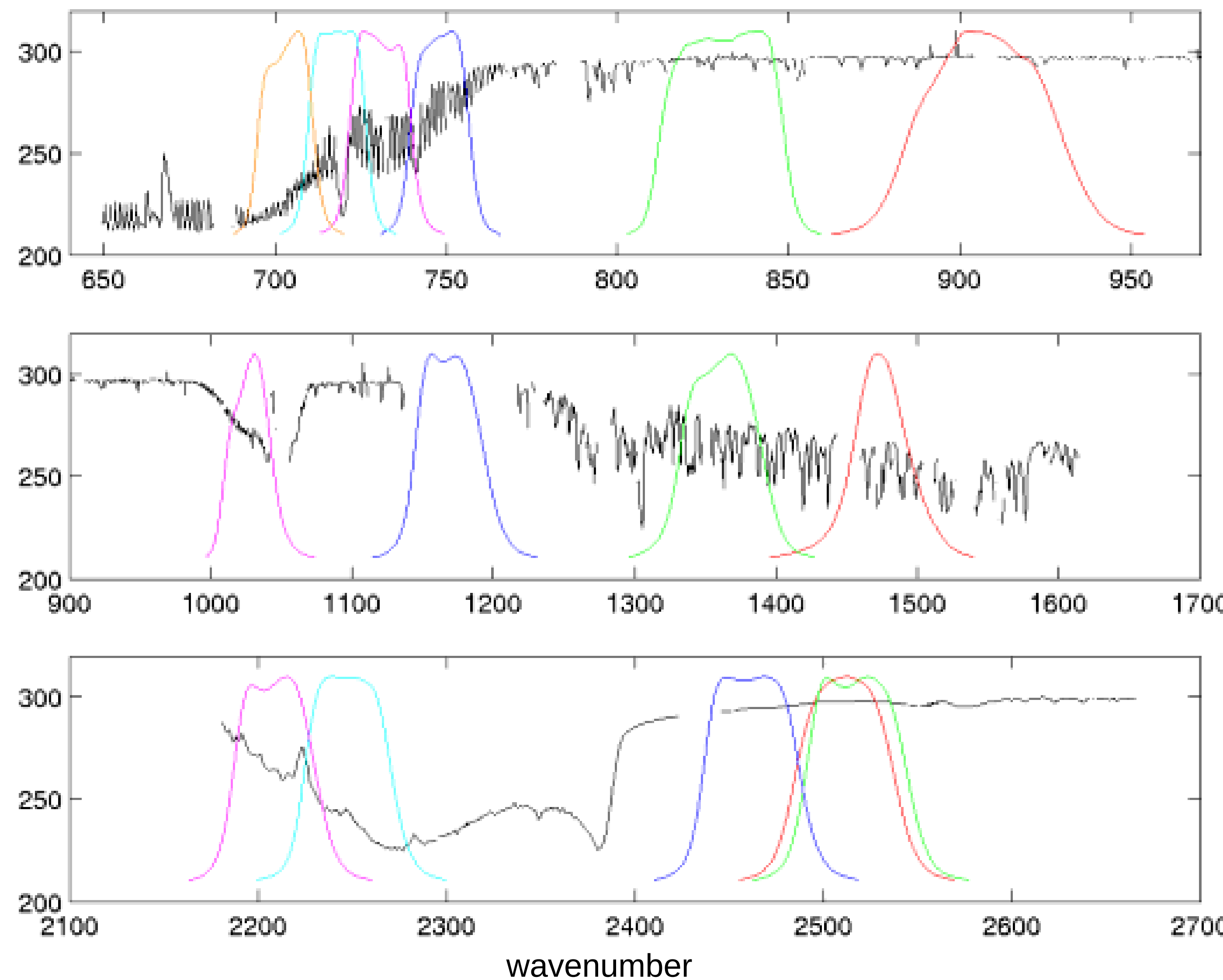


# Space-based Observing Systems
# Operational Environmental Satellites



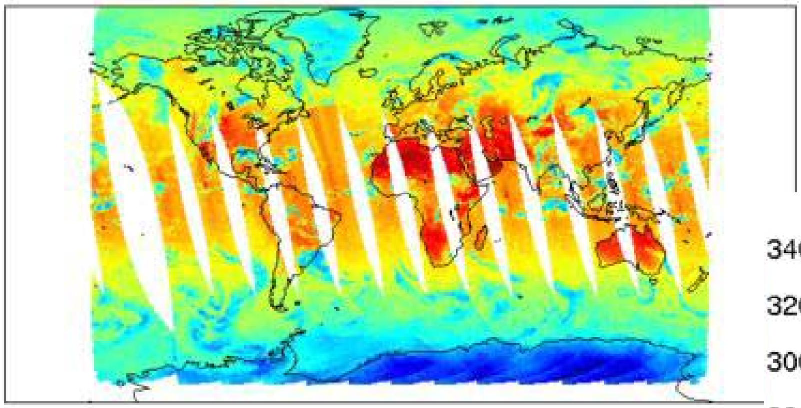
# Backup

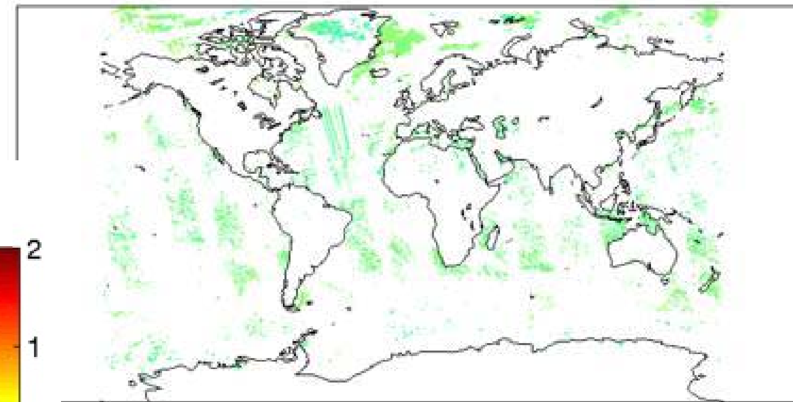
# AIRS spectrum and Aqua MODIS Band Spectral Response Functions

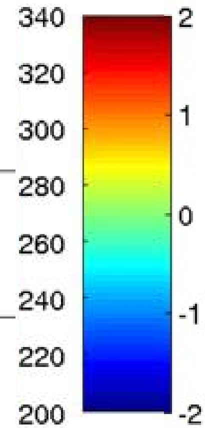



| MODIS Band | / | wavelength(μm) |
|---|---|---|
| 36 | / | 14.2 |
| 35 | / | 13.9 |
| 34 | / | 13.7 |
| 33 | / | 13.4 |
| 32 | / | 12.0 |
| 31 | / | 11.0 |
| 30 | / | 11.0 |
| 29 | / | 9.7 |
| 28 | / | 7.3 |
| 27 | / | 6.8 |
| 25 | / | 4.5 |
| 24 | / | 4.4 |
| 23 | / | 4.1 |
| 22 | / | 4.0 |
| 21 | / | 4.0 |

# Fantastic AIRS - MODIS Agreement for Band 22 (4.0$\mu$m)!

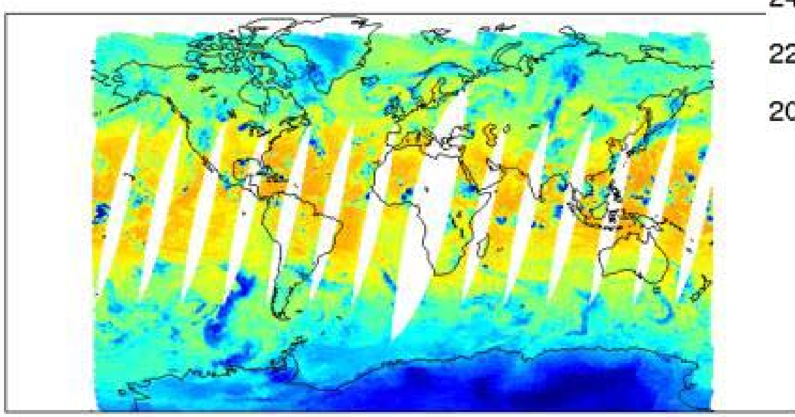


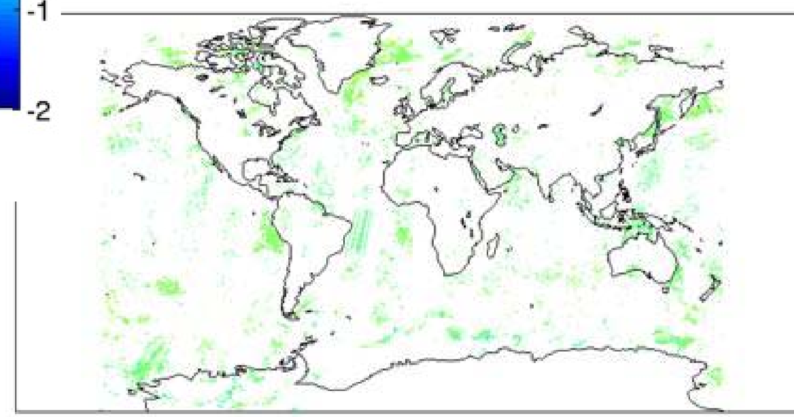


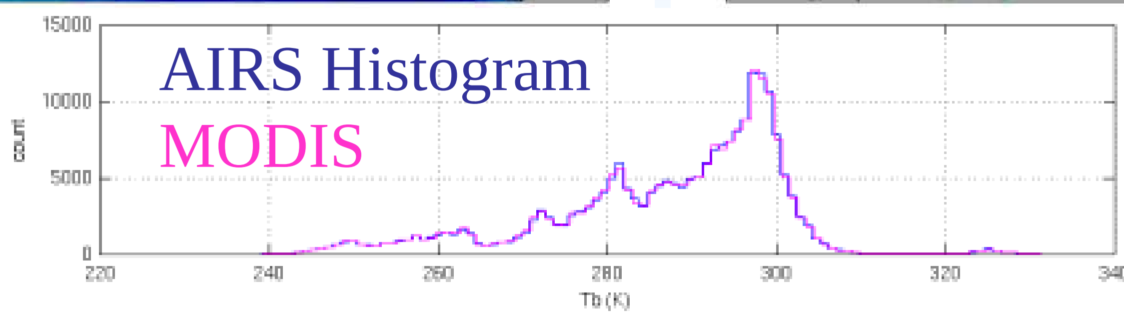



AIRS Tb (K)

AIRS minus MODIS (K)

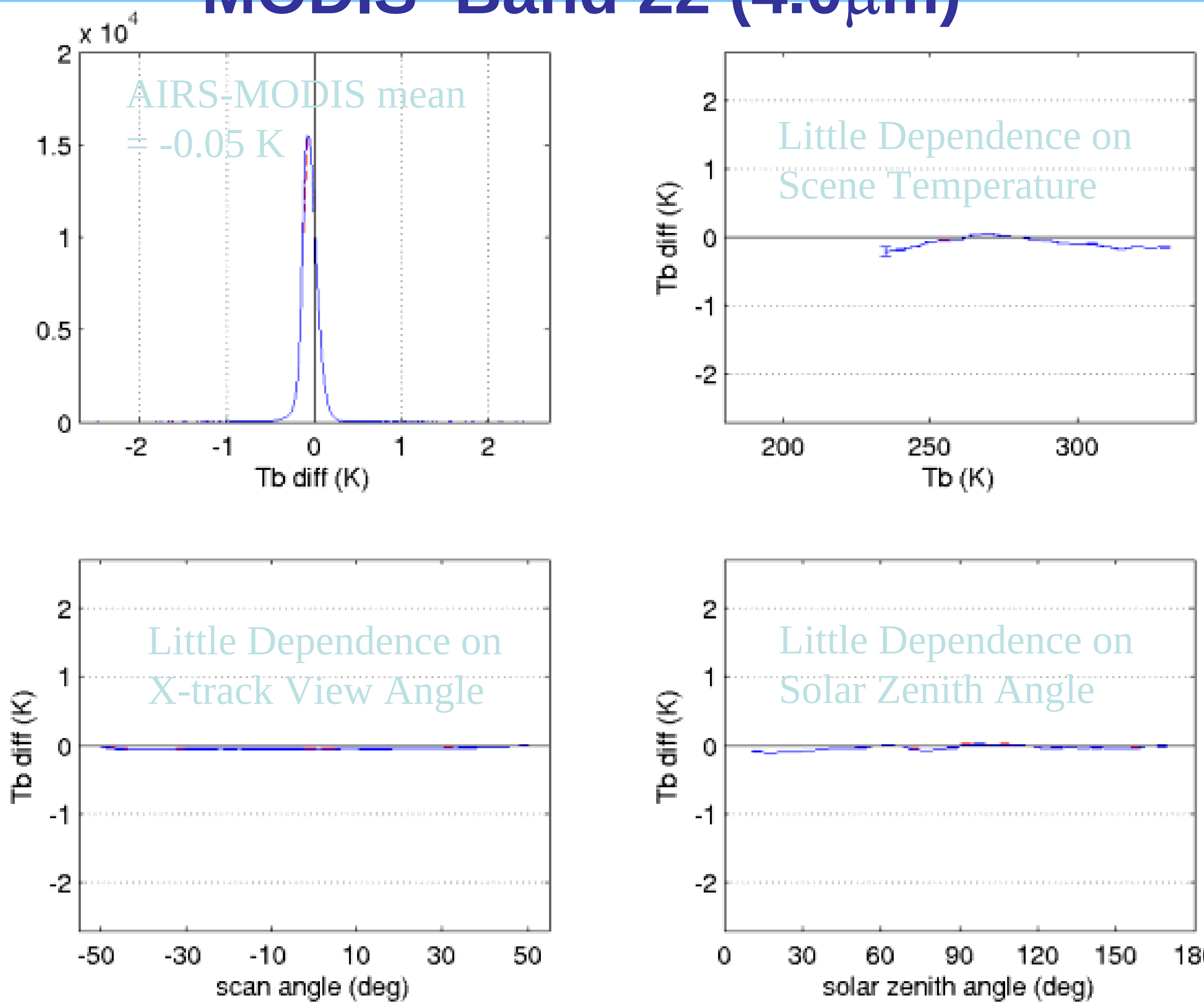







Uniform Scenes Selected

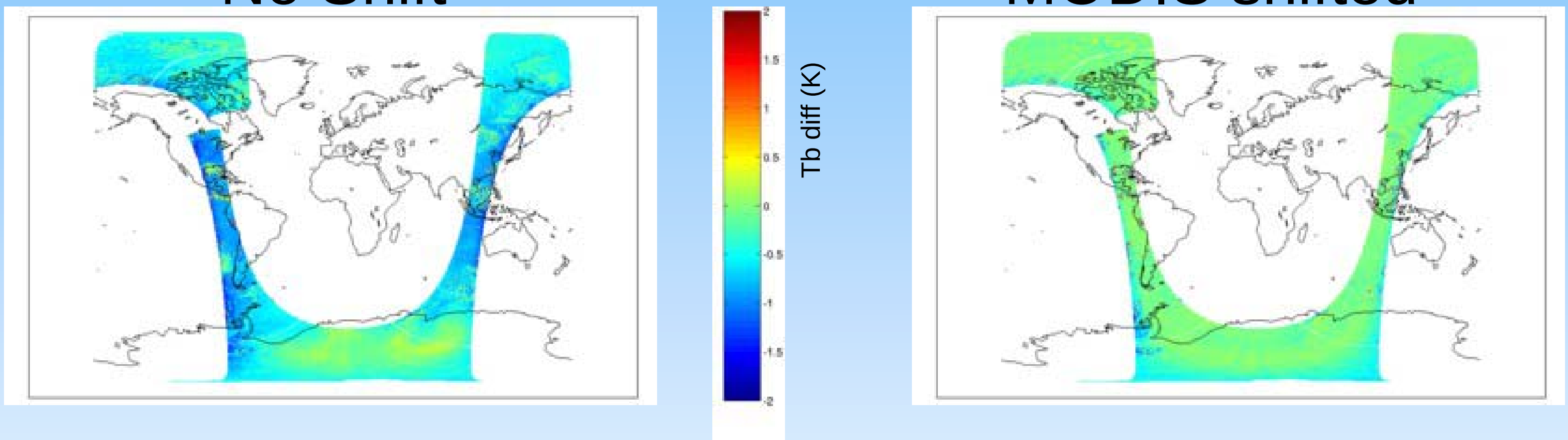
# MODIS Band 22 (4.0μm)



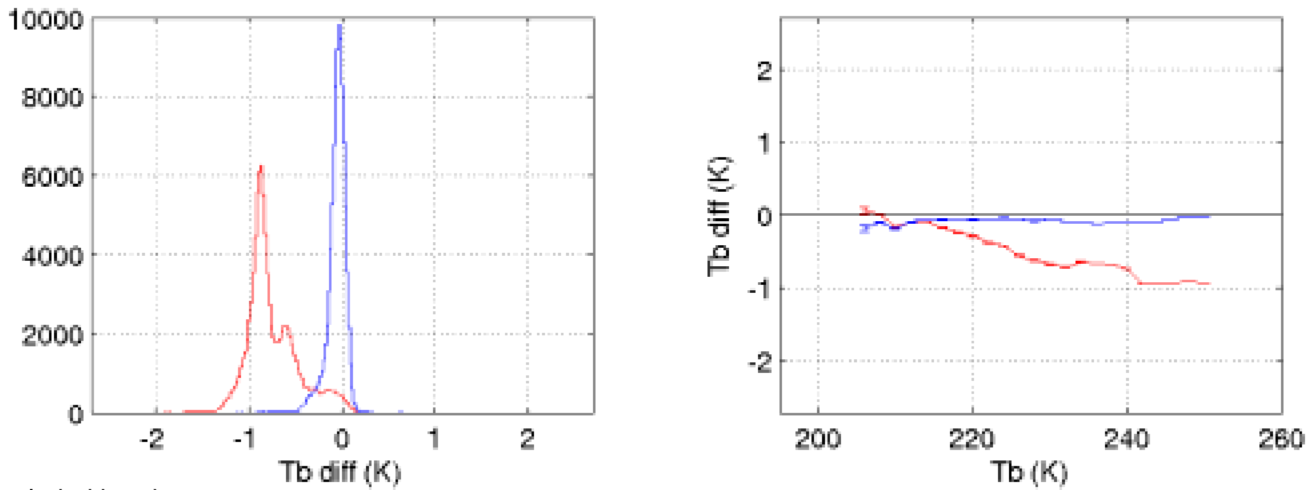
# Shifting MODIS Band 35 (13.9 μm) by 0.8 $cm^{-1}$ Works

## to Remove Mean bias and Scene Tb Dependence

No Shift | MODIS shifted



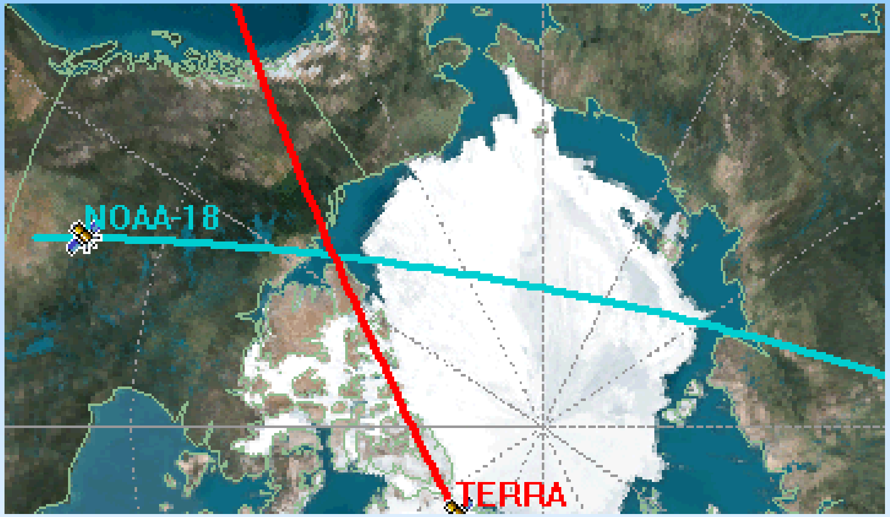

AIRS-MODIS: un-shifted, shifted




(ce (0.21K) not included here)

# Simultaneous Nadir Overpass (SNO) Method
## -a core component in the Integrated Cal/Val System

*POES intercalibration*




• Useful for remote sensing scientists, climatologists, as well as calibration and instrument scientists

•Support new initiatives (GEOSS and GSICS)

• Significant progress are expected in GOES/POES intercal in the near future

•Unique capabilities developed at NESDIS

•Has been applied to microwave, vis/nir, and infrared radiometers for on-orbit performance trending and climate calibration support

•Capabilities of 0.1 K for sounders and 1% for vis/nir have been demonstrated in pilot studies

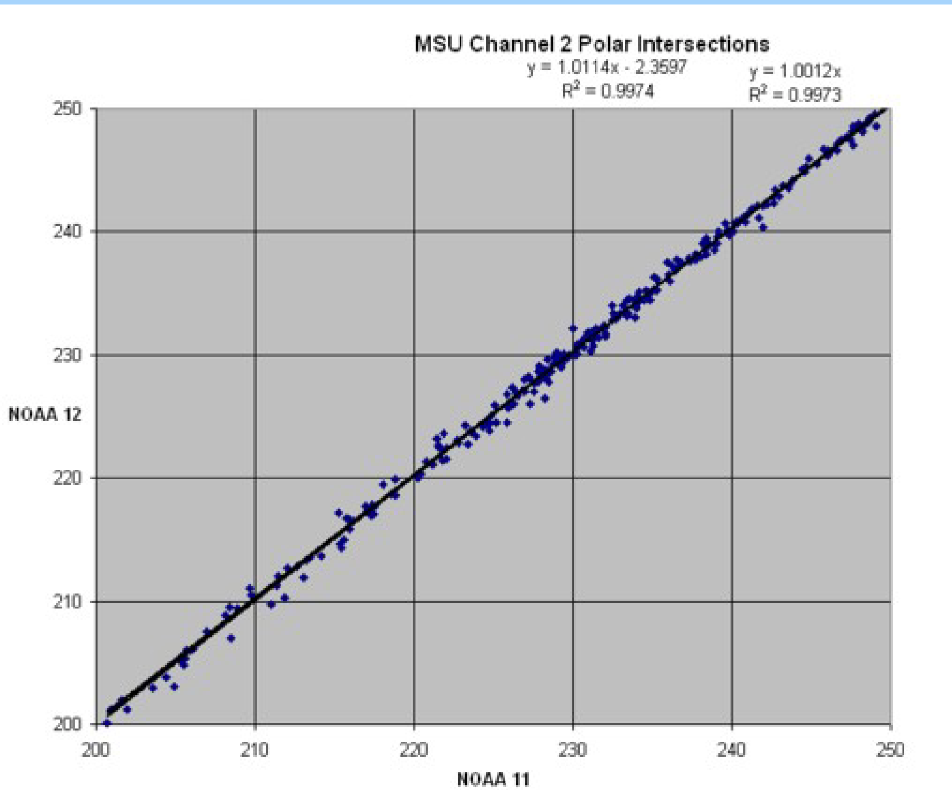
•Method has been adopted by other agencies

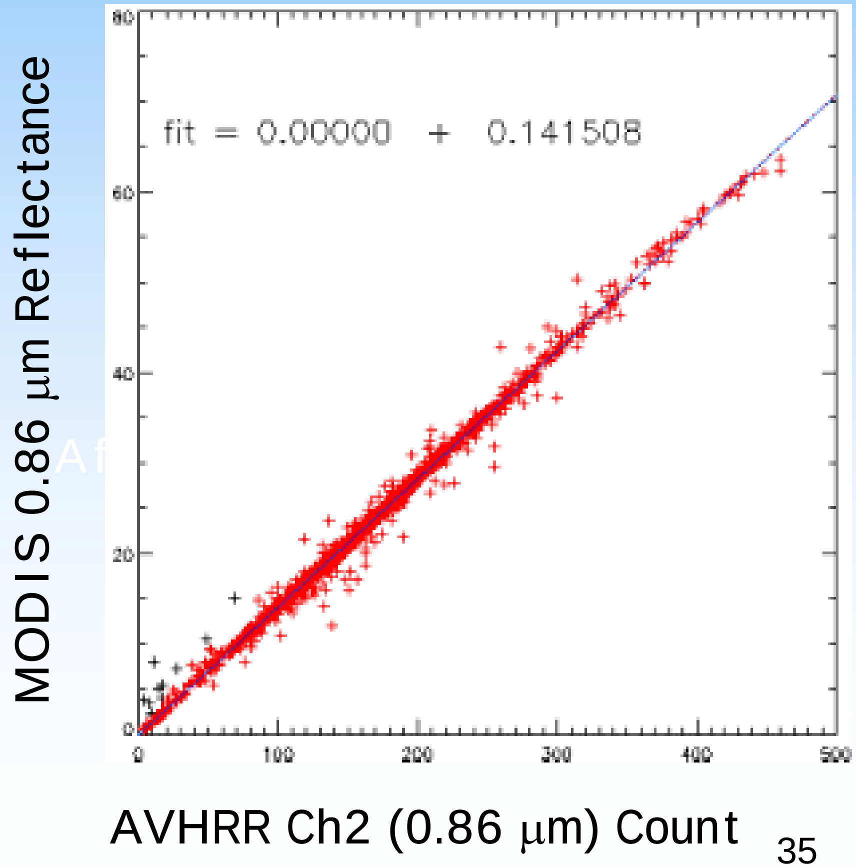
GOES vs. POES

# SNO Applications

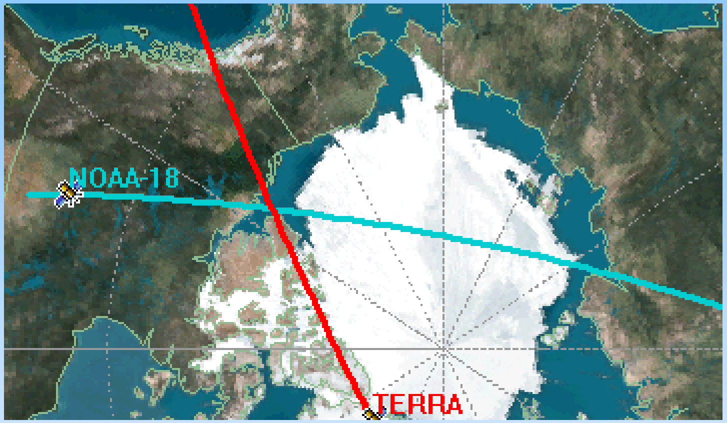
*NOAA-12 vs NOAA-11 MSU Channel 2*

*Example of one month of SNO's between TERRA/MODIS and NOAA-17 AVHRR*

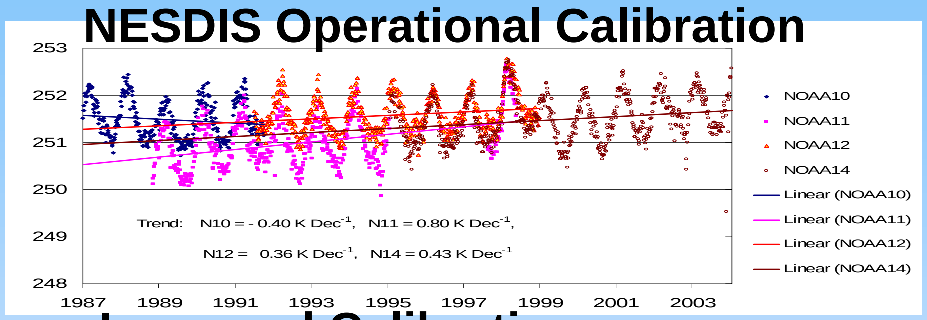


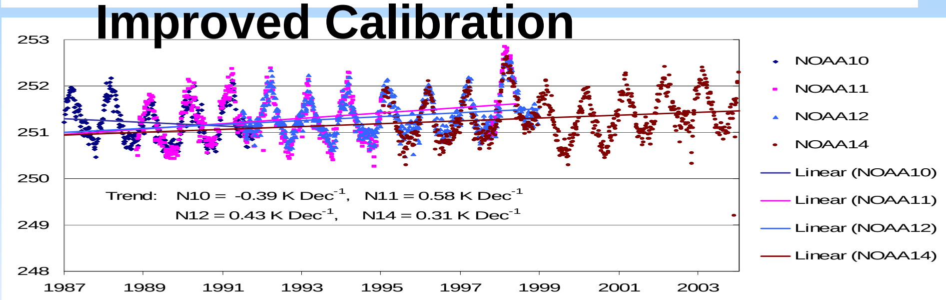



# Satellite Intercalibration improves MSU time series

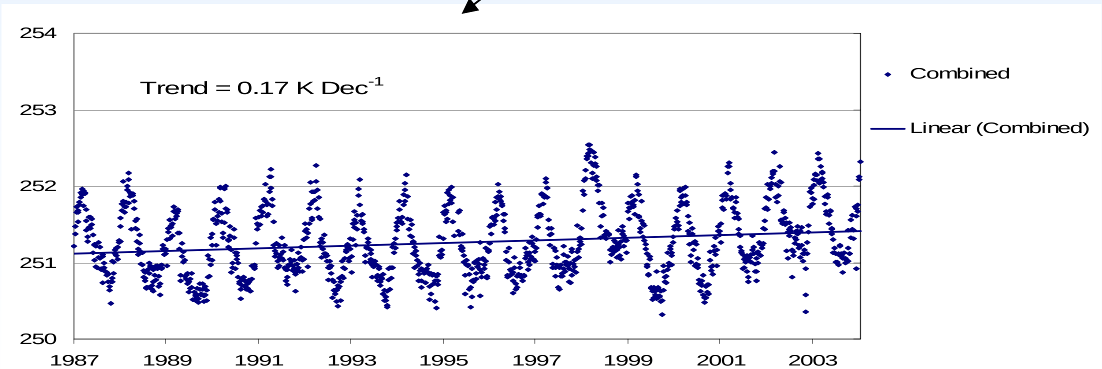



Simultaneous Nadir Overpass (SNO)




Improved calibrated radiances using SNO- improved differences between sensors by order of magnitude.




**Trends for nonlinear calibration algorithm using SNO cross calibration**

**0.20 K Decade$^{-1}$**