2019 International Workshop on Radiative Transfer Models for Satellite Data Assimilation

WMO GSICS Requirements on Radiative Transfer

Mitch Goldberg, NOAA

Chief Scientist for Low Earth Orbiting Satellites

GSICS EP Chair

Global Space-based Inter-Calibration System

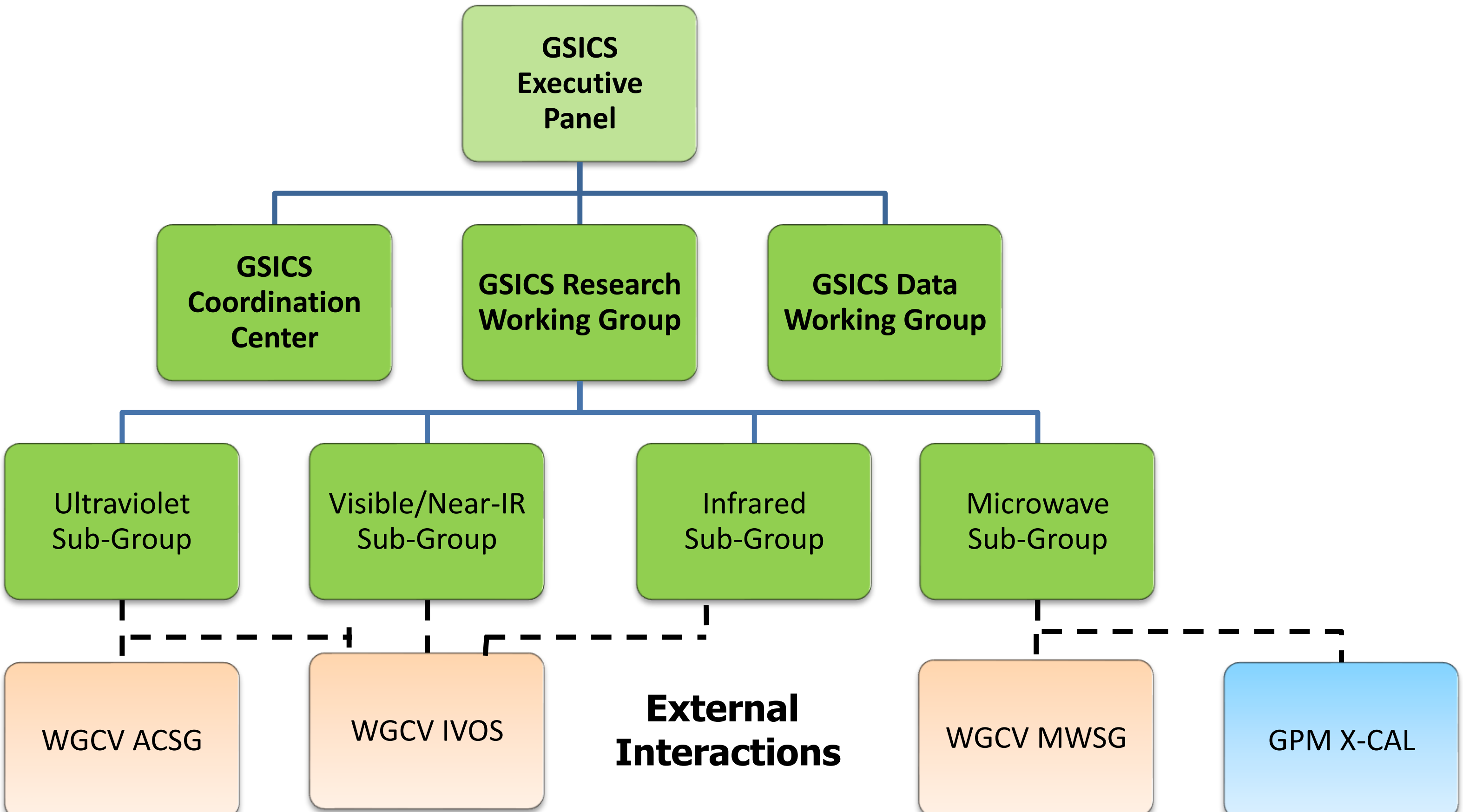
- **What is GSICS?**
  - Global Space-based Inter-Calibration System
  - Initiative of CGMS and WMO
  - Effort to produce consistent, well-calibrated data from the international constellation of Earth Observing satellites
- **What are the basic strategies of GSICS?**
  - Improve on-orbit calibration by developing an integrated inter-comparison system
    - Initially for GEO-LEO Inter-satellite calibration
    - Being extended to LEO-LEO
    - Using external references as necessary
  - Best practices for calibration & characterisation
- **This will allow us to:**
  - Improve consistency between instruments
  - Reduce bias in Level 1 and 2 products
  - Provide traceability of measurements
  - Retrospectively re-calibrate archived data
  - Better specify future instruments
  - Develop a cadre of experts in calibration
  - Easy access to the health of observing systems.

GSICS Global Space-based Inter-Calibration System

EUMETSAT CNES JMA
NOAA CMA KMA
ISRO NASA WMO
USGS NIST JAXA
ESA ROSHYDROMET IMD ROSCOSMOS

Global Space-based Inter-Calibration System

GSICS Organization



Do we Care about Satellite Biases in NWP?

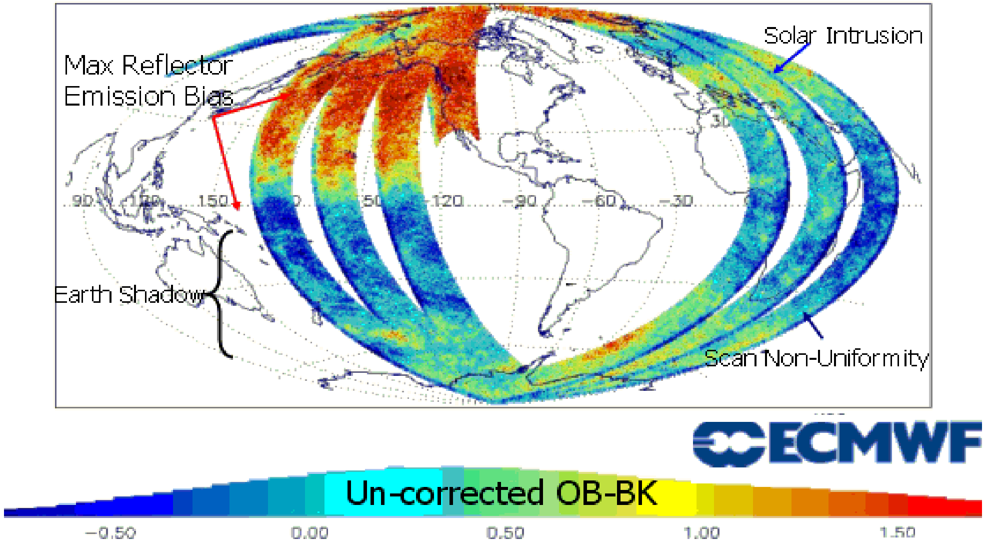
After McNally, Bell, et al. ECMWF, 2005 & 2009

Yes! Because:

1) We wish to understand the origin of the bias and ideally correct instrument / RT / NWP model at source

2) I*n principle* we do not wish to apply a correction to unbiased satellite data if it is the NWP model which is biased. Doing so is likely to:

- **Re-enforce the model bias and degrade the analysis fit to other observations**
- **Produce a biased analysis (bad for re-analysis / climate applications)**



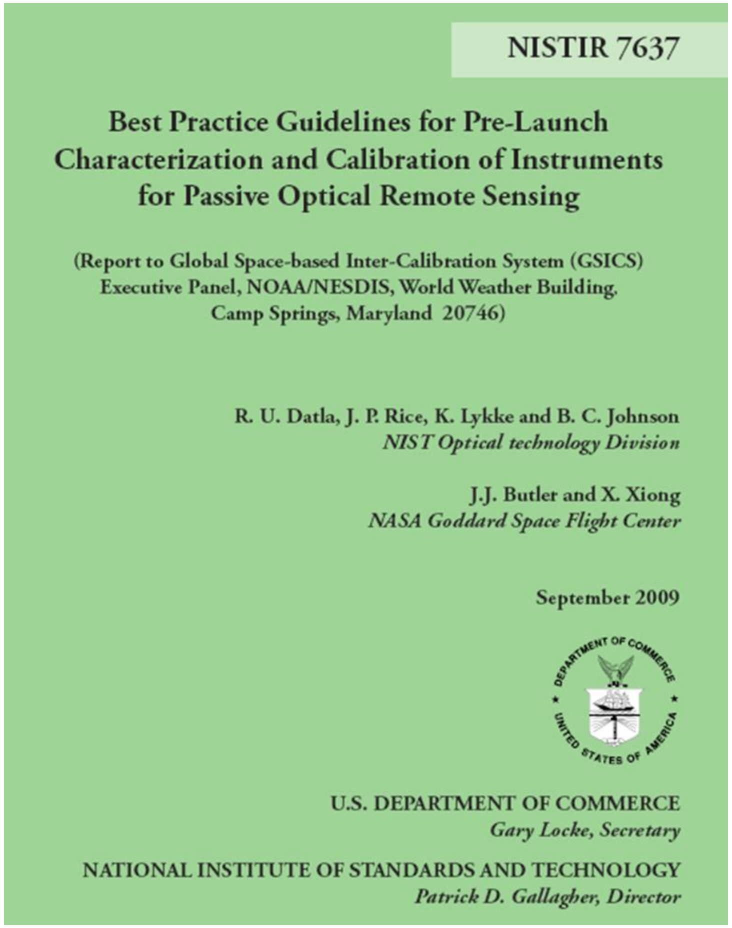
More accurate satellite observations will facilitate discovery of model errors and their correction. Additional gains in forecast accuracy can be expected.

Critical 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**



NISTIR 7637

Best Practice Guidelines for Pre-Launch Characterization and Calibration of Instruments for Passive Optical Remote Sensing

(Report to Global Space-based Inter-Calibration System (GSICS) Executive Panel, NOAA/NESDIS, World Weather Building, Camp Springs, Maryland 20746)

R. U. Datla, J. P. Rice, K. Lykke and B. C. Johnson
NIST Optical technology Division

J.J. Butler and X. Xiong
NASA Goddard Space Flight Center

September 2009

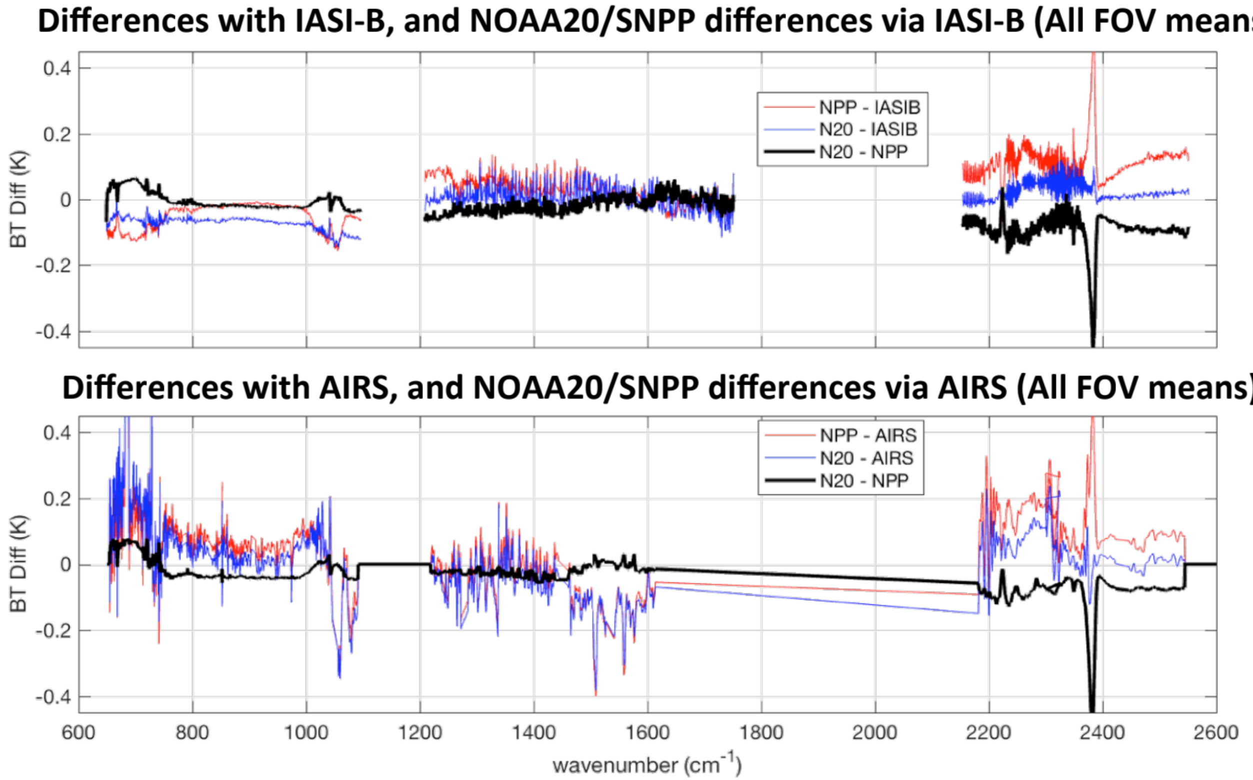
U.S. DEPARTMENT OF COMMERCE
Gary Locke, Secretary

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Patrick D. Gallagher, Director

GSICS Global Space-based Inter-Calibration System

Reference Instruments – IASI and CrIS

Example Cal/Val Result: SNOs with IASI and AIRS



Dave Tobin

- Differences between NOAA20 CrIS and SNPP CrIS are less than 0.1K
- Differences from IASI-B are less than 0.2K, Differences from AIRS are less than 0.4K
- Larger diffs observed for cold SW scenes, but with NOAA20 CrIS agreeing better with IASI and AIRS as compared to SNPP CrIS. Expect some improvements with polarization correction.

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

Calibration Support Segments (CSS)

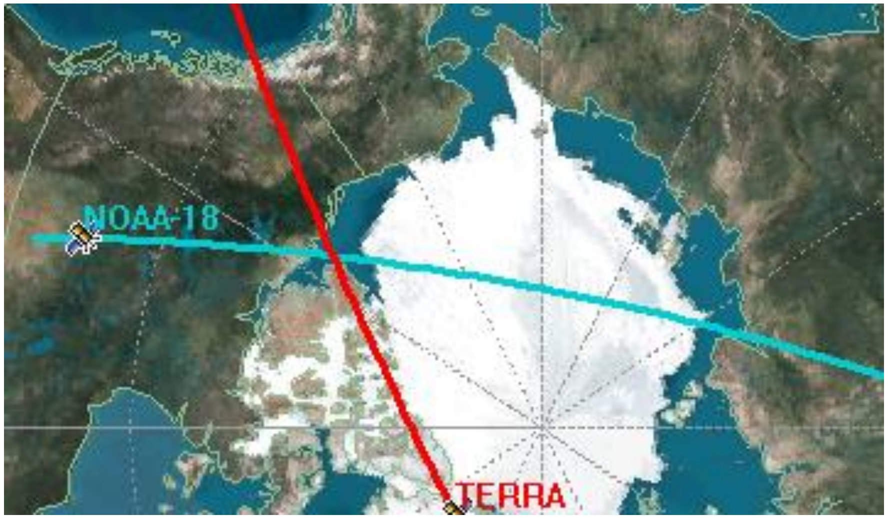
- **The GSICS Calibration Support Segments (CSS) will be carried out by participating satellite agencies, national standards laboratories, major NWP centers, and national research laboratories. CSS activities are:**
- **Prelaunch Characterisation, reference instruments, SI traceability**
- **Earth-based 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, airborne and ground-based instruments will help nail down satellite instrument calibrations**

Four Earth-based reference sites in China

Site	Characteristic	Location	Purpose
Dunhuang	Gebi Desert, homogenous surface, dry atmosphere, and high visibility	40° 10′ N, 94° 20′ E Elevation: 1176 m	On-orbit calibration for VNIR band
Qinghai	Lake, Good Lambertian feature, dry atmosphere, and high visibility	36° 45′ N, 100° 20′ E Elevation: 3196 m	On-orbit calibration for TIR band
Beijing	Laboratory on the top of NSMC building	116.46° N, 39.92° E Elevation: 48 m	• Validation for the calculation from radiation transfer code with very high spectral resolution • Benchmark measurements
Lijiang	Local meteorological observation station, dry atmosphere, high visibility	100.25° N, 26.86° E Elevation: 2300 m	Pre-launch calibration for VNIR band of engineering and flight model

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

•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

GOES vs. POES

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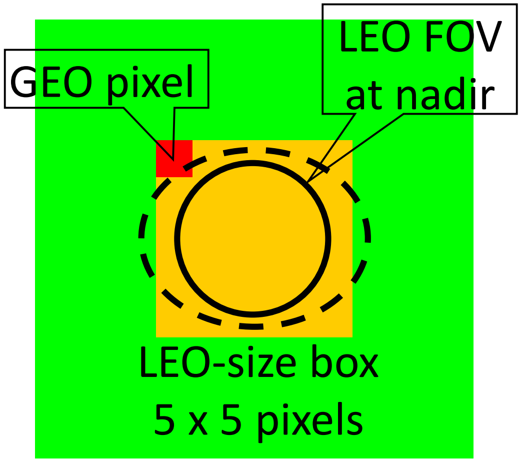
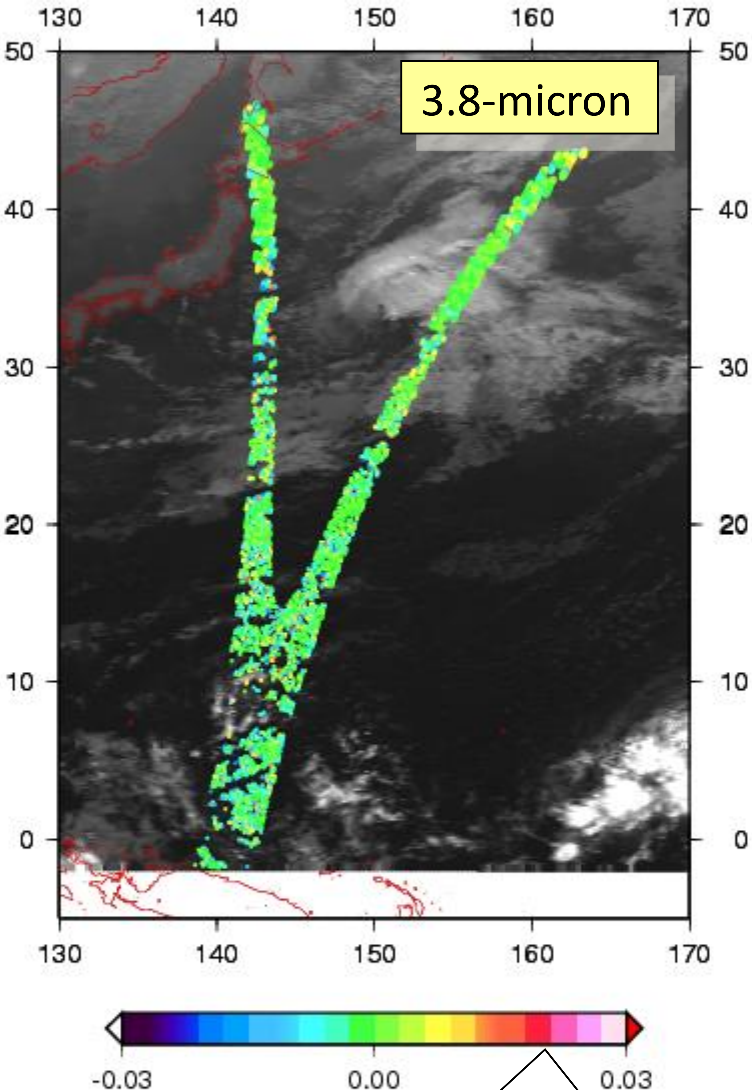
Intercalibration Algorithm



- **Key match-up conditions between GEO and LEO**
  - **Difference of observing times < 1800 (sec)**
  - **Difference of 1/cos(sat. zenith angles) < 0.05**
  - **Environment uniformity check**
    - To choose only spatially uniform area to alleviate navigation error, MTF, observing time difference, optical path difference, etc.
    - Environment domain = 11x11 IR pixel box (MTSAT-1R vs. AIRS)
    - env_stdv_tb < (TBD)
  - **Representation check of LEO-size GEO pixels in the environment**
    - z-test
    - LEO FOV = 5x5 IR pixel box (MTSAT-1R vs. AIRS)
    - abs(fov_mean_tb – env_mean_tb) < Gaussian x env_stdv_tb / 5

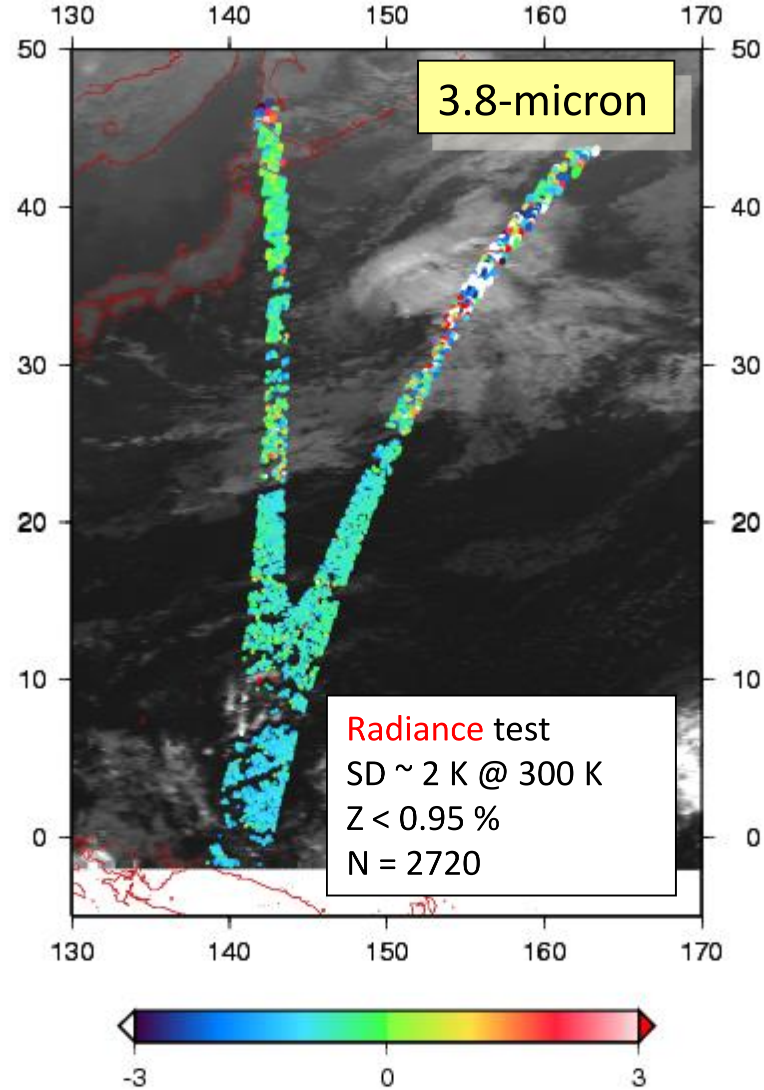
Radiance Comparison and TB Comparison

Radiance Residual



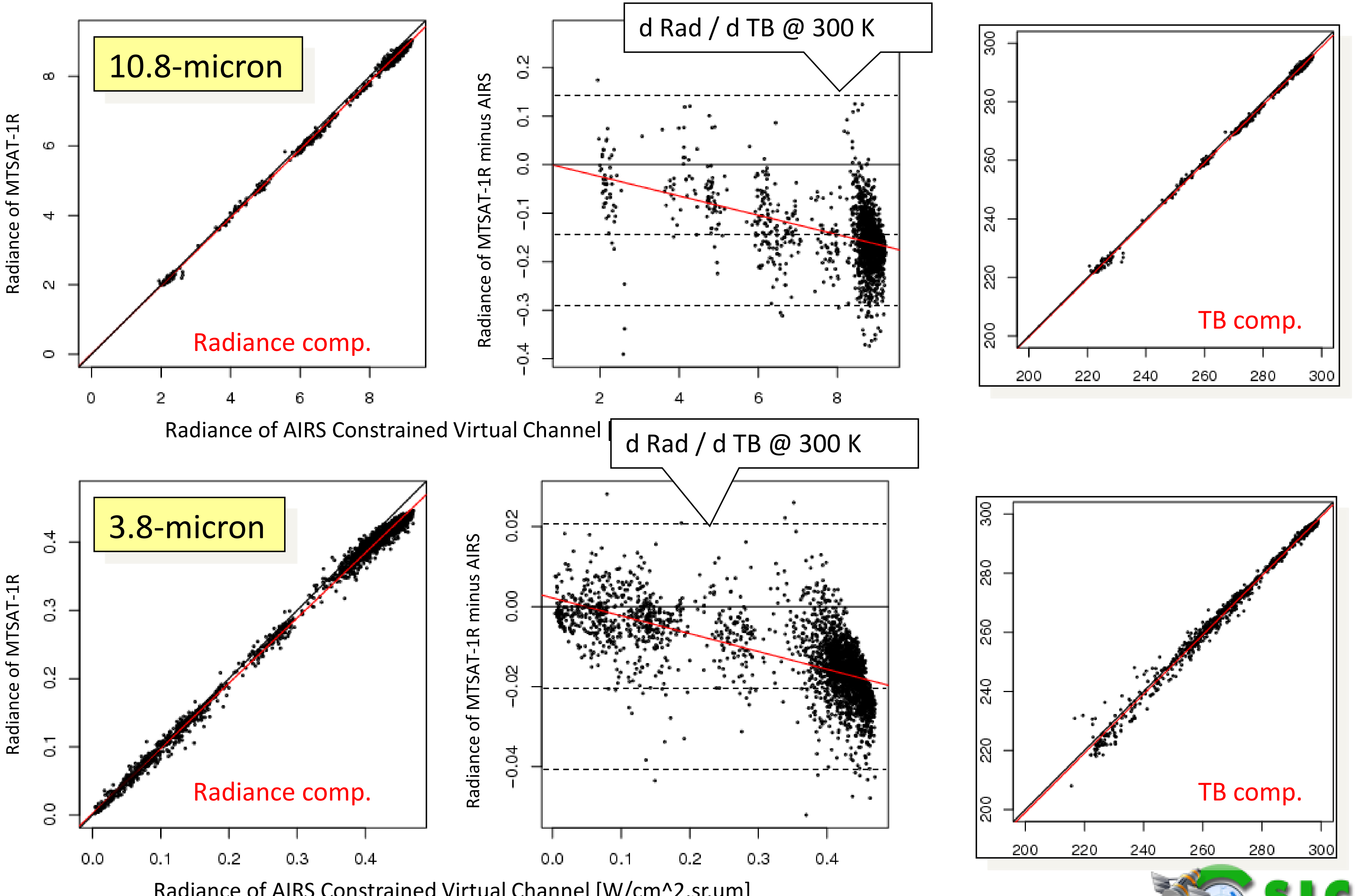
d Rad / d TB @ 300 K

TB Residual



Radiance test
SD ~ 2 K @ 300 K
Z < 0.95 %
N = 2720

TB Comparison and Radiance Comparison



JMA F90 Modules

New satellite implemented by replacing either GEO module "access_geo" or LEO module "access_leo"

program **geo_leo_intercal_ir**

[variable definition] geo, leo, colloc

call open_geo(geo, GeoFile)

call get_geo_radiance(geo)

call open_leo(leo, LeoFile)

call get_leo_data(leo)

call colloc_geo_leo(geo, leo, colloc)

call get_simgeo_convolution

call get_simgeo_constrain

(geo, leo, colloc)

call write_colloc_netcdf/HDF

(geo, leo, colloc, CollocFile)

call close_geo(geo)

call close_leo(leo)

module **common_constants**
- Basic constants defined

module **access_geo**
- Definition of GEO data structure
- Subroutines to open/close GEO, get GEO data, deallocate arrays

module **access_leo**
- Definition of LEO data structure
- Subroutines to open/close LEO, get LEO data, deallocate arrays

module **collocate_geo_leo**
- Definition of collocation data structure
- Subroutines to collocate GEO-LEO, deallocate arrays

module **simulate_georad_convolution**

module **simulate_georad_constrain**
- Subroutines to estimate GEO radiances from LEO data, deallocate arrays

module **write_colloc**
- Subroutine to write out results

CMA Modules

New satellite implemented by replacing either GEO module “access_geo” or LEO module “access_leo”

program **geo_leo_intercal_ir**

[variable definition] geo, leo, colloc

call open_geo(geo, GeoFile)
call get_geo_radiance(geo)

call open_leo(leo, LeoFile)
call get_leo_data(leo, rc)

call colloc_geo_leo(geo, leo, colloc)

call get_simgeo_convolution(geo,leo,colloc)
call get_simgeo_constrain(geo,leo,colloc)

call output(geo, leo, colloc)

call close_geo(geo)
call close_leo(leo)

call destroy_geo(geo)
call destroy_leo(leo)
call destroy_colloc(colloc)
call destroy_simgeo_***()

module **common_constants**
- Basic constants defined

module **access_geo**
- Definition of GEO data structure
- Subroutines to open/close GEO, get GEO data, deallocate arrays

module **access_leo**
- Definition of LEO data structure
- Subroutines to open/close LEO, get LEO data, deallocate arrays

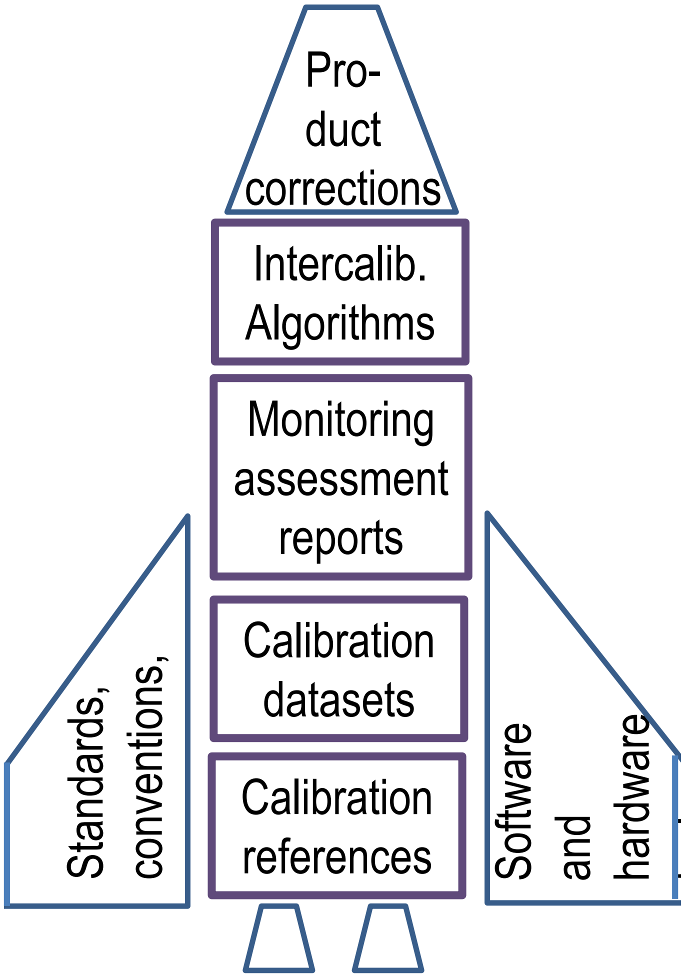
module **collocate_geo_leo**
- Definition of collocation data structure
- Subroutines to collocate GEO-LEO, deallocate arrays

module **simulate_georad_convolution**
module **simulate_georad_constrain**
- Subroutines to estimate GEO radiances from LEO data, deallocate arrays

module **(output)**
- Subroutine to write out results

GSICS Deliverables

- GSICS Products for users of satellite data, including calibration corrections/coefficients
- GSICS Algorithms, which describe inter-calibration processes, (described by ATBD)
- GSICS Monitoring Reports, assessments
- GSICS Reference datasets, including Solar spectrum, …
- GSICS Tools for use by inter-calibration developers, (GIRO, SBAF, …)
- GSICS recommended standards, conventions and guidelines,
- GSICS User Services, information , Websites



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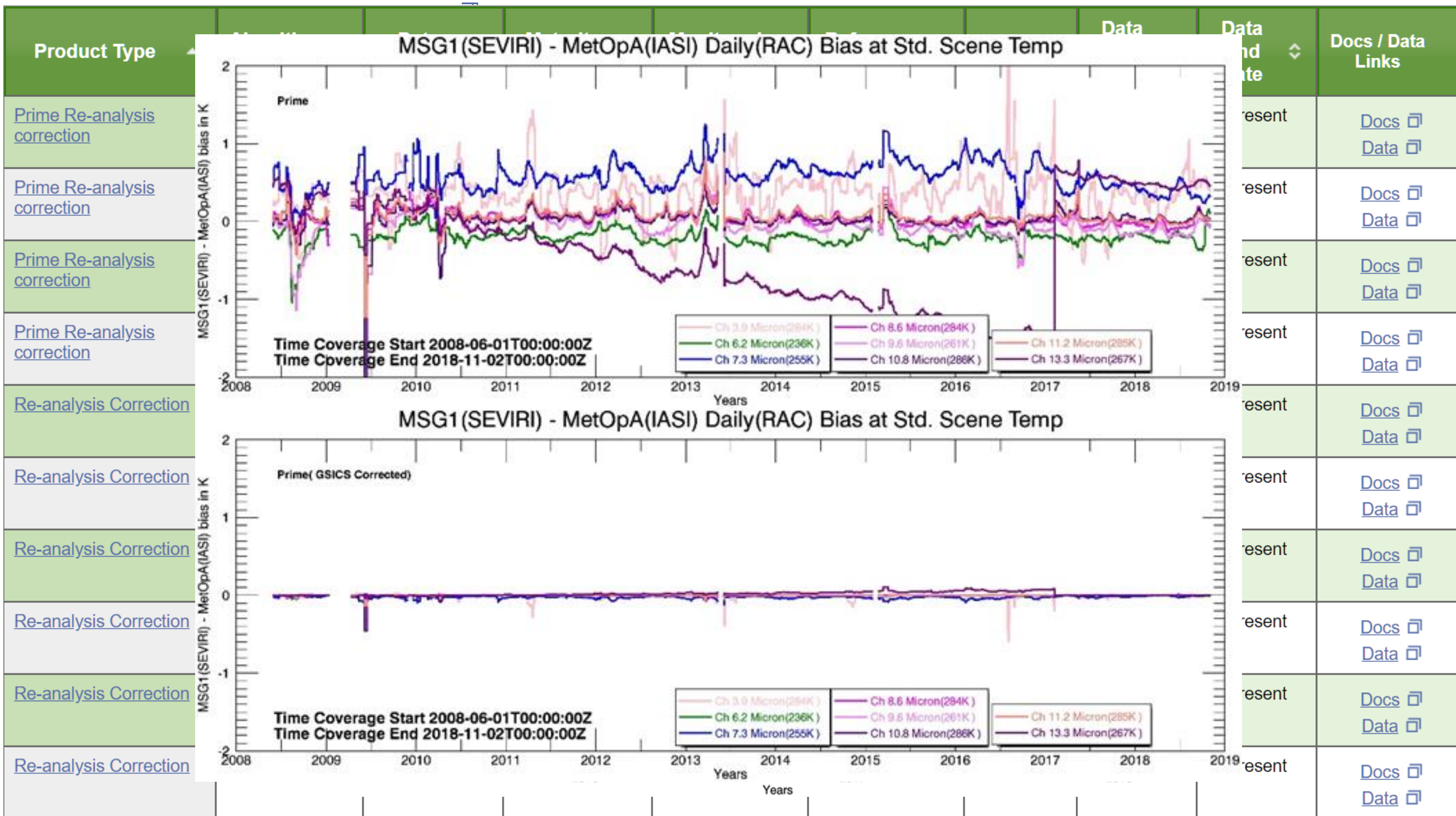
New Visualization Feature on GSICS Product Catalog - more than 50 products

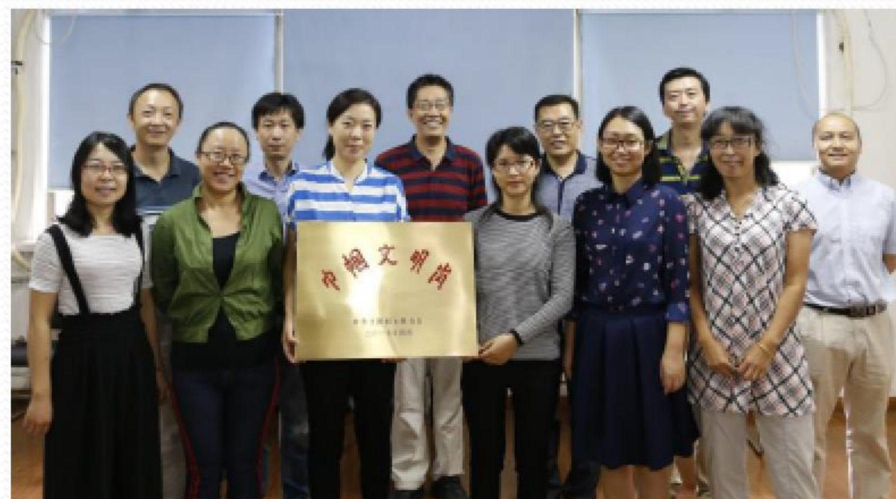
https://www.star.nesdis.noaa.gov/smcd/GCC/ProductCatalogImages.php



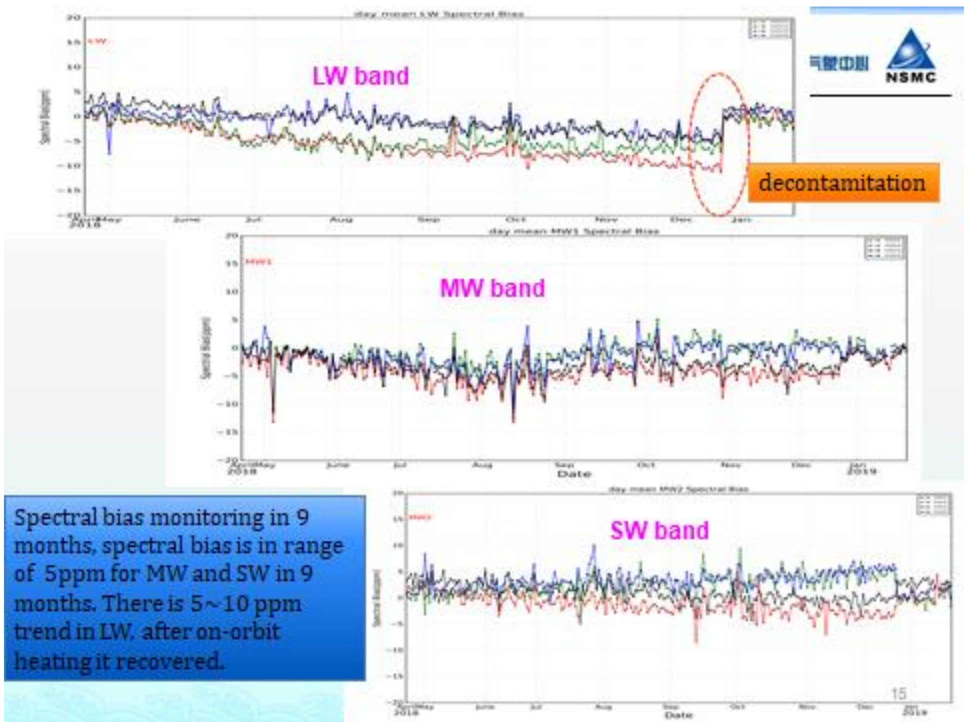
Global Space-based Inter-Calibration System

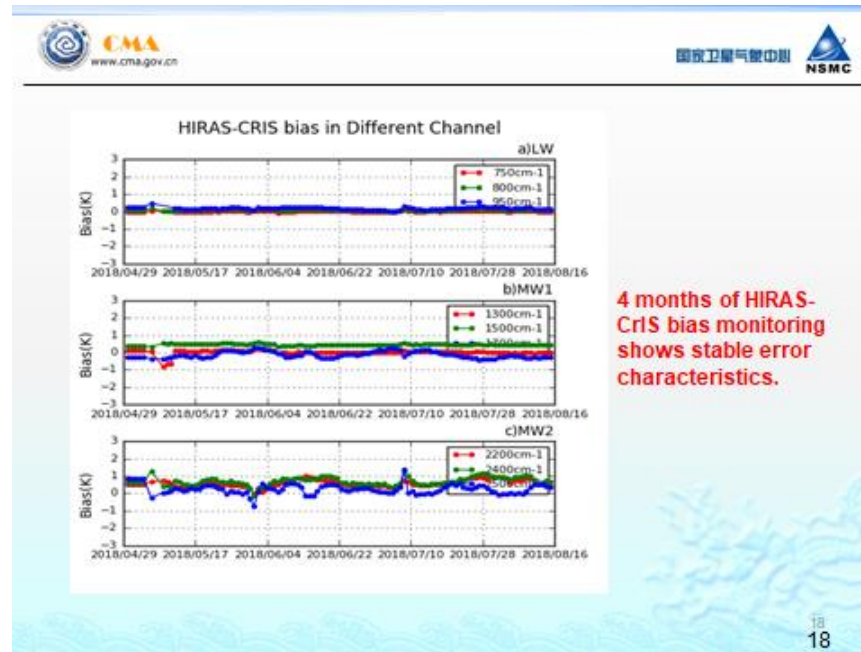
CMA is a significant contributor to GSICS

Look! CMA GSICS team!



Example from CMA for HIRAS monitoring





GSICS Annual State of the Observing System

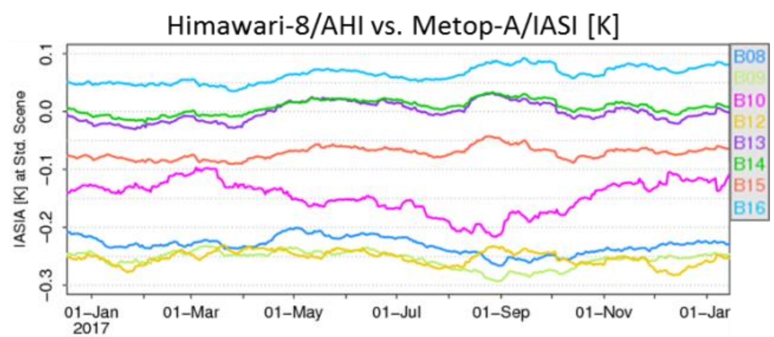
Annual assessment of observing system performance with respect to reference instruments using a common template

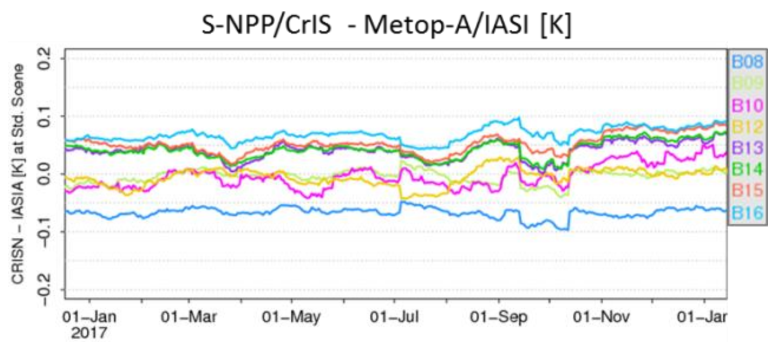
Calibration Performance: Himawari-8/AHI Infrared Bands

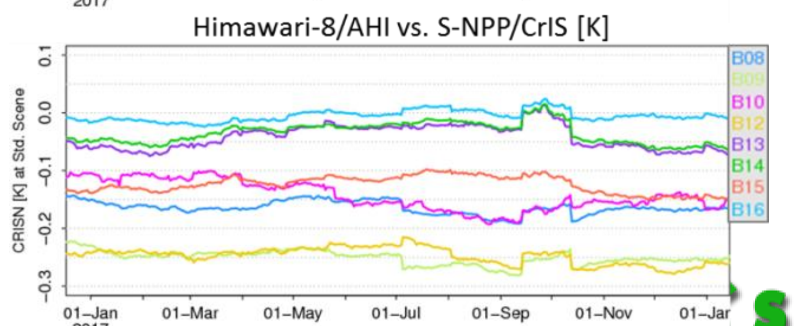
Summary Statistics of Himawari-8/AHI IR Calibration Performance in 2017 (All uncertainties are k=1)

	Channel Name (Central Wavelength in µm)	BAND07 (3.9)	BAND08 (6.2)	BAND09 (6.9)	BAND10 (7.3)	BAND11 (8.6)	BAND12 (9.6)	BAND13 (10.4)	BAND14 (11.2)	BAND15 (12.4)	BAND16 (13.3)
	Std. Radiance as Tb (K)	286.0	234.6	243.9	254.6	283.8	259.5	286.2	286.1	283.8	269.7
Metop-A/ IASI	Mean Bias (K)	-0.11	-0.173	-0.212	-0.129	-0.05	-0.216	0.036	0.045	-0.04	0.078
	Stdv. of Bias (K)	0.008	0.012	0.009	0.014	0.012	0.017	0.018	0.019	0.017	0.015
S-NPP/ CrIS	Mean Bias (K)	-0.07	-0.16	-0.24	-0.15	N/A	-0.23	-0.02	-0.01	-0.01	0.03
	Stdv/ of Bias (K)	0.039	0.011	0.012	0.026	N/A	0.013	0.013	0.012	0.010	0.005

- The statistics are derived from Himawari-8/AHI GSICS Re-Analysis Correction (ATBD)
- Standard Radiance: typical scene defined by GSICS for easy inter-comparison of sensors' inter-calibration biases







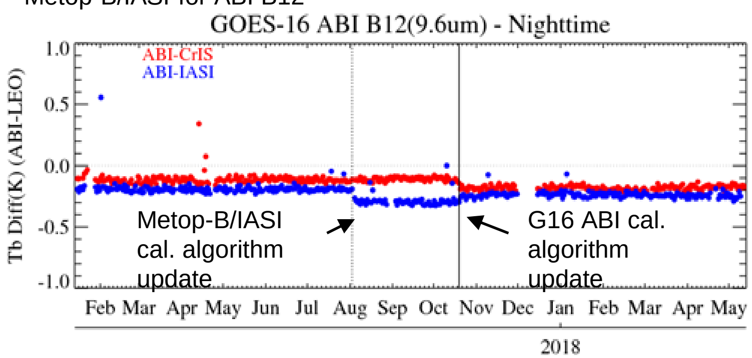
Calibration Performance: GOES16/ABI Infrared Bands

Summary Statistics of GOES-16/ABI IR Calibration Performance in December 2017 (All uncertainties are k=1)

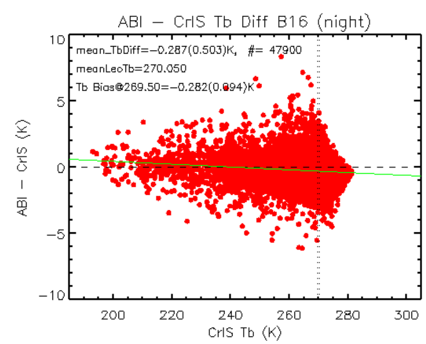
	Channel Name (Central Wavelength in µm)	BAND07 (3.9)	BAND08 (6.2)	BAND09 (6.9)	BAND10 (7.3)	BAND11 (8.6)	BAND12 (9.6)	BAND13 (10.4)	BAND14 (11.2)	BAND15 (12.4)	BAND16 (13.3)
	Std. Scene Tb (K)	286.0	234.5	244.0	254.5	284.0	259.5	286.0	286.0	283.5	269.5
Metop-B/ IASI	Bias at Std. Scene(K)	-0.167	-0.196	-0.218	-0.170	-0.204	-0.227	-0.210	-0.141	-0.153	-0.294
	Stdv. of Bias (K)	0.120	0.082	0.093	0.108	0.147	0.110	0.160	0.165	0.169	0.160
S-NPP/ CrIS	Bias at Std. Scene(K)	-	-	-0.259	-0.202	-	-0.160	-0.227	-0.167	-0.176	-0.282
	Stdv of Bias (K)	-	-	0.045	0.052	-	0.047	0.073	0.073	0.073	0.094

- The uncertainty and statistics are calculated following the GSICS standard GEO-LEO IR inter-calibration algorithm
- GOES-16 ABI IR calibration is very stable with mean Tb bias to CrIS/IASI less than 0.3K. No significant scene dependent Tb bias to the reference instruments for all the IR channels
- GOES-16 ABI post-launch test started in Jan. 2017 and became operational on 18 December 2017. L1B data are available to the public since after the provisional maturity on 1 June 2017.
- Stable reference and monitored instruments can quickly detect and identify calibration events (e.g. Metop-B/IASI and GOES-16 ABI Ground updates) and validate the algorithm (e.g. ABI cal. algorithm update in October 2017)

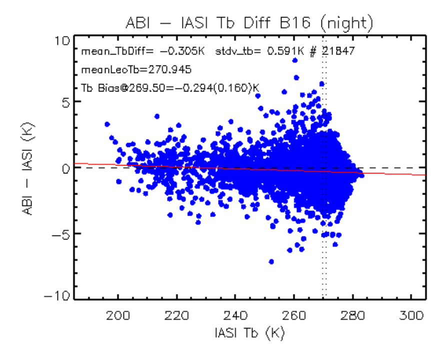
Time series of GOES-16 ABI daily mean Tb bias to SNPP/CrIS and Metop-B/IASI for ABI B12



Scene dependent Tb bias to SNPP/CrIS for ABI B16



Scene dependent Tb bias to Metop-B/IASI for ABI B16



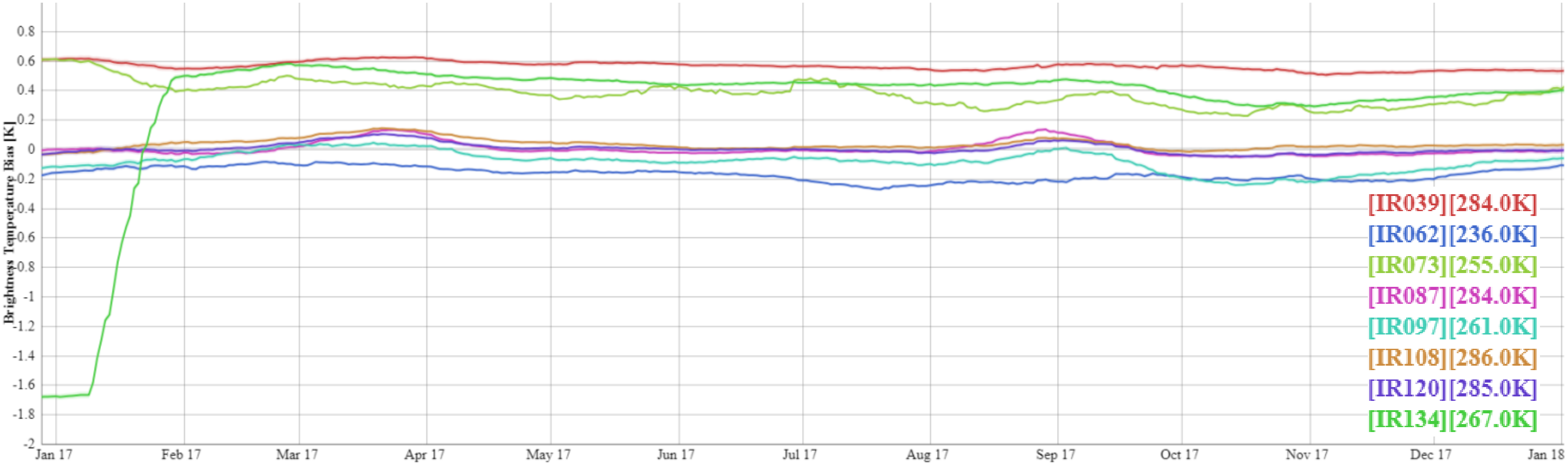
Calibration Performance: Meteosat-8/SEVIRI IR Bands

Summary Statistics of Meteosat-8/SEVIRI IR Calibration Performance in 2017 (All uncertainties are k=1)

Channel Name	IR3.9	IR6.2	IR7.3	IR8.7	IR9.7	IR10.8	IR12.0	IR13.4
Standard Radiance as Tb (K)	284	236	255	284	261	286	285	267
Mean Bias (K)	+0.57	-0.16	+0.38	+0.01	-0.08	+0.04	+0.01	+0.35
Standard Deviation of Bias (K)	0.03	0.05	0.08	0.05	0.07	0.04	0.03	0.40
Mean Drift Rate of Bias (K/yr)	-0.07	-0.10	-0.22	-0.04	-0.14	-0.05	-0.05	+0.35

- The statistics are derived from Meteosat-8/SEVIRI Operational GSICS Re-Analysis Correction vs. Metop-A/IASI
- Biases defined for Standard Radiance: typical scene for easy inter-comparison of sensors' inter-calibration biases
- Decontaminations introduce calibration jumps – most obvious in the IR13.4 channel due to ice contamination

Time series of Meteosat-8/SEVIRI Tb biases w.r.t. Metop-A/IASI at standard radiance

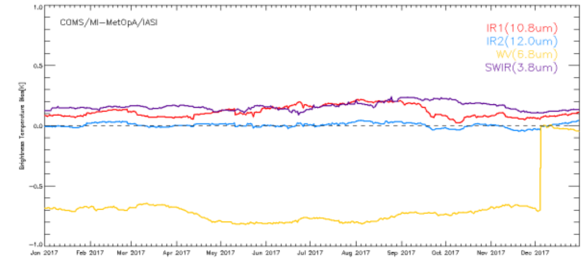


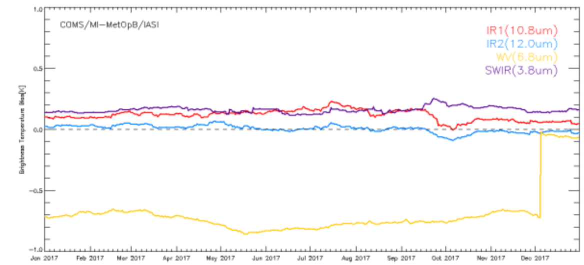
Calibration Performance: COMS/MI Infrared Bands

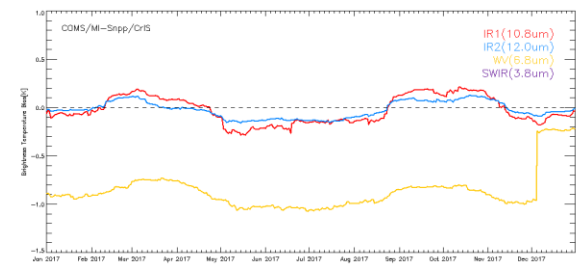
Summary Statistics of COMS/MI IR Calibration Performance in 2017 (All uncertainties are k=1)

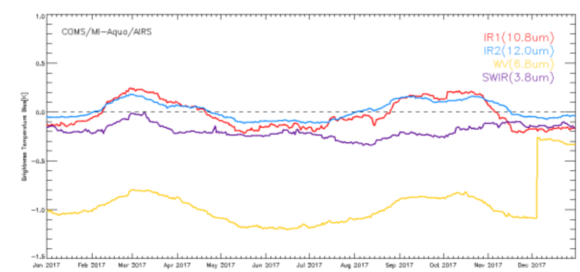
	MetOp-A/IASI				MetOp-B/IASI			
Channel Name	IR3.8	IR6.8	IR10.8	IR12.0	IR3.8	IR6.8	IR10.8	IR12.0
Std Rad as Tb (K)	286	238	286	285	286	238	286	285
Mean Bias (K)	0.16	-0.02	0.12	0.004	0.15	-0.06	0.11	0.004
Stdv of Bias (K)	0.03	0.01	0.05	0.02	0.02	0.01	0.04	0.03
Mean Drift Rate of Bias (K/yr)	-0.14	-	-0.12	-0.01	-0.15	-	-0.14	-0.04

	Snpp/CrIS				Aqua/AIRS			
Channel Name	IR3.8	IR6.8	IR10.8	IR12.0	IR3.8	IR6.8	IR10.8	IR12.0
Std Rad as Tb (K)	286	238	286	285	286	238	286	285
Mean Bias (K)	-	-0.23	-0.03	-0.02	-0.19	-0.30	-0.02	0.02
Stdv of Bias (K)	-	0.01	0.14	0.08	0.07	0.02	0.14	0.09
Mean Drift Rate of Bias (K/yr)	-	-	+0.03	+0.03	+0.19	-	-0.005	-0.007







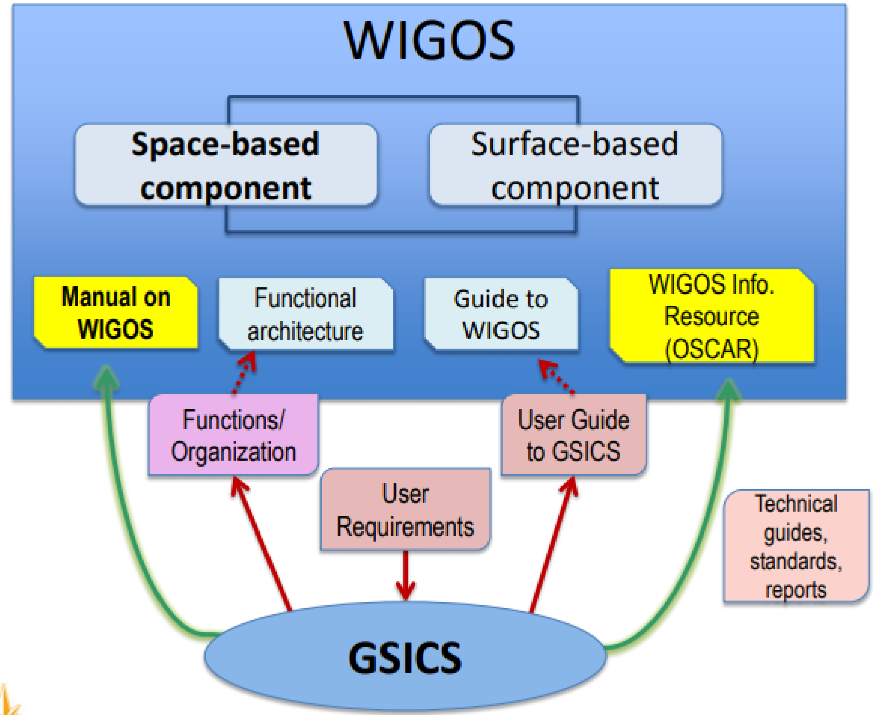


- The statistics are derived from COMS/MI Operational GSICS Re-Analysis Correction vs. Metop-A/IASI, Metop-B/IASI, Aqua/AIRS, Snpp/CrIS
- Biases defined for Standard Radiance: typical scene for easy inter-comparison of sensors' inter-calibration biases
- Operation of MI with shifted WV SRF of 3.5cm^{-1} started in 5 December 2017.

How is GSICS Integrated into WIGOS

Recognizing GSICS as an element of WIGOS

- ✓ The new Manual on WIGOS requires calibration along GSICS standards
- ✓ WIGOS/OSCAR will contain links to GSICS calibration information



Reference:
http://www.wmo.int/pages/prog/sat/meetings/documents/GSICS-EP-16_Doc_06-01_reference-documents.pdf

WMO Integrated Global Observing System (WIGOS)

Inter-Commission Coordination Group on the WMO Integrated Global Observing System Task Teams

ICG-WIGOS is authorized to establish Inter-Commission task teams as and when required with representatives of international partner organizations to address WIGOS standardization process, WMO regulatory material issues, and improvement of WIGOS observing components.

WEdB

The WIGOS Editorial Board

TT-WMD

The Task Team on the WIGOS Metadata:

- Terms of Reference
- Membership

TT-WDQMS

The Task Team on the WIGOS Data Quality Monitoring System

TT-WDP

The Task Team on the WIGOS Data and Partnerships

TT-WSI

- Terms of Reference
- Membership

4.3.1 Calibration and traceability

4.3.1.1 Satellite operators shall perform a detailed instrument characterization before launch.

4.3.1.2 After launch, satellite operators shall calibrate all instruments on a routine basis against reference instruments or calibration targets.

Notes:

1. Advantage should be taken of satellite collocation to perform on-orbit instrument intercomparison and calibration.
2. Calibration must be done in accordance with methodologies established and documented by the Global Space-based Inter-calibration System and the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation.

4.3.1.3 Satellite operators shall ensure traceability to the International System of Units (SI) standards.

Note: The *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (2010 Update), GCOS-138 (WMO/TD-No. 1523) calls for sustained measurement of key variables from space traceable to reference standards and recommends implementing and evaluating a satellite climate calibration mission.

4.3.1.4 To ensure traceability to the International System of Units (SI) standards, satellite operators shall define a range of ground-based reference targets for calibration purposes.

Integrated Cal/Val System Architecture

Calibration Opportunity Prediction

Data Acquisition Scheduler

Calibration Opportunity Register (CORE)

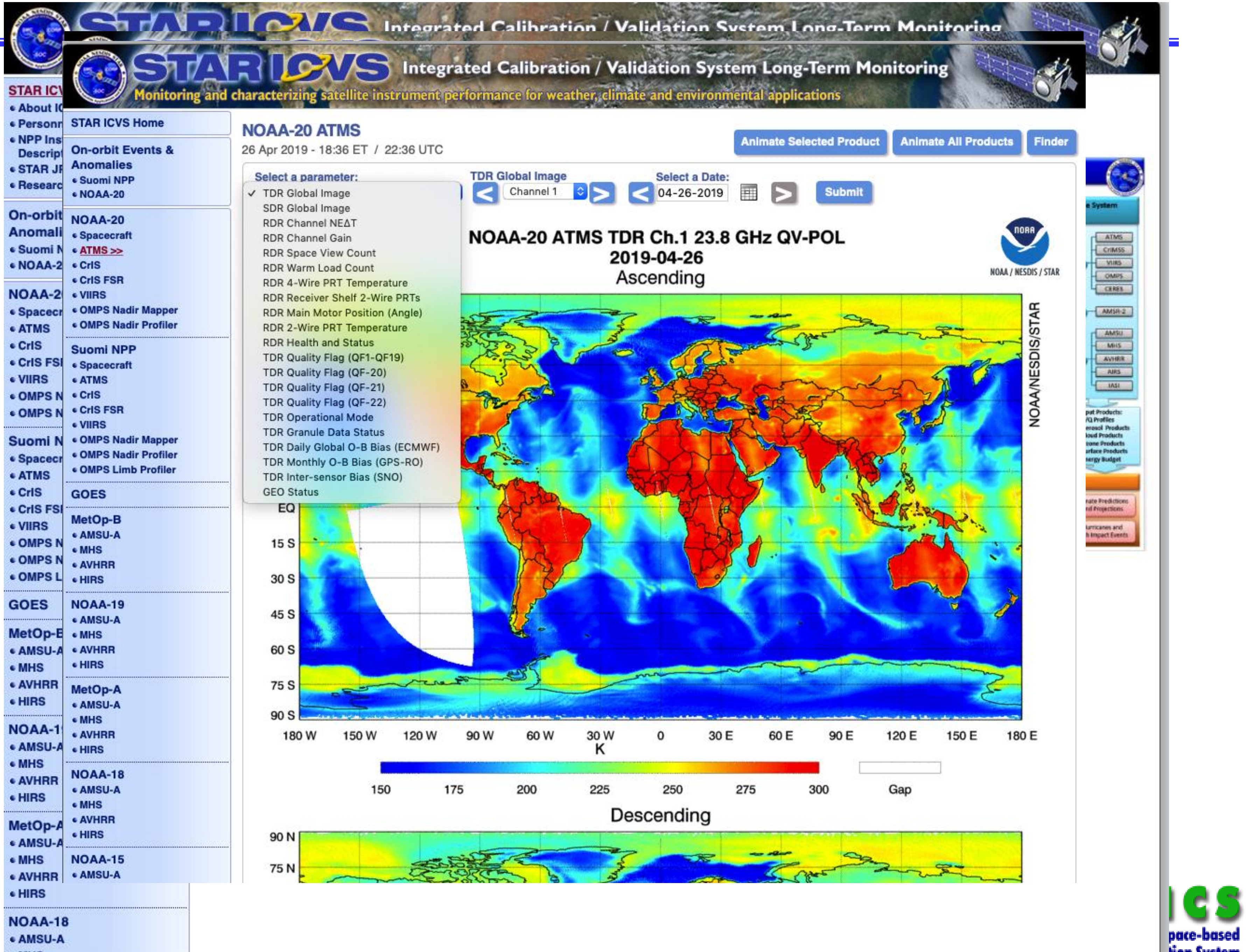
Raw Data Acquisition for Calibration Analyses

Stored Raw Data for Calibration Analyses

- SNO/ SCO Rad. Bias and Spectral Analysis
- Calibration Parameter Noise/ Stability Monitoring
- RTM Model Rad. at Calibration Reference Sites
- Inter-sensor Bias and Spectral Analysis
- Earth & Lunar Calibration
- Geolocation Assessment (Coastlines, etc.)

Assessment Reports and Calibration Updates

GSICS Global Space-based Inter-Calibration System


STAR ICVS
Integrated Calibration / Validation System Long-Term Monitoring
Monitoring and characterizing satellite instrument performance for weather, climate and environmental applications
STAR ICVS Home
On-orbit Events & Anomalies
Suomi NPP
NOAA-20
NOAA-20
Spacecraft
ATMS >>
CrIS
CrIS FSR
VIIRS
OMPS Nadir Mapper
OMPS Nadir Profiler
Suomi NPP
Spacecraft
ATMS
CrIS
CrIS FSR
VIIRS
OMPS Nadir Mapper
OMPS Nadir Profiler
OMPS Limb Profiler
GOES
MetOp-B
AMSU-A
MHS
AVHRR
HIRS
NOAA-19
AMSU-A
MHS
AVHRR
HIRS
MetOp-A
AMSU-A
MHS
AVHRR
HIRS
NOAA-18
AMSU-A
MHS
AVHRR
HIRS
NOAA-15
AMSU-A
NOAA-20 ATMS
26 Apr 2019 - 18:36 ET / 22:36 UTC
Animate Selected Product
Animate All Products
Finder
Select a parameter:
TDR Global Image
SDR Global Image
RDR Channel NEΔT
RDR Channel Gain
RDR Space View Count
RDR Warm Load Count
RDR 4-Wire PRT Temperature
RDR Receiver Shelf 2-Wire PRTs
RDR Main Motor Position (Angle)
RDR 2-Wire PRT Temperature
RDR Health and Status
TDR Quality Flag (QF1-QF19)
TDR Quality Flag (QF-20)
TDR Quality Flag (QF-21)
TDR Quality Flag (QF-22)
TDR Operational Mode
TDR Granule Data Status
TDR Daily Global O-B Bias (ECMWF)
TDR Monthly O-B Bias (GPS-RO)
TDR Inter-sensor Bias (SNO)
GEO Status
TDR Global Image
Channel 1
Select a Date:
04-26-2019
Submit
NOAA-20 ATMS TDR Ch.1 23.8 GHz QV-POL
2019-04-26
Ascending
NOAA / NESDIS / STAR
NOAA/NESDIS/STAR
EQ
15 S
30 S
45 S
60 S
75 S
90 S
180 W
150 W
120 W
90 W
60 W
30 W
0
30 E
60 E
90 E
120 E
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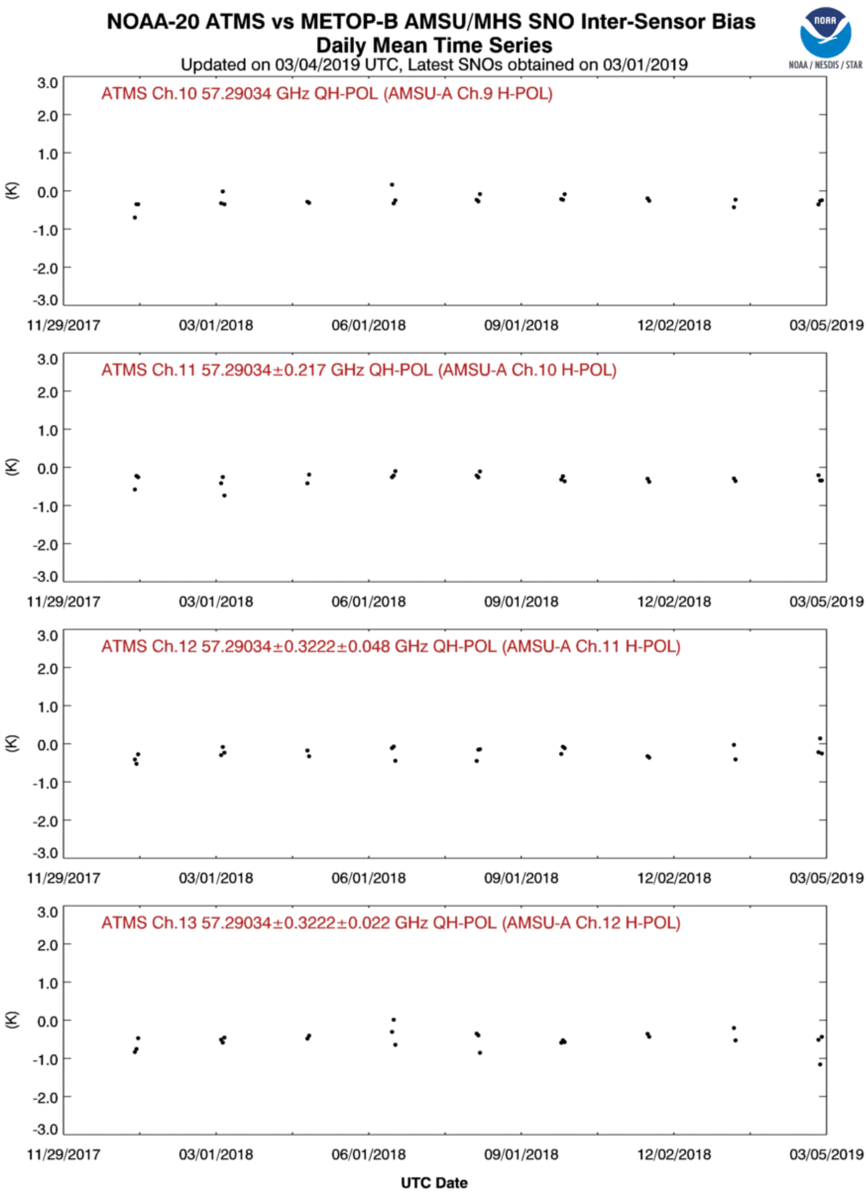
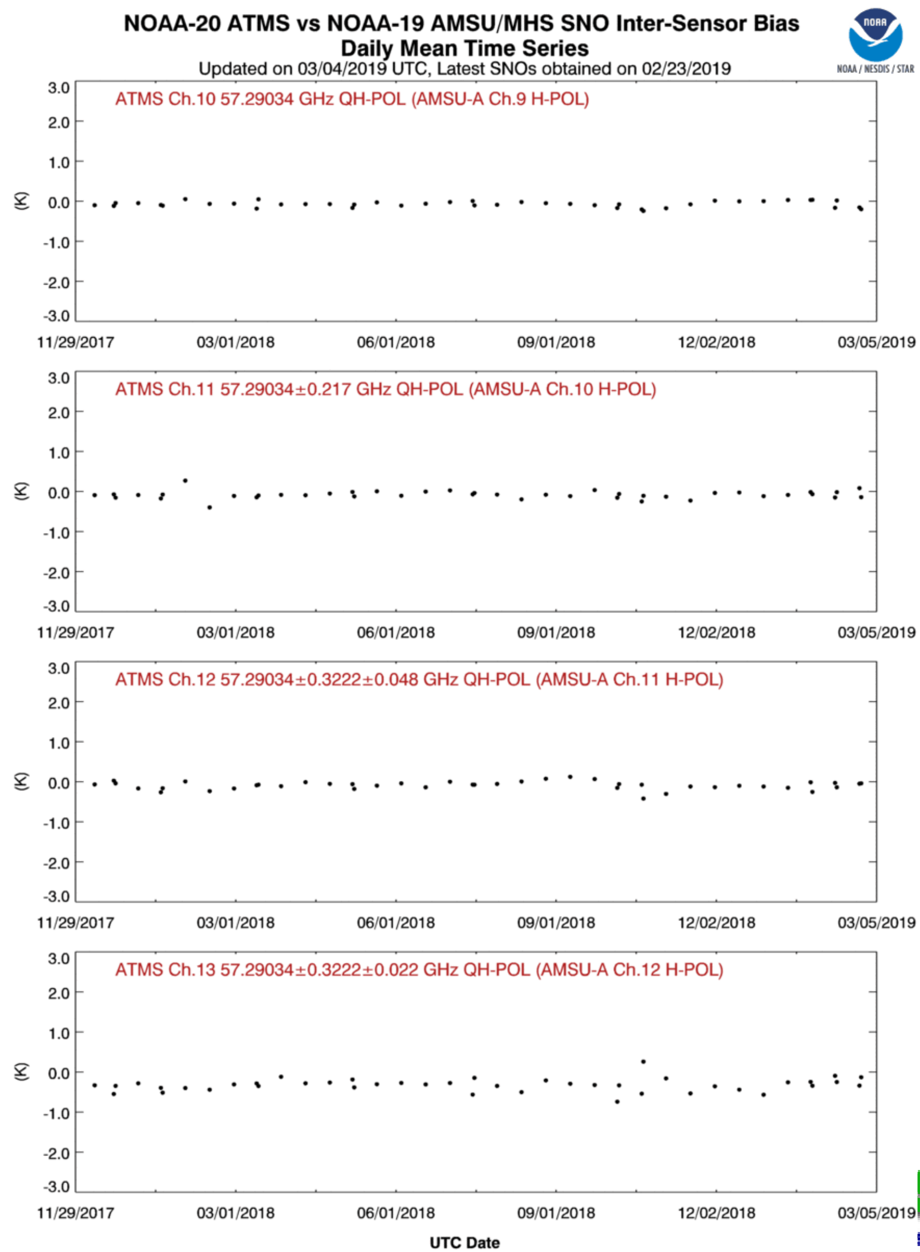
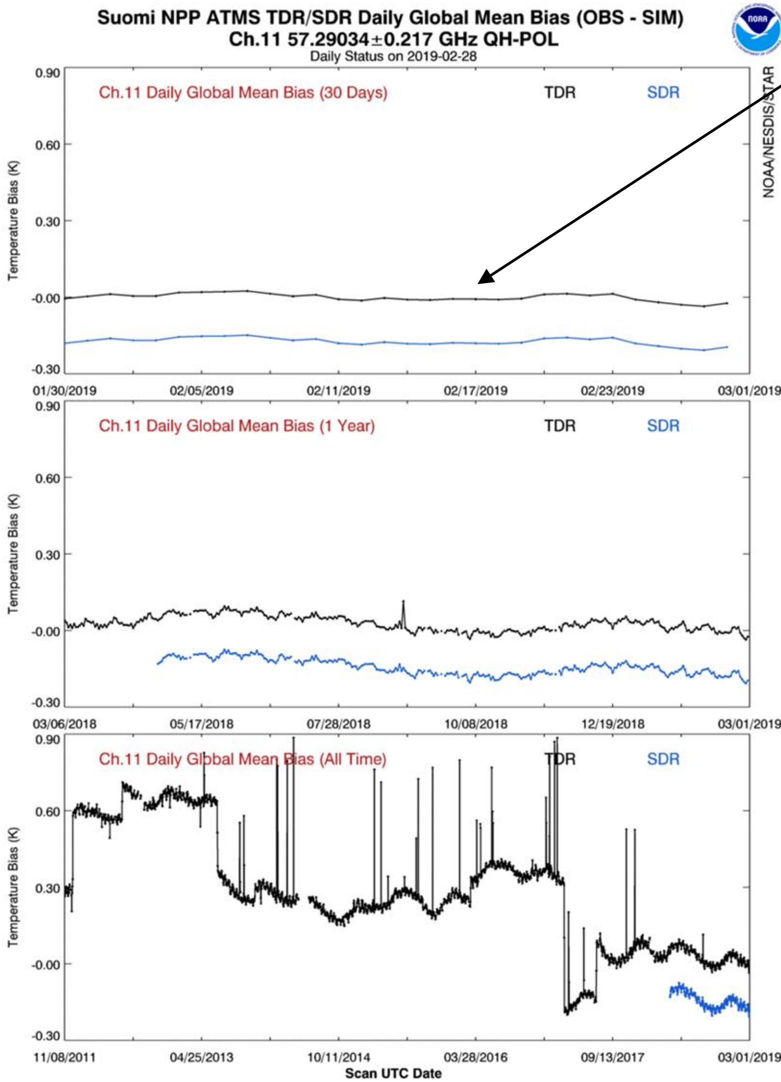
250
275
300
Gap
Descending
90 N
75 N

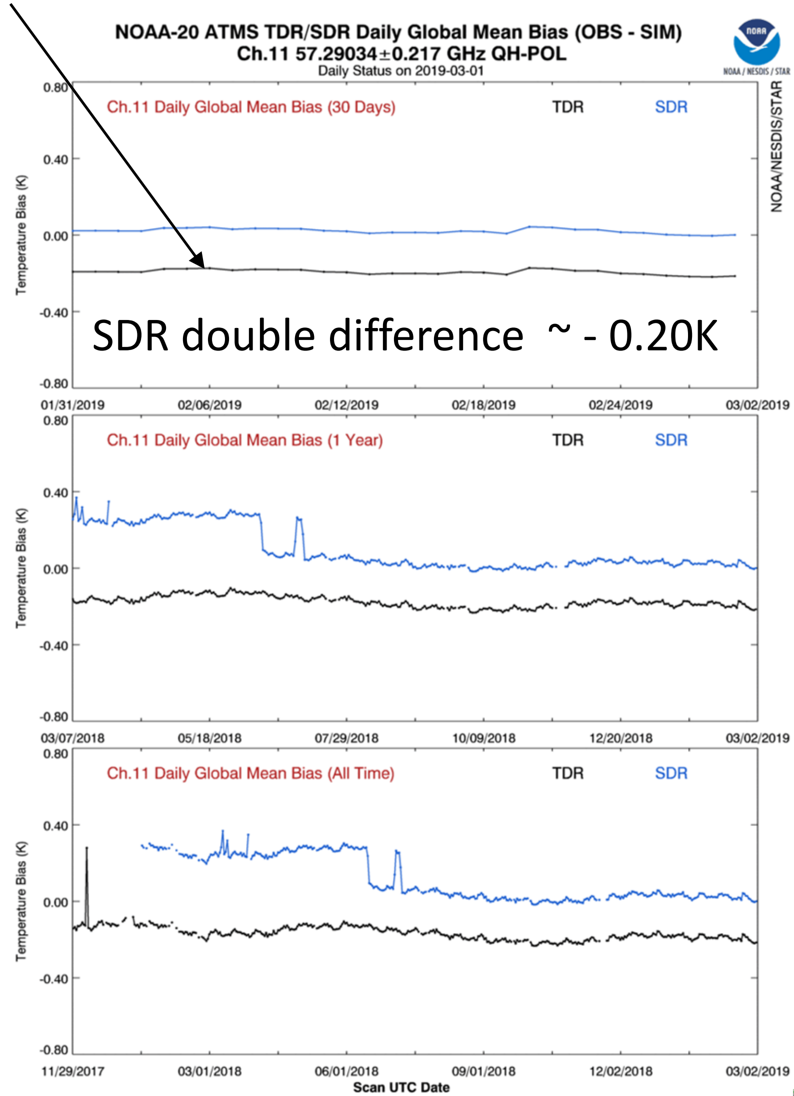

NOAA-20 ATMS vs METOP-B AMSU/MHS SNO Inter-Sensor Bias
Daily Mean Time Series
Updated on 03/04/2019 UTC, Latest SNOs obtained on 03/01/2019
NOAA / NESDIS / STAR
ATMS Ch.10 57.29034 GHz QH-POL (AMSU-A Ch.9 H-POL)
ATMS Ch.11 57.29034±0.217 GHz QH-POL (AMSU-A Ch.10 H-POL)
ATMS Ch.12 57.29034±0.3222±0.048 GHz QH-POL (AMSU-A Ch.11 H-POL)
ATMS Ch.13 57.29034±0.3222±0.022 GHz QH-POL (AMSU-A Ch.12 H-POL)
(K)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
11/29/2017
03/01/2018
06/01/2018
09/01/2018
12/02/2018
03/05/2019
UTC Date


NOAA-20 ATMS vs NOAA-19 AMSU/MHS SNO Inter-Sensor Bias
Daily Mean Time Series
Updated on 03/04/2019 UTC, Latest SNOs obtained on 02/23/2019
NOAA / NESDIS / STAR
ATMS Ch.10 57.29034 GHz QH-POL (AMSU-A Ch.9 H-POL)
ATMS Ch.11 57.29034±0.217 GHz QH-POL (AMSU-A Ch.10 H-POL)
ATMS Ch.12 57.29034±0.3222±0.048 GHz QH-POL (AMSU-A Ch.11 H-POL)
ATMS Ch.13 57.29034±0.3222±0.022 GHz QH-POL (AMSU-A Ch.12 H-POL)
(K)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
11/29/2017
03/01/2018
06/01/2018
09/01/2018
12/02/2018
03/05/2019
UTC Date

NOAA GPRC – quantifying differences between ATMS and AMSUs
Example of SNPP-NOAA-20 ATMS CH11 difference

TDR Double difference NPP – NOAA-20 ~ 0.20 K



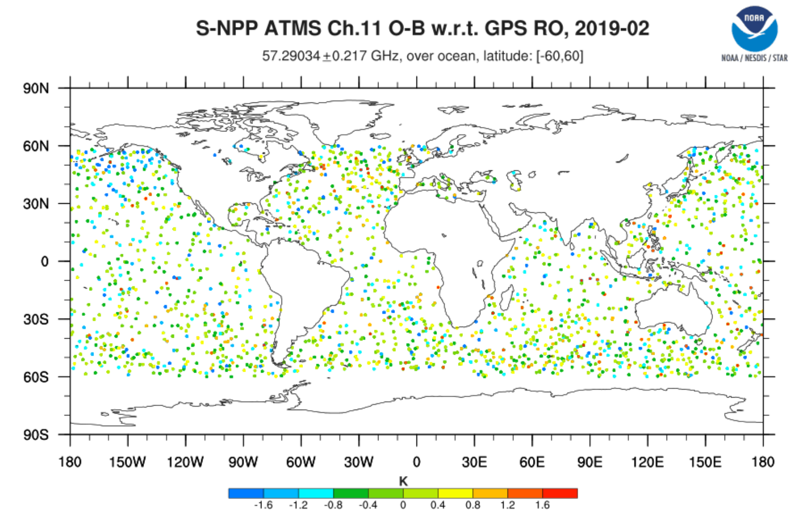


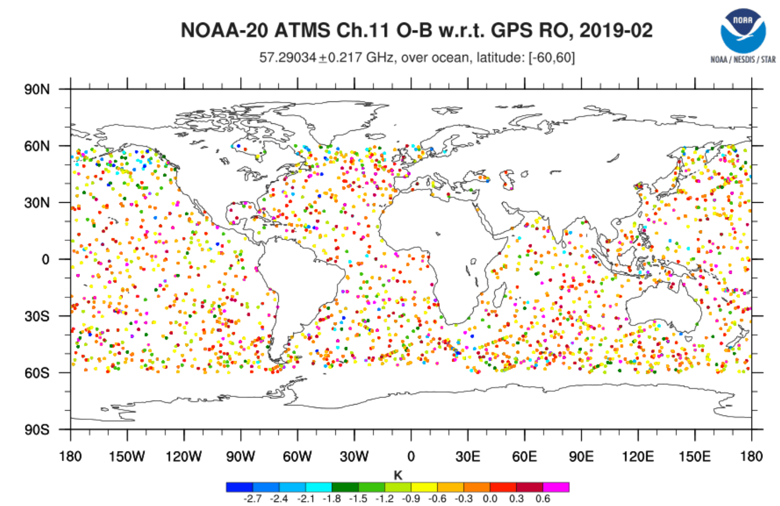
SDR double difference ~ - 0.20K

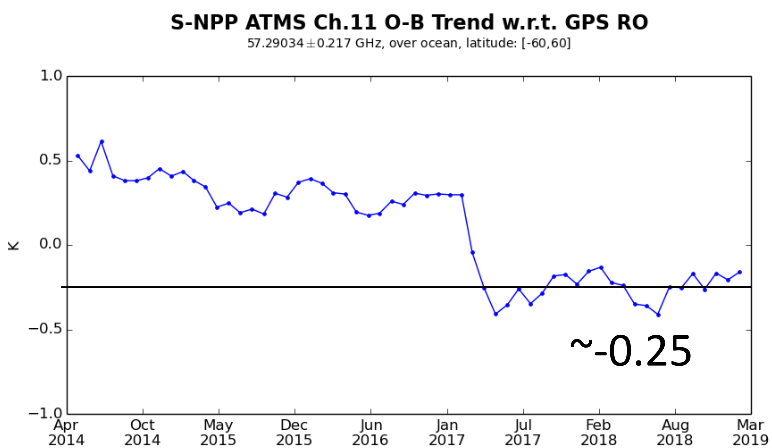
USING ECMWF AS A REFERENCE FOR DOUBLE DIFFERENCE

Difference between ECWMF and GPSRO in Double Difference Calculation is ~ 0.05

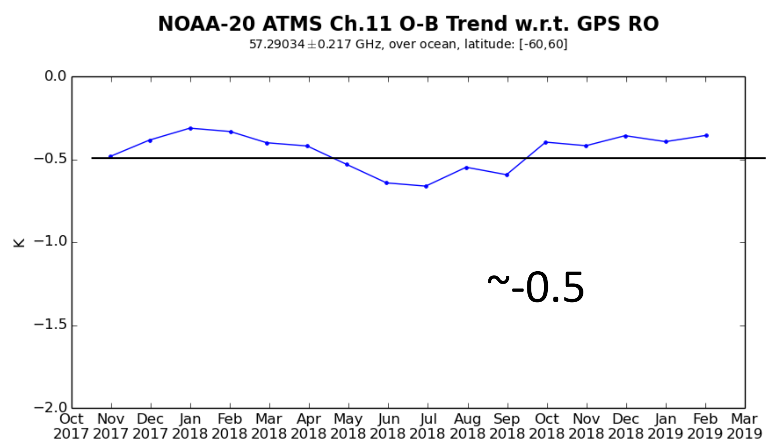
Using GPSRO - Double difference ~ 0.25







TDRs



USING GPSRO AS A REFERENCE FOR DOUBLE DIFFERENCE

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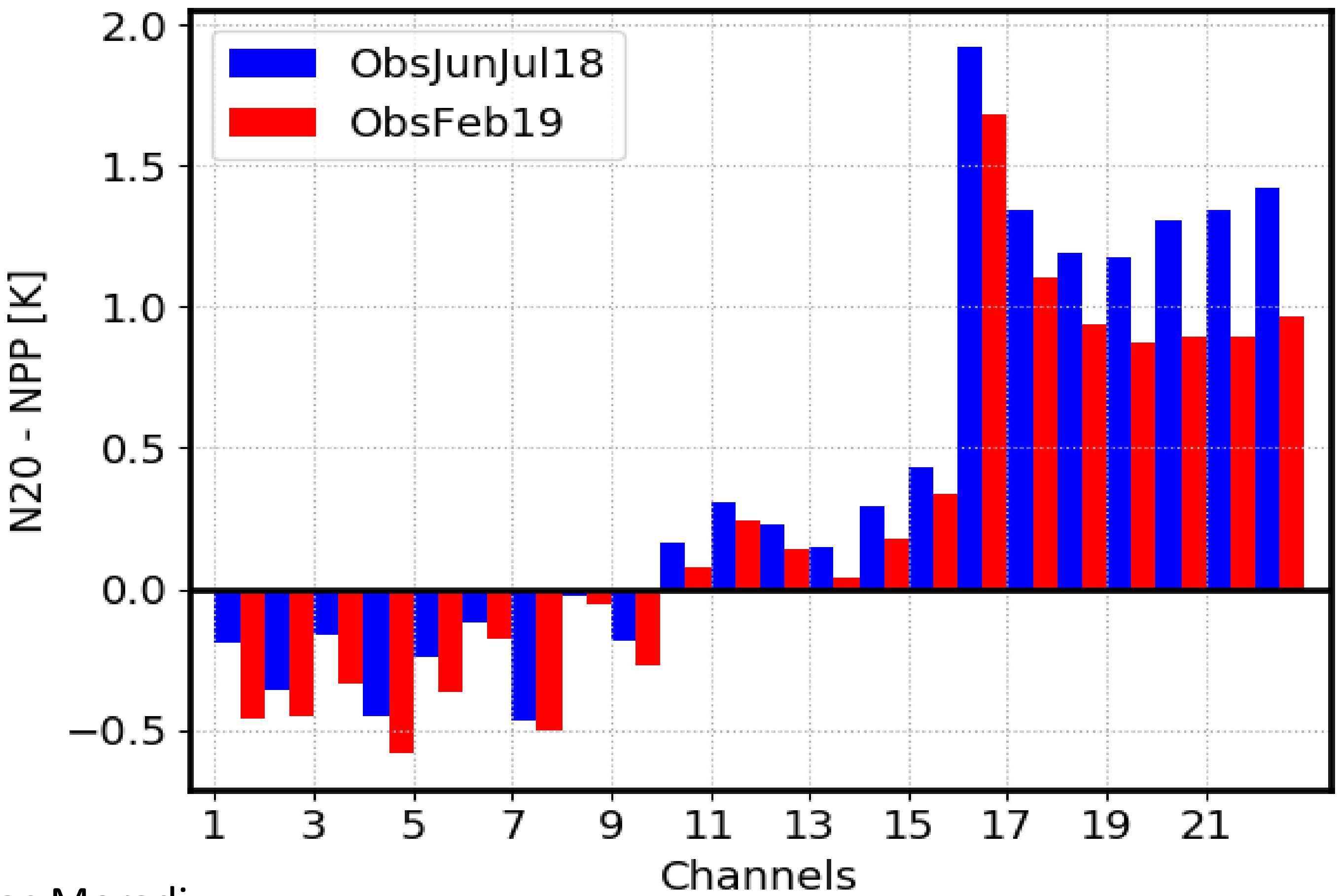
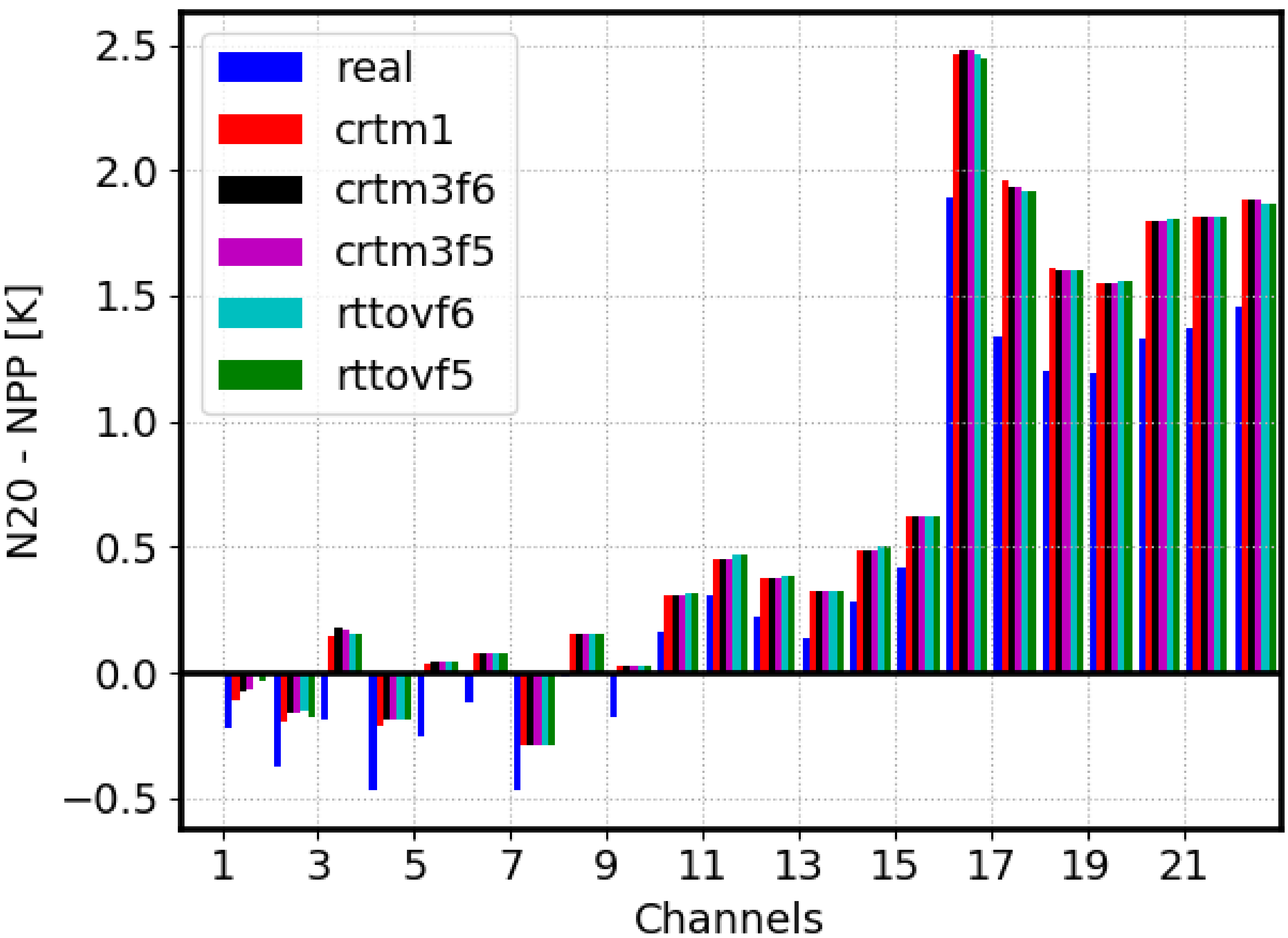
Double difference: [RT – NPP] – [RT – N20] (RT=0)

Is there an advantage of two satellites in the same exact orbit for intersatellite calibration?



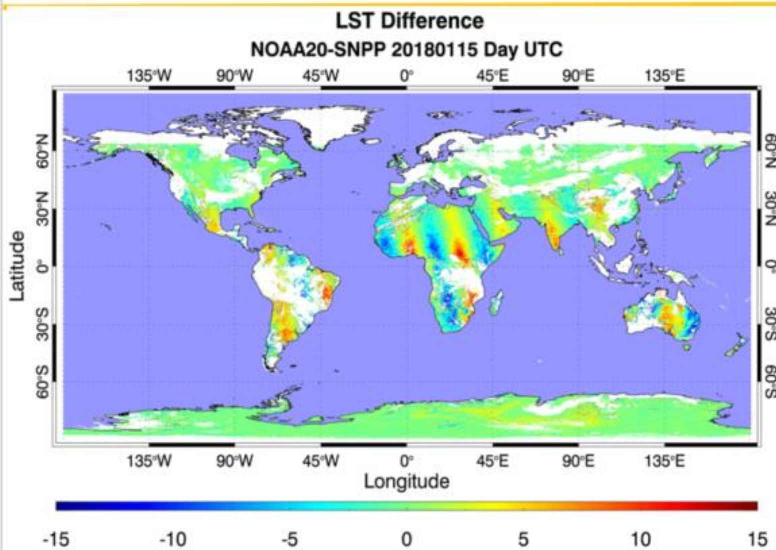
From Isaac Moradi

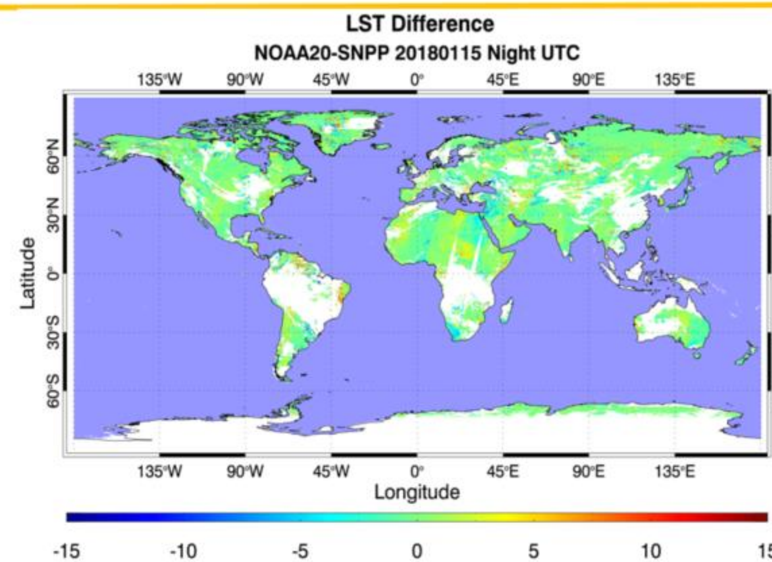
Double difference: [RT – NPP] – [RT – N20]



During the Provisional Review Time, we observed the orbit-shape difference between SNPP LST and N20 LST . Mitch suggested that such difference may be significantly reduced in the mean LST difference of certain time period at least cover one orbit-repeat period. The LST team made up the mean differences images and plots then, illustrated in the next few slides.

NOAA 20 VIIRS LST vs SNPP LST

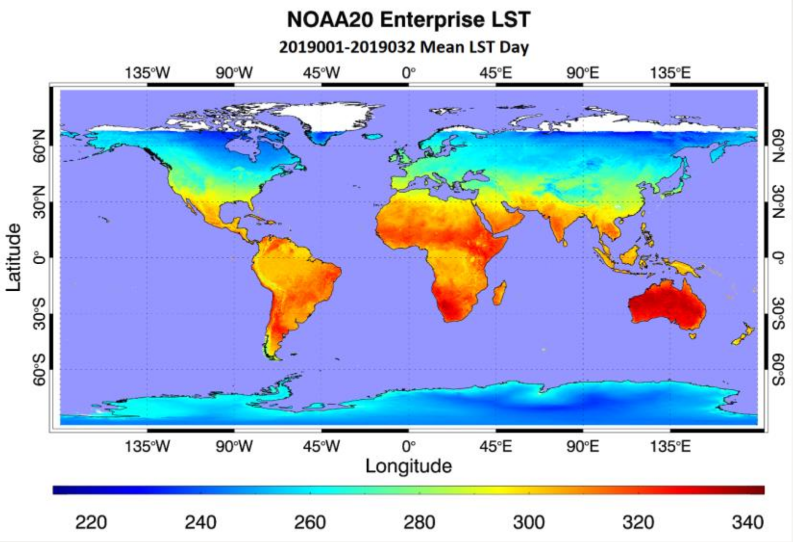


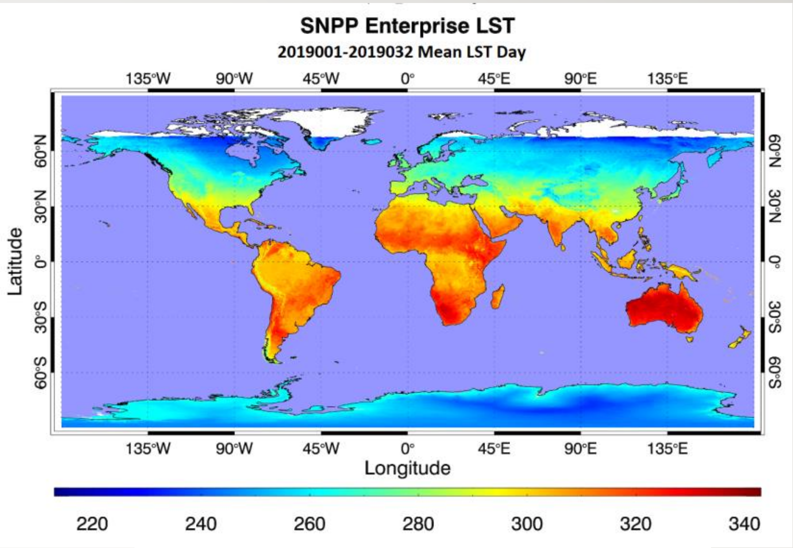


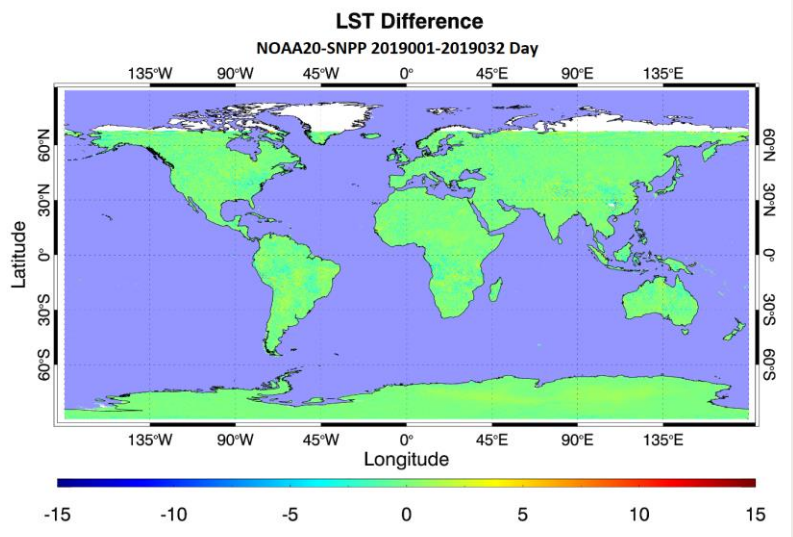
Condition
- NOAA20 and SNPP LST were generated using the latest LUT
- Two days in each month of 2018 were selected for comparison
- LST difference for day (Left) and night (Right) were presented

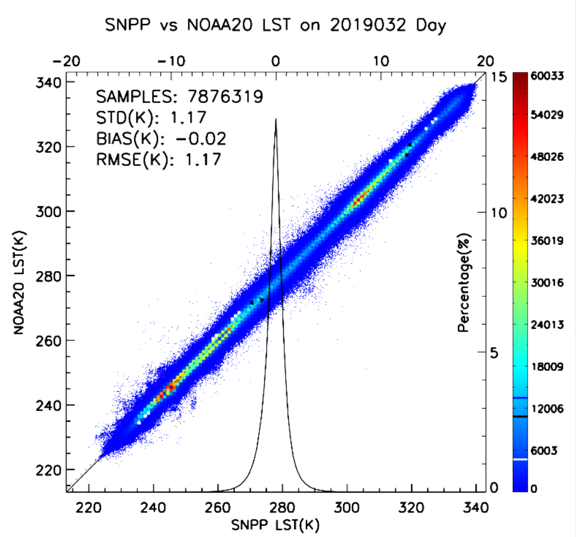
Results
- Daytime LST diff. presents an orbit-related pattern particularly at mid and low latitude
- The LST diff. is small at high latitude area for both daytime and nighttime

32 Day Mean LST: Day

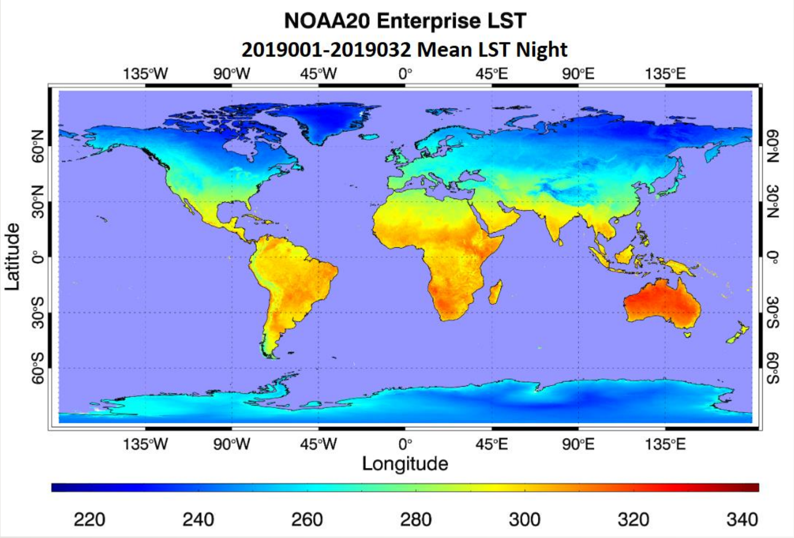


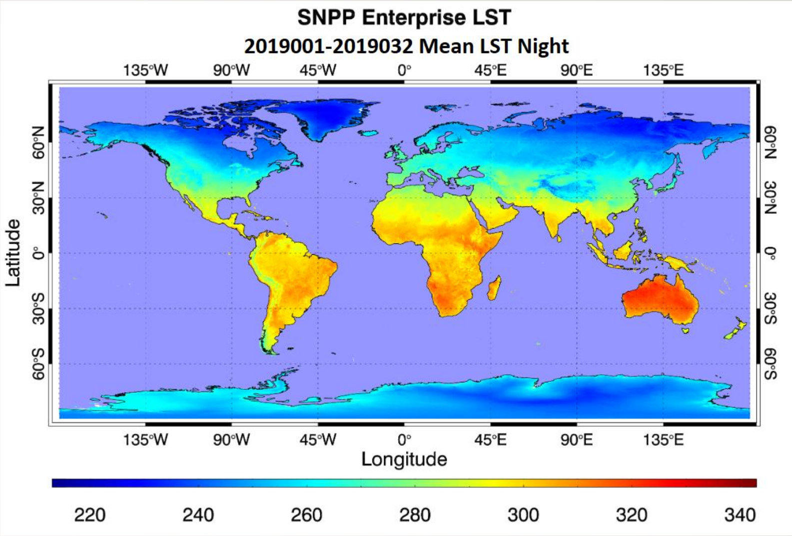


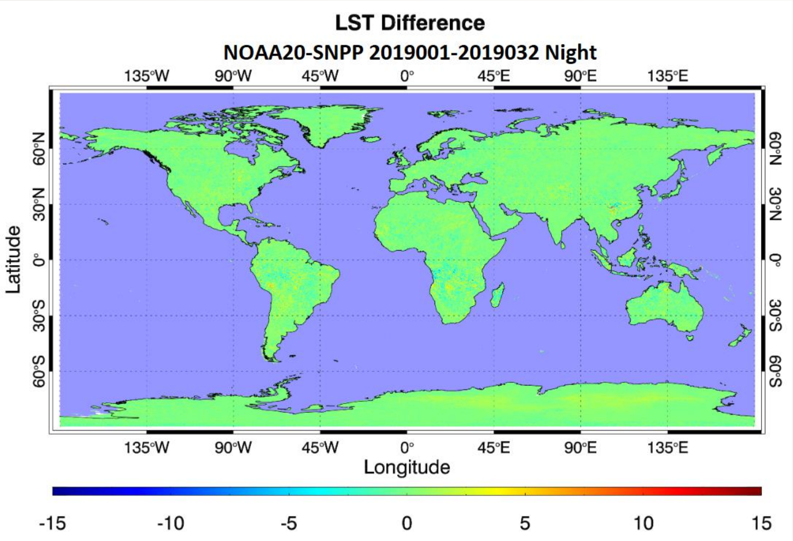


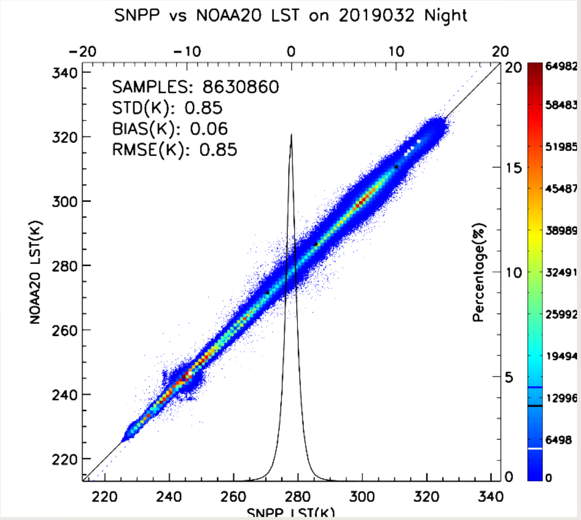


32 Day Mean LST: Night









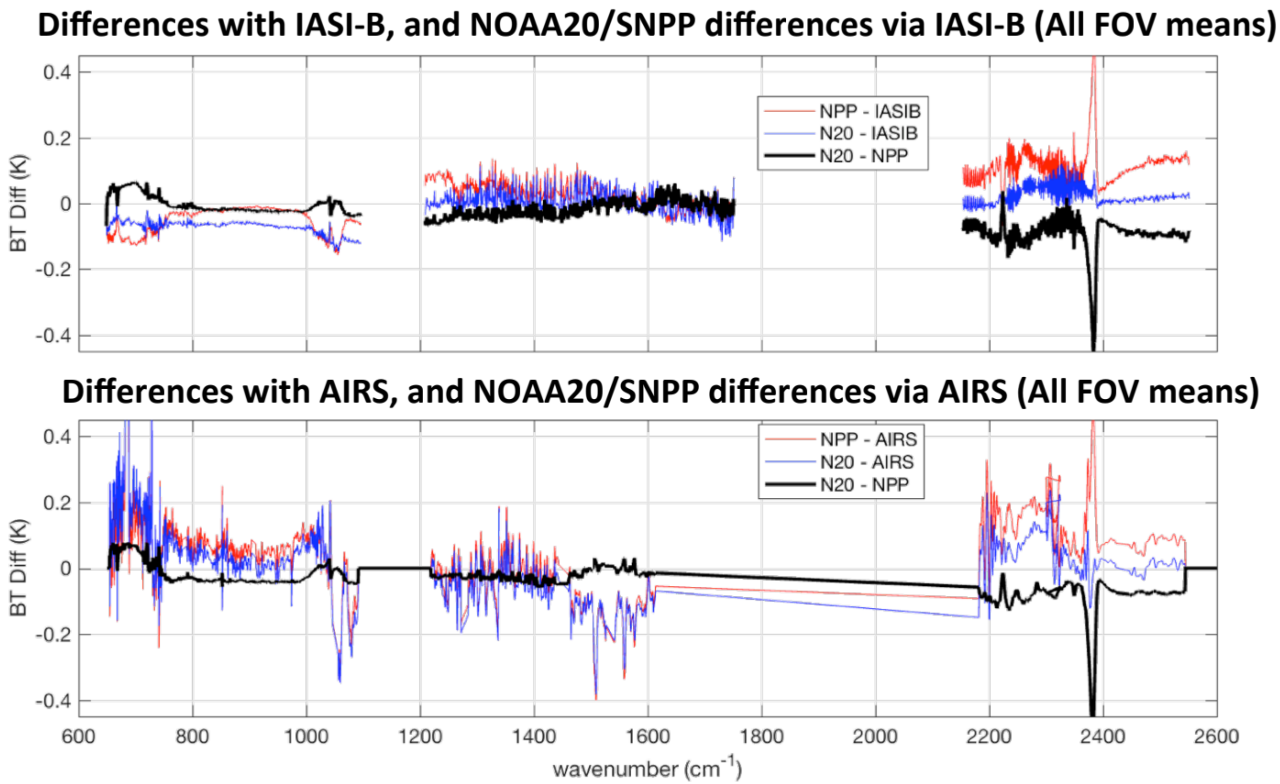
What are the GSICS requirements on Radiative Transfer?

- Assume that IASI and CrIS are within 0.01 and there is absolutely no drift.
- But how is the data used?   You need radiative transfer to project the data into the geophysical parameters you are after.
- The projection efficiency will be a function of the accuracy of the RT.
- At the same time we need truth data - GRUAN-like quality radiosondes allow us to test RT models – which model fits the radiance better?
- And reference quality satellites can test the truth

GSICS Global Space-based Inter-Calibration System

Reference Instruments – IASI and CrIS

Example Cal/Val Result: SNOs with IASI and AIRS

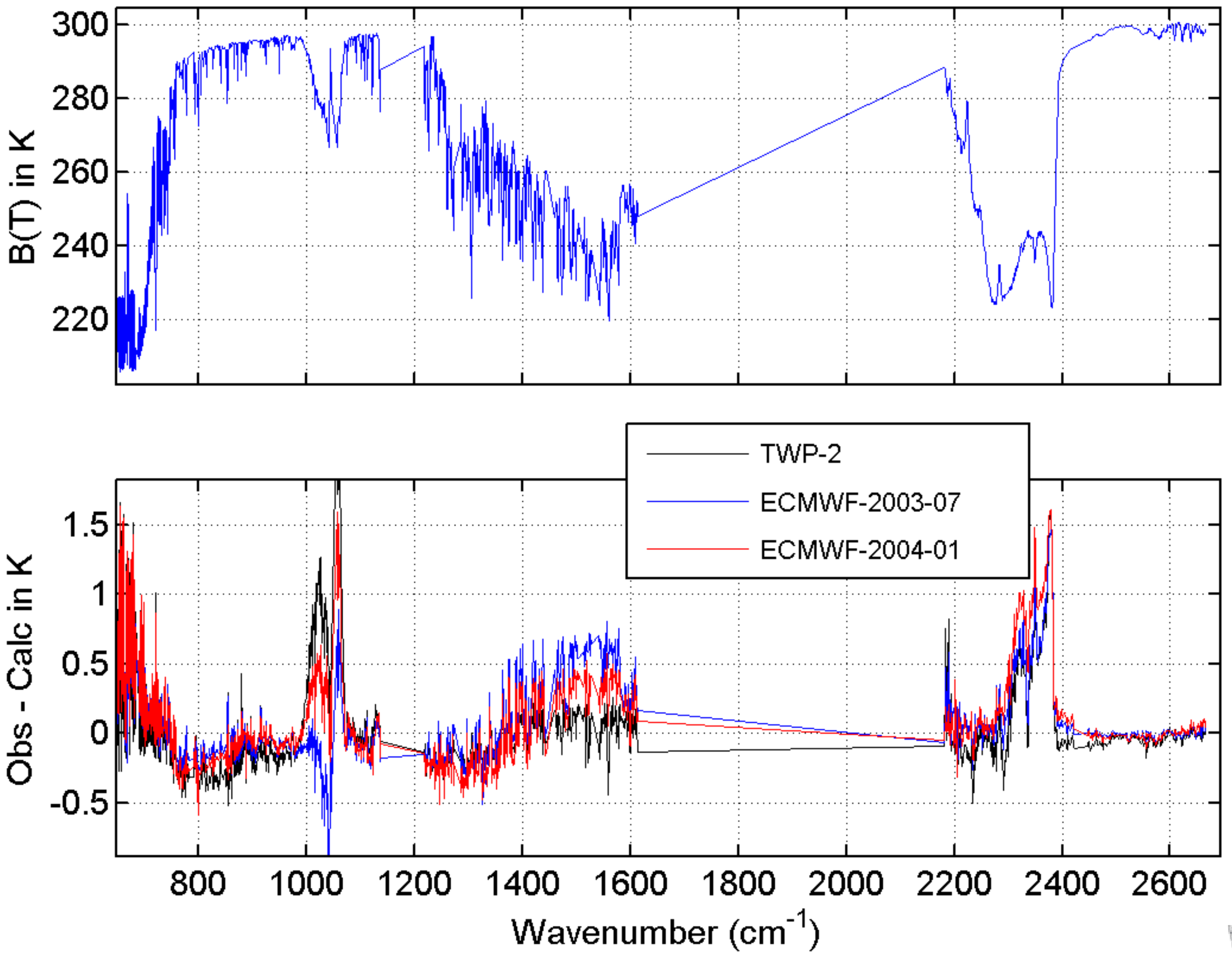


Dave Tobin

- Differences between NOAA20 CrIS and SNPP CrIS are less than 0.1K
- Differences from IASI-B are less than 0.2K, Differences from AIRS are less than 0.4K
- Larger diffs observed for cold SW scenes, but with NOAA20 CrIS agreeing better with IASI and AIRS as compared to SNPP CrIS. Expect some improvements with polarization correction.

Global Space-based Inter-Calibration System

DOE ARM SITE - TWP-2 RT Validation (from Strow)



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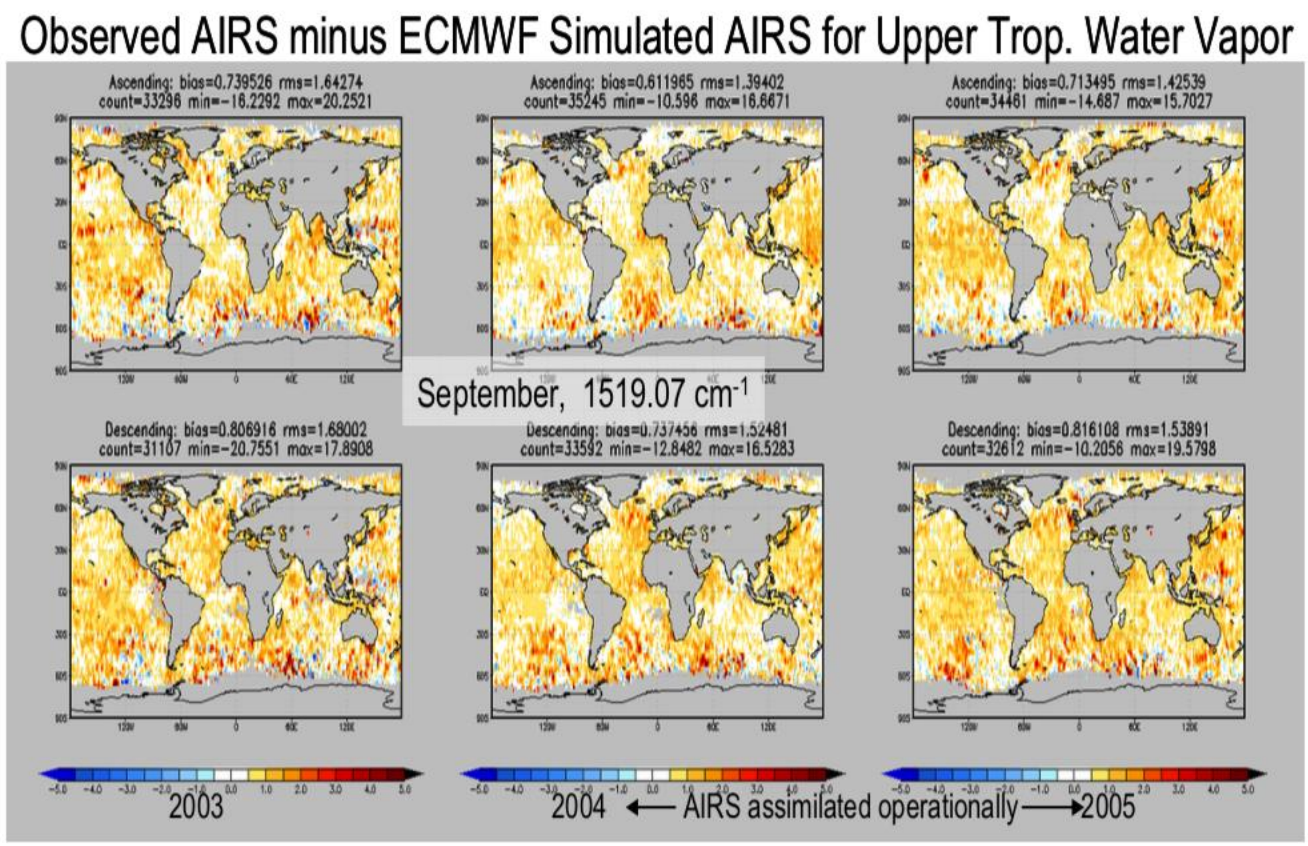
Reference instruments can be used to see which model analysis agree with the observations



GSICS
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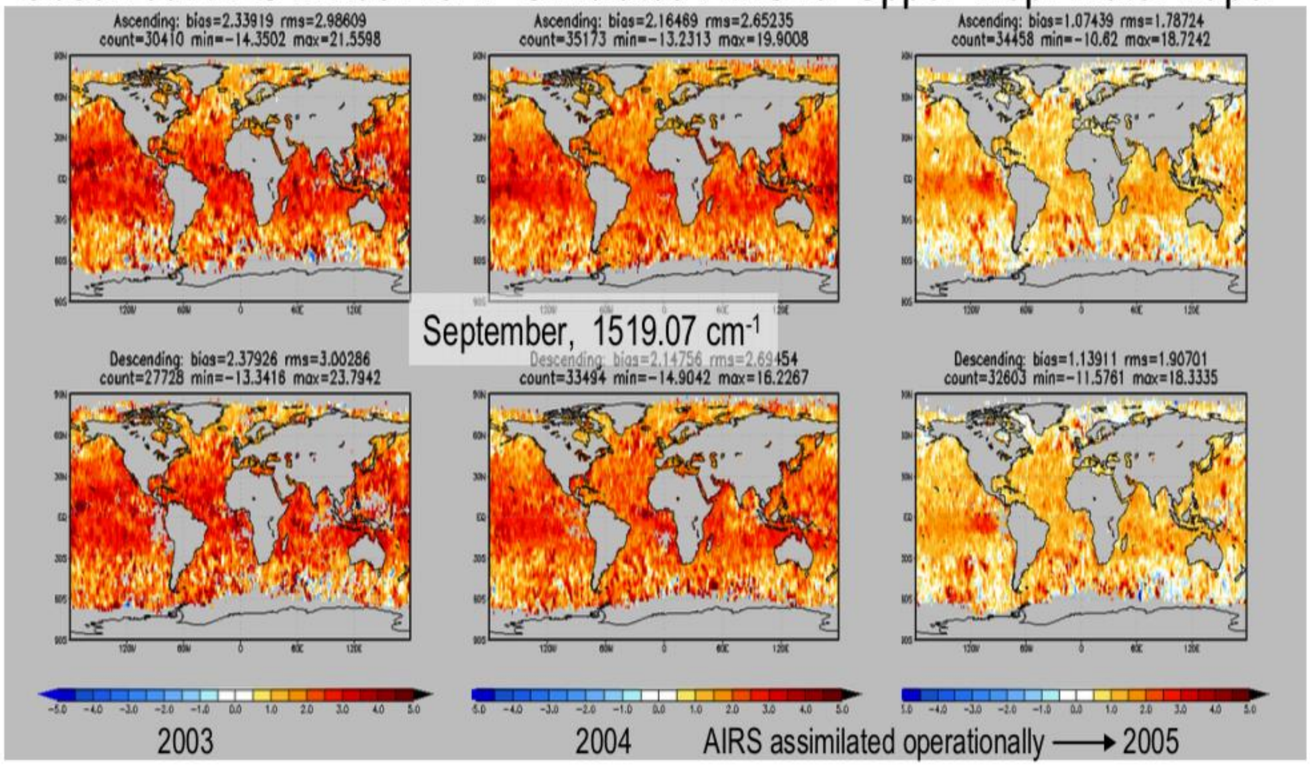
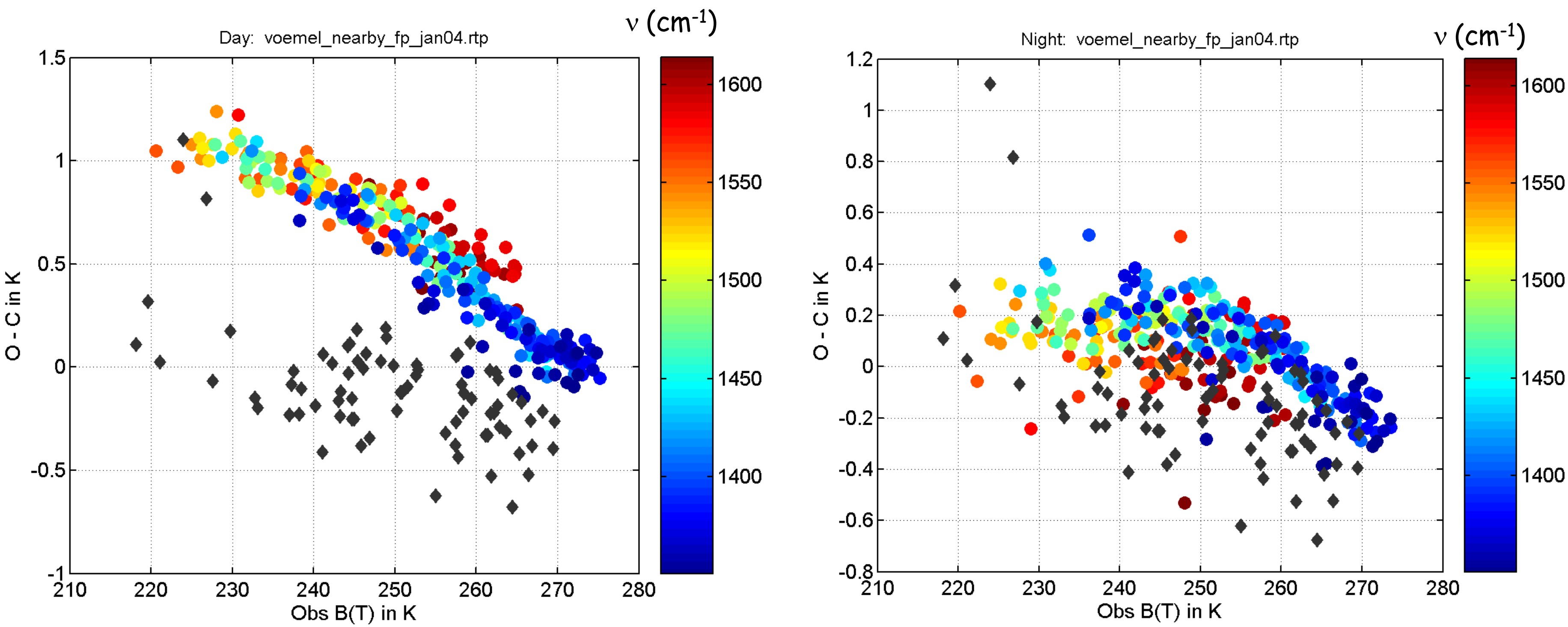
Observed AIRS minus NCEP Simulated AIRS for Upper Trop. Water Vapor



Frost-Point Observations Show Significant Deviations

Frost-Point Observations by H. Voelmer: NOAA Boulder

Represents far fewer observations than RS-90's and inconsistencies day vs night.



Diamonds are CO_2 Biases for channels with similar peaking weighting functions.

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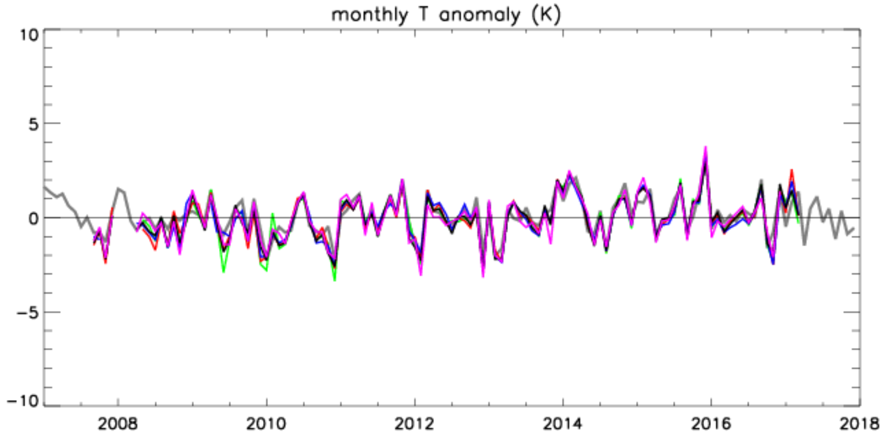
From Larrabee Strow

Lindenberg; ch2 -TMT (middle-troposphere)
GRUAN computed using MW weighting function

GRUAN trend: 0.126 (0.04) K/yr
Microwave trend: 0.092(0.04) K/yr
GPSRO trend: 0.102(0.05) K/yr

Microwave
GRUAN 00Z
GRUAN 06Z
GRUAN 12Z
GRUAN 18Z
GPSRO



Correlation:

Microwave vs. GRUAN corr: 0.90

GPSRO vs. GRUAN corr: 0.94

GPSRO data is provided by Johannes Nielsen at EUMETSAT ROM SAF at DMI

GSICS Global Space-based Inter-Calibration System

So what are the GSICS model requirements

- **GSICS uses radiative transfer models to monitor instrument performance in addition to satellite intercomparisons.**
- **We need "reference" radiative transfer model endorsed by a community of RT experts working to together.**
  - **verified using "reference" satellites observations (GSICS) and " reference" ground truth (GRUAN)**
- **Remember - McNally and Bell:**
  - **We wish to understand the origin of the bias and ideally correct instrument / RT / NWP model at source**
  - **It was not just the instrument -- includes the RT.**