Validation and Calibration of MSU/AMSU Measurements and Radiosonde Observations Using GPS RO Data for Improving Stratospheric and Tropospheric Temperature Trend Analysis

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Outline

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

Overview

- Goals/Challenges:

1. **Quantify the quality of RO data, and use GPS RO data to help identify a set of operational radiosonde network**
2. **Using GPS RO data in the stratosphere and the identified radiosondes in the troposphere to validate MSU and AMSU measurements from RSS, UAH, and NESDIS**
3. **Generating long-term stratospheric and tropospheric climate quality temperature datasets by reprocessing nine years of AMSU/MSU data from 2001 to 2009**

Challenges of defining Climate Trend using MSU/AMSU data

Satellites: Comparability and Reproducibility ?

1) Not designed for climate monitoring

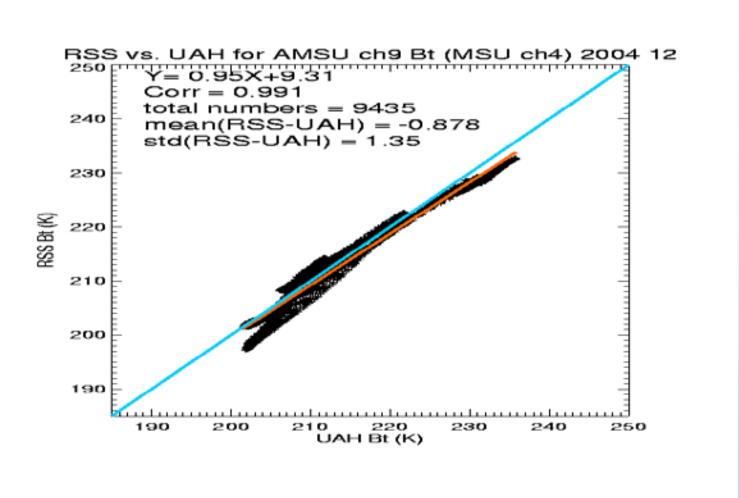
2) Changing platforms and instruments

(No Comparability)

a. Satellite dependent bias, b. geo-location dependent bias, c. orbital drift dependent bias

3) Different processing/merging method lead to different trends (RSS vs. UAH).

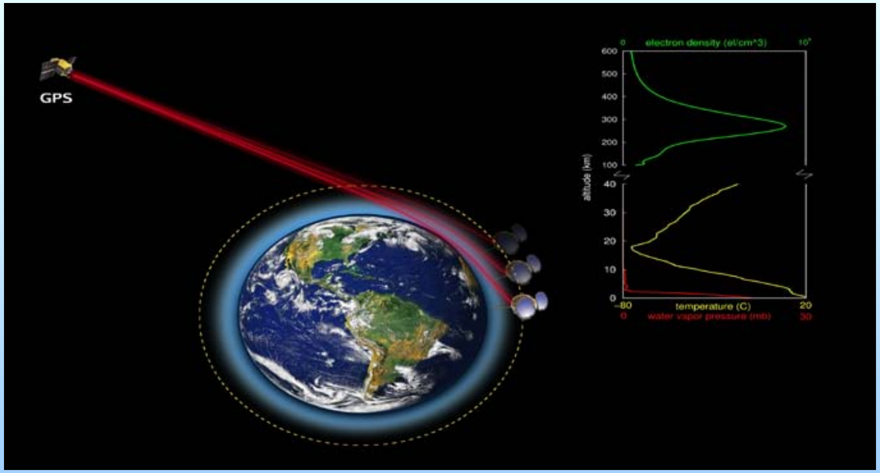
(No Reproducibility)

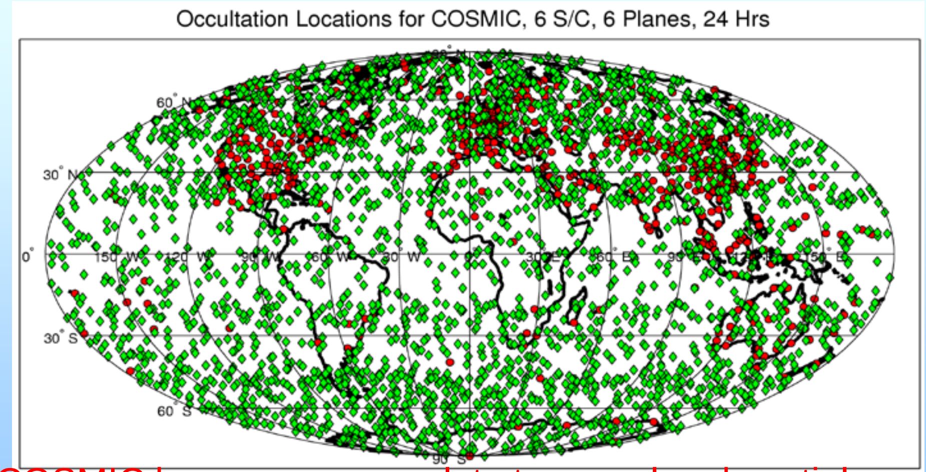


Overview

Characteristics of GPS RO Data

- Measure of time delay: no calibration is needed
- Requires no first guess sounding
- Uniform spatial/temporal coverage
- High precision, no geo- location dependent bias
- No satellite- to- satellite bias
- Independent of processing procedures





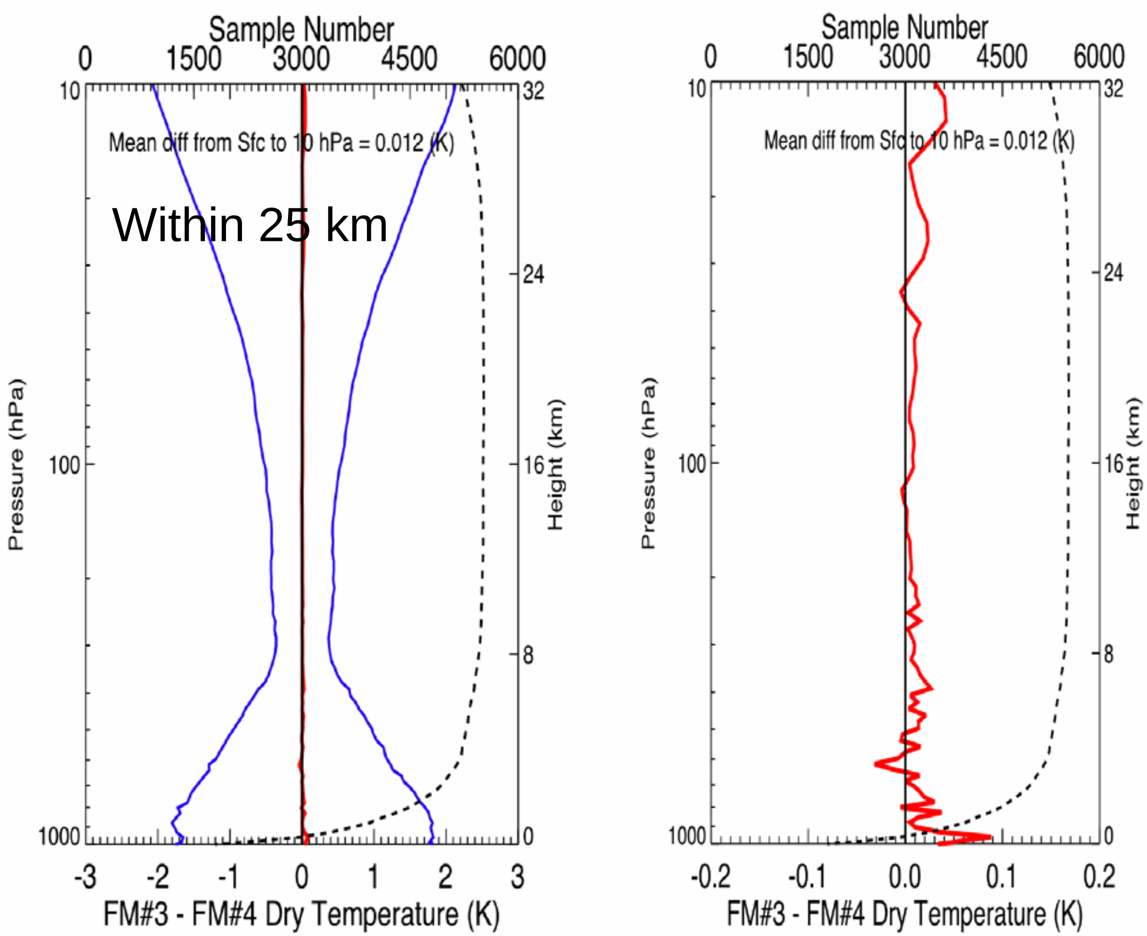
COSMIC has a more complete temporal and spatial global coverage

Overview

- Source Data –
- CHAMP data (from Jan. 2002 to Dec. 2008) from UCAR CDAAC,
- COSMIC data (from June 2006 current) from UCAR CDAAC
- MSU/AMSU data from NESDIS ($NESDIS_{OPR}$) for NOAA 14 (MSU), NOAA 15 (AMSU), NOAA 16 (AMSU) and NOAA 18 (AMSU) from 2002 to 2009
- Aqua AMSU from 2002 to current, RSS, UAH and $NESDIS_{NEW}$ data from their related FTP sites
- Global radiosonde data from NCAR archive, and
- ECMWF data from NCAR archive.
- Deliverables:
- High quality temperature records in both troposphere and stratosphere
- Traceable standards for GPS RO metadata, including the change of observing practices, the bending angle, phase, amplitude, and time delay of radio signals.
- Identified radiosonde sets.
- ECVs addressed:
- Temperature records in both troposphere and stratosphere
- Current/expected user communities:
- NOAA, NASA, NCEP, ECMWF, national/international climate/satellite community

Approaches

I. Quantify the quality of RO data



Dry temperature difference between FM3-FM4 receivers

Using FM3-FM4 pairs in early mission

Need to quantify all COSMIC-COSMIC pairs

Precision < 0.05 K

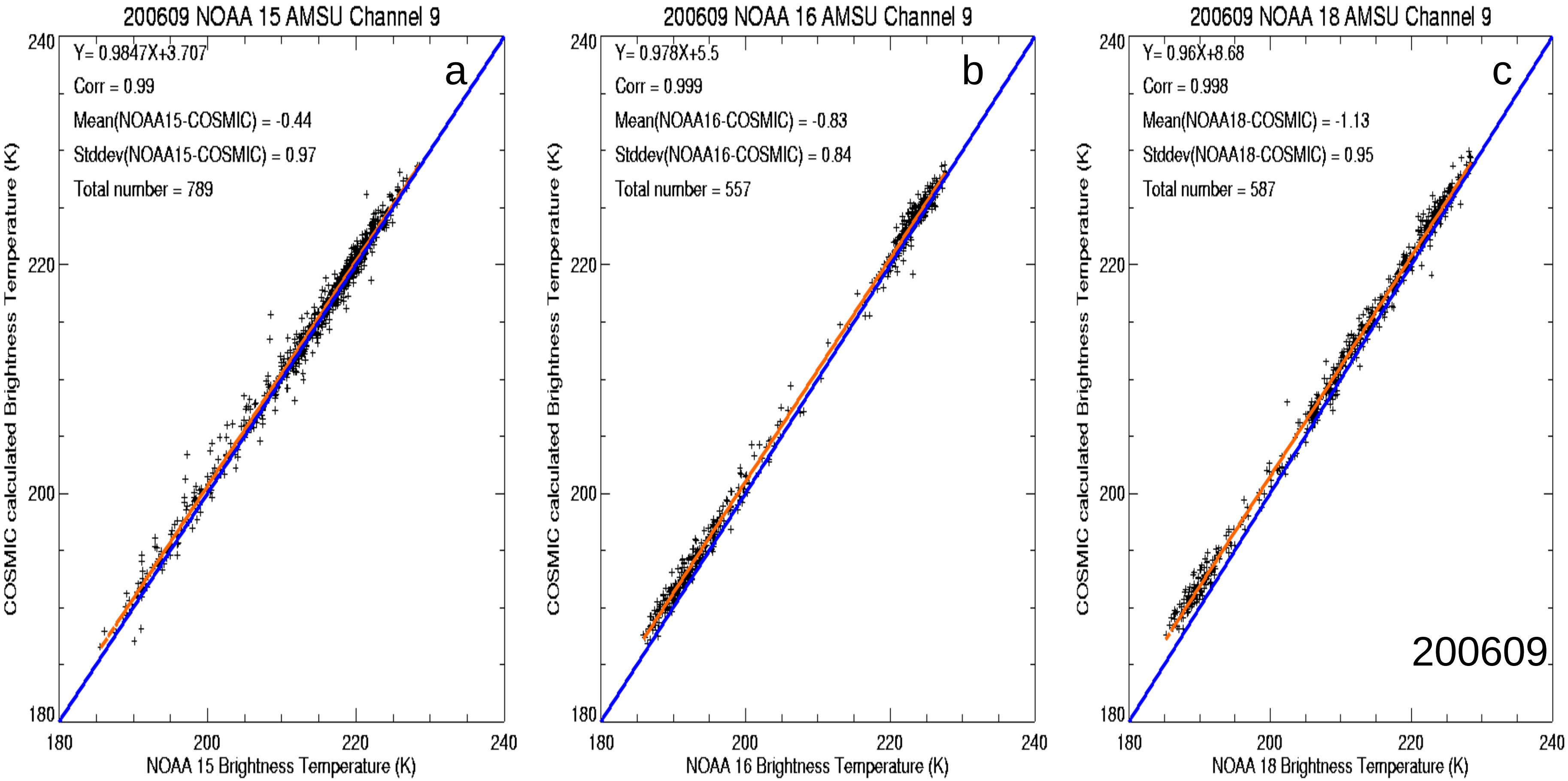
(Ho et al., TAO, 2009)

(Anthes et al., BAMS, 2008)

Approaches

II. Use RO-simulated MSU/AMSU Tbs to calibrate/validate MSU/AMSU Tbs

Resolve satellite dependent bias



N15, N16 and N18 AMSU calibration against COSMIC (Ho et al, TAO/COSMIC special issue 2009)

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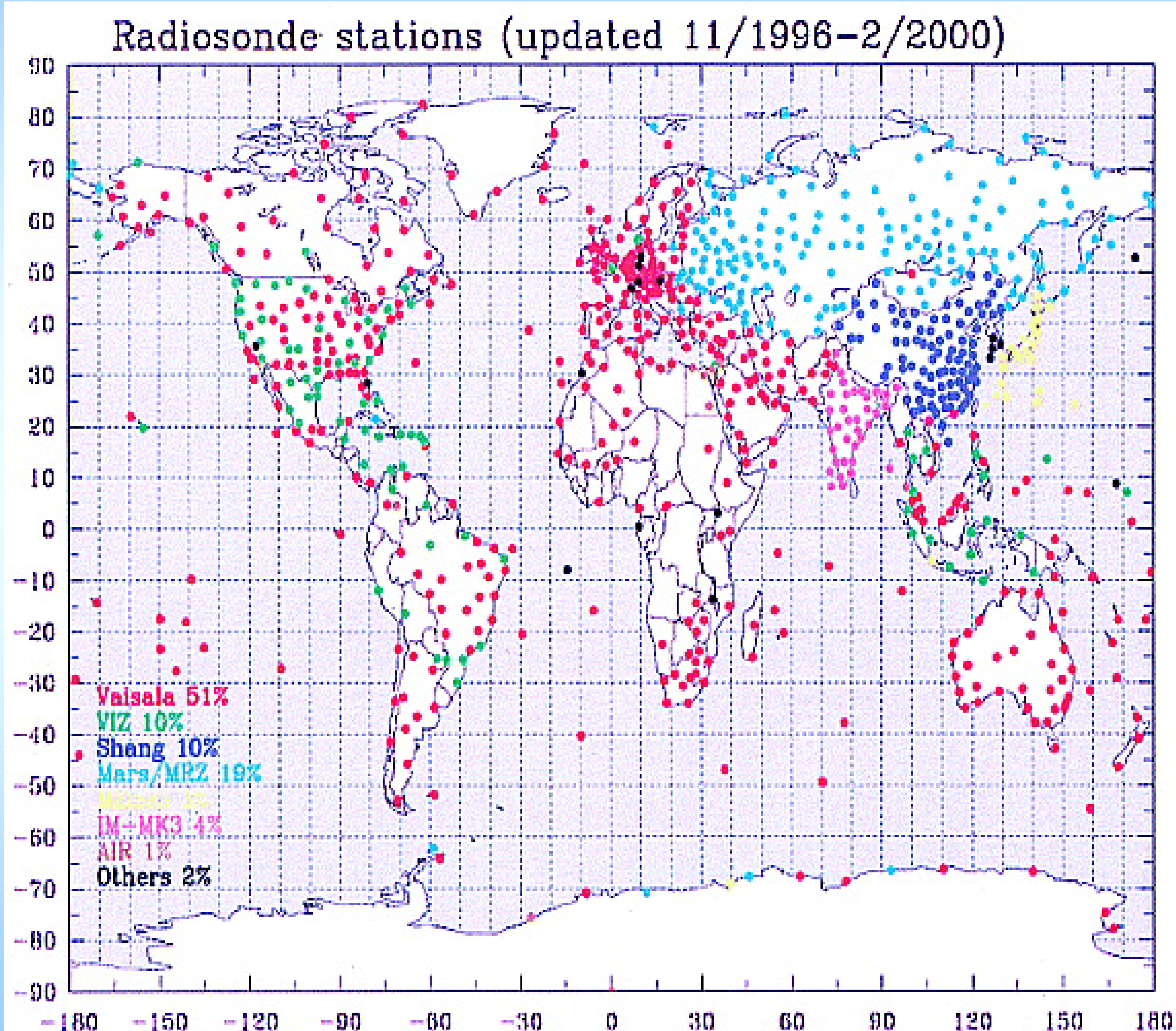
Approaches

III. Using RO data to assess the quality of radiosonde data



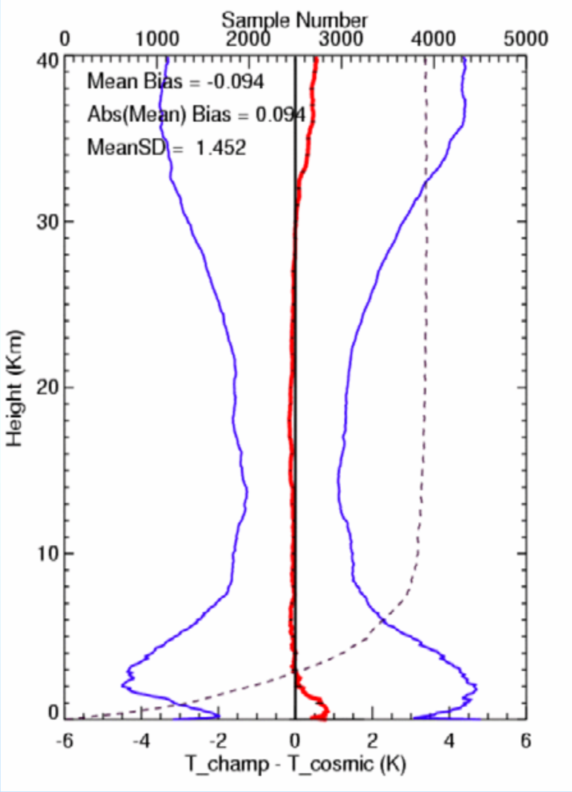
Region	Sonde Type	Matched Sample
Russia	AVK-MRZ	2000 (20%)
China	Shang	650 (6.1%)
USA	VIZ-B2	600 (5.9%)
Others	Vaisala	3140 (30%)

Results/Accomplishments

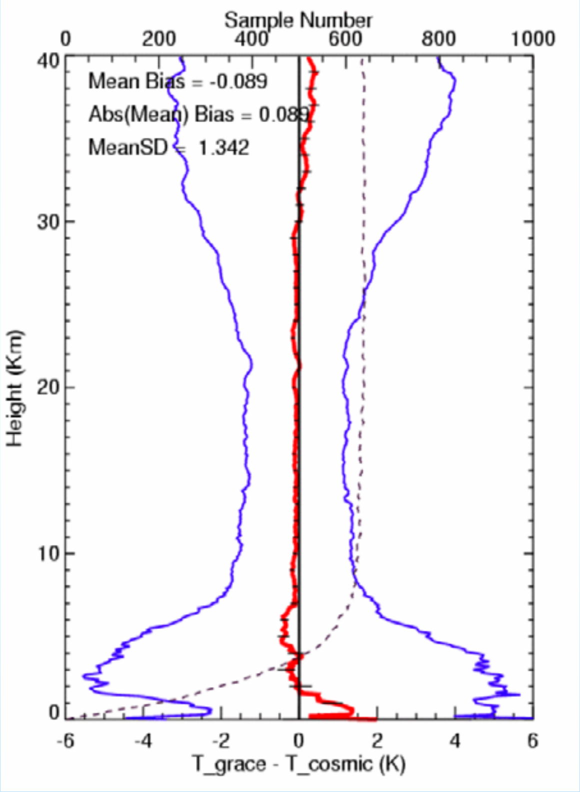
I. Quantify the Precision/Accuracy/Stability of RO data

Global COSMIC, CHAMP, SAC-C, GRACE-A, Metop/GRAS Comparison

Within 60 Mins, and 50 Km



CHAMP-COSMIC
2007-2008



GRACE-COSMIC
2006

- Comparison of measurements between old and new instrument
- CHAMP launched in 2001
- COSMIC launched 2006
- GRACE launched 2002

Don’t need to have stable calibration reference

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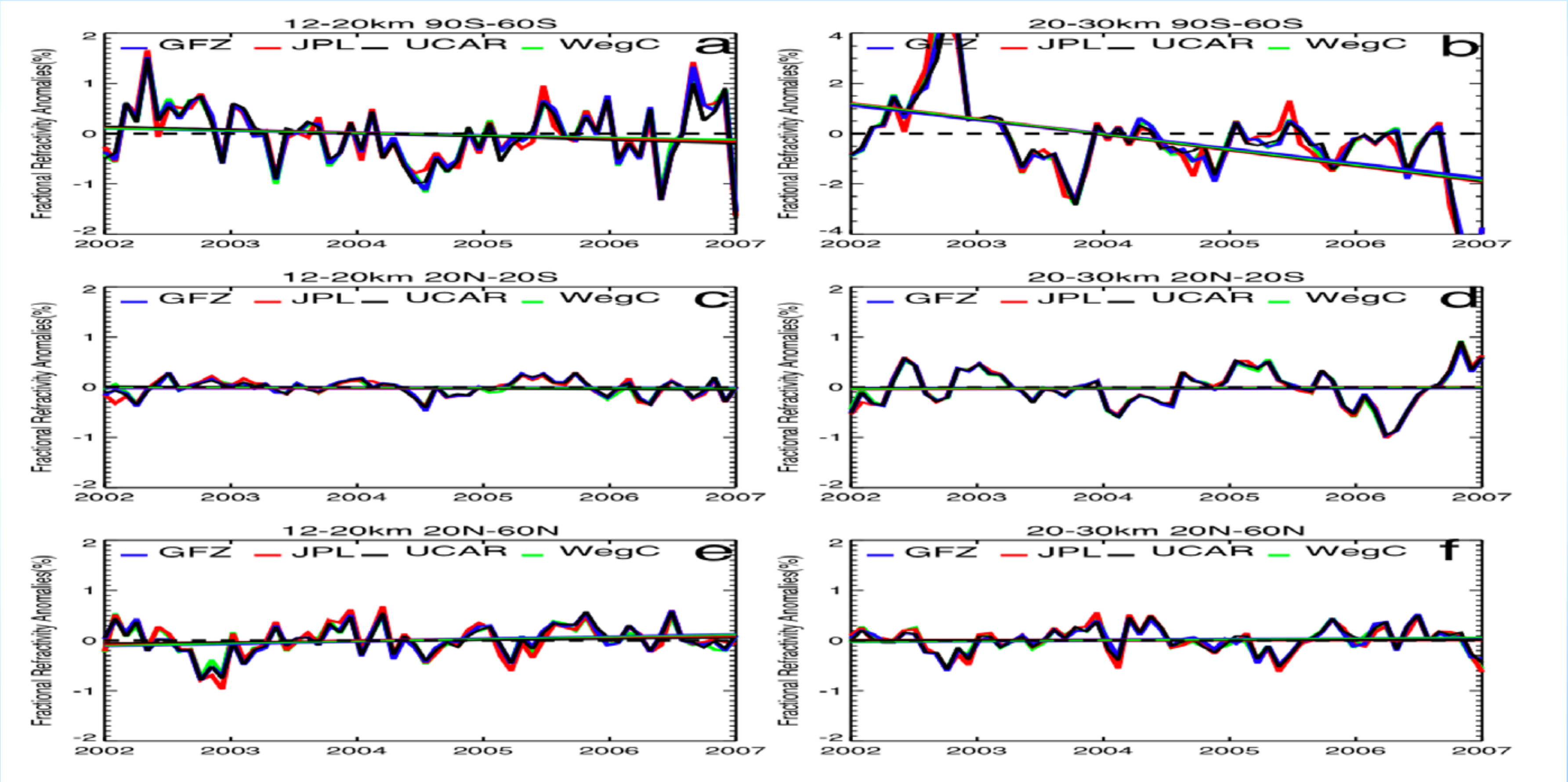
Results/Accomplishments

II. Quantify the Reproducibility of RO data, the uncertainty of RO data

Comparisons RO data processed by GFZ, JPL, UCAR, and WegC

Fractional Refractivity Anomalies



(Ho et al. JGR, 2009)

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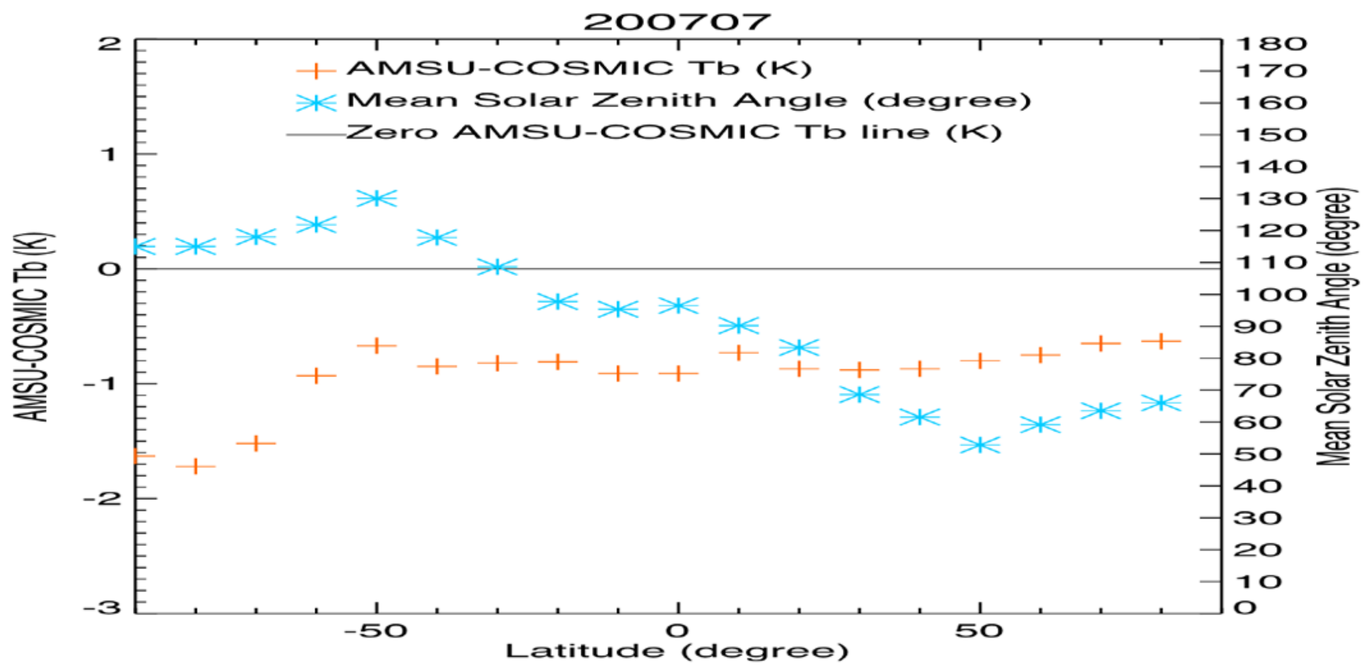
Results/Accomplishments

III. Use of RO Data to Identify the Location/local-time Dependent Brightness Temperature Biases for regional Climate Studies

To resolve geo-location dependent bias



Unbiased, good anchor for radiance assimilation

(Ho et al. OPAC special issue, 2009)

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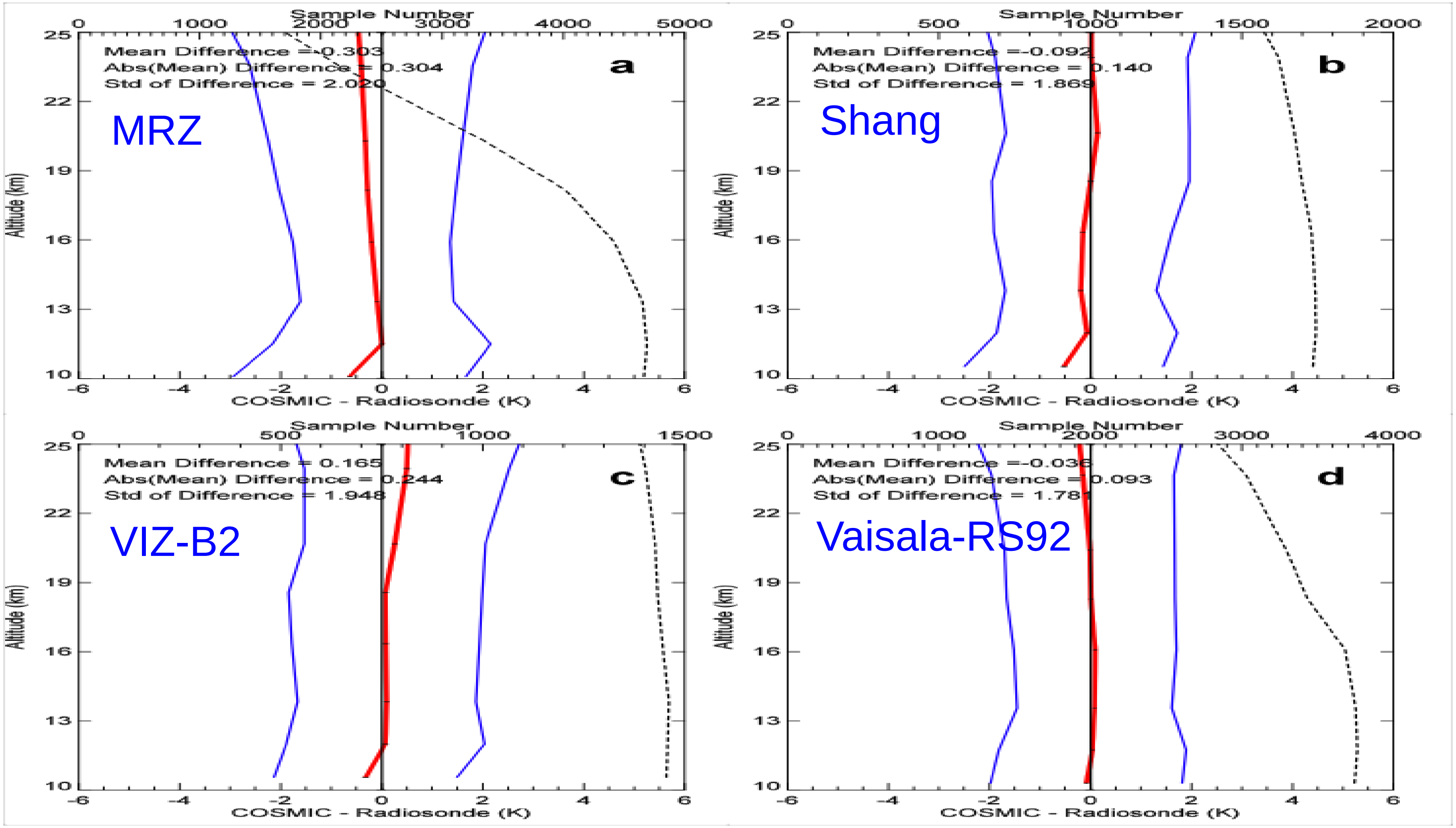
Results/Accomplishments

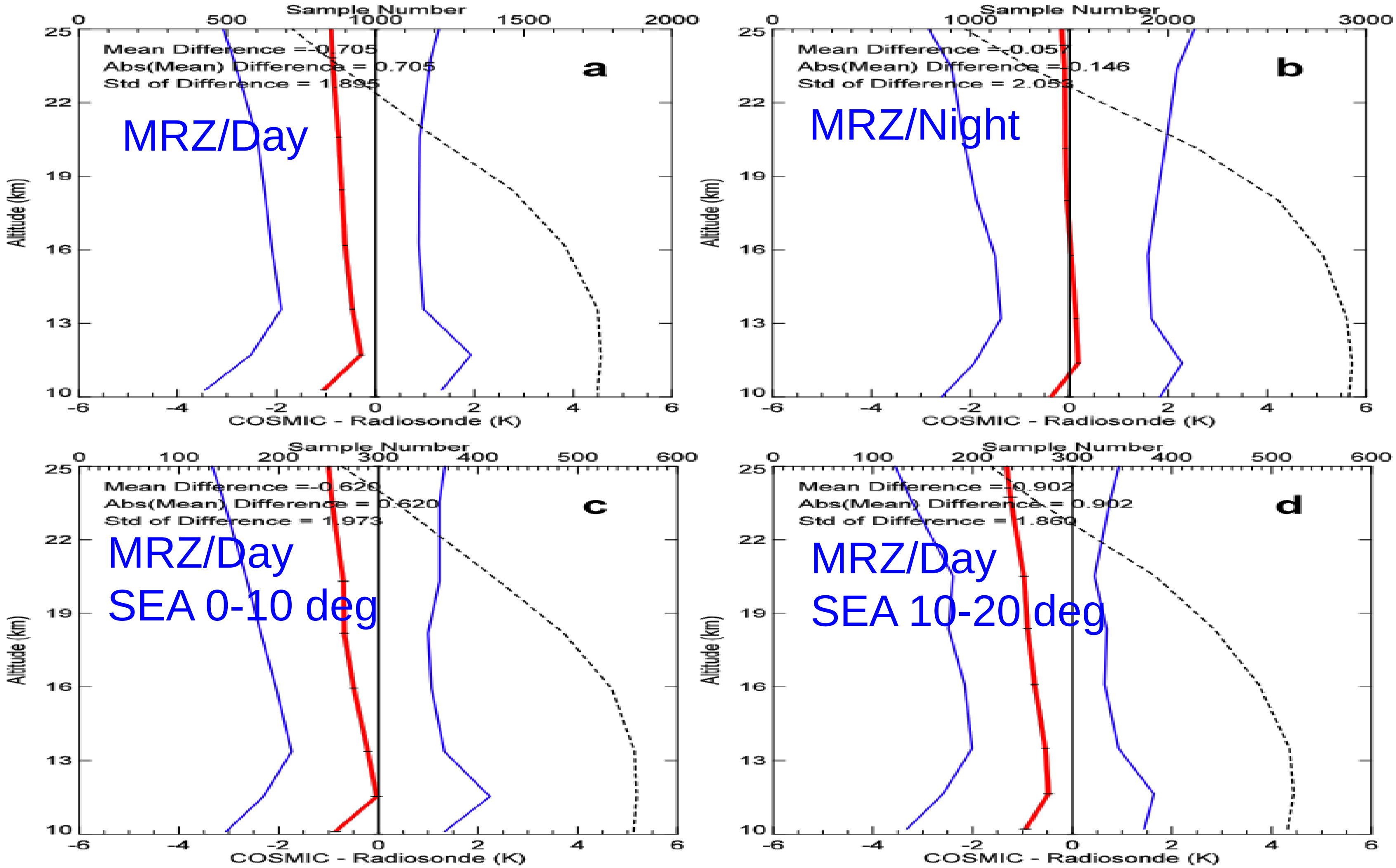
IV. Using RO data to assess the quality of radiosonde data



(He and Ho, GRL 2009)

Results/Accomplishments

IV. Using RO data to assess the quality of radiosonde data

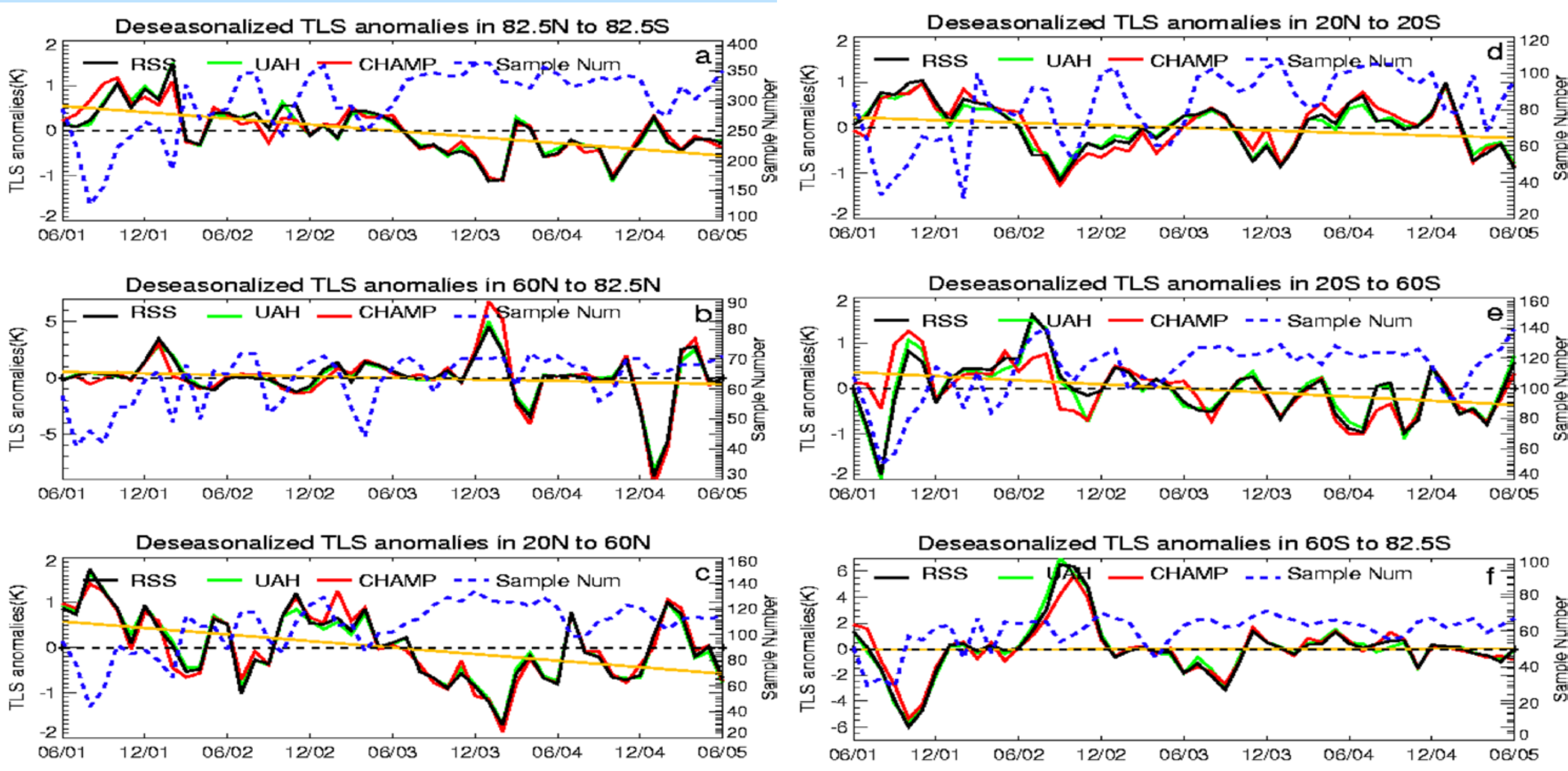


(He and Ho, GRL 2009)

Validation Strategy/Results

I. Comparing RO, RSS, UAH temperature time series from 2001 to 2006

De-seasonalized TLS anomalies



(Ho et al., GRL, 2007)

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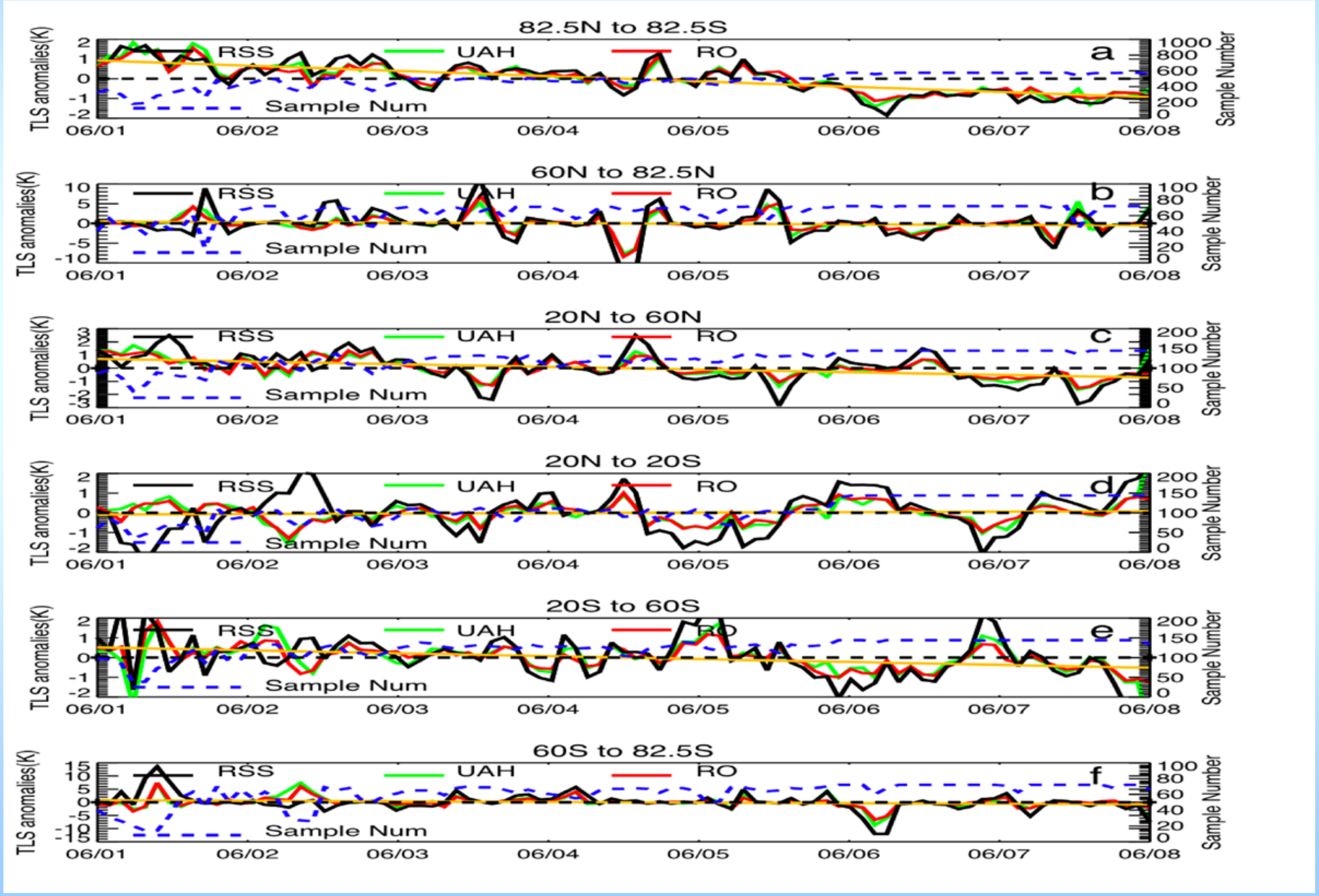
Validation Strategy/Results

II. Comparing RO, RSS, UAH temperature time series from 2001 to 2008

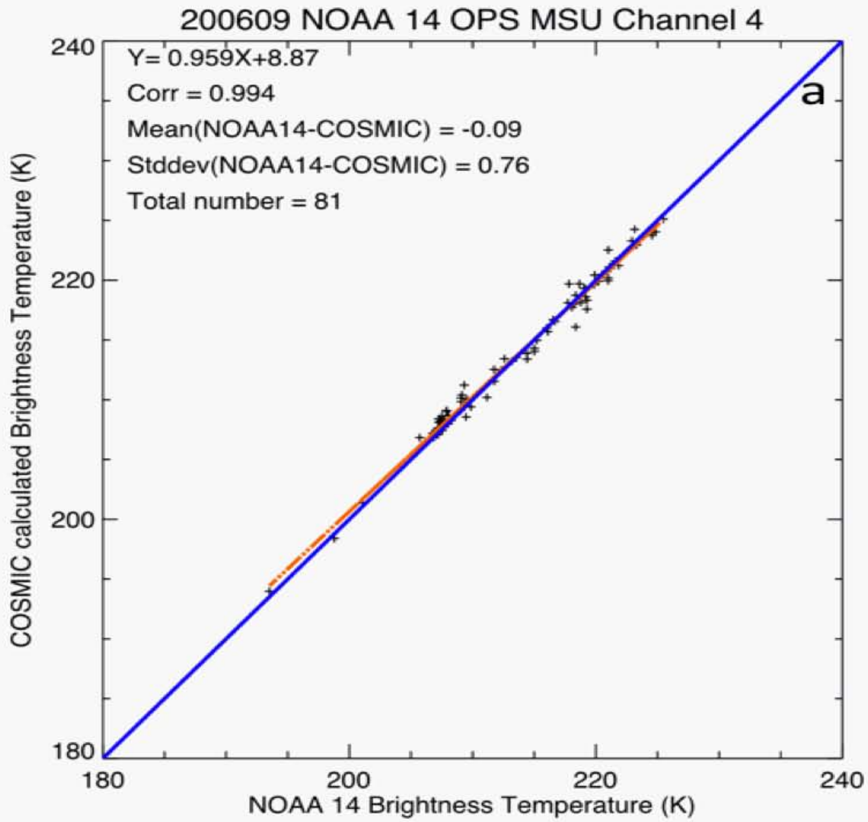
De-seasonalized TLS anomalies



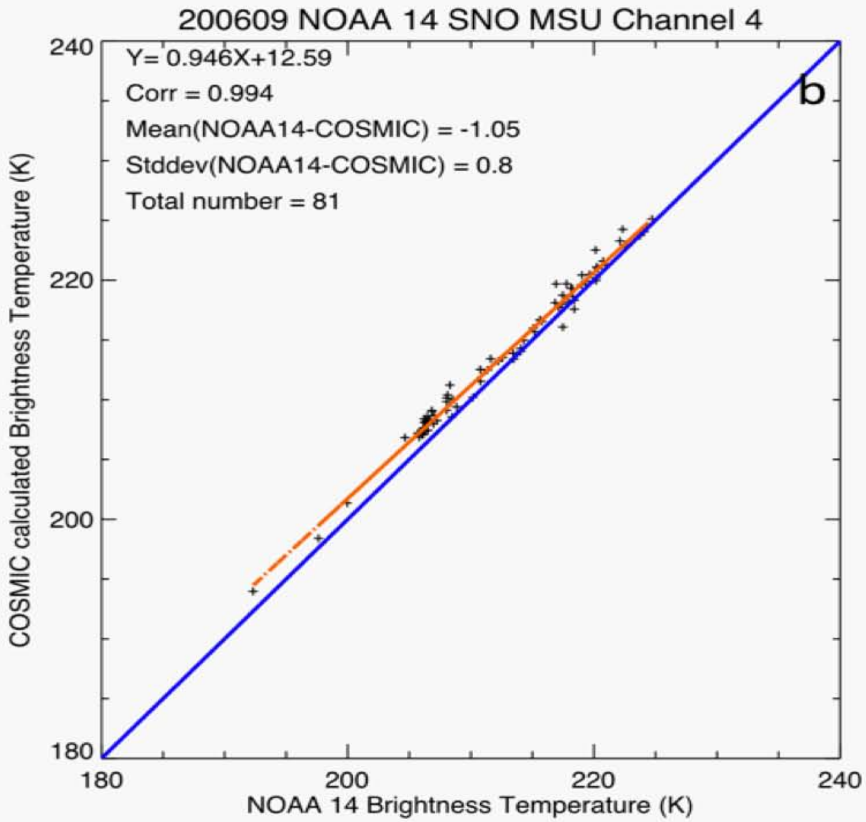
Validation Strategy/Results

III. Comparisons of COSMIC/CHAMP data with NESDIS_{NEW} MSU data and NESDIS_{OPR} MSU data

NOAA operational results



SNO results



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Product Maturity

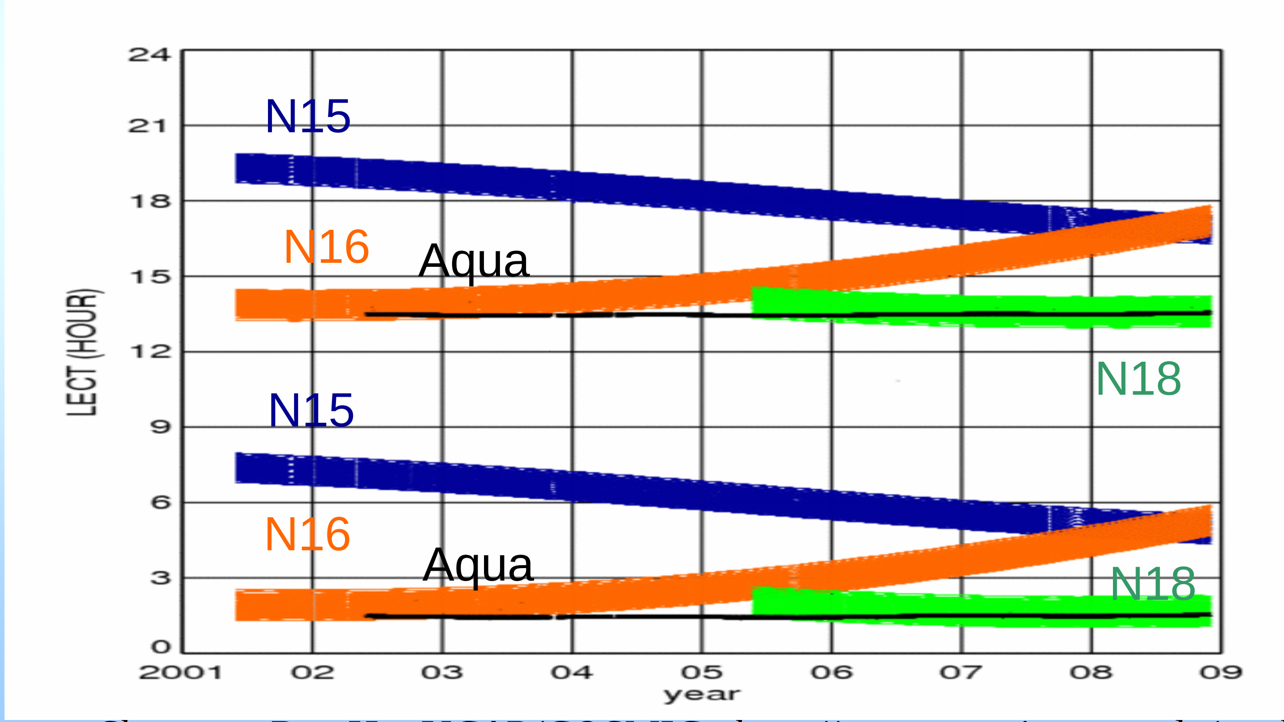
<Please fill in cells as appropriate; Best guess/estimates acceptable; See Example>

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

- current or possible future problems:
- SNO issues
- Identify orbital drift effect on MSU/AMSU temperature
- Approaches to get around or mitigate the problem:

- COSMIC/CHAMP has the full diurnal coverage which can be used to identify orbital drift effect on MSU/AMSU.
- Aqua AMSU has no drift.



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Research- to- Operations or Delivery Plan

- MSU/AMSU vs. COSMIC/CHAMP monthly calibration coefficients from 2001 to 2009
- Identified radiosodnes sets from 2001 to 2009
- NESDID, RSS, and UAH data

1) Applying SNO to calibrated MSU4 BTs
2) Applying SNO to calibrated MSU2 and MSU3 BTs
3) Applying the calibrated MSU4 BTs to calibrate overlapped 9 years of MSU/AMSU BTs
4) Applying the calibrated MSU2 and MSU3 BTs and recalibrating 9 years of MSU/AMSU data
5) Documenting the GPS RO metadata and making them available to the public
6) Documenting all the comparison and evaluation procedures and temperature records

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Schedule

	Aug. 2009- Oct. 2009	Nov. 2009 – Jan. 2010	Feb. 2010 – Apr. 2010	May. 2010 – Jul. 2010
1) Applying SNO to calibrated MSU4 BTs				
2) Applying SNO to calibrated MSU2 and 3 BTs				
3) Applying the calibrated MSU4 BTs to calibrate overlapped 9 years of MSU/AMSU BTs				
4) Applying the calibrated MSU2 and MSU3 BTs to SNO and recalibrating 9 years of MSU/AMSU data				
5) Documenting the GPS RO metadata and making them available to the public				
6) Documenting all the comparison and evaluation procedures and temperature records				
7) Delivering all the temperature records to NCDC				

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Resources

- Number of personnel employed for project:
  - PI and a visiting scientist
- Key equipment or observatories used:
  - 8CPU PC, Linux system with 4Tbs
  - Satellite RO and microwave sounding data
- Key collaborating projects or personnel
  - NOAA CCDD and SDS Dr. Cheng-Zhi Zou (NOAA/NESDIS)
- NOAA points-of-contact or collaborators
  - Bill Murray, NCDC, Cheng-Zhi Zou, NESDIS
- Target NOAA Data Center: NCDC