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. **Generating long-term stratospheric and tropospheric climate quality temperature datasets by reprocessing AMSU/MSU data from 2001 to 2010**
2. **Quantify the quality of RO data, and use GPS RO data to help identify a set of operational radiosonde network**
3. **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**
4. **Quantify the trend uncertainty**

Challenges of defining Climate Trend using MSU/AMSU data

Satellites: Comparability and Reproducibility ?

1) Not designed for climate monitoring

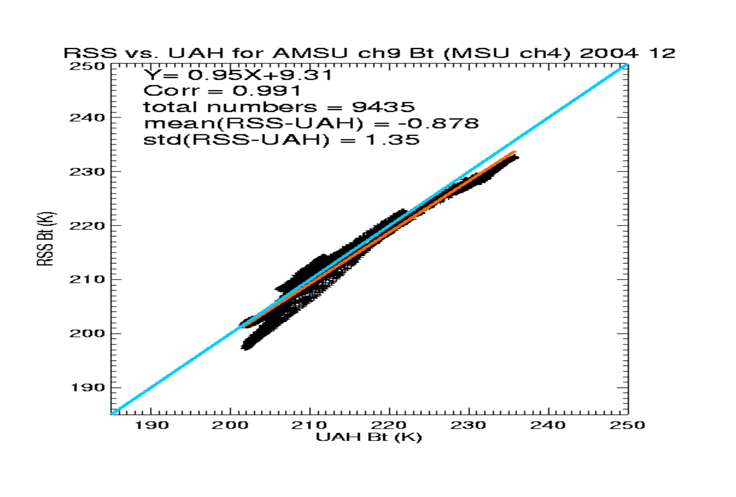
2) Changing platforms and instruments

(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).

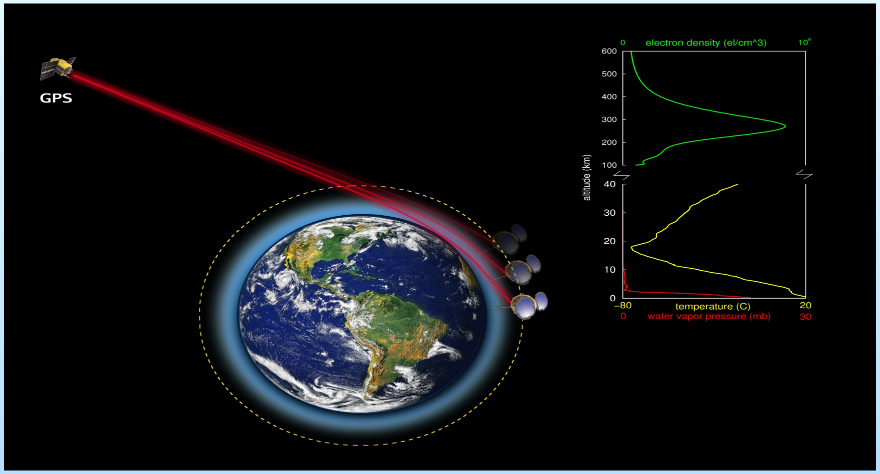
(No Reproducibility)

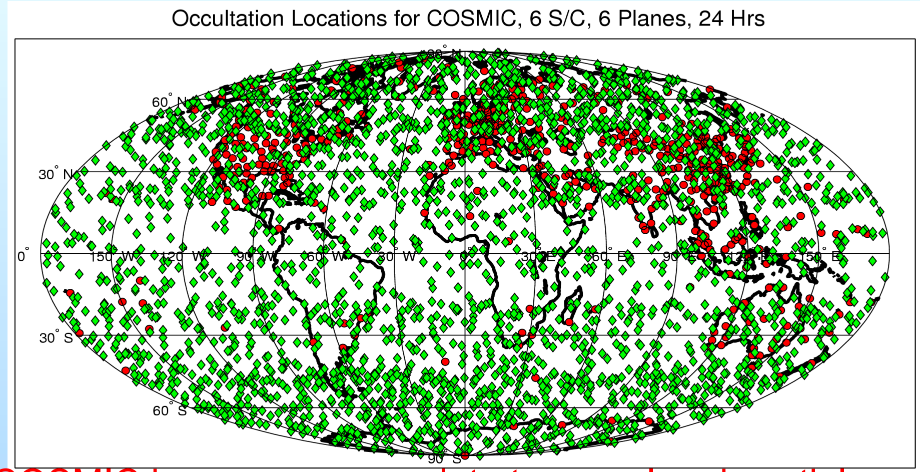


Overview

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





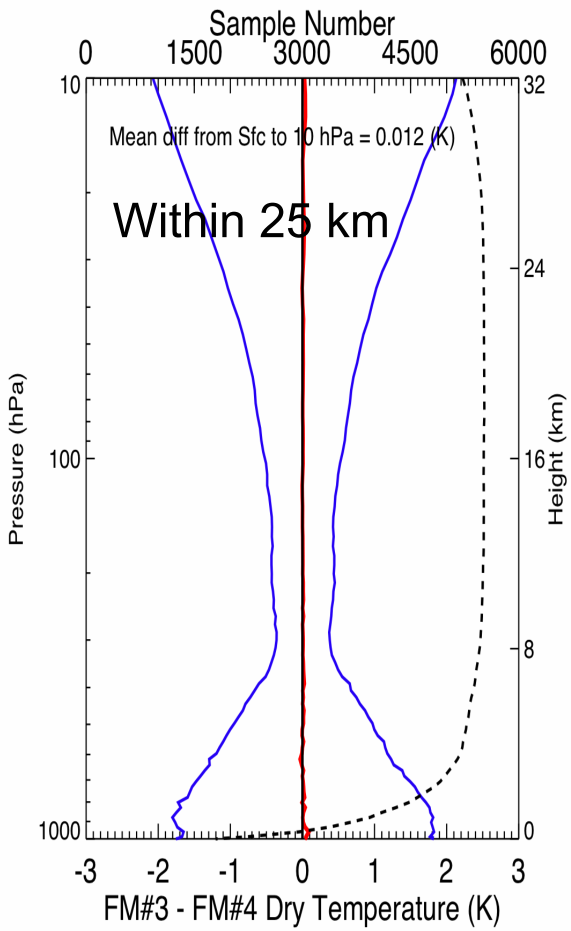
COSMIC has a more complete temporal and spatial global coverage

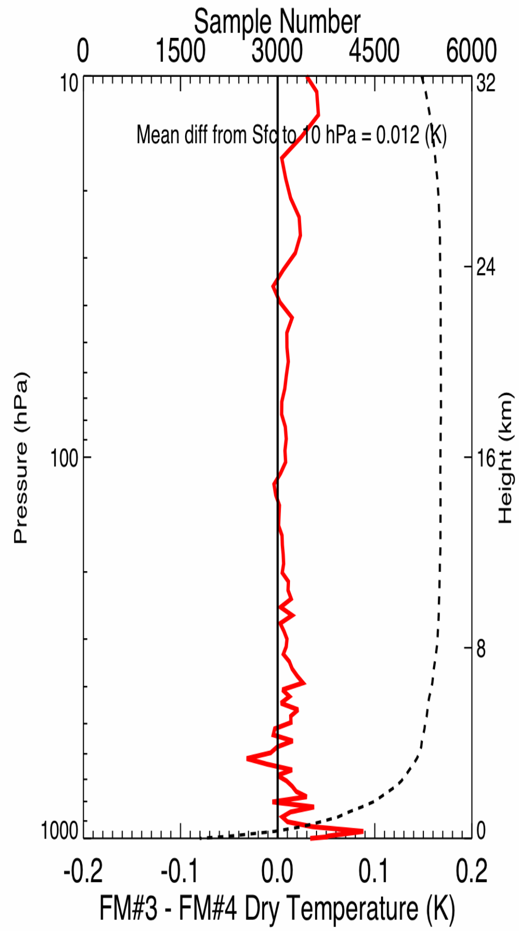
Overview

- 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/Results/Accomplishments

I. Quantify the quality of RO data





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)

Dry temperature difference between FM3-FM4 receivers

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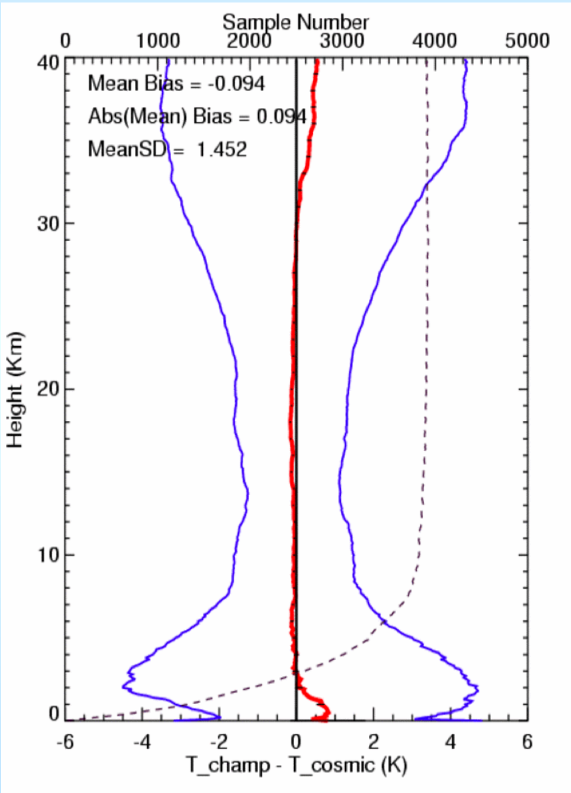
Approaches/Results/Accomplishments

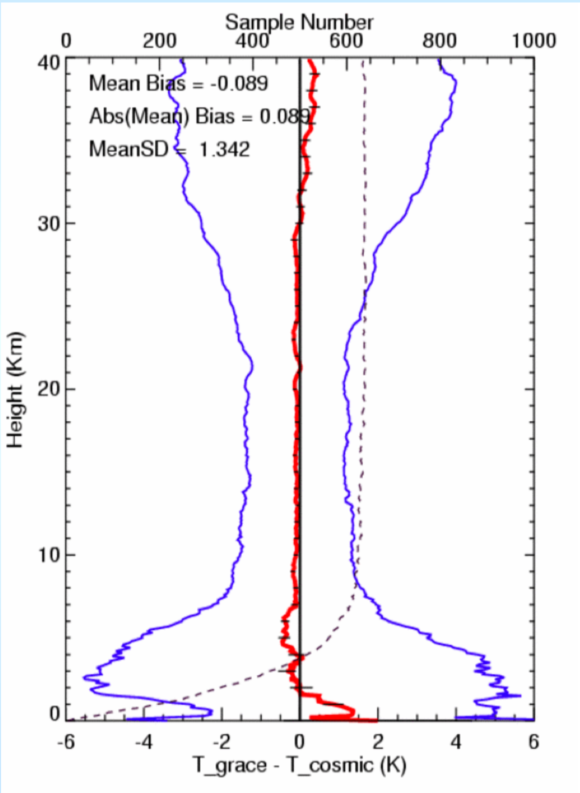
II. Quantify the Precision/Accuracy/Stability of RO data

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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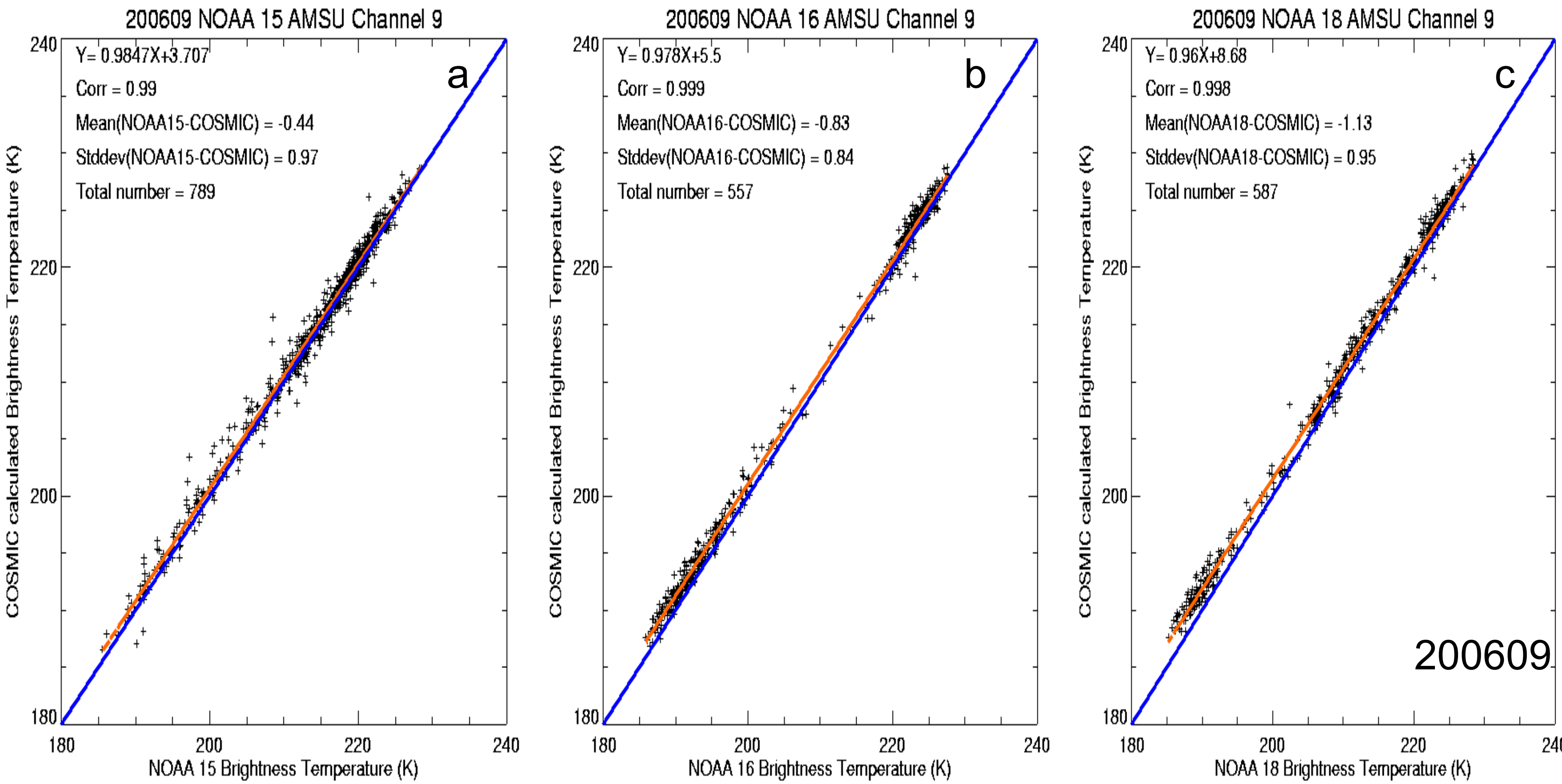
Approaches/Results/Accomplishments

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

Resolve satellite dependent bias

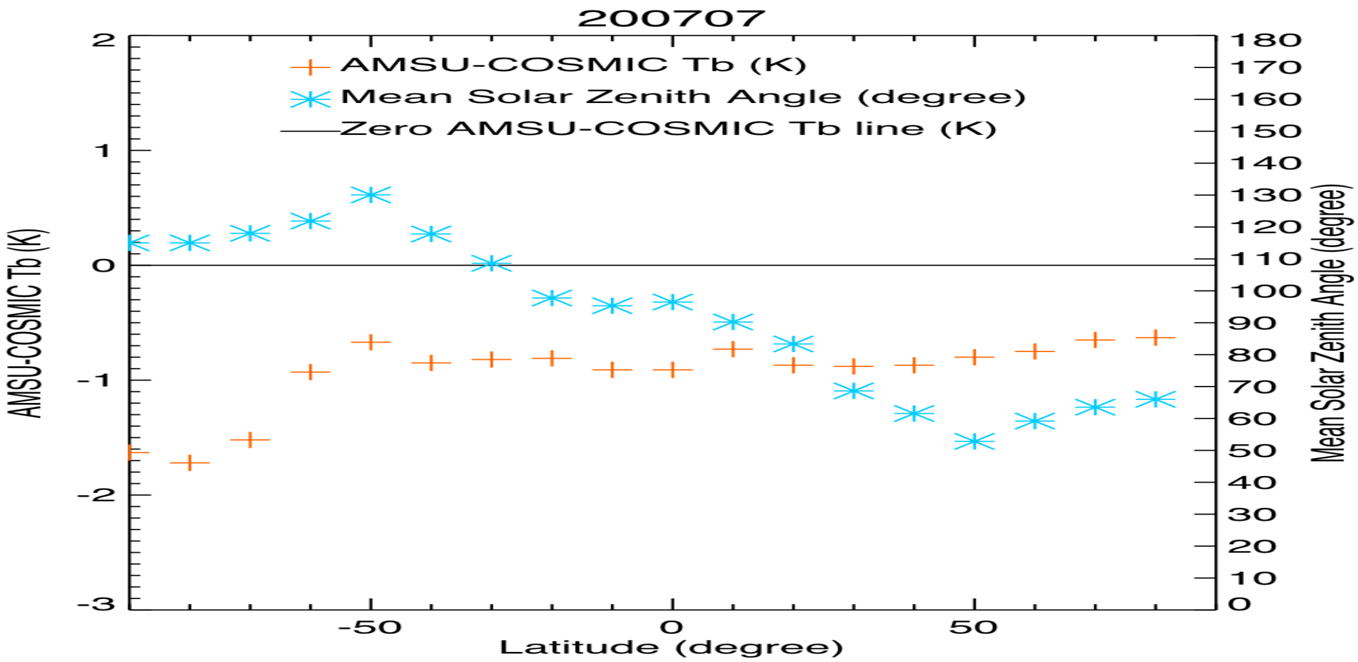


N15, N16 and N18 AMSU calibration against COSMIC (Ho et al, TAO/COSMIC special issue 2009)

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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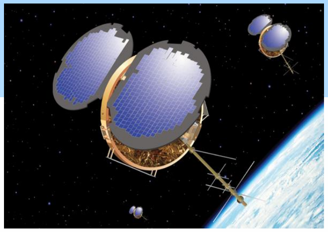
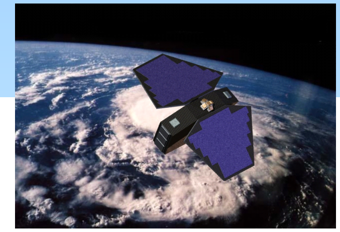
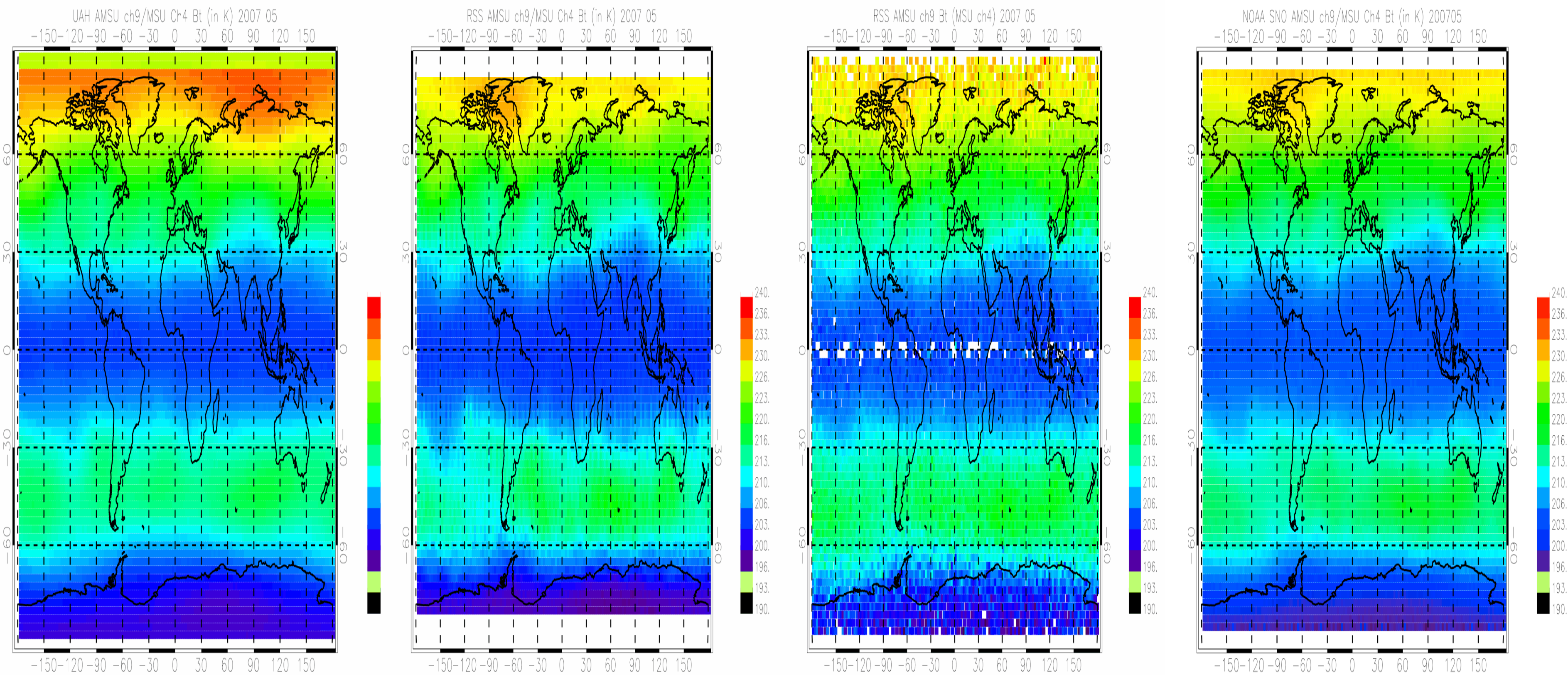


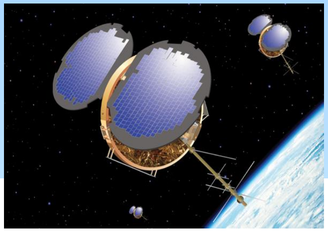
Comparisons of RO-calibrated AMSU with those from RSS, UAH, and SNO



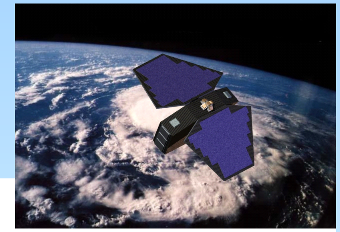
UAH **RSS** **RO_AMSU** **SNO**

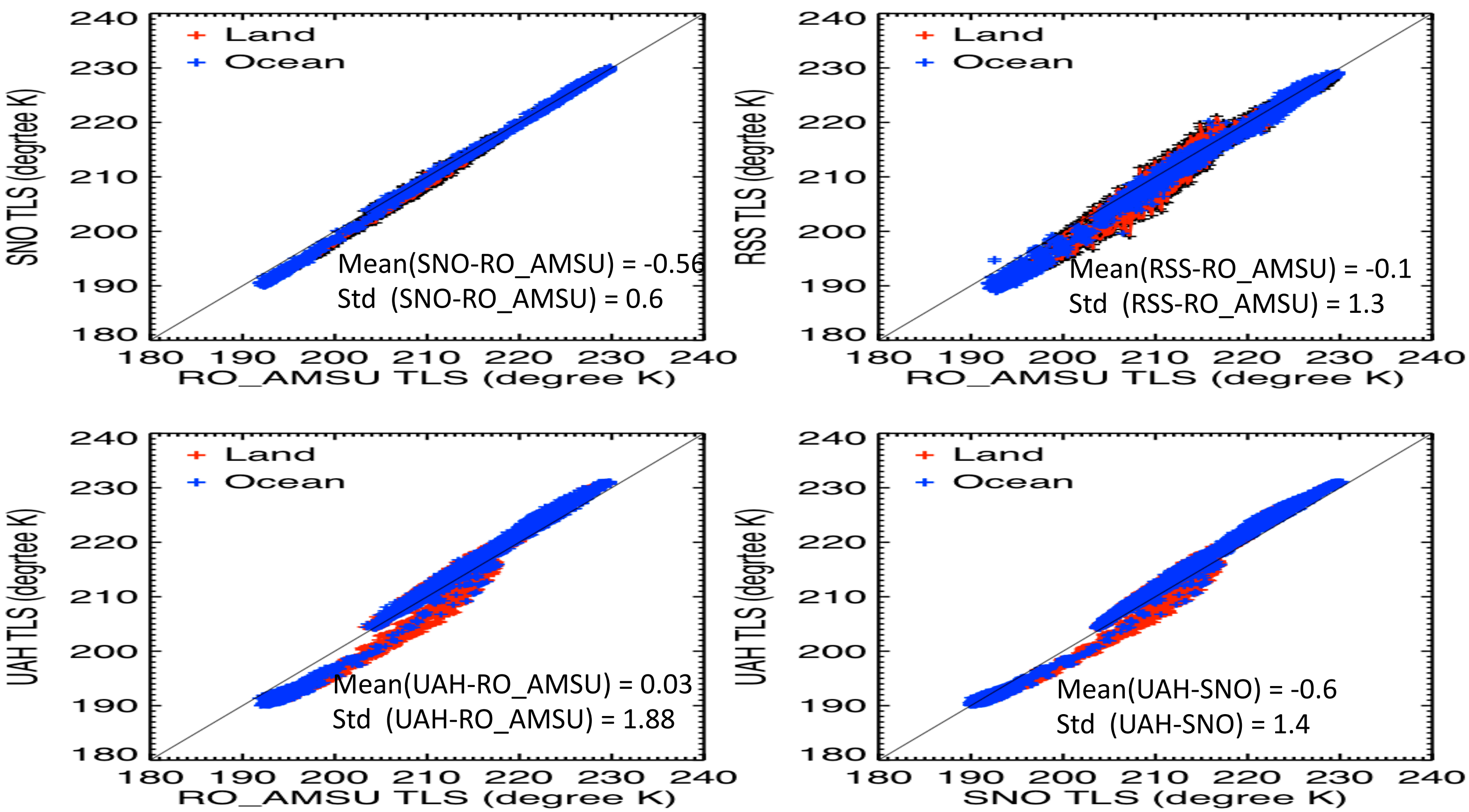


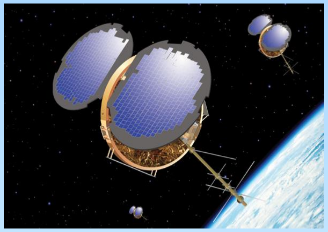
200705 TLS



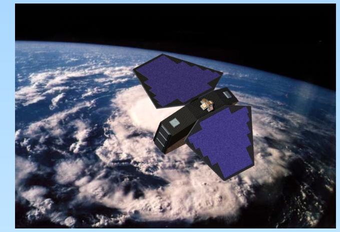
Comparisons over Lands and Oceans

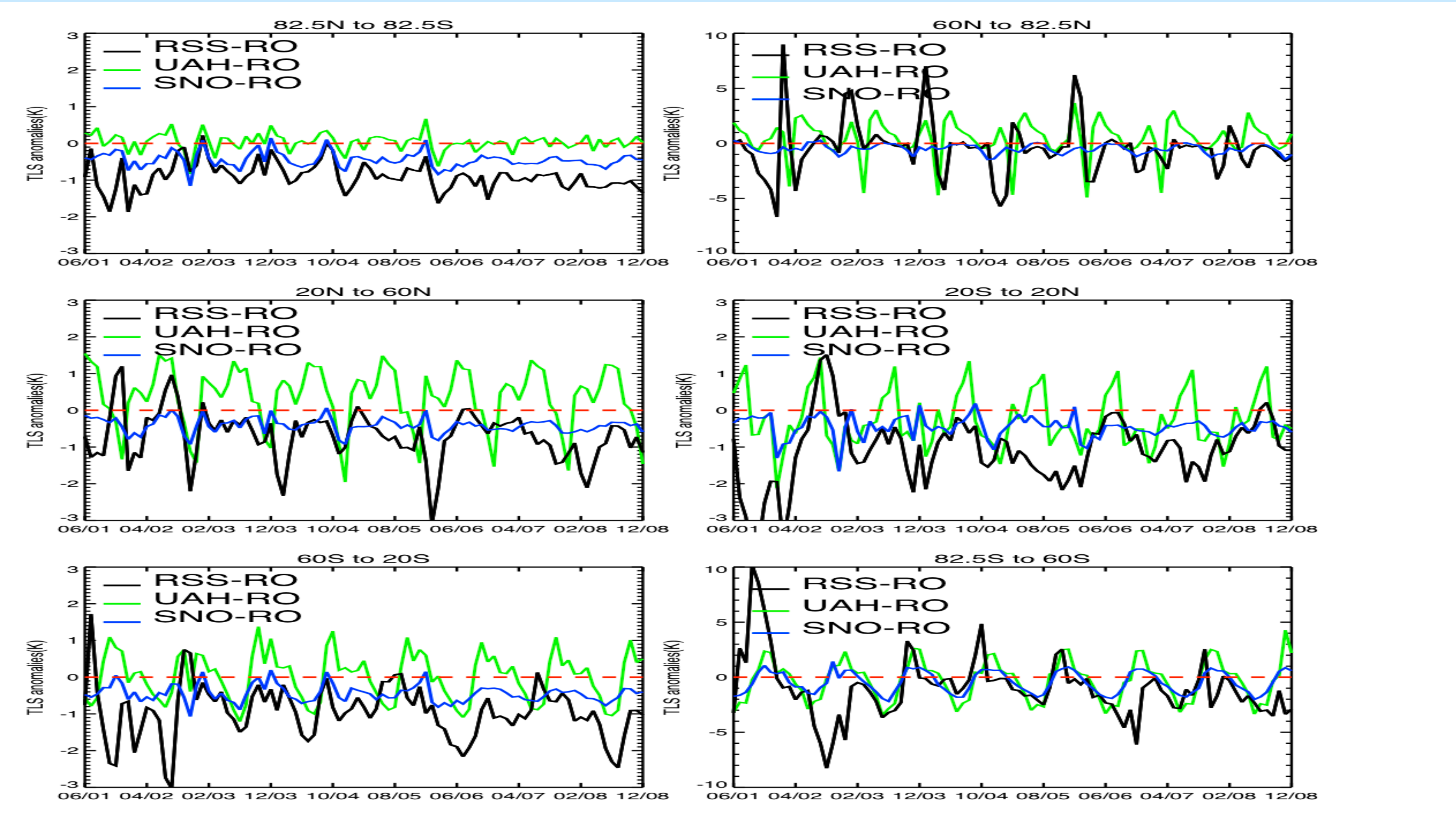


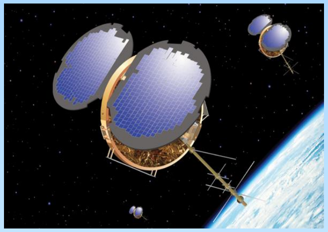




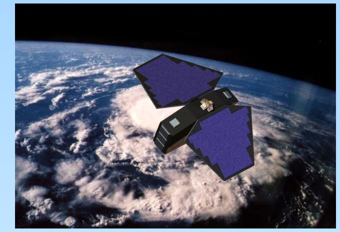
Time series of TLS difference

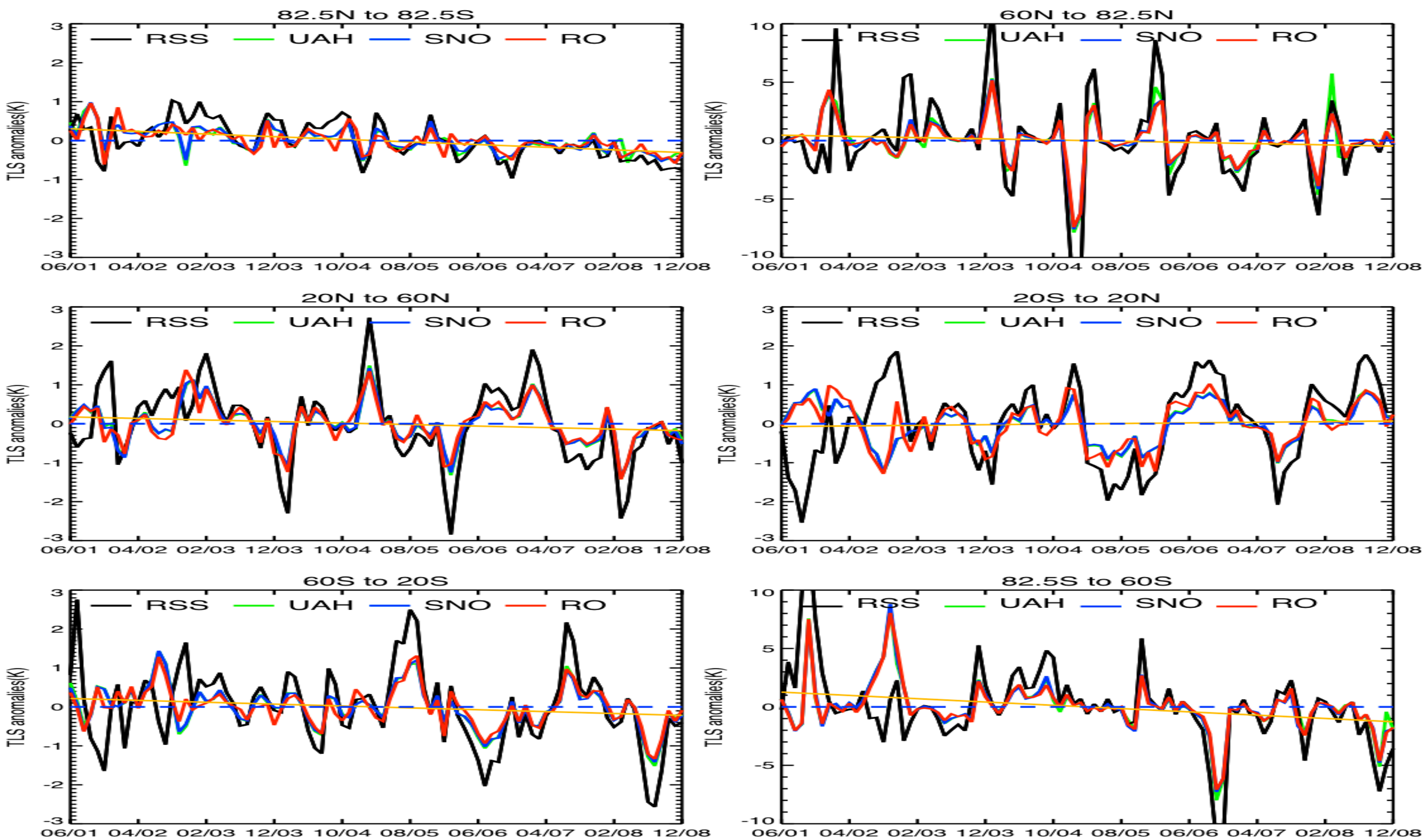






Time series of TLS anomalies

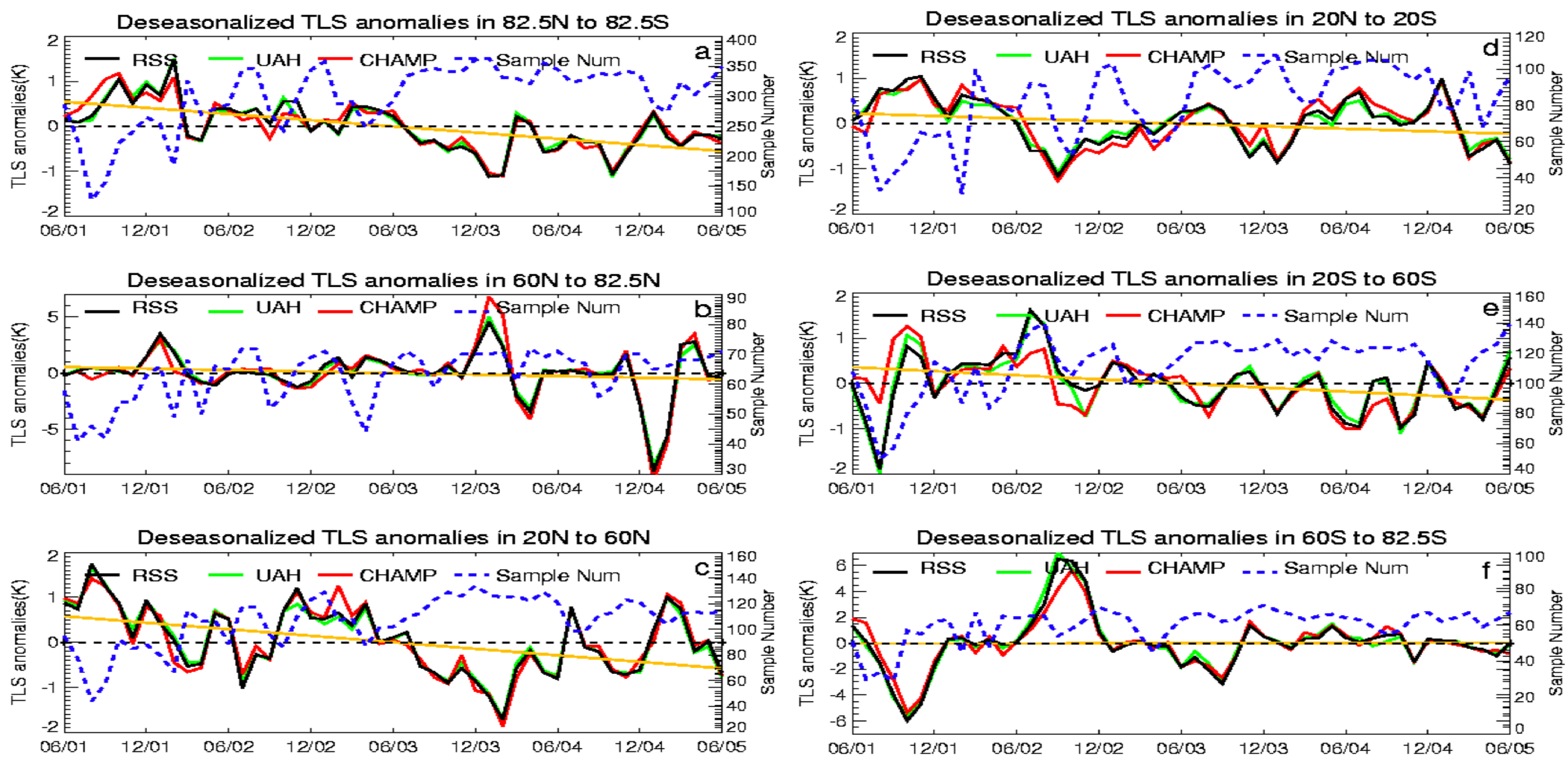




Validation Strategy/Results

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

De-seasonalized TLS anomalies



(Ho et al., GRL, 2007)

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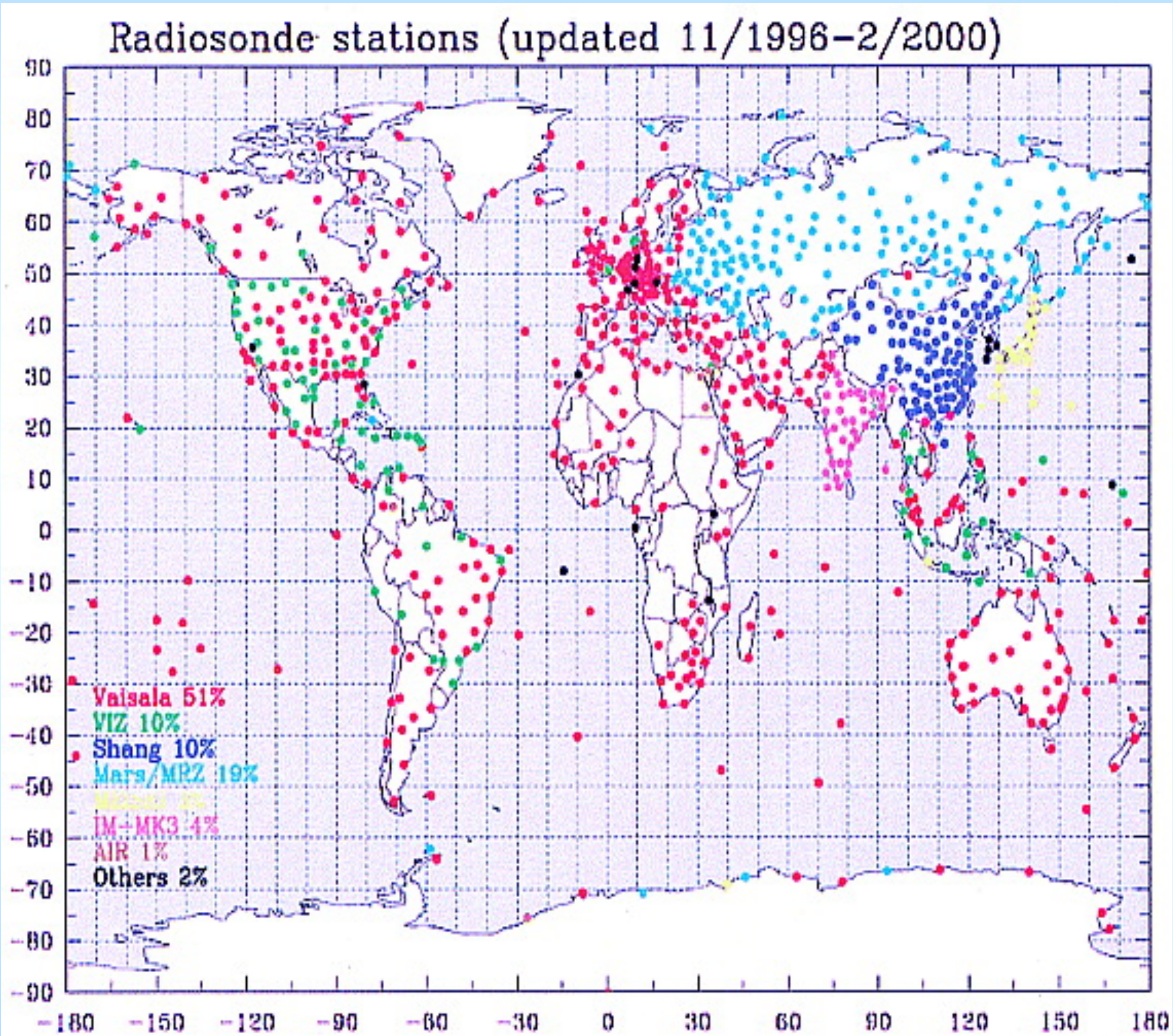
Approaches

IV. 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%)

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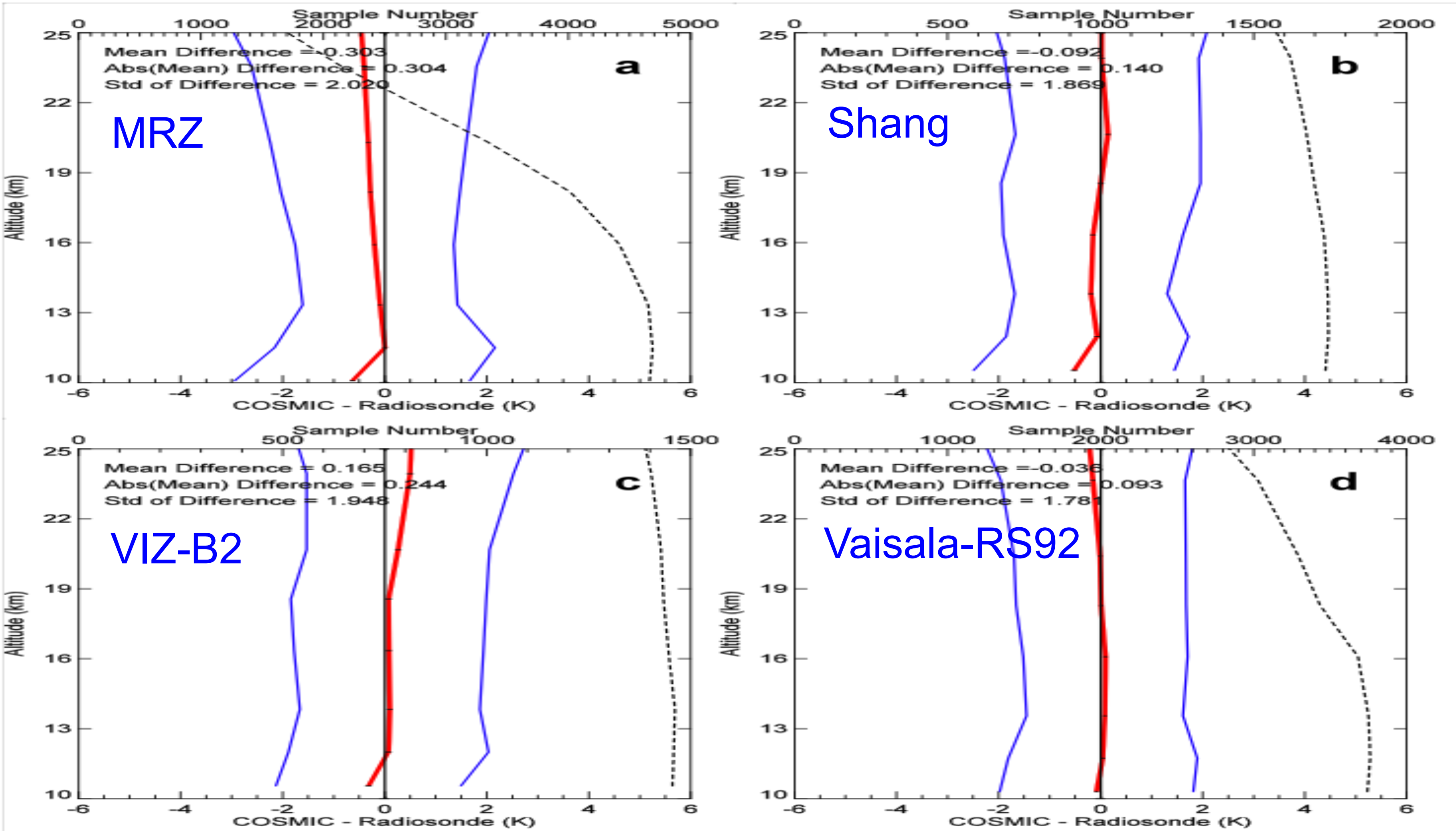
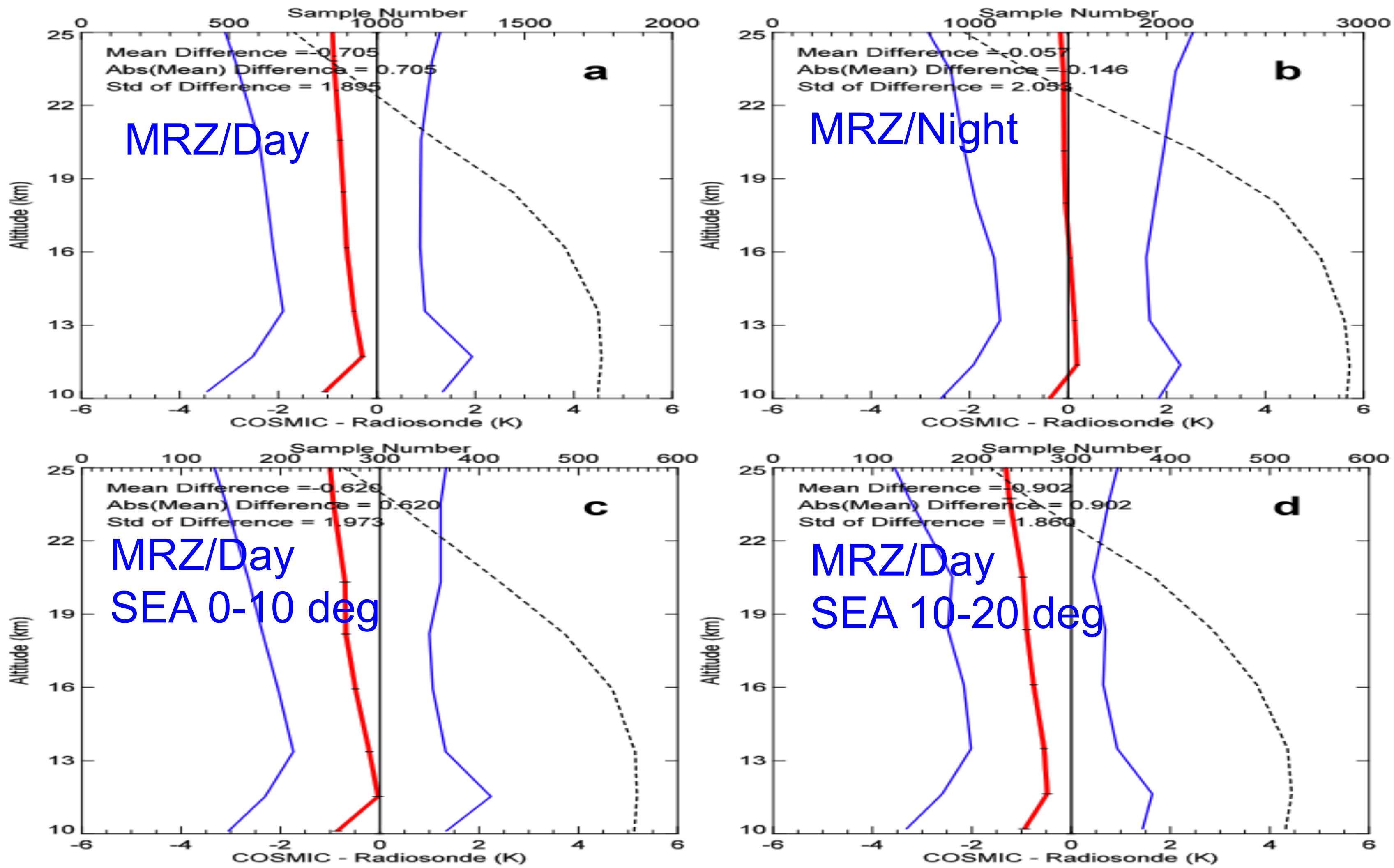
Results/Accomplishments

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



(He and Ho, GRL 2009)

Using RO data to assess the quality of radiosonde data



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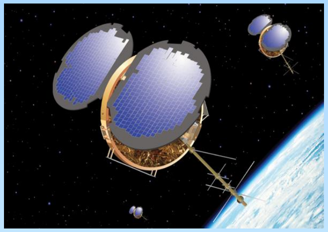
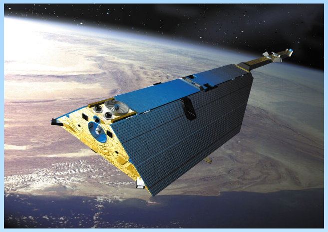


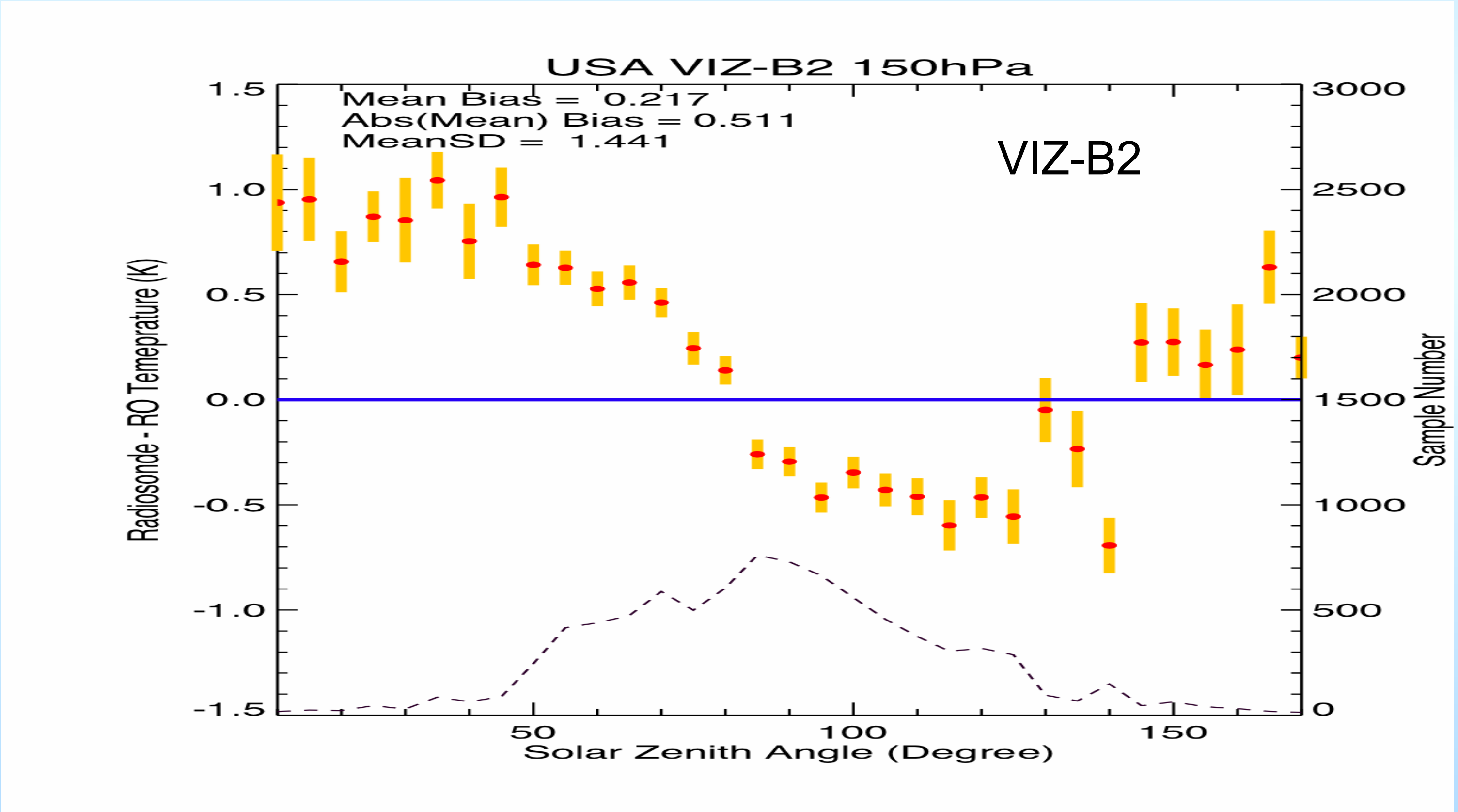
Using RO data to Correct Diurnal variation of Radiosonde Temperature Anomalies



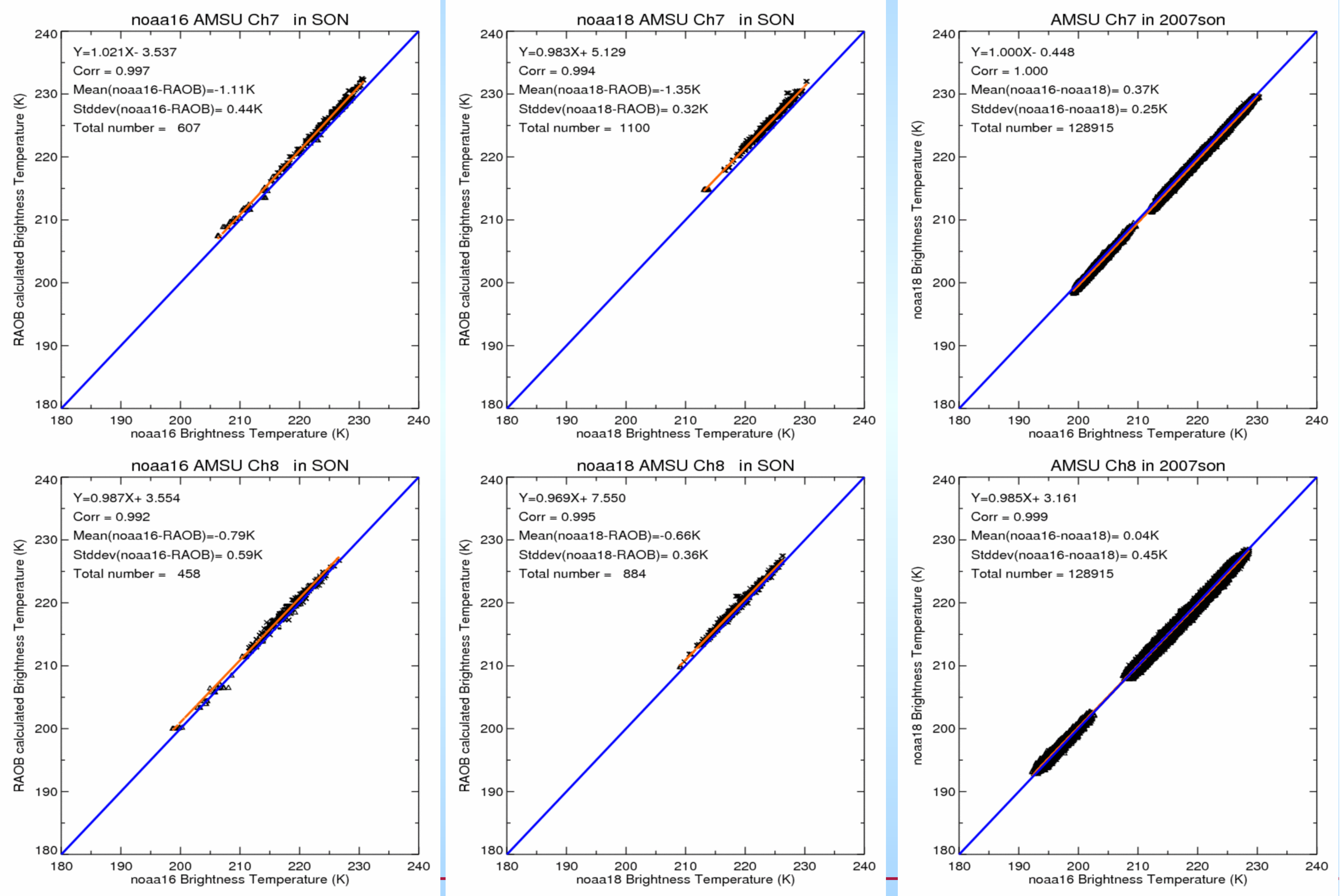
Solar absorptivity = 0.15
IR emissivity = 0.85

150 hPa

COSMIC from 2006 to 2009
CHAMP from 2001 to 2008
Radiosodne data DS351.0 from NCAR



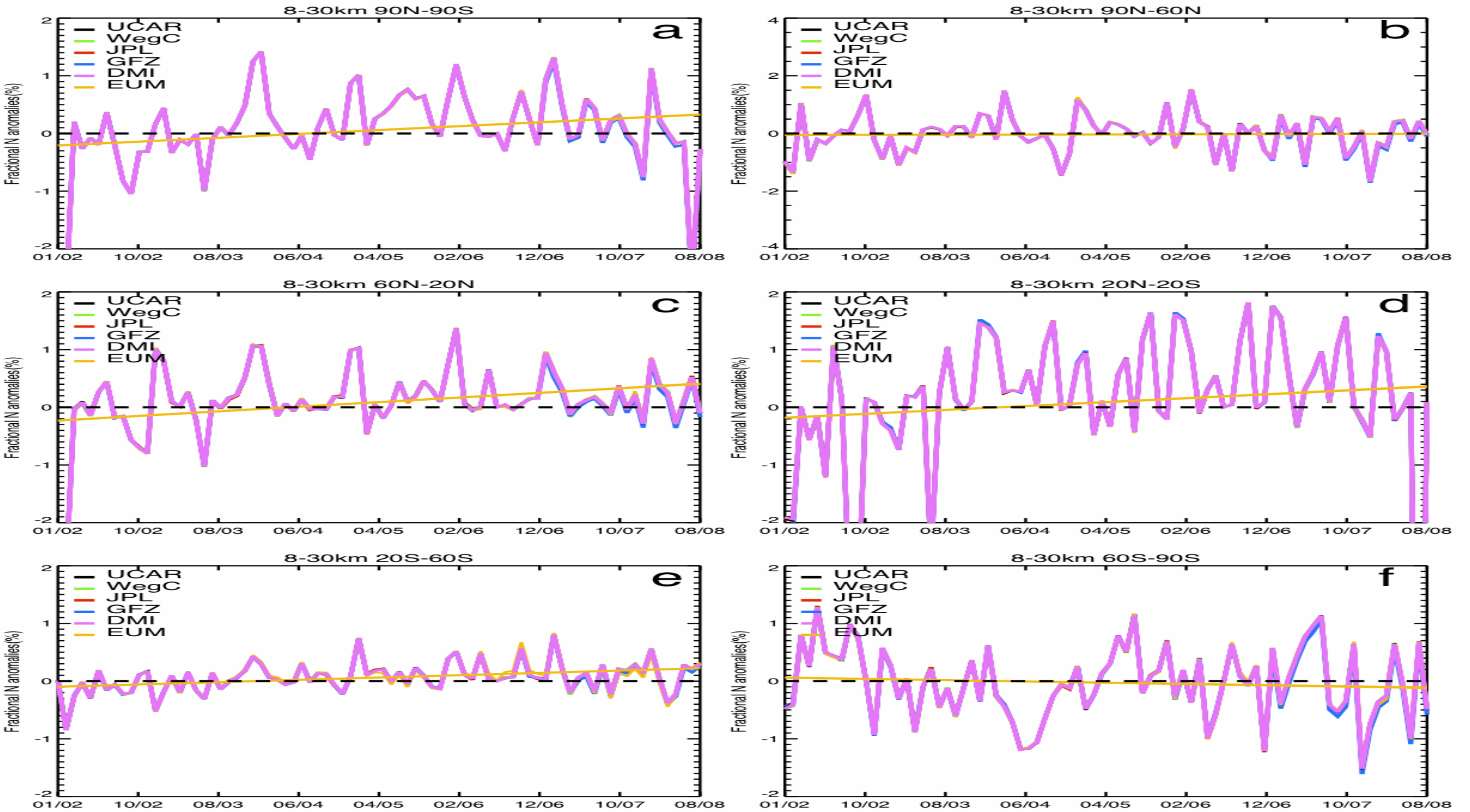
2007 noaa16 noaa18 RS92



Results/Accomplishments

Quantify the structure uncertainties of RO data

Comparing RO data from different centers



8-30 km

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

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10. Ho, S.-P., Y. H. Kuo, Zhen Zeng and Thomas Peterson, A Comparison of Lower Stratosphere Temperature from Microwave Measurements with CHAMP GPS RO Data, *Geophy. Research Letters,* 34, L15701, doi:10.1029/2007GL030202, 2007.

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

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 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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