Construction of Consistent Microwave Sensor Temperature Records and Tropopause Height Climatology using MSU/AMSU Measurements, GPS RO Data, and Radiosonde Observations

Shu-peng Ben Ho[1,2], Cheng-Zhi Zou[3], Ying-Hwa Kuo[1,2]

[1] COSMIC Project Office, Univ. Corp. for Atmospheric Research, Boulder, CO.

[2] National Center of Atmospheric Research, Boulder, CO.

[3] NOAA/NESDIS/Center for Satellite Applications and Research, 5200 Auth Road, Camp Springs, MD 20746-4304, USA

Phone : 303-4972922, Email: spho@ucar.edu, *http://www.cosmic.ucar.edu/~spho/*

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 pixel-level MSU/AMSU temporal and spatial temperature anomalies using GPS RO data from 2001 to 2012 as climate benchmark datasets.**
2. **The 'adjusted' MSU/AMSU data that were calibrated by multiple RO missions will serve as reference data to calibrate other overlapped MSU/AMSU data from 1978 to 2013. Those radiosondes that are consistent with RO profiles are used to calibrate MSU/AMSU measurements and the calibrated MSU/AMSU data will be used to calibrate other overlapped MSU/AMSU data.**
3. **To use GPS RO soundings collected from multi-RO missions to construct tropopause height climatology from 2001 to 2013.**

Challenges of defining Climate Trend using MSU/AMSU data

Satellites: Comparability and Reproducibility ?

1) Not designed for climate monitoring

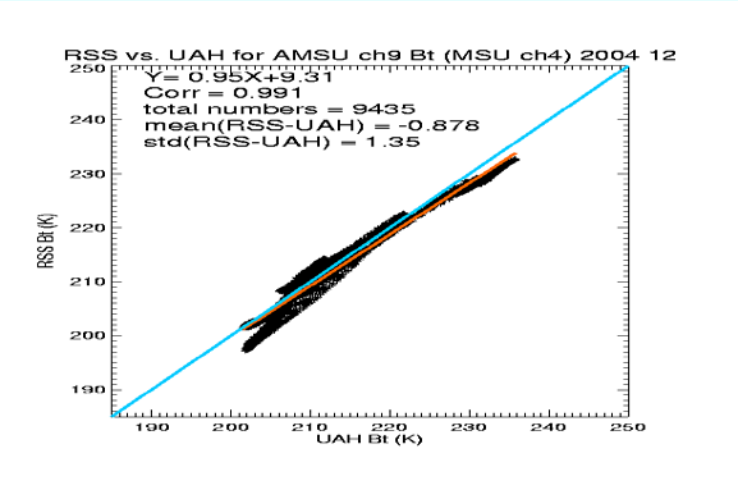
2) Changing platforms and instruments

(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).

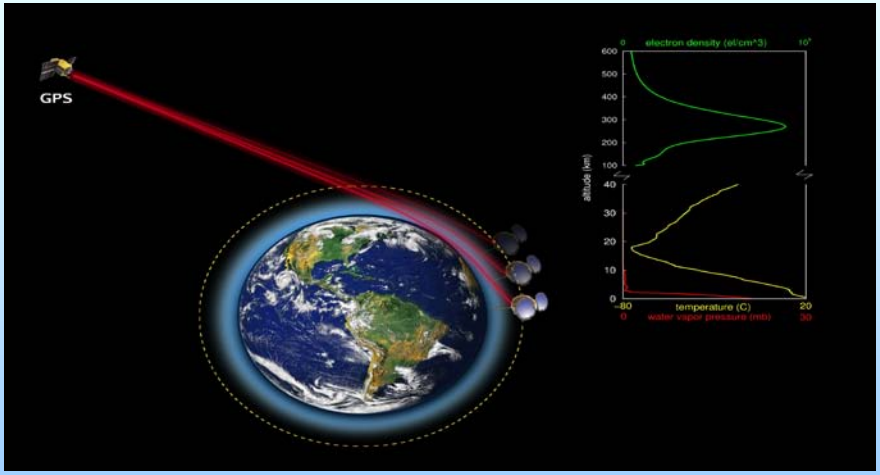
(No Reproducibility)

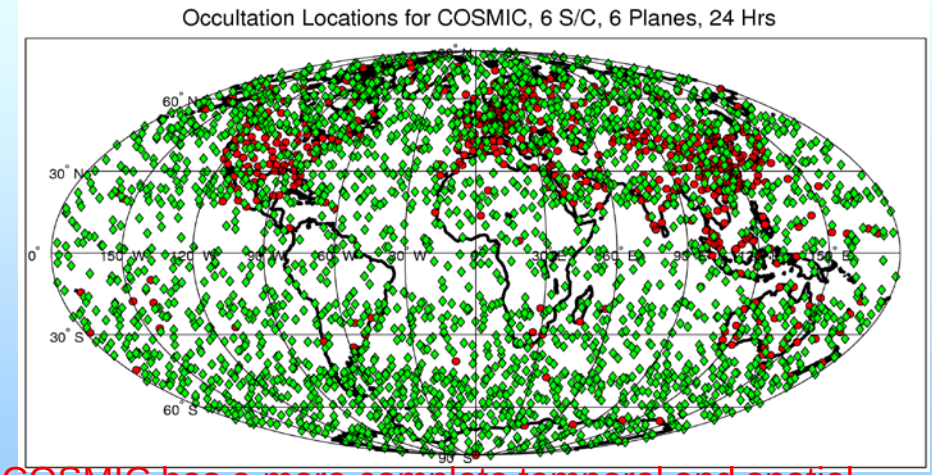


Overview

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





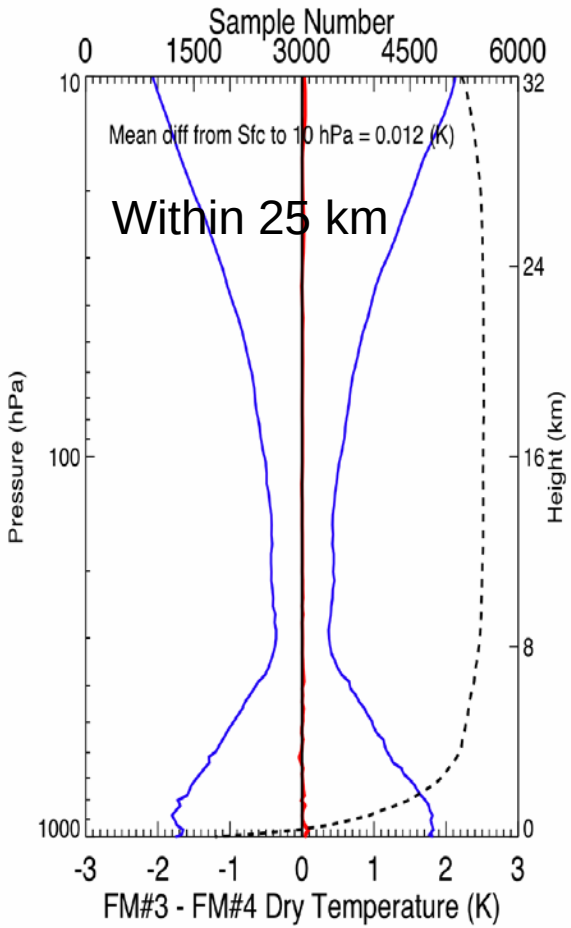
COSMIC has a more complete temporal and spatial global coverage

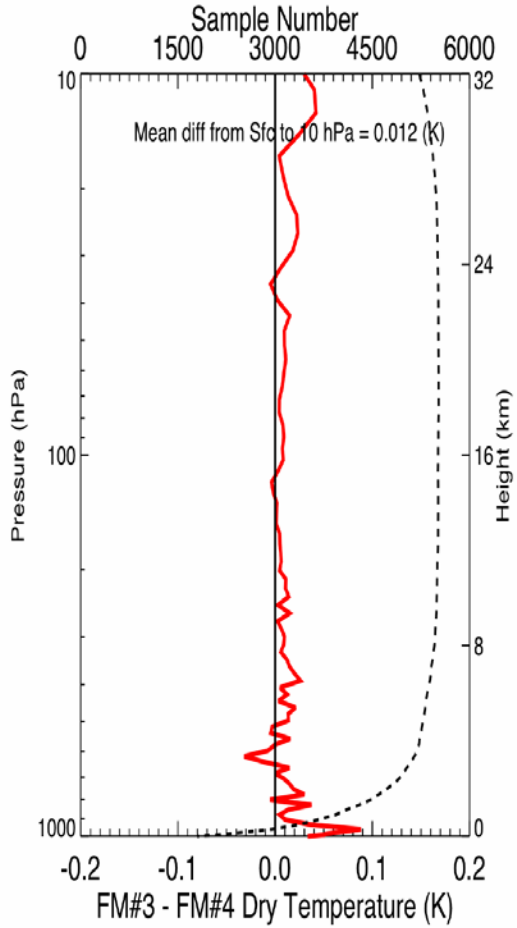
Overview

- Source Data –
- CHAMP data (from Jan. 2002 to Dec. 2008) from UCAR CDAAC, JPL, Wegc, DMI, EUM, GFZ
- COSMIC data (from June 2006 to the current) from UCAR CDAAC, JPL, WegC
- GRACE, SAC-C, Metop-A etc.
- MSU/AMSU data from NESDIS ($NESDIS_{OPR}$) for NOAA 14 (MSU), NOAA 15 (AMSU), NOAA 16 (AMSU) and NOAA 18 (AMSU) from 2002 to 2013
- 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 MSU/AMSU temperature records in both troposphere and stratosphere from 1978 to 2013
- Traceable standards for GPS RO metadata, including the change of observing practices, the bending angle, phase, amplitude, and time delay of radio signals.
- Tropopause height climatology form 2001 to 2013
- 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: a. Quantify the precision of the 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)

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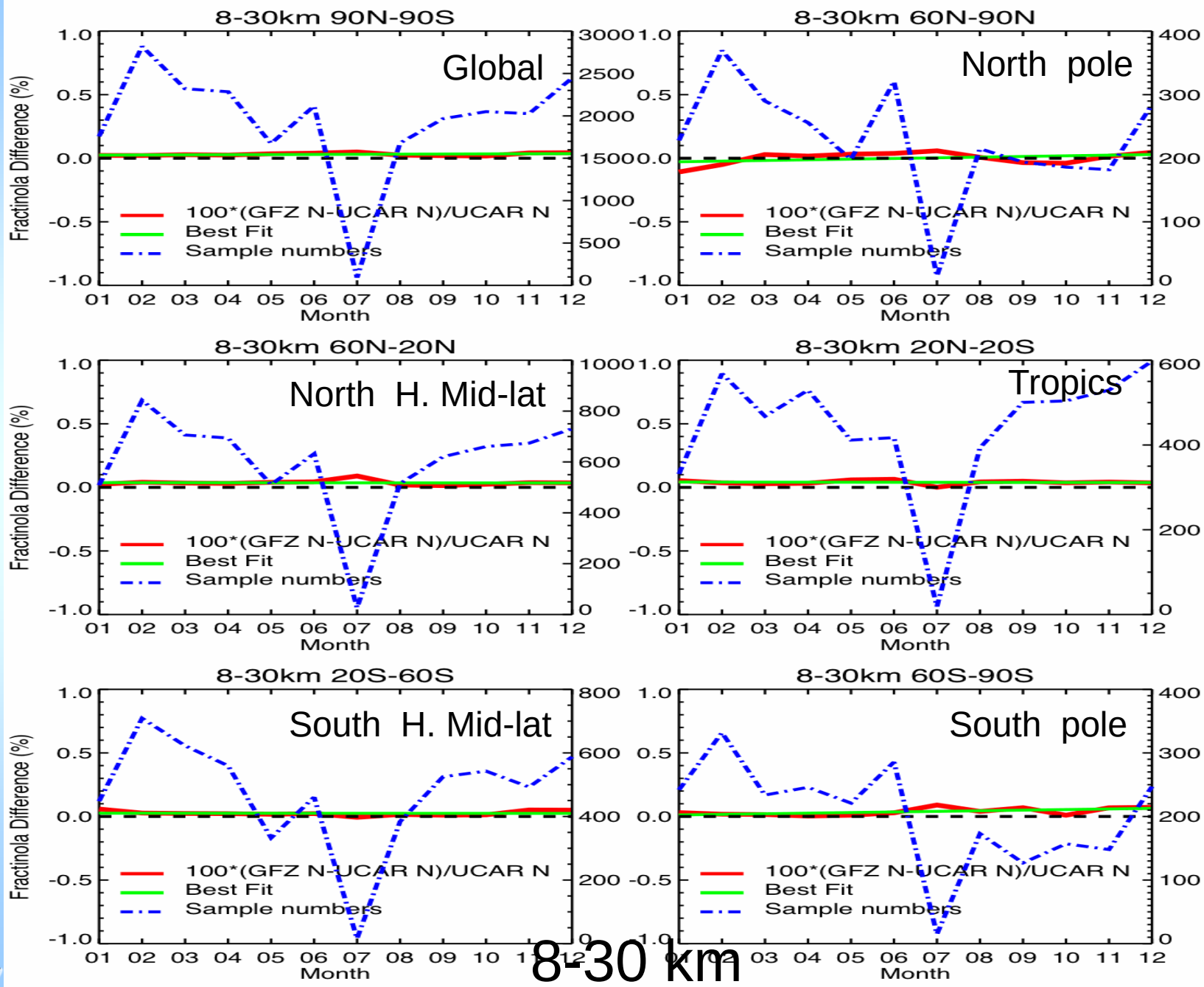
b. Quantify the quality of RO data among different centers

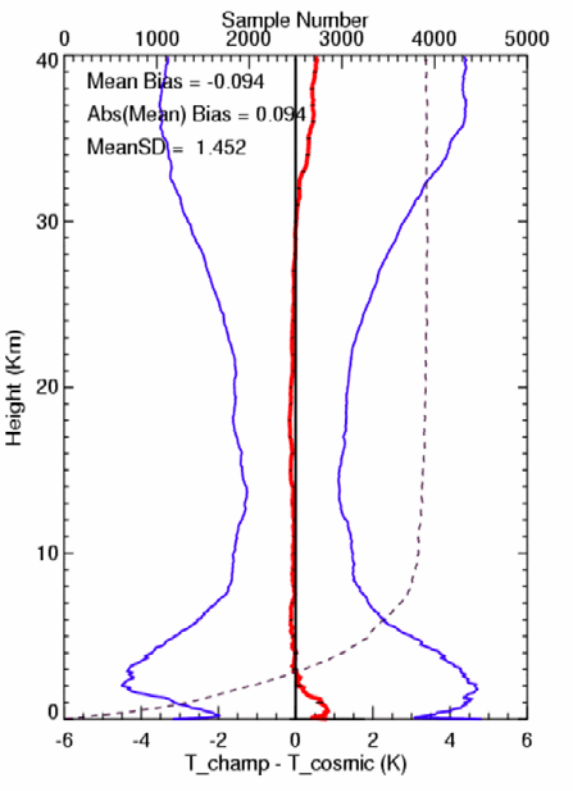


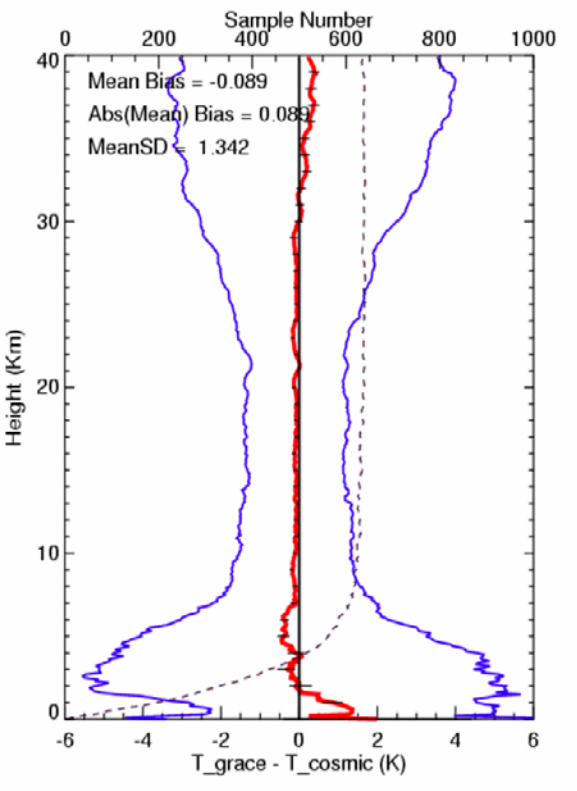
8-30 km

c. 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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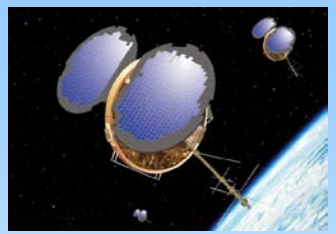
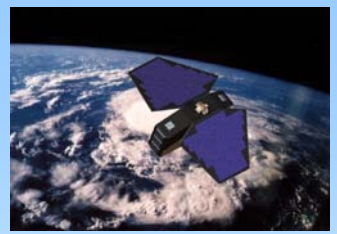


II. Construction of a consistent RO and MSU/AMSU Temperature Climate Data Records



1. Data:

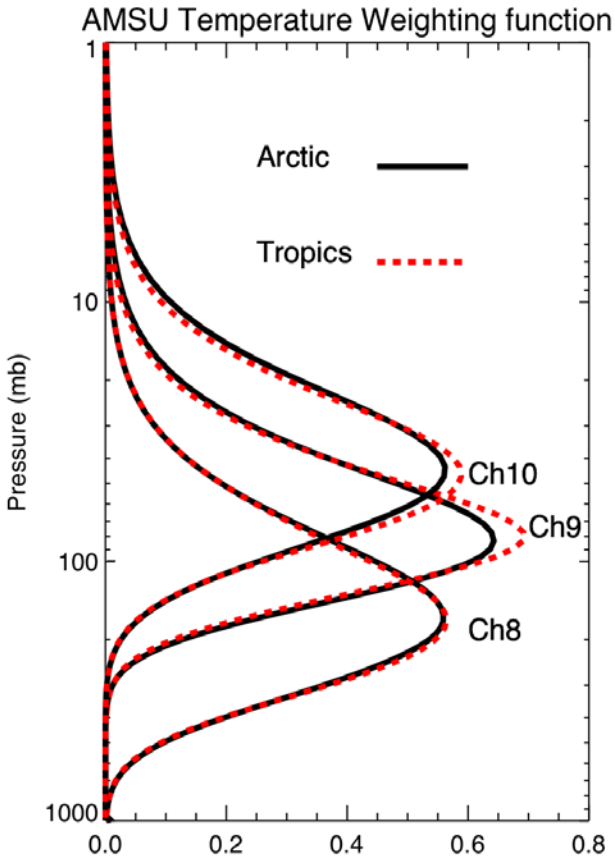
COSMIC from 200606 to 200912
CHAMP from 200106 to 200806
RSS V3.2 200106-200912
UAH V5.1 200106-200812
SNO V2.0 200106-200912

2. Apply CHAMP and COSMIC soundings to AMSU forward model to simulate AMSU TLS

3. Match simulated GPS RO TLS to NOAA AMSU TLS within 30 minutes and 0.5 degree to find calibration coefficients for different NOAA satellites so that we can

a. use GPS RO data to inter-calibrate other NOAA satellite

b. use the NOAA satellite measurements calibrated by GPS RO data to calibrate multi-year AMSU/MSU data and generate consistent RO and MSU/AMSU TLS climate data records



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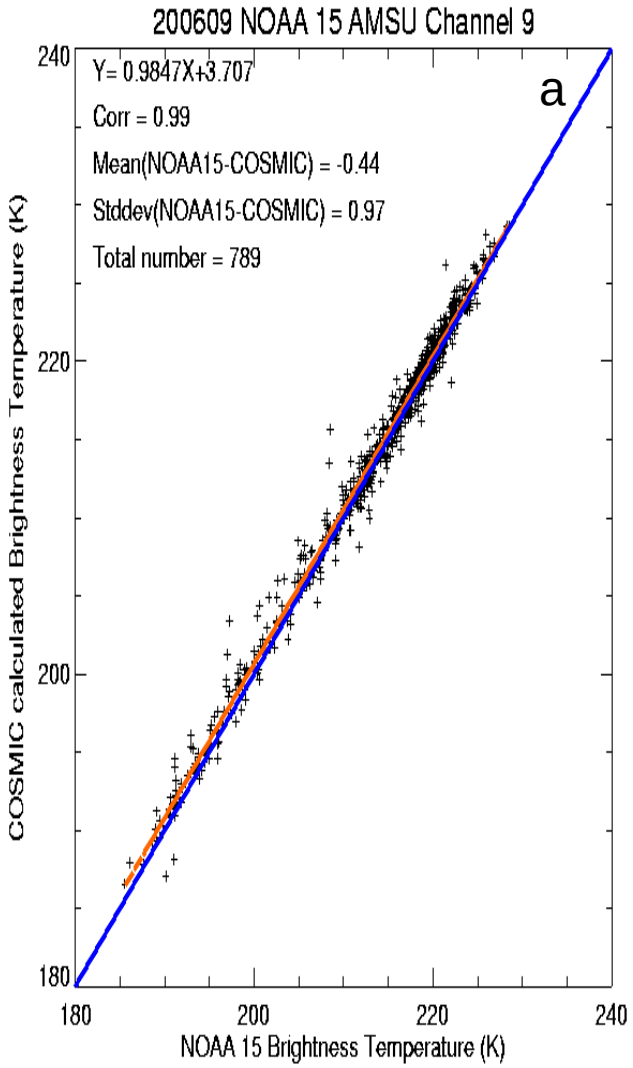
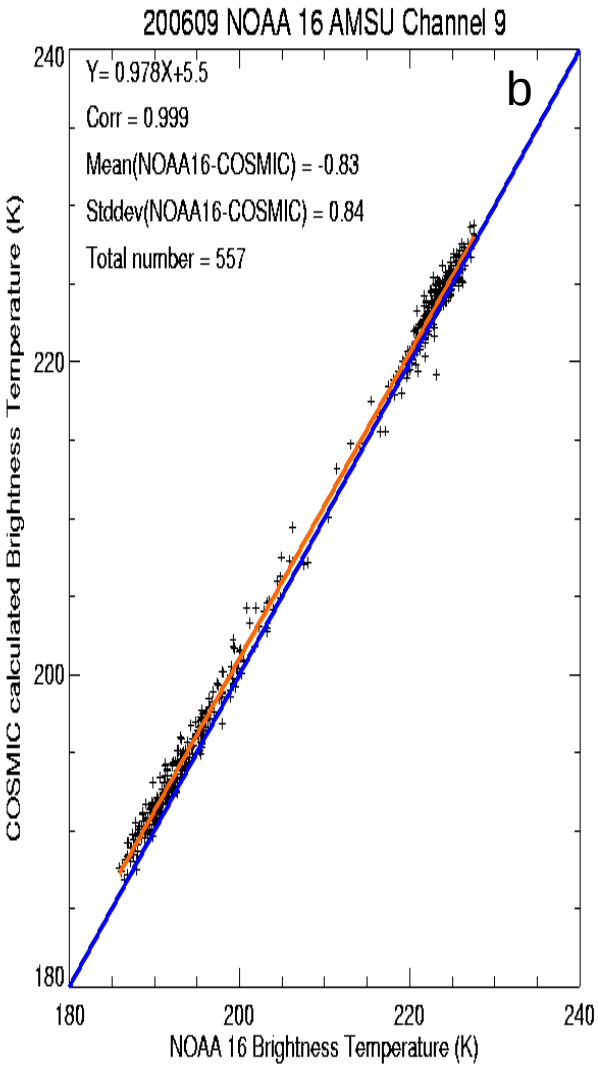
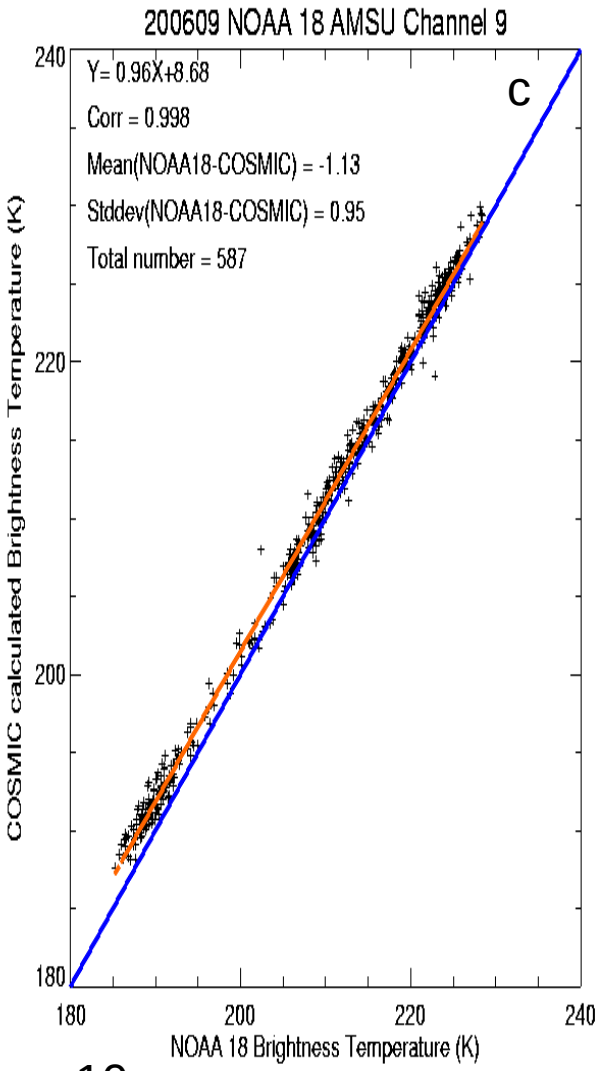
Can we use RO data to calibrate other instruments ?

200609

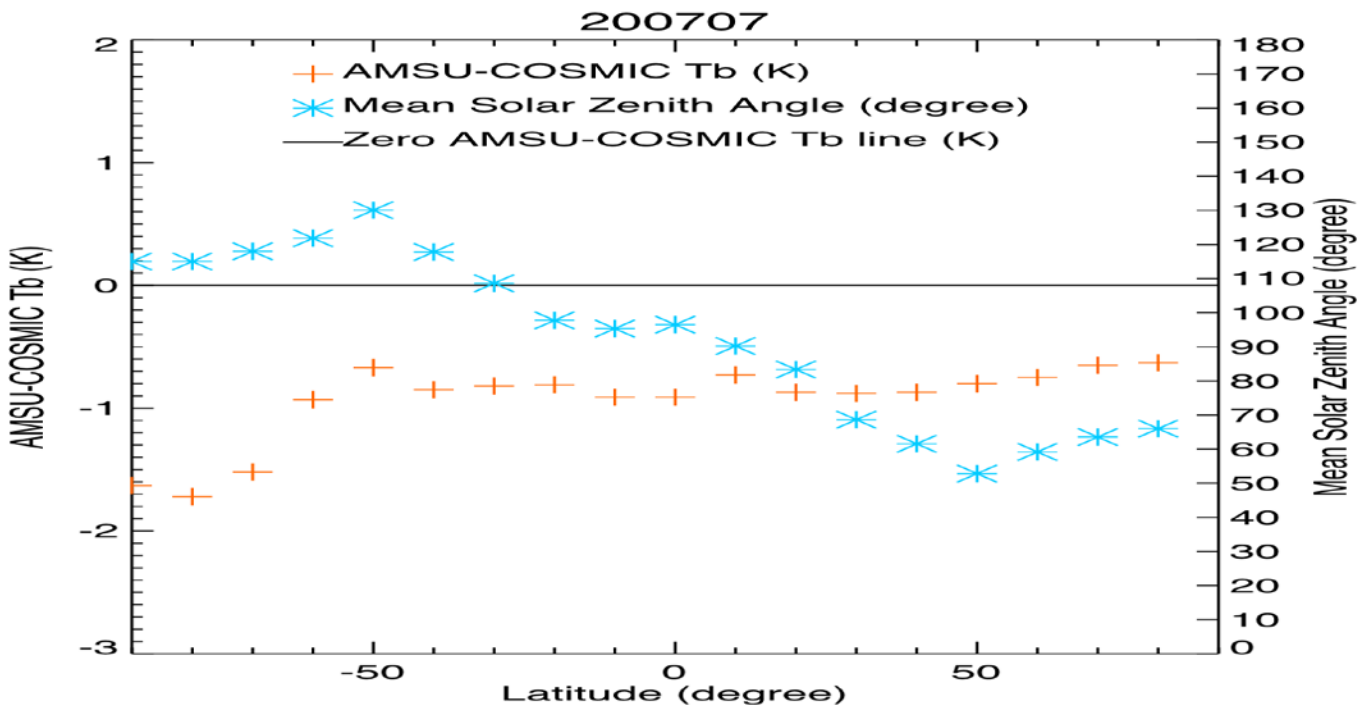






N15, N16 and N18 AMSU calibration against COSMIC

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



Unbiased, good anchor for radiance assimilation

(Ho et al. OPAC special issue, 2007)

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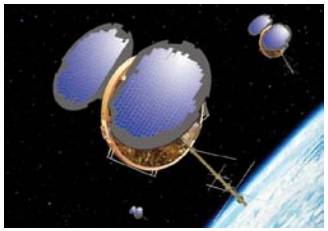
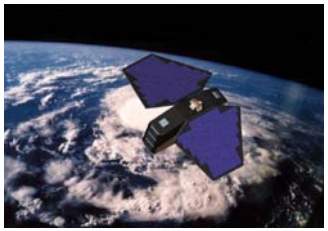
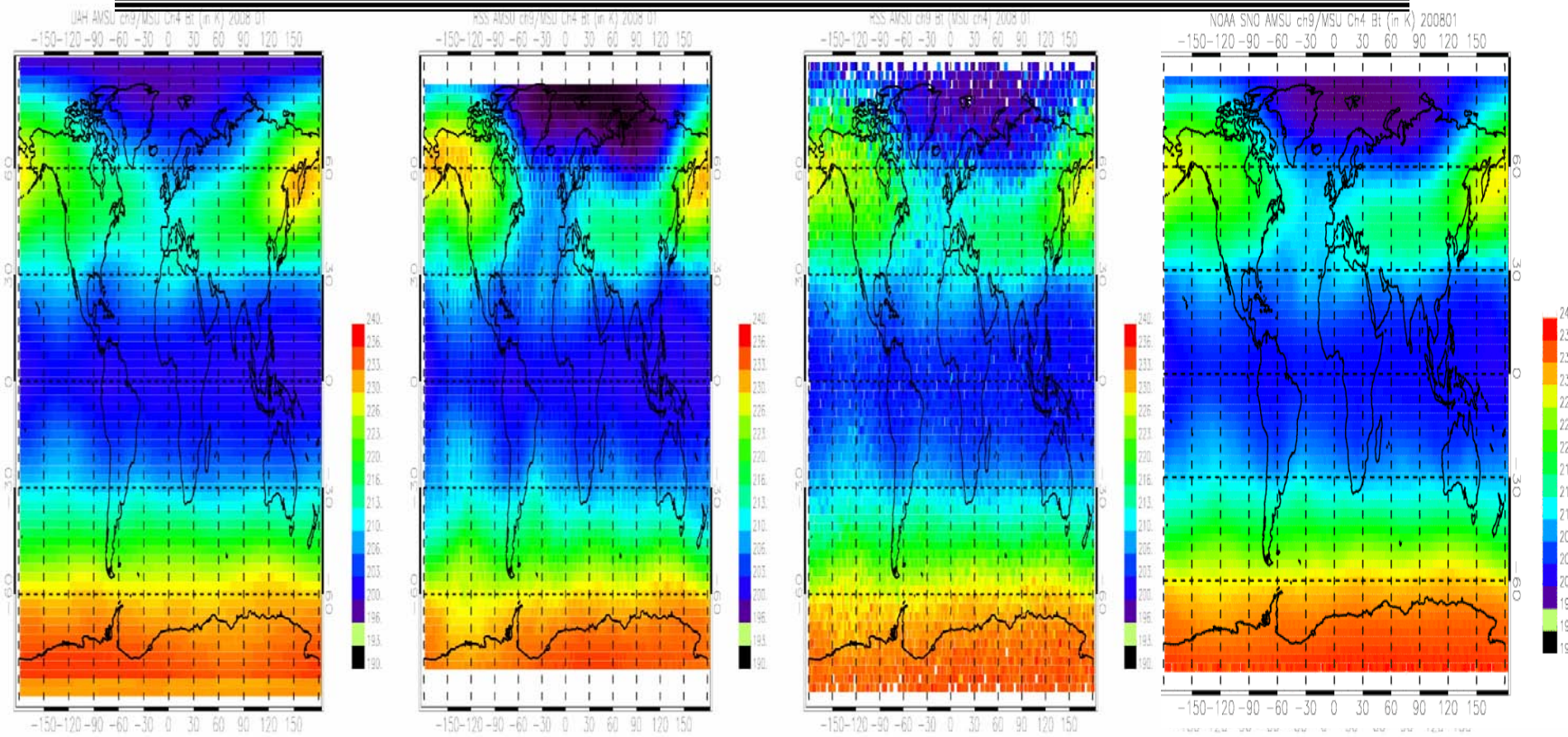


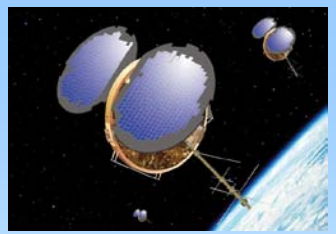
Comparisons of RO-calibrated AMSU with those from RSS, UAH, and SNO



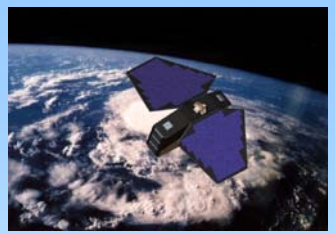


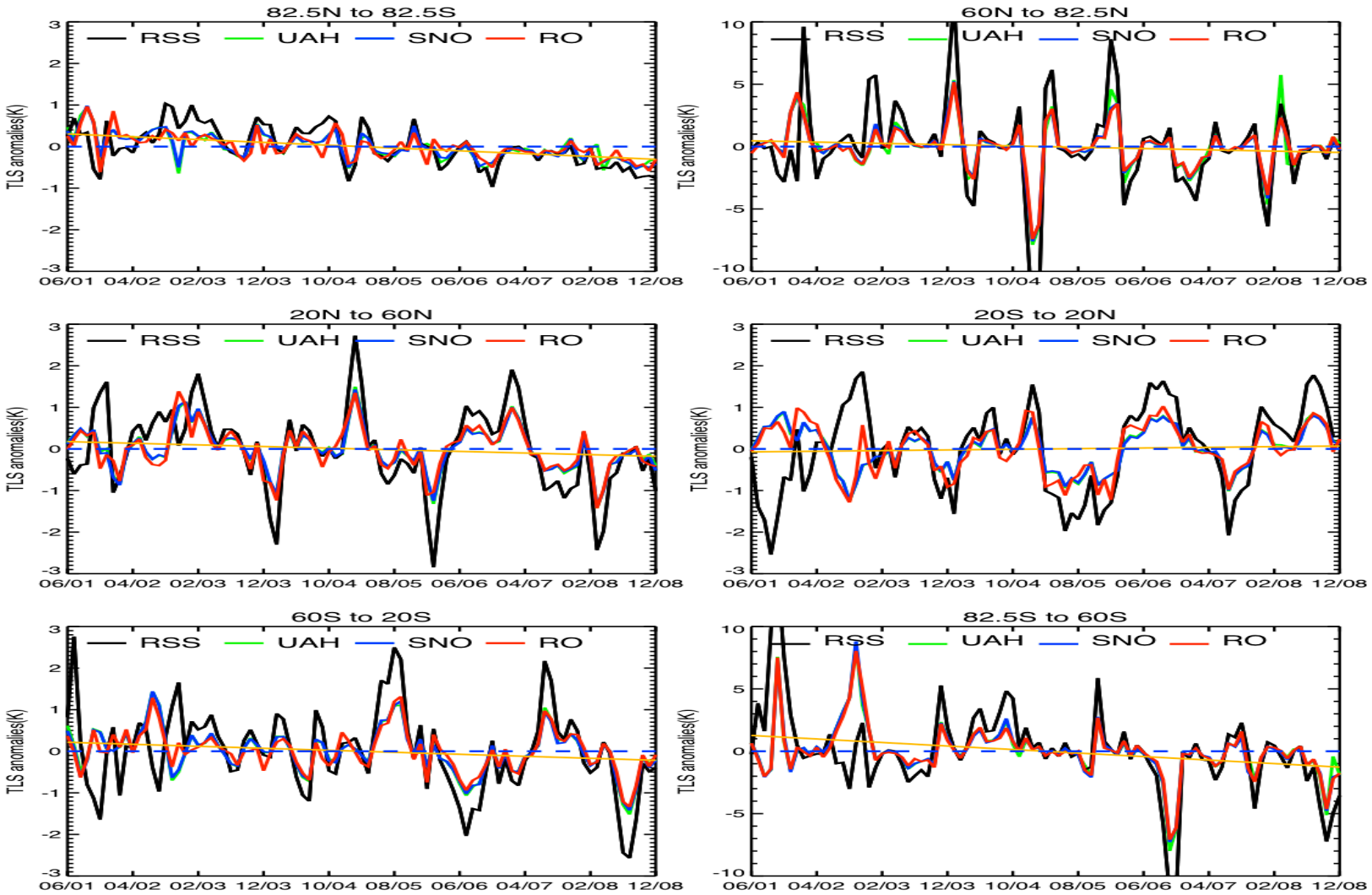
UAH RSS RO_AMSU SNO

200801

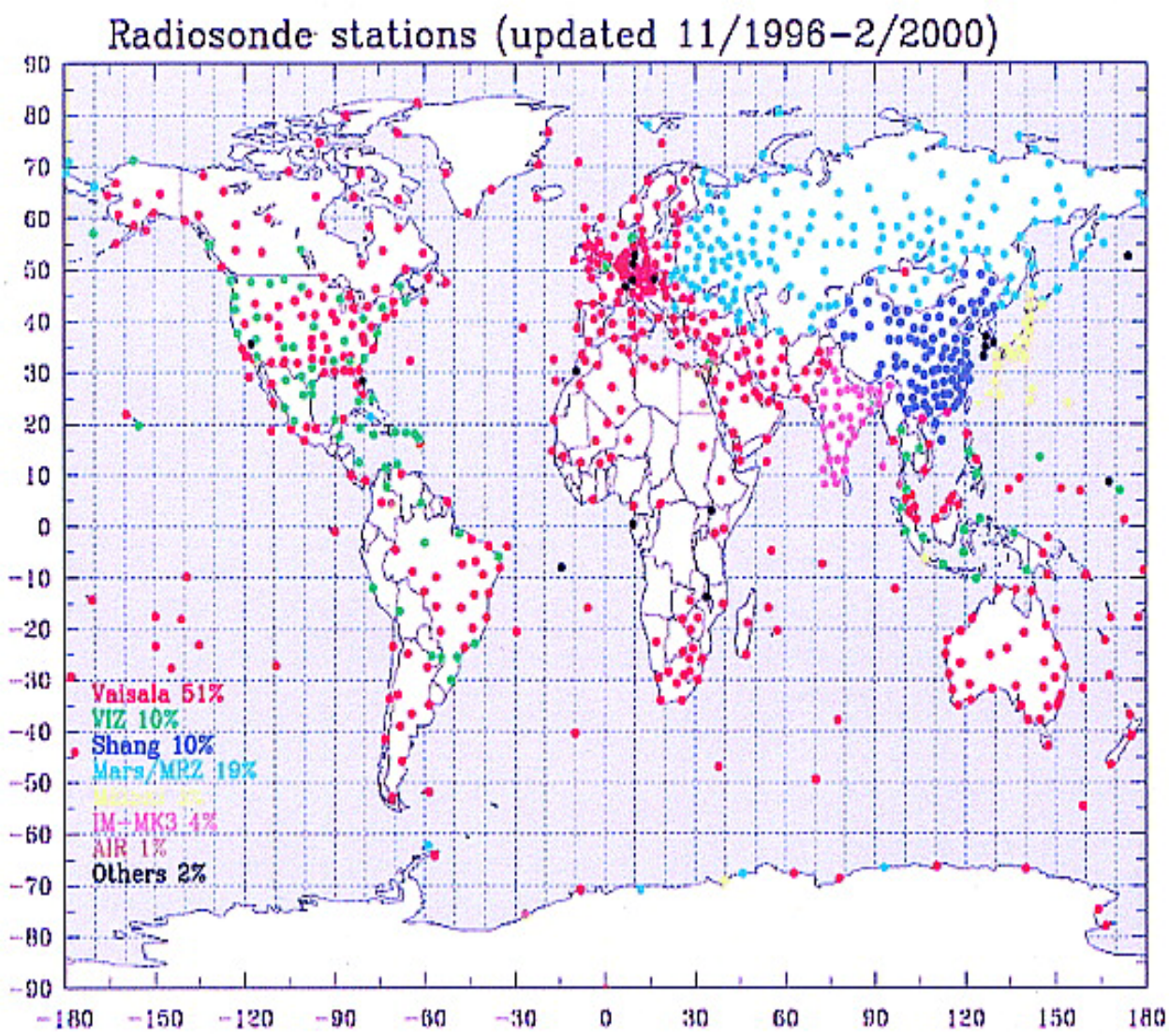


Time series of TLS anomalies





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%)

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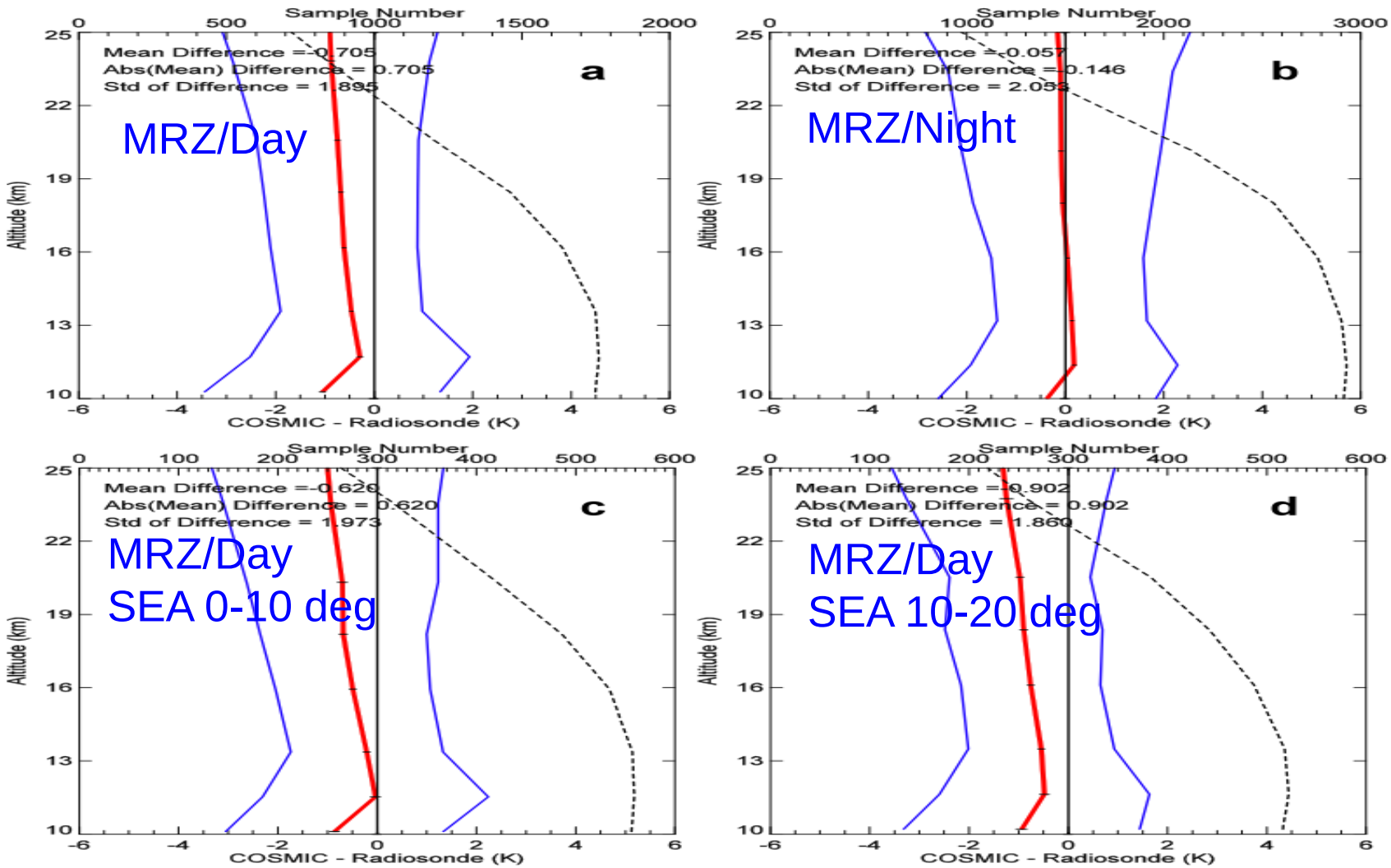
Using RO data to assess the quality of radiosonde data



(He and Ho, GRL 2009)

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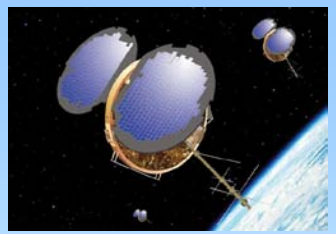
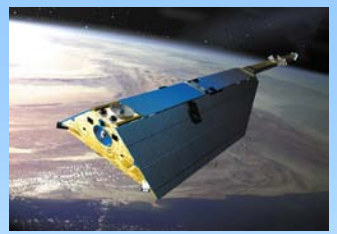


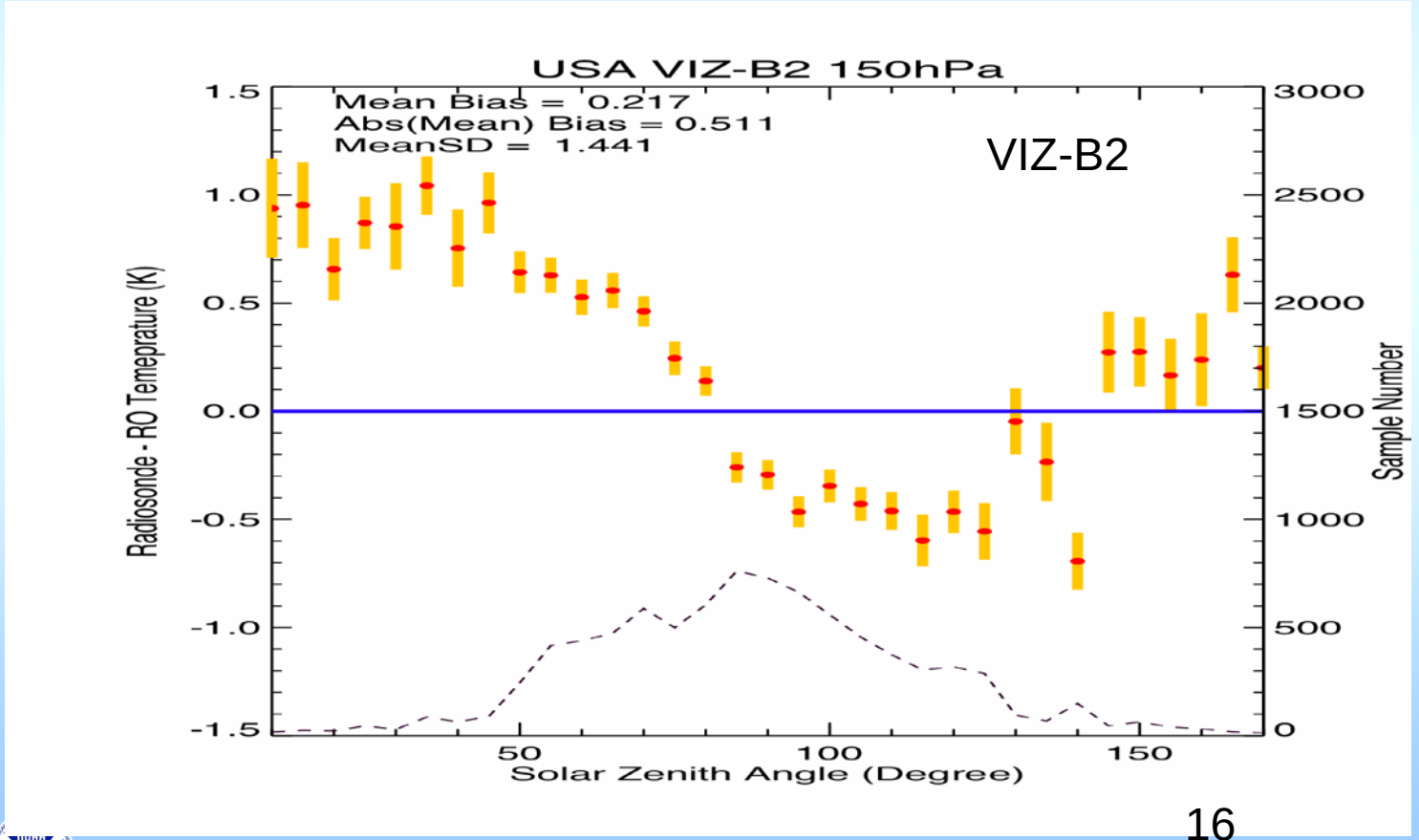
Using RO data to Correct Diurnal variation of Radiosonde Temperature Anomalies



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



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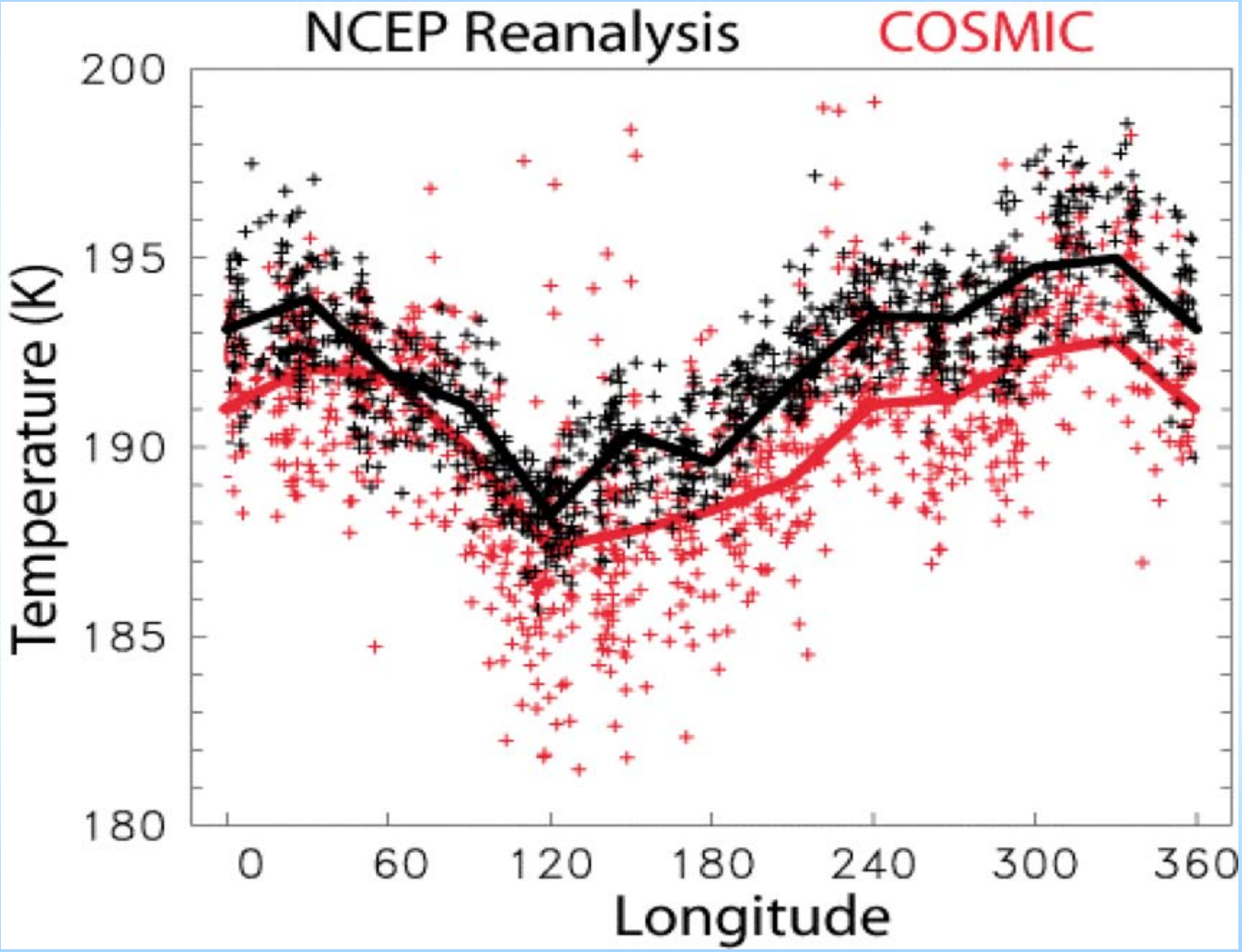
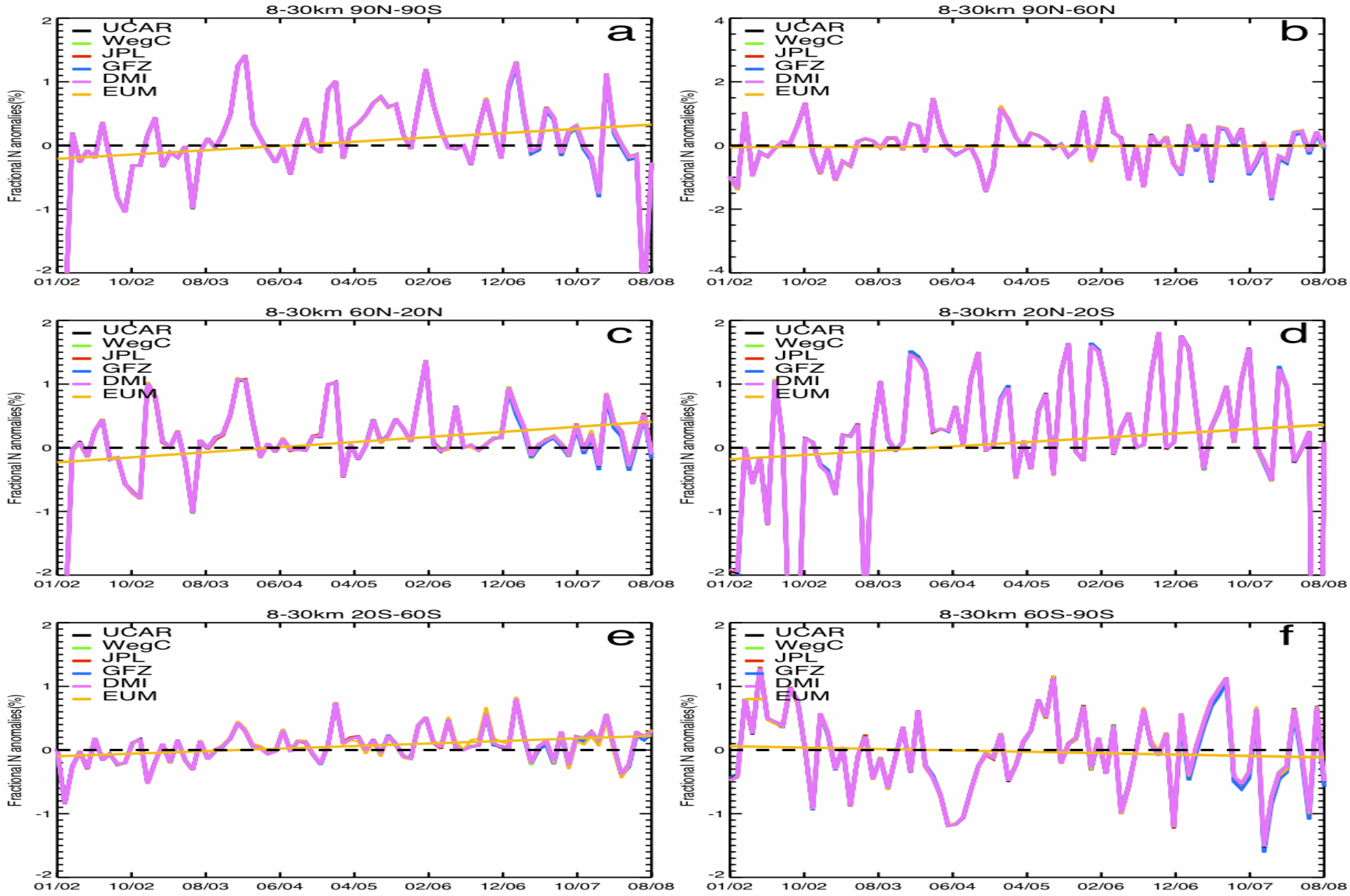
IV. Construction of a consistent RO tropopasue height climatology



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

Resources

- Number of personnel employed for project:
  - PI and a post-doc 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