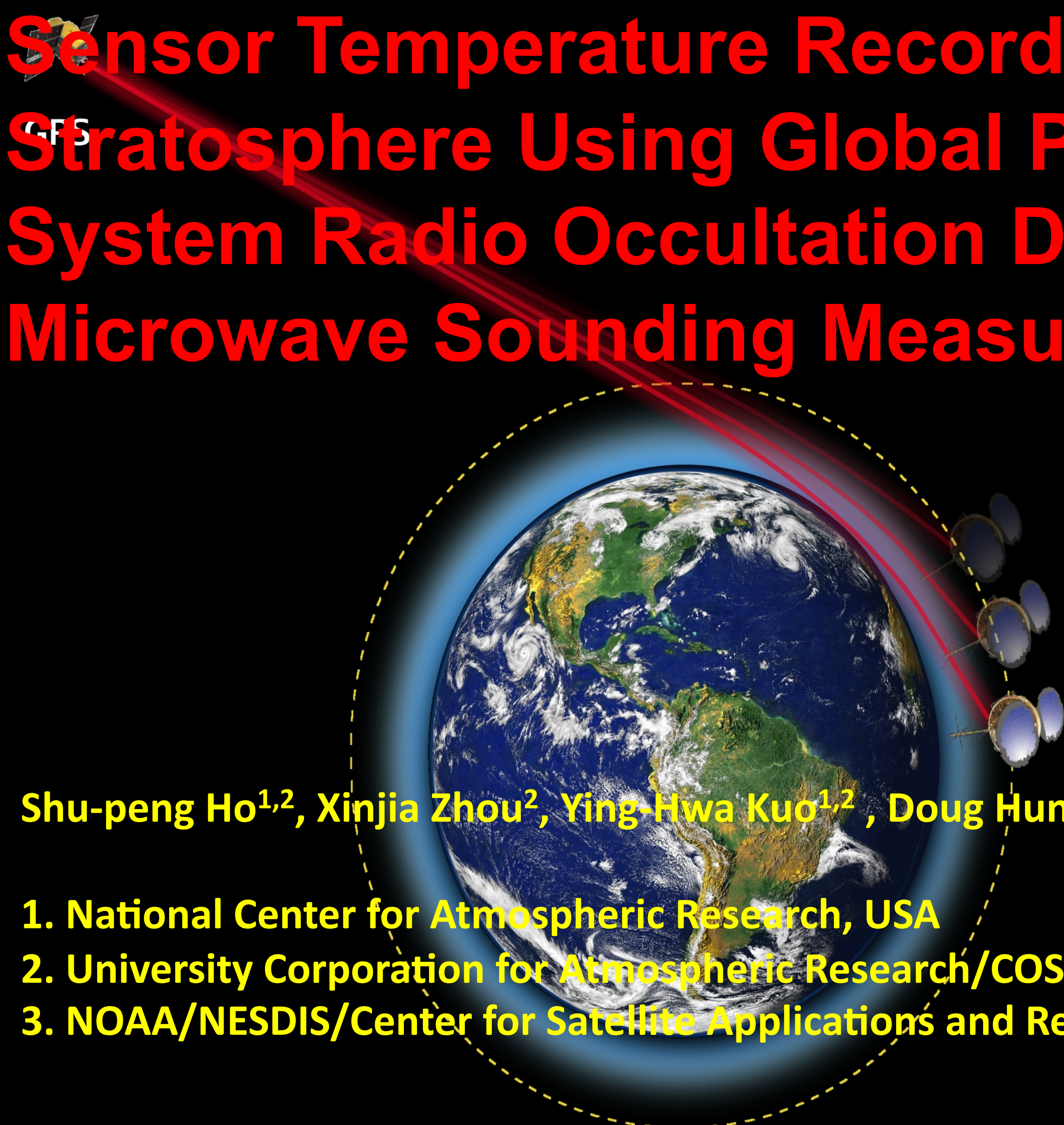
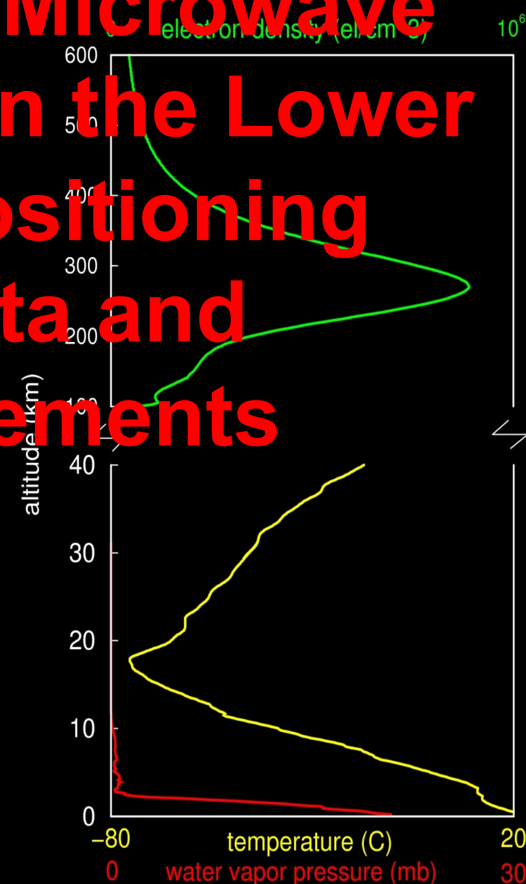
Construction of a Consistent Microwave Sensor Temperature Record in the Lower Stratosphere Using Global Positioning System Radio Occultation Data and Microwave Sounding Measurements





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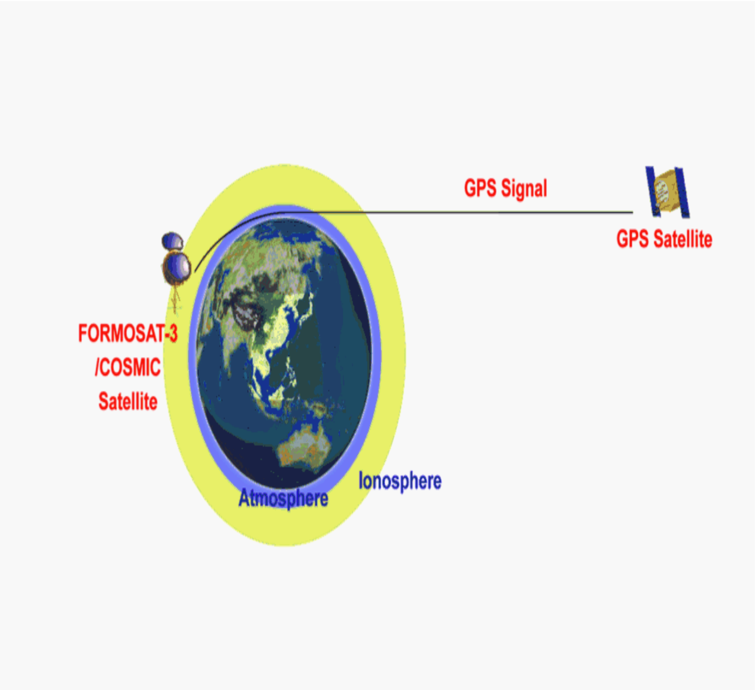
1. Motivation:

1) MSU/AMSU data from 1978 to 2010 are very valuable for temperature climate data records
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) Construction of a Consistent Microwave Sensor Temperature Record in the Lower Stratosphere Using Global Positioning System Radio Occultation Data and Microwave Sounding Measurements

2. Outlines :

- Challenges to define/validate a global trend
- Long term stability of GPS RO data for climate monitoring
- Construction of a consistent Microwave Sensor Temperature Record in the lower stratosphere using GPS RO and microwave sounding measurements
- Comparisons of RO-AMSU, RSS, UAH, and SNO



3. Conclusions and Future Work

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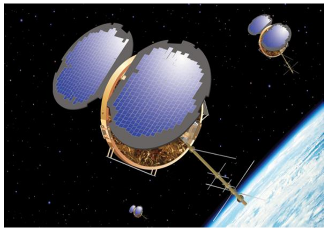
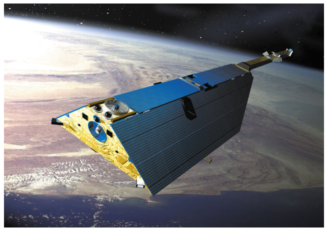


Challenges for defining the Global Temperature Trend using MSU/ AMSU data



Satellites: Comparability and Reproducibility ?

1) Not designed for climate monitoring

2) Changing platforms and instruments

(No Comparability)

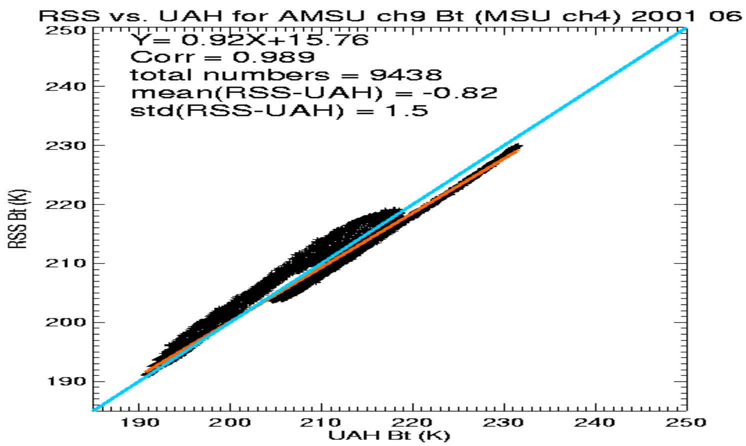
a. Satellite dependent bias, b. geo-location dependent bias, c. orbital drift dependent bias

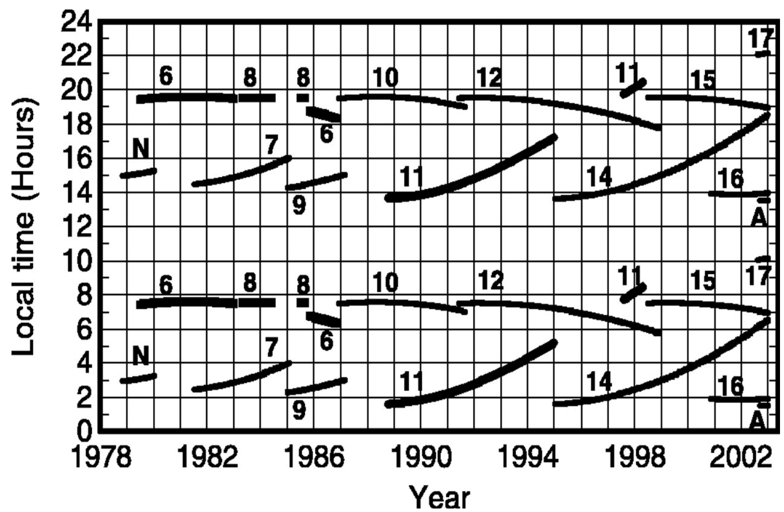
3) Different processing/merging method lead to different trends (RSS vs. UAH).

(No Reproducibility)

Radiosondes: changing instruments and observation practices; limited spatial coverage especially over the oceans.

We need measurements with high precision, high accuracy, long term stability, reasonably good temporal and spatial coverage as climate benchmark observations.





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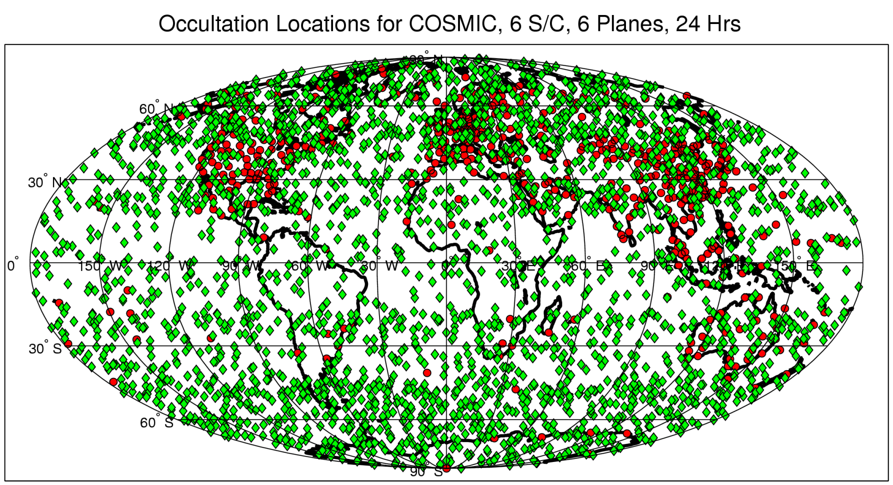
Characteristics of GPS RO Data

- **Measure of time delay (SI traceability) : no calibration is needed**
- **Requires no first guess sounding**
- **Uniform spatial/temporal coverage**
- **High precision (<0.05K)**
- **Insensitive to clouds and precipitation**
- **No mission dependent bias**
- **Less sensitive to inversion algorithm (Ho et al., 2009b JGR)**

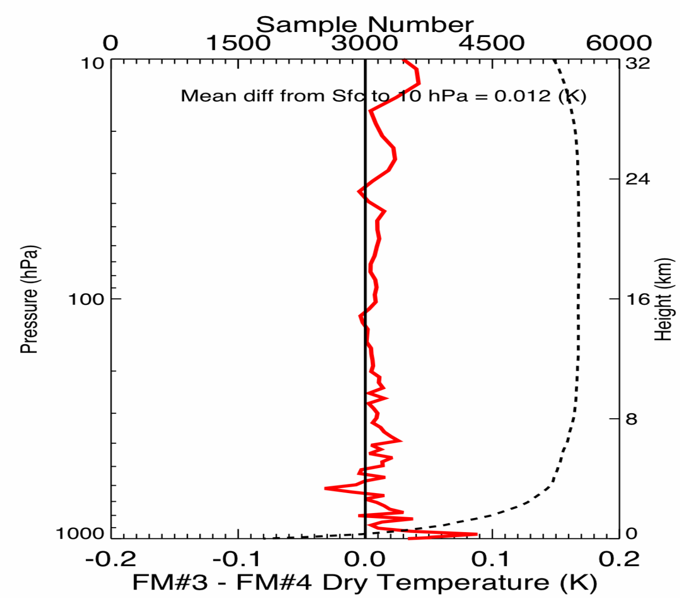
Precision < 0.05 K

Using FM3-FM4 pairs
in early mission

(Ho et al., TAO, 2009a)
(Anthes et al., BAMS, 2008)



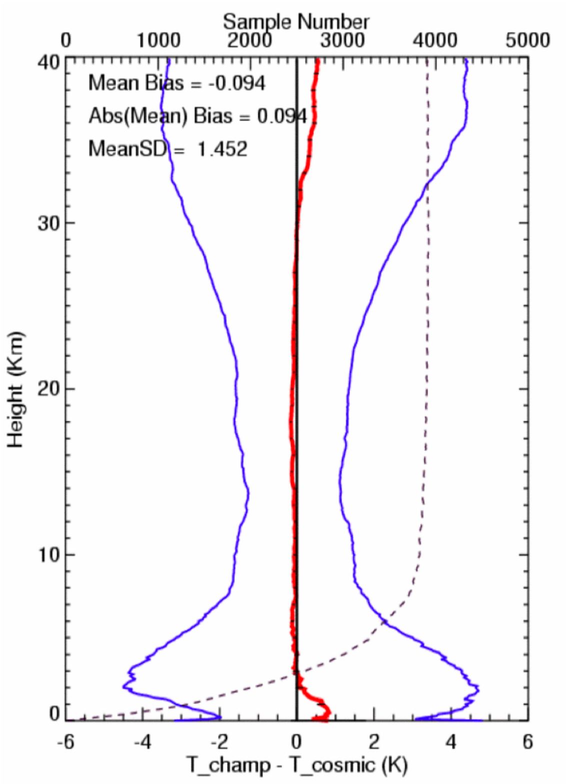
COSMIC



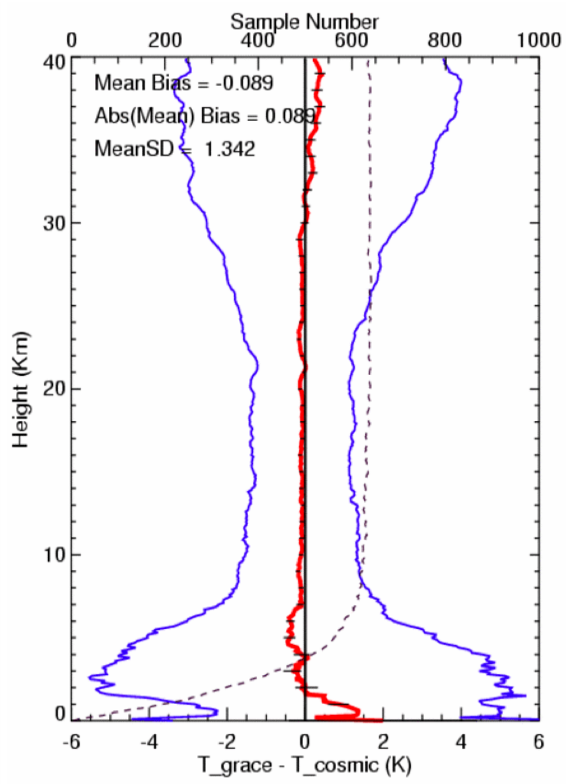
No mission dependent bias

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

Within 60 Mins, and 50 Km



CHAMP-COSMIC
2007-2008

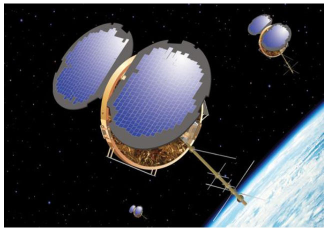


GRACE-COSMIC
2006

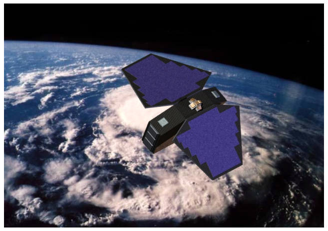
- Comparison of measurements between old and new instrument
- CHAMP launched in 2001
- COSMIC launched 2006
- GRACE launched 2002

Don't need to have stable calibration reference

(Ho et al., 2010 JGR
in preparation)



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



Approaches:

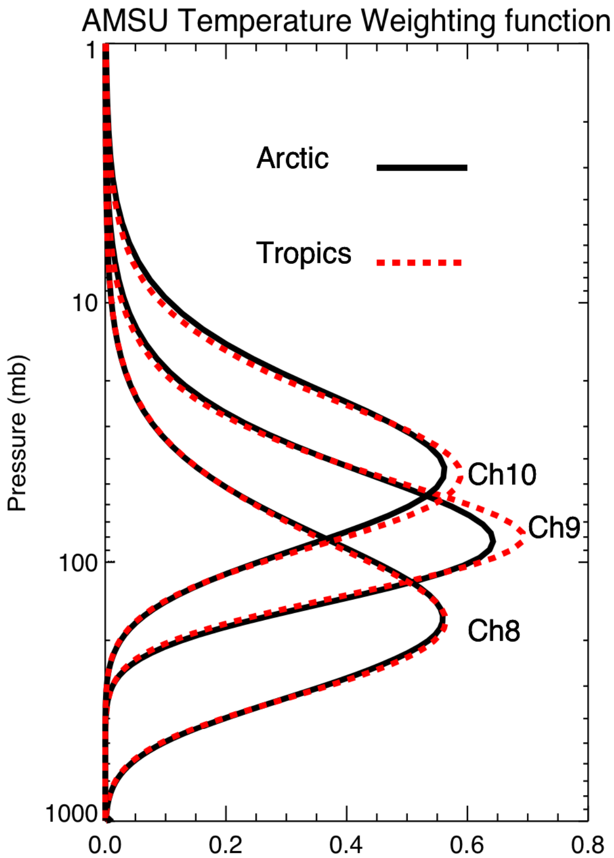
1. Data:
COSMIC from 200606 to 200912
CHAMP from 200106 to 200806
RSS V3.2 200106-200912
UAH V5.1 200106-200812
SNO V2.0 200106-200912

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

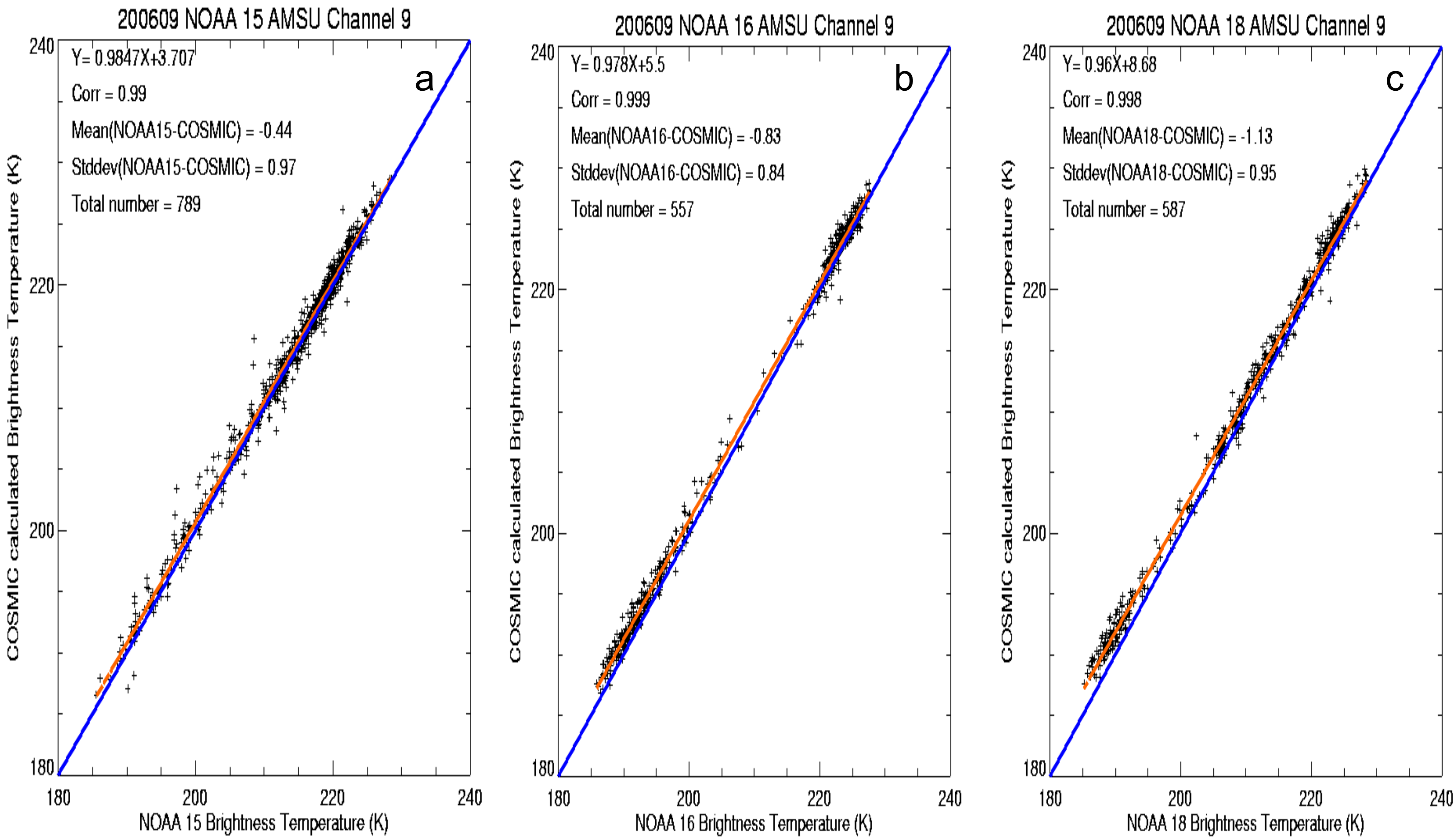
a. use GPS RO data to inter-calibrate other NOAA satellite

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



Approaches: Constructing RO-AMSU brightness temperature calibration coefficients for each month from 200106 to 200912

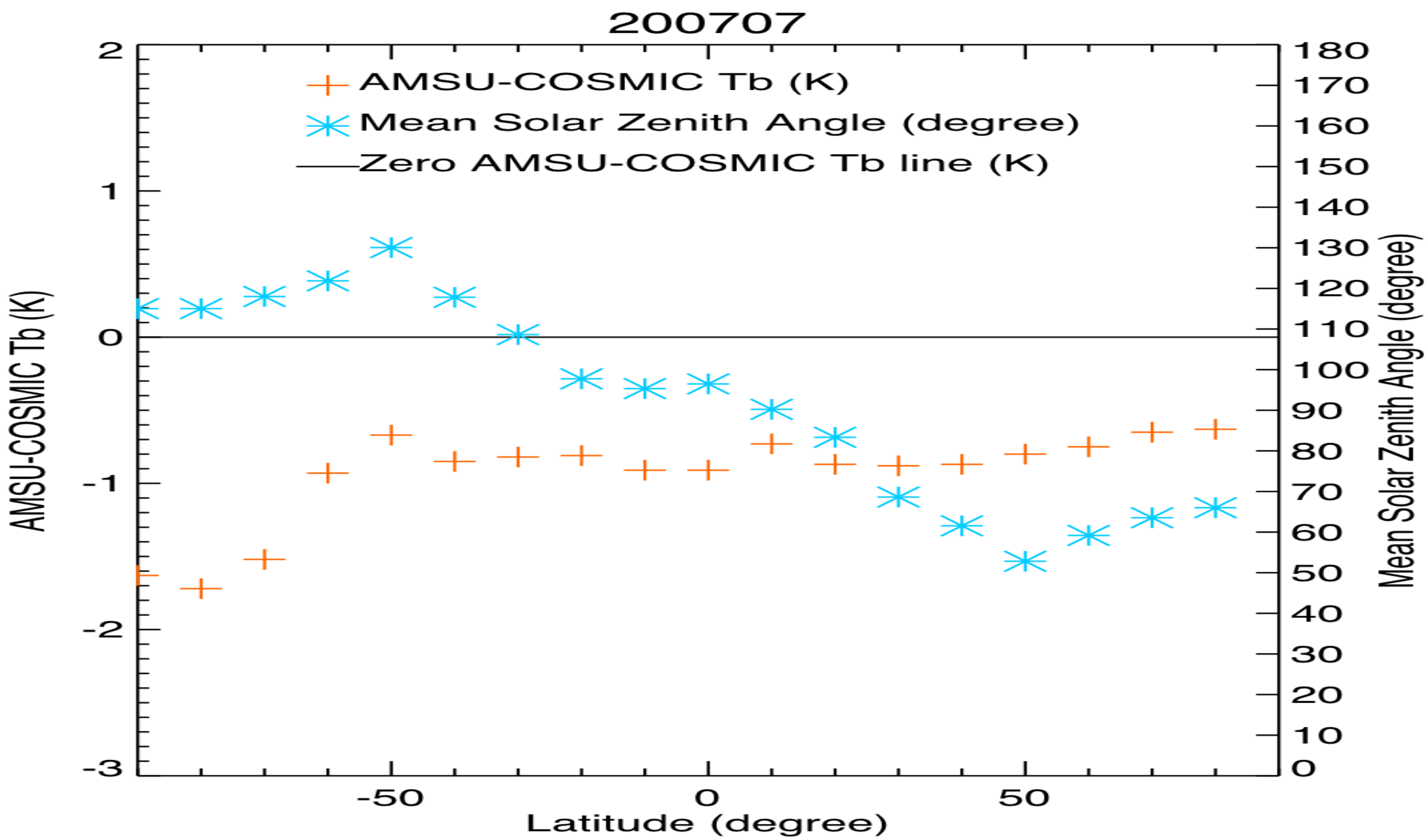
N15, N16 and N18 AMSU calibration against COSMIC



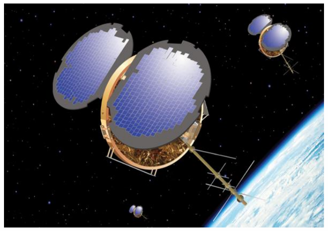
(Ho et al., 2009a TAO)

200609

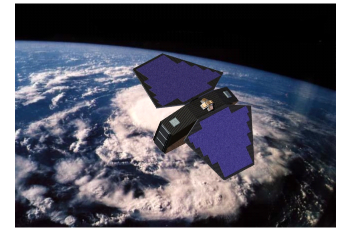
Approach: Use of RO Data to Identify the Location/local-time Dependent Brightness Temperature Biases for regional Climate Studies



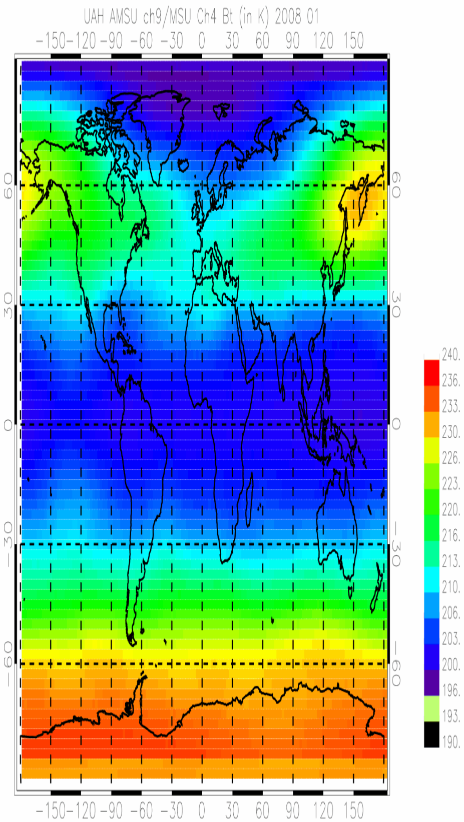
(Ho et al. OPAC special issue, 2009c)



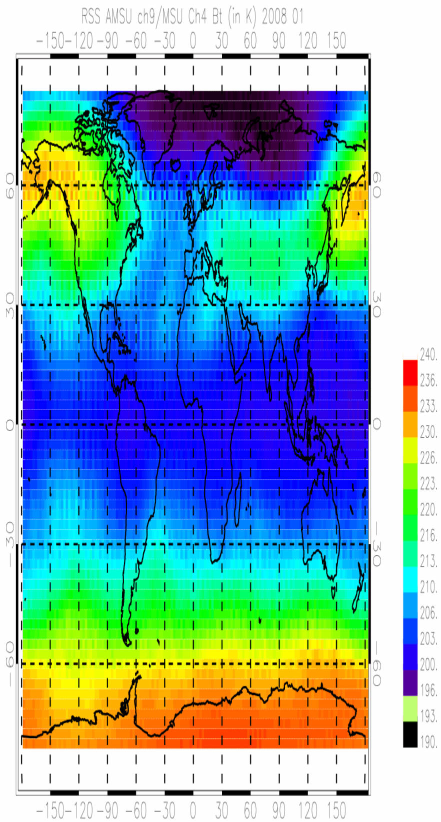
Comparisons of RO-calibrated AMSU with those from RSS, UAH, and SNO



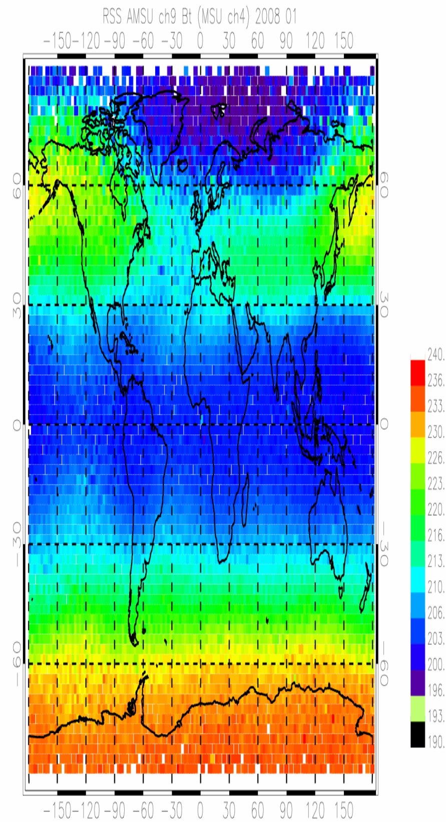
UAH



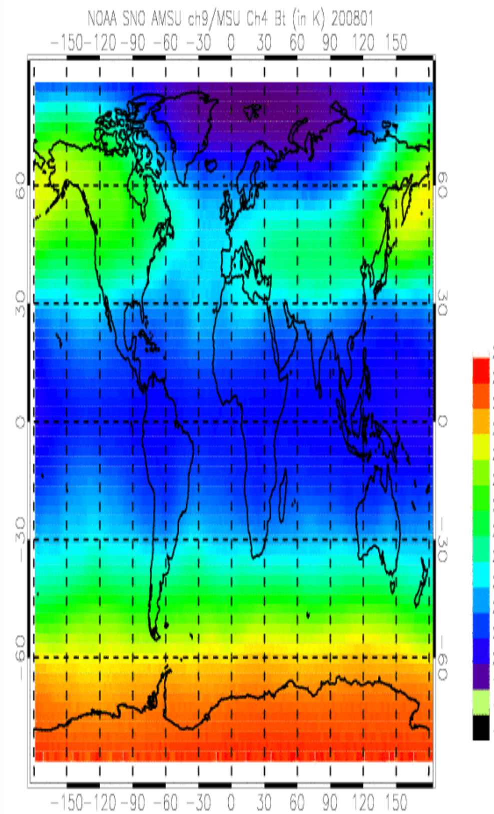
RSS



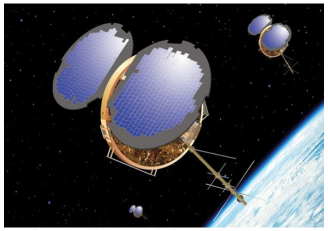
RO_AMSU



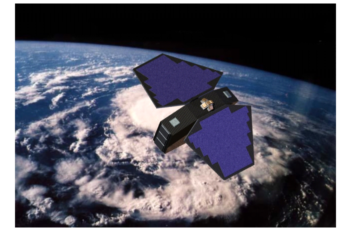
SNO



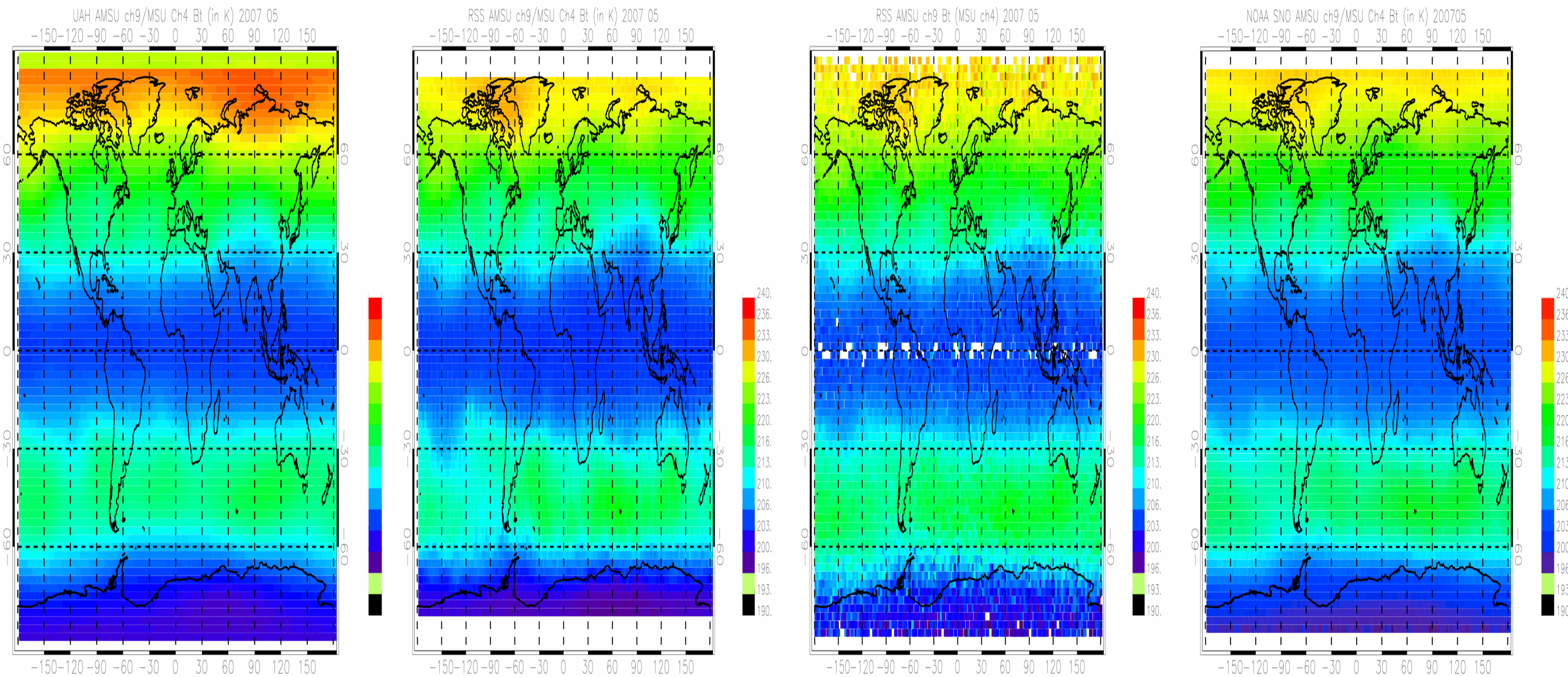
200801 TLS



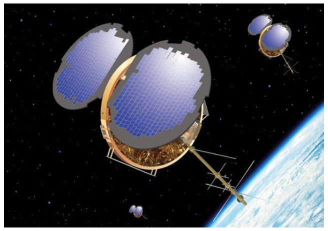
Comparisons of RO-calibrated AMSU with those from RSS, UAH, and SNO



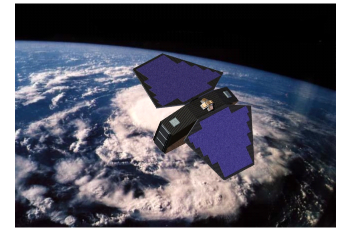
UAH **RSS** **RO_AMSU** **SNO**

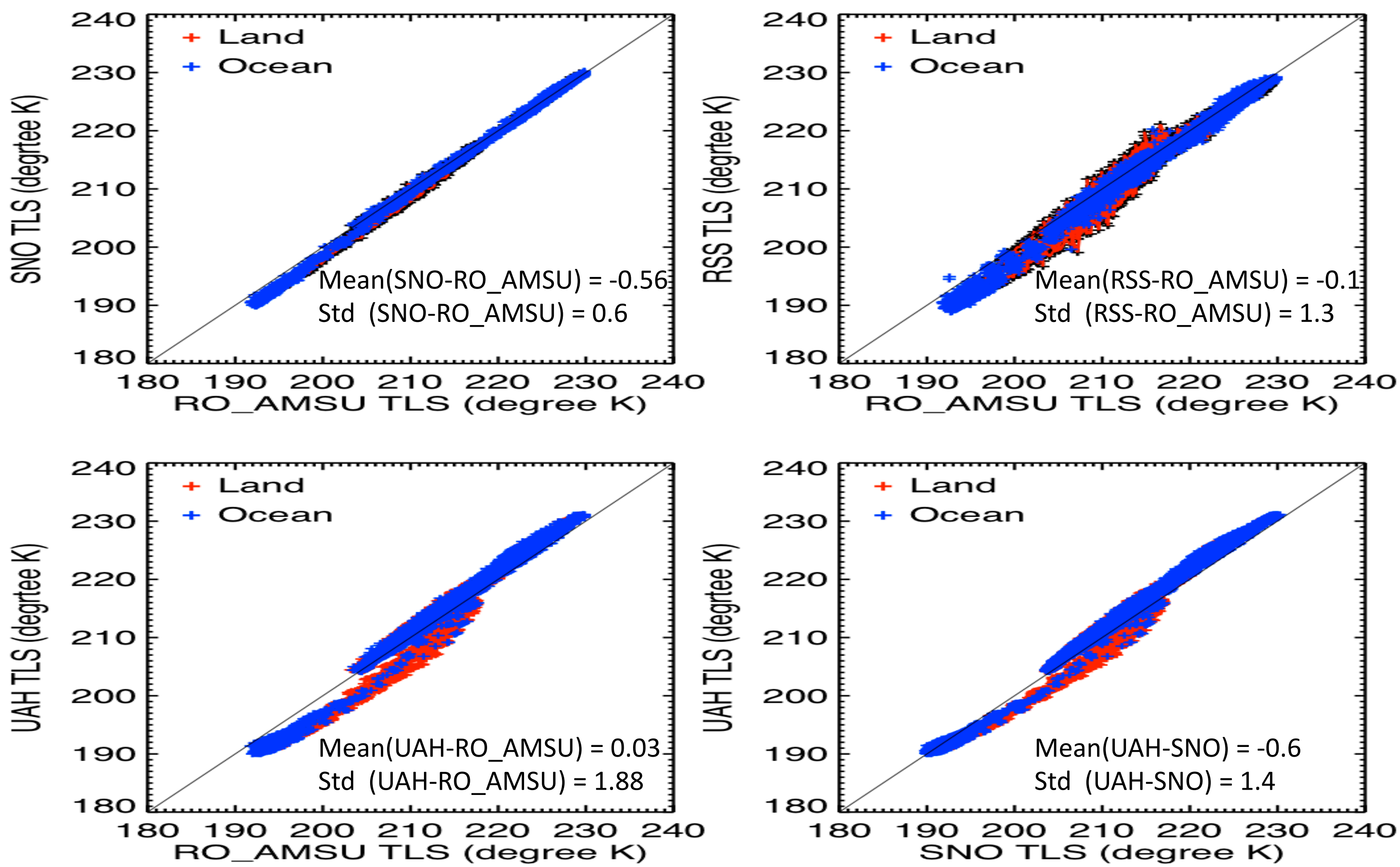


200705 TLS

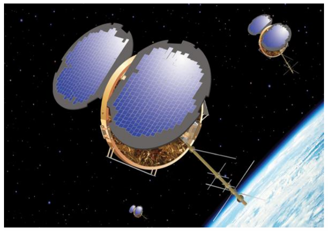


Comparisons over Lands and Oceans

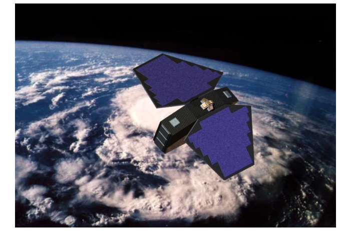


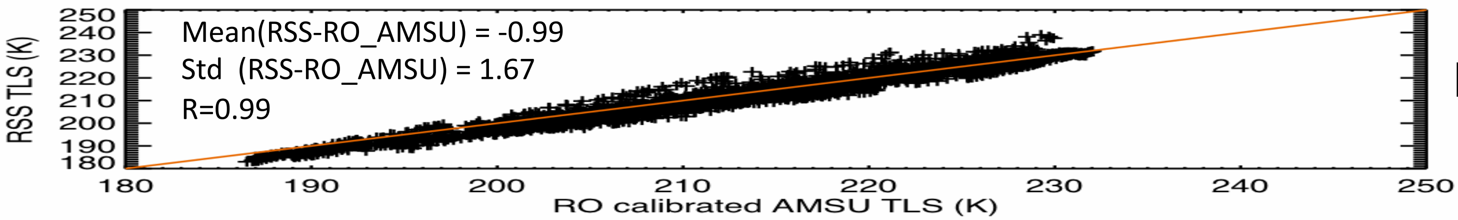


200705 TLS

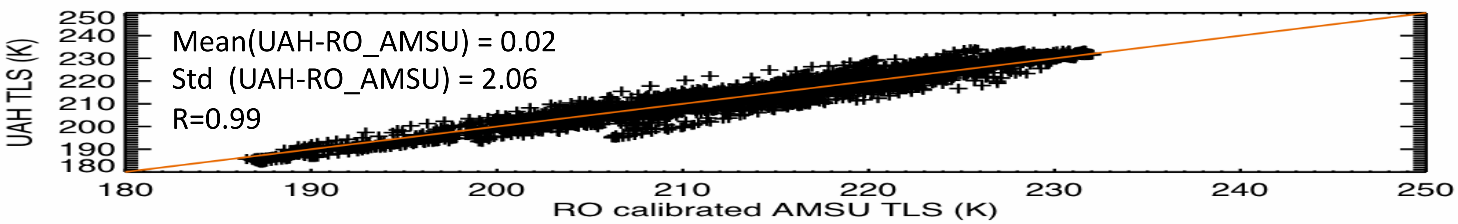


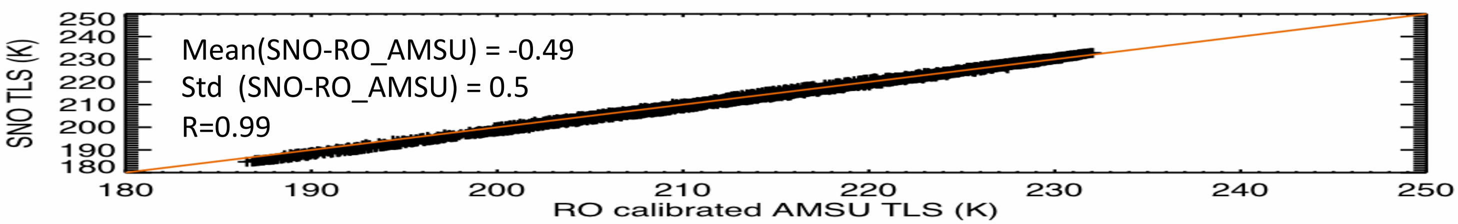
Scattering plots of 10 x10 degree binned TLS from 200106 to 200812

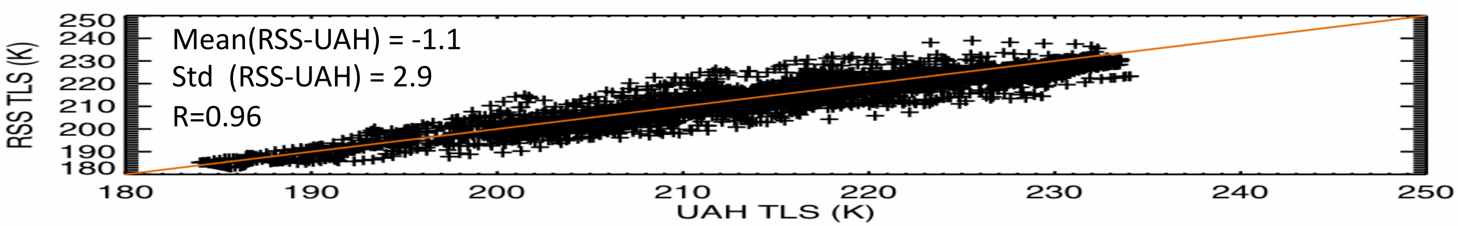


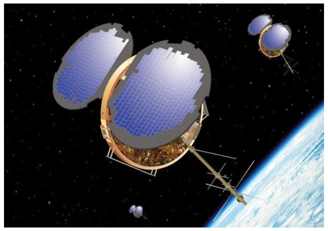


Binning all into 10x10 grid

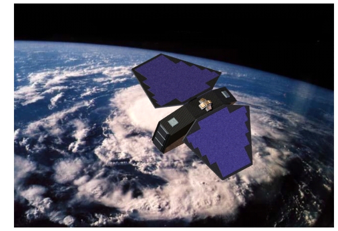


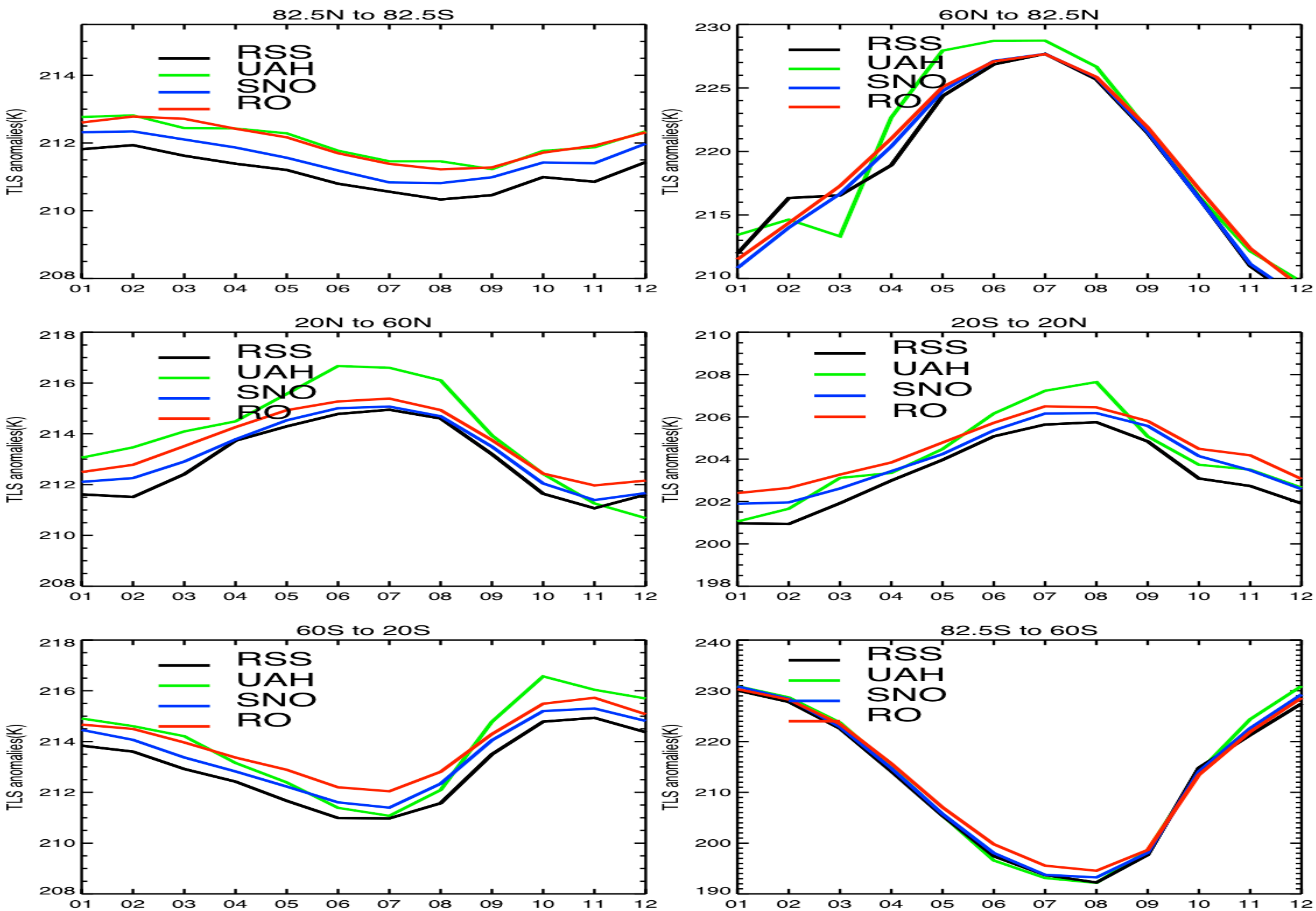


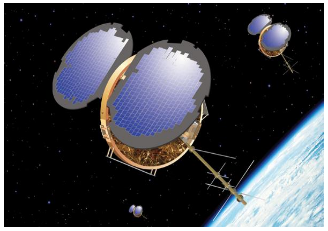




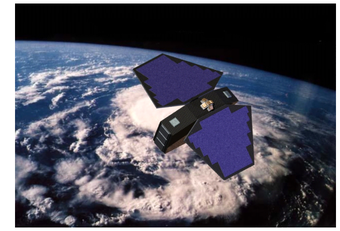
Monthly Mean for each month

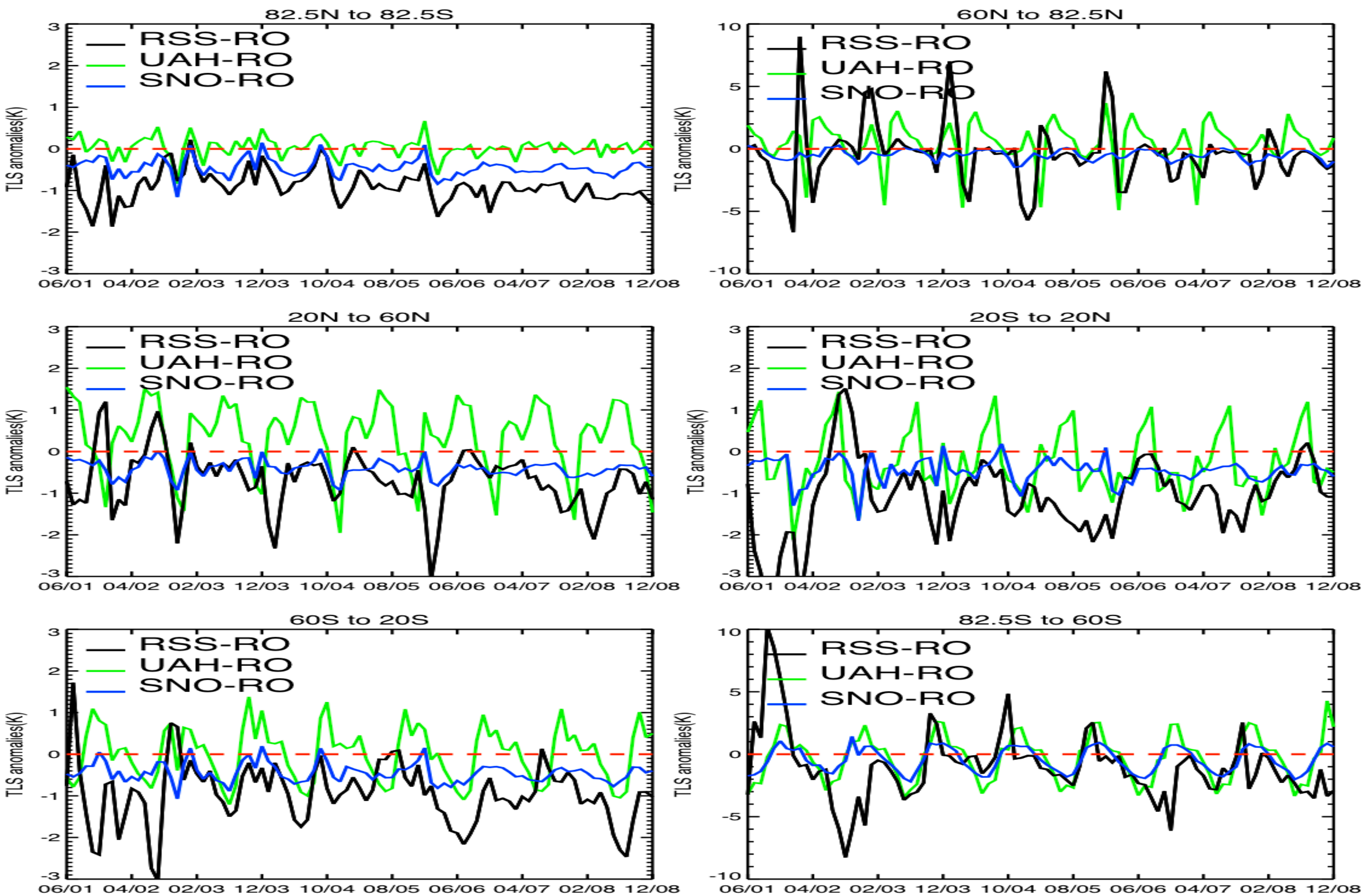


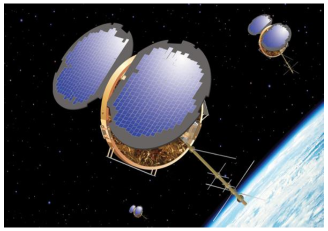




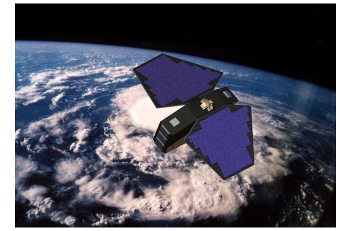
Time series of TLS difference

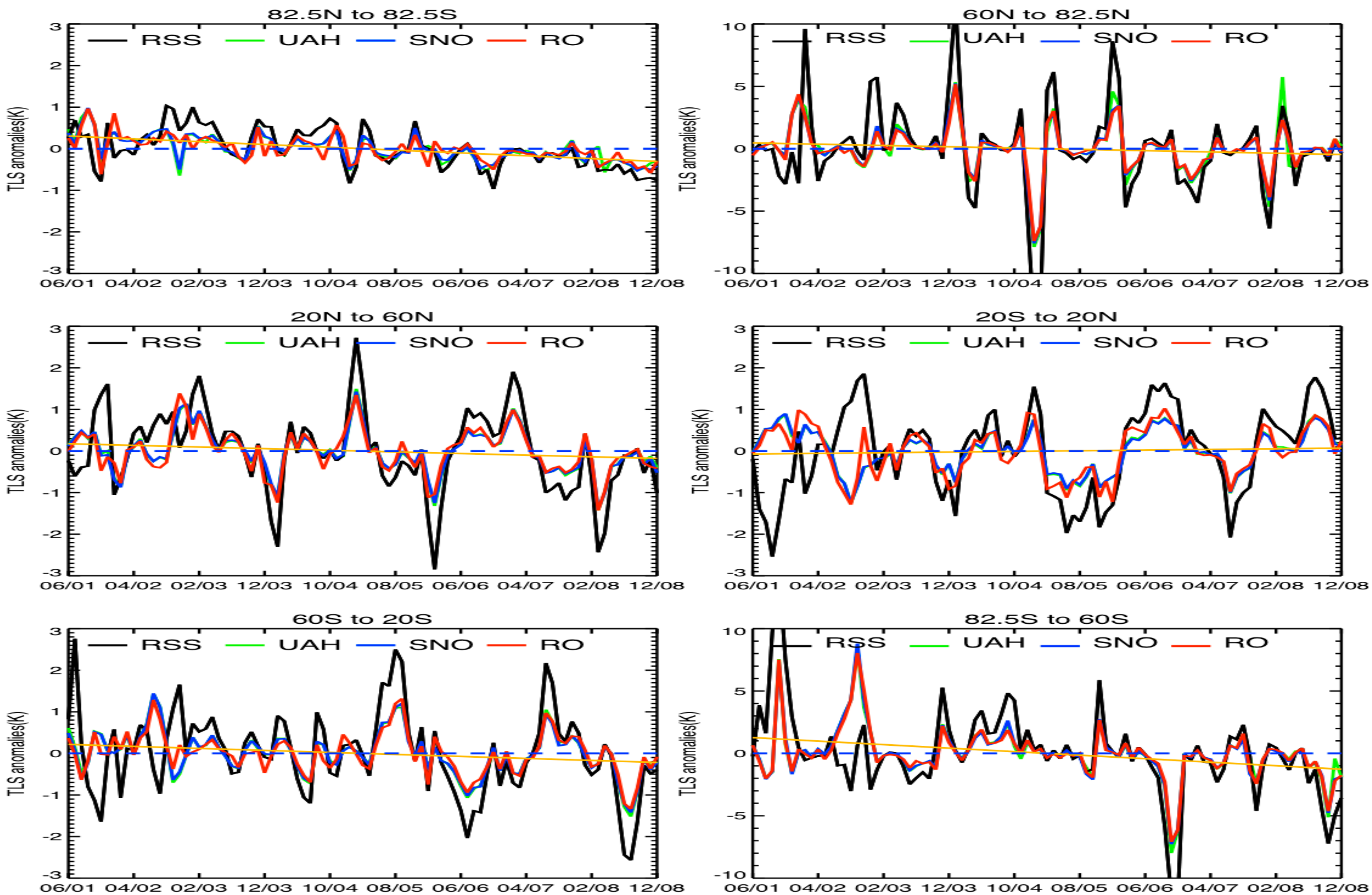


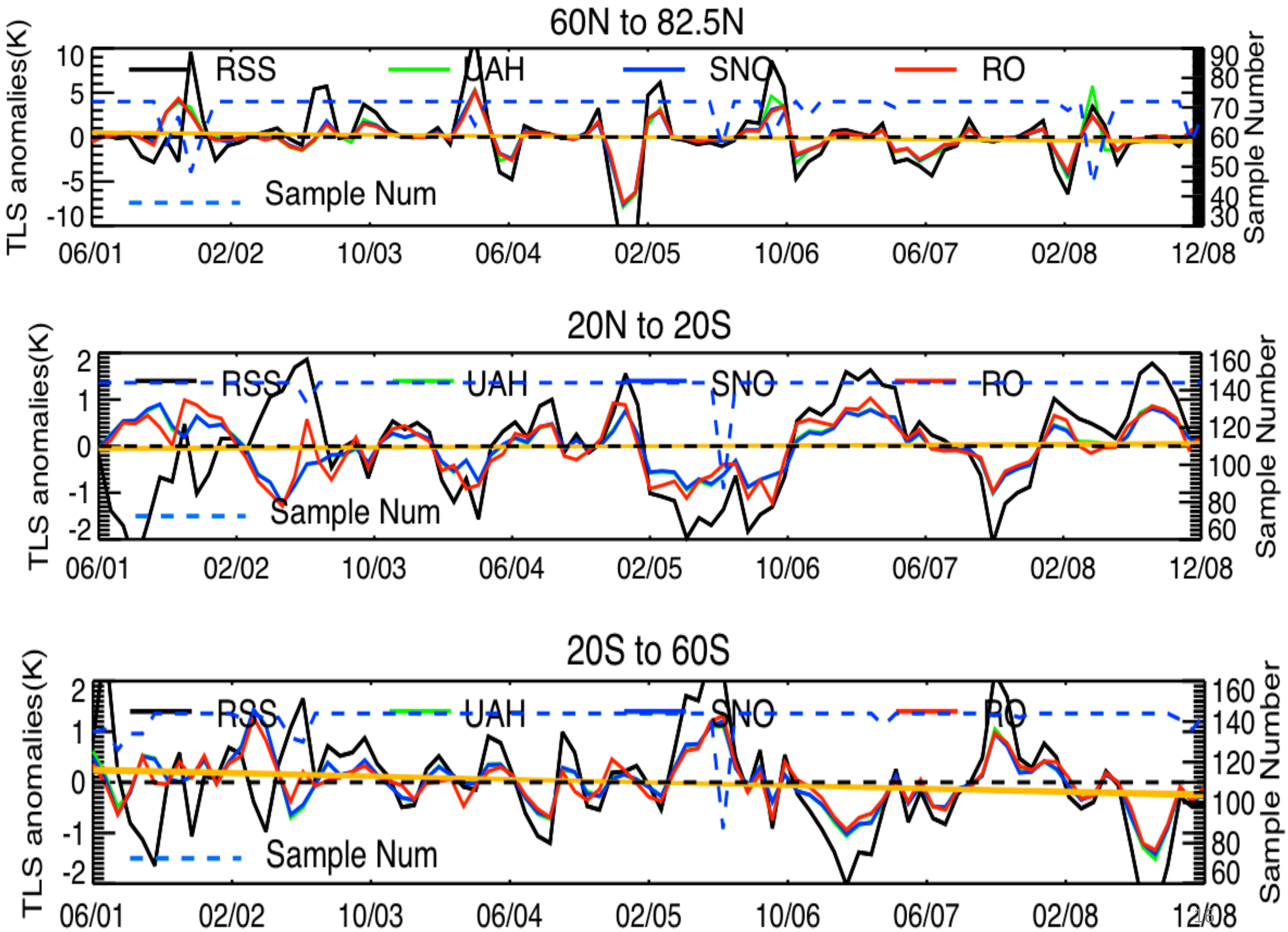




Time series of TLS anomalies



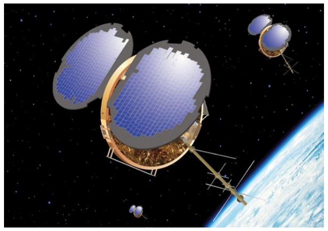



60N to 82.5N
RSS
UAH
SNO
RO
Sample Num
TLS anomalies(K)
Sample Number
06/01
02/02
10/03
06/04
02/05
10/06
06/07
02/08
12/08
20N to 20S
20S to 60S

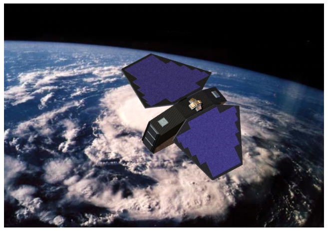
	RSS	UAH	SNO	RO_AMSU	RSS-RO_AMSU	UAH-RO_AMSU	SNO-RO_AMSU
82.5°N-82.5° S	**-0.59**	**-0.46**	**-0.48**	**-0.41**	**-0.18**	**-0.05**	**-0.07**
60°N - 82.5° N	**-1.04**	**-0.67**	**-0.74**	**-0.62**	**-0.42**	**-0.05**	**-0.12**
20° N - 60° N	**-0.60**	**-0.30**	**-0.31**	**-0.24**	**-0.42**	**-0.06**	**-0.07**
20° N - 20° S	**0.55**	**0.07**	**0.05**	**0.1**	**0.45**	**-0.03**	**-0.05**
20° S - 60° S	**-0.52**	**-0.38**	**-0.37**	**-0.29**	**-0.23**	**-0.09**	**-0.08**
60°S - 82.5° S	**-3.22**	**-1.70**	**-1.80**	**-1.70**	**-1.52**	**0.0**	**-0.1**

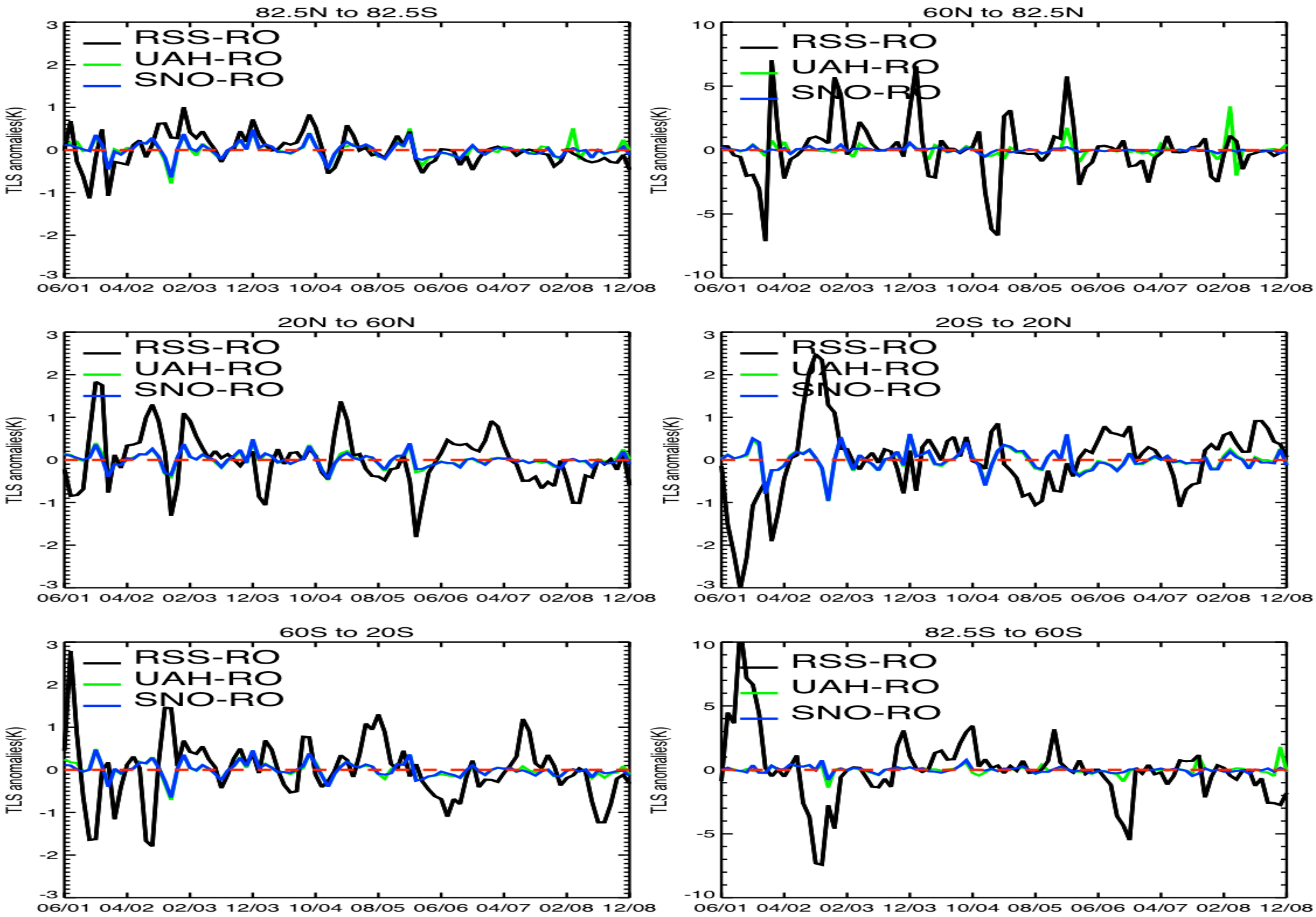
The 2001-2008 trends of de-seasonalized lower stratospheric Tb anomalies (in K/5yrs) for RSS, UAH, RO-AMSU Tb, RSS-RO_AMSU and UAH-RO_AMSU for the global (82.5°N-82.5° S) and five latitudinal zones.

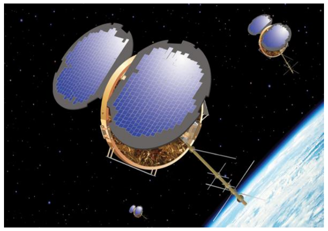
Although the de-seasonalized TLS anomalies from UAH and SNO are, in general, agree well with that from RO-calibrated AMSU TLS in all latitudinal zones, small trend differences are found among SNO, UAH, and RO-calibrated AMSU.



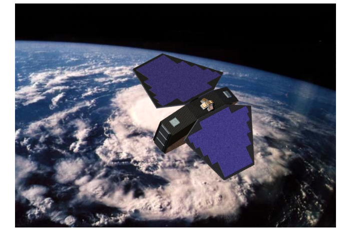
Difference of TLS anomalies

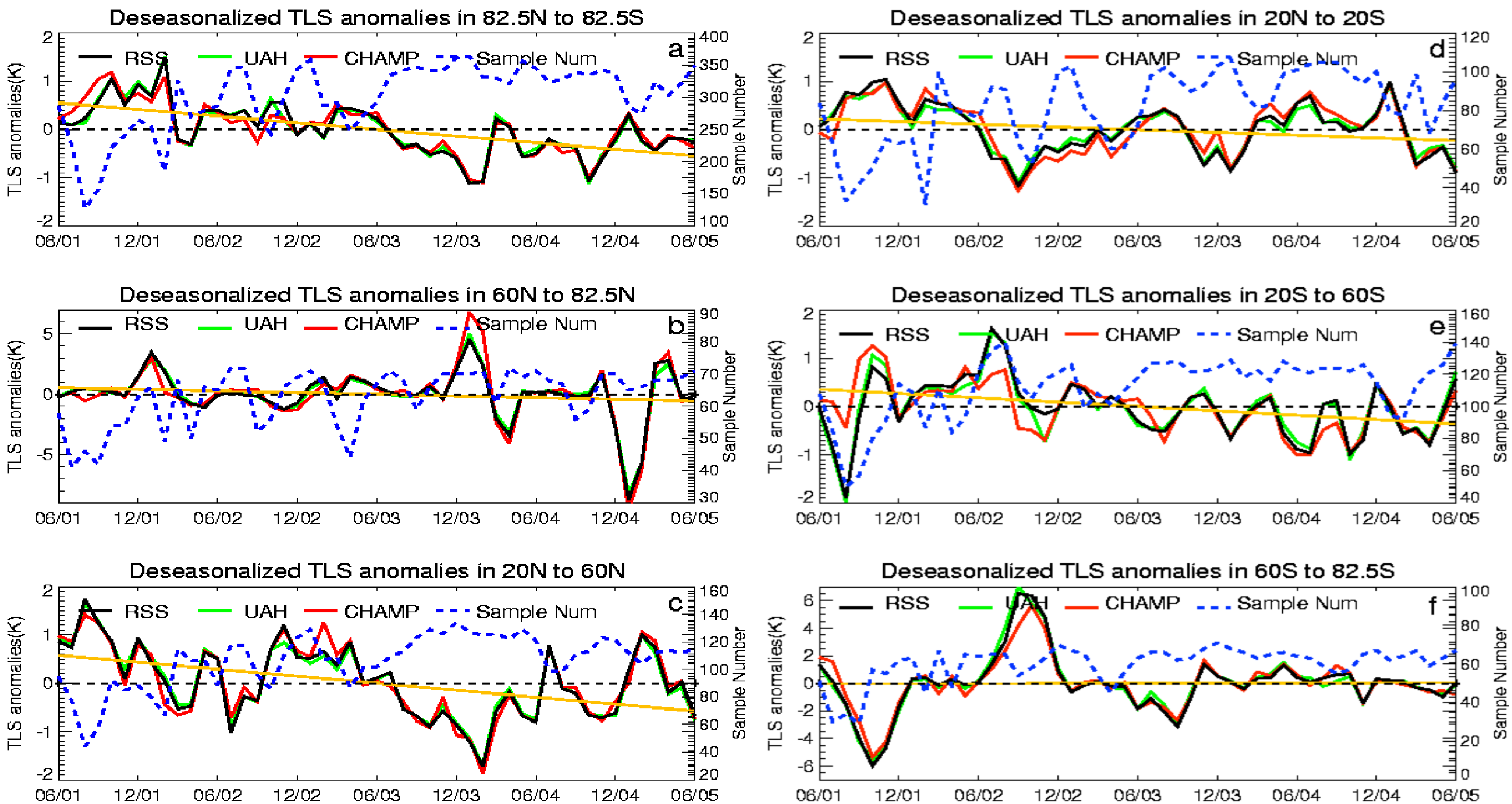






Difference of TLS anomalies for UAH V5.1 vs. V5.2 RSS V2.1 vs. V3.2





(Ho et al., 2007)

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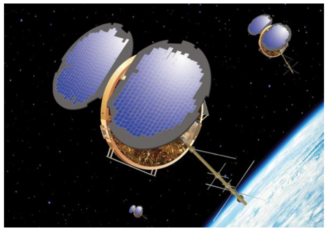
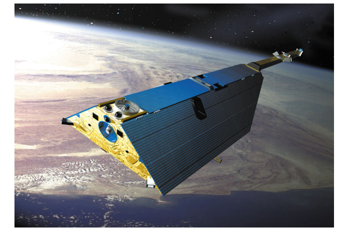
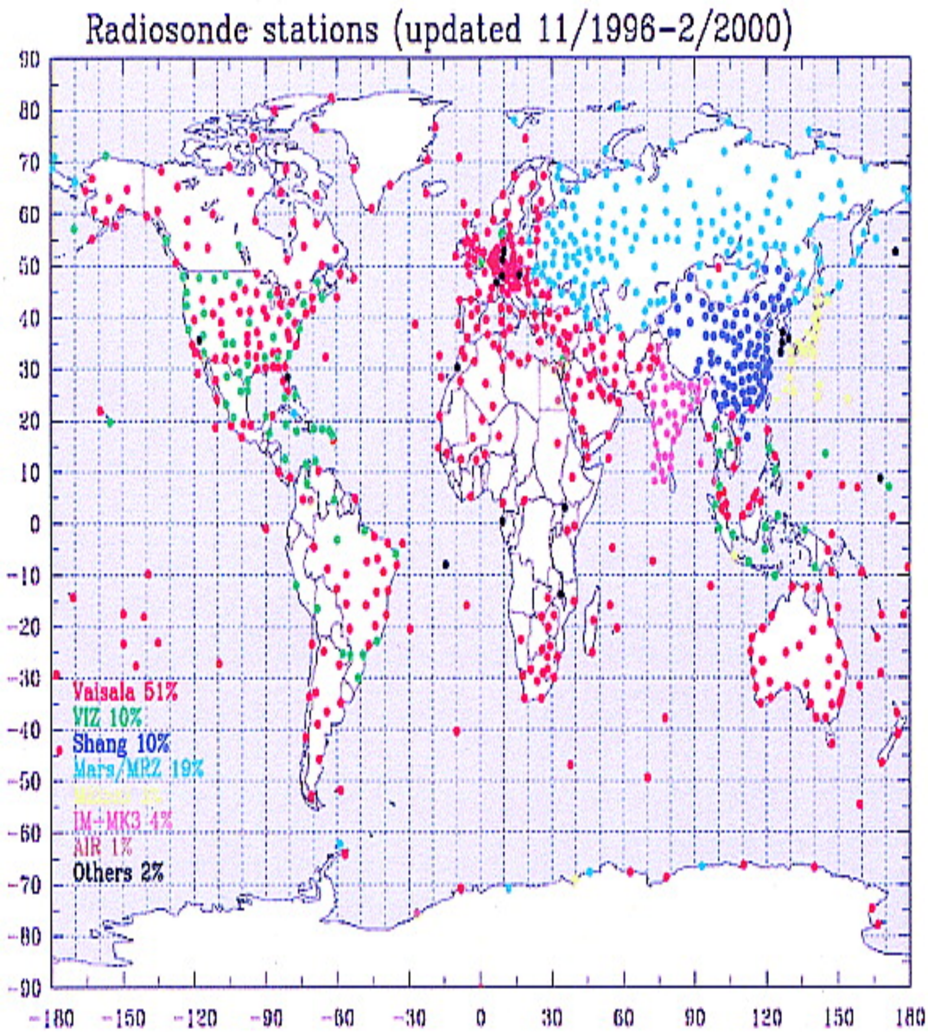


Approach: Using Multi-year of RO data to assess the quality of radiosonde data

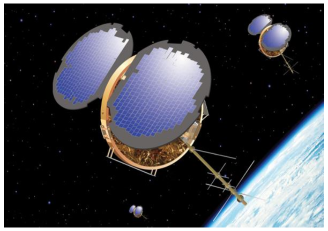




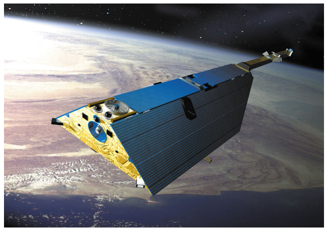
COSMIC from 2006 to 2009
CHAMP from 2001 to 2008
Radiosodne data DS351.0 from NCAR
- originally acquired from NCEP.
- contains the original data values transmitted by stations \
- no radiative or other corrections from NCEP are included in this dataset

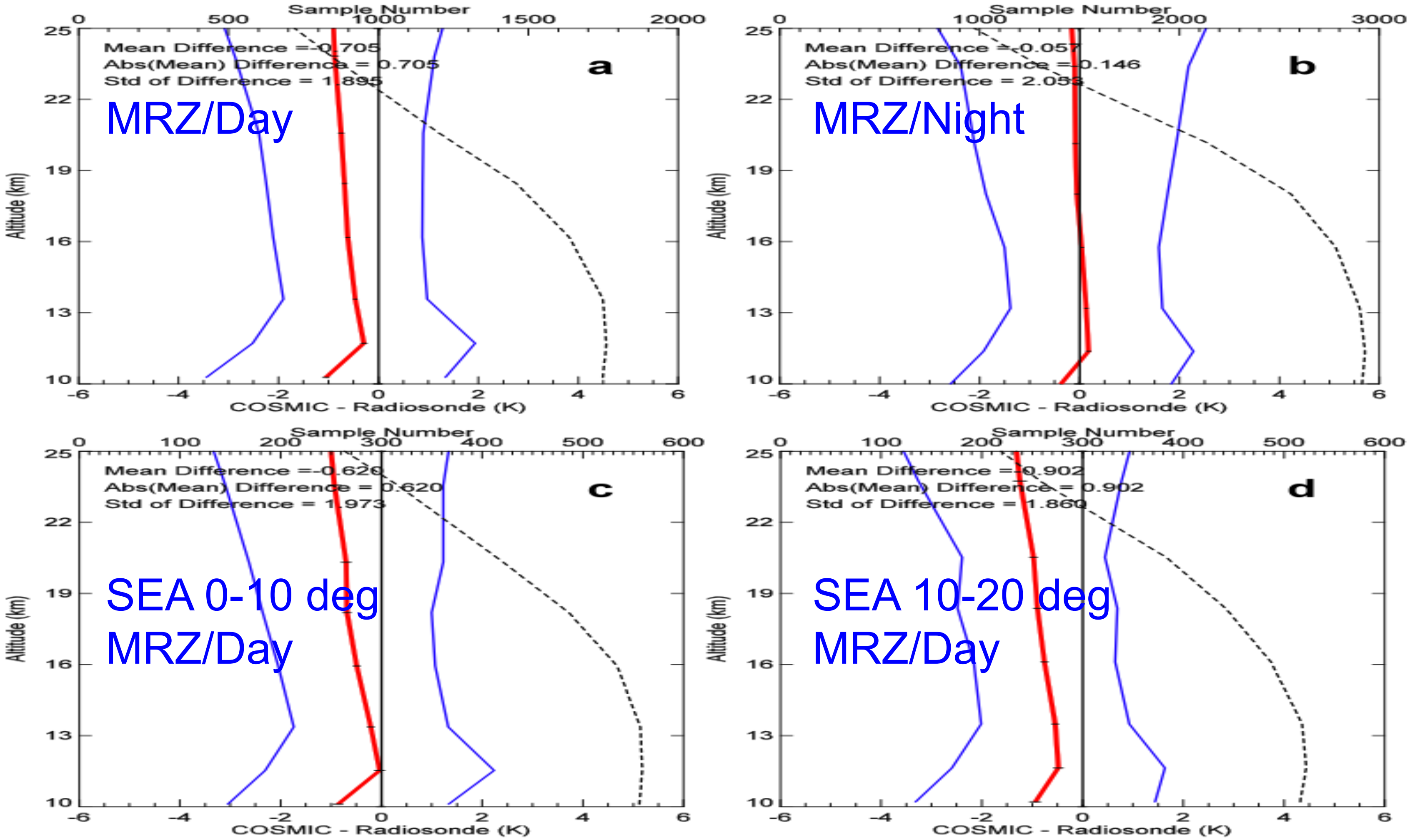
Region	Sonde Type	Matched Sample
Russia	AVK-MRZ	2000 (20%)
China	Shang	650 (6.1%)
USA	VIZ-B2	600 (5.9%)
Others	Vaisala	3140 (30%)

Collocate COSMIC/CHAMP and radiosonde profiles
< 200 km
< 3 hrs (He and Ho 2009 GRL)

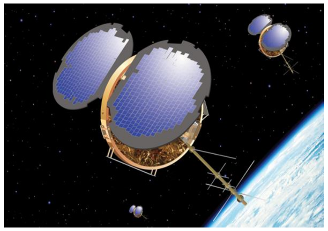


Identify systematic radiosonde temperature biases using RO data

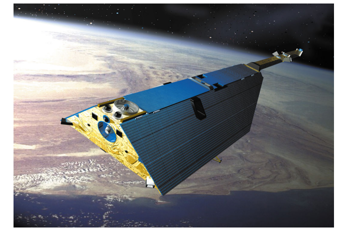




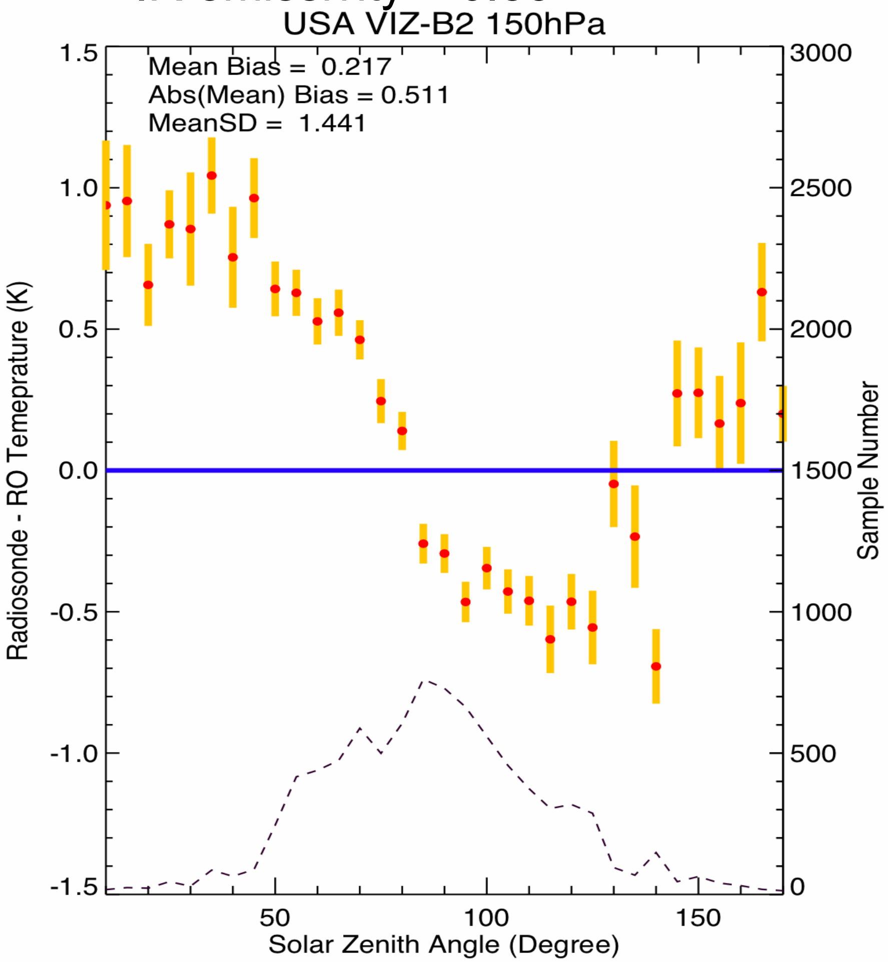
(He and Ho 2009 GRL)



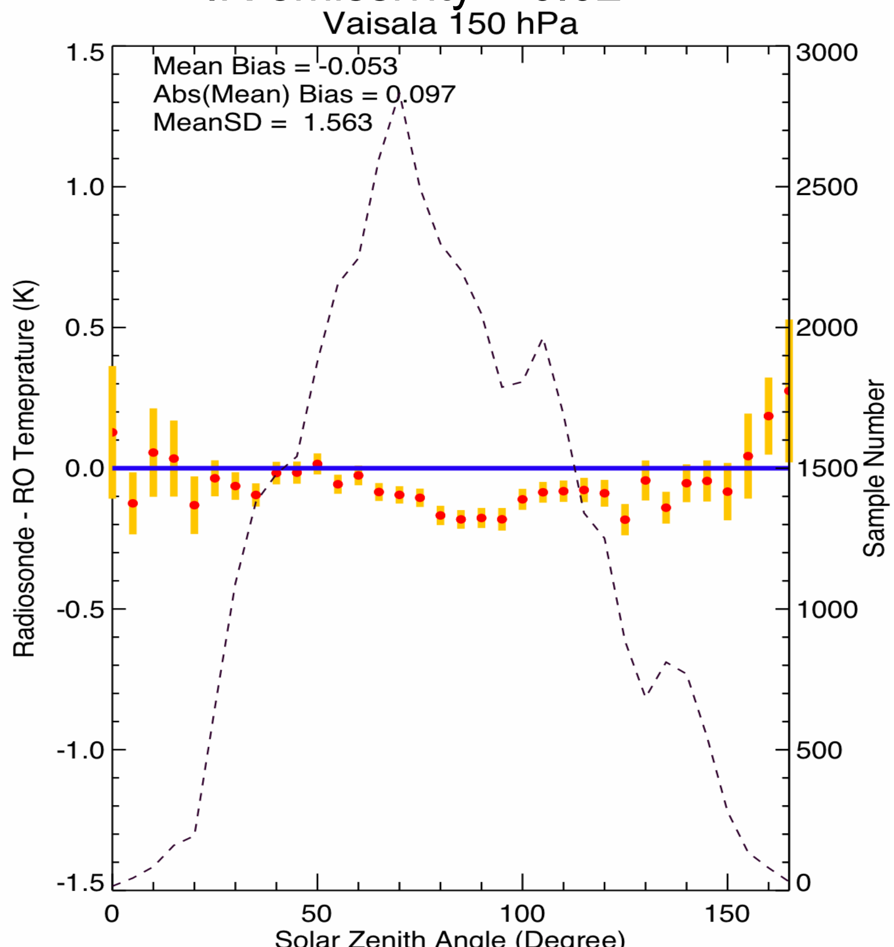
Using RO data to Correct Diurnal variation of Radiosonde Temperature Anomalies



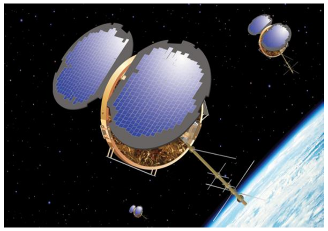
Solar absorptivity = 0.15
IR emissivity = 0.85



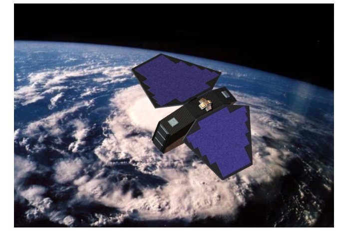
Solar absorptivity = 0.15
IR emissivity = 0.02



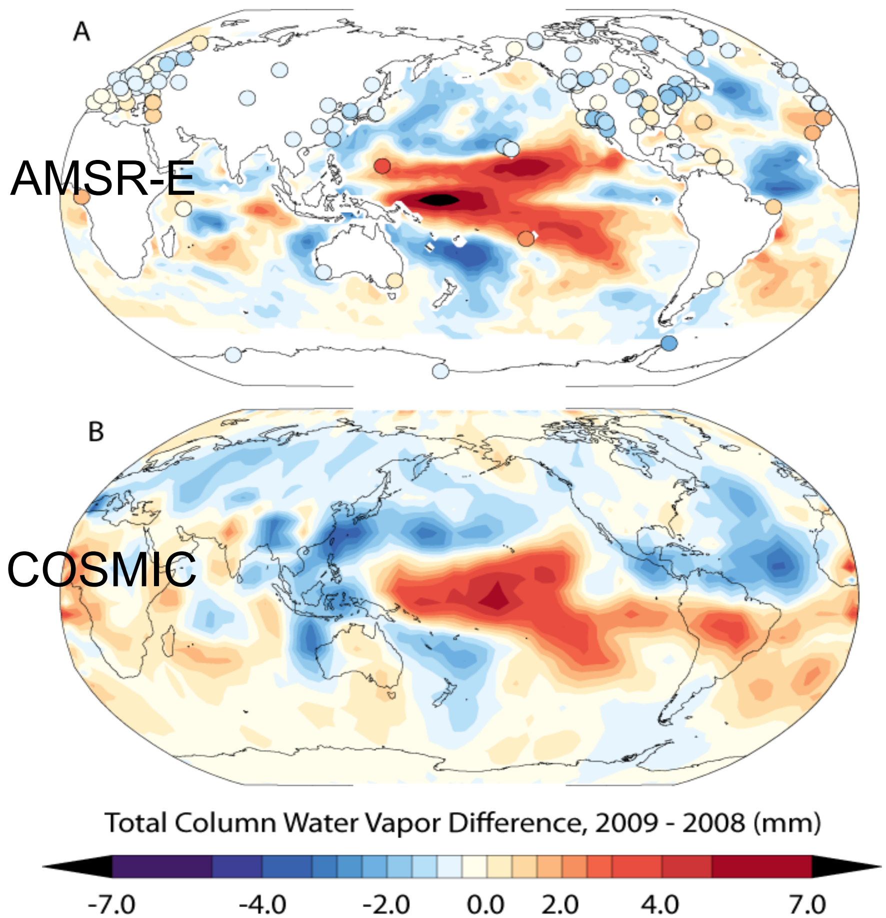
(Ho et al., 2010 in preparation)



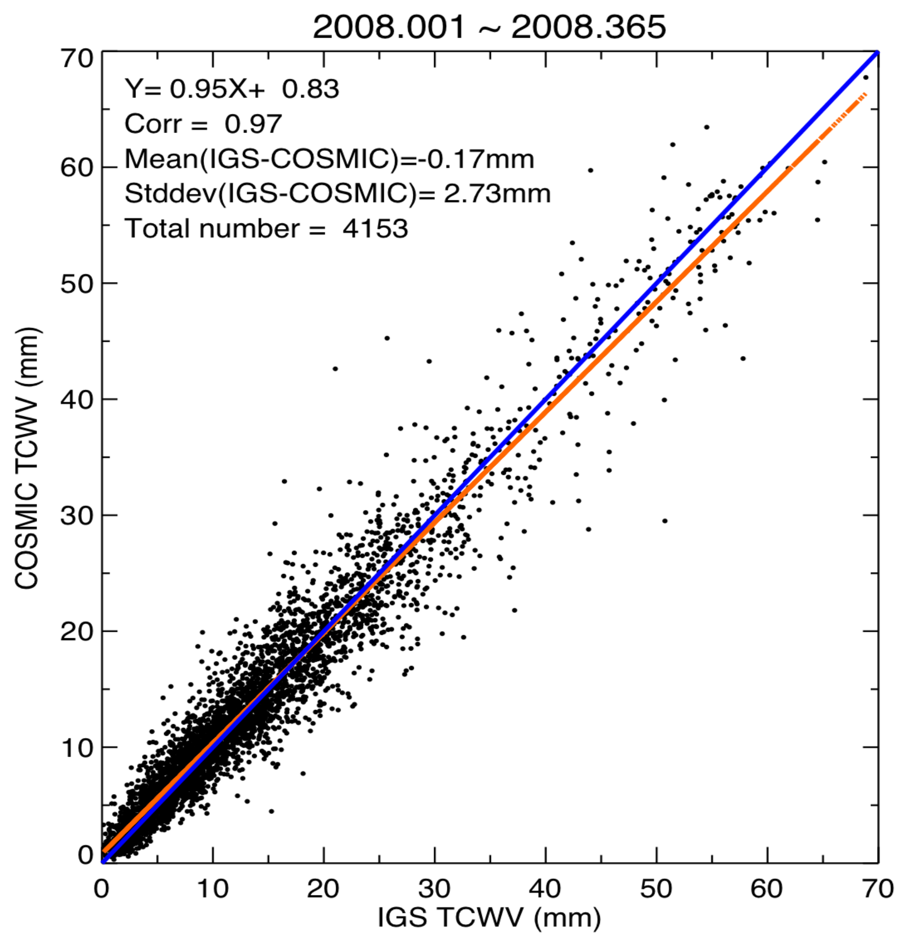
COSMIC vs. AMSR-E and GB-GPS total column water vapor



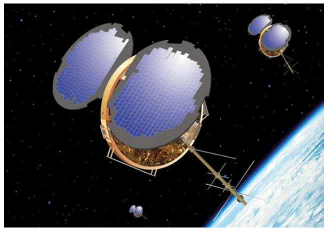
TWP 2009-2008



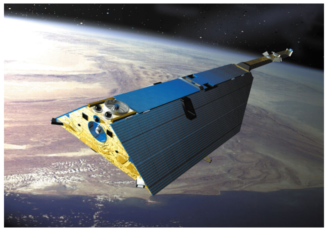
(Mears et al., 2010 BAMS)



(Ho et al., 2010 BAMS)



Conclusions and Future Work



•The 0.02K-0.05 K precision of RO soundings are very useful to inter-calibrate AMSU/MSU data.

•The long term stability of GPS RO data is very useful for climate monitoring.

•The RO calibrated AMSU TLS matches better with SNO and RSS in terms of variations (higher correlation coefficient) and matches better with UAH and SNO in terms of mean.

•The de-seasonalized TLS anomalies from UAH and SNO are, in general, agree well with that from RO calibrated AMSU Tb in all latitudinal zones. **Small trend differences are found among SNO, UAH, and RO-calibrated AMSU.**

•In the future we will use RO calibrated AMSU/MSU to calibrate overlapped AMSU/MSU to construct temperature trend analysis using 30 years of MSU/AMSU data. GPS RO data is suitable for climate monitoring.

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