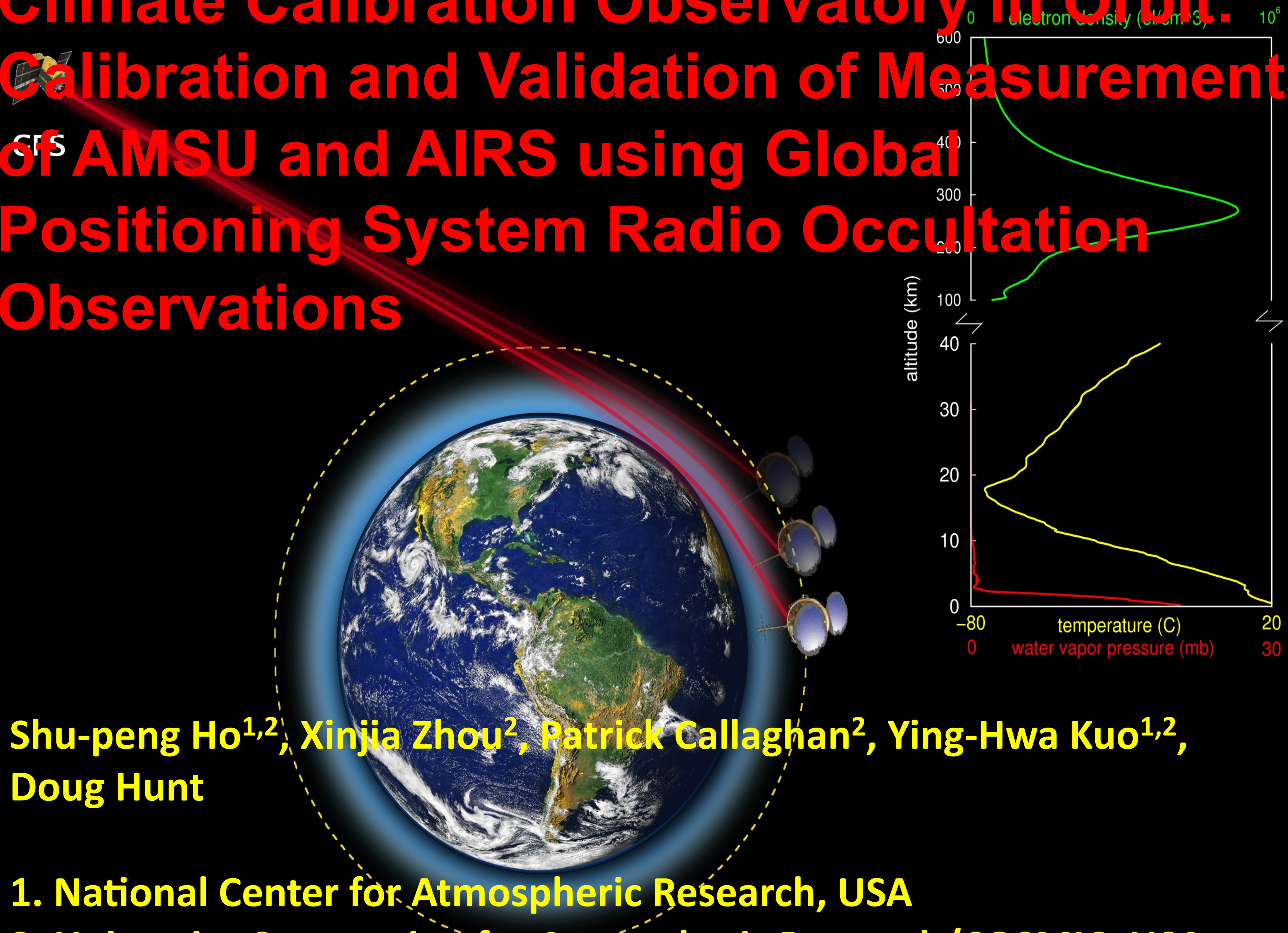
Climate Calibration Observatory in Orbit: Calibration and Validation of Measurements of AMSU and AIRS using Global Positioning System Radio Occultation Observations



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1. Motivation:

1) MSU/AMSU : MSU/AMSU data from 1978 to 2010 are very valuable for temperature climate data records

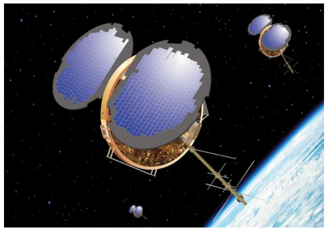
2) AIRS: AIRS exhibit biases in retrieving atmospheric temperatures, limiting their value in observing long-term climate change. These biases have diverse and complex dependencies on the temperature being measured, the season and geographical location, surface conditions, and sensor temperature.

3) Construction of a Consistent Microwave Sensor Temperature Record in the Lower Stratosphere Using Global Positioning System Radio Occultation Data and Microwave Sounding Measurements; validate the drift of AIRS temperature retrievals

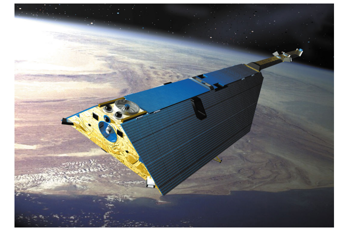
2. Outlines :

- 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 and comparisons of RO-AMSU, RSS, UAH, and SNO
- Using RO temperature profiles to validate AIRS temperature retrievals

3. Conclusions and Future Work



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



Satellites: Comparability and Reproducibility ?

1) Not designed for climate monitoring

2) Changing platforms and instruments

(No Comparability)

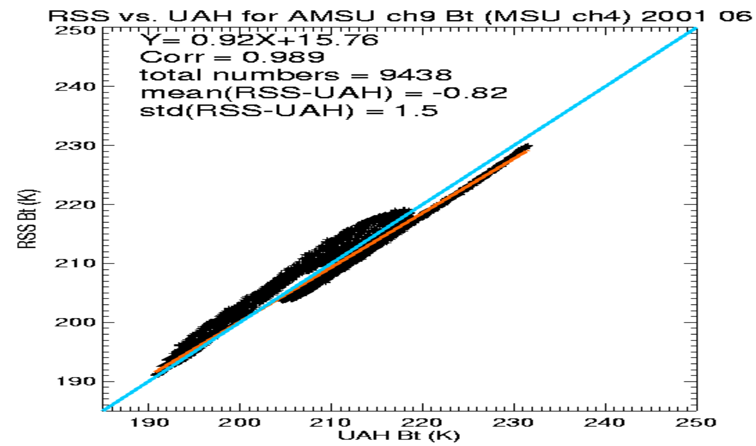
a. Satellite dependent bias, b. geo-location dependent bias, c. orbital drift dependent bias

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

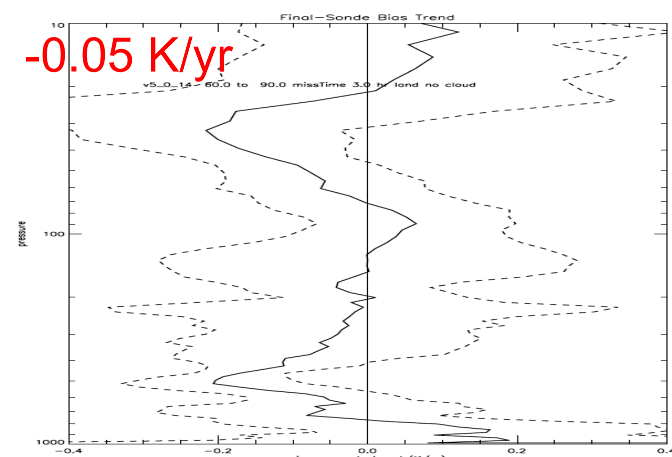
(No Reproducibility)

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.



AIRS-sonde trend 60-90N over land no Cloud



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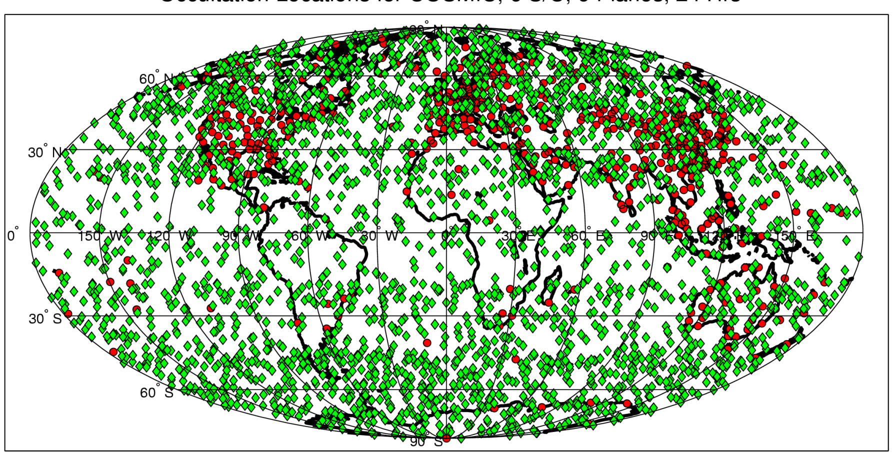
Characteristics of GPS RO Data

- **Measure of time delay: no calibration is needed**
- **Requires no first guess sounding**
- **Not affect by clouds**
- **Uniform spatial/temporal coverage**
- **High precision (<0.05K)**
- **Insensitive to clouds and precipitation**
- **No mission dependent bias**

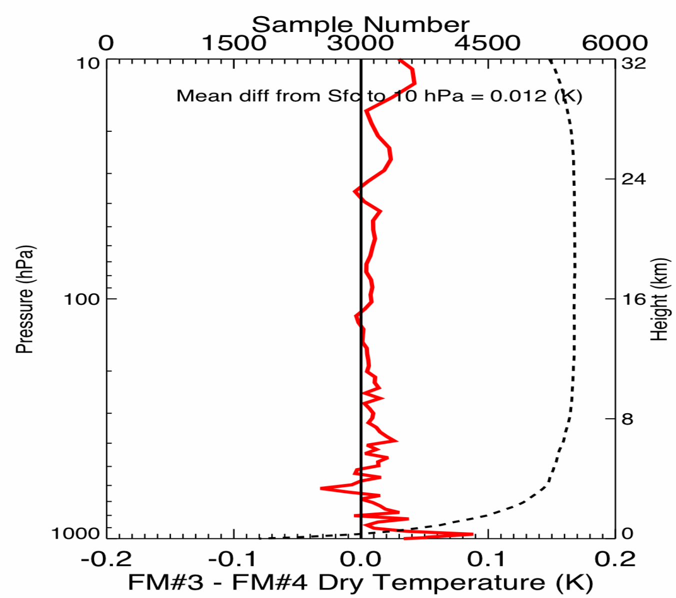
Precision < 0.05 K

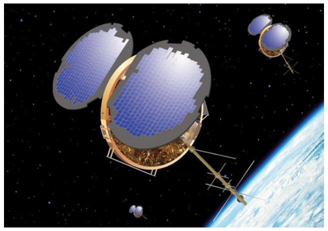
Using FM3-FM4 pairs
in early mission

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

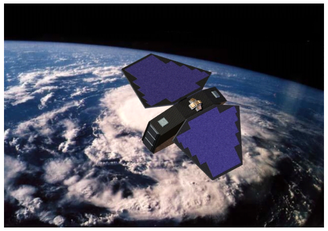


COSMIC





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



Approaches:

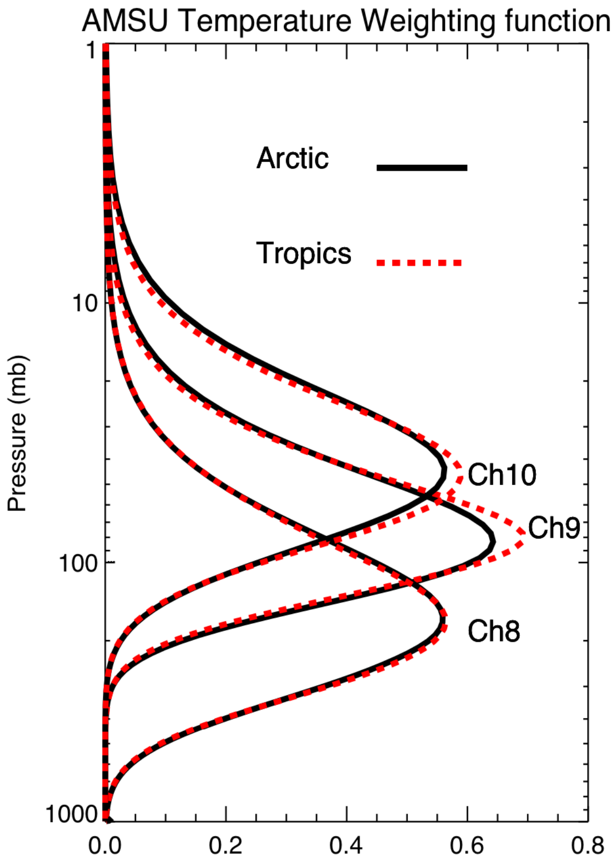
1. COSMIC from 200606 to 200912
CHAMP from 200106 to 200806
RSS V3.2 200106-200912
UAH V5.1 200106-200812
SNO V2.9 200106-200912

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

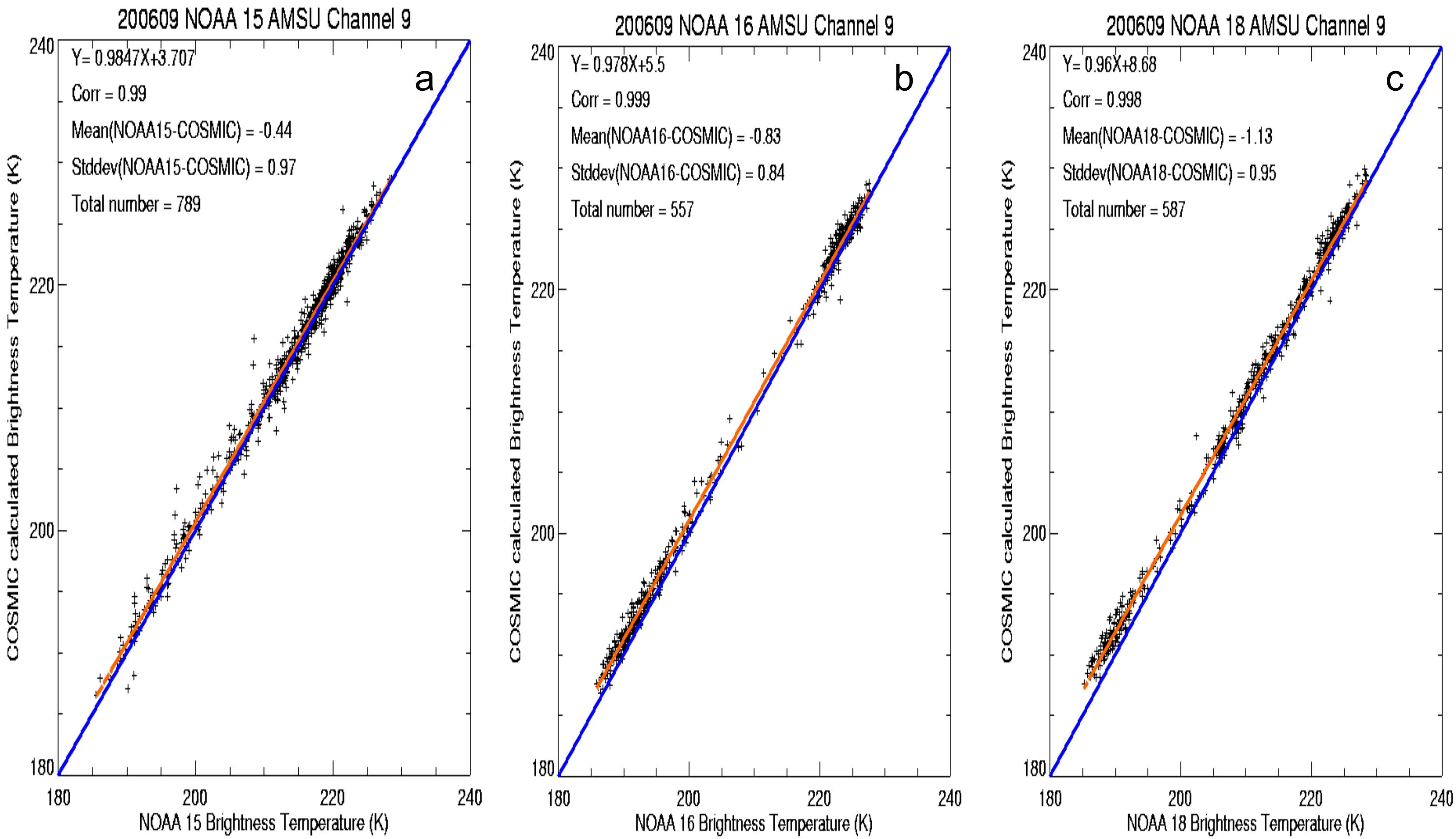
3. Match simulated GPS RO TLS to NOAA AMSU TLS within 30 minutes and 0.5 degree to find calibration coefficients for different NOAA satellites so that we can

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



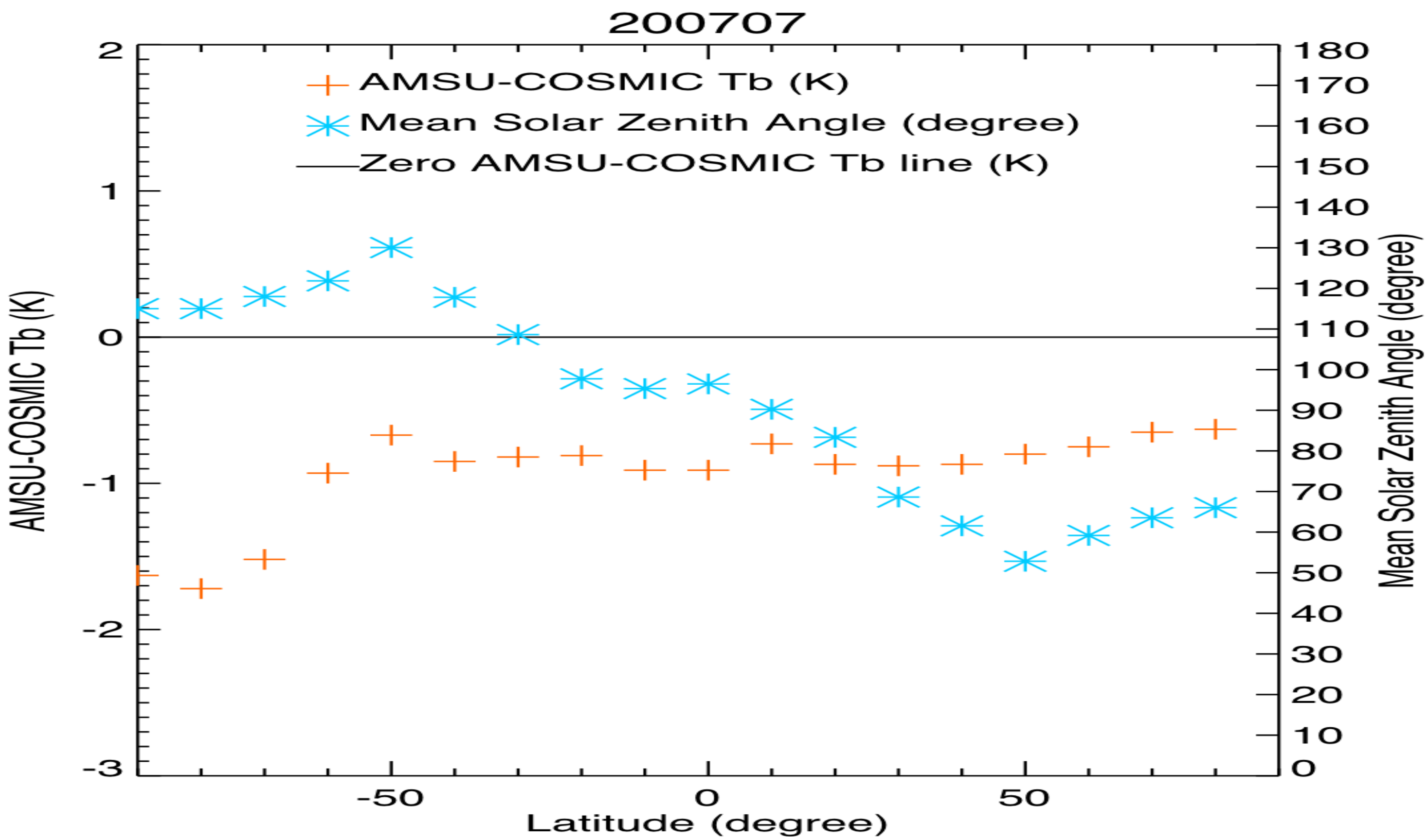
Approaches: Constructing RO-AMSU brightness temperature calibration coefficients for each month from 200106 to 200912



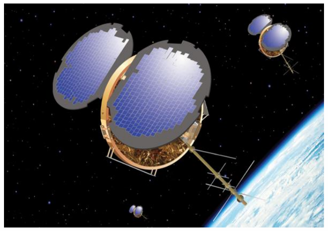
N15, N16 and N18 AMSU calibration against COSMIC

200609

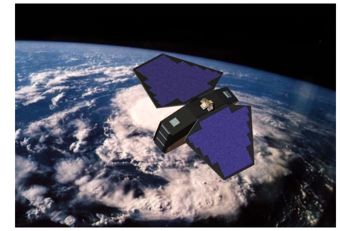
Approach: Use of RO Data to Identify the Location/local-time Dependent Brightness Temperature Biases for regional Climate Studies



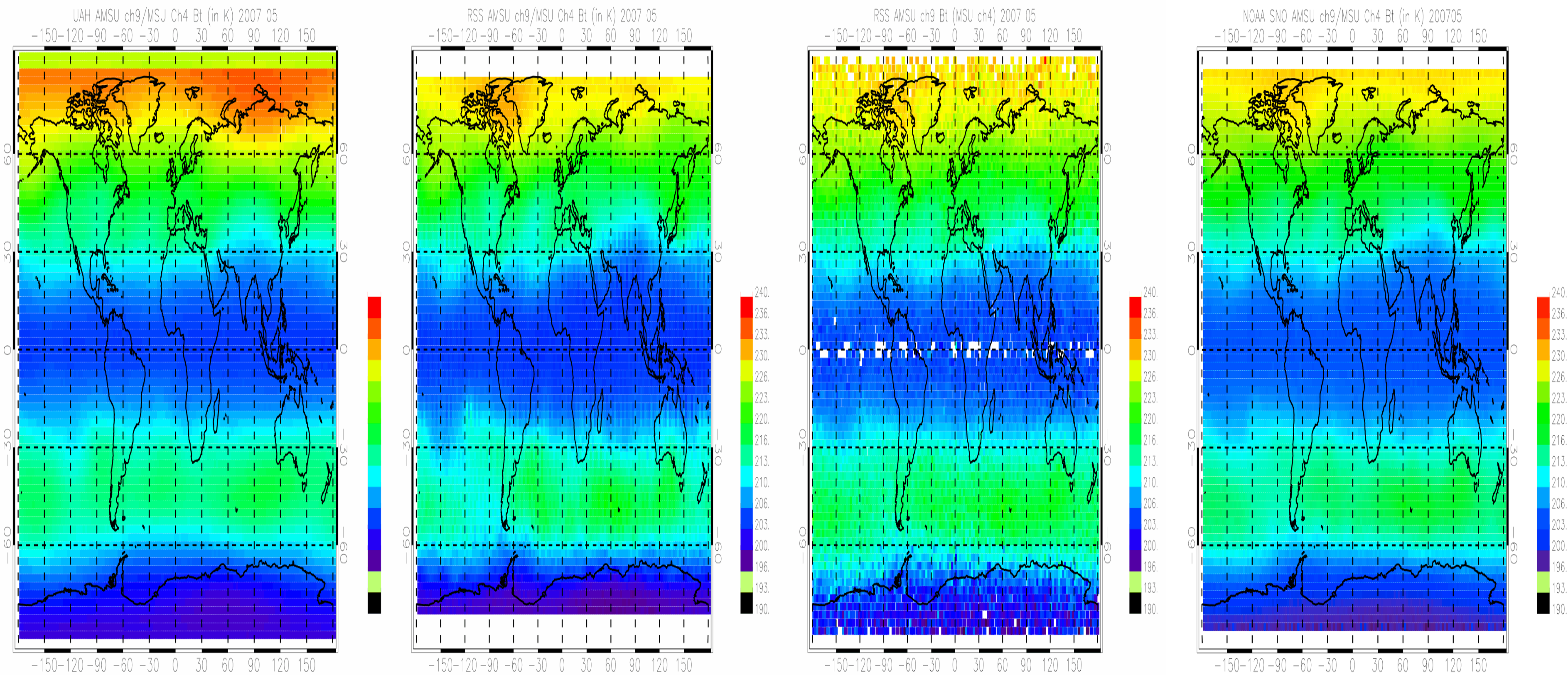
(Ho et al. OPAC special issue, 2009)



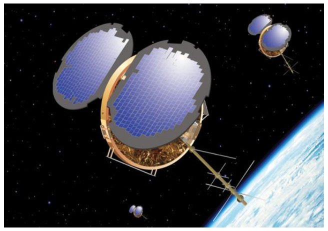
Comparisons of RO-calibrated AMSU with those from RSS, UAH, and SNO



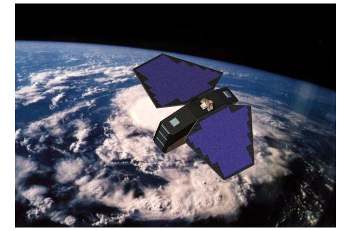
UAH **RSS** **RO_AMSU** **SNO**

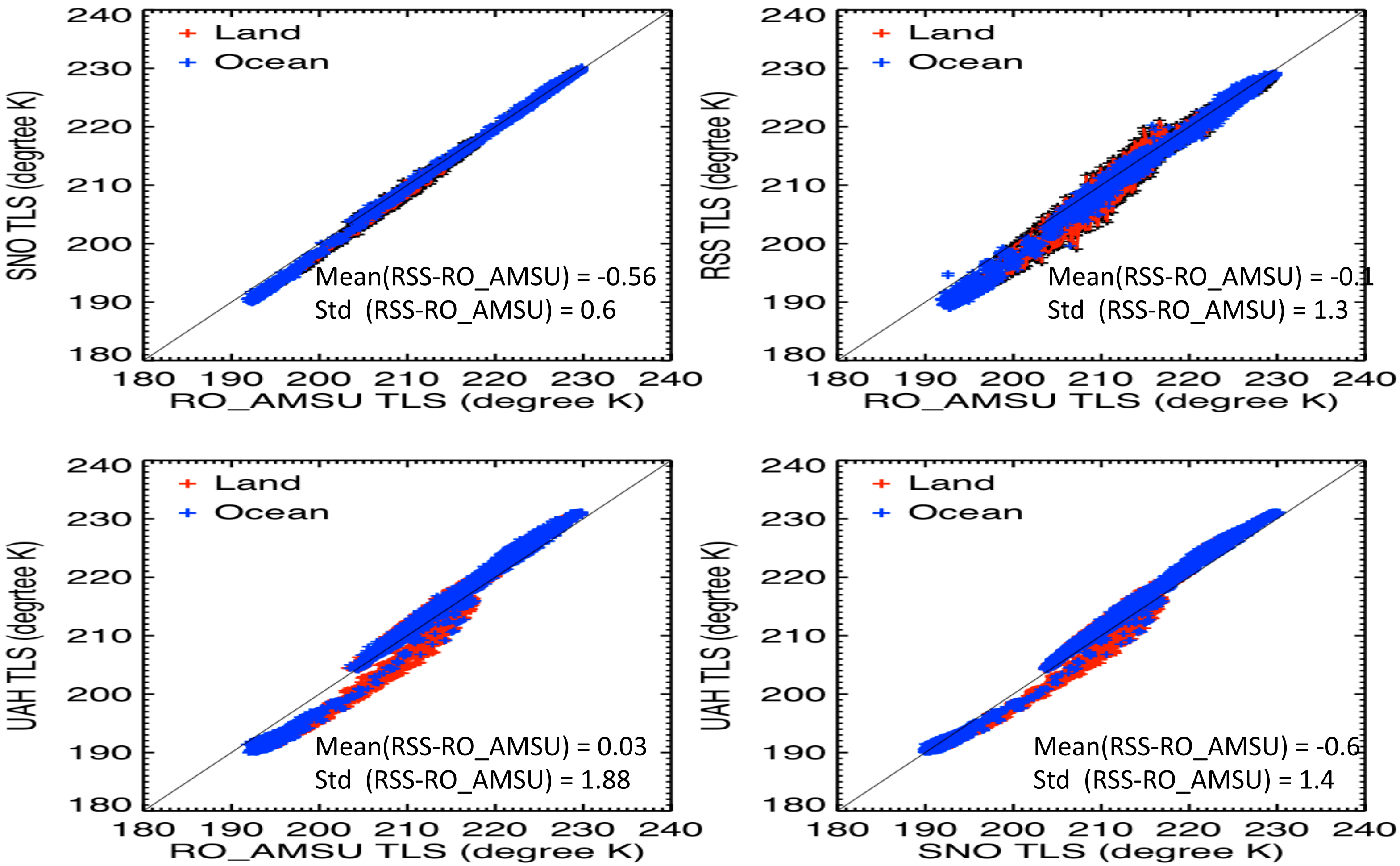


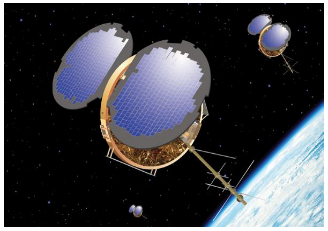
200705 TLS



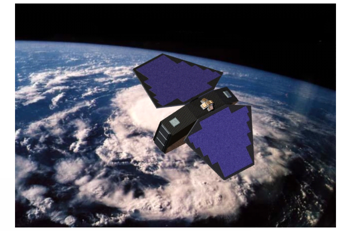
Comparisons over Lands and Oceans

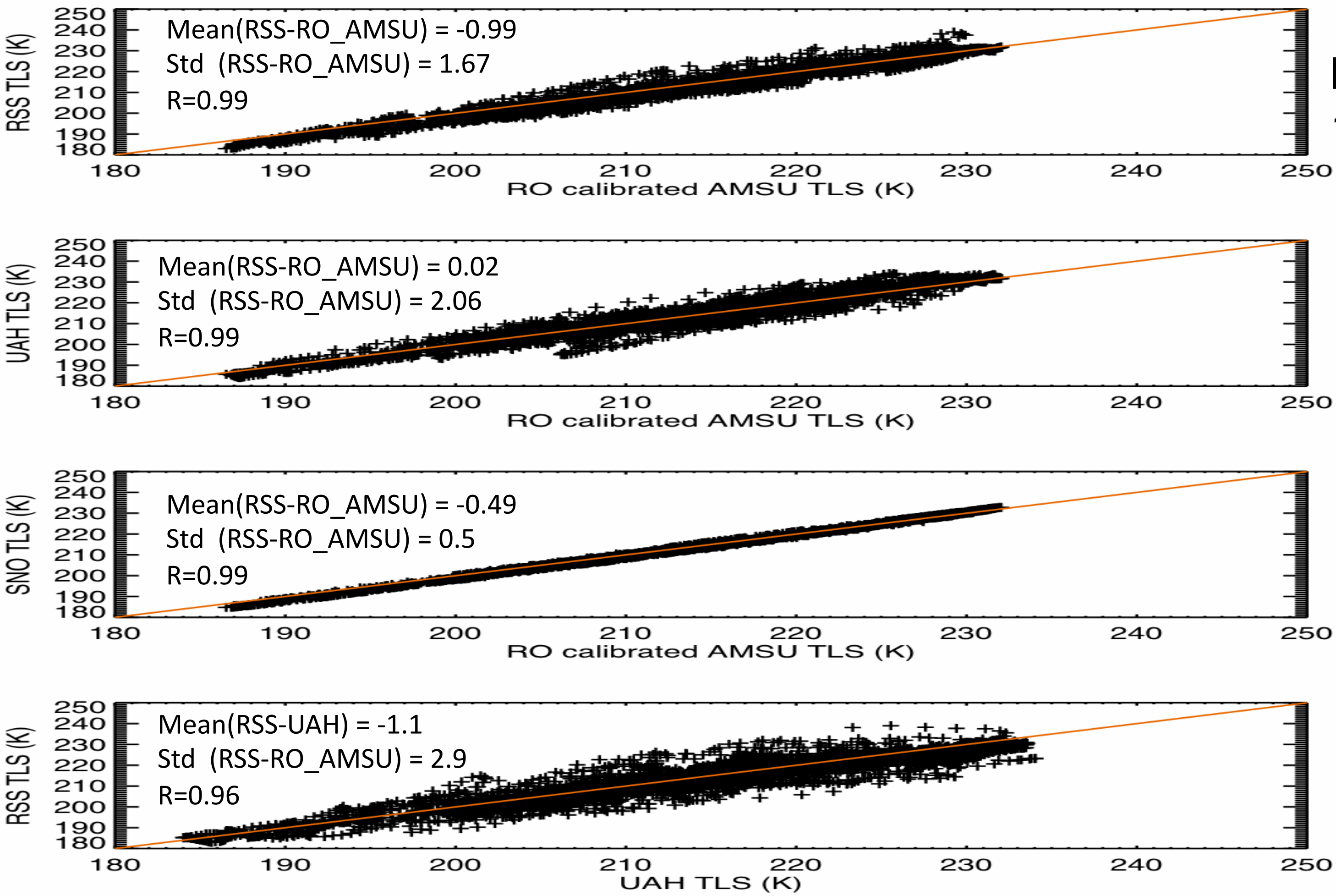




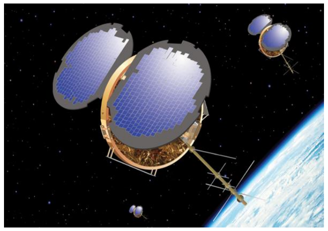


Scattering plots of 10 x10 degree binned TLS from 200106 to 200812

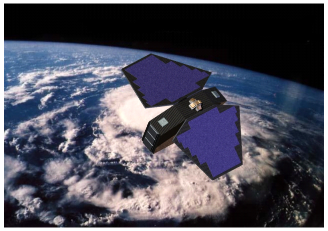


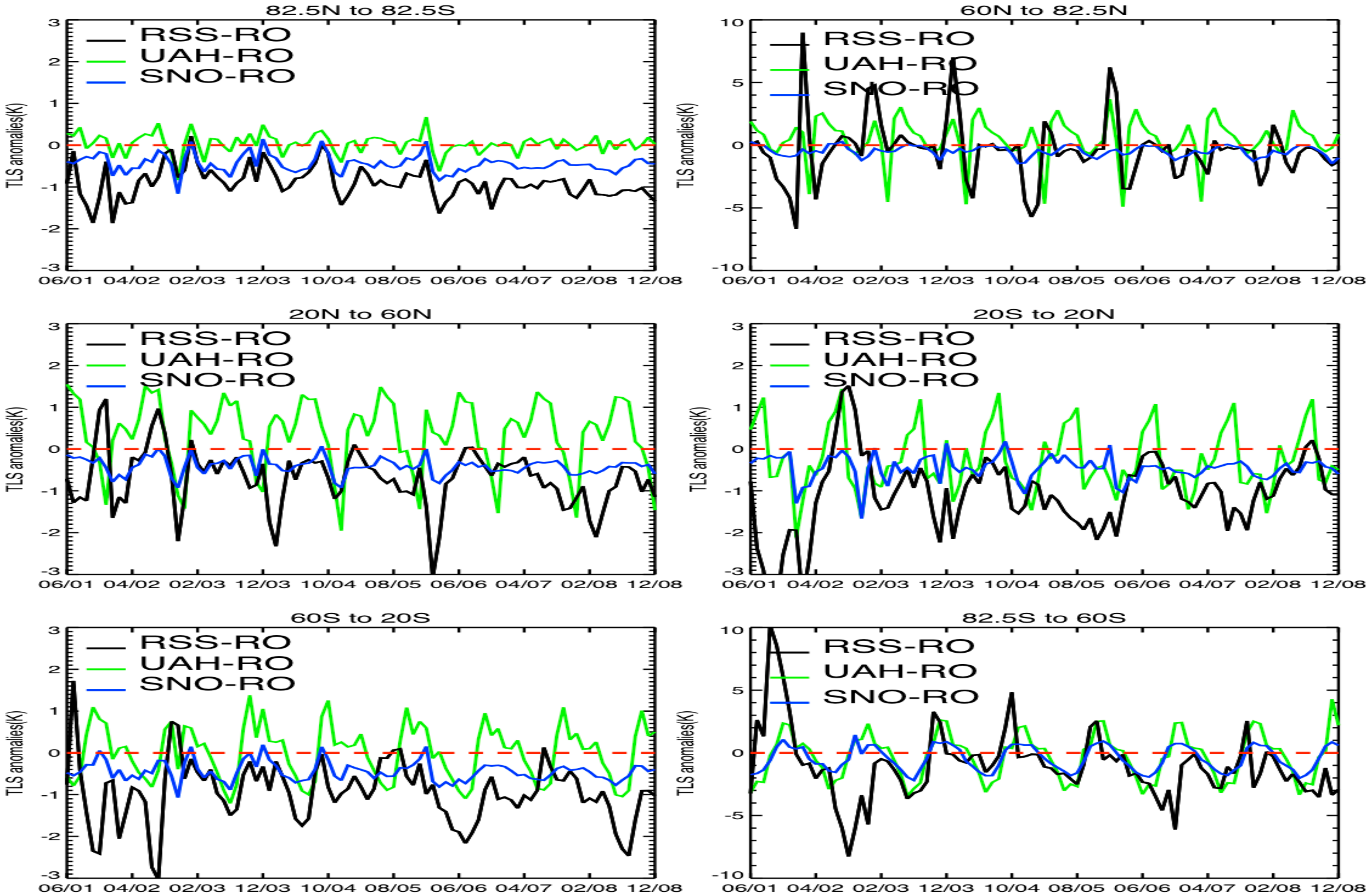


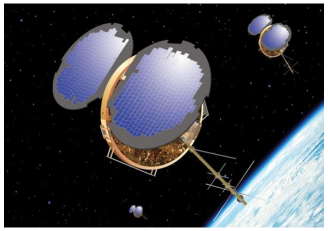
Binning all into 10x10 grid



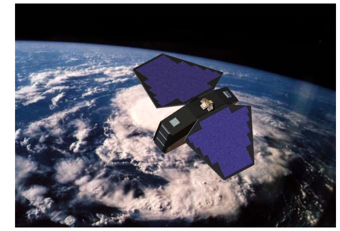
Time series of TLS difference

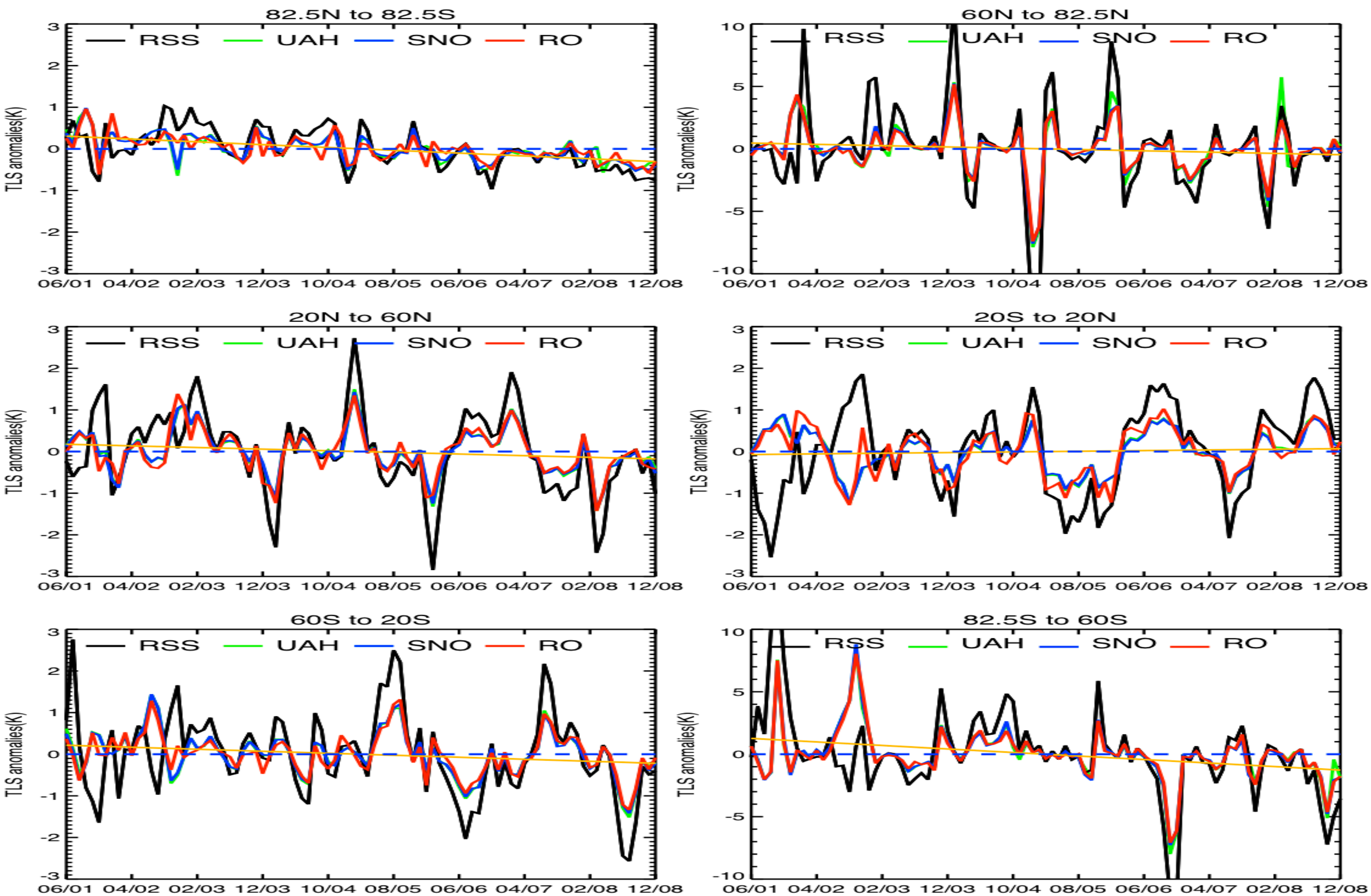






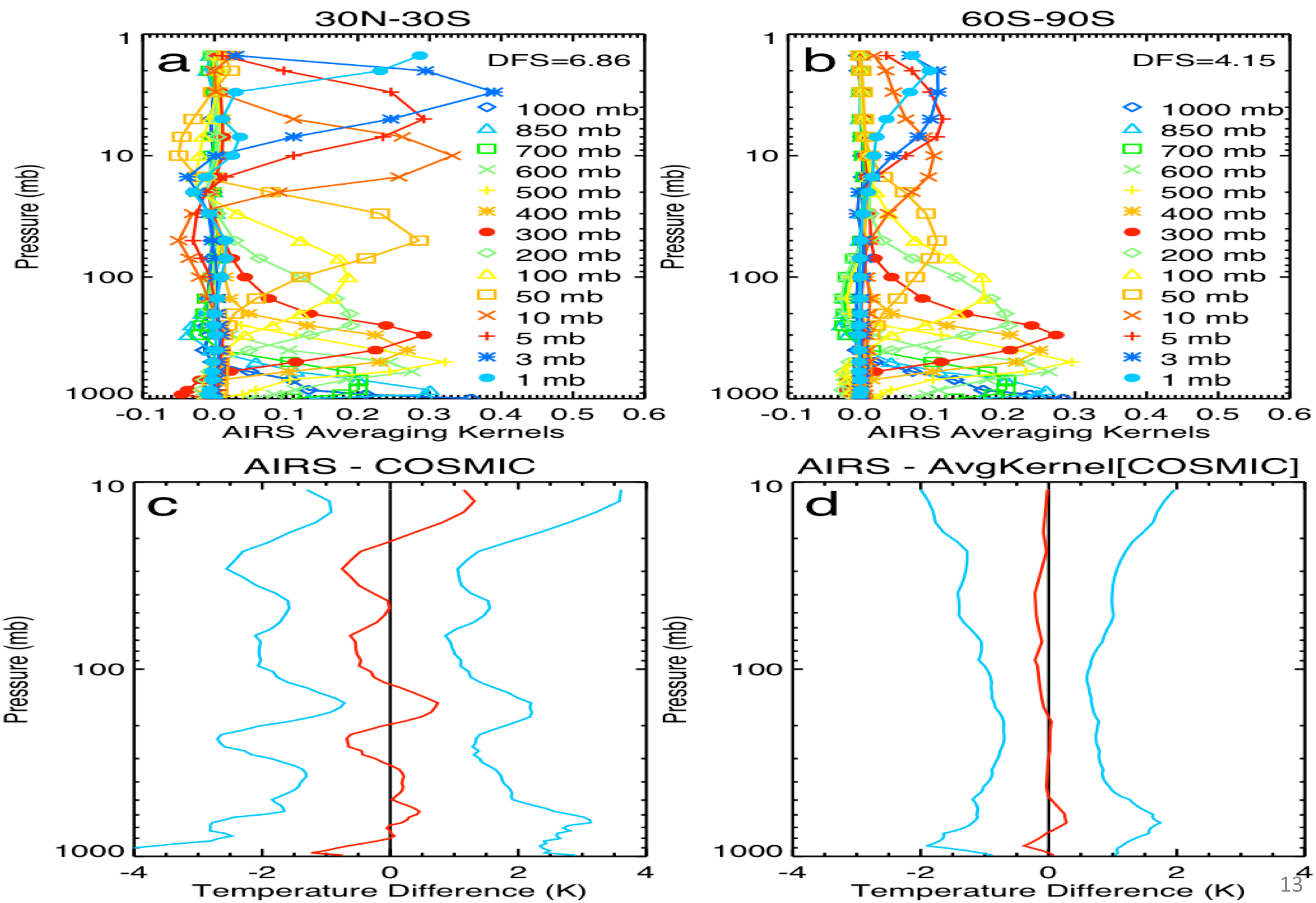
Time series of TLS anomalies





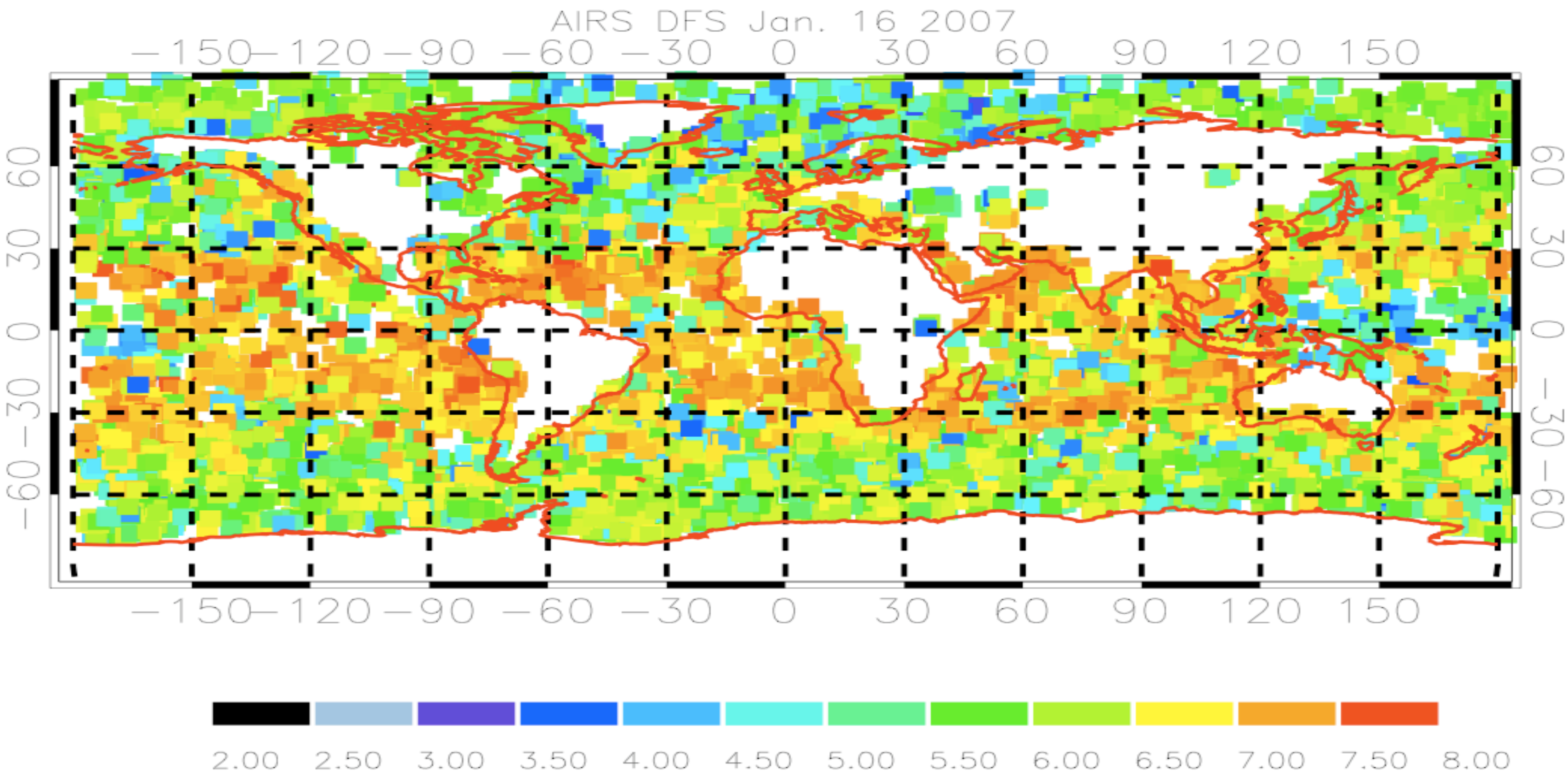
Approach: using AIRS a priori and averaging kernels to smooth RO profiles

$$T_{AIRS}^{Ret} = A_{AIRS}T_{True} + (I - A_{AIRS})T_{AIRS}^{Apr}$$



DFS is a function of atmospheric and surface conditions.
So AIRS temperature retrievals depend on the a priori profile and atmospheric/surface conditions, and also the retrieval methods.

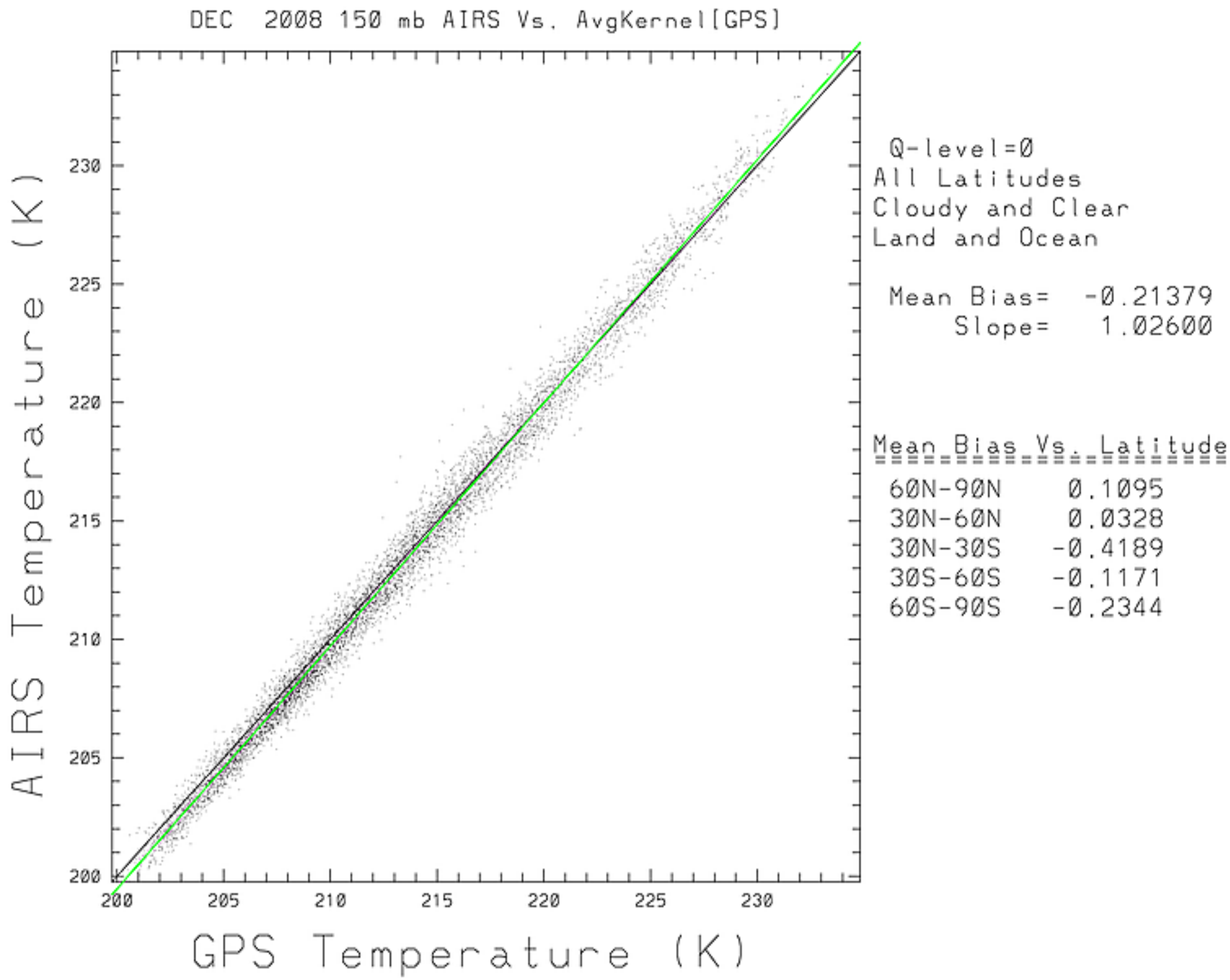
$$T_{AIRS}^{\mathrm{Re}t} = A_{AIRS}T_{True} + (I - A_{AIRS})T_{AIRS}^{Apr}$$

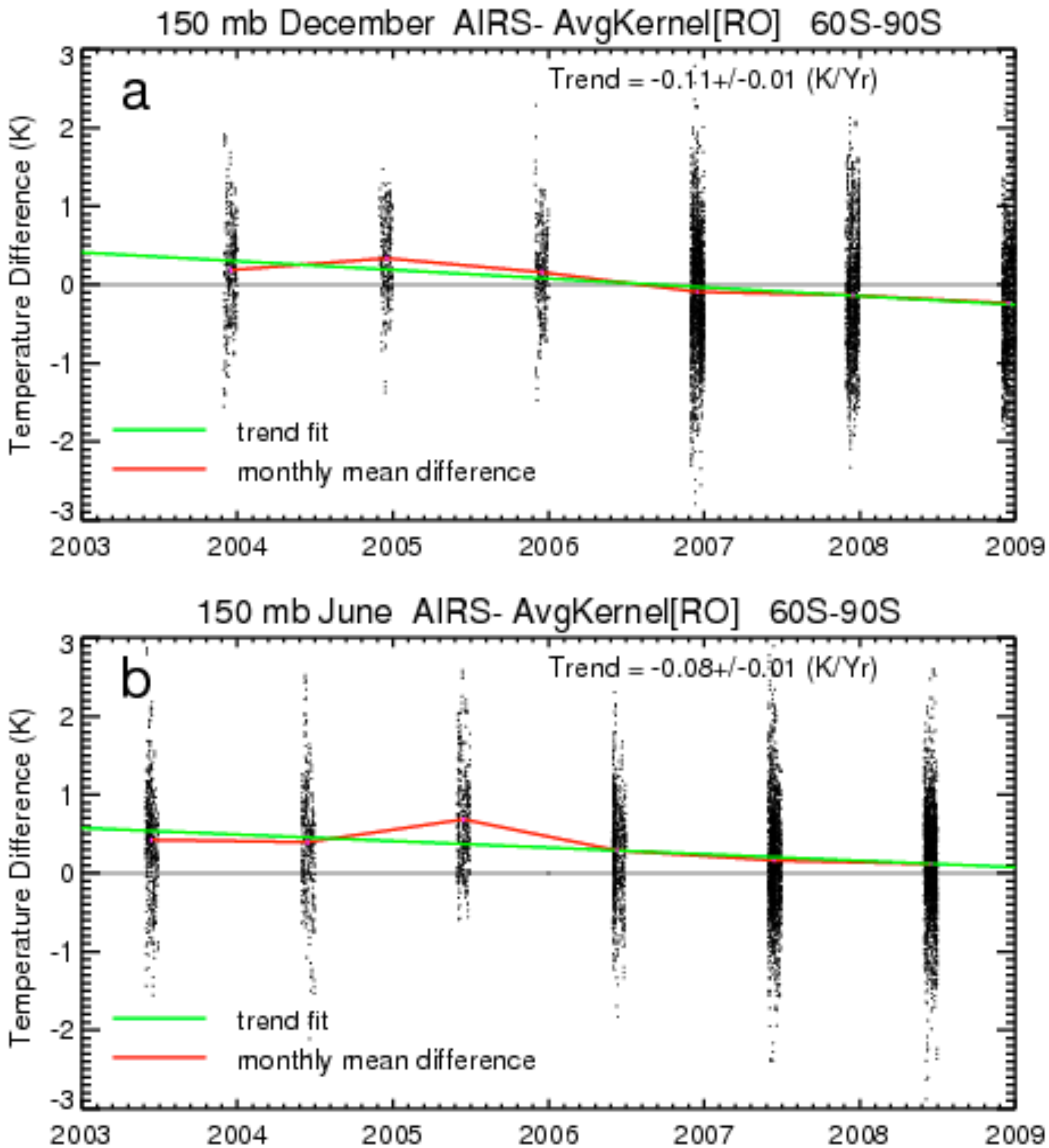


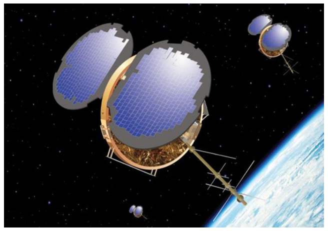
150 mb AIRS vs. smoothed COSMIC Temperature (K)

Corr ~ 1.0

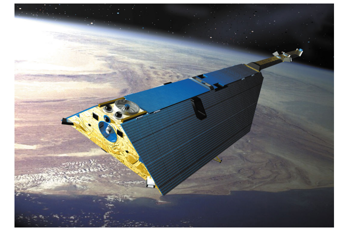
We can use the defined slope and offset to calibrate AIRS temperatures




150 mb December AIRS- AvgKernel[RO] 60S-90S
a
Trend = -0.11+/-0.01 (K/Yr)
Temperature Difference (K)
trend fit
monthly mean difference
2003
2004
2005
2006
2007
2008
2009
150 mb June AIRS- AvgKernel[RO] 60S-90S
b
Trend = -0.08+/-0.01 (K/Yr)



Conclusions and Future Work



•The 0.02K-0.05 K precision of COSMIC will be 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 RSS in terms of variations (higher correlation coefficient) and matches better with UAH in terms of mean.

•Although the de-seasonalized TLS anomalies from UAH and RSS are, in general, agree well with that from RO calibrated AMSU Tb in all latitudinal zones, statistically significant trend differences are found between RSS to RO_AMSU and UAH to RO_AMSU.

• RO data identify AIRS temperature trend drift about -0.07K/yr

•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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