Status of IR/RO Comparisons

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CLARREO SDT Team Meeting, Ann Arbor, Michigan

Contents

1. Michelle Feltz Master's Thesis Results (Assess COSMIC using AIRS Obs BT)
2. Draft of Decadal Survey White paper (Stratospheric Trends)

Michelle Feltz UW-Madison Master's Thesis Summary:

Multi-year Assessment of COSMIC Radio Occultation & AIRS Hyperspectral IR Sounder Stratospheric Temperatures

International Radiation Symposium (IRS)

Auckland, New Zealand

April 2016

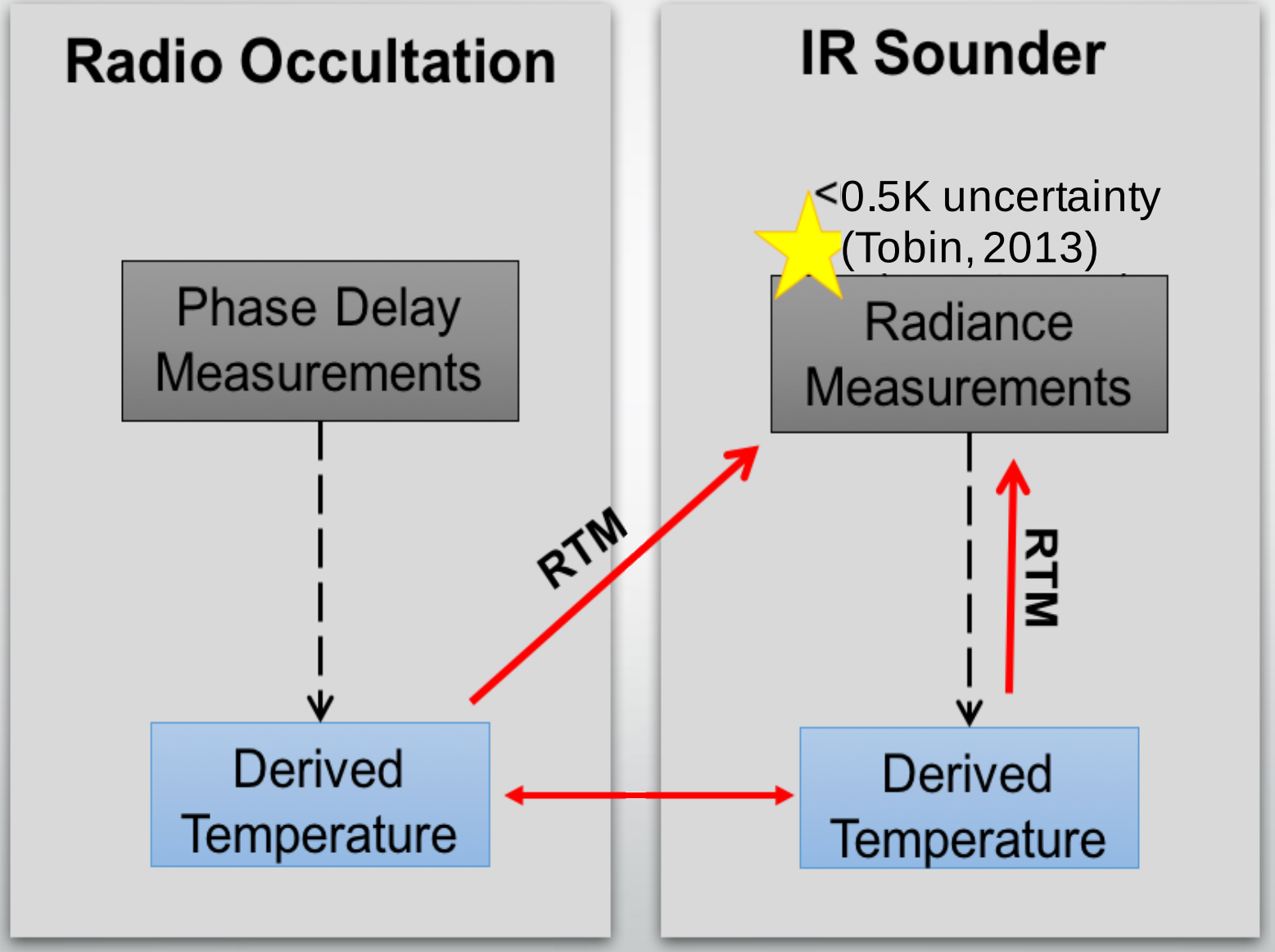
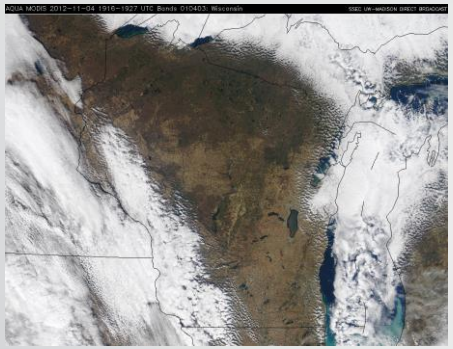
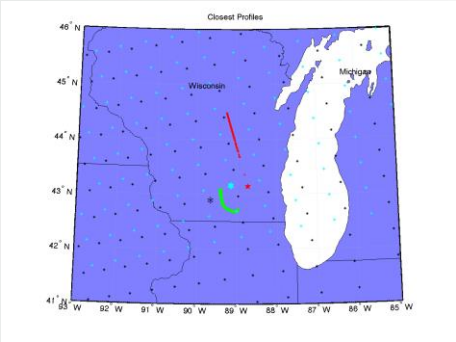

Radio Occultation
IR Sounder
<0.5K uncertainty
(Tobin, 2013)
Phase Delay Measurements
Radiance Measurements
RTM
RTM
Derived Temperature
Derived Temperature

Illustration of Radiative Transfer Calculations

IR/RO Matchup Over Madison, WI (04Nov2012)





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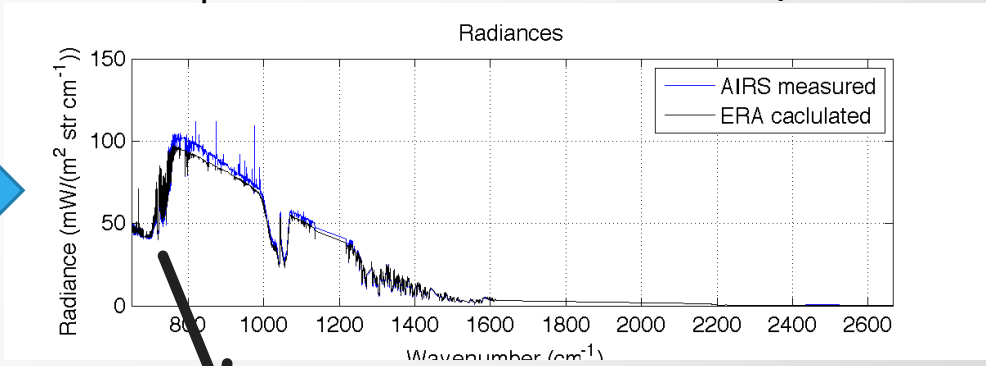
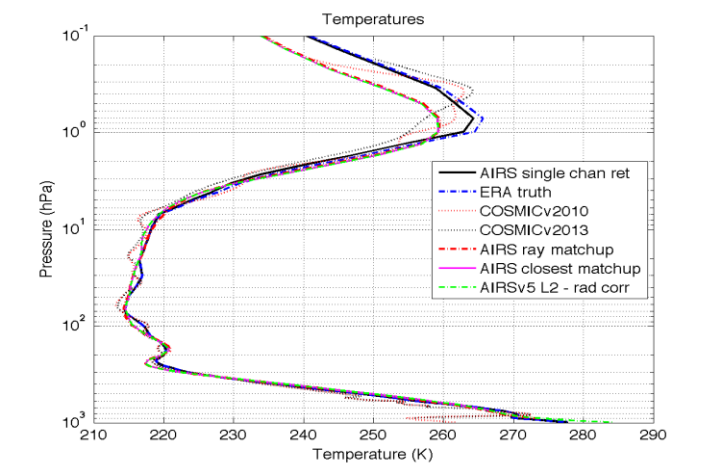
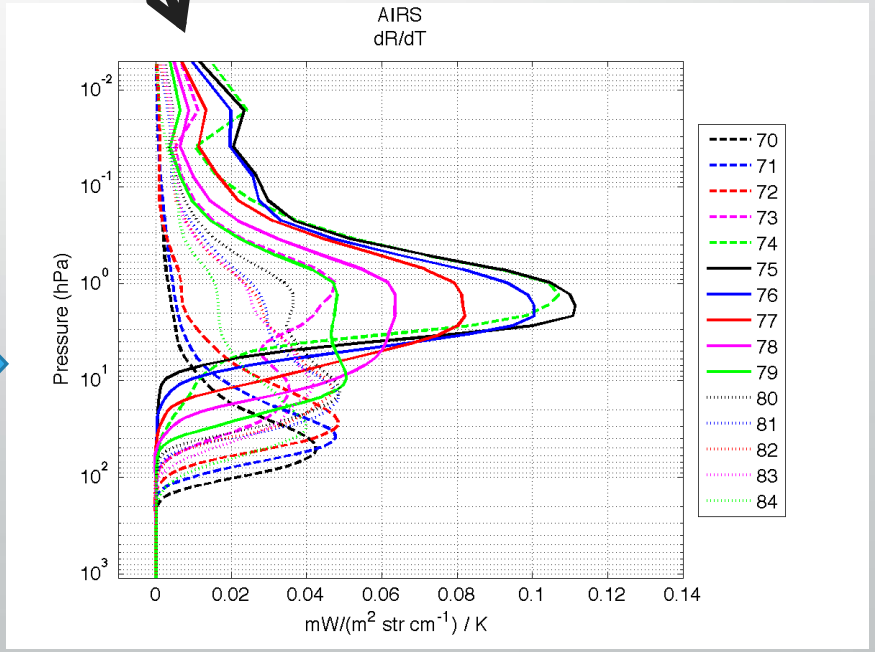
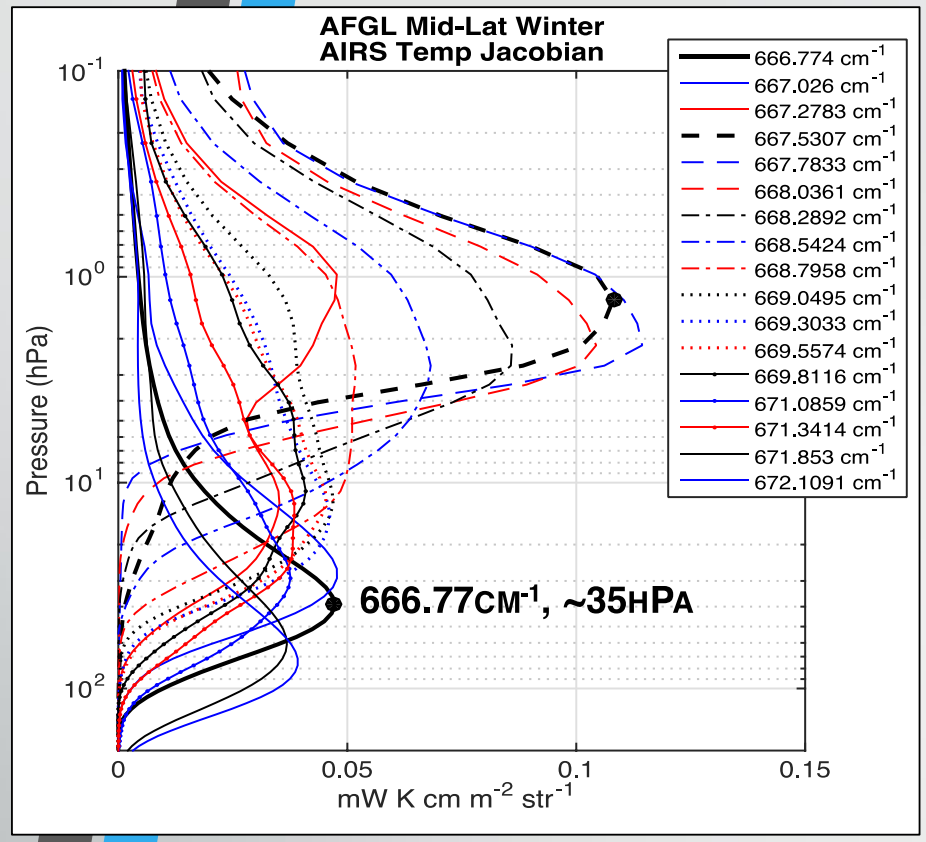
AIRS Spectral Channels Used (666-672 cm^{-1})

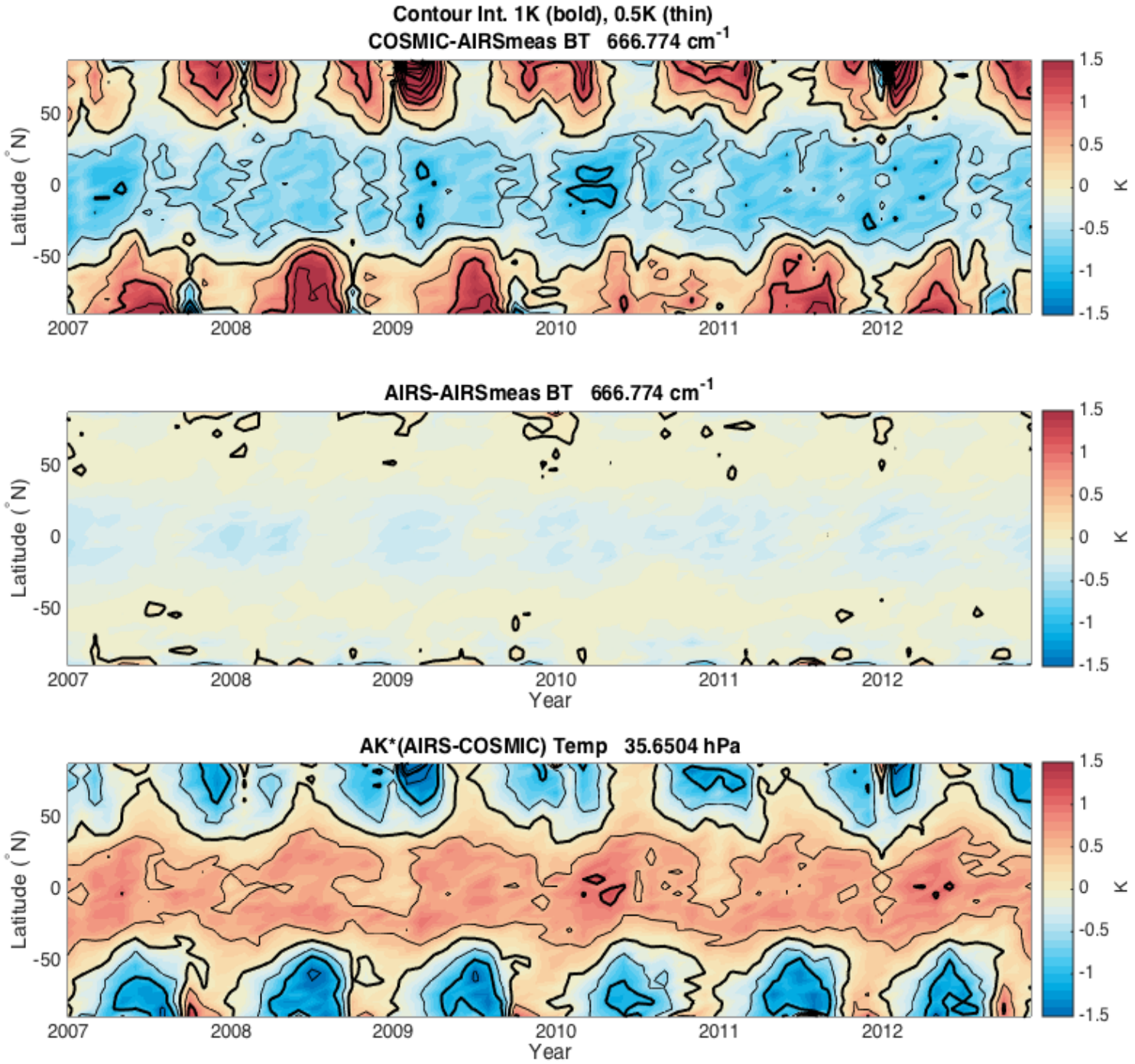




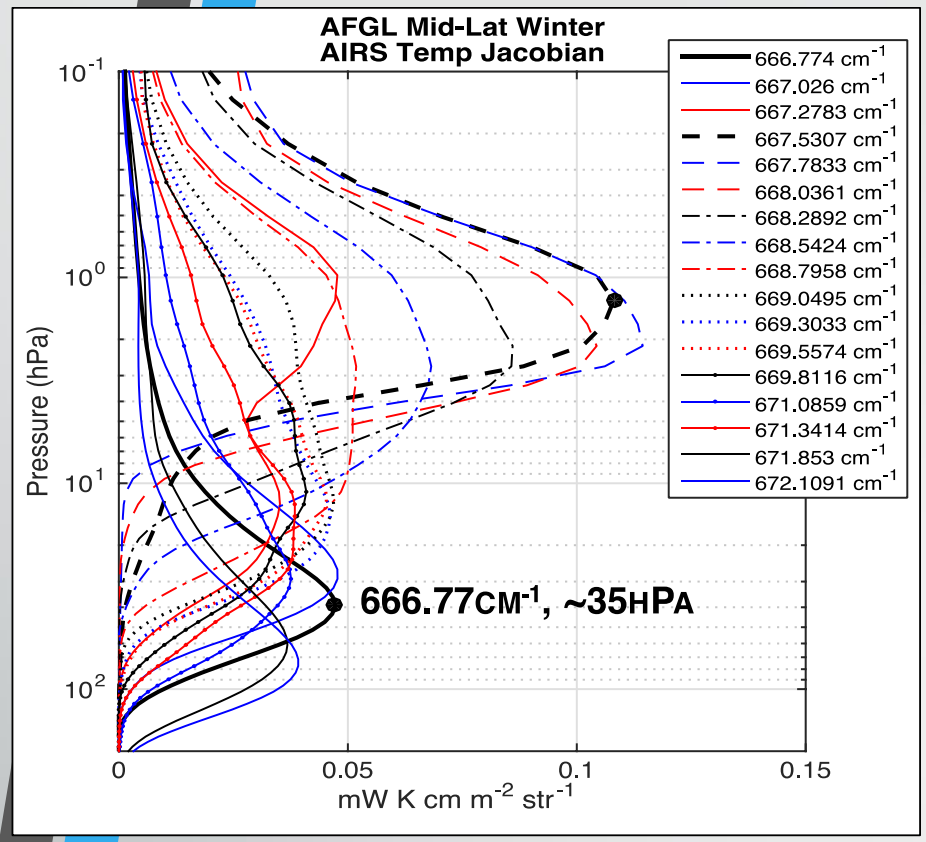
Upper
Middle
Lower

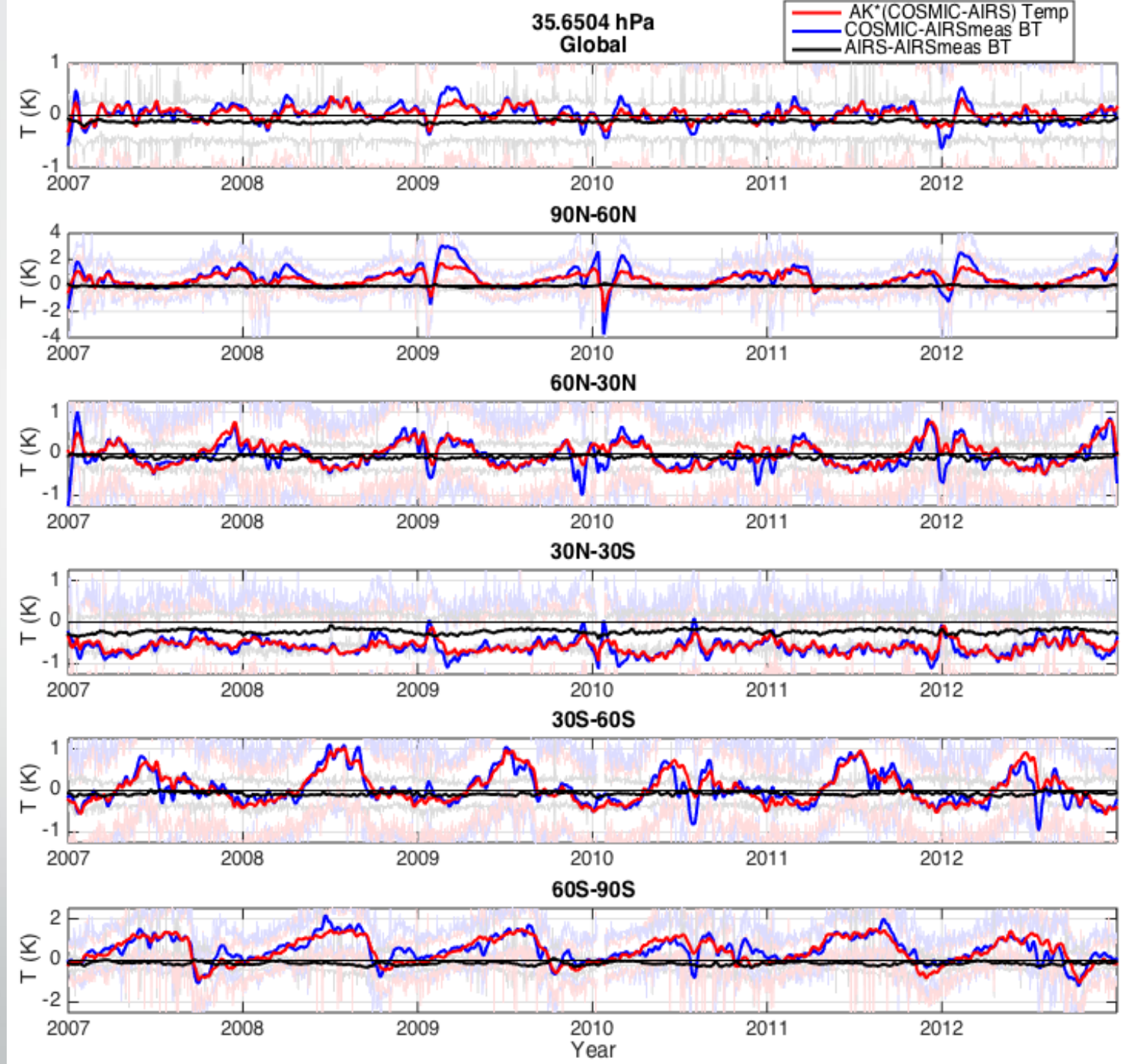




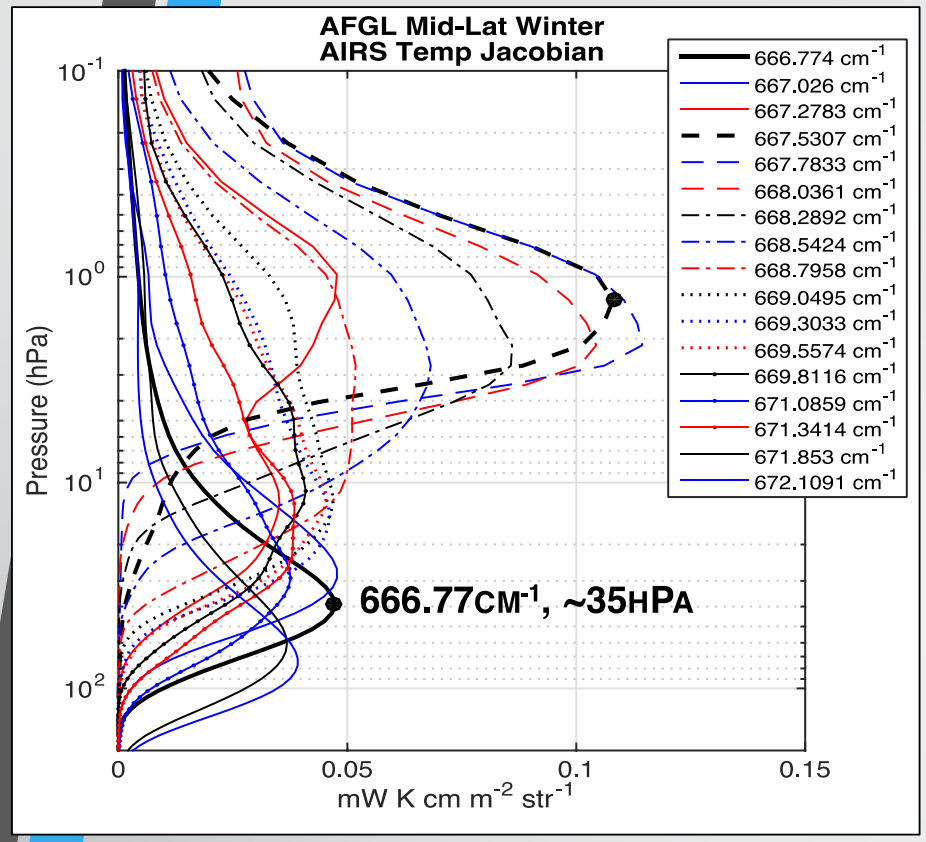


- AIRS retrieved temperature is in good agreement with BT observations.
- Distinct Seasonal/Latitude dependence to the COSMIC-AIRS BT bias. Note lower panel is AIRS-COSMIC so sign is reversed.

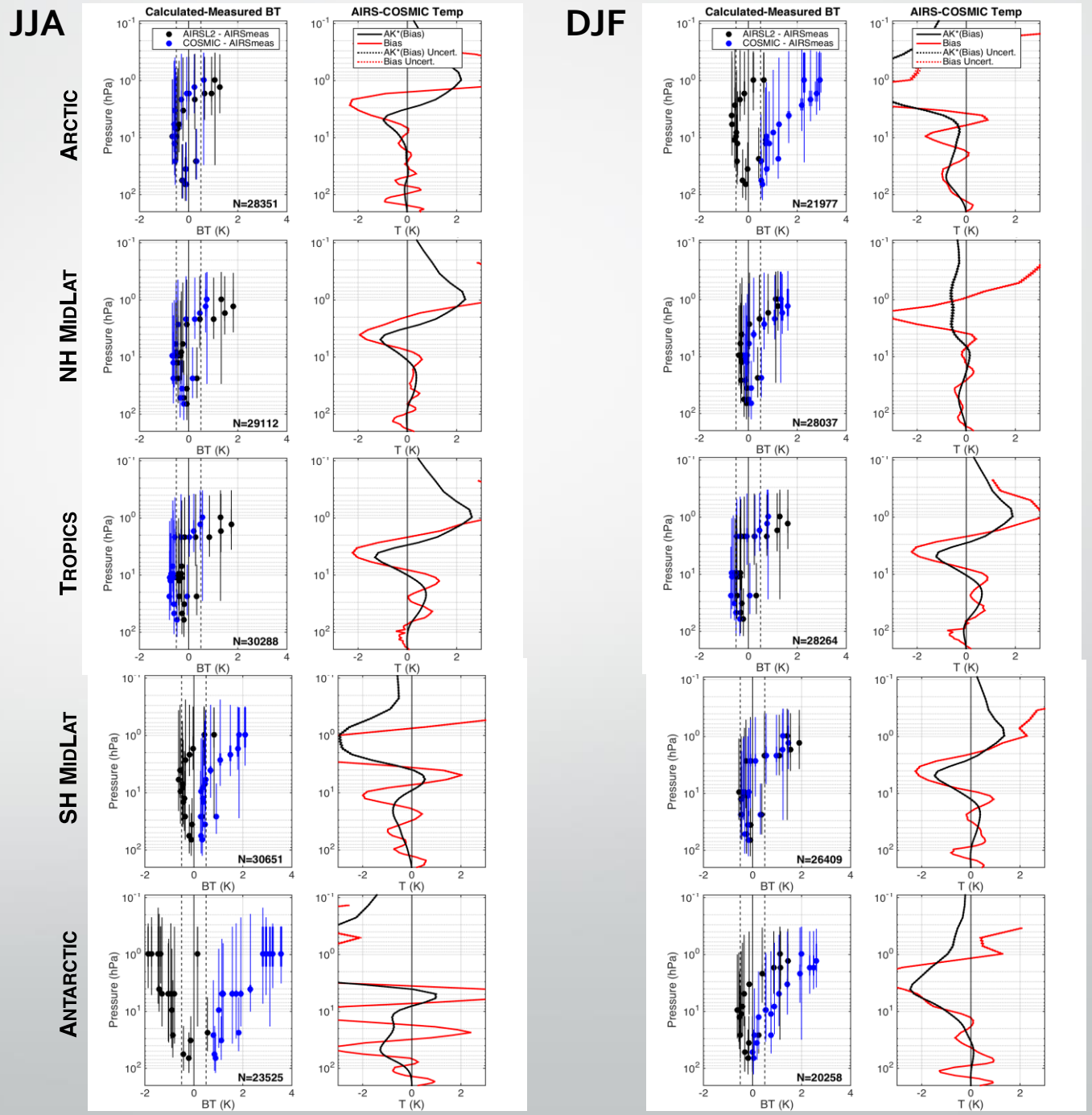




- AIRS retrieved temperature is in good agreement with BT obs.
- Distinct Seasonal dependence to the COSMIC-AIRS bias.
- Temperature bias error and Brightness Temperature bias error are quite consistent.



- With the exception of the Antarctic, the AIRS calculated BT agrees with the observed BT within +- 0.5 K.
- Mean COSMIC calculated BT is within +- 0.5K of AIRS observed BT up to about 10hPa.
- Errors increase in the Upper Stratosphere (0.5 K – 2K)



Summary of M. Feltz Thesis Results

- Demonstrated the use of IR observed brightness temperatures as a quantitative reference for the assessment of RO dry temperature profiles.
- Six year mean of COSMIC dry temperature product is within 0.5 K of the AIRS observed BT for tropical and mid-latitudes from 100 hPa to 10 hPa.
- Errors are larger for higher altitudes and higher latitudes.
- There is a strong seasonal dependence of the bias outside the tropics.
- This assessment method can be used for CLARREO IR and RO assessment.

The Long-term Challenge of Detecting Unambiguous Trends in Stratospheric Temperature

Robert Knuteson (University of Wisconsin-Madison)
and
Xu Liu (NASA LaRC)

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CLARREO Science Definition Team Meeting, Ann Arbor, Michigan
10 May 2016

Quantified Objective

Reduce the measurement uncertainty of global atmospheric temperature in the lower, middle, and upper stratosphere by a factor of at least 3. Enable stratospheric global temperature trend detection with minimum time delay relative to a perfect observing system

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IMPORTANCE

Two societal goals are commonly associated with the knowledge of stratospheric temperature trends;

1. Monitoring ozone layer recovery following the Montreal Protocol agreement on limiting production of ozone destroying chemicals.
2. Detection and attribution of climate change from the effect of increasing greenhouse gases on the radiative cooling of the stratosphere, in particular the doubling of carbon dioxide concentration in the 21st century.

The scientific goals of measuring stratospheric temperature include

- Verifying coupled chemistry climate models
- Verifying coupled ocean-atmosphere climate models with and without coupled chemistry
- Confirming measured trends in ozone by latitude and in vertical concentration profile
- Improved understanding of stratospheric circulation through latitudinal change in temperature
- Improved understanding stratospheric water vapor changes through temperature changes in the tropopause

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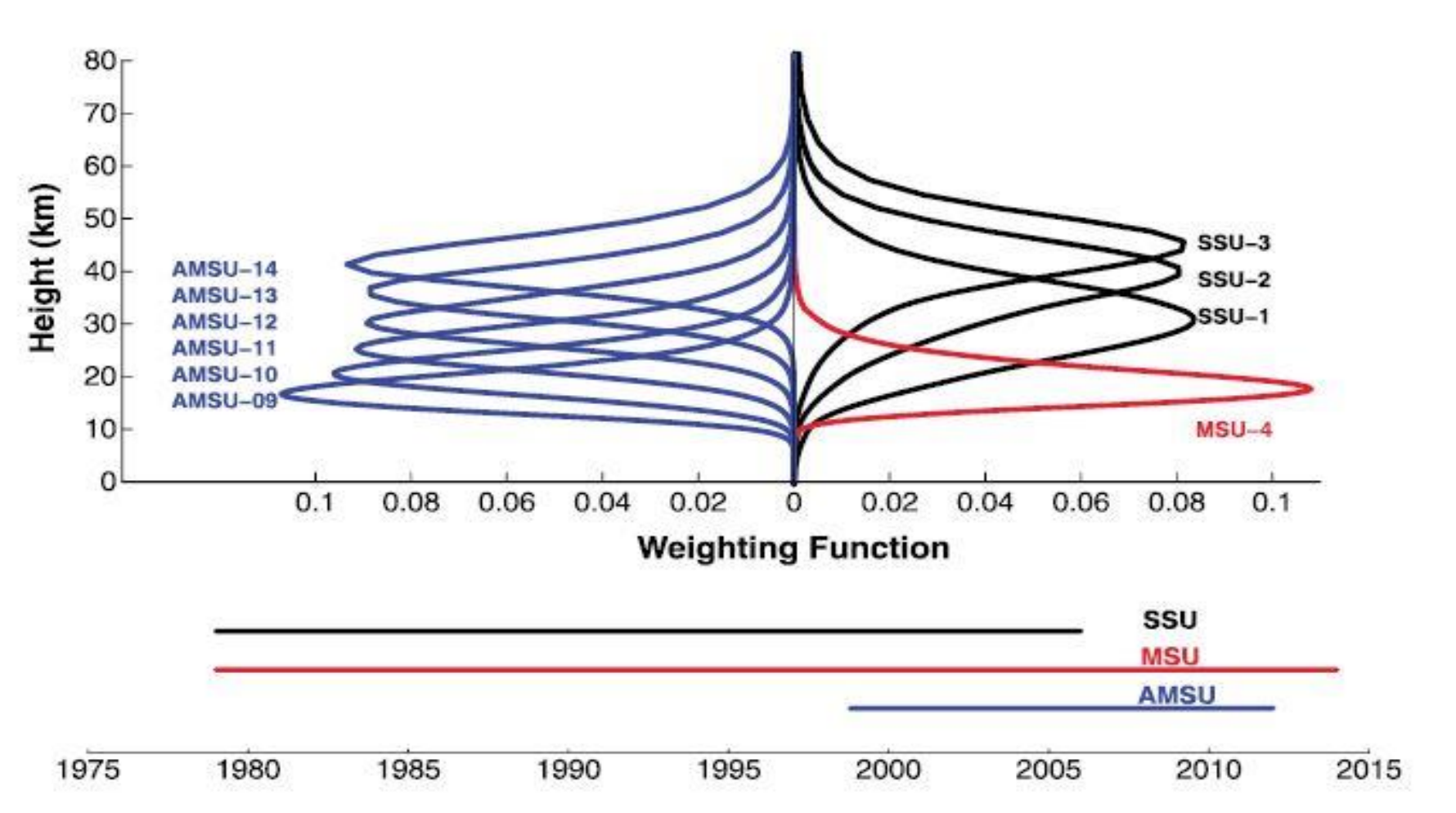

- 1979 – 1995 SSU channels -1, -2, -3
- 2002 – current AMSU channels -14, -13, -12, -11, 10
- 2002 - current AIRS channels (span similar range as SSU and AMSU

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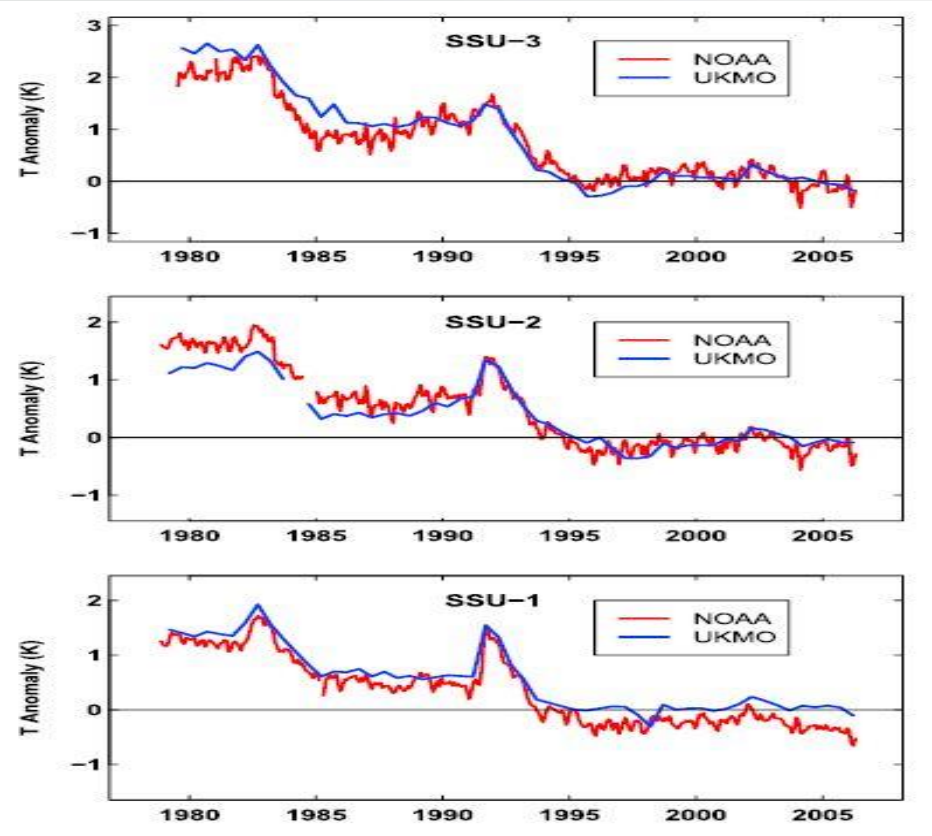

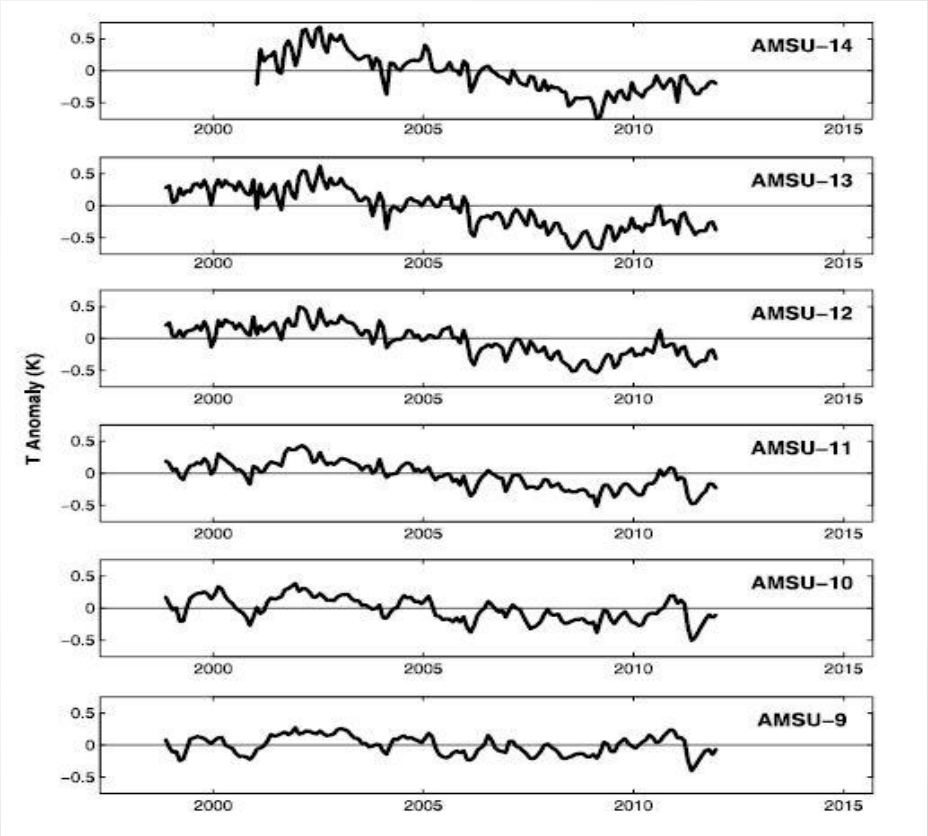

- SSU "Hockey Stick" Temperature Trend (1979 - hinge point 1996 - 2005)
- CO_2 increase causes cooling trend in stratosphere
- O_3 decrease causes cooling but increase leads to warming
- Hypothesis is that ozone recovery is canceling CO_2 cooling
- AMSU data suggests smaller cooling trend continues in upper stratosphere
- Pan et al. 2015 shows similar trends in AIRS data.

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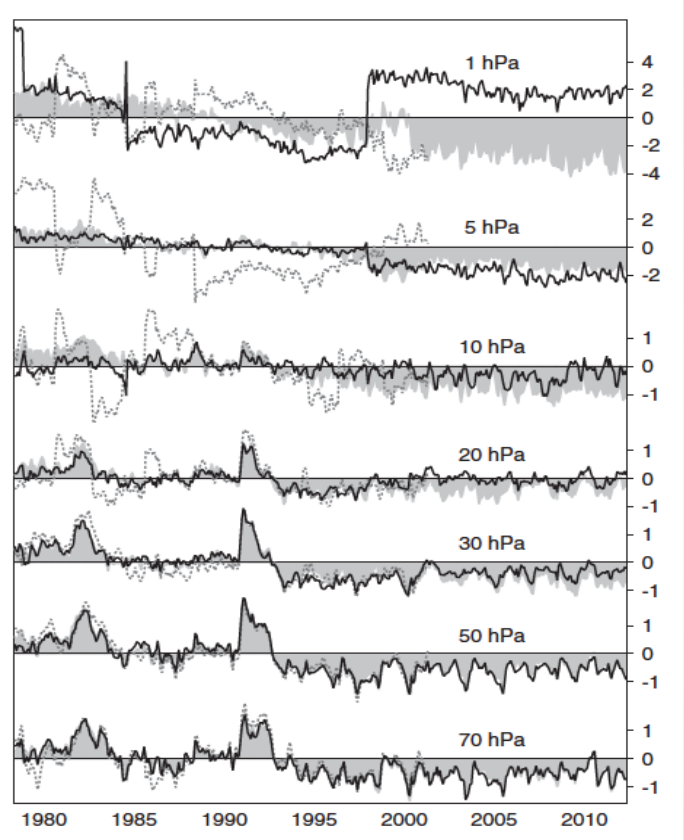

- Simmons et al. (2014) ECMWF Reanalysis (ERA-Interim)
- Temperature anomaly (left) and Sensor Bias (right)
- Radiosondes used as "anchor" measurements in Lower Strat
- Bias estimates show improvement of bias errors over time (1979 – current)
- AMSU sensor to sensor bias is > about 1K
- AIRS/IASI/CrIS inter-calibration < about 0.5K (not shown here)
- CLARREO IR < 0.1K

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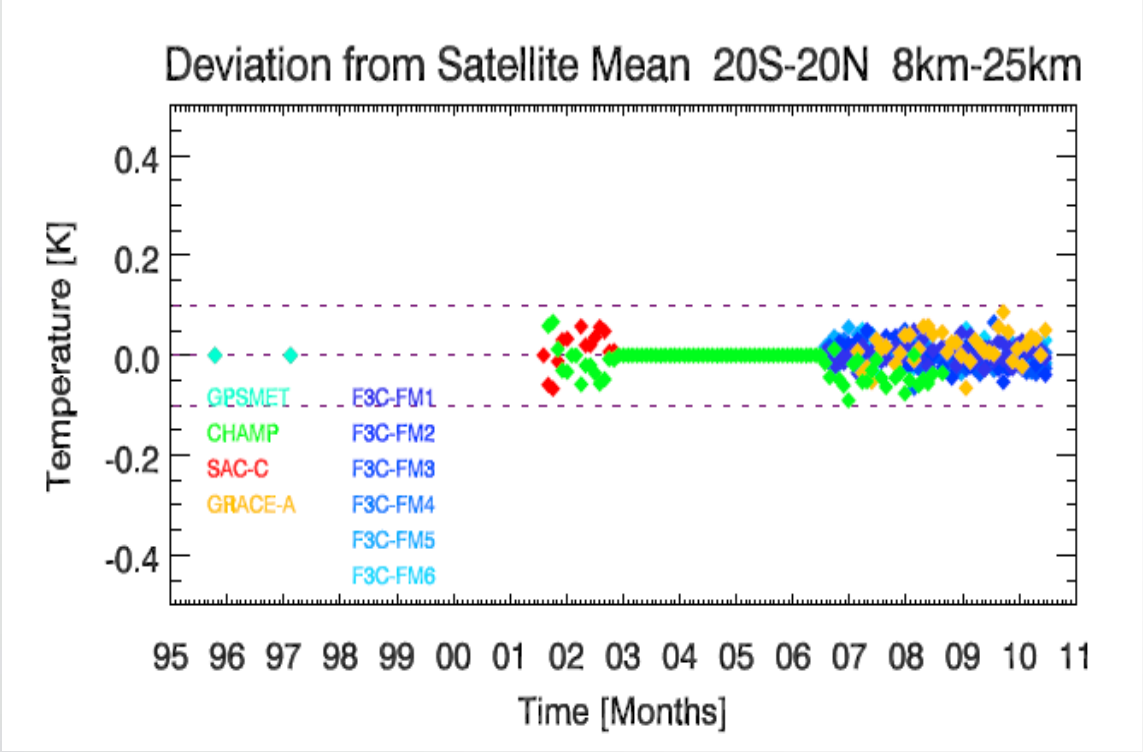

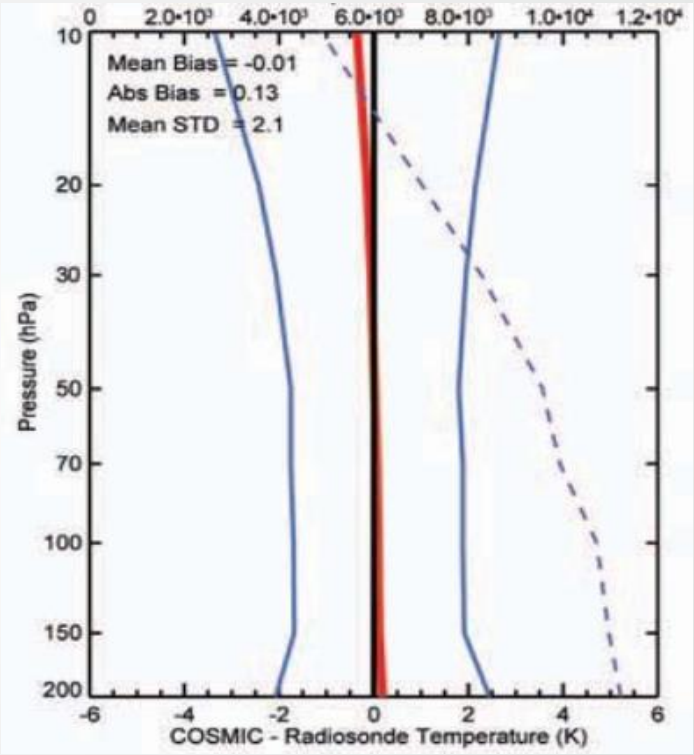

- GPS RO sensor-to-sensor reproducibility is < 0.1K (left panel)
- Comparison of derived temperature versus RS92 radiosonde < 0.15K (right panel)
- GPS RO error increases with height in the stratosphere. Lower strat is best.
- GPS RO error increases with latitude. Tropical regions are best.
- CLARREO RO should improve height accuracy of retrievals by reducing noise levels.

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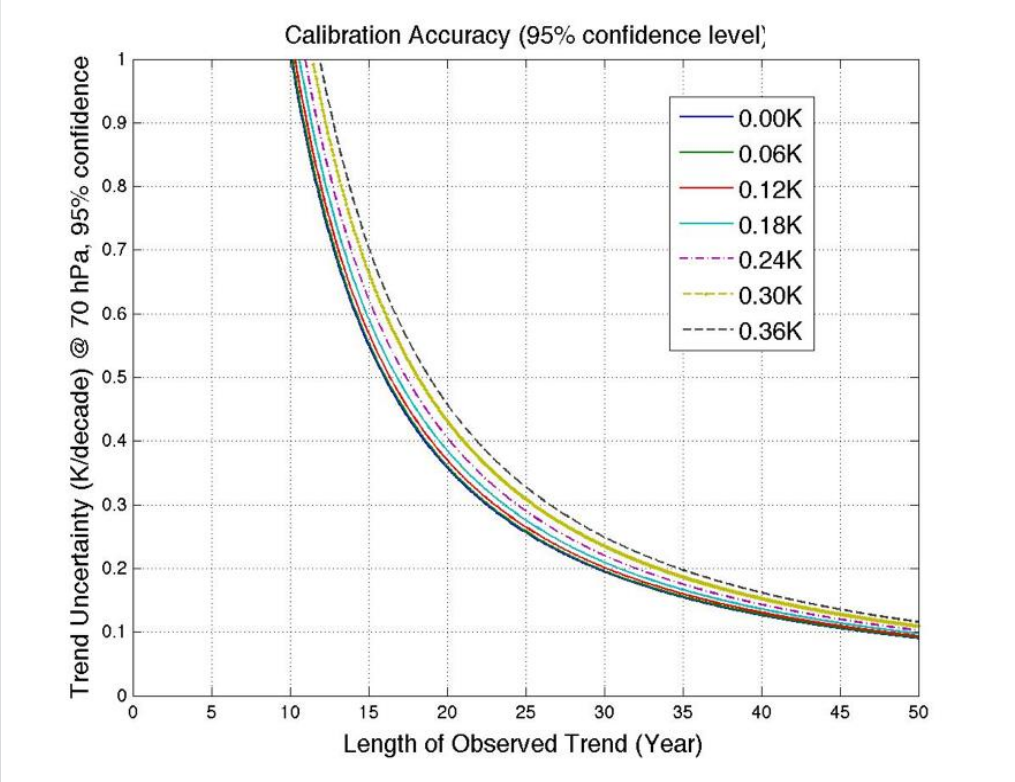

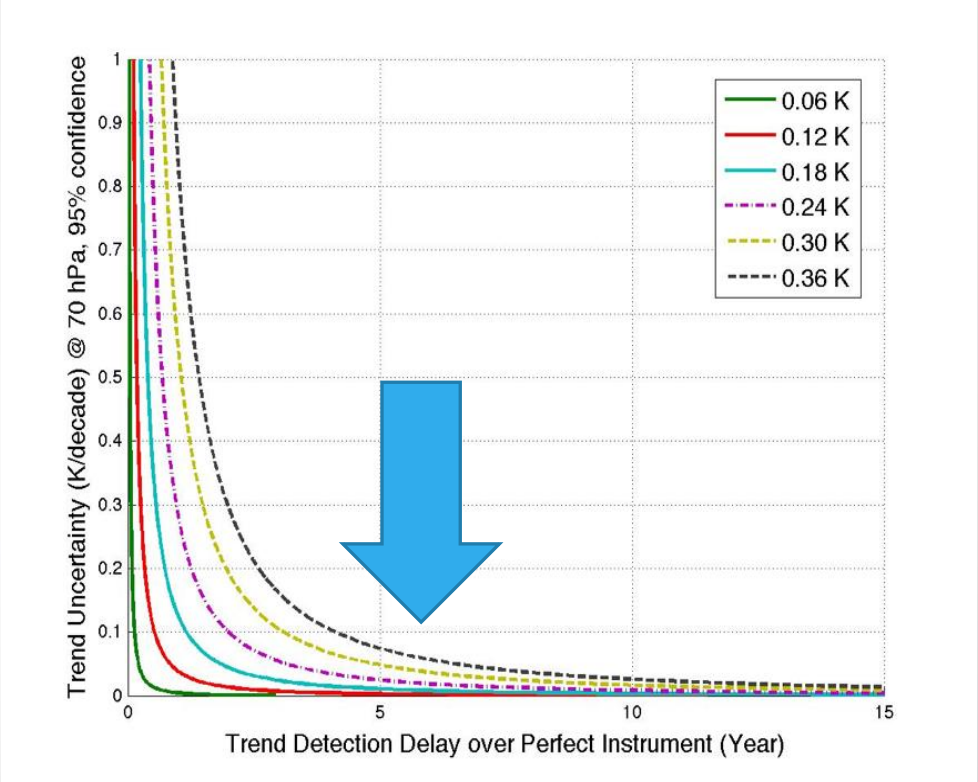

- Xu Liu (LaRC) used reanalysis data to compute natural variability and auto-correlation
- Used the formula of Leroy et al. (2008) to compute TTD trends (left panel)
- Degradation of TTD over ideal instrument increases rapidly for small trends (right)
- Taken at face value a trend of 0.2 K would require 30 years even for an ideal sensor.
- Side Note: The natural variability used here is higher than the IR obs variability.

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SCORING CONSIDERATIONS

The following table included for summary purposes only and as a guide for discussion.

Type	I	U	Q	S	B
MW (AMSU/ATMS)	5	1	0.5	0.5	1.25
GPS RO	5	0.7	0.7	0.8	2.0
IR (AIRS/CrIS/IASI)	5	1	0.7	0.8	2.8
CLARREO RO	5	1	0.9	0.8	3.6
CLARREO IR	5	1	1	0.8	4.0

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