STRATOSPHERIC TEMPERATURE MONITORING USING A COLLOCATED IR/ GPSRO DATASET

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ITSC-19 Jeju, Korea
31 March 2014

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What am I selling?

- **Pure "Organic" Radiances**

1. Traceable to SI (international standards) through multiple independent paths

2. Unbiased and simple processing methods

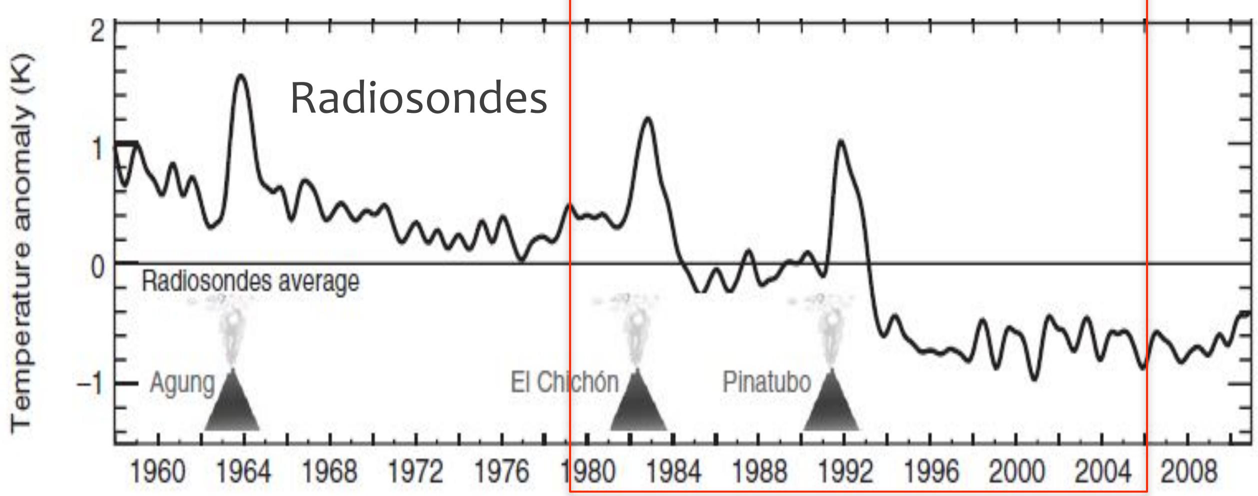
3. Explicitly free from contamination by ancillary information from other datasets.

Who needs this product?
Stratospheric Temperature Monitoring

Advanced Review

Stratospheric temperature trends: our evolving understanding

Dian J. Seidel,[1*] Nathan P. Gillett,[2] John R. Lanzante,[3] Keith P. Shine[4] and Peter W. Thorne[5]



WIREs Clim Change 2011 vol 2 pp592–616 DOI: 10.1002/wcc.125

- 50 year radiosonde Lower Strat. Temperature record: cooling 1958-1995 then **constant since 1996**.

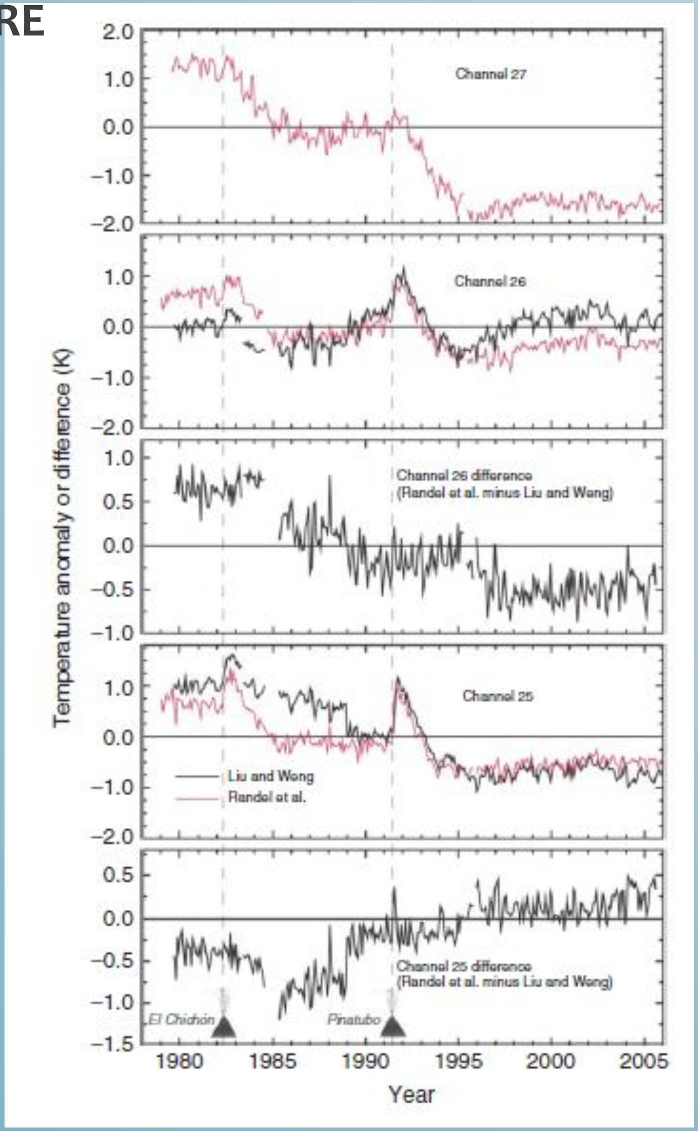
STRATOSPHERE

HERITAGE SATELLITE SOUNDER

Upper

Middle

Lower



SSU channel 27

SSU channel 26

SSU channel 26
Structural Uncertainty

SSU channel 25

SSU channel 25
Structural Uncertainty

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- 25 year Satellite Stratospheric Sounder Temperature record: cooling 1979-1995 then **constant through 2005**.

Stratospheric Temperature Weighting Functions: dR/dT

Heritage Stratospheric Sounders: SSU & MSU (1979-2005)

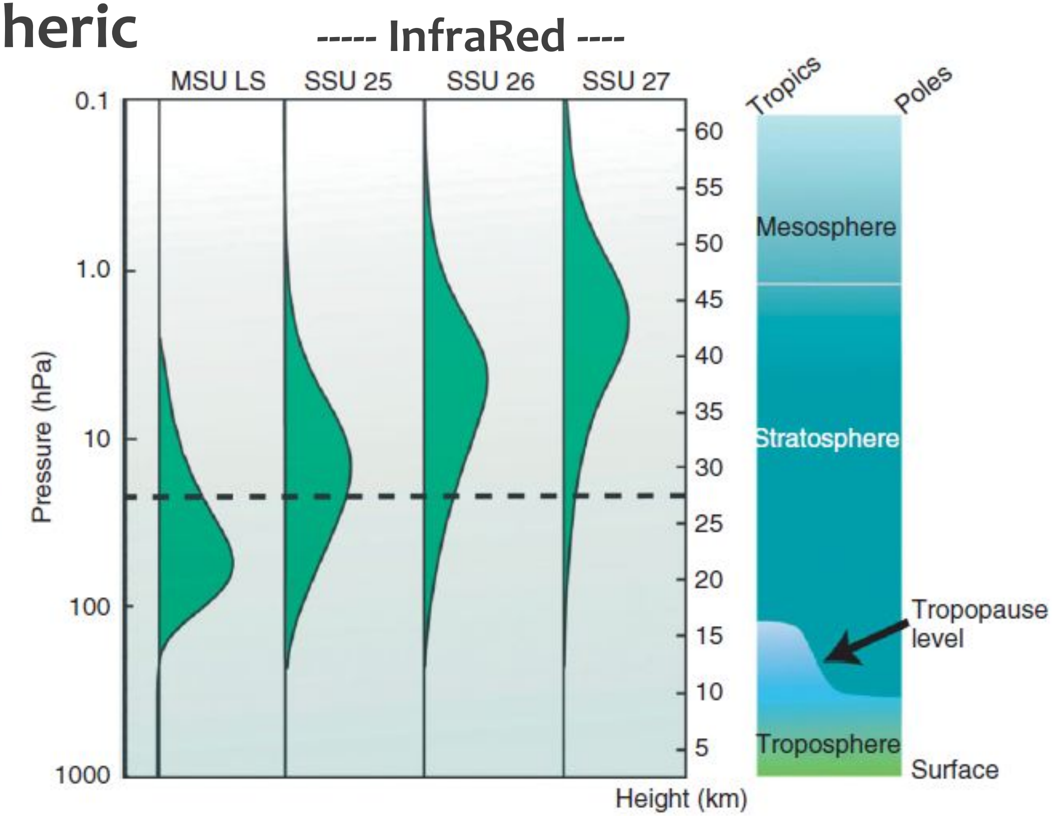

FIGURE 2 | Vertical sampling of satellite and radiosonde observations of stratospheric temperature. *Left*: vertical weighting functions for satellite Microwave Sounding Unit (MSU) and Stratospheric Sounding Unit (SSU) stratospheric temperature observations as a function of pressure (left axis) and height (right axis). The dashed line at about 27 km (30 hPa) indicates the typical maximum height of historical global radiosondes data coverage (Figure 1). *Right*: schematic of atmospheric vertical structure and its latitudinal variation. (Modified from Climate Change Science Program Synthesis and Assessment Product 1.1[4])

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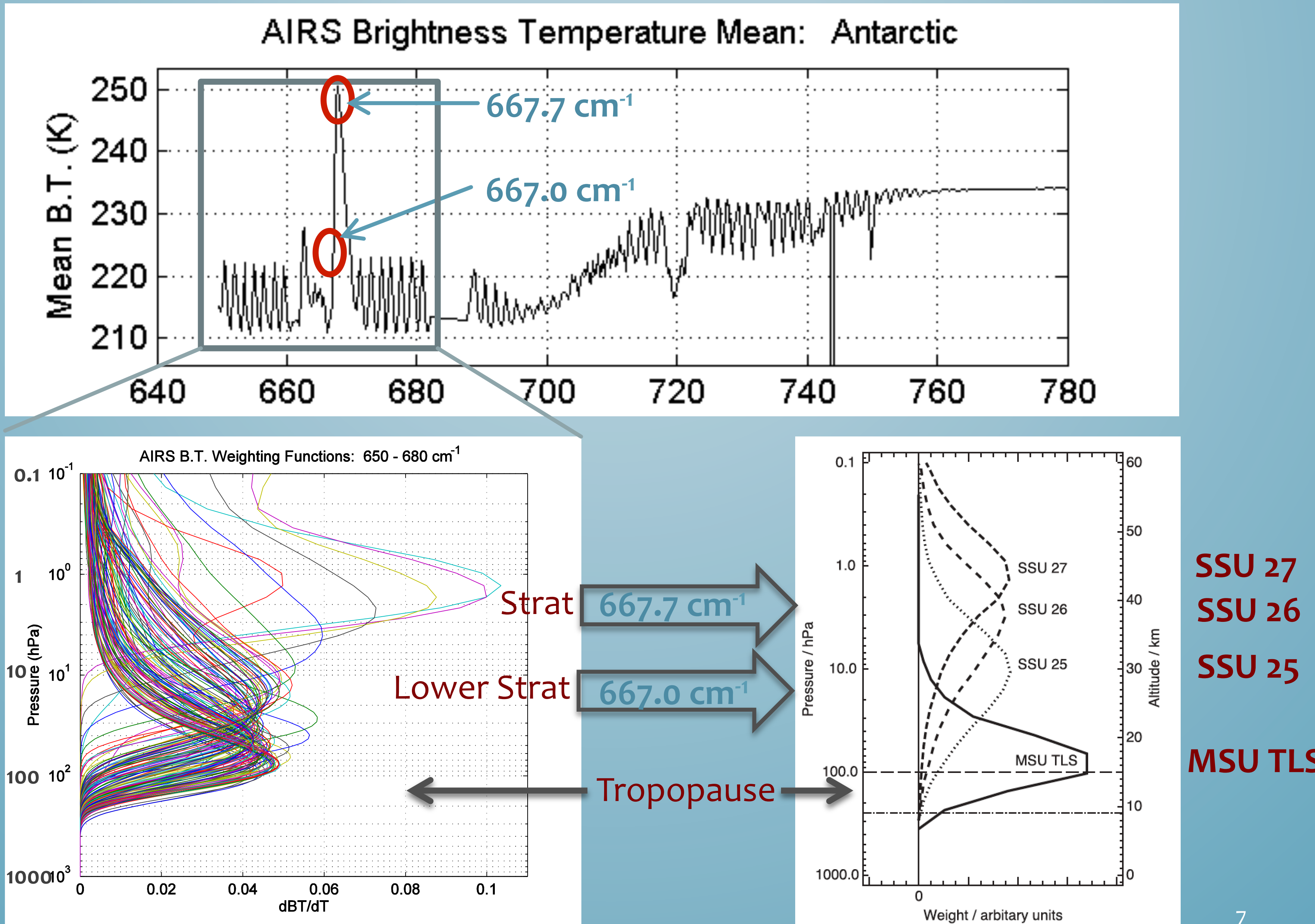
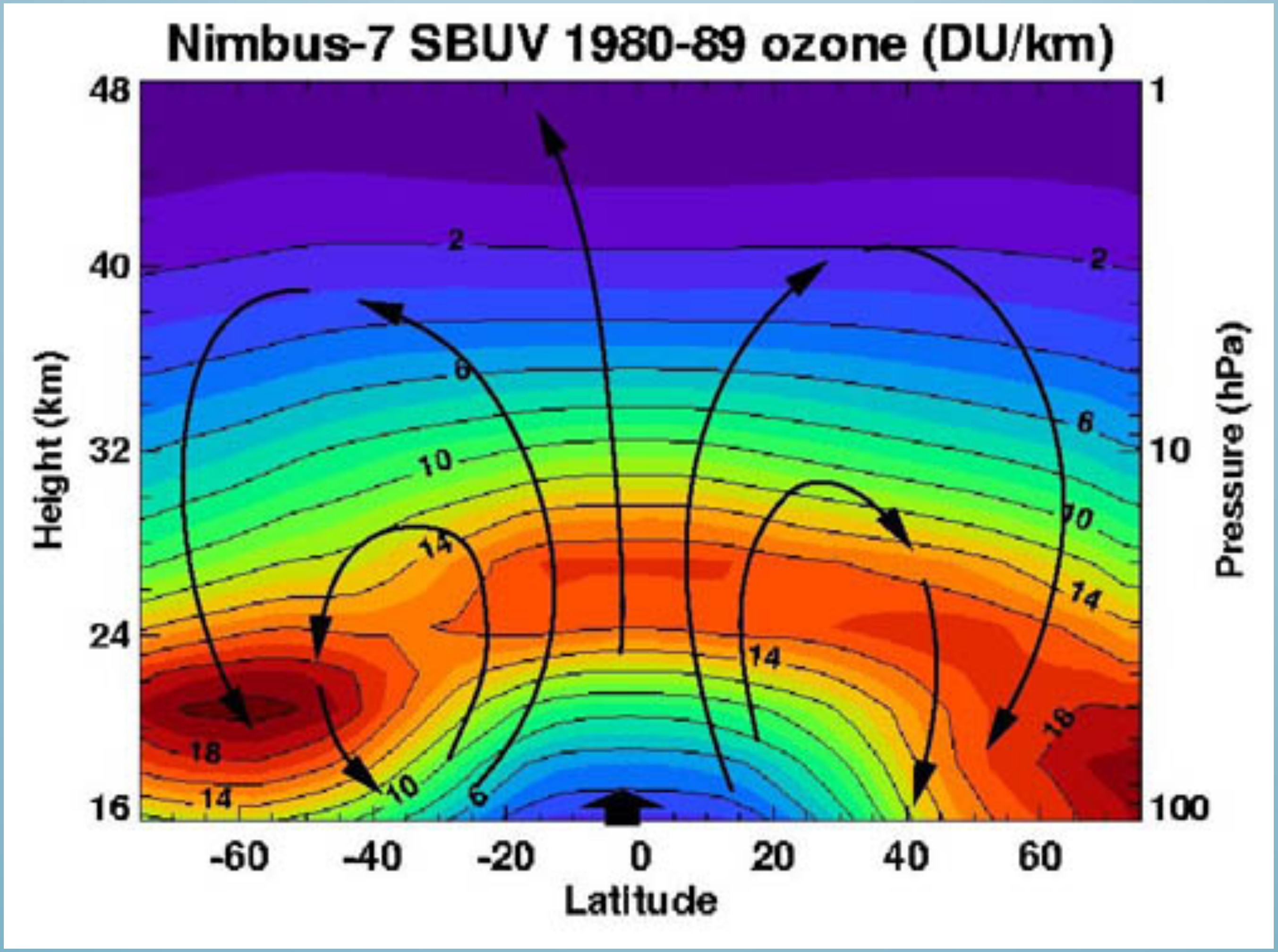
- **Can we use hyperspectral IR to provide a new and better reference for stratospheric trends into the future? Yes!**

Hyperspectral IR Sounder: Stratospheric Wgt Fcns



Sensitivity of weighting functions suggest AIRS, IASI, CrIS could continue this record.

HEATING OF THE STRATOSPHERE



Absorption of UV radiation from the sun by the ozone layer in the tropics provides a source of heating which elevates stratospheric temperatures and creates a tropopause largely separating the tropospheric and stratospheric dynamics. The distribution of ozone is largely explained by the Brewer-Dobson model.

SSU & MSU Climatology (1979-2005)

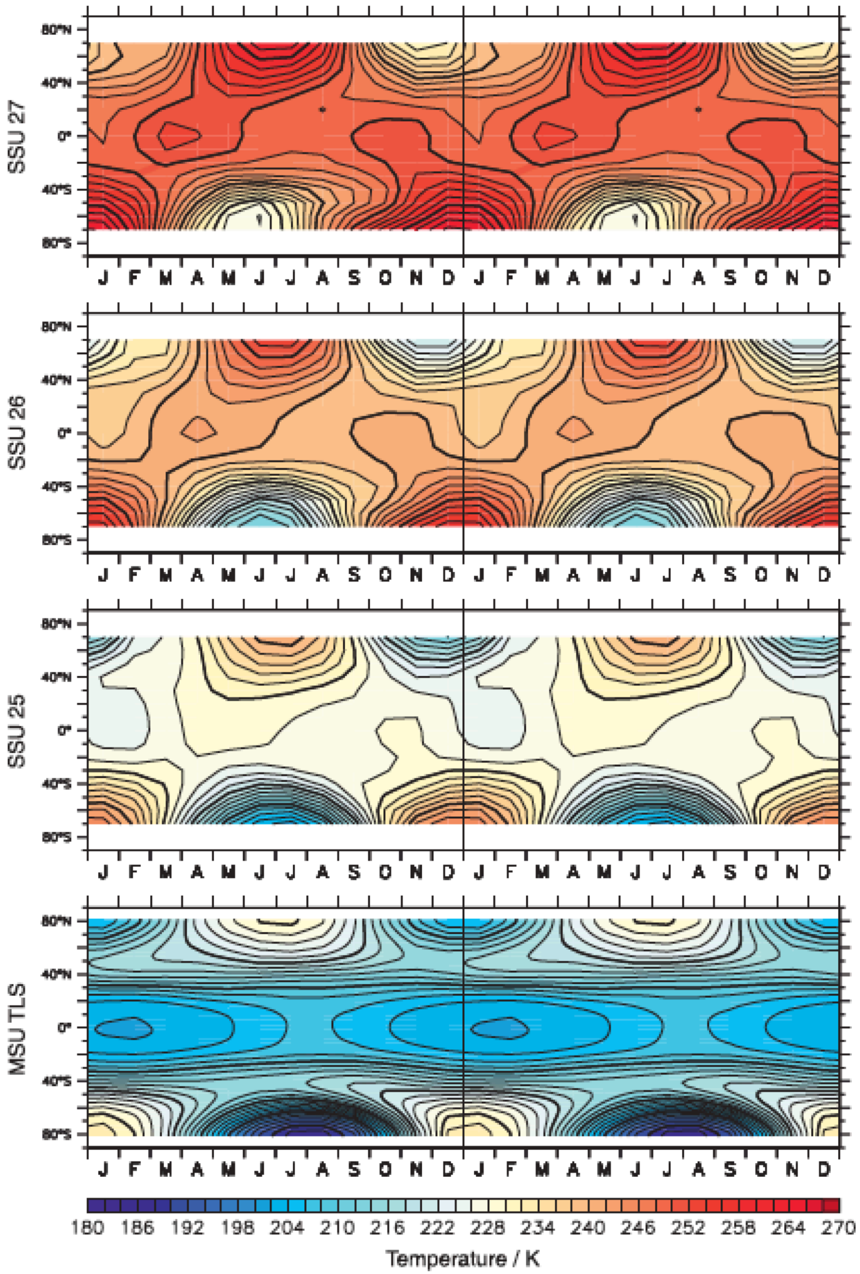
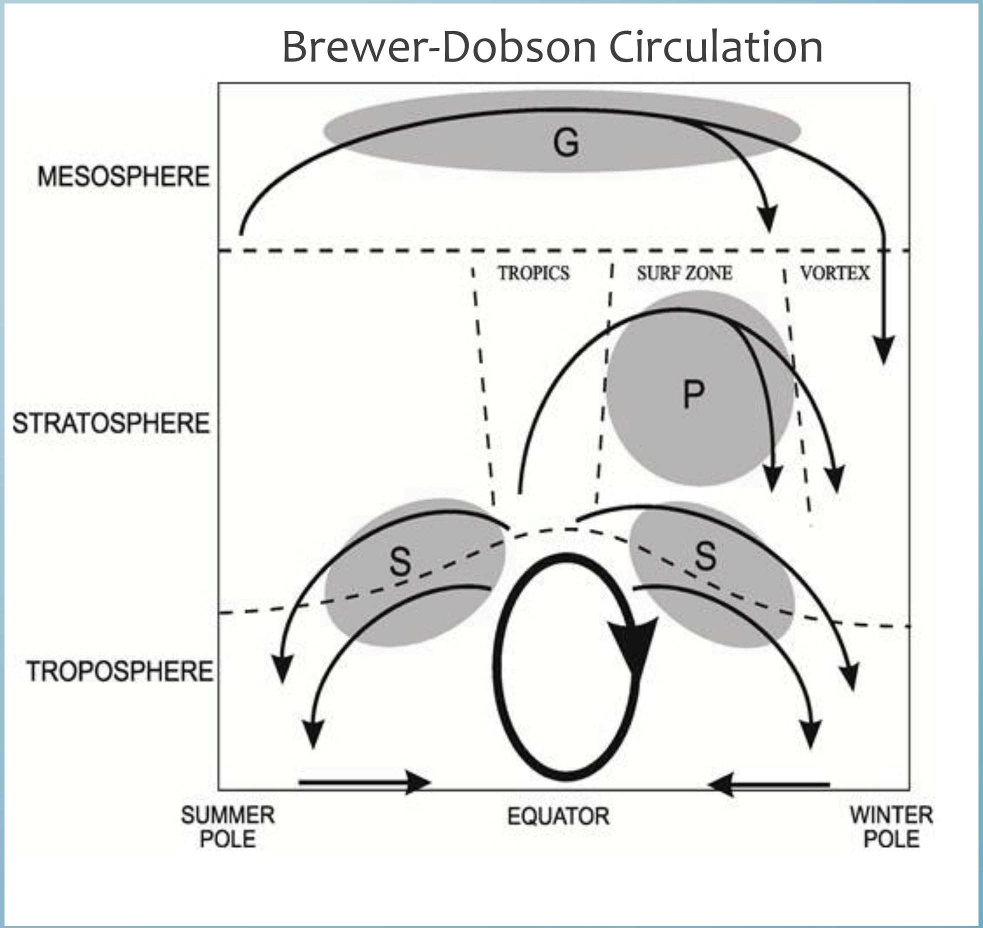


FIG. 2. Latitude–month climatological annual cycle of temperature for (bottom to top) the MSU-TLS and SSU-25, -26, and -27 data. The contour interval is 2 K, with every 10 K highlighted by thicker lines. Two complete cycles are shown.

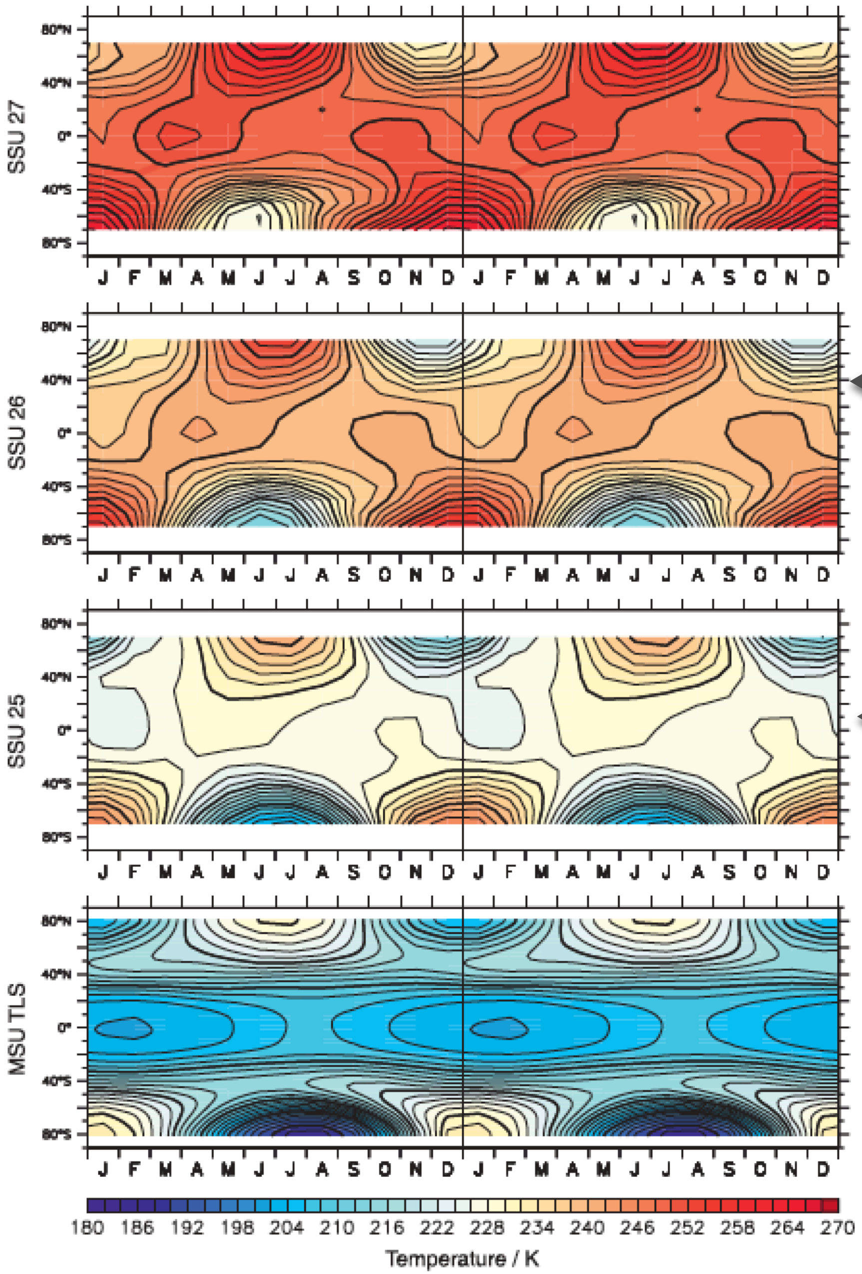
The Latitude Dependence of Stratospheric Temperature exhibits a Seasonal Variation that is explained by the Brewer-Dobson Circulation model.



But the SSU record ended in 2005!
Can hyperspectral IR continue this climatology?

From Young et al., 2011, J. Climate.

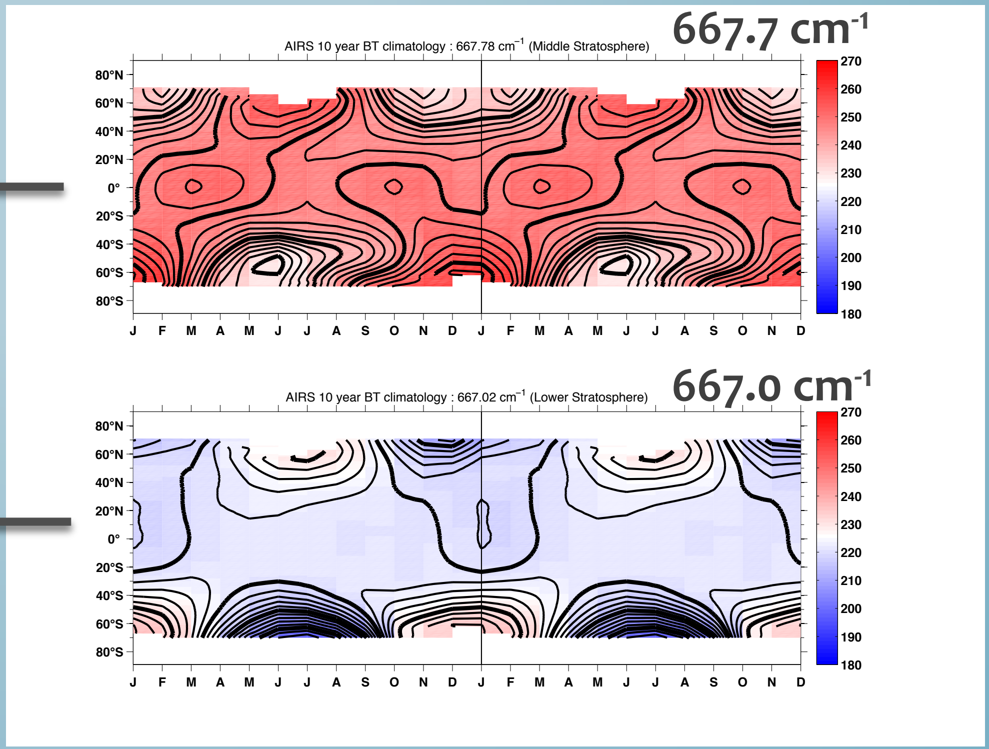
SSU & MSU Climatology (1979-2005)



From Young et al., 2011, J. Climate.

AIRS IR 10-year Climatology (2003-2012)

CIMSS has produced a 10 year radiance climatology from NASA AIRS radiance data.



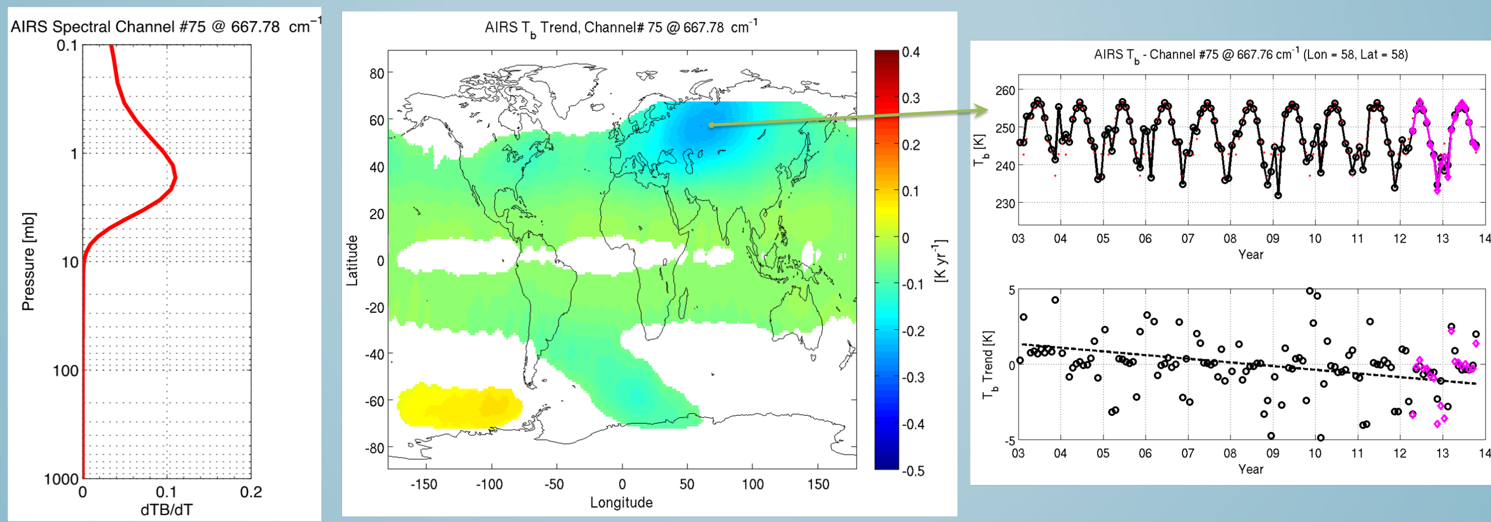
Contour lines show the same patterns in AIRS.
Please note the color scale could not be matched.

This result confirms the assertion that the hyperspectral infrared can be used to continue the record of stratospheric monitoring from SSU in support of climate studies.

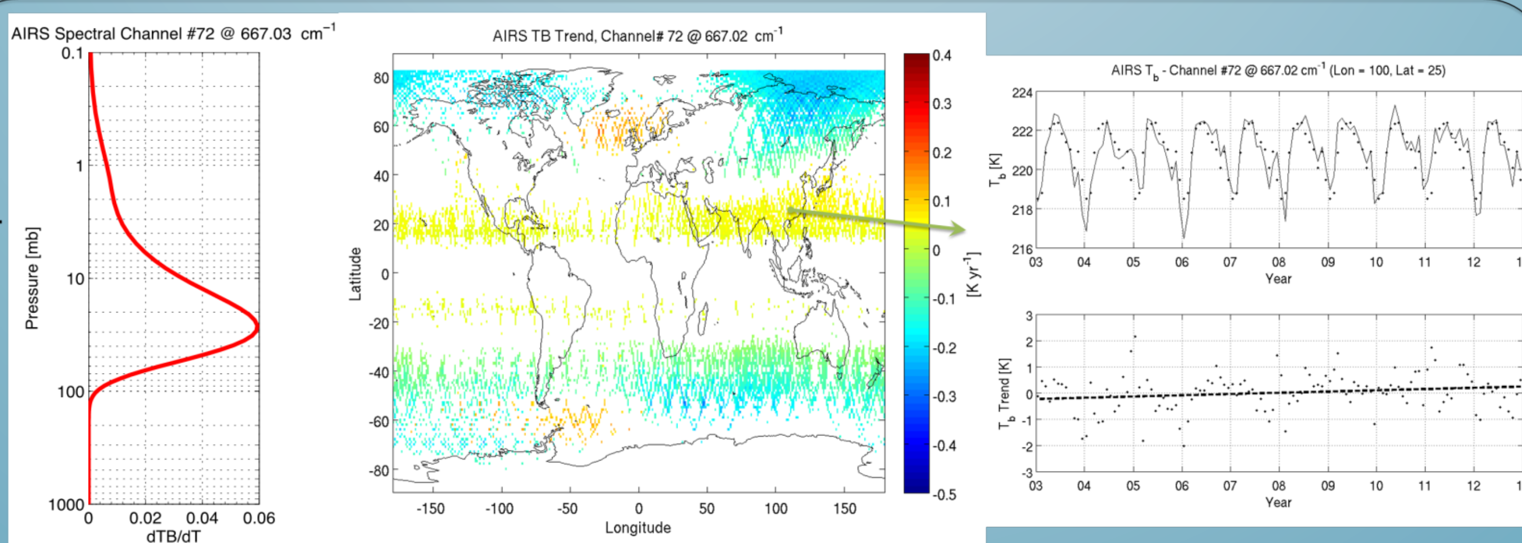
AIRS 10 YEAR DECADAL TB TRENDS: 2003-2012

DeSlover et al., Detecting Climate Signatures with High Spectral Resolution Satellite Infrared Measurements, SPIE Europe, Dresden, Sept. 2013.

Middle Stratosphere

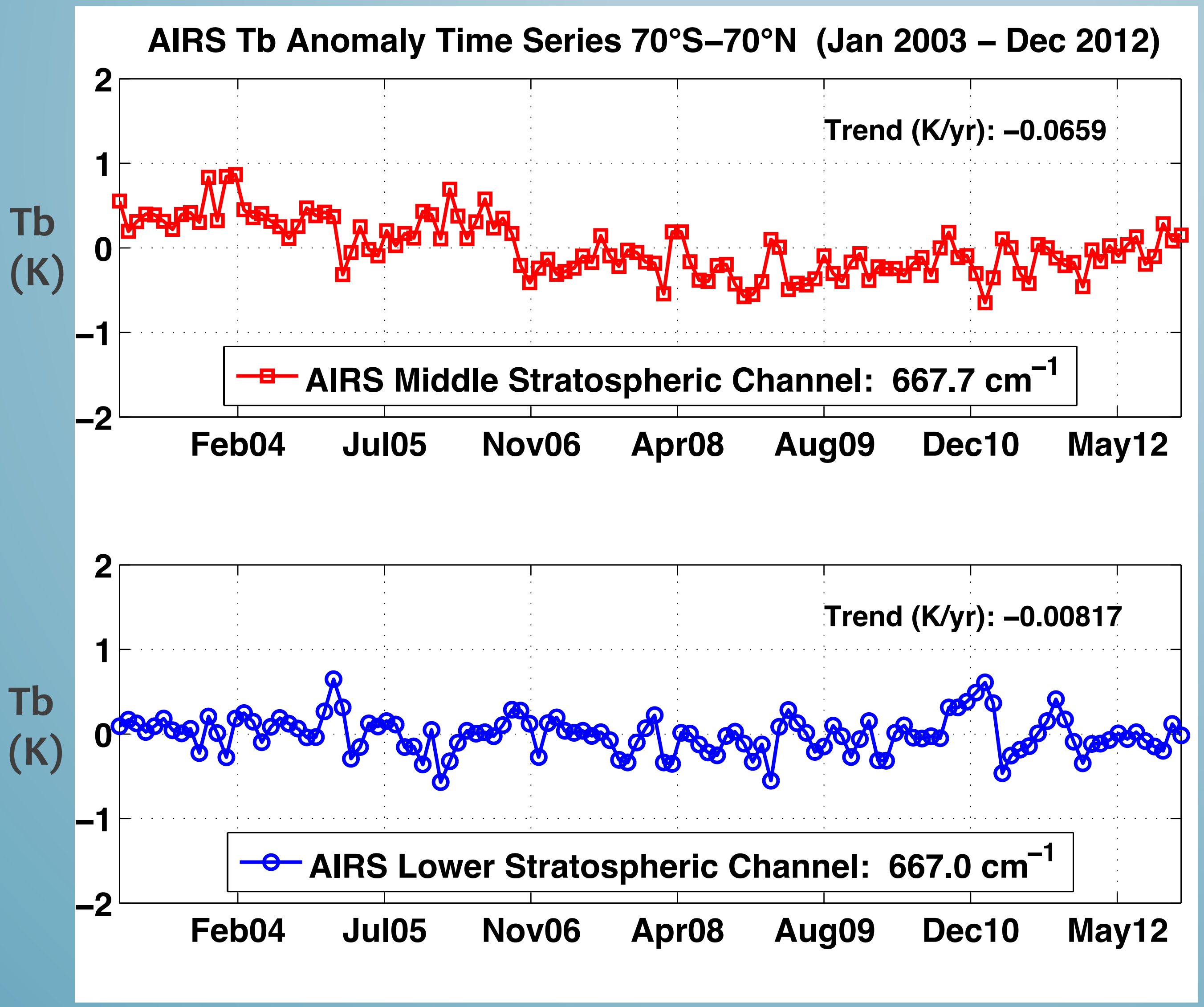


Lower Stratosphere



The time to detect significant trends on regional scales can take decades. Look next at zonal average time series similar to SSU record.

AIRS 10 YEAR DECADAL TB TRENDS: 2003-2012



<u>Middle Stratosphere</u>

AIRS decadal TB trend is about 0.6K/decade. Consistent with GCM predictions for 100 year temperature trends due to CO_2 Doubling.

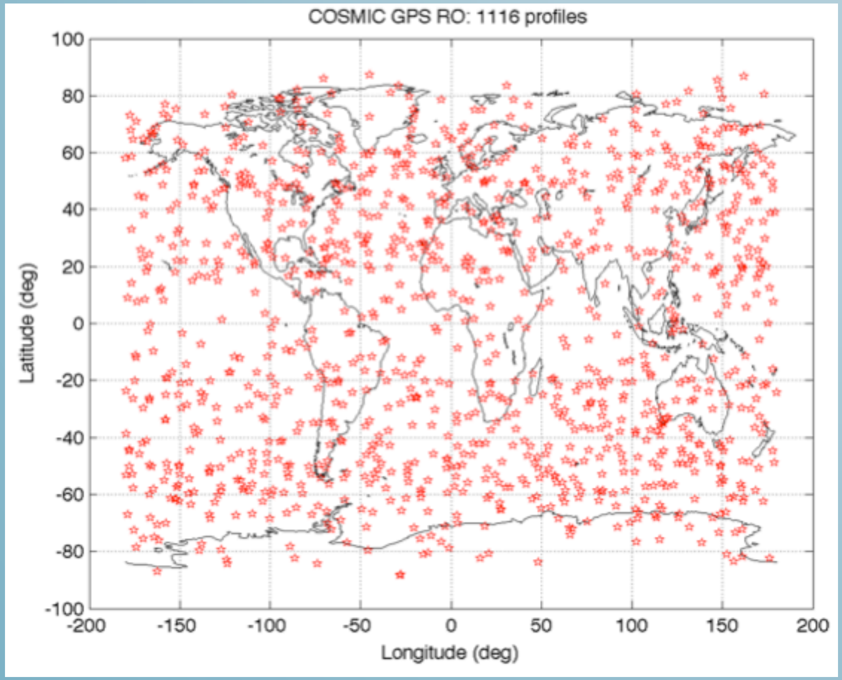
<u>Lower Stratosphere</u>

AIRS decadal TB trend is nearly zero. Consistent with radiosonde data.

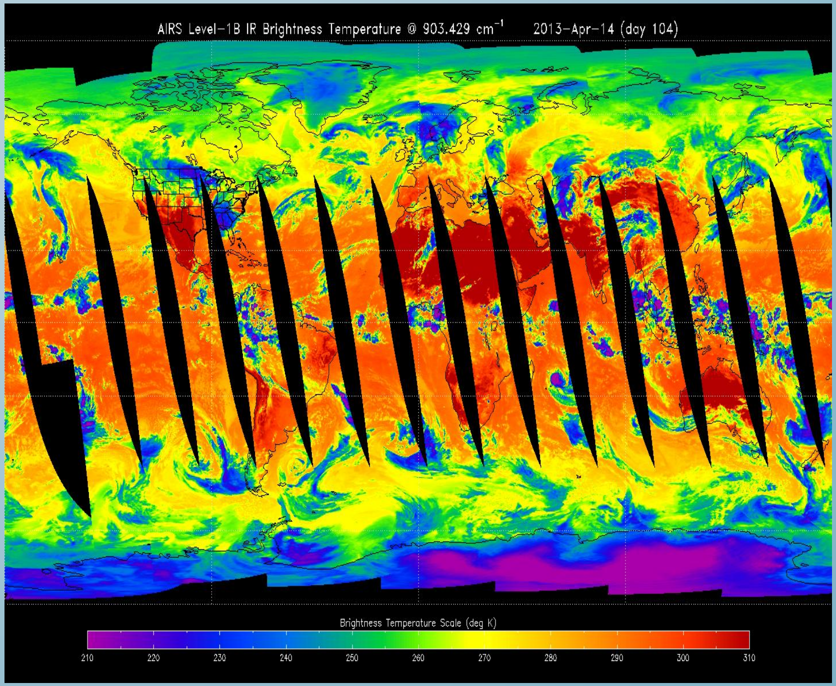
How do we know this trend is not an instrument artifact? Perhaps a drift in channel frequency? How can we interpret TB trends when records span multiple satellites? (See Hank's Talk for the answer!)

The UW IR/GPSRO Combined Dataset

COSMIC GPS RO

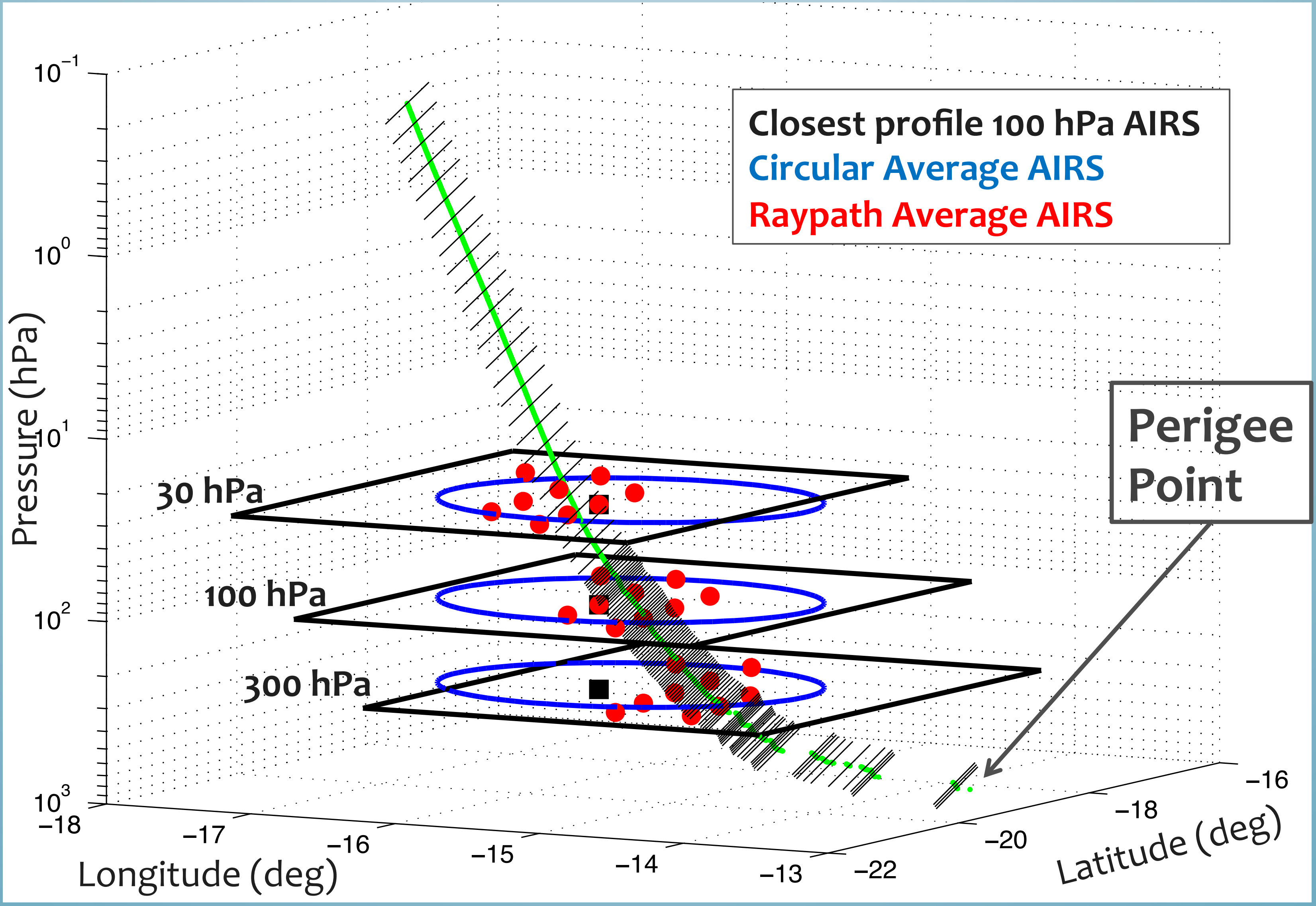


AIRS IR Sounder



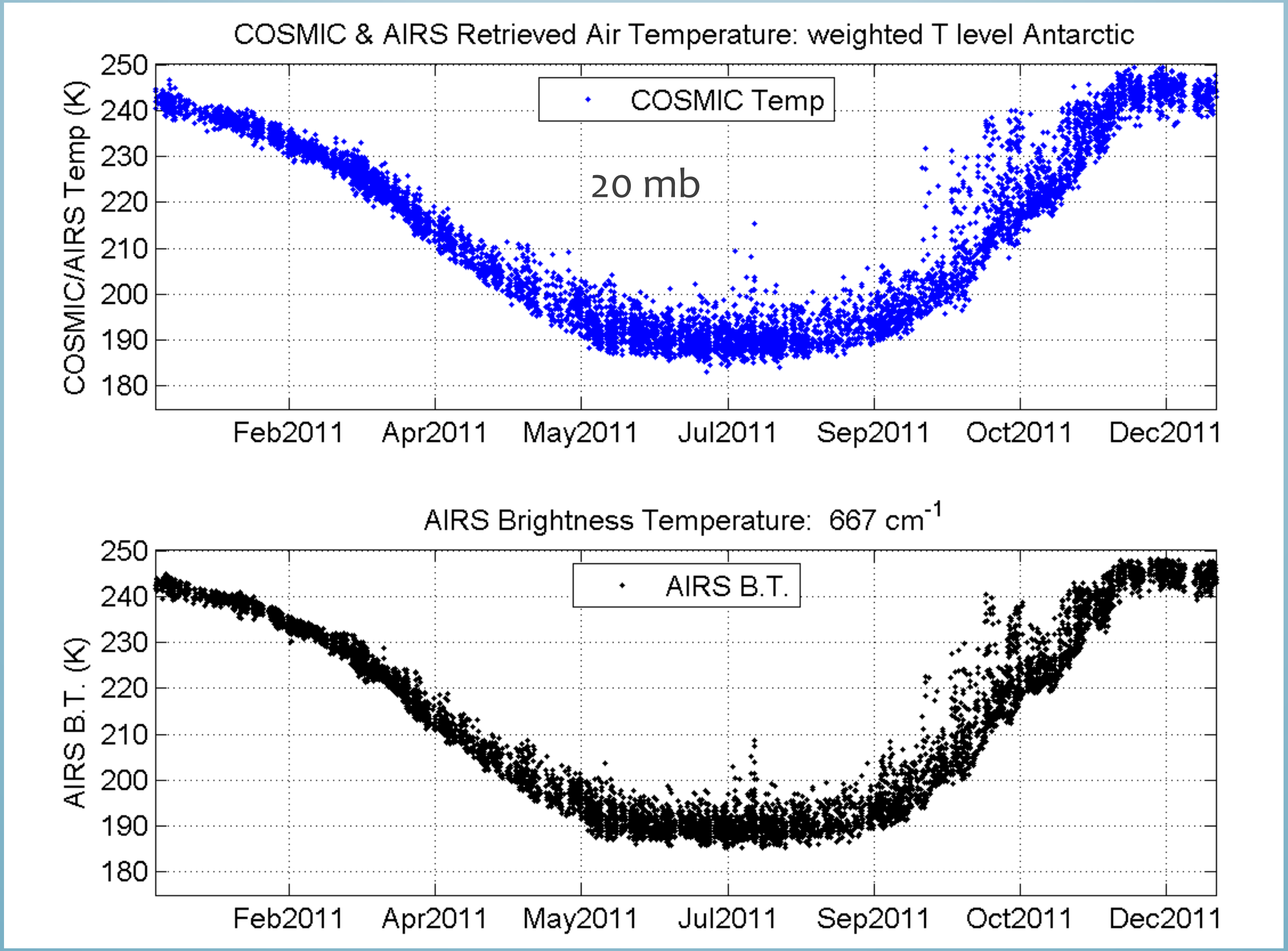
COSMIC-I: ~ 1,000 vertical Temperature profiles per day
IR Sounder: ~ 324,000 vertical Temperature profiles per day

GPS RO Profile intersection with IR retrieval fields



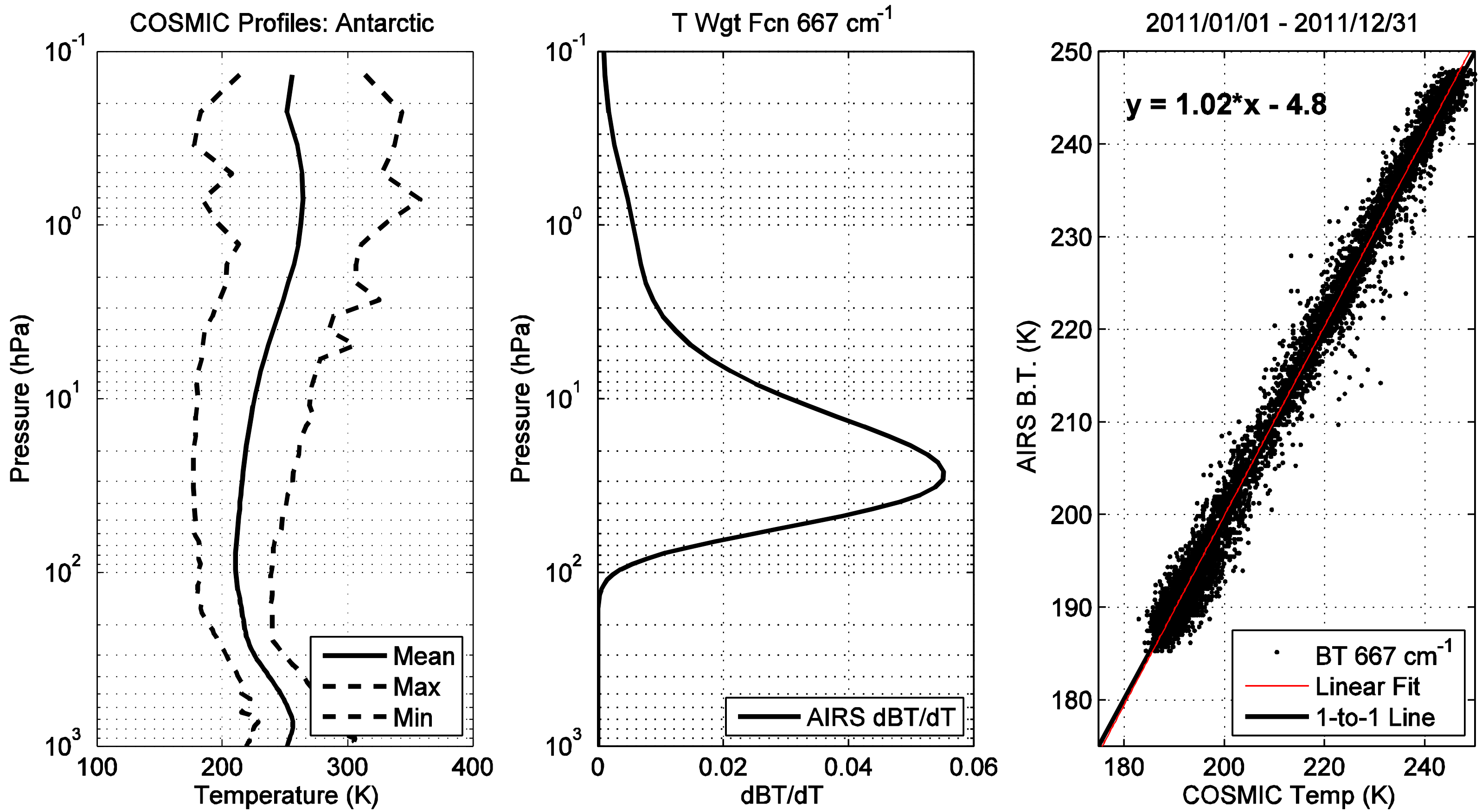
See Michele Feltz poster for details on matchup methodology.
Feltz et al. (2014), JGR Atmospheres, in press.

AIRS and COSMIC Time Series 2011: Antarctica



Co-located IR BT and weighted COSMIC temperatures can be used for time series trend analysis to confirm trends seen in the individual AIRS or COSMIC datasets.

GPS/IR Matchup Dataset Example: Antarctica



COSMIC profiles for Antarctica during Jan-Dec 2011 are matched with AIRS spectra. Each COSMIC dry temperature profile is weighted using calculated dBT/dT profile for a single AIRS channel (667.0 cm^{-1}) selected to peak in the lower stratosphere.

The fit over all scene temperatures is within 2% (correlation of 0.98).

CONCLUSIONS

- The hyperspectral InfraRed observations from AIRS, IASI, and CrIS provide the natural continuation of the SSU sensor for the monitoring of stratospheric temperature change.
- The greatly improved radiometric uncertainty (absolute calibration) of the observed radiances provides a much better reference for the detection of decadal trends needed for climate studies.
- Further work needs to be performed to verify the observed radiance trends through intercomparison of IR sensors and comparison to GPS radio occultation profiles.
- A CLARREO-type reference satellite would provide the convincing proof that trends derived from sounders are indeed real and not instrument artifacts.