A Conundrum? AIRS Measured Global Decadal Increases in Greenhouse Gases and No Decadal Increase in Global Surface Temperatures.

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Overview

- Guiding Principles
- Motivation
- AIRS and MODIS calibration
- Hyperspectral GHG Trends
- AIRS global annual trends
- Conundrum Explanations

AIRS Guiding Research Rationale

- AIRS Gridded Radiances. Weather and Climate models assimilate radiances. Model and climate products are grid oriented. Generated 1st FDDR of gridded all sky AIRS radiance product. MODIS Obscov gridding system extended to AIRS to remove artifacts.
- AIRS is Hyperspectral. Calculated directly from observed gridded radiances global and regional AIRS OLW spectra decadal trends. Greenhouse gases show increased trends. OLW spectra enables optimal channel selection for BT correlations with Surface Temp., SOI, MJO, etc.
- MODIS and AIRS on Aqua. Two independent IR calibrated instruments with same field of view on same satellite. Calculated relative instrument drift of 0.1K over 5 years. No Long Wave IR channels on VIRS.
- AIRS is a Big Data System. Developed ‘Gridderama’, a hyper-dimensional array for accessing, visualizing, archiving and publishing reproducible research experiments that maintain simple provenance and reproducibility.

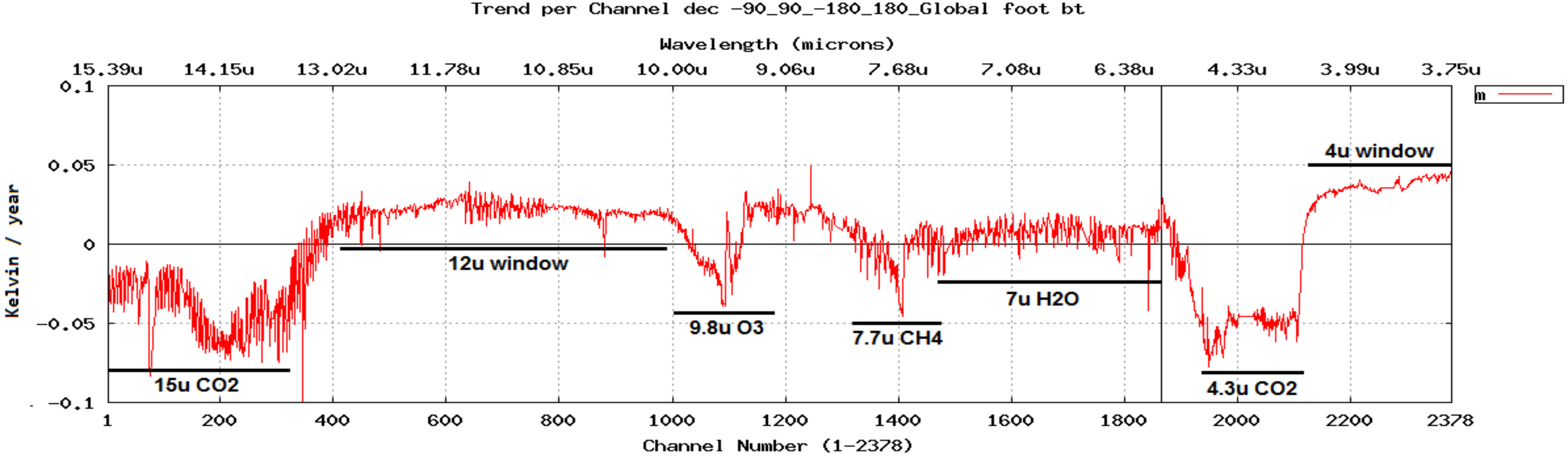
Motivation

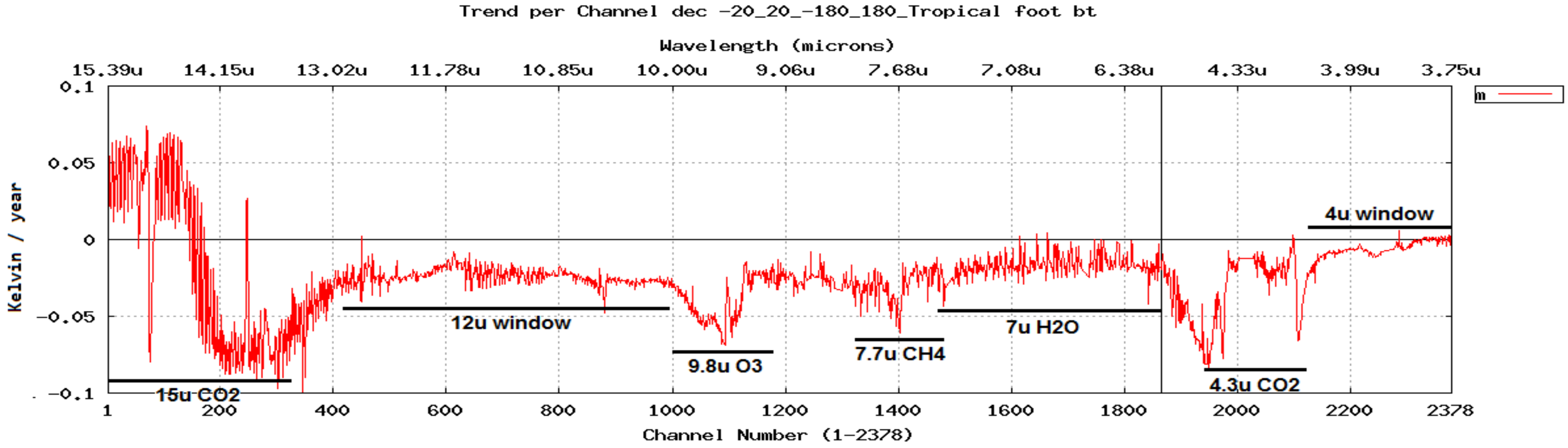
- J. Houghton IPCC- 1990,1995 "a strong link exists between increases in greenhouse gases and surface temperature".
- Goody et al. (1996) showed that IR radiance observations could be used directly to detect the climatic response to greenhouse gas forcing.
- Keith,D.W. and Anderson, J.G.,(2001) assert "the direct use of radiances in climate analysis provides a more mathematically direct comparison between theory and observation.
- Harries et. al., (2001) Compared OLR spectrum from IRIS 1970 and IMG 1997 and measured significant increases in GHG "consistent with radiative forcings".
- AIRS and MODIS on the same satellite, observing the same fields of view with completely different calibration techniques and different spectrometers provide a precise relative calibration over near decadal year time frame.
- AIRS and MODIS form a unique fundamental 10 year record of inter-calibrated, continuous, stable data from one satellite.
- No AIRS or MODIS level 1b gridded data products available from instrument science teams. No long Wave IR channels on VIRS.

Gridding AIRS Radiance I Data

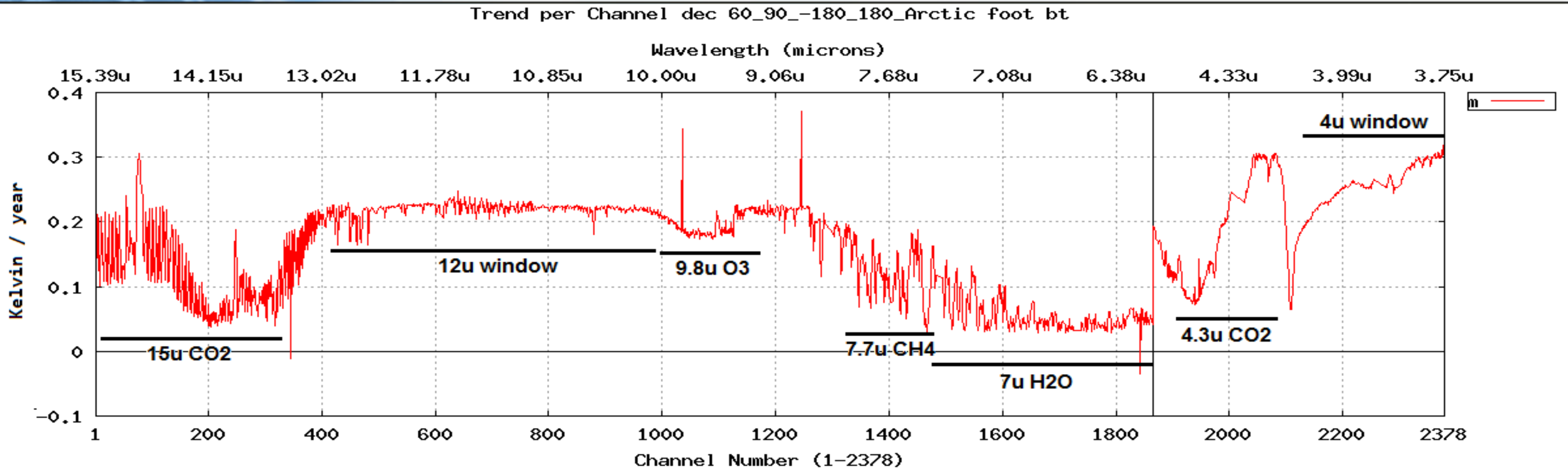
- All AIRS level 1b data downloaded from GESDISC to UMBC. One year of MODIS level 1b IR data and 10 Sept.'s copied.
- AIRS level 1b radiance footprints are mapped into Brightness Temperature arrays of **1.0^0 x 0.5^0 for 326 NOAA operational channels and 2.0^0x2.0^0** grid cells for 2378 channels from Sept. 1, 2002 to Aug. 31, 2012.
- Forward method, map center of each footprint into grid cell. Obscov method maps proportion of footprint area in grid cell inclusive of scan angle and bowing.
- For each grid cell resolution, we store the daily average desc. BTs for each spectral channel, the no. of footprints, St. Dev., the max BT. Similarly for asc.

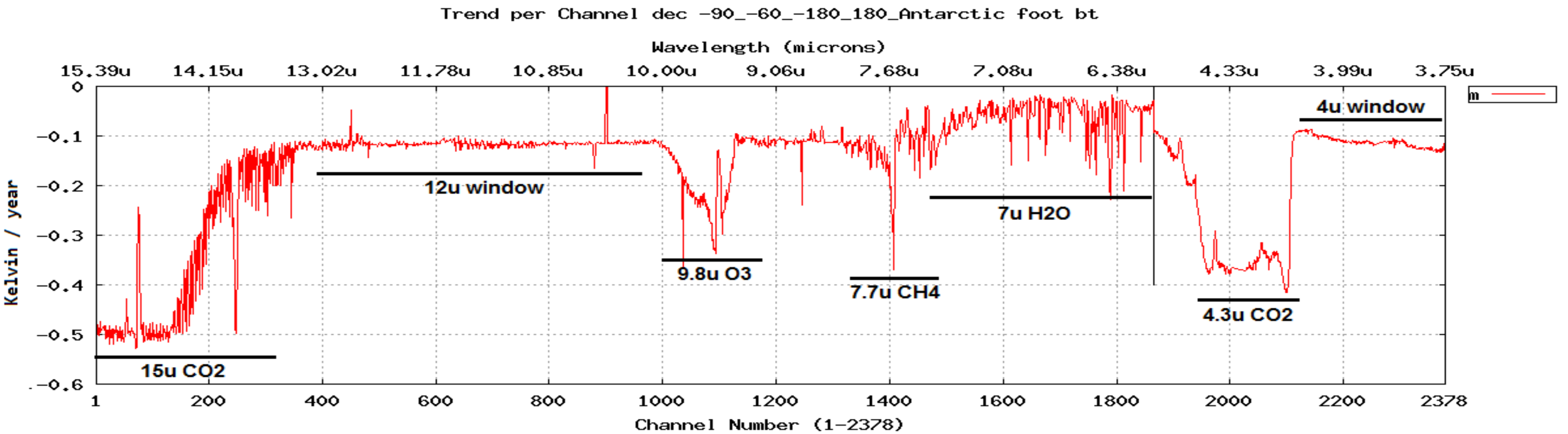
Global (Top) Eq. (Bot) Decadal OLW Spectrum Trends



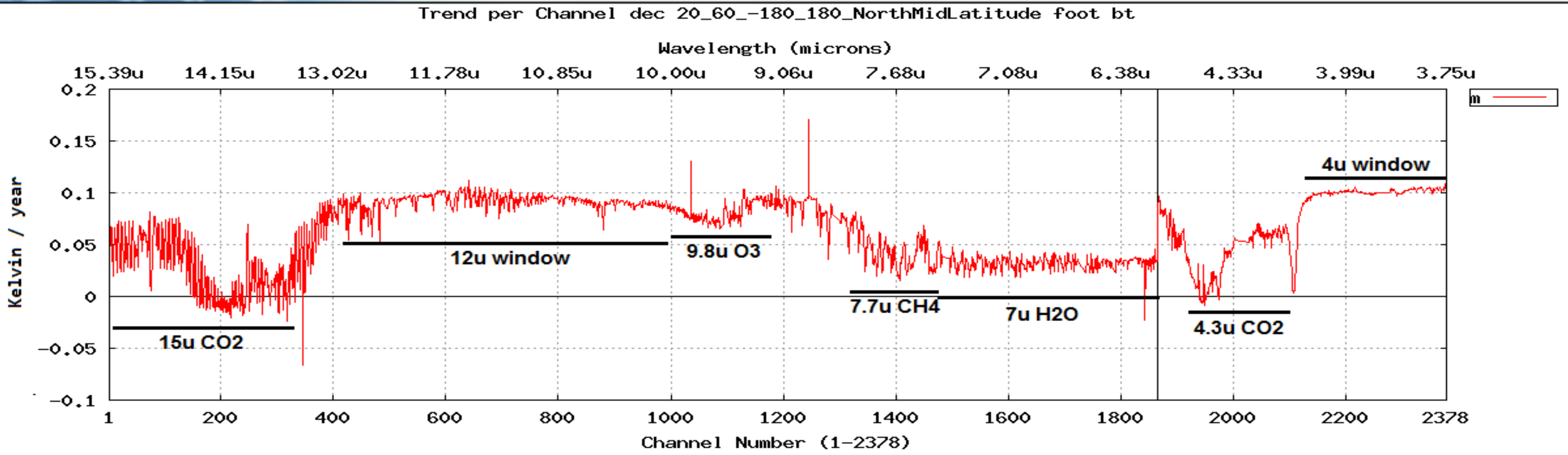


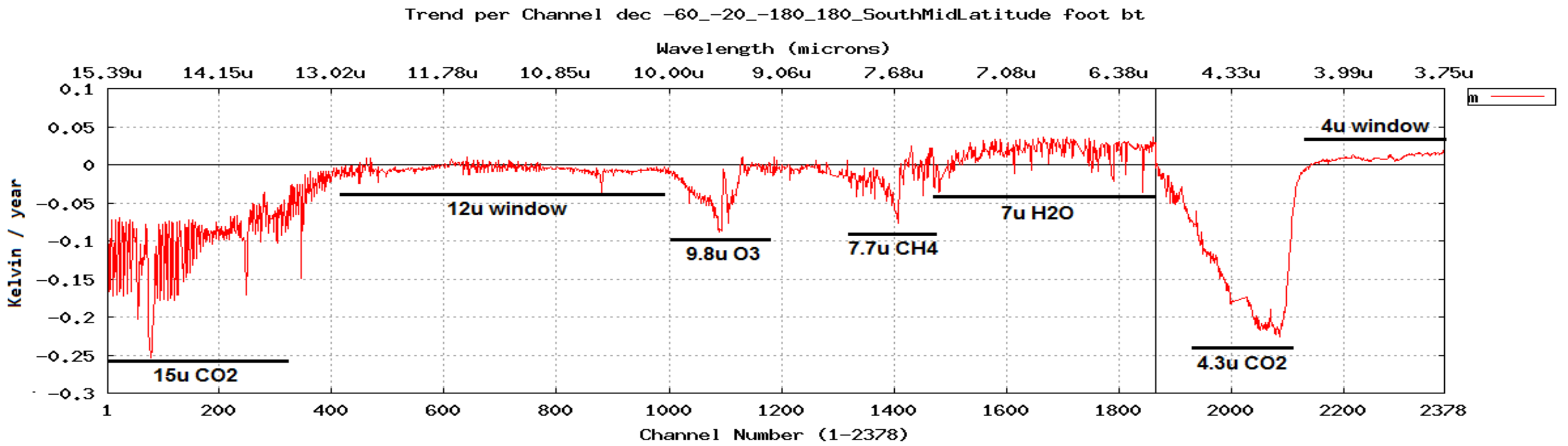
Global Arctic (top) and Antarctic (Bot) OLW Trends



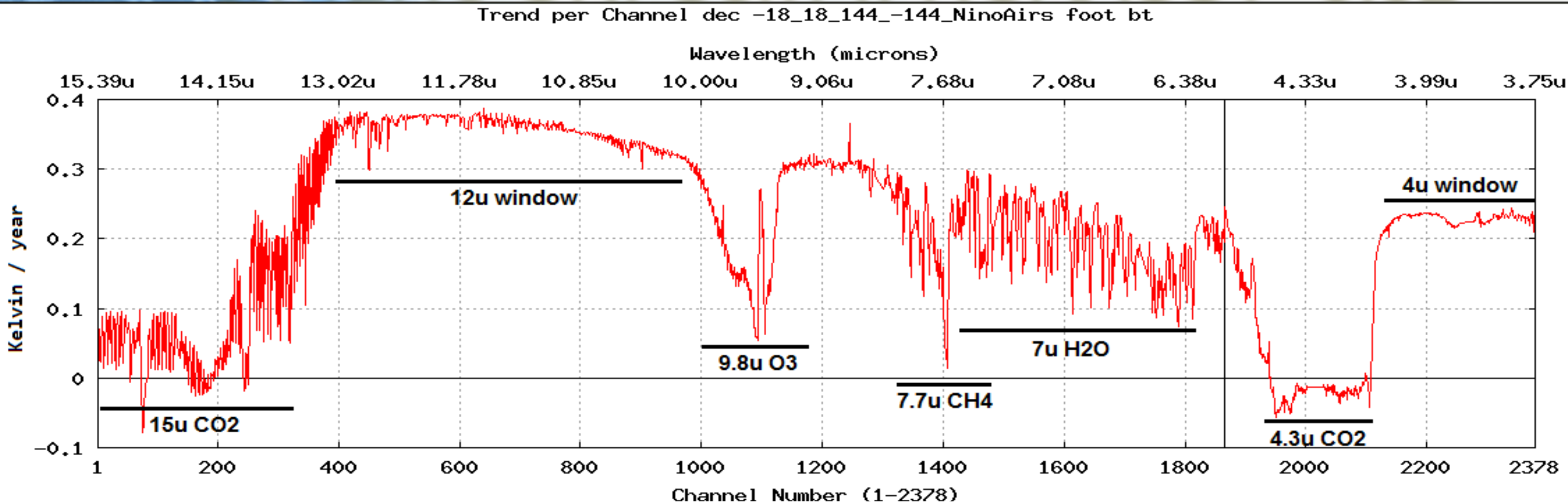


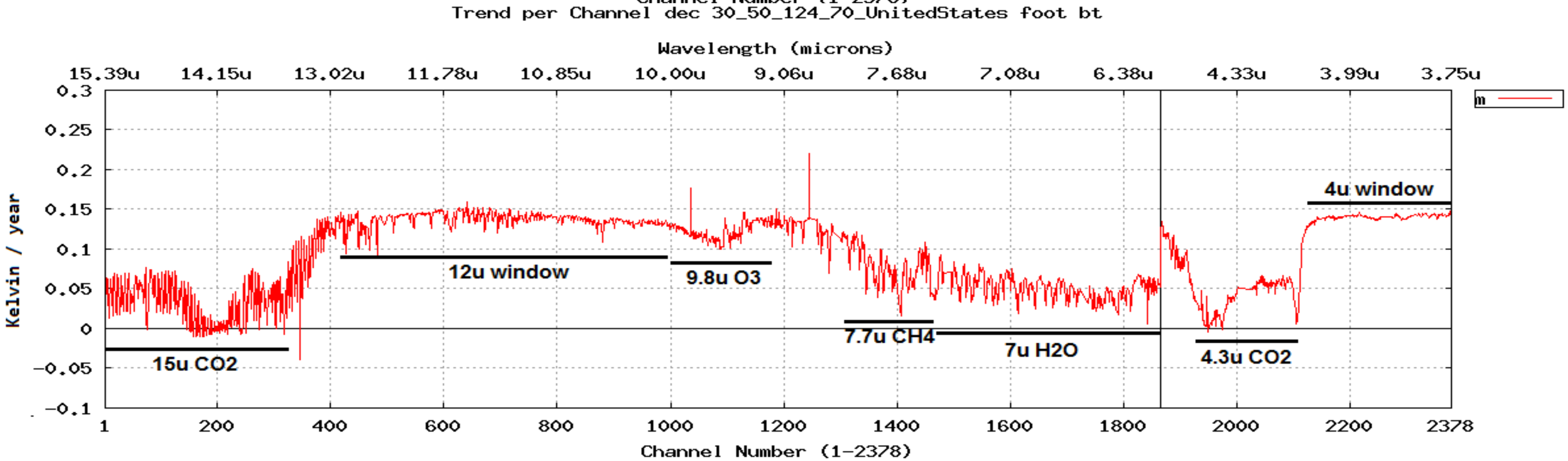
Extra Tropical OLW Spectra
20N-60N (Top) 20S-60S (Bot)



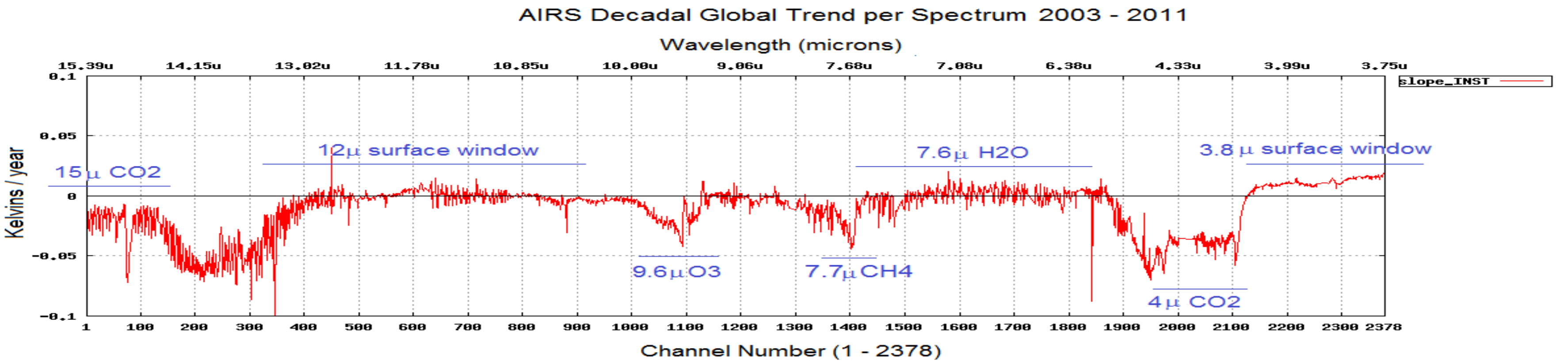


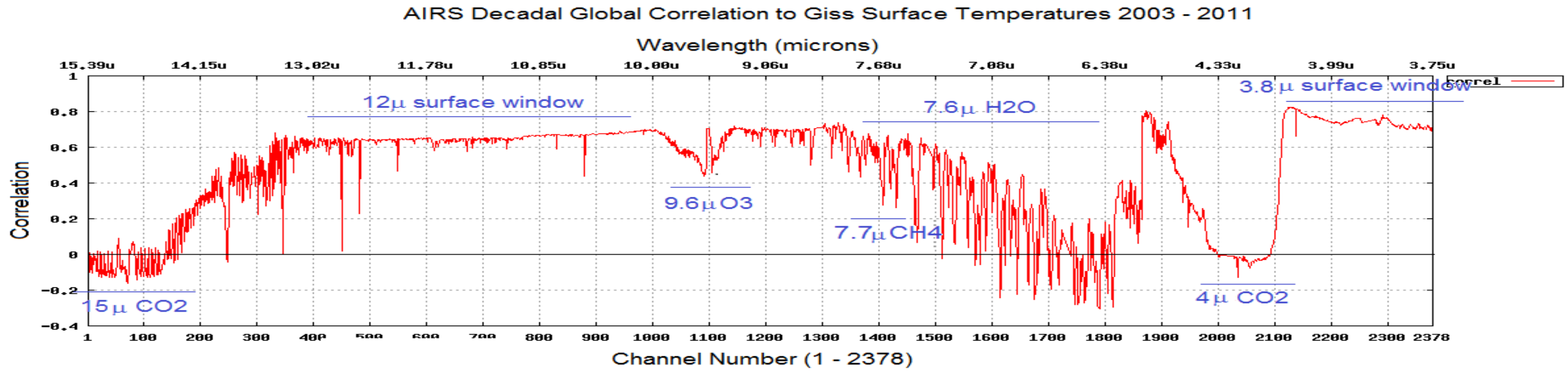
ONI (top) and US (Bot) OLW Spectra ch 12.18 ONI Corr. w NOAASST=0.92





AIRS Spectra Trends annotation for trace gasses

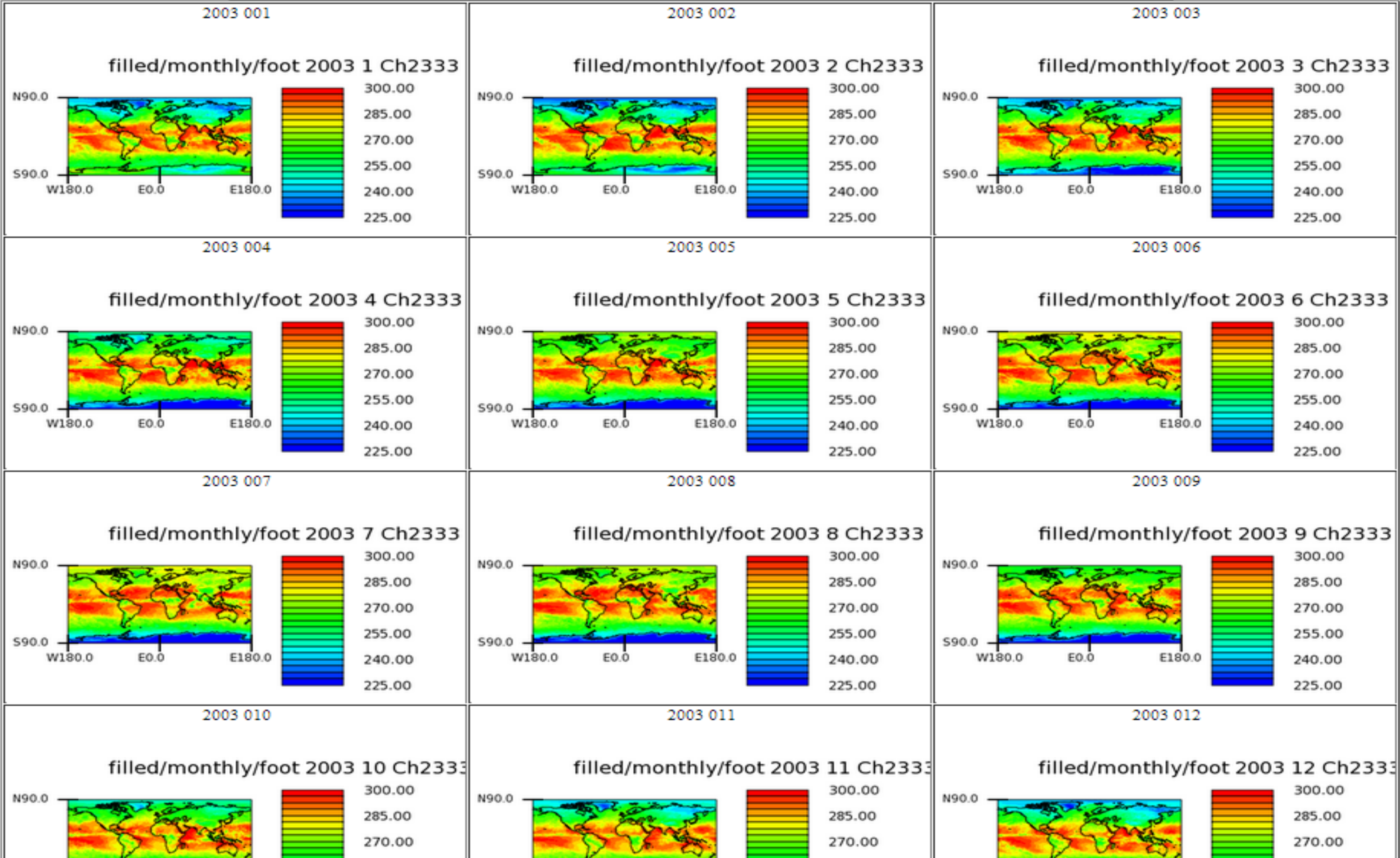




Decadal Global AIRS OLW Trends (top) correlation to GISS surface temperatures (bottom)

Data CatalogAIRSC2X2/filled/average_hdf/monthly/foot/dec bt 2333

Navigate:											
	year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	suffixes	bt	count	max	min							
	channel	50	74	528	1354	1878	2126	2333				

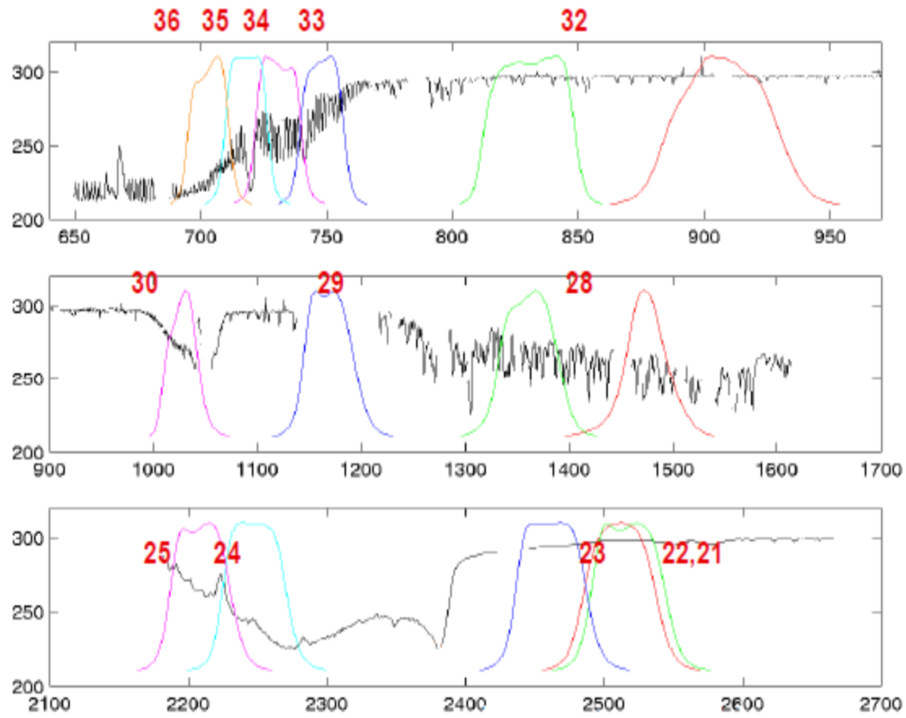


AIRS surface BT trend overview

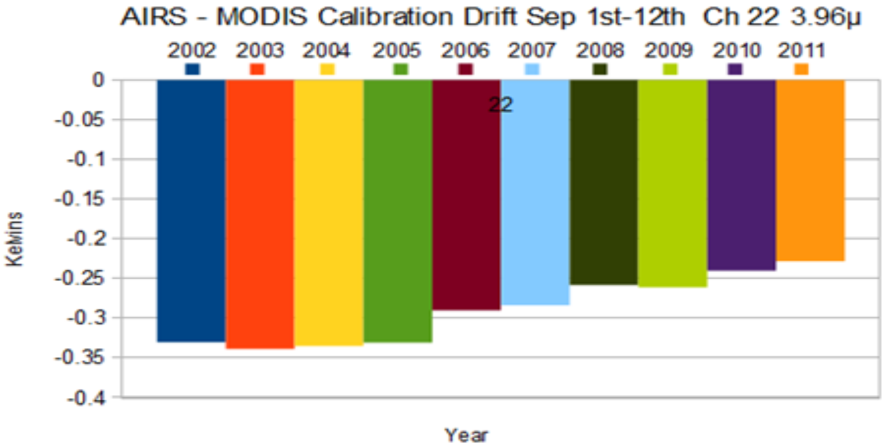
- Daily **MODIS level 1b radiance** footprints mapped into Brightness Temperature arrays of **1.0^0 x 0.5^0** grid cells for 2005 and for each month of Sept. from year 2002 to 2011
- Calibration validation: **AIRS convolved with MODIS** Spectral Response Functions and compared with MODIS (on Aqua) for calibration validations **for Sept. 1-12**,over 10 years.
- Present **10 year AIRS anomalies** (removed yearly and seasonal averages) for all channels and compared *4.16μ and 12.18μ* window channels .
- AIRS surface BT **correlated with GISS** global surface temperature data.

Establishing Stability of AIRS and MODIS Convolving AIRS using MODIS SRFs

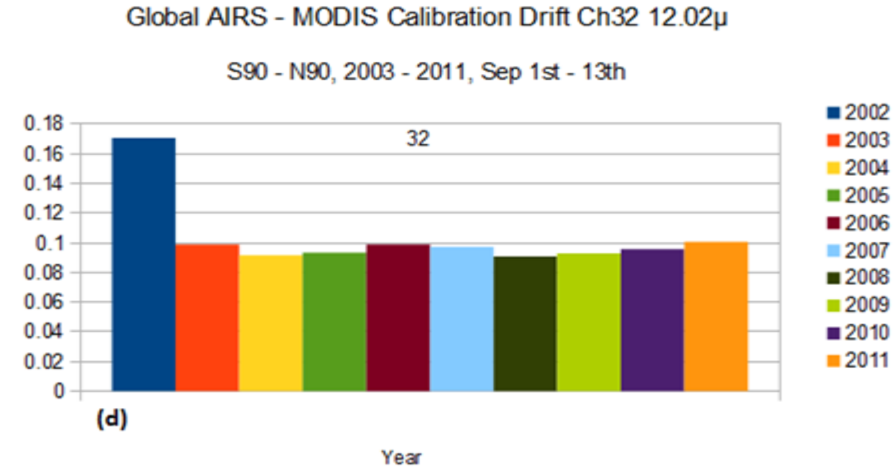
- MODIS on same satellite with AIRS
- Integrated convolved AIRS channels in MODIS spectral range
- Adjusted scan angle of MODIS to match AIRS
- Compare 4µ and 12µ



ConvAirs-Modis Calibration bias



(a)



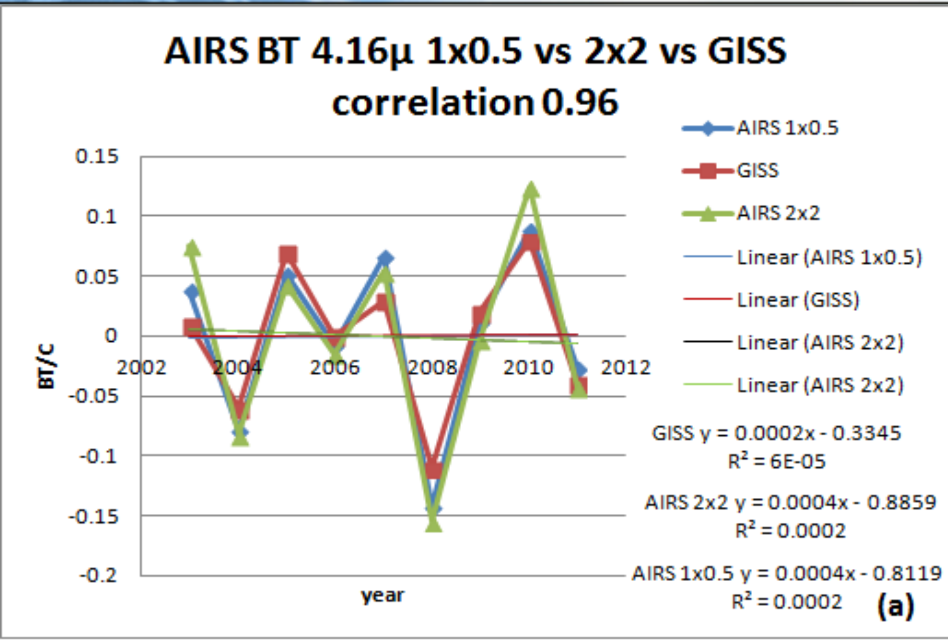
(d)

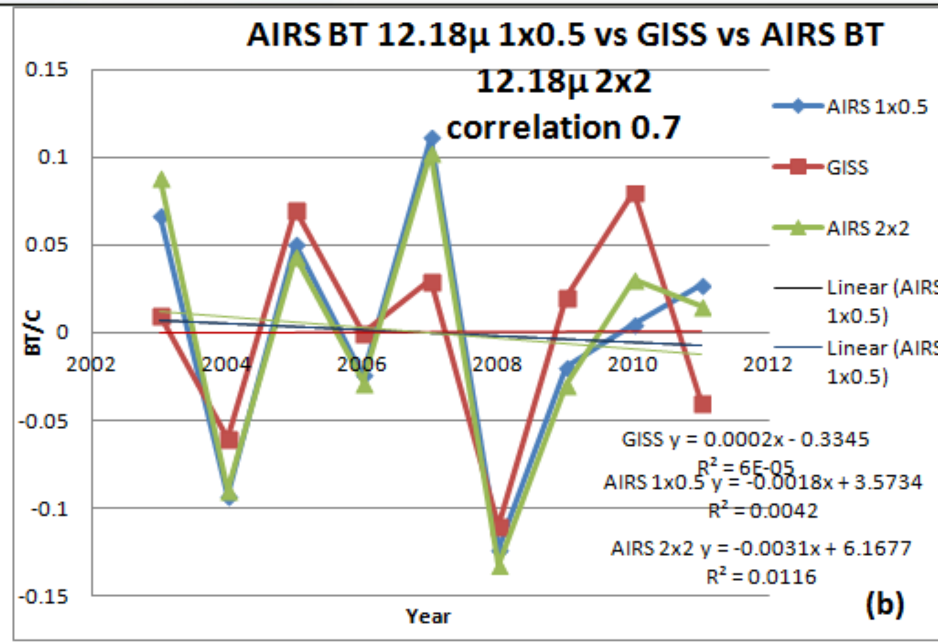
Fig.a. convAIRS-MODIS ch. 3.96µ 2002-2005 has **a cold bias of 0.3^{0}K and a drift of 0.1^{0}K for** 2006--2011. The **year-to-year global trend is 0.013^{0}K. AIRS may not be suitable for detecting decadal annual trends**

Fig.d. **12.02µ is extremely stable for decade with a trend of 0.001^{0}K and neglible AIRS warm bias.** AIRS is **suitably calibrated for determining decadal trends as small as 0.1^{0}K for window ch. 12u**

- **Claim: Need stability and accuracies of 0.01K for global annual changes.**

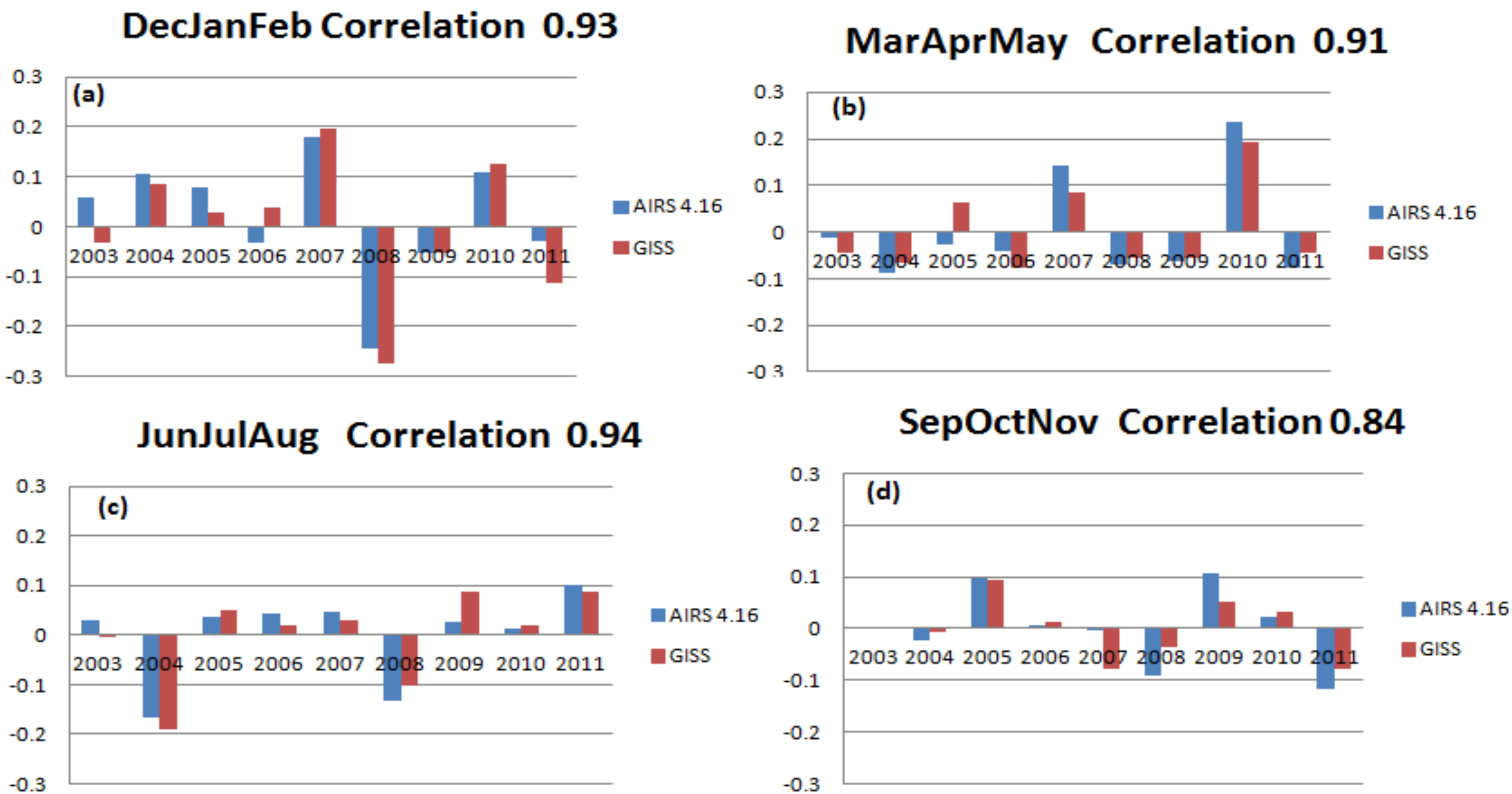
Sensitivity of AIRS global surface BT trends





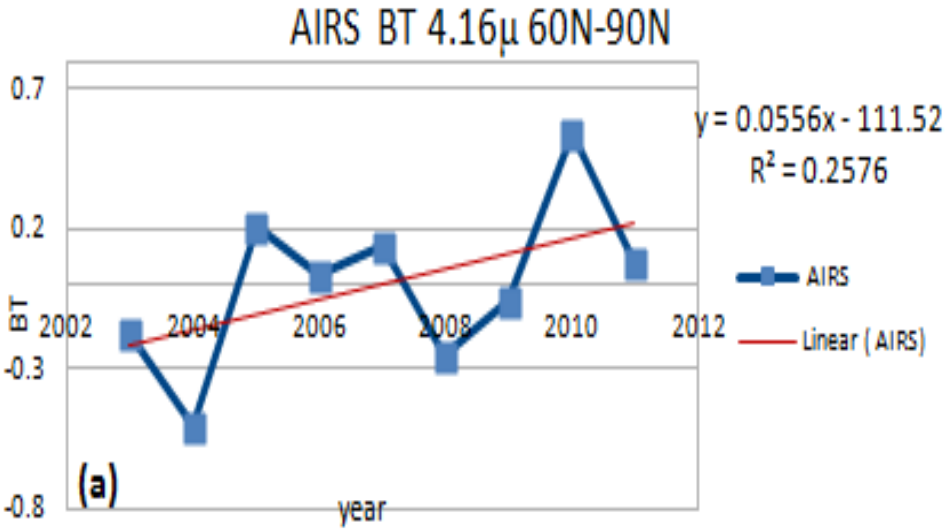
- Fig.a AIRS surface BT and GISS ST global annual mean anomalies **trends are flat for ch. 4.16µ** with an annual **correlation of 0.96**, slight difference in 2007
- Fig b. AIRS ch. **12.18µ exhibits poorer annual correlations with GISS of 0.7** and a slight decadal cooling trend of 0.0018^{0}K from possible cloud effects.
- Both consistently colder in years 2004, and 2008 by ~0.07^{0}K and 0.12^{0}K (Fig. 2a). Similar colder years and magnitude for AIRS ch. 12.18
- However, the AIRS 12.18µ, years 2007, 2010 and 2011 shows larger differences from **GISS ST of -0.075, -0.08 and 0.06** (fig. b).

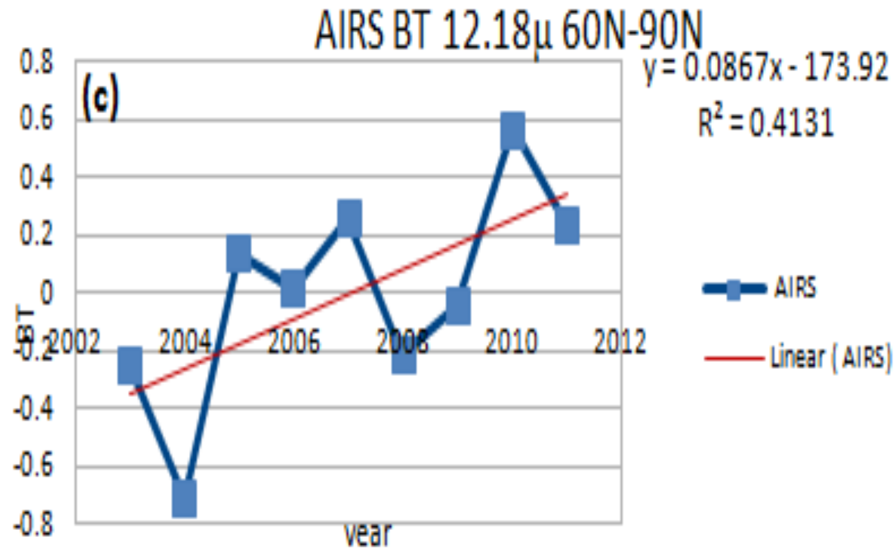
AIRS 4.16 micron and GISS seasonal anomalies



- AIRS BT shows **high correlations (>0.9)** with GISS ST in all seasons except SepOctNov with corr. of 0.84

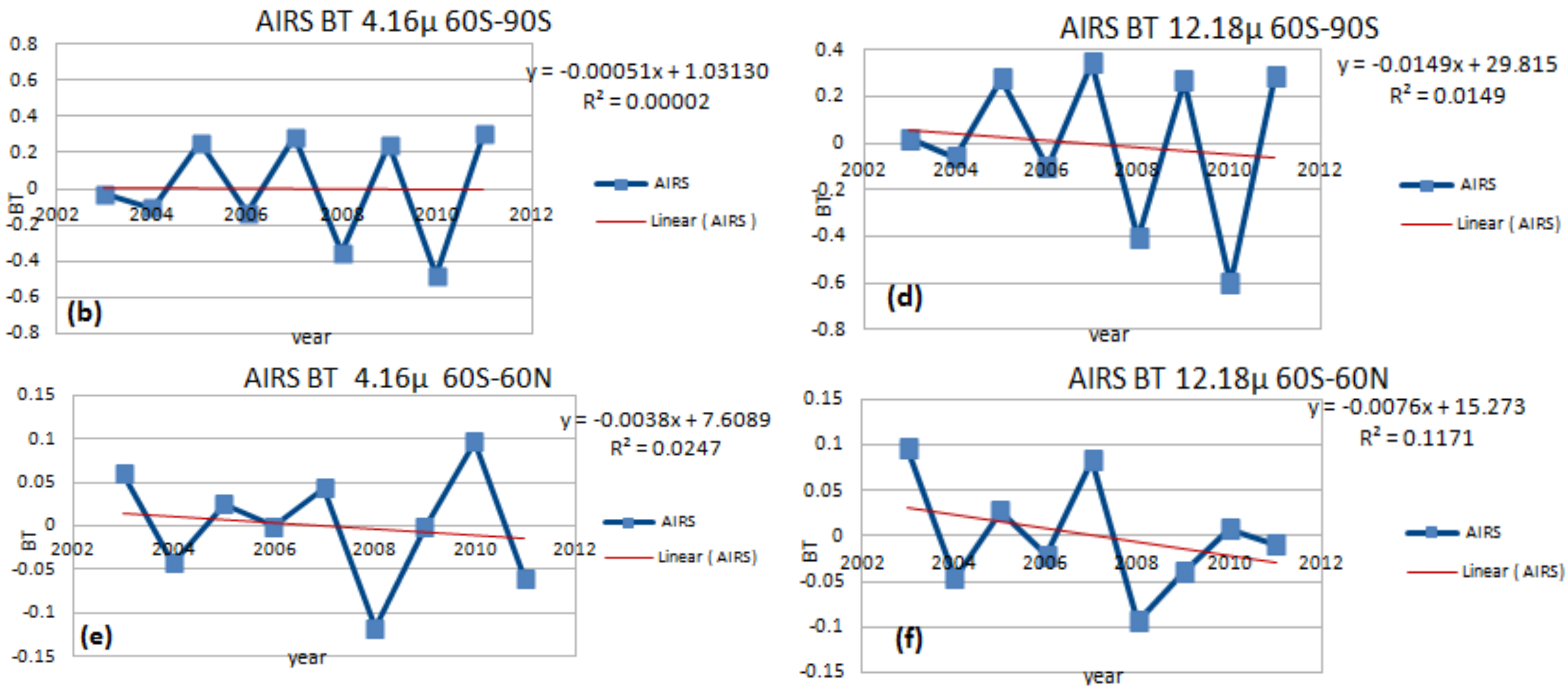
AIRS annual BT trends in Arctic



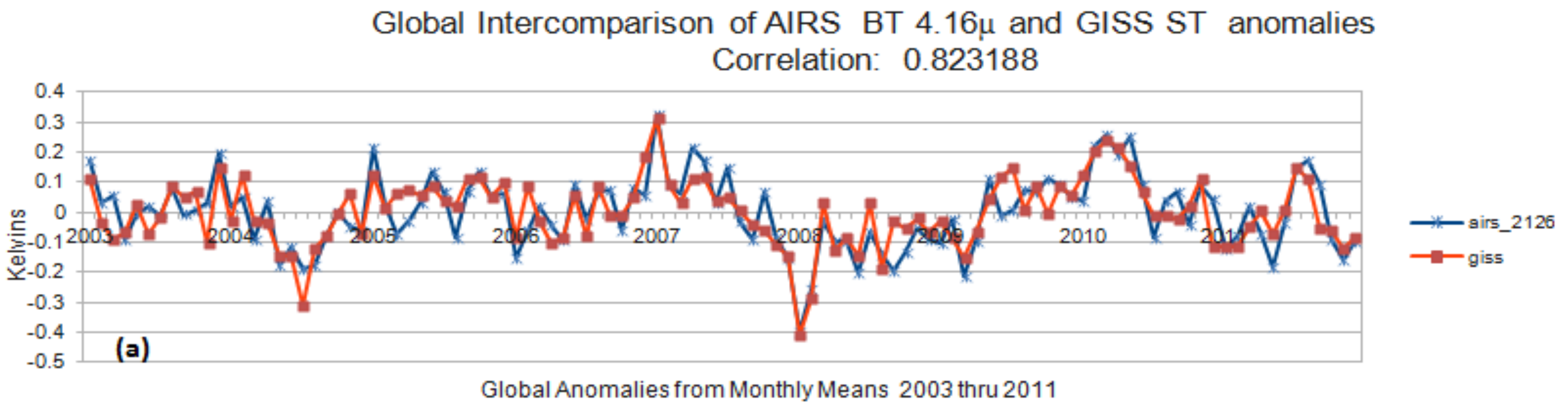


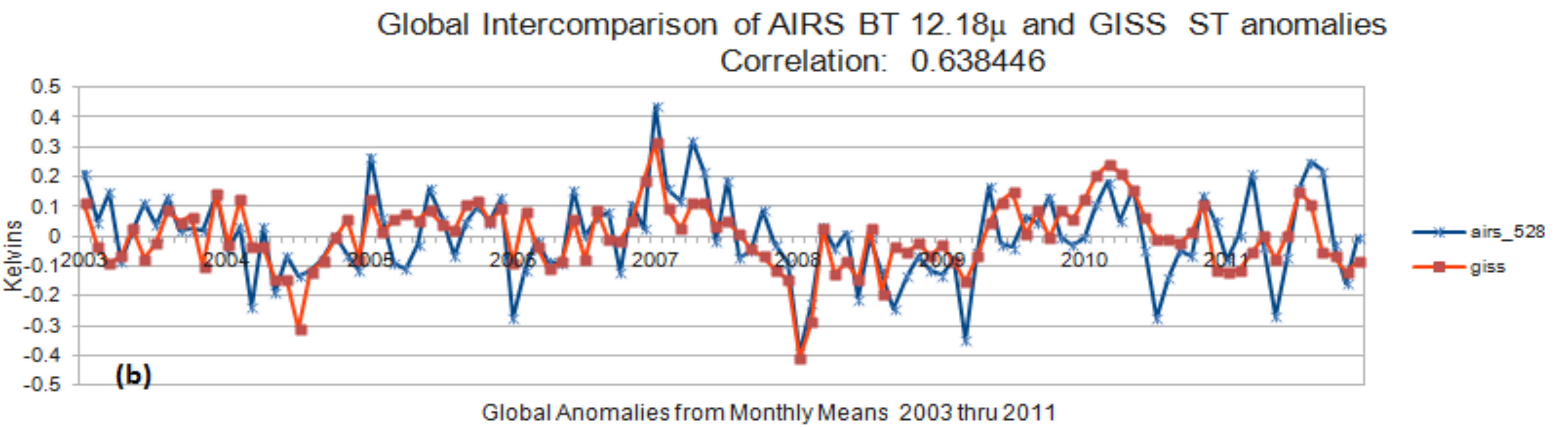
- **Significant warming trend in the Arctic of 0.06^{0}K** per year for channel 4.16μ with yearly changes varying as much as **0.7^{0}K** and a **decadal gain of 0.6^{0}K** (Fig. 4a).
- Slightly larger trend observed by AIRS channel **12.18μ of 0.087^{0}K/yr** in Fig. 4c
- Both AIRS 4.16μ and 12.18μ show correspondingly large year to year **Arctic oscillations of ~-0.8^{0}K to 0.6^{0}K** adding credibility to the observation of a decadal warming in the Arctic.

AIRS annual BT trends in Antarctic



- Fig. 4b and Fig. 4d show that **trends are flat for 60S-90S** in AIRS channel 4.16µ and less significant of 0.014^0K cooling for AIRS channel 12.18µ.
- Both AIRS 4.16µ and 12.18µ channels show **little cooling trends of 0.004 and 0.008 respectively in the middle latitude (60S-60N)** for this reported period (2003-2011).





- Largest monthly differences between AIRS ch. 4.16u and GISS are
- $<0.15^0$K occur during years 2005, 2009
- Largest monthly AIRS differences with GISS for ch.12.18µ are <.25 in years 2005and 2010. AIRS ch 4.16µ gives better similarities with GISS than ch 12.18u

Big Data Solution: Gridderama

- Developed "Gridderama", a robust software open infrastructure using a hypercube array storage. AIRS level1b from 9/1/2002
- Facilitates multi-terabyte parallel data processing task.(55TB) Compressed HDF4 files, 2x2deg file,
- Ensures integrity, tracking provenance, logging errors.
- Provides extensive visualization. Total monthly grid products ~300GB
- All data, code, logs and visualizations are available online and browseable via a real-time "Data Catalog" interface. Non real time
- http://bluegrit.cs.umbc.edu/~dchapm2/airs-grid

Each data product a hypercube (6 or 8 D)

idx	Dimension	Typical Ranges	Implementation
8	Monthly Average Strategy	Avg(grid), Weight(foot), Max, Min	Directory
7	Diurnal Phase	Daytime(asc) OR Nighttime(dec)	Directory
6	Year	2002 to 2012	Directory
5	Day (or Month) of Year	1 to 366 OR 1 to 12	Filename
4	Daily Averaging Method	Avg Max Min OR Count	File Extension
3	Spectral Channel	1 to 2378	Internal
2	Latitude	1 to 90	Internal
1	Longitude	1 to 180	Internal

Table 1. Eight dimensional hypercube
decadal gridded hyperspectral monthly averages within the gridded data product.

Summary

- Proved global annual BT averages converge at $2^0 x 2^0$ grid resolution with $1^0 x 1^0$ grid resolution.
- Net global AIRS OLW spectra shows GHG decadal trends slightly increasing; while tropics decreasing. Northern extra-tropics increasing, Southern extra tropics decreasing; Arctic increasing, Antarctic decreasing. US and SOI increasing.
- MODIS and AIRS show surface BT drift of 0.1^0K in 4u window and ~0.01^0K in 12u window. Leaning toward a MODIS degradation in 4u.
- Correlation of global AIRS surface BT ch 4.16 with GISS surface Temps is 0.96. Corr. with NOAA SOI for ch ??? is 0.97. Arctic surface BT warming is ~0.07^0K/yr with annual changes ~0.1^0K/yr . Antarctic surface BT cooling is -0.006^0K/yr but shows a striking biannual oscillation of 0.4^0K

- **Conundrum:** GHG is increasing in Northern Hemisphere but decreasing in Southern Hemisphere. Why is there no cross equatorial increase in mixing o GHG? Why are annual oscillations of growing amplitude in the Antarctic?

Conundrums

- GHG is increasing in Northern Hemisphere but decreasing in Southern Hemisphere. Why is there no cross equatorial mixing of GHG int the SH?
- Why are there annual oscillations with growing amplitudes in the Antarctic surface BTs? Is it related to variations in the size of the O3 hole or is due to a non linear dynamical instability.
- Do we need sub 1 degree resolution to establish converged sensitivity of global annual trends?

BACK UP