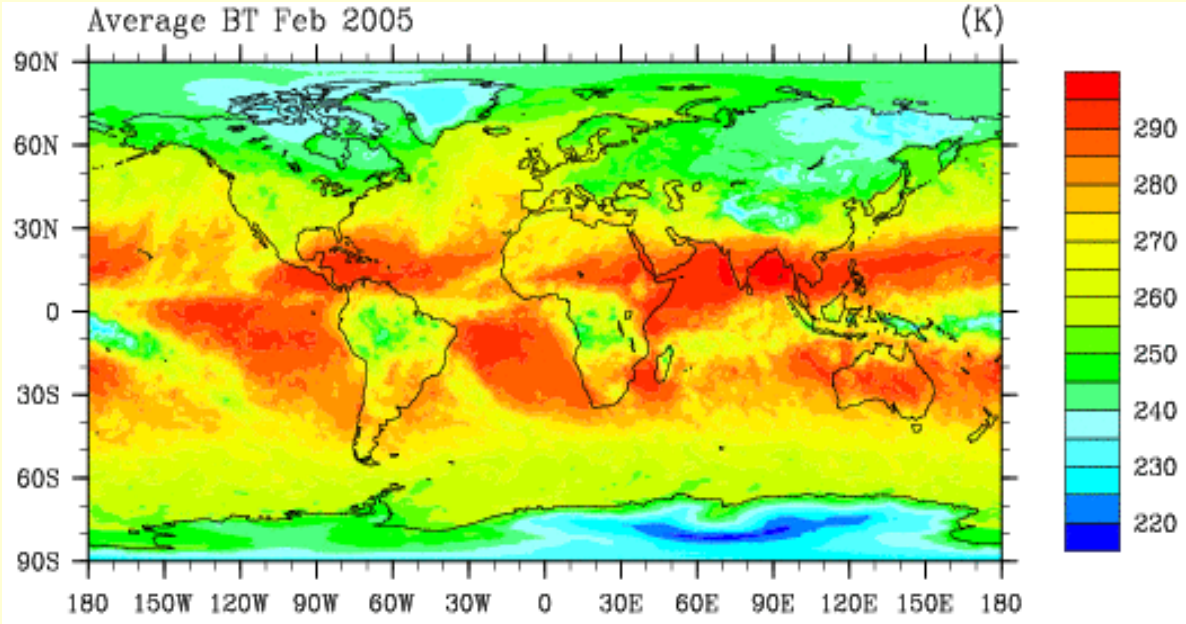
“From Climate Change to Hurricanes: How IR radiances from fraternal Aqua instruments validate AIRS products"



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Presented at
NASA Sounder Science Team Meeting
Nov.4, 2010
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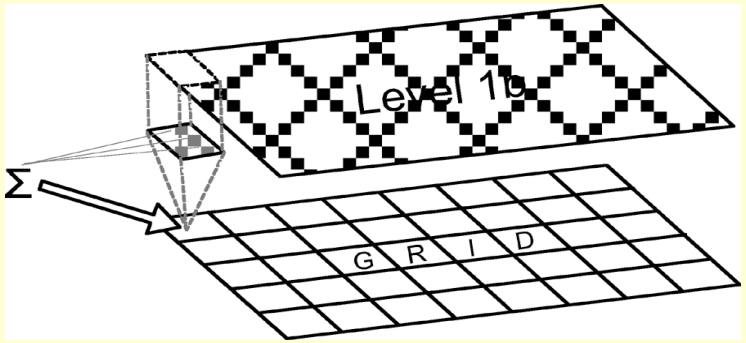
Overview

- Basis for Gridded IR Radiance Records
- Climate Change Applications
- Hurricane Super Resolution Applications
- Summary

AIRS Fundamental Data Record: 6+ yr gridded IR radiances



- Product:
  - Lat-lon grid resolution of 0.5^0 x 1.0^0
  - Level 1B IR radiances (324 ch.) mapped onto grid cells assigned by footprint center and/or by grid cell coverage at arbitrary resolution
  - Level 3 daily average radiances for each grid cell. Stored Asc., Desc, BT, Min, Max, Count, sum of $(\text{rad.})^2$ (1/1/2003-12/31/2009)

- Gridding is a lossy compression(reduces 1 year of AIRS from 6 TB to 1 TB and MODIS from 36 TB to 1 TB, suggested by M. Goldberg)
- Analysis products are **based directly on L1B observations**
- Products are becoming available from Service Oriented Atmospheric Radiance (SOAR) gridding system http://bluegrit.cs.umbc.edu/soar

AIRS/MODIS comparison

- The objective of AIRS/MODIS comparisons
  - Inter-comparison of observations to validate instrument stability over time
  - To develop the applications that utilize the spatial and spectral properties from both instruments,
- Method:
  - MODIS Spectral Response Functions (SRF) are used to convolve with AIRS spectral channels to form synthetic MODIS

A sample AIRS brightness temperature spectrum overlaid with the Aqua MODIS Spectral Response Functions(Tobin et.al.)

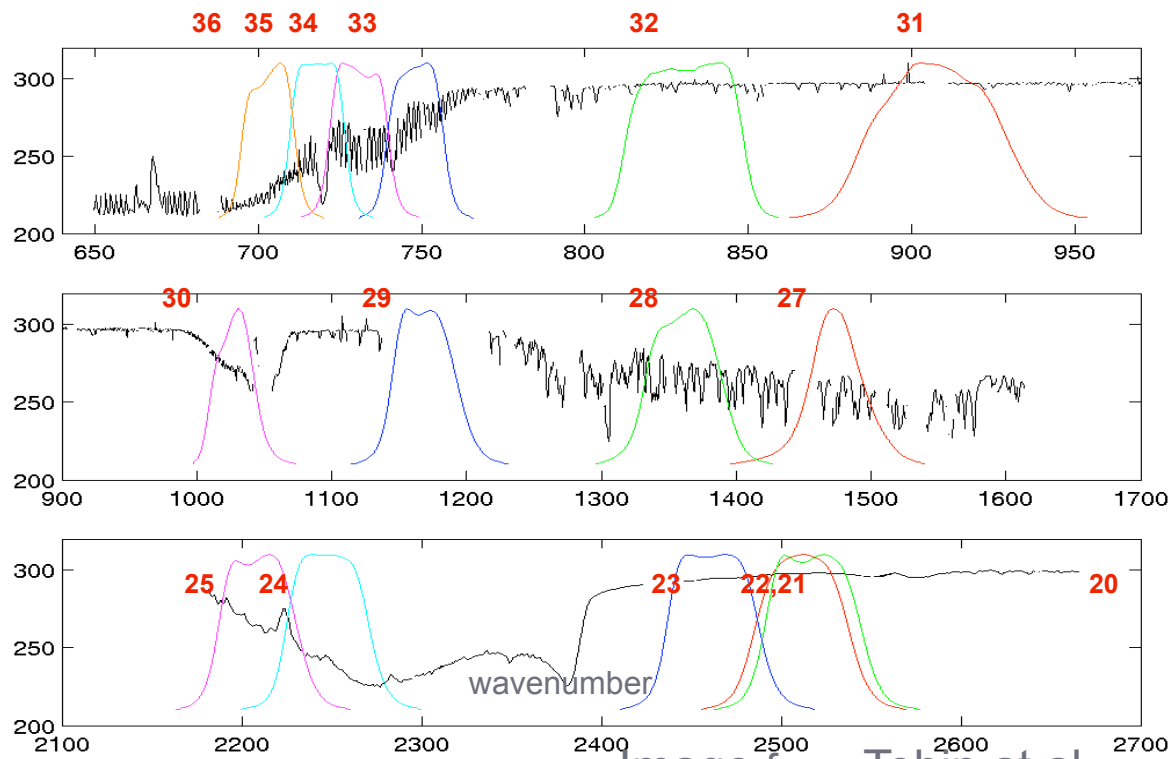


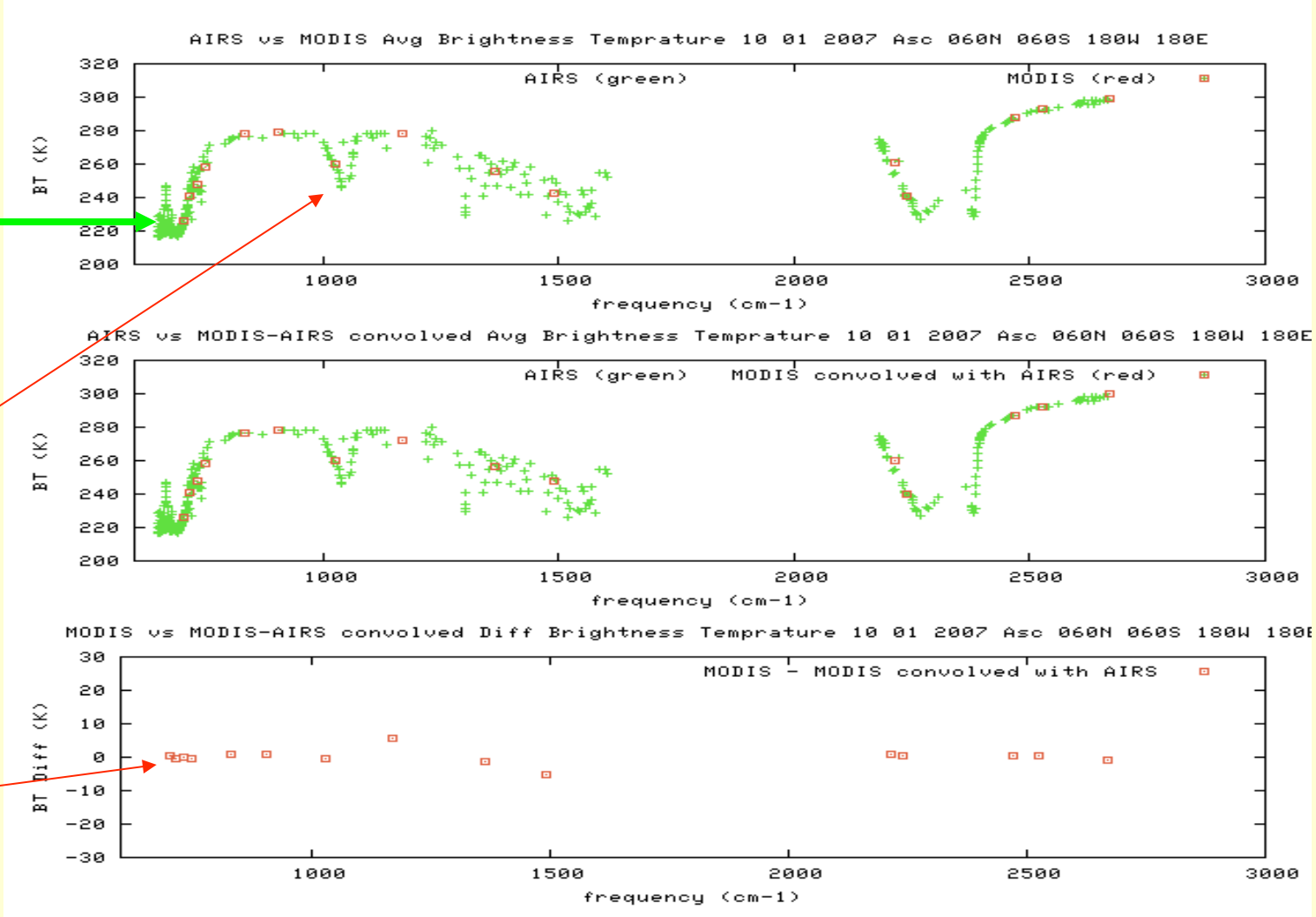
Image from Tobin at al.

AIRS/MODIS comparison

GREEN are AIRS observations

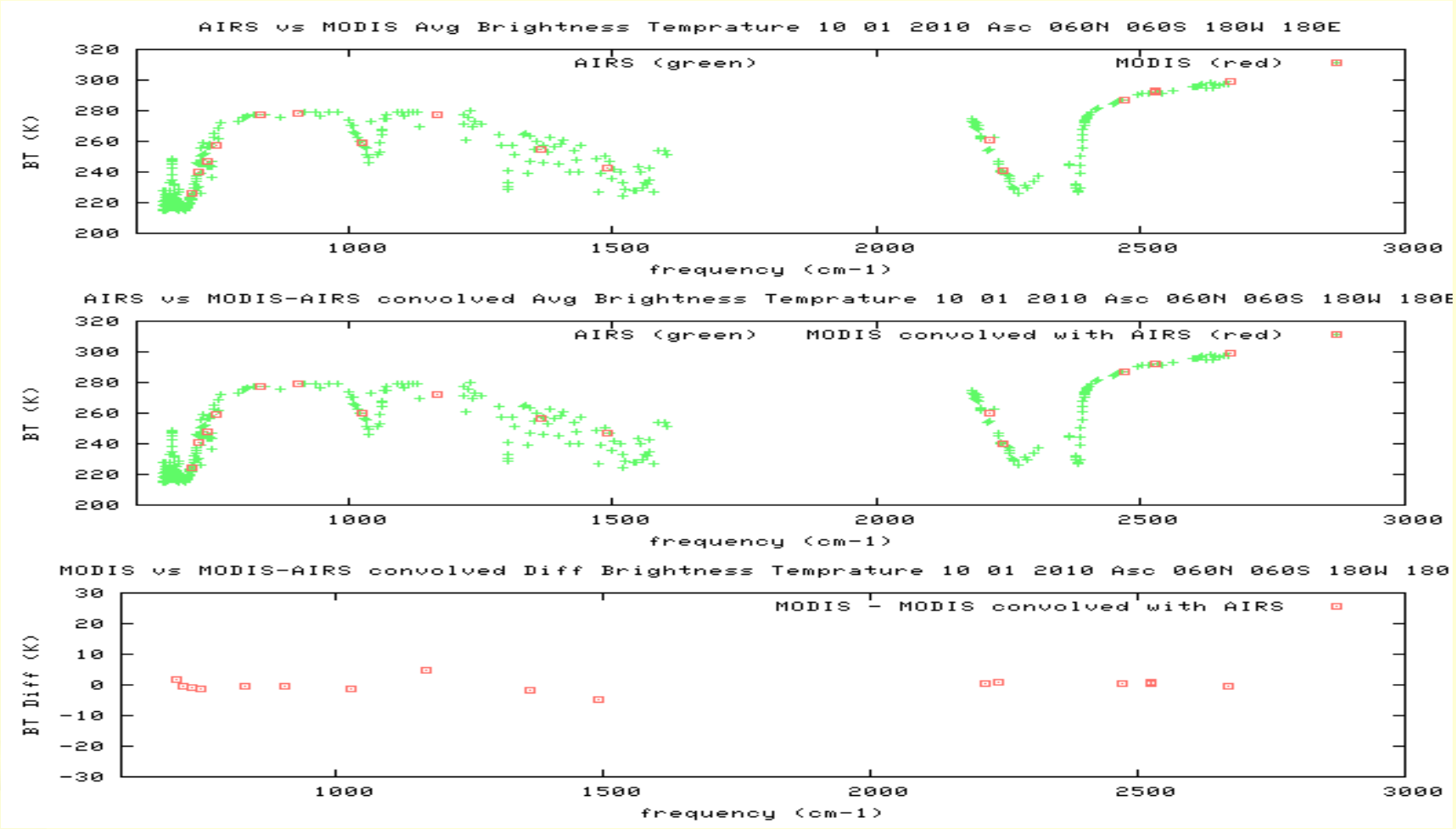
RED are MODIS observations

Difference between MODIS & MODIS convolved with AIRS



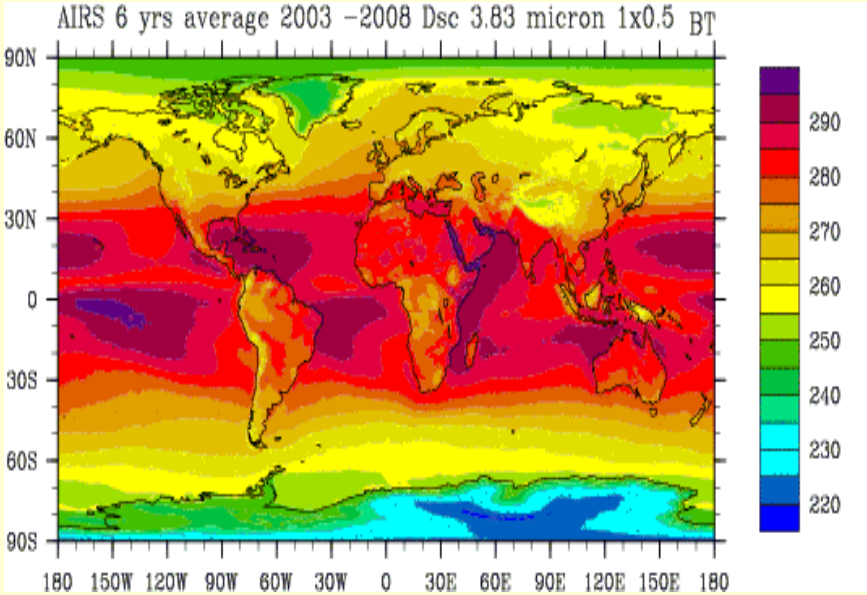
- AIRS/MODIS Brightness Temperatures for **OCT. 1, 2007 at 0.5°x1°**
- Consistent stable instrument measurements after 5+ years!
- Avg difference ex. Ch 29 and Ch 27 between MODIS and ConvMODIS is 0.14K[5] with a st. dev. <0.8 after 5 years.

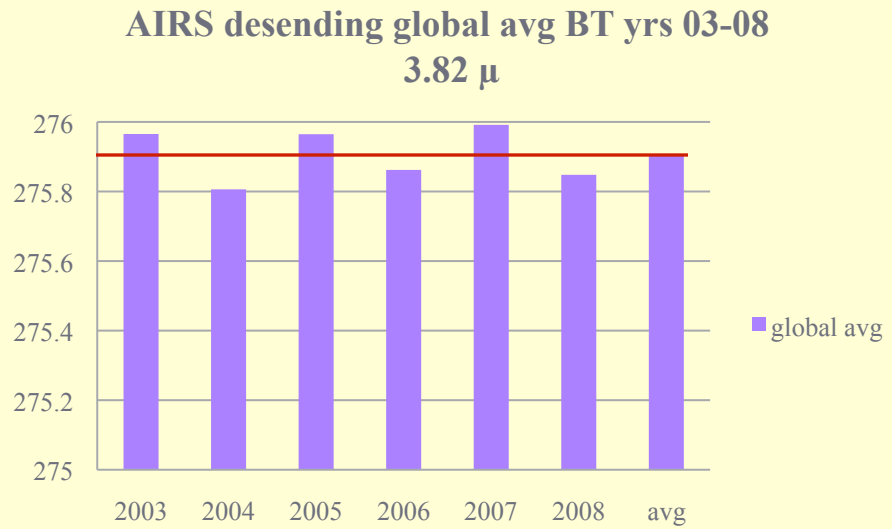
AIRS/MODIS comparison

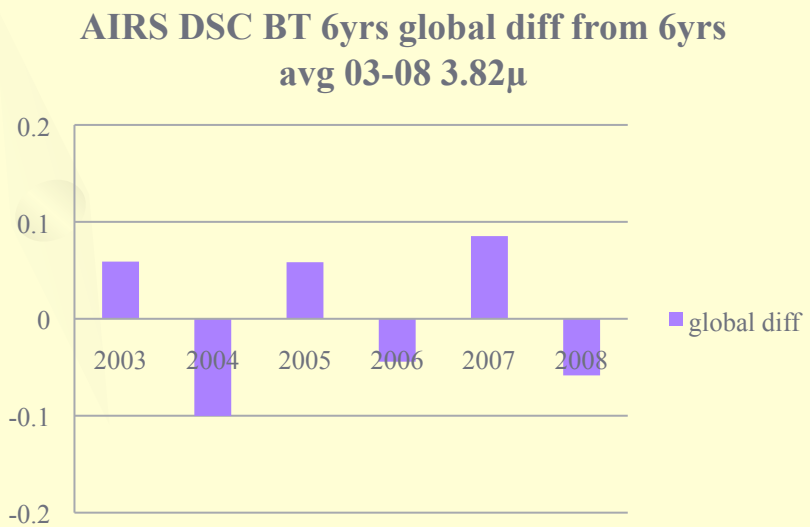


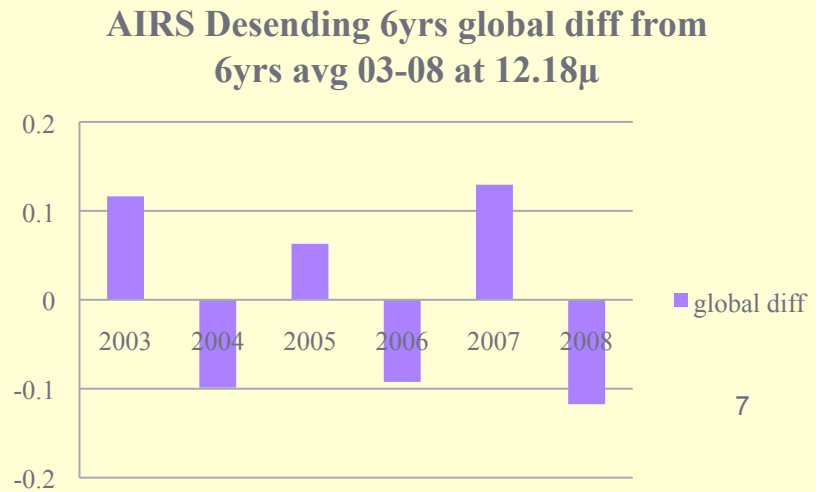
- AIRS/MODIS Brightness Temperatures for **OCT. 1, 2010 at 0.5°x1°**
- Consistent and relatively stable instrument measurements after 8+ years!
- Avg. difference ex. Ch 29 and Ch 27 between MODIS and ConvMODIS is -0.17K with a st. dev. <1.0 after 8 years.

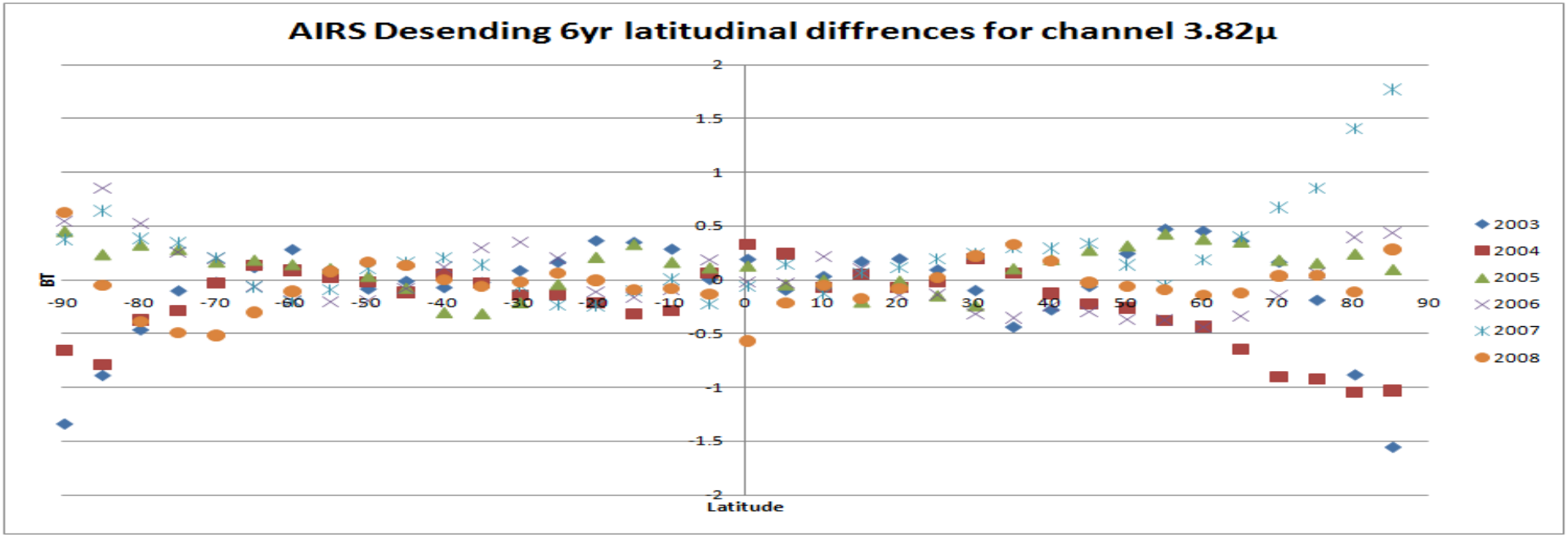
Yearly Global BTs and 6 Year Average

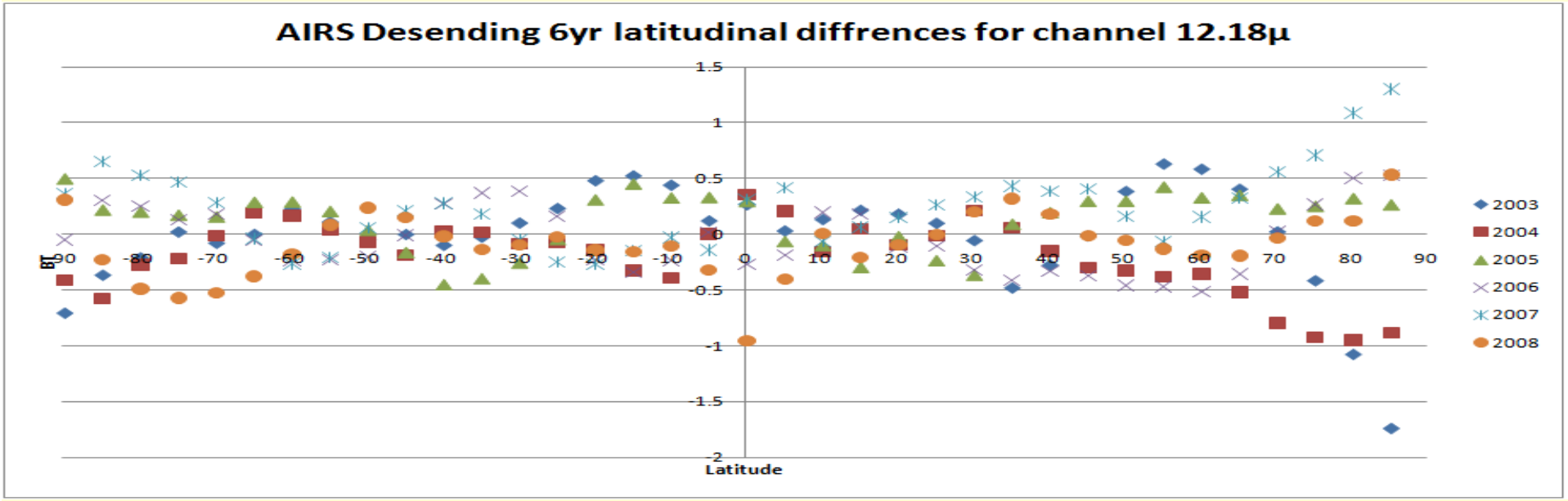








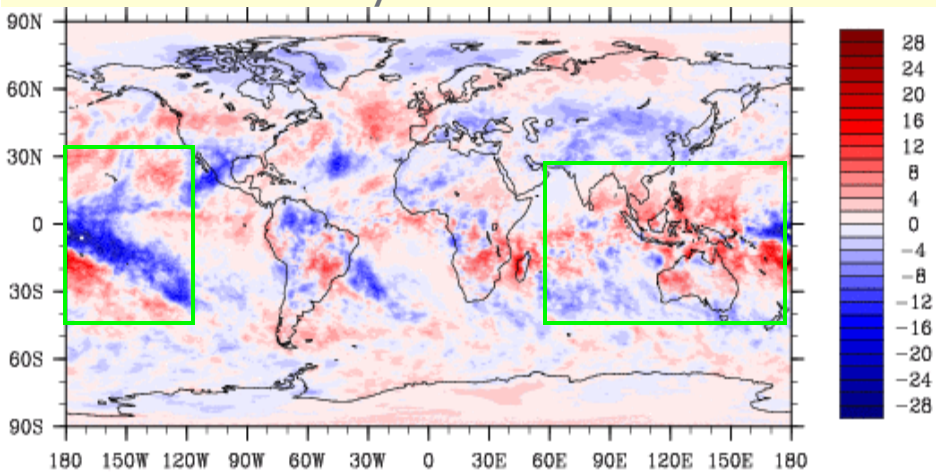




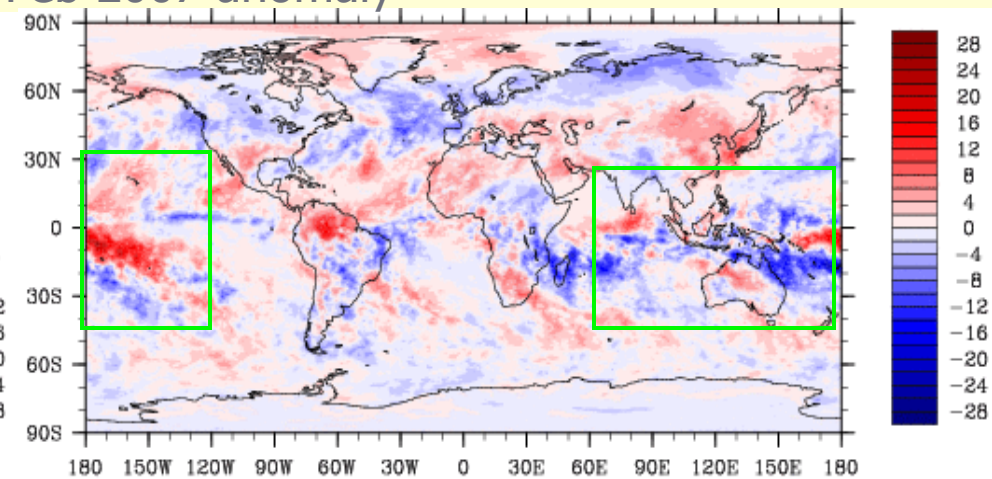
AIRS Yearly BT latitudinal differences from a 6 year latitudinal average shows larger variability and an apparent warming trend at high latitudes for the spectral channels 3.82 um and 12.18um.

AIRS Monthly anomaly 0.5°x1° at 12.18 µm

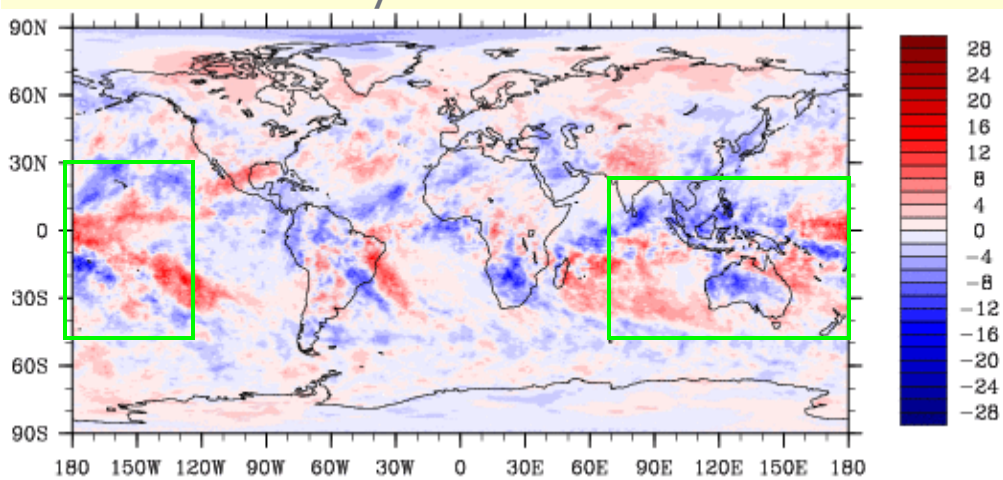
Feb 2005 anomaly



Feb 2007 anomaly



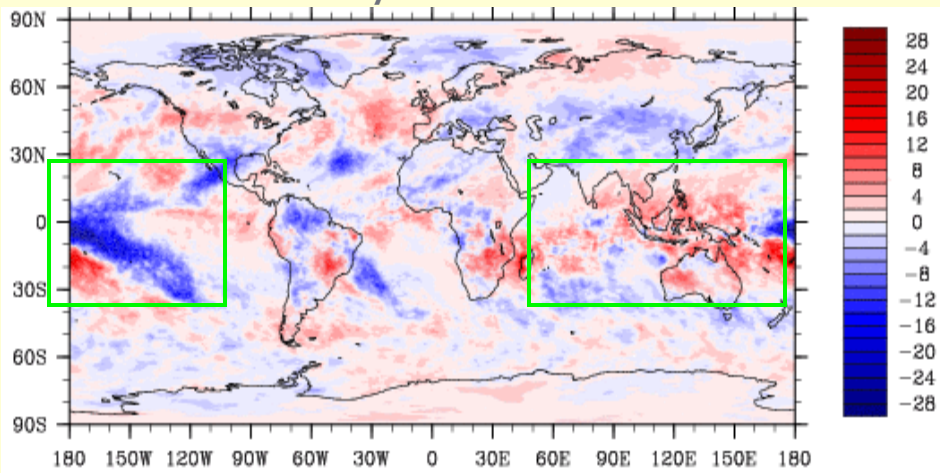
Feb 2006 anomaly



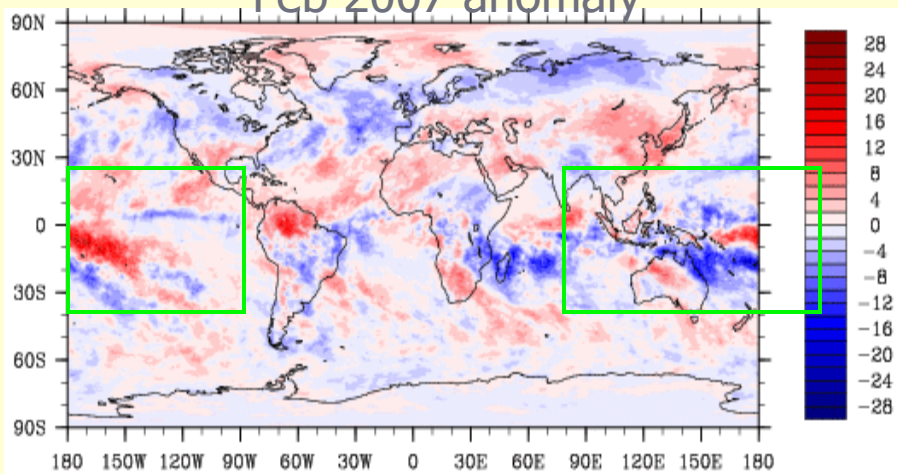
- Year to year variances
- Cold radiances Feb 05 (strong El Nino year) convective cloud, Warm radiances Feb 07 cloud clear surface in Western Pacific
- Similar in Indian Ocean and West Pacific area
- Feb 05 warmer than other 2 year in East US (hurricanes)
- Variances in Intertropical Convergence Zone

MODIS monthly anomaly 0.5°x1° at 11.8-12.3μm

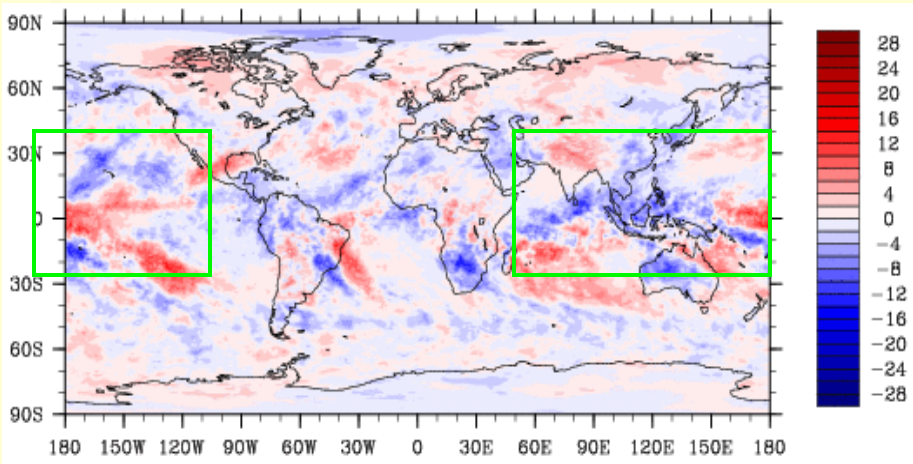
Feb 2005 anomaly



Feb 2007 anomaly

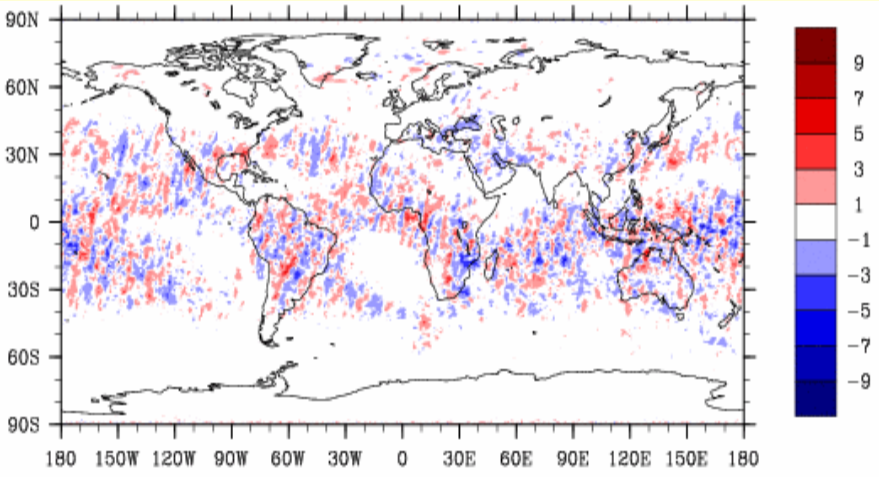


Feb 2006 anomaly

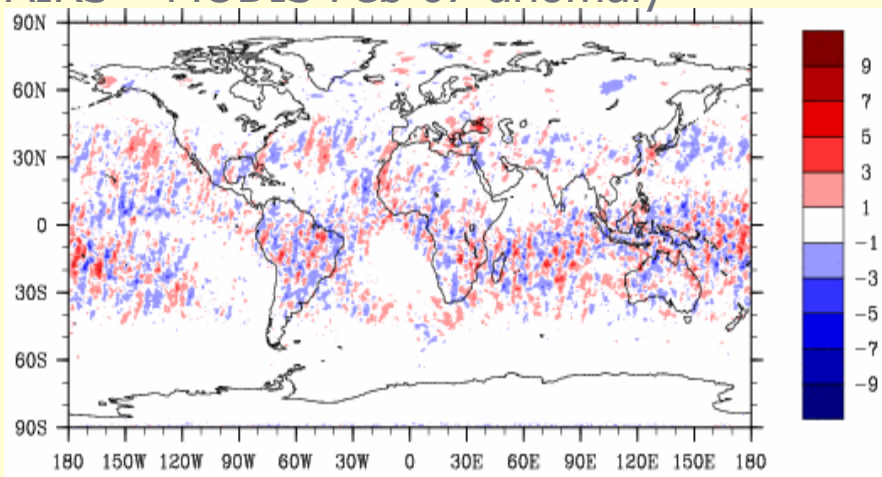


AIRS – MODIS monthly anomaly

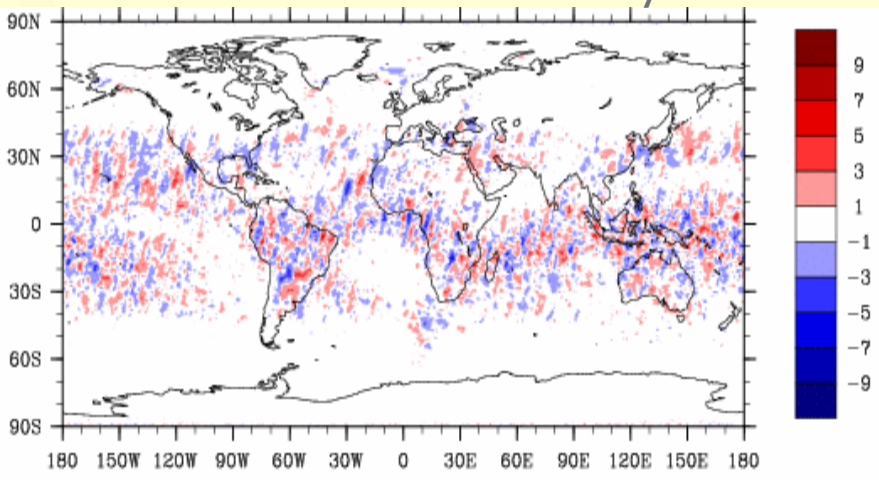
AIRS – MODIS Feb 05 anomaly



AIRS – MODIS Feb 07 anomaly

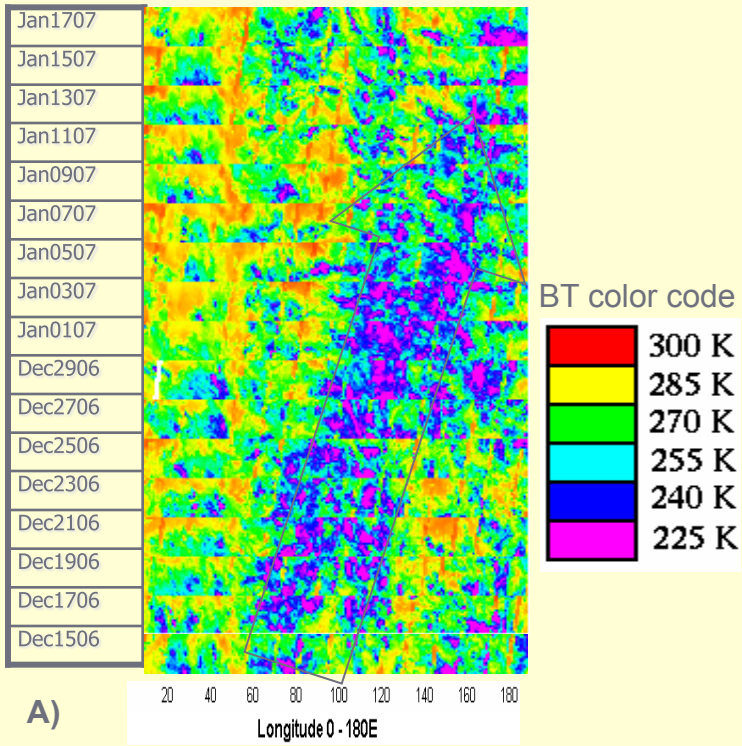


AIRS – MODIS Feb 06 anomaly



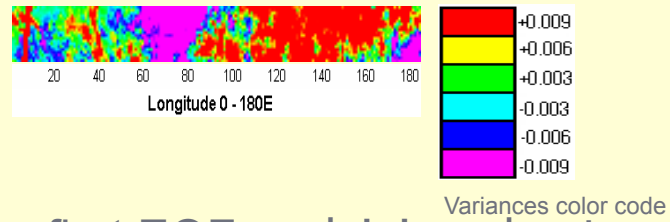
- Intertropical convergence zone
- Possible variance or bias in the intensity of the two data sets
- Possible geo-location differences
- Needs further investigation

MJO- results



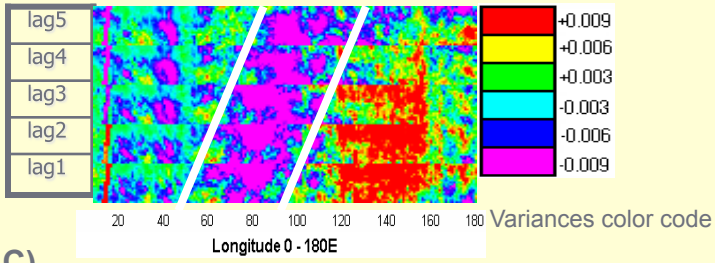
A)

2 day running mean of MODIS channel 32 (Surface/Cloud Temperature) at 0.5°x1 11.7 μm -12.2 μm 5S-5N 0-180E Brightness Temperature descending orbit from Dec 15 2006 to Jan 17 2007.



B)

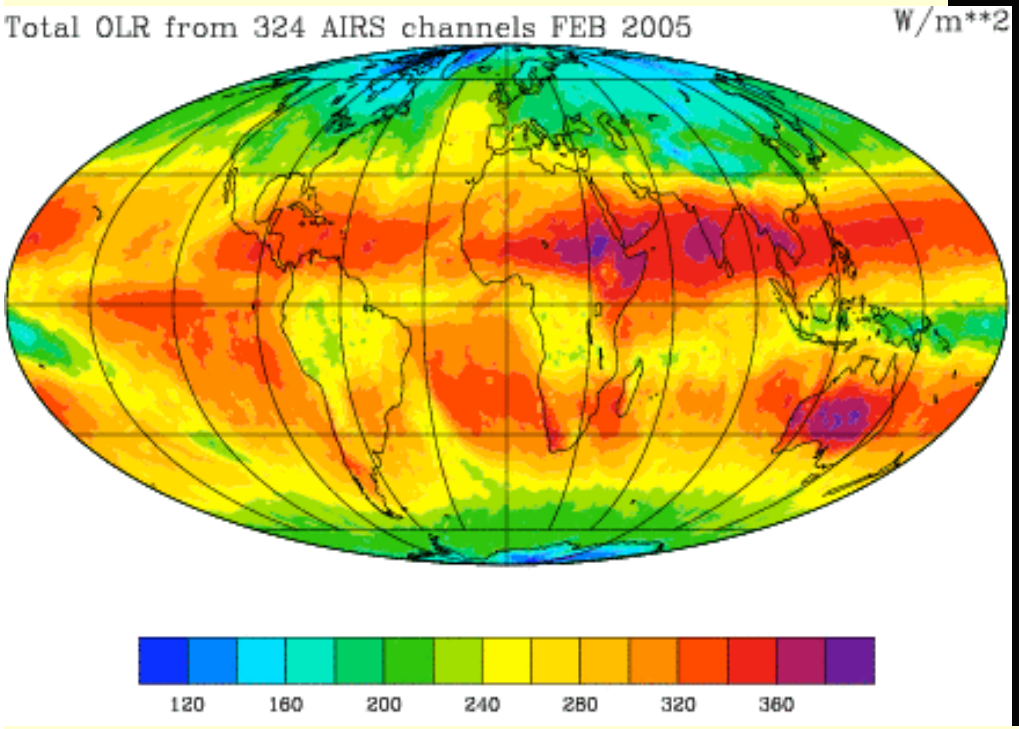
The first EOF explaining about 14.3% variance

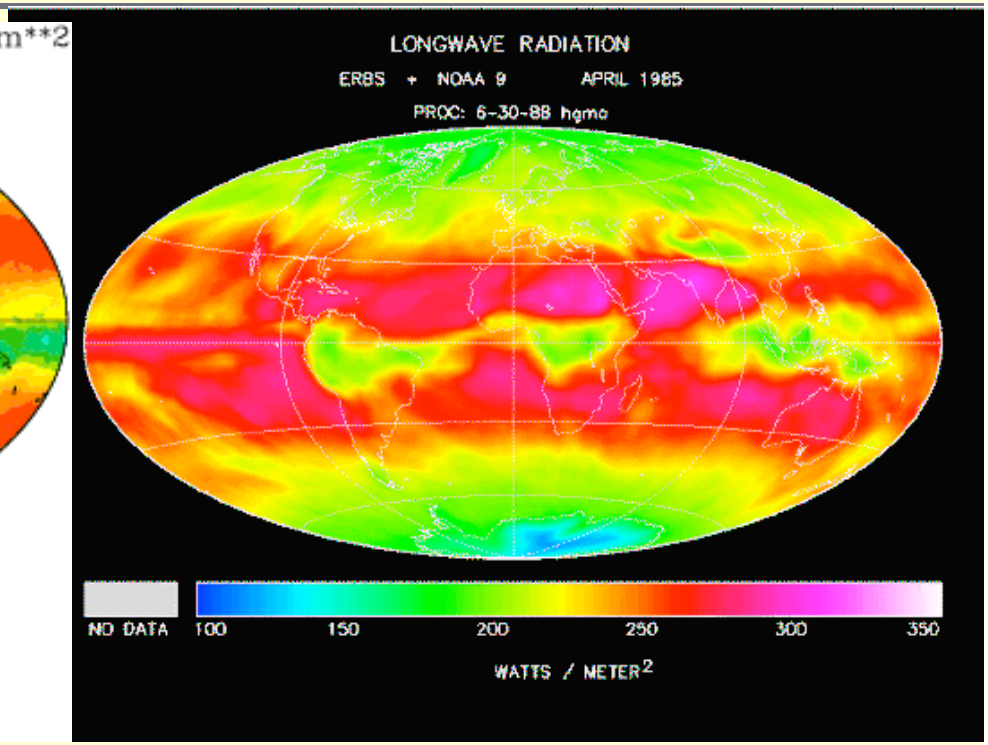


C)

The extended EOF which captures the dynamics using a temporal lag of 2 day running mean.
(B. Tian AIRS MJO Profiles)

AIRS/MODIS total OLR 0.5°x1°





- AIRS total OLR Feb. 2005

CERES OLR April 1985

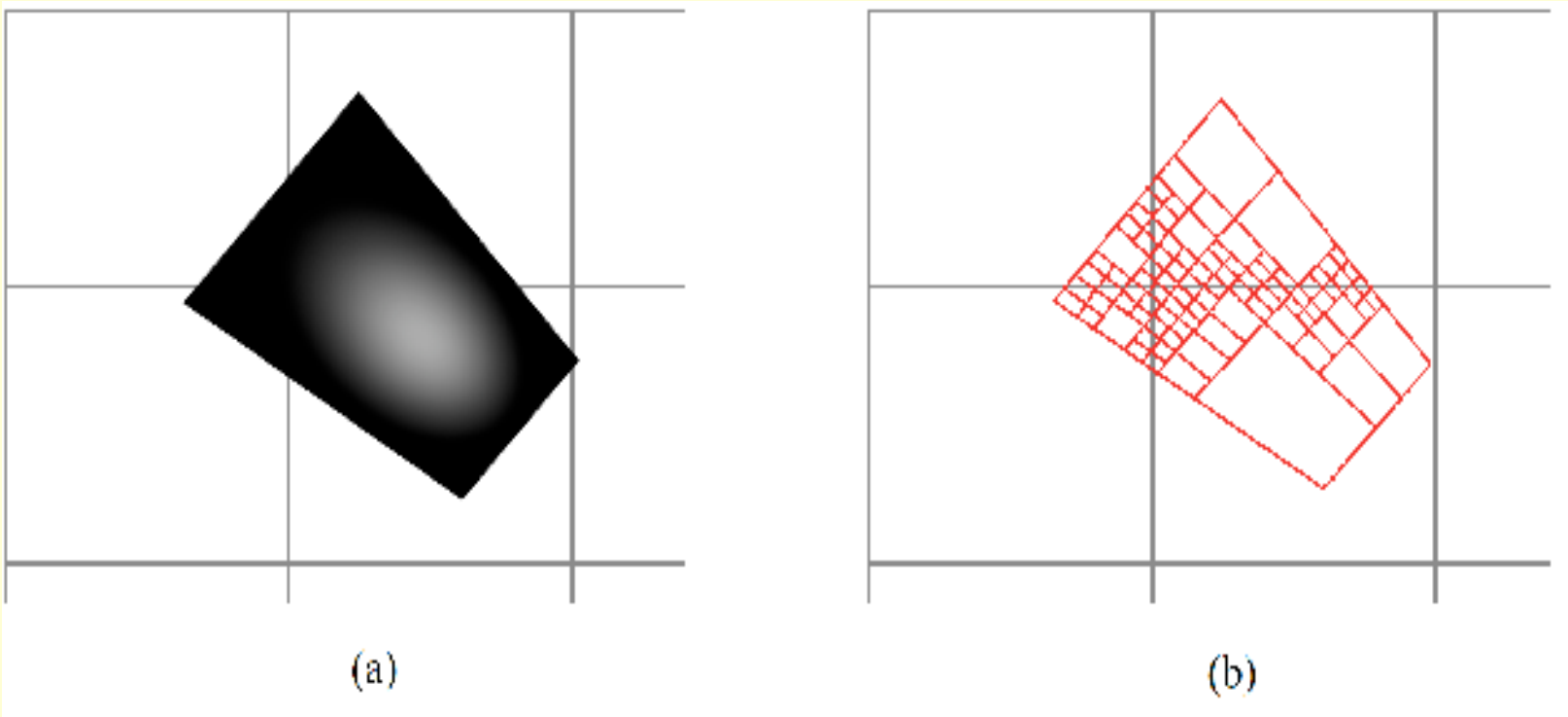
Observation Coverage Algorithm (Obscov): Calculate radiance from grid cell

Determine what percentage of a footprint lies in a grid cell using quad tree algorithm.

Radiance from a grid cell is the product of the distribution of the spatial response function for each channel and area of footprint in grid cell.

Thus, we numerically integrate the footprint within the grid cell by recursively subdividing footprint until it is completely within a gridcell. Raycasting is used in recursion to geolocate points.

Can be used with any instrument for known spatial response function.



A precise gridding algorithm

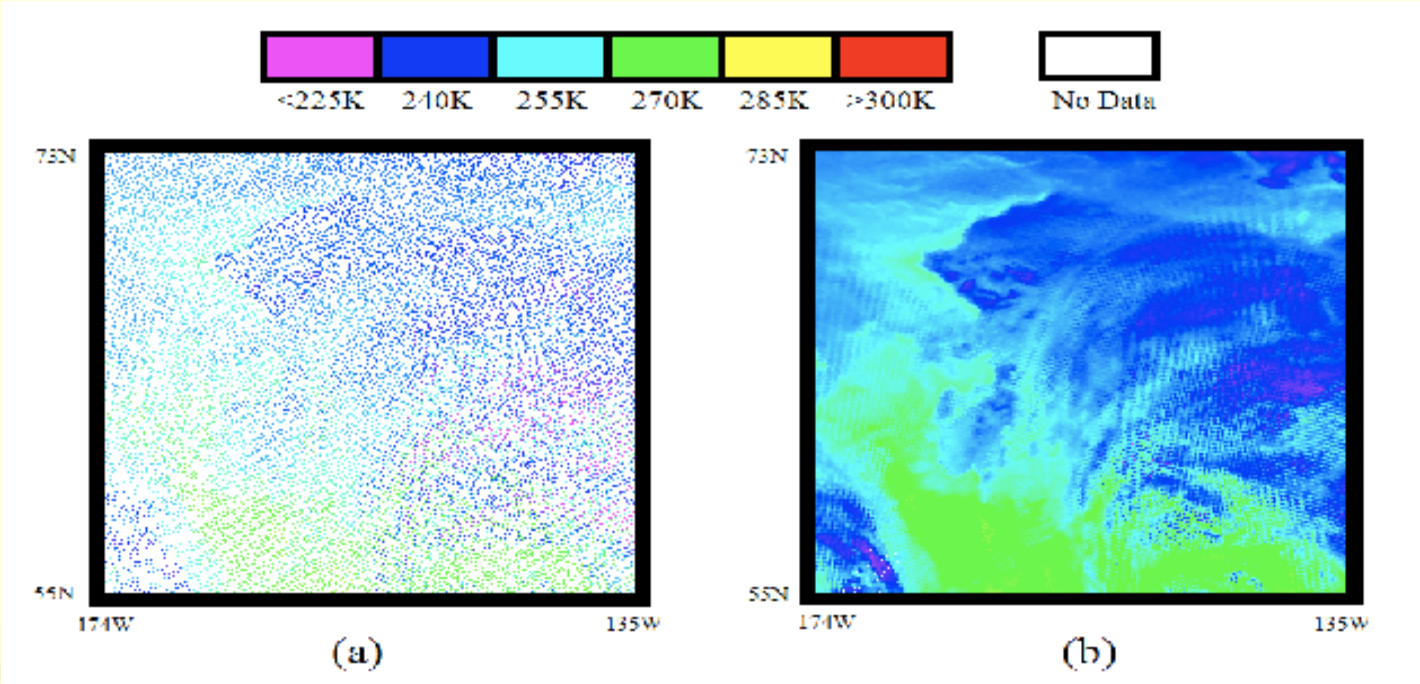
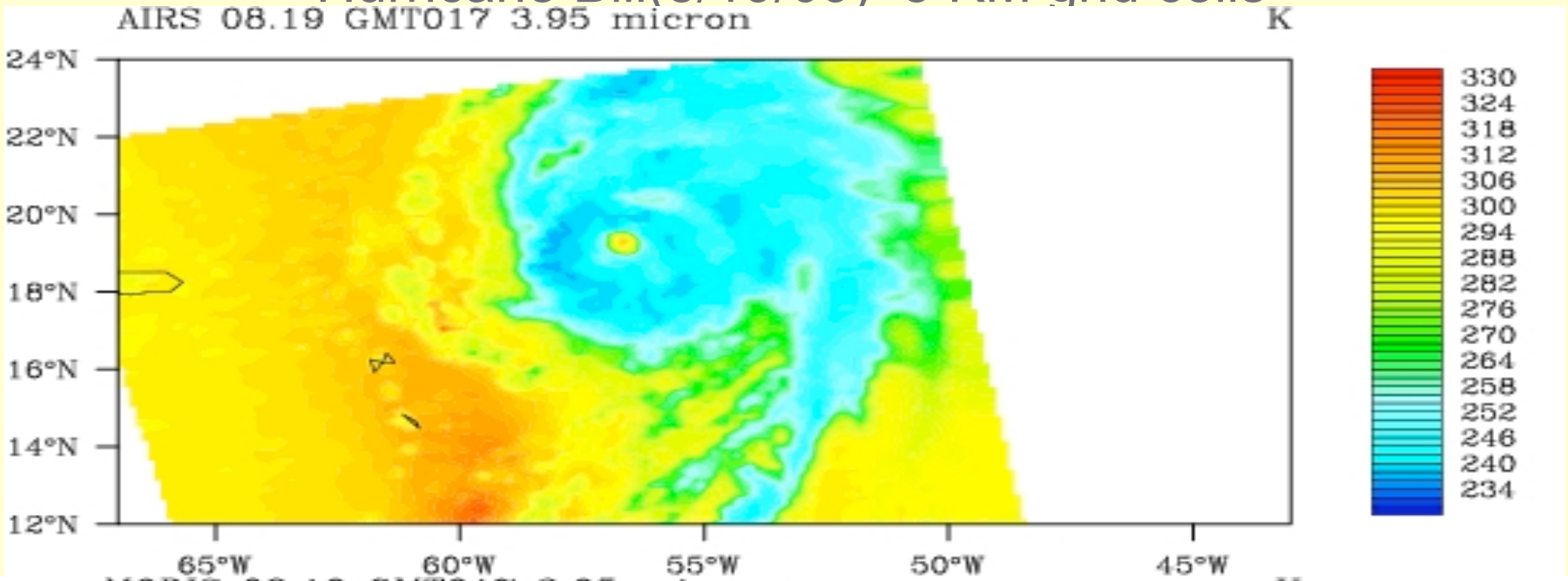
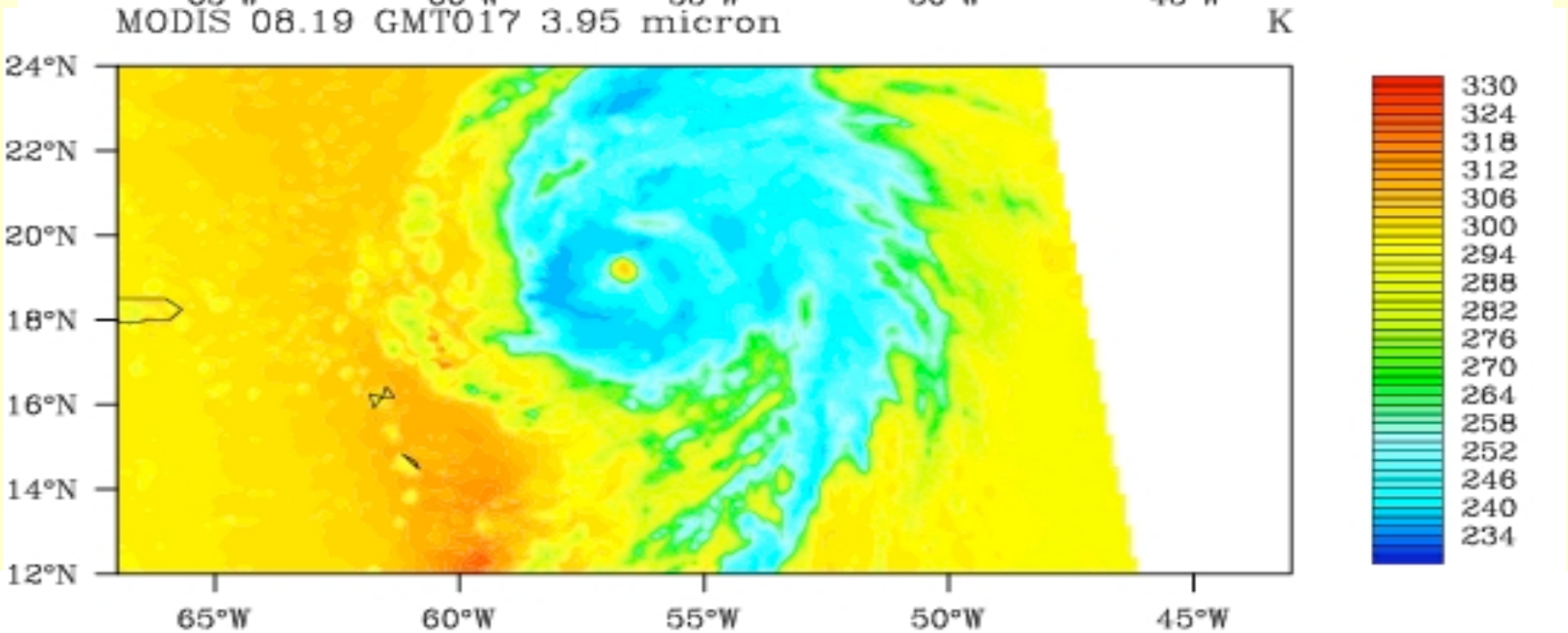


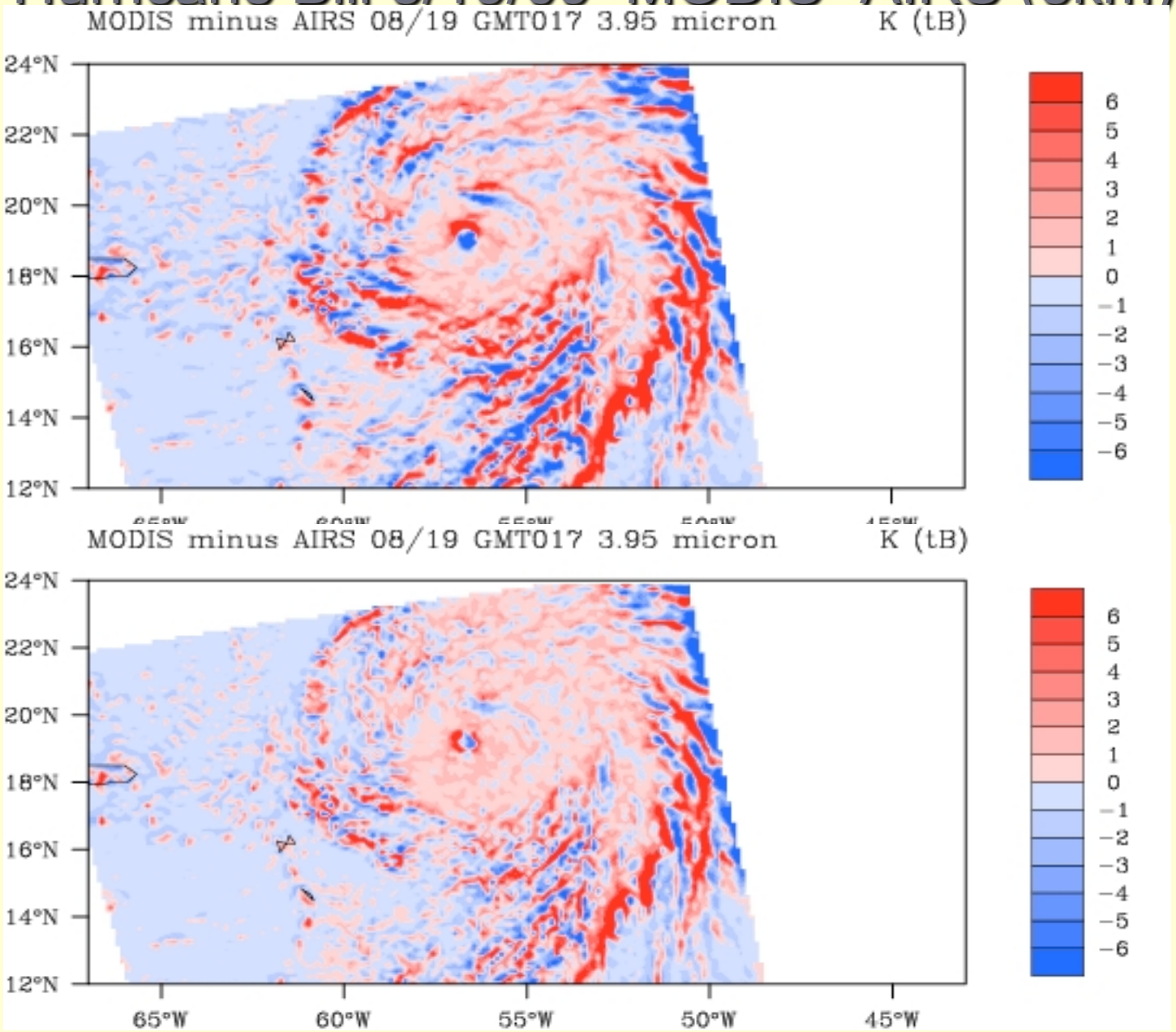
Figure a and b show the colored brightness temperatures in the gridding of AIRS data over Alaska at 0.5^0 x 1.0^0 resolution for the AIRS window channel in the 12 um region for Jan. 1, 2008. Figure a is the standard grid representation assigning the observation to the grid cell containing the center of each footprint. Figure b calculates the emitted radiation from each grid cell using the spatial response function

Hurricane Bill(8/19/09) 5 KM grid cells





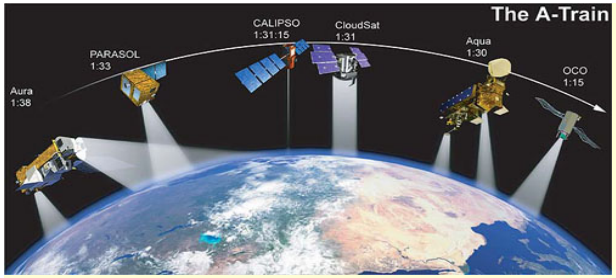
Hurricane Bill 8/19/09 MODIS- AIRS (5km)



Lower image of MODIS – AIRS shifted 3 km

Summary

- Moving towards implementing an 8 year FDIR[3] of gridded AIRS data at 0.5^0 x 1.0^0 for NOAA operational 324 channels
  - Convolved AIRS and MODIS IR spectral radiance measurements have not exhibited a degradation in over 8+ years for selected days
  - Yearly latitudinal averaged surface BT showed a 1.5K warming variance at high latitudes over 6 years and 0.5 K in mid and tropical latitudes
  - A 5 day global gridded radiance at 100km and 50 km showed 0.2K difference
  - Global gridded radiances show regional monthly anomalies, ENSOs. ITCZ
  - Can track MJO and OLR directly from calibrated radiance observations
- Developed observation coverage algorithm for precise gridding of radiances at arbitrary resolution (Obscov)
  - Accurate mapping of radiances to converging grid cells at high latitudes
  - Sub-footprint resolution algorithm (5km) applicable to Hurricane data assimilation and regional climate analysis studies
  - Observed a 3 km geo-location difference with MODIS. Could impact AIRS VIS



Rationale for AIRS Gridded IR Radiances Data Records

- NOAA, NASA and DOD have collected volumes (Petabytes) of multi satellite IR sensor data for the past 41 years. No continuity of IR radiance data records available. Situation similar to pre-reanalysis era.
- Weather forecasting and reanalysis systems have shifted to assimilating IR radiances rather than sounding temperatures. Climate monitoring shifting from sounding retrievals to observed radiances. A paradigm shift.
- Technology evolution (storage and computing services) making gridded AIRS/ MODIS level 1B IR radiance data available for desktop analysis
- AIRS/MODIS on Aqua stable for 8 years and expected to be operational until 2012. Gridding these two IR radiance sensor data sets from the same sat form a validated Fundamental Decadal IR Radiance Record (NAS/NRC) that can directly monitor global and regional decadal changes.

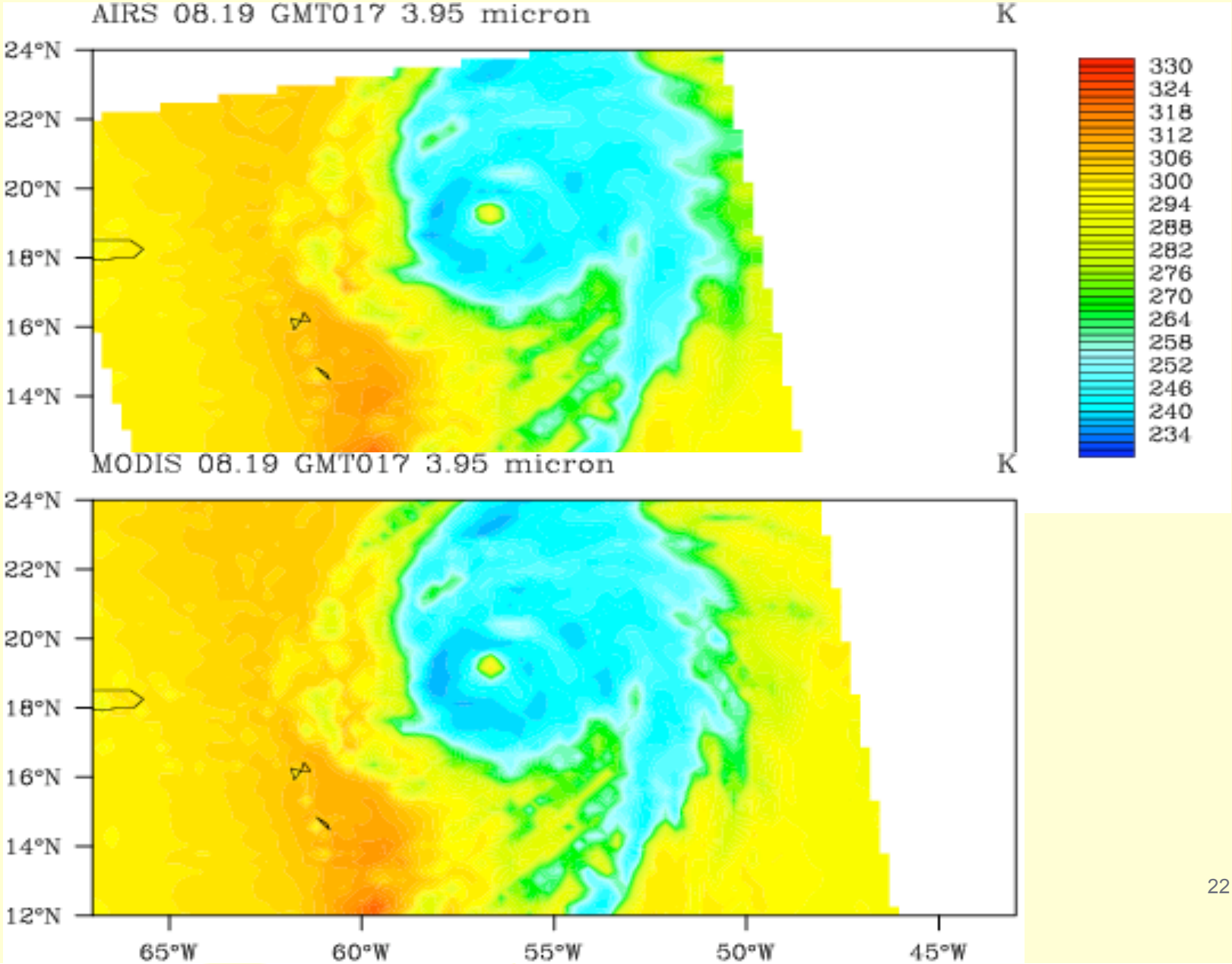
- Thank You for the Invitation

- BACK UP SLIDES

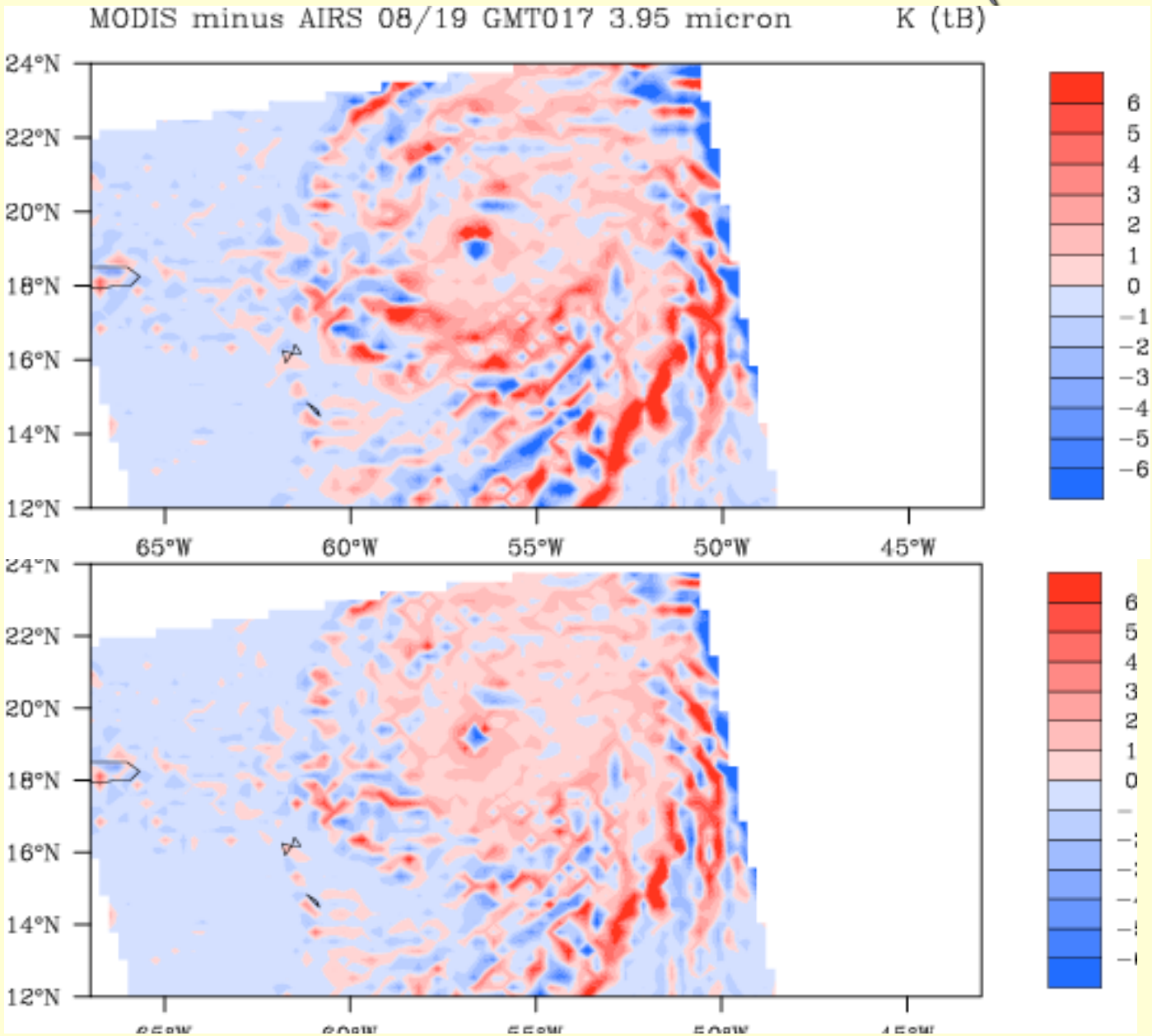
Hurricane Bill(8/19/09) 10 KM grid cell

- AIRS

MODIS



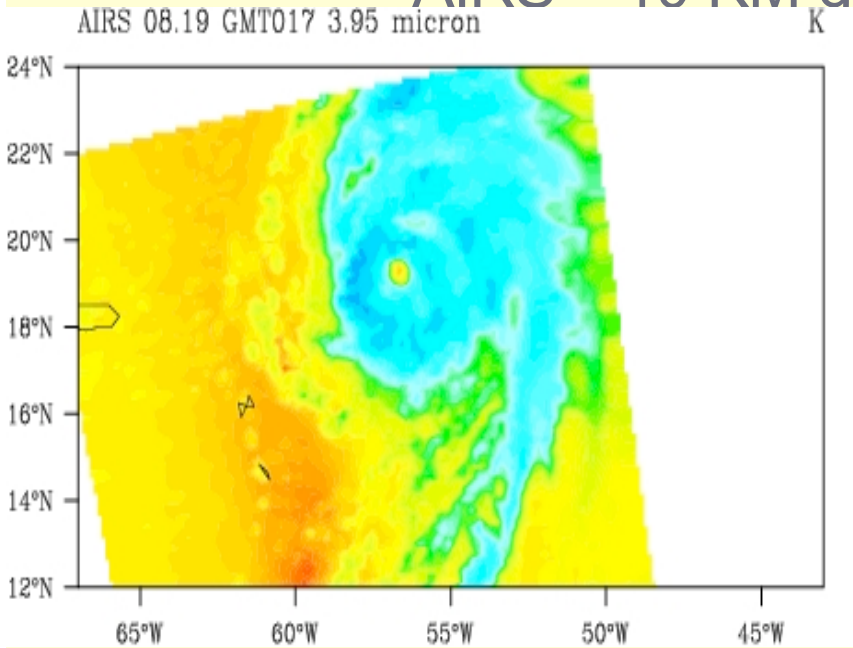
Hurricane Bill 8/19/09 MODIS- AIRS (10 km)

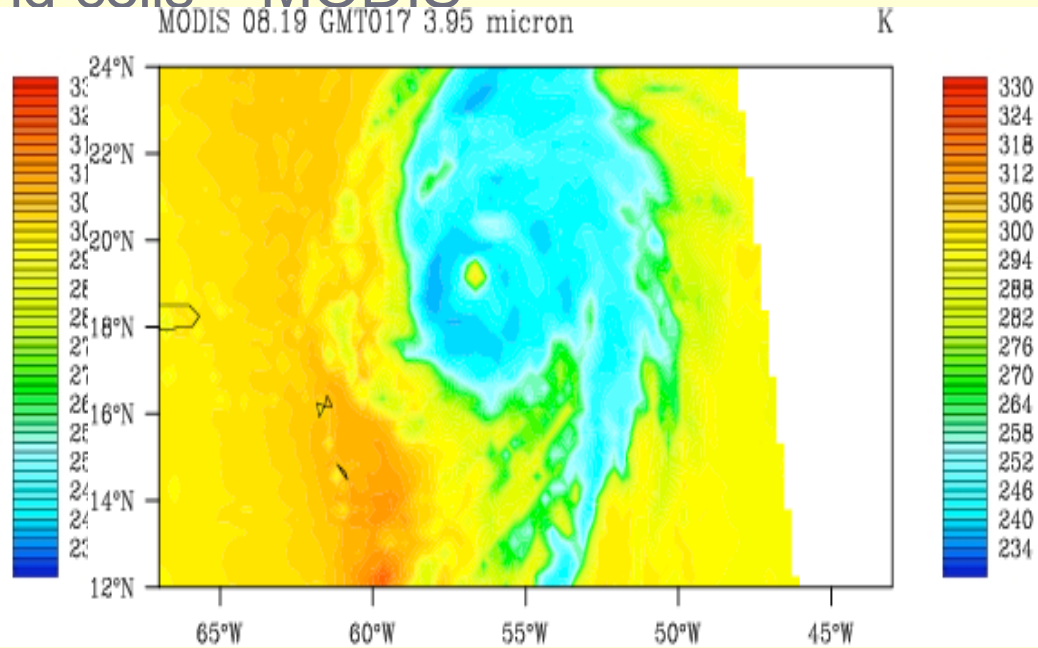
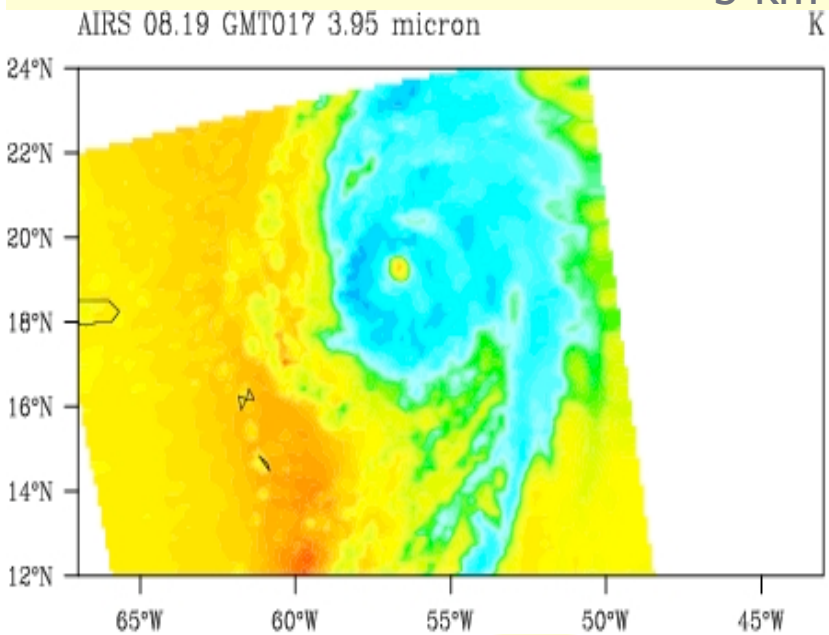
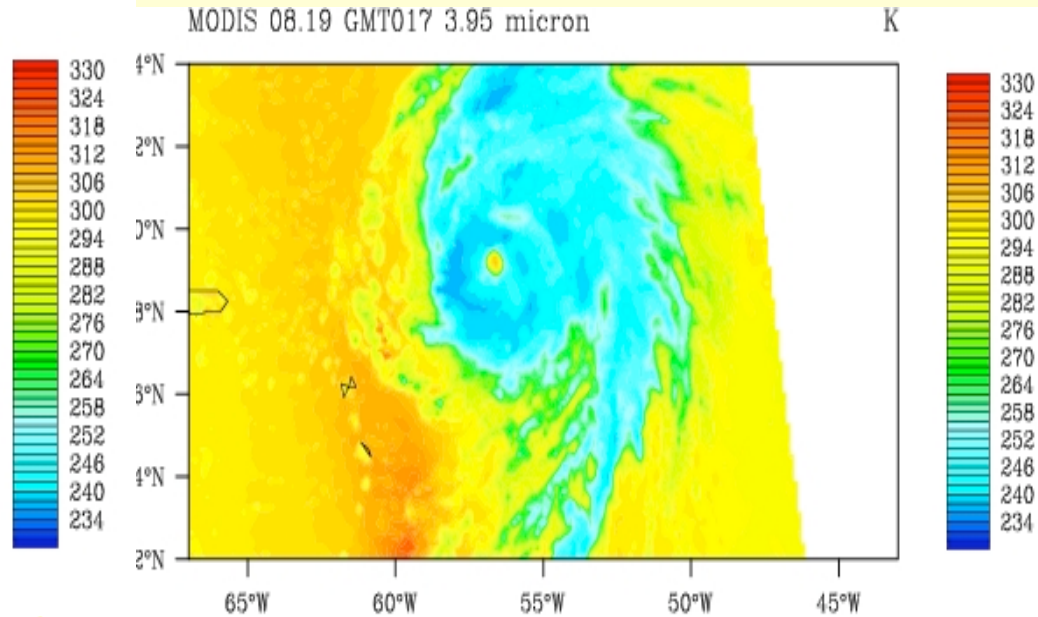


Lower image of MODIS – AIRS shifted 3 km

Hurricane Bill(8/19/09)

AIRS 10 KM grid cells MODIS





5 km grid cell