GEO/LEO Infrared Intercalibration

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1st Meeting of GSICS Research Working Group (GRWG-I)

22-23 January 2007

NOAA Science Building

Camp Springs, MD

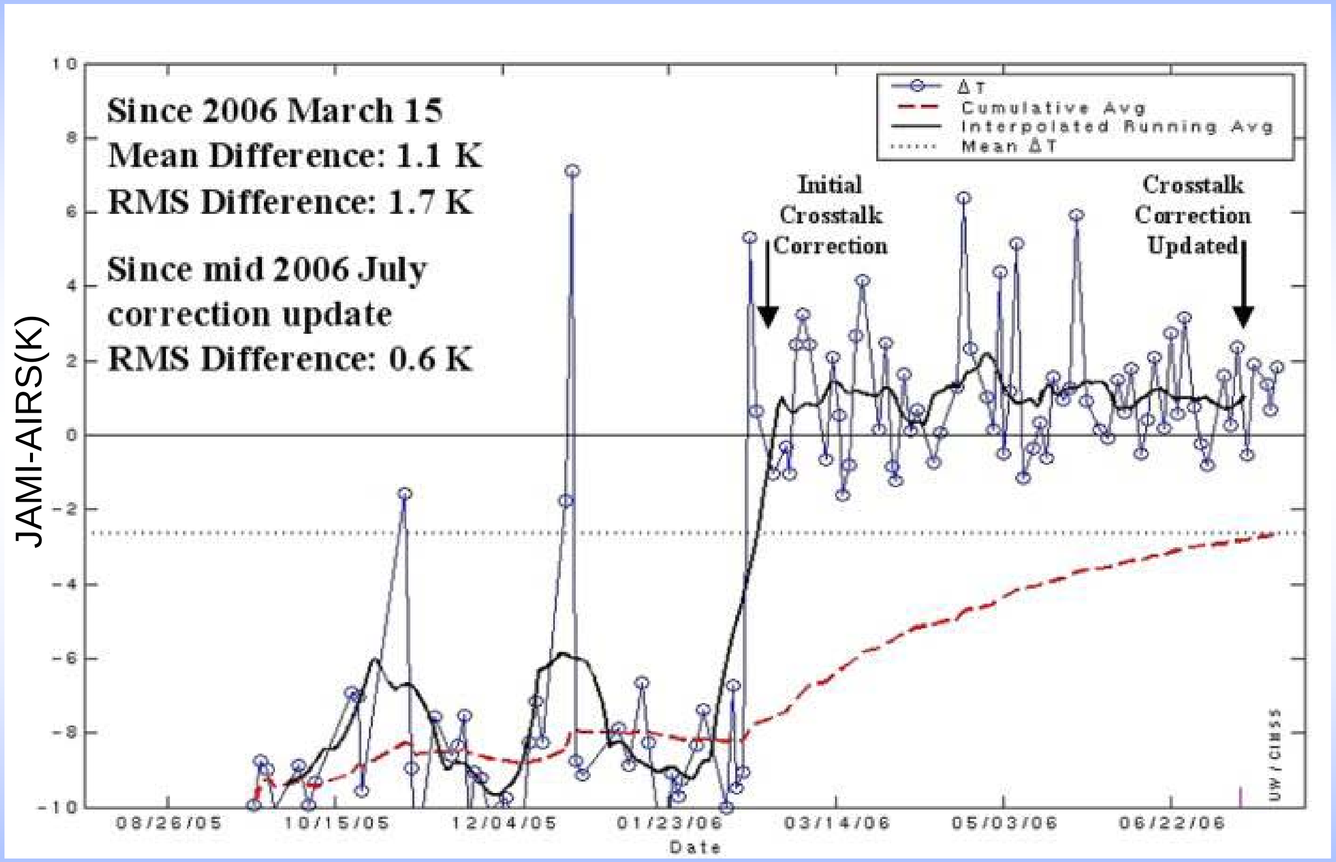
PURPOSE

- Intercalibrate the world's operational geostationary imagers with a single polar-orbiter.
- Assess radiometric accuracy.
- Especially important during post-launch check-outs.

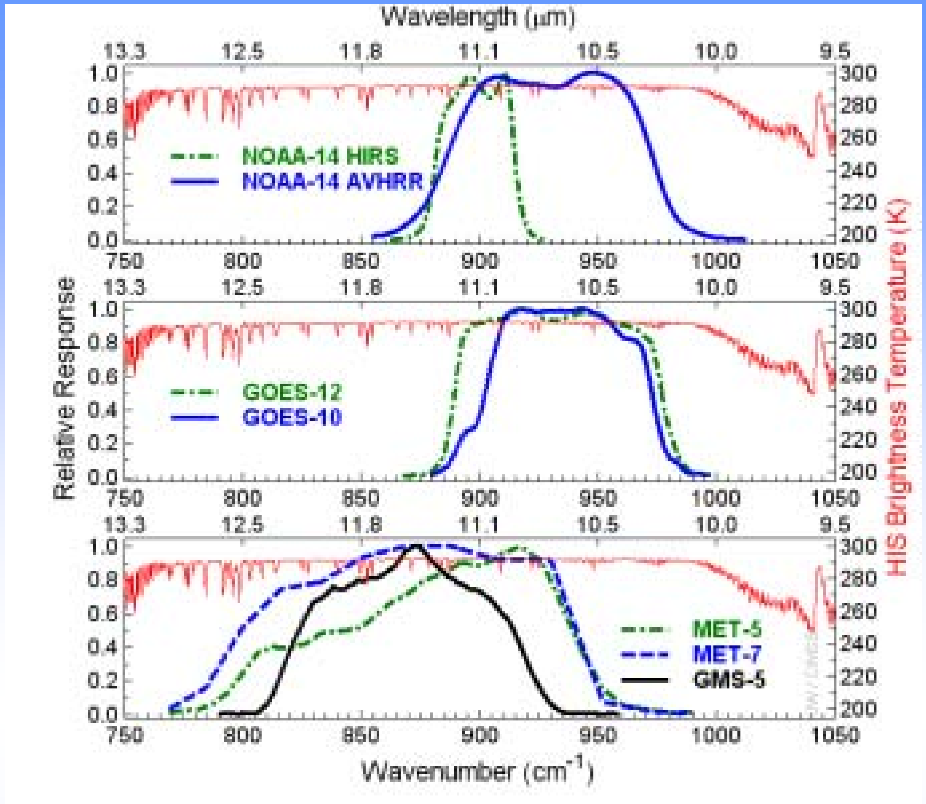
  Or times of calibration flux:

  New ground system, new processing software, etc.

MTSAT-1R (JAMI) IR4 (3.7μm) band compared to AIRS

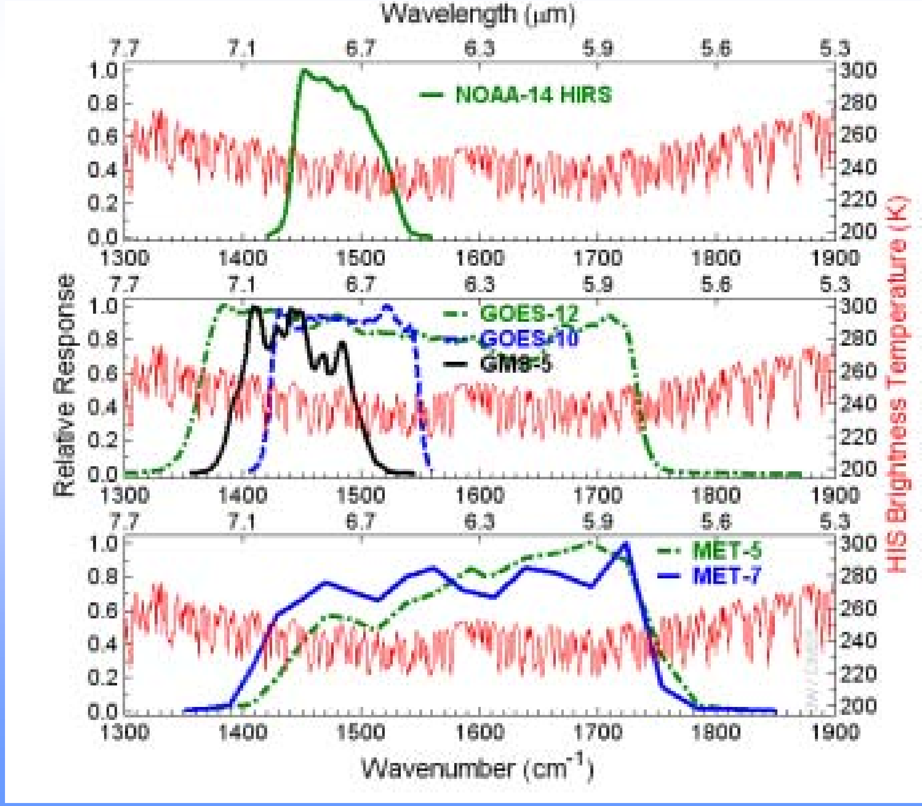


Quantifying Improvements through Intercal

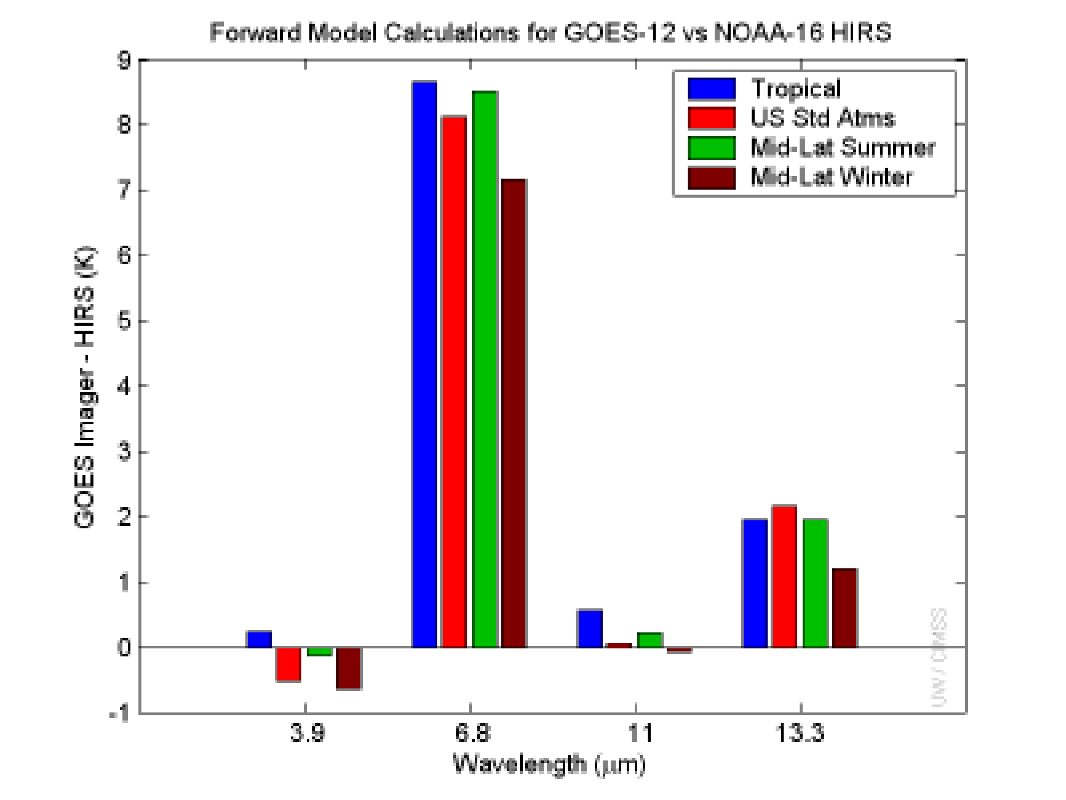


Must account for spectral response function differences between broad-bands channels.

Comparisons can only show differences between instruments; they cannot truly measure calibration accuracy.



Highlighting the difficulties intercalibrating broadband instruments: **Correcting for Spectral Response Differences**



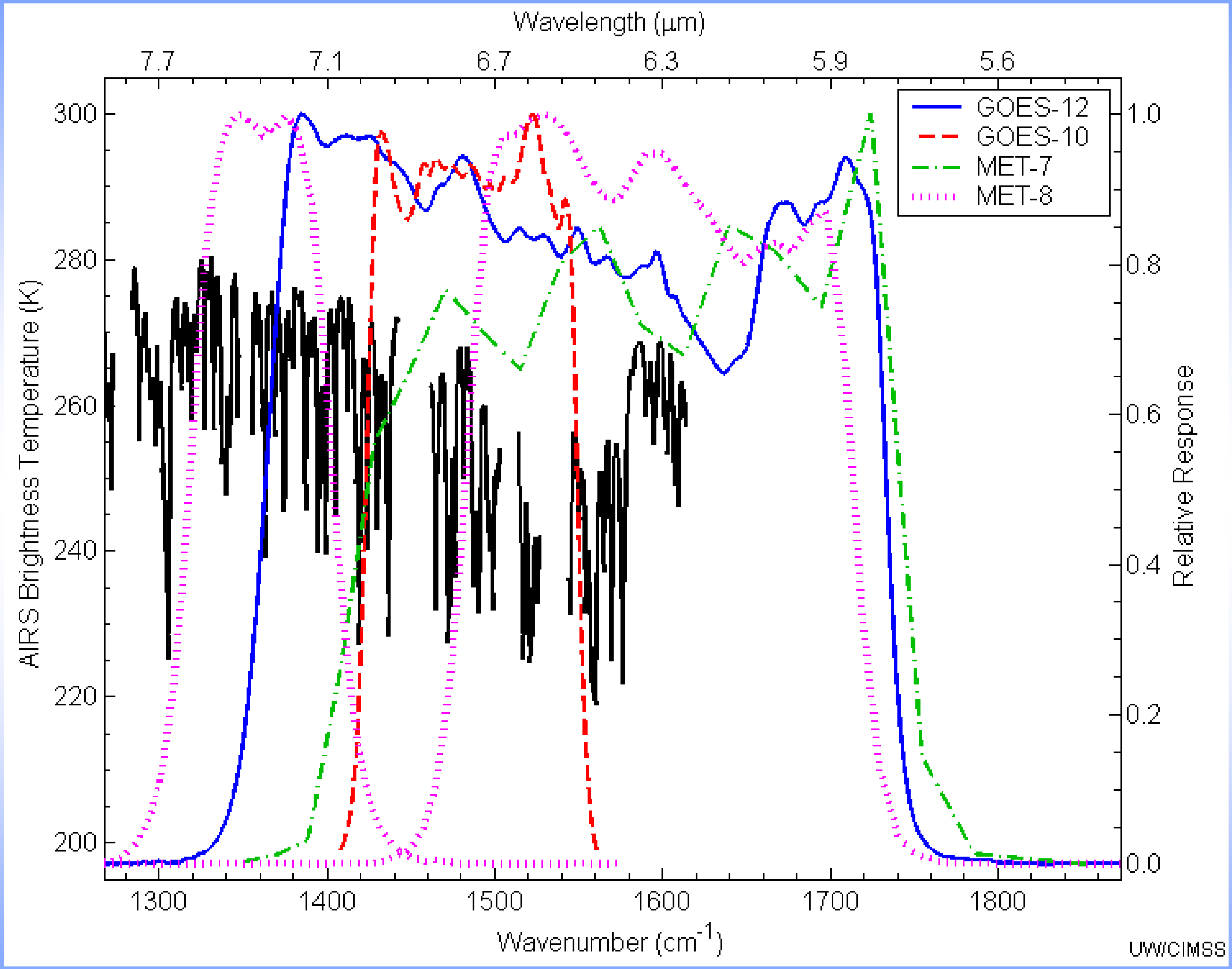
- Is it even reasonable to compare these water vapor bands?
- How do you characterize the state of the atmosphere?

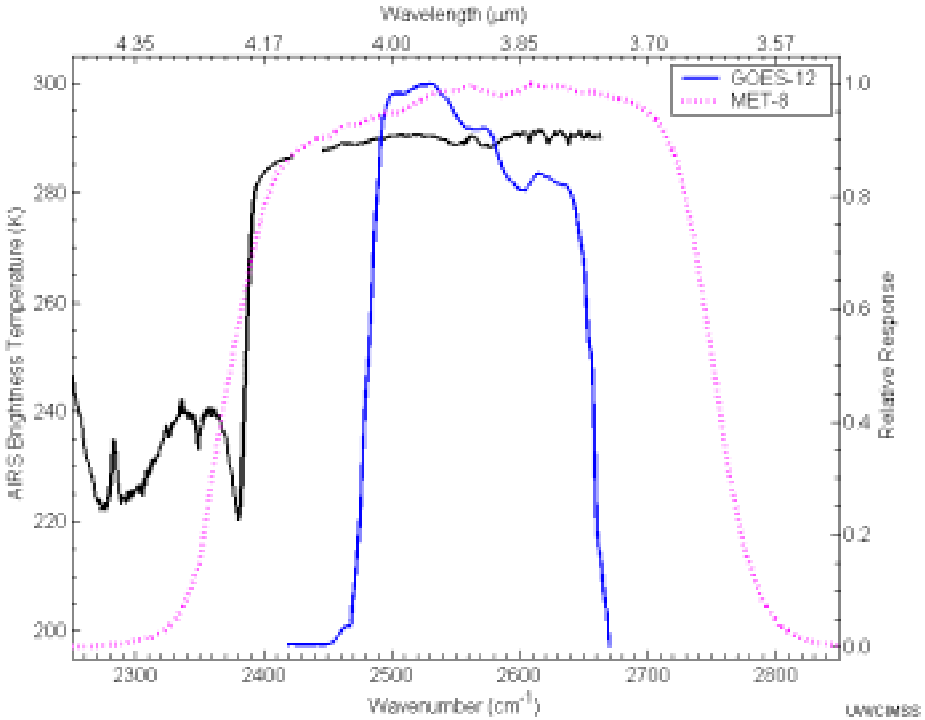
Why AIRS?

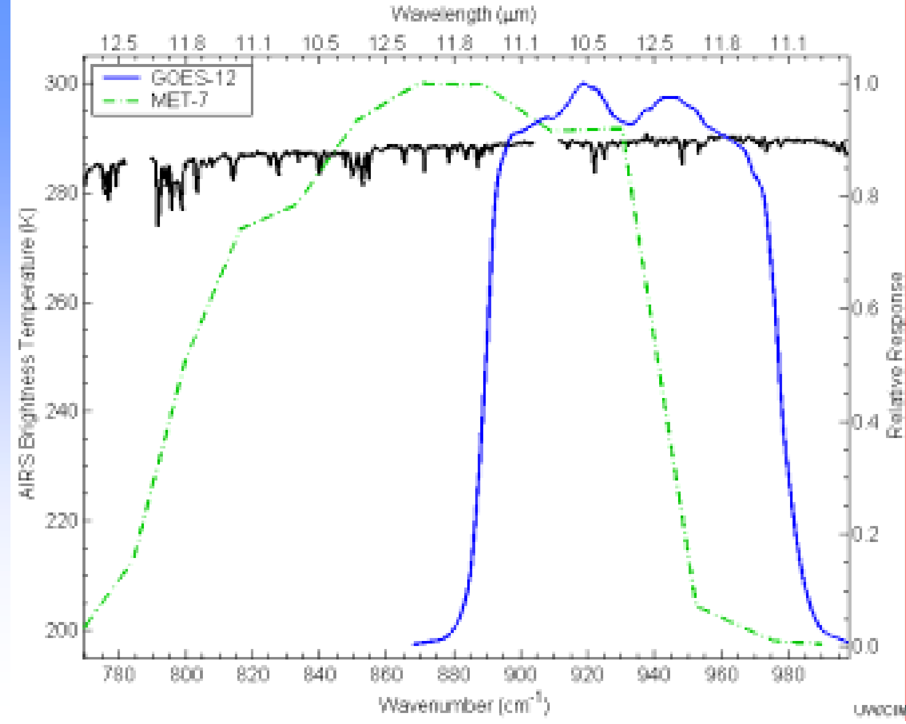
- AIRS has been proven to be extremely well calibrated.
- Hyperspectral data can be manipulated spectrally to fit nearly any broadband instrument.
- AIRS can be used for both quick and long-term intercalibration.

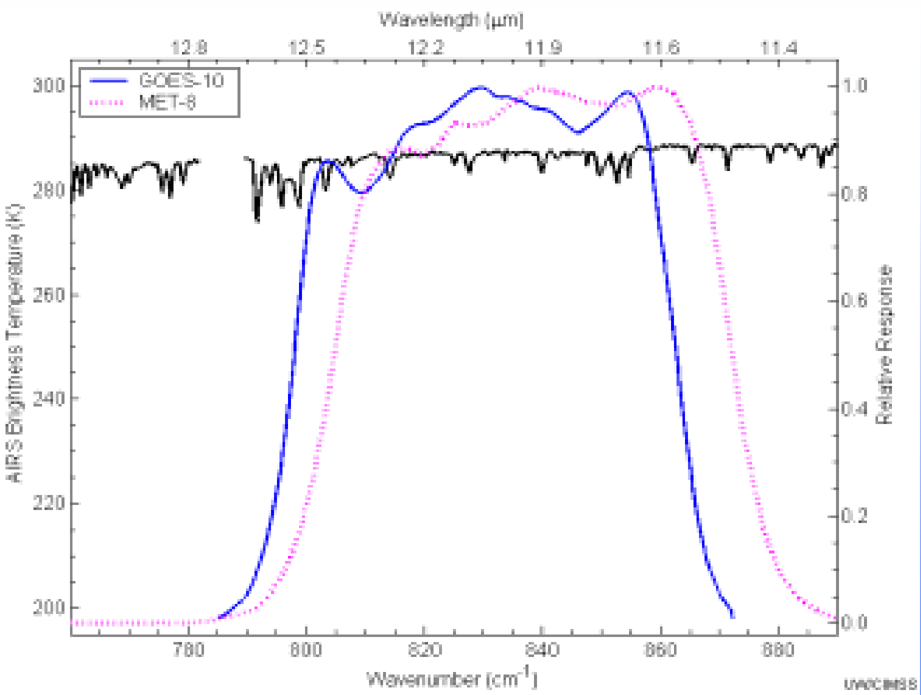
Drawbacks to AIRS

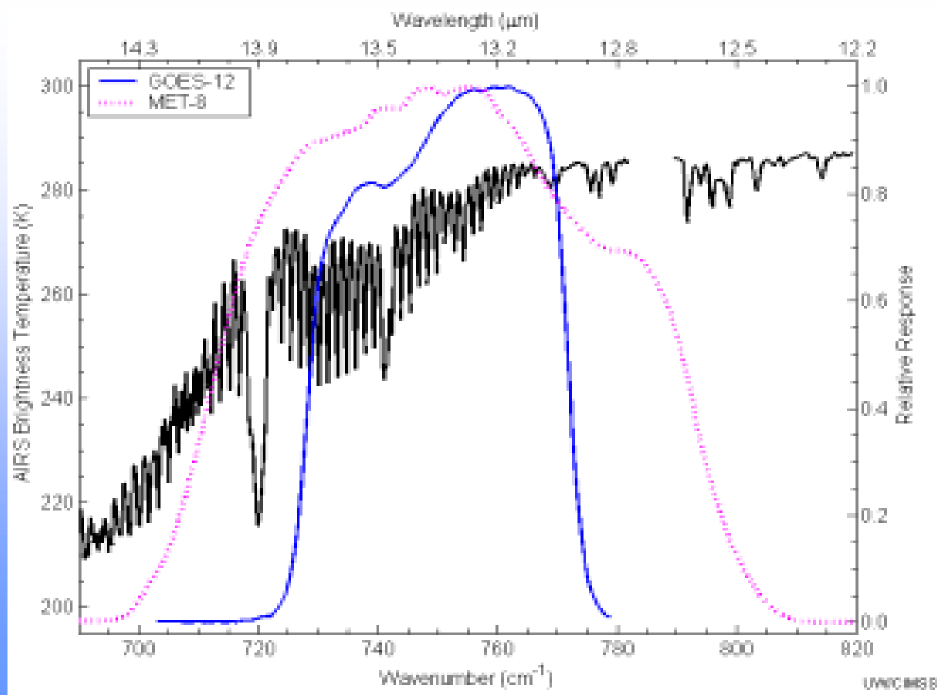
- AIRS footprint size is rather large (~13km) compared to geostationary imagers with 3-5km footprints (is also a problem with HIRS).
- There are spectral gaps (some very large) in AIRS data


Wavelength (µm)
7.7
7.1
6.7
6.3
5.9
5.6
GOES-12
GOES-10
MET-7
MET-8
300
280
260
240
220
200
AIRS Brightness Temperature (K)
1.0
0.8
0.6
0.4
0.2
0.0
Relative Response
1300
1400
1500
1600
1700
1800
Wavenumber (cm-1)
UW/CIMSS


Wavelength (µm)
4.35
4.17
4.00
3.85
3.70
3.57
GOES-12
MET-8
AIRS Brightness Temperature (K)
Relative Response
Wavenumber (cm^{-1})
UW/CIMSS

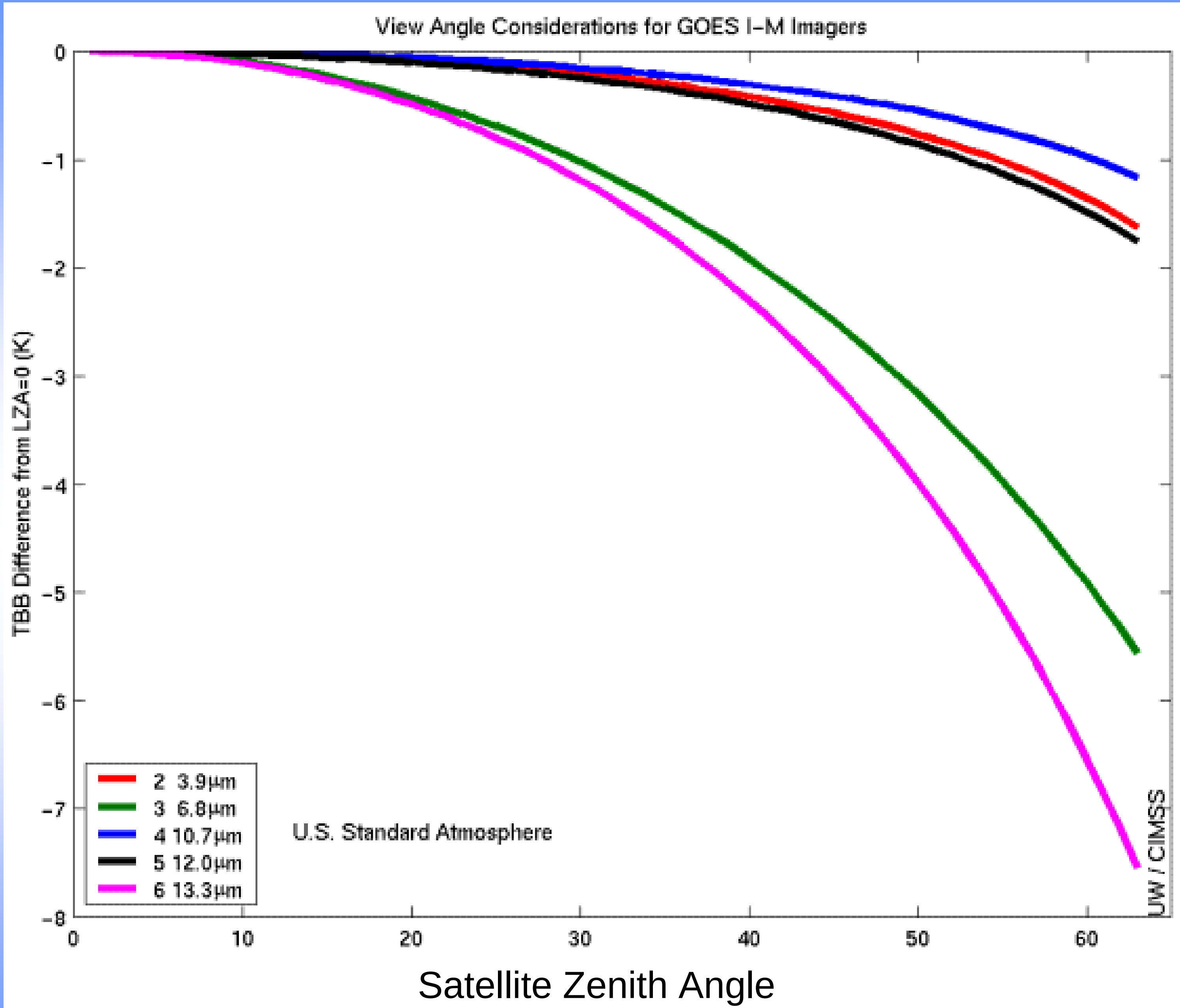

Wavelength (µm)
GOES-12
MET-7
AIRS Brightness Temperature (K)
Relative Response
Wavenumber (cm^{-1})


Wavelength (µm)
12.8
12.5
12.2
11.9
11.6
11.4
GOES-10
MET-8
AIRS Brightness Temperature (K)
Relative Response
Wavenumber (cm^{-1})
UW/CIMSS


Wavelength (µm)
14.3
13.9
13.5
13.2
12.8
12.5
12.2
GOES-12
MET-8
AIRS Brightness Temperature (K)
Relative Response
Wavenumber (cm^{-1})
UW/CIMSS

METHODS

- Collocation in time and space.
  - Within 30 minutes at geostationary subpoint
  - Low Satellite View Angles (< 14)


View Angle Considerations for GOES I-M Imagers
TBB Difference from LZA=0 (K)
0
-1
-2
-3
-4
-5
-6
-7
-8
0
10
20
30
40
50
60
2 3.9µm
3 6.8µm
4 10.7µm
5 12.0µm
6 13.3µm
U.S. Standard Atmosphere
UW / CIMSS
Satellite Zenith Angle

METHODS

- Collocation in time and space.
  - Within 30 minutes at geostationary subpoint
  - Low Satellite View Angles (< 14)
- Spatial smoothing
  - 100km "running average" mitigates the negative effects of poor spatial and temporal collocation, poor navigation, and spatial resolution differences.
  - Average radiances, not temperatures.
- Convolve AIRS Radiance spectra with GEO SRF.
  - Compare mean scene brightness temperatures (converted from mean scene radiances).

$$L_i = \frac{\int_{v_1}^{v_2} R(v) S_i(v)\, dv}{\int_{v_1}^{v_2} S_i(v)\, dv}$$

	Convolve radiances and convert to an effective temperature using FK1, FK2, BC1, BC2				Convert radiances to temperature using monochromatic conversion and then convolve temperatures				Effective Temperature – Convolved Temperature Difference				Average Difference for each band
µm	std	wet	dry	col	std	wet	dry	col	Std	wet	dry	col	
3.9	288.28	301.31	306.12	274.65	288.23	301.17	306	274.65	0.05	0.14	0.12	0	**0.1**
6.8 (10)	238.34	249.89	248.59	244.09	236.18	246.6	245.85	241.57	2.16	3.29	2.74	2.52	**2.7**
6.8 (12)	242.23	253.9	252.32	246.83	238.46	249.29	248.31	243.45	3.77	4.61	4.01	3.38	**3.9**
11	288.75	299.15	305.76	275.55	288.72	299.12	305.72	275.54	0.03	0.03	0.04	0.01	**0.0**
12	287.46	296.68	303.52	275.01	287.41	296.62	303.4	275.01	0.05	0.06	0.12	0	**0.1**
13	270.58	279.24	282.14	261.2	269.33	277.91	280.46	260.04	1.25	1.33	1.68	1.16	**1.4**

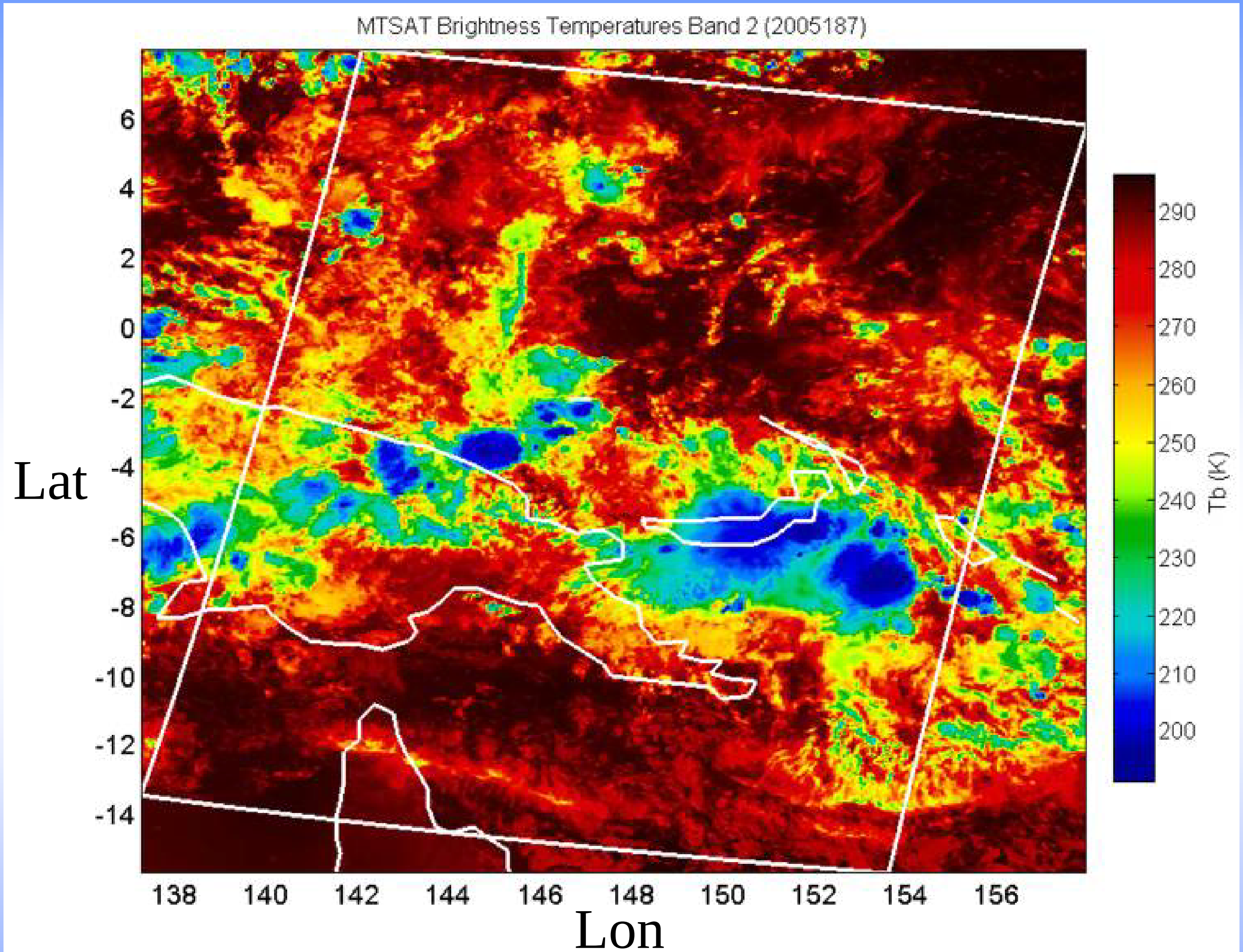
Std = U.S. Standard Atmosphere

Wet = Warm & Moist

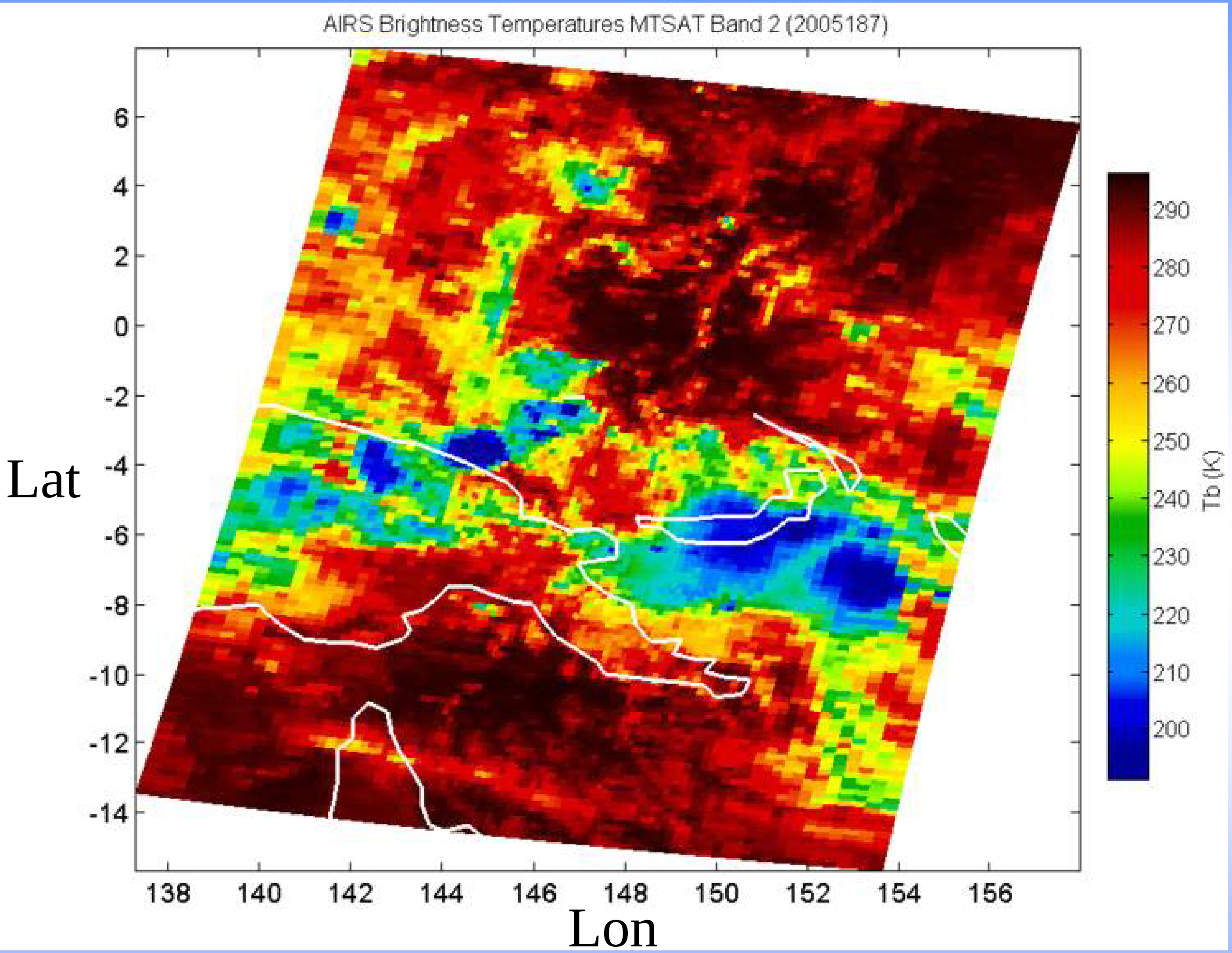
Dry = Hot & Dry

Col = Cold

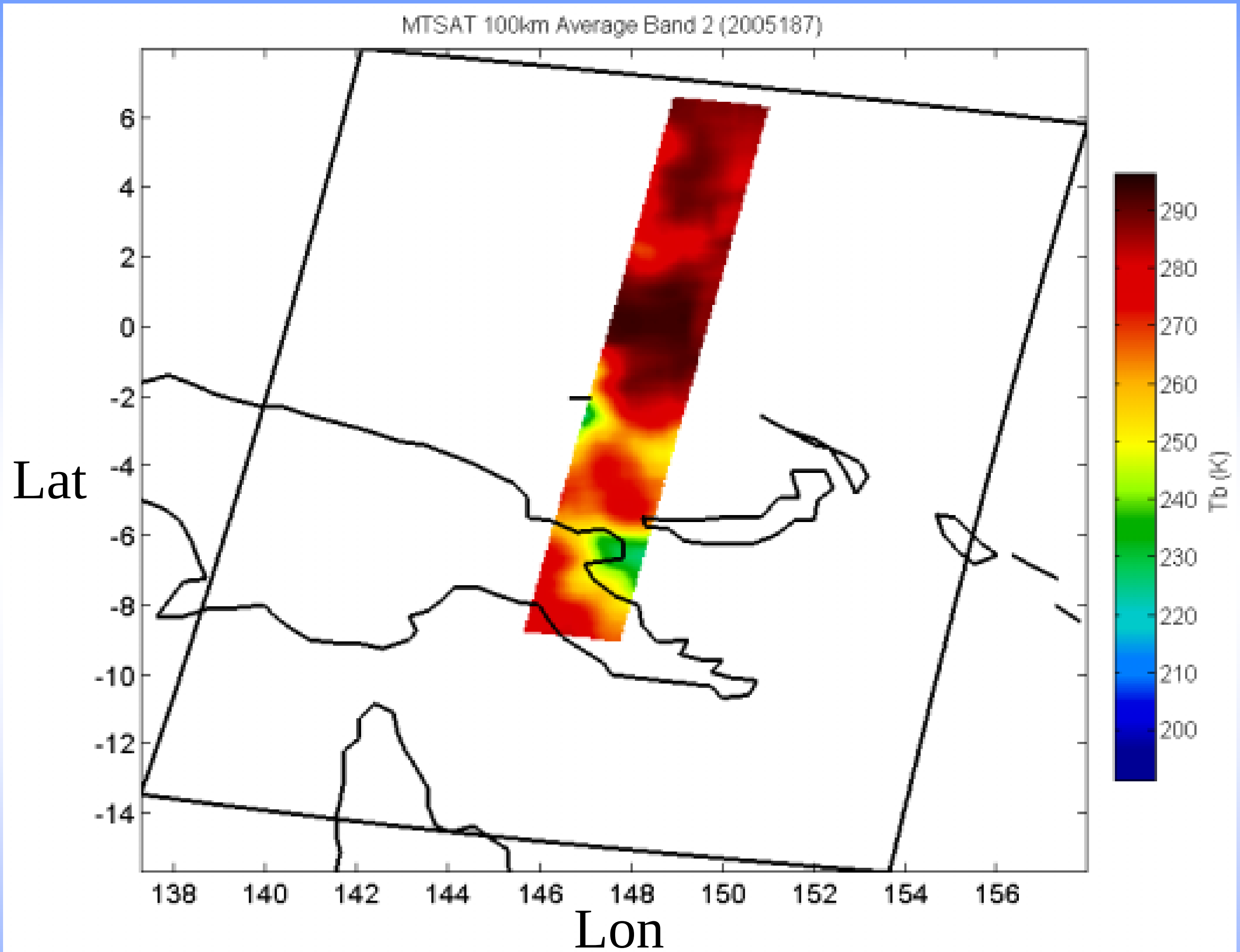
* Bands are from GOES-12 except for 6.8(10) and 12 which are from GOES-10



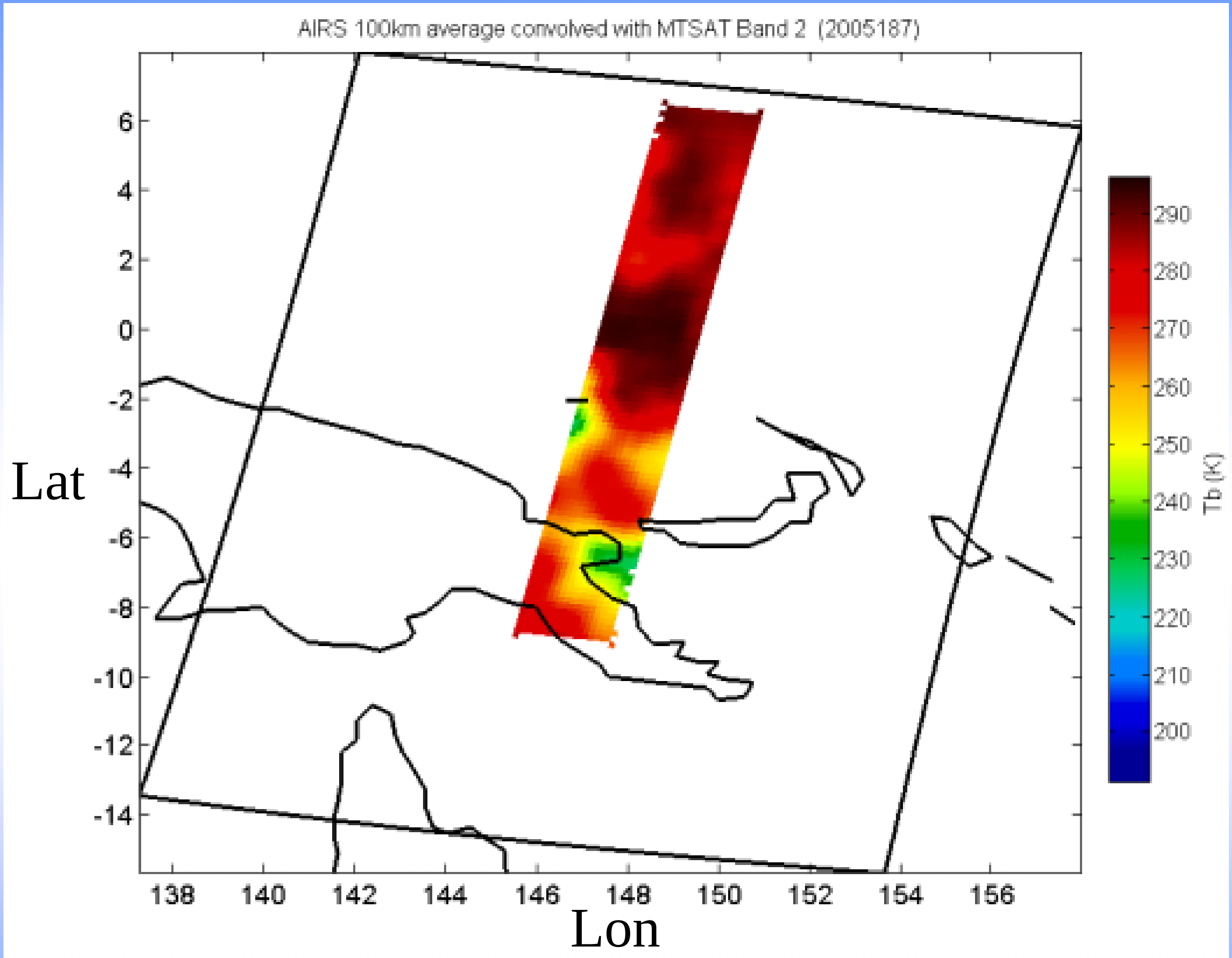
MTSAT 11μm 07 July 2005 at 15:33UTC



AIRS convolved with MTSAT 11μm 07 July 2005 at 15:36UTC



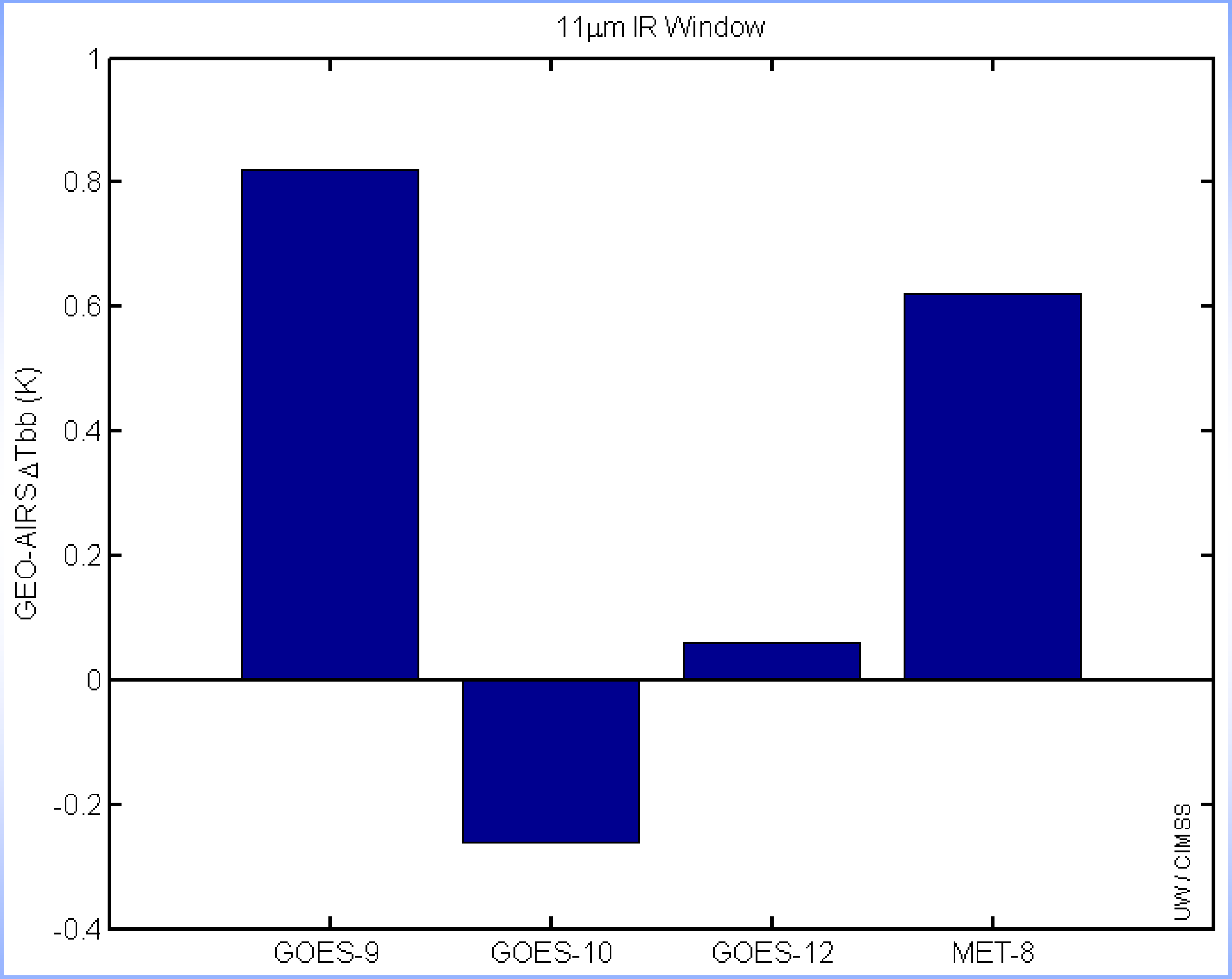
100km-smoothed MTSAT comparison area



100km-smoothed AIRS convolved with MTSAT comparison area

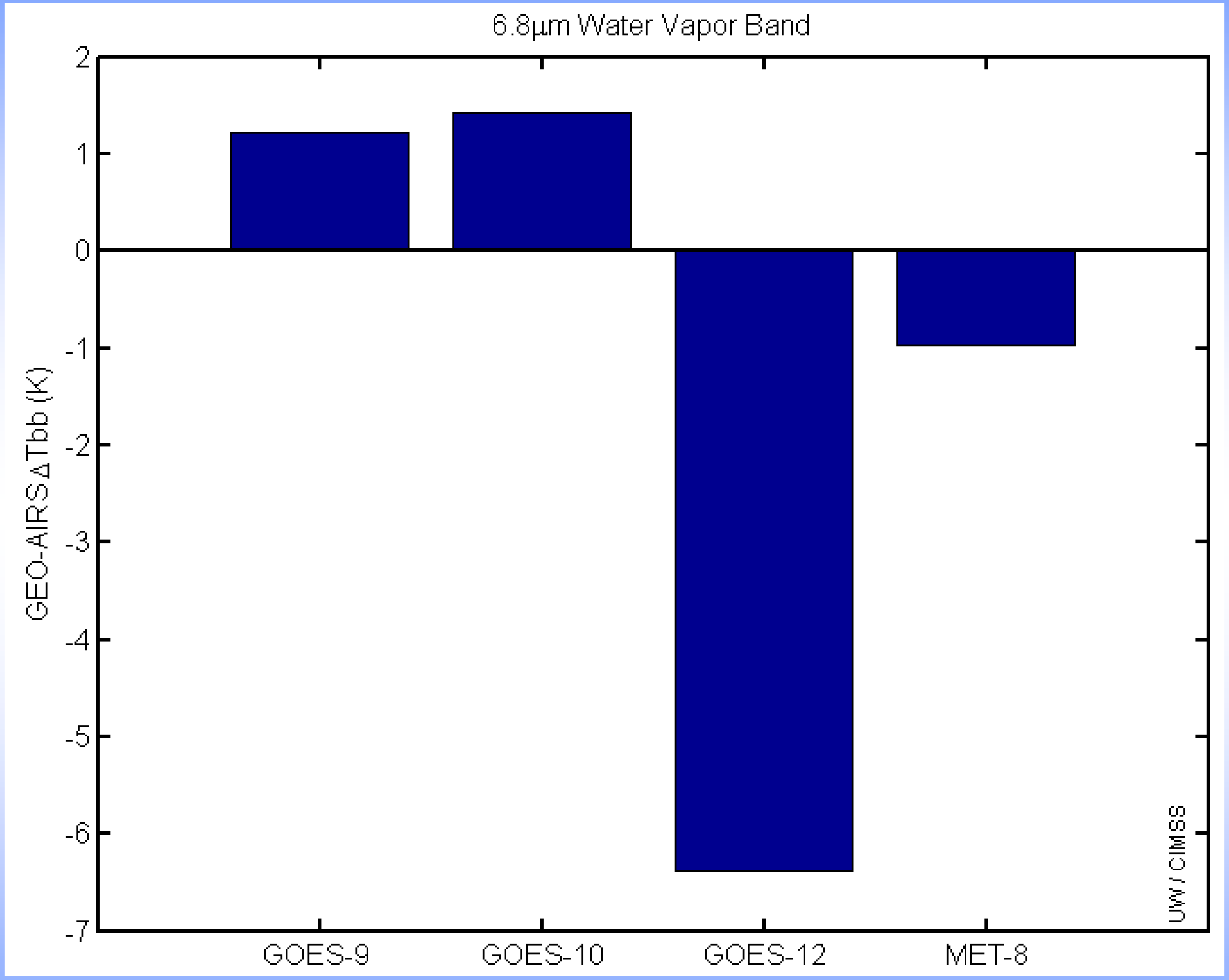
(ΔTbb = -0.4 K)

1-23 June 2005

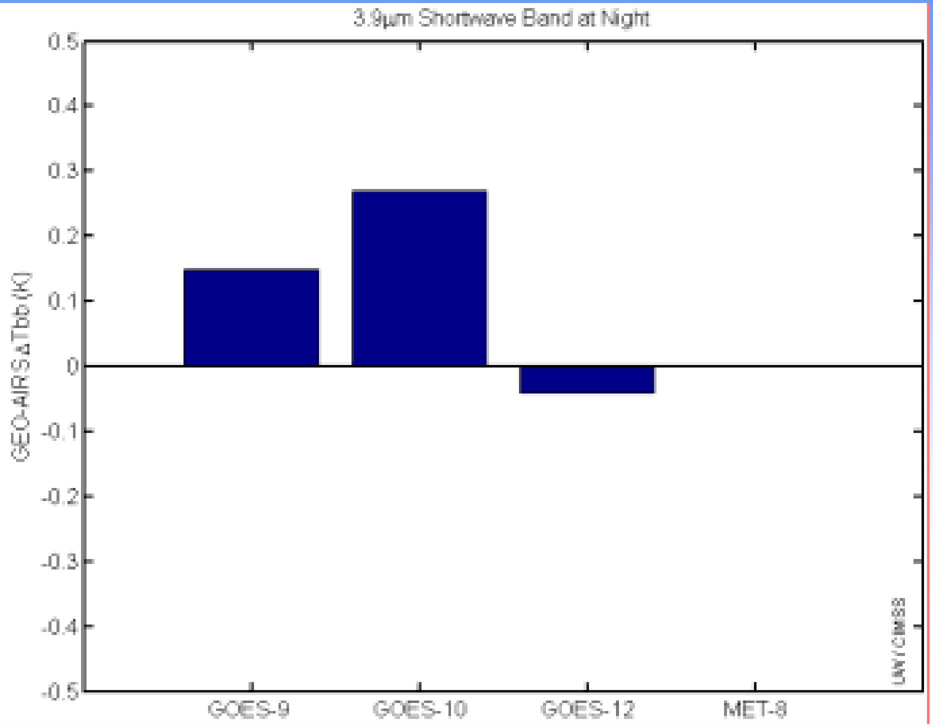


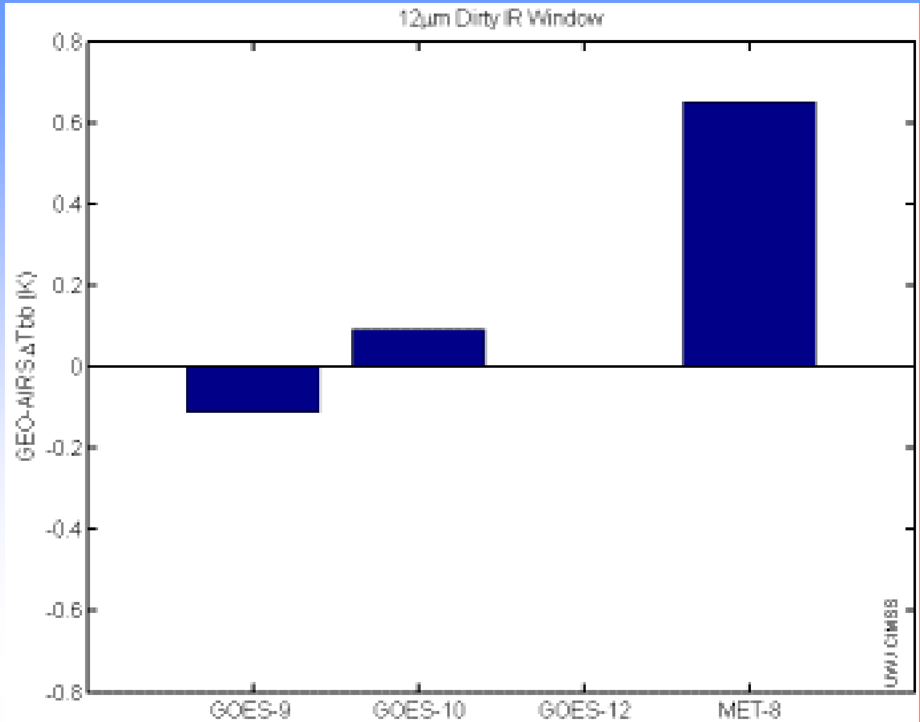
11μm IR Window Brightness Temperature Differences (GEO-AIRS)

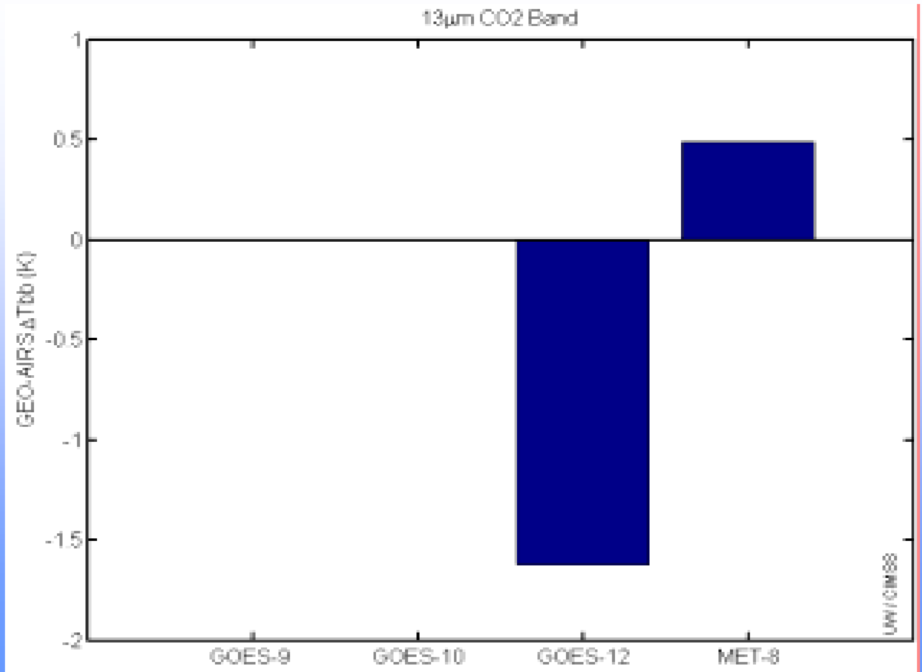
1-23 June 2005



6.8µm (7.3µm)Water Vapor Brightness Temperature Differences (GEO-AIRS with spectral gaps)







GEO-AIRS Brightness Temperature Differences

1-23 June 2005

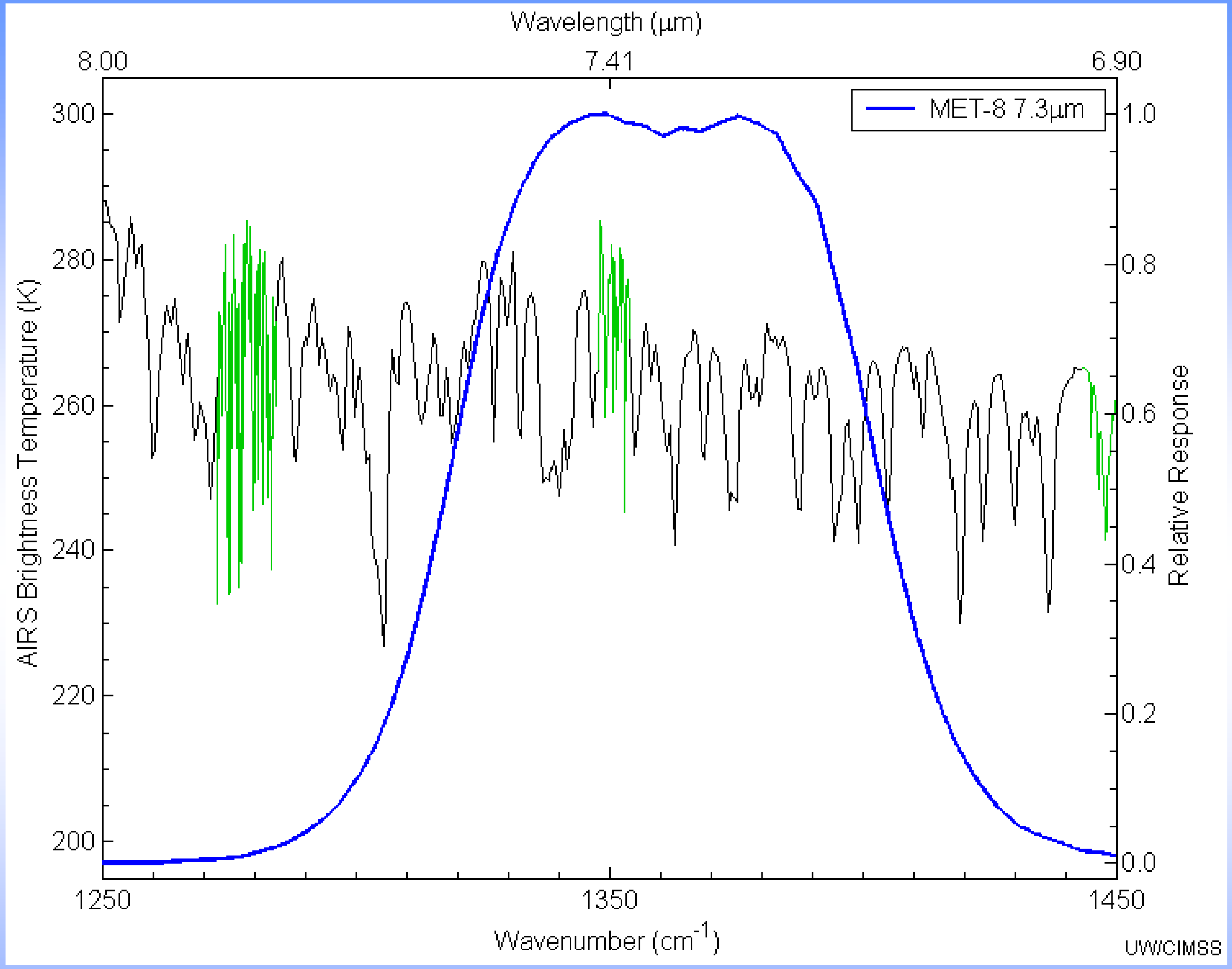
(note the different scales)

IR Window (11μm) comparisons with AIRS (1-23 June 2005).

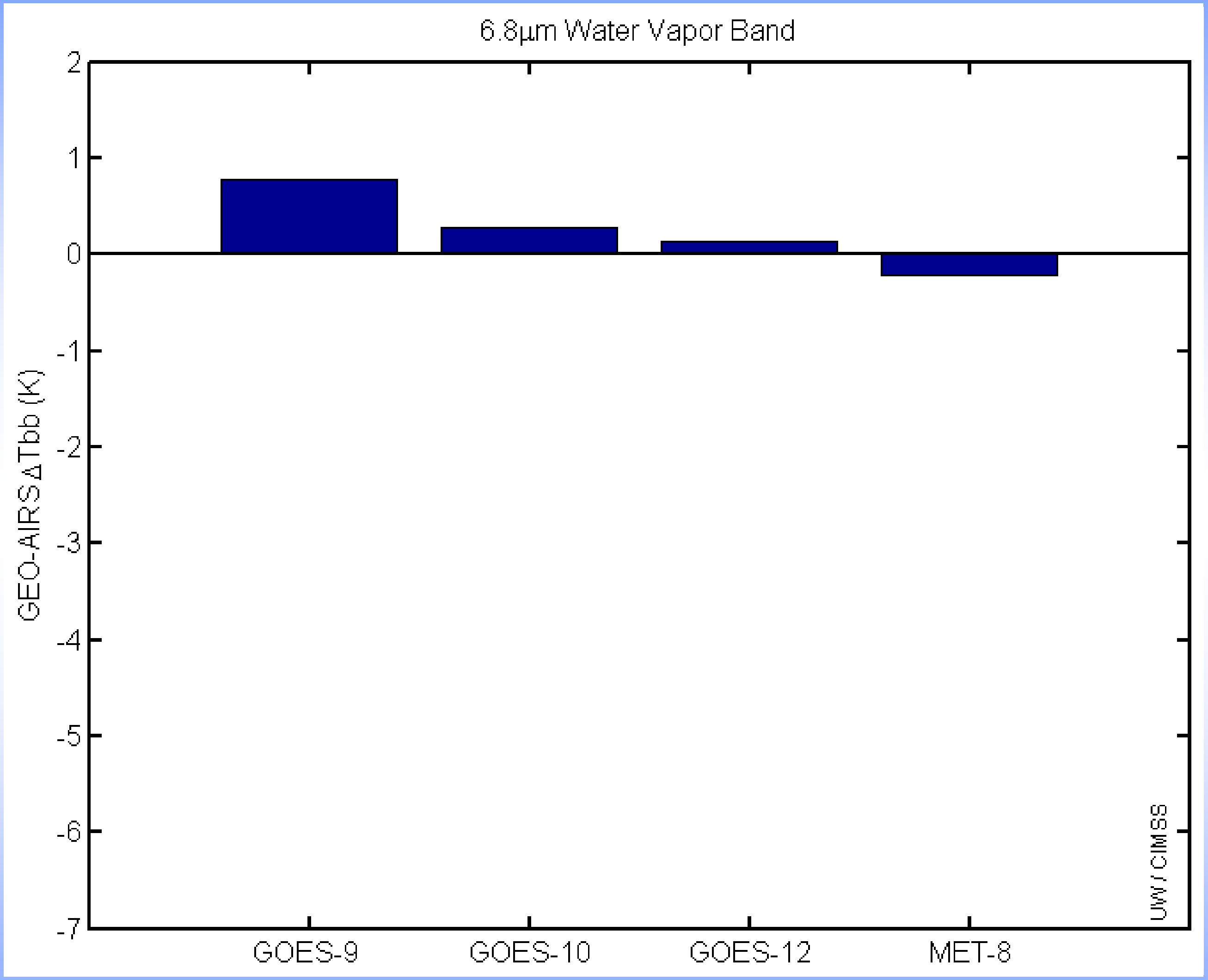
Geo:	GOES-9	GOES-10	GOES-12	Met-8
N	13	5	14	15
ΔTbb (K)	**0.8**	**-0.3**	**0.1**	**0.6**
STD (k)	0.8	0.2	0.5	0.1

WV channel(~6.8μm) comparisons with AIRS (1-23 June 2005).

Geo:	GOES-9	GOES-10	GOES-12	Met-8 (7.4)
N	13	5	14	15
ΔTbb (K)	**1.2**	**1.4**	**-6.4**	**-1.0**
STD (k)	0.4	0.2	0.3	0.2



Meteosat-8 7.3µm Spectral Response (blue) with AIRS spectra (black). Gaps filled with adjusted US Standard Atmosphere spectra (green).



6.8µm (7.3µm)Water Vapor Brightness Temperature Differences (GEO-AIRS). Before and After filling gaps.

WV channel(~6.8μm) comparisons with AIRS (1-23 June 2005).

Geo:	GOES-9	GOES-10	GOES-12	Met-8 (7.4)
N	13	5	14	15
ΔTbb (K)	**1.2**	**1.4**	**-6.4**	**-1.0**
STD (k)	0.4	0.2	0.3	0.2

WV channel(~6.8μm) comparisons with spectral gaps filled.

Geo:	GOES-9	GOES-10	GOES-12	Met-8 (7.4)
N	13	5	8	15
ΔTbb (K)	**0.8**	**0.3**	**0.1**	**-0.2**
STD (k)	0.4	0.2	0.3	0.2

Shortwave channel(3.9μm) comparisons with AIRS (1-23 June 2005).

Geo:	GOES-9	GOES-10	GOES-12
N	13	5	14
Day	5	0	10
Night	8	5	4
ΔTbb (K)	**0.3**	**0.3**	**-0.4**
Day	**0.4**	**NA**	**-0.6**
Night	**0.2**	**0.3**	**-0.04**
STD (k)	0.5	0.1	0.4
Day	0.3	NA	0.4
Night	0.6	0.1	0.2

SUMMARY

- The infrared bands on most geostationary imagers are well calibrated to within specifications (1K) for most bands.
- A simple technique to fill AIRS spectral gaps with a modified US Standard Atmosphere spectra improves comparisons for several bands.
- AIRS can be used for both quick and long-term intercalibration.

Immediate Future of Intercalibration: High spectral sounders used to validate radiances from broadband imagers (with aircraft flights and ARM site measurements used to validate space-borne high spectral sounders).

Use IASI to assess spectral gap compensation methods.