AIRS validation using two years of (obs-calc)

George Aumann
Jet Propulsion Laboratory

and

Larrabee Strow
University of Maryland, Baltimore County

7 March 2006

Outline

Why do we want to look at (obs-calc)

How are we doing it

Results

Why ?

→ 1. For applications of AIRS data to climate questions we want to validation to the full AIRS spectral and dynamic range.
For this we can use mean(obs-calc)

2. For the use of AIRS data in weather forecasting we want to understand what to expect using the mean and stdev of (obs-calc)

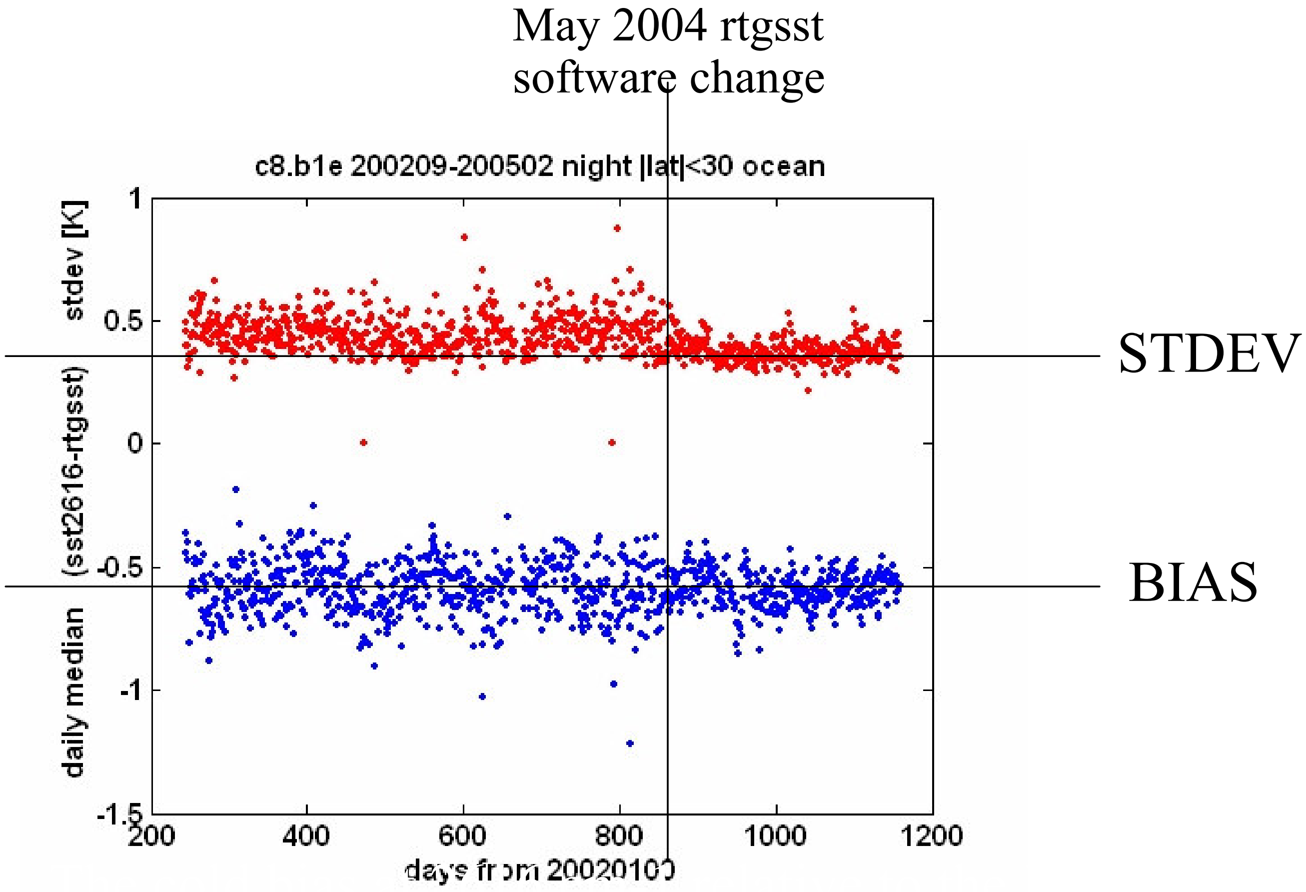
→ 3. We want to establish a system performance metric for the analysis of future hyperspectral sounders, IASI and CRIS.
For this we can use the mean and stdev(obs-calc)

Previously we have used clear night ocean data to validate the absolute accuracy and stability of the AIRS radiance in the 2616 cm-1 window channel

The accuracy at 2616 cm-1 in the 290-305 K range is 10+/-120 mK with stability of <16 mK/year for all data from 200209-200508 (JGR 2006 AIRS Validation)

How good is the calibration for the other 2377 channels?

At 2616 cm-1 the 600 mK cold bias is explained to 10 +/- 120 mK



H. H. Aumann

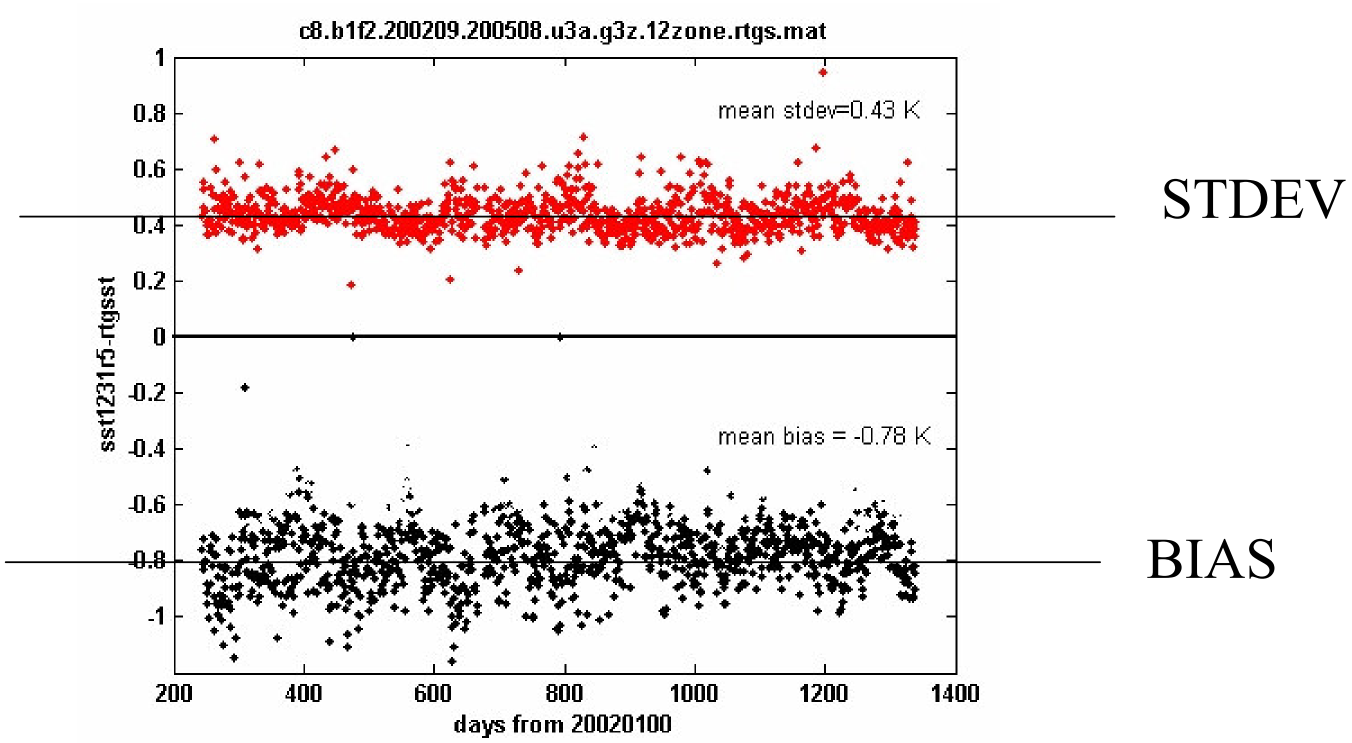
The comparison with the RTGSST is limited to window channels.

For 2616 cm-1, where the mean water absorption is 0.2K
all but 10 +/- 120 mK of the observed 600 mK cold bias is
is explained and not calibration related.

We have done the calculation for 14 other window channels.
The basic result is the same, but the result has more noise and
larger unexplained offset due to the much larger (and less certain)
water correction.

Next we show the result for 1231 cm-1.
This channel is in detector module M4d.
The mean water absorption at 1231 cm-1 is 2.5 K.

At 1231cm-1 there is a 800 mK cold bias which is explained to -170 +/- 160 mK



sst1231-rtgsst stats are very similar to sst2616-rtgsst
Due to the increased noise, the May 2004 shift is less obvious

How good is the calibration for the other 2378-2 channels?

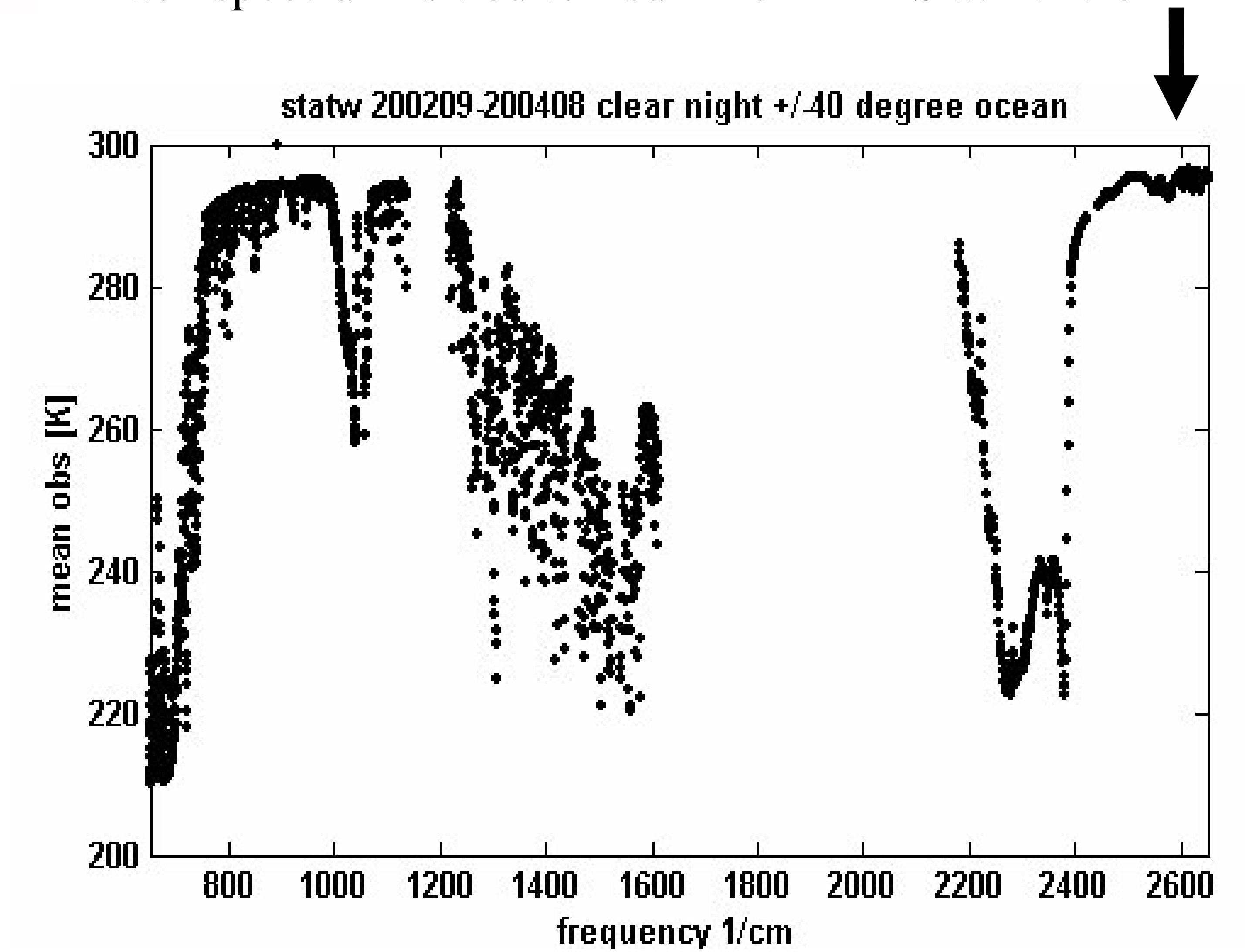
Results from one underflight of SHIS in November 2002
are in the JGR Validation issue. It covers about 50% of the AIRS channels

Results from Von Walden's Dome Concordia (obs-calc) analysis
from December 2003/January 2004 are in the JGR Validation issue.
It covers about 50% of the AIRS channels.

Results from the EAQUATE underflight of SHIS in September 2004
shown at the AMS meeting in Atlanta show a significant 0.3K shift
between SHIS and AIRS in large areas of weak atmospheric absorption

We use (obs-calc) to validate the full spectrum and over a two year time period

Two year mean tropical night ocean spectrum.
Each spectrum is tied to Tsurf from AIRS at 2616 cm-1



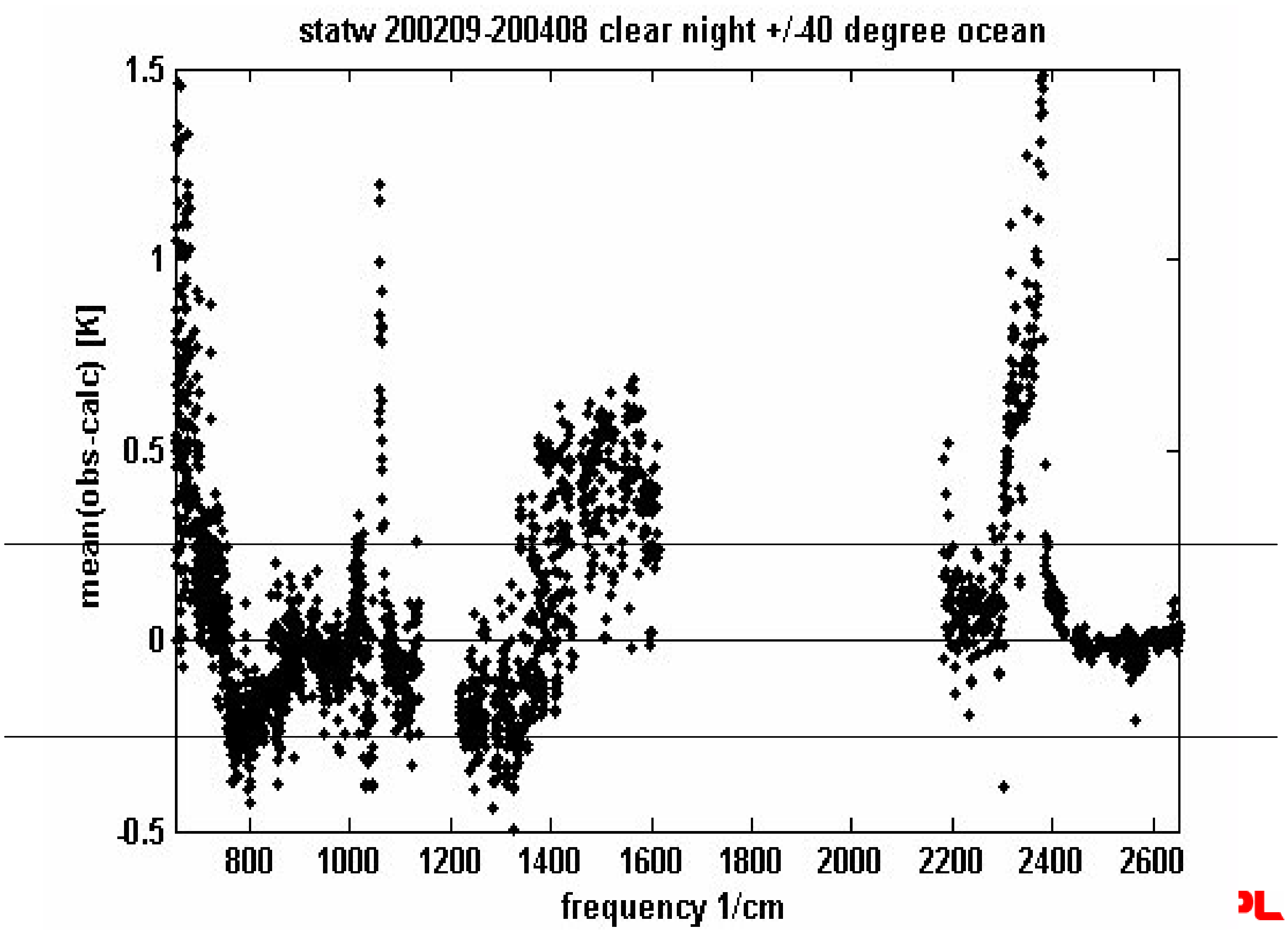
Next we show the two year mean (obs-calc)
calc=calculated brightness temperature from the
"known" state of the atmosphere

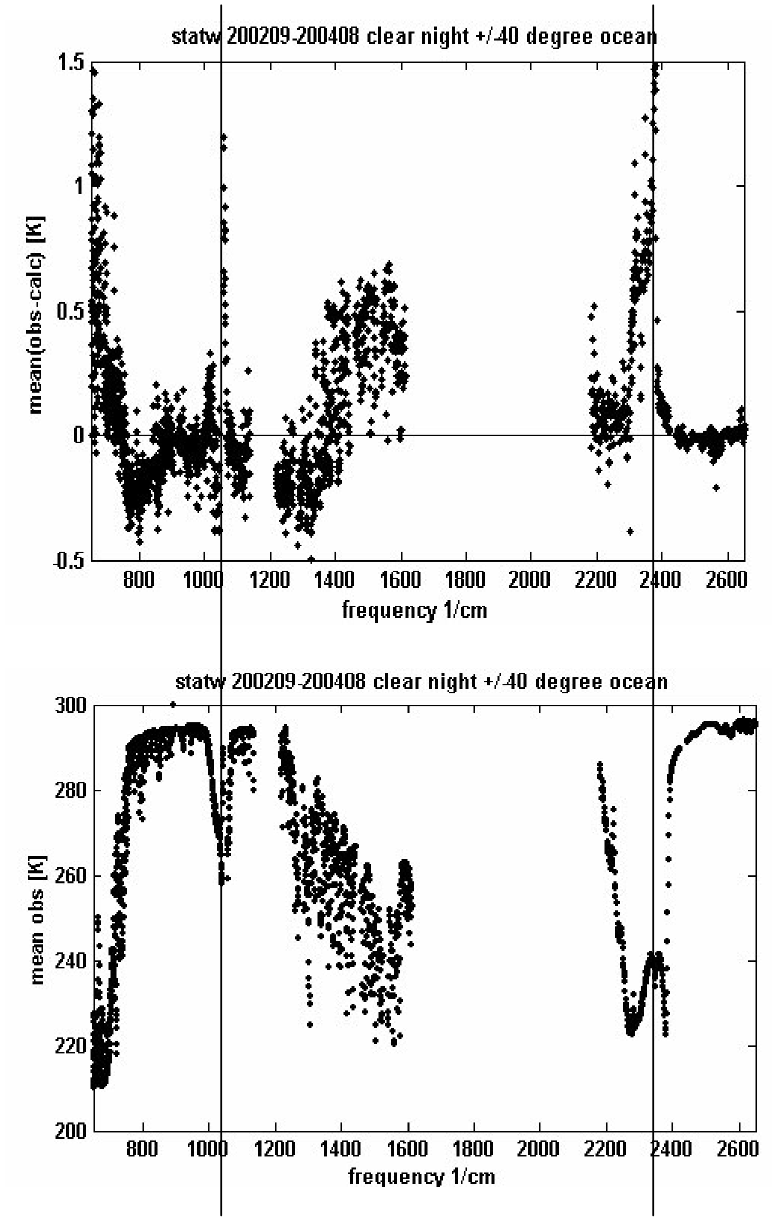
We use the ECMWF T(p) q(p) for calc, except
replace TSurf by the SST from 12 window channel
in the 2600 cm-1 area and
normalize the total water using bt2616-bt2607

Use the January 2003 AIRS RTA for calc for
clear night ocean +/-40 degree latitude

(obs-calc) using two years of data makes sense only if the
instrument is regionally and globally stable on this time scale.

For 2253 of the 2388 channels (obs-calc)=0.06+/-0.28 [K]
(excluded NeDT>1K) min=-1.3 max=1.5 K





The patterns in the bias suggest the larger values are due to calc, not obs.

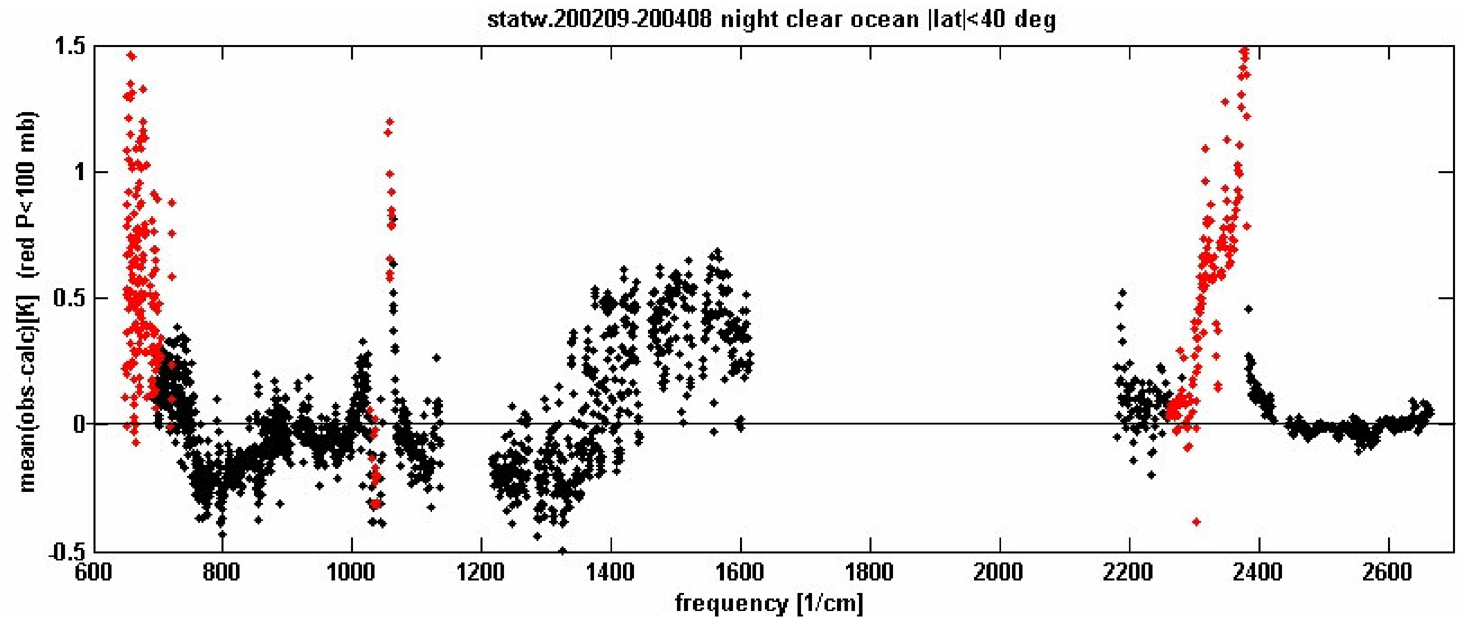
The ECMWF temperature, Ozone and water are suspect above 200 mbar.

The less water sensitivity the lower the bias in windows

AIRS has more water vapor in the lower troposphere, more in the upper troposphere. than ECMWF (due to AMSU assimilation?)

The stratosphere is 1.5 K warmer than ECMWF at 4 microns and 15 microns

Remove all channels above 100 mb from the bias evaluation of (obs-calc)

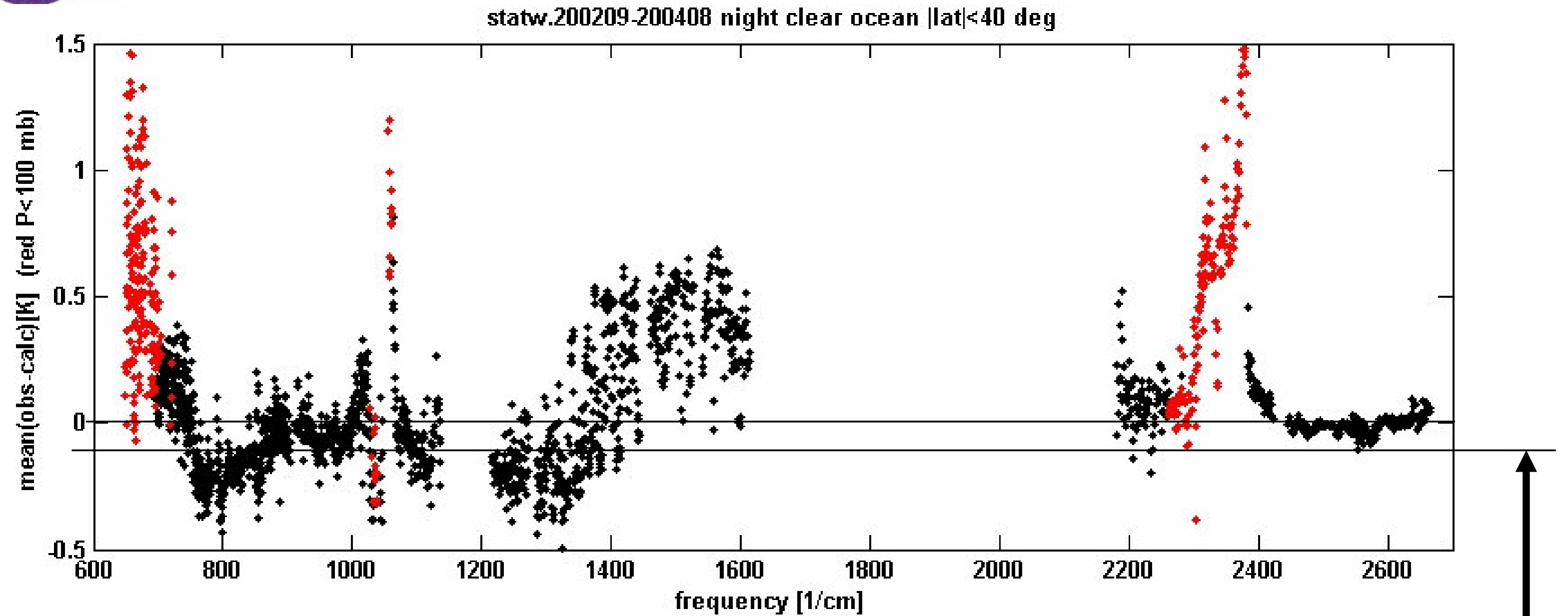


(obs-calc)= -0.0188 stdev= 0.2028 K 1903 pts
min=-1.083 max= 0.816

The AIRS calibration is good to 200 mK for channels between the surface and 100 mb.
This is consistent with the SHIS November 2002 result from 70 mb altitude.

H. H. Aumann JPL

There is much less water sensitivity in the 4 micron sounding channels.
The 4 micron P-branch channels have stratospheric water lines.



The -0.16 K cold bias seen in sst1231-rtgsst is confirmed

1. For applications of AIRS data to climate questions we want to validation to the full AIRS spectral and dynamic range.
For this we use mean(obs-calc)

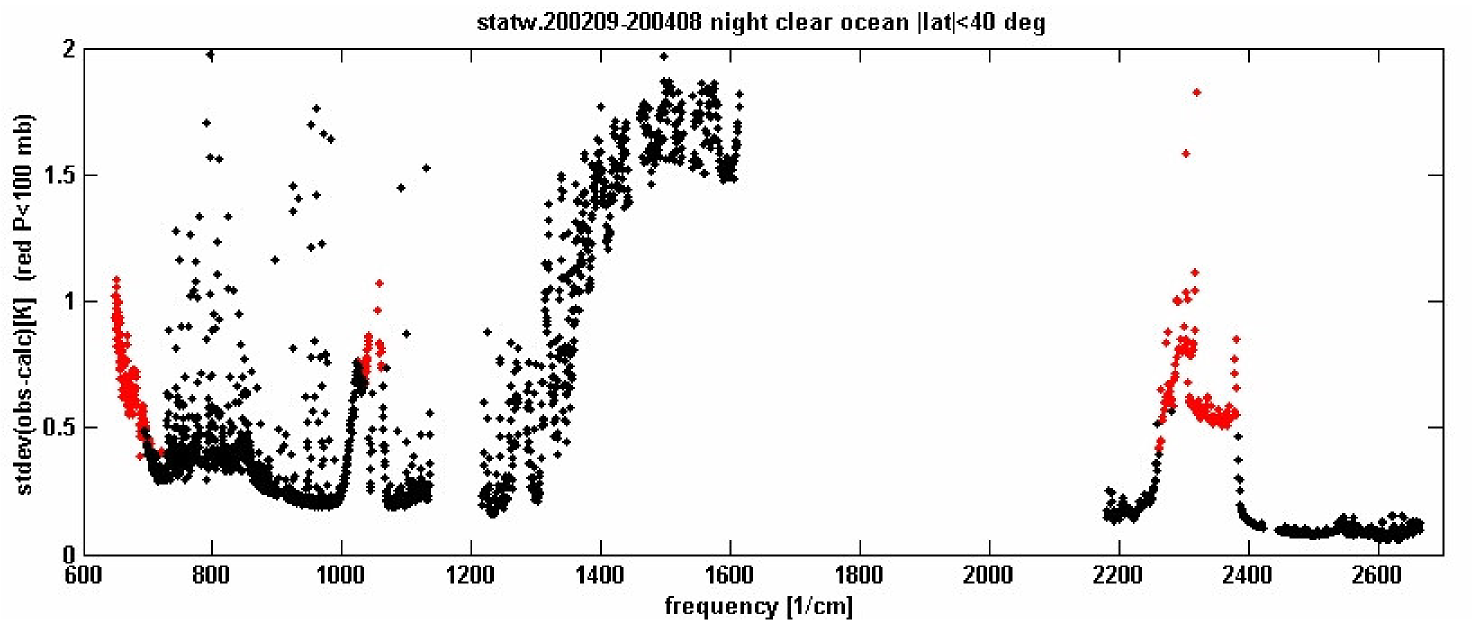
2. For the use of AIRS data in weather forecasting we want to understand what to expect using the mean and stdev of (obs-calc)

→ 3. We want to establish a system performance metric for the analysis of future hyperspectral sounders, IASI and CRIS.
For this we use stdev(obs-calc)

We analyze two years of stdev(obs-calc).

We can do this because we have already established the radiometric stability of AIRS on the years time scale.

stdev(obs-calc) is used in data assimilation as an empirical component in the noise covariance matrix



We have seen from the analysis of bias(obs-calc) that the ECMWF background field is questionable at p<100mb and in the water profile.

A two year analysis of bias(obs-calc) can be generated for any instrument
If properly tuned, the bias can be made arbitarily small.

If the instrument is radiometrically and spectrally stable regionally and globally on a two year time scale,

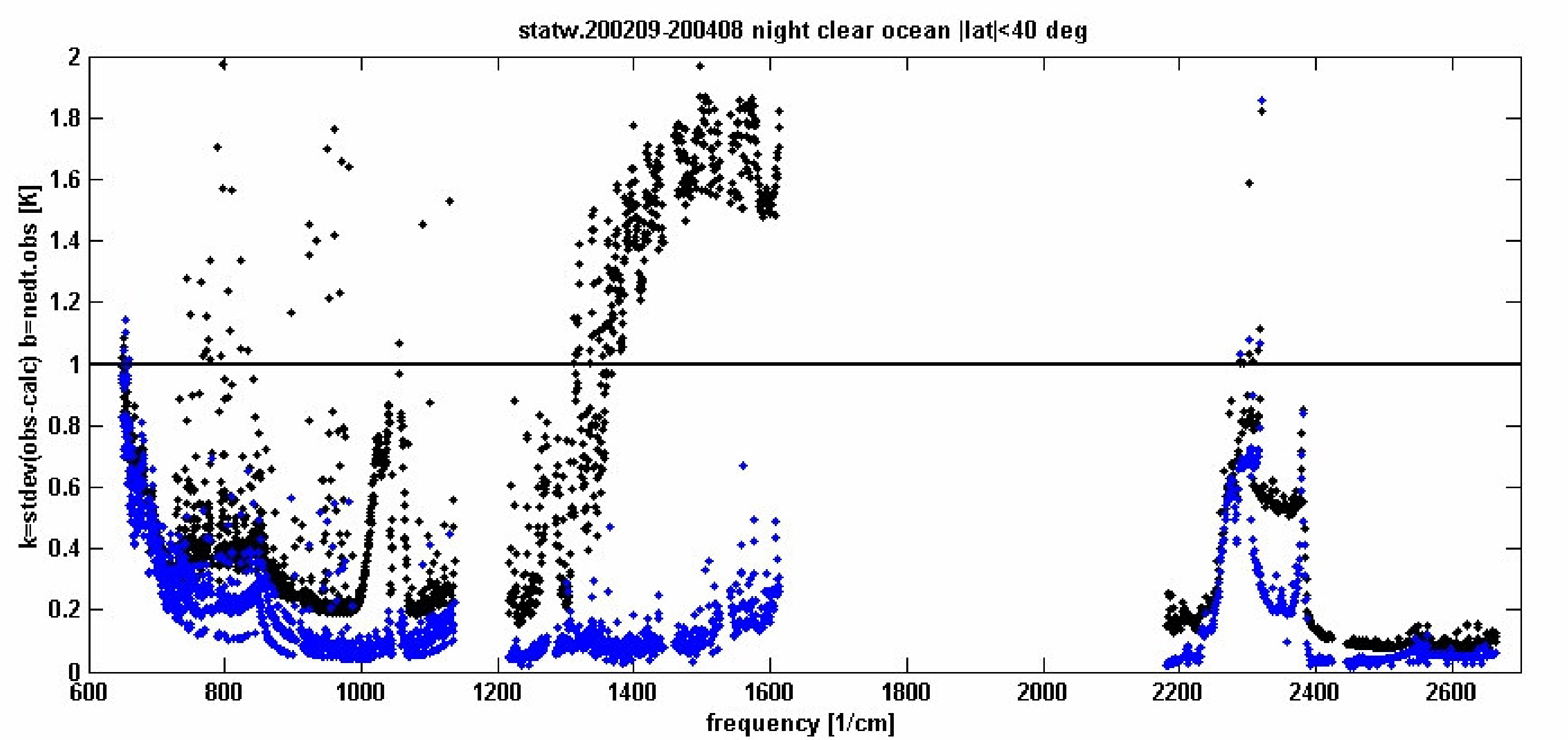
and

If the state of the atmosphere is accurately known

we expect that stdev(obs-calc)=NeDT

We refer to this NeDT as the dynamic NeDT is it obtained in the scan line as opposed to the static NeDT obtained from looking at the OBC or SV.

stdev(obs-calc) for channel where ECMWF is reliable at the required level of accuracy agrees well with the NeDT reported by the Level 1b.



stdev(obs-calc) for channels where ECMWF is not reliable is grossly inflated, weakening the potential weight of the AIRS data in the assimilation process.

NeDT evaluated at the mean spectral brightness temperature year2.

The direct difference of year1-year2 simply shows inter-annual differences. We have to use double differences.

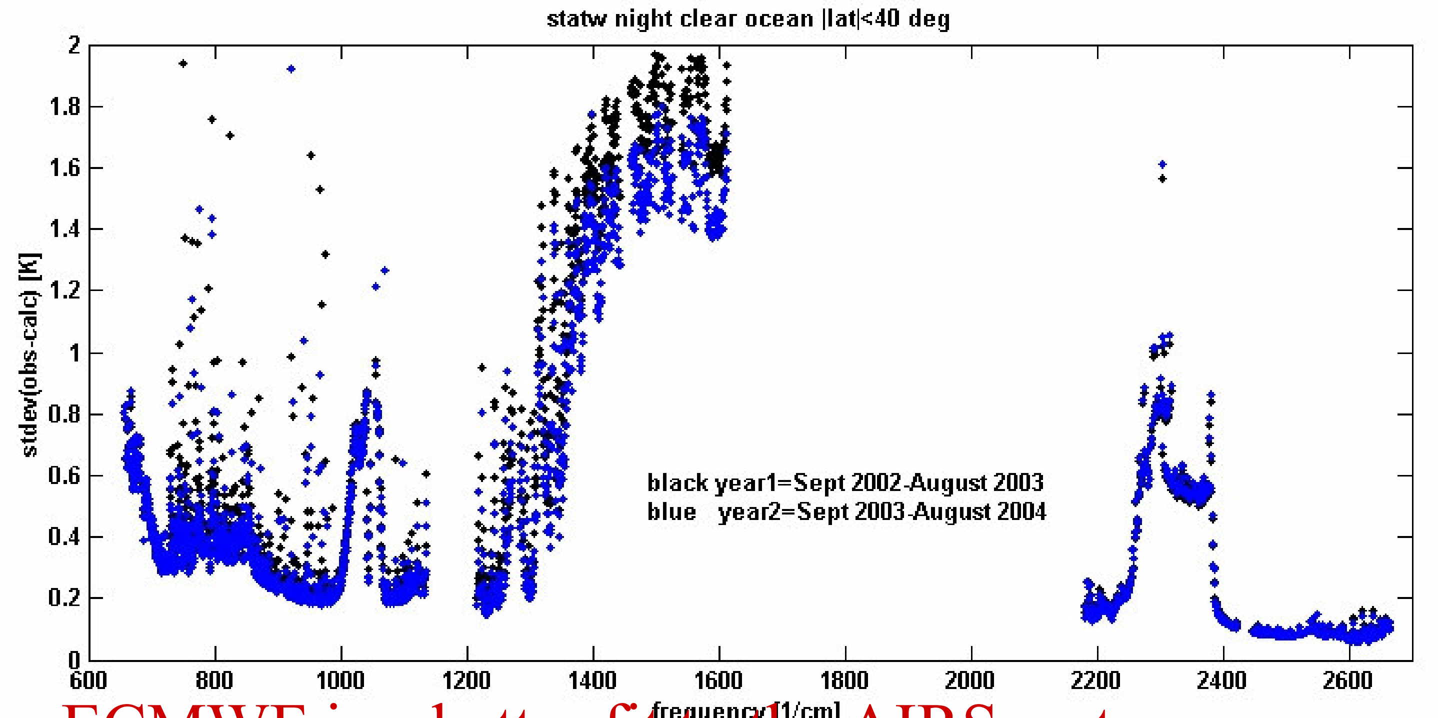
stdev(obs-calc) year1-year2

bias(obs-calc) year1-year2

The same RTA and the 200209 frequency table are used for AIRS

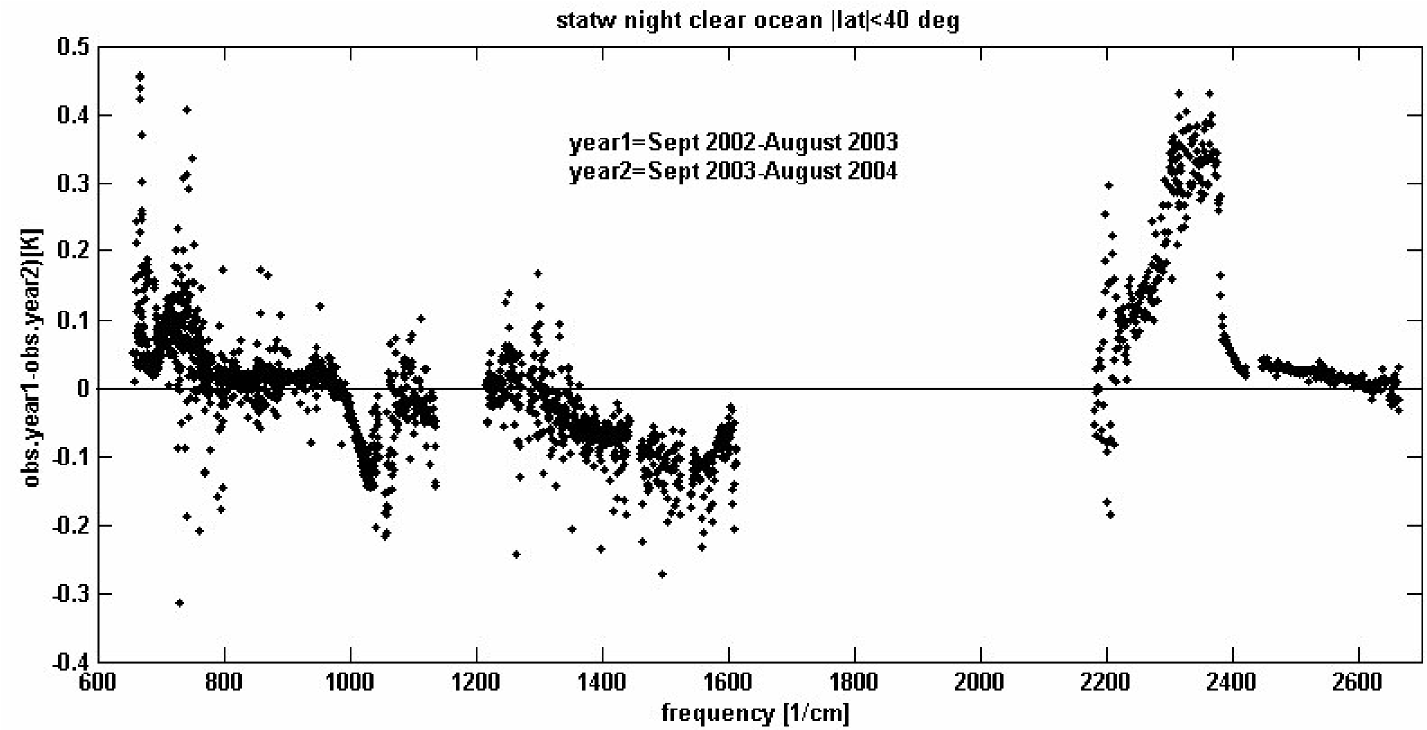
If a change is noticed, we have to analyze where it

Between the first and the second year of AIRS data stdev(obs-calc) has decreased in channels sensitive to water

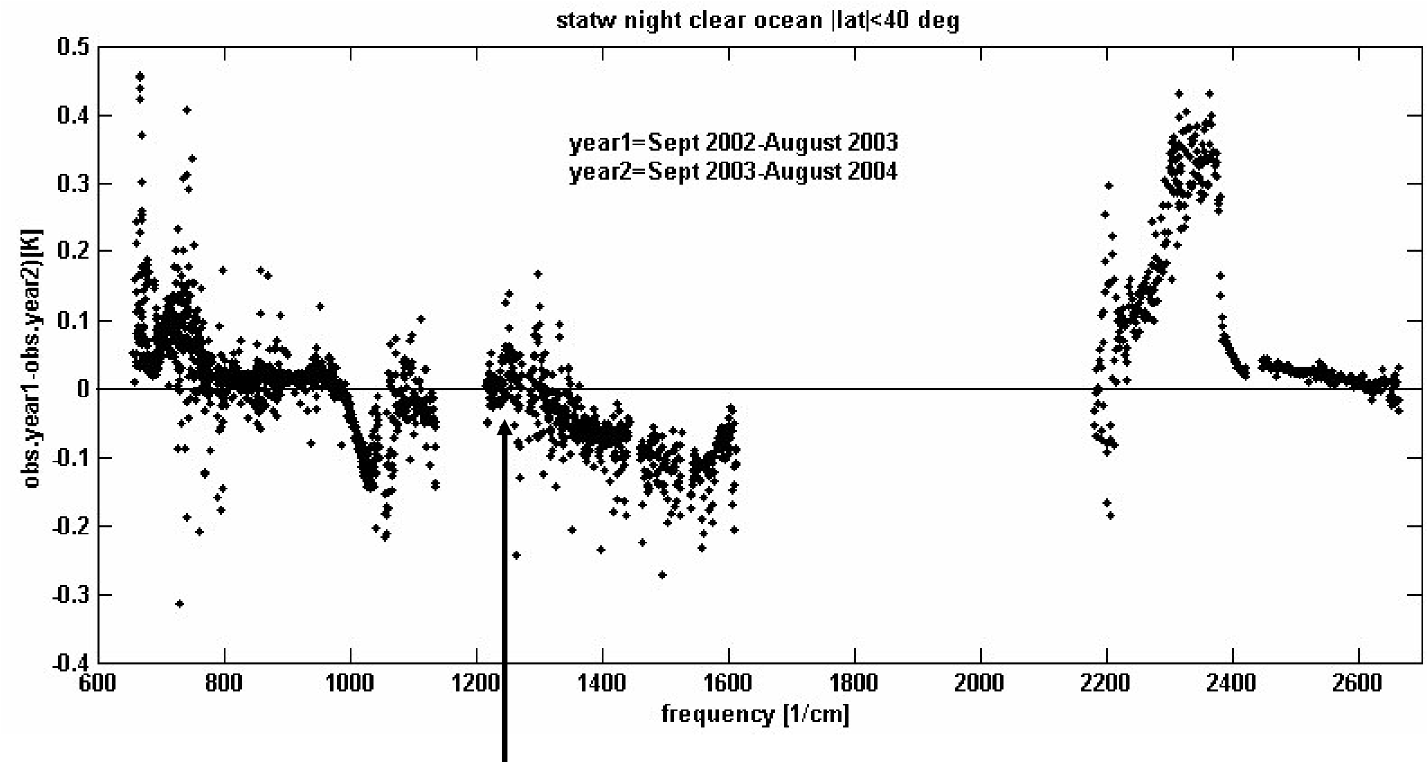


ECMWF is a better fit to the AIRS water spectrum
in the 2nd year. Related to assimilation of AIRS

Between the first and the second year of AIRS data (obs-calc) appear to be related to changes at ECMWF



The shift in the bias between the first and the second year of AIRS data in (obs-calc) in uncontested spectral areas is less than 20 mK



The 1231 cm-1 channel is stable at the better than 10 mK/year level

H. H. Aumann

The analysis of (obs-calc) using AIRS establishes the state of art of the NPW models and the RTA .

The character of (obs-calc) using AIRS establishes the benchmark for the assessment of the performance of future sounders

Summary and Conclusions

We analyzed (obs-calc) for 2 years of night clear ocean data from +/- 40 degree latitude using ECMWF profiles

mean(obs-calc) allows for the accurate assessment for the absolute calibration accuracy and stability

stdev(obs-calc) for channel where ECMWF is reliable accuracy agrees well with the NeDT reported by the Level 1b.

The changes between year1 and year2 for channel not sensitive to ECMWF changes are less than 20 mK

The 0.3K shift reported by Smith at the January 2006 AMS meeting is not seen in annual mean difference between (obs-calc) using ECMWF

The AIRS analysis of (obs-calc) establishes the benchmark for the evaluation of IASI and CRIS

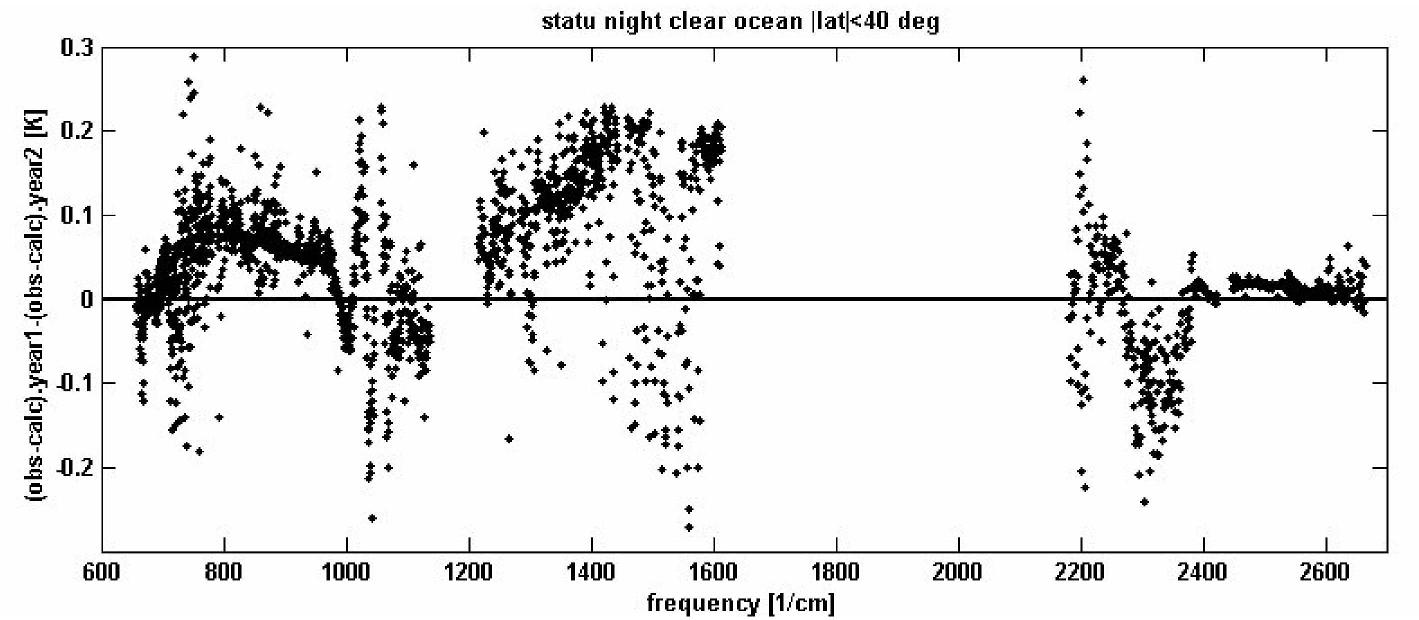
Appendix

1. Would the results have changed if we had used the ECMWF profiles totally unmodified?

2. The 2002 -2004 shift in AIRS-SHIS

Our conclusions would not change had we used the totally unmodified ECMWF profiles

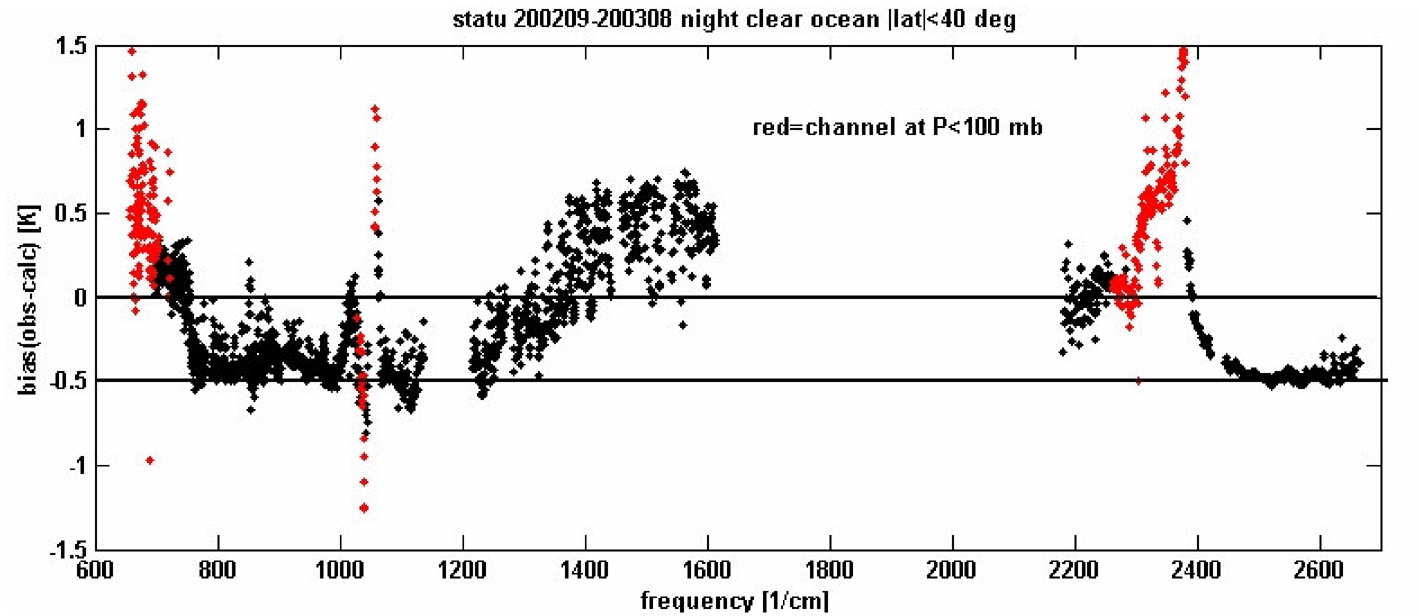
(obs-calc) year1-year2



The change in the water vapor in the 2nd year shifts the 10 micron window channels by 80 mK

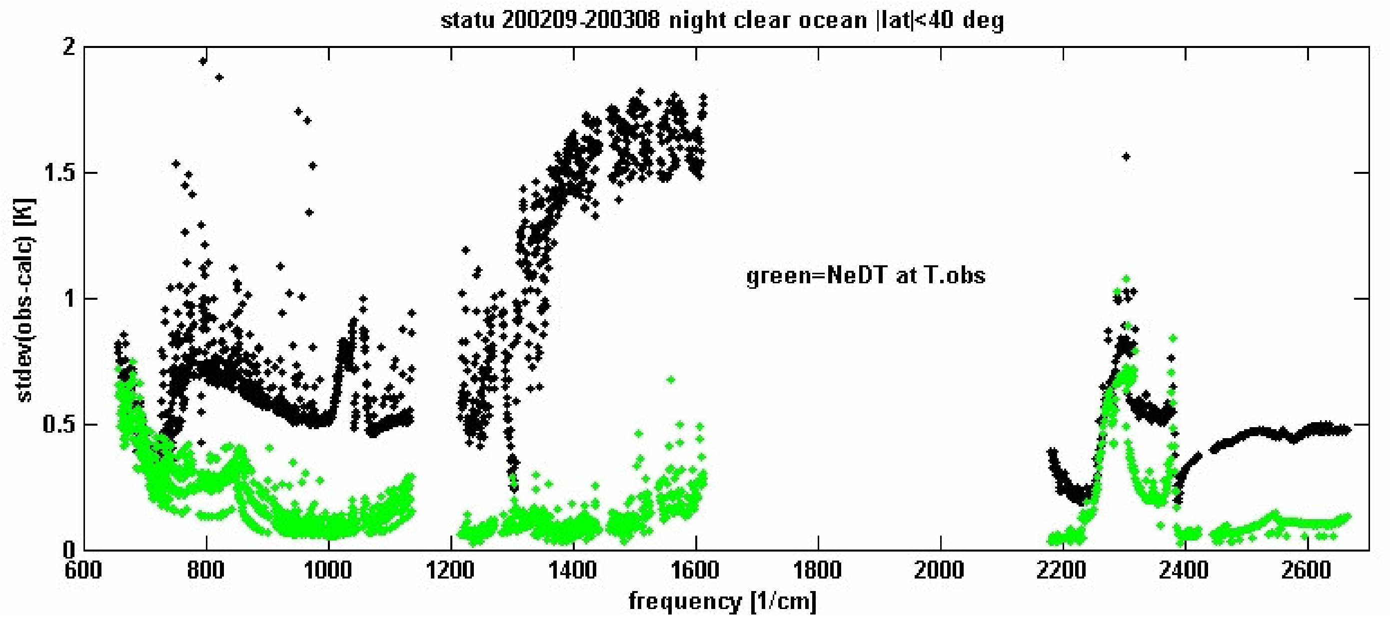
H. H. Aumann

Our conclusions would not change had we used the totally unmodified ECMWF profiles



TSurf from ECMWF is about 0.4 K warmer at night than the skin temperature measured by AIRS.
This is the day/night skin/buoy bias

If the ECMWF profile is used without the water scaling, then the uncertainty in the ECMWF water profile dominated stdev(obs-calc)



Appendix

1. Would the results have changed if we had used the ECMWF profiles totally unmodified?

2. The 2002 -2004 shift in AIRS-SHIS

Tobin et. al 2006 SHIS-AIRS Validation Paper shows agreement between SHIS and AIRS at the 0.1K level in 2002

Bill Smith's Atlanta January 2006 AMS Presentation shows a shift between SHIS and AIRS of 0.3K in 2004 in areas of weak atmospheric absorption

This shift is not seen in the evaluation of the (obs-calc).2002 – (obs-calc).2004 using ECMWF

The double difference (shis-calc)-(airs-calc) cancels common effects at the altitude below the aircraft at 20 km.

Differences are expected for significant absorbers, such as Ozone, Water and Methane, present above 20 km.

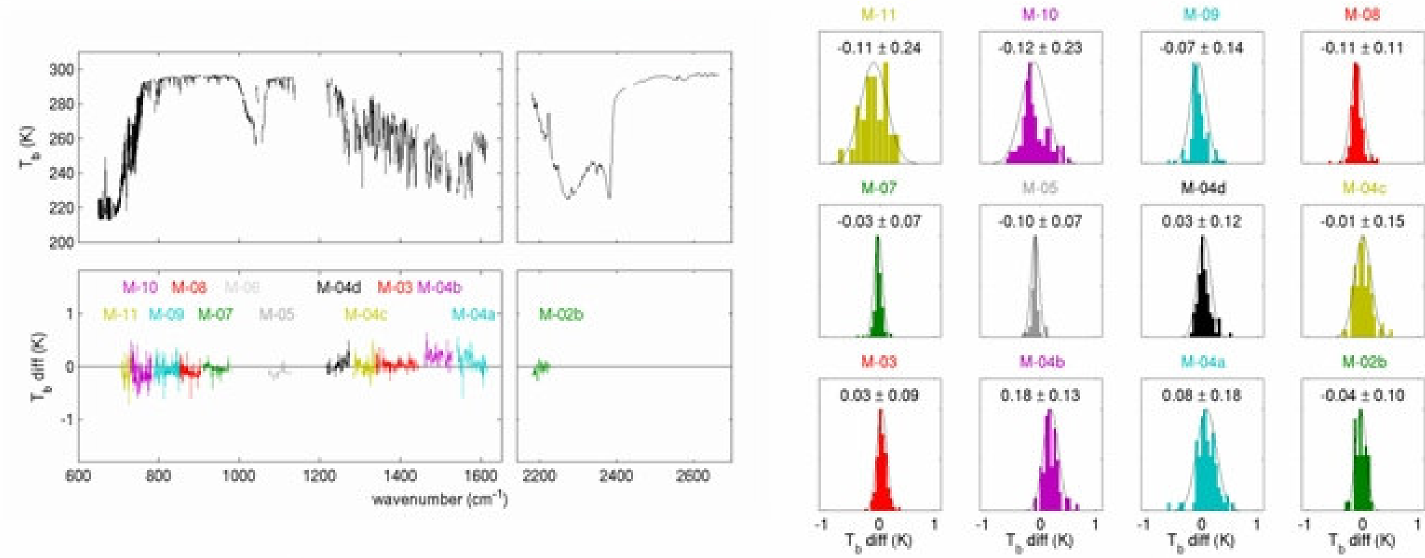
The SHIS absolute calibration is claimed to be good to 100 mK absolute (3 sigma).

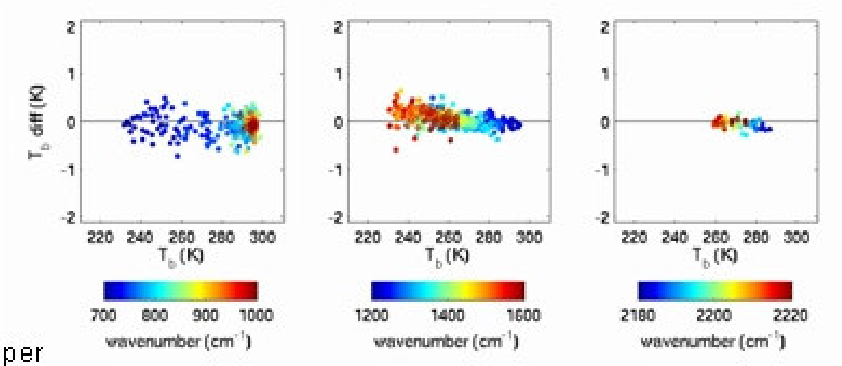
The SHIS-AIRS cancellation should be perfect for window channels, like 1231 cm-1.

But: We see differences of 300 mK at 1231 cm-1 between Nov 2002 and September 2004.

Tobin et. al 2006 SHIS-AIRS Validation Paper shows agreement at the 0.1K level

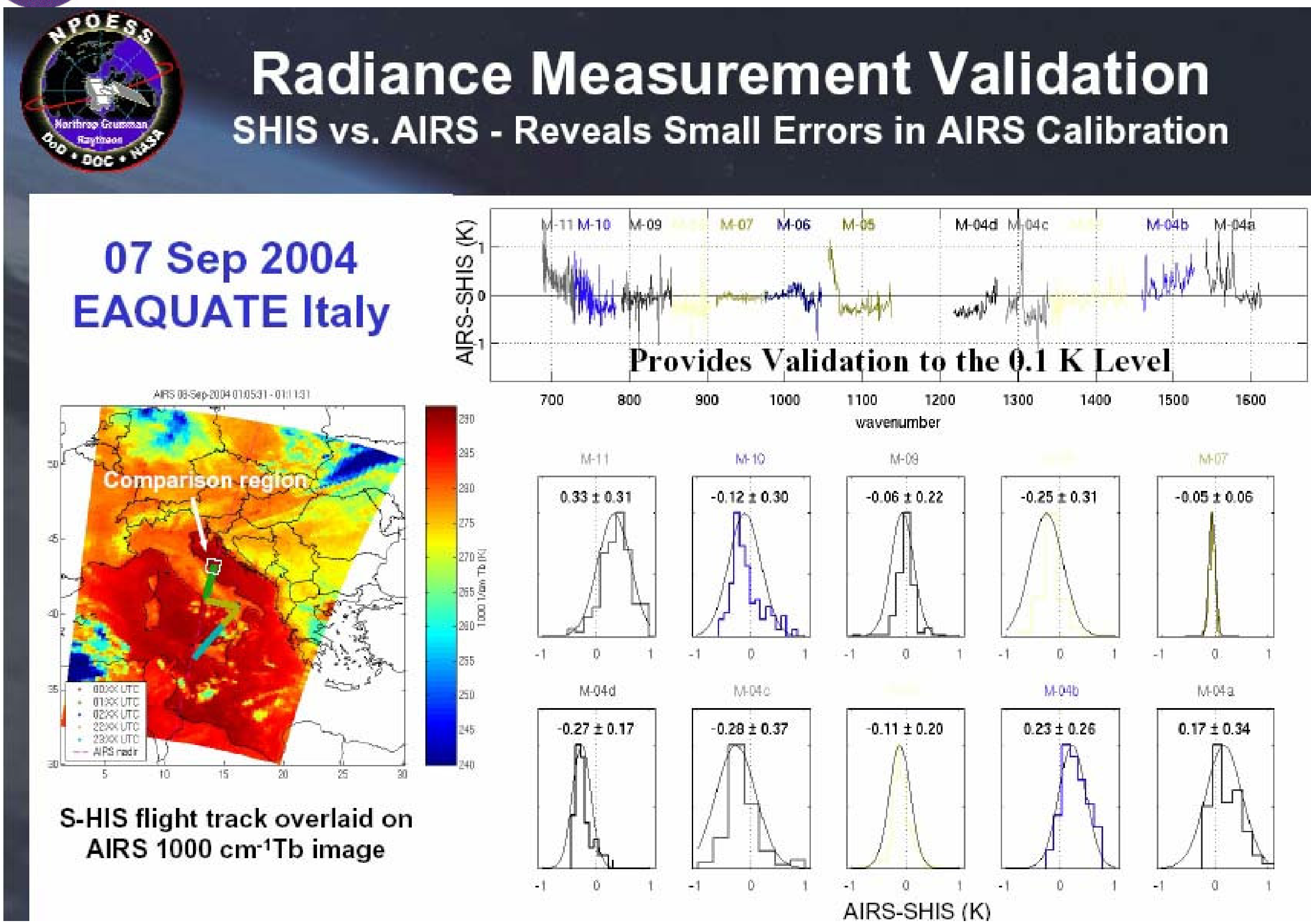
AIRS / S-HIS comparison, accounting for viewing geometry and spectral resolution/sampling differences and excluding channels with 1) significant contribution from above the aircraft altitude and 2) solar contribution.



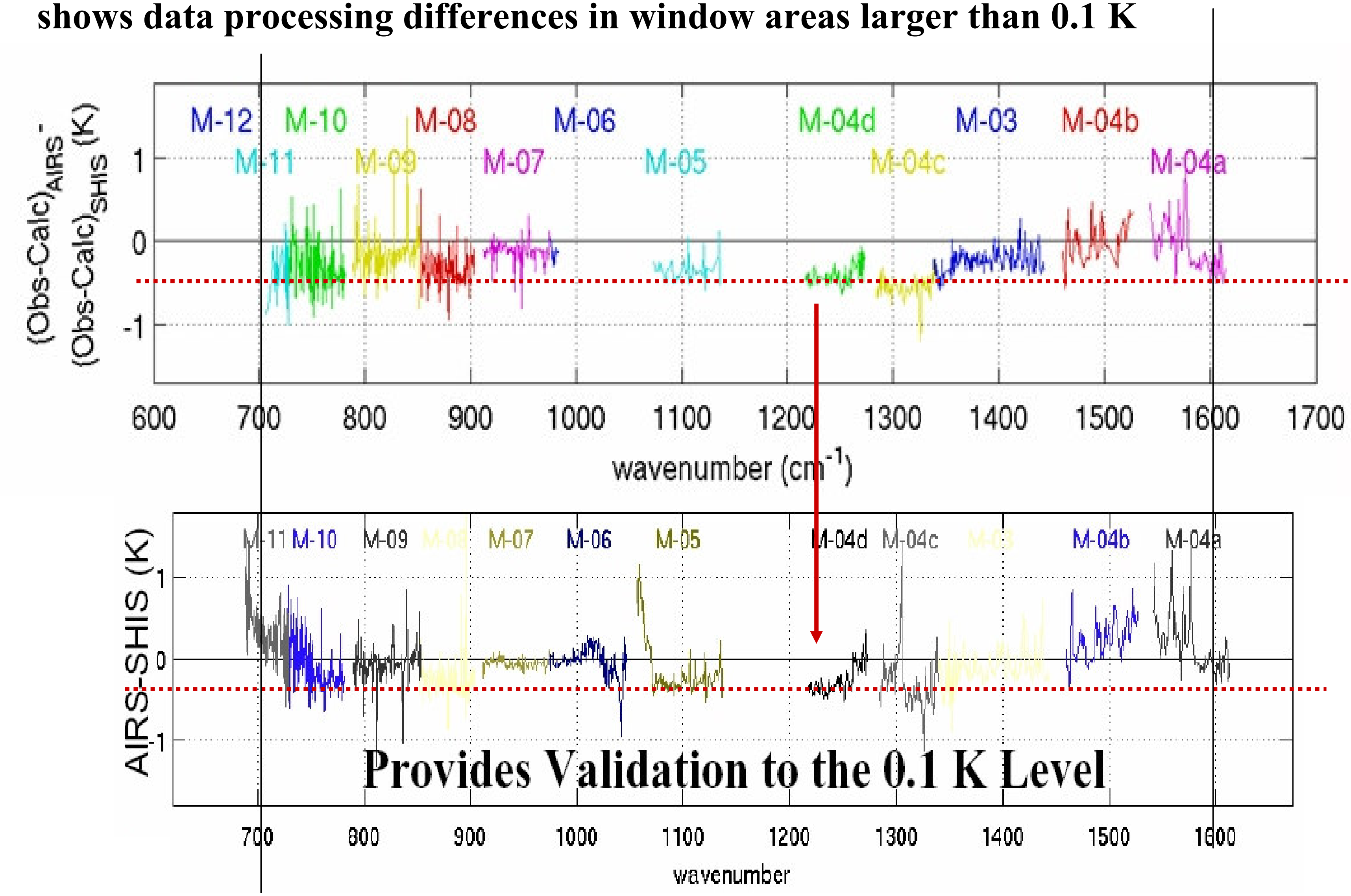


21 November 2002
Daytime Gulf of Mexico
Tobin et al. 2006
JGR AIRS Validation paper

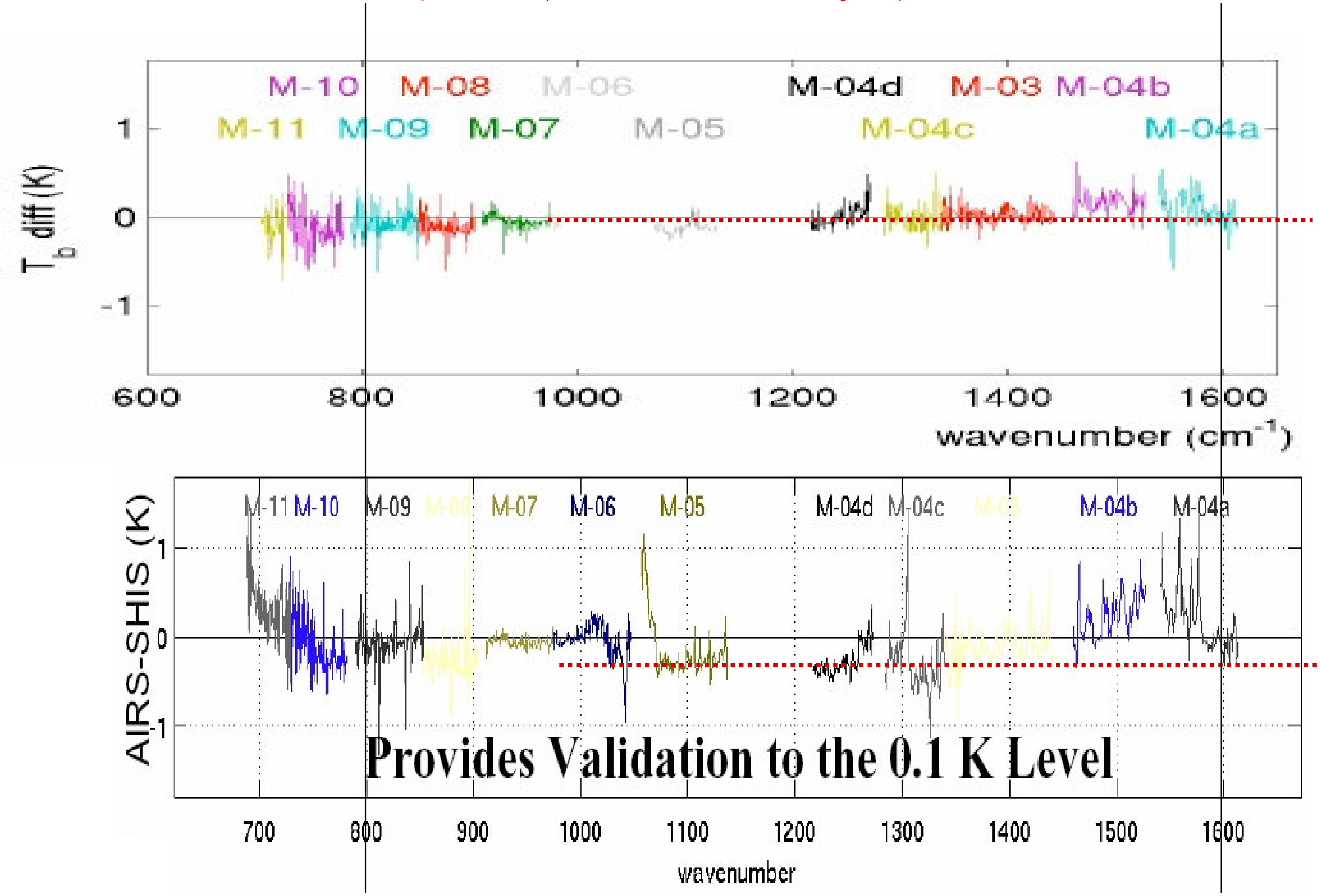
From Bill Smith's Atlanta January 2006 AMS Presentation



20040907 EAQUATE presented by Revercomb on 10 March 2006 (top) and Smith at the January 2006 AMS meeting in Atlanta (bottom) shows data processing differences in window areas larger than 0.1 K



Note the 0.3K shift from zero between 2002 Gulf of Mexico (top) and 2004 EAQUATE (bottom, Smith analysis) in M4d and M5 area



AIRS validation using two years of (obs-calc)

George Aumann
Jet Propulsion Laboratory

and

Larrabee Strow
University of Maryland, Baltimore County

We analyzed (obs-calc) for 2 years of night clear ocean data from +/- 40 degree latitude. The mean(obs-calc) allows for the accurate assessment for the absolute calibration accuracy. The observed 200 mK for two years of data is consistent with the 200 mK obtained for SHIS in November 2002. The stdev(obs-calc) for channel where ECMWF is reliable agrees well with the NeDT reported by the Level 1b.assimilation process. The stability of the measurement, evaluated use the difference between 1st year and 2nd year mean values is better than 50 mK in those channels not sensitive to changes at ECMWF.