AIRS Radiance Validation Over Ocean from Sea Surface Temperature Measurements

EOS Aqua TGRS-IEEE Paper

Denise Hagan and Peter Minnett

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Goal of Validation Exercise:

- Establish confidence in behavior of sensor and confirm absence of gross, critical problems with instrument performance

- Confidence must be established early on to meet requirement for redelivery of L1B radiance software to NASA launch plus 7 months

Focus of Paper:

- Demonstrate accuracy of methods and in situ SST data for early validation of AIRS L1B calibrated radiances
- Compare AIRS "window" channel radiances, 'adjusted' to the surface', with high accuracy ocean sea surface temperature measurements

Why Use AIRS Window Channels Over Ocean?

- Window regions void of large gas absorption lines, less sensitive to error in spectral wavelength assignment

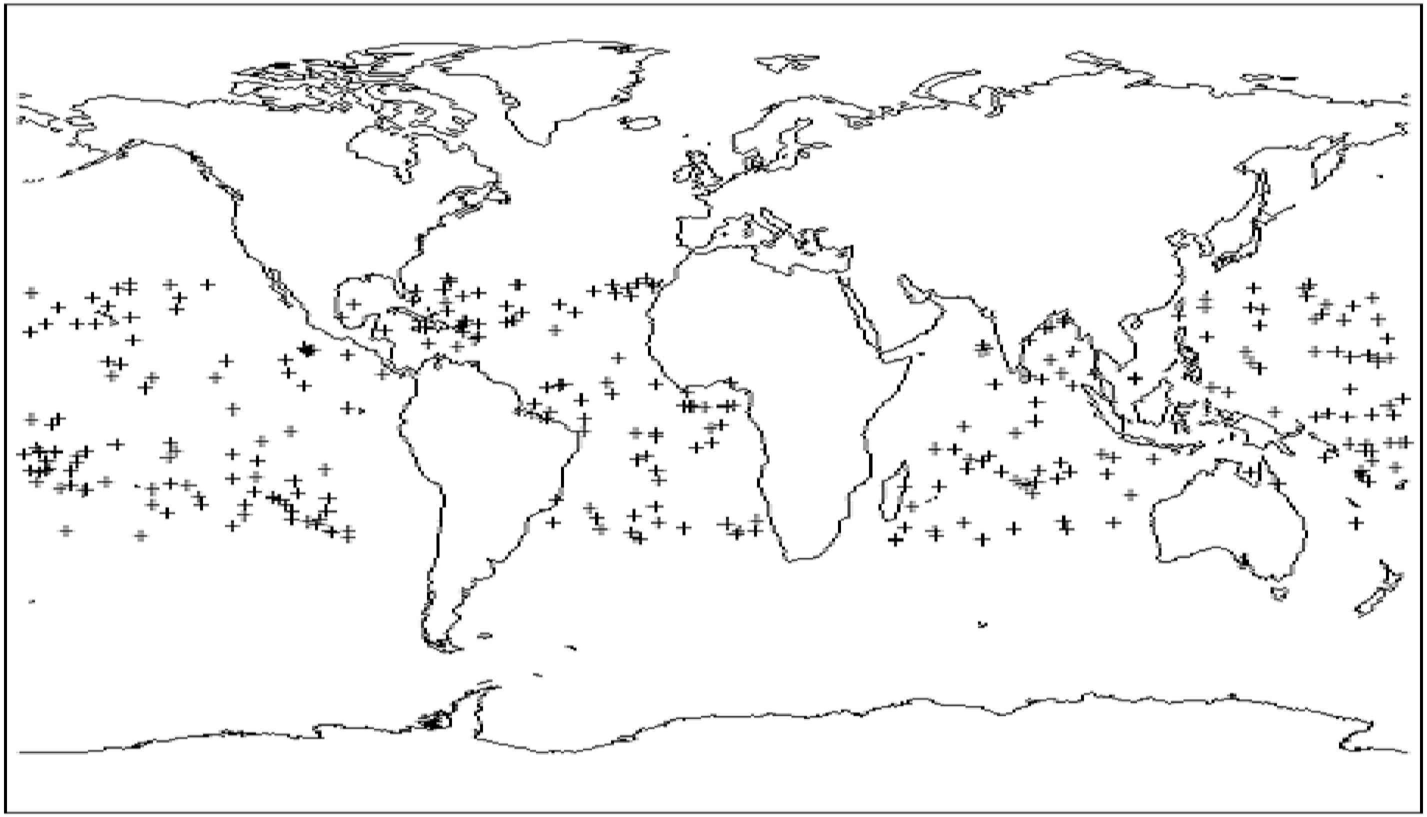
- Ocean surface emission near unity; large regions uniform in temperature

AIRS Radiance Validation Over Ocean from Sea Surface Temperature Measurements

Types of SST Data Sources:

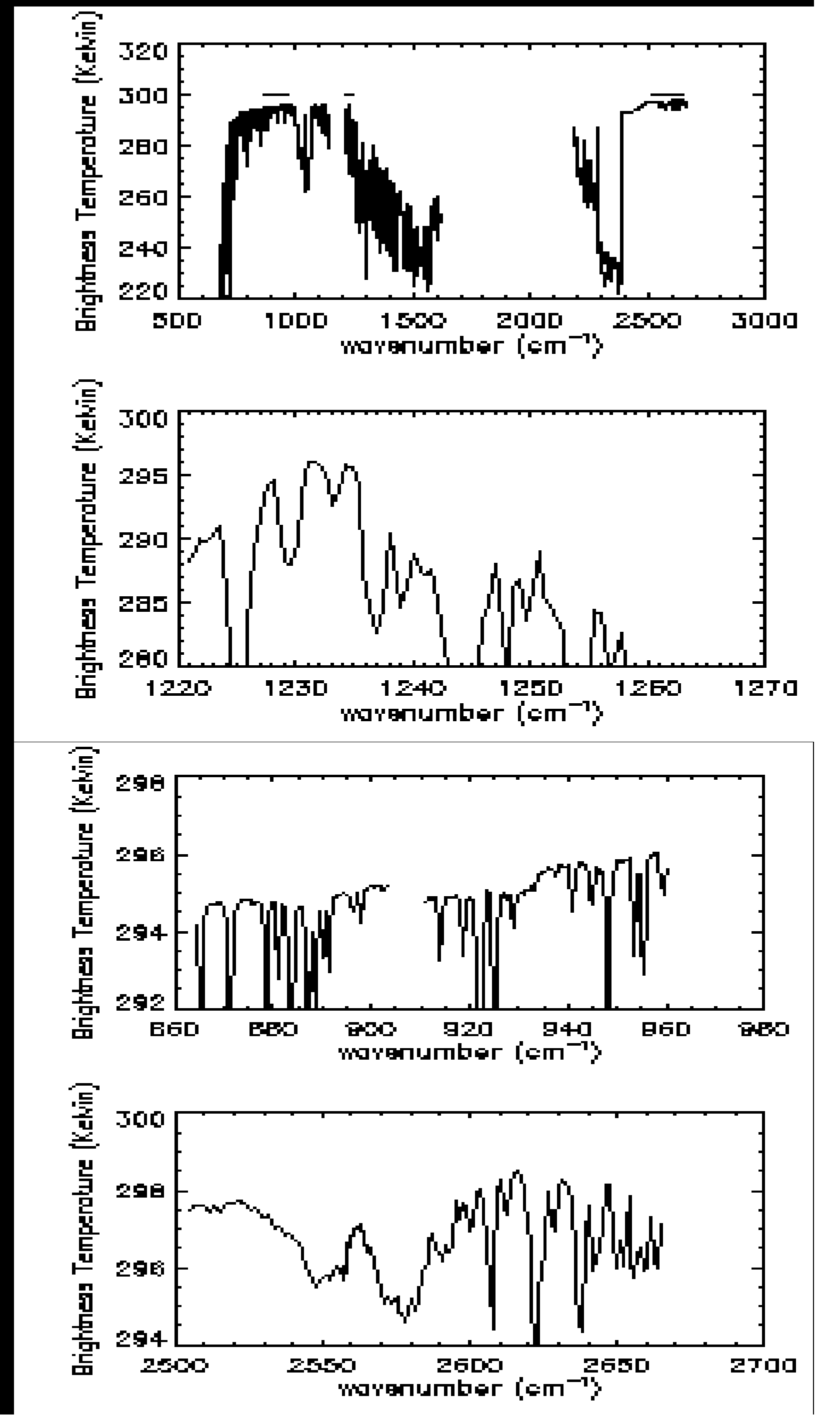
- Point Measurements: Drifting Buoy, Ship Radiometric, Ship Intake, Fixed Buoy
- Blended Satellite-In situ Mapped Products:
  Reynolds-Smith
  NCEP RTG-SST
- Satellite Mapped SST: TRMM Microwave Imager
  NCEP AVHRR
  AVHRR Pathfinder
  MODIS

- In situ buoys best currently available standard on a global scale
- Large percentage located in bulk latitudes



Window Channels

Spectral Wavelength (cm^{-1})	NEΔT per detector (at 250 K)	Absolute Accuracy (at 280K)
868	0.22	0.25
885	0.20	0.2
893	0.19	0.2
900	0.17	0.2
938	0.14	0.2
943	0.14	0.2
951	0.13	0.2
957	0.13	0.2
963	0.12	0.2
963	0.12	0.2
1232	0.11	0.1
1235	0.11	0.1
2522	0.31	0.1
2561	0.33	0.15
2616	0.33	0.2
2632	0.39	0.2
2646	0.40	0.2



Temperature Uncertainties (Kelvin) in Window Radiance Validation Method for Single Channel, Single Footprint

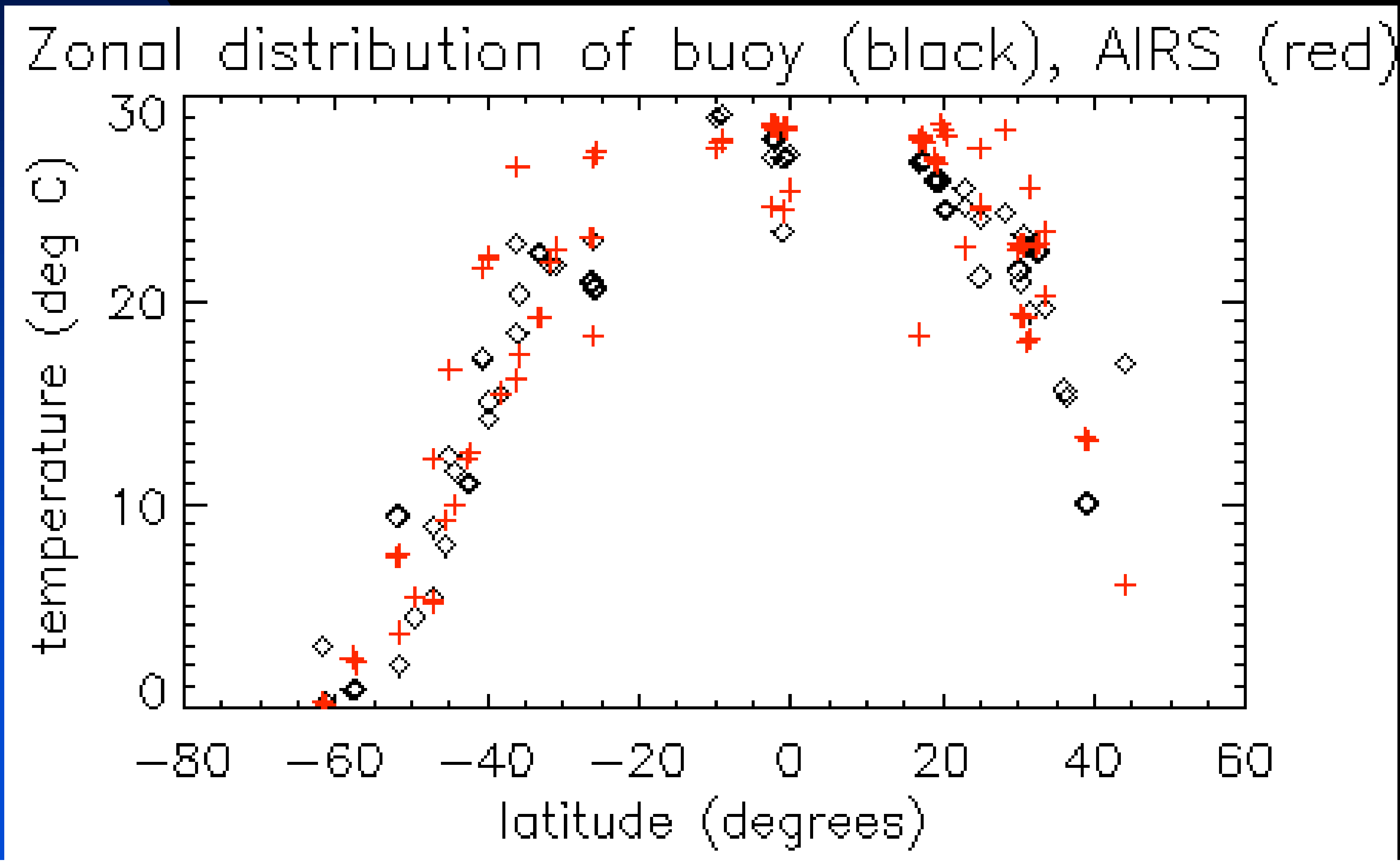
Spectral Wavelength (cm^{-1})	NE ΔT (at 250K) per detector	Absolute Accuracy (at 280 K)	From Surface Emissivity	From RTA Tropical	Drifting Buoy Accuracy	Cloud Filter Bias*	Surface Skin Effect
2616	0.33	0.2	0.011	0.2 0 .02 0.05	0.1	1.6	0.2
93 8	0.14	0.2	0.02	0.2 0.33 0.82	0.1	2.4	0.2

Excluding cloud uncertainty and RTA worst case, the total RSS uncertainty $\lesssim$ 0.5 Kelvin

*Bias for undetected cloud in 10% of FOV, radiating at 265K.

Comparison of AIRS simulated radiances at 2616 cm $^{-1}$, adjusted to surface, and drifting buoy SST observations for 12-15-00

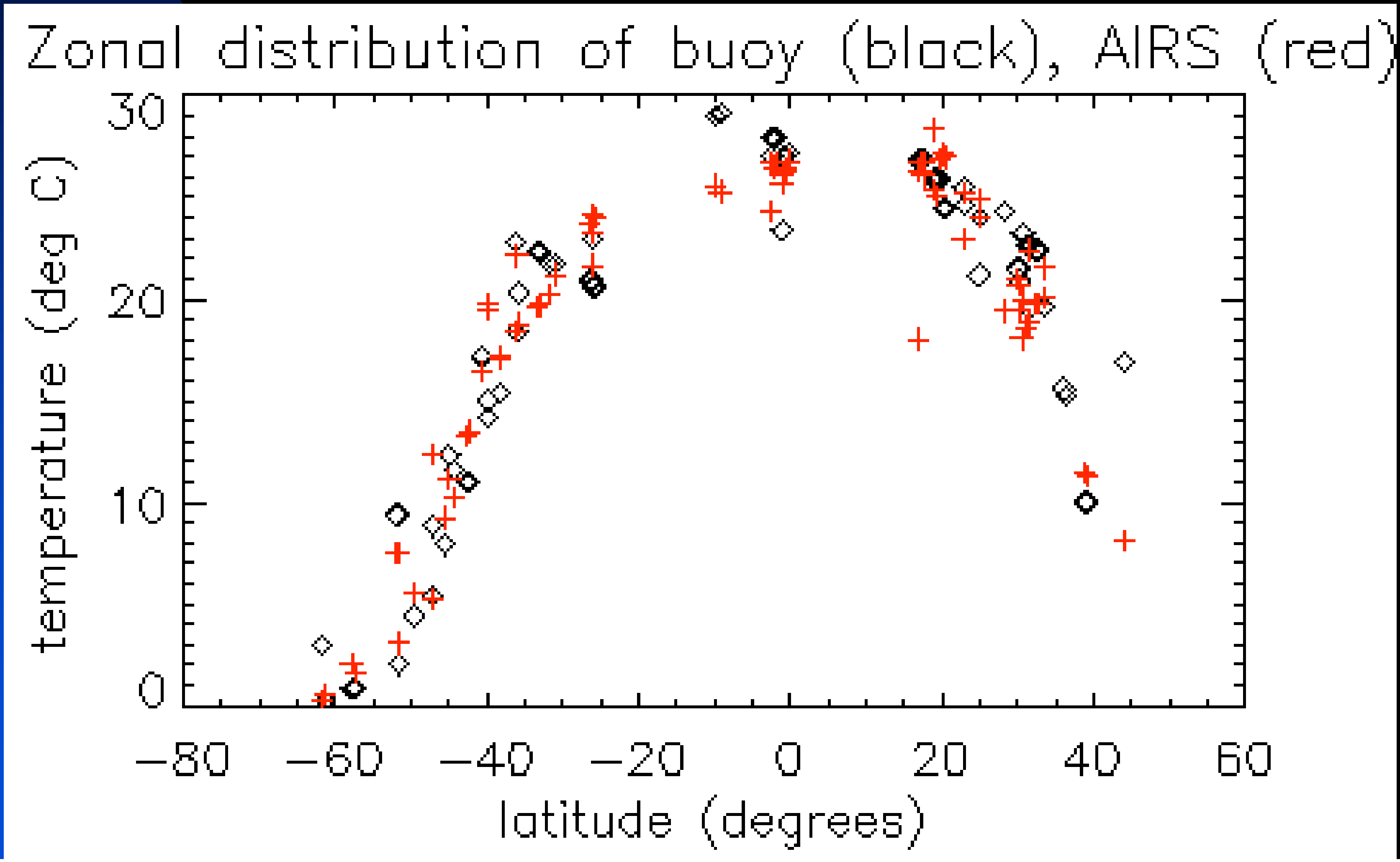
"Clear Sky" AIRS minus Buoy 0.25 $\pm$ 1.3 C N=74; Includes day and night observations; bias and rms improve with night only observation



Comparison of AIRS simulated radiances at 938 cm $^{-1}$, adjusted to surface, and drifting buoy SST observations for 12-15-00

"Clear Sky" AIRS minus Buoy 0.09 $\pm$ 1.44 C N=74

The RMS can be substantially reduced by eliminating obvious outliers

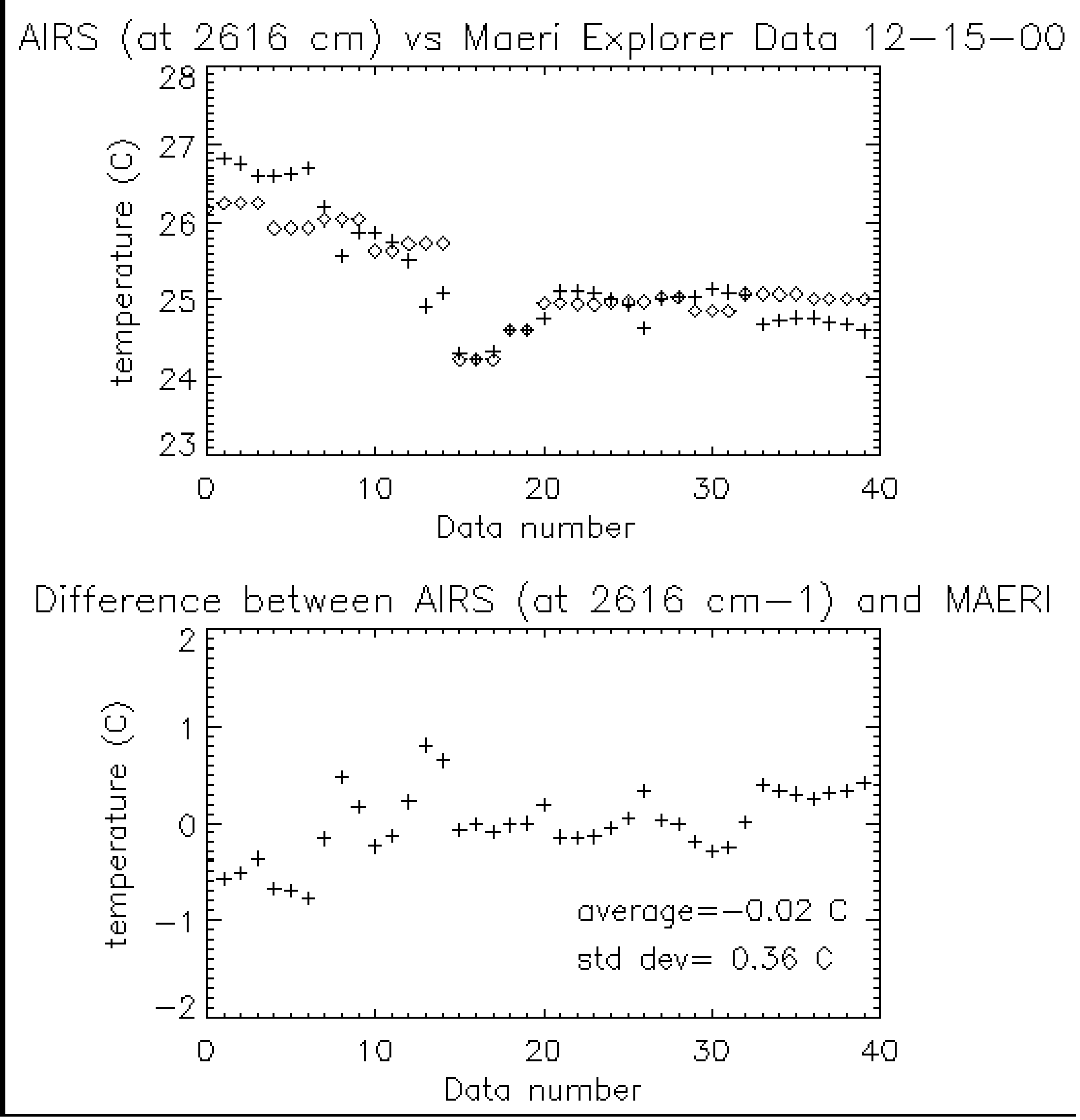


Shipboard radiometric data (MAERI), sparse but accurate in situ source

AIRS simulated window radiances minus MAERI

2616 cm $^{-1}$: -0.02 + 0.36 C

Clear-sky

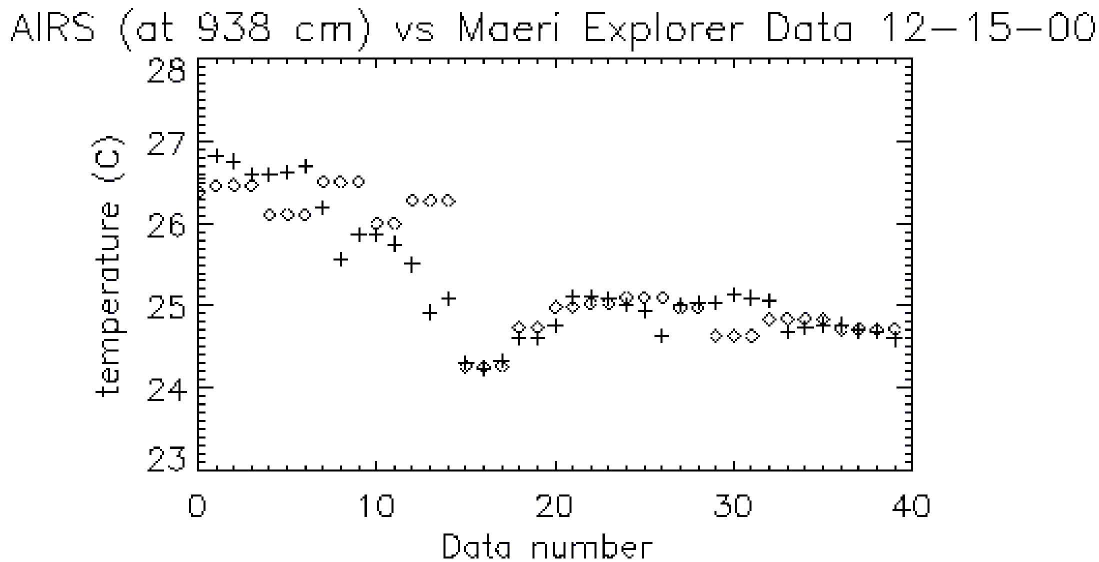


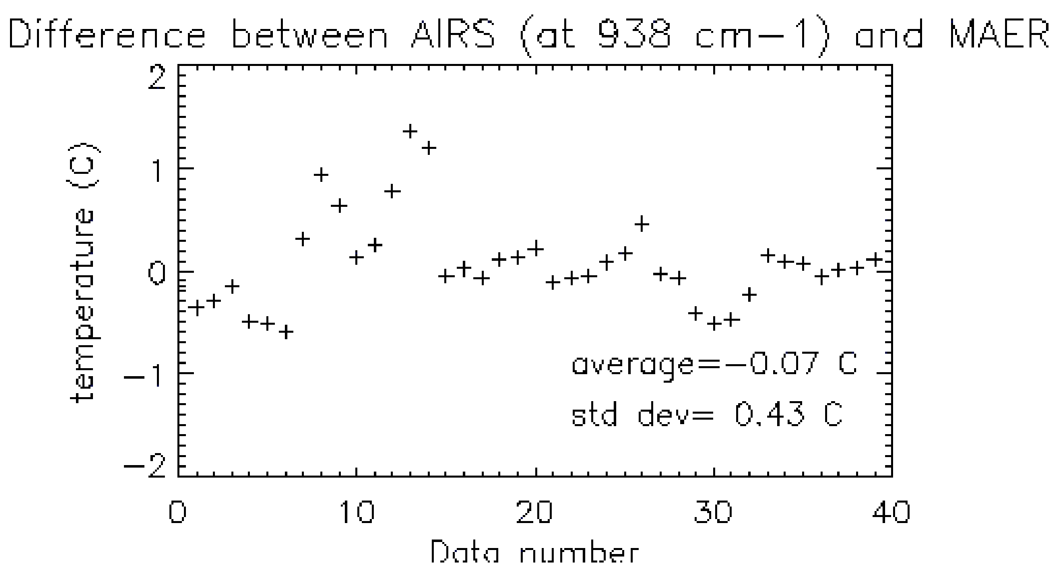
Shipboard radiometric data (MAERI), sparse but accurate in situ source

AIRS simulated window radiances minus MAERI

938 cm $^{-1}$: -0.07 + 0.43 C

Clear-sky





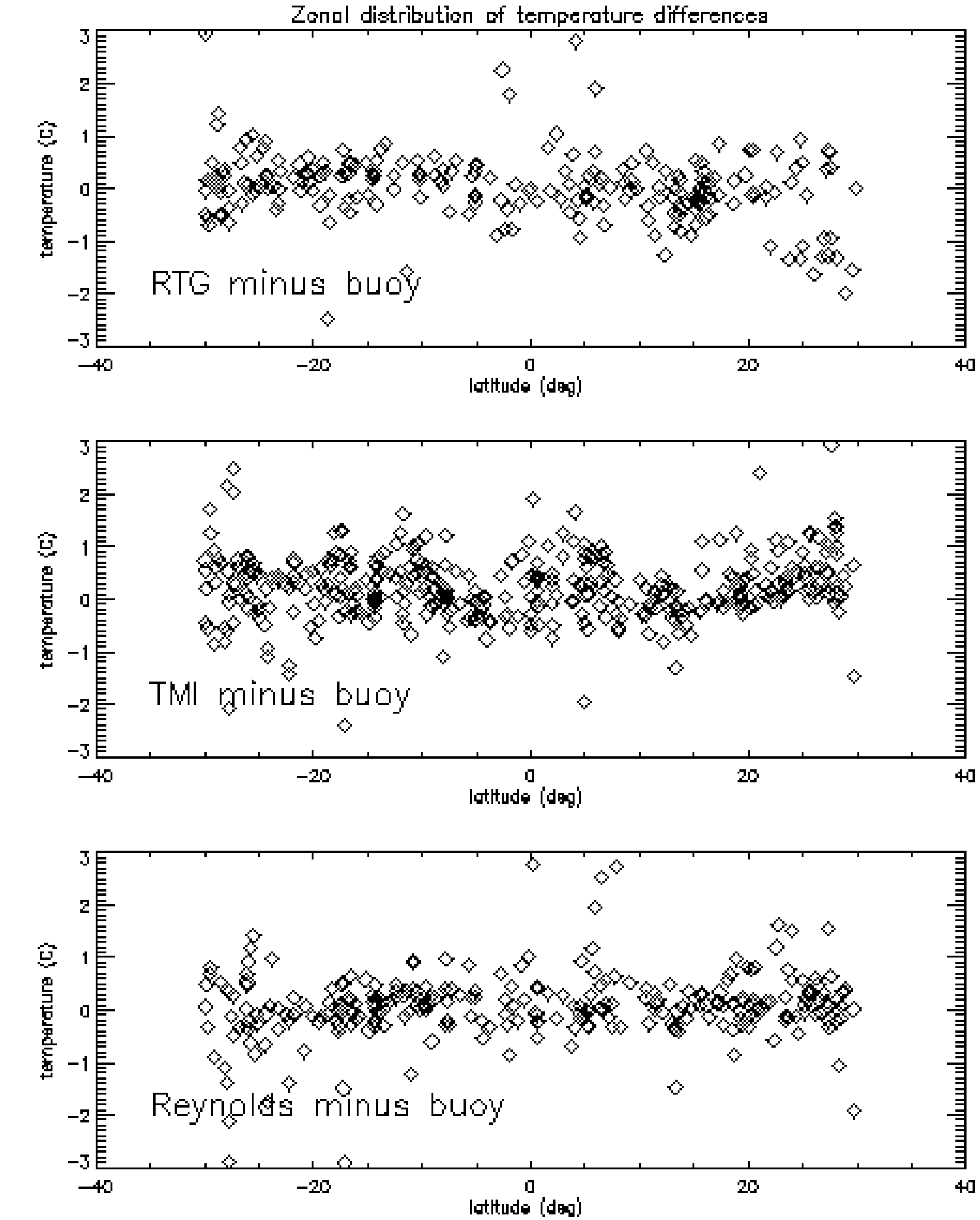
Matchup Comparisons between Drifting Buoys, Ship Radiometric Data (M-AERI) and Mapped SST Products:

Daily (12-15-00)	Kelvin (N=number of matchups)
SST-RTG minus buoy	0.04 ± 0.66 (N=236)
Reynolds minus buoy	0.08 ± 0.63 (N=294)
TMI minus buoy	0.23 ± 0.62 (N=424)
Multi-year	
AVHRR-buoy	0.02± 0.53 (N>12000)
AVHRR minus M-AERI	0.07± 0.31 (N=219)
MODIS minus M-AERI	0.20 ± 0.26 (N=242)

*Bias and standard deviation determined for 12-15-00. Data sets filtered to remove large outliers.

Dispersion of data for SST surface analysis products relative to drifting buoys

single day, bulk latitudes

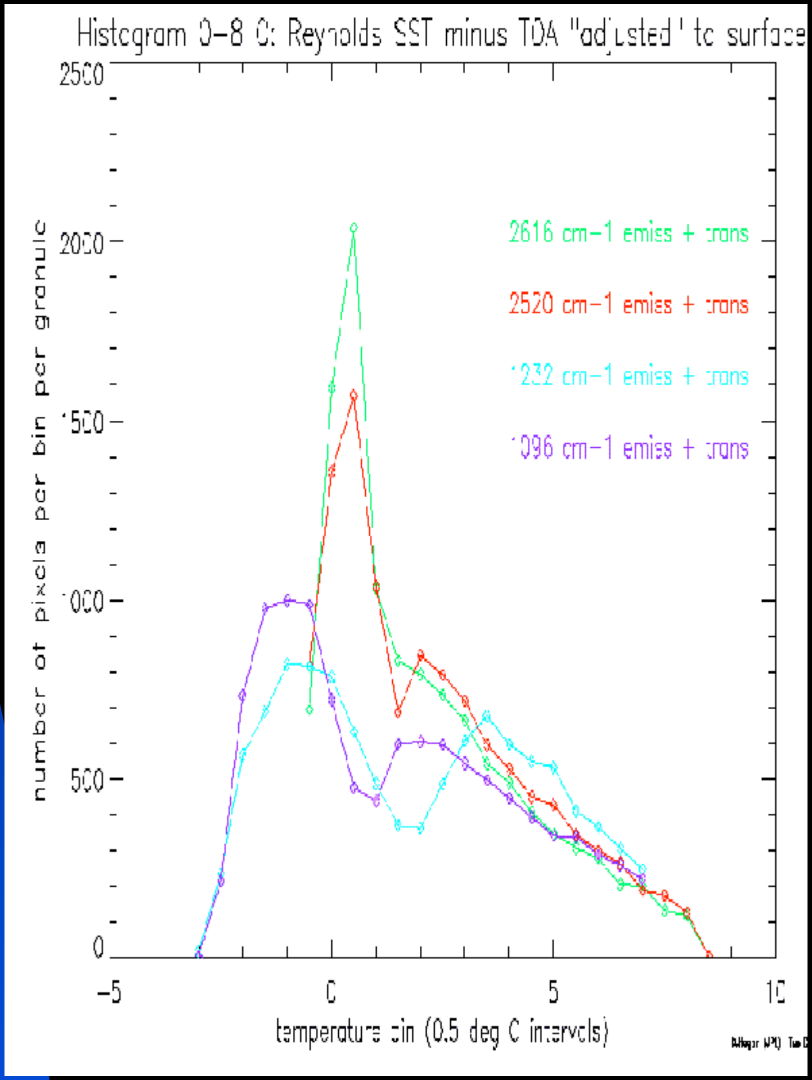


SST mapped products used early on when point measurements too sparse. Bridging approach

Difference statistics per granule (eg. 12150 AIRS footprints minus interpolated SST product) show distinct modes in short wave regions

Histograms of "clear sky" regions show small bias, especially at 2616 cm^{-1}

Reynold's product minus AIRS brightness temperatures for one test granule (12150 footprints) and partly cloudy conditions



Summary

- During early mission operations, accuracy of AIRS calibrated window radiances, based on single channel, single footprint match-up comparisons, can be determined to within about 1% accuracy (equivalent to 0.5 K in brightness temperature, at 300 K and 938 cm^{-1}) using a combination of in situ and mapped SST products
- Validation begins with night only comparisons using mapped SST products (30-60 days) and proceeds to more accurate comparisons in seventeen short and longwave window channels using ship and drifter data.

Summary continued

- To demonstrate the residual uncertainties, techniques have been applied to surface marine data for December 15, 2000, and to simulated AIRS radiances.
- Simulated top-of-atmosphere radiances were adjusted for deficits in brightness temperature related to atmospheric continuum absorption and surface emission, and then differenced from SST observations.
- Point measurements show biases close to the desired calibration accuracy; dispersion of global drifting buoy higher than regional ship radiometric for one simulated comparison day.