

The Validation of AIRS Retrievals

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Abstract

The initial validation of Atmospheric Infrared Sounder (AIRS) experiment retrievals was completed in August 2003 as part of public release of version 3.0 data. The associated analyses are reported at <http://daac.gsfc.nasa.gov/atmodyn/airs/>, where data may be accessed. Here we describe some of those analyses, with an emphasis on cloud cleared radiances, atmospheric temperature profiles, sea surface temperature, total water vapor and atmospheric water vapor profiles. The results are applicable over ocean in the latitude band ± 40 degrees.

Cloud Cleared Radiances

Cloud cleared radiances were validated by comparison with simulated radiances from the European Center for Mediumrange Weather Forecasting (ECMWF) forecasts. Figure 1 shows the mean radiances and difference statistics for retrieved cloud fractions of 40-50% for

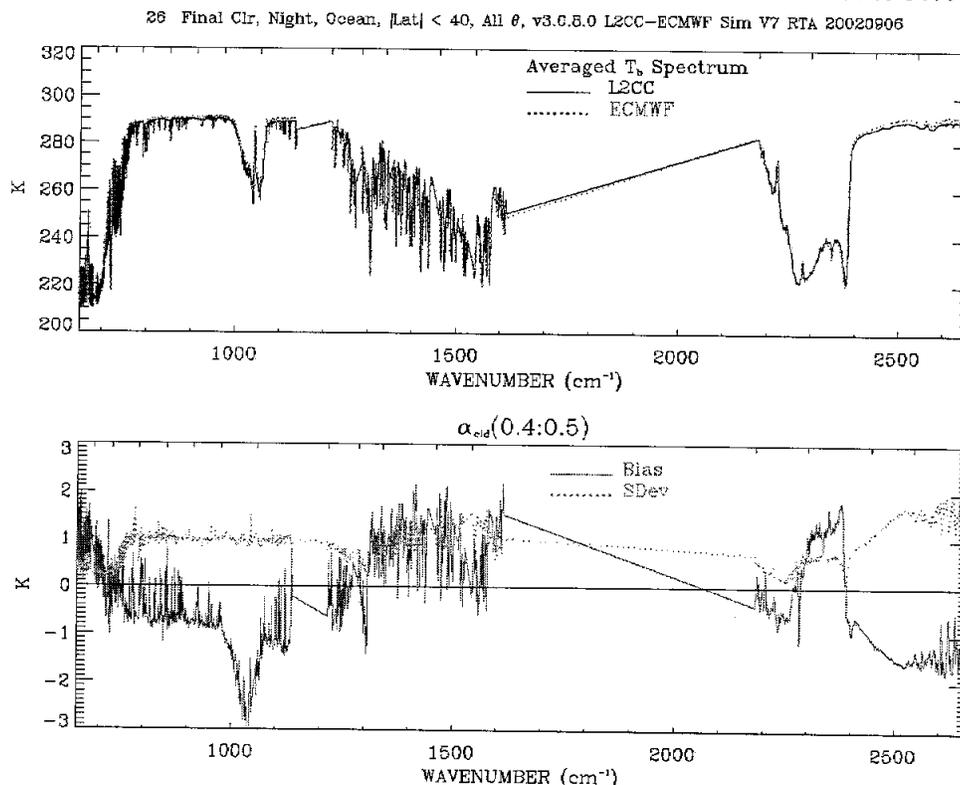


Figure 1. Mean spectra of AIRS cloud-cleared radiances and ECMWF-modeled spectra (upper panel), and statistics of differences for retrieved cloud fraction of 40-50% (lower panel), 6 September 2002.

September 6, 2002. Brightness temperature differences are as large as 2 K, especially in the water vapor channels (around 1500 wavenumbers) are apparent. Efforts are ongoing to determine whether the differences are due to AIRS retrievals or to model representation, particularly water vapor. Errors exceed 3-5 K for retrieved cloud fractions of 60-70% suggest a fundamental limit to cloud clearing applicability.

Sea Surface Temperature

Sea surface temperatures (SST) were validated against three data sets: the European Center for ECMWF analyses, operational buoys, and a shipborne radiometer. Differences with ECMWF are $-0.8 \text{ K} \pm 1.0 \text{ K}$. Differences against buoys are $-0.8 \text{ K} \pm 1.1 \text{ K}$. Both results are skewed by rejection of retrievals deviating from National Centers for Environmental Prediction (NCEP) forecast SST by more than 3 K. SST comparisons with a ship-borne radiometer are $-0.85 \pm 1.2 \text{ K}$, and these are not based on rejected retrievals. The time series of differences between AIRS retrieved and radiometer observed SST are shown in Fig. 2.

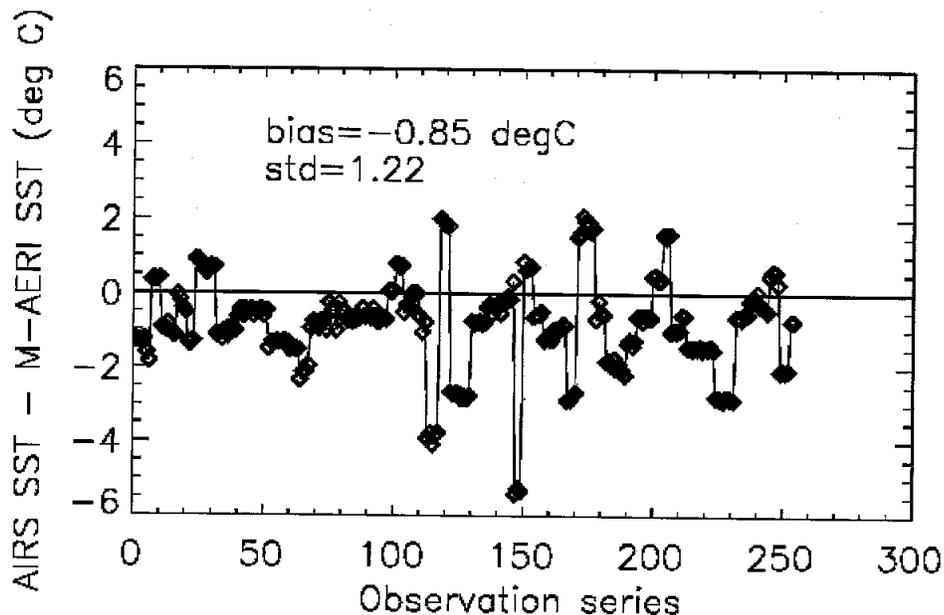


Figure 2. Difference between AIRS retrieved SST and SST observed by the Marine-Atmospheric Emitted Radiance Interferometer onboard the *Explorer of the Seas* cruise ship.

Temperature Profiles

Temperatures were validated against the ECMWF model and operational and dedicated radiosondes. Figure 2 shows the profile of RMS temperature differences compared with the ECMWF model. Results are similar for operational and dedicated radiosondes. These results are also based on a rejection by a 3 K SST difference with the NCEP forecast SST. Similar values are seen for differences based on cloud fractions of 50% or less, without resorting to comparison with NCEP SST.

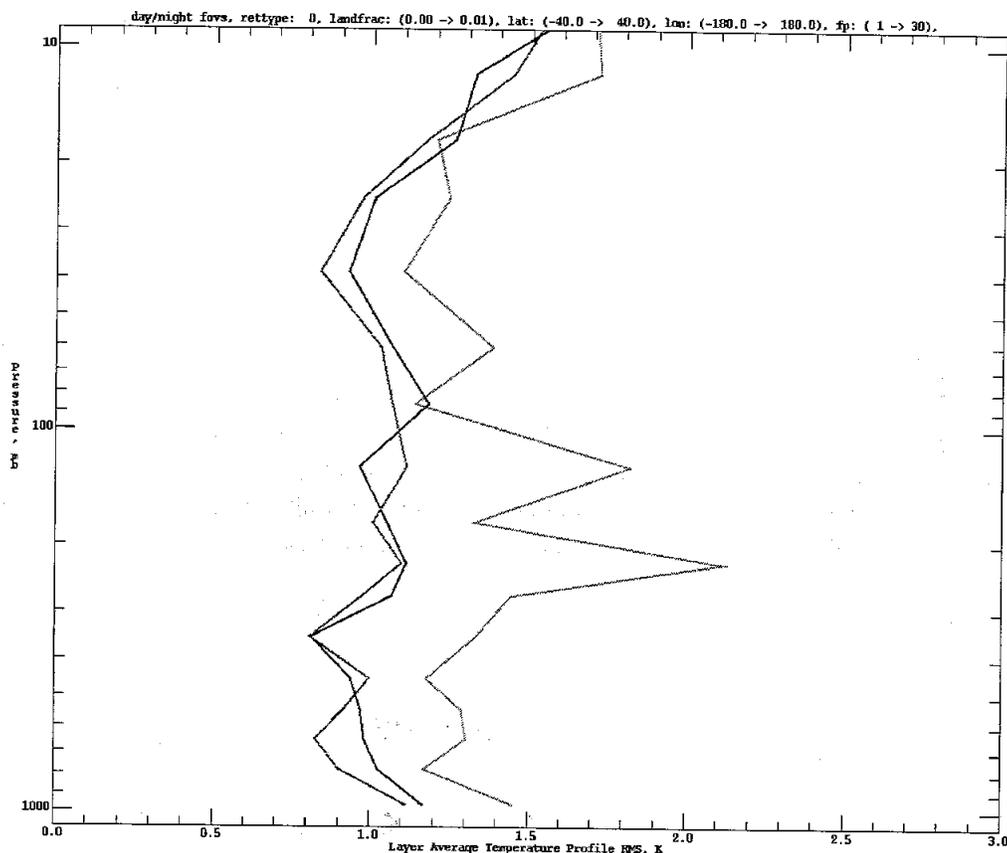


Figure 3. Root-mean-squared differences between AIRS retrieved and ECMWF temperatures in one-kilometer thick layers. Green is microwave-only retrievals, blue is regression retrievals, and red is infrared retrievals.

Total Water Vapor

Total water vapor retrievals were compared against ECMWF, and operational and dedicated radiosondes. These results are summarized in Table 1. Note that the biases are 2% or smaller at every location except Nauru, the location of the Atmospheric Radiation Measurement Program Tropical Western Pacific (ARM TWP) site. Nauru has some of the highest water vapor loading in the atmosphere, up to 80 mm, and the discrepancy is due to a slight

Data source	Relative Bias, percent	Relative RMS, percent
ECMWF analyses	0.01	16.2
Operational sondes	1.9	13.7
Dedicated Sondes, Chesapeake Platform	-0.1	10.6
Dedicate Sondes, Nauru (ARM TWP)	-10.0	11.4

Table 1. Differences in total water vapor for several data sets.

misrepresentation of the water vapor continuum in the forward radiative transfer model contained in the AIRS retrieval software. (Continuum characteristics are very difficult to measure in the laboratory.) This has been corrected in the latest version of the forward model and the retrieval software. The infrequency of the very high water loading typical of Nauru is apparent in statistics for the other data sources. A scatterplot of total water vapor from the Chesapeake Light Platform is shown in Figure 4. The Platform is located 15 km off the mouth of Chesapeake Bay, and the sondes were launched during September and October 2003. The large dynamic range is due to a combination of geophysical variability and balloon that burst in the lower atmosphere

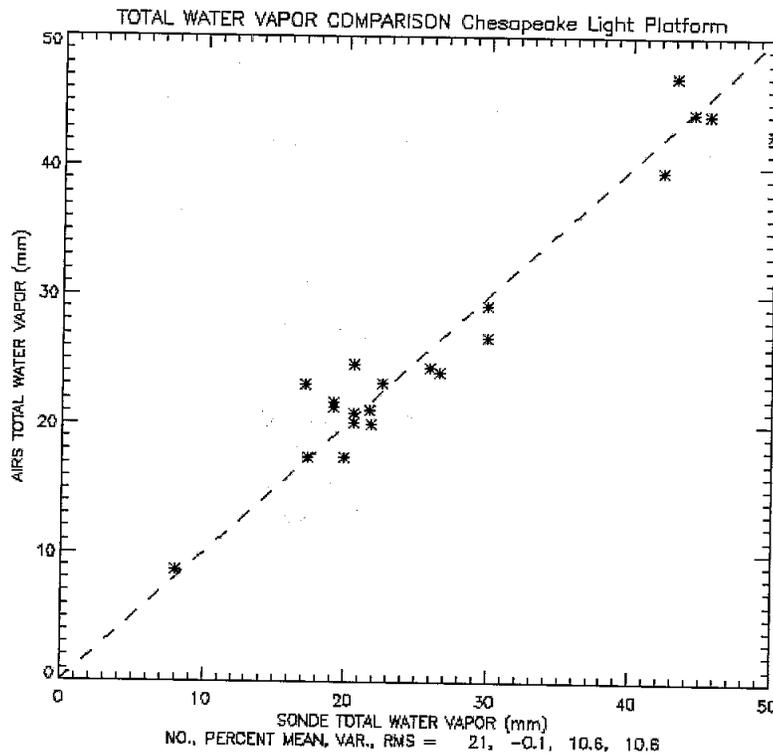


Figure 4. AIRS retrieved total water vapor versus radiosonde observations for dedicated sondes launched from the Chesapeake Light Platform.

Water Vapor Profile

Water vapor profiles were validated against the ECMWF model and operational radiosondes. The emphasis in this initial validation effort was on lower tropospheric water vapor. Table 2 shows the mean and variance of the differences between AIRS retrievals and the three data sources. The 1100 to 700 mean and variance are roughly consistent with the results for total water vapor shown above. The cause of the differences at upper levels is being investigated. They could have several causes, including model shortcomings, time and space disagreements between AIRS and dedicated sondes, known problems with sondes above 500 mb, and problems with the AIRS retrieval system. Identifying and correcting the latter is an active area of research for the AIRS science and validation teams.

Layer	ECMWF (%)	Operational Sondes (%)
1100 to 700 mb	-1.8 ± 9.6	3.6 ± 11.0
700 to 500 mb	-1.1 ± 31.2	0.0 ± 26.5
500 to 350 mb*	-12.5 ± 30.0	-3.7 ± 50.5

Table 1. Differences in layer averaged water vapor for several data sets.