

Results from CrIS/ATMS Obtained Using an AIRS "Version-6 like" Retrieval Algorithm

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Background

The AIRS Science Team Version 6 retrieval algorithm is currently producing very high quality level-3 Climate Data Records (CDRs) from AIRS that will be critical for understanding climate processes. CDRs are gridded level-3 products which include all cases passing AIRS Climate QC

AIRS CDRs should eventually cover the period September 2002 through at least 2020

CrIS/ATMS is the only scheduled follow on to AIRS/AMSU

The objective of this research is to generate a long term CrIS/ATMS level-3 data set that is consistent with that of AIRS/AMSU Version-6, or an improved version of it.

Research Plan

The AIRS Science Team has made significant improvements to AIRS Version-6 and plans to reprocess all AIRS data with AIRS Version-7 in the relatively near future. Research is continuing toward the development of AIRS Version-7. The current version is called AIRS Version-6.22. We have adapted AIRS Version-6.22 to run with CrIS/ATMS. AIRS Version-6.22 and CrIS Version-6.22 both run now at JPL. JPL plans to generate, in the relatively near future, many months in common of AIRS Version-6.22 and CrIS 6.22 data products, or possibly products using improved versions of each retrieval system. We will evaluate the results by comparison of monthly mean AIRS and CrIS products, and more significantly, their inter-annual differences and, eventually, anomaly time series.

Overview of AIRS/AMSU Version-6 Retrieval Methodology

AIRS Version 6 is a physically based retrieval system

Uses cloud cleared radiances $\hat{R}_i$ to determine the state vector X

$\hat{R}_i$ represents what AIRS would have seen in the absence of clouds

Basic steps

1) Generate a Neural-Net based initial guess X^0 using AIRS/AMSU observations R_i
2) Generate cloud clearing coefficients that provide $\hat{R}_i$ for all channels
3) Sequentially determine: T_s, $T(p)$, $q(p)$, $O_3(p)$, $CO(p)$, and $CH_4(p)$ using $\hat{R}_i$ in subsets of channels i selected for each step
   Finds state X such that $R_i(X)$ best match $\hat{R}_i$ where $R_i(X)$ is the computed radiance for state X
4) Derive cloud parameters such that $R_i\ (X^{CLD})$ best matches observed radiances R_i where X^{CLD} is the final state vector including cloud parameters
5) Compute Outgoing Longwave Radiation (OLR) using an OLR Radiative Transfer Algorithm in conjunction with X^{CLD}
6) Generate QC flags for all parameters
   QC=0 passes Data Assimilation QC; QC=1 passes Climate QC

Major Improvements in Version-6.22 Over Version-6

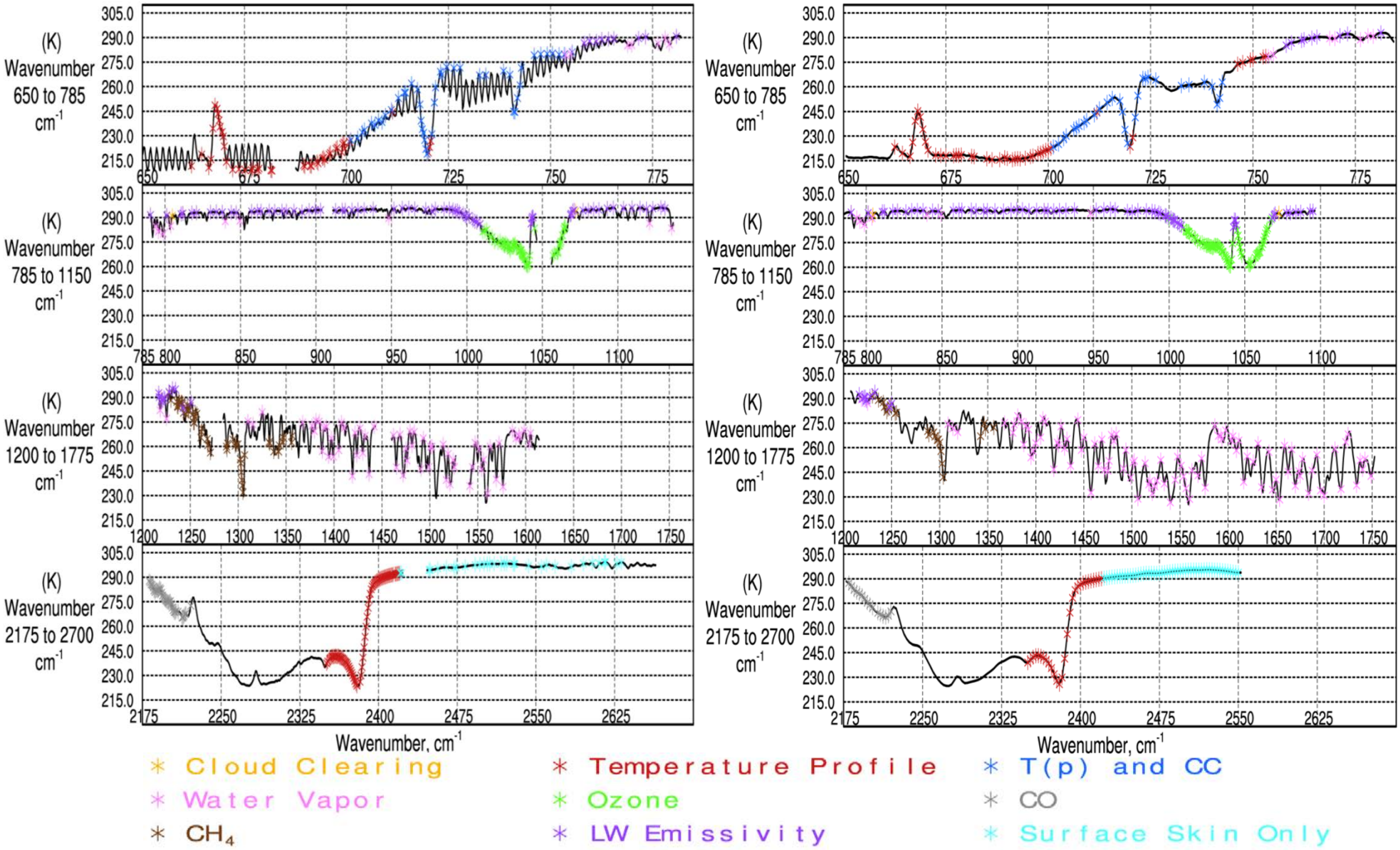
Version-6.22 is very much like Version-6 with some modifications in details. The major changes are given below.

- *$O_3(p)$* retrieval step uses many more channels and also simultaneously solves for surface spectral emissivity in the vicinity of the O_3 absorption band near 1000 cm^{-1}. Version-6.22 retrievals of *$O_3(p)$* have improved considerably compared to Version-6.
- *q(p)* retrieval step uses many more channels in Version-6.22 compared to Version-6 and also allows for changes from the *q(p)* first guess which have more vertical structure than Version-6, especially in the boundary layer. Version-6.22 retrievals of *q(p)* have improved considerably compared to Version-6.
- *T(p)* retrieval step now includes all tropospheric sounding CO_2 channels, but only if the cloud corrections made to the brightness temperatures of those channels are less than 5K. We also loosened the *T(p)* Data Assimilation (DA) QC thresholds to allow for more cases, while still keeping RMS errors of *T(p)* with QC=0 on the order of 1K or less.

Sample Cloud Free Brightness Temperature Spectrum

AIRS Version-6.22 Channels

CrIS Version-6.22 Channels



Sample AIRS and CrIS brightness temperature computed for cloud free scenes. The AIRS and CrIS channels we use in different steps in the retrieval process are indicated in the figures by different colored stars. AIRS is sampled twice as densely as CrIS.

CrIS/ATMS Neural-Net Coefficients

Like in AIRS Version-6, Version-6.22 uses Neural-Net methodology to generate the first guess $T^o(p)$, $q^o(p)$, and T^o_{surf} for each AIRS/AMSU or CrIS/ATMS (Field of Regard) FOR. The CrIS/ATMS Neural-Net coefficients were trained by Bill Blackwell and co-workers at Lincoln Labs using data on select time periods. These coefficients are then used on all time periods.

The CrIS Neural-Net coefficients were trained using CrIS/ATMS observations early in the NPP mission. CrIS and ATMS calibration procedures were modified in November 2013. The quality of CrIS/ATMS retrievals improved after this change, even though the Neural-Net coefficients began to produce a biased first guess. They will need retraining.

Bill Blackwell has indicated that he will generate new CrIS/ATMS Neural-Net coefficients trained on radiances using the newest CrIS/ATMS calibration procedures when they are finalized. In the meantime, we are using and evaluating results using the old Neural-Net coefficients.

Comparison of AIRS Version-6, AIRS Version-6.22, and CrIS Version-6.22 Results

The following results are shown for the single day, December 4, 2013. EOS Aqua and NPP orbits overlap closely on this day. This is important for comparison purposes to minimize time-of-day sampling differences. This day also occurs after the major upgrade in ATMS calibration procedures.

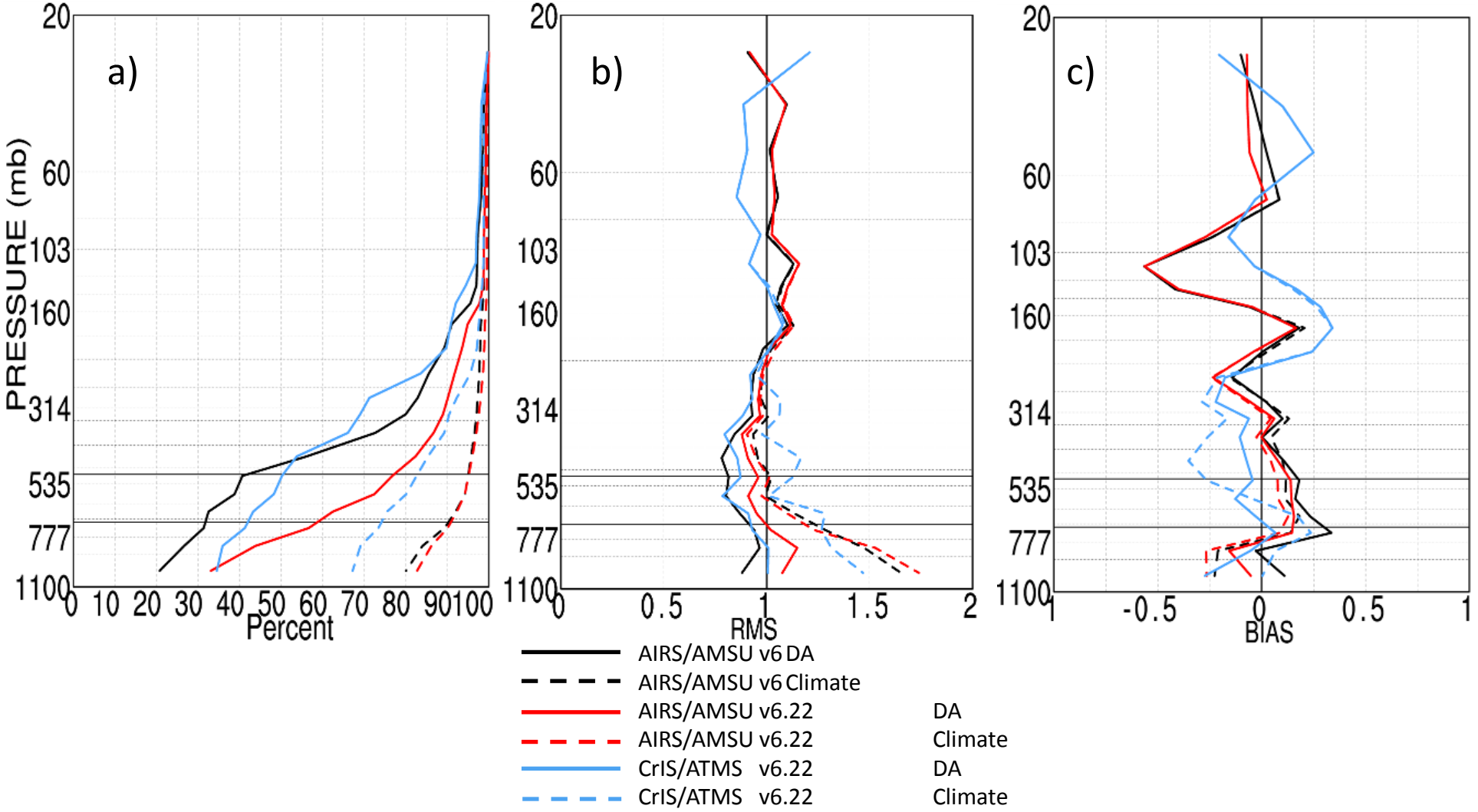
QC'd level-2 results are shown for all experiments in terms of yields, RMS errors, and biases compared to ECMWF for *T(p)*, *q(p),* and ocean surface skin temperature T_s.

In addition, AIRS Version-6, AIRS Version-6.22, and CrIS/ATMS Version-6.22 level-3 gridded fields are shown and compared to measures of truth for total O_3 burden and total precipitable water W_{tot}. AIRS and CrIS results using Version-6.22 are significantly improved compared to Version-6 for both water vapor and ozone products.

Finally, daily fields of other select products of Version-6.22 AIRS and Version-6.22 CrIS are compared and show good agreement with each other, especially over ocean.

December 4, 2013 Global Statistics

Percent of all Cases Accepted 1km Layer Mean Temperature (K) RMS Differences From ECMWF 1km Layer Mean Temperature (K) Bias Differences From ECMWF



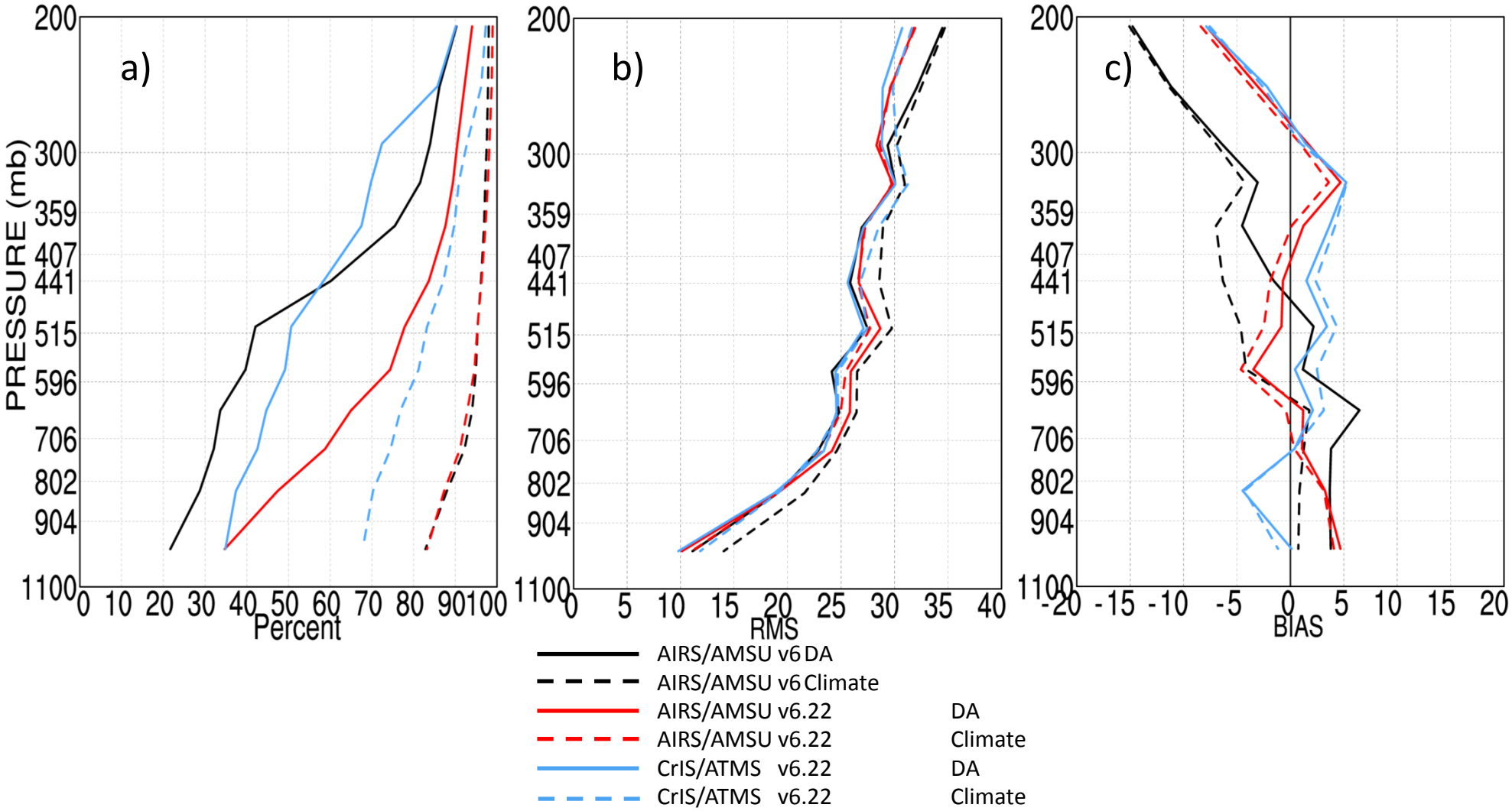
Global QC'd 1 km layer mean temperature profile statistics for December 4, 2013 for different retrievals and different QC thresholds. CrIS results use both the AIRS Version-6.22 DA and Climate thresholds. CrIS results using DA QC has a lower yield than AIRS Version-6.22 with smaller errors, as expected. CrIS results with Climate QC has a lower yield and larger errors than AIRS, possibly indicative of poorer performance in cloudier scenes than AIRS.

December 4, 2013 Global Statistics

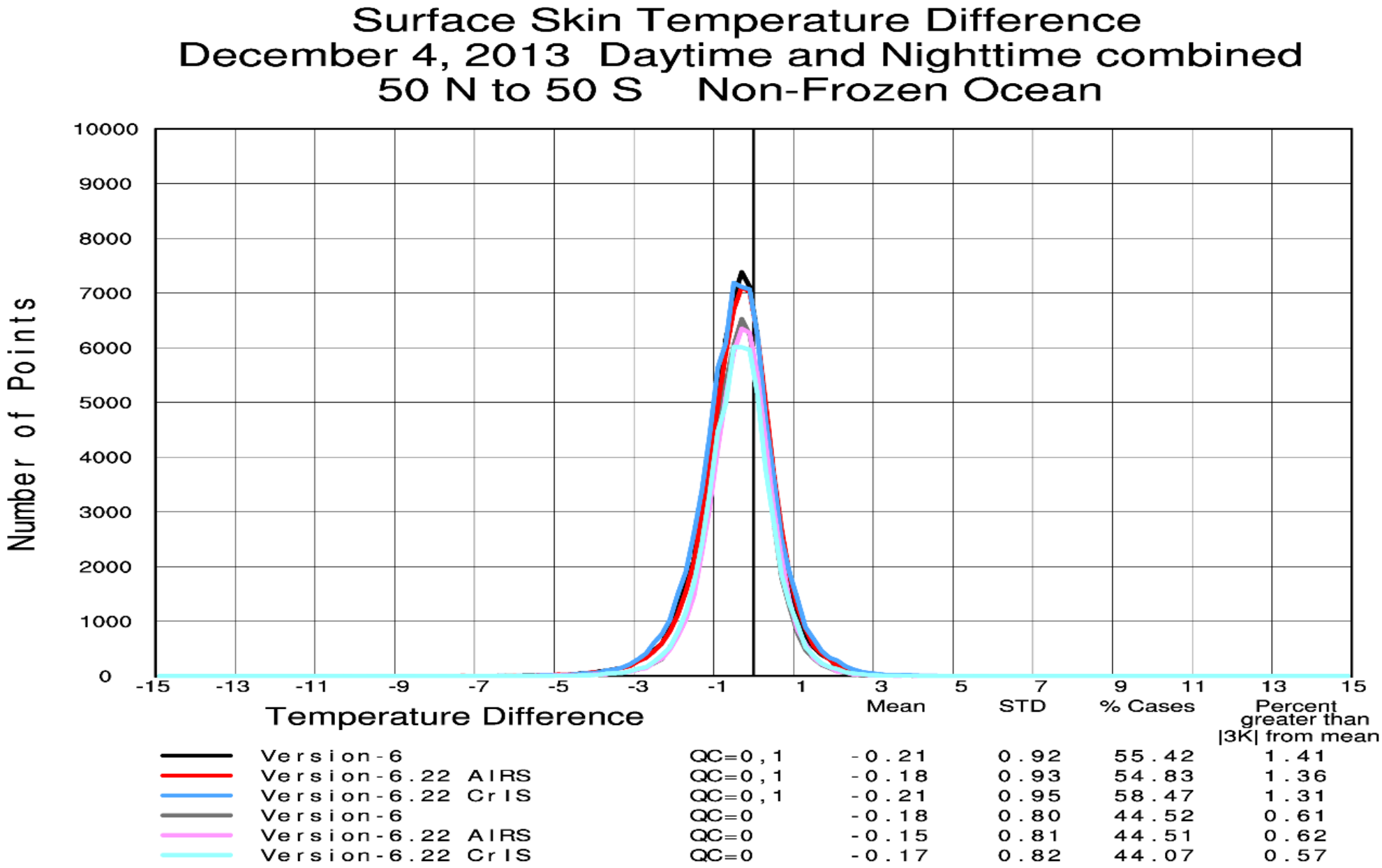
Percent of all Cases Accepted

1km Layer Precipitable Water RMS % Differences From ECMWF

1km Layer Precipitable Water Bias % Differences From ECMWF



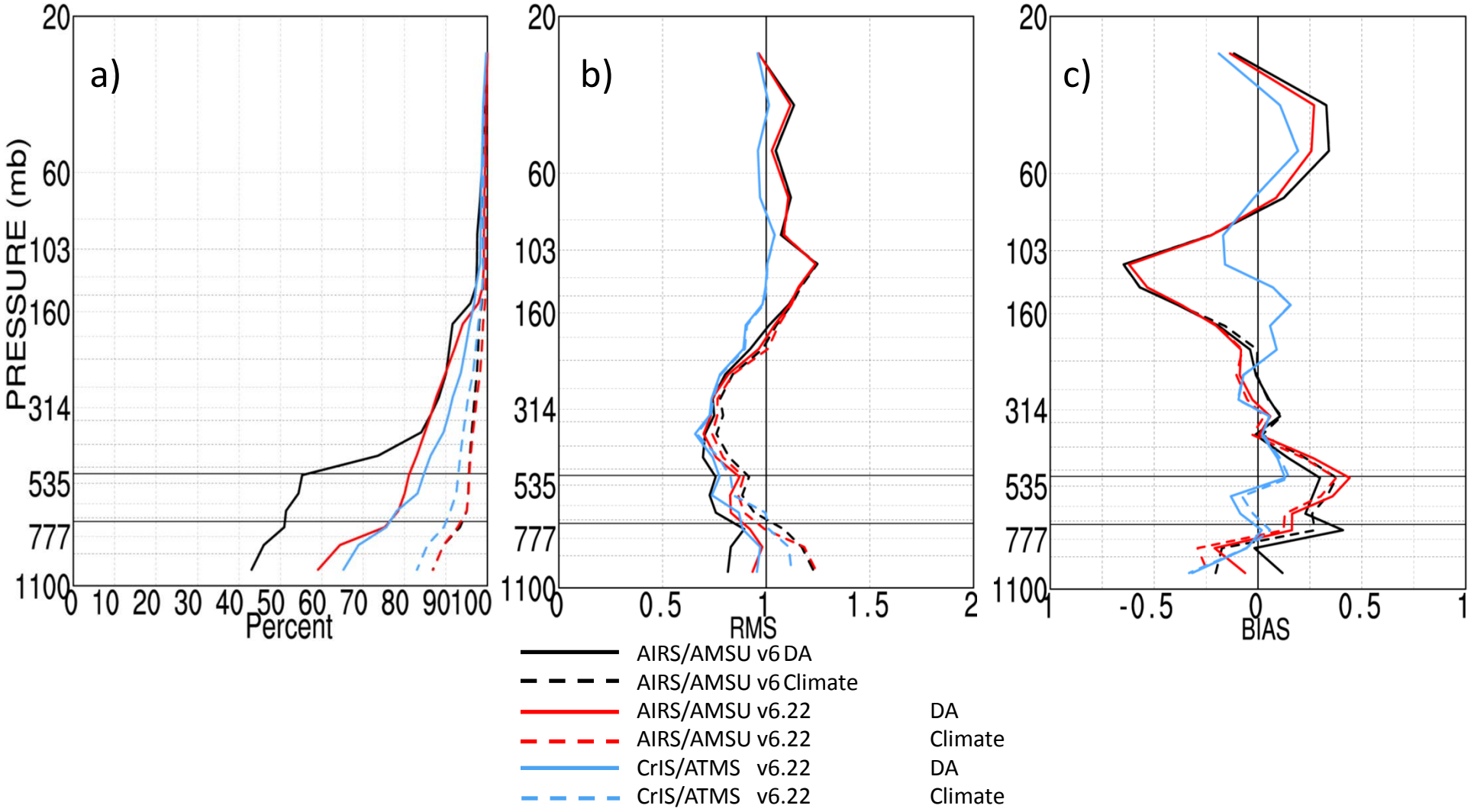
Global QC'd 1 km layer precipitable water profile statistics for December 4, 2013 for different retrievals and different QC thresholds. AIRS and CrIS Version-6.22 results are both superior to those of AIRS Version-6 with regard to both RMS errors and biases, especially with Climate QC.



Counts of QC'd values as a function of errors of AIRS Version-6, AIRS Version-6.22 and CrIS Version-6.22 sea surface temperatures using both DA (QC=0) and Climate (QC=0,1) QC thresholds. All three sets of results are excellent and are comparable quality with each other. CrIS SW spectral coverage truncated at 2550 cm^{-1} does not degrade ocean SST.

December 4, 2013 50°N to 50°S Ocean

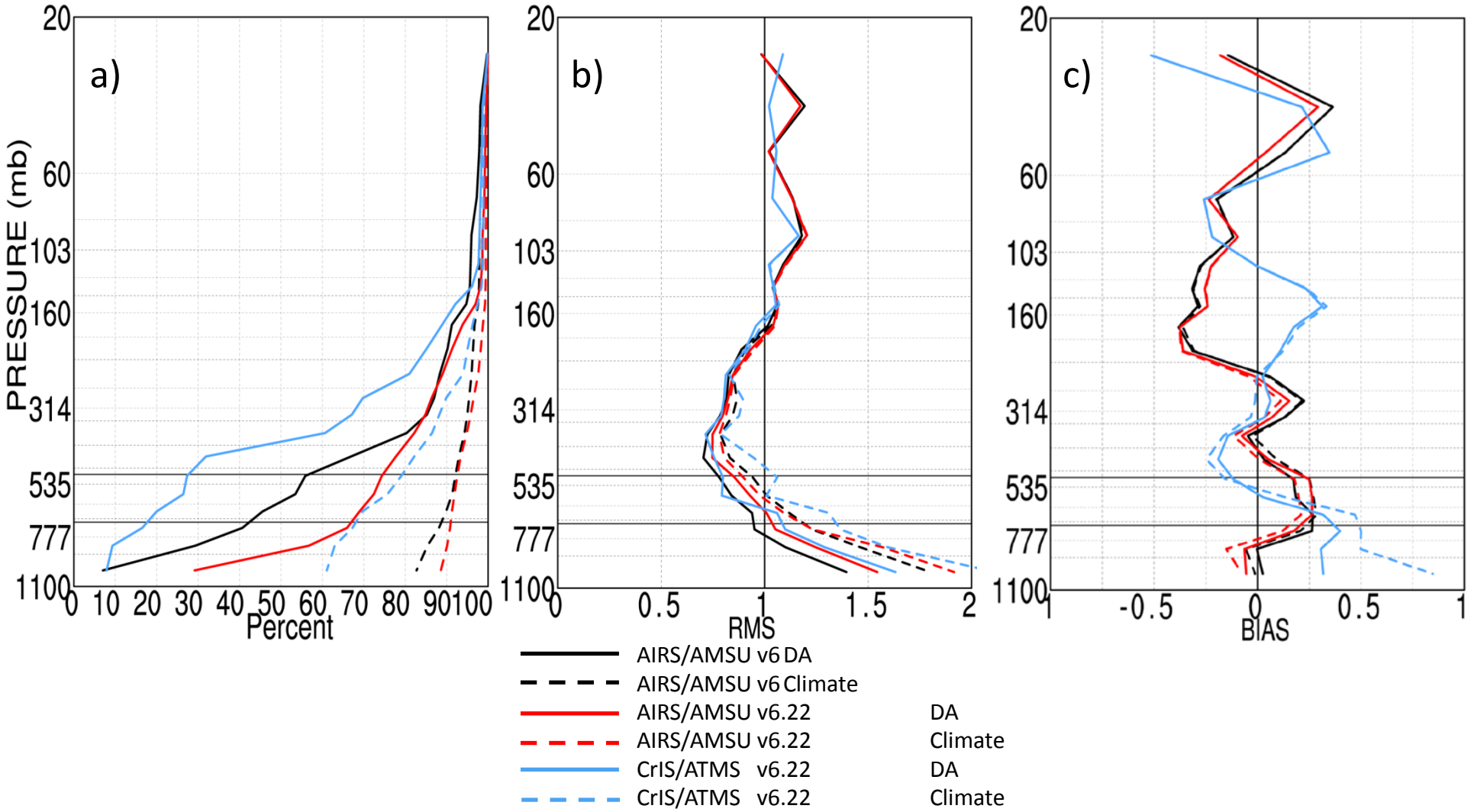
Percent of all Cases Accepted 1km Layer Mean Temperature (K) 1km Layer Mean Temperature (K)
RMS Differences From ECMWF Bias Differences From ECMWF



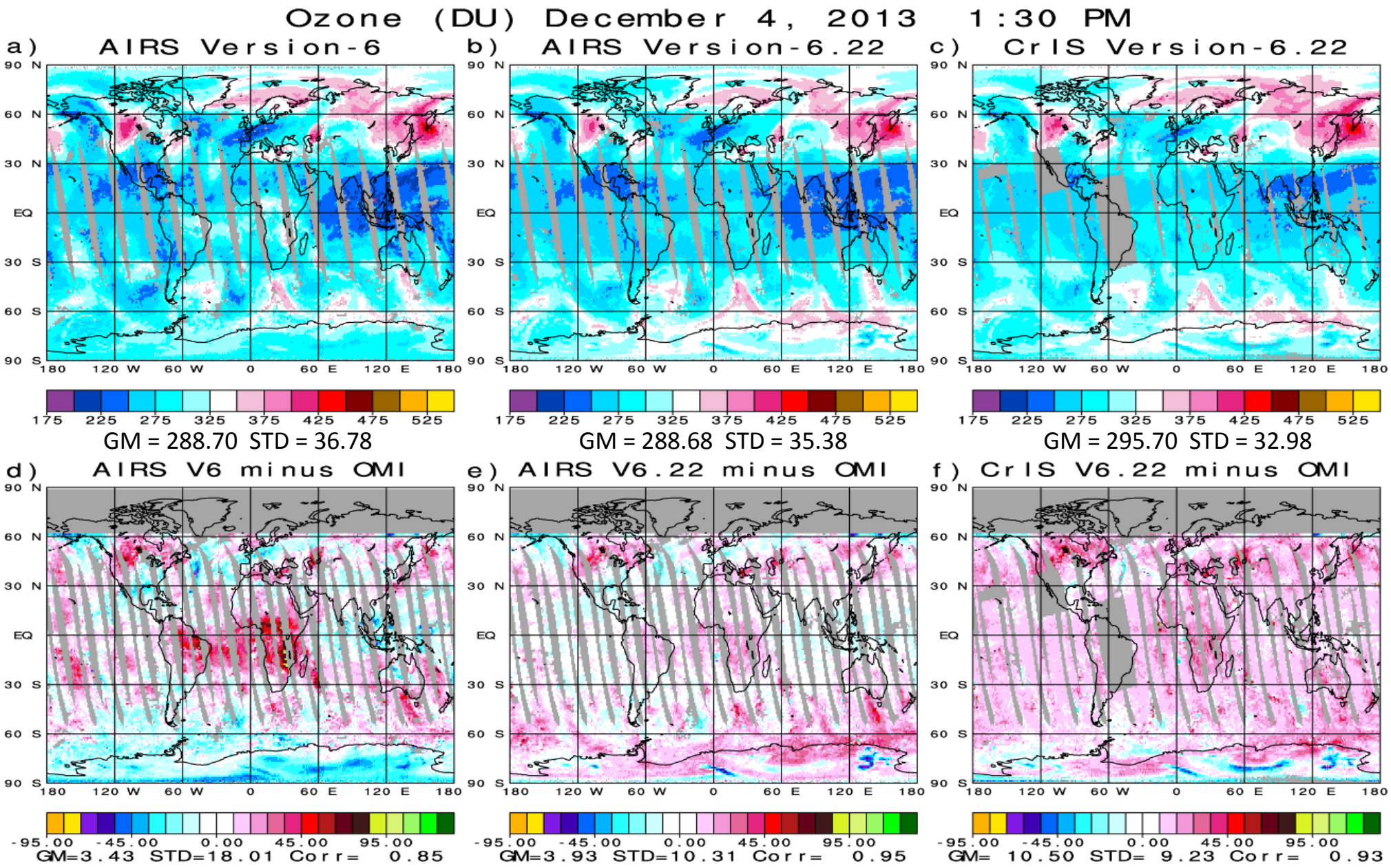
CrIS/ATMS statistics for *T(p)* are similar to those of AIRS/AMSU over mid-latitude ocean using each of DA and Climate QC thresholds.

December 4, 2013 50°N to 50°S Non-Ocean

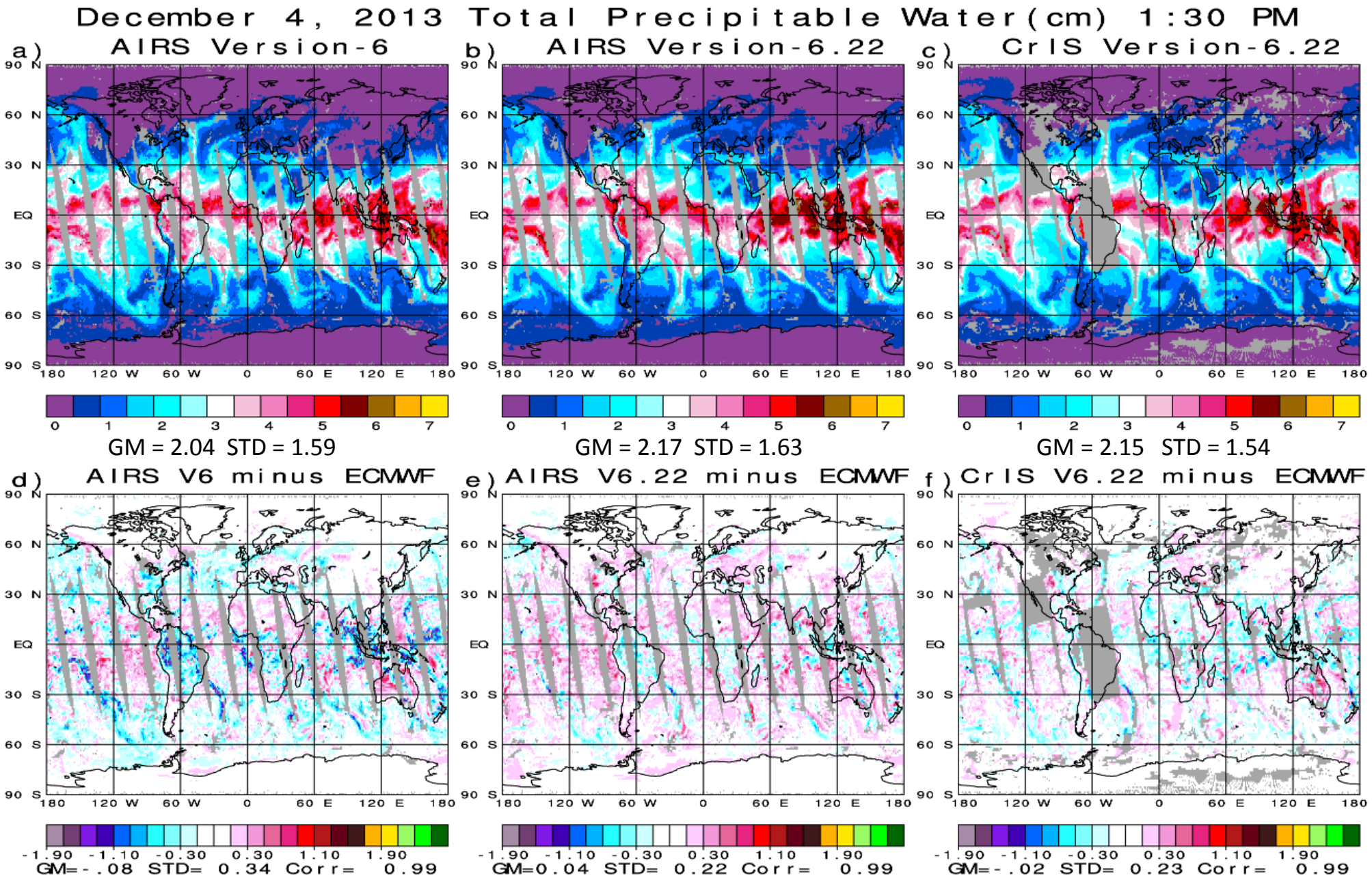
Percent of all Cases Accepted | 1km Layer Mean Temperature (K) RMS Differences From ECMWF | 1km Layer Mean Temperature (K) Bias Differences From ECMWF



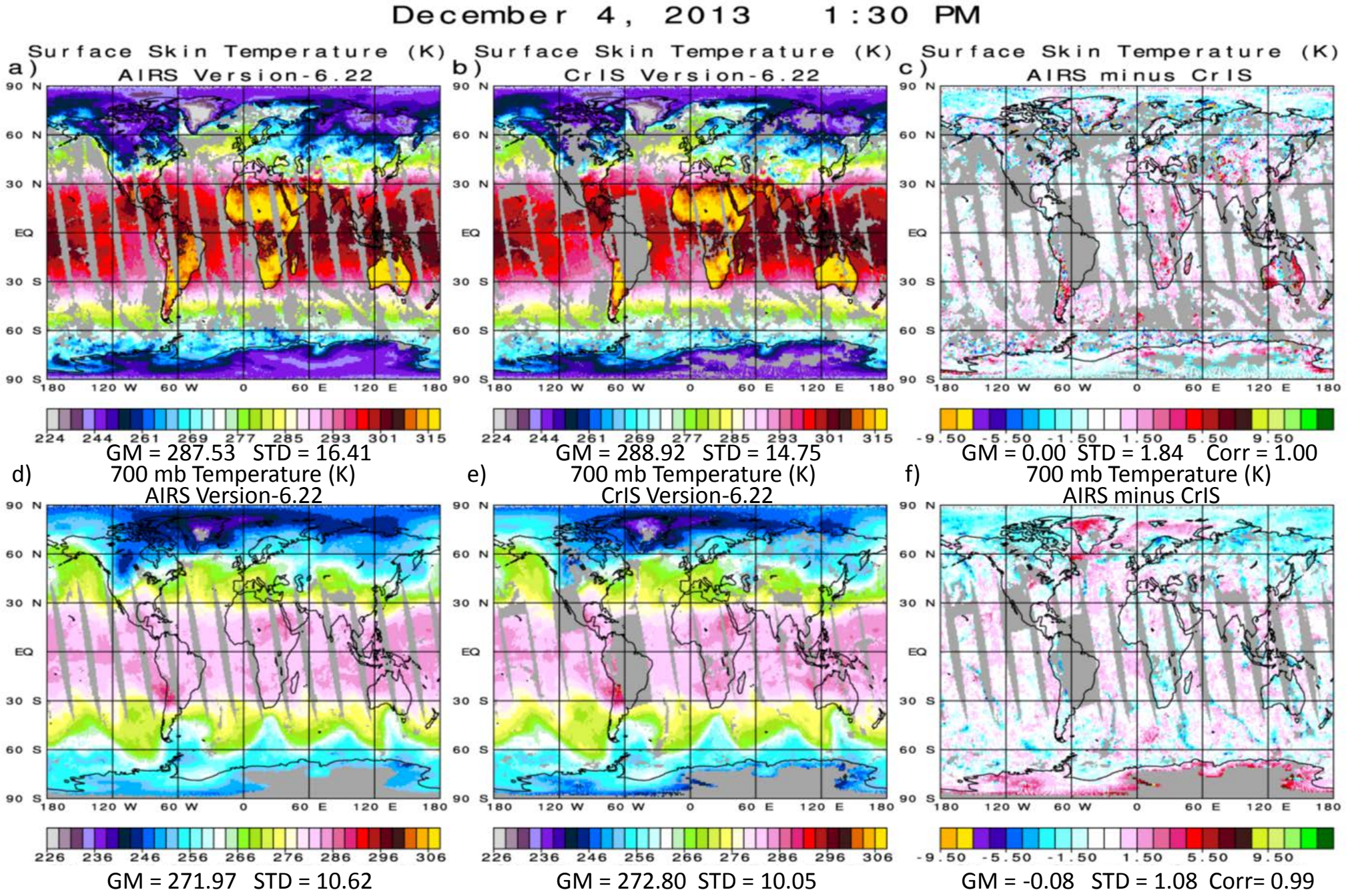
CrIS/ATMS statistics for *T(p)* are poorer over land than those of AIRS/AMSU, with regard to % yield, RMS differences from ECMWF, and bias structure, especially for the more cloudy cases included using Climate QC. This could be a consequence of poorer CrIS/ATMS land surface skin temperatures than those of AIRS/AMSU resulting from truncated SW CrIS spectral coverage.



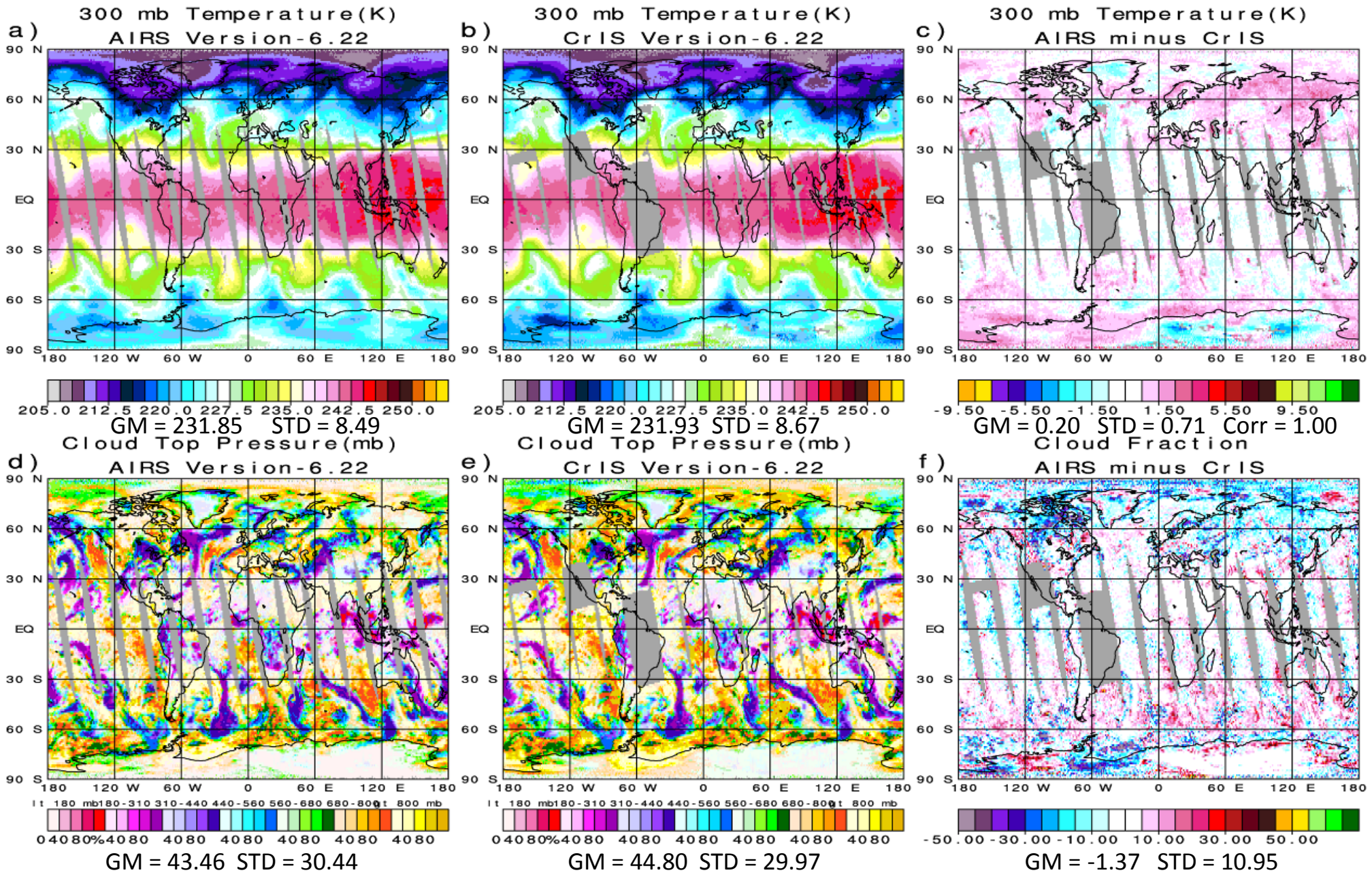
AIRS Version-6, AIRS Version-6.22, and CrIS Version-6.22 QC'd fields of total O_3 for ascending orbits on December 4, 2013, and their differences from OMI. CrIS is missing parts of some orbits. AIRS V6.22 agrees much better with OMI than AIRS V6 with regard to both STD and spatial correlation. CrIS V6.22 statistics are comparable to AIRS V6.22 but CrIS is biased high.



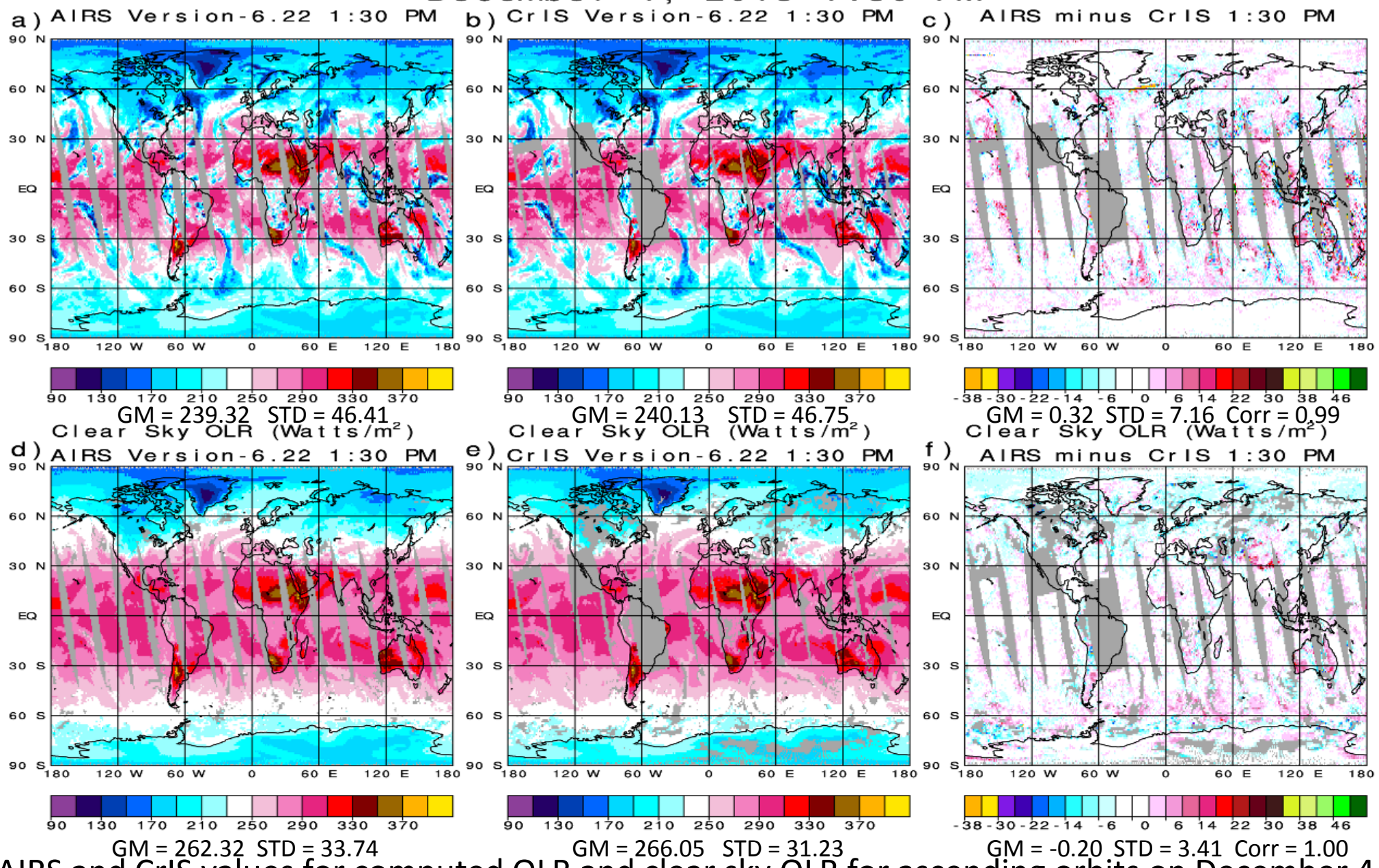
Derived QC'd fields of Total Precipitable Water (W_{TOT}) for the ascending (1:30 PM) orbits of AIRS and CrIS, and their differences from the ECMWF 3-hour forecast for this time period, which we take as truth. AIRS V6.22 W_{tot} is much more accurate than V6, especially in areas of high cloud cover. CrIS W_{tot} is very good as well.



Comparison of AIRS and CrIS retrieved values of surface skin temperature and 700 mb temperature for ascending orbits on December 4, 2013. Results agree very well over the tropical oceans. There are some differences over land, especially at high latitudes.



Comparison of AIRS and CrIS retrieved values of 300 mb temperatures and cloud parameters from December 4, 2013. Cloud fields show both p_c (color) and α (intensity). Agreement over tropical ocean is excellent in both fields. Again, some differences occur at high latitudes.



AIRS and CrIS values for computed OLR and clear sky OLR for ascending orbits on December 4, 2013. Agreement of both fields is excellent with regard to global mean and spatial correlation. Some of the differences in OLR are a result of EOS Aqua and NPP orbits not aligning up as well East of 90 E.

Summary

We tested and evaluated Version-6.22 AIRS and Version-6.22 CrIS products on a single day, December 4, 2013, and compared results to those derived using AIRS Version-6.

- AIRS and CrIS Version-6.22 $O_3(p)$ and $q(p)$ products are both superior to those of AIRS Version-6
- All AIRS and CrIS products agree reasonably well with each other
- CrIS Version-6.22 $T(p)$ and $q(p)$ results are slightly poorer than AIRS over land, especially under very cloudy conditions.

Both AIRS and CrIS Version-6.22 run now at JPL. Our short term plans are to analyze many common months at JPL in the near future using Version-6.22 or a further improved algorithm to assess the compatibility of AIRS and CrIS monthly mean products and their interannual differences

Updates to the calibration of both CrIS and ATMS are still being finalized. JPL plans, in collaboration with the Goddard DISC, to reprocess all AIRS data using a still to be finalized Version-7 retrieval algorithm, and to reprocess all recalibrated CrIS/ATMS data using Version-7 as well.


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