Status and Plans for Version-7 at SRT

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Background

At the last AIRS Science Team Meeting, I presented results for SRT AIRS/AMSU Version-6.28 and 6.28a, and showed that both performed significantly better than Version-6.22. Version-6.28a uses newer Neural-Net coefficients than Version-6.28. Version-6.28 is now running at JPL, as is CrIS/ATMS Version-6.28, which are scientifically equivalent. In my summary at that meeting, I presented the following two liens against AIRS Version-6.28:

- AIRS Version-6 total O_3 agreed better with OMPS at very high latitudes in polar summer than does Version-6.28, especially over Antarctica. We should find out why and correct this result.
- The AIRS Version-6.28 water vapor profile is biased high against ECMWF in the mid-lower troposphere. We want to see if we can correct this artifact.

Algorithm Modifications Since Version-6.28a

We have made considerable progress since Version-6.28a. Our current Version is 6.33. Algorithm modifications have been made in the following areas which improved retrieval accuracy:

- *T(p)* retrieval step

  We removed channels beyond 2398 cm^{-1} from the *T(p)* retrieval and no longer simultaneously solve for T_s.

- *q(p)* retrieval step

  We removed 35 channels on the peaks of the strongest water vapor lines from the *q(p)* retrieval and also combined the top 10 water vapor perturbation functions into two functions.

- $O_3(p)$ retrieval step

  We made a number of changes described later.

- All profile retrieval steps

  We improved a detail in the channel noise error covariance matrix.

Modifications Made to $O_3(p)$ Retrieval and QC

Two types of modifications were made to the O_3 profile retrieval and QC steps.

- We no longer use channels on the 26 strongest O_3 absorption lines in the O_3 profile retrieval step if the brightness temperature difference between 1043 cm^{-1} (little O_3 absorption) and 1041 cm^{-1} (peak O_3 absorption) is less than 20K. This indicates that this case is less sensitive to O_3. In addition, we modified the surface emissivity perturbation function in frozen cases. These modifications improved poor O_3 retrievals in polar summer.
- We now reject the O_3 profile if the first iteration in the second pass $O_3(p)$ retrieval step tries to change O_3 in a coarse layer by a factor of 2 or more. This indicates that there is a problem either in the O_3 initial state or in the cloud cleared radiances. Rejection of these cases eliminated many retrievals with very large errors in total O_3.

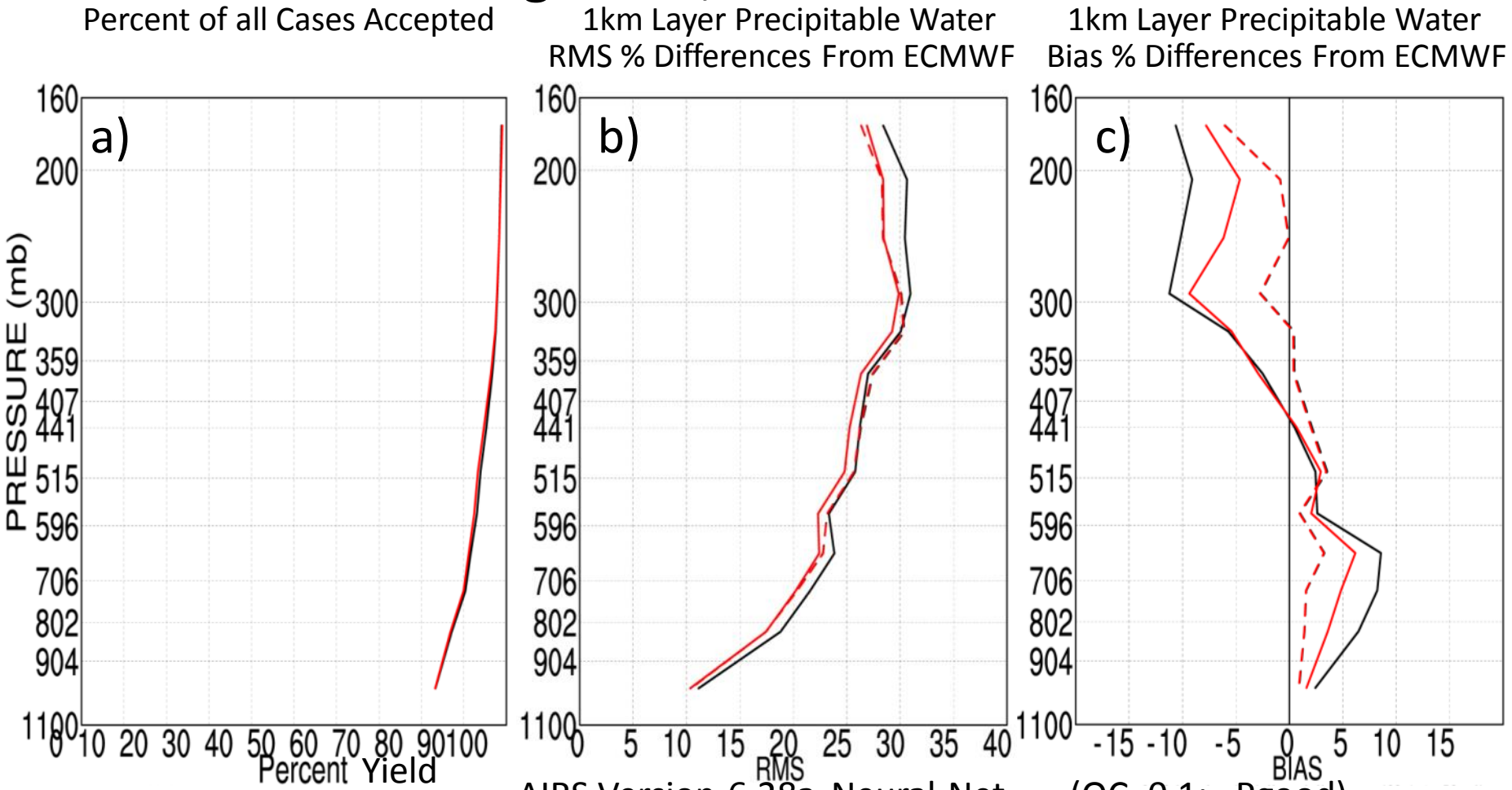
Result Shown

The following figures compare results of AIRS Version-6.33 with those of AIRS Version-6.28a for both August 15, 2013 and January 15, 2014. Results demonstrate AIRS Version-6.33 improvements made in each of the water vapor profile and O_3 profile retrieval steps as compared to Version-6.28.

AIRS Version-6.33 O_3 profile retrievals can be run starting from either Gordon Labow's 2011 monthly mean zonal mean $O_3(p)$ climatology or from newer Gordon Labow zonal mean O_3 climatologies that address the effects of the O_3 hole poleward of 60°S.

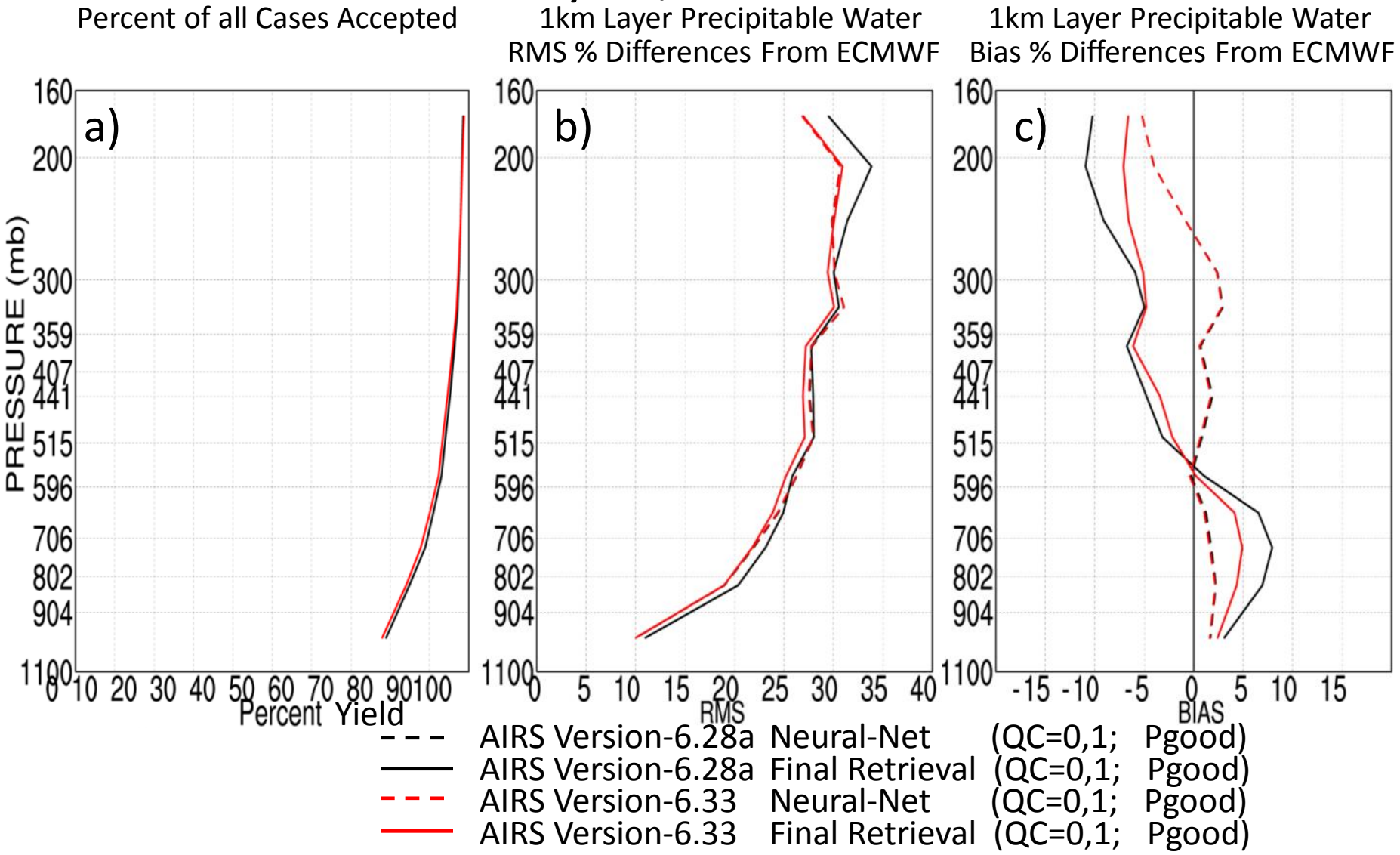
The results shown next use the 2011 $O_3(p)$ climatology. Discussion and results of the treatment of O_3 retrievals in the presence of the Antarctic O_3 hole will be shown subsequently. This is a potential important improvement beyond Version-6.33.

August 15, 2013 Global

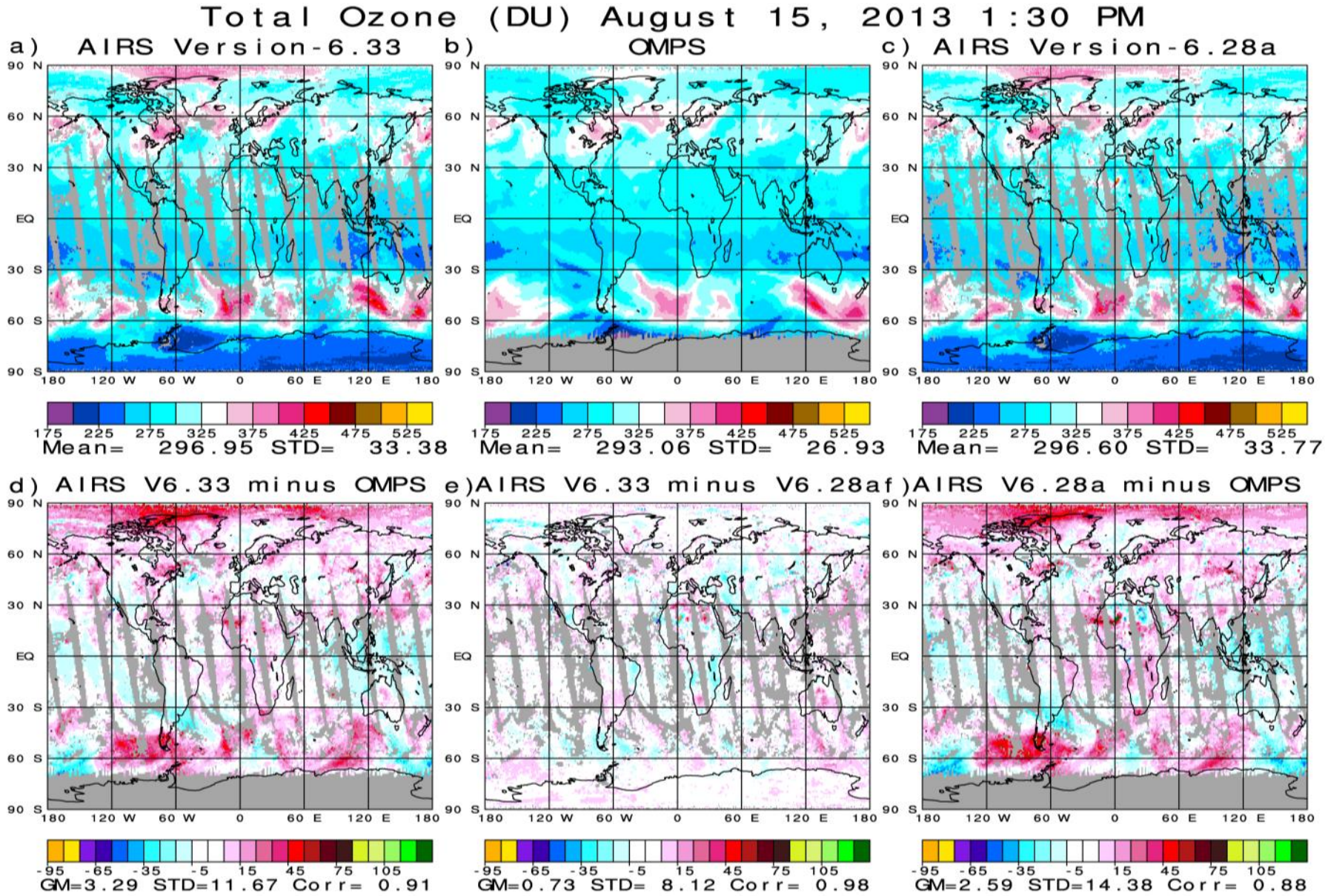


AIRS Version-6.33 water vapor retrieval accuracy is improved considerably over Version-6.28a both in terms of RMS errors and bias structure. Version-6.33 accuracy is better than the Neural-Net, while 6.28a accuracy was poorer.

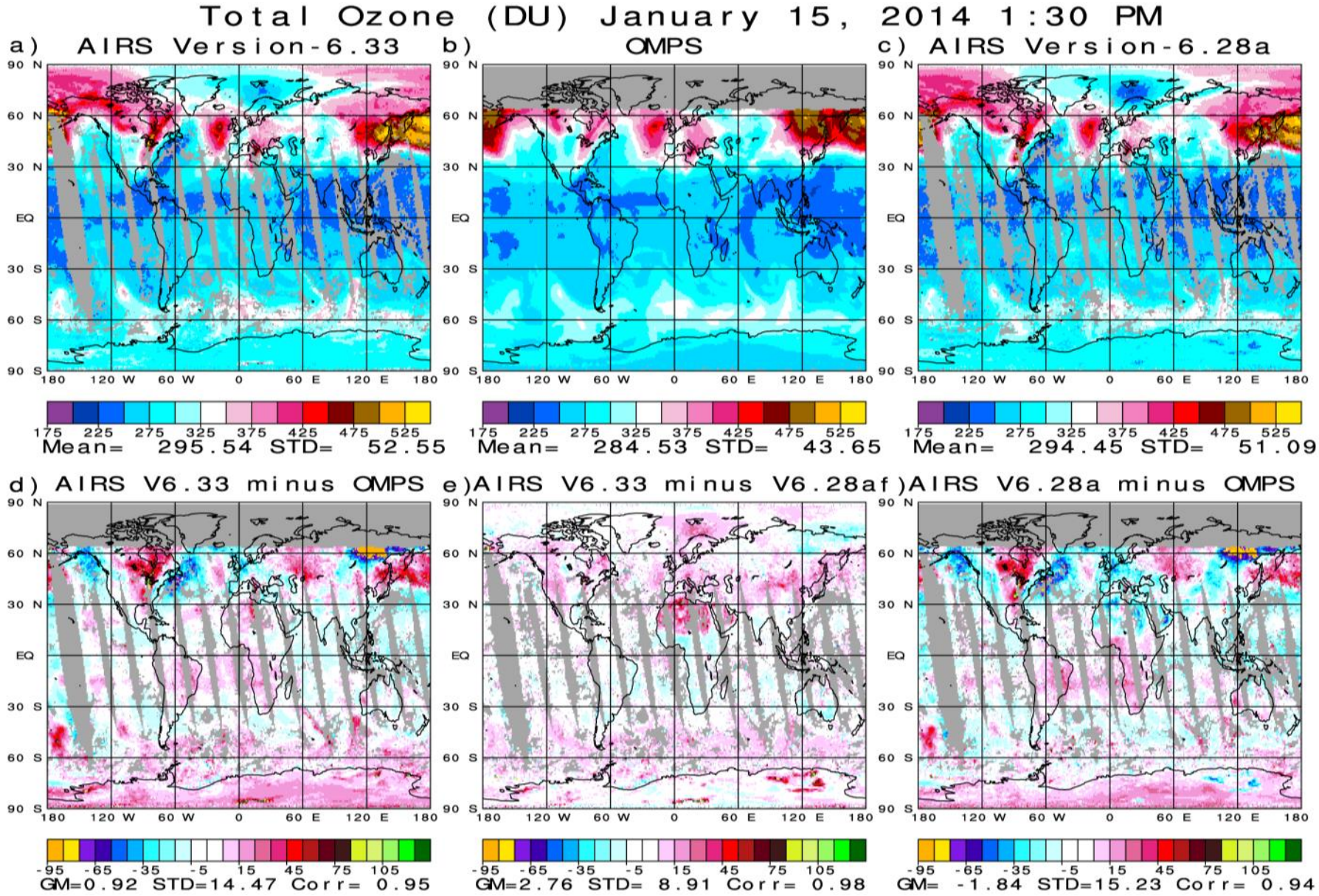
January 15, 2014 Global



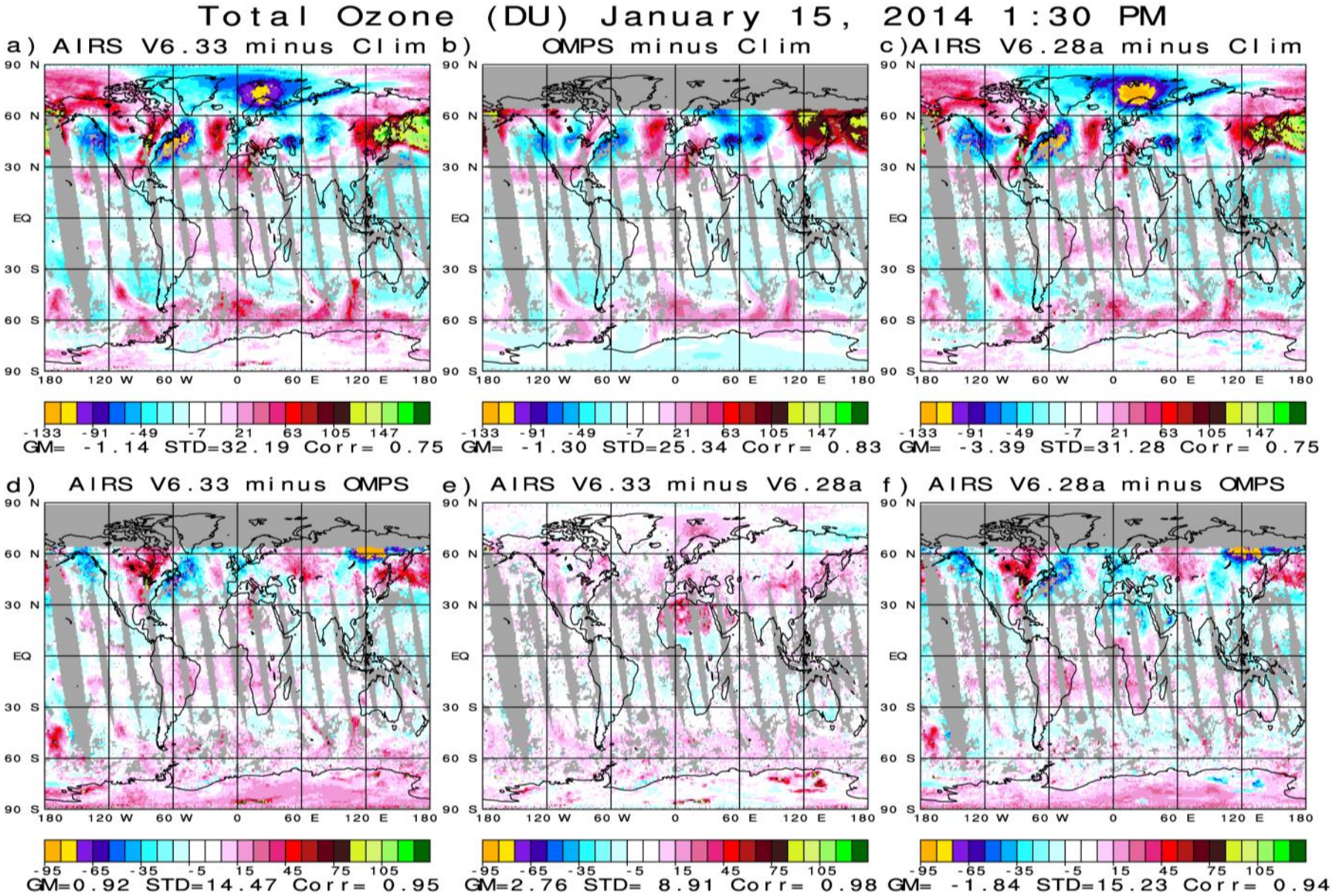
Similar results are found in January.



AIRS Version-6.33 total ozone agrees better with OMPS than does Version-6.28a, especially over land.



AIRS Version-6.33 total O_3 again agrees better than Version-6.28a with OMPS over land. There are large wave structures differences between AIRS and OMPS poleward of 30°N.



AIRS differences from climatology poleward of 30°N are larger than those of OMPS. This means AIRS moves the initial guess too far. Version-6.33 is somewhat better than Version-6.28a in this regard.

Antarctic Ozone Hole

The Antarctic ozone hole is a phenomenon in which there is a time dependent area, poleward of 60°S, containing a substantial decrease in total O_3. This typically occurs from early August to November.

Major ozone loss occurs when sunlight hits the South polar region in austral spring, releasing *Cl* and *Br* atoms from polar stratospheric clouds which destroy most O_3 from 200-50 mb.

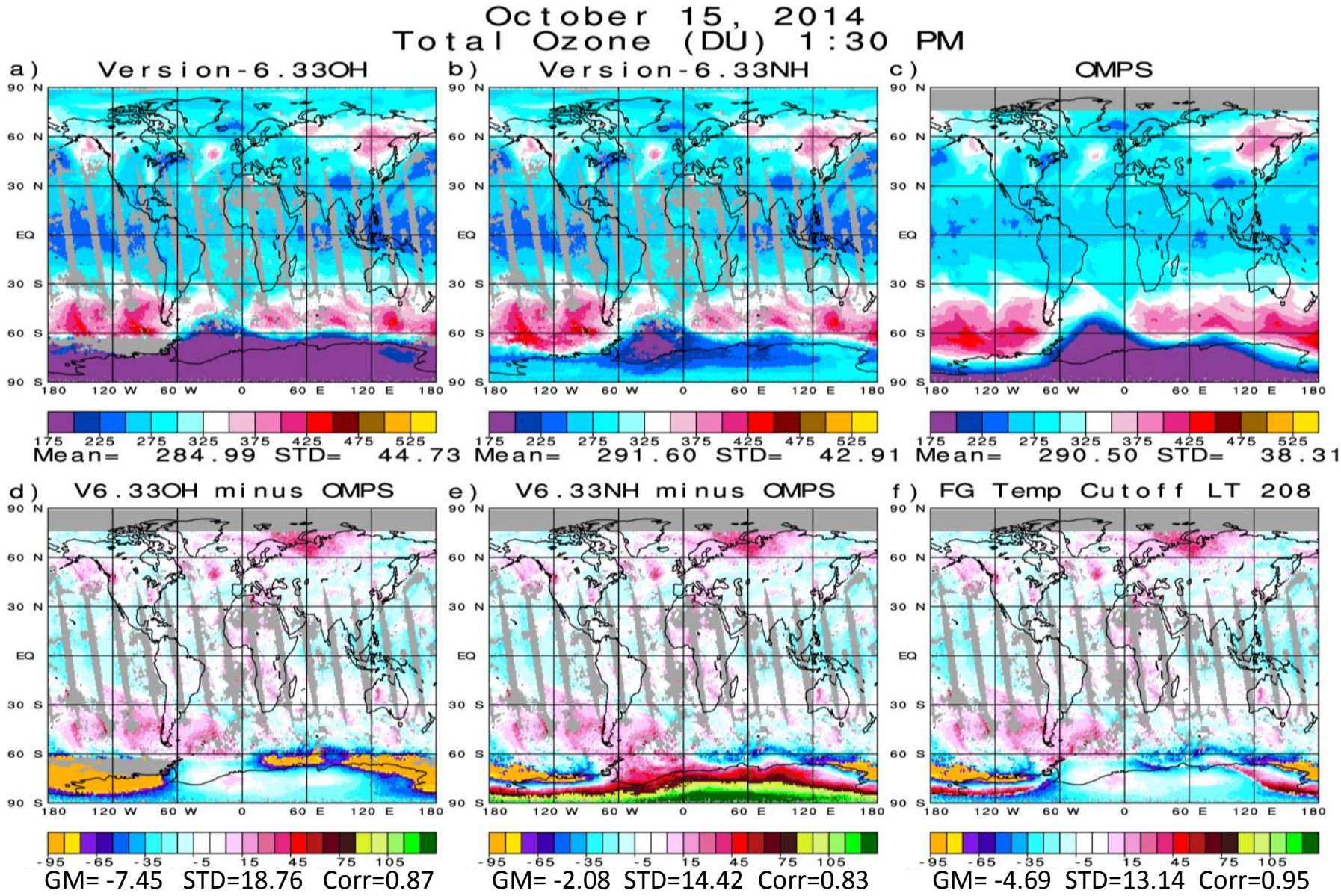
AIRS radiances used to determine $O_3(p)$ for a given retrieval do not contain sufficient information to accurately reflect this large stratospheric drop in $O_3(p)$.

50 mb temperatures are highly correlated with the 50 mb O_3 mixing ratio. We can use AIRS 50 mb temperature information to decide whether ozone hole conditions exist.

Version-6.33 Approach to Address the O_3 Hole

Gordon Labow has prepared two new monthly mean zonal mean $O_3(p)$ climatologies, Ozone Hole (OH) and Non-Ozone Hole (NH) which differ from each other poleward of 60°S. Currently, Version-6.33 can use either climatology as the $O_3(p)$ first guess.

The following charts show results for August 15, 2014 comparing total O_3 with OMPS derived using either the OH climatology or the NH climatology everywhere. We also show results using a candidate ozone hole approach in which we use the Neural-Net 50 mb temperature guess to decide which climatology to use. We use the initial guess so we can make that choice before, not after, we perform a retrieval. In the following chart, we show a blended result using the OH O_3 result if the 50 mb guess is < 208K, and the NH result otherwise.



A large ozone hole exists South of 60°S on this day. AIRS OH agrees well with OMPS over the ozone hole, but not outside of it. AIRS NH agrees well outside of it. Figure f) uses the NH product if the 50 mb FG temperature is ≥ 208K and use the OH product if it is < 208K.

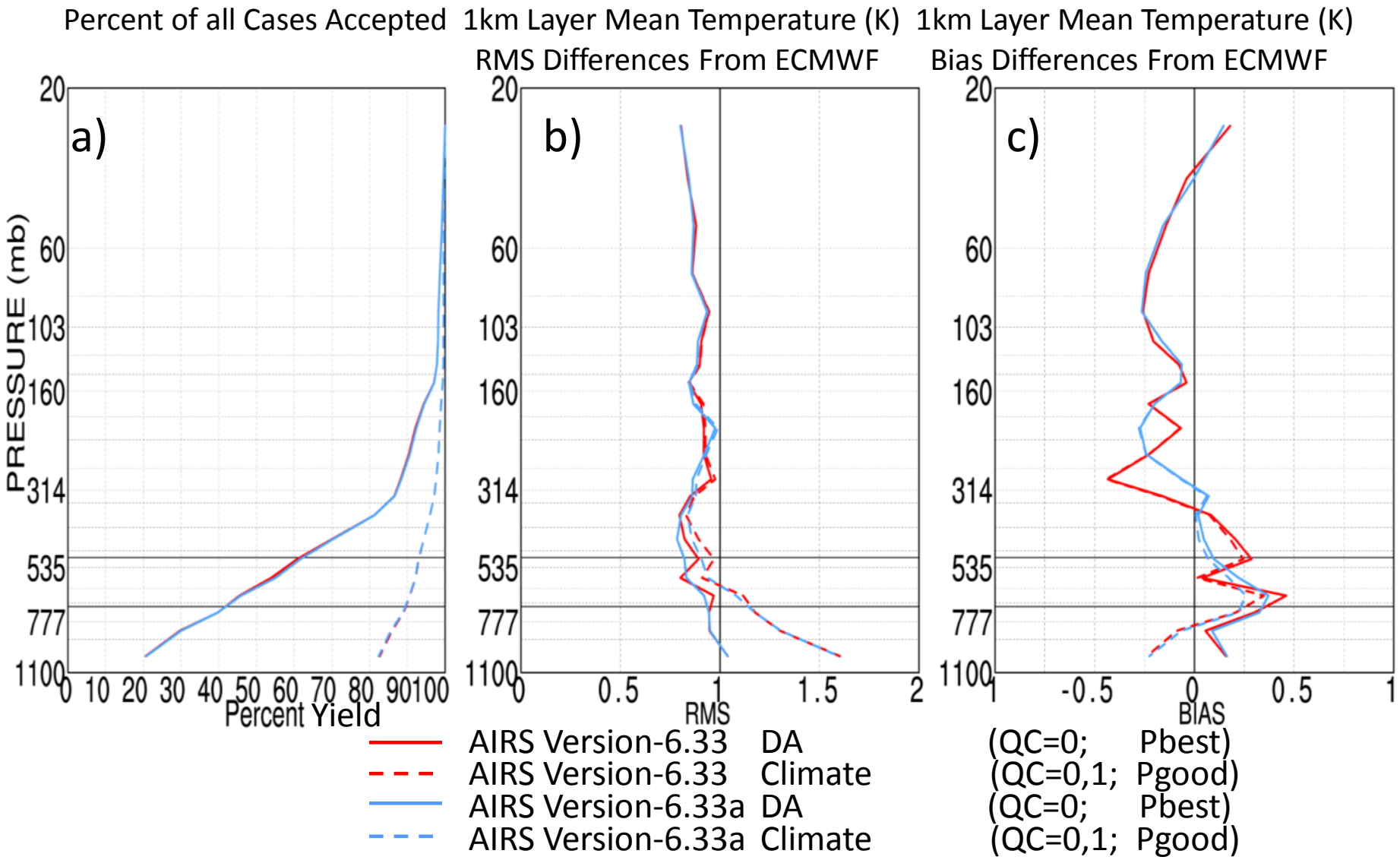
Version-6.33a

Version-6.33a is just like Version-6.33 but uses the latest AIRS/AMSU Neural-Net coefficients recently received from Adam Milstein, which correct a bug that caused oscillations on a small vertical scale. Adam also sent us new AIRS Only, CrIS/ATMS and CrIS Only coefficients.

Having AIRS Only coefficients will allow a consistent system build at JPL. Currently Version-6.28a does not run in production at JPL because Adam's previous AIRS/AMSU Neural-Net coefficients did not have an AIRS Only analog.

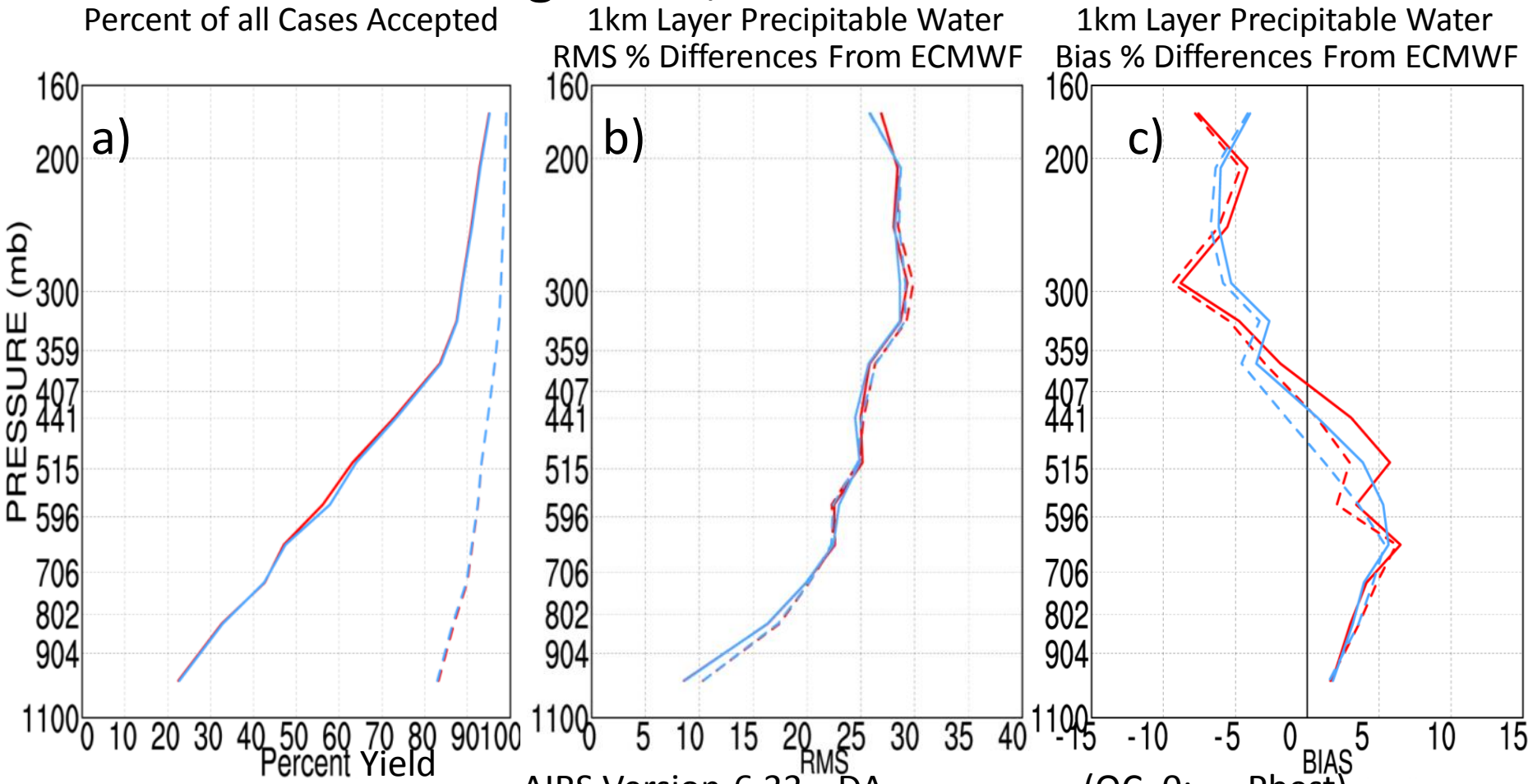
Version-6.33a *T(p)* and *q(p)* RMS error and bias structures are both improved considerably compared to Version-6.33 in August. There is no appreciable change in January. The bug affected only months in Northern Hemisphere summer and fall.

August 15, 2013 Global



AIRS Version-6.33a 1 km layer mean temperatures are more accurate than those of Version-6.33, and have smaller positive biases at 700 mb and 500 mb, as well as smaller negative biases at 300 mb.

August 15, 2013 Global



AIRS Version-6.33a 1 km layer mean precipitable water bias structure is significantly improved upon Version-6.33 with regard to the moist bias at 500 mb and the dry bias at 300 mb. These were shortcomings of Version-6.33.

SRT Plans for Version-7

Required

- Implementation of the latest AIRS/AMSU and AIRS Only Neural-Net coefficients at JPL.
- Finalization of a comprehensive methodology to select when, and when not, to start the $O_3(p)$ retrieval step with the ozone hole first guess. Implement code at JPL to store both $O_3(p)$ first guesses and select which one to use before the physical retrieval begins.

Important

- Conduct research to see the extent that we can alleviate the shortcoming that current $O_3(p)$ retrievals tend to produce Total O_3 that differs more from the zonally averaged climatology than does OMPS. This will produce more accurate wave structure at mid-high latitudes.
- Conduct further optimization of O_3 QC procedures.

SRT Plans for Version-7 (cont.)

Desirable

- Conduct more studies optimizing all steps in the retrieval process, including the retrieval of cloud parameters.

Also Desirable – needs input from others

- AIRS Version-6 *CO*, CH_4, and possibly other trace gas retrieval algorithms have not been updated for a long time. It would be desirable to include recent improvements from Juying Warner, NOAA, and possibly others into Version-7 provided it doesn't delay Version-7 going into production. Hopefully, we can start production within six months.