Major Upgrades to the AIRS Version-6 Ozone Profile Methodology

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Background

This research is a continuation of part of what was shown at the last AIRS Science Team Meeting in the talk "Improved Water Vapor and Ozone Profiles in SRT AIRS Version-6.X" and the AIRS February 11, 2015 NetMeeting "Further improvements in water vapor and ozone profiles compared to Version-6".

AIRS Version-6 was finalized in late 2012 and is now operational.

Version-6 contained many significant improvements in retrieval methodology compared to Version-5.

However, Version-6 retrieval methodology used for the water vapor profile $q(p)$ and ozone profile $O_3(p)$ retrievals is basically unchanged from Version-5, or even from Version-4. Subsequent research has made significant improvements in both water vapor and O_3 profiles compared to Version-6. This talk will concentrate on O_3 profile retrievals. Improvements in water vapor profile retrievals are given in a separate presentation, April 22 at 1:50 PM.

Version-6.X Modifications to the Ozone Profile Retrieval Step

Version-6.X included new changes made to the $O_3(p)$ retrieval step as well as an increase in the number of stratospheric channels used in the $T(p)$ retrieval step.

- 22 O_3 channels were added, including the strongest O_3 lines.
- 2 longwave (ℓw) spectral emissivity functions with hinge-points near 1000 cm^{-1} were added and solved for as part of both the ℓw emissivity and O_3 retrieval steps.
- Ozone retrievals took into account the tropopause pressure

These modifications significantly improved AIRS derived total O_3 compared to Version-6.

John Blaisdell ran Version-6.X at JPL in his own area for all of August 2013 and August 2014, as well for select other days.

We have made further improvements to both the water vapor profile retrieval and the ozone profile retrieval steps beyond Version-6.X. We refer to this new version of the AIRS retrieval system as Version-6.19.

Version-6.19 Updates to Ozone Profile Retrieval Step

- Added many more ozone profile perturbation functions
- Better balanced the size of the ozone profile and local spectral emissivity perturbation functions
- Removed contribution of uncertainty in water vapor to ozone noise covariance matrix
- Added a second pass ozone retrieval
- Improved $O_3(p)$ QC
  Version-6.X ozone QC flag was the same as for W_{TOT} (p_{good}=p_{surf})
  New ozone QC flag is given by the RMS difference (K) of observed minus computed brightness temperatures in the ozone profile retrieval step.
- Version-6.19 uses newest ozone profile climatology from Gordon Labow as the first guess.

John Blaisdell recently ran Version-6.19 in his own area at JPL for all of August 2013 and August 2014 and some select days.

Significance of AIRS O_3 Profiles

AIRS and OMI are both in A-train orbits

AIRS total O_3 can complement OMI total O_3 for three reasons

- A small portion of the OMI scan line is missing because a piece of the thermal blanket obscured part of the FOV
- AIRS provides products both at 1:30 PM and 1:30 AM local time while OMI is 1:45 PM only. Therefore, AIRS provides twice daily coverage of rapidly travelling O_3 waves.
- AIRS provides O_3 products during polar night

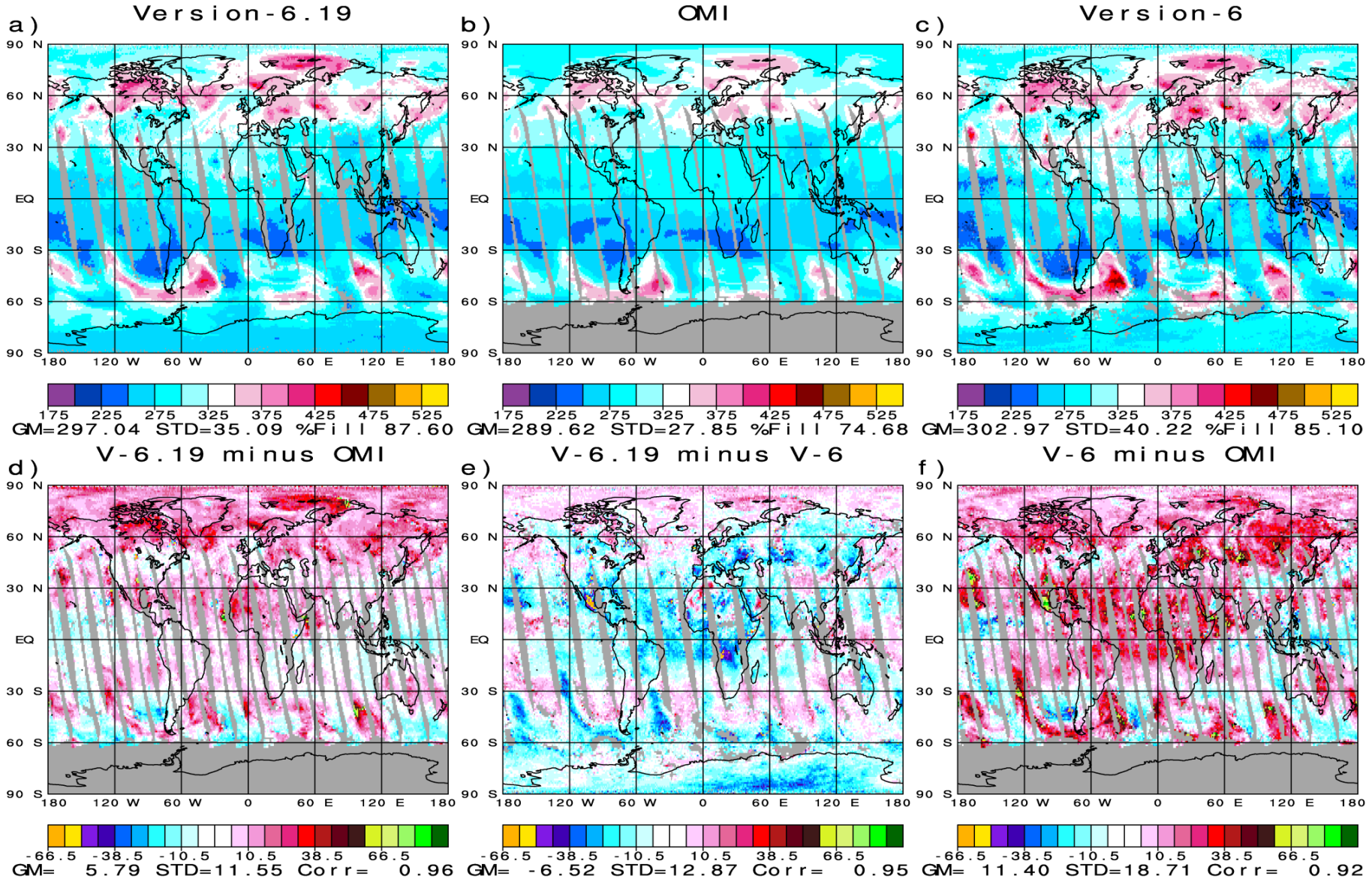
This is a potentially huge benefit

For AIRS total O_3 products to be useful, they must be consistent with OMI

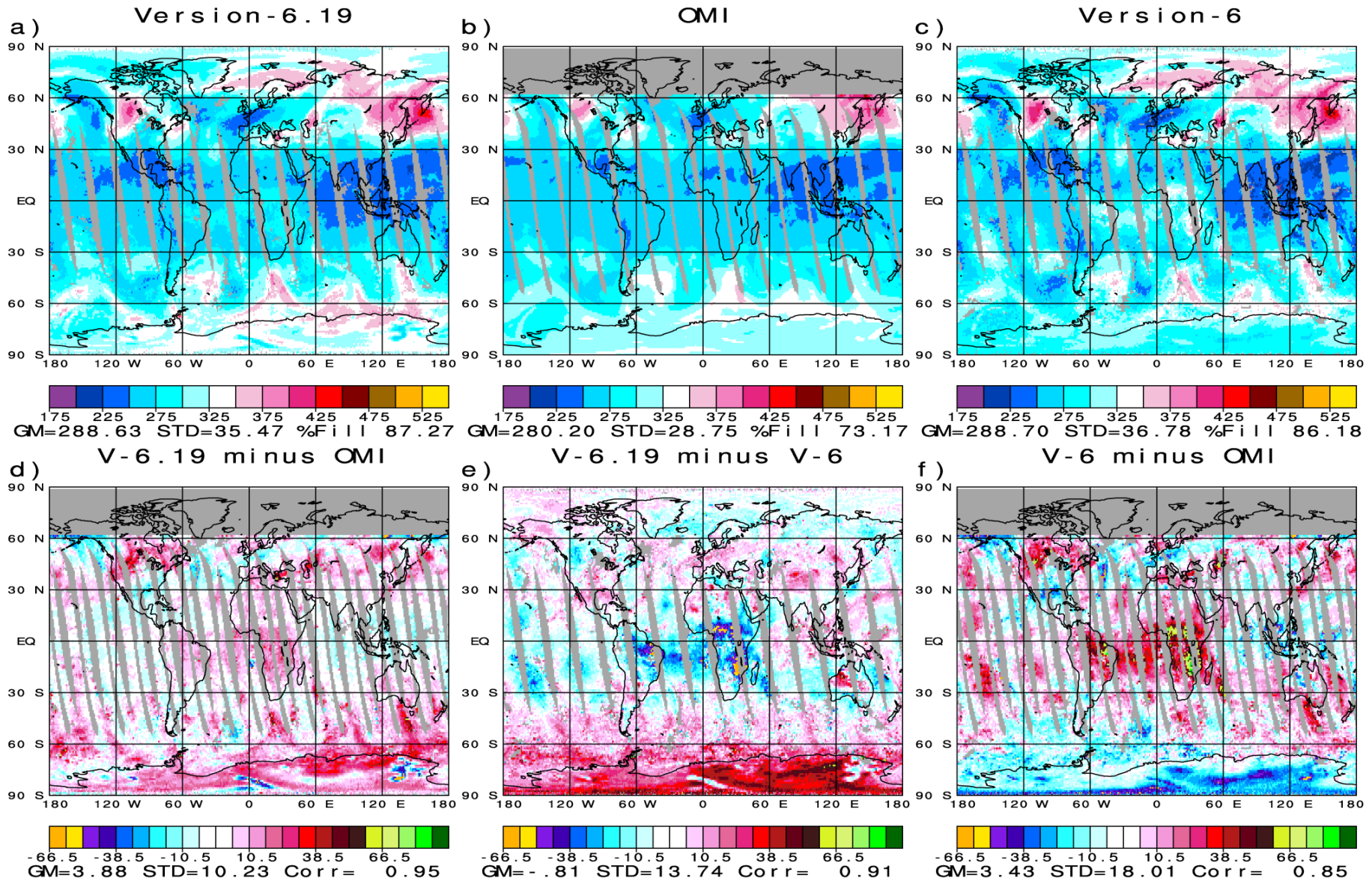
- In addition, AIRS provides the O_3 profile while OMI only provides total ozone burden

Tropospheric $O_3(p)$ mixing ratios are important with regard to both climate studies as well as indications of pollution sources

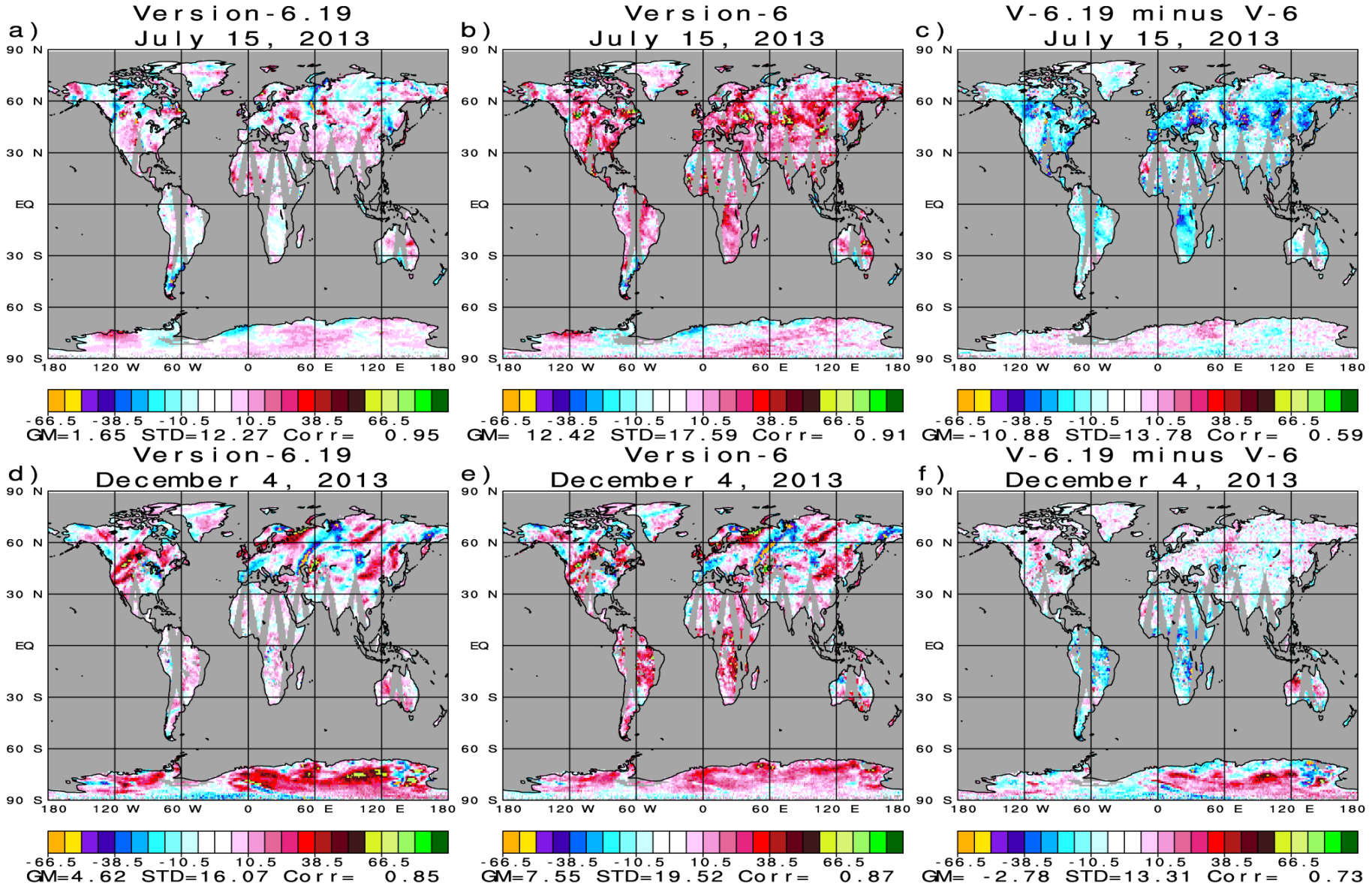
The following charts compare OMI with Version-6.19 and Version-6.



While not perfect, Version-6.19 total O_3 matches OMI much better than does Version-6 in Northern Hemisphere summer.

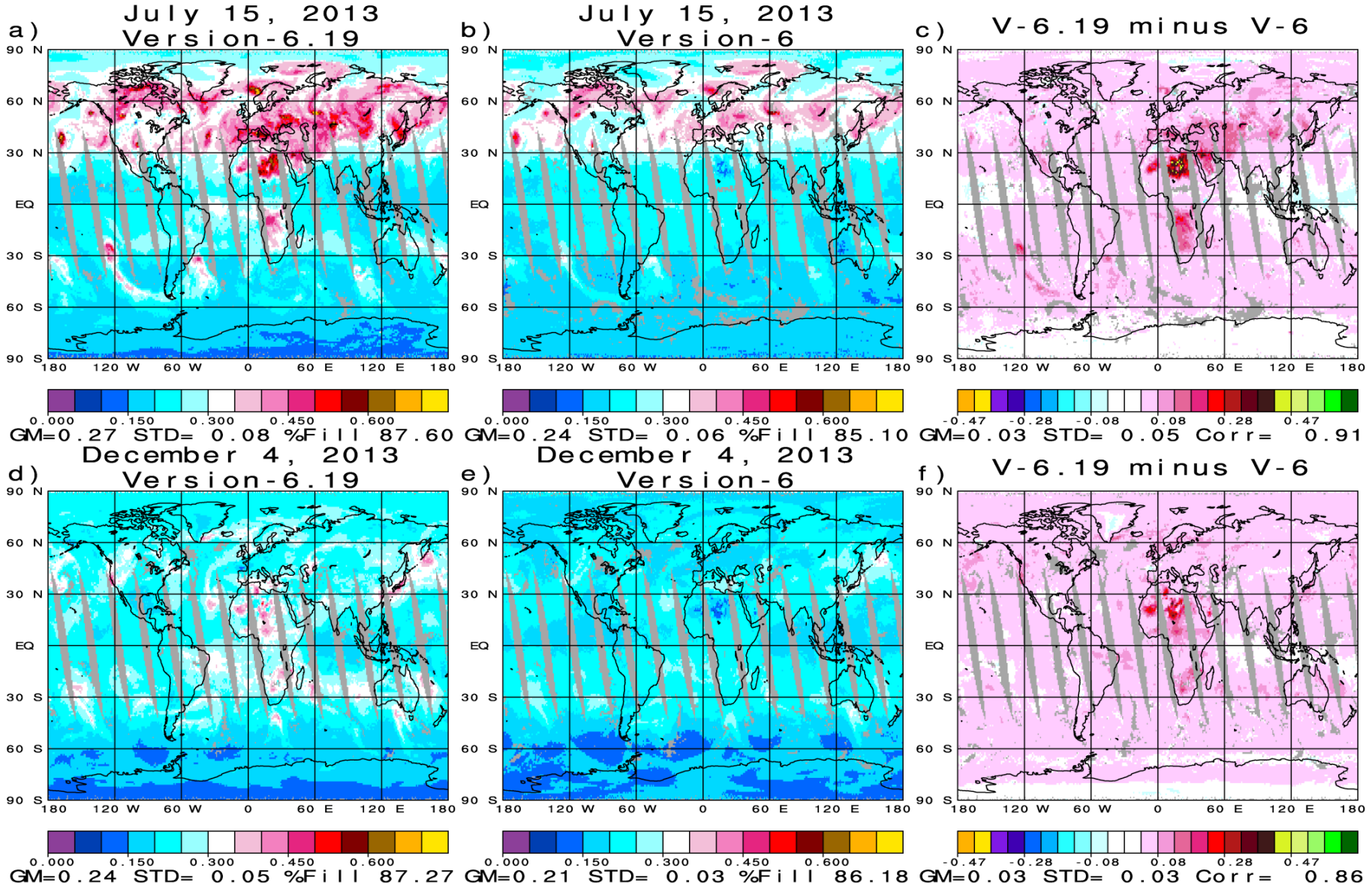


Version-6.19 matches OMI much better in Northern Hemisphere winter as well, especially over Antarctica.

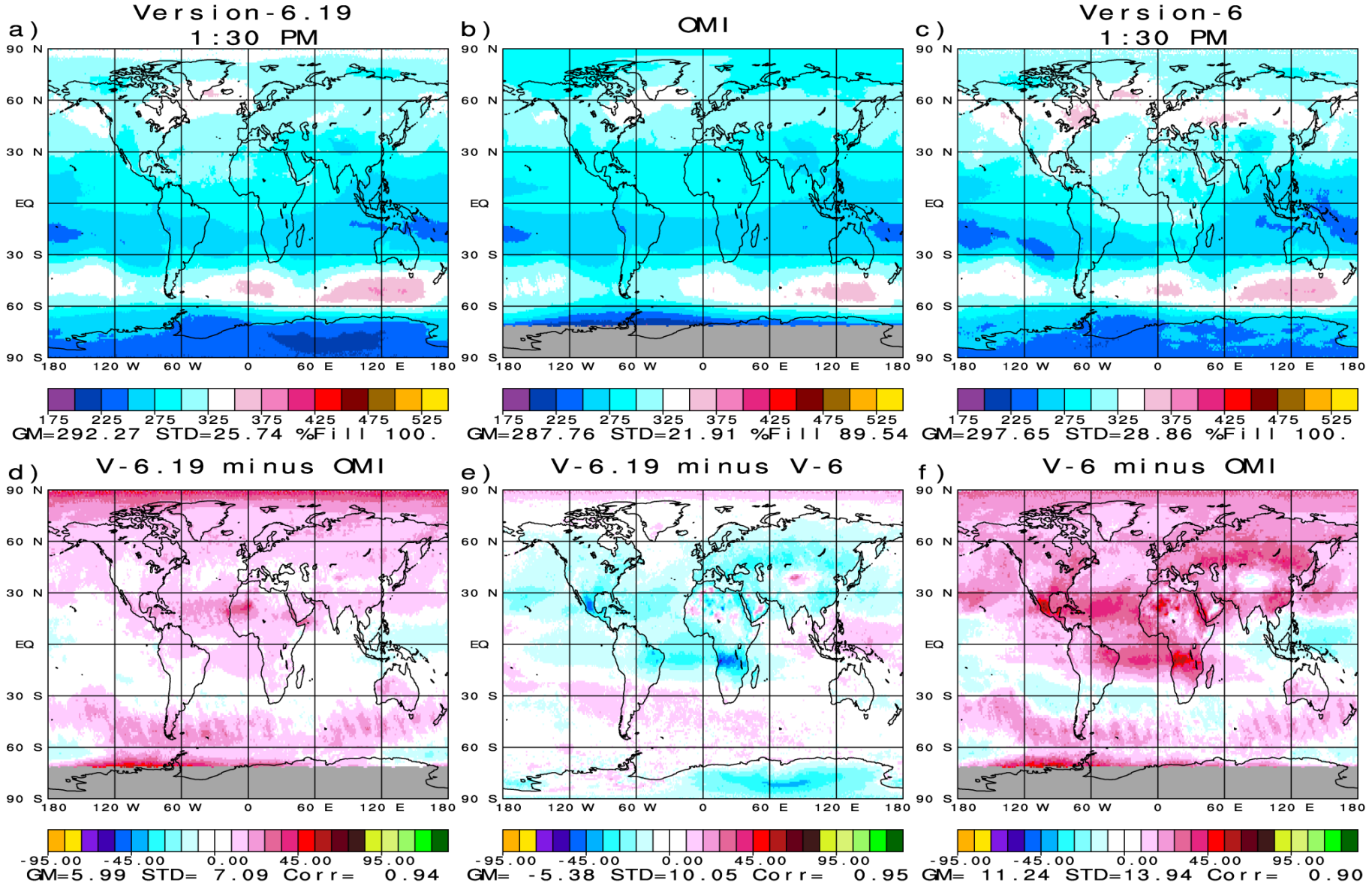


Version-6.19 day/night total ozone differences are much smaller over tropical land than those of Version-6, as they should be.

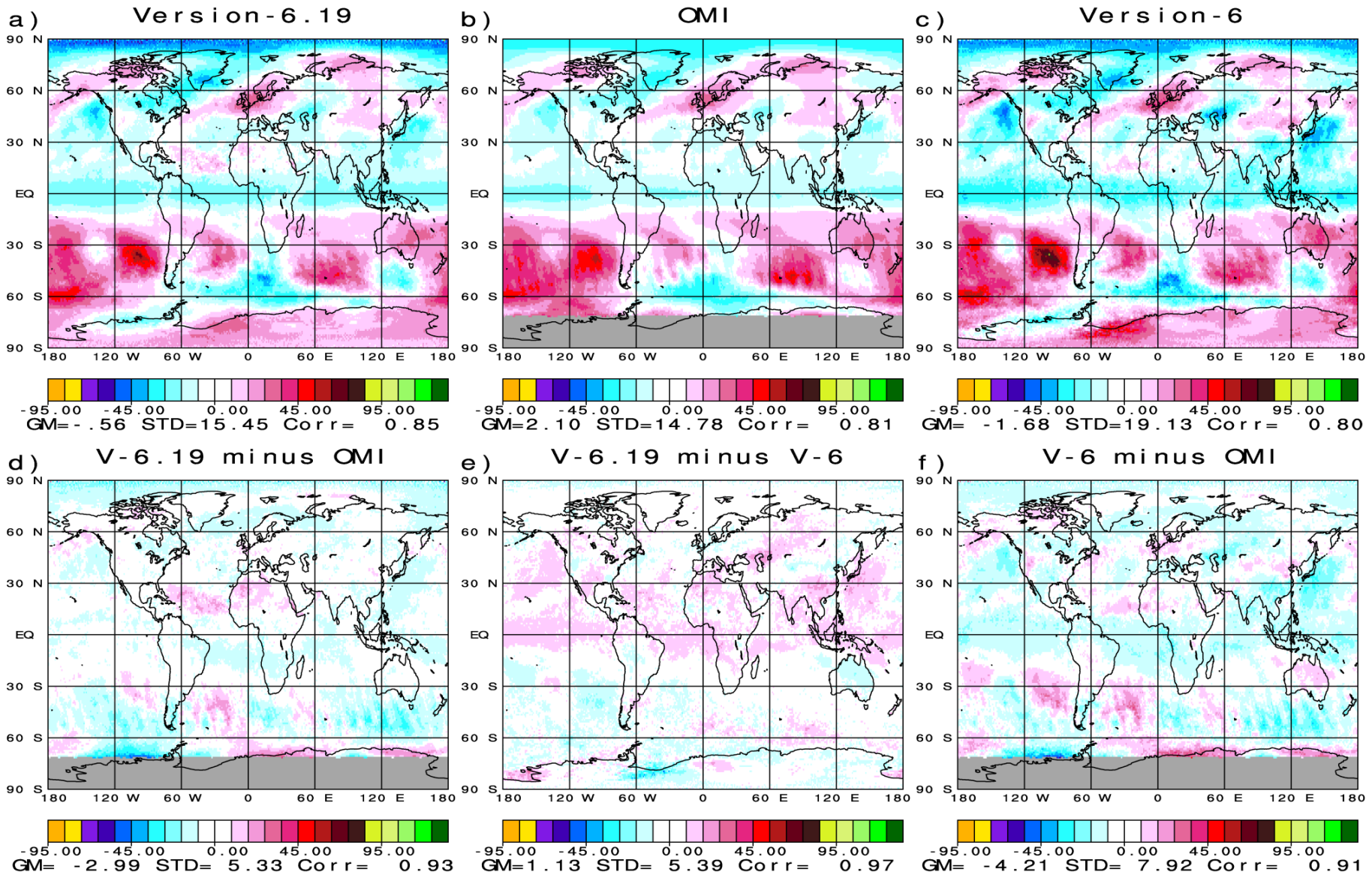
500 mb Ozone Mixing Ratio Multiplied by 100



Version-6.19 500 mb ozone mixing ratios show spatial distributions which match those of analyses (not shown). Version-6 shows very little spatial structure, especially in the tropics.



AIRS Version-6.19 August 2013 monthly mean total ozone matches OMI much better than AIRS Version-6.



Version-6.19 August 2014/August 2014 interannual differences match OMI much better as well.

Findings with Regard to Ozone Profile

Improved Version-6 total ozone is significantly better than Version-6

- AIRS 1:30 PM total O_3 matches OMI total O_3 much better, especially in mid-latitudes and the tropics. Some improvement is still needed.
- Spurious 1:30 PM minus 1:30 AM differences of total O_3 over land are reduced considerably. Still needs further improvement.

We are being encouraged by P.K. Bhartia and others in the GSFC Atmospheric Chemistry Group to further improve these results and reprocess all AIRS data as soon as possible.

- In addition, fields of tropospheric O_3 mixing ratio show reasonable structure not found in Version-6. Members of GMAO examined monthly mean values of Version-6.19 tropospheric O_3 mixing ratios and showed excellent agreement between our results and those coming from MERRA reanalysis. They want this new AIRS product both to validate MERRA, and possibly for assimilation purposes.

Recommendations

We feel that it is in the interest of NASA and the AIRS Science Team to reprocess the entire AIRS Data Set at the DAAC with a further improved AIRS Version-6 algorithm in the relatively near future, preferably starting within a year. Reprocessed water vapor profiles and ozone profiles will both be greatly improved compared to Version-6.

At least two items need further improvement before possible reprocessing of the AIRS data

- Improved ozone profiles in the presence of Saharan dust over the ocean
- Improved upper stratospheric temperatures in polar winter

Improved Ozone Profiles Over Ocean in the Presence of Saharan Dust

It is evident that Saharan dust over ocean is producing spurious signals in total ozone which are not caught by our current level-2 ozone QC.

We must be able to do at least one of the following before reprocessing the AIRS data:

1) Correct the problem as part of further improved ozone retrieval methodology

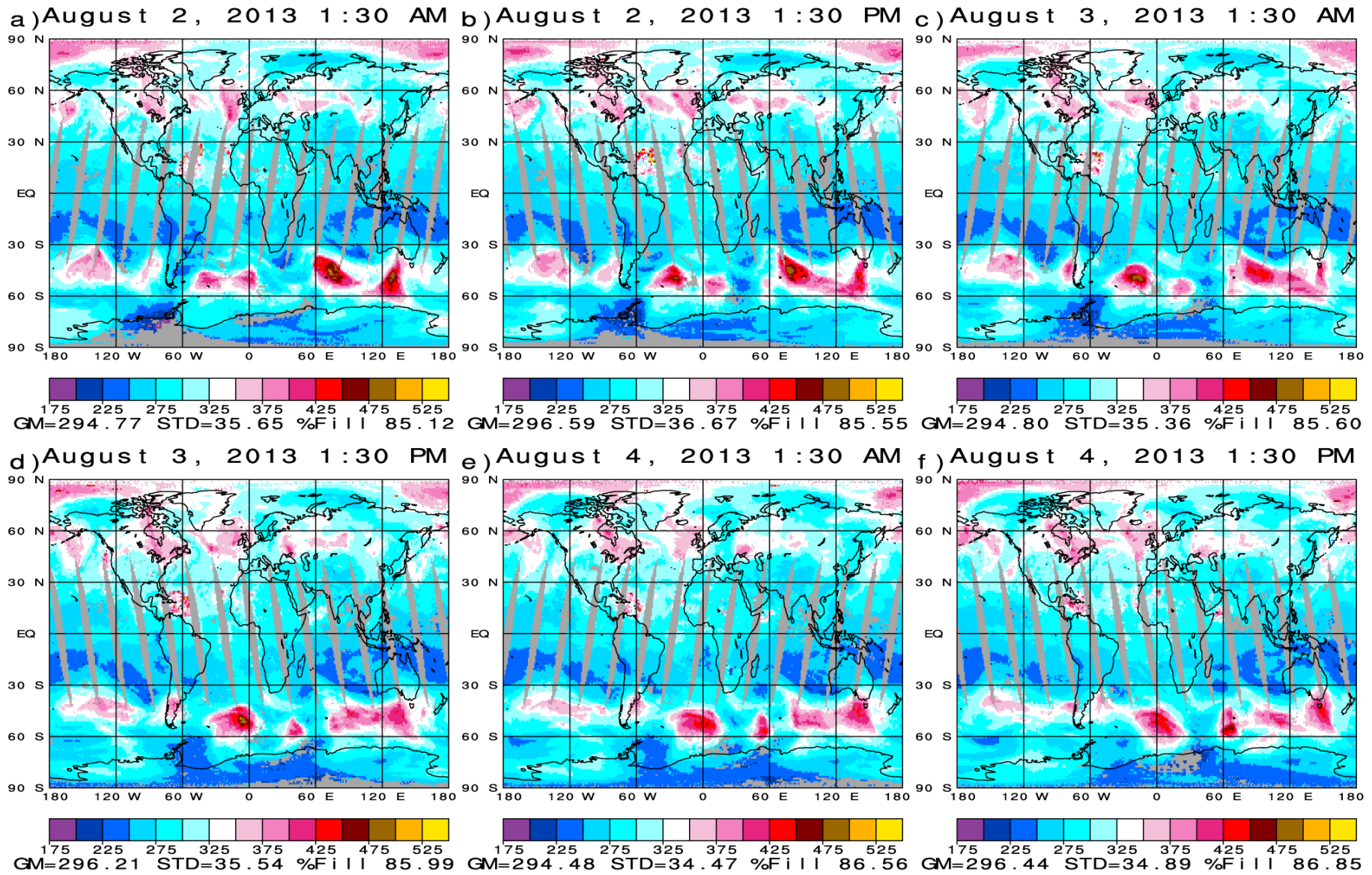
or

2) Improve ozone QC methodology to flag these profiles as bad

or, least desirable and not easy,

3) Identify these retrievals as bad and not include them in the level-3 product by comparison with neighboring retrievals

The next figure shows an example of this problem in JPL Version-6.19 ozone results.



Spuriously high values of AIRS total O_3 are found off the west coast of the Sahara Desert and propagate westward. These spurious features follow the movement of Saharan dust across the Atlantic Ocean.

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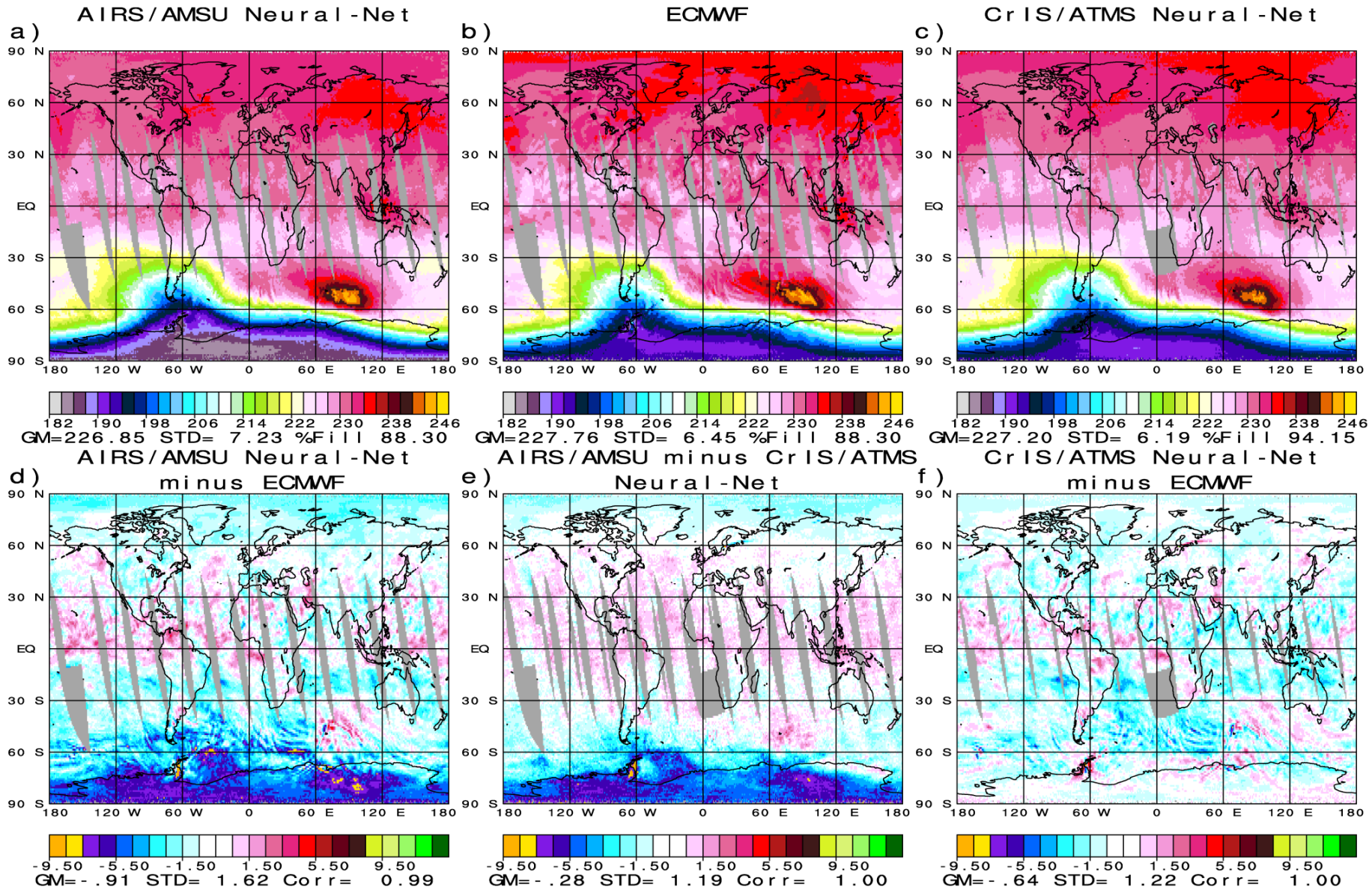
Improved Upper Stratospheric Temperatures in Polar Winter

Bill Blackwell and co-workers have generated CrIS/ATMS neural-net coefficients which perform much better than those of AIRS/AMSU in the upper stratosphere in polar winter.

AIRS/AMSU polar winter upper stratospheric temperatures are subsequently degraded significantly compared to those of CrIS/ATMS. This degrades AIRS polar winter ozone products as well.

These very poor temperatures must be improved upon before we reprocess all the data. Bill Blackwell has indicated he and co-workers will generate new AIRS/AMSU neural-net coefficients that hopefully will alleviate this problem.

An example of degraded performance of AIRS/AMSU neural-net upper stratospheric temperatures compared to CrIS/ATMS is given in the next viewgraph.



The AIRS/AMSU 10 mb neural-net guess performs comparably to CrIS/ATMS except over the south pole in polar winter, where it is biased very cold compared to ECMWF.

Proposed plan of action working toward a Final Build

Our goal is to have a potentially final build at JPL for use in reprocessing AIRS/AMSU and AIRS Only retrievals by two months before the next AIRS Science Team Meeting, roughly four months from now. This will allow for two months of testing and evaluation at JPL.

We plan to examine further improvements in retrieval and QC methodology for all products. We welcome contributions from others as part of this final build.

We hope to have a decision with regard to starting the reprocessing of all AIRS data shortly after the next AIRS Science Team Meeting. The Goddard DISC has said that they are amenable to conducting this reprocessing.