

Major Upgrades to the AIRS Version-6 Water Vapor Profile Methodology[†]



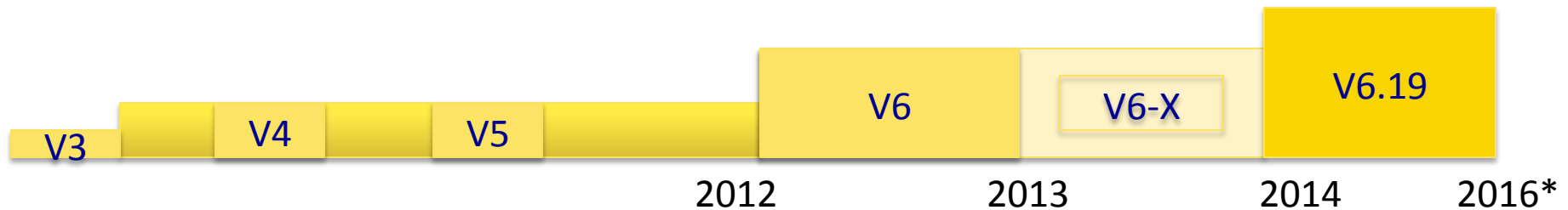
Joel Susskind, John Blaisdell, Lena Iredell, and Jae N. Lee

NASA GSFC Sounder Research Team (SRT)
CERES Science Team Meeting, LaRC VA, May 6, 2015

[†] This presentation is based on the material presented at AIRS science team meeting in April, 2015 (Pasadena, CA).



Background



- 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 $q(p)$ retrievals is basically unchanged from Version-5, or even from Version-4. Subsequent research has made significant improvements in water vapor profiles since 2013 compared to Version-6.
- A further updated algorithm is planned to be operational in 2016*. This talk will concentrate on improvements in Version-6.19 water vapor retrievals compared to Version-6.

Major Problem with Version-6 and Water Vapor Results

Users noticed spurious day/night differences in AIRS V6 water vapor.

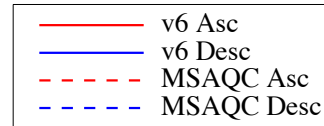
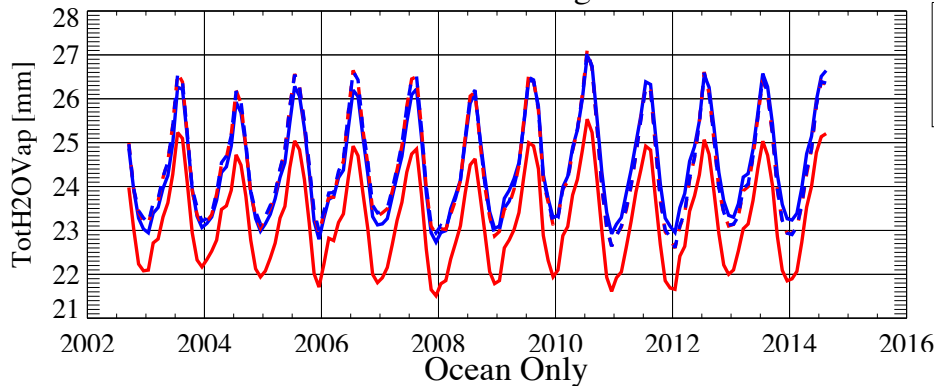
- June Wang at SUNY Albany showed in the last AIRS Science Team Meeting that Version-6 total precipitable water W_{TOT} has a spurious feature in that global mean daytime W_{TOT} is considerably lower than global mean nighttime W_{TOT} .
- Andrey Savtchenko at the DISC showed that this feature is not found in either microwave only or MERRA reanalysis W_{TOT} data sets. Version-6.19 did not recognize the existence of this spurious feature and did nothing to correct it.
- CERES MERRA evaluation team in the comparison of AIRS and MERRA2 also noticed large day/night differences in AIRS V6 water vapor.



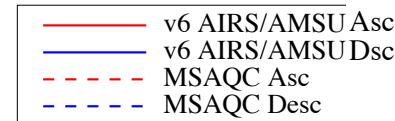
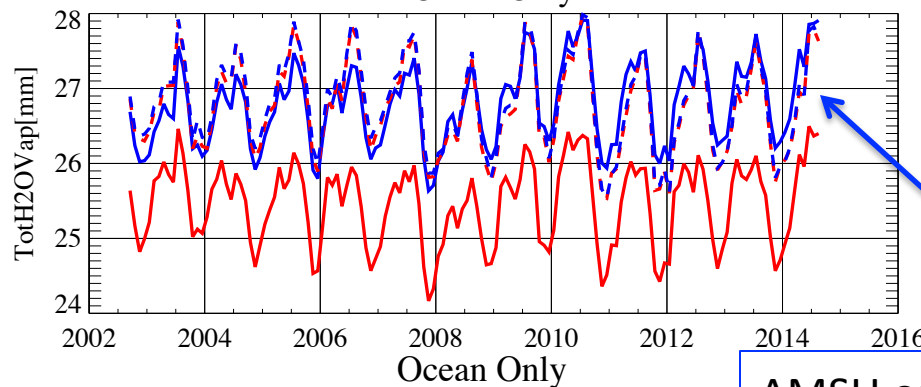
Bias in AIRS V6 Total Water Vapor during Daytime

Courtesy of Thomas Hearty

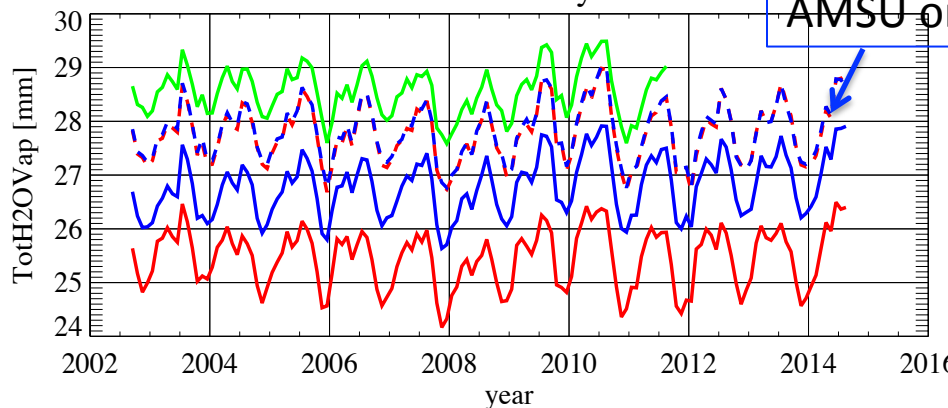
Global Average



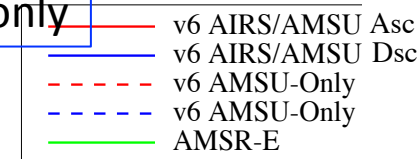
- MERRA is sampled like AIRS (sun-synchronous), using AIRS V6 quality criteria.
- Ascending: day time V6 water vapor is off from MERRA sampled like AIRS.



Asc
MERRA



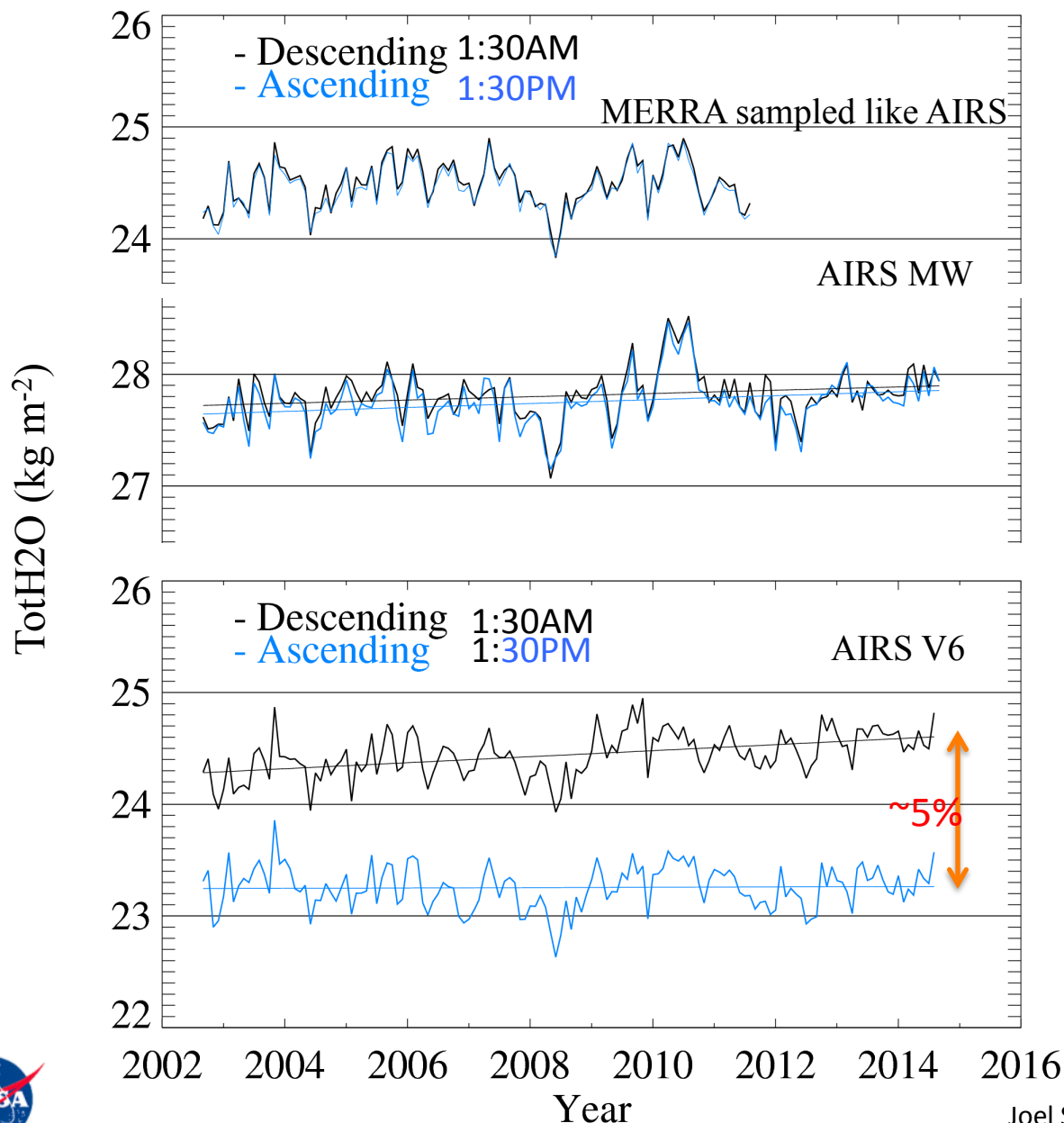
AMSU only



- ~7% Day/night difference does not exist in "MERRA" and "AIRS V6 AMSU-only".

Bias in AIRS V6 Total Water Vapor during Day (Global)

Courtesy of Andrey Savtchenko



- The global mean total water vapor is estimated by removing 6 PCs (annual, semi-annual, ENSO, decadal, etc).
- The day/night difference in the column water vapor in MERRA sampled like AIRS, and AIRS AMSU, is considerably less than in the AIRS V6 retrieval.

Version-6.19 Updates to Water Vapor Profile Retrieval

1. Removed shortwave channels centered on weak water vapor lines

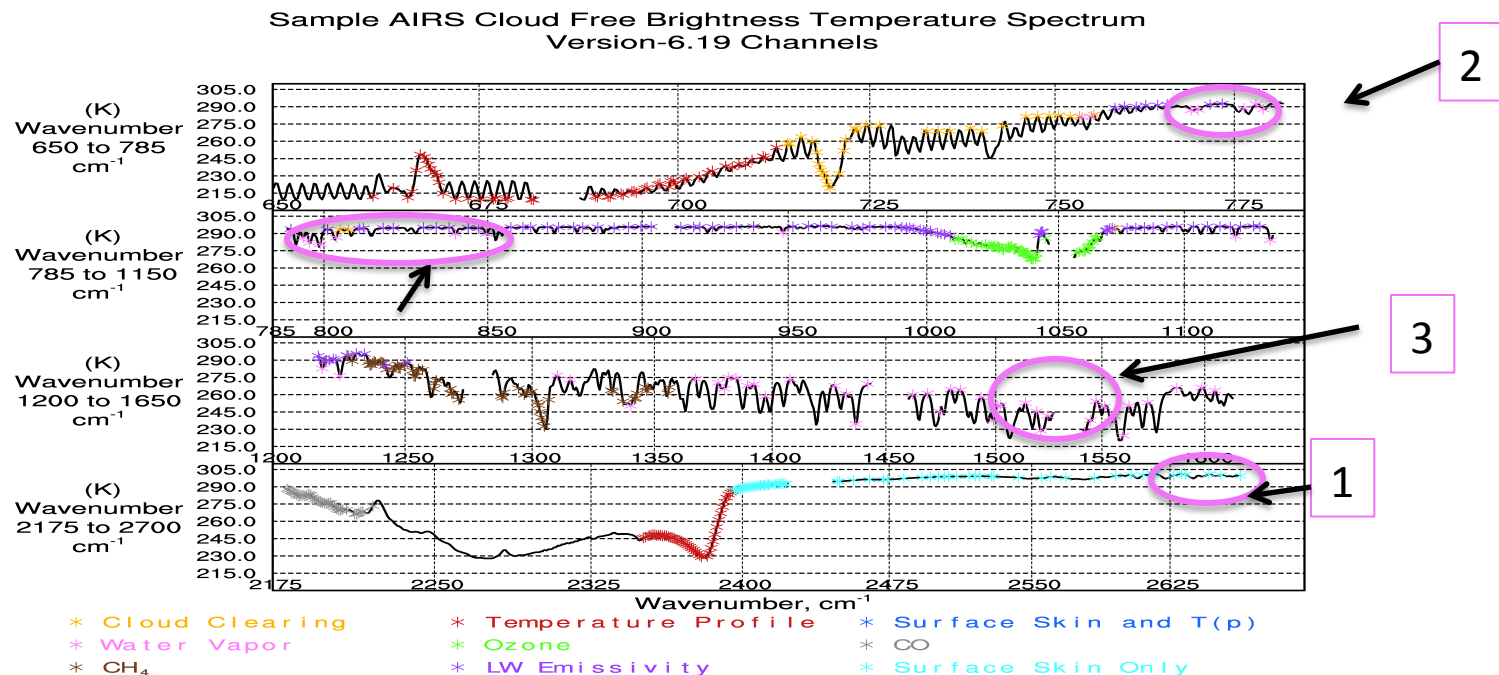
-> These channels were the cause of the spurious daytime water vapor results

2. Added many channels on weak water lines in the longwave window region

-> Helped water vapor retrievals in the boundary layer

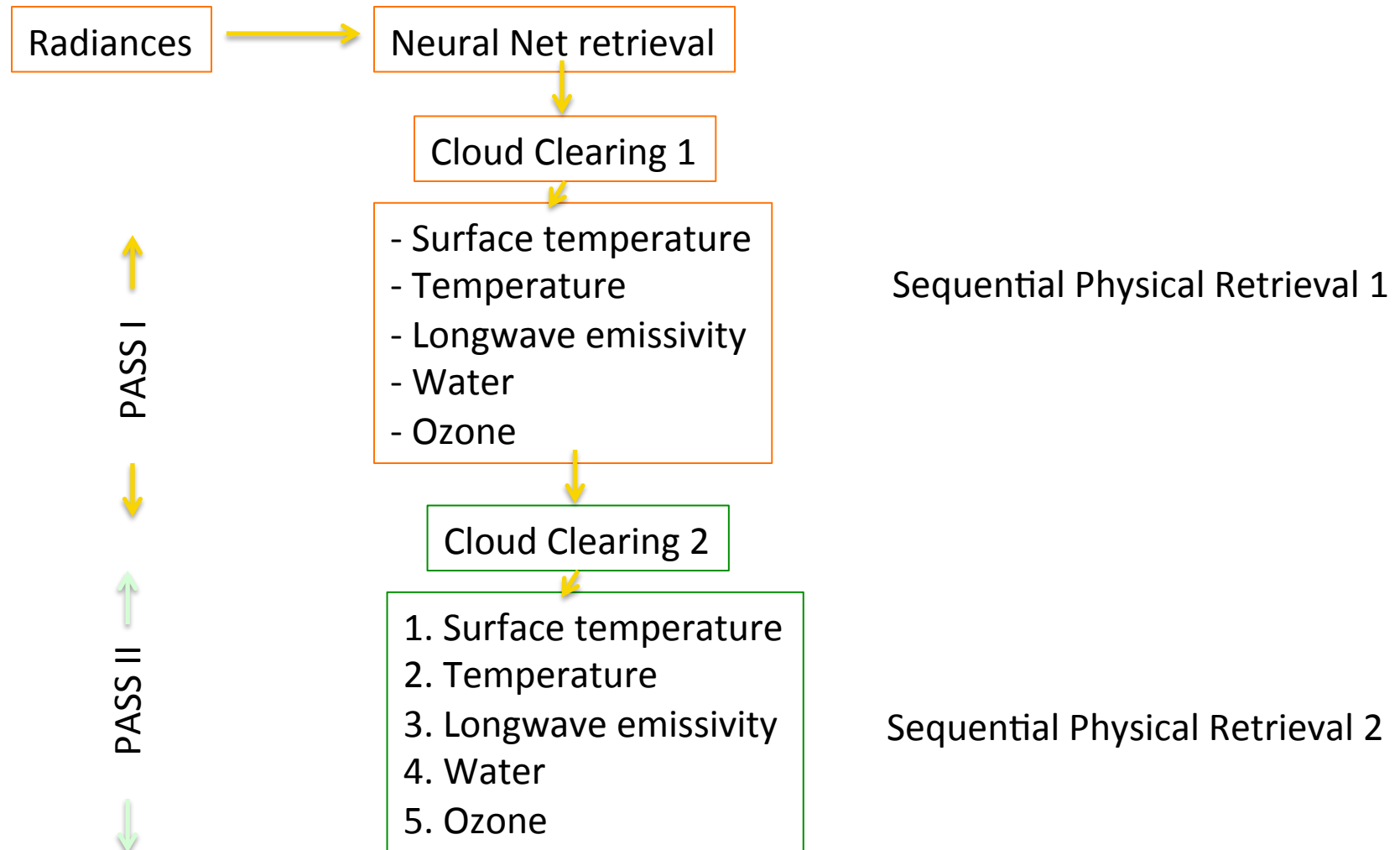
3. Removed peaks of strongest water vapor lines

-> They were hurting upper tropospheric water vapor retrievals



4. Added a second pass water vapor retrieval step

->This slows down the retrieval process but improved water vapor results



Version-6.19

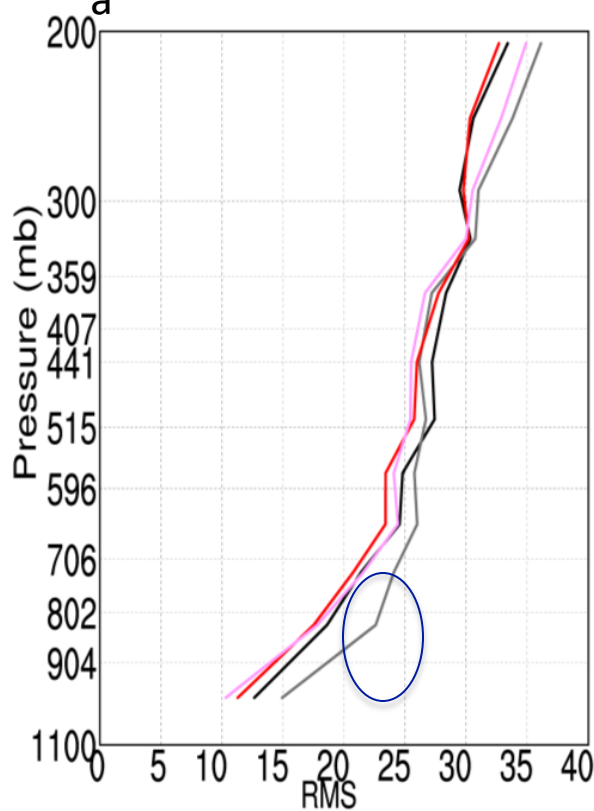
1. Additional changes in Version-6.19 include all previous updates made to the $q(p)$ retrieval since Version-6:
 - Modified Neural-Net $q^0(p)$ guess above the tropopause
Linearly tapers the neural net guess to match climatology at 70 mb, not at the top of the atmosphere
 - Changed the 11 trapezoid $q(p)$ perturbation functions used in Version-6 so as to match the 24 functions used in $T(p)$ retrieval step
2. These modifications resulted in improved water vapor profiles in Version-6.19 compared to Version-6.
 - Version-6.19 is tested for all of August 2013 and August 2014, as well for select other days. Before finalized and operational in 2016, the V-6.19 can be acquired upon request for limited time intervals.



Global Water Vapor Profile July 15, 2013

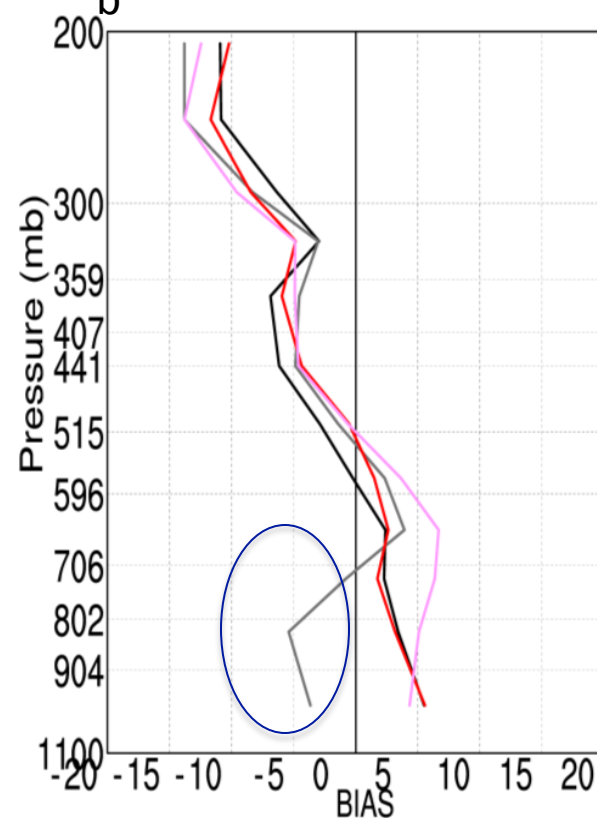
1 Km Layer Precipitable Water

RMS % Differences from ECMWF



— Version-6
 — Version-6
 — Version-6.19
 — Version-6.19

Bias % Differences from ECMWF



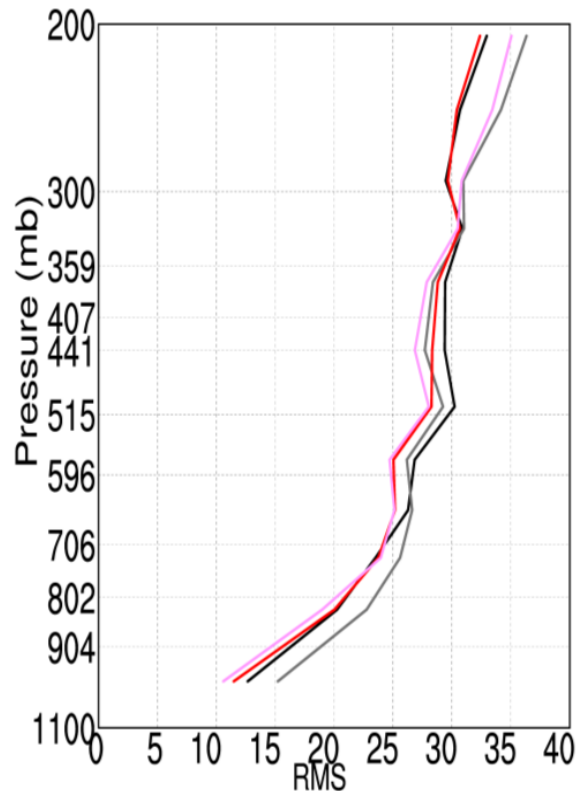
1:30 AM Climate (QC=0,1; Pgood)
 1:30 PM Climate (QC=0,1; Pgood)
 1:30 AM Climate (QC=0,1; Pgood)
 1:30 PM Climate (QC=0,1; Pgood)

Version-6.19 $q(p)$ accuracy is improved compared to Version-6 at all levels, especially in the mid-lower troposphere during the day, in NH summer.

Global Water Vapor Profile December 4, 2013

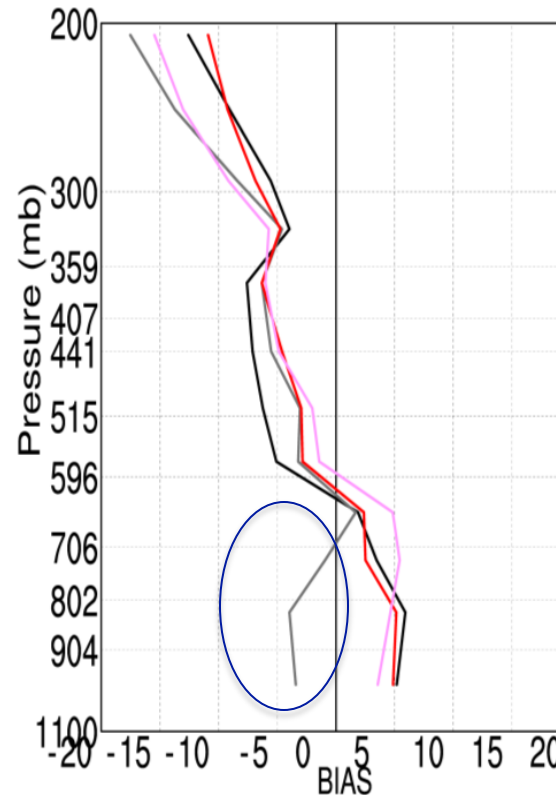
1 Km Layer Precipitable Water

RMS % Differences from ECMWF



— Version-6
 — Version-6
 — Version-6.19
 — Version-6.19

Bias % Differences from ECMWF



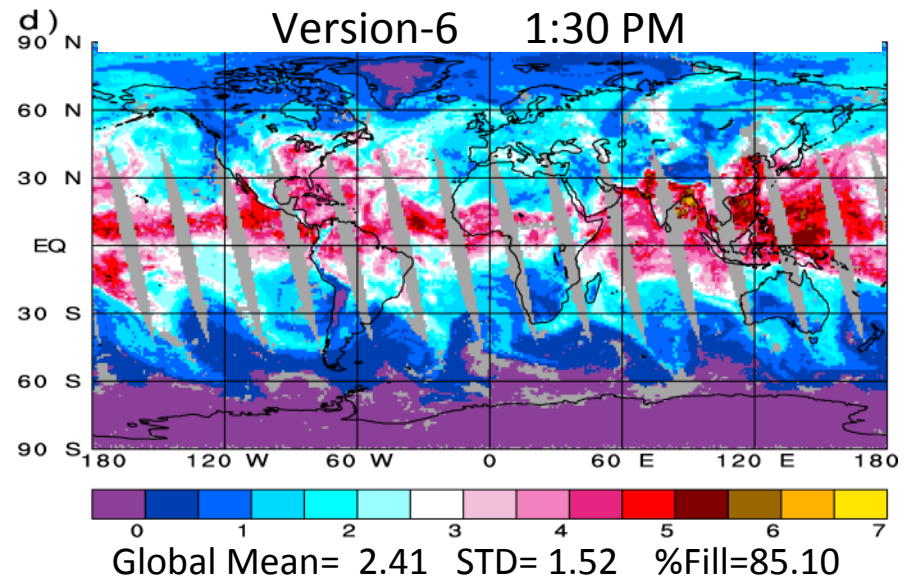
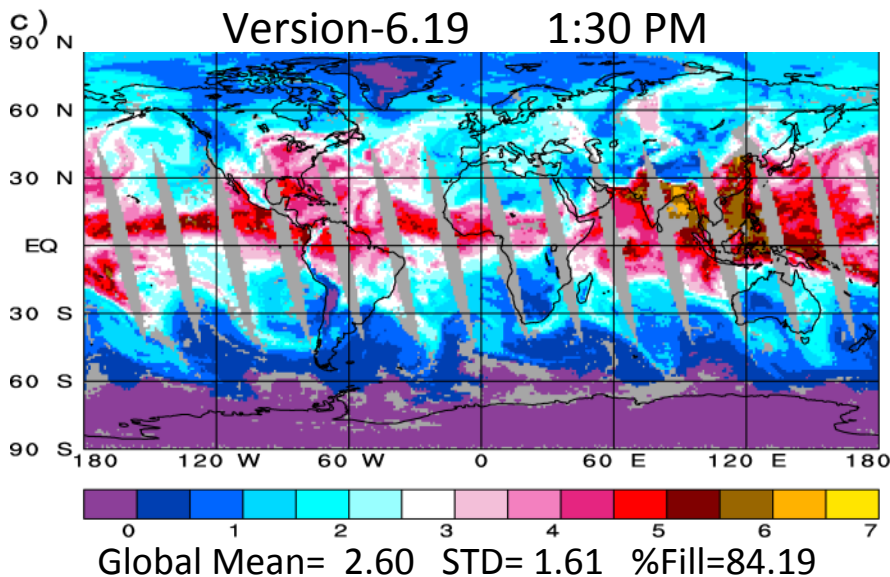
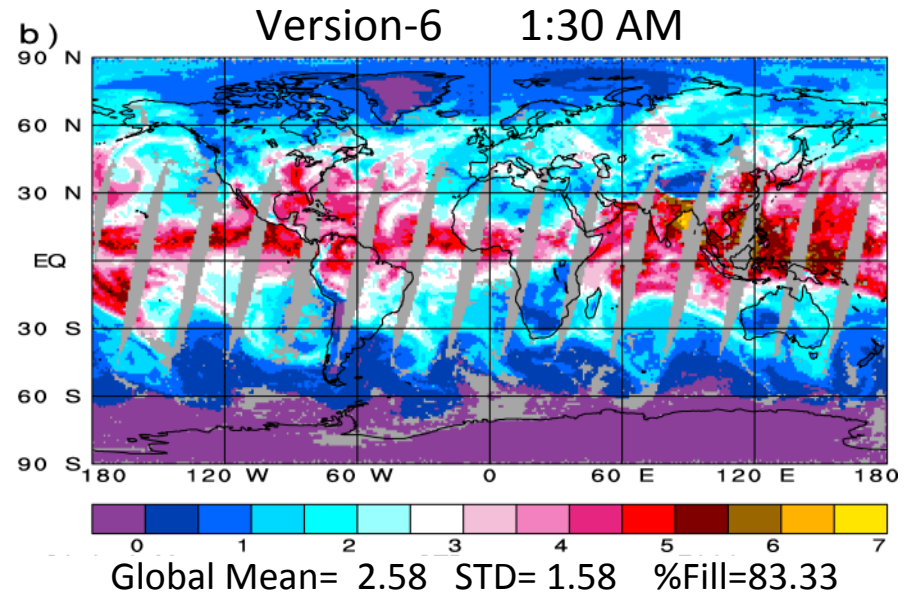
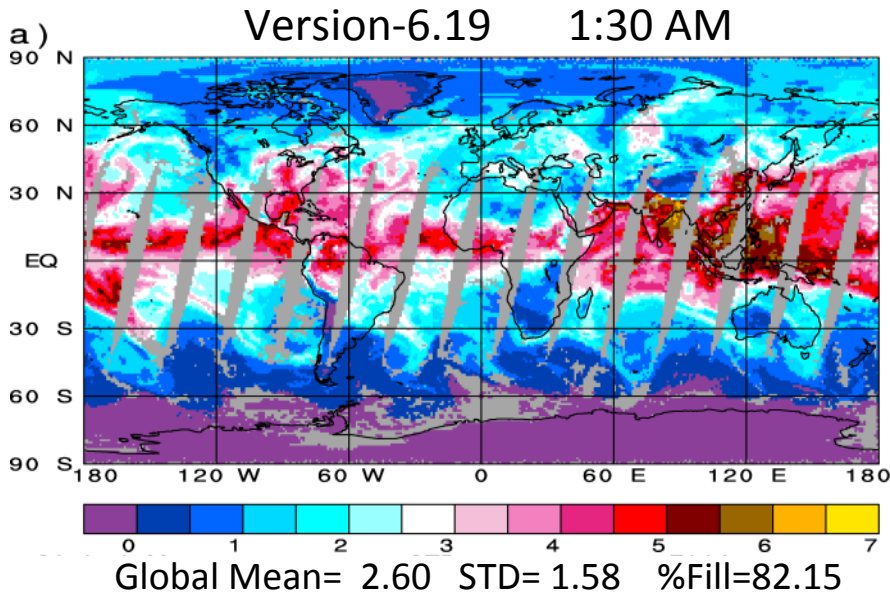
1:30 AM Climate (QC=0,1; Pgood)
 1:30 PM Climate (QC=0,1; Pgood)
 1:30 AM Climate (QC=0,1; Pgood)
 1:30 PM Climate (QC=0,1; Pgood)

Version-6.19 $q(p)$ accuracy is improved compared to Version-6 at all levels, especially in the mid-lower troposphere during the day, in NH winter.

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Total Precipitable Water (cm) July 15, 2013

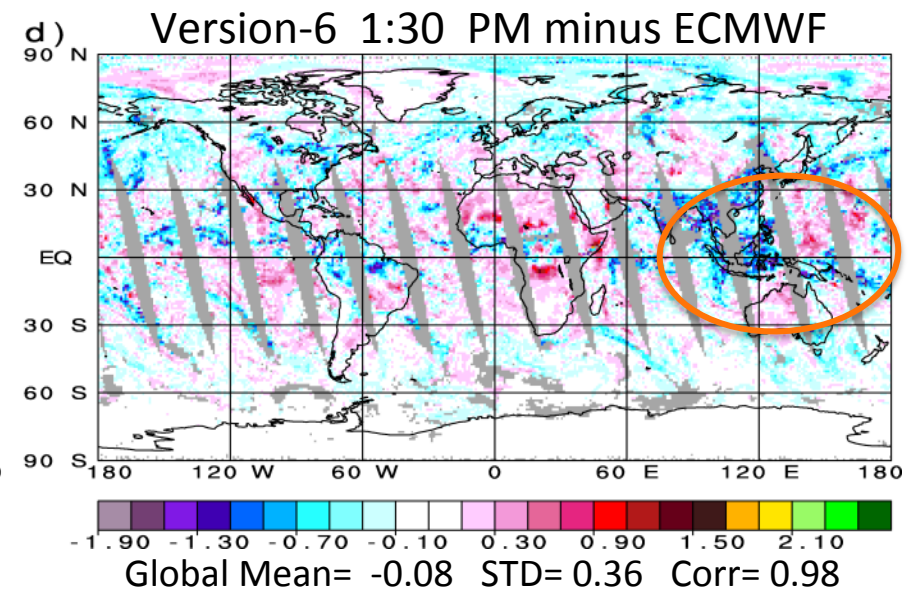
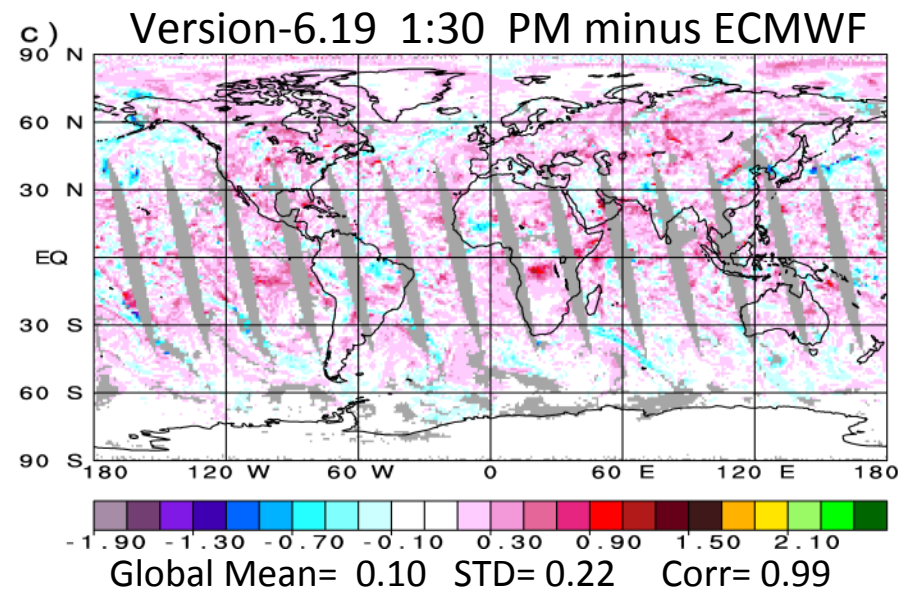
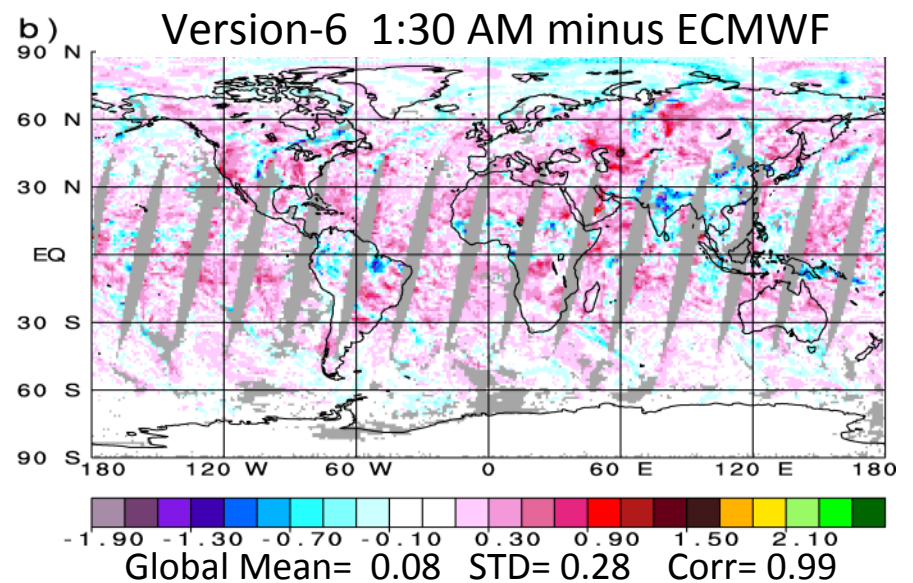
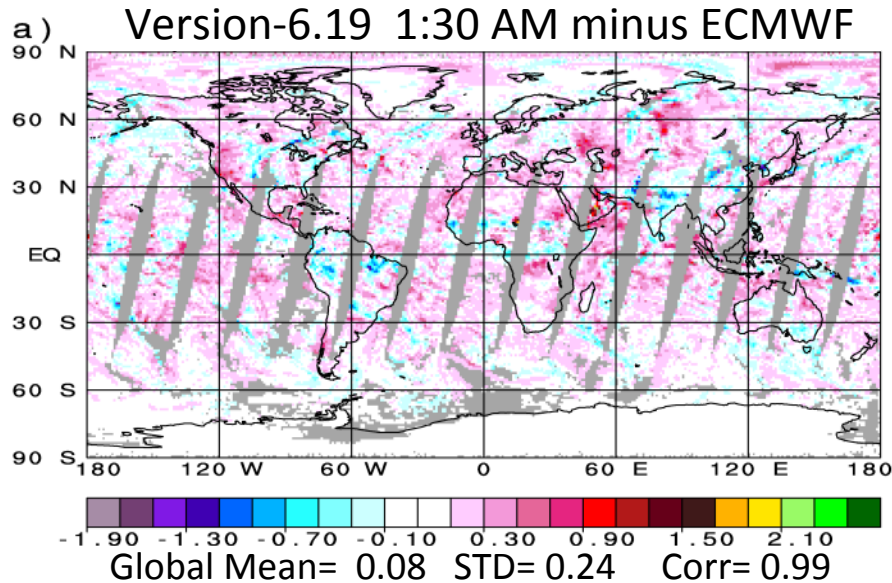


Spurious day/night difference in Version-6 global mean total precipitable water is removed in Version-6.19.

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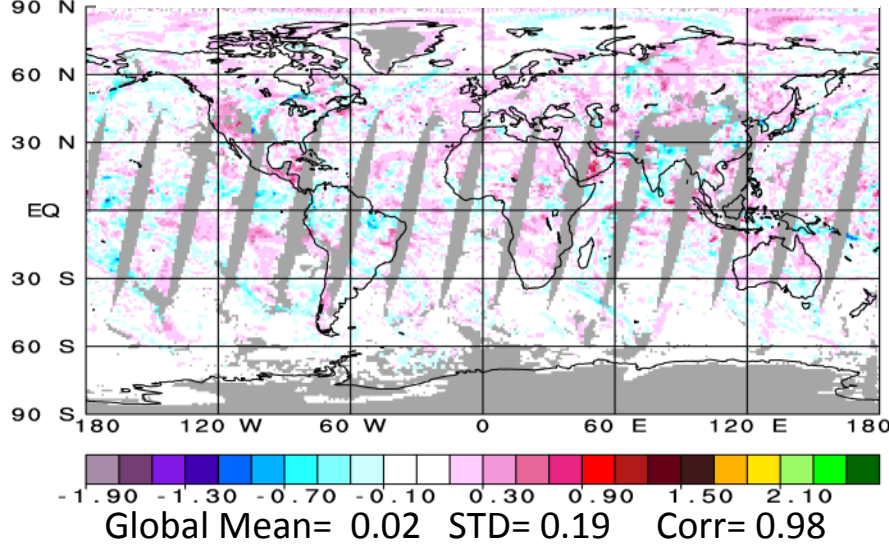
Total Precipitable Water (cm) July 15, 2013



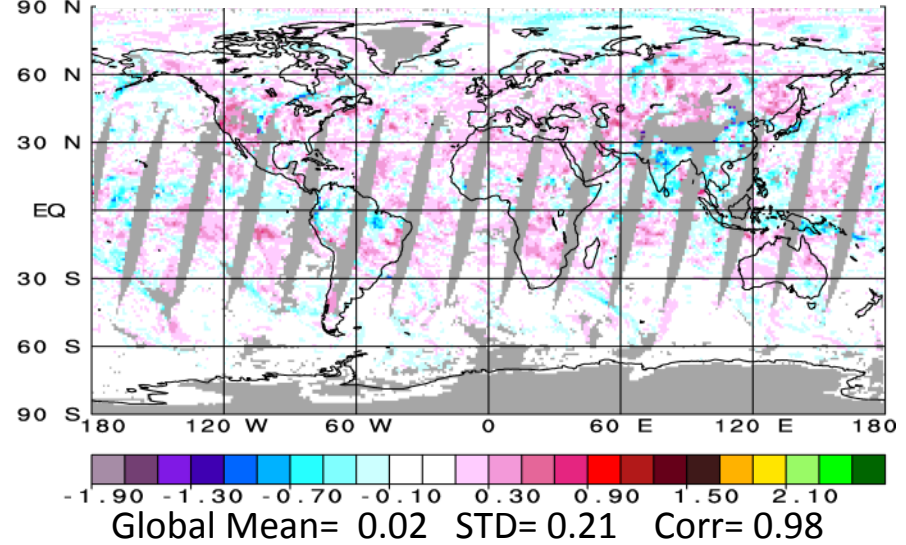
Version-6.19 total precipitable water agrees better with ECMWF during the night, and much better with ECMWF during the day, especially in high cloud regions.

Total Precipitable Water 850 mb to top (cm) July 15, 2013

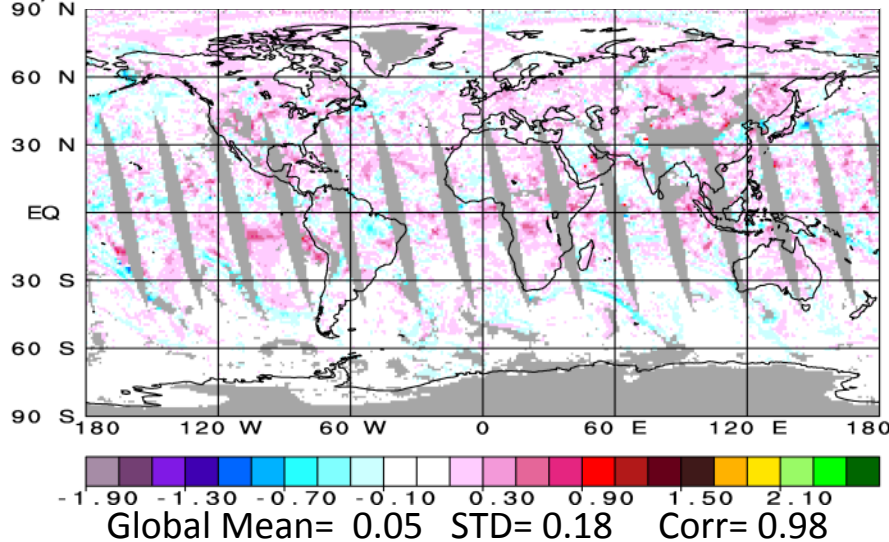
a) Version-6.19 1:30 AM minus ECMWF



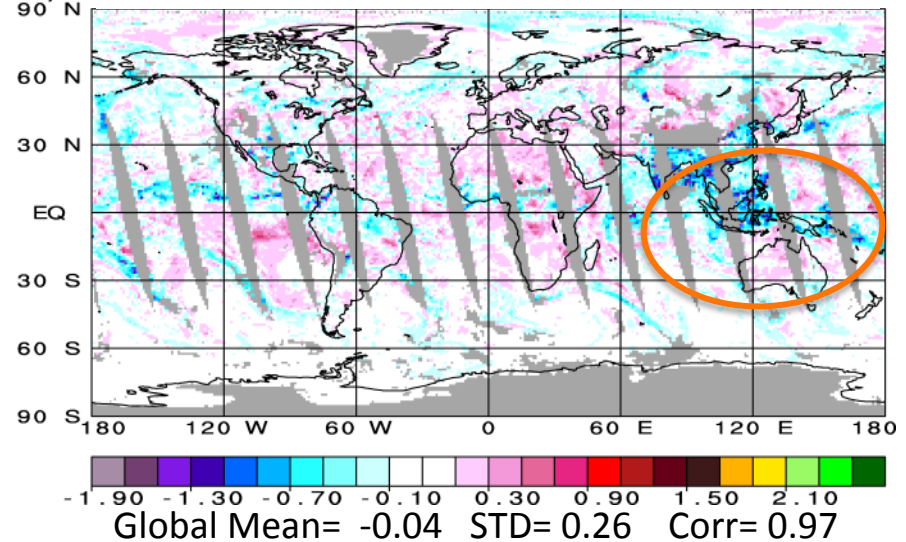
b) Version-6 1:30 AM minus ECMWF



c) Version-6.19 1:30 PM minus ECMWF

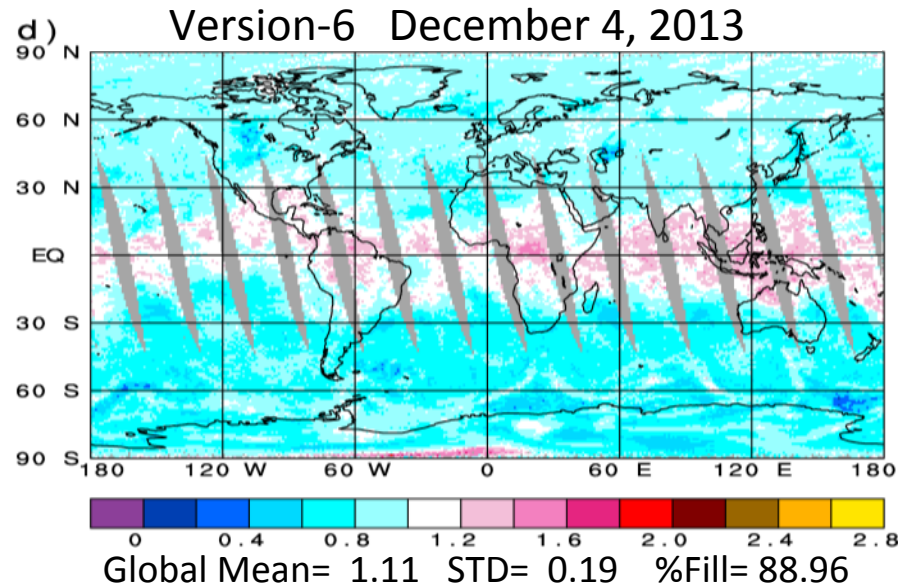
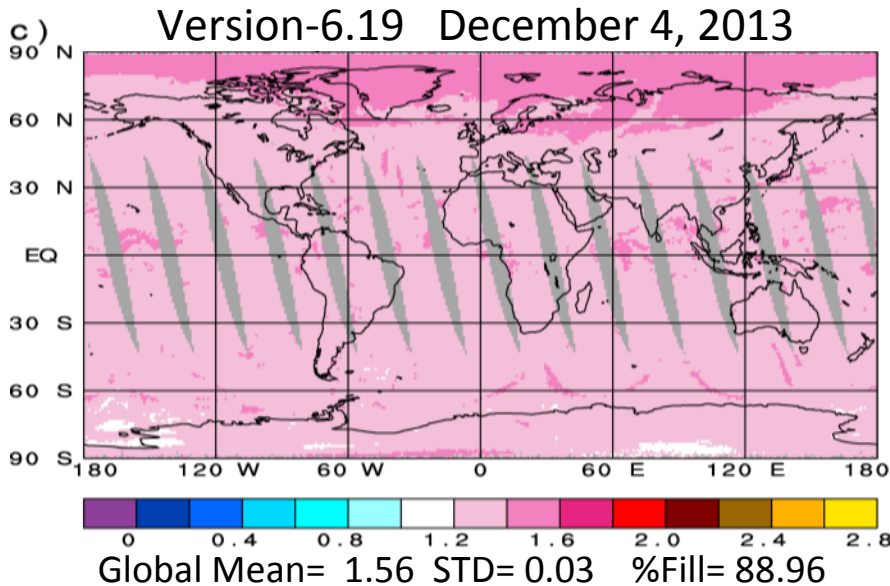
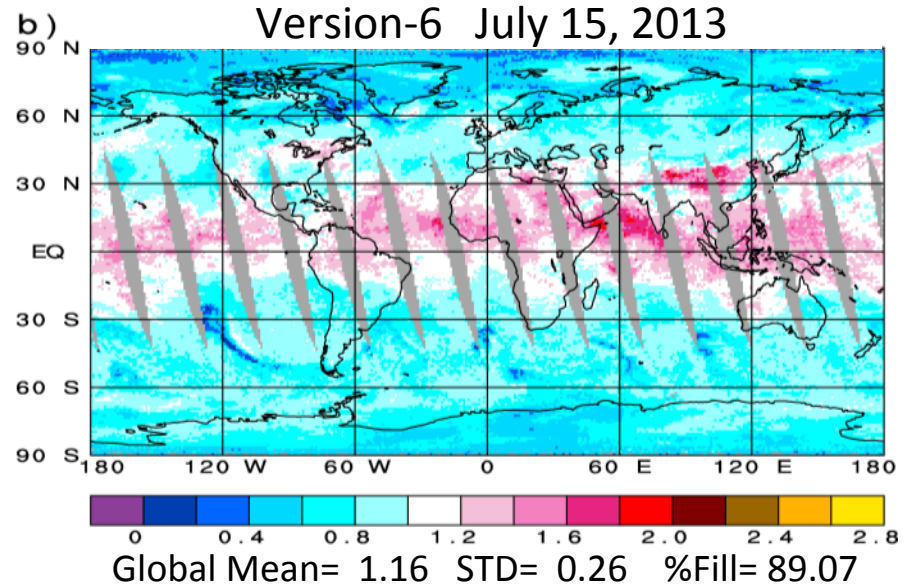
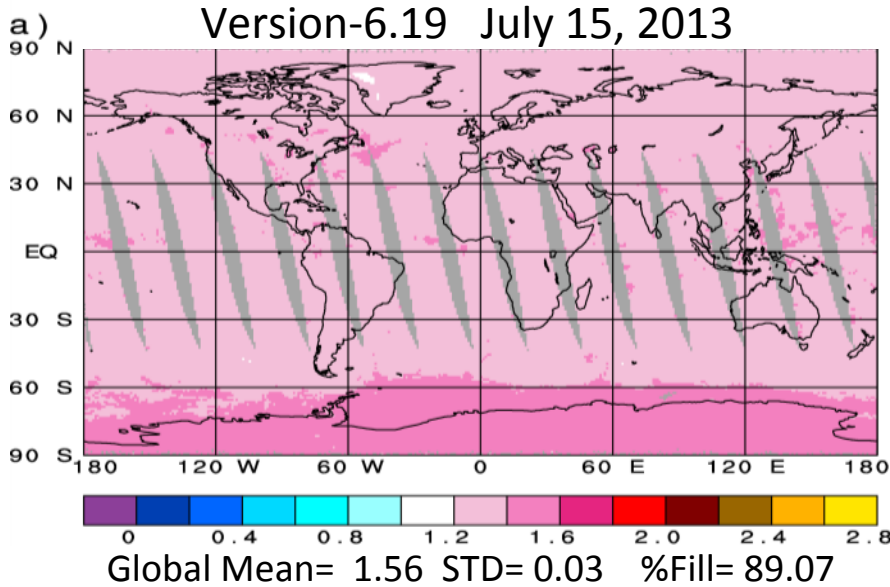


d) Version-6 1:30 PM minus ECMWF



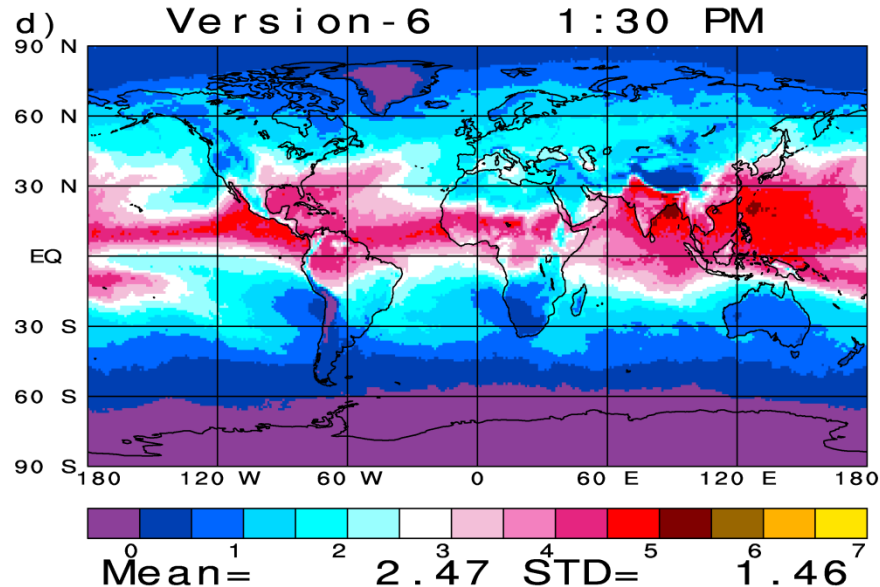
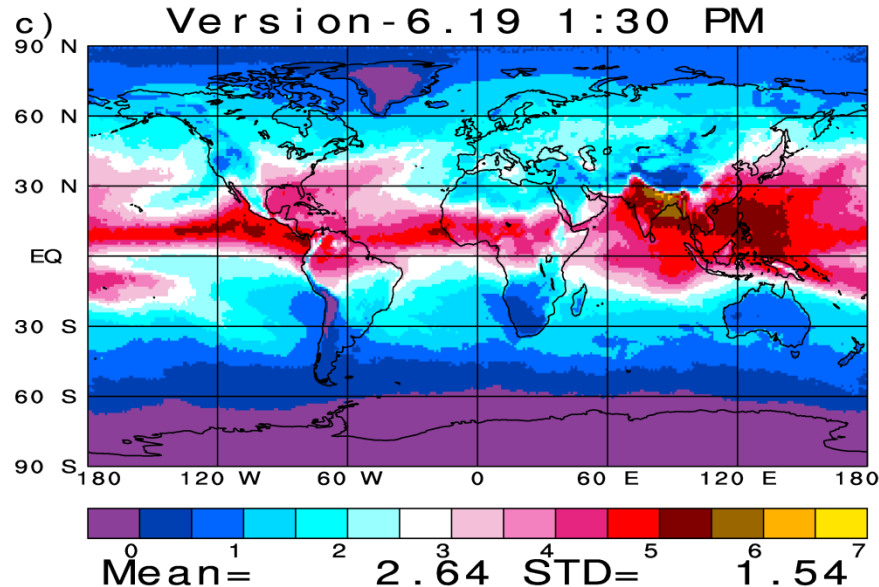
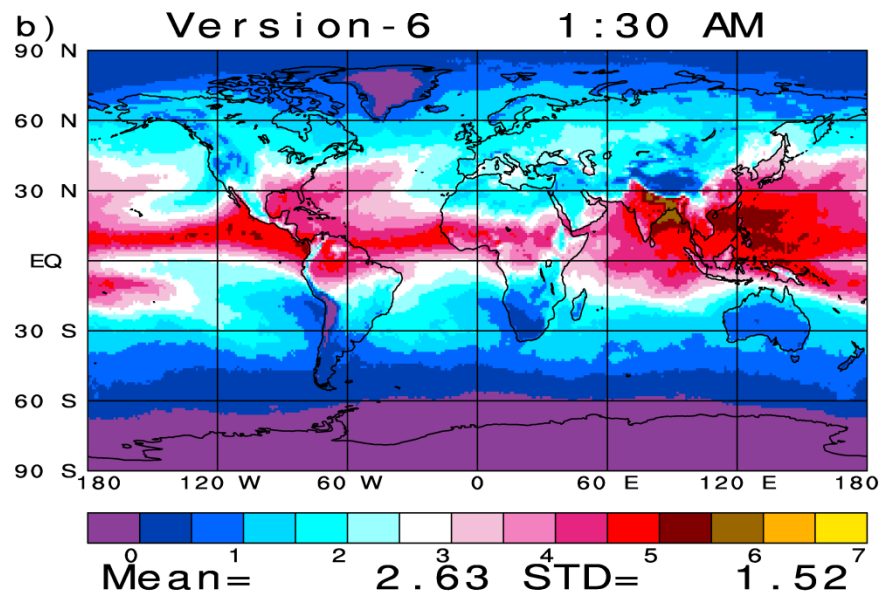
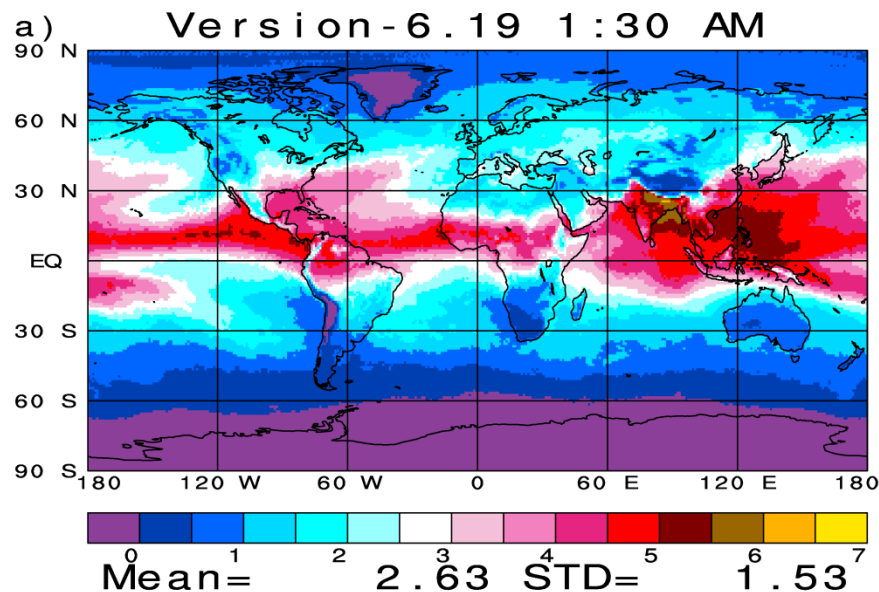
Version-6.19 total precipitable water above 850 mb is also more accurate than Version-6, especially during the day.

Total Precipitable Water 50 mb to top (mm*10000) 1:30 PM



Version-6 upper stratospheric water vapor showed spurious features related to tropospheric convection. These spurious features are not found in Version-6.19. AIRS WV observations do not contain much information above 200mb.

Total Precipitable Water (cm) August 2013



Version-6.19 eliminates the spurious day/night difference in monthly mean global mean total precipitable water found in Version-6.

Findings with Regard to Water Vapor Profile

Version-6.19 water vapor profiles are more accurate than Version-6 in a number of ways:

- 1 km layer precipitable water is more accurate in all layers day and night
This is especially true in the mid-lower troposphere and boundary layer at 1:30 PM
- The spurious dry bias in Version-6 lower tropospheric water vapor at 1:30 PM has been eliminated

Even more significantly

- The spurious $\approx 7\%$ negative day minus night difference in global mean total precipitable water in Version-6 has been eliminated
The bias was due primarily to low 1:30 PM values in regions with large amounts of mid-high level cloud cover
- In addition, Version-6 had very unphysical values of stratospheric water vapor that have now been corrected, or at least improved upon.



Future plans

- We have also updated ozone retrieval to be more consistent with OMI.
- We would like to see more AIRS $q(p)$ and ozone comparison with MERRA 2 data to find if further improvements need to be made.
- We can provide some updated V6.19 data to users.
- Meanwhile, we plan to post a statement on artifacts of day/night differences in V6 total column water on the AIRS science team website.
- AIRS Science Team plans to reprocess all AIRS/AMSU data with improved retrieval methodology within the next year.

