

# Major Upgrades to the AIRS Version-6 Water Vapor Profile Methodology<sup>†</sup>



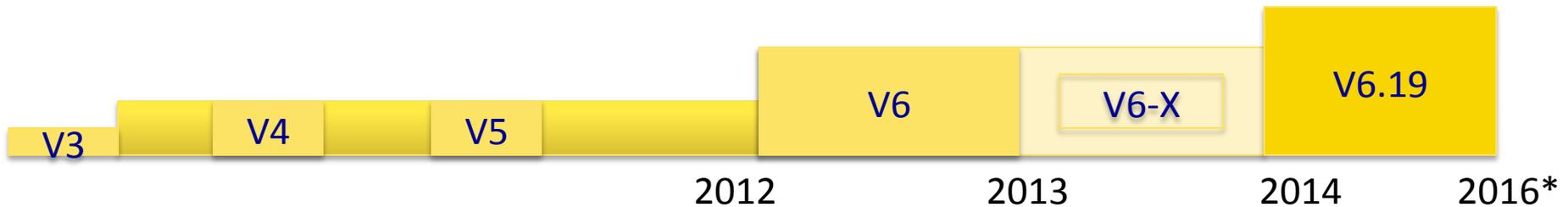
Joel Susskind, John Blaisdell, **Lena Iredell**, and Jae N. Lee

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

<sup>†</sup> 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

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

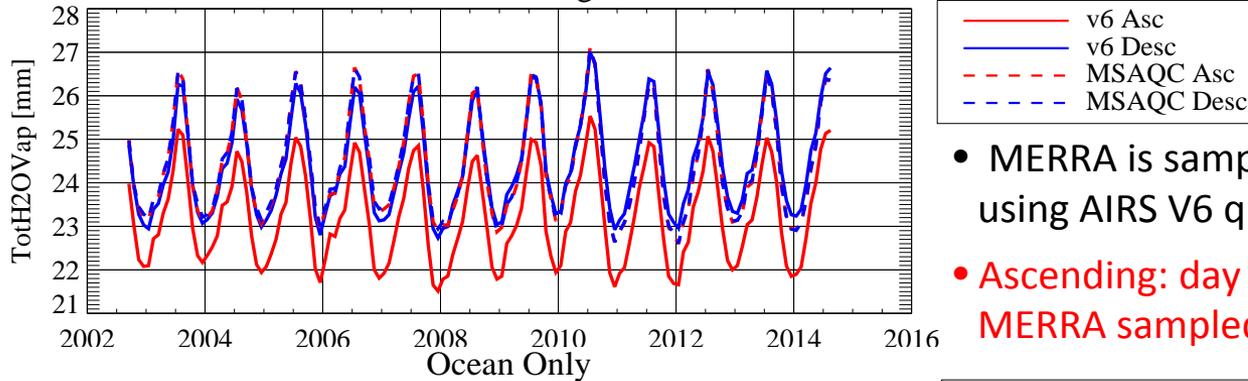
- June Wang at SUNY Albany showed in the last AIRS Science Team Meeting that Version-6 total precipitable water  $W_{TOT}$  has a spurious feature in that global mean daytime  $W_{TOT}$  is considerably lower than global mean nighttime  $W_{TOT}$ .
- Andrey Savtchenko at the DISC showed that this feature 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.
- 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

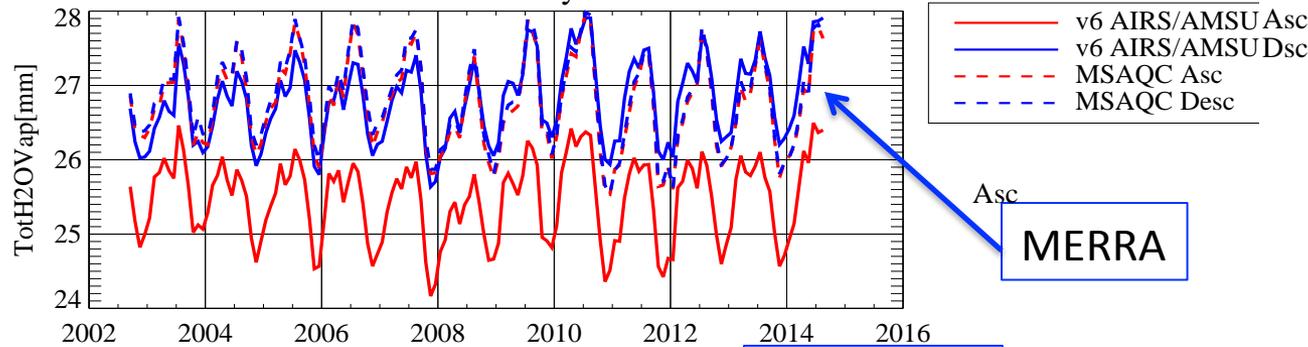
Courtesy of Thomas Hearty

Global Average



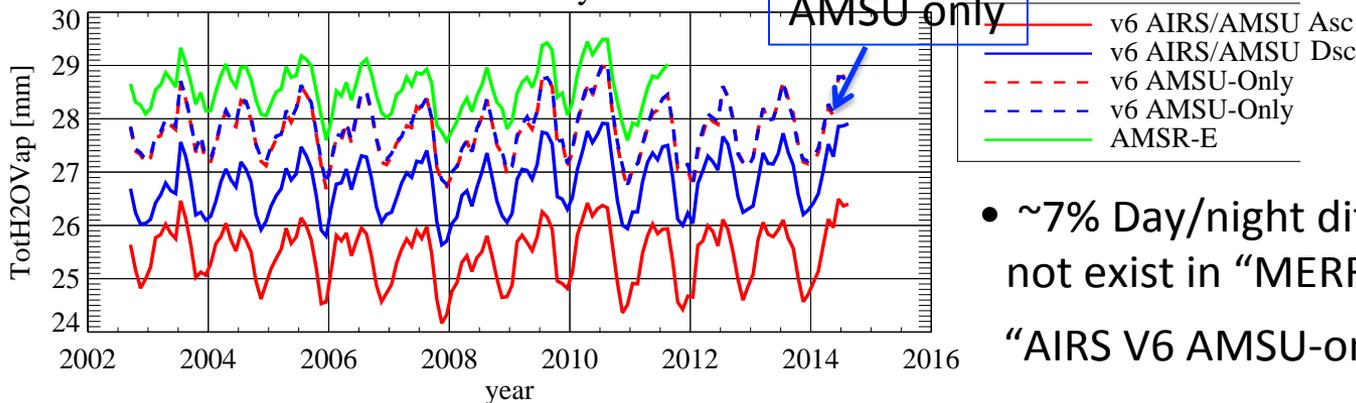
- MERRA is sampled like AIRS (sun-synchronous), using AIRS V6 quality criteria.
- Ascending: day time V6 water vapor is off from MERRA sampled like AIRS.

Ocean Only



Asc  
MERRA

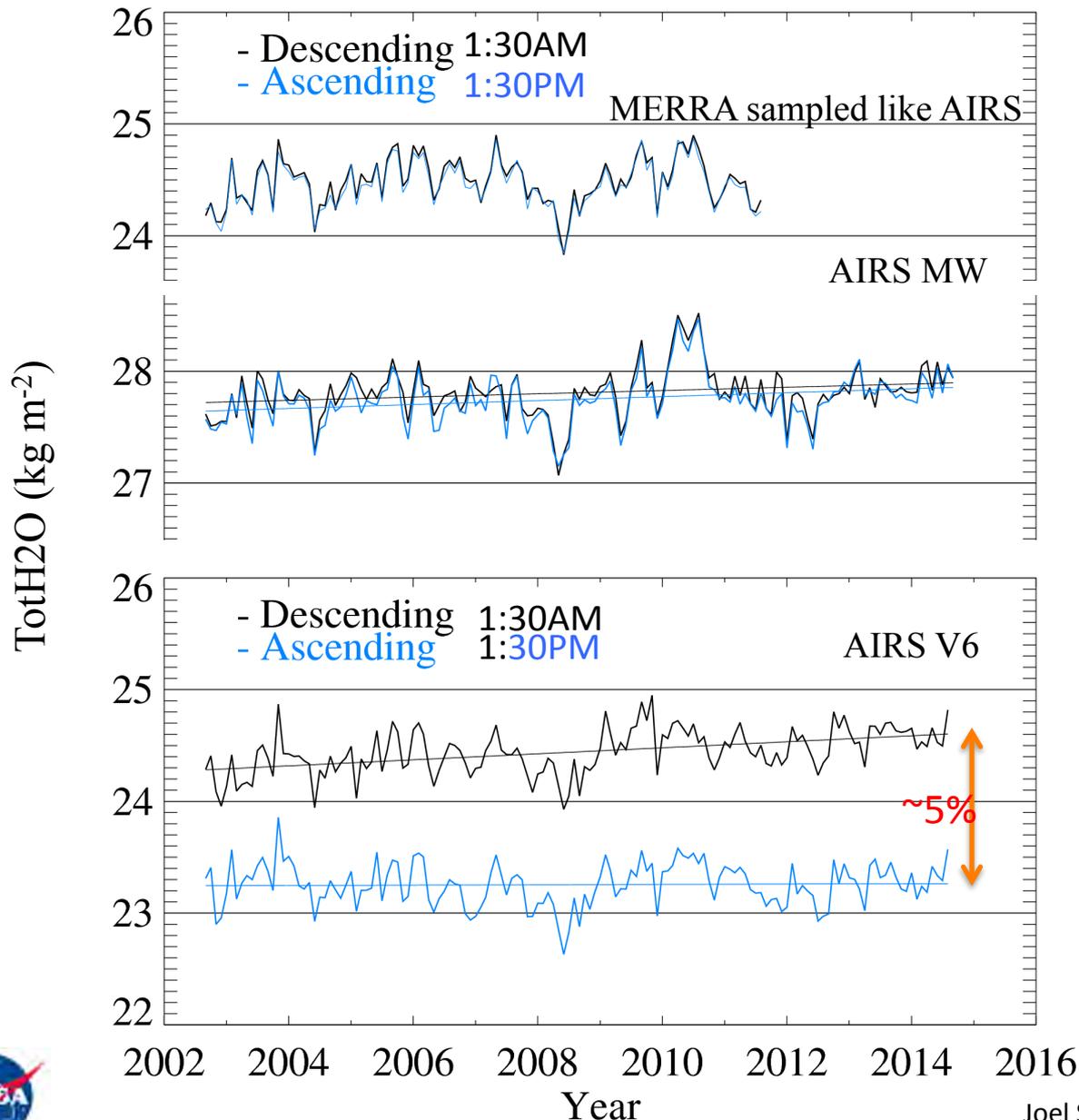
Ocean Only



- ~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

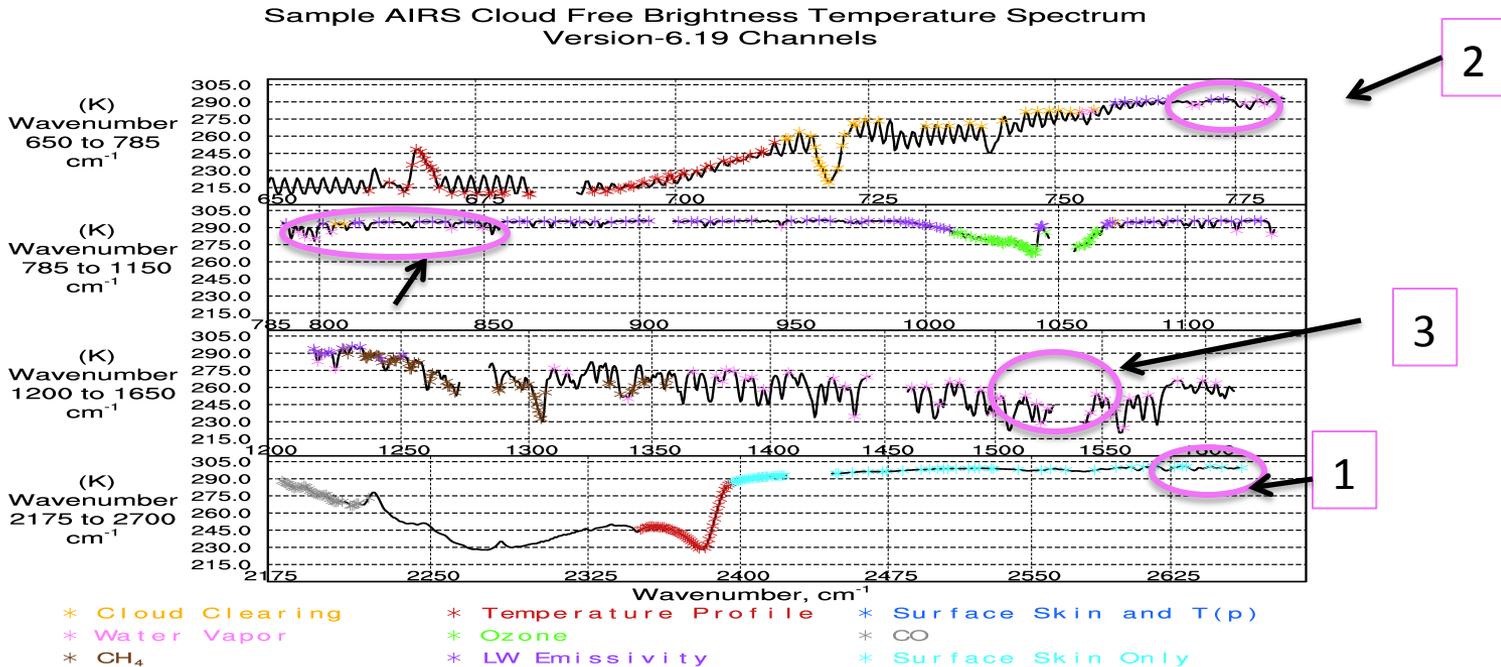


- The global mean total water vapor is estimated by removing 6 PCs (annual, semi-annual, ENSO, decadal, etc).
- The day/night difference in the column water vapor in MERRA sampled like AIRS, and AIRS AMSU, is considerably less than in the AIRS V6 retrieval.



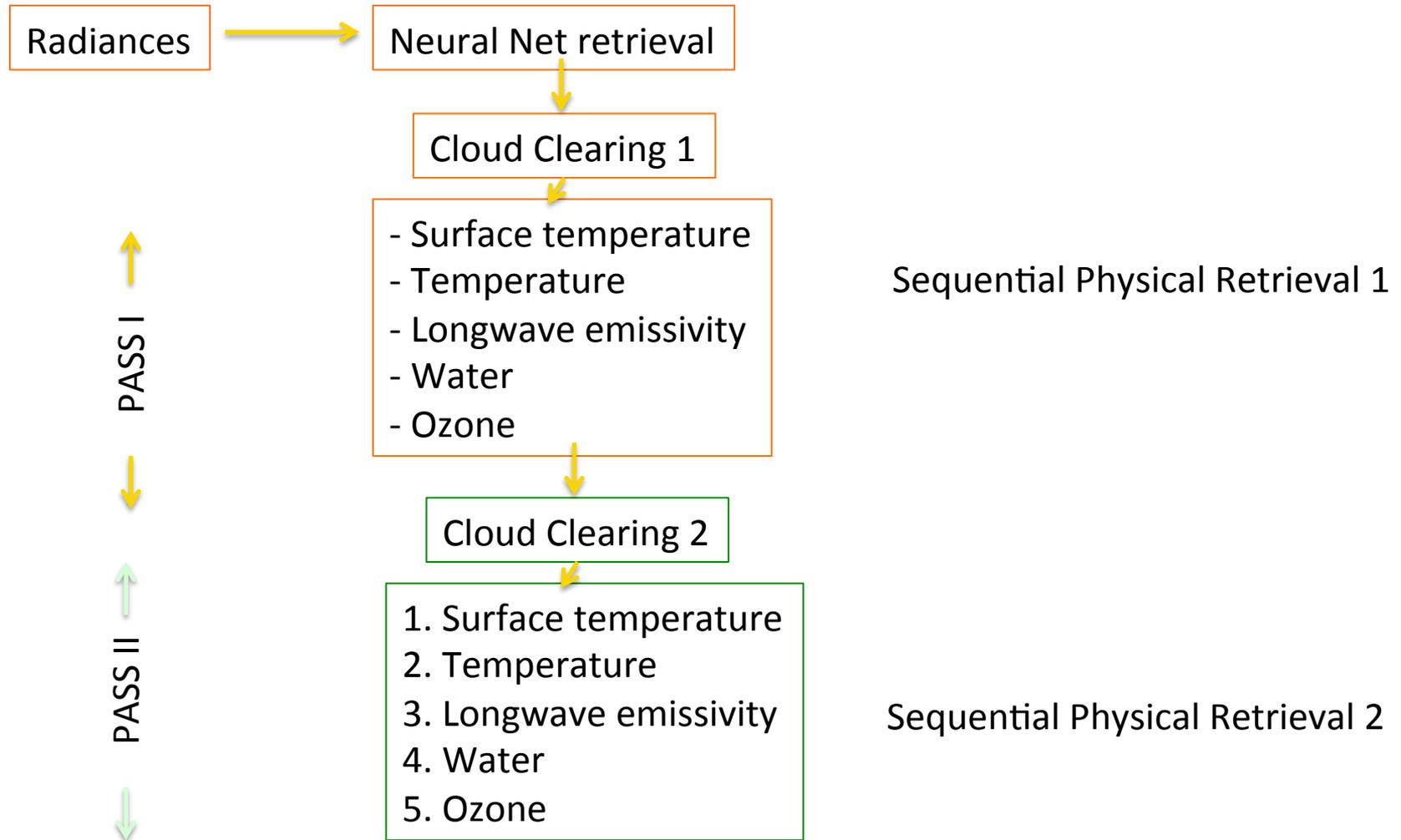
# Version-6.19 Updates to Water Vapor Profile Retrieval

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

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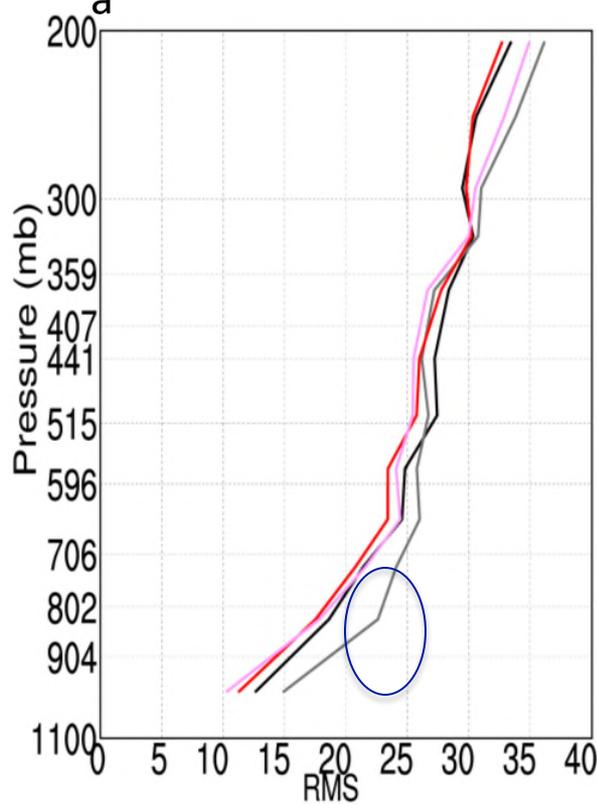
1. Additional changes in Version-6.19 include all previous updates made to the  $q(p)$  retrieval since Version-6:
  - Modified Neural-Net  $q^0(p)$  guess above the tropopause  
Linearly tapers the neural net guess to match climatology at 70 mb, not at the top of the atmosphere
  - Changed the 11 trapezoid  $q(p)$  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

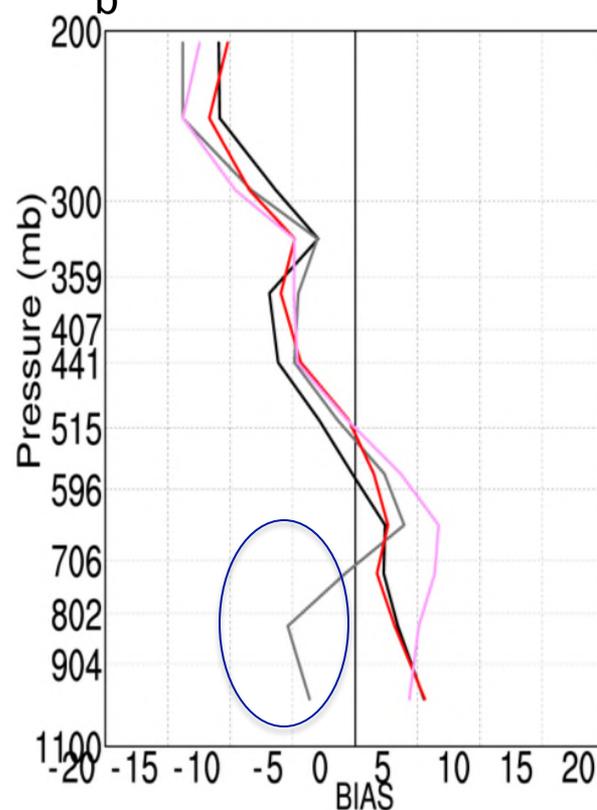
## 1 Km Layer Precipitable Water

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)

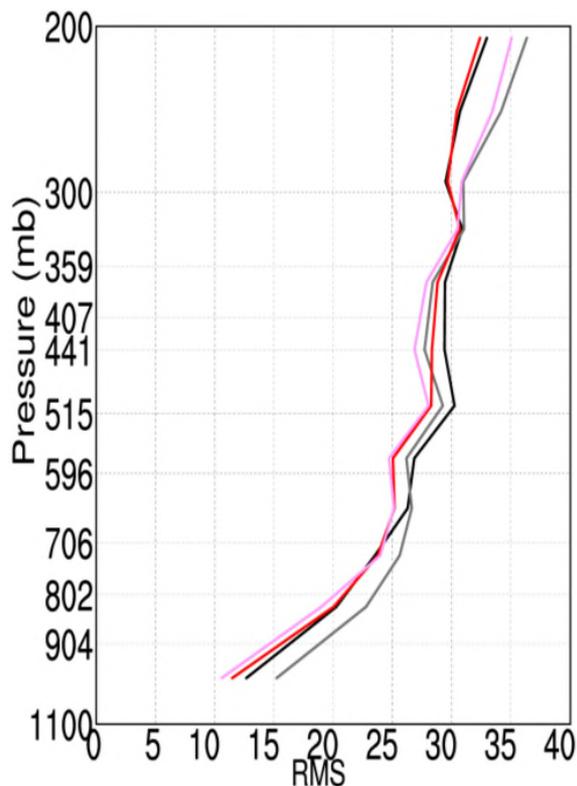
Version-6.19  $q(p)$  accuracy is improved compared to Version-6 at all levels, especially in the mid-lower troposphere during the day, in NH summer.



# Global Water Vapor Profile December 4, 2013

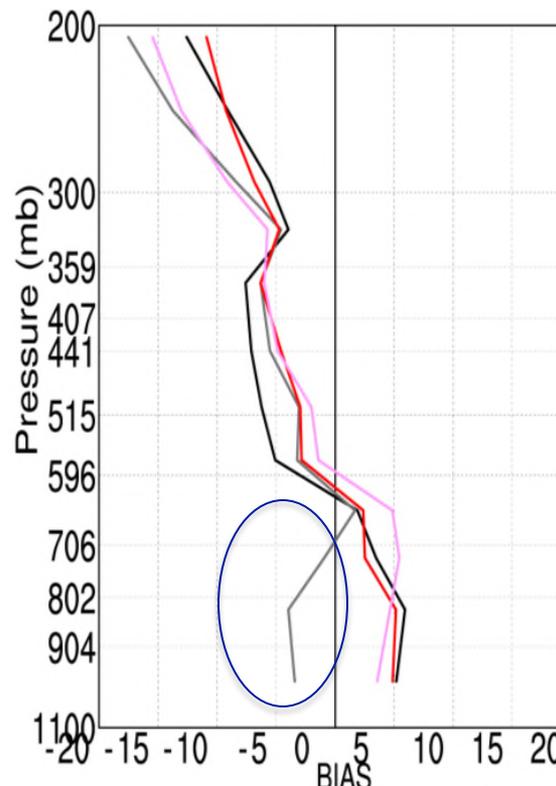
## 1 Km Layer Precipitable Water

RMS<sub>a</sub> % Differences from ECMWF



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

Bias<sub>b</sub> % Differences from ECMWF

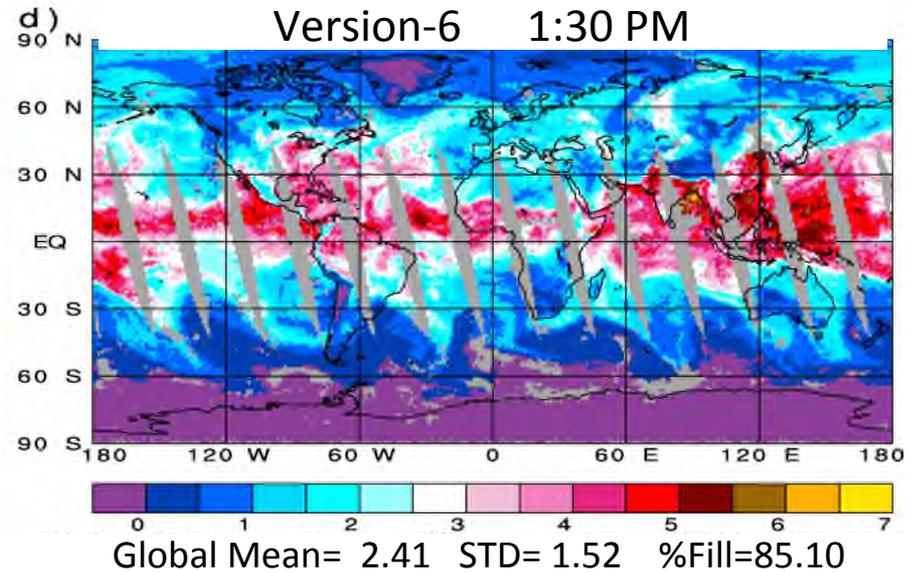
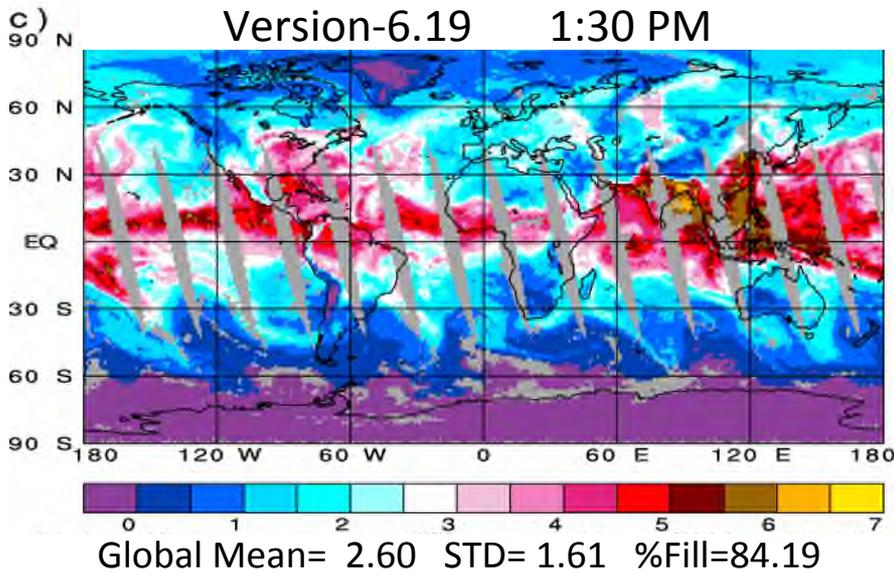
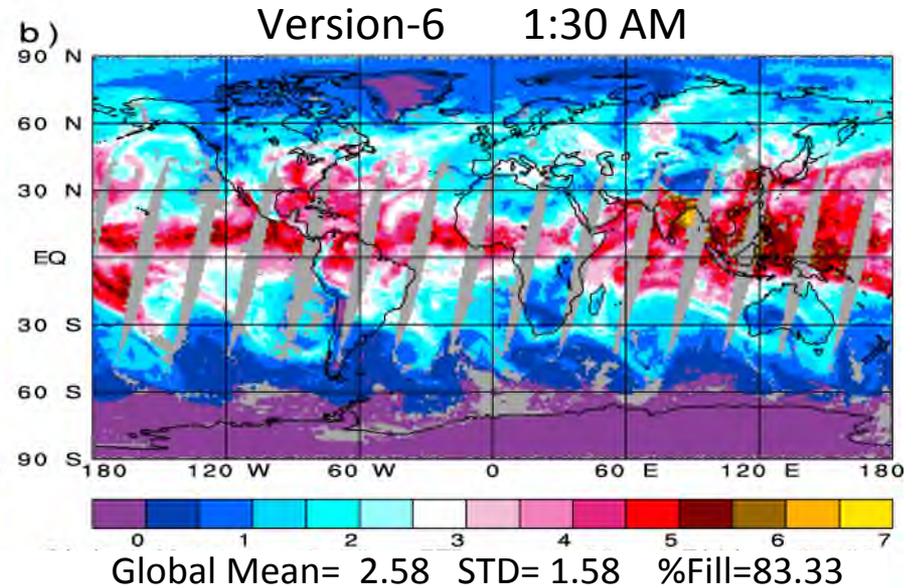
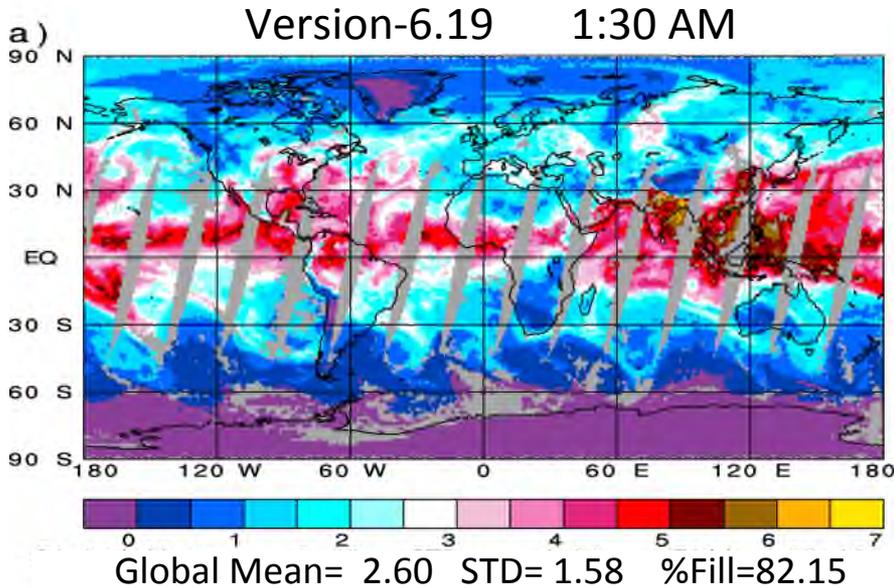


- 1:30 AM Climate (QC=0,1; Pgood)
- 1:30 PM Climate (QC=0,1; Pgood)
- 1:30 AM Climate (QC=0,1; Pgood)
- 1:30 PM Climate (QC=0,1; Pgood)

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.



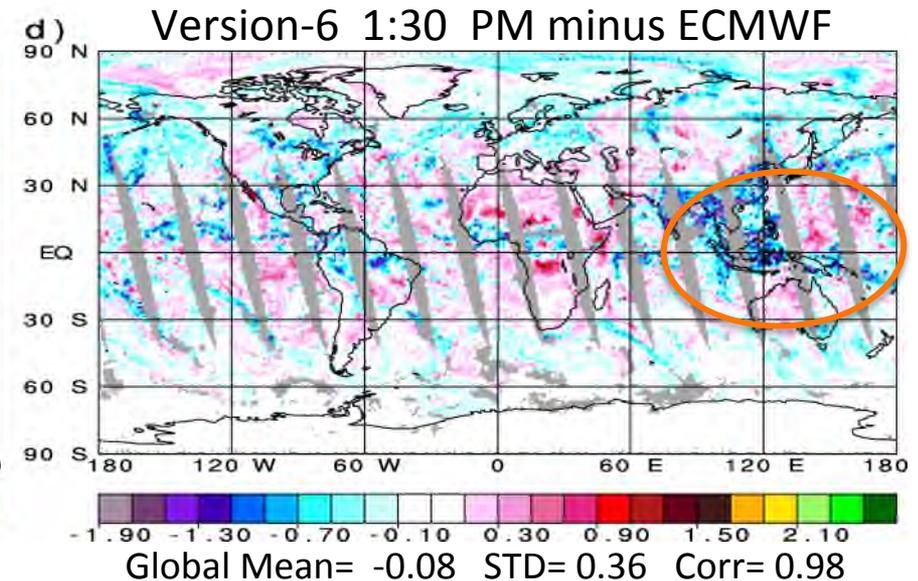
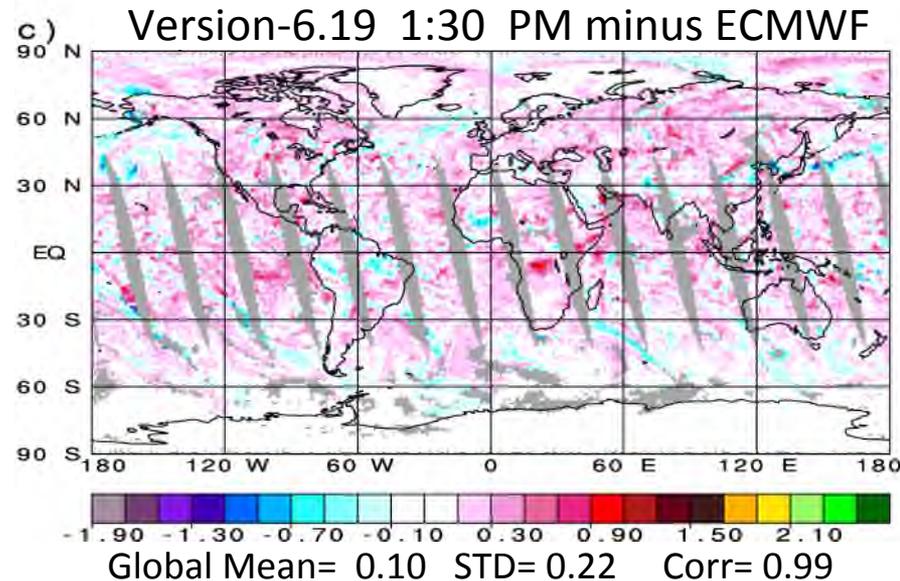
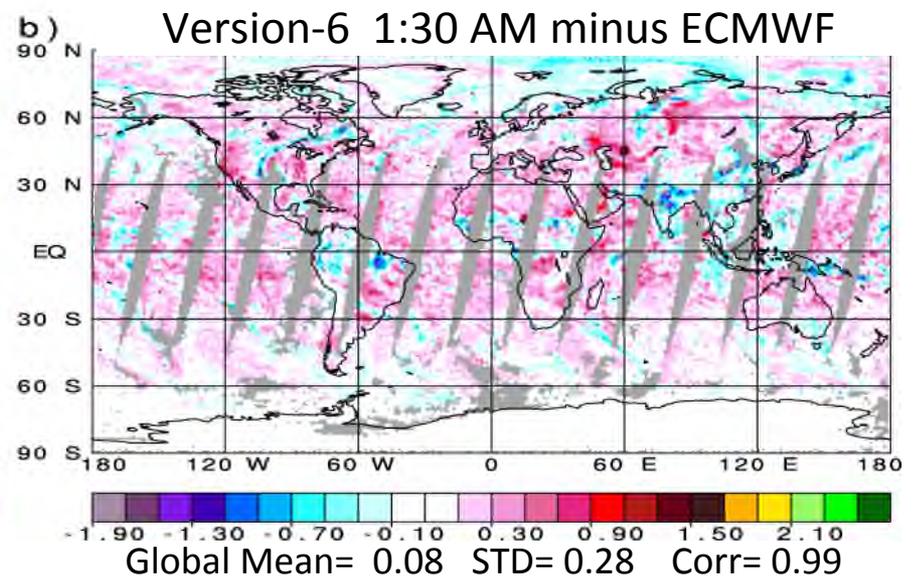
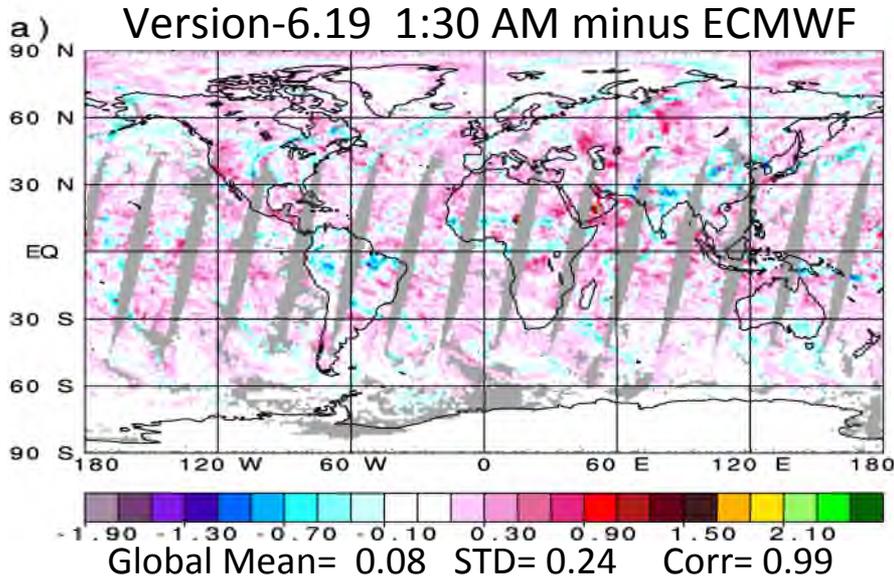
# Total Precipitable Water (cm) July 15, 2013



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



# Total Precipitable Water (cm) July 15, 2013

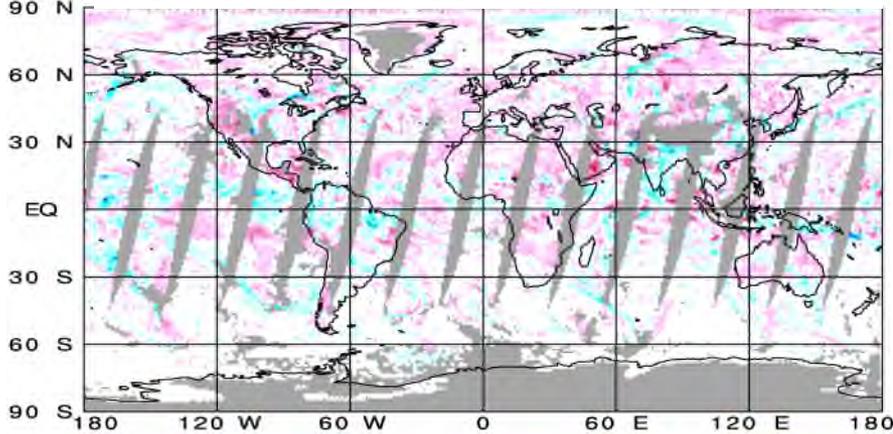


Version-6.19 total precipitable water agrees better with ECMWF during the night, and much better with ECMWF during the day, especially in high cloud regions.



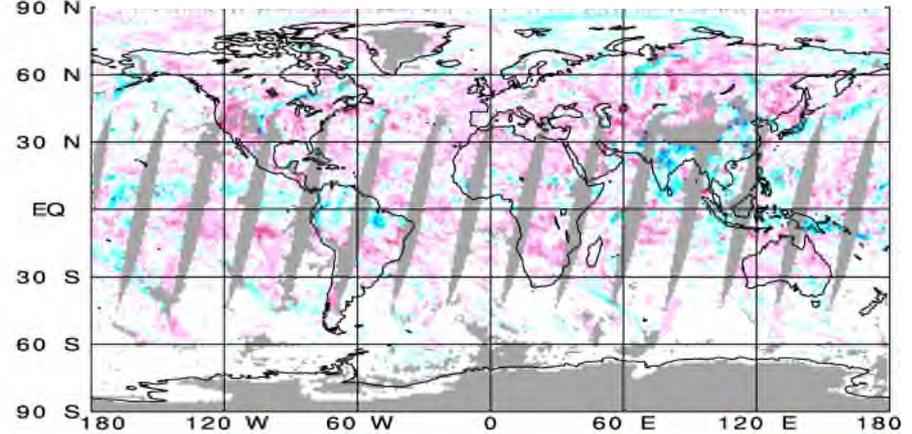
# Total Precipitable Water 850 mb to top (cm) July 15, 2013

a) Version-6.19 1:30 AM minus ECMWF



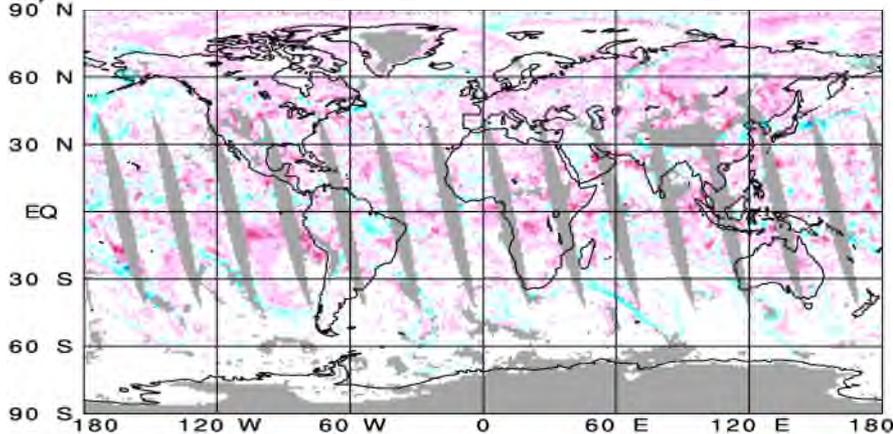
-1.90 -1.30 -0.70 -0.10 0.30 0.90 1.50 2.10  
Global Mean= 0.02 STD= 0.19 Corr= 0.98

b) Version-6 1:30 AM minus ECMWF



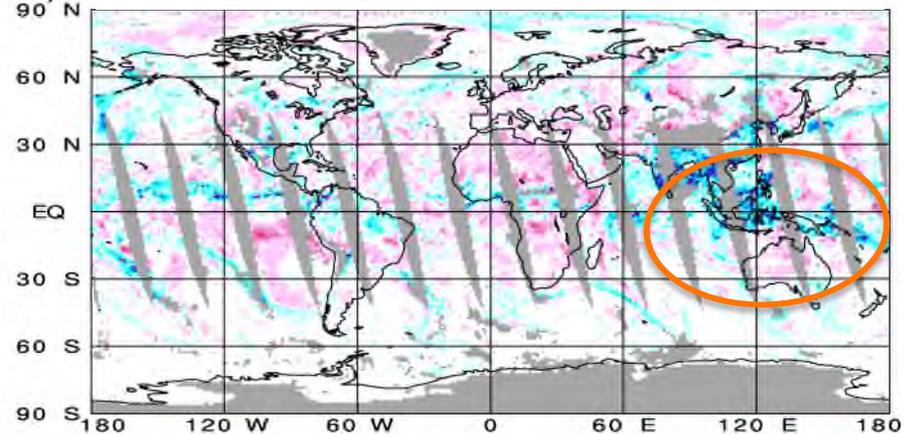
-1.90 -1.30 -0.70 -0.10 0.30 0.90 1.50 2.10  
Global Mean= 0.02 STD= 0.21 Corr= 0.98

c) Version-6.19 1:30 PM minus ECMWF



-1.90 -1.30 -0.70 -0.10 0.30 0.90 1.50 2.10  
Global Mean= 0.05 STD= 0.18 Corr= 0.98

d) Version-6 1:30 PM minus ECMWF

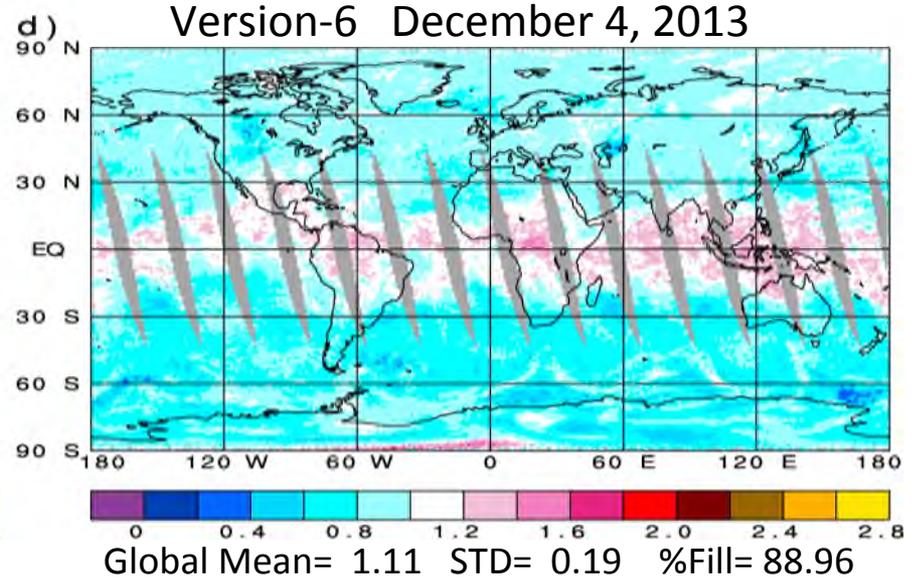
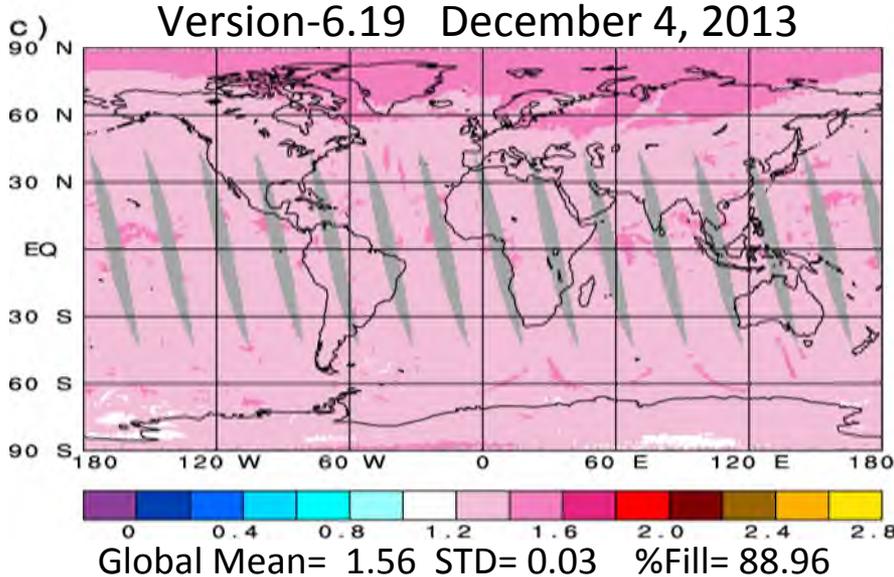
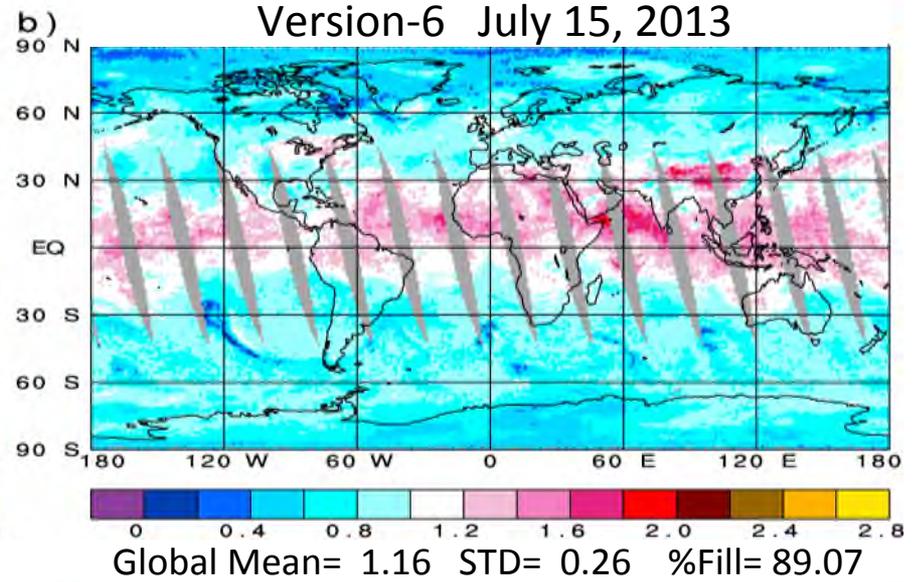
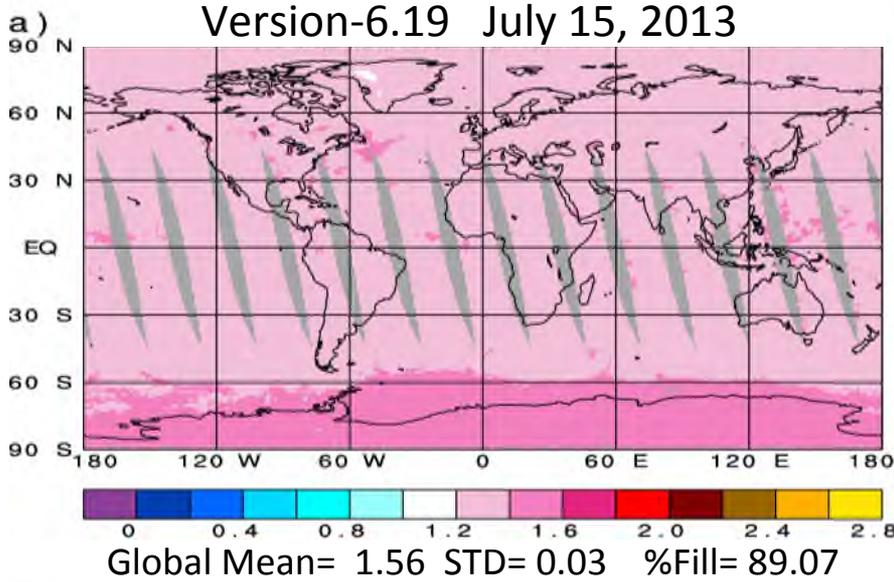


-1.90 -1.30 -0.70 -0.10 0.30 0.90 1.50 2.10  
Global Mean= -0.04 STD= 0.26 Corr= 0.97

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



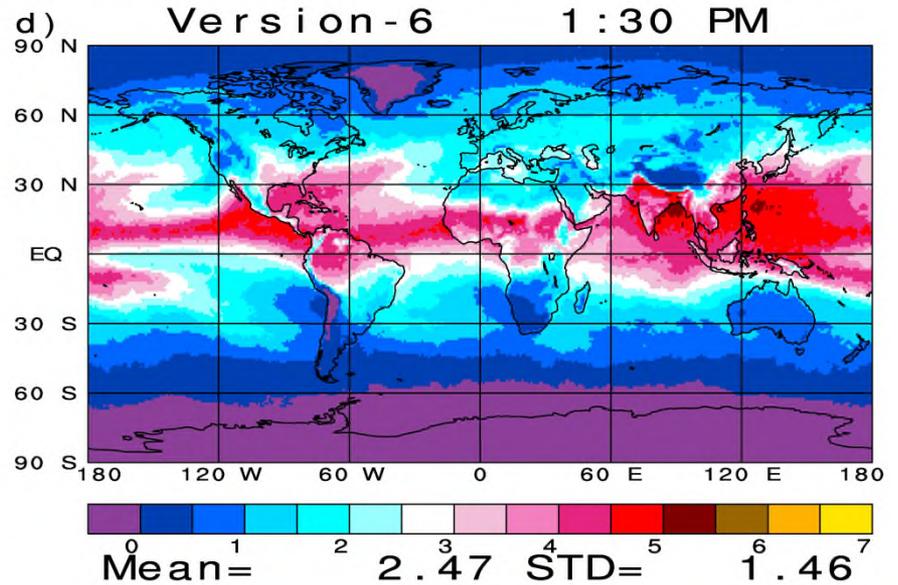
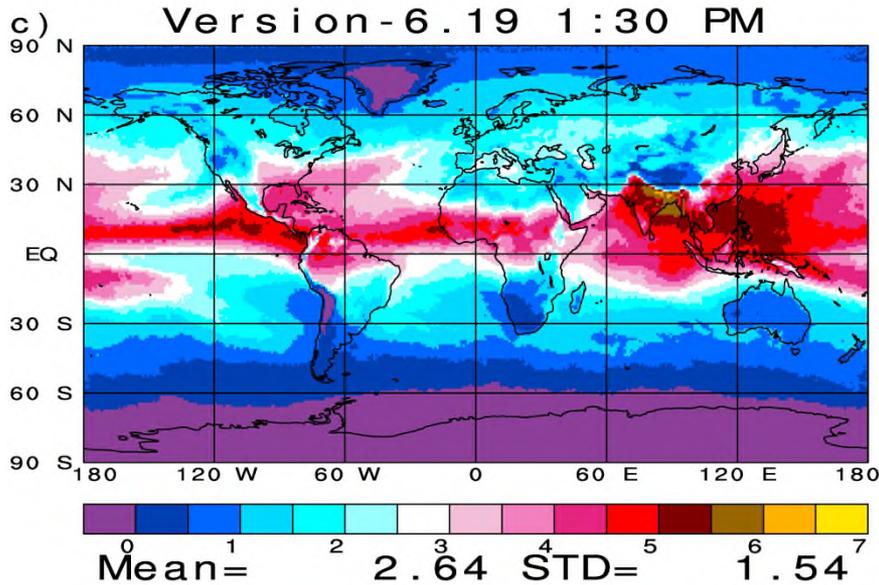
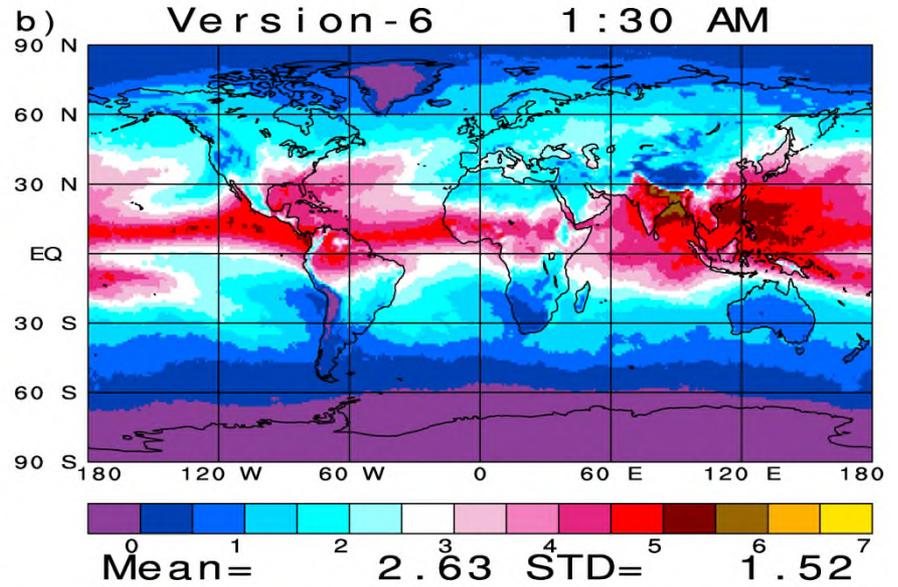
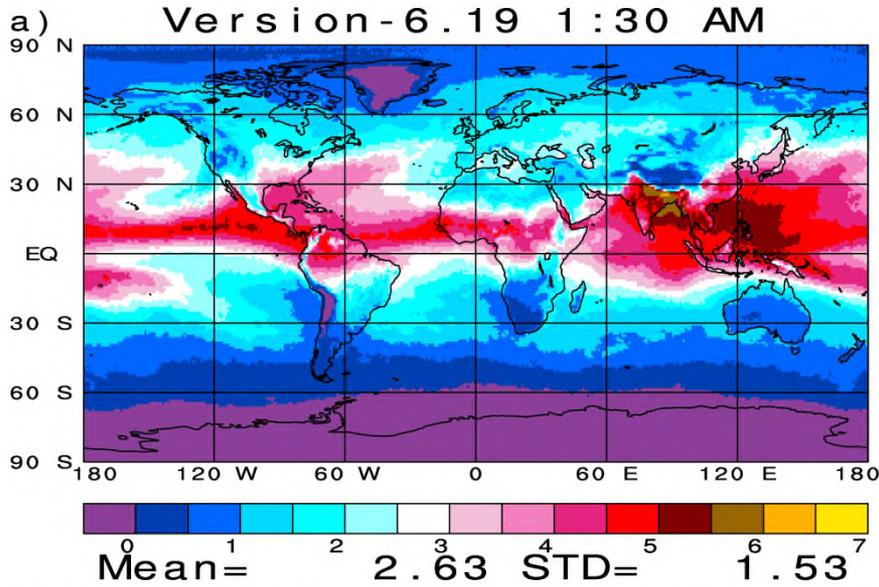
# Total Precipitable Water 50 mb to top (mm\*10000) 1:30 PM



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

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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

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- 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.

