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

Joel Susskind,
John Blaisdell, and Lena Iredell

NASA GSFC Sounder Research Team (SRT)

AIRS Science Team Meeting

Pasadena, California

April 22, 2015

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 water vapor retrievals. Improvements in O_3 profiles were given in a separate presentation yesterday.

Version-6.X

Version-6.X was described in the last Science Team Meeting

Version-6.X included all previous changes 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 four fine levels above the tropopause
- 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
- Increased the damping used in *q(p)* step because we now have more functions

These modifications resulted in improved water vapor profiles in Version-6.X 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.

Major Problem with Version-6 and Version-6.X Water Vapor Results

June Wang at SUNY Albany showed in the last 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 GCM analysis W_{TOT} data sets. Version-6.X did not recognize the existence of this spurious feature and did nothing to correct it.

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.

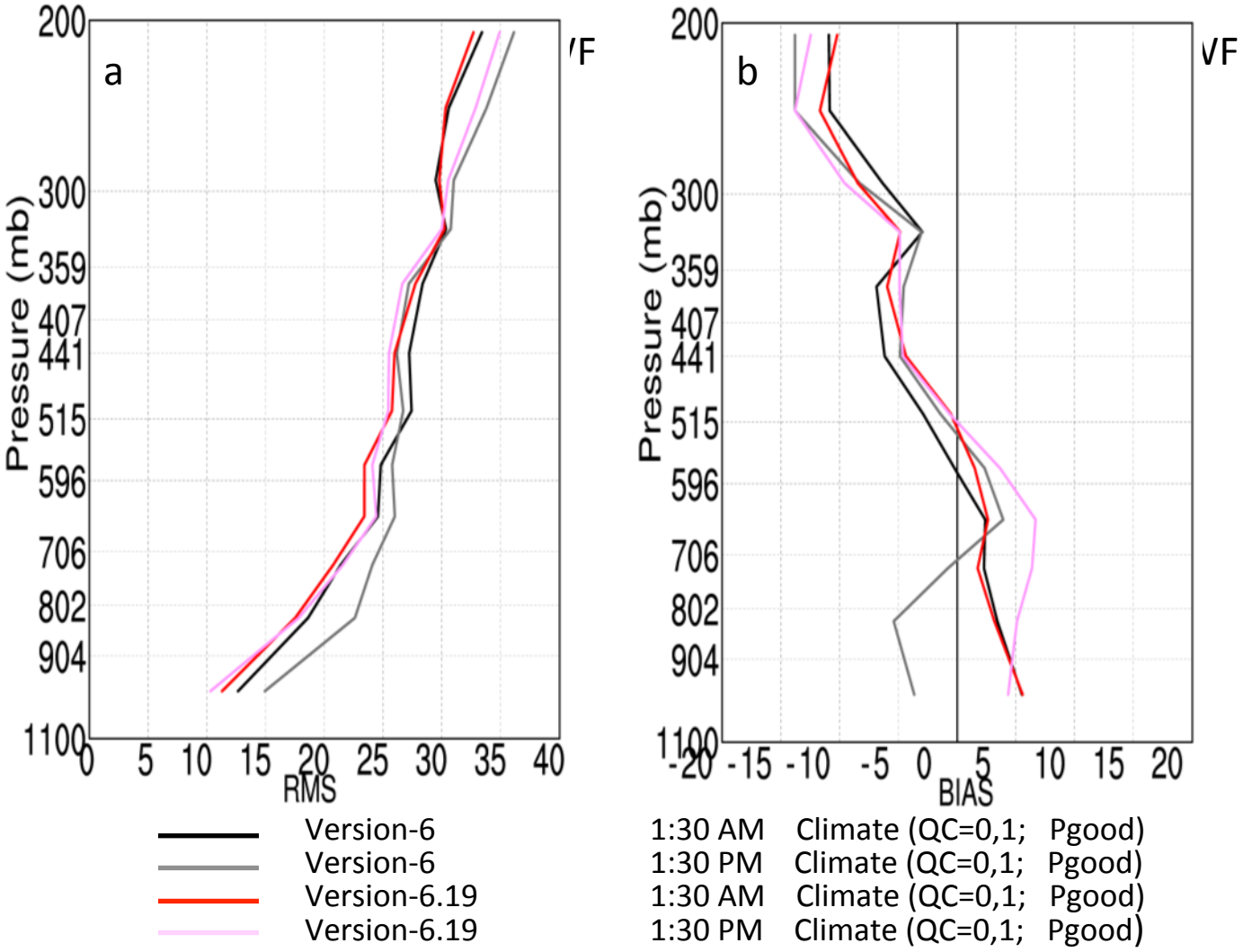
Version-6.19 Updates to Water Vapor Profile Retrieval

- **Removed shortwave channels centered on weak water vapor lines**
  - These channels were the cause of the spurious daytime water vapor results
- Added many channels on weak water lines in the longwave window region
  - Helped water vapor retrievals in the boundary layer
- Removed peaks of strongest water vapor lines
  - They were hurting upper tropospheric water vapor retrievals
- Added a second pass water vapor retrieval step
  - This slows down the retrieval process but improved water vapor results
  - This also helped the new second pass ozone profile retrieval step

John Blaisdell recently ran Version-6.19 in his own area at JPL for all of August 2013 and August 2014, as well as for select other days

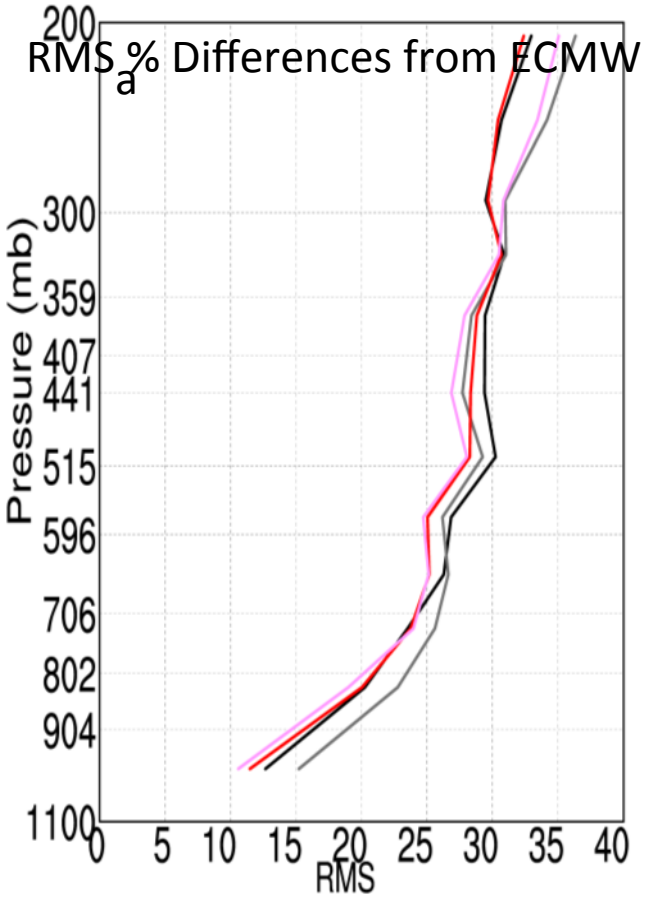
The following material compares Version-6.19 water vapor with Version-6

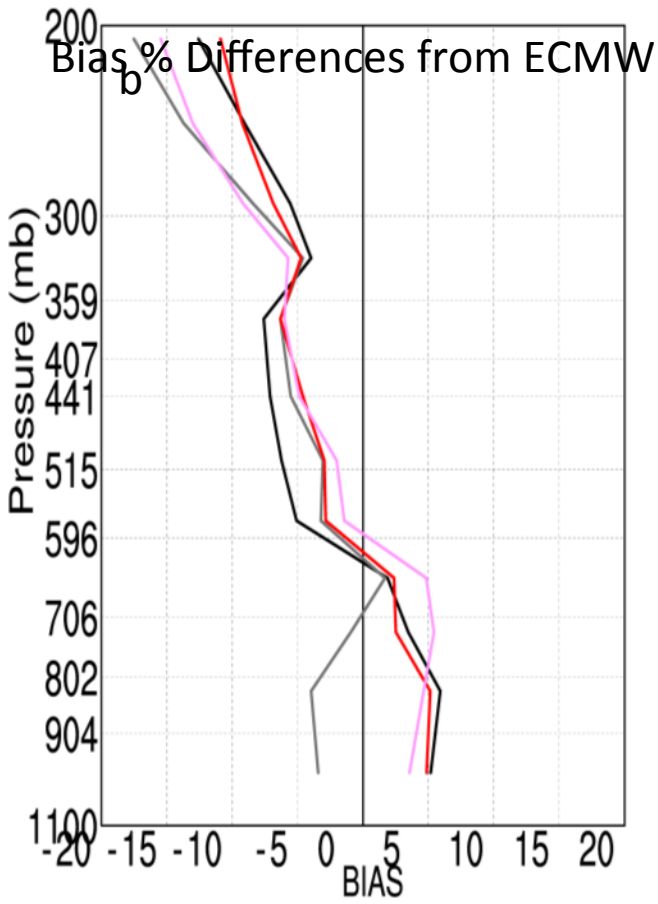
Global Water Vapor Profile July 15, 2013
1 Km Layer Precipitable Water



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

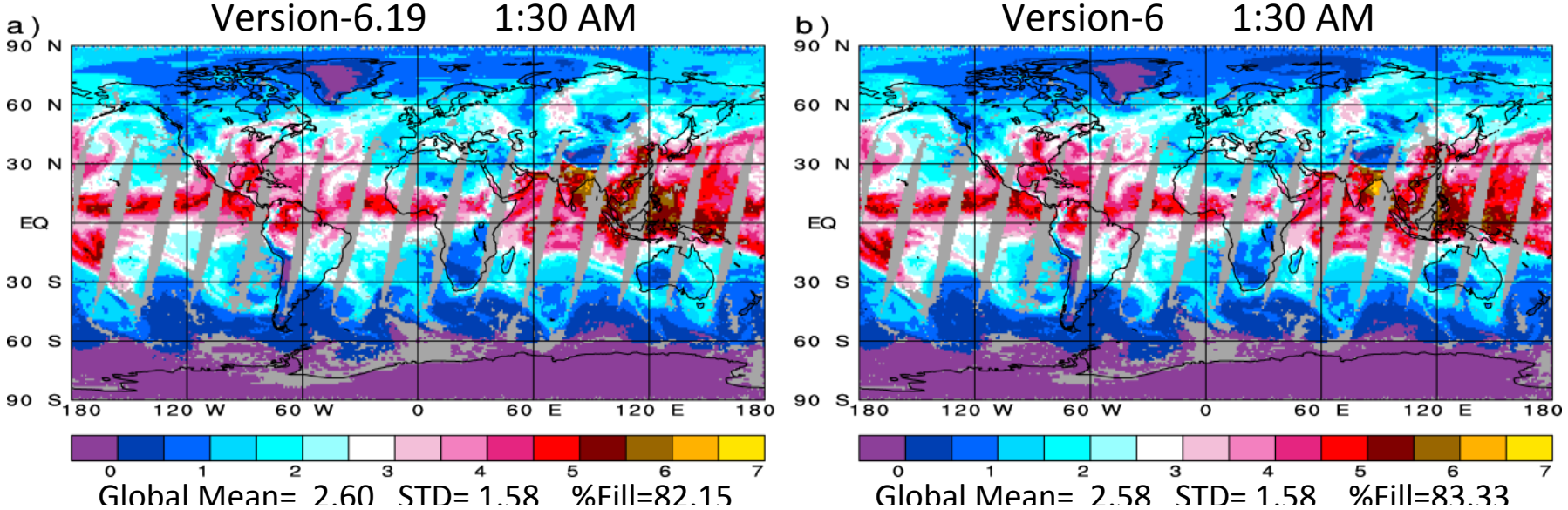




Version-6	1:30 AM	Climate (QC=0,1; Pgood)
Version-6	1:30 PM	Climate (QC=0,1; Pgood)
Version-6.19	1:30 AM	Climate (QC=0,1; Pgood)
Version-6.19	1:30 PM	Climate (QC=0,1; Pgood)

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.

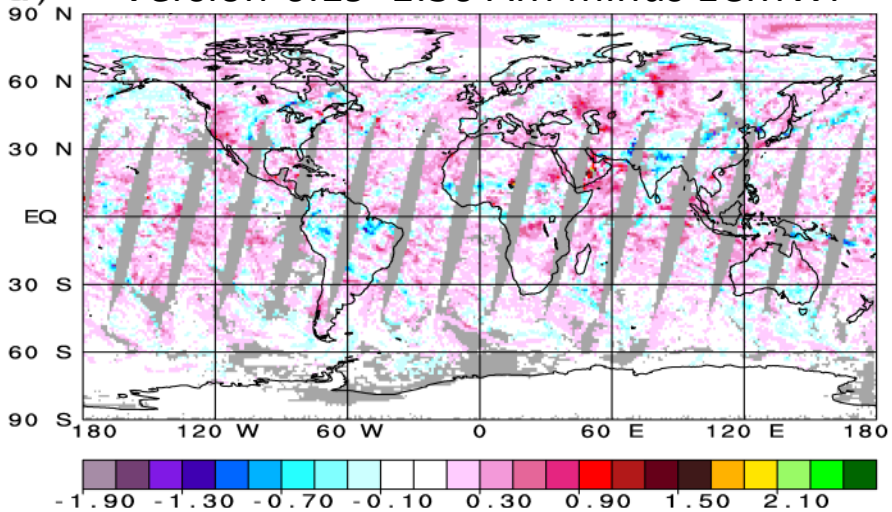
Total Precipitable Water (cm)
July 15, 2013



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

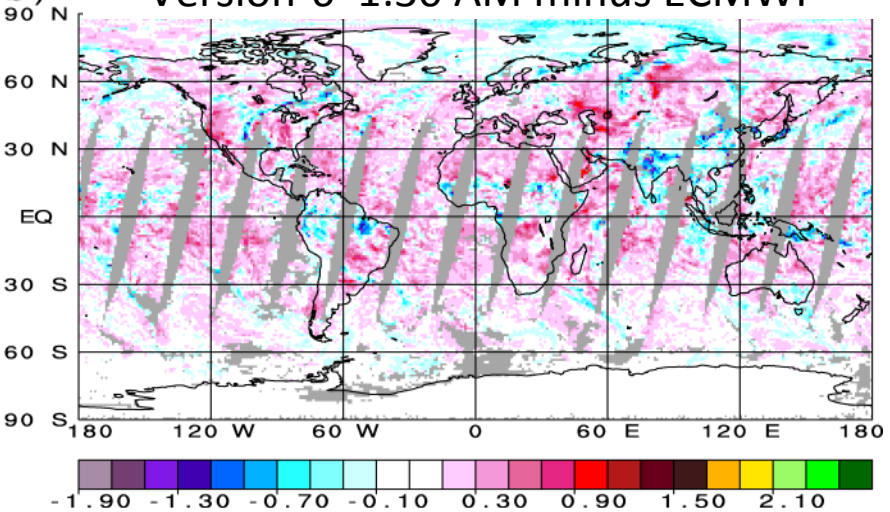
Total Precipitable Water (cm) July 15, 2013

a) Version-6.19 1:30 AM minus ECMWF



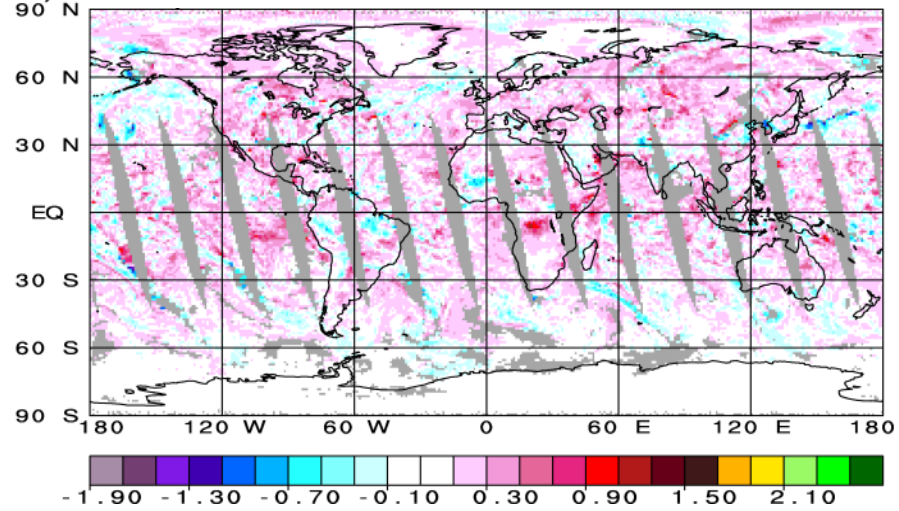
Global Mean= 0.08 STD= 0.24 Corr= 0.99

b) Version-6 1:30 AM minus ECMWF



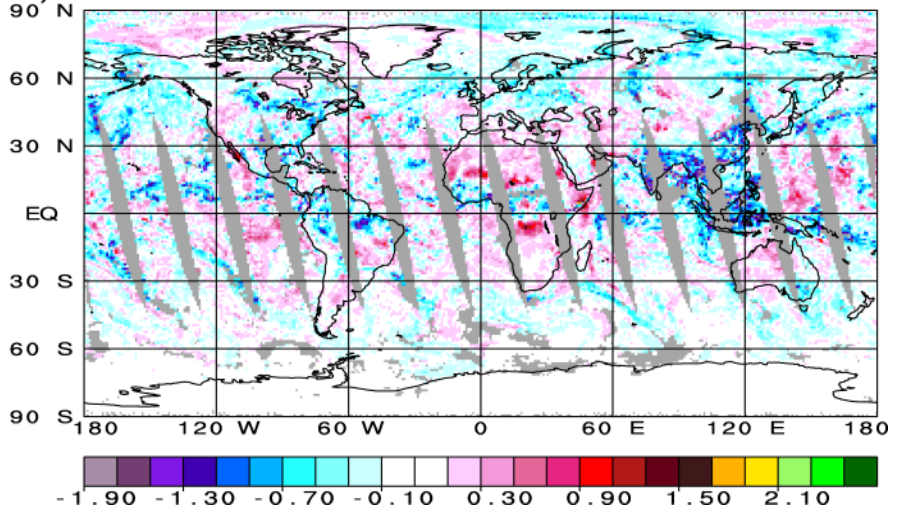
Global Mean= 0.08 STD= 0.28 Corr= 0.99

c) Version-6.19 1:30 PM minus ECMWF



Global Mean= 0.10 STD= 0.22 Corr= 0.99

d) Version-6 1:30 PM minus ECMWF

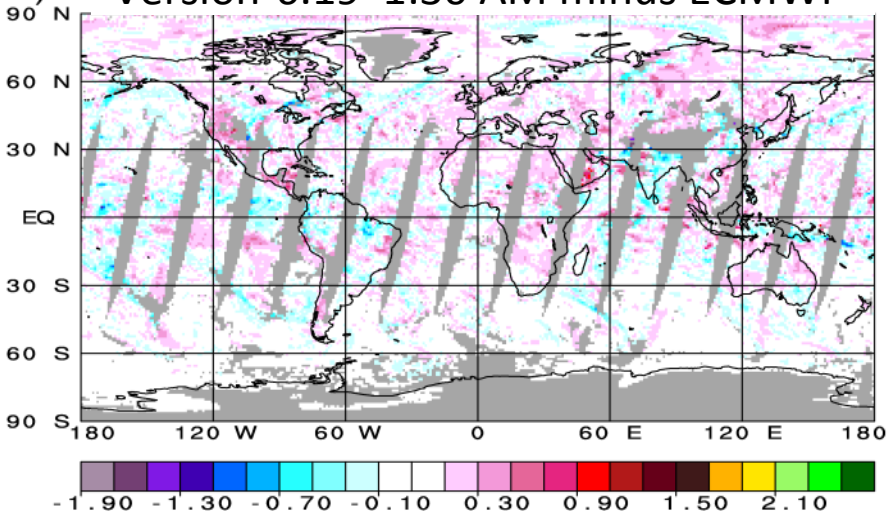


Global Mean= -0.08 STD= 0.36 Corr= 0.98

Version-6.19 total precipitable water agrees better with ECMWF during the night, and much better with ECMWF during the day.

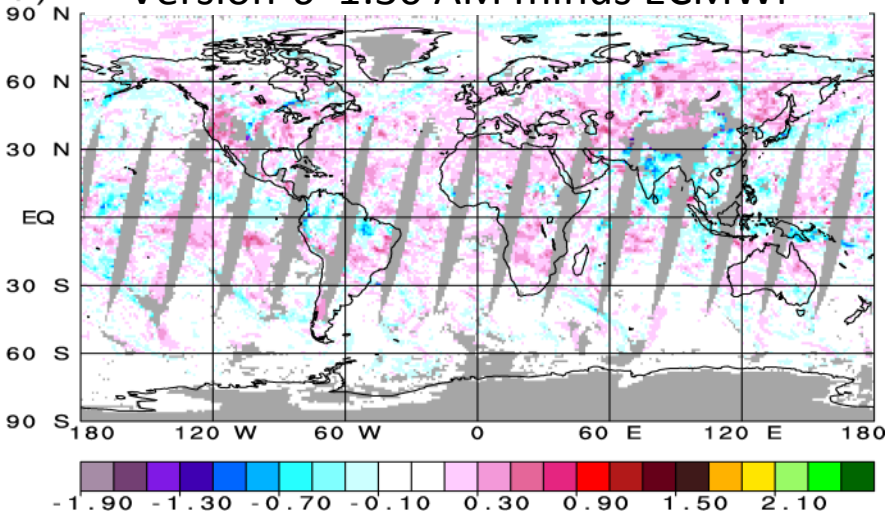
Total Precipitable Water 850 mb to top (cm) July 15, 2013

a) Version-6.19 1:30 AM minus ECMWF



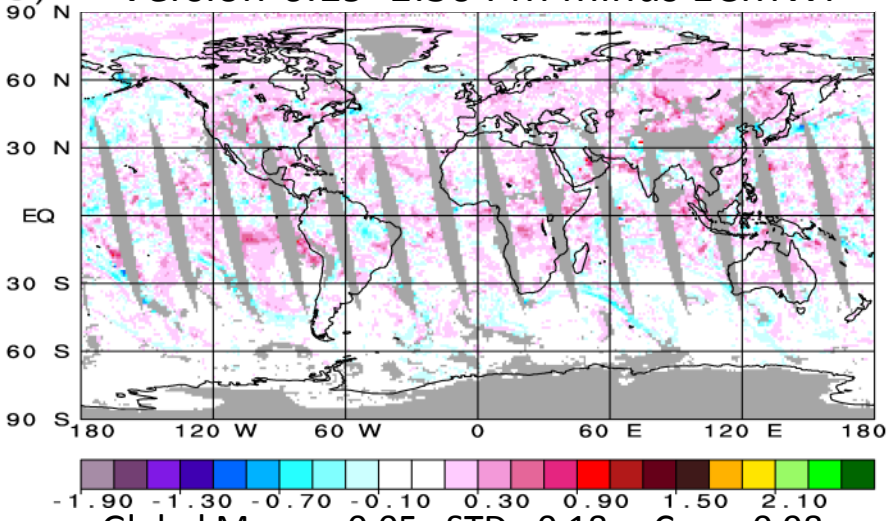
Global Mean= 0.02 STD= 0.19 Corr= 0.98

b) Version-6 1:30 AM minus ECMWF



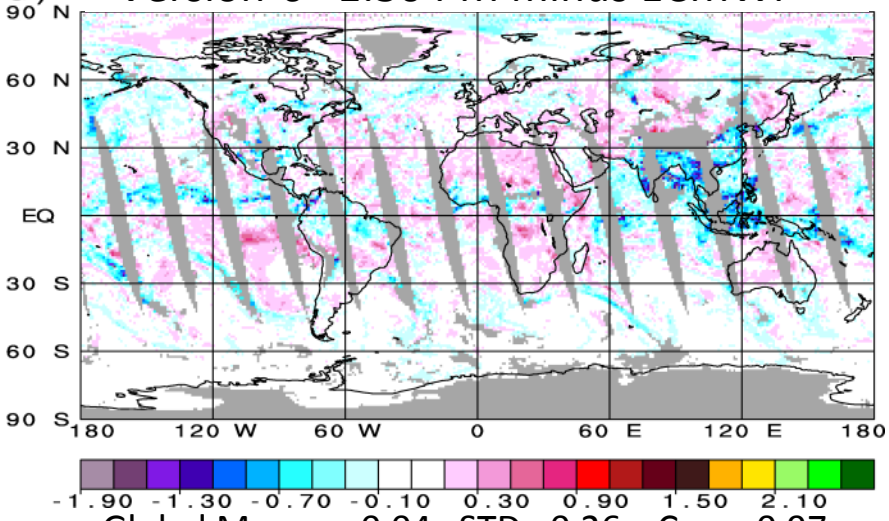
Global Mean= 0.02 STD= 0.21 Corr= 0.98

c) Version-6.19 1:30 PM minus ECMWF



Global Mean= 0.05 STD= 0.18 Corr= 0.98

d) Version-6 1:30 PM minus ECMWF

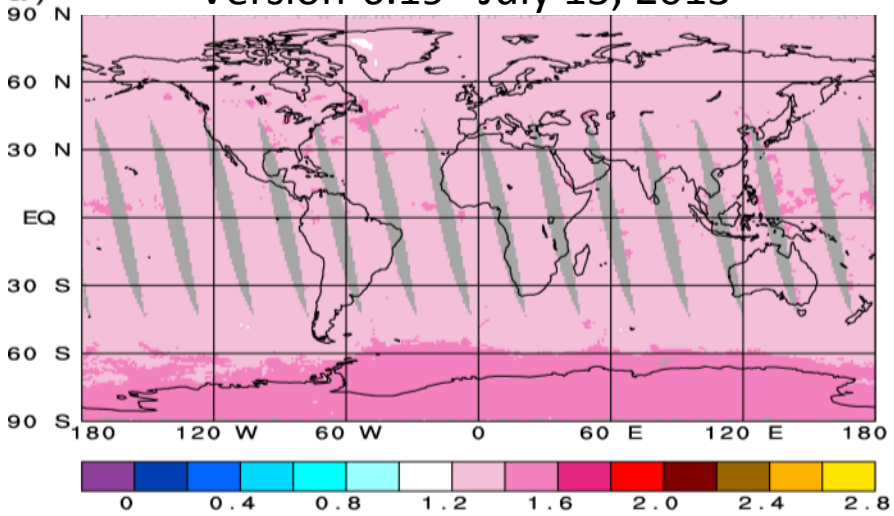


Global Mean= -0.04 STD= 0.26 Corr= 0.97

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

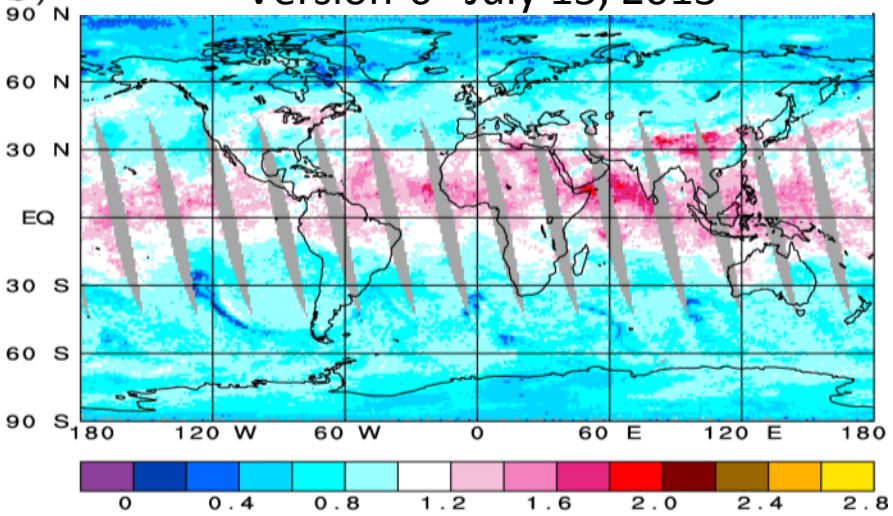
Total Precipitable Water 50 mb to top (mm*10000) 1:30 PM

a) Version-6.19 July 15, 2013



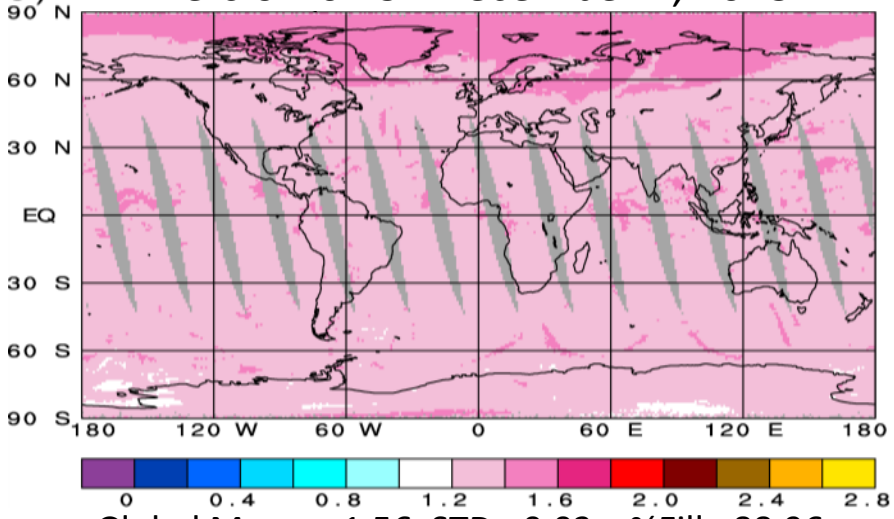
Global Mean= 1.56 STD= 0.03 %Fill= 89.07

b) Version-6 July 15, 2013



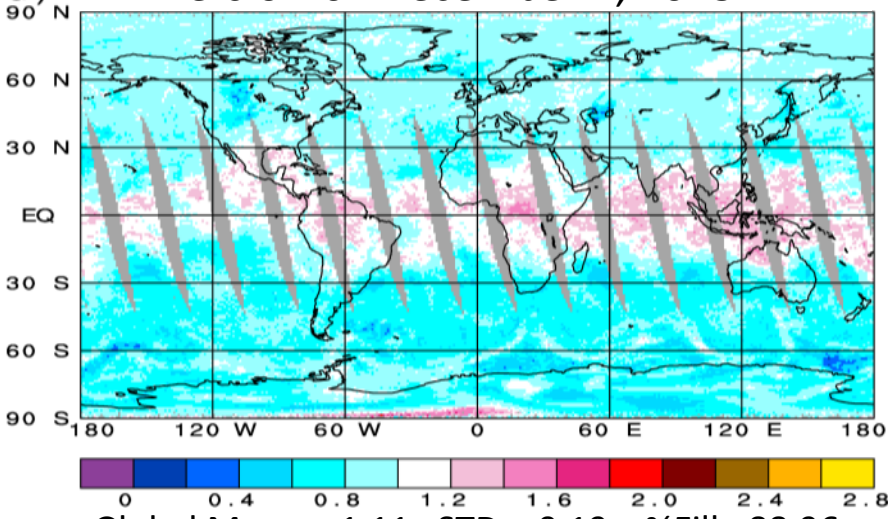
Global Mean= 1.16 STD= 0.26 %Fill= 89.07

c) Version-6.19 December 4, 2013



Global Mean= 1.56 STD= 0.03 %Fill= 88.96

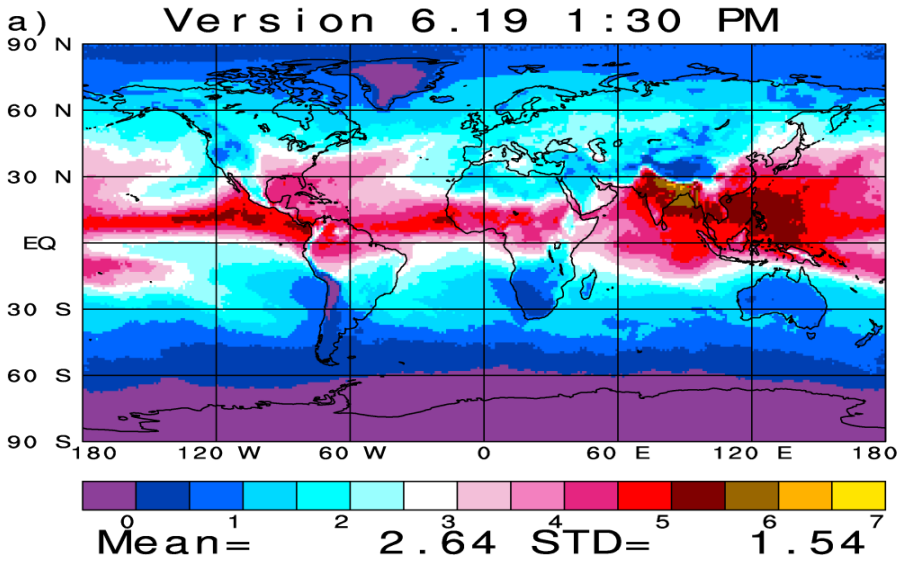
d) Version-6 December 4, 2013

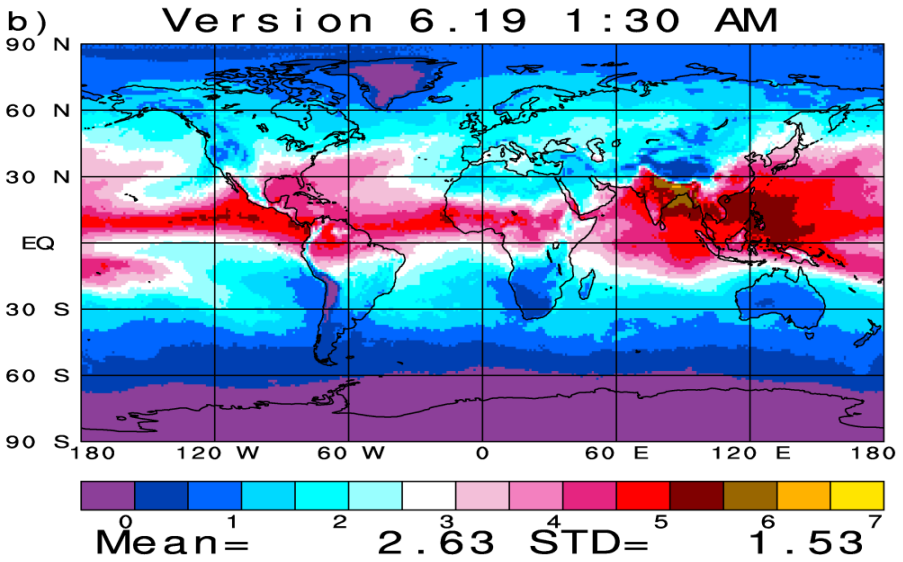


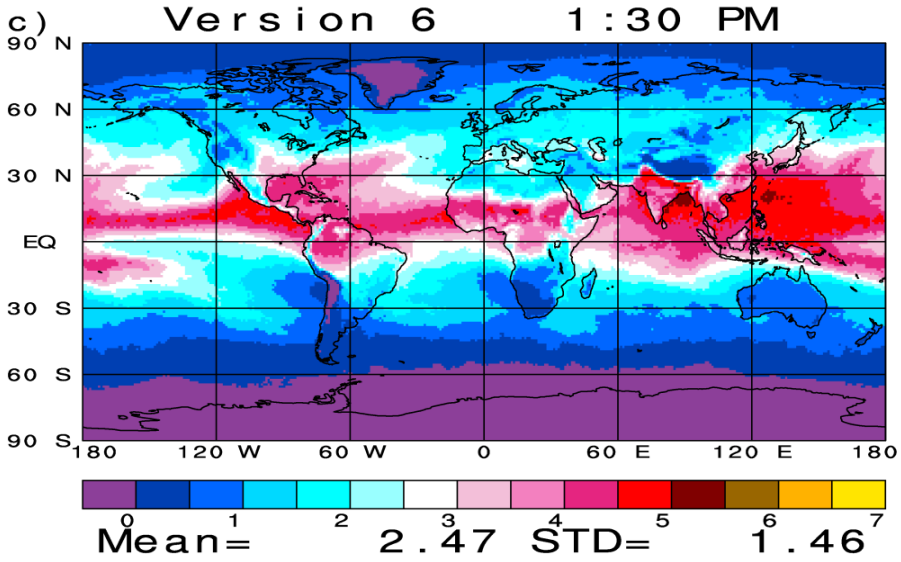
Global Mean= 1.11 STD= 0.19 %Fill= 88.96

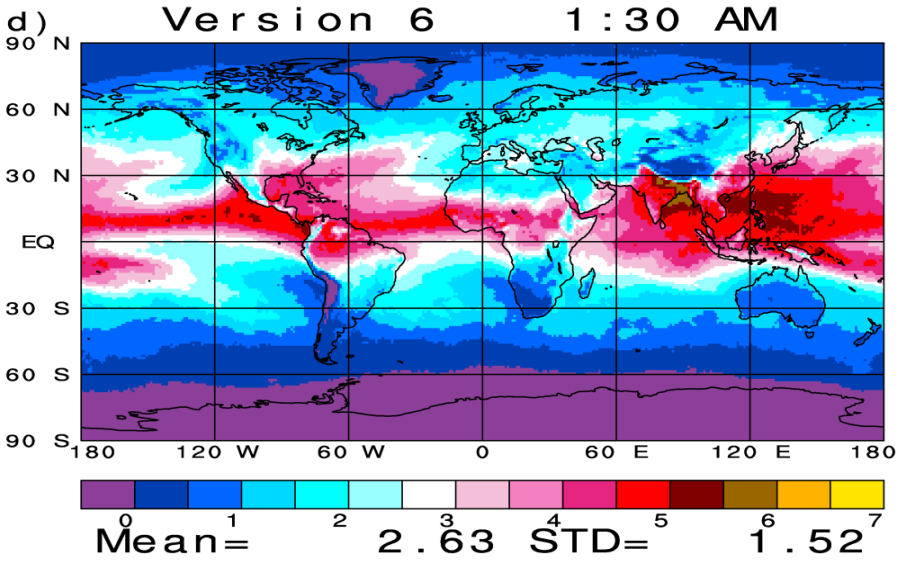
Version-6 upper stratospheric water vapor showed spurious features related to tropospheric convection. These spurious features are not found in Version-6.19.

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 ≈ 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.

Version-6.19 Improvements in Ozone Profile

Version-6.19 improvements in ozone profiles were described in a different talk yesterday. Version-6.19 ozone profile improvements compared to Version-6 are even more dramatic than those of water vapor profile. That talk strongly recommends that the AIRS Science Team begins to reprocess all AIRS/AMSU data with improved retrieval methodology within the next year, and indicates what further improvements need to be made and tested before we commence reprocessing.