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

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+ 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.

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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

- 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.

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

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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

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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

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

Bias $\%$ Differences from ECMWF

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

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

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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.

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