P1.6 SHORT-TERM, SEASONAL AND INTERANNUAL VARIABILITY OF THE VERTICAL DISTRIBUTION OF WATER VAPOR OBSERVED BY AIRS

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1. INTRODUCTION

The Atmospheric Infrared Sounder (AIRS) consists of a suite of instruments (Aumann et al. 2003) on board the Aqua spacecraft which retrieve atmospheric parameters over the globe at radiosonde quality on a daily basis in non-precipitating conditions with less than 80% cloud cover.

Although quantitative global measurements of water vapor have been available since the 1980's (Grody et al. 1980), the vertical resolution of these measurements was very coarse. AIRS provides global coverage amounting to 324,000 precipitable water vapor profiles with spatial resolution at nadir of 45 km. The vertical resolution of AIRS tropospheric is 2 km for the subset of these soundings which result from combined microwave and infrared soundings throughout the entire vertical extent of the atmosphere. This subset includes relatively cloud-free scenes and comprises about 30% of the total, or roughly 100,000 per day.

2. DATA

The AIRS Level 2 geophysical standard product files provide temperature and water vapor profiles on 28 World Meteorological Organization standard layers from the surface to 0.1 mb. The Level 2 fields are spatially resolved at the sounding locations, a regular but asynoptic grid. These data are intended for use by meteorologists and researchers studying localized, time-variable phenomena.

We have developed Level 3 global gridded products from the Level 2 products, including water vapor to 100 mb. The Level 3 fields are Level 2 quantities spatially and temporally averaged. Daytime and nighttime orbits are kept separate in the averages. These products are reported on daily, 8-day and monthly temporal scales at 1x1 degree spatial resolution. Water vapor is reported at 12 vertical levels from the surface to 100 mb. All Level 3 data will be available to the scientific community beginning Jan, 2005 from the Goddard Earth Sciences Data and Information Services Center Distributed Active Archive Center (DAAC) as part of the V4.0 delivery by the AIRS Project to that facility. Interested users will find links to documentation and data access pages at the URL:

http://daac.gsfc.nasa.gov/atmodyn/airs/

Additional information by submitting questions to:

http://airs-inquiry.jpl.nasa.gov/feedback/feedback_form.cfm

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3. EXAMPLES OF AIRS WATER VAPOR

3.1 LEVEL 3 GLOBAL WATER VAPOR VERTICAL DISTRIBUTION

The following three images were derived from the AIRS height resolved water vapor Level 3 product. Much of the horizontal variability in Figures 1-3 is associated with monsoon systems and Intertropical, South Pacific and South Atlantic Convergences Zones.

The distribution of water vapor is highly variable in the vertical dimension with concentrations varying more than four orders of magnitude with height. (Seidel 2002). The progression of Figure1-3 shows the dramatic reduction of water vapor with height as measured by the AIRS instrument.

Figure 1 presents the global distribution of total precipitable water vapor from 1000 mb to 700 mb, combining day and night retrievals.

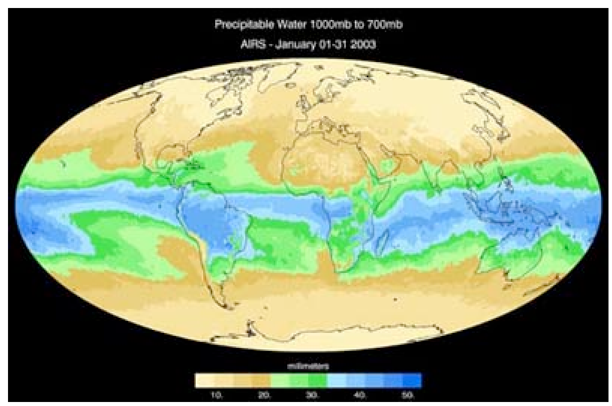

Figure 1. Jan, 2003 monthly average precipitable water vapor below 700 mb. Daytime and nighttime retrievals.

Figure 2 is the precipitable water vapor distribution in the 700 mb to 500 mb layer.

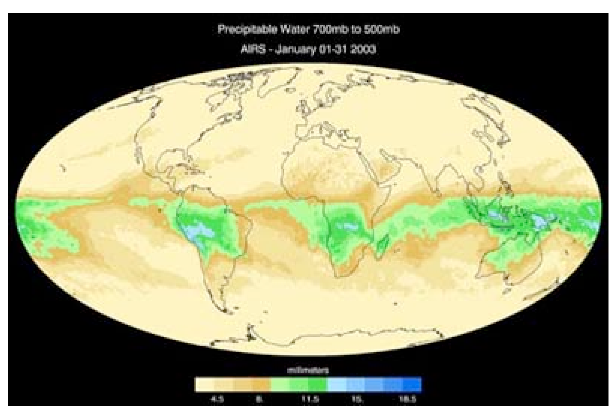

Figure 2. Jan, 2003 monthly average total precipitable water vapor in the 700 mb to 500 mb layer.

Figure 3 is the precipitable water vapor distribution in the 500 mb to 100 mb layer.

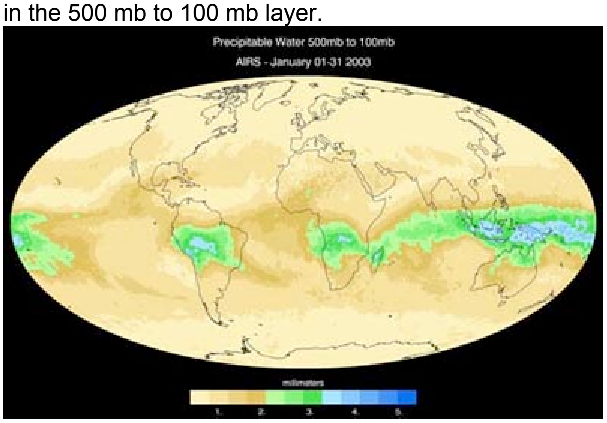

Figure 3. Jan, 2003 monthly average total precipitable water vapor above 500 mb.

3.2 LEVEL 2 NORTH AMERICAN WATER VAPOR VERTICAL STRUCTURE FOR 9/13/04

The following series of images shows the water vapor vertical structure around North America at the peak of the 2004 Atlantic hurricane season. They were created using all retrievals in the AIRS Level 2 Standard Product and layer quantities were converted to millimeters of precipitable water vapor. The high water loading over very warm deserts (i.e., Sahara Desert in Africa and Southwestern US desert just North of the Gulf of California) is likely spurious since the retrieval of water vapor over very warm land masses is problematical in the version of the retrieval algorithm employed (Version 3.6.0.0). The hurricanes in this series of images include:

- Hurricane Ivan is seen entering the Gulf of Mexico between the Yucatan peninsula and Western Cuba
- Hurricane Jeanne is entering the Eastern Caribbean and is located just East of the Leeward Islands
- Hurricane Isis is located directly South of Baja California
- Remnants of hurricane Howard are located several hundred miles further West in the Pacific

Figure 4 shows the integrated water vapor burden below the 100 mb pressure level. Retrievals failed in the NE quadrant of Ivan as well as the eyewalls of the other tropical storms due to heavy precipitation.

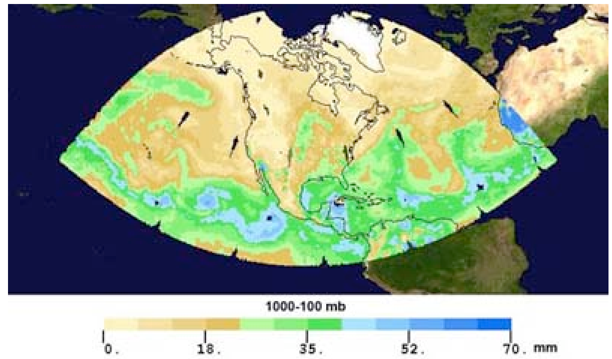

Figure 4. Total column precipitable water vapor.

Figure 5 shows the lower tropospheric precipitable water vapor burden (1000 mb to 700 mb). Note that approximately half the total column precipitable water vapor resides in the layer below 700mb. The water vapor in this pressure regime is absent where topography interferes (for example, the Rocky Mountains)

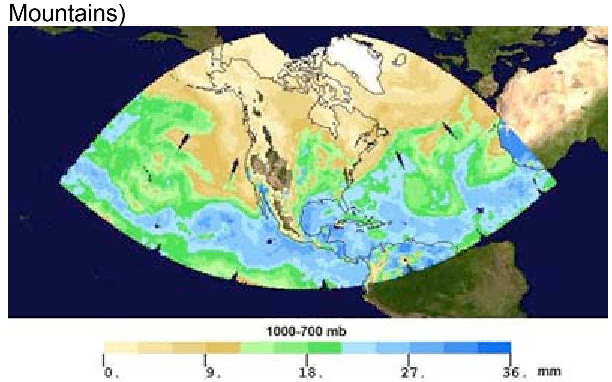

Figure 5. Lower troposphere precipitable water vapor.

Figure 6 shows the 700 mb to 500 mb precipitable water vapor burden. Approximately one third of the total column precipitable water vapor resides in this pressure layer. We are currently examining the vertical partitioning of water vapor due to a wide variety of phenomena including hurricanes.

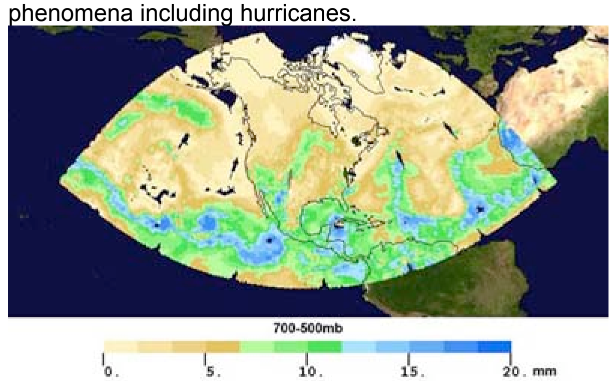

Figure 6. Precipitable water vapor in the 700-500 mb layer.

Figure 7 shows the precipitable water vapor burden in the 500 mb to 300 mb layer. The water vapor in this level is significantly enhanced by the upwelling supported by the tropical storms.

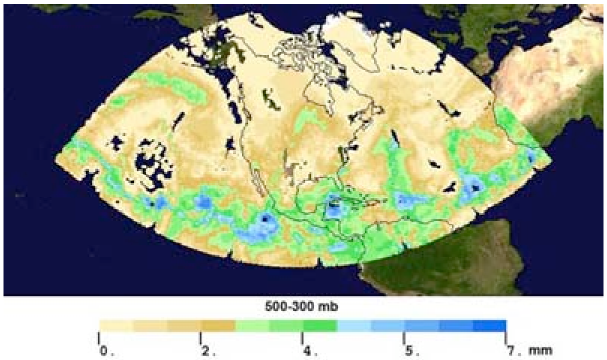

Figure 7. Precipitable water vapor in the 500-300 mb layer.

Figure 8 shows the precipitable water vapor burden in the 300 mb to 100 mb layer. As with the previous figures, the tropical storms are seen to significantly impact the water vapor burden in this layer.

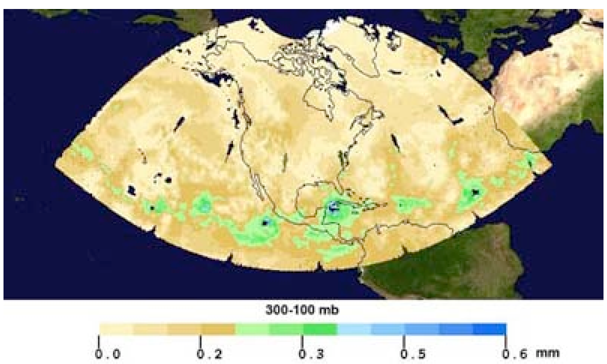

Figure 8. Precipitable water vapor in the 300-100 mb layer.

3.3 NORTH AMERICAN WATER VAPOR VERTICAL STRUCTURE FOR 1/31/04

The following series of images show the water vapor vertical structure in the mid-latitudes centered on North America during the winter season. Note the dramatic decrease in water vapor content of the Northern hemisphere atmosphere during this season compared to September. The color bar scales for matching figures (Sept vs Jan) are equal.

Figure 9 shows the water vapor burden below the 100 mb pressure level. The Northern hemisphere atmosphere is much drier than in September.

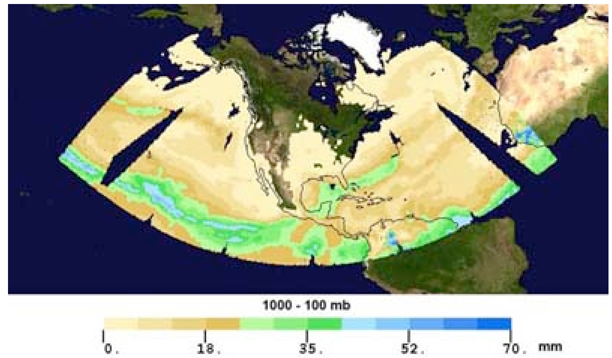

Figure 9. Total column precipitable water vapor.

Figure 10 shows the lower tropospheric precipitable water vapor burden (1000 mb to 700 mb).

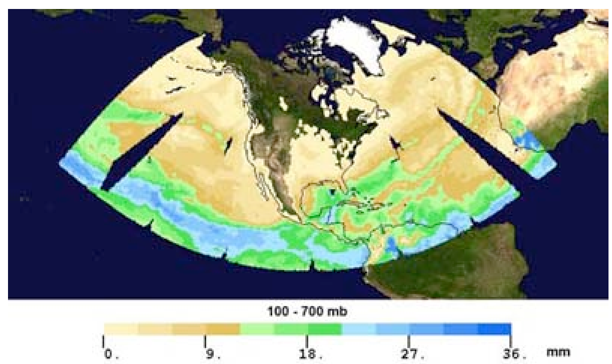

Figure 10. Lower troposphere precipitable water vapor.

Figure 11 shows the precipitable water vapor burden in the 700 mb to 500 mb layer.

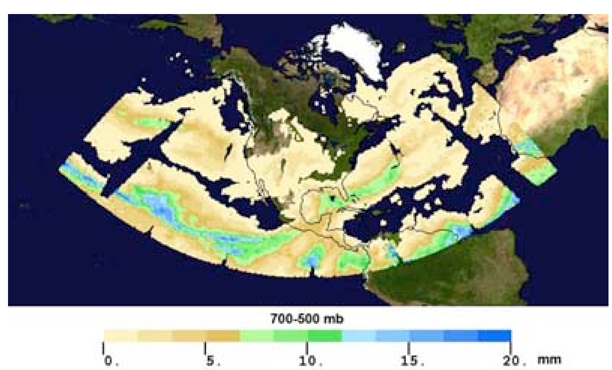

Figure 11. Precipitable water vapor in the 700-500 mb layer.

Figure 12 shows the precipitable water vapor burden in the 500 mb to 300 mb layer.

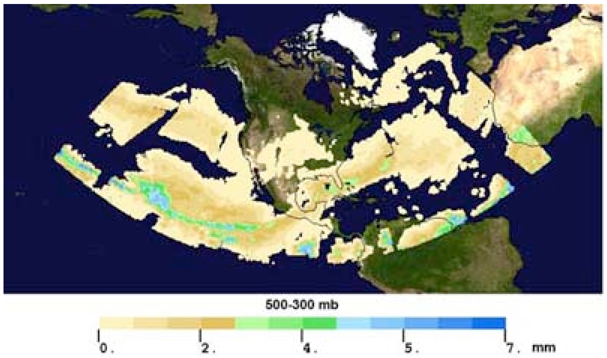

Figure 12. Precipitable water vapor in the 500-300 mb layer.

Figure 13 shows the precipitable water vapor burden in the 300 mb to 100 mb layer.

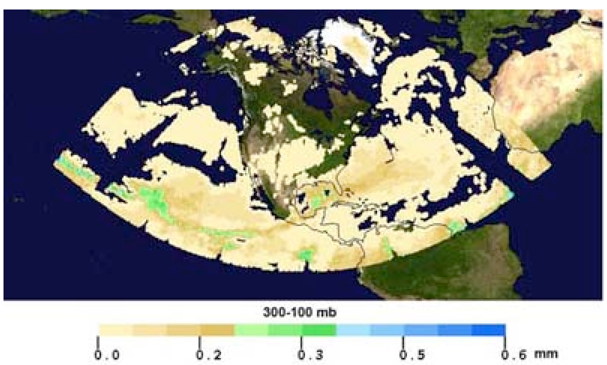

Figure 13. Precipitable water vapor in the 300-100 mb layer.

4. SUMMARY

As the figures shown here demonstrate, quantitative insight into global, seasonal and regional distribution and variability of water vapor is now available to researchers through AIRS retrieved data products.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Aumann, H. H., M. T. Chahine, C. Gautier, M. D. Goldberg, E, Kalnay, L. M. McMillin, H. Revercomb, P. W. Rosenkranz, W. L. Smith, D. H. Staelin, L. L. Strow and J. Susskind, 2003: AIRS/AMSU/HSB on the Aqua mission: design, science objectives, data products and processing system, IEEE Transactions Geosciences and Remote Sensing, 41, 253-264.

Grody, N.C., Gruber, A. and Shen, W.C., 1980: Atmospheric water content derived from the Nimbus-6 scanning microwave spectrometer over the tropical Pacific, J. Appl. Meterolo., 19, 989-996.

Seidel, Dian J. 2002: Water Vapor: Distribution and Trends, Encyclopedia of Global Environmental Change, John Wiley & Sons, Ltd