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A PILOT STUDY OF SCIENTIFIC DATA STEWARDSHIP WITH GLOBAL WATER VAPOR

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1. INTRODUCTION

Scientific data stewardship of Climate Data Records (CDR's) is a topic of increasing interest within NOAA and the climate community. Satellite observations of Earth taken since the 1960's provide an invaluable record of Earth's climate which will be explored by future scientists for many years. Archive recovery, documentation and data management are vital tasks to ensure that these records are of sufficient quality for future users.

Scientific data stewardship of satellite data encompasses efforts beyond just preserving the archive. NOAA's scientific data stewardship program (Bates, 2004) has elements to involve researchers in efforts which will ensure that CDR's from space are understood as well as is possible. Orbital drifts, instrument changes over time, discontinuities between different sensors, and algorithm changes all can introduce spurious effects into satellite CDR's. Often these impacts may not be discovered until years after a dataset is created. Stewardship of CDR's seeks to understand and mitigate these effects to increase their value for present and future researchers. A recent report (NRC, 2005) provides the elements of a successful scientific data stewardship program from satellite.

In this pilot study, the NASA Water Vapor Project (NVAP) water vapor record (Randel et al 1996) is created for a few months to allow intercomparison with results from the NASA Atmospheric Infrared Sounder (AIRS) instrument. AIRS is a hyperspectral sounding instrument with more capability to measure water vapor profiles than any of the previous instruments used in NVAP. The NVAP dataset currently covers the time period 1988-2001, while AIRS did not become available until mid-2002. A few months of NVAP data from 2003 and 2004 have been created using heritage algorithms and inputs, and compared to AIRS results. This is a common situation in long-term satellite CDR's – a new sensor with more capability becomes available and it is desirable to use the new knowledge to understand the historical record. By taking a new look at a CDR with a new sensor, many of the elements of scientific data stewardship can be applied to improve the CDR.

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2. DATASETS

The NVAP dataset is a widely-used, global, daily, 1-degree resolution blended product suitable for studies of water vapor in the climate system (Randel et al, 1996; Simpson et al, 2001). NVAP contains layered water vapor fields as well as TPW fields. NVAP has layered precipitable water at 1000-700, 700 – 500, 500 – 300 and above 300 hPa.

NVAP was constructed by blending observations from radiosondes, satellite sounder instruments (NOAA TIROS Operational Vertical Sounder (TOVS, or ATOVS after 1998)), and passive microwave radiometers (Special Sensor Microwave / Imager (SSM/I)). The TRMM Microwave Imager (TMI) was used for 2000-2001. Retrievals are performed on each dataset, and the results are then blended together to create a global merged field. NVAP currently covers the time period 1988 – 2001. Our goal in the creation of the global NVAP dataset to compare with AIRS is to achieve a product which mimics a withdrawal of the NVAP data from the NASA DAAC, as if it existed in 2003-2004.

NVAP data for 1988-2001 is available from the NASA Langley DAAC at:
http://eosweb.larc.nasa.gov/PRODOCS/nvap/table_nvap.html.

Seven months of data from 2003 and 2004 were obtained for all instruments used in this study. These months (January, September 2003; January, March, May, July, November 2004) were selected to sample all seasons and to compare one month (January 2003) where AIRS contains Humidity Sounder for Brazil (HSB) data to a corresponding month (January 2004) without HSB data (the instrument failed in February 2003). The following sections describe each instrument's input dataset and the source from which it was obtained.

a. Atmospheric Infrared Sounder (AIRS)

AIRS data from the *Aqua* satellite was obtained from NASA's Jet Propulsion Laboratory (JPL) website at http://airs.jpl.nasa.gov/. This study used the Level 3 gridded daily standard physical retrieval product (AIRX3STD Version 4.0) that was available at a 1º latitude x 1º longitude spatial resolution. Water vapor products are available for both total column (total precipitable water (TPW)), and for twelve individual layers between 1000 hPa to 0.005 hPa (average mixing ratio (q)).

b. Special Sensor Microwave Imager (SSM/I)

SSM/I Temperature Data Records (TDR) from *Defense Meteorological Satellite Program (DMSP) Air Force F13* and *F14* satellites were obtained from NOAA's Comprehensive Large Array-data Stewardship System (CLASS) website at http://www.class.noaa.gov/. Gridded data was generated for a 0.5º latitude x 0.5º longitude spatial resolution from individual orbit data. Only total column products are derived from SSM/I in NVAP.

c. Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI)

TMI Version-3a products from the *TRMM* satellite were obtained from Remote Sensing Systems' website at http://www.ssmi.com/. Data was available at daily temporal resolution and 0.25º latitude x 0.25º longitude spatial resolution. Only total column products can be derived from TMI.

d. Advanced Television and Infrared Operational Satellite (TIROS) Operation Vertical Sounder (ATOVS)

ATOVS sounding profile data from *NOAA-15* and *-16* satellites was obtained from the National Climatic Data Center (NCDC) in Asheville, North Carolina. Gridded data was generated for a 0.5º lat x 0.5º long spatial resolution from individual orbit data. Total column data is available, as well as data for five levels from 1000 hPa to 300 hPa.

3. RESULTS

In this section we show our initial results of comparing AIRS and NVAP for January 2003.

Figure 1 shows the AIRS 1000 and 500 hPa mixing ratio fields for January 1, 2003. The AIRS TPW is created by an integration of 12 AIRS levels of mixing ratio. AIRS mixing ratios are averages between the stated pressure level and the next AIRS level above it; thus the 1000 hPa mixing ratio averages the 1000-925 hPa layer and the 500 hPa mixing ratio averages the 500-400 hPa layer. AIRS captures vertical structure which eluded previous satellite instruments. Note the moisture plume at 500 hPa over the central Pacific which is not apparent at 1000 hPa. The fact that the 500 hPa AIRS map is not simply a reflection of the 1000 hPa map implies that AIRS is capturing vertical variations in water vapor. Black areas in Fig. 1 are where no retrieval was performed. At 1000 hPa, this includes areas of high topography, while at 500 hPa heavy clouds and precipitating areas are not retrieved. AIRS misses some diamond-shaped regions each day near the equator due to orbital geometry.

The monthly means for January 2003 created from the daily NVAP and AIRS fields are shown in Figure 2. In Fig. 2, (a) is the NVAP blended mean, (b) is the ATOVS mean from NOAA-15 and –16, (c) is the SSM/I mean from DMSP F-13 and F-14, and (d) is the TMI mean. The AIRS monthly mean created from daily Level 3 AIRS data is shown in panel (e). The NVAP blended mean over land is the same as the ATOVS mean, since ATOVS is the only sensor used for input over land. Over ocean, the NVAP merged mean is a weighted average of SSM/I, TMI and ATOVS results.

Note in Fig. 2 that the SSM/I and TMI fields display a high degree of similarity. This is encouraging since they use nearly the same physical measurements with two different retrieval algorithms. The ITCZ is well-defined in all of the various fields. The ATOVS TPW appears to be less moist than the AIRS, SSM/I or TMI fields. Notice also that there are a few persistently cloudy regions where the ATOVS has no retrievals during the month.

ATOVS appears to be more of an outlier in the difference maps in Figure 3. The AIRS monthly mean TPW has been subtracted from the monthly mean TPW from NVAP merged, SSM/I, TMI and ATOVS. Red areas indicate that the given retrieval is drier than AIRS, while blue indicates the given retrieval is moister. The NVAP blended product shows its greatest difference from AIRS over South America and Africa, but the sign of the difference is not the same over the two continents. The SSM/I and TMI difference maps are very similar. Except for South America, the ATOVS fields are mostly moister than AIRS over land. ATOVS is drier than AIRS over most of the oceans, with differences ranging up to 10 mm in some areas. These large differences are not seen with the SSM/I or TMI comparisons.

4. CONCLUSIONS AND FUTURE WORK

A pilot study of scientific data stewardship of a global water vapor record has begun. A major challenge was extending the NVAP dataset forward in time to match with the AIRS operational period.

The comparison of TPW indicates that the ATOVS TPW field is an outlier from the other datasets. These results make it questionable whether the ATOVS sounding product should be used in climate studies. The ATOVS sounding product has historically been used in NVAP production, in particular to provide soundings over land and provide vertical structure.

AIRS validation and reprocessing is an ongoing process, so results from this study must be viewed in that light. As AIRS validation increases in maturity, it can be used in scientific data stewardship studies with greater confidence in the AIRS products.

5. ACKNOWLEDGMENTS

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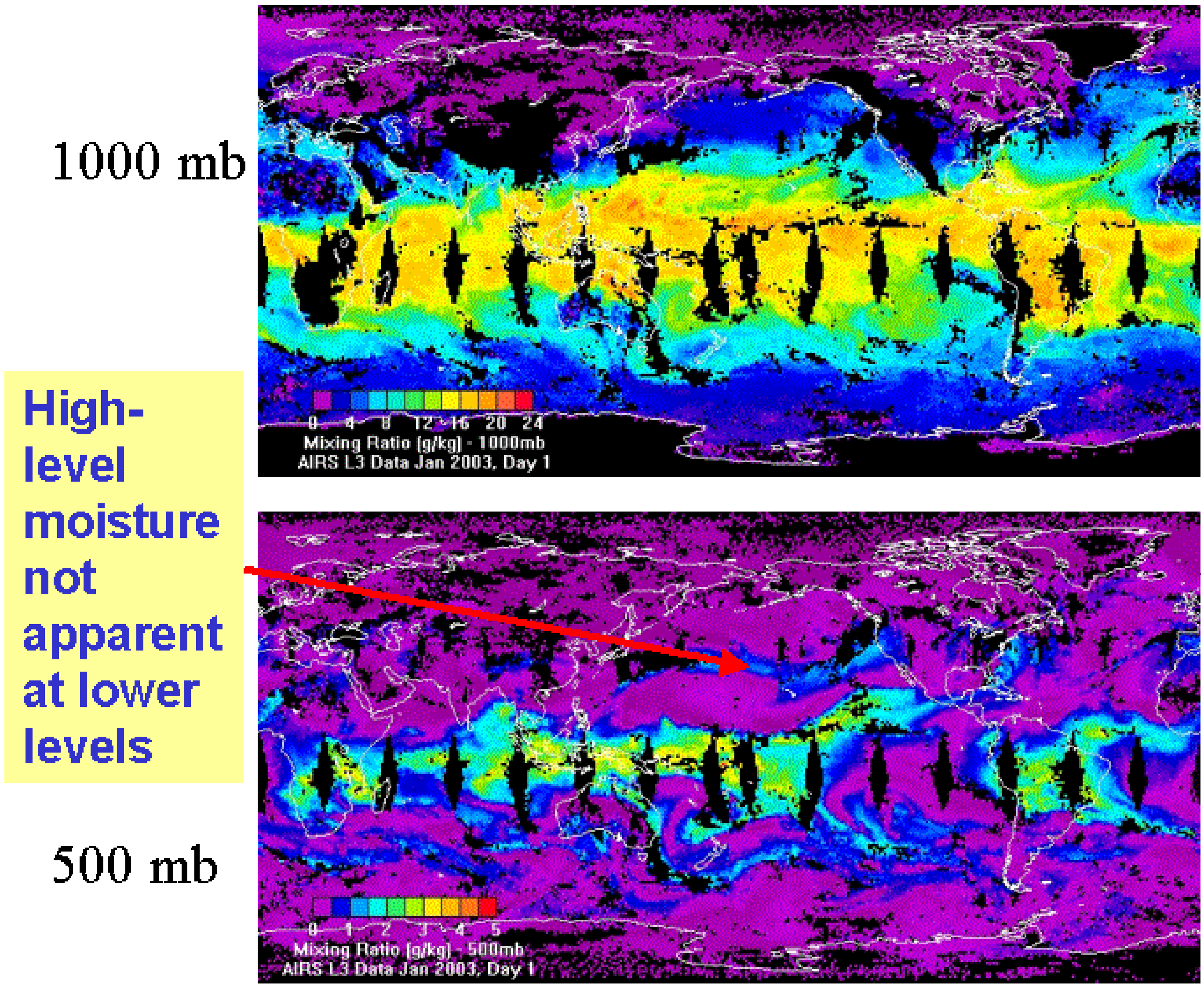

Figure 1: AIRS 1000 and 500 hPa mixing ratio retrievals for January 1, 2003. Note the moisture plume at 500 hPa which is not evident at 1000 hPa. This is an example of the type of vertical atmospheric moisture structure which AIRS captures.

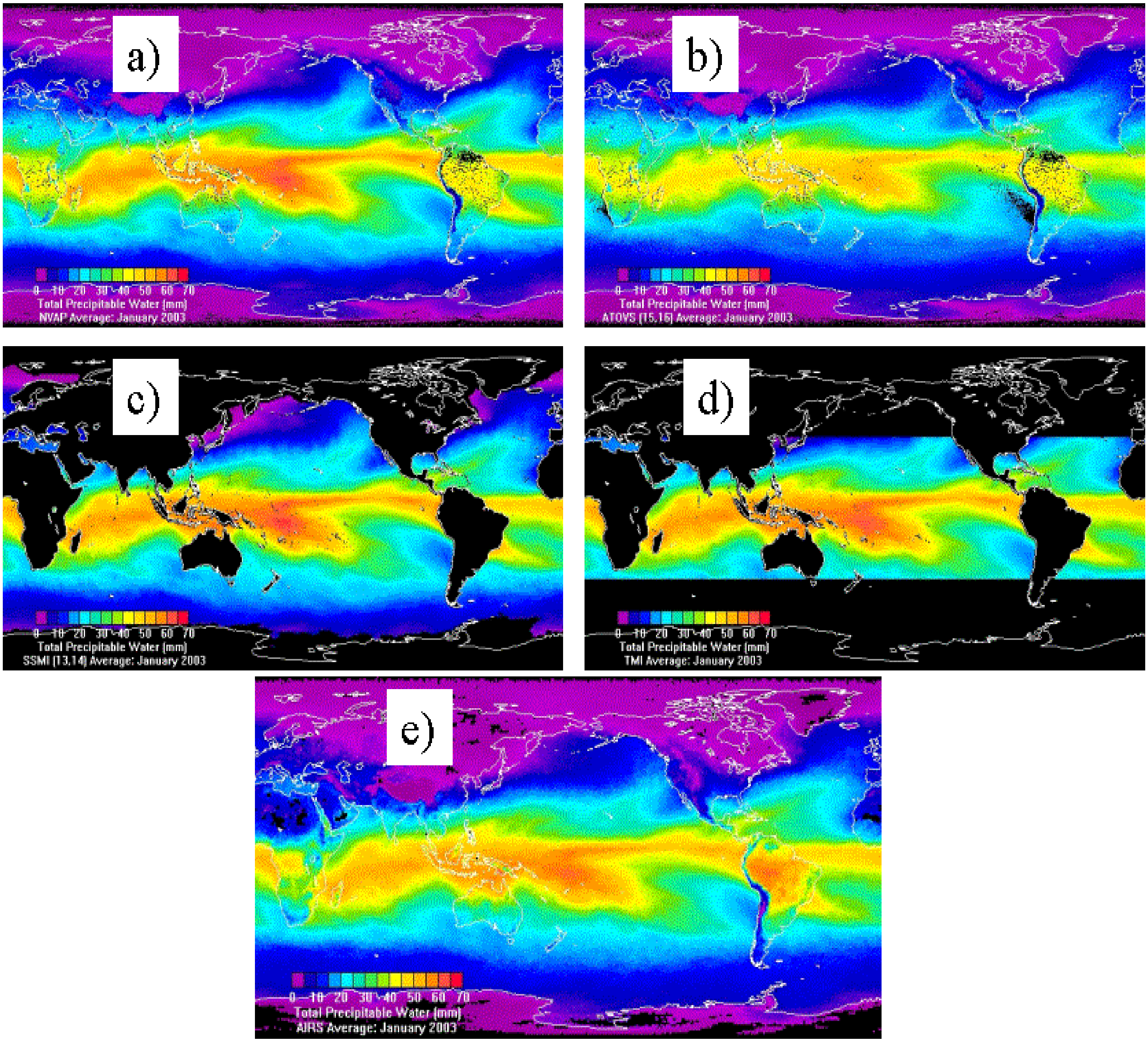

Figure 2: Mean TPW fields for January, 2003. a) NVAP blended mean. b – d) NVAP component means of (b) ATOVS from NOAA-15 and –16, (c) SSM/I from DMSP F-13 and F-14, (d) TMI. e) The AIRS monthly mean created from daily Level 3 AIRS.

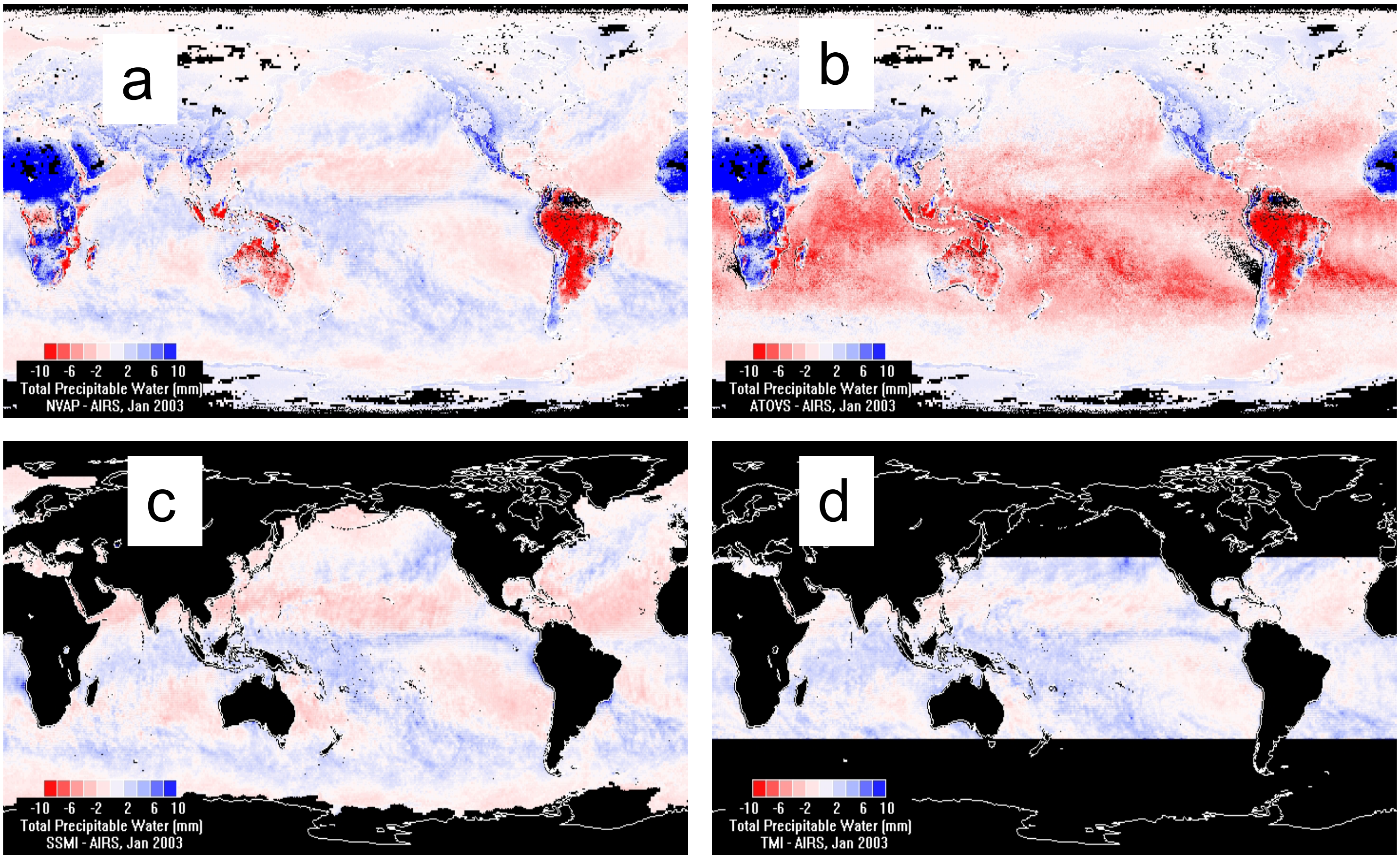

Figure 3: NVAP components minus AIRS TPW for January, 2003. Red areas are where AIRS is moister, blue is AIRS drier. Scale is from –10 to +10 mm. a) NVAP blended minus AIRS TPW. b) ATOVS (NOAA-15 and-16) minus AIRS. c) SSM/I (F-13 and F-14) minus AIRS. d) TMI minus AIRS.