P2.4 INTERNAL CONSISTENCY OF THE NVAP WATER VAPOR DATASET

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1. INTRODUCTION

The NVAP (NASA Water Vapor Project) dataset is a global dataset at 1 x 1 degree spatial resolution consisting of daily, pentad, and monthly atmospheric total precipitable water (TPW) products (Randel et al. 1996). The analysis blends measurements from the Television and Infrared Operational Satellite (TIROS) Operational Vertical Sounder (TOVS), the Special Sensor Microwave/Imager (SSM/I), and radiosonde observations into a daily collage of TPW. The original dataset consisted of five years of data from 1988 to 1992. Recent updates have added five additional years (1993-1997).

Since each of the TPW sources (TOVS, SSM/I, and radiosonde) do not provide global coverage, the individual sources compliment one another by providing spatial coverage over regions and during times where the others are not available. *Over land regions TOVS is the primary data source*. Where there is a coincident radiosonde and satellite measurement the radiosonde measurement is used. Over the ocean where there is a collocated TOVS and SSM/I measurement, SSM/I is weighted by 10% of the TOVS measurement. Thus, *over the oceans SSM/I is the primary data source*. For this type of spatial and temporal blending to be successful, each of the source components should have similar or compatible accuracies. If this is not the case, regional and time varying biases may be manifested in the NVAP dataset. This study examines the consistency of the first 8 years of NVAP source data by comparing daily collocated TOVS and SSM/I TPW retrievals with collocated radiosonde TPW observations. The results of the comparison are used to explain differences seen between the NVAP and the National Centers for Environmental Prediction (NCEP) reanalysis TPW (Kalnay et al. 1996).

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2. NVAP AND NCEP COMPARISONS

Global averages of TPW from NVAP compare favorably with values from the NCEP reanalysis dataset (Fig. 1). The anomalies of both datasets, in general, describe similar interannual trends in TPW. Note that both data sets exhibit a dry period between 1992 and 1994 following the eruption of Mt. Pinatubo. This correlates with a cooling in the lower troposphere indicated by measurements from the Microwave Sounding Unit on the NOAA series of operational polar orbiting satellites (Christy et al. 1995). Also, the anomalies of both datasets indicate an essentially flat trend for the eight year period. There are also differences between the datasets. NVAP TPW exhibits a

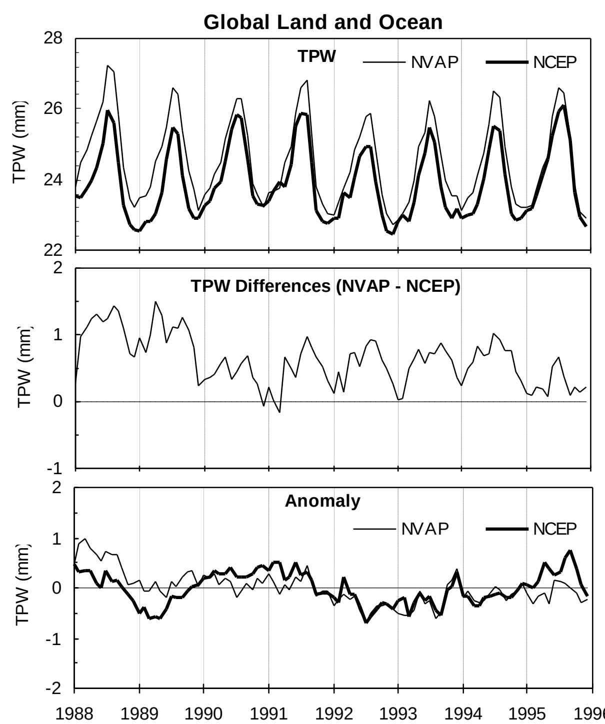

Figure 1. NVAP and NCEP global TPW time series comparison.

seasonal moist bias relative to the NCEP values for the summer months in the northern hemisphere. This time varying bias ranges from 0.0 mm to approximately 1.0 mm. The NVAP data indicates a moist anomaly during the first two years while the NCEP shows a mostly dry anomaly. From 1990-92 NCEP indicates a relative moist period (positive anomaly) while NVAP does not.

Differences between NVAP and NCEP TPW are more pronounced when different regions are examined. For example, comparisons over the NH land regions (Fig. 2) indicate seasonal biases between the datasets of approximately 1-3 mm. Note that during 1992, the NVAP anomaly indicates a deeper drying than NCEP associated with the Mt. Pinatubo effect. Moreover, NVAP exhibits a relative drying with respect to NCEP between 1990 and 1994 . This is seen in the TPW differences as well as in the anomaly differences (bottom panel Fig. 2). This characteristic drying is seen over the land regions in both the northern and southern hemispheres, and is not seen over the oceans except to a slight degree over the NH equatorial oceans.

Another regional example illustrating significant differences between the datasets is the northern midlatitude oceans (Fig. 3). Over this region NVAP exhibits a seasonal dry bias with respect to NCEP ranging from about 0.0 - 1.5 mm for the majority of the months during the first 5 years. Beginning in 1993 the bias amplitude increases to a moist bias of 1.5 mm in the summer months and a dry bias of approximately 2.0 mm in the winter months. The NVAP anomalies again show a deeper drying than NCEP during 1992 associated with the Mt. Pinatubo effect. Large differences are also seen between the anomalies beginning in 1993. During this period NVAP exhibits a seasonal varying anomaly indicating a dry bias during the winter months and a moist bias during the summer months. This is in contrast with the NVAP anomalies during the first 5 years and with the NCEP anomalies during the same period. These NVAP TPW characteristics are also seen in the southern hemisphere midlatitude ocean TPW time series as well, but not for the equatorial oceans.

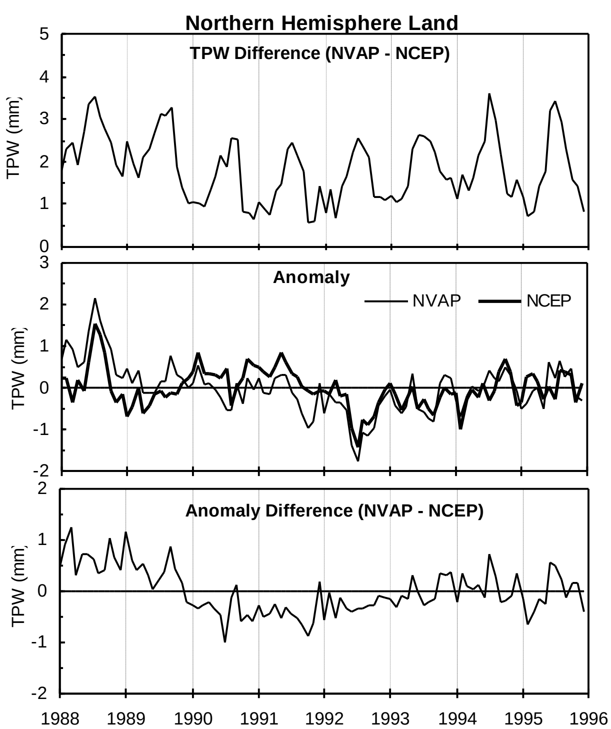

Figure 2. NVAP and NCEP TPW comparison over the northern hemisphere land regions.

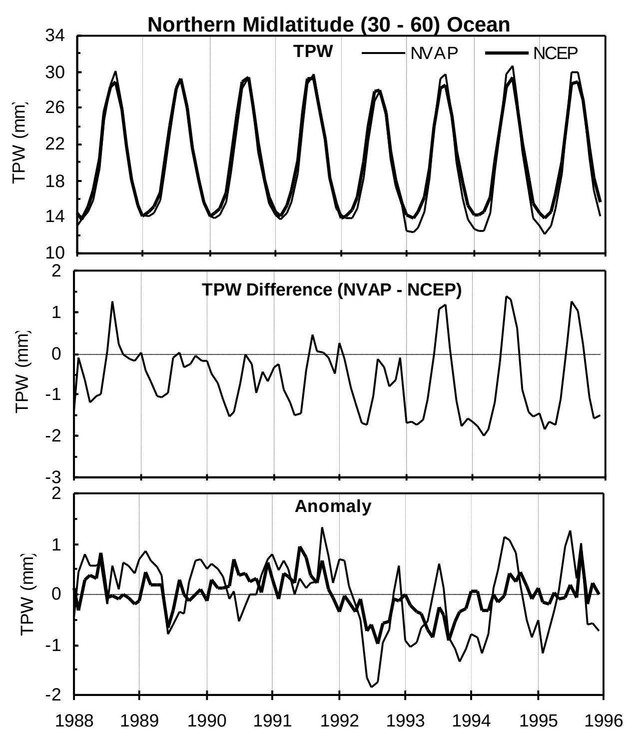

Figure 3. NVAP and NCEP TPW comparison over the mid-latitude ocean regions.

The differences seen between the datasets may be attributed to either dataset or both. In the NVAP/NCEP ocean comparison above, the discontinuity of the NVAP TPW time series (top panel Fig. 3) beginning in 1993 suggest that there was a change in the follow-on portion of the NVAP dataset. Also, one might infer that the departure of the NVAP TPW from the NCEP values suggests that the change had a negative impact on the NVAP dataset. Since the primary source of the NVAP TPW over the oceans is from SSM/I observations, the continuity of the SSM/I source data is in question.

In the above NVAP/NCEP northern hemisphere land comparison (Fig. 2), it is not apparent as to which dataset is responsible for the interannual discrepancy in the anomalies as seen in the anomaly difference plot (bottom panel Fig. 2). Since this anomaly characteristic is only observed over the land regions, it is reasonable to suspect the time consistency of the TOVS source data.

3. INTERCOMPARISON OF THE NVAP DATA SOURCES

The creators of the NVAP data set make available the individual component or source TPW datasets used to make the merged TPW daily product (Randel et al. 1996). Each component dataset is on the same grid as the combined dataset. The individual component datasets provide the daily average measurements that have also been averaged spatially within a one degree grid box. No interpolation is done for grid boxes containing no measurements. Though the satellite and radiosonde measurements represent the daily average TPW for a given grid box, there are differences associated with sampling. The radiosonde gridded daily measurements are usually comprised of an average of two measurements made at the synoptic times. Also, each grid box usually contains just one radiosonde location. The satellite grid boxes may contain, on occasion, only one time of day measurement dependent on the location and number of satellites, but also may be the average of several spatial measurements within a grid box. The time of radiosonde measurements are simultaneous through out the world while the time of the satellite measurements vary based on local equator crossing times of the particular satellite. These sampling differences as well as the accuracy of the measurements may also contribute to the variances in the daily comparisons.

In this analysis the TOVS and SSMI TPW daily grid point values were compared to collocated radiosonde grid values. For each daily-collocated radiosonde and satellite grid point value, the difference was calculated (satellite minus radiosonde). From these differences the mean difference and the standard deviation of the differences were calculated for a month of collocations. Also calculated was the mean TPW of the monthly sample from each source. In order to compare results easily between regions and instruments, the statistics are presented in terms of relative mean difference (RMD) and relative standard deviation (RSTD) with respect to a reference TPW. The radiosonde mean TPW was taken to be the reference for comparisons involving radiosonde measurements.

Figure 4 shows the NH comparison results for the TOVS and radiosonde case. The RMD is seen to vary with time with values of near zero to approximately 10%. TOVS is seen to exhibit an over all dry bias with respect to the radiosonde of approximately 5%. The cause of the varying accuracy of the TOVS TPW is unknown. Possible causes include algorithm processing changes, as well as satellite instrument and calibration effects. The onset of the accuracy change (approx. Nov. 1992) does not coincident with a new satellite launch. Note that the variation in the RMD has similar characteristics as the anomaly difference in Fig. 2. Moreover, the correlation coefficient between the two curves is 0.69. This comparison suggests that a TOVS dry bias is likely a major contributor to the NVAP/NCEP comparison differences over the land regions between 1990-1994.

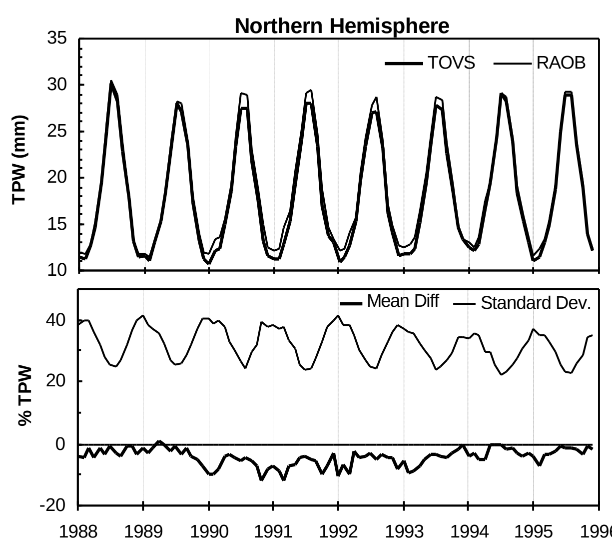

Figure 4. TOVS and radiosonde TPW collocation comparison over the northern hemisphere.

Figure 5 shows the comparison results for the SSM/I and radiosonde case. The radiosondes in this comparison are associated with launches from small islands and ships as well as radiosonde measurements along coast lines that may reside in a 1 degree grid box containing both land and water. It is seen that the RMD is quit large from 1988 to 1993. It has a seasonal variation from about 5% in the summer months to over 20% in the winter months. This SSM/I moist bias is seen to reduce significantly beginning in 1993 with a seasonal variation of less than 10%. Note that the RSTD is also reduced significantly for this period. The cause for the accuracy change was due to algorithm improvements put in place beginning with the 1993 dataset updates. The improvements include: a more robust precipitation check, improved land and ice contamination schemes, and the implementation of the 22 GHz channel in the retrieval process (D. L. Randel 2000, personal communication). The desired impact was to reduce the moist biases in the low TPW regions and seasons, which is confirmed in Fig. 5. Though the NVAP TPW departure from the NCEP TPW in Fig. 3 (top panel) suggests a possible NVAP degradation beginning 1993, the radiosonde comparison suggests that it is NCEP that has the TPW bias (moist). However, the improvement in the SSM/I processing causes a discontinuity in the TPW data. The result is a corrupted anomaly time series which does not reveal the correct climatological variability in TPW. Even though the NCEP TPW likely possesses a moist bias, its anomaly trend is more consistent with the TPW variations over the period.

4. CONCLUSIONS

Intercomparisons of the first 8 years of source data that is used in constructing the NVAP dataset indicates that there are data inconstancies in the SSM/I and TOVS data. In the case of the SSM/I data, an algorithm change implemented with the processing of the 1993 and later data produces a discontinuity in the TPW time series. Though the change appears to improve the TPW values as compared to radiosonde measurements, the TPW anomalies are effected adversely. This impact is mostly seen in the midlatitude regions.

For the case of the TOVS data, there is an observed drift in the accuracy of the TPW values from approximately 1990 through 1993 causing the TOVS TPW to be dry biased with respect to collocated radiosonde measurements. This dry bias is evident in TPW anomaly comparisons between NVAP and the NCEP reanalysis.

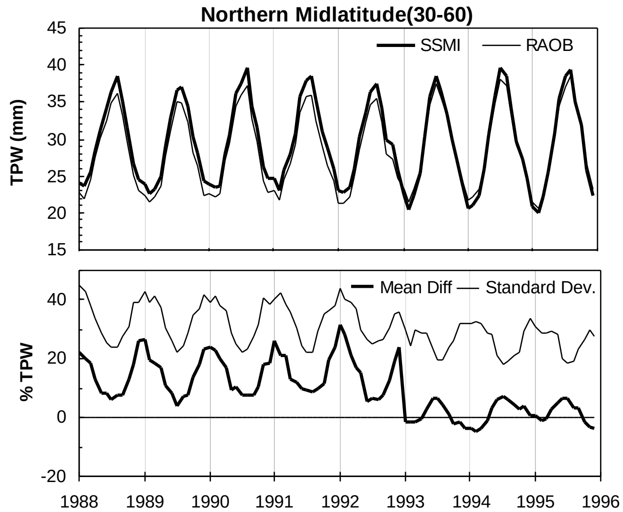

Figure 5. SSM/I and radiosonde TPW collocation comparison over the northern mid-latitudes.

Acknowledgements

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