Cloud Climate Applications for the AVHRR Record

Michael J Foster¹; Andrew Heidinger²

¹Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, University of Wisconsin-Madison
²Office of Research and Applications, NOAA/ NESDIS, Madison, WI, USA

Abstract

NOAA's Advanced Very High Resolution Radiometer (AVHRR) record begins in 1978 and represents over three decades of continuous cloud measurements. The Pathfinder Atmospheres Extended (PATMOS-x) team processes this record using consistent algorithms and inter-sensor calibrated radiance, making the data well suited for climate monitoring and assessment of extreme environmental events. Identifying statistically significant trends in cloud amount or its properties requires the additional step of quantification and aggregation of various sources of uncertainty. The method we have adopted to identify and aggregate several, oft-correlated sources of uncertainty is to generate normalized monthly anomaly histograms. These histograms can in turn be used to estimate bias based on the location, time of year, cloud homogeneity and viewing geometry of individual measurements. A distribution of these biases, accumulated over time and space, are used to create monthly estimates of uncertainty. The parameters used to generate these histograms include:

- Relative Azimuth Angle
- Sensor Zenith Angle
- Cloud Fraction

The histograms shown here have been created using the PATMOS-x/AVHRR record over much of North America (1981-2012). The cloud fraction parameter is used as a proxy for cloud homogeneity. To account for seasonal and geographic variations, the histograms are created for 1.0 degree boxes for each month. Furthermore ice clouds and water clouds are considered separately.

Mean Liquid Water Path

Figure 1. North American monthly mean liquid water path taken from PATMOS-x/AVHRR (1981-2012). Values are calculated for 1.0 degree boxes using cloud optical thickness and particle effective radius.

Figure 2. PATMOS-x/AVHRR (1981-2012) monthly liquid water path uncertainty estimates. Values calculated for 1.0 degree boxes. Units are percent difference from the mean.

Figure 3. Same as Figure 2 but the units are in g/m².

Figure 4. North American monthly liquid water path 3-dimensional histograms using sensor zenith angle, relative azimuth angle and cloud fraction as the 3 parameters. The units are percent difference from the mean liquid water path (normalized separately for each cloud fraction bin). These histograms represent the average of those created for each 1.0 degree box.

Figure 5. Same as Figure 4 but for ice water path.

Figure 6. Time series of PATMOS-x/AVHRR monthly liquid water path anomalies over North America. Shading represents uncertainty estimates, calculated using the methods described above. Monthly averages have been removed to account for seasonal effects. The median and standard deviation for all pairs of overlapping satellite months are located in the bottom right corner. For months with more than two satellites available all pairing combinations are included.