25PF3

TEMPORAL AND SPATIAL VARIABILITY OF ATMOSPHERIC WATER VAPOR

S. H. Melfi, Keith Evans*, David Whiteman,
and Richard Ferrare*
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
Phone: 301-286-6348 Facsimile: 301-286-1762

Atmospheric water vapor is highly variable in both time and space. One obvious indication of this variability is the complex structure of clouds. Variability ranges over scales from a few seconds (centimeters) to several minutes (kilometers) associated with turbulence, up to scales of a few hours (tens of kilometers) associated with gravity waves and on to scales of days (hundreds of kilometers) associated with the diurnal cycle and globe circling Rossby waves.

Knowledge of moisture variance is important for a number of reasons. One is the representativeness of a single measurement. A radiosonde profile of water vapor may accurately measure moisture along the ascent of the balloon but will be limited in providing an indication of moisture structure extending around the ascent in either space or time. Clearly, moisture variance is important in siting upper air stations and determining the frequency of observations. Another important reason to understand moisture variance relates to remote satellite measurements. Both infrared and microwave sensors onboard satellites observe the atmosphere over instantaneous "footprints" of a few tens of kilometers. Variability of moisture within these footprints will influence the sensors' accuracy, precision, and sensitivity and will complicate comparisons with "groundtruth". Probably, the most important reason to understand water vapor variance has to do with general circulation models (GCM's). These numerical models which are used to predict weather and forecast climate attempt to simulate atmospheric dynamics and moisture processes to provide a realistic picture of the state of the atmosphere and its future evolution. Because of computing costs, the modeled atmosphere is divided into a limited number of grid points, with spacings typically several hundred kilometers on a side and several hundred meters high. Water vapor processes such as surface fluxes, cloud formation, convection and precipitation occur on scales smaller than a typical grid. The important effects of this sub-grid variance is included in the models through some form of approximation (parameterization). The success of these parameterization schemes depend on a good understanding and knowledge of moisture variability.

We have previously reported on the temporal spectra of water vapor mixing ratio measurements utilizing a ground-based Raman lidar (Evans *et al.*, 1992). Data from two additional field missions have been spectrally analyzed. An example from data acquired at Wallops Island, Va on September 14, 1993, is shown in figure 1. The spectra has the shape of a power law distribution with a slope of about minus two. In general, we have found that the spectral shape (-2) appears to be invariant with altitude and location and that the differences from site-to-site and with altitude are primarily in overall variance magnitude.

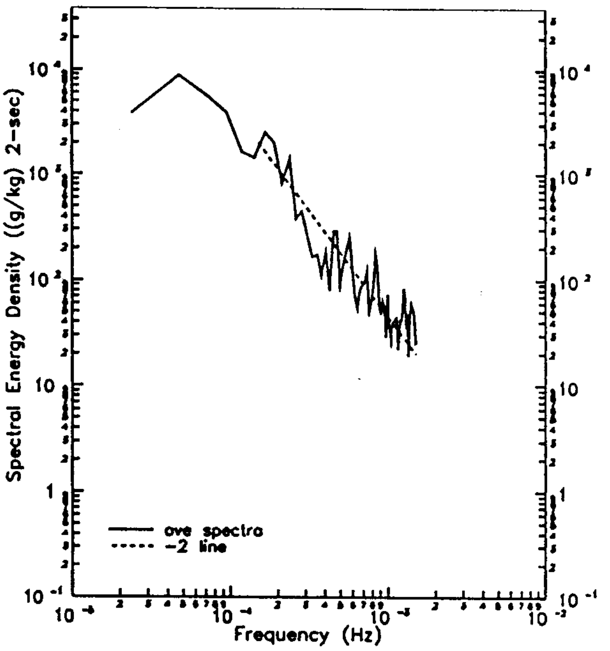
Vertical profiles of water vapor data have also been spectrally analyzed. An example from data acquired on September 14, 1993 is shown in figure 2. The spectra also appears to be a power law distribution with a slope of about minus two.

Details of the Raman lidar will be presented along with other examples of spectrally analyzed data. The significance of a power law spectral distribution will be discussed during the presentation.

* Hughes-STX, 4400 Forbes Blvd., Lanham, MD 20706

REFERENCE

Evans, K., S. H. Melfi, R. Ferrare, and D. Whiteman, "Water Vapor Variance Measurements Using A Raman Lidar," *Proceedings Sixteenth International Laser Radar Conference*, NASA CP 3158, pp 485-487.



Figures 1. The average water vapor temporal spectra for 11 altitudes at 75 meter intervals centered at a height of 1.5 km. The data were acquired at Wallops Island, VA on Sept. 14, 1993.

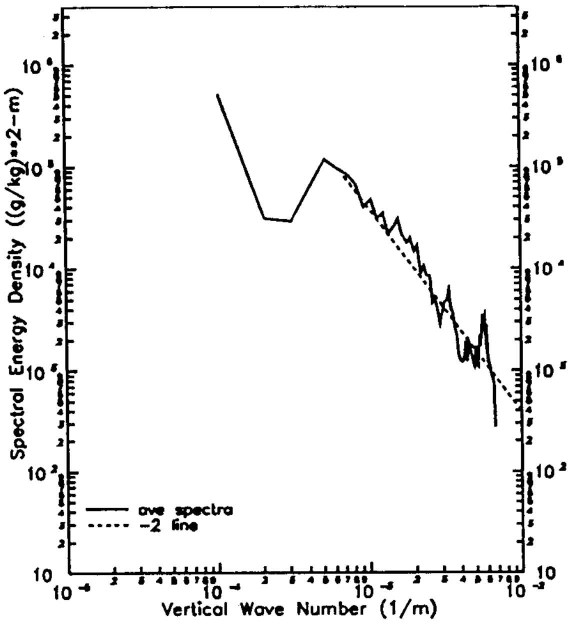


Figure 2. The water vapor vertical spectra from the average of 85 profiles acquired over an 8-hour period at Wallops Island, VA on Sept. 14, 1993.