EVALUATION OF UPPER TROPOSPHERIC WATER VAPOR AND CLOUDINESS IN GLOBAL CLIMATE MODELS USING SATELLITE DATA

National Oceanic and Atmospheric Administration Grant, # NA56GP0431
SSEC # 2050

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Progress report June 1, 1995 - March 31, 1996

Technical Discussion

This phase has been devoted to exploratory studies, examining space-time spectra and developing the tools for systematic processing of data from the GOES Pathfinder Benchmark Period. The project has been conducted by Francis Bretherton, without charge, and a Post Doctoral Fellow Barbara Whitney (approximately ½ time), with collaboration from Brian Soden of NOAA-GFDL.

Pending delivery of a Sun Workstation and associated software, the issue of cloud clearance for the water vapor channel was re-examined, in particular the reason for certain non-linear relationships between the 11μm and 6.7μm radiances associated with tropical cirrus clouds, which were noted in passing by Soden and Bretherton (1993) . This theoretical study concluded that a plausible explanation is provided by the different absorption coefficients of ice in the two channels, which make itself apparent only for small particles (< 5 μm diameter). This difference opens the possibility that a systematic determination of this curvature could provide a measure of the presence of small cloud particles versus larger ones, an important diagnostic for validations of cirrus cloud cover in GCMs. Exploration of the practicality of measure is included with later tasks under the project. However, an implication of this extra degree of freedom in the cloud model underlying the cloud clearance algorithm is that it is unwise to extrapolate too far from partially cloudy pixels to clear skies, so that, from the point of view of determining water vapor, moderately cloudy pixels should be treated as missing data.

Following delivery of the workstation, the productivity of the exploratory phase has been substantially enhanced by investment in IDL, a commercial software package for data manipulation and visualization. After mastering the basic interface, it has enabled much more rapid prototyping of different algorithms and their effects.

Displays were devised to monitor the performance of the cloud clearance algorithm as applied to small cluster of pixels of various size. With an appropriate cut-off for moderately cloudy pixels, it seems to function quite consistently over regions of 4x4 pixels (64 km by 64 km).

To simplify interpretation, the initial focus has been in the tropics over the oceans. In cloud free regions, high resolution semi-variograms of relative humidity, as determined from 16 km resolution water vapor images, show very substantial anisotropy, consistent with theoretical

predictions of the effects of vertical wind shear. The variability in the direction of the wind shear is typically substantially less (a factor of 3 - 5) than that in the transverse direction. From these semi-variograms, natural variability can be reliably distinguished from instrument noise. For GOES-7 at this epoch (July 1987) the instrument noise shows the expected characteristics (E-W stripes) and is satisfactorily small. The limitations of the technique in partially and moderately cloudy regions are now being explored, in the light of the theoretical conclusion described above. Such quantification of the fine structure of the water vapor field is a basic building block for the broader examination of the relationship between upper tropospheric water vapor and the occurrence of deep convective clouds which is a subject of the second phase of this study.

Such static, single image, measures of variability are now being extended to the temporal dimension, building on extensive experience elsewhere in the Space Science and Engineering Center with so-called "water vapor winds". These are pattern displacement vectors for the fine structure in the water vapor images. The focus is on the full interpretation of such vectors and their uncertainty as a statistical characteristics of the water vapor field itself, rather than as wind determinations that are then fed into operational weather prediction models. Representations of space-time spectra are of greater utility for evaluation of the performance of Global Climate Models.

Attention so far has been on development of the necessary tools, using only a small sample of the data which is available. However, access to the GOES Pathfinder Archive has proved to be straightforward and effective, and is not expected to be a significant obstacle to the more extensive statistical studies that are planned.

Reference

Soden, Brian J., and Francis P. Bretherton, 1987, "Upper Tropospheric Relative Humidity from the GOES 6.7μm Channel: Method and Climatology for July 1987." Journal of Geophysical Research, **98**, 16,669-16,688.