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## REMOTE SENSING OF WATER VAPOR FEATURES

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### Background

Water vapor plays a critical role in the atmosphere. It is an important medium of energy exchange between air, land, and water; it is a major greenhouse gas, providing a crucial radiative role in the global climate system; and it is intimately involved in many regional scale atmospheric processes. Our research has been aimed at improving satellite remote sensing of water vapor and better understanding its role in meteorological processes. Our early studies evaluated the current GOES VAS system for measuring water vapor and have used VAS-derived water vapor data to examine pre-thunderstorm environments. Much of that research was described at the 1991 Research Review. A second research component has considered three proposed sensors--the High resolution Interferometer Sounder (HIS), the Multispectral Atmospheric Mapping Sensor (MAMS), and the Advanced Microwave Sounding Unit (AMSU). Future research will use GOES I water vapor data.

### The Past Year's Efforts

We have focussed on MAMS and AMSU research during the past year.

1) CONVECTIVE CASE. Graduate student Rick Knabb is utilizing MAMS data collected over the Florida peninsula on 16 October 1990. Split window channel radiances are being used to analyze mesoscale moisture variations. The split window variance ratio (SWVR) technique developed by Dr. Gary Jedlovec is being employed. It takes advantage of MAMS' fine spatial resolution (100 m) to calculate the ratio of the variances of split window channel brightness temperatures. Since the split window channel transmittance ratio has been shown to be similar to the SWVR, a regression between transmittance ratio and PW can be determined and used with the imagery to retrieve PW.

Most of the work to date has been to develop the regression between transmittance ratio and PW for this particular case. That relationship shows a strong inverse logarithmic fit to the data, with a standard error less than 1 mm of PW. There is some uncertainty (scatter) in the relation, and extensive sensitivity testing has shown that this is attributable to variations in the vertical distribution of temperature, and most importantly, dew point. That is, for a given value of PW, there is an infinite number of possible dew point profiles. These differing distributions affect the split window transmittances, and ultimately the PW determined by regression. The transmittances and PW are much less affected by temperature. The sensitivity analysis indicates that the MAMS/SWVR technique provides PWs that are accurate to within 3 mm. Based on these efforts, we believe that we have a good understanding of the strengths and weaknesses of the SWVR algorithm.

Rick is just beginning to use the MAMS/SWVR technique on the October 1990 case over Florida. He has written code to make the PW calculations on our PC McIDAS, with a man-in-the-

loop selecting the retrieval locations. There are several interesting mesoscale features on the case day. A large area of thunderstorms over Cape Canaveral initiates outflow to its southwest, including a series of arc cloud lines. The MAMS flight crosses the outflow boundary and appears to be in a good position to document moisture differences on its two sides. Another area of interest is northeastern Florida, which experiences rapidly decreasing dew points during the MAMS overflights. The high resolution MAMS-derived PWs likely will yield a detailed analysis of this dry advection event. The research on this period will document the utility of the SWVR technique as applied to high resolution MAMS data.

2) LAND SURFACE CASE. Graduate student Mike Nichols is exploiting MAMS imagery to study how land surface characteristics relate to cumulus cloud formation. The MAMS-derived characteristics include land surface temperature (LST), normalized difference vegetation Index (NDVI), and soil moisture. The case being studied is the 18 August 1988 MAMS overflight of the Tennessee River Valley.

LSTs are calculated using a statistical split window technique similar to that used to obtain sea surface temperatures. Regression coefficients are developed based on radiative transfer calculations. The resulting equations give LSTs that are similar to those derived by Jedlovec for a previous case. LSTs over the area are found to vary greatly in both time and space. NDVI is calculated from MAMS data using standard procedures. The relation between LST and NDVI is being explored. Correlation coefficients between these terms are near -0.75 during the case study. Soil moisture is obtained from time changes in MAMS-derived surface temperatures. The MAMS-derived values have been compared with those from observed rainfall data using the Antecedent Retention Index (ARI). Results indicate that areas receiving the least rainfall during the preceding two months experience the greatest LST changes during the morning MAMS overflights, thereby implying lowest soil moisture content.

The Oregon State University Planetary Boundary Layer (PBL) Model is being used to calculate cloud fractions for comparison with those from MAMS. Soil moisture, one of the key inputs to this one dimensional model, is obtained from MAMS as described above. Model runs are made at numerous locations on the case study day. An older version of the PBL cloud model component has been found to give results that are superior to those from a newer version.

The role that terrain plays in cloud development also is being investigated. Results show that where terrain is a factor, only the steepest gradients produce cloud lines. Conversely, where topographic changes are small, boundary layer clouds form initially over areas with the highest soil moisture. Finally, precipitable water is being calculated using the SWVR technique (see above). Initial results indicate only small variations across the study area.

3) AMSU EFFORTS. Graduate student Brad Muller is sponsored by a NASA Graduate Student Researchers Program. However, since his efforts are so closely related to those sponsored by the RTOP, it is appropriate to comment on them briefly. Brad has assembled and modified existing numerical algorithms into a multiple scattering microwave radiative transfer model. He is using this code to perform sensitivity studies to understand the effects of temperature, water vapor, and liquid and ice clouds on upwelling AMSU brightness temperatures. He also is applying the code to mesoscale model (LAMPS)-derived atmospheres to calculate patterns of AMSU moisture channel brightness temperatures. The LAMPS output is then used to quantify processes that create the mid-to upper-level dry band/moisture boundaries that will be seen in AMSU water vapor imagery.

## Current Focus and Future Plans

The current grant will expire at the end of calendar year 1992. All of the research described above will be completed by that time. New research, to be conducted with Dr. Gary Jedlovec of NASA/MSFC, will begin in late 1992. Those efforts will involve the upcoming GOES I-M satellite series. Our goals are to 1) Understand features in GOES I water vapor imagery and their relationships to atmospheric processes, 2) Quantify the information content of GOES I imagery and derived products, 3) Develop new procedures for examining water vapor that take advantage of GOES I's enhanced capabilities, and 4) As a result, improve our understanding of the role of atmospheric water vapor. An important point is that much of the research will be conducted using simulated imagery. Thus, it will not be impacted by delays in the launch of the satellite.

## Publications

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