N90-12062

TITLE: **Global Atmospheric Moisture Variability**

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SIGNIFICANT ACCOMPLISHMENTS IN THE PAST YEAR:

Research efforts during FY88 have focused on completion of several projects relating to analysis of FGGE data during SOP-1 and on expanded studies of global atmospheric moisture. In particular, a revised paper on the relationship between diabatic heating and baroclinicity in the South Pacific Convergence Zone (SPCZ) was submitted to the QJRMS. A summary of completed studies on diagnostic convective parameterization was presented at the Satellite Meteorology and Oceanography Conference last February. These investigations of diabatic heating in the SPCZ have demonstrated the requirement for a more quantitative description of atmospheric moisture. As a result, we have directed our efforts toward use of passive remote microwave measurements from the Nimbus-7 SMMR and the DOD's SSM/I as critical sources of moisture data. Our activities this year are summarized as follows.

1. Use of IR gradient information in rainfall estimation

In an attempt to extend infrared (IR) rainfall estimation techniques to middle latitude stratiform rain situations, an algorithm has been developed which incorporates gradients of IR brightness temperature, T_b. The premise of this approch is that in vertically sheared flows typical of middle latitudes, horizontal gradients of T_b can help discriminate vortical cloud bands and comma clouds in which there is a tendency for slantwise ascent of air parcels with precipitation concentrated on the upstream flank of the cloud shield. A data set consisting of over 1500 3-hour cumulative rainfall amounts and colocated GOES-E IR T_bs and gradients of T_b has been compiled. Results suggest that T_b and its horizontal gradient possess *independent* information on rain rate and that consideration of the T_b gradient adds significantly to the skill of the algorithm.

2. SMMR Precipitable Water During FGGE SOP-1.

Because the convective intensity of the SPCZ during FGGE SOP-1 was apparently modulated by processes acting on intraseasonal time scales, it is of interest to determine how the associated moisture fields (precipitable water) also behaved. We conducted a pilot study to assess the ability of SMMR to detect variability of large scale tropical moisture over weekly and longer time scales. For the period 10 January through 13 February 1979 composites of the difference between 22 and 18 GHz (horizontal polarization) have been produced. Prabhakara et al, (1982 JAM) has developed a quantitative relationship between these T_b differences and precipitable water. During this period, significant changes in the global structure of precipitable water over tropical oceans were observed. In mid January the SPCZ and that portion of the ITCZ associated

with the Australian Monsoon were quite moist with precipitable water values in excess of 5 cm. By early February the SPCZ had weakened (dried) somewhat. Concurrently the ITCZ east of 180° and the southwest Indian Ocean had shown considerable moistening. This sequence of events is consistent with the results from studies which indicate convective anomalies in the Indian Ocean being out of phase with those in the mid-Pacific and SPCZ regions.

This variability has been confirmed in the ECMWF and GLA analyses for the same period. An examination of 160 colocated values of grid point data and SMMR precipitable water averaged over a 4.0° square showed high correlations: SMMR/GLA, .81; SMMR/ECMWF, .83; and GLA/ECMWF, .87. Given that the SMMR data are totally independent from the GLA and ECMWF values, and that the SOP-1 period provided an unequaled observational density, the passive microwave data base seems to be a substantially under-utilized resource.

3. Analysis of SSM/I geophysical retrievals

We have recently begun an examination of precipitable water, total liquid water and wind speed derived from the Special Sensor Microwave Imager (SSM/I) launched in June 1987. These geophysical retrievals have been produced by Dr. Frank Wentz of Remote Sensing Sytems, Santa Barbara, CA. To date we have been working with data for September 1987 (descending nodes only). The monthly mean precipitable water shows anticipated patterns of a moist ITCZ, dry "oceanic deserts" west of continents, and strongly resembles climatological sea surface temperature patterns. Because SSM/I coverage per unit time is four times that of SMMR owing to duty cycle and swath width, analysis of evolving synoptic scale structures will be possible. Several instances of extratropical cyclone development and a case of a tropical cyclone recurving and merging with a mid-latitude baroclinic wave have been identified.

Total liquid water (cloud and rain water) during the same period is largest over the ITCZ and western tropical Pacific. However, there are some regions in the tropical Southern Hemisphere which, although high in precipitable water content, are relatively free of cloud liquid water. These may possibly be descending branches of local Hadley circulations.

Surface wind speeds determined from SSM/I exhibit considerable coherence. In cases where vortical structure in in precipitable water suggests a mature or deepening cyclone, wind speedsform a "bullseye" pattern increasing radially inward. During September, the Antarctic circumpolar trough exhibits peristently high wind speeds, evidence of weak frictional effects due to the lack of continents at these latitudes. One potential problem with SSM/I winds is an apparent high bias in regions of large liquid water content.

FOCUS OF CURRENT RESEARCH AND PLANS FOR NEXT YEAR:

We are currently directing most of our efforts toward developing the SSM/I data base, associated image processing routines, and statistical analysis programs. We are also examining NMC gridpoint analyses for comparison to SSM/I geophysical quantities. During the next year we plan to apply spectral analysis techniques (e.g. power, coherence, phase, bandpass filtering) to quantify the structure and variability of moisture and surface wind speed on synoptic to intraseasonal scales. This analysis will also be performed on global gridpoint data sets (NMC or ECMWF analyses) to assess current capability of assimilated global data to quantitatively describe the atmospheric component of the global water cycle.

These results should also be of interest to other researchers in the 146 RTOP area who are investigating global moisture and diabatic processes. We plan to coordinate with theses groups relative to observational periods, case study selection and numerical modeling strategies. We will also finish producing IR rainfall estimates for use in several other 146 RTOP efforts. Production of regional 12h precipitation estimates at 2.5° resolution for several case studies for Drs. Colucci

and Smith is underway.

PUBLICATIONS:

(Referreed)

Robertson, F. R., D. G. Vincent and D. M. Kann, 1988: The role of diabatic heating in maintaining the upper-tropospheric baroclinic zone in the South Pacific. (Revised and submitted to Quart. J. Royal Meteor. Soc.).

(Non-referreed)

Huang, H.-J., D. G. Vincent and F. R. Robertson, 1988: Precipitable water derived from Nimbus-7 SMMR measurements and its comparison to FGGE III-b data during January 10- February 13, 1979. Preprints of Third Conference on Satellite Meteorology and Oceanography, January 31-February 5, 1988, Anaheaim, CA, Americam Meteorological Society, Boston, MA, 64-69.

Robertson, F. R. and D. G. Vincent, 1988: Vertical profiles of heating derived from IR-based precipitation estimates during FGGE SOP-1. Preprints of Third Conference on Satellite Meteorology and Oceanography, January 31-February 5, 1988, Anaheaim, CA, Americam Meteorological Society, Boston, MA, 334-339.