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TITLE: **Global Variability of Water Vapor and Condensate from SSM/I**

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SIGNIFICANT ACCOMPLISHMENTS IN THE PAST YEAR:

In the three years since its launch, the Special Sensor Microwave Imager (SSM/I) has provided the beginnings of a data set crucial to the study of the Earth's global hydrologic cycle. Our investigations with SSM/I have centered largely on two themes: 1) an analysis of the variability in atmospheric moisture as a signature of dynamic and kinematic processes, and 2) development of high quality data sets for determining moisture balance and, eventually, diabatic heating on regional and planetary scales. To date, most of the emphasis has been on the precipitable water field since algorithms for this quantity appear to be the most mature. In addition, we have also begun to work with liquid water, precipitating ice and ocean surface wind stress fields. The retrievals used in these studies are from algorithms developed by Wentz (RSS Tech Rpt. 1989) and Spencer (1988 JTECH).

Storm track analysis

The duty cycle of the SSM/I (nearly complete global sampling every four days) allows the study of variability about means longer than several weeks. Monthly means of SSM/I precipitable water (PWC) and total liquid water (TLW) and their standard deviations have been derived for the purpose of identifying middle latitude storm tracks. We have found that in comparison to ECMWF analyses, the SSM/I generally depicts stronger monthly mean horizontal gradients. The tropical convergence zones, as seen by SSM/I appear somewhat more moist and the subtropical ridges noticeably drier. An implication of this is that for moisture balance calculations which used the SSM/I PWC, sharper, more intense rainfall maxima would result.

2-D Diagnostic assimilation

To analyze the space/time variability of SSM/I variables, a data set with uniform, synoptic sampling is required. Unfortunately, because of the asynoptic nature of sun-synchronous orbits and non-overlapping swaths at tropical latitude this coverage is not available from the raw data. Significant progress has been made in applying Lagrangian methods to interpolate the data into a synoptic format. In studying lag correlation statistics of the SSM/I swath data it is apparent that the propagation (phase vector) of synoptic disturbances is well related to lower tropospheric winds. A simple transport model was developed that uses lower tropospheric winds to horizontally advect water vapor or cloud water. The model uses a nudging term to update the analysis so that at at any (x,y) location the solution agrees exactly with the SSM/I observations. The evolving solution is sampled at regular time intervals to yield synoptic analyses of SSM/I variables. This data set can form the basis of bandpass analyses to isolate synoptic from longer term variability.

4-D Multiphase water analysis

The analysis described above provides a synoptic mapping employing rather minimal adjustment to the SSM/I data. To derive a data set which yields consistent diagnoses of vapor, cloud and precipitation requires vertical structure as well. A model has been constructed that uses SSM/I observations as a constraint on an evolving 3-dimensional moisture field. The basic formalism for the 4-Dimensional multi-phase water analysis (4-DMPW) is a diagnostic assimilation procedure. In this methodology, wind fields from ECMWF gridded analyses have been used to drive conservation equations for vapor, liquid and ice. These equations, which also use bulk parameterizations of microphysics (e.g. condensation, autoconversion, collection, precipitation evaporation and fallout) are updated, or constrained in such a way that where SSM/I observations are available, the analysis agrees to within measurement accuracy. The qualifier "diagnostic" means that the wind field and temperature are specified from the ECMWF analyses and not predicted by this constrained model.

Our initial investigations suggest that this methodology can provide realistic, 3-dimensional evolving fields of vapor and condensate. The moisture balance and vertical structure of condensate derived by this method makes use of the best moisture field (SSM/I), and is kinematically consistent with global wind fields and simple but fairly realistic bulk microphysics. We have also noted that, as expected, analysis results are sensitive to the quality of the specified vertical motion, and that current analyses of this variable are in need of improvement.

FOCUS OF CURRENT RESEARCH AND PLANS FOR NEXT YEAR:

Results from the 2-D model which provides a synoptic analysis of SSM/I data are being examined to assess the sensitivity to the specification of phase speed from ECMWF wind analyses. We will use these moisture and cloud fields as a basis for bandpass analysis of various scales. We expect the variability of storm tracks location and intensity, as evidenced by SSM/I to be a very useful indicator of low-frequency (intraseasonal) and short-term climate variability.

The studies to date with the 4-D MPW analysis have been exploratory. We will pursue including more sophisticated representations of shallow and deep convection within this diagnostic assimilation framework. We are currently exploring ways of using SSM/I ice and liquid water signatures to alter the ECMWF vertical motion fields.

Many of the analyses refered to here will be available for critiquing the NCAR Community Climate Model in a collaborative effort with the Climate Modeling Section. Some of the TLW fields have already been used in developing and tuning moist physics packages for the next version of the model, CCM2. In addition, we are collaborating with Dr. Akira Kasahara in application of the the SSM/I moisture and inferred vertical motion / divergence patterns to the cumulus initialization problem.

PUBLICATIONS:

Robertson, F. R. and J.R. Christy, 1989: Global analyses of water vapor, cloud and precipitation constrained by SSM/I retrievals. Preprints, Fifth IAMAP Scientific Assembly, 31 July-5 August, 1989 Reading, England.

Robertson, F.R., 1990: Global analyses of water vapor, cloud and precipitation derived from a diagnostic assimilation of SSM/I geophysical retrievals. Preprints, Fifth Conference on Satellite Meteorology and Oceanography, Sept 3-7, 1990, London, England.