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TITLE: Global Water Cycle

INVESTIGATORS:

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RESEARCH OBJECTIVES:

This research is the MSFC component of a joint MSFC / Pennsylvania State University Eos Interdisciplinary Investigation: "The Global Water Cycle: Extension Across the Earth Sciences." The primary objective of this investigation is to determine the scope and interactions of the global water cycle with all components of the Earth system and to understand how it stimulates and regulates change on both global and regional scales.

There are three integrating priorities under which the research tasks are organized: (1) Documentation of Earth System state and change, (2) Focused studies on controlling processes, and (3) Integrated conceptual and predictive modeling. The near-term tasks in which MSFC is involved are:

(1) Spatial/temporal variability of atmosperic water vapor and condensate as revealed in SSM/I.

(2) Diagnostic assimilation of SSM/I data (and eventually other satellite data sources) into a consistent global analysis of water vapor and condensate.

(3) Diagnostic analyses of diabtic heating and E-P from global gridded analyses.

(4) Correlative analysis of MSU brightness temperature variability with other diagnostics of the intensity of the global hydrologic cycle.

(5) Creation of an optimal climatological precipitation and streamflow data set from multiple platforms.

(6) Evaluation of the CCM hydrologic cycle and tests of improved parameterization of deep and shallow convection and PBL.

(7) Investigation of the sensitivity of the CCM climate response to SST and land surface hydrology anomalies.

(8) Mesoscale and regional aspects of atmospheric/land surface interaction.

SIGNIFICANT ACCOMPLISHMENTS IN THE PAST YEAR:

Discussion of research related to tasks (1) and (2) is presented below. Other tasks will be discussed in separate presentations during the review.

(1) Water vapor variability

To analyze the space/time variability of SSM/I variables, a data set with uniform, synoptic sampling is desired. 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.

(2) Multi-phase 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.

(3) Diabatic heating

An analysis of five-day mean global heating rates diagnosed from ECMWF gridded analyses has been published. This work, formerly supported under a different RTOP will be continued next year under Eos funding (see accompanying contribution by John Christy).

(4) MSU temperature analysis
(See accompanying contribution by John Christy.)

(5) Optimal precipitation and streamflow analysis
Multi-parameter radar measurements will play a large role in understanding the relationships between cloud microphysics, satellite imagery and rain rate. An examination of CP-2 data from the June 13, 1986 COHMEX case has shown that the drop size distribution varies significantly with storm life cycle stage. This has implications for sampling strategies for verifying or calibrating rain retrieval algorithms.

(6) CCM Hydrologic cycle
A preliminary analysis of the large-scale water vapor structure in the CCM1 (T42) was completed and presented at the NCAR CCM Workshop in 1990. Further use of the CCM1 will continue after resolution of problems arising from changing to UNICOS.

(7) CCM1 climate sensitivity to lower boundary forcing
(See contribution by Dan Fitzjarrald.)

(8) Mesoscale modeling of atmosphere/surface interaction
A version of the Biosphere-Atmosphere Transfer Scheme (BATS) has been linked to the LAMPS mesoscale model. Proposed studies with this coupled system are contained within a proposal for FY92 funding submitted under Climate Modeling NRA.

FOCUS OF CURRENT RESEARCH AND PLANS FOR NEXT YEAR:

The analysis of SSM/I moisture variability is currently focusing on the analysis of synoptic-scale variability. An analysis of intraseasonal behavior has also been started and will be completed this summer. The focus of the 4-dimensional multiphase water anlaysis will continue to be on diagnostic treatment of convection and the treatment of surface fluxes.

CCM-related research will encompass: (1) sensitivity studies with imposed SST anomalies, (2) experiments with observed SST forcing, (3) comparison of CCM moisture lag-correlation relationships to those from SSM/I, and (4) diagnostics of cloud radiative forcing and its associated generation of available potential energy.

PUBLICATIONS:

Robertson, F.R. and C. Cohen, 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.

Wang, S., 1991: Regional modeling of the eastern north Pacific marine boundary layer. *Mon. Wea. Rev.* (To be submitted).

Wright, P.D. and S.J. Goodman, 1991: A multi-parameter examination of a mesoscale convective system. Preprints, 25th International Conference on Radar Meteorology of the AMS, Paris, France, June 24-28, 1991.