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TITLE: Global Water Cycle

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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 long-term 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.

Thre integrating priorities characterize the organization of research our research tasks: (1) Documentation of Earth System state and change, (2) Focused studies on controlling processes, and (3) Integrated conceptual and predictive modeling.

SIGNIFICANT ACCOMPLISHMENTS IN THE PAST YEAR:

(1) Water vapor variability

Last year we reported on initial efforts at analyzing higher frequency modes of variability in SSM/I data, particularly the column integrated water vapor. We have now conducted a more complete analysis of synoptic to intraseasonal variability of column integrated water vapor and liquid water. Bandpass analyses, 1-point lag correlation maps, and power spectra have been produced which document moisture variability. Middle latitude oceanic storm tracks are defined by high 2-8 day bandpass variance maxima in the water vapor and liquid water fields. Moisture variability has proven an especially useful tool in documenting Southern Hemisphere oceanic systems because of the paucity of data there. In the tropics we have noted the largest variance in water vapor on all time scales is found on the periphery of the Western Pacific warm SSTs. Along the SST maxima water vapor variability is at a minimum and liquid water variability a maximum.

(2) Multi-phase water analysis

At present, global data sets of moisture have rather poor determinations of vertical structure. We are continuing our investigation of combining SSM/I integrated water vapor with kinematic constraints (u,v,and omega) from gridded analyses (e.g. ECMWF) as a means of reconstituting vapor, cloud and precipitation in 3-D and in time. The basic formalism for this 4-dimensional multi-phase water analysis (4-DMPW) is what we term a diagnostic assimilation procedure. 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 evolving model vapor is nudged to those values.

We have formulated a parameterization of convection which now allows us to explore the role of vertical moisture transport by subgrid processes. At present we are examining the production of cirrus originating from convective detrainment. We will be comparing these diagnostic results to available climatology such as ISCCP.

Because the 3-D structure of moisture is strongly constrained by vertical transport processes, we have spent some effort this year evaluating the consistency between ECMWF omega fields and SSM/I vapor, liquid water, and ice. For features of scales >1500 km we find substantial agreement in patterns of large-scale ascent and positive anomalies of water vapor and condensate--even on a daily basis.

(3) Global Modeling

We have been examining the thermal response of the CCM1 atmosphere to forcing by observed SST anomalies during 1979-1986. We have seen that the global response to warming events shows very good agreement with elevations in MSU tropospheric temperature anomalies. However, subsequent cooling when SSTs return to normal is not well captured by the model. A warm bias has thus accumulated in the model in comparison to MSU measurements.

(4) Optimal Precipitation and Streamflow Analysis and Hydrologic Processes

Observed precipitation analyses (Chang's SSM/I, Spencer's MSU, Jaeger, Legates and Arkin precipitation climatologies) have been assembled at MSFC in order to make comparisons with the CCM1 model integrations (including the Genesis version). We are especially targeting an interomparison of ENSO warm event and cold event years (e.g. DJF 1986-1987 versus 1989-1990) to understand the model's response to natural climate variations.

In addition, a land climatology is still immature so high resolution data from the CaPE field program will be compared with satellite estimates to develop a method to calibrate and scale up the rainfall estimate procedure over land areas (particularly the Southern Hemisphere) to produce an optimal global blended analysis. In a related activity, a version of the Biosphere-Atmosphere Transfer Scheme (BATS) has been linked to the LAMPS mesoscale model. This model version is being used to study regional scale aspects of hydrologic processes.

FOCUS OF CURRENT RESEARCH AND PLANS FOR NEXT YEAR:

We are currently producing an integration of a modified version of the CCM1 in collaboration with Penn State University. This integration uses observed SSTs as our earlier effort but includes a more realistic treatment of land surface processes. The robustness of the various rainfall climatologies will be assessed to help produce an optimally blended rainfall analysis for model verification.

Our plans for the next year include: (1) Completion of our analysis of the water and heat balances of the CCM using as verification our SSM/I moisture and MSU temperature analyses, (2) Analysis of vertical cloud and moisture structure produced by our 4-D Multi-phase Water Analysis. This will be compared further to ISCCP data and should yield insight into the dynamics of global and regional cloud patterns, preciupitation, and water vapor anomalies, (3) Regional and global modeling experiments with lower boundary temperature and soil moisture anomalies, (4) Regional analyses of hydrologic cycle budgets over the CaPE domain.

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 analysis 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., 1992: An examination of transient moisture anomalies over the global oceans as revealed by SSM/I. (Manuscript to be submitted to J. Geoph. Res.)

Robertson, F. R. and J. R. Christy, 1992: Structure, propagation, and growth rates of transient anomalies in the tropospheric temperature field as depicted by MSU. Preprints Sixth AMS Conference on Satellite Meteorology and Oceanography, Atlanta, GA. Jan, 1992.