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Final Report - DOE project

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Modeling Decade to Century Scale Variability in the Atmosphere/Ocean

John E. Kutzbach, PI

Summary of Activities

Studies of the intrinsic variability of the coupled climate system are a critical element in the detection and prediction of anthropogenic climate change. This project has focussed on studying the intrinsic variability of a coupled atmosphere/ocean model: the Fast Ocean/Atmosphere Model (FOAM). With an emphasis on efficient computational algorithms and the use of a relatively low-resolution atmosphere coupled to a high-resolution ocean, FOAM is a computationally efficient model ideally suited for the long integrations required to study interannual, decadal, and century-scale variability with and without the additional forcing being provided by human activities (greenhouse gas emissions, land use changes) or natural mechanisms (earth orbital changes, natural changes in earth's greenhouse gas concentrations).

The initial FOAM model has been run for a 500-year control simulation and multiple simulations of 100-200 years with altered boundary conditions. The FOAM model has been found to simulate interannual to decadal variability as reported by Jacob (1997). This thesis by Jacob used statistical analysis of the space-time structure of the model's variability to demonstrate that the model simulates modes of variability similar, in varying degrees, to observed phenomena such as El Nino and the Pacific Decadal Oscillation (PDO).

The model's simulation of the modern tropical climatology and of the tropical portion of El Nino/ENSO showed the greatest similarity with observations. For this reason, we focussed initial analysis on the tropics. In one study, we compared the simulation of El Nino in the modern-day climate with the simulation of El Nino with an altered seasonal cycle of solar radiation (Liu et al. , 2000). This study showed that increasing the amplitude of the seasonal cycle of solar radiation in the northern hemisphere caused:1) enhanced Asian summer monsoons, 2) an intensified Walker circulation (strong equatorial easterlies across the Pacific), 3) a more La Nina-like base-state climate (colder eastern and central equatorial Pacific SSTs), and 4) reduced amplitude of El Nino events as measured by variations in equatorial Pacific SSTs. This suppresion of El Nino in periods of enhanced seasonal insolation cycles in in agreement with some observations.

We also explored the Pacific Interdecal Variability of the FOAM model (Wu et al, 2001), finding that the model contained a decadal mode that resembled ENSO-like variability, but at the decadal time scale.

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In another study, we showed that tropical deforestation in Indonesia could modify the regional atmospheric circulation in ways that caused strong tropical ocean feedback in the Indian Ocean and additional reduction in rainfall over land (Delire et al, 2001).

Having demonstrated the utility of the model for initial studies of coupled atmosphere/ocean variability in the tropics through analysis of long century to multi-century integrations, we have turned our attention to improving the climatology of the model in middle and high latitudes where the initial version of FOAM had a strong cold bias that distorted the climatology. This improvement has required considerable experimentation with the parameterizations of sea-ice processes and snow/land-albedo processes. We are now at the point of bringing out a new version of FOAM that will have much-improved climatology in middle and high latitudes (Jacob et al, in prep).

We have continued to try to make FOAM track the NCAR CSM by incorporating various CSM submodels. We have successfully replaced the thermodynamic sea ice model in FOAM with the thermodynamics from the latest release of CSM (version 1.4). Further incorporation of CSM components is on hold until the release of CSM 2.0, which will feature several changes to the land and sea ice models. While CSM is in development, we have explored replacing the land model in FOAM with the dynamic vegetation model, LPJ and have had encouraging results from initial fully coupled integrations.

Finally, we have successfully deployed FOAM on a wide range of Distributed Shared Memory (DSM) and pure DM architectures. At the beginning of this project, FOAM only ran on its development platform, the IBM SP2. FOAM now runs on the SP3, the Origin 2000, multiprocessor sun workstations and on linux clusters with various switching technologies (myrinet, ethernet, scali). Its performance on these platforms and the software design of FOAM are described in Jacob et al. (2001).

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Publications:

Delire, C., P. Behling, M. Coe, J. Foley, R. Jacob, J. Kutzbach, Z. Liu, and S. Vavrus (2001). Simulated response of the atmosphere-ocean system to deforestation in the Indonesian Archipelago. *Geophysical Research Letters* 28: 2081-2084.

(pulled for separate input)

Jacob, R. L. (1997). Low frequency variability in a simulated atmosphere ocean system. Ph. D. Thesis, Dept. of Atmospheric and Oceanic Sciences, University of Wisconsin – Madison, 155pp.

Jacob, R.L, C. Schafer, I. Foster, M. Tobis and J. Anderson (2001). "Computational Design and Performance of the Fast Ocean Atmosphere Model, Version 1", *Proc. 2001 International Conference on Computational Science*V. N. Alexandrov, J. J. Dongarra, C. J. K. Tan (editors), Springer-Verlag

Jacob, R. L. et al. (2002) Low frequency variability in a coupled atmosphere/ocean model (in prep).

Liu, Z., J. Kutzbach and L. Wu (2000). Modeling climatic shift of El Nino variability in the Holocene. *Geophysical Research Letters* 27:2265-2268.

Wu, L., Z. Liu, and R. Gallimore (2001). Pacific Interdecadal Variability in a coupled model. Dynamics of Atmospheric and Oceanic Circulations and Climate, *China Meteorological Press*, pp 486-507.

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Top