COUPLING MODELS OF CLIMATE SUBSYSTEMS: SENSITIVITY EXPERIMENTS

(Abstract)

by

Stephen H. Schneider

(National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307, U.S.A.)

The simulation of climate on Pleistocene time scales requires coupling subsystems with response time scales which vary over several orders of magnitude. Most models of the coupled atmosphere-ocean-cryosphere (AOC) system have treated the global ocean as a single isothermal reservoir, resulting in a relatively slow time scale for the surface temperature response. A series of one-dimensional box ocean models and a box-advection diffusion ocean model (Harvey and Schneider in press [b]) are used to demonstrate that the ocean temperature does not respond with a single time scale. In particular, the first half or more of the response of a mixed layer to a radiative perturbation is governed by the relatively small thermal inertia of the mixed layer, rather than by the thermal inertia of the deep ocean. It is only the final approach to equilibrium which is governed by the thermal inertia of the deep ocean. The box-advection-diffusion ocean models are added to the AOC model of Källén and others (1979), the last of which used a single isothermal ocean reservoir and exhibited internal oscillations. We have found that, by adding a multiple time-scale ocean to their model, internal oscillations can be suppressed, thereby confirming the importance of distinguishing between the mixed layer and deeper ocean thermal response time scales (Harvey and Schneider in press [a]).

Other issues of importance in practical simulations using coupled AOC models involve asynchronous coupling between the submodels. Typical computational time steps of atmosphere, ocean and glacial submodels can be different by an order of magnitude, necessitating asynchronous coupling between these submodels. Although asynchronous coupling can reduce computation time significantly, it can also cause large errors in the transient climatic response to external forcings. Several examples based on the box-advection diffusion model mentioned above have been calculated to illustrate the kinds of errors that different asynchronous schemes can introduce into coupled AOC model simulations. In particular, fixing atmospheric temperatures leads to very large errors, whereas fixing turbulent energy fluxes between atmospheric and oceanic integration time causes less error in global transient temperature calculations. However there are still likely to be large (but compensating) errors in regional temperature trends with this asynchronous scheme. Although no asynchronous coupling schemes have been tested on the more difficult problem of asynchronous coupling of atmospheric, oceanic and glacier submodels, the experience we have gained with atmosphere/ocean asynchronous coupling schemes strongly suggests that considerable testing will be needed because of the potential errors any particular scheme may introduce in such simulations.

ACKNOWLEDGMENT

The National Center for Atmospheric Research is sponsored by the US National Science Foundation.

REFERENCES

Harvey L D D, Schneider S H In press [a] Sensitivity of internally-generated climate oscillations to ocean model formulation. *In* Berger A, Imbrie J, Hays J, Kukla G, Saltzman B (*eds*) *Milankovitch and climate understanding the response to orbital forcing*. Dordrecht, Reidel Publishing Co.

Harvey L D D, Schneider S H In press [b] Sensitivity of transient climate response to ocean model formulation. Part I. Experiments with a globally averaged model. *Journal of Geophysical Research*

Källén E, Crafoord C, Ghil M 1979 Free oscillations in a climate model with ice-sheet dynamics. *Journal of the Atmospheric Sciences* 36(12): 2292-2303

https://doi.org/10.3189/S0260305500003979 Published online by Cambridge University Press