Abstract View

Volume 5, Issue 1 (January 1975)

Journal of Physical Oceanography
Article: pp. 3–29 | Abstract | PDF (2.60M)

A Global Ocean-Atmosphere Climate Model. Part I. The Atmospheric Circulation

Syukuro Manabe, Kirk Bryan, and Michael J. Spelman

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, N.J. 08540

(Manuscript received February 8, 1974, in final form June 28, 1974)

DOI: 10.1175/1520-0485(1975)005<0003:AGOACM>2.0.CO;2

ABSTRACT

Options:
- Create Reference
- Email this Article
- Add to MyArchive
- Search AMS Glossary

Search CrossRef for:
- Articles Citing This Article

Search Google Scholar for:
- Syukuro Manabe
- Kirk Bryan
- Michael J. Spelman

A joint ocean-atmosphere model covering the entire globe has been constructed at the Geophysical Fluid Dynamics Laboratory (GFDL) of NOAA. This model differs from the earlier version of the joint model of Bryan and Manabe both in global domain and inclusion of realistic rather than idealized topography. This part of the paper describes the structure of the atmospheric portion of the joint model and discusses the atmospheric circulation and climate that emerges from the time integration of the model. The details of the oceanic part are given by Bryan *et al.* (1974), hereafter referred to as Part II.

The atmospheric part of the model incorporates the primitive equations of motion in a spherical coordinate system. The numerical problems associated with the treatment of mountains are minimized by using the “sigma” coordinate system in which pressure, normalized by surface pressure, is the vertical coordinate. For vertical finite differencing, nine levels are chosen so as to represent the planetary boundary layer and the stratosphere as well as the troposphere. For horizontal finite differencing, the regular latitude-longitude grid is used. To prevent linear computational instability in the time integration, Fourier filtering is applied in the longitudinal direction to all prognostic variables in higher latitudes such that the effective grid size of the model is approximately 500 km everywhere.

For the computation of radiative transfer, the distribution of water vapor, which is determined by the prognostic system of water vapor, is used. However, the distributions of carbon dioxide, ozone and cloudiness are prescribed as a function of latitude and height and assumed to be constant with time. The temperature of the ground surface is determined such that it satisfies the condition of heat balance.

The prognostic system of water vapor includes the contribution of three-dimensional advection of water vapor and condensation in case of supersaturation. To simulate moist convection, a highly idealized procedure of moist convective adjustment is introduced. The prediction of soil moisture and snow depth is based upon the budget of water, snow and heat. Snow cover and sea ice are assumed to have much larger albedos than soil surface or open sea, and have a very significant effect upon the heat balance of the surface of the model.

Starting from the initial conditions of an isothermal and dry atmosphere at rest, the long-term integration of the joint model is conducted with the economical method adopted by Bryan and Manabe in their earlier study. The climate that emerges from this integration includes some of the basic features of the actual climate. However, it has many unrealistic features, which underscores the necessity of further increasing the computational resolution of horizontal finite differencing.

In order to identify the effect of the ocean currents upon climate, the joint model climate is compared with another climate obtained from the time integration of a so-called “A-model” in which oceanic regions are occupied by wet swampy surfaces without any heat capacity. Based upon the comparison between these two climates, the possible effects of oceanic heat transport on the climate are discussed. For example, the results show that the total poleward transport of energy is affected little by the oceanic heat transport. Although ocean currents significantly contribute to the transport, the atmospheric transport of energy in the presence of the latter decreases by approximately the same magnitude. Therefore, the total transport in the joint model differs little from that in the A-model. Further comparison between the two models indicates that ocean currents significantly affect not only the horizontal distribution of surface temperature of both oceans and continents but also the global distribution of precipitation.

top ▲

Headquarters: 45 Beacon Street Boston, MA 02108-3693
DC Office: 1120 G Street, NW, Suite 800 Washington DC, 20005-3826
amsinfo@ametsoc.org Phone: 617-227-2425 Fax: 617-742-8718
Allen Press, Inc. assists in the online publication of *AMS* journals.