Climate Simulations Based on a Different-Grid Nested and Coupled Model

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ABSTRACT

An atmosphere–vegetation interaction model (AVIM) has been coupled with a nine-layer General Circulation Model (GCM) of Institute of Atmospheric Physics / State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (IAP / LASG), which is rhomboidally truncated at zonal wave number 15, to simulate global climatic mean states. AVIM is a model having inter-feedback between land surface processes and eco–physiological processes on land. As the first step to couple land with atmosphere completely, the physiological processes are fixed and only the physical part (generally named the SVAT (soil–vegetation–atmosphere–transfer scheme) model) of AVIM is nested into IAP / LASG L9R15 GCM. The ocean part of GCM is prescribed and its monthly sea surface temperature (SST) is the climatic mean value. With respect to the low resolution of GCM, i.e., each grid cell having longitude 7.5° and latitude 4.5°, the vegetation is given a high resolution of 1.5° by 1.5° to nest and couple the fine grid cells of land with the coarse grid cells of atmosphere. The coupling model has been integrated for 15 years and its last ten–year mean of outputs was chosen for analysis.

Compared with observed data and NCEP reanalysis, the coupled model simulates the main characteristics of global atmospheric circulation and the fields of temperature and moisture. In particular, the simulated precipitation and surface air temperature have sound results. The work creates a solid base on coupling climate models with the biosphere.

Key words: Land surface process (LSP), General circulation model (GCM), Nesting and coupling, Climate simulation

1. Introduction

Since the two important models, BATS (Dickinson et al. 1986) and SiB (Sellers et al. 1986), have been advanced in the 1980s, the simulation of land surface processes (LSP) has improved continuously and many models have been built with various complexities. The SiB model was simplified and developed to be SSiB model (Xue et al. 1991) which decreases the calculated quantities greatly. A model, which focuses on water and heat exchange on land and can be coupled with GCM, was presented by Sun and Lu (1990). Meanwhile, a simple land surface process model for use in climate studies (Ji and Hu 1989) was also advanced and developed later into AVIM (Ji 1995) through incorporating detailed depictions of plant physiological processes. These land models were coupled with atmospheric models to some extent. However, their achievements are at most couplings between physical processes on land and

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those in the atmosphere. The physiological and ecological processes of LSP are rarely studied for bidirectional interactions between biosphere and atmosphere due to their complexities. Without biospheric feedback to atmosphere, there is only the one-sided response of biosphere to air. Consequently, an important and promising task for LSP research is to fulfill the complete coupling between biosphere and atmosphere.

2. Simple introduction of models and coupling

AVIM is a land surface process model including both physical transports among soil–vegetation–air and dynamic processes of physiology and ecology (Ji 1995). Unlike other LSP models, its main feature is the dynamic computation of physiological and ecological processes, thus providing a foundation base for the later full coupling of land with air. The model has been tested in different regions with various vegetation types (Ji 1995; Ji and Hu 1999; Ji and Yu 1999), revealing that AVIM has the capacity for simulating physical and biological processes on local and continental scales over surfaces covered by different types of vegetation. In this paper, a snow cover model (Yan and Ji 1995) is incorporated to consider more comprehensive information about the land surface. By analyzing the simulated climatic mean status, it follows that nesting and coupling the fine-grid-cell LSP model with the coarse-grid-cell GCM can improve the climate simulation.

IAP/LASG L9R15 GCM originates from the version of Simmons (1985), with spherical coordinates in the horizontal direction and $\sigma$-coordinate in the vertical. Since the end of 1991, a series of works have been done towards its reformation and development (Wu et al. 1996). A standard stratification of temperature was introduced into the dynamical framework

![Skeleton of coupled model](image)