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Review

Physical Processes in Atmospheric Models

Edited by D. R. Sikka and S. S. Singh

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The focus of this collection of papers in the book, is one of the current hot topics central to the theme of Numerical Weather Prediction especially for tropics and monsoon regions. This volume has been ably put together and edited by Sikka and Singh from the product of an Indo-US Seminar at the Indian Institute of Tropical Meteorology, Pune, during 6 - 10 August 1990

The book is divided into seven chapters. The first one with ten papers on cumulus convection and parameterization has understandably received maximum attention. Five of these compare the performance of various schemes currently used, in case studies mostly related to monsoons. The impact study of Someshwar Das *et al.* focusses attention on the role of cumulus scales themselves on the large scale flows. In the absence of any cumulus parameterization scheme in the model excess rainfall was found to be produced though not at the correct locations. The inclusion of cumulus parameterization scheme by one of several methods—versions of Kuo, Betts etc — generally underpredicted the rainfall rates. The Betts scheme was, however, found the best of the lot by K. Alapati *et al.* A basic question examined by Arakawa and Xu is the extent to which one can parameterize cumulus convection deterministically without additional prognostic equations. The answer, according to them, is not unique, as the process very much depends on grid size. Bett's paper exploring the change in convective boundary layer structure to the change in two key parameters — SST and surface wind — perhaps could have been included in the chapter on planetary boundary layer, as also the paper on strato-cumulus break-up in a cloud-top marine boundary layer. The oft-neglected role of cumulus convection in the evolution of large scale momentum fields has been discussed by Donner with applications to two distinct tropical studies. In another study the role of downdrafts in decreasing the cumulus heating and drying has been highlighted. This phenomenon has not yet been widely included due to modelling difficulties.

Four papers are found in the chapter on planetary boundary layer, land surface processes and air-sea interaction. Two of them use a version of ECMWF model for their runs, simulating boundary layer structures and other circulation features. An important conclusion emerging from the study of B.K. Basu is the need to include a simple (coupled-air-sea) model to predict the SST in medium range and longer range models. The impact of thermal diffusion on the evolution of near-surface tropical flow in a prescribed initial state using a steady, linearised sigma model, and an estimation of heat fluxes over the Indian Ocean using satellite data, are two other papers in this chapter. A comparison study, like in chapter one, of different methods (eddy correlation, profile, bulk aerodynamic, etc) would have been useful to the modellers.

The chapter 3 on radiation and radiative effects of the clouds has five papers. Though specific schemes are not compared, nevertheless in a comprehensive survey of the methods for parameterizing the interaction of radiation and clouds, Stephens discusses the pertinent issues concerning cloud-radiation interactions. Among the points discussed are the importance of, (*i*) microphysics on albedo of clouds, (*ii*) macroscopic characteristics of clouds on their albedo and emittance, (*iii*) ice-crystal characteristics on the bulk radiative properties of cirrus clouds. Two different methods are used to solve the equations of radiative flux transfer—(*i*) the two stream method in which the equation is solved analytically with appropriate boundary conditions. This is used to parameterize the process of solar radiation transfer, (*ii*) the emissivity method invoked for longwave raditation transfer ignoring scattering completely. The cloud specification scheme from large scale variables

in the model introduces more errors than the raditation computation scheme itself, according to a study by Harshvardhan. Kruger and Xu addressing the same problem find relative humidity the best indicator of stratiform cloud while the convective cloud amount is best diagnosed by cumulus mass flux which is readily available in a model using Arakawa-Shubert cumulus parameterization. A method based on Katayama's scheme for computing the radiative fluxes has been discussed by Tandon. Another paper using GCM simulations stresses the need for realistic cloud radiative forcing.

The next two chapters have 3 papers on envelop orography and gravity wave drag. The other two papers on initialization of humidity in numerical weather prediction models and generation of synthetic temperature and wind data from a prescribed pressure field are no doubt important, though they are not defined by the title of the book. The method of parameterization included by Vernekar *et al.* in the COLA GCM model showed improvement of forecasts in a winter situation while Singh and Rajagopal did not find any impact in their case study on monsoon depression. The importance of trapped waves and the flow characteristics conducive for the exertion of significant gravity wave drag have been examined by Durran.

The sixth chapter on sensitivity studies has eight papers. Some of the results from these studies are : (*i*) increase of moisture availability decreases the speed of equatorial waves, (*ii*) increase in grid resolution improves the spatial and temporal simulation of rainfall rates, (*iii*) air-sea interaction introduces a high frequency component to the basic low frequency model mode resulting in an aperiodic frequency variability. These conclusions have of course to be evaluated with the details of the model configurations, prescribed basic state etc. Another paper gives details of a numerical model for baroclinic ocean dynamics. A review of the experiments for improving the physical parameterization in Goddard Laboratory GCM is contained in a paper by Sud and Walker. The last paper in the chapter giving details of the simulation of tropical convergence zone by using different cumulus parameterization schemes in a global climate model could have been part of chapter one also.

The last chapter on biosphere and land surface processes has three papers. Though the data sets currently available are deficient for the development of biophysically based vegetation models and their incorporation in the GCMs meaningfully, nevertheless the inclusion of such processes like the stomatal resistance in the latent heat flux transfer have to be considered for realistic evapotransportation and precipitation rates from the models. The influence of vegetation cover in the EMCWF model simulating the monsoon has been shown by Kar. The last paper in the chapter demonstrates the influence of meso-scale spatial variability but the proposed procedure involving spectral analysis or equivalent procedures is rather complex.

This volume is, perhaps, a measure of the state of the art in several aspects of physical parameterization and sets the stage for much of the research activity that has to be followed for realistic predictions in the tropics and monsoon regions.

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