Diurnal Oscillation of the Convective Boundary Layer Part 1: Cloud-free Atmosphere

CHING-CHI WU
Department of Atmospheric Sciences
National Taiwan University, Taipei, Taiwan, R.O.C.
AND
WEN-YIH SUN
Department of Earth and Atmospheric Sciences
Purdue University, West Lafayette, IN 47907, U.S.A.

(Received 21 March 1990; revised 15 May 1990)

ABSTRACT

A simple one-dimensional ensemble average PBL model, including condensation, evaporation, atmospheric radiation, and the surface energy budget, is used to study the evolution of the planetary boundary layer in a cloud-free atmosphere. In this model, the turbulent kinetic energy E is predicted by a prognostic equation. The length scale (l) of Sun and Ogura, and Deardorff is modified; the eddy coefficient is proportional to $\sqrt{E}l$, as suggested by Deardorff; and the similary equations proposed by Businger *et al.* are used for the surface layer. In addition, the force restoring method is adopted to predict the surface temperature and an analogous method is used to calculate the surface soil moisture. The model is used to simulate the data of Wangara Day 33. The simulated results are in good agreement with both those observed and those produced by the other more complicated model.

1. INTRODUCTION

In recent years, many sophisticated models of the planetary boundary layer (PBL) have been developed. In Deardorff's three-dimensional model (1974a, b), a major portion of eddy flux is explicitly calculated and the subgrid-scale turbulence is modeled by a second-order closure approximation. A large amount of computing time and central memory is required in his experiment because of the very small space and time intervals required for both. Therefore, his subgrid-scale turbulence parameterization is very difficult to apply in a mesoscale model.

On the other hand, the one-dimensional higher-order ensemble average turbulence model for both cloud-free and cloudy planetary boundary layers has been studied by many people; for example, Yamada and Mellor (1975, 1979),