Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02308, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02308
EGU General Assembly 2008
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Parameterization of PBL processes in an Atmospheric General Circulation Model: Description and Preliminary Assessment

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This paper presents the basic features and assessment of a newly developed planetary boundary layer (PBL) parameterization that has been implemented in the UCLA Atmospheric General Circulation Model (AGCM). The traditional framework of the UCLA AGCM uses a sigma-type vertical coordinate for the PBL that shares a coordinate surface with the free atmosphere at the PBL top. This framework facilitates an explicit representation of processes concentrated near the PBL top, which is crucially important especially for predicting PBL clouds. In the new framework, we introduce multiple layers between the PBL top and Earth's surface, allowing for predictions of the vertical profiles of potential temperature, total water mixing ratio and horizontal winds within the PBL. The vertically integrated "bulk" turbulent kinetic energy (TKE) is also predicted for the PBL. The PBL-top mass entrainment is determined through an equation including the effects of TKE and the radiative and evaporative cooling processes concentrated near the PBL top. The surface fluxes are determined from an aerodynamic formula that uses a combination of the square root of TKE and the grid-scale surface wind to represent the velocity scale. The turbulent fluxes within the PBL are determined through a hybrid approach combining the effects of large convective and small diffusive eddies. We analyze the results of AGCM simulations with the new formulation of PBL focusing on the seasonal and diurnal variations. The simulated seasonal cycle of stratocumulus over the eastern oceans is realistic, so are the diurnal cycles of the PBL depth and precipitation over land. The simulated fluxes of latent

heat, momentum and short wave radiation at the ocean surface show significant improvements over the previous versions of the AGCM based on the single-layer PBL.