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Influence of diurnal variation in PBL on climate simulated by a GCM

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The influence of planetary boundary layer parameterization on large-scale conditions was investigated using the improved Mellor and Yamada (MY) scheme, containing modified closure constants based on large-eddy simulation data and a modified mixing length, in which it varies with stability of the surface layer. The analyses focused on diurnal variations in vertical mixing of the planetary boundary layer and their effect on large-scale conditions in a climate model.

The modified MY scheme produces enhanced vertical mixing due to increased mixing length under unstable conditions in the lower atmosphere and increased stability function under stable conditions in the upper atmosphere, especially over land in the summer hemisphere. Greater mixing during the daytime leads to enhanced maximum values of heat and moisture and diurnal amplitude, and resulting in increased mean value. During nighttime, mechanical mixing affects the minimum values of heat and moisture, mitigating the abrupt decrease in heat and moisture, and resulting in increased mean values as a consequence of enhanced minimum values.

The difference in vertical mixing between the MY and modified MY schemes is apparent during daytime, coincident with a change in mixing length. In particular, near-surface vertical mixing is strongly enhanced, resulting in dry and warm air in the lower atmosphere and reduced low cloud. Over land, the mixed boundary layer extends to higher levels than over ocean, meaning that warm and dry air occurs at higher levels; this phenomenon shows clear seasonal variations. Over ocean, warm and dry air is largely confined to the lowest model levels, overlain by relatively cold and moist air. The upward shift in water distribution has a strong effect on the distribution of low cloud. Although the modified MY scheme leads to enhanced thermal mixing (reflecting surface heat forcing) and improved wet and cold biases in the lower atmosphere, these changes tend to be confined to low levels.