雲解像モデルに基づく積雲対流スキームの開発

Development of cumulus parameterization based on cloud-resolving model

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A cumulus parameterization was developed using cloud-resolving model. Cloud-resolving model was used to estimate macrophysical cloud properties which were considered in the cumulus parameterization through modeling of entrainment and detrainment rates. Analysis on composite structure of updraft convective clouds simulated by cloud-resolving model indicated that there was similarity in the both structures of deep and shallow convection. The similar structures were possible to be modeled using updraft velocity of cloud mass flux in conjunction with in-cloud buoyancy and detrainment. Based on the composite analysis on data obtained from the cloud-resolving model, (organized) entrainment could be parameterized using in-cloud buoyancy and a recently proposed (organized) detrainment model. The developed cumulus parameterization diagnoses the updraft velocity when the model determines updraft convective cloud structure, considering lateral mass exchanges performed by entrainment and detrainment. The downdraft cloud structure was analogously parameterized by height-dependent entrainment using negative in-cloud buoyancy which was produced by evaporation (and sublimation) of precipitation. The diagnosed cloud structure was generalized in which shallow and deep convection was treated in a unified manner.
An atmospheric general circulation model (AGCM) was developed employing a composite grid system and recently presented parameterizations (land surface, non-orographic gravity wave and boundary layer schemes), and the developed cumulus parameterization was implemented into the AGCM, in order to examine sensitivity to the selected parameters and physical performance of the scheme. Evaluations of the scheme were performed using the AMIP-type low-resolution experiments against climatological reanalysis data. In the evaluations, difference of detrainment model was especially examined, and it was found that (organized) detrainment model had significant impact on the model’s physical performance. This was because the present entrainment rate was modeled using detrainment rate, and thus these parameters were strictly connected each other. Although all employed detrainment models were based on the fact that detrainment was proportional to buoyancy loss in convective clouds, a detrainment model originally developed for shallow convection showed worse physical performance, and detrainment model which was based on cloud-resolving model and did not separate modeling procedure for different convection depths worked better.

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