Spatial-scale Characteristics of Three-dimensional Cloud-resolving Radiation Budget by Monte Carlo Radiative Transfer Simulations

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Clouds have greenhouse effects that prevent cooling of ground surface and lower atmosphere by absorbing terrestrial infrared radiation, along with cooling effects by blocking the solar radiation. Those effects play an important role in determining the Earth's radiative energy budget which varies regionally and seasonally. Especially, in cloud-resolving scale, complex geometry and inhomogeneity of clouds affect significantly on three dimensional radiative energy budget of the solar and terrestrial radiation. Modeling of three-dimensional radiative processes and its spatial-scale characteristics is key issues for reliable simulations of cloud-resolving system.
In this study, three-dimensional atmospheric radiative transfer model has been developed for the purpose of evaluating the cloud-resolving radiation budget. Monte Carlo method has been employed as a basic scheme because the method is easily applicable to complex three-dimensional system rather than explicit analytical radiative transfer scheme. Multiple-scattering, absorption, and emission effects are taken into account to the radiative transfer process. The gas absorption data optimized with correlated-k distribution method are implemented in order for efficient broadband calculation. In addition, the dependent sampling method enables simultaneous calculations at multi-wavelength, which is suitable to sub-band integrations of the correlated-k distribution data.
The Monte Carlo radiative transfer model was applied to cloud scenes calculated by large eddy simulation model, and cloud-resolving radiative energy budgets were estimated for several different spatial-scales. Performance of the Monte Carlo radiative transfer model and the spatial-scale characteristics of three dimensional radiation effects will be discussed from the point of view of cloud-resolving radiation budget.

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