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Modeling of three-dimensional Monte Carlo radiative transfer for analysis of global cloud-resolving radiation budget

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Clouds have a greenhouse effect that prevents cooling of surface and lower atmosphere by absorbing terrestrial radiation, along with cooling effects by blocking the solar radiation. Those effects play an important role in determining the Earth's radiation budget which varies regionally and seasonally. Especially, complex geometry and inhomogeneity in clouds affect significantly on the energy distribution of solar radiation and terrestrial radiation. Sophisticated modeling of clouds and three-dimensional radiative processes are key issues for reliable simulations of cloud-resolving system and its radiation budget.
In this study, three-dimensional atmospheric radiative transfer model has been investigated and developed for the purpose of evaluating global cloud-resolving radiation budget. For the radiation budget evaluation, many broadband calculations covering solar and terrestrial radiations in complex geometry and inhomogeneous cloud system are required. In addition, multiple-scattering and absorption effects should be taken into account properly to radiative transfer process. Those requirements to radiative transfer calculation tend to make it complicated and time-consuming scheme. Based on reviews of several radiative transfer schemes, the Monte Carlo method has been employed in this study, because the method is easily applicable to complex three-dimensional system and suitable to broadband calculation than explicit analytical radiative transfer scheme. Especially, the method of dependent sampling has been employed in order to calculate more than one wavelength at the same time, and is combined with correlated k-distribution method. The method is applicable to both solar and terrestrial radiative transfer, and enable efficient broadband calculations of radiative flux. Performance, validation and application of the Monte Carlo radiative transfer model developed in this study will be presented and discussed from the point of analysis of cloud-resolving radiation budget.