A Study of Atmospheric Absorption of Solar Radiation Using Cloud Fields Derived from a Cloud Resolving Model

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Introduction

A three-dimensional (3-D) broadband solar radiative transfer scheme is formulated by integrating a Monte Carlo photon transport algorithm with the Fu-Liou radiation model. It is applied to fields of tropical mesoscale convective clouds and subtropical marine boundary-layer clouds; a two-dimensional (2-D) cloud-resolving model generated them. The effects of cloud geometry on the radiative energy budget are examined by comparing the full resolution Monte Carlo results with those from the independent column approximation (ICA), which applies the plane-parallel radiation model to each column.

For the tropical convective cloud system, it is found that cloud geometry effects always enhance atmospheric solar absorption regardless of solar zenith angle. In a large horizontal domain (512 km), differences in domain-averaged atmospheric absorption between the Monte Carlo and the ICA are less than 4 W m^{-2}. However, for a smaller domain (e.g., 75 km) containing a cluster of deep convective towers, domain-averaged absorption can be enhanced by as much as 20 W m^{-2} in the daytime. For a subtropical marine boundary-layer cloud system during the stratus-to-cumulus transition, calculations show that the ICA works very well for domain-averaged fluxes of the stratocumulus cloud fields, even for a very small domain (4.8 km). For the trade cumulus cloud field, the effects of cloud sides and horizontal transport of photons become significant. Calculations have also been made for both cloud systems including black carbon aerosol and a water vapor continuum. It is found that cloud geometry produces no discernible effects on the absorption enhancement due to the black carbon aerosol and water vapor continuum. See Fu et al. (1998) for more details.

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