IRS2012-66
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

Investigation of the vertical structure of warm cloud microphysical properties using the cloud evolution diagram, CFODD, simulated by three-dimensional spectral bin microphysical model

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This paper investigates the vertical structure of warm cloud microphysical properties by using a three-dimensional (3D) spectral bin microphysical model assuming a dynamical structure off the west coast of California. A time series of Contoured Frequency by Optical Depth Diagrams (CFODDs), which were proposed by previous studies by using CloudSat/CPR and MODIS Aqua satellite observation data, are calculated for the first time by a 3D model assuming two types of aerosol condition, i.e. polluted and pristine. This contrasts with previous studies that obtained CFODDs using either a two dimensional idealized model or an accumulation of monthly and global observation data. The results show that the simulated CFODDs are characterized by distinctive patterns of radar reflectivities similar to those observed by satellite remote sensing, although the calculation domain of this study is limited to an area of 30 $\times$ 30 km2, whereas the satellite observations are of a global scale, and vertical grid spacing of the model is much finer than the CloudSat sampling volume. A cloud microphysical box model is then applied to the simulated cloud field at each time step to identify the dominant process for each of the characteristic patterns. The results reveal that the wide variety of satellite-observed CFODD patterns can be attributed to different microphysical processes occurring in multiple cloud cells at various stages of the cloud life cycle.