



Modeling and remote sensing of precipitation processes in tropical convection

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We summarize our studies of some basic hydrologic variables [column ice and water cloud contents (*IWP*, *LWP*), their ratio (*CR*), precipitation (*Ps*)], and corresponding processes (a cloud microphysics rate ratio, time rate of change of *CR*, and precipitation efficiency) in 2D and 3D cloud-resolving models (CRM) in comparison with satellite data.

First of all, we discuss a new method to separate the convective component of the precipitation from the reminder. The new method is based on threshold values of cloud ratio defined as the ratio of the ice water path (*IWP*) to the liquid water path (*LWP*). *IWP* and *LWP* are vertically integrated ice and water cloud content, respectively. The so-defined cloud ratio is physically linked to the cloud microphysics in cloud resolving model. While the microphysical budgets cannot be observed, the relative measure of ice and water cloud contents can be retrieved from satellite measurements. Our analysis suggests that rainfall can be defined as convective, mixed, and stratiform when the corresponding range of cloud ratios are smaller than 0.4, 0.4-1.0, and greater than 1, respectively. The corresponding budgets indicate that the collection of cloud water by rain and the melting of graupel are the main microphysical processes responsible for development of convective and stratiform rainfall respectively. The vapor condensation and deposition are the main sources for growth of water and ice clouds in convective and stratiform rainfall, respectively. The cloud ratio of 0.4-1 is considered as mixed convective and stratiform rainfall, in which the collection of cloud water by rain and the melting of graupel are equally important rain-producing microphysical processes.

We also discuss a proper definition of precipitation efficiency (PE) that should be based on cloud-microphysics processes (CMPE) or water cycling processes including water vapor and hydrometeor species (LSPE). These PEs are examined using cloud-resolving model simulations. The results reveal that LSPE and CMPE are highly correlated, and that they are insensitive to the spatial scales of averaged data, yet moderately sensitive to the time period of averaged data. Some simplified PEs may be derived by neglecting some source terms in budget equations. But the simplified PEs are more scale dependent due to neglected terms.

We are carrying out a further analysis of the above key hydrologic variables in different large-scale disturbances and environments using satellite data, in order to evaluate the simulated hydrologic cycles in different models using explicit cloud micro-physics schemes.