Investigating the Tropical Coastal Convection Systems Using Cloud Resolving Simulations and Satellite Observation

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Abstract

The present study aims to understand the roles of convection organization and precipitation diurnal cycle (DC) during the critical transition periods of South China Sea (SCS) summer monsoon onset using cloud resolving model (CRM) and satellite observation. Idealized 3-dimentional CRM simulations with interactive land surface model were carried out. The wide ocean domain was bounded on the east and west boundary by narrow land stripes, with a mountain range parallel to the shoreline over the west coast. In the control simulation with no vertical shear, the basin-scale local circulation is established, with active DC over land and suppressed condition in the open ocean. A strong horizontal moisture gradient in the free troposphere from land to ocean is maintained. The coastal convection, which is initiated around midnight, propagates towards the open ocean only within 150 km from the coast. In the experimental simulation, a weak low-level wind shear was imposed, and the local circulation is modulated by the differential responses of convection between land and ocean. The land DC is slightly suppressed than the control. The diurnally triggered coastal systems over the windward shore become much more organized, and propagate well over 350 km towards the open ocean. These organized coastal systems lead to increasing moisture over the coastal ocean, indicating the moisture mode instability. The idealized CRM simulations capture the fundamental features of the coastal systems over SCS observed from the 17-year precipitation estimates of the Tropical Rainfall Measuring Mission (TRMM) 3B42 datasets and 7-year vertical cloud mask and radiative flux data based on the joint CloudSat-CALIPSO retrievals over SCS. Pre-onset and post-onset composite statistics of the convection systems, identified by contiguous rain pixels, show that the SCS summer monsoon onset is signified by the presence of medium and large convection systems over ocean, particularly to the west coast of the Philippines. The large systems contribute to > 60% of post-onset precipitation over ocean, with strong diurnal variation in their occurrence, intensity, and propagation. The post-onset growth in deep convective cloud size is also identified. Cloud radiative forcing associated with the stronger increase in mid-level cloud and anvil at night leads to enhancement of cloud-radiative

feedback at nighttime. The current results highlight the sensitivity of moist convection processes, such as the triggering and organization of convection, and the life cycle of MCSs, to the environmental conditions over the monsoonal regions.