A Modeling Study of the Severe Afternoon Thunderstorm Event at Taipei on 14 June 2015: The Roles of Sea Breeze, Microphysics, and Terrain

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On 14 June 2015, a severe afternoon thunderstorm event developed within the Taipei basin, which produced intense rainfall (with rainfall rate of 131 mm h^{-1}) and urban-scale flooding. Cloud-resolving simulations using the WRF model were performed to capture reasonably well the onset of see breeze, the development and evolution of this afternoon thunderstorm system. The WRF model had four nested grids (with the finest grid size of 0.5 km) in the horizontal and 55 layers in the vertical to explicitly resolve the deep convection over complex terrain. It is found that convection was initiated by sea breeze at foothill and by upslope wind at mountain peak, respectively. Convective available potential energy (CAPE) was increased from 800 to 3200 J kg^{-1} with abundant moisture transport by the sea breeze from 08 to 12 LST, fueling large thermodynamic instability for the development of afternoon thunderstorm. Strong convergence between sea breeze and cold-air outflow triggered further development of intense convection, resulting in heavy rainfall over Taipei city. Microphysics sensitivity experiments show that evaporative cooling played a major role in the propagation of cold-air outflow and the production of heavy rainfall within basin plain (terrain height < 100 m), while melting cooling played a minor role. The terrain-removal experiment indicates that the local topography of Mount Datun at coastal region may produce the channel effect through Danshui River Valley, intensify sea-breeze circulation and transport more moisture. This terrain-induced modification of sea breeze circulation made its dynamic and thermodynamic characteristics more favorable for convection development, resulting in stronger afternoon thunderstorm system with heavier rainfall within the Taipei City.

Key words: afternoon thunderstorm; heavy rainfall; sea breeze; cold pool; terrain effect

References

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