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Climatology Study of Low-level Cloud and Fog in Mountain Terrain Using Satellite Observations and Modeling

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The presence of orographic clouds and fog has major environmental and economic implications that the potential shift in the space-time distribution can effectively redistribute freshwater resources and threaten the sustainability of the ecology, geomorphology and hydrology of mountainous regions and adjacent basins. This includes the Southern Appalachian Mountains, which rely closely on the moisture input from fog, cap clouds and light rainfall, as well as cloud forests in the Andes with frequent occurrence of dense fog. However, the applicability of fog forecasting models becomes limited in regions of complex terrain. The motivation of this project is to develop a satellite-based hydroclimatology and physical parameterization of orographic low-level clouds and fog regimes in the Southern Appalachians using a general methodology that can be applied to mountainous regions elsewhere. An algorithm for the detection and extraction of stratus clouds and fog was developed using cloud base height product from 8-years of CALIPSO and CloudSat observations, and evaluated against ground-based measurements from ceilometers. This population of low-level clouds and fog will be analyzed with GOES infrared and visible imagery, MODIS products, and with airport cloud height and visibility records to expand the spatial coverage beyond narrow satellite sensor swaths. The climatology will be further developed through integration with results from WRF high-solution simulations for selected periods since the bulk of the PMM network has been in place (2008-present) to aid in defining meteorological and time-of-day constraints in the interpretation of simulated satellite profiles through a satellite-sensor simulator. A 4-day WRF simulation is performed at Pegion Basin in the Southern Appalachian Mountains with increasing horizontal (0.25 km grid spacing) and vertical (up to 80 sigma levels) resolution and evaluated against observations collected during the Integrated Precipitation and Hydrology Experiment (IPHEx) campaign in 2014. The overarching goal is to infer a representation of the diurnal cycle, seasonal and inter-annual variations of the vertical distribution of LWC and hydrometeors in orographic clouds and fog that vary spatially with landform toward developing a more general parameterization of seeder-feeder interactions in microphysical models.