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Augmenting the PERSIANN-CCS with lightning information

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The relationship between lightning, ice microphysics and precipitation has been well established; but so far it is somewhat limited in its application for satellite precipitation estimation (SPE). We have developed an algorithm to use lightning information, obtained from the U.S. National Lightning Detection Network (NLDN), to augment the Precipitation Estimation from Remotely Sensed Imagery using an Artificial Neural Network - Cloud Classification System (PERSIANN-CCS), a well-known methodology for SPE. Co-located lightning data from NLDN are used to delineate cloud patches, segmented from Geostationary Operational Environmental Satellite 12 (GOES-12) infrared data, into either electrified patches (ELPs) or non-electrified patches (NELPs). A set of features is extracted separately for the ELPs and NELPs. The cloud patches are classified and clustered using self-organizing maps (SOM) neural network. A set of brightness temperature and rain rate (T-R) relationships is derived corresponding to different clusters from SOM. Then, rain rates are estimated for the different cloud patches based on their representative T-R relationships. Our study area is in United States, covering portions of the states of Louisiana, Arkansas, Kansas, Tennessee, Mississippi, and Alabama. Nearly 16,000 satellite images from half-hourly GOES-12 observations in 2008 were used for the rainfall estimation.

The Equitable Threat Scores (ETS) of daily and hourly precipitation estimates show that incorporating lightning information can improve precipitation estimation in the winter and fall. In winter, the ETS improvement is almost 15% for daily and 12% for hourly rainfall (at thresholds below 15 mm/hour). During the same period, there is also a drop in the False Alarm Ratio (FAR) and a corresponding increase in the Probability of Detection (POD) at most threshold levels. During summer and spring, no significant improvements have been noted, except for the BIAS scores for hourly rainfall estimates at higher thresholds (above 5 mm/hour) in the summer months. We speculate that during winter more of the ice processes is packed into a thinner stratiform layer with lower cloud tops and freezing levels, and hence more of the ice contributing to precipitation on the ground; and we expect information from lightning, related to the ice microphysics processes, to provide surrogate information about rainfall rate.