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The Temporal Evolution of Satellite-Derived Deep Convective Cloud Properties

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Geostationary satellite observations are an effective tool for quantifying the macro- and microphysical properties of deep convective clouds as a function of time. Various cloud properties can be derived from geostationary weather satellites, such as the Geostationary Operational Environmental Satellite (GOES), including: cloud top temperature (day and night), cloud top height (day and night), cloud top phase (day and night), visible cloud optical depth (day), cloud effective particle radius (day and night, with additional limitations at night), and cloud emissivity (day and night). These cloud properties, some of which can be fully retrieved at all times of the day, can then be tracked in time to provide insight into the physical processes driving the convection. In addition, the temporal trends in the convective cloud properties can potentially be used to make short-term convective weather forecasts. With the primary goal of improving short-term forecasts of storm evolution, we focus on characterizing the lifecycle of convection initiated over the United States as a function of storm severity using GOES data, Doppler radar, and storm reports. The temporal trends in the convective cloud properties can be analyzed by treating convective storms as cloud objects. A cloud object is a collection of spatially connected satellite pixels that meet a certain requirement or set of requirements. More specifically, our analysis procedure consists of 5 steps. The first step is to retrieve cloud properties (cloud phase, height, temperature, emissivity, effective particle radius, optical depth, liquid water path, and ice water path) using algorithms developed by the National Oceanic and Atmospheric Administration (NOAA). Next, cloud objects are constructed using a cloud emissivity based metric to determine object membership. Once the satellite pixels that meet the cloud object membership criteria are sorted into cloud objects, several cloud property statistics are computed for each cloud object. The fourth step is to track the cloud objects in time using high temporal resolution GOES data. The final step is to analyze the time series of convective cloud properties for a variety of storms of varying severity using Doppler radar and storm reports to determine storm severity.

It will also be shown that the same techniques that can be used to study the lifecycle of meteorologically driven convection can also be used to detect special cases of cumulonimbus cloud development that can occur as a result of volcanic eruptions or wildfires. Detecting anomalous events due to volcanic eruptions is important for aviation safety as volcanic ash can severely damage aircraft. In addition, both volcanic convection and convection spawned by wildfires (pyro-convection) has important implications for better understanding the transport of aerosols and gases (e.g. water vapor) to the upper troposphere and lower stratosphere.