Temporal Experiment for Storms and Tropical Systems (TEMPEST) CubeSat Mission

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The current suite of Earth-observing satellites, including TRMM, CloudSat/CALIPSO and GPM, is capable of measuring comprehensive cloud and precipitation parameters using radar or radiometric observations. However, each of these low Earth-orbiting satellites provides only a snapshot in time of each storm's development, due to their repeat-pass times of many hours to days. Geostationary (GEO) observations can provide high temporal resolution, but they are presently limited to the visible and infrared that observe only the tops of clouds. However, processes that control the development of cloud systems and the transition to precipitation occur primarily on less than 30 minute time scales.

The proposed TEMPEST CubeSat constellation directly observes the time evolution of clouds and identifies changes in time to detect the moment of the onset of precipitation. The TEMPEST millimeter-wave radiometers penetrate into the cloud to directly observe changes as the cloud begins to precipitate or ice accumulates inside the storm. The evolution of ice formation in clouds is important for climate prediction because it largely drives Earth's radiation budget. TEMPEST improves understanding of cloud processes and helps to constrain one of the largest sources of uncertainty in climate models.

TEMPEST provides observations at five millimeter-wave frequencies from 90 to 183 GHz using a single compact instrument that is well suited for a 6U CubeSat architecture and fits well within the NASA CubeSat Launch Initiative (CSLI) capabilities. Five identical CubeSats deployed in the same orbital plane with 5-10 minute spacing at 390-450 km altitude and 50°-65° inclination capture 3 million observations of precipitation, including 100,000 deep convective events in a one-year mission. TEMPEST provides critical information on the time evolution of cloud and precipitation microphysics, thereby yielding a first-order understanding of how assumptions in current cloud-model parameterizations behave in diverse climate regimes.