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Temporal Experiment for Storms and Tropical Systems Technology Demonstration (TEMPEST-D): Risk Reduction for 6U-Class Nanosatellite Constellations

Steven C Reising (1), Todd C Gaier (2), Christian D Kummerow (1), Sharmila Padmanabhan (2), Boon H Lim (2), Shannon T Brown (2), Cate Heneghan (2), Chandrasekar V Chandra (1), Jon Olson (1), and Wesley Berg (1)

(1) Colorado State University, Fort Collins, CO, United States (Steven.Reising@ColoState.edu), (2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States

TEMPEST-D will reduce the risk, cost and development time of a future constellation of 6U-Class nanosatellites to directly observe the time evolution of clouds and study the conditions that control the transition from non-precipitating to precipitating clouds using high-temporal resolution observations. TEMPEST-D provides passive millimeter-wave observations using a compact instrument that fits well within the size, weight and power (SWaP) requirements of the 6U-Class satellite architecture. TEMPEST-D is suitable for launch through NASA's CubeSat Launch Initiative (CSLI), for which it was selected in February 2015.

By measuring the temporal evolution of clouds from the moment of the onset of precipitation, a TEMPEST constellation mission would improve our understanding of cloud processes and help to constrain one of the largest sources of uncertainty in climate models. Knowledge of clouds, cloud processes and precipitation is essential to our understanding of climate change. Uncertainties in the representation of key processes that govern the formation and dissipation of clouds and, in turn, control the global water and energy budgets lead to substantially different predictions of future climate in current models.

TEMPEST millimeter-wave radiometers with five frequencies from 89 GHz to 182 GHz penetrate into the cloud to observe key changes as precipitation begins or ice accumulates inside the storm. The evolution of ice formation in clouds is important for climate prediction and a key factor in Earth's radiation budget. TEMPEST is designed to provide critical information on the time evolution of cloud and precipitation, yielding a first-order understanding of assumptions and uncertainties in current cloud parameterizations in general circulation models in diverse climate regimes.

For a potential future one-year operational mission, five identical 6U-Class satellites would be deployed in the same orbital plane with 5- to 10-minute spacing deployed in an orbit similar to the International Space Station resupply missions, i.e. at $\sim$400 km altitude and $\sim$51° inclination. A one-year mission would capture 3 million observations of precipitation greater than 1 mm/hour rain rate, including at least 100,000 deep convective events. Passive drag-adjusting maneuvers would separate the five CubeSats in the same orbital plane by 5-10 minutes each, similar to deployment techniques to be used by NASA's Cyclone Global Navigation Satellite Systems (CYGNSS) mission.