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Temporal Experiment for Storms and Tropical Systems Demonstration (TEMPEST-D): A 6U-Class Satellite Mission to Enable Temporally-Resolved Global Measurements of Clouds and Precipitation

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The Temporal Experiment for Storms and Tropical Systems (TEMPEST) mission consists of a constellation of 5-10 identical 6U-Class satellites (6U CubeSats) observing storms at 5 millimeter-wave frequencies with 3-6 minute temporal sampling in the same orbital plane. This innovative satellite constellation mission would enable the first global observations of the evolution of clouds and their transition to precipitation on the time scale of individual storm cell development. TEMPEST millimeter-wave radiometer measurements are able to penetrate deep into the cloud interior to observe microphysical changes as the cloud begins to precipitate and as ice accumulates inside the storm. Through such global observations, TEMPEST would improve understanding of cloud processes and provide critical information to constrain some of the largest sources of uncertainty in cloud models critically needed for weather forecasting. Recent results of Bayesian retrievals from synthetic brightness temperatures at the TEMPEST frequencies based on a high-resolution WRF model show that changes in liquid water path and ice water path can be reliably retrieved, even at different view angles and close temporal spacing for satellites in the TEMPEST constellation. The TEMPEST goals are synergistic with those of NASA CYGNSS and TROPICS science missions.

The TEMPEST Demonstration (TEMPEST-D) mission is currently underway to reduce the risk, cost and development time for the full TEMPEST mission constellation. The objectives of TEMPEST-D are to raise the TRL of the instrument and spacecraft systems from 5 to 9 and to provide the first in-space demonstration of a millimeter-wave radiometer based on an InP HEMT low-noise amplifier front-end for Earth science measurements. The success criteria of TEMPEST-D are to demonstrate cross-calibration between TEMPEST millimeter-wave radiometers and NASA/JAXA GPM Microwave Imager and NOAA & ESA/EUMETSAT Microwave Humidity Sounder satellite instruments as well as to demonstrate differential drag capabilities similar to those used in NASA CYGNSS (in a different form factor) to achieve the required temporal separation of a 6U-Class satellite constellation in a single orbital plane.

The TEMPEST-D radiometer instrument performs millimeter-wave observations at 89, 165, 176, 180 and 182 GHz using a single compact, low-mass and low-power instrument designed for 6U-Class satellites. TEMPEST-D began in Aug. 2015, with a rapid development cycle to deliver the satellite to NanoRacks for launch integration by March 2018. TEMPEST-D has been manifested by NASA CSLI for a planned May 2018 launch on a Cygnus Antares rocket from Wallops to the ISS. Deployment of the TEMPEST-D satellite into a 400-km orbit at 51.6° inclination is expected several months after its arrival at ISS.