Temporal Experiment for Storms and Tropical Systems Technology Demonstration (TEMPEST-D) Mission for Global Observations of Clouds and Precipitation from CubeSat Constellations

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The Temporal Experiment for Storms and Tropical Systems (TEMPEST) proposed mission consists of a constellation of 5 identical 6U-Class satellites (6U CubeSats) observing storms at 5 millimeter-wave frequencies with 5-10 minute temporal sampling in the same orbital plane. This innovative satellite 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 radiometers are able to penetrate deep into the cloud interior to observe microphysical changes as the cloud begins to precipitate or ice accumulates inside the storm. Through these global observations, TEMPEST would improve understanding of cloud processes and provide critical information to constrain one of the largest sources of uncertainty in cloud models critically needed for weather forecasting.

The TEMPEST technology 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 6 to 9 and to provide the first in-space demonstration of a millimeter-wave radiometer based on an InP HEMT low-noise amplifier for Earth science measurements. The success criteria are to demonstrate cross-calibration between TEMPEST millimeter-wave radiometers and NASA/JAXA GPM Microwave Imager and/or NOAA & ESA/EUMETSAT Microwave Humidity Sounder instruments as well as to demonstrate differential drag capabilities similar to those used in NASA CYGNSS to achieve the required temporal separation of a 6U-Class satellite constellation in a single orbital plane.

The TEMPEST-D radiometer instrument makes precise millimeter-wave observations at 89, 165, 176, 180 and 182 GHz using a single compact instrument designed for 6U-Class satellites. The direct-detection topology of the radiometer receiver substantially reduces both power consumption and design complexity compared to heterodyne receivers. The TEMPEST-D instrument performs precise, end-to-end calibration using a cross-track scanning reflector to view an ambient blackbody calibration target and cosmic microwave background directly every 2 seconds. The TEMPEST-D radiometer instrument has been fabricated and successfully tested under environmental conditions (vibration, thermal cycling and vacuum) expected in low-Earth orbit.

TEMPEST-D began in Aug. 2015, with a 2.5-year development to deliver the satellite for launch integration by Feb. 2018. TEMPEST-D has been manifested by NASA CSLI for launch on ELaNa-23 on Cygnus Antares 230 to the ISS in May 2018. Deployment of the TEMPEST-D satellite into a 400-km orbit at 51.6° inclination is expected several months after its arrival at ISS.