Millimeter and Submillimeter Wave Remote Sensing Using Small Satellites

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Cloud ice properties and processes are fundamental variables determining atmospheric radiation and precipitation. Limited understanding and gaps in current knowledge lead to poor representation of these clouds in global circulation models (GCMs), which is a primary cause of large uncertainties in climate prediction. Ice clouds are used as a tuning parameter in GCMs to achieve agreement with observations at the top of the atmosphere for the radiation budget, and at the bottom for precipitation; the lack of ice cloud measurements has left the intermediate altitudes unconstrained. Millimeter (mm)- and submillimeter (submm)-wave radiometry is widely recognized for its potential to fill the cloud measurement gap in the middle and upper troposphere. Therefore, it is imperative to make these critical measurements from space by developing a cost effective, compact mm- and submm-wave instrument for cloud observations that can be deployed on future small satellites.

Goddard Space Flight Center (GSFC) has extensive experience in developing mm/submm-wave radiometers for airborne instruments, including Compact Scanning Submillimeter-wave Imaging Radiometer (CoSSIR). CoSSIR has flown on several airborne campaigns, and demonstrated that submm-wave radiometry provide key cloud measurements in the mid-to-upper troposphere. Based on the successful results of this airborne instrument and its demonstrated utility for submm-wave sensing of ice clouds, GSFC is pursuing the development of a compact, conical-scan, multi-band radiometer for a Low Earth Orbit (LEO) satellite mission. GSFC has conducted a study that considers the types of mm/submm-wave instruments that fit within the 10–90 kg mass range. Variables considered in the study include the number, frequency and channels of receivers in the 183–874 GHz range, scan topology, aperture size, and orbit altitude. Also considered were technologies to improve sensitivity and reduce power of the receivers.

The outcome of the study is a suite of options yielding an instrument compatible with GSFC's recently developed Small Rocket/Spacecraft Technology (SMART) bus. The SMART bus is a microsatellite prototype that enables the implementation of focused science and technology missions without the need to spend large resources typical of high-performing spacecraft. The SMART bus payload mass and power capacities are 30–50 kg and 284–314 W, respectively. The SMART bus is a promising candidate for small mm/submm-wave distributed LEO satellites for cloud remote sensing applications. In this presentation we will describe our anticipated instrument, advances in technology development, and its scientific applications. We will also present the instrument accommodation within the SMART bus.