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SmallSat Microwave Instrument Technologies at NASA for Clouds and Precipitation Measurements

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Numerical climate and weather models depend on high-quality, three dimensional clouds and precipitation measurements from spaceborne satellites for model validation and improvements. Existing spaceborne weather satellites capable of making these high-quality measurements are, however, limited to few instruments deployed in low Earth orbits (LEOs). These observations are sparse in time with respect to the typical time-scale of weather phenomena (tens of seconds to hours), and therefore, are unable to provide adequate sampling of the short-time evolution of weather processes, which is necessary to validate and improve the current assumptions and skills of numerical weather models. The high costs associated with developing these conventional satellites and instruments in general have prevented the launching of multiple copies to address the time sampling problem.

Fortunately, microsatellites and nanosatellites (a.k.a. CubeSats) have emerged in recent years as a viable remote sensing platform due to their combined characteristics of low-cost, easy-access to space, and rapid advancements in technologies and capabilities. These unique features also enable the deployment of satellite constellations to substantially increase the time sampling and/or the spatial coverage on the targets of interests.

Within the US National Aeronautics and Space Administration (NASA), the Earth Science Technology Office (ESTO) is leading the effort in developing new, CubeSat- and SmallSat-class instruments and instrument technologies for Earth observations, as well as the effort in launching the CubeSat-class instruments to flight validated their intended remote sensing capabilities. Among them are several miniaturized, low-cost microwave and millimeter-wave instruments capable of providing quantitative measurements of various cloud and precipitation process parameters [1]. This paper will summarize these instrument concepts, the progress to date, and the preliminary science results.

1. E. Peral, E. Im, L. Wye, S. Lee, S. Tanelli, Y. Rahmat-Samii, S. Horst, J. Hoffman, S.-H. Yun, T. Imken, and D. Hawkins, "Radar Technologies for Earth Remote Sensing From CubeSat Platforms," *IEEE Proceedings*, **106**, 3, March 2018, pp. 404-418, doi:10.1109/JPROC.2018.2793179.