NWP-Based Simulation of Microwave Imaging CubeSat Fleet Observations

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The U.S. National Research Council identified the Precipitation and All-weather Temperature and Humidity (PATH) mission as one of ten recommended missions in 2007. PATH would have unique capabilities of providing cloud and rain cell imaging at spatial resolution comparable to AMSU-A/B (e.g. ~15-30 km) and at sub-hourly temporal resolution (e.g. ~15-30 minutes). At least three candidates of geostationary microwave array spectrometer concepts have been identified to make PATH goals achievable yet at huge cost compared to the concept of LEO fleet of nanosatellites. Due to recent advances in microwave receiver and filter technology, the concept of the constellation of ~30-40 CubeSat nanosatellites with payload of cross-track scanning spectrometers using sounding channels at both the 118.7503 GHz oxygen line and the 183.31 GHz water vapor line has been identified as an alternative but cost effective means of achieving PATH goals. Several CubeSat concepts are being developed and demonstrated at the University of Colorado, MIT/LL, NASA/JPL and NASA/GSFC.

Observing system simulation experiments (OSSEs) of CubeSat fleet microwave observations are currently required to demonstrate the basic features of the constellation and provide simulated data for assisting the engineering development of the constellation in many aspects. To this end, efforts have been carried out at CU to develop a NWP-based multi-module simulator of the CubeSat fleet concept. A mesoscale severe weather event (e.g. Hurricane Sandy in Oct. 2012) described by North American Mesoscale (NAM) model was selected as the main target of the simulation. The output of WRF weather model sampled at 5 km in space and at 15 minutes in time provided a series of atmosphere states which were used as inputs of the Unified Microwave Radiative Transfer (UMRT) model to calculate the brightness temperature at the top of the atmosphere. Based on an individual CubeSat specification, such as randomized orbit geometry, received polarization vector rotation, antenna beam pattern as a function of scan angle and polarization, and the observation channel selections, the brightness temperature was converted into the received antenna temperature along with the additive Gaussian noise. A 2-D microwave radiation imagery of the severe weather event of Hurricane Sandy with pixels represented by the antenna temperature could be formed at the observation time of a single CubeSat. Repeating the simulation process for other CubeSats which fly over the event every ~15-30 minutes generated a sequence of microwave imageries of Hurricane Sandy at the same time interval. Demonstration of microwave imaging CubeSat fleet observations at such high temporal resolution is the goal of this paper. The meteorological features of Hurricane Sandy shown in different imageries will be compared and the impact of the CubeSat fleet settings on the microwave imagery will be discussed.