Geophysical Research Abstracts
Vol. 21, EGU2019-8635, 2019
EGU General Assembly 2019

Building a Multi-Channel Hail Climatology in the GPM Domain

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Large hail is a primary contributor to damages and loss around the world, in both agriculture and infrastructure. The sensitivity of passive microwave radiometer measurements to scattering by hail led to the development of proxies for severe weather (including hail). Several proxies have been developed, most of which use brightness temperature thresholds from 37-GHz and higher frequency microwave channels onboard a suite of weather satellites in low earth orbit.

Using 16+ years of data from the Tropical Rainfall Measuring Mission (TRMM, 36S to 36N), we pair TRMM brightness temperature-derived precipitation features to surface hail reports in the United States to train a hail retrieval on passive microwave data from the 10, 19, 37, and 85 GHz channels. Instead of setting thresholds, we fit logistic probability curves to the microwave data to estimate a probability of hail for any feature's set of brightness temperatures.

We then apply this hail retrieval to features in the Global Precipitation Measurement (GPM) domain (69S to 69N) to develop a nearly global passive microwave-based climatology of hail. The extended domain of the GPM satellite into the higher latitudes and the sampling of ice- and snow-covered regimes pose challenges for retrieving likely hailing precipitation features. We find that normalizing brightness temperature depressions by the height of the troposphere and filtering features using low and high frequency microwave data in combination provide the most realistic results for an estimated global distribution of the frequency of hail.

Our results show the highest hail frequencies in the region from northern Argentina through Paraguay, Uruguay and southern Brazil; the central United States; and a swath of Africa just south of the Sahel. Smaller hotspots include Pakistan, eastern India, and Bangladesh. A notable difference between these results and many prior satellite-based studies is that central Africa, while still quite active in our climatology, does not rival the aforementioned regions in retrieved hailstorm frequency.