Microphysical properties of ice particles as revealed by satellite microwave polarimetric measurements and radiative transfer modeling
A proposed cloud scattering polarization parameterization for un-polarized fast RT models

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1. Motivation
- Stratiform clouds have shown to produce highly polarized TBV (TBV=TBVH) passive microwave observations at frequencies above 80 GHz (~10K at 166 GHz), due to the depolarization and aggregation growth of snowflakes that are predominantly oblate and horizontally oriented. This contrasts with convective regions that show smaller polarization, as grappled hydrometeors, that become randomly oriented. Polarized microwave observations could thus be used to classify observations as convective/stratiform.

- A number of questions arise when radiative transfer (RT) experiments are used to explore polarized microwave cloud signals: are polarized models robust? What do observations have to offer?

- Operational radiative transfer models do not account for polarized scattering. We propose here to derive an estimate of the polarization difference (TBVH) at 89 and 166 GHz to be applied to un-polarized calculations, based on the analysis of one year of GMI observations.

2. Methodology
- All 2015 TBV and TBVH observations at 37, 89 and 166 GHz are analyzed over both land and ocean surfaces, and parameterized using a Hermite cubic spline interpolation.

- A radiative transfer (RT) modeling framework is applied to a case study with coincident GMI observations: deep convection in Southeastern South America to physically support the statistical relationships parameterized. The Atmospheric Radiative Transfer Simulator (ARTS) DOFT scattering solver is coupled with the Goddard Profiling Algorithm (GPROF) hydrometer mixing ratios, to model the sensitivity of polarized signals to ice particle microphysics parameters.

3. Overview of the observed cloud polarization characteristics GMI Level 1C global data analysis: Focus on the 36.5, 89 and 166 GHz polarized channels

Data analysis reveals the existence of the previously documented 'bell-curve' type relation between the vertical brightness temperature (TBV) and the difference between the vertical and horizontal polarization (TBVH), by i.e., Prigent et al. (2001), Galligani et al. (2013), Defer et al. (2014) and Gong et al. (2017).

4. Case study: an intense mesoscale convective system over north-eastern Argentina on 13 January 2018

Associated severe weather events such as intense precipitation (14.5 mm h⁻¹), hail and intense lightning activity (two deaths). GMI observations at 14 UTC show strong brightness temperature depressions associated with deep cloud. The low TBV (convection) show TBVH values close to 0 K, while regions with less pronounced TBV depressions (stratiform) show TBVH values ~7K at 89 GHz and 10K at 166 GHz.

The parameterization derived from the global satellite dataset agrees well with this specific summer mid-latitude case.

5. RT modelling to physically support statistical relationships parameterized

The single scattering properties were calculated using the T-matrix, for spheroids (both randomly oriented and horizontally aligned) and the DDA Liu (2006) sector habit with the equal mass size approach to ensure consistency (Galligani et al., 2017) with the WRF particle size distribution. Different oriented spheroids were tested and their microphysical properties include densities ranging from 0.1-0.3 g/cm³ and aspect ratios of 1.1, 1.3 and 1.6.

A. Scatter plot of the TBV simulated vs. the median simulated TBVH over land for the case study in Figure 3.

B. Applied parameterization to different transects: reconstructing TBVH from the simulated TBV

6. Future work: Test the RT framework with the recently available ARTS Microwave Single Scattering Database with oriented particles.

E. Bibliography