Project: 1314
Project title: Snow Single-Scattering
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Report period: 2024-07-01 to 2025-04-30

Introduction and general comments

The Snow Single-Scattering computing project, connected to the DFG-funded PROM-PRISTINE initiative aims to use the DKRZ computing resources to perform scattering simulations of snowflakes in the microwave. These simulations are used to enhance the capabilities of EMVORADO, which is the polarimetric radar forward operator for the ICON model.

The project has continued sustained production during the reported period. The main limitations encountered were connected to the limited human resources allocated to the project. Nonetheless, a considerable amount of the expected goals have been achieved and the project is moving forward to its final phase. 3 publications are currently under preparation reporting the results of the presented project.

Description of the experiments

The first phase of the project focused on the most commonly found snowflakes in the database for representative single ice crystals and snowflake aggregates (Fig. 1). We performed computations for 256 targets (for each of the 2 types) with sizes that are linearly spaced from 50 microns to 2 centimeters. Also, 3 electromagnetic frequencies and sampling orientations on 2562 uniformly distributed (on an icosahedron) orientations. In total, approximately 5 million individual calculations were performed.



Figure 1: Rendering of two targets used for the scattering simulations. A pristine dendritic ice crystal on the left and an aggregate of dendrites on the right.



Figure 2: Matching of observed (upper panels) and simulated (lower panels) spectral polarimetric radar signatures. Differential phase shift (left panels) and differential reflectivity (right panels) are here presented. The shaded area represent the uncertainty with respect to the mean values due to the random nature of the construction of the conical graupel target.

This initial dataset has been implemented in the EMVORADO forward simulator of the ICON model and publication about this progress is planned.

The next phase of the project involved the realization of a larger set of snowflake shapes representing better the natural variability of such particles. This effort involved the simulation of hundreds of different snowflake shapes and the data collection of these production is being prepared for an additional data publication in collaboration with other groups of the DFG SSP PROM priority program.

A final "bonus" product of the presented project is has been the possibility to simulated the polarimetric response of conical graupels. Recent observational evidence of an oscillatory behaviour in radar spectral polarimetric returns from frozen hydrometeors has been discovered. What makes this observation peculiar is the fact that this type of signatures was previously known to come only from liquid hydrometeors. A collocated video probe relvealed the presence of conical graupels within the precipitation particles. By means of the project simulation expertiese it has been possible to model such signatures achieving remarkable matching between observations and simulations. A short publication reporting these findings is under preparation.