Project: 1314
Project title: Snow Single-Scattering
Principal investigator: Davide Ori b381492
Report period: 2023-07-01 to 2024-04-30

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 started sustained production during the reported period. The main limitations encountered were connected to the limited human resources allocated to the project. This fact led to the expiration of a considerable amount of nodehours, especially during the third trimester when the PI of the project went on parental leave and the postdoc assigned to the specific tasks concentrated their vacation time. Nonetheless, a considerable amount of the expected goals have been achieved and the project is moving forward to its next phase.

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). Initially, we planned to perform computations for 256 targets (for each of the 2 types) with representative sizes that are linearly spaced from 50 microns to 2 centimeters. Also, 8 electromagnetic frequencies and sampling orientations on 642 uniformly distributed (on an icosahedron) orientations. In total, approximately 2.6 million individual calculations were planned.

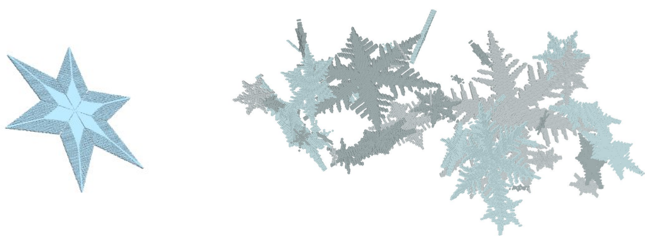

Figure 1: Rendering of two targets used for the scattering simulations. A pristine dendritic ice crystal on the left and an aggregate of dendrites on the right.

In practice, a larger set of sampling orientations was necessary to achieve the desired

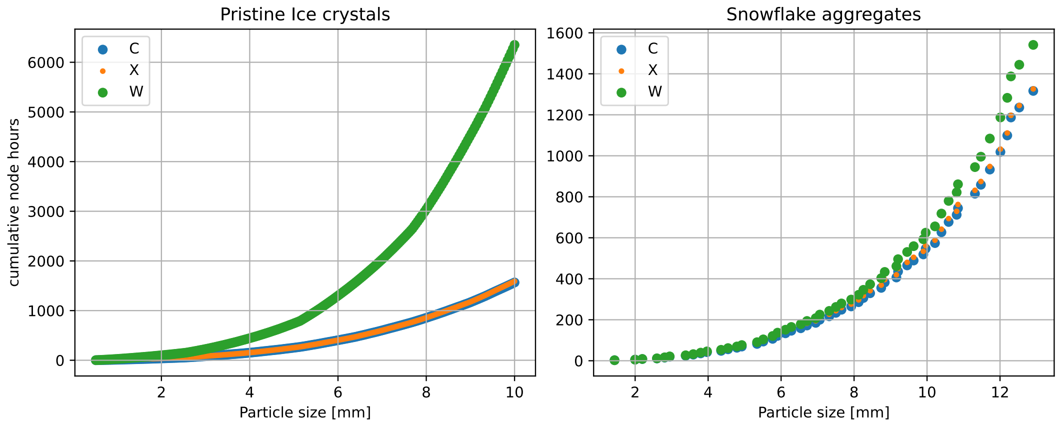

Figure 2: Cumulative nodehours used for the calculations of the scattering properties of frozen hydrometeors as a function of target size and electromagnetic frequency.

convergence of the averaged results. For this reason, the number of individual orientations was increased to 2562 (following the next icosahedral subdivision). Consequently, the number of frequencies used was restricted to the most common 3 (namely C, X, and W bands) to prioritize efforts and save computing time.

Also concerning the modeling of targets that are representative of realistic snowflake aggregates, we realized that it is impractical to simulate aggregated snowflakes that are smaller than a few millimeters. On the other hand, it was also difficult to simulate aggregates of sizes larger than a centimeter. For this reason, the current dataset of results contains only 56 shapes for aggregated snowflakes.

Fig 2 shows the progressive cumulative nodehours required for the simulation of the scattering properties for each type of snow particle at different frequencies. A total amount of 16 thousand nodehours has been used so far. Interestingly, the required computing resources depend on the used electromagnetic frequency intensively for what concerns single ice crystals. This is probably connected to the fact that those shapes are highly asymmetrical (non-spherical) and the convergence of the numerical algorithm used suffers from such extreme shape. The results from this analysis are useful to more precisely estimate the computational requirements for the next phase.

In total, 2.4 million individual scattering calculations have been performed. Notably, we had to prioritize some electromagnetic frequencies to compensate for the increased requirements in terms of orientation sampling. Also, the most demanding calculations (i.e. the ones for aggregates larger than 1.5 centimeters) are still missing, but are expected to complete in the last trimester of the report period. Unfortunately, it was not possible to use the computing power of GPU nodes due to the need to develop the scattering code for such a purpose and the lack of time to dedicate to development efforts, but it remains a significant point of interest due to the potential benefits in terms of computing efficiency.