

RECENT ADVANCES TO THE OPENSSP PARTICLE AND SCATTERING DATABASE

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ABSTRACT

We highlight recent progress in and discuss future plans for the OpenSSP particle and scattering property database. Ongoing work has focused on expanding the types of particles to include polycrystals and melting snowflakes. Future expansion will include rimed particles, hail, and aligned snowflakes.

Index Terms— Electromagnetic scattering, precipitation, GPM

1. INTRODUCTION

The complex morphologies of ice particles and snow flakes presents a challenge when interpreting remote sensing observations of falling snow. Simplified particle models with scatterers represented by spheres or spheroids do not fully capture particle interactions with electromagnetic radiation [1, 2]. Following these findings, various efforts have yielded a scattering properties for a range of pristine ice particles and snow aggregate, yet gaps in these databases remain [3].

The OpenSSP particle and scattering property database is one specific catalog that provides snow particle models and the resulting scattering calculations [4, 5]. Ice crystal growth is simulated through a quasi-physical vapor deposition process [6]. These crystals are then aggregated according to a set of heuristics. The resulting particles are representative of crystals found in nature. The electromagnetic scattering properties for these crystals are then calculated using the discrete dipole approximation (DDA) [7]. This procedure is repeated for a range of depositional growth regimes, creating a range of crystal morphologies, resulting aggregates, and corresponding scattering properties, resulting in a large collection of particles that can then be selectively used estimate snowfall from active and passive microwave sensors.

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To address some of the gaps listed by Kneifel et al. [3], we are working to expand the OpenSSP database. Ongoing efforts have made significant progress towards including melting particles and polycrystals. These features will be discussed in Section 2. Plans for future enhancements will be listed in Section 3.

2. CURRENT WORK

2.1. Melting Particles

Melting snowflakes are probably the most important gap in scatter databases that needs to be addressed. The mixture of water and ice enhances reflectivity and increases attenuation, but isolated empirical characterization of the melting layer is difficult. Initial analysis of such particles showed that the scattering properties of such particles quickly approach those of liquid water at the onset of melting [8]. Inclusion of these particles for geophysical retrievals requires significant caution. Given the high resolution of the melting particles [8], particles must be upscaled to a coarser resolution to reduce long DDA run times. However, when blurring particles to a lower resolution, we find it is impossible to conserve particle mass, and such errors propagate to the derived scattering properties. An example of the errors in scattering properties from blurring particles to a more computationally-tenable resolution is seen in Fig. 1.

In performing this analysis, we discovered an even more fundamental violation of mass conservation: the rectilinear spacing of the melting particle grids means that the resulting particle has ice and liquid voxels that have the same volumes. When a voxel melts, it retains the same volume, slightly increasing the mass of the particle. These inconsistencies in particle mass are an obstacle to practical use of such models. A more comprehensive explanation of this topic, along with an innovative approach to solve it, are the subject of a companion paper [9].

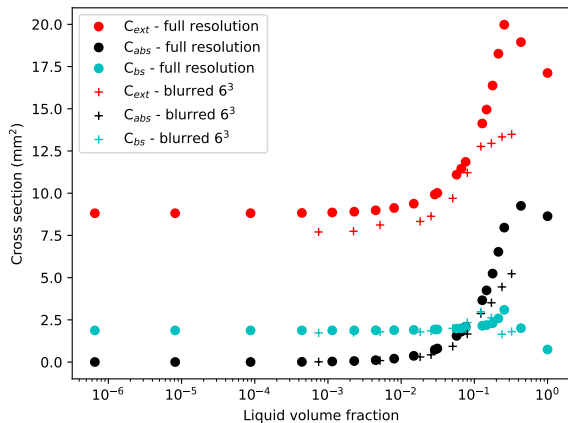


Fig. 1. Extinction, absorption, and backscattering cross-sections for a melting particle series for both full resolution and blurred. The blurring results in 6^3 fewer pixels. This blurring results in differences in the resulting scattering properties as well as a violation of mass conservation, the latter of which is apparent by the differing liquid volume fractions for the circle and plus symbols.

2.2. Polycrystals

The pristine ice crystals that currently populate OpenSSP are the result of a single depositional growth regime, i.e., a specific temperature and supersaturation range, or have a singular growth axis or plane. However, particles in observed in nature are often the product various growth regimes and can have more than one growth axis. Prominent examples of these types of particles are capped columns and bullet rosettes, respectively. We have extended the depositional growth model used for pristine crystals to allow for such particles. Fig. 2 shows a simulated capped column, while Fig. 3 shows a synthetically-grown bullet rosette with a closeup of the bullet shape at the juncture point. We are currently finalizing an adaptive grid that allows for variable grid resolution within a single particle to optimize particle growth. Once complete, we will generate a large collection of particles for subsequent scattering calculations.

3. FUTURE PLANS

In addition to current work, we also have a number of plans to extend the reach of the OpenSSP database, and to better characterize the database as a whole. Future particles will include rimed snow, including graupel, and hail. Riming is an important processes that is common, even when graupel is not present. Graupel and hail are necessary for convective studies. We are also working to

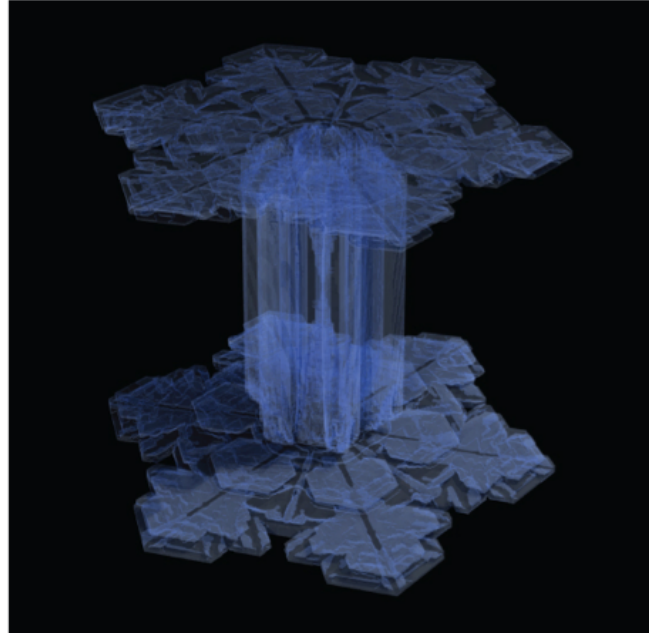


Fig. 2. Capped column grown with our extension of the Gravner-Griffeath depositional growth model [6].

include horizontally-aligned particles necessary for investigating polarized brightness temperatures and polarimetric radar variables. Finally, an important goal for OpenSSP is to characterize uncertainties in the particle models and the scattering calculations. The analysis of mass conservation for melting particles is just one aspect of this characterization.

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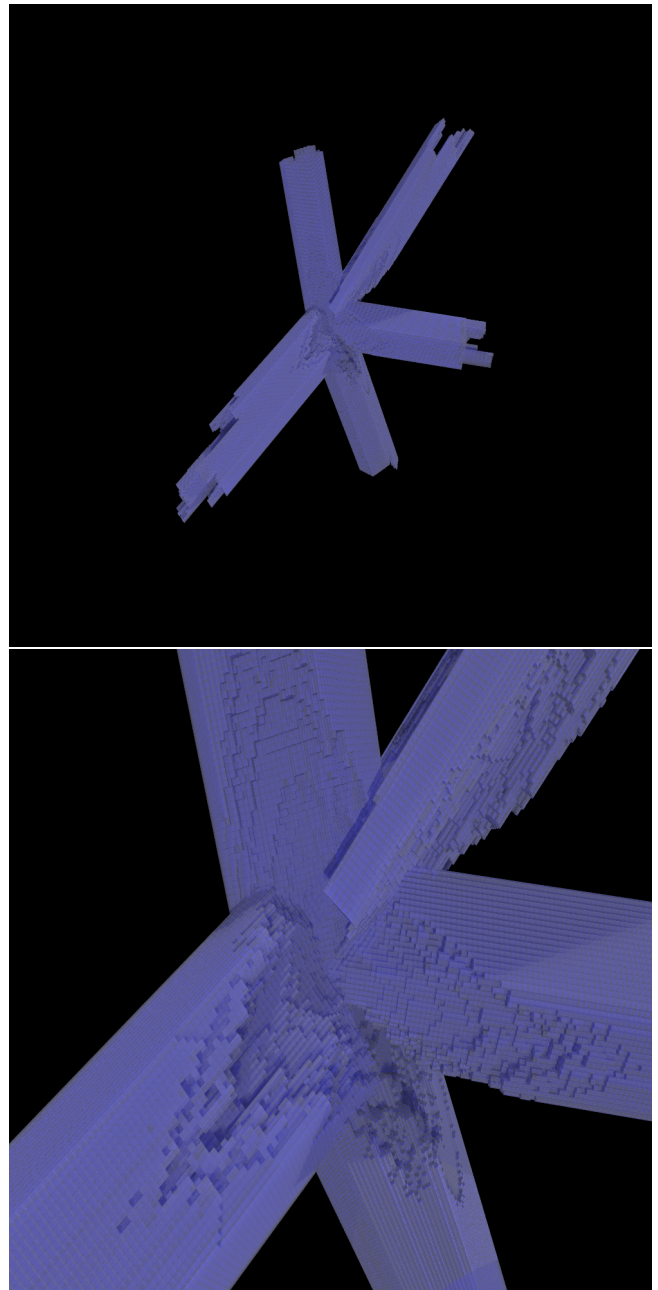


Fig. 3. Five-column bullet rosette (top) with closeup of bullet structure (bottom). As with the capped column, this particle was grown using an extended version of the Gravner-Griffeath depositional growth model.