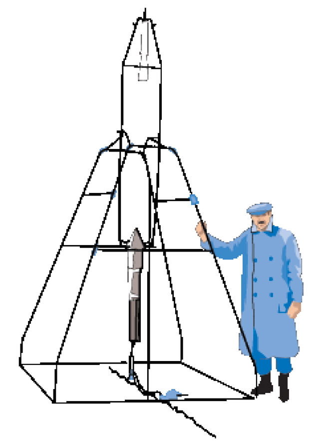
The OpenSSP Particle Scattering Database

Current Status and Future Plans

I.S. Adams[1], K.-S. Kuo[1,2], W.S. Olson[1,3], T. Clune[1], C. Pelissier[1,4], R. Schrom[1,5], A. Loftus[1,2], and S.J. Munchak[1]

[1]NASA/GSFC, [2]UMD/ESSIC, [3]UMBC/JCET, [4]SSAI, [5]USRA



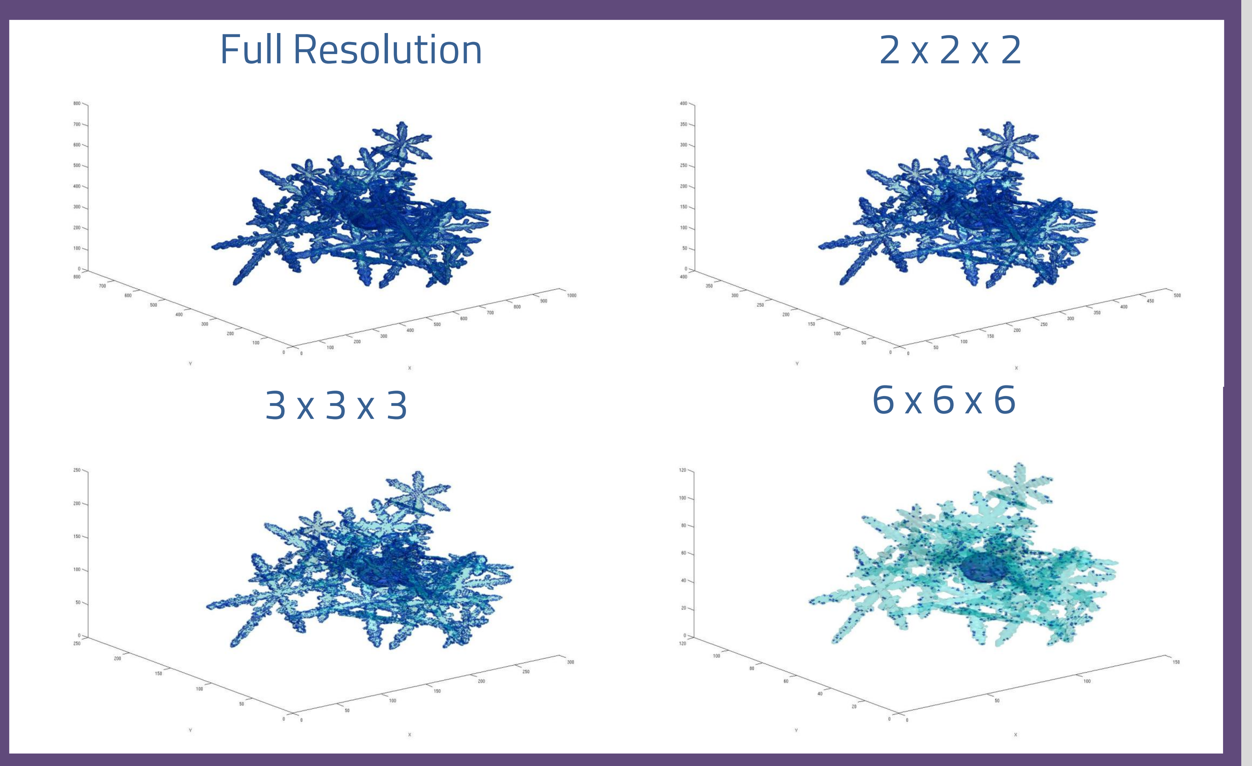
Introduction

High-fidelity models of hydrometeors and the related electromagnetic scattering properties are necessary tools for interpreting remote sensing observations and relating observables (such as radar reflectivity and microwave brightness temperature). The OpenSSP database offers exactly these capabilities. Synthetic ice crystals are generated through a quasi-physical method that replicates vapor deposition. These particles are then aggregated, and scattering methods, such as the discrete dipole approximation (DDA) or the method of moments (MoM/CBFM), are applied to the resulting crystal and aggregate structures. Recent studies demonstrate that OpenSSP, as well as other particle scattering databases, produce simulated remote sensing observables that show greatly improved agreement over simple particle models that employ spherical or spheroidal geometries. These scattering libraries are particularly necessary for multi-frequency (e.g., radar dual-wavelength measurements) and multi-sensor (i.e., combined active and passive) approaches for quantifying clouds and precipitation. To expand the purview of the database, we are in the process of including melting particles, polycrystals (ice crystals with multiple growth modes or regimes), and aligned particles. Moreover, we are assessing inherent uncertainties in the particles and the scattering calculations for inclusion in retrieval algorithms.

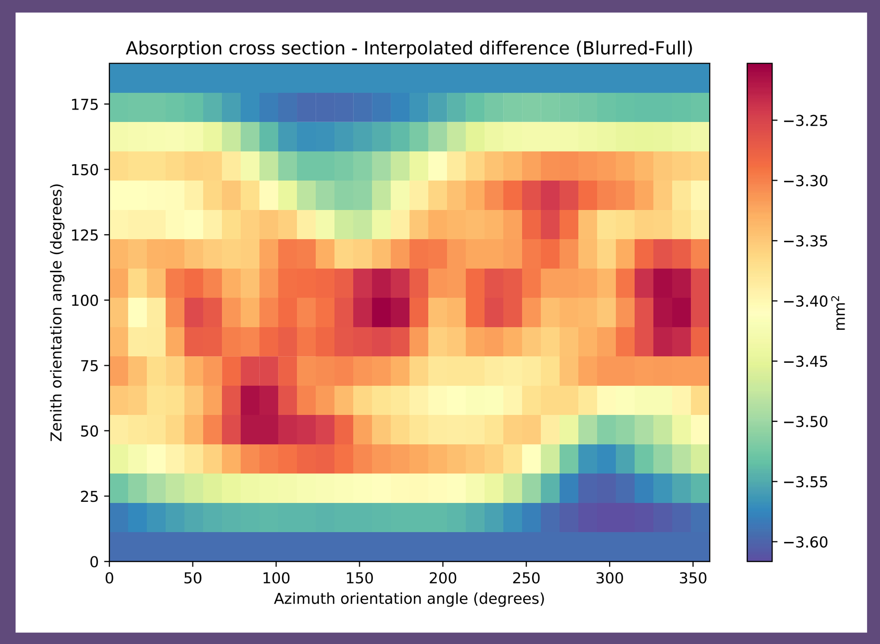
Melting Particles

Melting particles are a high priority for future inclusion in OpenSSP. Our approach includes developing a quasi-physical framework based on Smooth Particle Hydrodynamics (SPH) to melt particles from the OpenSSP database. While that code is in development, we are analyzing particles melted by collaborator Dr. Benjamin Johnson. One challenge with handling these particles is that the native resolutions (up to 8 million dipoles) result in long computation times for DDA calculations. While "blurring" the particles makes the scattering problem more tractable by reducing the number of elements, it violates mass conservation which, in turn, produces errors in both melt water fraction and the associated scattering properties. This analysis is an ongoing effort while we also produce the first set of scattering properties from the particles provided by Dr. Johnson. Once the SPH code is complete, we will be able to tune melting parameters and generate melting particles for a large number of melting realizations. For more information see posters 122 and 139.

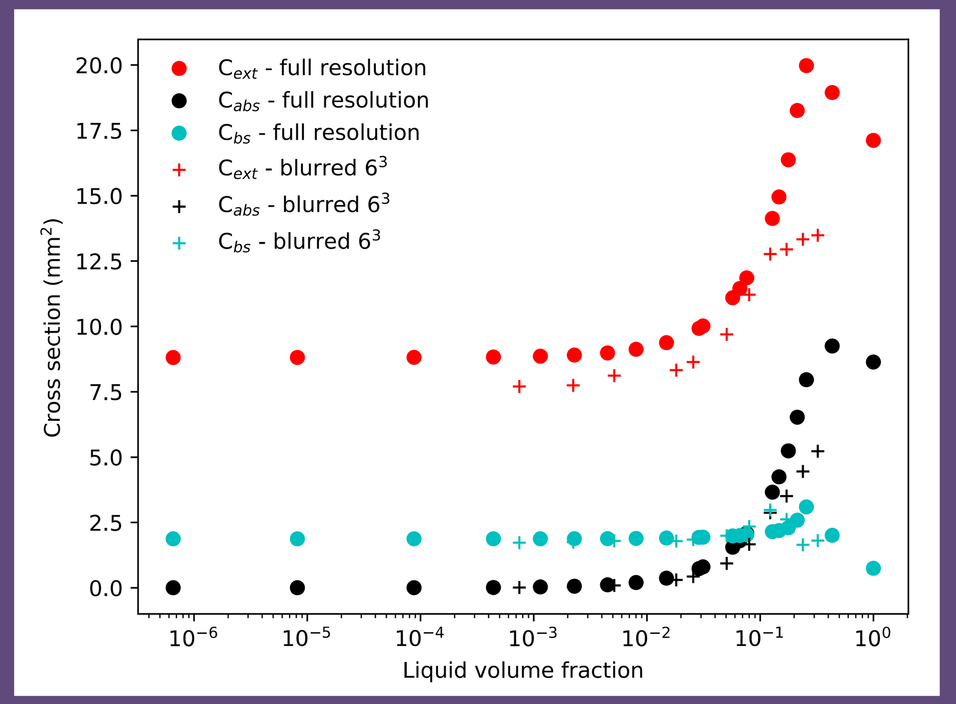
Rendered Particle for Different Blurring Resolutions



Errors in Absorption Cross Section from Blurring

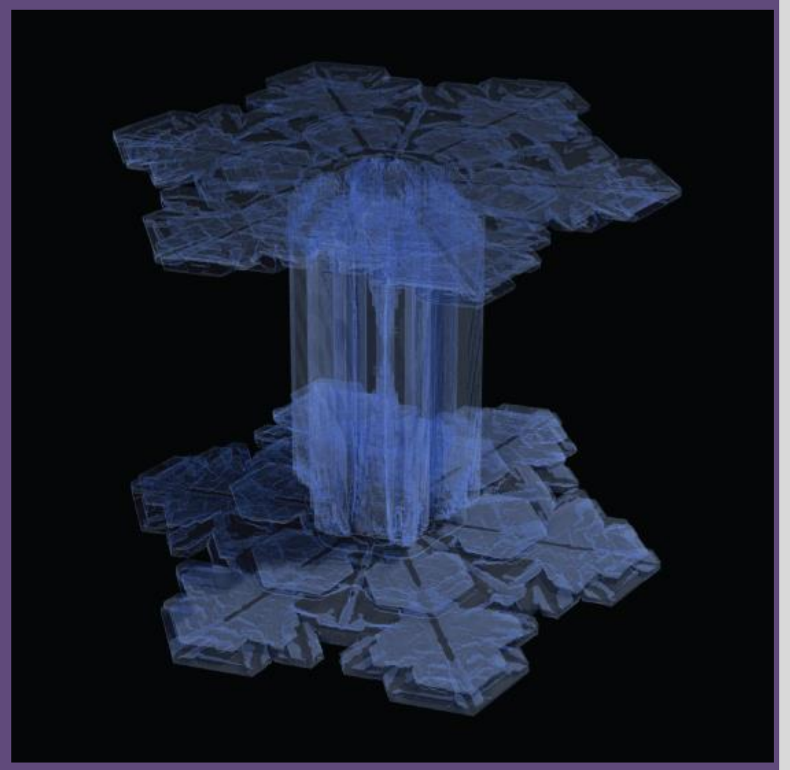


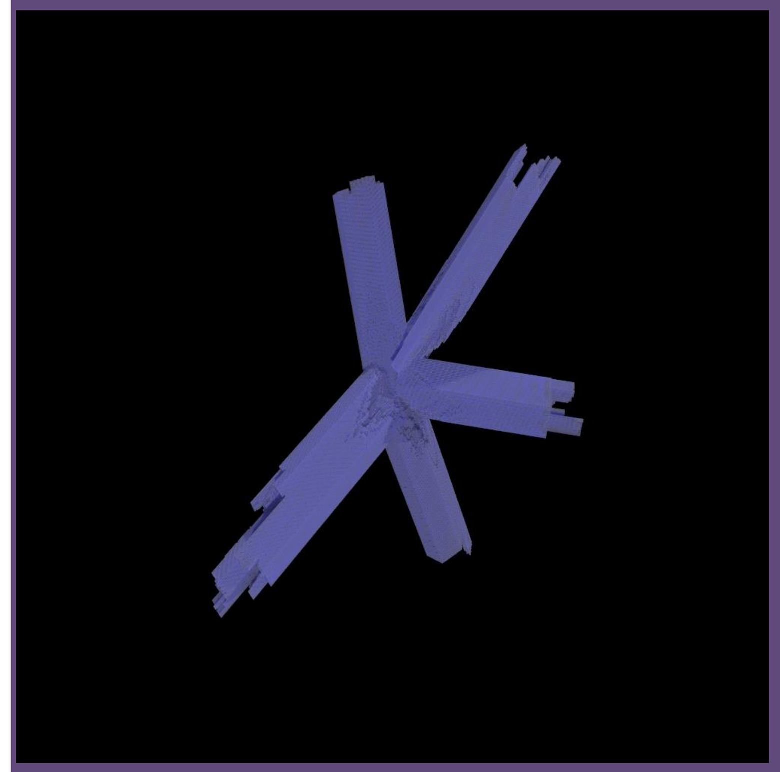
Impact of Blurring as a Function of Liquid Fraction

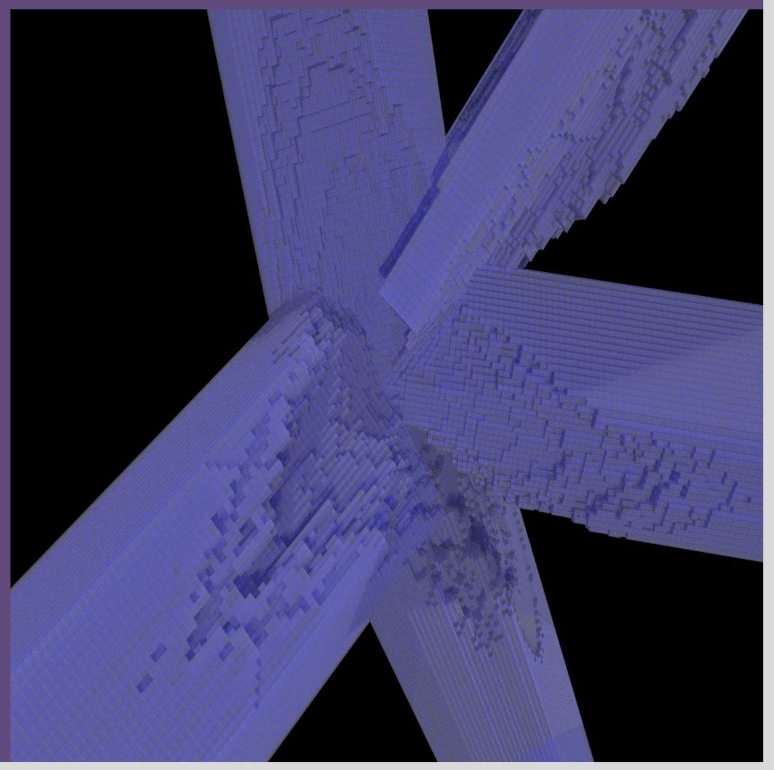


Polycrystals

Polycrystals are often observed by in situ particle probes; therefore, including these hydrometeors is important for developing comprehensive particle and scattering properties libraries. By extending the vapor deposition code used to generate pristine crystals, we have been able to grow crystals with multiple growth modes (capped columns, top) or multiple seeding points (rosettes, middle). Recent advances in the code now also allow us to generate bullet-like structures at rosette junctures (bottom)



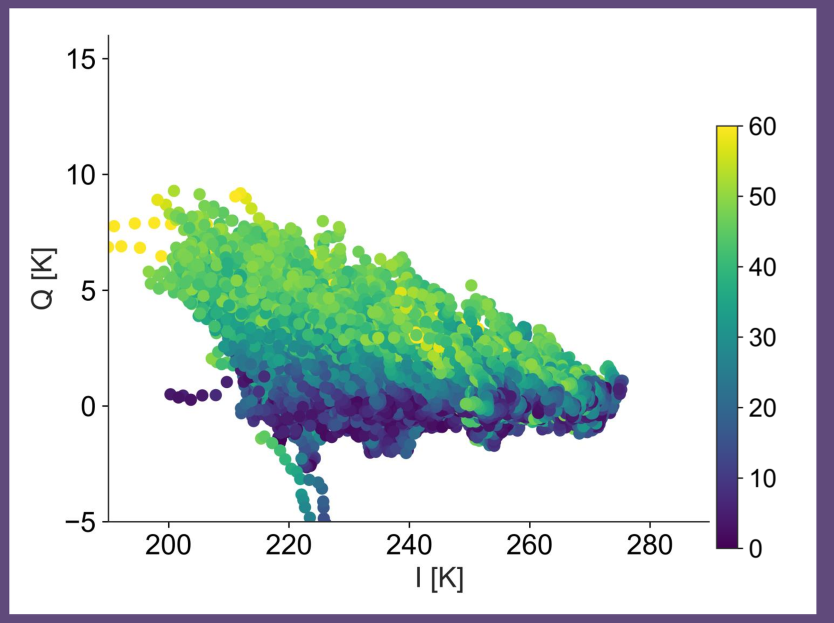




Applications

The ultimate goal of this project is a catalog that is representative of the range of hydrometeors that would be observed by cloud and precipitation remote sensors and that includes uncertainty estimates that are necessary for useful quantitative estimates. One of the tools we will use to perform this uncertainty analysis is the Atmospheric Radiative Transfer Simulator (ARTS) which allows us to simulate sensor observables and compare them to measurements collected from GPM and mission-related field campaigns. Below is a statistical comparison of brightness temperature intensity (I) and polarization (Q) between observations from the Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR, top) and ARTS simulations for two different types of horizontally-aligned cloud ice crystals: hollow columns (top) and plates (bottom). For the extent of the dynamic range that we were able to simulate in this study, the column produced Q that was smaller than observations while the plates produced Q that agreed well with the CoSMIR data. Colors denote incidence angle.

CoSMIR Observations



Hollow Column Simulations

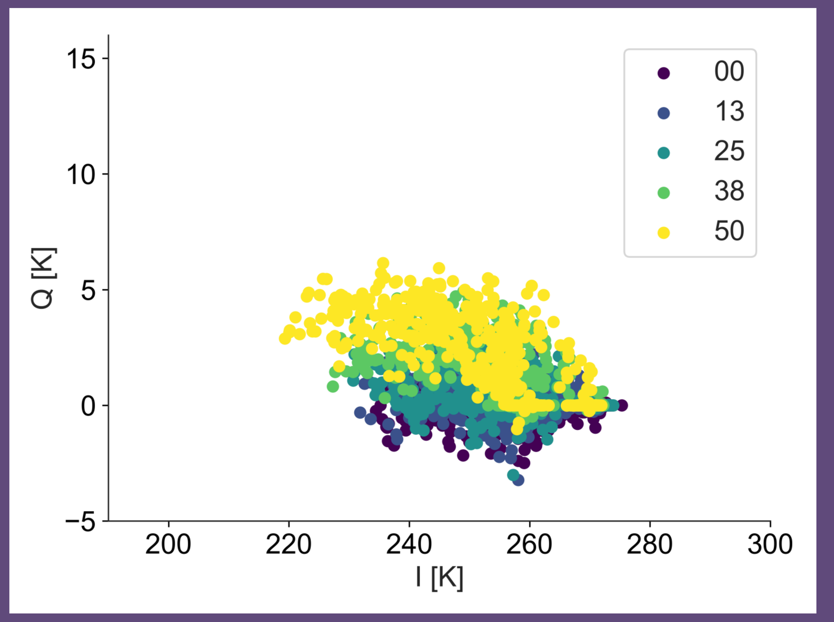


Plate Simulations