SPP 2115

Polarimetric Radar simulations with realistic Ice and Snow properties and mulTI-frequeNcy consistency Evaluation

PRISTINE

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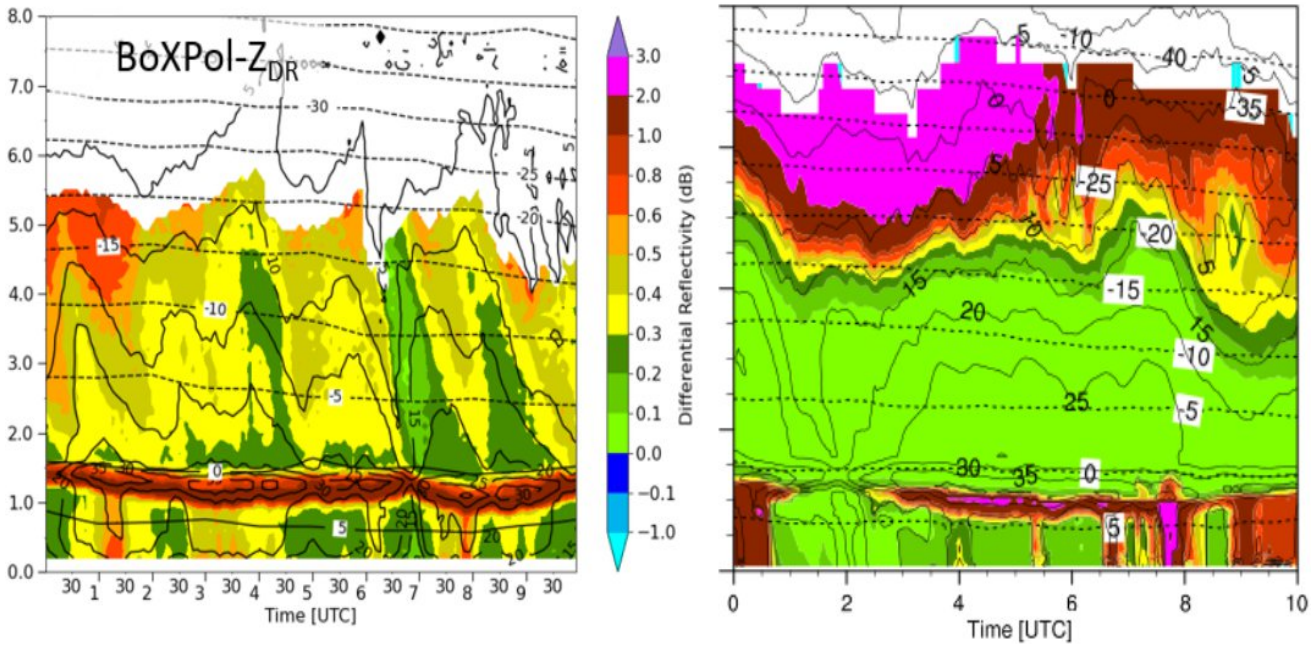
PROM All-hands Meeting
Leipzig 2024

Biases in T-Matrix polarimetric calcuations

Observation

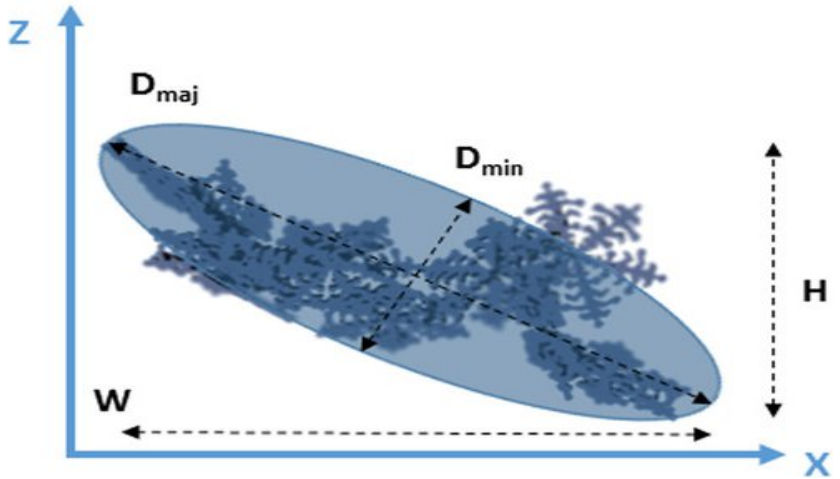
Model+PFO



Shrestha et al., 2021

Spheroidal scattering model as a major source of uncertainty (Schrom and Kumiljan, 2018)

T-Matrix based simulations show a **consistent deficit** in terms of **polarimetric response** in the dendritic growth layer where large, “fluffy” particles prevail



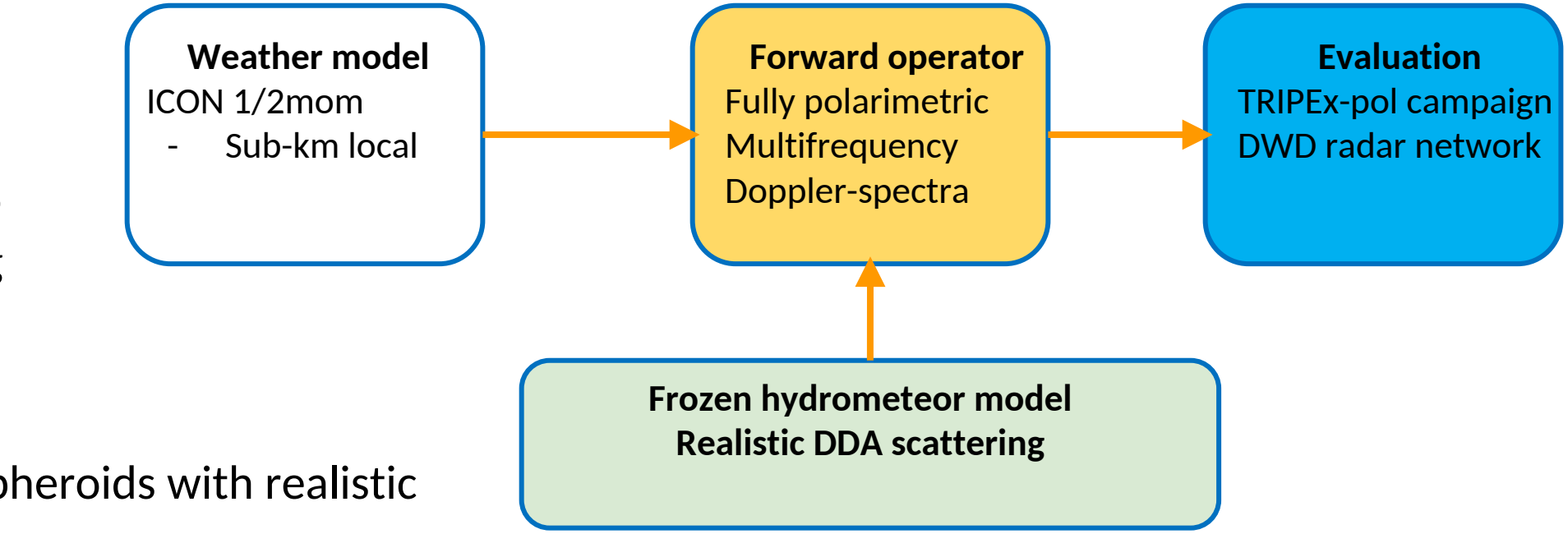
Von Lerber et al., 2017

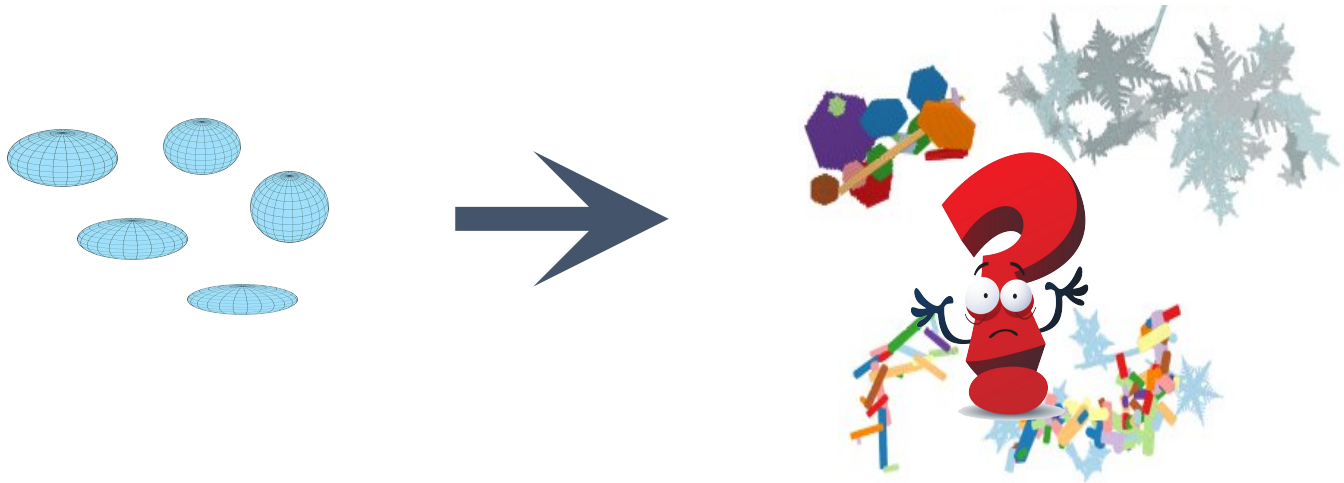
Strategy

- Extend EMVORADO with new scattering tables and evaluate with real data

- Simply substitute spheroids with realistic shapes

- Ok, but … which one?





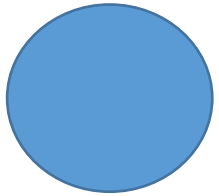
ICON bulk microphysics

ICON does not provide much information about the shapes of realistic particles - only the mass-size relation

Cloud drop

10-100 um
10^7-10^9 /m3

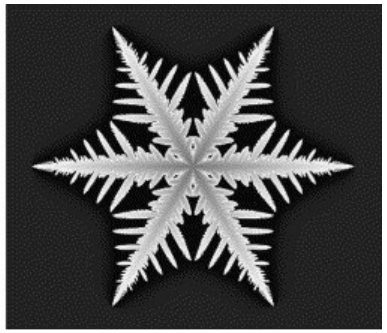
Rain drop



0.1-5 mm
10^3-10^5 /m3

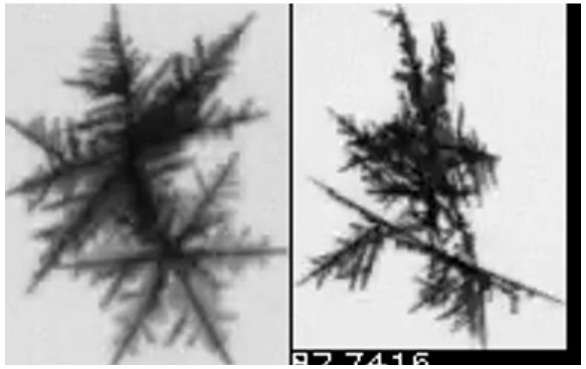
T-Matrix

ice crystal



10-500 um
10^2-10^6 /m3

snow flakes



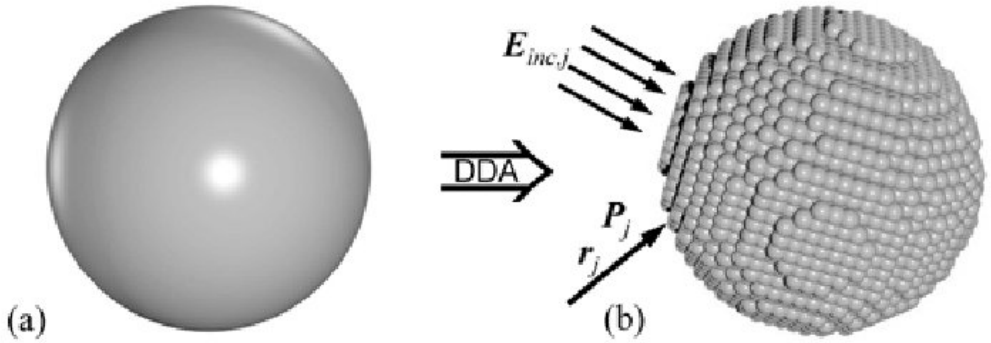
1mm-1 cm
10^2-10^6 /m3

DDA

graupel/hail

1mm-10cm
10^3-10^6 /m3

T-Matrix

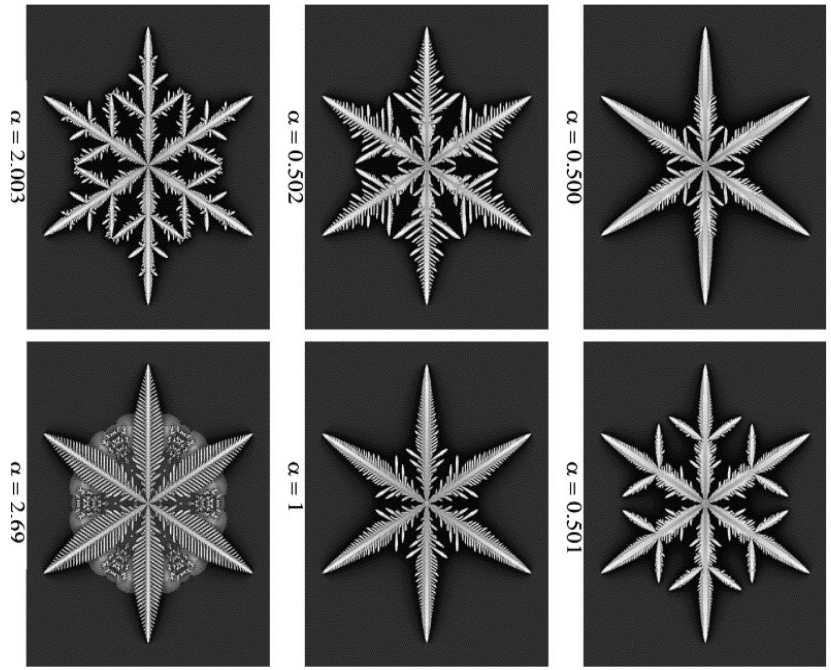


Principles of DDA:

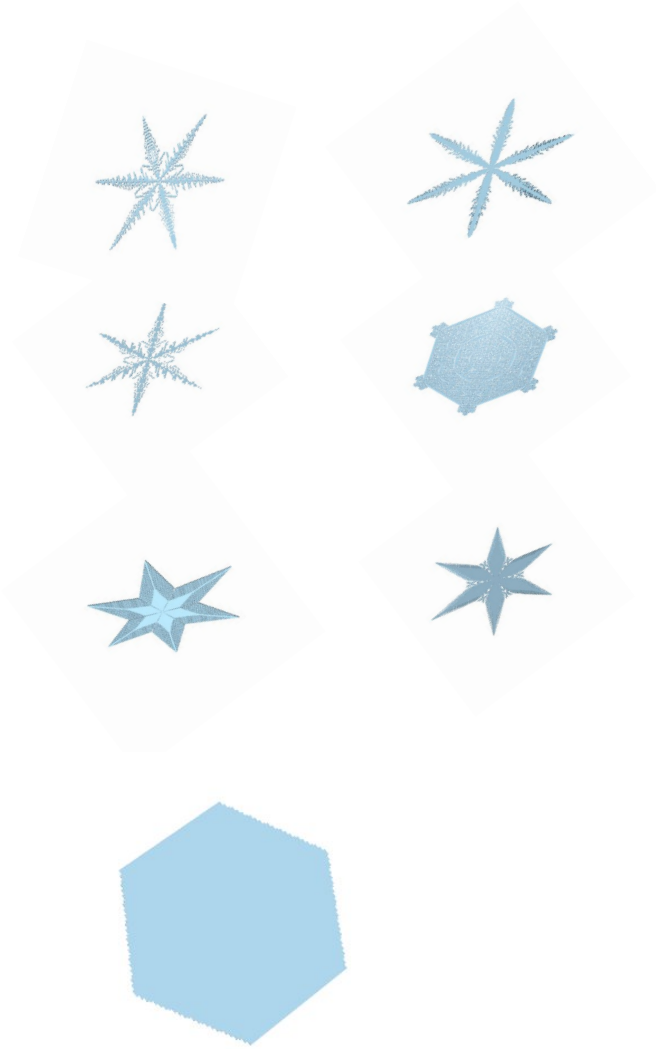
- arbitrarily shaped targets
- approximated by discrete dipoles
- dipoles on a regular grid for efficient computations

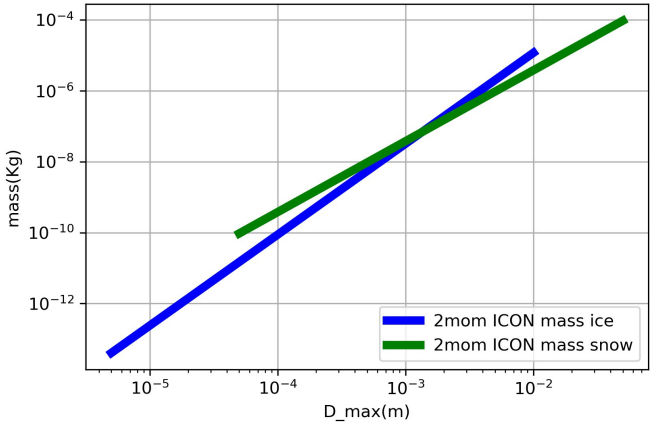
Simulating ice crystals

Reiter's Algorithm (2005)
2D hexagonal lattice



Simulated dendrite crystals



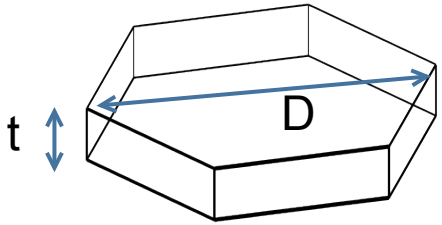


ICON m-D relation snow and ice

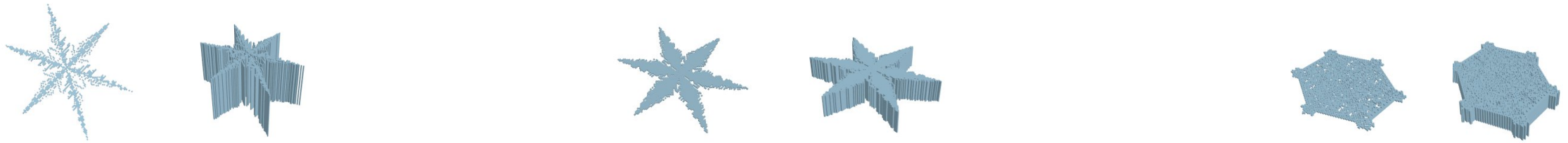
Plate crystals for very small (non branched) size

m-D relation and aspect ratio

aspect ratio ar= t/D

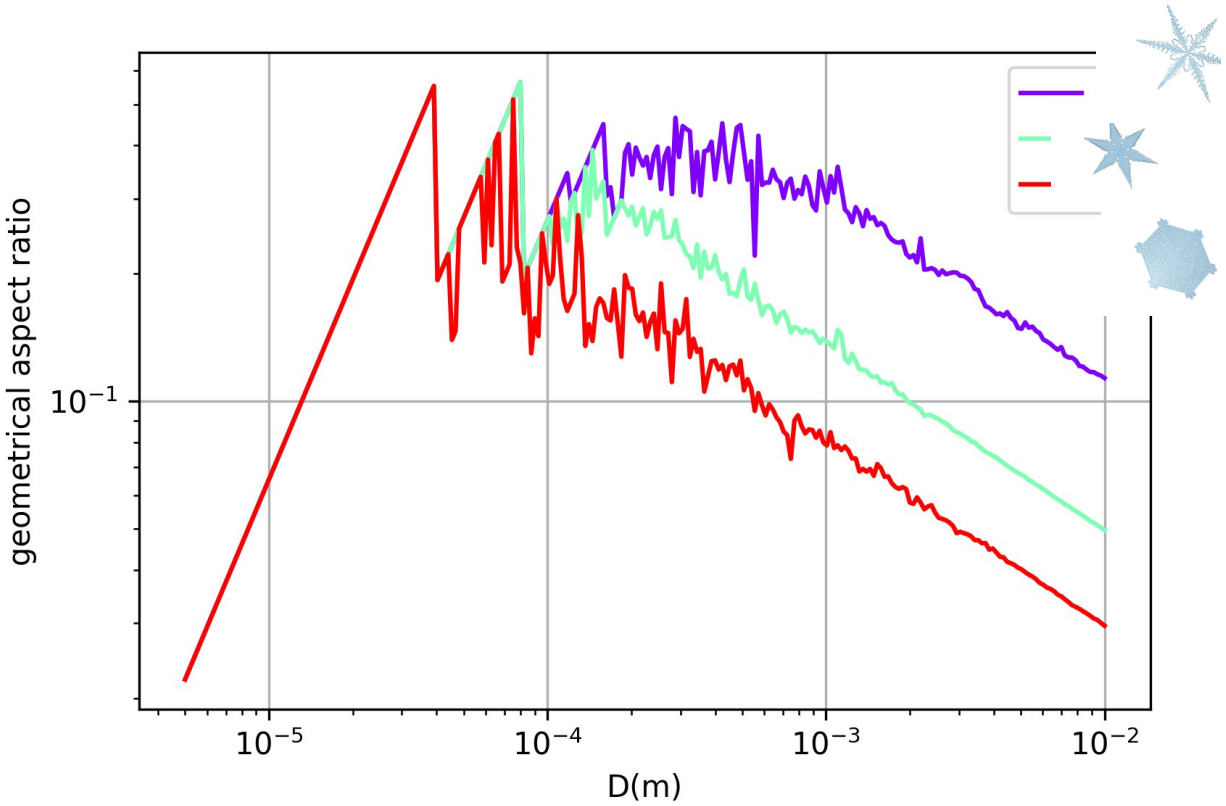


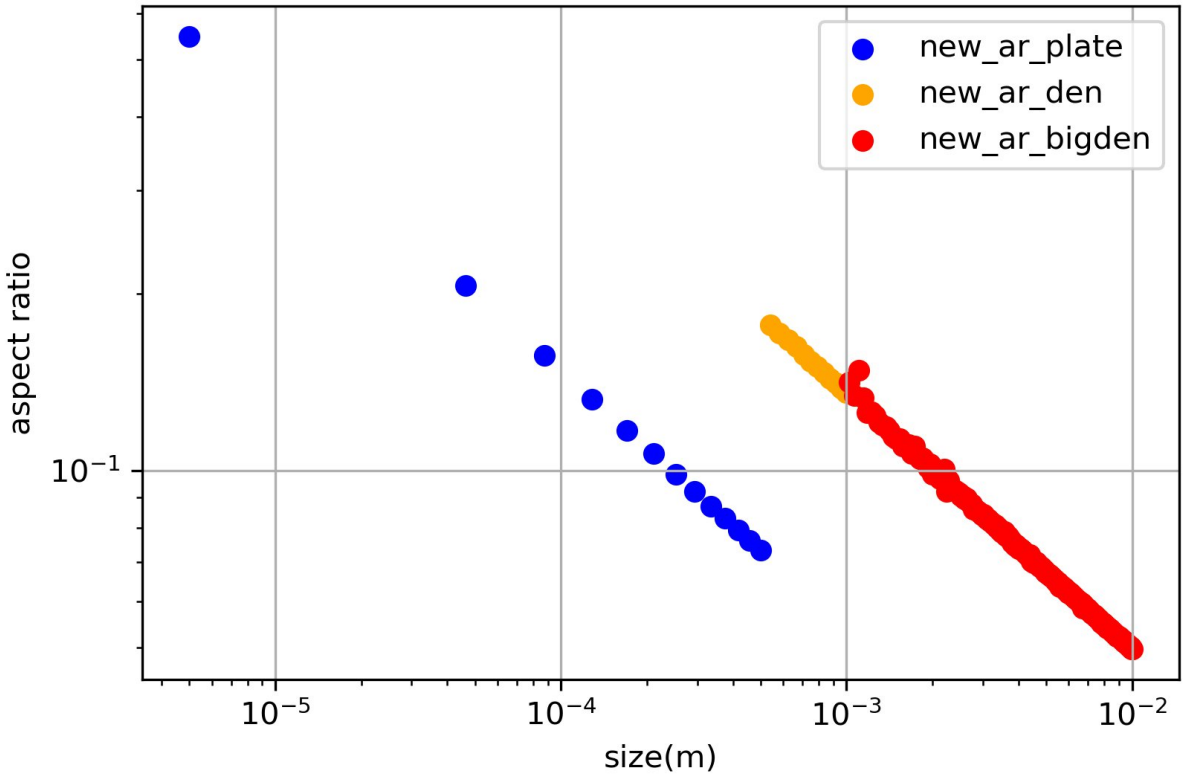
By adjusting aspect ratio we can match the desired mass consistent with ICON m-D relationship.



Shape resolution

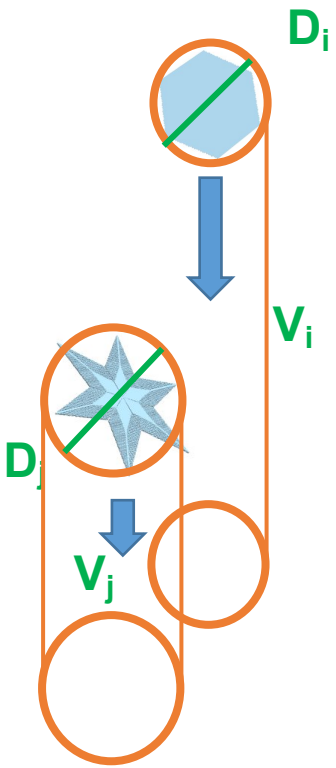
- First iteration - fixed resolution (20e-6m)
- Second iteration - replaced with higher resolution in the smaller size less than 1mm





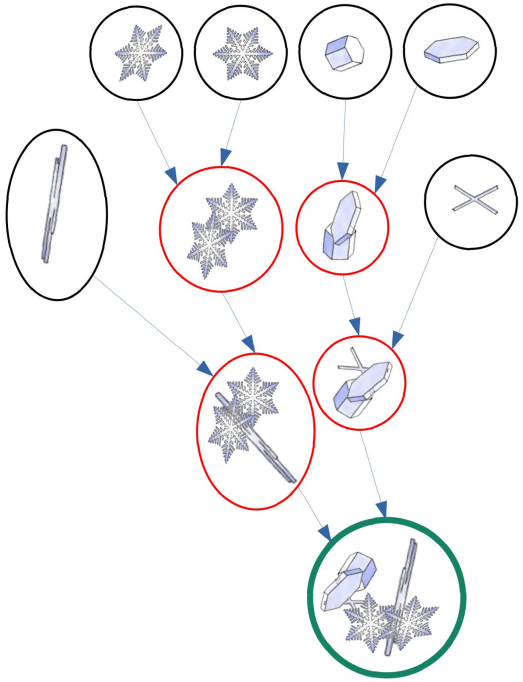
Plates smaller than 0.05mm, as in smaller size range, the crystals are not branched, 0.05mm to 1mm dendrite

Snowflakes - AGGREGATION

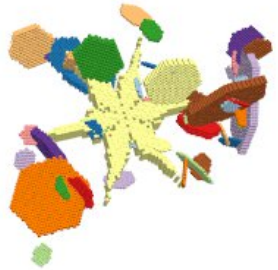


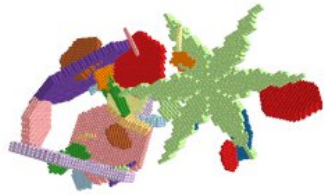
$$K_{i,j} = (D_i^2 + D_j^2)|v_i - v_j|$$

Physically-based Differential-sedimentation Kernel

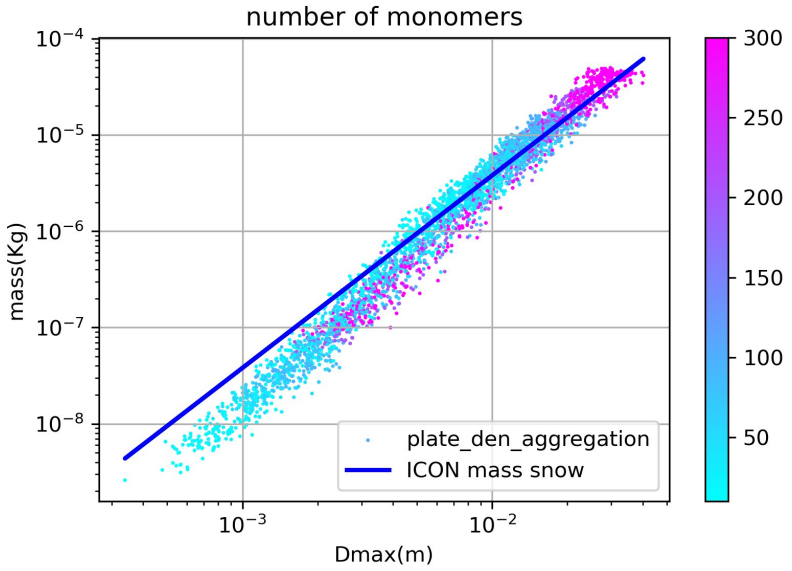


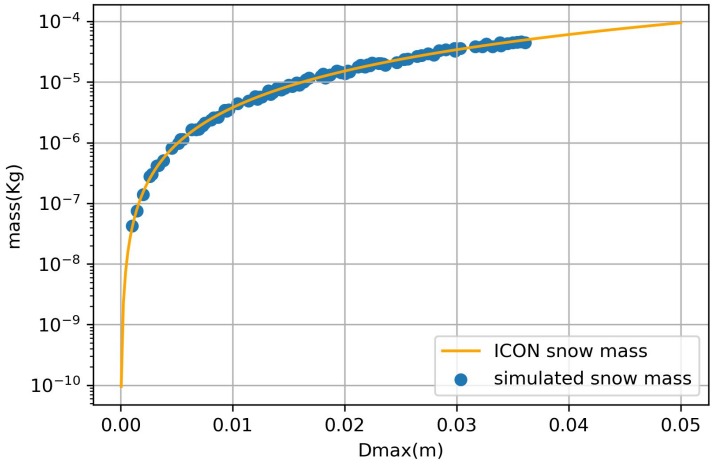
Schematic Diagram of the aggregation process





randomly generated snowflakes





Snow Particle **SELECTION** according to ICON m-D

DDA Scattering Calculations – L0 dataset

Frequency	Single crystal size	Single crystal resolution	Aggregate size	Aggregate resolution
C- band (5.6 GHz) X- band (9.6 GHz) Ka band (35.6 GHz) W band (94 GHz)	Upto 0.05 mm plate	5e-7m and 1e-6m	1.4mm to 3.6 cm	20e-6m
	0.05 mm to 1 mm dendrite	2e-6m		
	1mm to 10 mm dendrite	20e-6m		

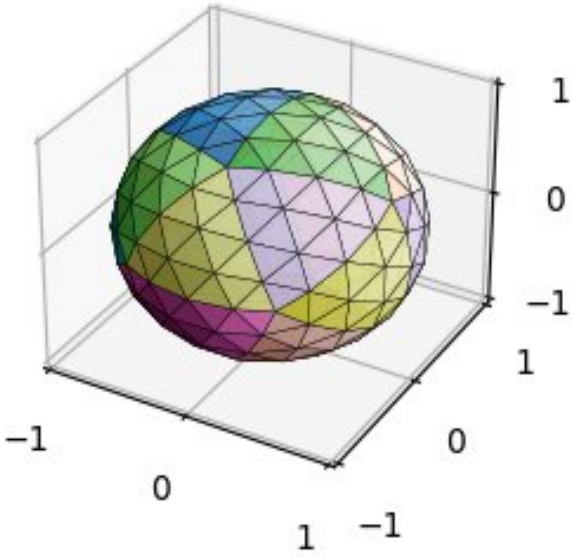
For aggregates we calculate upto 8 subdivisions (642 angles)
For single crystals, we calculate upto 16 subdivisions (2562 angles)

DDA – L1 dataset

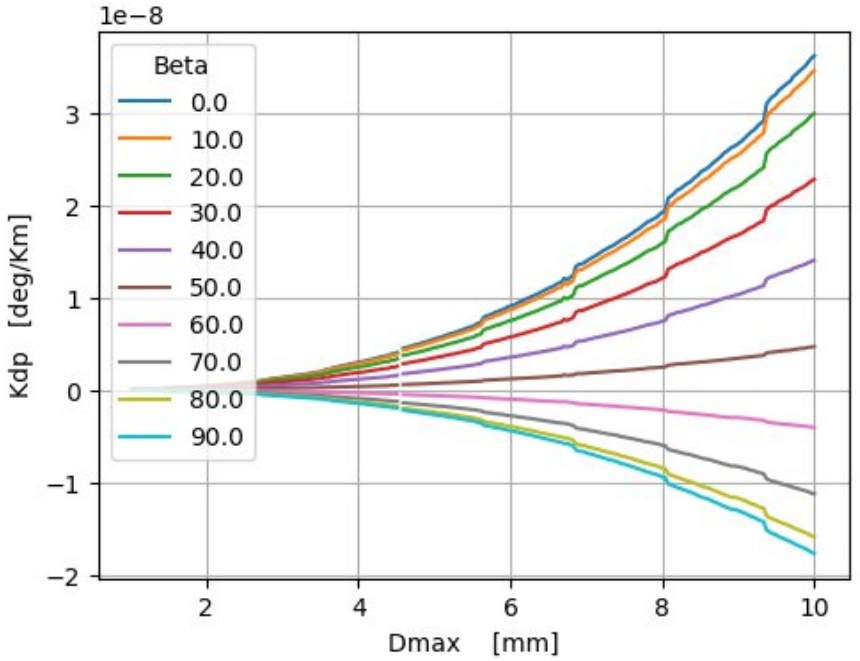
$$< Z >_{aro} (el, \beta) = \int f_\alpha(\alpha) f_\gamma(\gamma) Z(\alpha, \beta, \gamma, el)$$

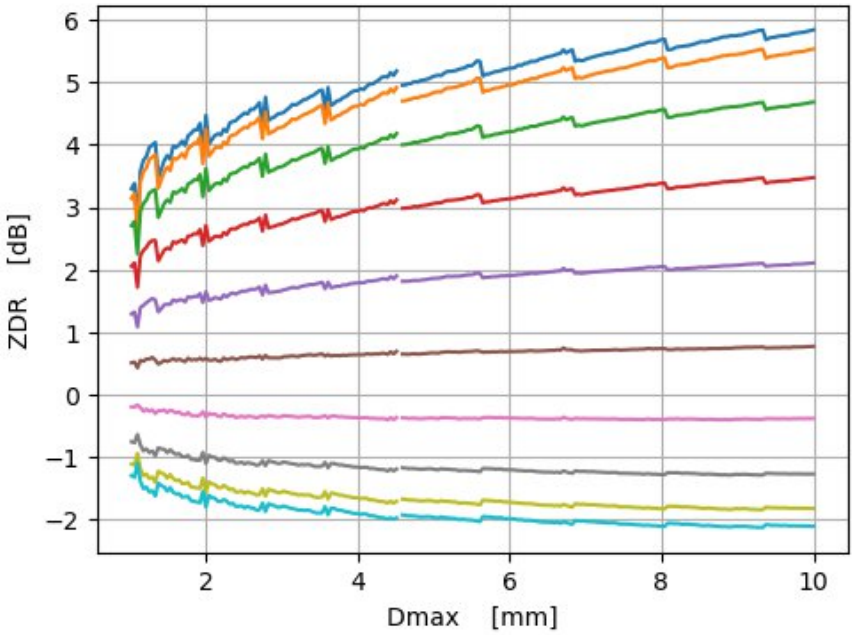
$$\hat{Z}(el) = \int f_\beta(\beta) < Z >_{aro} (el, \beta)$$

- Data dimensionality reduction with Azimuthally Random Orientation (ARO) averaging
- Reduced unique DDA simulations by uniform orientation sampling and interpolation

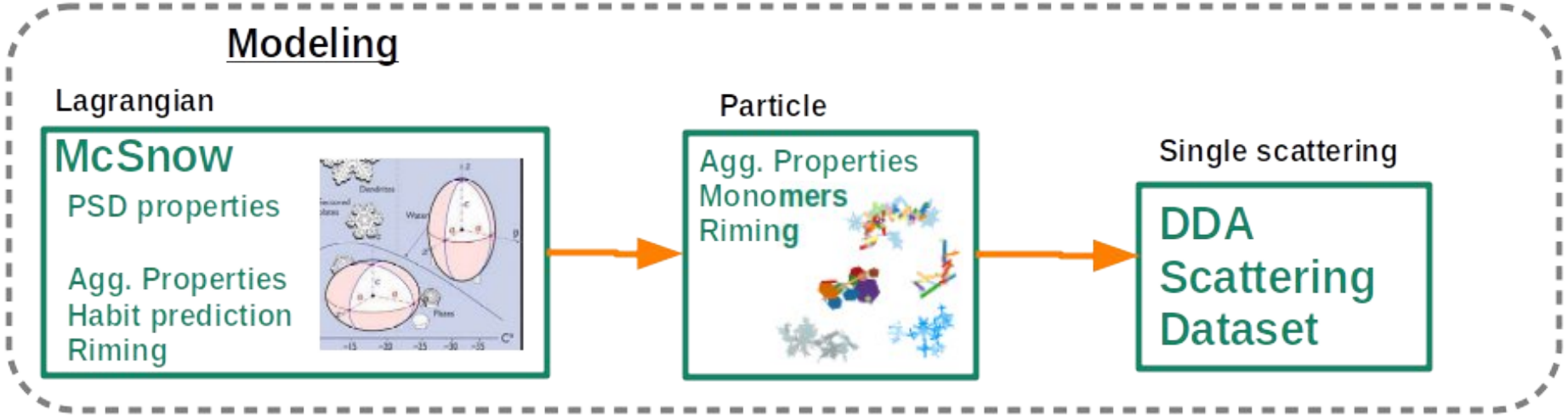


Icosphere uniform sampling
Brath et al. (2020)

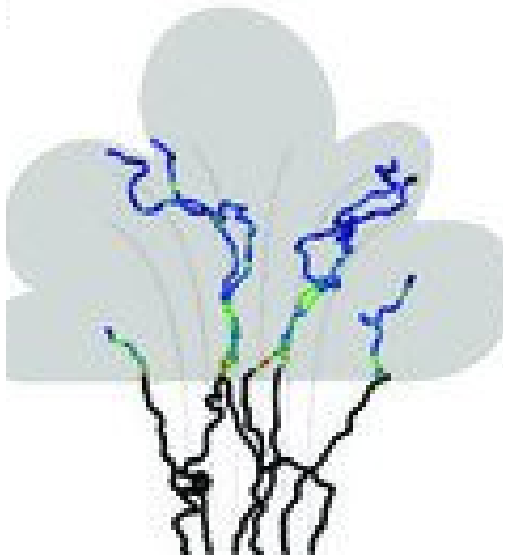




Avoid arbitrary particle selection



McSnow



Semi-Lagrangian 1D model (Brdar and Seifert, 2018) follows cloud particle trajectories

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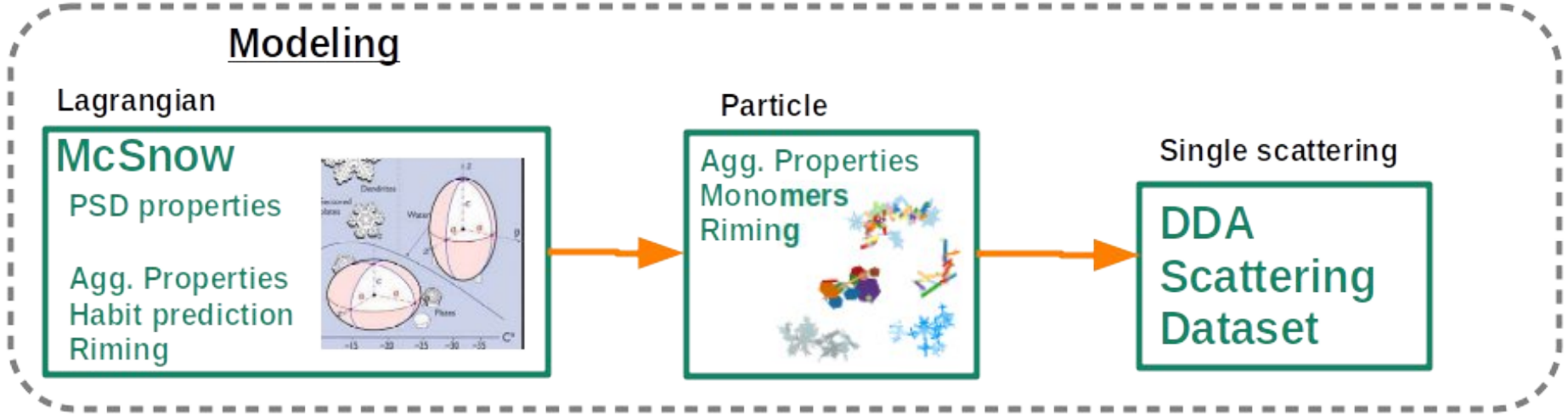

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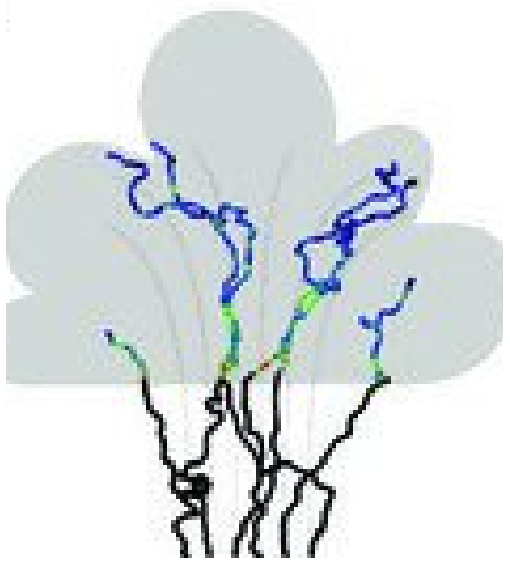

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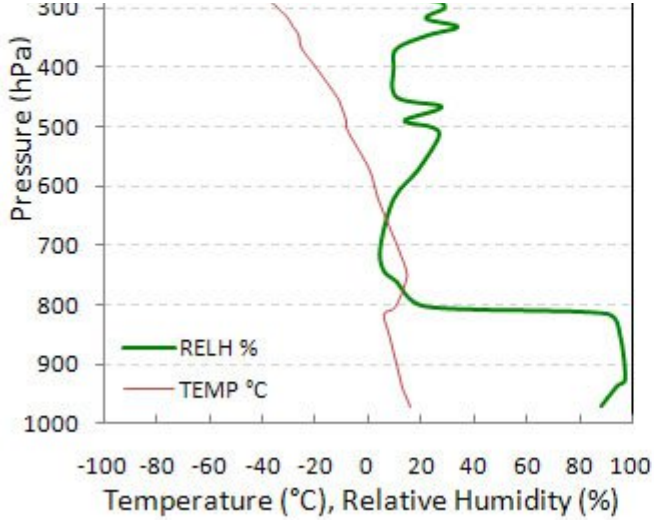
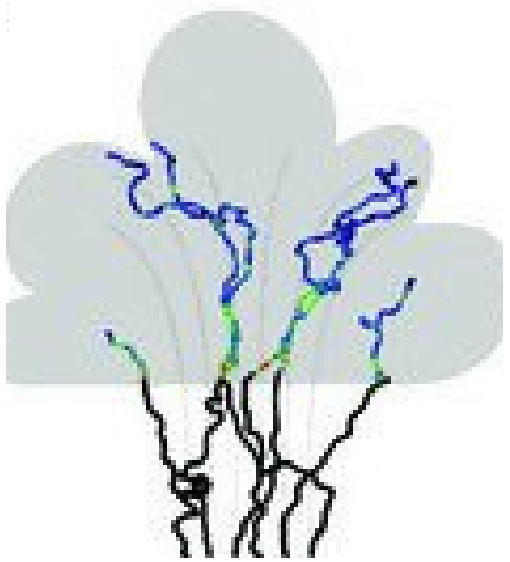


1 - Thermodynamic profile from ICON

Avoid arbitrary particle selection

McSnow



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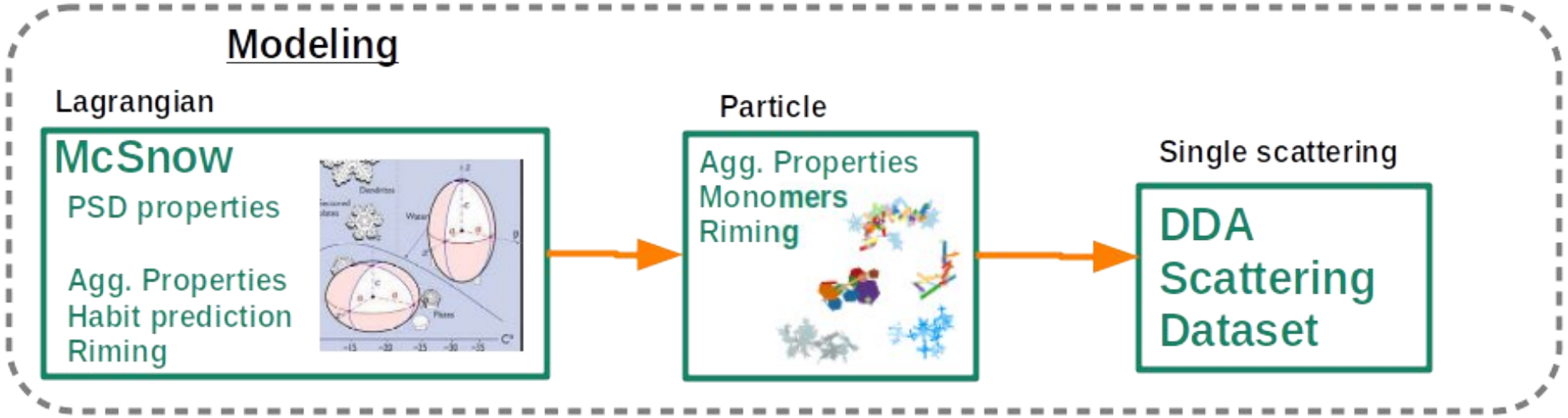

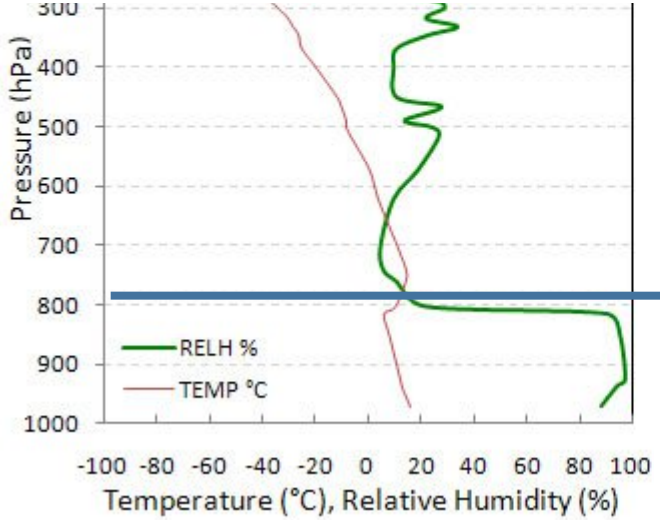

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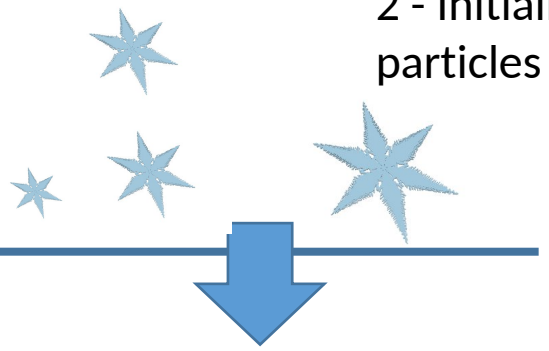
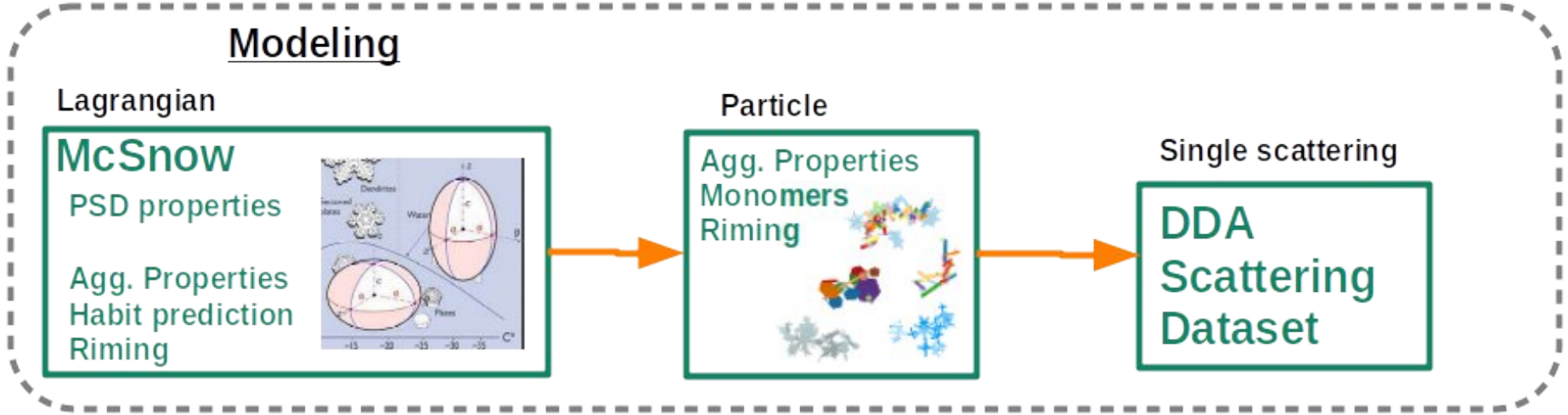
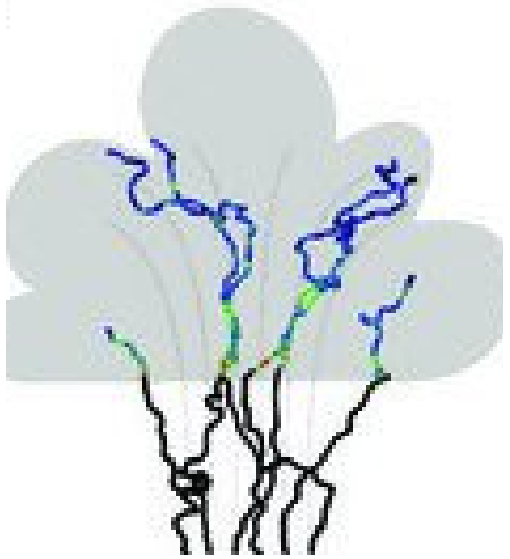


2 - Initialization layer - constant flux of particles with size distribution

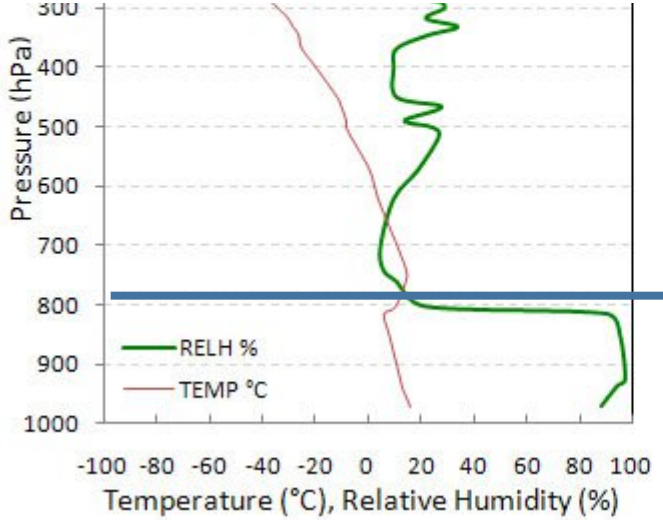
Avoid arbitrary particle selection



McSnow



Semi-Lagrangian 1D model (Brdar and Seifert, 2018) follows cloud particle trajectories

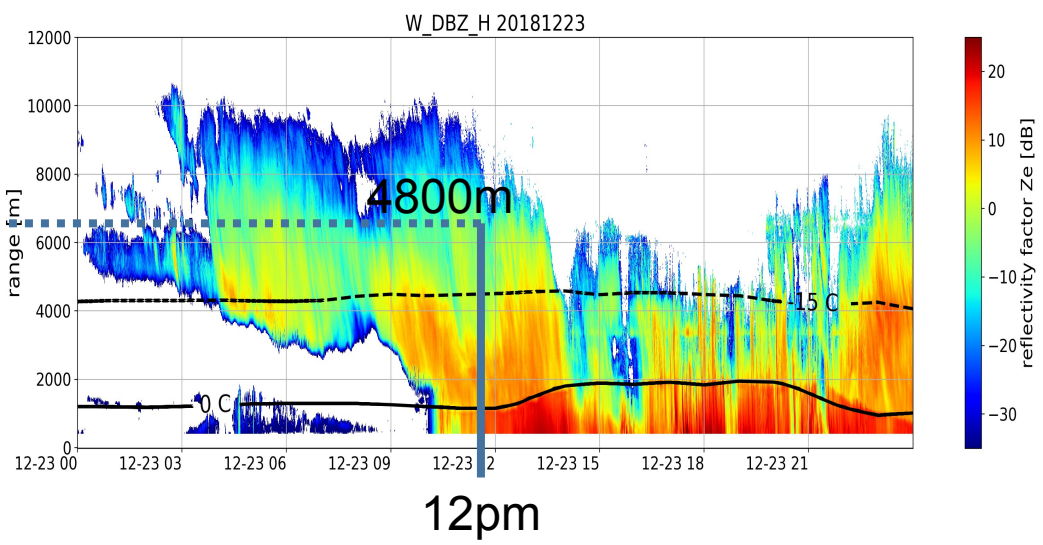


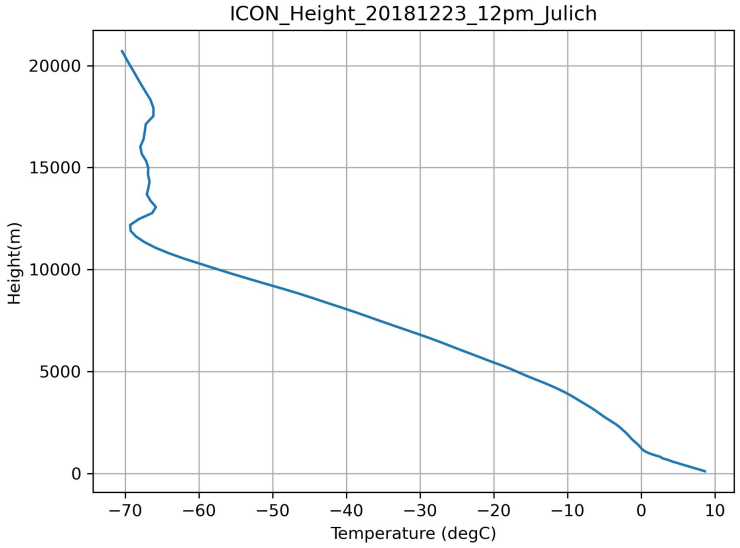
1 - Thermodynamic profile from ICON

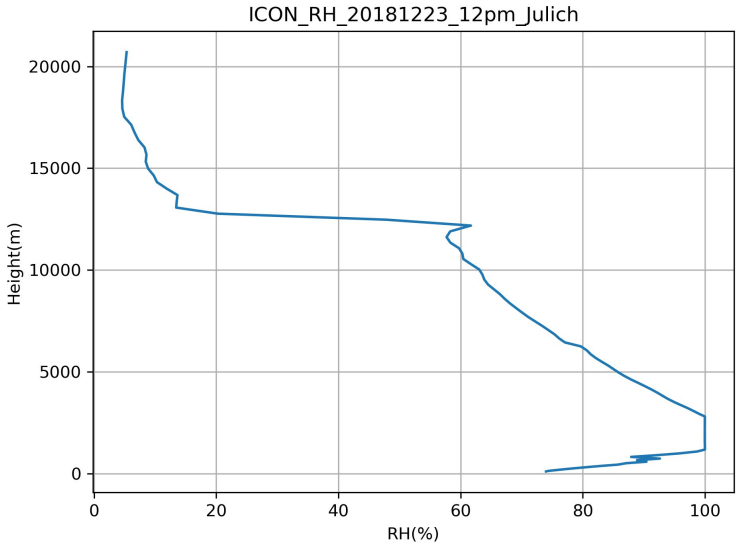
2 - Initialization layer - constant flux of particles with size distribution

3 - Lagrangian Microphysics
Sedimentation
Depositional growth
Aggregation
Riming
Melting
sublimation

Event Selection – TRIPEx-Pol 2018 campaign (Jülich) 23.12.23





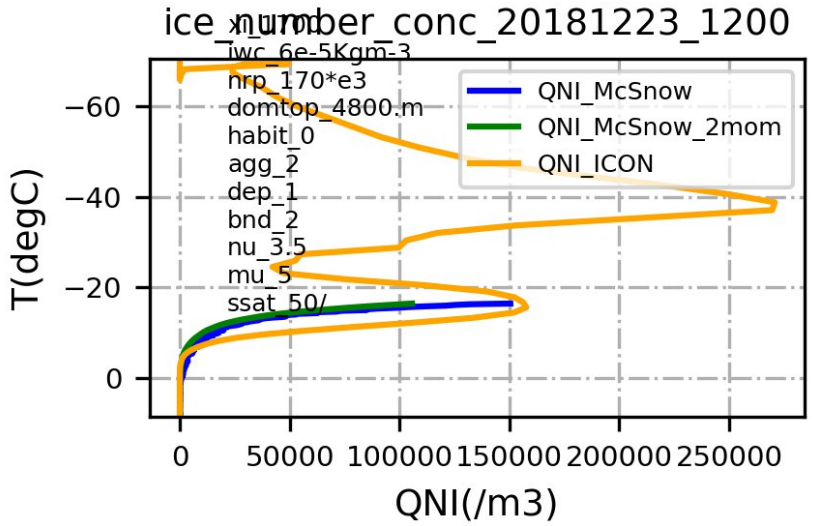


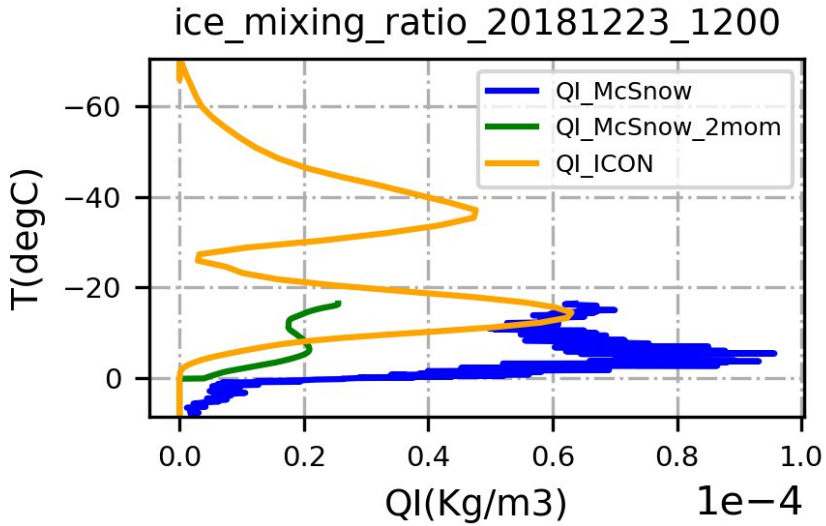
Important to check McSnow's performance for real physical cases

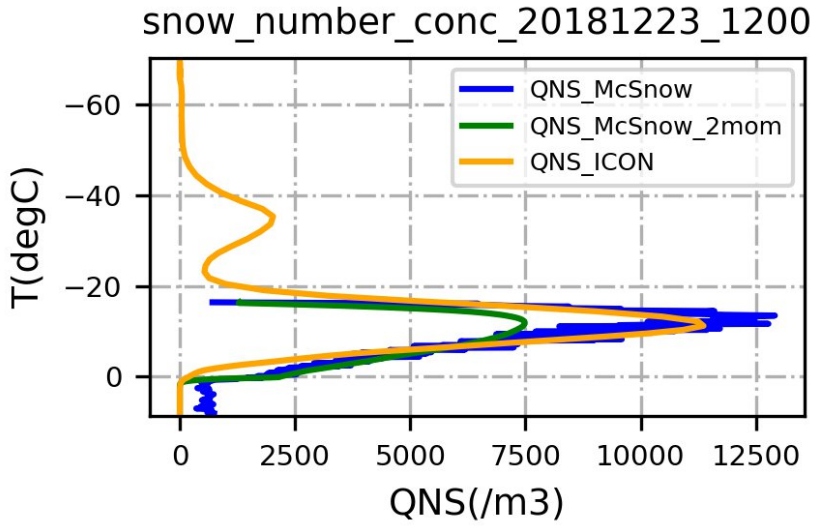
Selection of events where we find stratiform occurance of clouds

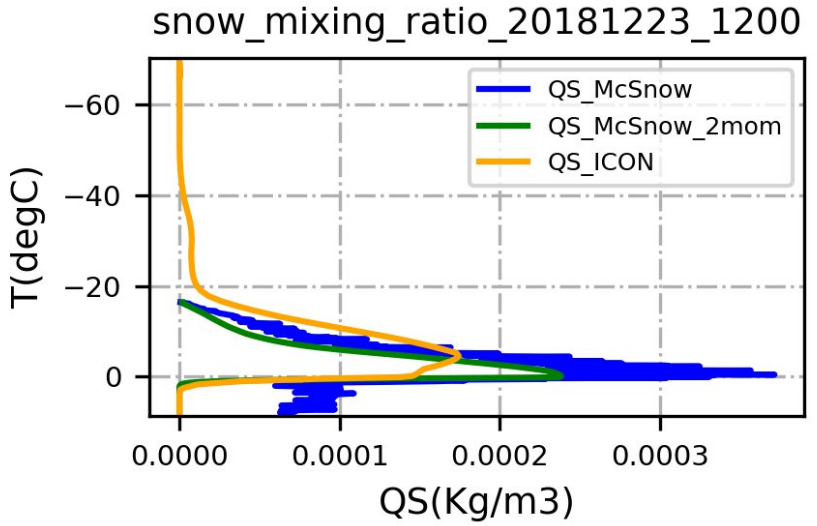
Also, to compare and check how the McSnow 1D microphysics does compare with ICON 3D microphysics

Event Selection – TRIPEx-Pol 2018 campaign (Jülich) 23.12.23



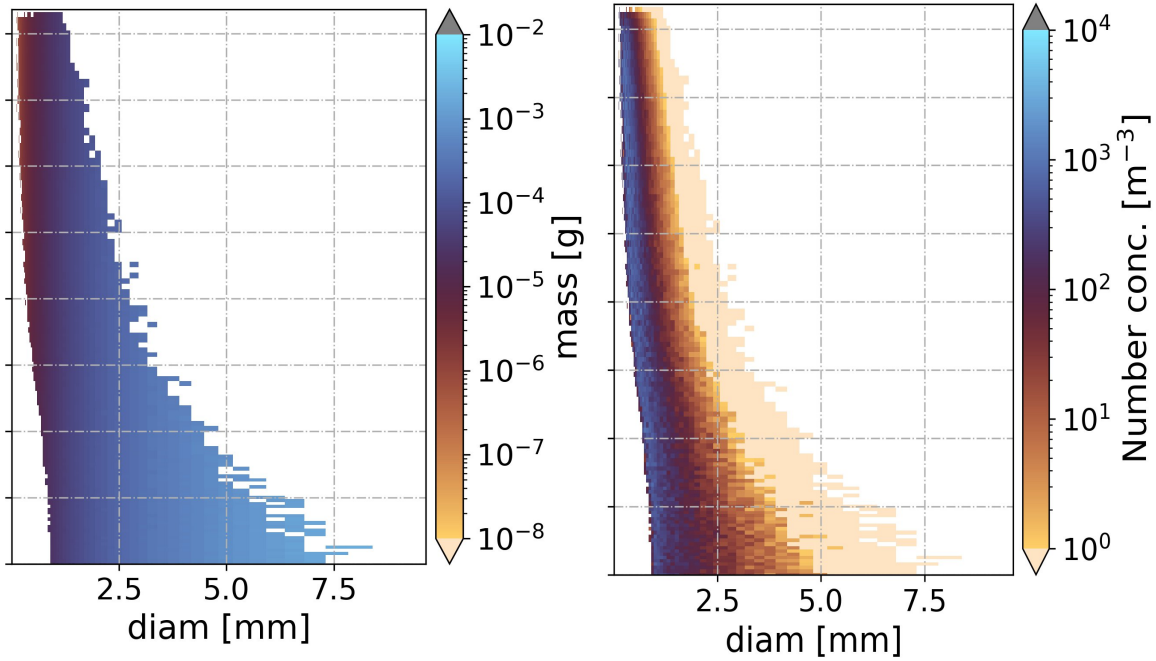


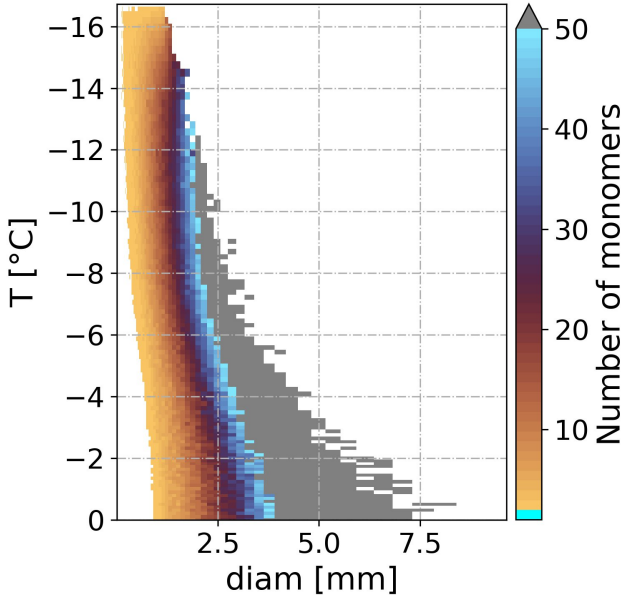




reseonable match with ICON 3D parameters we get

Detailed Aggregate properties

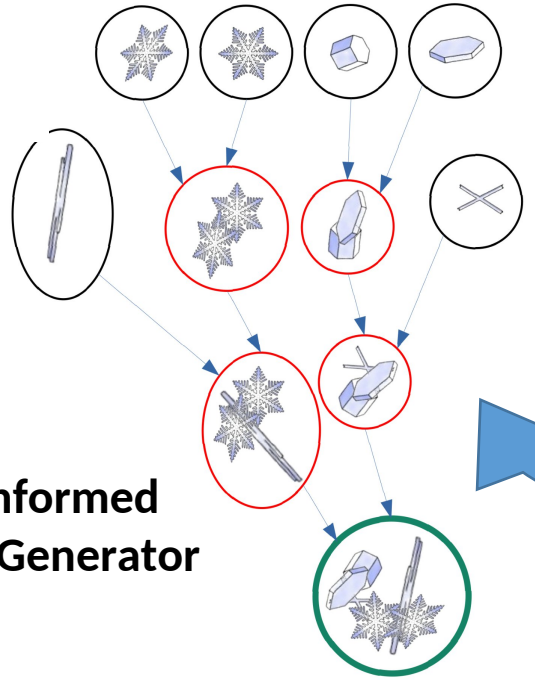




<u>Bulk properties</u>

Average mass-size relation

Size Distribution



Detailed model-informed Particle Generator

<u>Per Particle:</u>

Number of monomers

monomer mass distribution

shape information