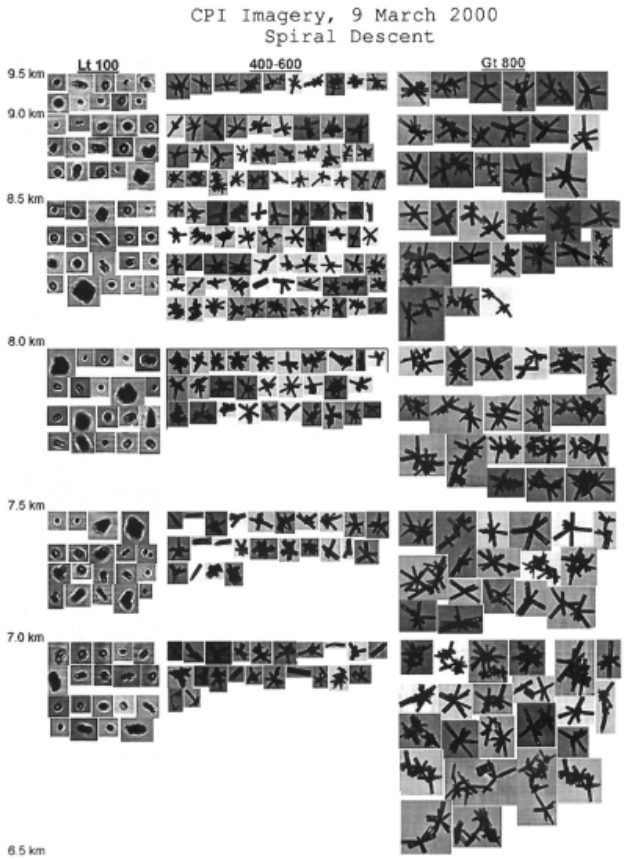
Particle Scattering Focus Group

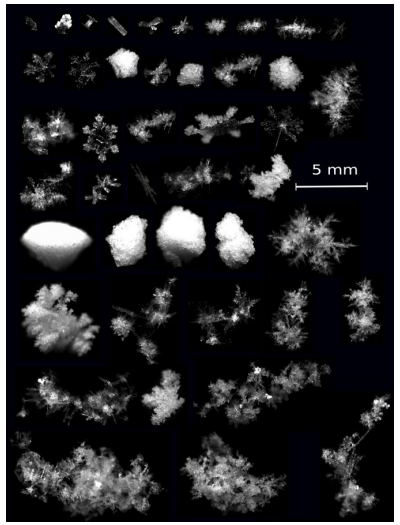
- Goal: Exchange ideas/works on:
  - How to build “radiatively” realistic particles (shape/density/structure/melting etc.) ?
  - How to efficiently compute/approximate their single scattering properties?
  - How to implement these properties in radiative transfer models or radar reflectivity computations?
  - What are the requests from algorithm development group regarding to scattering database?
- Activities:
  - Characterize ice particle shape/density/structure, etc.
  - Generate scattering database
  - Implement scattering database into radiative transfer models, constrained by observations
  - Want to hear: “I’d like to have scattering properties for such type(s) of particles”

Build “models” of particles

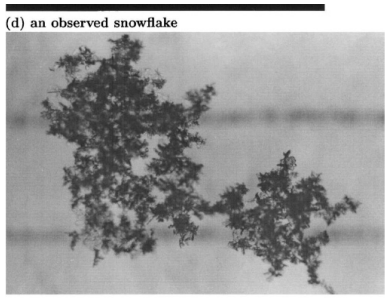
Real Worlds



Field & Heymsfield (2003)



MASC images
by Tim Garrett



Maruyama & Fujiyoshi (2005)

Idealized

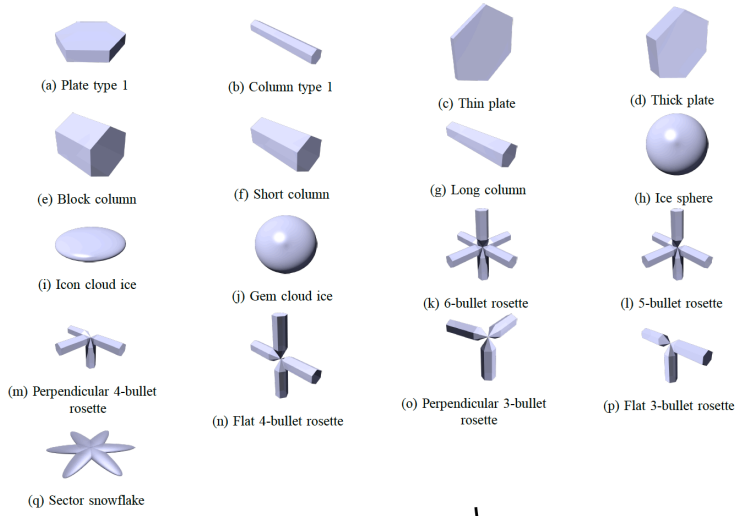


Figure 1. Single crystal habits included in the first database version. Shown particle orientation varies between the habits. Despite images **(h)** and **(j)** looking identical, they depict different particles; gem cloud ice **(j)** is a habit consisting of oblate spheroids with aspect ratio ≈ 0.92.

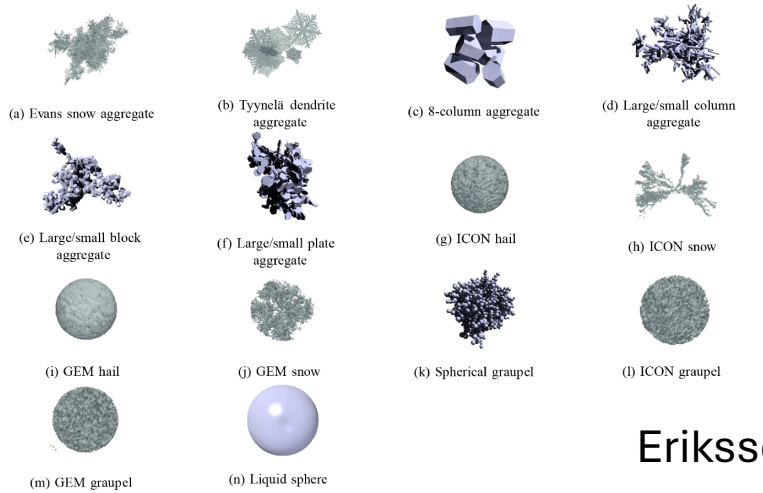


Figure 2. Aggregate and liquid habits included in the first database version. Shown particle orientation varies between the habits.

Eriksson et al. (2018)

Scattering Databases

Compiled by Kneifel et al. (2020)

Table 15.1 Databases of scattering properties for snow particles at microwave frequencies

Publication	Particle habits	Morphology	Size range (μm)	Frequency range (GHz)	Orientations	Scattering Method	Availability
Liu (2008)	N1e, C1e, C1g, C2a, P1a, P1c, P1f	Pristine	50–10000	13.4–340	Random	DDA	https://github.cam/rhoneyagar/scatdb
Pelty and Huang (2010)	N1e, P1e	Aggregated	125–10000	13.4–89	Random	DDA	Author
Botta et al. (2010)	N1e	Aggregated, melted	500–11000	3, 35.6	Horizontal	GMM	Author
Tyynelä et al. (2011)	P1e, P1f	Aggregated	200–24000	5.6–94	Horizontal	DDA	http://helios.fmi.fi/~tyynelaj/
Tyynelä et al. (2013)	N1e, P1a, P1d, C2a	Pristine, aggregated	450–8500	3–220	Horizontal	DDA	http://helios.fmi.fi/~tyynelaj/
Nowell et al. (2013)	C2a	Aggregated	800-12000	10.7-183.3	Random	DDA	https://github.com/rhoneyager/scatdb
Ori et al. (2014)	Cle	Aggregated, melted	1000–15000	5.6–157	Random	DDA	Author
Tyynelä and Chandrasekar (2014)	Nle, Cle, Pla, P1e, P1f, C2a, R4b	Pristine. aggregated	100–24000	2.7–220	Horiz., random	DDA	http://helios.fmi.fi/~tyynelaj/
Leinonen and Szyrmer (2015)	P1e	Aggregated, rimed	700–20000	9.7–94	Gaussian	DDA	Author
Leinonen and Moisseev (2015)	Nle, Pla, P1e, C2a	Aggregated	200–10000	13.6–94	Gaussian	DDA	Author
Lu et al. (2016)	Nle, Cle, Pla, Plc, Pld, R4c	Pristine, aggregated	100–62000	9.4–94	Horizontal	GMM, DDA	https://www.arm.gov/data/data-sources/icepa.rt-mod-120
Kuo et al. (2016)	N1e, P1a, P1c, P1d, P1e, P1f, P2c	Pristine, aggregated	260–14000	3–190	Random	DDA	https://storm.pps.eosdis.nasa.gov/storm/OSSPTest.jsp
Johnson et al. (2016)	N1e, P1e	Aggregated, melted	100–14000	13.4–183	Random	DDA	Author
Ding et al. (2017)	Cle, C1f, Pla, C2a	Pristine, aggregated	2–10000	1–874	Random	II-TM, IGOM	Author
Eriksson et al. (2018)	N1e, Cle, C1g, P1a, C2a, P1c, P1f	Pristine, aggregated	10–22000	1–886	Random	DDA, Mie	https://doi.org/10.5281/zenodo.1175572

Particle habits are listed according to the classification by Magono and Lee (1966)
Note that some of the databases include also particle types that are not classified, such as soft/solid spheroids

ARTS database

What are lacking?

- Need more understanding for riming and melting particles, particularly
  - Riming particles:
    - Need particle structure info
  - Melting particles
    - Need particle structure info
    - Need good scattering computation method
- Bridge Scattering Table Makers to Models/Algorithm Developers: which particle(s) are suitable for a given cloud/precipitation type?
  - Consistency studies
  - Implementation to radar/radiometer simulators

Suggested for focus group discussions

- Identify gaps in the scattering database
  - Crystals/aggregates with low b values?
  - Riming particles
  - Melting particles
- Enhance simulators with realistic particles
  - Radiometer simulators: RTTOV-SCATT, CRTM,…
  - Radar simulators (melting layer, etc.)
- Consistency studies
  - Model – observation consistency; Radar-Radiometer consistency
  - What to use in simulators: Guidance for data assimilations, algorithm developers --- from “reality” to “idealized”, or “what should be used as defaults in popular simulators?”

Survey Questions

- What are your interests in particle scattering studies:
  1. Ice particle microphysics (morphology, structure, density, …)
  2. Scattering computation methods
  3. Radar/Radiometer simulators
  4. Application of ice scattering table in algorithm development/data assimilation etc.
  5. Other _____
- For scattering table developers, what are the challenges for you to generate scattering tables
  1. How to generate realistic particles
  2. Suitable computational method
  3. Don’t know what users need
- For scattering table users,
  1. Couldn’t find the particle shape I want in existing tables, such as _____
  2. Don’t know what particle shapes are best suited for my study
  3. I’d like to have the scattering table arranged/archived in a way like _____
- I have the following suggestions to better coordinate studies among members in our group