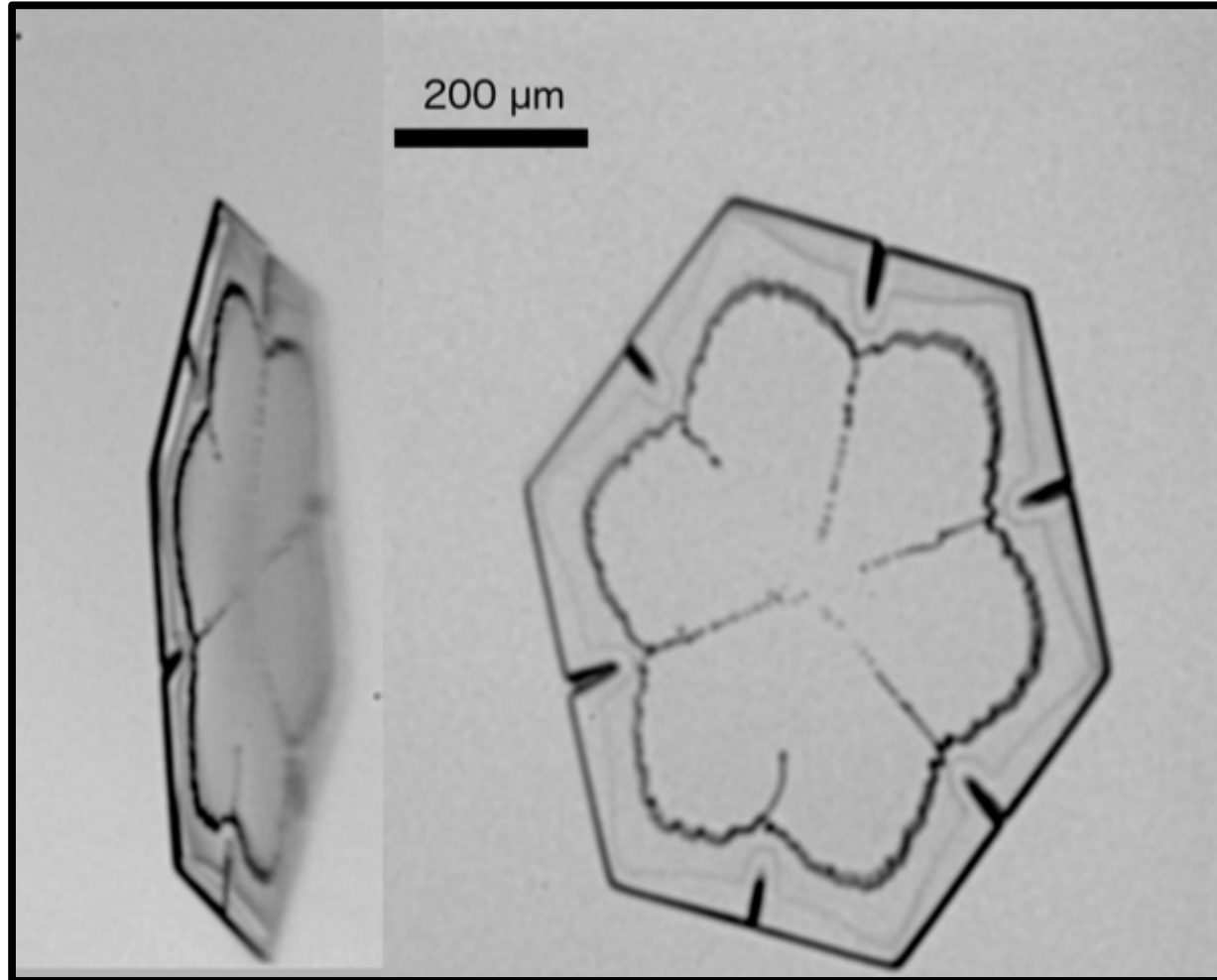


# Ice Crystal Growth



PHIPS images of plate crystal.

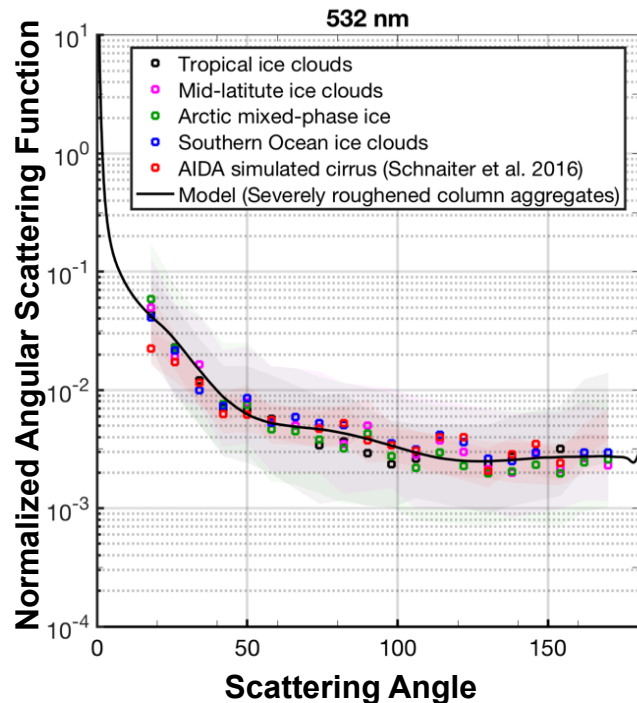
# Particle Habit Imaging and Polar Scattering (PHIPS) Probe



- Measure the angular light scattering function of individual cloud particles that are identifiable as belonging to a particular habit.
  - ➔ Improved remote sensing observations.
- Obtain high resolution stereo-graphic images with sufficient detail to improve understanding of riming and aggregation processes.
  - ➔ Improved cloud micro-physical modeling.
- Provide reliable phase identification on small and intermediate sized cloud particles.
  - ➔ Improved understanding of precipitation.

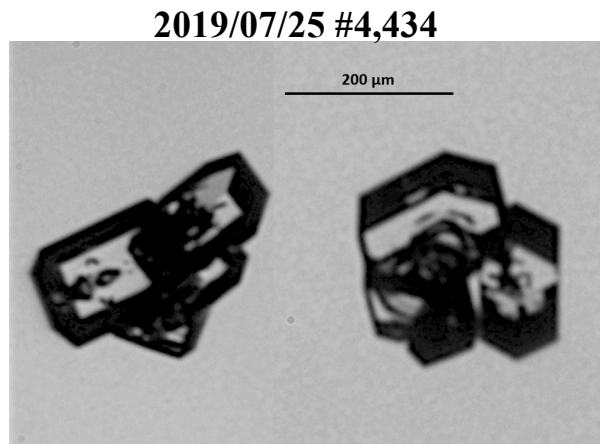
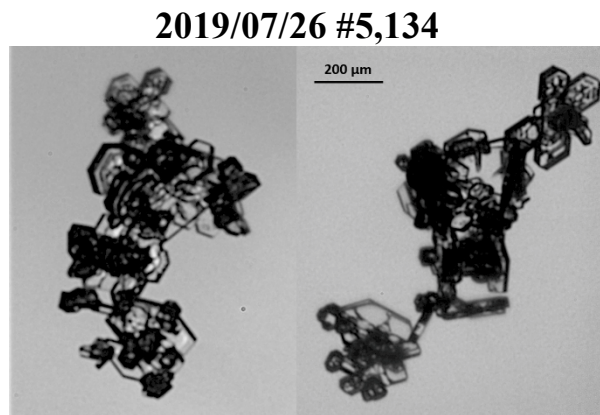
# Measurements and Observations of the PHIPS Probe

## Angular Light Scattering Function



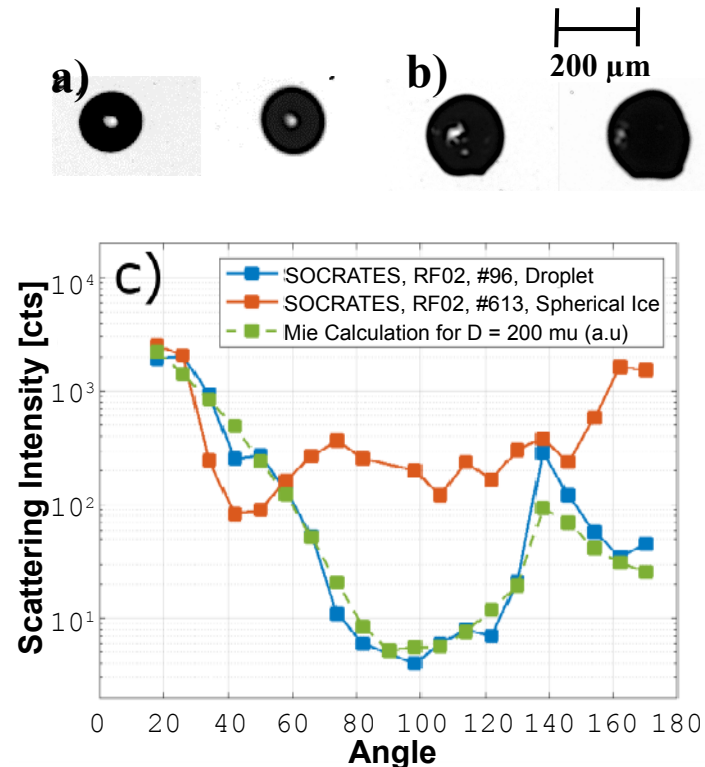
Averaged angular scattering functions from different campaigns, which was used to validate the MODIS C6 ice optical model (Järvinen et al., 2018).

## Stereo-graphic Images



Stereo image pairs obtained within Cirrus cloud anvils over Florida.

## Phase Identification



Stereo image pairs of a droplet (a) and a quasi-spherical ice particle (b), and the corresponding angular scattering function (c) (Waitz et al., AMT in preparation).

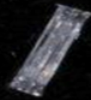


# Ice Crystal Types (Many Methods)

**Needle**



**Column**



**Bullet Rosette**



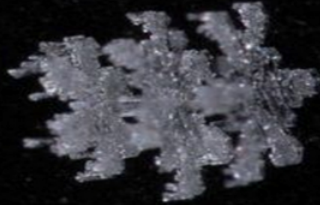
**Capped Column**



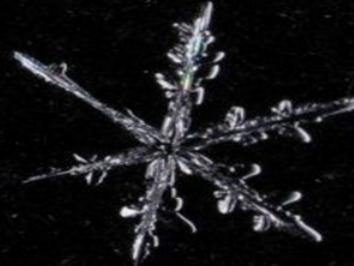
**Stellar Dendrite  
with Light Riming**



**Triple  
Capped Column**



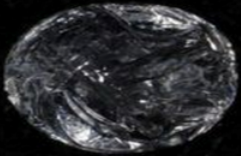
**Dendrite**



**Sectored Plate  
with Light Riming**



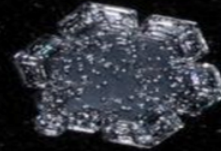
**Ice pellet**



**Sectored Plate**



**Plate with  
Light Riming**



**Plate**

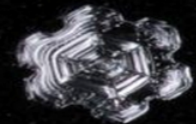
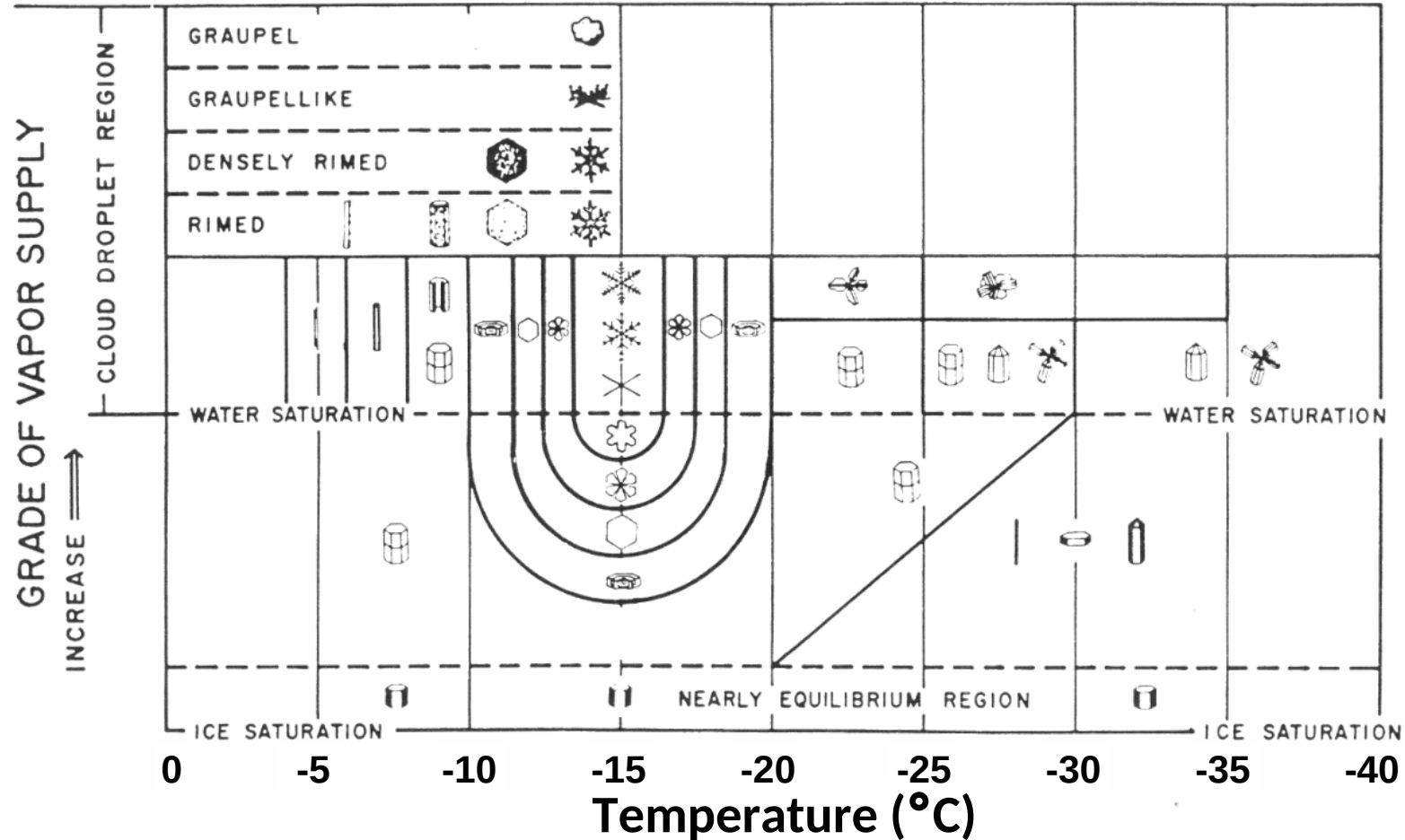


Image adapted from University of Manitoba.

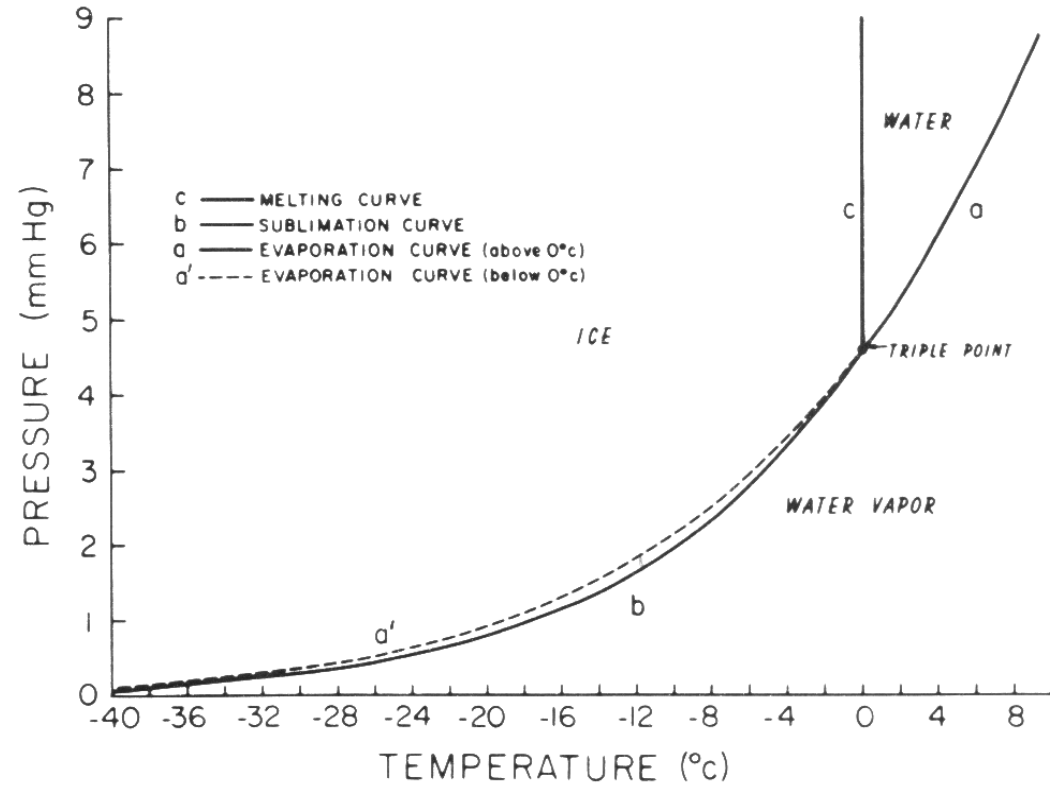
# Crystal Habit Formation



Habit depends on air temperature and vapor supply during formation.

# Clausius Clapeyron Equation

- Previous discussion related the vapor pressure in equilibrium with a pure, plane water (liquid) surface to temperature.
- If the water is frozen, however, the water molecules are held more securely to the surface and the amount of vapor in equilibrium with that surface is less.



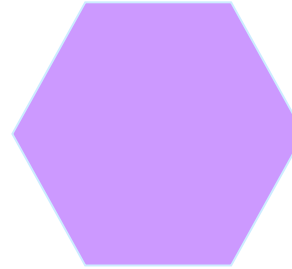
# Difference Affects Growth Rates

High Vapor Pressure

Lower Vapor Pressure



Diffusion



# Mixed Cloud (Ice and Liquid)

- Ice crystals will grow rapidly.
- Water droplets will evaporate.
- Large fraction of the ice crystals falling as precipitation tend to be stellar types, even though they form in a very narrow region of the temperature/ humidity conditions possible in clouds.
- Also get a large number of plate types of crystals.