On the Parameterization of Ice Vapor Growth in Numerical Cloud Models

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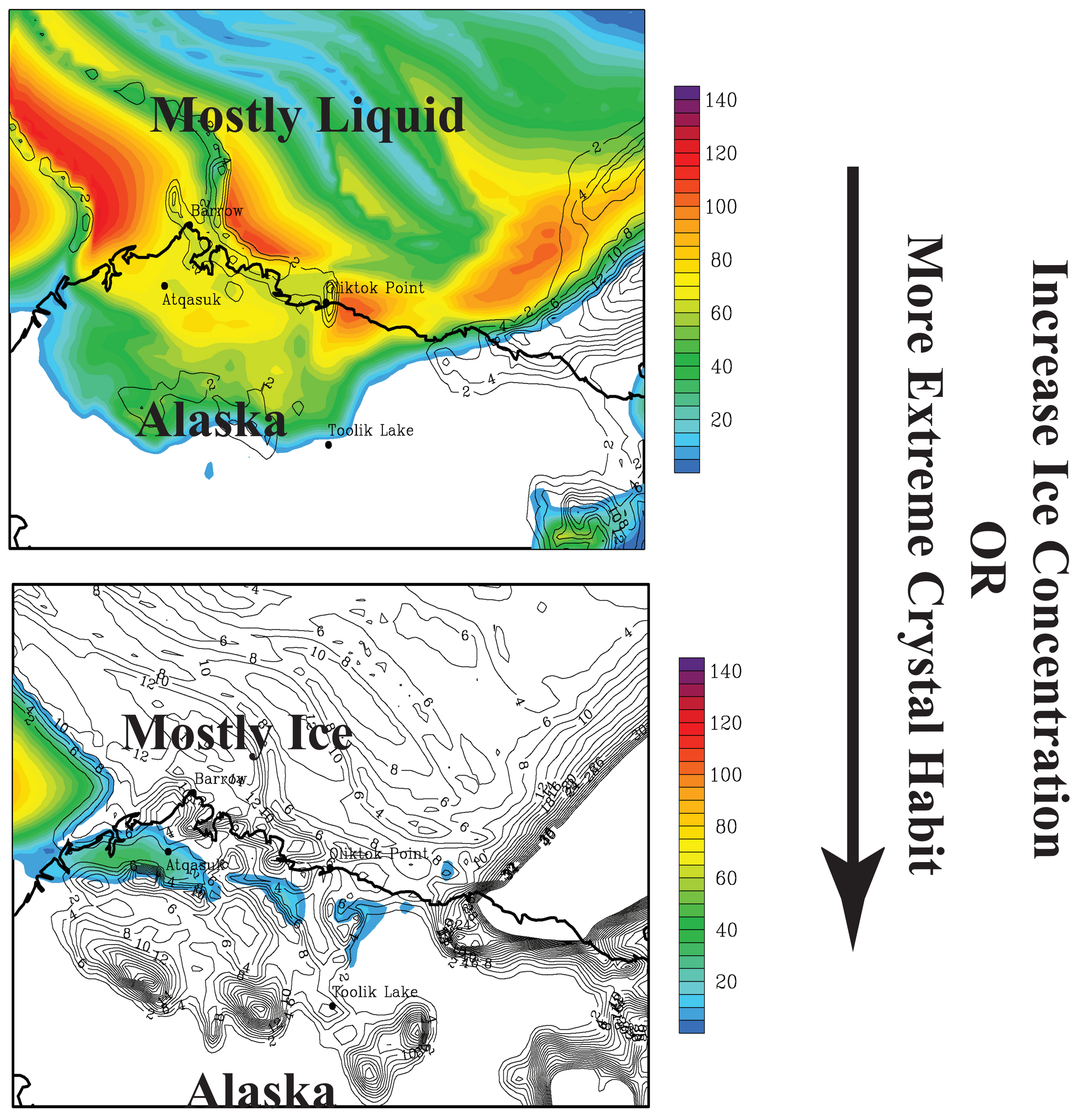
- Ice Vapor Growth Matters -

Mixed-phase clouds are common at low and mid-levels from the Mid-latitudes to the Arctic

Liquid tops that precipitate ice are common as are multiple-layer mixed-phase clouds



Avramov and Harrington (2010)

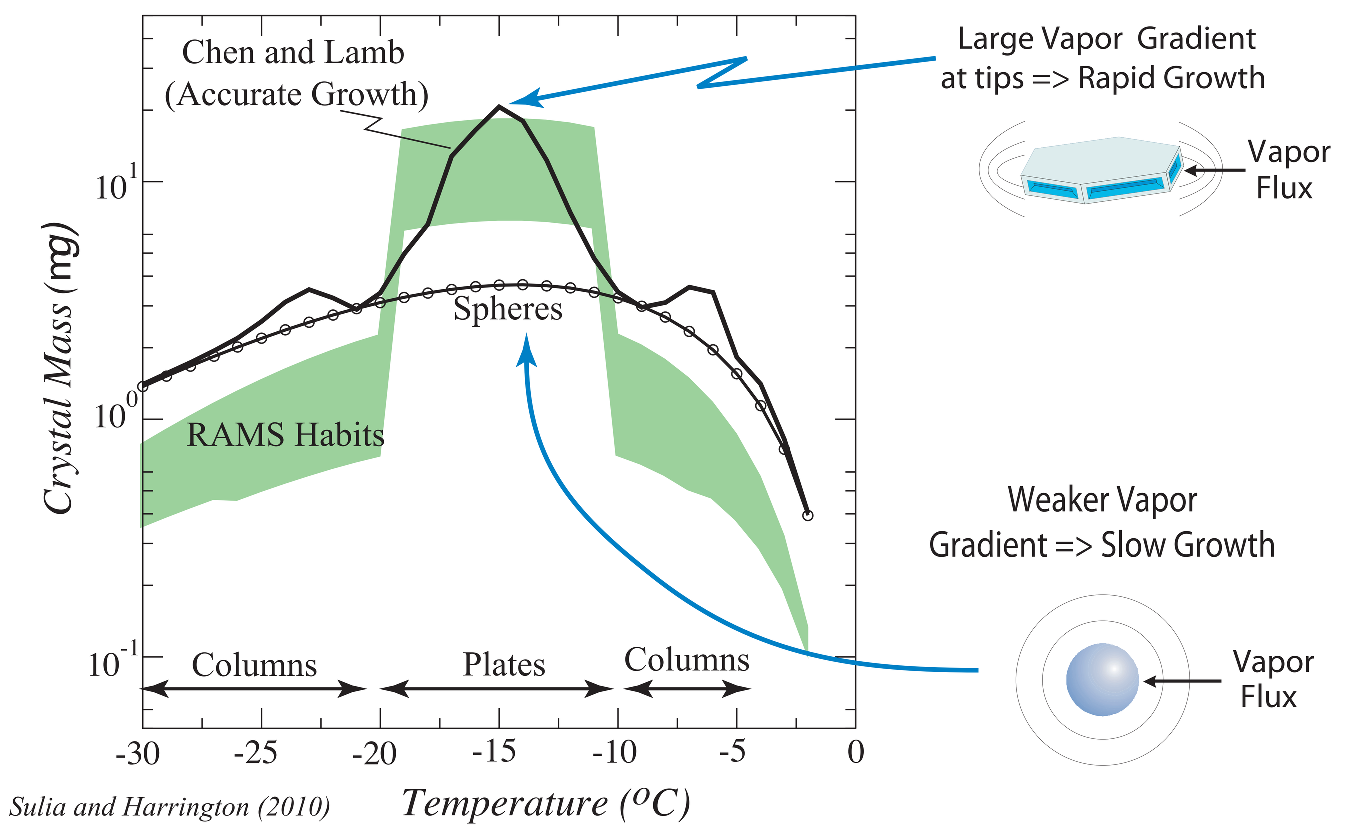
Glaciation occurs when small liquid drops are converted to large precipitating ice particles through vapor growth, which can eventually lead to cloud dissipation.

Time-Scale for Mixed-Phase Glaciation Depends on Ice Concentration and Ice Habit!

- Habit Parameterizations -

Crystal Habit → Strongly affects vapor growth rate
→ Current Models Employ Spheres or Simple Shapes that do not evolve!

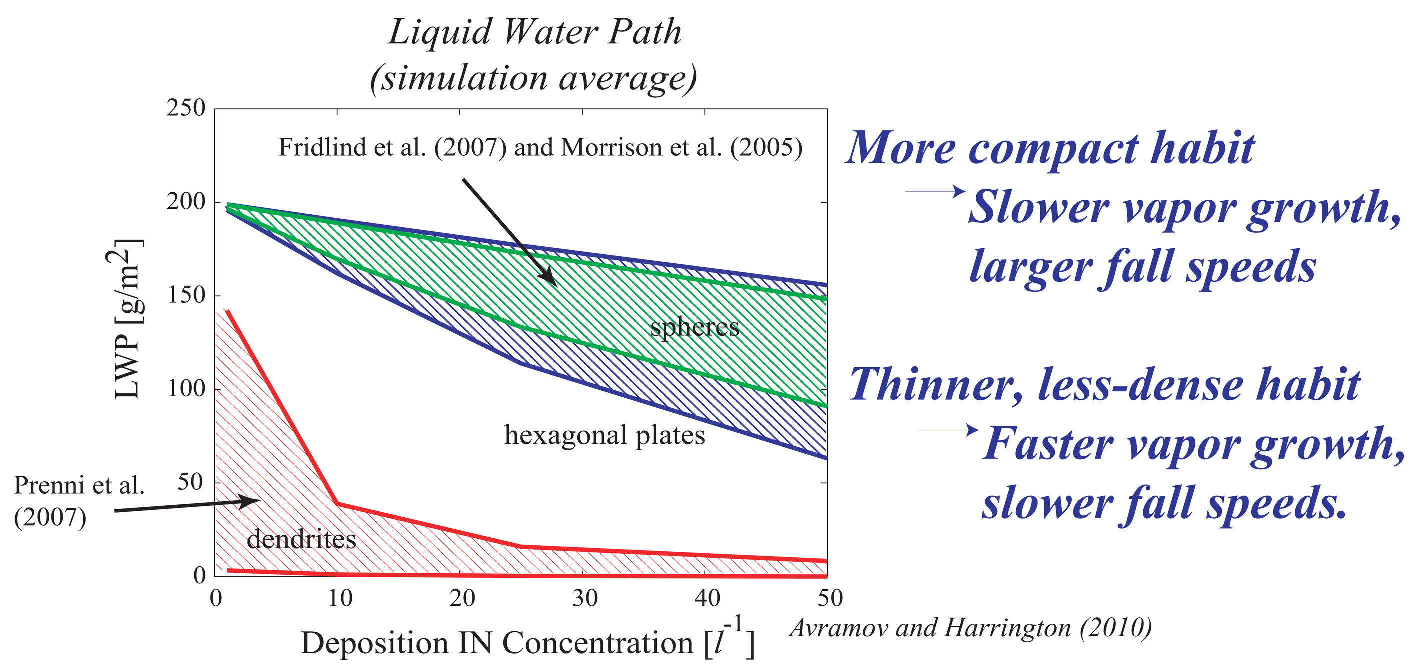
More "compact" habits → weaker growth rates
More "extreme" habits → stronger growth rates



Sulia and Harrington (2010)

Simple Habit Methods:

Simple Habit parameterizations lead to relatively large ranges of possible growth rates (above).
→ Large range of possible predicted liquid water paths in mixed-phase clouds for given ice concentration



Avramov and Harrington (2010)

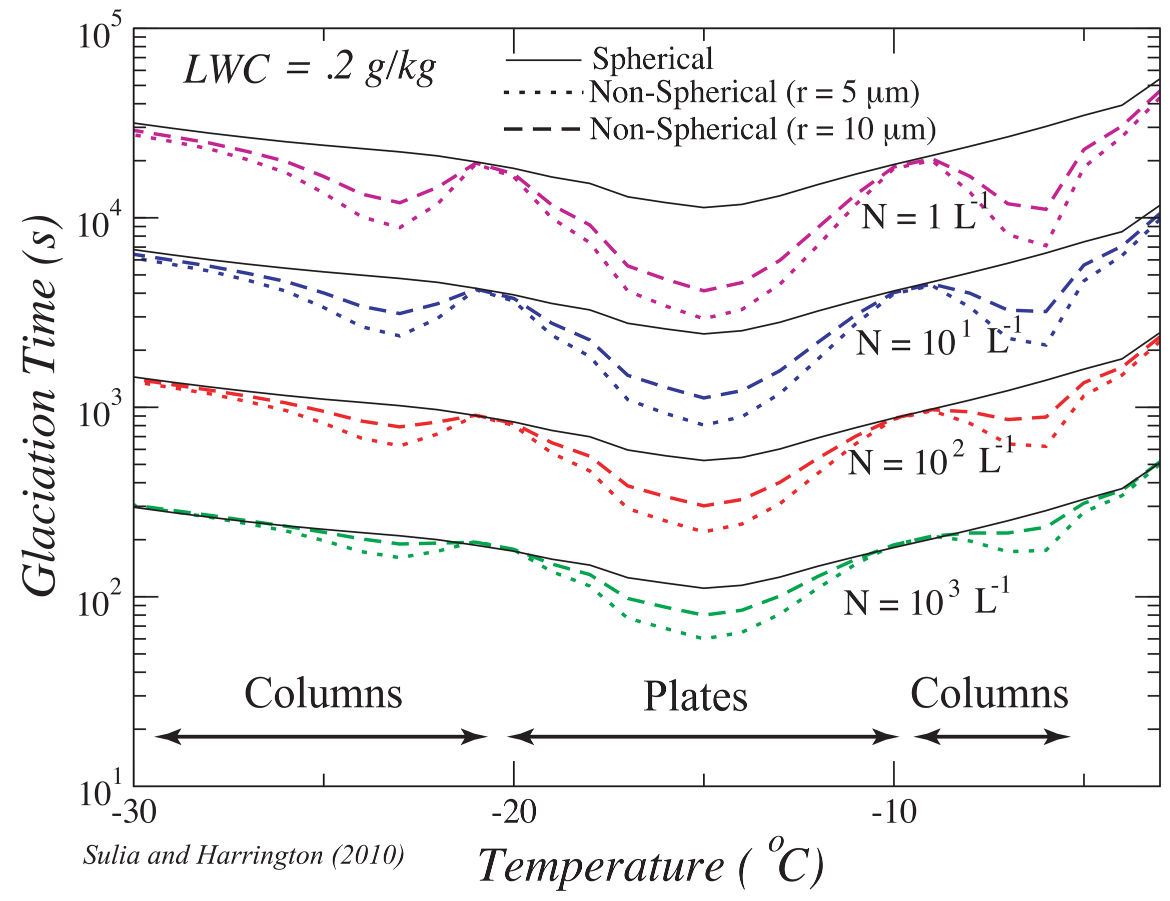
More compact habit
→ Slower vapor growth, larger fall speeds

Thinner, less-dense habit
→ Faster vapor growth, slower fall speeds.

Accurate Habit Methods:

Primary habit evolution can be predicted with first-order accuracy using the methods of Chen and Lamb (1994).

Detailed Computations with this method show that mixed-phase glaciation depends on concentration, habit, and initial size of the nucleated ice particles.



Sulia and Harrington (2010)

Mixed-Phase Glaciation

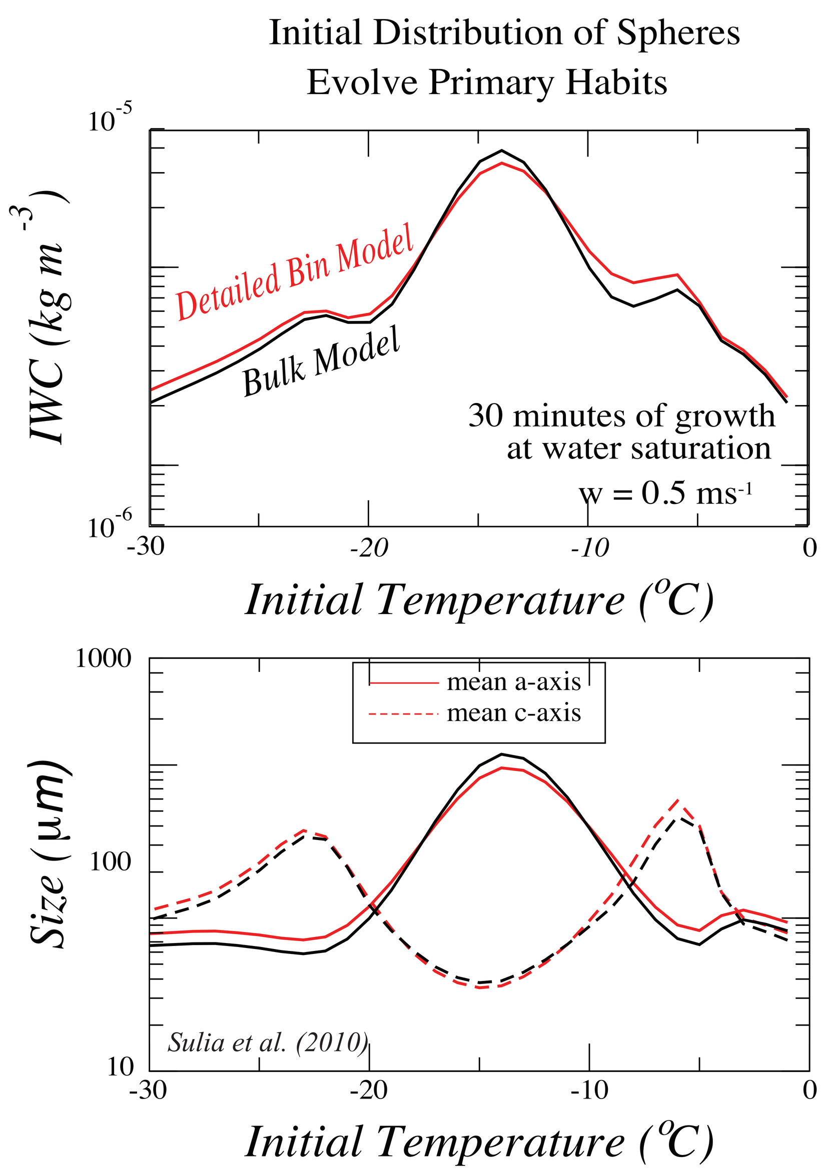
- → Depends on ice habit and initial size
- → ***Predicting a and c axes important:*** Shorter glaciation times at T where strong dendritic/column growth
- → Matches spherical models at T of habit transitions
- → Spherical methods underpredict growth by a large amount.
- → ***Higher ice concentrations:*** smaller differences with spherical growth.

- Bulk Habit Parameterization -

A new bulk habit prediction method has been developed which captures the evolution of primary habits and their influence on glaciation.

(1) The method tracks the shape history which simplifies computation.

(2) This simplification makes the method applicable to bulk cloud models.

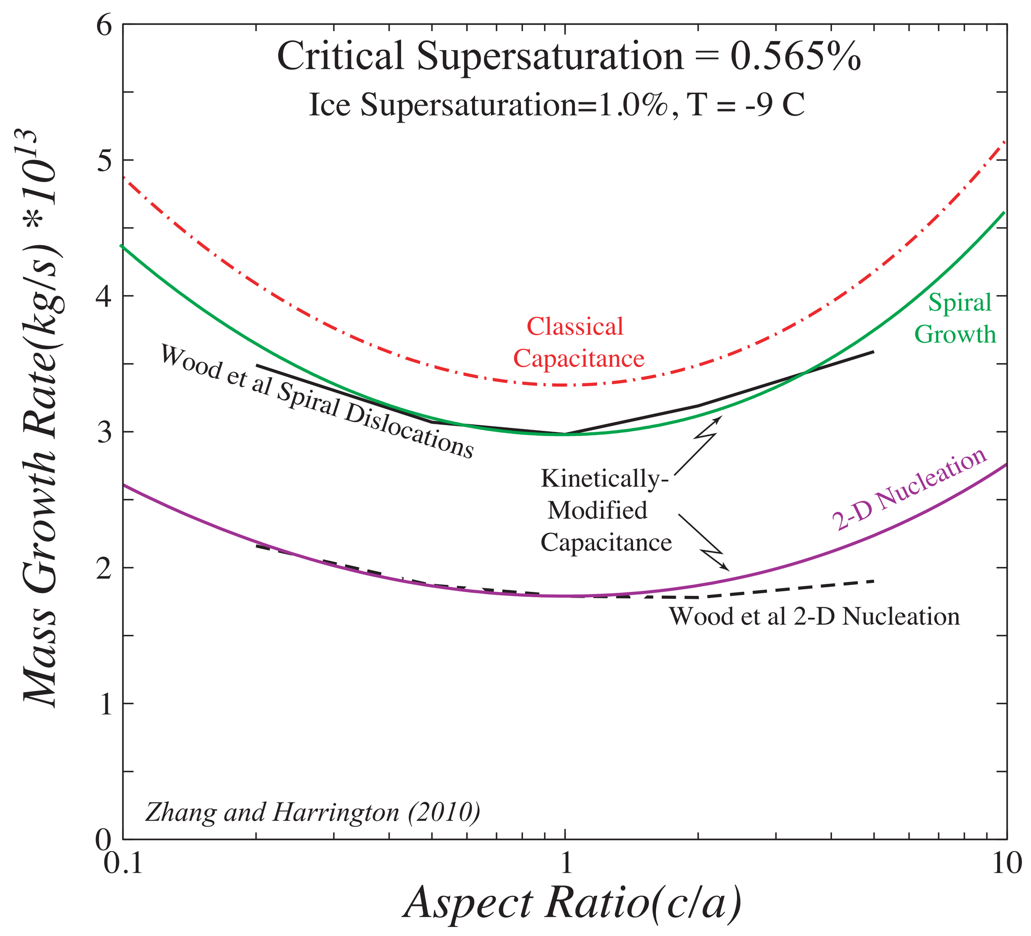


The method accurately evolves initially-spherical ice into non-spherical habits and compares well to a detailed bin model that tracks crystal habit.

- Surface Kinetic Resistance -

At low ice supersaturations not all vapor molecules are incorporated into the ice crystal surface.

Growth rates are reduced drastically, but current vapor growth methods do not account for this consistently.



A kinetically-modified model has been derived in order to correct growth at low ice supersaturations. The method compares well with results from detailed crystal growth models.

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