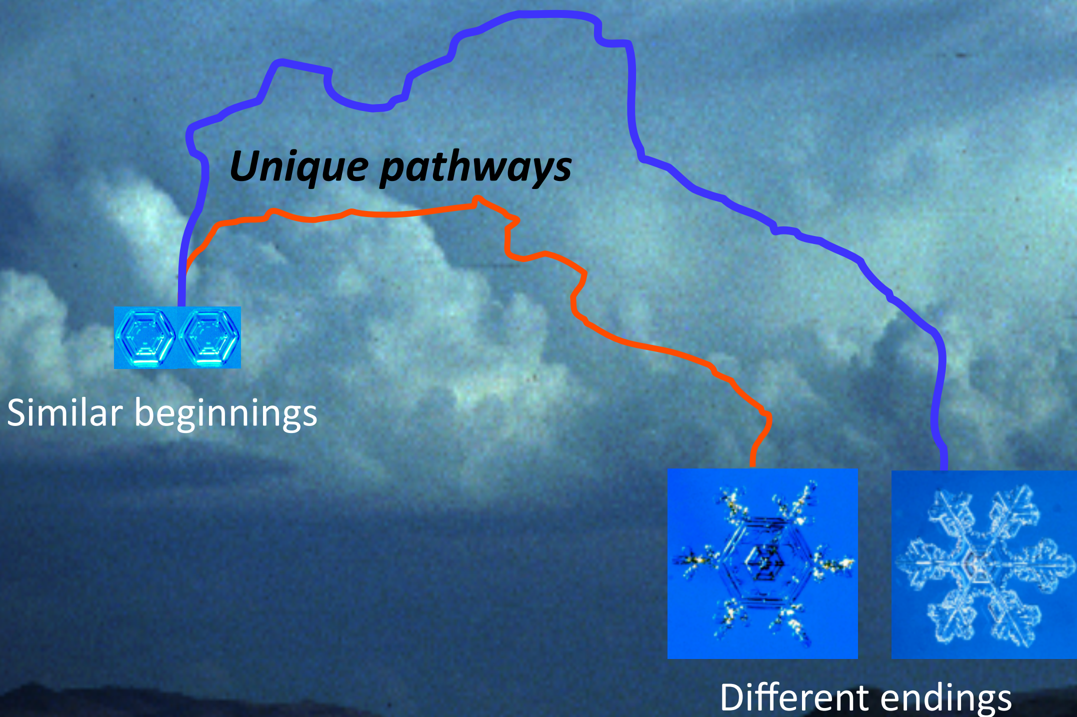
# Impacts of Bulk Ice Habit Evolution on The Microphysical Characteristics of Mid-Latitude Squall Lines.





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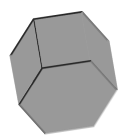
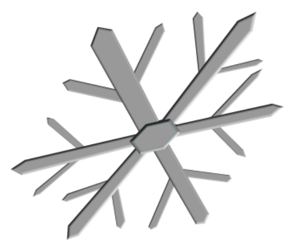
*Department of Energy*

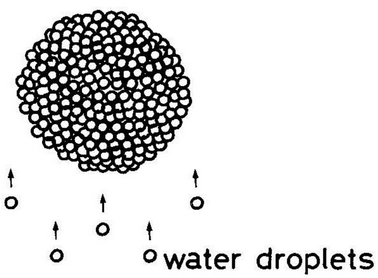
# *Traditional Bulk Modeling Methods*

*Define Classes of Ice:*

*Small ice* *snow* *graupel*



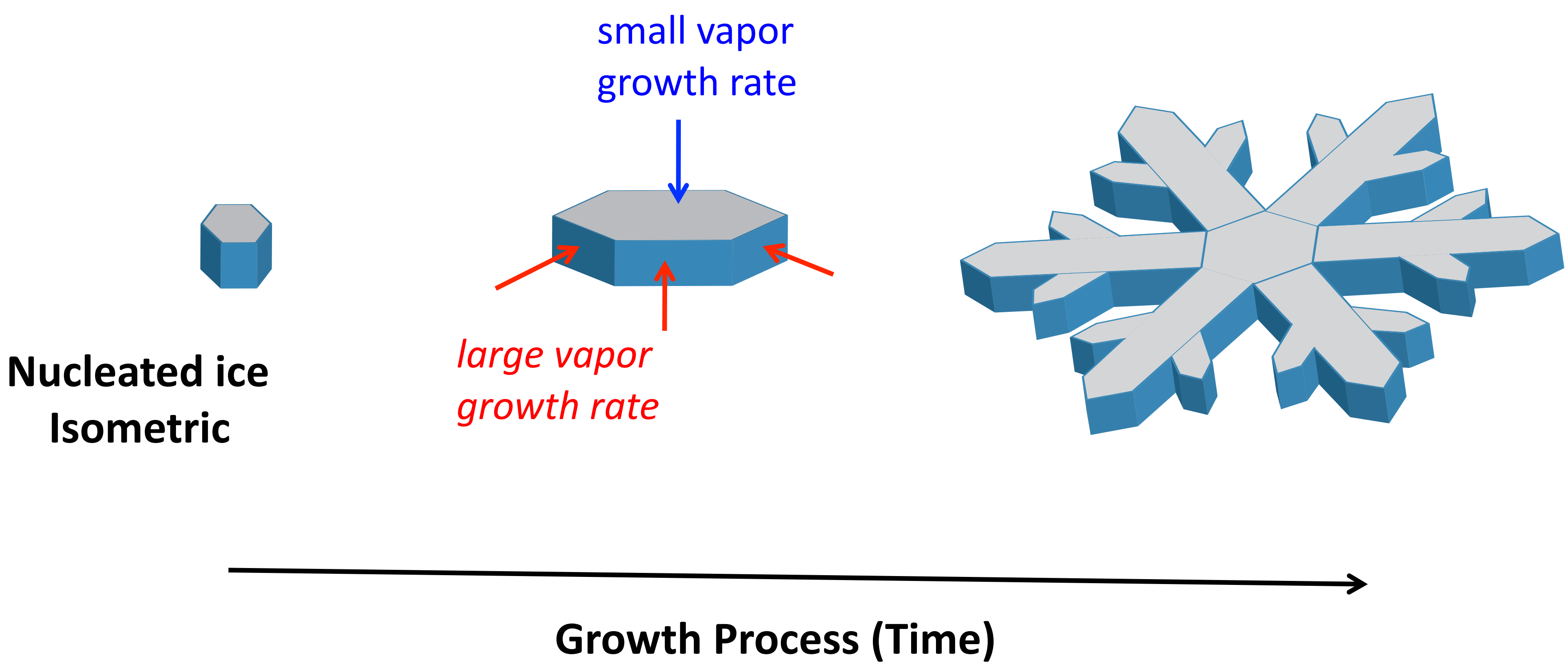





*Rate equations used to transfer particles among classes.*

# - Bulk Habits: Gradual Transitions –

## *Vapor Growth*



# - Bulk Habits: Gradual Transitions –

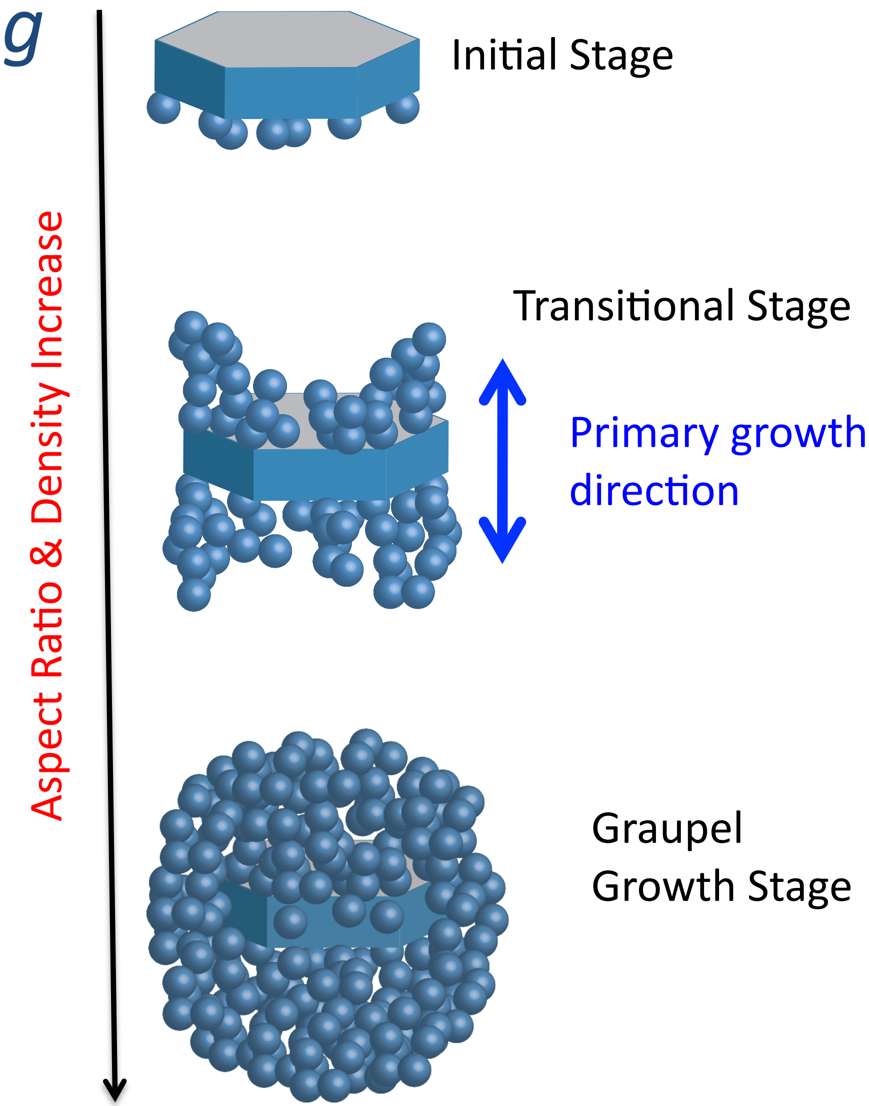
## *Riming*

Transition state modeled

Minor axis collects liquid first

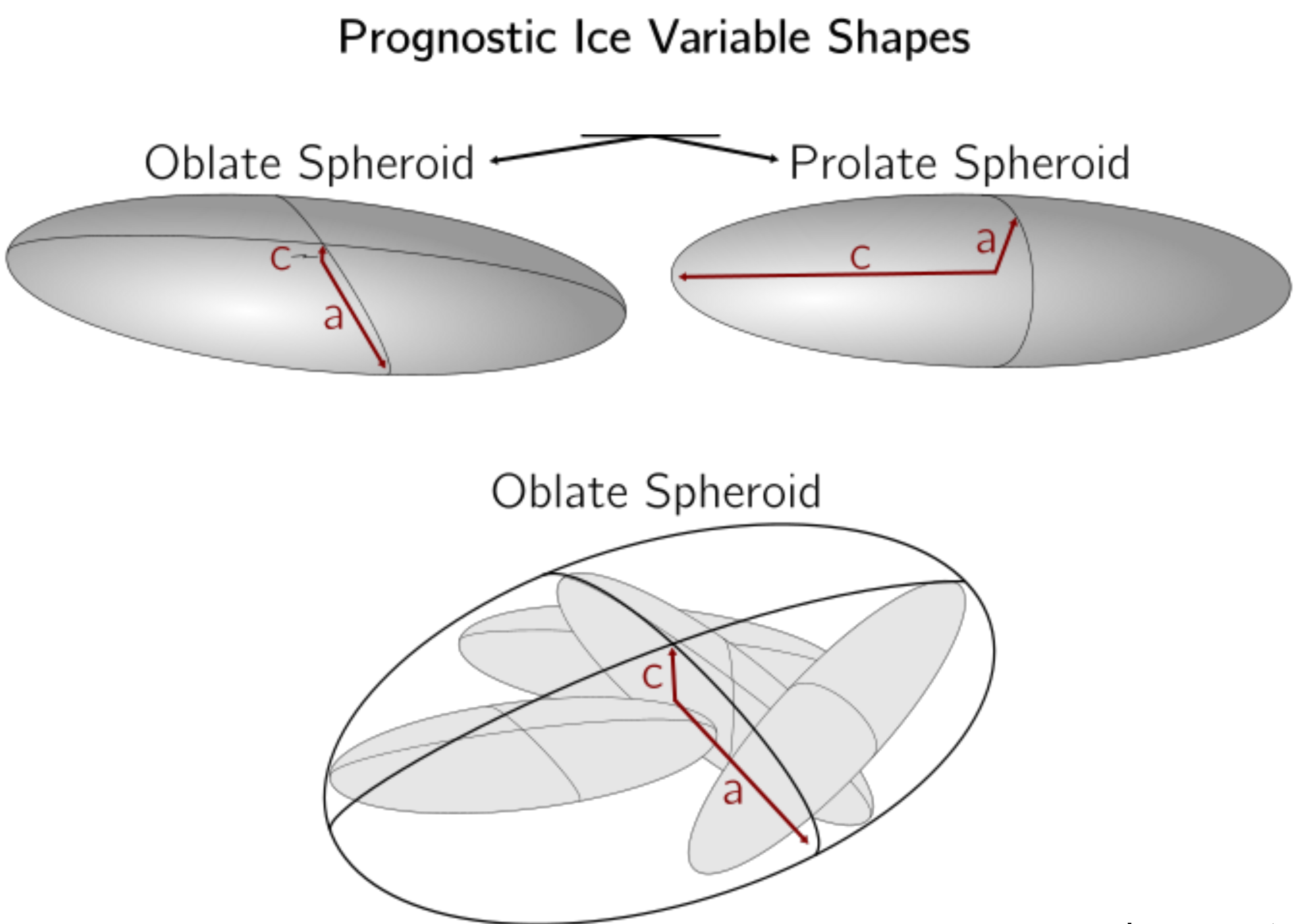
Collection efficiencies: Theory/data

Density added during growth
derived from lab measurements




*Jensen and Harrington (2015)*

# - Bulk Spheroidal Habit Model –




Jensen et al. (2017)

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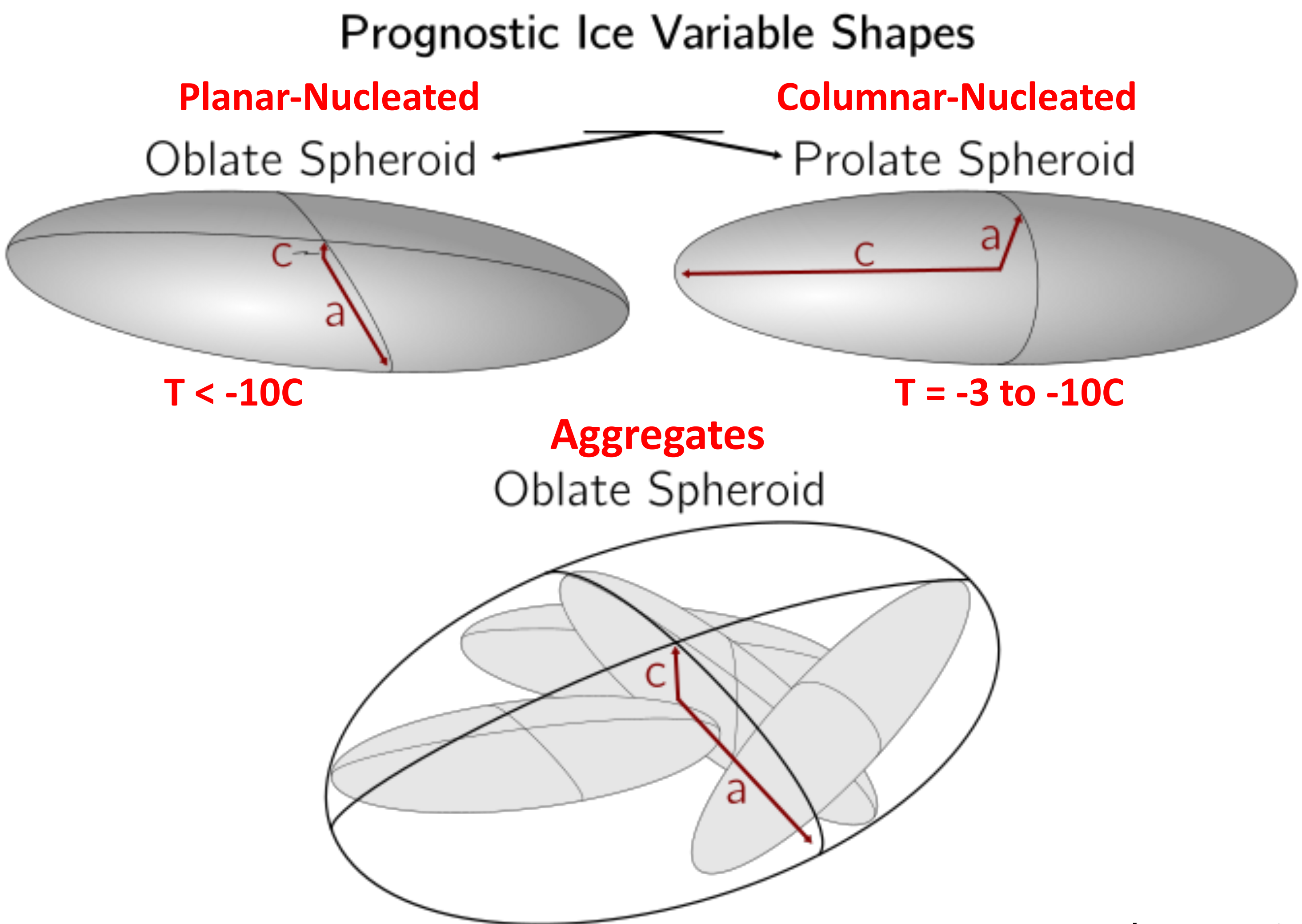



Jensen et al. (2017)

# - Habit Evolving Microphysics -

*Prognostic Variables:*

*(1) Mass mixing ratio*

*(2) Number mixing ratio*

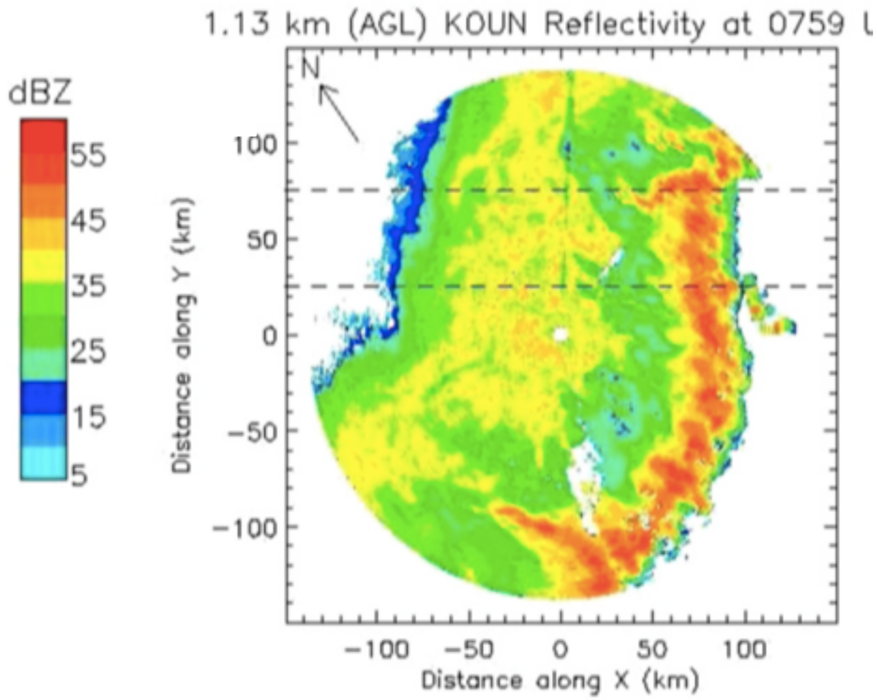
*(3) Effective density (volume mixing ratio)*

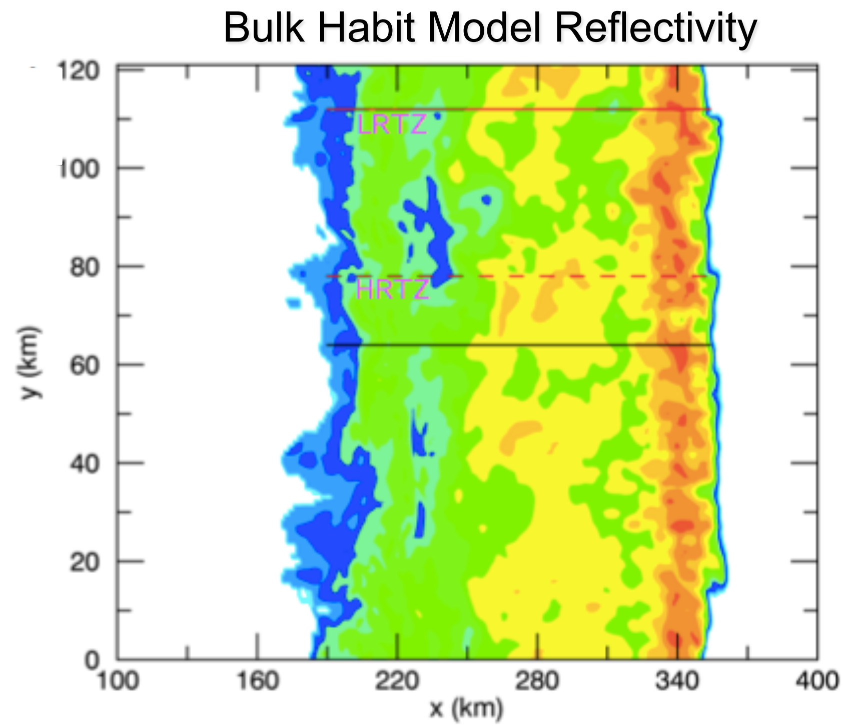
*(4) Aspect ratio (aspect ratio*volume mixing ratio)*

*Ice Formation: homogeneous, heterogeneous nucleation*

*secondary ice production (rime-splintering)*

# - Squall-line Case (2007) -




*Control simulation captures basic features:*

*leading convective line, transition zone,*

*extended stratiform precipitation region*

Jensen et al. (2018)

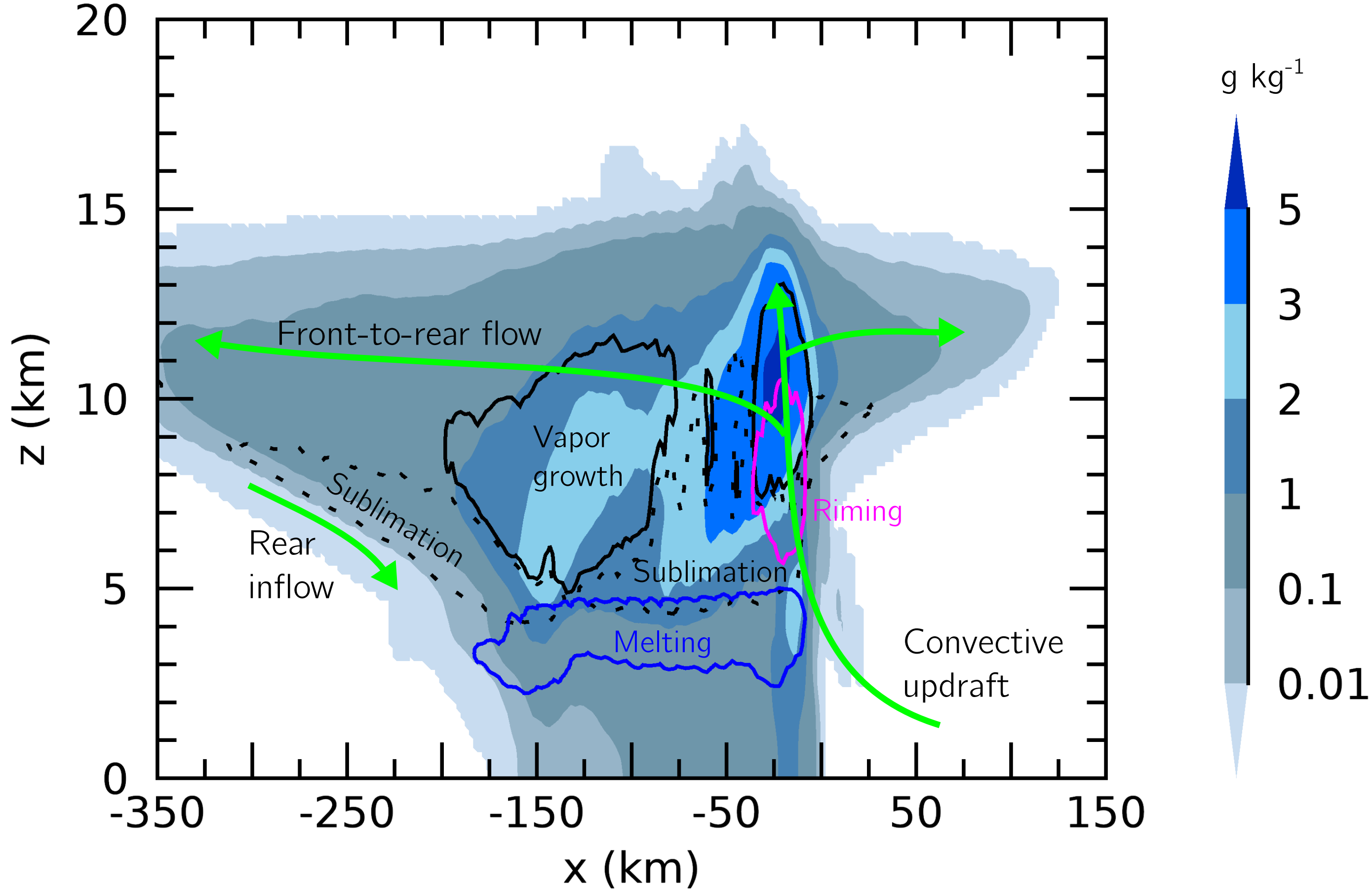
# - Squall-line Case (2007) -

*Many models have trouble reproducing these observed features (Morrison et al., 2015 and others)*

*What microphysical processes led to the simulated structure?*

*How does predicting shape and effective density contrast with traditional methods with more abrupt transitions in particle characteristics?*

# - Microphysical Processes -




Jensen et al. (2018)

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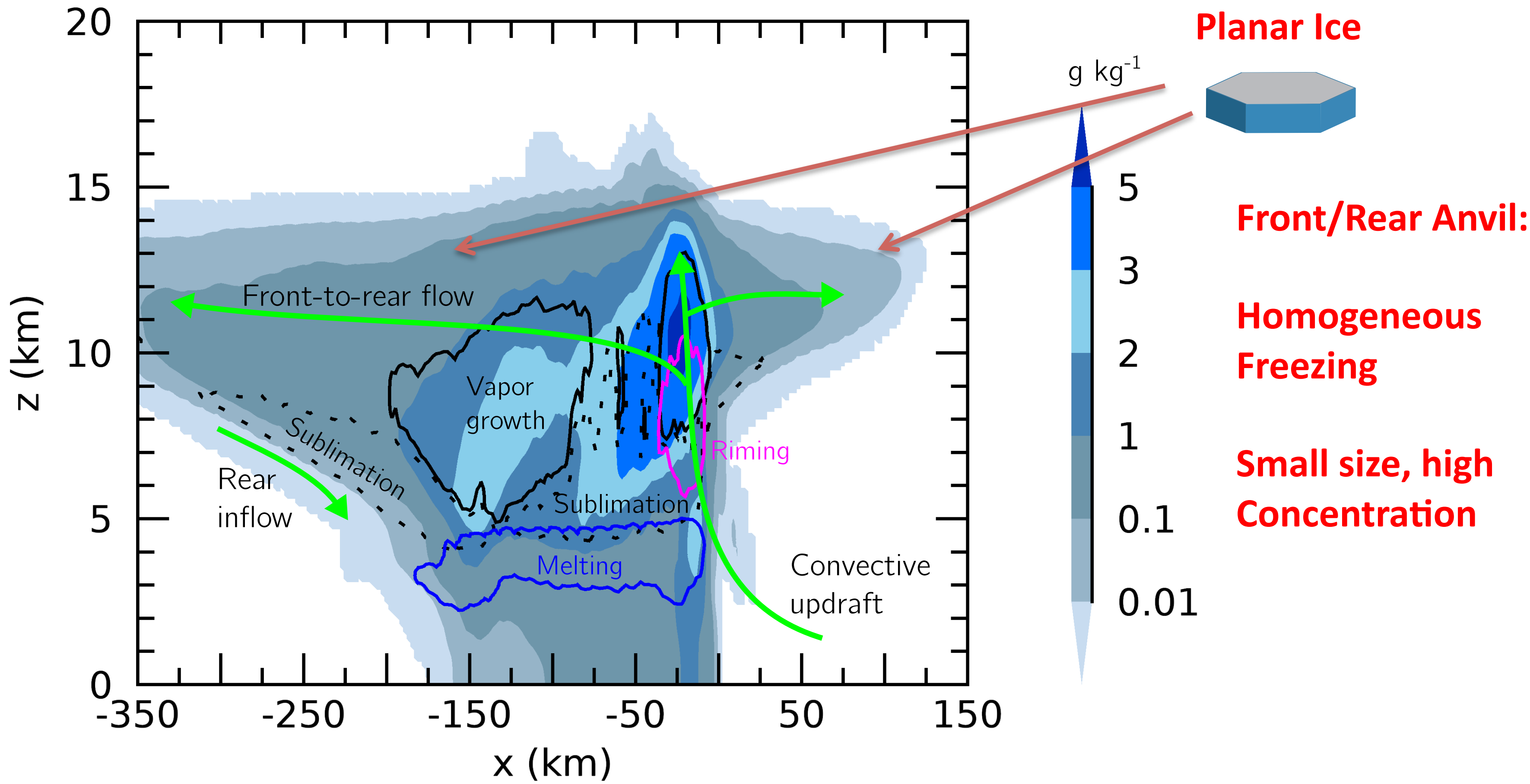


Jensen et al. (2018)

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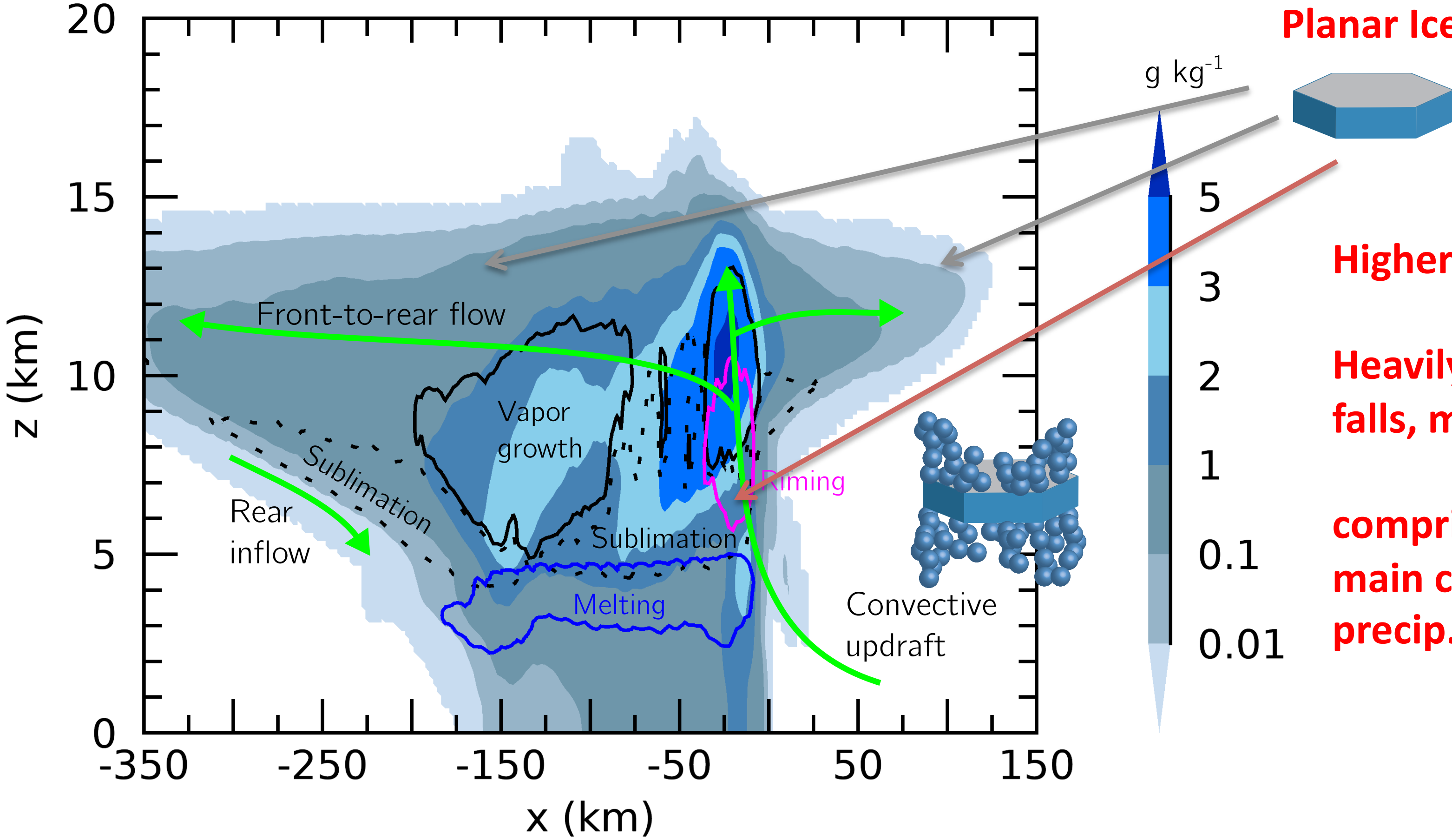


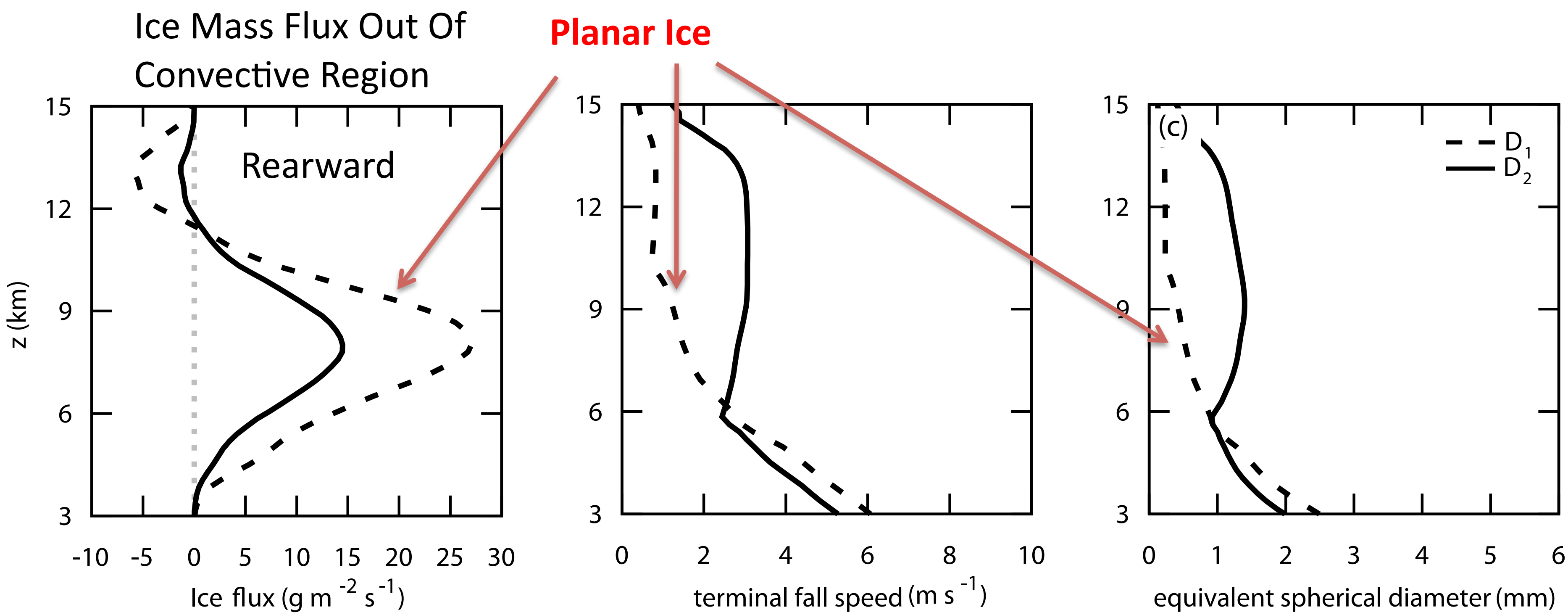

**Higher T:**

**Heavily rimed, falls, melts**

**comprises main convective precip.**

Jensen et al. (2018)

# - Microphysical Processes -

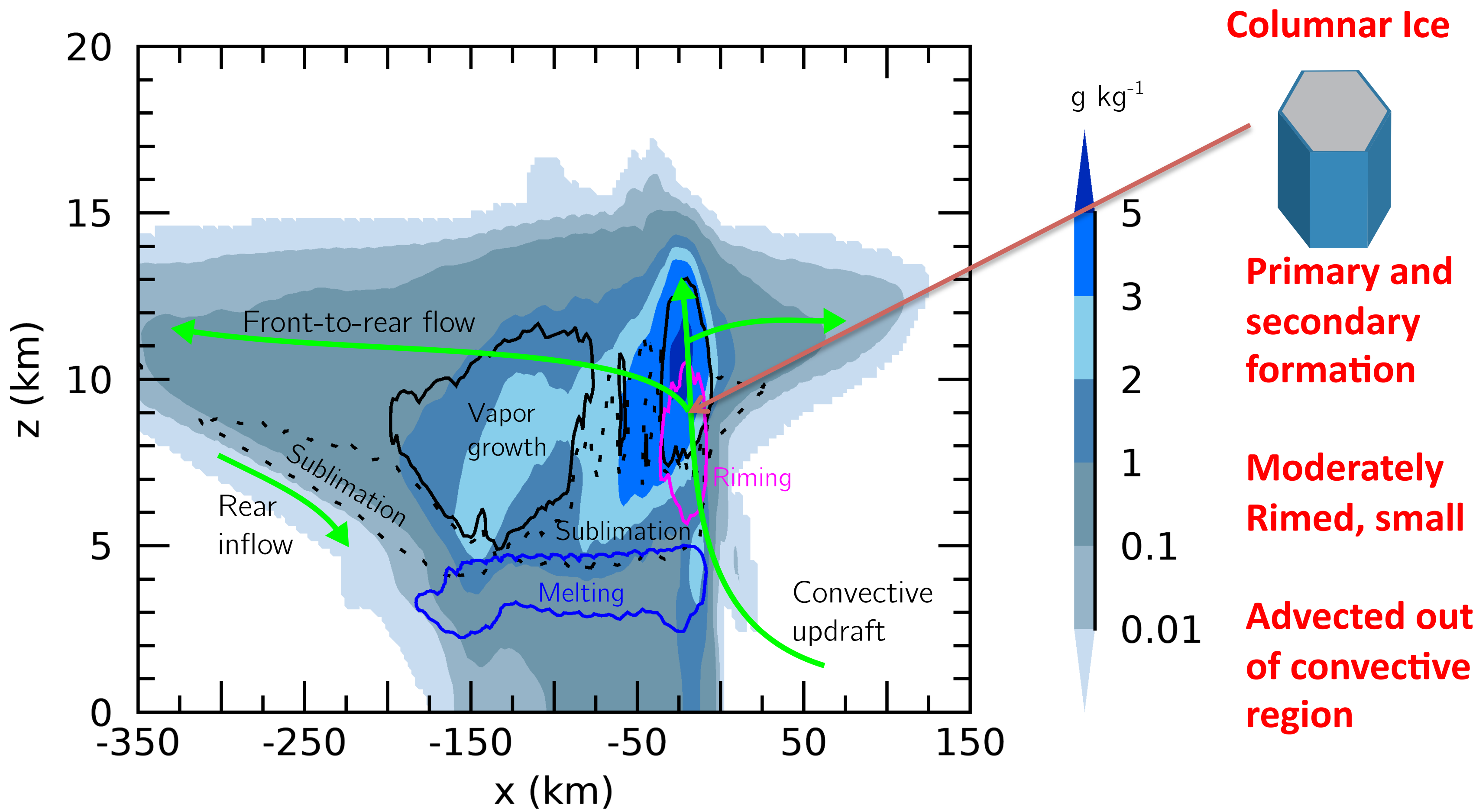



*Planar Ice: Large mass flux, small sizes and fall speeds*

*=> Composes the front and rear anvils*

Jensen et al. (2018)

# - Microphysical Processes -




Jensen et al. (2018)

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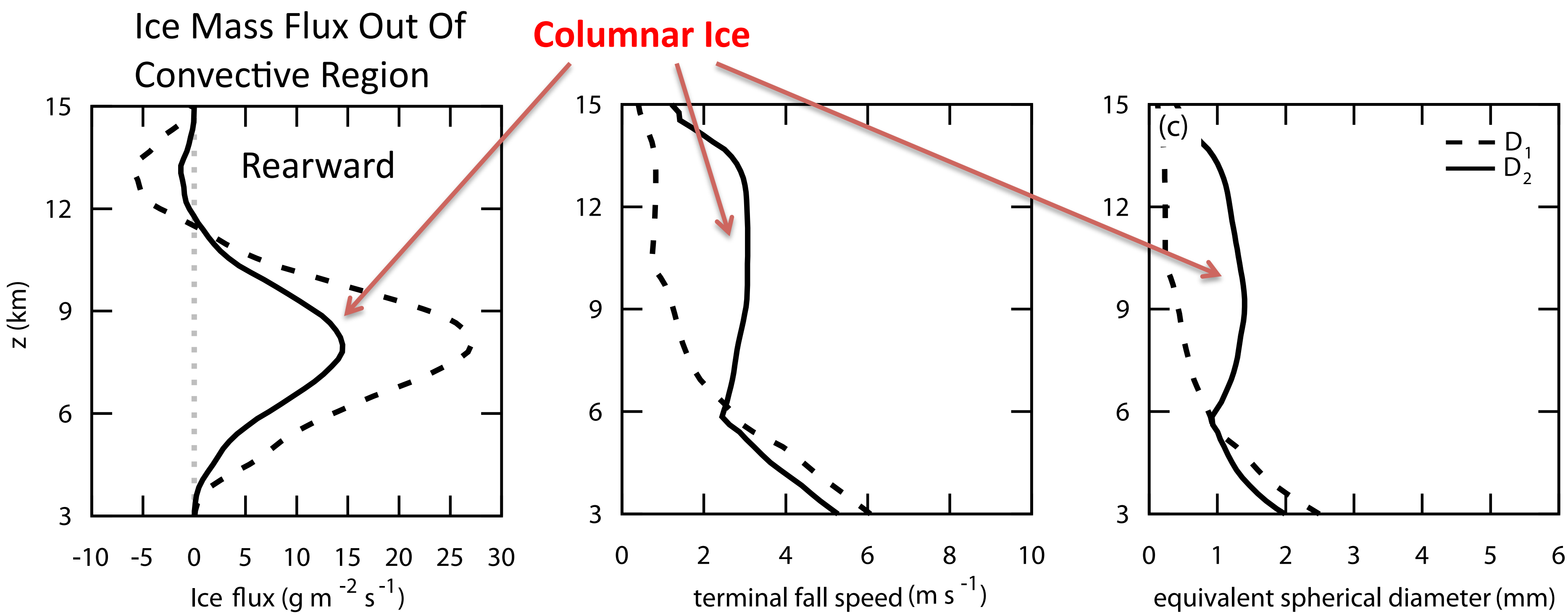


*Columnar Ice: Smaller mass flux, fall speeds 2-4 m/s*

*=> Advected over transition zone, source of stratiform precipitation*

Jensen et al. (2018)

# - Squall-line Case (2007) -

*Convective precipitation: melted small hail from planar ice*

*Anvil composed of small, nearly isometric planar crystals*

*Stratiform region composed of*

*Small rimed columns advected from updraft*

*Planar crystals formed and grown in mesoscale updraft*

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*Planar crystals formed and grown in mesoscale updraft*

*Aggregates had minor influence on microphysics*

*Rime splintering and evolving density had major impacts*

# - Squall-line Case (2007) -

*Without rime-splintering: Larger particles, greater fall speeds*

*Fills in transition zone with precip*

*Stratiform precipitation disappears*

*Without evolving density: Mimic traditional schemes (snow)*

*Threshold used -> 900 kg* $m^{-3}$ *for D < 100 microns*

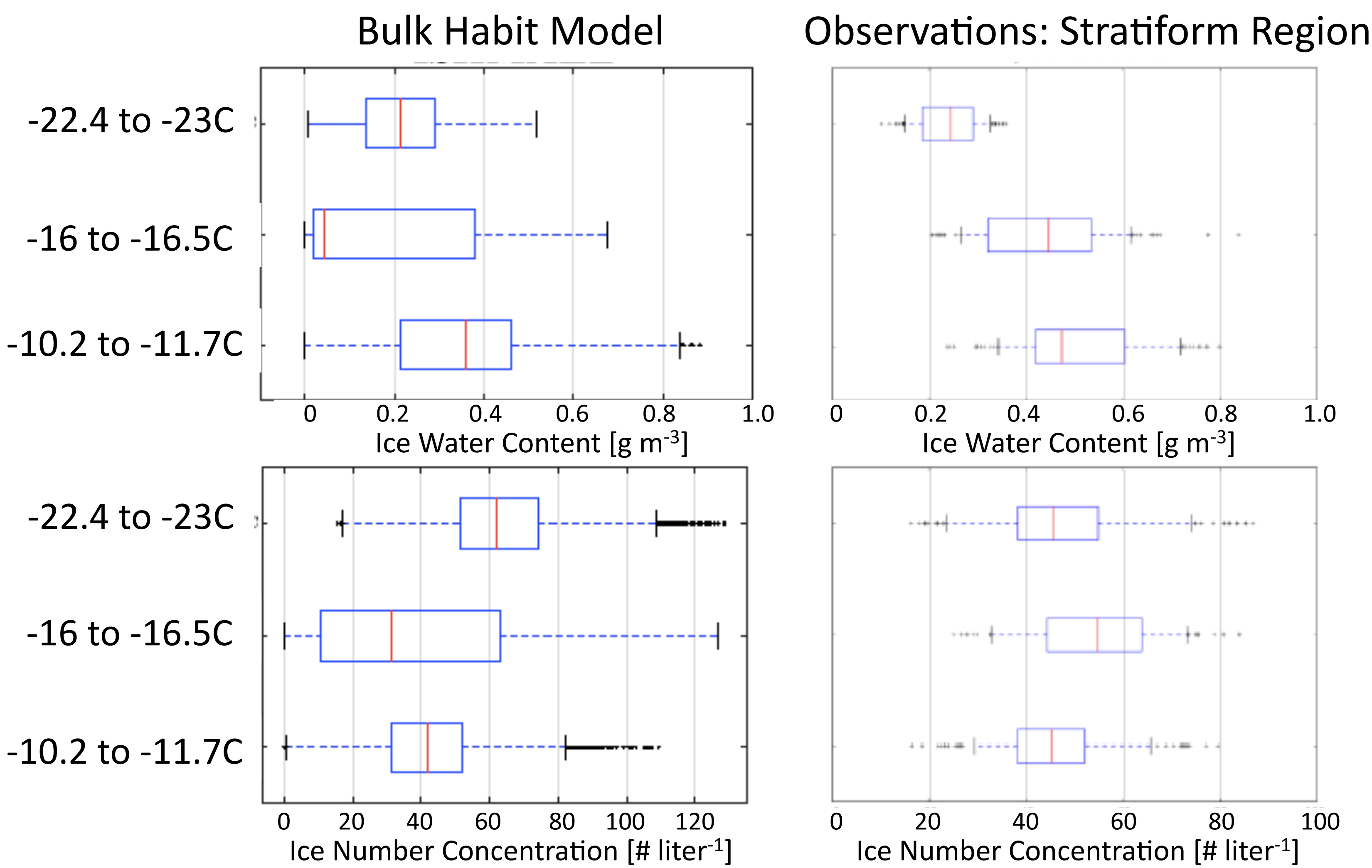
*100 kg* $m^{-3}$ *for D > 100 microns*

*Squall line development depends on chosen threshold*

*Cold pool development slowed by abrupt fall speed change*

# - MC3E May 20 Case -

*Simulated structure similar to 2007, but have in-situ observations*




Dunnavan et al. (2018a)

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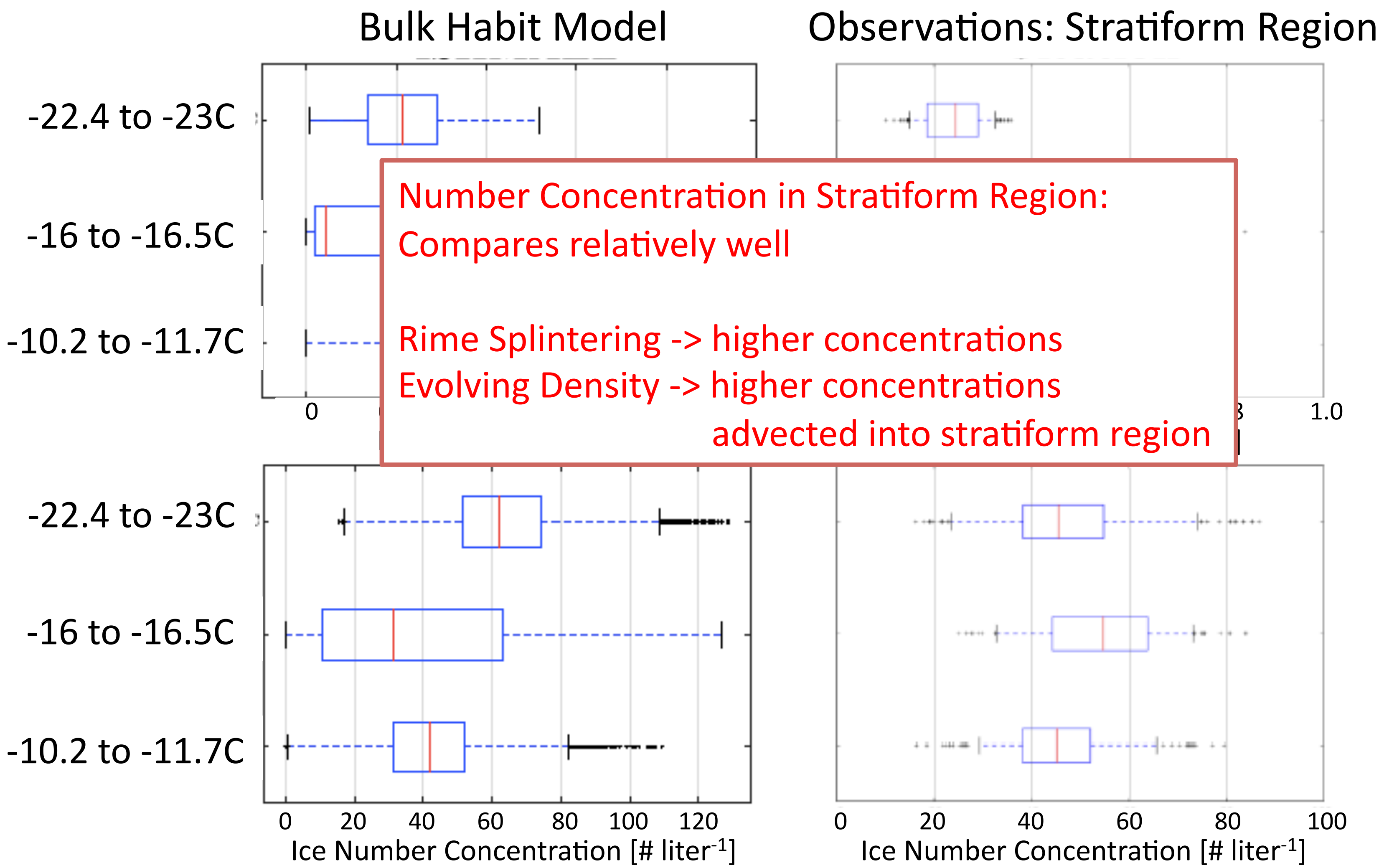
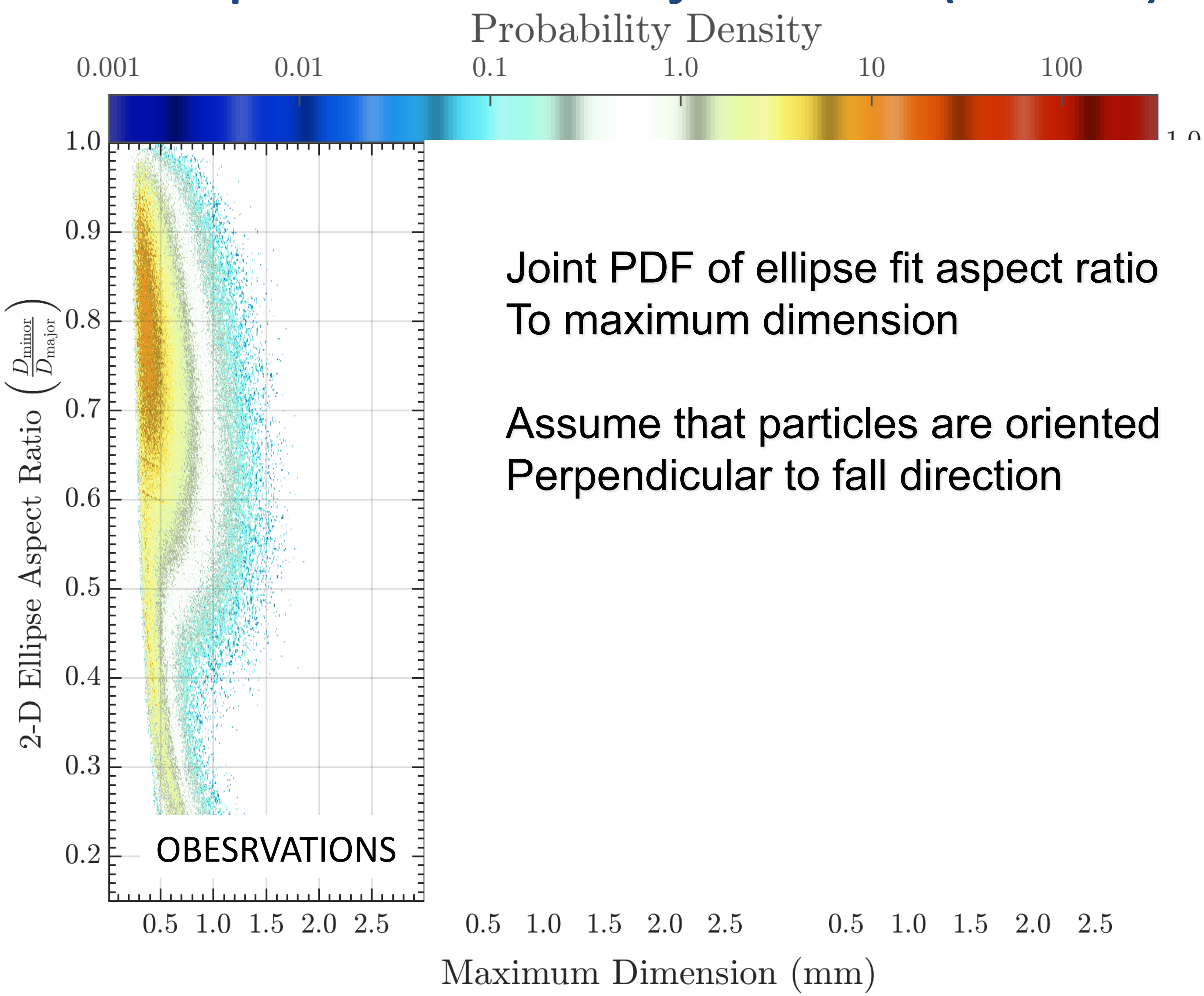



Number Concentration in Stratiform Region:
Compares relatively well

Rime Splintering -> higher concentrations
Evolving Density -> higher concentrations
advected into stratiform region

Dunnavan et al. (2018a)

# - Aspect Ratio Projections (MC3E) -

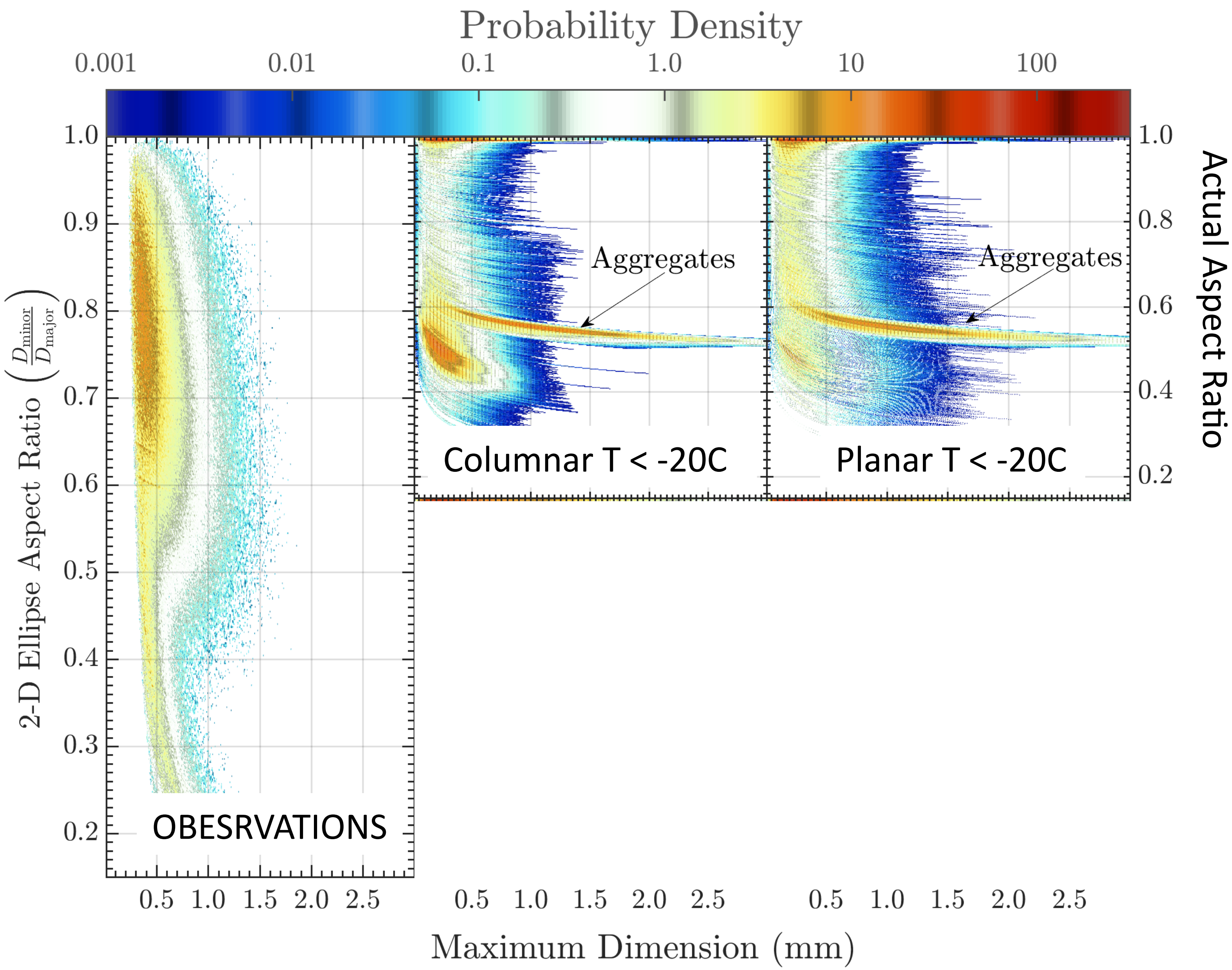



Joint PDF of ellipse fit aspect ratio
To maximum dimension

Assume that particles are oriented
Perpendicular to fall direction

Dunnavan et al. (2018a)

# - Comparing with Observed Aspect Ratio Projections -




Dunnavan et al. (2018a)

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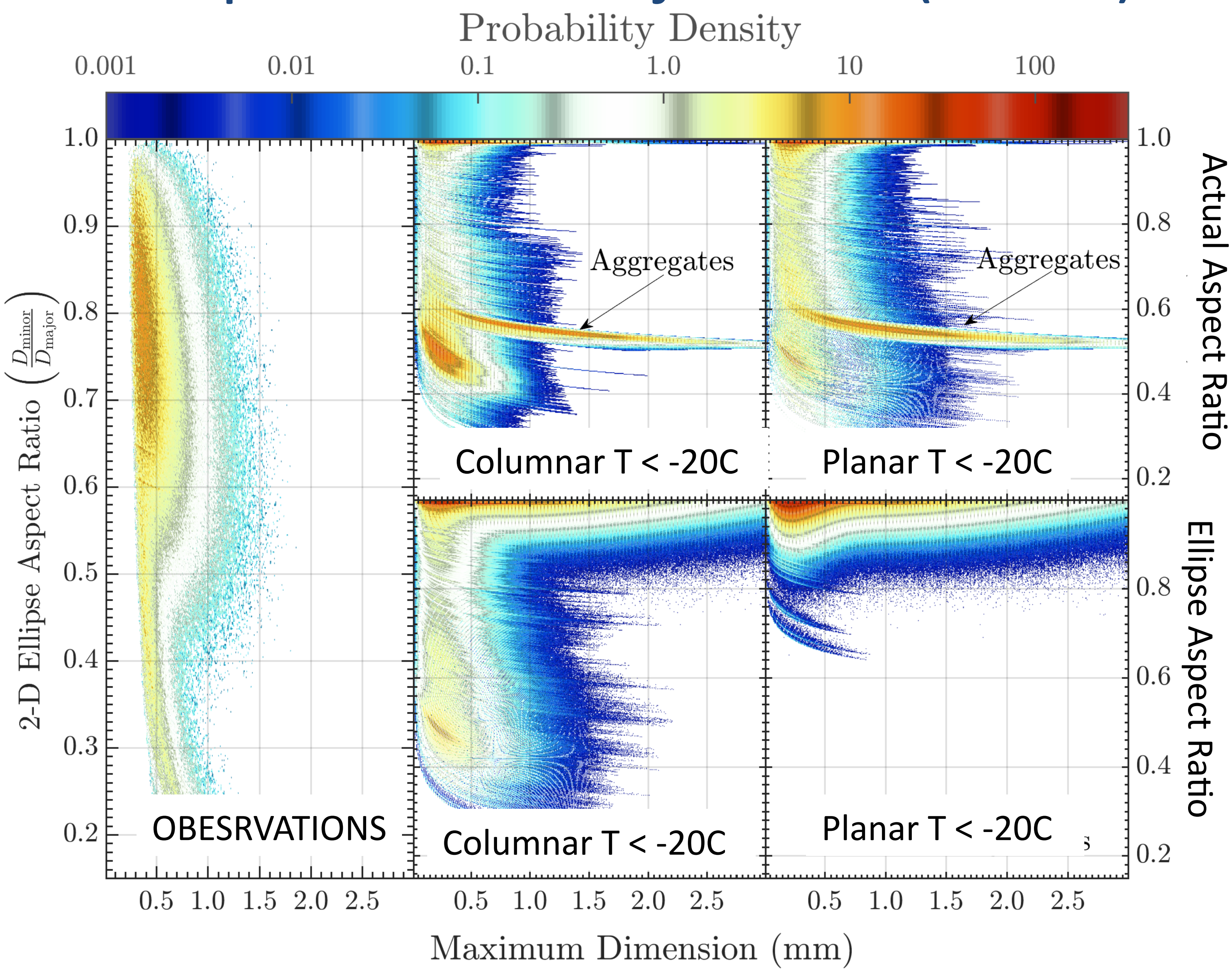


Dunnavan et al. (2018a)

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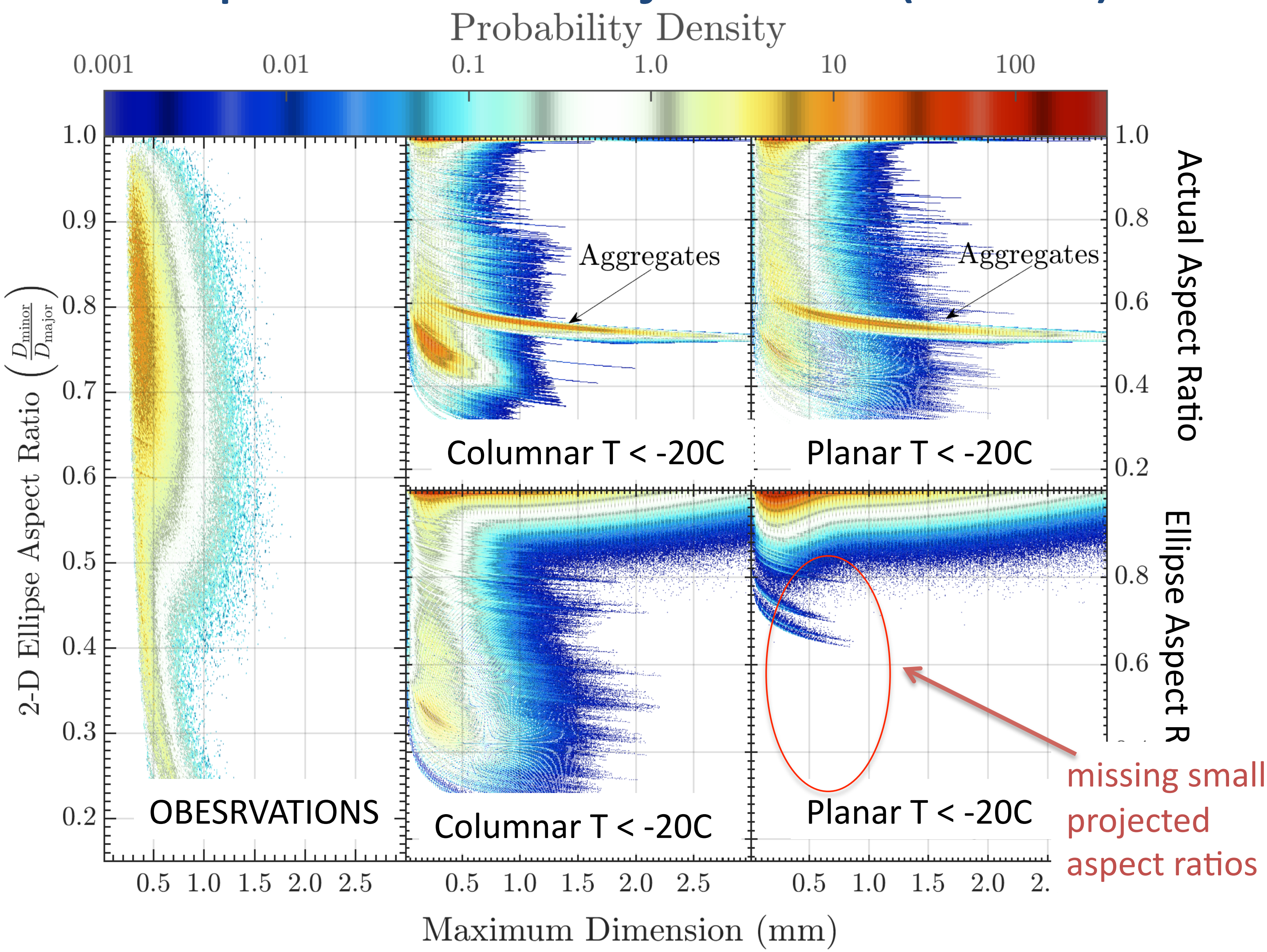
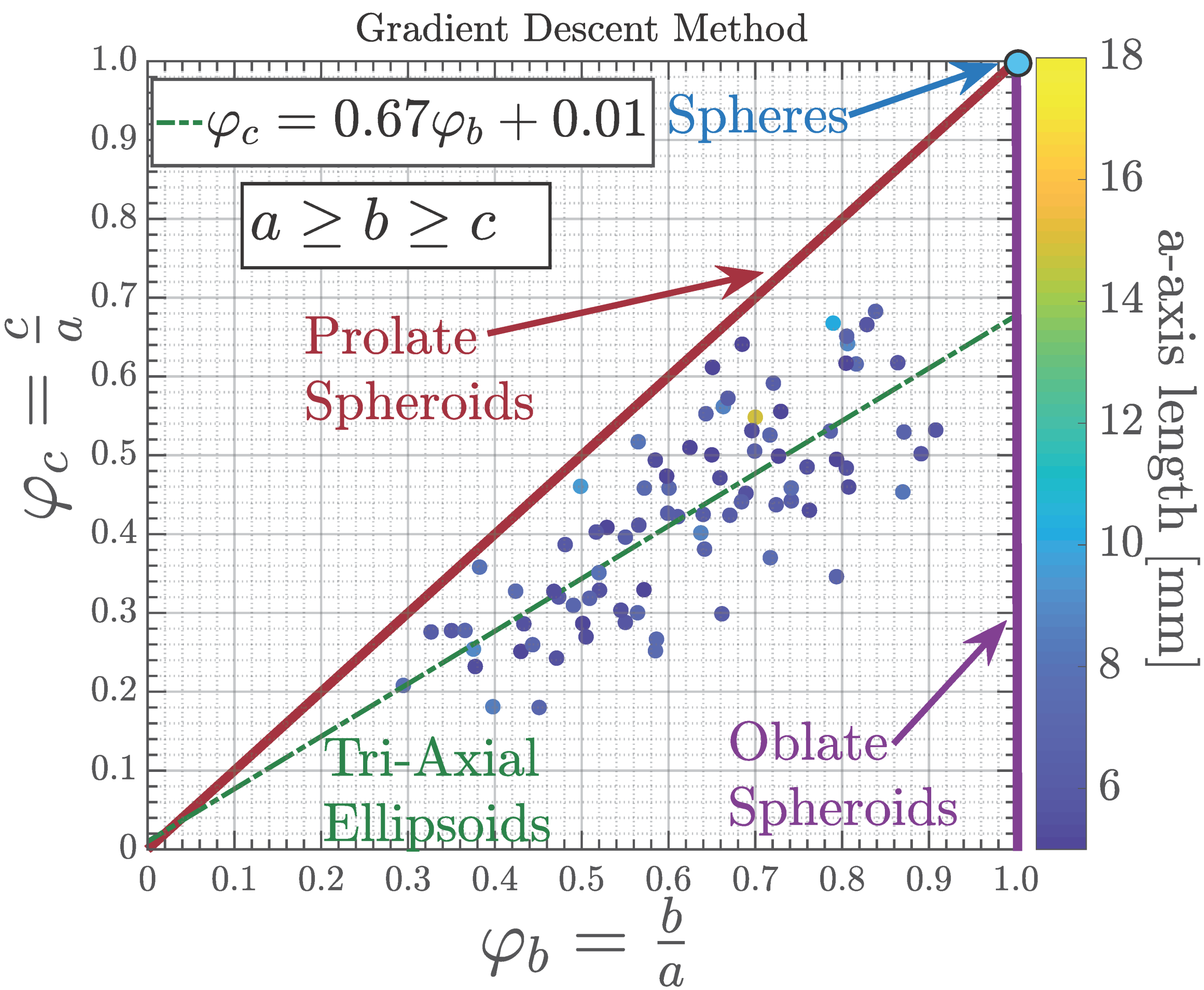



Dunnavan et al. (2018a)

# - Are We Misrepresenting Aggregates? -




MASC Observations:

Better represented as ellipsoids

Simple empirical relation between ellipsoid and prolate aspect ratios

Dunnavan, Jiang et al. (2018b)

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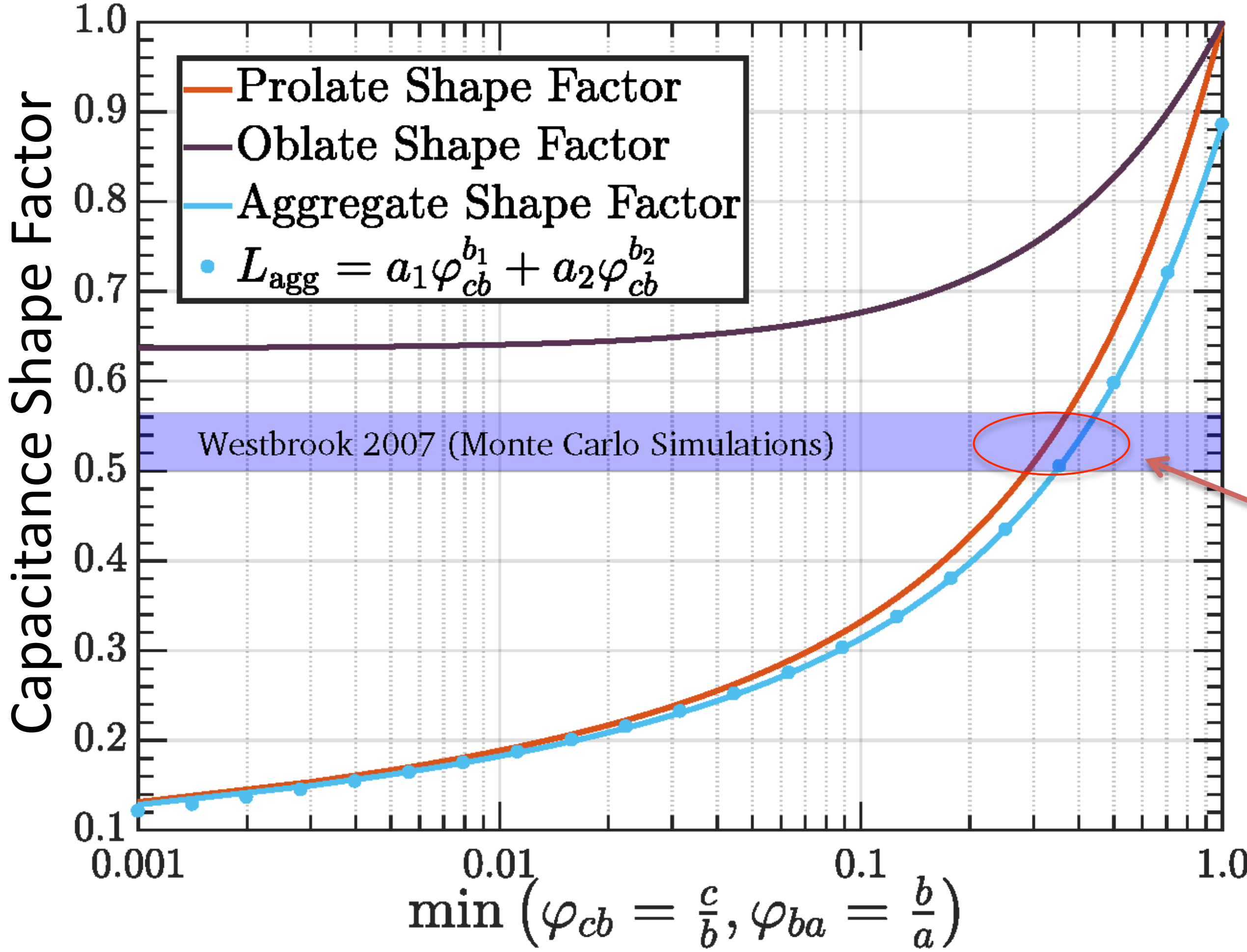


Capacitance for Vapor growth:

Closer to Monte Carlo simulations within typical range of aggregate aspect ratios (0.2 to 0.6)

Hypergeometric function but can be parameterized (blue dots)

Dunnavan, Jiang et al. (2018b)

# - Summary -

*Simulations corroborate earlier theories that the size spectrum and fall speed of hydrometeors advected out of the convective updraft are critical for transition zone/stratiform precipitation.*

*Riming and rime density evolution appear to be important. Evolving density: Lose sensitivity to snow -> graupel transfer function as in traditional schemes.*

*Comparisons with observation are best if columns nucleate below -20C or by aggregates.*

*The model likely misrepresents aggregates, as observations suggests that an ellipsoidal representation is accurate.*