The deposition coefficient ($\alpha$) is a critical term in the prediction of atmospheric ice crystal growth. Often $\alpha$ is set to 1.0 and ice crystals often grown as reduced density spheres where ice particle capacitance is equal to its radius. Here, we capture nonspherical growth of ice crystals by modeling ice particles as oblate or prolate spheroids. 

Harrington et al. (2013) use a bulk PSD modification of the method used by Zhang and Harrington (2014, 2015) in their Kinetically Limited Adaptive Habit (KLAH) bin model, using the radius 2nd moment.

Maxwell's Growth Equation for Single Ice Particles:

$$\frac{dn}{dt} = 4\pi p c C(a, c) G'(P, T, a, c, a_0)$$

Adaptive Habit Size Spectrum (based on a-axis):

$$n(a) = \frac{N_c}{\Gamma(\nu)} \left( \frac{a}{a_0} \right)^{-\nu} \frac{1}{4a_0^4} \exp \left(-\frac{a}{a_0}\right)$$

Total ice mass (integrating across size spectrum):

$$\frac{dM}{dt} = \int \frac{dn}{dt} (a) da$$

Deposition coefficient prediction uses a bulk PSD model that compares to that of a bin approach? How well does $\alpha$ prediction in a bulk model compare to that of a bin approach? Does the adaptive habit bulk model predict realistic ice particle shapes? Two nonlinear links for nonspherical evolution:

1. $C(a, c)$ = Capacitance (shape) of ice crystal
2. $G'$ = Effective Diffusivity (Mass and Thermal)

Comparison of Predicted Aspect Ratios with In-situ Projections

- One way to test predicted model aspect ratios is to compare with in-situ 2-D ellipse fit projections.
- However, spherical aspect ratios do not necessarily correspond to 2-D projected ellipse aspect ratios derived from in-situ probes. 
- Therefore, we extend the approach of Jiang et al. (2016) for particles predicted by the ISHMAEL WRF microphysics scheme described in Jensen et al. (2017).
- Ratio of deposition coefficients determined by temperature a priori following Chen and Lamb (1994) such that $\alpha = \frac{\gamma}{T}$.
- The choice of this inherent growth ratio parameterization (Fig 4a) can drastically affect the formation and structure of mesoscale convective systems (MCSs) as shown in a comparison of model surface rain reflectivity (Fig 4b) at various times.
- Old ISHMAEL scheme reduces ice number concentrations during aggregation but new ISHMAEL scheme includes aggregate category.
- 2-D C optical array probe (OAP) images fit with ellipses following approach by Welzl 1991.
- Ice particles taken from the stratiform region in the new and old ISHMAEL at 6 hours (Fig 5a) are projected by calculating ellipse conic sections based on particle orientations.
- Fig 5b is a joint PDF of the 2-D ellipse fit aspect ratio and major dimensions of these projections for observations and for these two model runs.

Results and Analysis (Parcel Model)

- Evolution with height consistent between different $\nu$.
- Strong agreement for every variable except deposition coefficient, particularly for higher shape factors.
- Evolution with height consistent between different $\nu$.
- Agreement not as strong as plate like case, but still quite good overall.

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