Is Size or Chemistry More Important for the Aerosol Indirect Effect?

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Background and Introduction
1. The indirect aerosol effect depends on the ability of aerosols to act as CCN, which is influenced by their size distribution and chemical composition.
2. Recent studies find conflicting results: Nenes et al. (2002) concluded that chemical composition sometimes rivals the effect of size distribution. Dusek et al. (2006) concluded that choosing the correct size distribution is more important for CCN.
3. Here we examine this issue using an adiabatic parcel model driven with observed and modeled ranges in size distributions and composition

Model
1. Adiabatic parcel model based on Liu et al. (1998)
2. Log-normal distributions for all aerosol models
3. Initial runs at 10°C, 900mb, and RH of 98%
4. Updraft speed is assumed constant with height
5. Model results use values from 300 m above cloud base


Fine mode aerosol nitrate Gas phase HNO3

Figure 1. Modeled nitrate in aerosol and gas phase from Feng and Penner (2007).

Size range based on measured continental results from Dusek et al. (2006):

Organic mass fraction based on measurements by Malm et al. (2004):

Figure 2. Measured particle size distributions for an industrial-influenced air mass (A) and for a rural continental air mass (B) from Dusek et al. (2006).

Figure 3. Annual average fine mode organic mass concentrations in µg/m3 and fine mode organic mass fraction (B) based on Malm et al. (2004).

Conclusions
1. Size distributions become important only at high updraft velocities.
2. Chemistry is important at all updraft velocities.
3. Future work will consider a larger range of size distributions and a larger range of number concentrations.

References:

Results:

Figure 4. Modeled droplet concentrations relative to base line for all cases.

Figure 5. Modeled droplet number concentration when size is assumed constant. At high updraft velocities and supersaturations, size becomes important but composition is important at all updraft velocities and supersaturations.

Figure 6. Modeled droplet number concentration when composition is assumed constant. Composition constraint is a good assumption at any updraft velocity or supersaturation.