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

Xi Chen, Erika Roesler, Yuxing Yun, and Joyce E. Penner

Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, Ann Arbor, MI, 48105

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. Initiate runs at 10ºC, 900mb, and RH of 98%
4. Updraft speed is assumed constant with height
5. Model results use values from 300 m above cloud base

Nitrate range based on model results from Feng and Penner (2007):

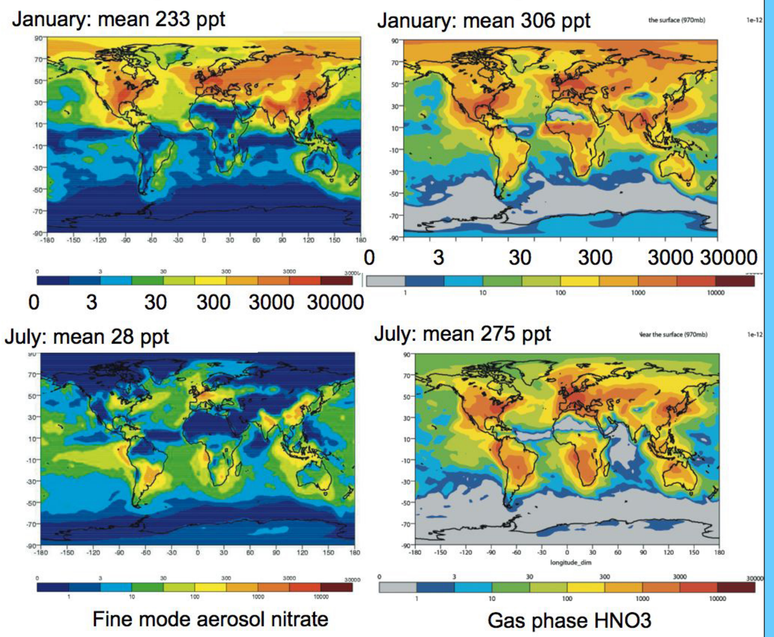

Figure 1. Modeled nitrate in aerosol and gas phase from Feng and Penner (2007).

	Case description	HNO_3 (ppb)	$(NH_4)_2SO_4$	OC	ó$_g$	r_g (cm)	N_{TOT} (cm^{-3})
1	Base_case	0.2	100%	0%	1.5	3.E-6	1000.0
2	Base case+size	0.2	100%	0%	2.0	3.E-6	1000.0
3	Change with 5ppb HNO_3	5.0	100%	0%	1.5	3.E-6	1000.0
4	Change 5 ppb HNO_3+size	5.0	100%	0%	2.0	3.E-6	1000.0
5	Change composition 4%OC	0.2	96%	4%	1.5	3.E-6	1000.0
6	Change composition 4%OC+size	0.2	96%	4%	2.0	3.E-6	1000.0
7	Change composition 20%OC	0.2	80%	20%	1.5	3.E-6	1000.0
8	Change composition 20%OC+size	0.2	80%	20%	2.0	3.E-6	1000.0
9	Change composition 4%OC with 5ppb HNO_3	5.0	96%	4%	1.5	3.E-6	1000.0
10	Change composition 4%OC with 5ppb HNO_3+size	5.0	96%	4%	2.0	3.E-6	1000.0
11	Change composition 50%OC	0.2	50%	50%	1.5	3.E-6	1000.0
12	Change composition 50%OC+size	0.2	50%	50%	2.0	3.E-6	1000.0
13	Change composition 80%OC	0.2	20%	80%	1.5	3.E-6	1000.0
14	Change composition 80%OC+size	0.2	20%	80%	2.0	3.E-6	1000.0

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

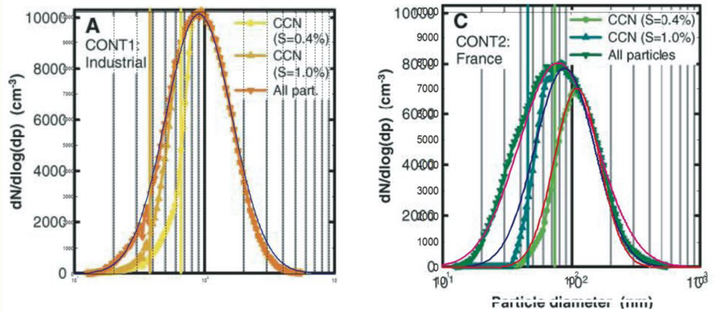

Figure 2. Measured particle size distributions for an industrial-influenced air mass (A) and for a rural continental air mass (B) from Dusek et al. (2006).

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

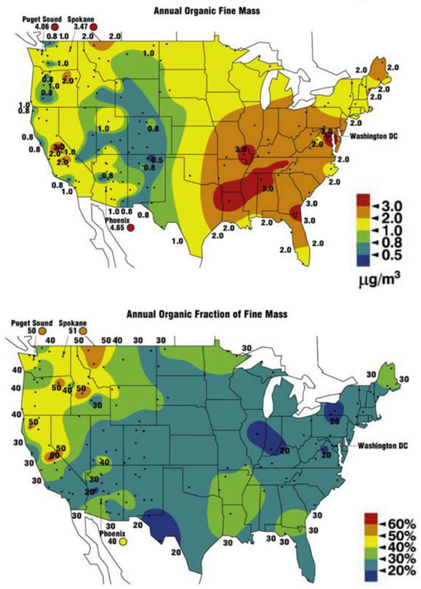

Figure 3. Annual average fine mode organic mass concentrations (A) in µm/m3 and fine mode organic mass fraction (B) based on Malm et al. (2004).

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:

1. Dusek, et al., Science, 312, 1375-1378, 2006.
2. Liu et al., J. Geophys. Res. 103, 16,145-16,158, 1998.
3. Nenes et al., Geophys. Res. Lett., 29, No. 17, 1848, 2002.
4. Malm et al., J. Geophys. Res., 109, D03306, doi: 10.1029/2003JD003739..
5. Ervens, et al., J. Geophys. Res., 110, D18211, doi:10.1029/2004JD005634.
6. Feng and Penner, J. Geophys. Res., 112, D01304, doi:10.1029/2005JD006404, 2007.

Results:

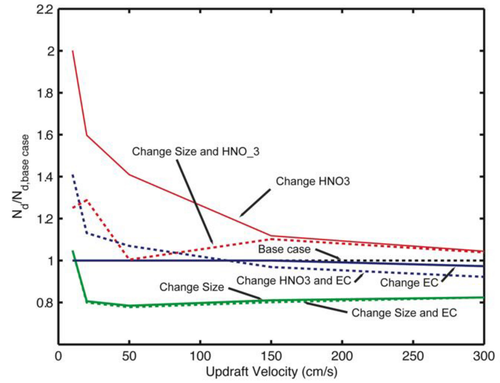

Figure 4. Modeled droplet concentrations relative to base line for all cases.

Constant size

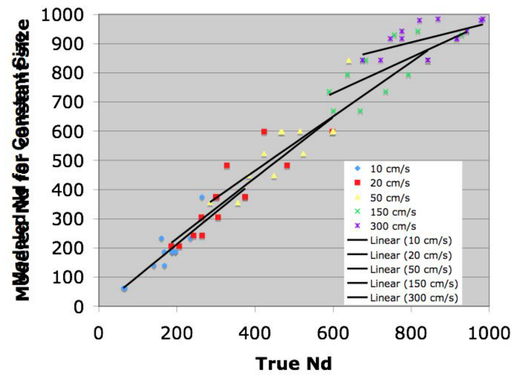

Figure 5. Modeled droplet number concentration when size is assumed constant. At high updraft velocities and supersaturation, size becomes important but composition is important at all updraft velocities and supersaturations.

Constant composition

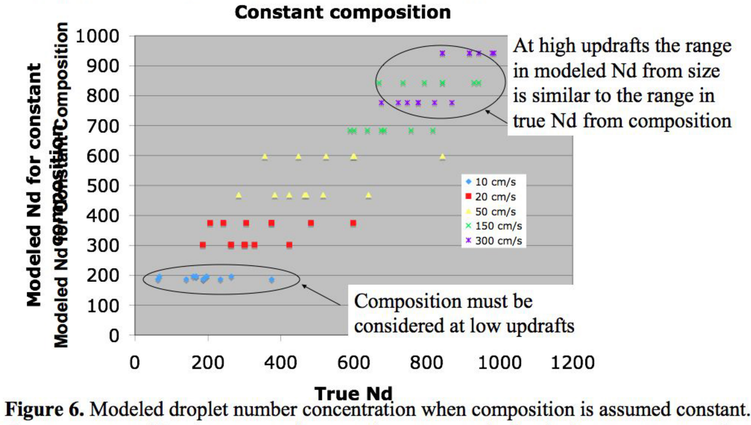

Figure 6. Modeled droplet number concentration when composition is assumed constant. Constant composition is not a good assumption at any updraft velocity or supersaturation.