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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The scavenging processes controlling the seasonal cycle in Arctic sulphate and black carbon aerosol" *by* J. Browse et al.

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This study explores the influence of model scavenging processes on the transport of sulfate and BC to the Arctic. Several model sensitivity studies are conducted and simulated aerosol concentrations are evaluated against surface aerosol observations in and near the Arctic. Overall, it is an interesting study and sheds light on the potential roles of drizzle and (lack of) ice scavenging for improving simulated Arctic aerosol concentrations, at least in one model. The experiment design and processing of observational data enabled meaningful evaluation. The manuscript is well written and helpful context and connections are provided throughout. My comments are mostly minor, but I raise

a couple of general concerns that should be addressed.

Major issues:

One general concern relates to the simplicity of some of the model treatments and how this simplicity may impact the sensitivity studies and conclusions. One example of this is that there does not seem to be any consideration of mixed-phase clouds, which are known to exist over a range of temperatures and which may be prevalent in the Arctic, at least in certain seasons and locations (e.g., Curry et al, 2000, BAMS). Riming may occur frequently in these clouds and there is strong evidence that riming is an effective scavenging process (e.g., Hegg et al, 2011 Tellus). How might treatment of mixed-phase clouds influence the sensitivity studies?

The ICE sensitivity studies assume that insoluble aerosols nucleate at temperatures below -15C, while soluble aerosols are not scavenged at all. It does not seem reasonable that only the insoluble aerosols should nucleate. Please explain the reasoning for this in more detail. Would it be more realistic to allow some ice nucleation of the soluble aerosols? It appears that this approach was intended to capture the lack of scavenging through collision and coalescence in ice clouds. Please elaborate on any limitations of this approach.

Another issue is that some of the results may be sensitive to the BC aging processes that determine the relative portions of soluble and insoluble BC, and/or to the assumed fraction of emitted BC that is soluble. For example (p3430,6): "all three drizzle runs have similar median BC concentrations due to the predominance of insoluble BC particles (from BB sources)...". There is observational evidence that a large portion of BC emitted from biomass (BB) sources is soluble, or the BC becomes soluble within minutes of emission. Although differences between SO4 and BC results are sometimes discussed in the context of differences in hygroscopicity, the general importance of BC aging for these results could be stated or discussed more generally.

One methodological issue needs to be clarified: p3424,26 states: "drizzle rate ... was

increased" - How was it increased? Was the parameterization listed in Equation 3 altered just in a small region? Was the drizzle rate simply held constant year round? Please describe this modification in more detail.

Finally, a previous study ("Importance of deposition processes in simulating the seasonality of the Arctic black carbon aerosol", JGR, doi:10.1029/2009JD013478) also evaluated, using some of the same observations, how changes in model deposition processes (in a different model) influence simulated Arctic aerosol concentrations, but this study was not cited. Please reference this study and explain key differences and similarities between it and the current study.

Minor issues:

Abstract, 14: "in a model" - please mention which model.

3411, 14-17: I don't see much distinction between the "up to 2C" warming since the 1980s and the 1C warming between 1976 and 2007. Is the only difference between these numbers the time period over which they were averaged?

3412, 25: "decline in BC beginning in the 1970s" - McConnell's ice core record actually shows a decline in BC beginning in the 1910s or 1920s!

3412, 26: I suggest including a reference for "global decrease in aerosol concentrations", or changing "global" to "regional".

3413, 13-15: Please qualify this statement a bit more carefully. Specifically, do you mean that global scavenging rates are insensitive to _global_ temperature changes less than 5C? It doesn't seem like you are making that assertion in your study.

3415, 11: Please define Dp where it is first used

3416, 5-20: This passage refers to measurements that assume MAE values that vary by 3-fold. This would seem to translate into large uncertainty in measured BC values. Is most of this spread caused by different assumptions about the magnitude of non-BC

light absorption at each site, in order to translate EBC to BC? If not, can you identify any other causes for this spread?

3419, 15: ISCCP was already defined.

3423, 22: are -> our

3423, 23: "upper limit for the given condensate lifetime." - What are the implications of this change being an upper limit? If it is important, you may want to return to this point in the discussion of the DRIZZ results and comparison with observations.

3424, 22: What are the measured drizzle rates at Barter Island?

3425, 7: "higher low cloud fraction introduced north of 60N results in Arctic CCN lifetimes... equivalent to" - How does cloud fraction influence CCN lifetime? Equations 2 and 3 show that CCN lifetime depends on LWP, z, and Nd, but not cloud fraction.

3429, 6: "... although the effects of drizzle scavenging are confined to the late spring and summer." - Why are the BC effects different from SO4 effects in this regard? Is it because much of the spring/summer BC is hydrophilic?

3431, 17: "This analysis suggests that Arctic drizzling low cloud acts as a filter, strongly suppressing the transport of aerosol between the marginal and high Arctic". - This only holds for aerosol that is transported into the lower altitudes of the Arctic. The sensitivity of results to the drizzle parameterization will depend on the amount of aerosol residing in the boundary layer or lower troposphere. As the authors discuss later, some of the transport mechanisms bring BC into the Arctic much above the drizzle zone. Some observational studies also show BC residing very high (up to 7 km) in the Arctic atmosphere (e.g., Brock et al, 2011, ACP). Please qualify this discussion accordingly.

3440, 25: "... means that the ice cloud scavenging effect becomes much less important in summer" - Do you mean "the suppression of ice cloud scavenging becomes less important"?

Table 1: Please indicate the meaning of "X" and "-". Assuming "X" means "included", are the symbols under column "ice-cloud scav" reversed? You might also consider separating effects by insoluble and soluble aerosol in this table.

Table 2: "stratacumulus"

Table 3: Why are the values under DRIZZICE italicized?

Fig 6: "SO4 (a,c) and BC (b,d)" seems to be mislabeled. Also, legends would help this figure.

Fig 9: Please describe the meaning of the gray shaded "Arctic SZ" regions of panels (a) and (b).

Fig 10: Larger axes labels would improve this figure.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 3409, 2012.