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

Anonymous Referee #2

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This paper makes an important contribution to model representations of wet scavenging. I anticipate that it will allow for more faithful reproductions of the observed seasonality of aerosol concentrations in the Arctic. My comments are mostly fairly minor as outlined below.

1. p. 3412 par. 2 Note also Garrett et al., 2012, Tellus, which extended analysis to Alert and to soot.
2. p. 3412, par. 3 Note also Hirdman et al., 2010, ACP 9351-9368.
3. p. 3419 "The two data sets differ substantially, however the MODIS fields are

used north of 60 because they agree much better with surface observations of cloud cover (Curry et al., 1996; Curtis et al., 5 1998)." A remarkably prescient analysis by Curry and Curtis? Perhaps this sentence can be written so that it doesn't seem to imply that MODIS analyses were being done in the mid-90s.

4. p. 3419. MODIS should be spelled out where it is introduced first.
5. p. 3421 "Aerosol lifetimes with respect to wet scavenging in warm (liquid-phase) clouds are of the order of 1 h even at light precipitation rates of 1mm d−1 (Curry et al., 1996)." This perpetuates a wide spread confusion about wet scavenging where it is presumed that clouds are somehow separate from the air around them. Because air is cycled through clouds, wet scavenging by clouds affects the entire mixed-layer in which they lie. Of course the Arctic tends to be fairly stable, but not so much so that clouds don't influence a layer deeper than their depth. Also, it might be worth mentioning here why scavenging times are so short independent of precipitation rate. The precipitation rate scales roughly as the liquid water path as in Eq. 2.
6. Please double check throughout that the references chosen actually apply to the text to which they are affixed. Did Davidson really discuss scavenging by droplets in their study of the Greenland ice sheet?
7. p. 3421 "Conversely ice crystals tend to form via the nucleation of ice onto individual particles and grow by vapour deposition rather than collision and coalescence". Anywhere that ice crystals form from a liquid cloud, riming is almost inevitable, and so collision-coalescence is an important process in cold clouds too. It needs to be clarified how riming is represented in the model simulations. Note that in the Arctic, liquid can be present at temperatures that are even colder than -15 C (e.g. Hobbs and Rangno, 1998).
8. p. 3422 It seems that black carbon is not scavenged in the model except at very

cold temperatures. Aged aerosols that reach the Arctic are likely to be internally rather than externally mixed (e.g. Covert and Heintzenberg, 1993), in which case I would expect that black carbon and soluble aerosols will be removed with nearly equal efficiency. Shouldn't this be represented in the simulations?

9. The point that Arctic rather than sub-Arctic precip seems most important to the precipitation is particularly interesting, and a bit counterintuitive given that precipitation rates are so much higher at lower latitudes. The sensitivity studies are very nice, but a bit black box. Can more insight be provided on how aerosol make it to 60 N without being scavenged? Is it that the plumes tend to be sub-saturated until they are cooled?

10. The Arctic is drier in winter than in summer due to reduced sources of moisture and convection. Why is this alone not sufficient to account for the seasonal cycle in scavenging without invoking cloud microphysical effects? It is very interesting that microphysical effects seem to be important, but surely these aren't the first order control?

11. Figure 11 is fantastic.

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