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The scavenging processes controlling the seasonal cycle in Arctic sulphate and black carbon aerosol

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The seasonal cycle in Arctic aerosol is typified by high concentrations of large aged anthropogenic particles transported from lower latitudes in the late Arctic winter and early spring followed by a sharp transition to low concentrations of locally sourced smaller particles in the summer. However, multi-model assessments show that many models fail to simulate a realistic cycle. Here, we use a global aerosol microphysics model and surface-level aerosol observations to understand how wet scavenging processes control the seasonal variation in Arctic black carbon (BC) and sulphate aerosol concentrations. We show that the transition from high wintertime to low summertime Arctic aerosol concentrations is caused by the change from inefficient scavenging in ice clouds to the much more efficient scavenging in warm liquid clouds. This seasonal cycle is amplified further by the appearance of warm drizzling cloud in late spring and summer at a time when aerosol transport shifts mainly to low levels. Implementing these processes in a model greatly improves the agreement between the model and observations at the three Arctic ground-stations Alert, Barrow and Zeppelin Mountain on Svalbard. The SO_4 model-observation correlation coefficient (R) increases from: -0.33 to 0.71 at Alert (82.5N), from -0.16 to 0.70 at Point Barrow (71.0N) and from -0.42 to 0.40 at Zeppelin Mountain (78N) while, the BC model-observation correlation coefficient increases from -0.68 to 0.72 at Alert and from -0.42 to 0.44 at Barrow. Observations at three marginal Arctic sites (Janiskoski, Oulanka and Karasjok) indicate a far weaker aerosol seasonal cycle, which we show is consistent with the much smaller seasonal changes in ice clouds compared to the higher latitude sites. Our results suggest that the seasonal cycle in Arctic aerosol is driven by temperature-dependent scavenging processes that may be susceptible to modification in a future climate.