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What drives the Arctic response to mid-latitude sulphate aerosol emissions?

Srinath Krishnan[1], Annica Ekman[1], Hans-Christen Hansson[2], and Ilona Riipinen[2]
[1]Stockholm University, Department of Meteorology, Stockholm, Sweden
[2]Stockholm University, Department of Environmental Science and Analytical Chemistry (ACES), Stockholm, Sweden

Modeling studies have shown that changes in sulphate aerosol emissions from both Europe and North America can have an impact on remote Arctic climate. The bulk of this response is driven by atmospheric changes, rather than through changes in meridional ocean heat transport. However, these simulations have focused on the Arctic response from an equilibrium perspective; i.e. the simulations are run for 200 years and the analyses are based on means of the last 50 years. While these simulations are useful to analyze the extent of contribution of mid-latitude aerosol emission changes, they cannot be used to investigate the mechanistic processes that initiate and drive the high-latitude response. We approach this problem by conducting two sets of initial condition ensemble simulations with >30 members for each set and focus our analysis on the first 30 years. Having a large number of ensemble members improves the signal-noise ratio and allows us to distinguish the model response to emission changes from internal variability. In the first set of simulations (control set), the aerosol emissions are set to year 2000. In the second set of simulations (perturbed set), we increase the European sulphate aerosol emissions to seven times the year 2000 value. We compare the two sets of simulations to evaluate the dynamical response of the atmosphere to the change in aerosol emissions. One of the key parameters that link the mid- and high-latitudes in the equilibrium response is the change in sea-ice area in the sub-polar latitudes. Reduced sea-ice coverage and greater open ocean area with lower mid-latitude aerosol emissions leads to increased ocean-atmosphere energy exchange and impacts the atmospheric meridional heat and energy budgets in the Arctic. We present the extent and seasonality of sea-ice changes for the first 30 years of our ensemble simulations and discuss their implications in the context of the mechanistical links between the mid- and high-latitudes.