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Isolating the atmospheric and oceanic roles in linking European aerosol emissions and the remote Arctic response

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Modeling studies such as Acosta et al. (2016) and Lewinschal et al. (2019) have shown that changes in European sulphate aerosol emissions can lead to a large climate response in the Arctic. It was hypothesized that this response is linked to an increase in ocean heat convergence (OHC) in the sub-polar regions (Acosta et al., 2016). Here, we test this by analyzing a series of idealized slab-ocean simulations where either the atmospheric aerosol emissions (atmospheric forcing) or the OHC (oceanic forcing) is modified. The ocean heat convergence fluxes are obtained from fully-coupled simulations conducted by Lewinschal et al., 2019, where European aerosol emissions are either fixed at “low-aerosol” values (i.e. fixed at year 2000) or at “high-aerosol” values (i.e. ramped up to 7 times the anthropogenic emissions from year 2000). The atmospheric forcing is evaluated from a simulation that uses a “high-aerosol” atmosphere, and ocean heat convergence fluxes from the “low-aerosol” fully coupled simulation; while the oceanic forcing is evaluated from a simulation with a “low-aerosol” atmosphere and ocean heat convergence fluxes from the “high-aerosol” fully-coupled simulation. Results indicate that the Arctic temperature response is driven by the atmosphere, or atmospheric-related processes, modulated by sea-ice extent and thickness changes in the sub-polar regions. We expand on these linkages between changes in anthropogenic aerosol emissions, sea-ice, energy transport and the Arctic amplification, from both annual and seasonal perspectives. These results enable us to speculate on the impacts of local and regional changes in climate forcers on remote regions, such as the Arctic.