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Wintertime Arctic Air Pollution over central Alaska: pre-ALPACA campaign

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The wintertime Arctic is influenced by air pollution transported from mid-latitudes, leading to formation of Arctic Haze, as well as local emissions such as combustion for heating and power production in very cold winter conditions. This contributes to severe air pollution episodes, with enhanced aerosol concentrations, inter-dispersed with cleaner periods. However, the formation of secondary aerosol particles (sulphate, organics, nitrate) in cold/dark wintertime Arctic conditions, which could contribute to these pollution episodes, is poorly understood.

In this study, which contributes to the Air Pollution in the Arctic: Climate, Environment and Societies - Alaskan Layered Pollution and Arctic Chemical Analysis (PACES-ALPACA) initiative, the Weather Research Forecasting Model with chemistry (WRF-Chem) is used to investigate wintertime pollution over central Alaska focusing on the Fairbanks region, during the pre-ALPACA campaign in winter 2019-2020. Fairbanks is the most polluted city in the United States during wintertime, due to high local emissions and the occurrence of strong surface temperature inversions trapping pollutants near the surface.

Firstly, different WRF meteorological and surface schemes were tested over Alaska with a particular focus on improving simulations of the wintertime boundary layer structure including temperature inversions. An optimal WRF set-up, with increased vertical resolution below 2km, was selected based on evaluation against available data.

Secondly, a quasi-hemispheric WRF-Chem simulation, using the improved WRF setup, was used to assess large-scale synoptic conditions and to evaluate background aerosols originating from remote anthropogenic and natural sources affecting central Alaska during the campaign. The model was run with Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants (ECLIPSE) v6b anthropogenic emissions and improved sea-spray aerosol emissions. Discrepancies

in modelled aerosols compared available data are being investigated (e.g. missing dark formation mechanisms, treatment of removal processes).

Thirdly, fine resolution simulations, using high resolution emissions (e.g. 2019 CAMS inventory), including local point sources, over the Fairbanks region, were used to investigate chemical and dynamical processes influencing aerosols under different meteorological conditions observed during the field campaign including a cold stable episode and a period with possible mixing of air masses from aloft. The model was evaluated against available aerosol, oxidant (ozone) and aerosol precursor data from surface monitoring sites and collected during the pre-campaign, including vertical profile data collected in the lowest 20m. The sensitivity of modelled aerosols to meteorological factors, such as relative humidity, temperature gradients and vertical mixing under winter conditions are investigated.