Characterising aerosol transport into the Canadian High Arctic using aerosol mass spectrometry and Lagrangian modelling

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We report the analysis of measurements made using an aerosol mass spectrometer (AMS; Aerodyne Research Inc.) that was installed in the Polar Environment Atmospheric Research Laboratory (PEARL) in summer 2006. PEARL is located in the Canadian high Arctic at 610 m above sea level on Ellesmere Island (80° N 86° W). PEARL is unique for its remote location in the Arctic and because most of the time it is situated within the free troposphere. It is, therefore, well suited as a receptor site to study the long-range tropospheric transport of pollutants into the Arctic. Some information about the successful year-round operation of an AMS at a high Arctic site such as PEARL will be reported here, together with design considerations for reliable sampling under harsh low-temperature conditions. Computational fluid dynamics calculations were made to ensure that sample integrity was maintained while sampling air at temperatures that average −40 °C in the winter and can be as low as −55 °C. Selected AMS measurements of aerosol mass concentration, size and chemical composition recorded during the months of August, September and October 2006 will be reported. The air temperature was raised to about 20 °C during sampling, but the short residence time in the inlet system (~25 s) ensured that less than 10% of semivolatiles such as ammonium nitrate were lost. During this period, sulfate was, at most times, the predominant aerosol component with on average 0.115 μg m−3 (detection limit 0.003 μg m−3). The second most abundant component was undifferentiated organic aerosol, with on average 0.11 μg m−3 (detection limit 0.04 μg m−3). The nitrate component, which averaged 0.007 μg m−3, was above its detection limit (0.002 μg m−3), whereas the ammonium ion had an apparent average concentration of 0.02 μg m−3, which was approximately equal to its detection limit. A few episodes, having increased mass concentrations and lasting from several hours to several days, are apparent in the data. These were investigated further using a statistical analysis to determine their common characteristics. High correlations among some of the components arriving during the short-term episodes provide evidence for common sources. Lagrangian methods were also used to identify the source regions for some of the episodes. In all cases, these coincided with the arrival of air that had contacted the surface at latitudes below about 60° N. Most of these lower-latitude footprints were on land, but sulfate emissions from shipping in the Atlantic were also detected. The Lagrangian results demonstrate that there is direct transport of polluted air into the high Arctic (up to 80° N) from latitudes down to 40° N on a time scale of 2–3 weeks. The polluted air originates in a wide variety of industrial, resource extraction and petroleum-related activity as well as from large population centres.

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