Stockholm University

Mathematical Statistics
Stockholm University
Master Thesis **2016:6**
http://www.math.su.se

An analysis of trends and source composition of Arctic lower tropospheric aerosols using Positive Matrix Factorization

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December 2016

Abstract

In this thesis we analyse over thirty years of continuous observations of 21 constituents in the aerosol and two gases of the lower Arctic troposphere at Alert, Canada on northern Ellesmere Island. Aerosols are defined as minute solid and/or liquid particles suspended in air. The analysis is an extension and expansion of the analysis in the report "*Arctic lower tropospheric aerosol trends and composition at Alert, Canada: 1980-1995*" (Sirois and Barrie, 1999). The analysis is made in two parts, the first part is a time series analysis of the observed atmospheric concentrations between 1980 and 2013. The second is a multivariate analysis called Positive Matrix Factorization (PMF) to reduce the dimensionality of data by factorizing constituents/gases into sources. Relevant background information and theory are explained including a detailed description of PMF. The PMF analysis is made using the licensed program PMF2 while all other model and data handling is done using R. For the time series analysis, the complete data set as well as a subset of data for the winter (peak) season were analysed separately. Long term and seasonal trends have been described using cubic smoothing splines. Since Alert is situated above the polar circle, during a large part of the year it is in complete darkness until the polar sunrise occurs: this affects the compositions of the aerosol. Therefore, a new approach for the PMF analysis was made in contrast to Sirois and Barrie (1999). Two different factorizations are made: one for the dark part of the pollution period and one for the light part of the pollution period. The two factorizations are made for 19 aerosol constituents and the gases: ozone and gas phase mercury, with data between 1995 and 2007. Some of the key results are: (i) a drastic drop of aerosol sulphate, acidity, ammonium and metals related to oil combustion in the mid 1990's, most likely due to the collapse of the economy of the former Soviet Union, and (ii) the spring time correlation shown between O3 , Hg and Br related to photochemistry involving sea salt in snow after polar sunrise.

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