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Source region identification of short-lived pollutants in the Arctic troposphere, and their seasonal and long-term evolvement, using LPDM output and measurement data

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Arctic air pollution has received renewed interest recently because of its contribution to climate change in the Arctic. Nevertheless, its sources are still not known with sufficient accuracy. Most of our understanding of Arctic air pollution sources is based on model simulations, analysis of air pollution episodes or, at best, statistical analysis of air mass back-trajectories. We have earlier presented a new approach (EGU 2008, AGU 2008), namely combining the output of a Lagrangian particle dispersion model, FLEXPART, with measurement data from Arctic air pollution monitoring sites (Alert, Barrow, Summit, Zeppelin). This approach is similar to existing statistical methods for analyzing back-trajectories in conjunction with air pollution monitoring data. However, it has the advantage that the underlying model calculations also take into account turbulence and convection in the atmosphere, which are ignored by ordinary trajectory calculations. FLEXPART is run 20 days backward in time from each of the stations and every three hours, for several years. With every calculation, a so-called potential emission sensitivity (PES) field is obtained, which identifies where the measured air mass has come into contact with the Earth's surface. It quantitatively measures the sensitivity of the signal obtained at the station, to emissions occurring at or near the surface. By combining these PES fields with measured concentrations of several trace species e.g., carbon monoxide, sulphate, black carbon, and ozone. By performing a statistical analysis, we identify where the measured species most likely originate. Statistical analyses are performed both for average concentrations as well as the 10th and 90th percentiles of the measured frequency distribution. We implement a bootstrap resampling procedure to verify the statistical significance of the patterns observed in our retrieved PES maps. By making use of all of our PES fields for the different stations we are also able to spot the general importance of different geographical regions as potential sources to air pollution events in the Arctic and how they have evolved in importance since the early 1990's.
Some of our findings are: carbon monoxide and sulphate measured at Zeppelin originate from the Eurasian continent throughout the year. The source regions for sulphate shift from western Eurasia in the early 1990's towards east and Russia for the last 5 years. For equivalent black carbon (EBC) measured at Barrow, high EBC events are predominately associated with long-range transport during autumn, winter and spring with northern Eurasia as the dominating source region. However, during summer the highest EBC values are dominated by local transport arriving from Alaska and are presumably caused by boreal forest fires there. For ozone measured at Zeppelin, we find that titration by NO emissions causes the lowest ozone concentration in winter to arrive from Europe, whereas in summer photochemical ozone formation and transport from Europe causes the highest ozone concentrations. In spring (and partly in summer), air with the lowest ozone concentrations arrive from within the Arctic, likely indicating the importance of ozone depletion events. This spring patterns is very intense also at Summit where the flow otherwise shows strong decoupling from the lowest part of the troposphere.