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Evaluation of aerosol sources at European high altitude background sites with trajectory statistical methods

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During the last years, the analysis of a great number of back-trajectories from receptor sites has turned out to be a valuable tool to identify sources and sinks areas of atmospheric particulate matter (PM) or to reconstruct their average spatial distribution. A number of works have applied different trajectory statistical methods (TSM), which allow working simultaneously with back-trajectories computed from one or several receptor points and PM concentration values registered there. In spite of these methods have many limitations, they are simple and effective methods to detect the relevant source regions and the air flow regimes which are connected with regional and large-scale air pollution transport.

In this study 5-day backward air trajectories arriving over 3 monitoring sites, were utilised and analysed simultaneously with the PM levels and chemical composition values registered there. These sites are located in the centre of Europe and can be classified into natural continental background (Schauinsland-SIL in Germany (1205 m asl), Puy de Dôme-PDD in France (1450 m asl) and Sonnblick-SBO in Austria (3106 m asl)). In the framework of the CARBOSOL European project, weekly aerosol samples were collected with High Volume Samplers (DIGITEL DH77) and PM10 (SIL and PDD) or PM2.5 (SBO) inlets, on quartz fibre filters. Filter samples were treated and analyzed for determining the levels of major organic fractions (OC, EC) and inorganic ions. Additionally, analyses for specific organic compounds were also carried out whenever was possible (Pio et al., 2007). For each day of the sampling period, four trajectories ending at 00:00, 06:00, 12:00 and 18:00 h UTC have been computed by the Norwegian Institute for Air Research NILU (SIL and PDD) and the Central Institute for Meteorology and Geophysics of Austria (SBO) using the FLEXTRA model (Stohl et al., 1995). In all, more than 8000 complete trajectories were available for analysis, each with 40 endpoints.

Firstly air mass back-trajectories have been grouped into clusters, each one representing a characteristic meteorological scenario. Some common features have been detected for the clusters obtained in the three monitoring sites. A clear seasonal pattern has been observed with marked fast westerly and northerly Atlantic flows during the winter, to low speed air circulation flows in summertime. The transition period between the occurrence of the longest trajectories in winter and the shortest ones in summer has been characterised by the advection of moderate flows from the north-eastern and eastern European mainland areas. Meteorological scenarios represented by trajectories coming from the Mediterranean basin and North-African regions, have also occurred during the summer months.

Then, Redistribution Concentration Fields (RCF, Stohl, 1996) have been computed for each single station and for SIL and PDD together with the aim to obtain more reliable information on PM10 sources, for the whole sampling period and also for the summer and winter seasons. With this methodology, it is possible to obtain spatial distributions of concentrations for specific tracers of PM sources. High concentration values of the element C obtained over a geographical region means that, on average, air parcels passing over that region result in high

concentrations of the element C at the receptor site.

The main results obtained with this analysis, suggests that current carbonaceous aerosol concentrations in central Europe are likely to be influenced significantly during the winter and autumn months by long-range transport of PM from the north-eastern and eastern regions of Europe. Emissions produced by fossil-fuel and biomass burning processes in these areas, are probably the main sources contributing to the transported aerosol. In contrast, in summer there is a higher contribution of the emissions from local and regional sources on the OC and EC levels at these background sites (Germany, Poland and the Baltic countries). Secondary organic aerosol carbon formed by the photo-oxidation of biogenic emissions mainly from Germany, seems to be predominant in this season. This seasonal cycle is mainly driven by the winter/summer contrast of the regional-scale vertical mixing. During the warm season the vertical air mass exchange is enhanced by a more efficient upward transport from the boundary layer to the mountain sites. During the winter months, the vertical mixing intensity is reduced. In this season the mean levels obtained for OC and EC were lower than those recorded during the summer. Their spatiotemporal variability was mainly governed by air mass transport from distant regions, especially from Eastern Europe regions, where significant amounts of fossil fuels and biomass are currently consumed. Furthermore, emissions from desert regions in North Africa seemed to significantly influence the central European background mineral aerosol concentrations throughout the year.

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