A GIS based approach to combine back trajectory statistics and land cover analysis for the source apportionment of aerosol constituents

D. van Pinxteren[1], E. Brüggemann[1], T. Gnauk[1], K. Müller[1], C. Thiel[2], H. Herrmann[1,*]
[1]Leibniz-Institute for Tropospheric Research, 04318 Leipzig, Germany
[2]University of Jena, Institute for Geography, Department of Earth Observation, 07743 Jena, Germany

Keywords: Source apportionment, Trajectory statistics, Size distribution, Chemical composition
Presenting author email: dominik@tropos.de

Source apportionment models have since long been used to elucidate the impacts of specific emissions on observed pollutant concentrations. Principal component analysis (PCA) and positive matrix factorisation (PMF) are popular examples of such receptor models.

Another common approach in source apportionment studies are trajectory statistical methods (TSMs, Stohl, 1998). The results of these methods are usually presented in the form of maps where possible geographic locations of source areas can be identified.

An alternative approach to back trajectory analysis was presented by Lammel et al., 2003. Rather than pinpointing geographic locations, the authors aimed at identifying ground surface types which determine the abundance of pollutants at a receptor site.

The present work aimed at further developing this approach. The proposed method based on the calculation of hourly back trajectories using the HYSPLIT model (Draxler, 2003) in the ensemble mode. In this mode, the air mass history of a 24 h aerosol sample is described by an ensemble of 648 trajectories, leading to a much better representation of possible air mass pathways as compared to the calculation of a few single trajectories.

The trajectories were intersected with freely available satellite-derived land cover data (GLC2000), by calculating an index $L_{ik}(P)$ for each back trajectory i within a sampling period P and for each land cover class k as follows:

(1)

where $j = 0,1,2,...,J$ corresponds to the hourly endpoints of trajectory i ($j=0$ is starting location and $J=96$ for 96 hours back trajectories as used here), F_{mnkj} corresponds to the area fraction F of land cover class k within grid cell (m,n) that is hit by the trajectory endpoint j and $w_j=1–j/J$ corresponds to a linear weighting function. Next, the index $L_k(P)$ is derived as the arithmetic mean of all $L_{ik}(P)$, i.e. the indices of all back trajectories that fall into the sampling period P. $L_k(P)$ thereby serves as a proxy for the age-weighted residence time above land cover class k within the sampling period P. Land cover classes under consideration in this work are: Marine areas, natural vegetation, agricultural lands, urban areas, and bare areas. In Figure 1 the cumulative residence times are shown for a dataset of 29 samples (see below).

The method has been implemented within a GIS-enabled database system to allow for an efficient processing of large datasets with low computational demands. To validate the modelled residence times and further calculated parameters (mean trajectory length, solar radiation along trajectory, and local height of the boundary mixing layer), a PCA was performed on a dataset including the modelled parameters and the concentrations of 10 particle constituents (inorganic ions and organic and elemental carbon) in 5 particle size ranges for 29 winter- and summertime samples, sampled during 2003 to 2005 at an urban background site in Leipzig, Germany.

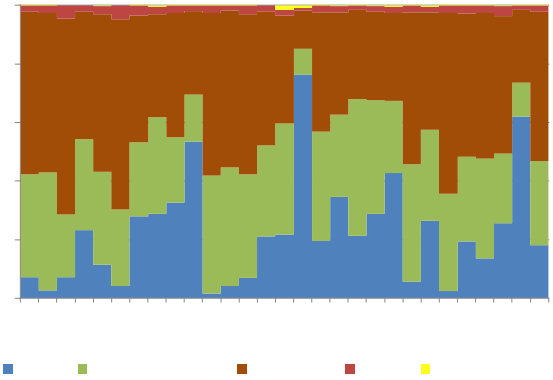

Figure 1: Cumulative residence times above the different land cover classes for all samples of the dataset

Six principal components could be extracted which together explained about 80 % of the total variance in the dataset. The factors could be attributed to the influence of meteorology on continental background pollution, secondary formation processes in polluted air masses, wood burning, aged sea-salt, local traffic, and long-range transported crustal material. Most of these factors have been frequently observed in previous European source apportionment studies (Viana et al., 2008), indicating the validity of the results. The modelled residence times and calculated meteorological parameters generally facilitated the interpretation of the extracted factors. The results proved that the intersection of trajectory data with land cover data by the presented method yields consistent and valuable additional information on the history of sampled air masses in the form of numeric indices which can readily be included into further data analysis.

Lammel, G., Brüggemann, E., Gnauk, T. et al. (2003) *J. Aerosol Sci.* **34**, 1.
Stohl, A (1998) *Atmos. Environ.* **32**, 947.
Viana, M., Kuhlbusch, T.A.J., Querol, X. et al. *J. Aerosol. Sci.* **39**, 827.