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Quantifying impact and sources of trans-boundary PM10 in eastern Germany

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A quantitative understanding of source contributions and source areas to particulate matter (PM) levels in a city is important to further develop clean air policies and efficient abatement strategies.

The "PM-East" study was conducted during winter 2016/17 to apportion PM sources at 10 urban and rural sites in eastern Germany and quantify trans-boundary PM10 transport from East Europe. This was done by comparing mean PM10 concentration during western and eastern air mass inflow under similar conditions and calculating an "increment East" as a proxy for the trans-boundary PM10 fraction.

Depending on meteorological conditions, trans-boundary PM10 ranged from 0 – 30 μg m-3 and on average contributed 13 μg m-3 or 44 % to the total PM10 concentration at the regional background sites. The trans-boundary contribution was found to be higher during periods with elevated PM10 levels and lower or even negligible for less polluted or cleaner conditions. Positive matrix factorisation (PMF) was performed based on the chemical PM composition and revealed several important sources: fresh salt, aged sea salt, secondary ammonium nitrate, secondary ammonium sulfate + organics, (solid fuel) combustion, and traffic. For the trans-boundary PM10 fraction, it was found that > 80 % can be explained by combustion emissions and secondary ammonium sulfate + organics. Based on a correlation of these two factors within the trans-boundary PM10 and higher trans-boundary PM10 concentrations during cold than during warm days, it is concluded that both primary emissions and secondary PM formation from domestic heating in eastern European countries, presumably from the combustion of wood and coal, were the dominant sources of trans-boundary PM in eastern Germany.

Applying an extended Lenschow approach by incorporating increment East values as trans-boundary contribution, a case study for a traffic-impacted pollution hotspot in the city of Berlin revealed an average contribution of 30 % from trans-boundary transport, while regional background, urban background, and local traffic explained about 40, 10, and 20 % of PM10 mass concentrations during days with eastern air mass inflow. Continued efforts to reduce urban PM pollution are thus needed at all spatial scales, addressing e.g. traffic emissions in cities, agricultural emissions in rural areas, and emissions from domestic heating with solid fuels, which have strong impacts on air quality especially in eastern European countries, but via long-range transport also in distant areas, as quantified in this work.

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