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Impact of long-range transport of dust on in-situ measurements of particulate matter and ozone – case study: Austria

C. TALIANU[1,2], P. SEIBERT[1]

[1] Institute of Meteorology (BOKU-Met), University of Natural Resources and Life Sciences, Vienna, Austria, camelia.talianu@boku.ac.at
[2] National Institute of Research and Development for Optoelectronics, Magurele, Romania

Mineral dust from desert area is an important source of natural aerosol. Under weather conditions, dust particles can be lifted in the atmosphere and can be transported over long distances due to atmospheric circulation. In the lower atmosphere, large mineral aerosol particles can strongly influence the concentrations of atmospheric trace gases (including ozone) and of particulate matter (PM). The aerosols are removed from the atmosphere through settling and dry and wet deposition. For in-situ measurements, the level of PM is a result of both dust from long-range transport and PM from local sources. If PM from local sources can be estimated, the difference of PM concentration can be attributed to transported aerosols.

The purpose of this analysis is to determine the correlations between the long-range transport of mineral dust over Austria and in-situ measurements of PM10, PM2.5 and ozone, using selected dust transport events recorded over Central Europe in the period May - June 2017.

The study has been performed for Illmitz, Austria (47°46′N, 16°48′E), an EMEP regional background site for reactive gases and aerosols, which provides daily mean concentrations for PM10 and PM2.5 and maximum daily ozone measurements.

Two cases of long-range transport of mineral dust over Austria were identified in the analyzed period using measurements from AERONET stations from and close to Austria: Vienna-BOKU, Vienna-UNIVIE, Munich, Leipzig. From these measurements, the aerosols optical properties (aerosol optical depth AOD, Angstrom exponent AE, single-scattering albedo) and aerosol size distributions have been retrieved. When the measurements were not available, the properties have been retrieved from MODIS satellite data. One can estimate the surface PM2.5 mass concentration from the AOD and profile of temperature and humidity using multiple linear regression, with the assumptions that the boundary layer is well mixed and there is no significant aerosol aloft in regions dominated by small particles (AOD > 0.15).

The regression coefficients were computed for four consecutive days, starting one day before the dust event occurs, using the measured daily averaged values for PM2.5, AOD at 500 nm, and the temperature and relative humidity profile. The meteorological fields are taken from ECMWF's ERA-Interim reanalysis, with a spatial resolution of 0.5º x 0.5º, 61 vertical levels from the surface to 150 hPa, and a time resolution of 3 h. Hourly averaged PM2.5 concentrations have been computed using these regression coefficients and the hourly averaged AOD at 500 nm retrieved from AERONET, when the dust events occurred. A good correlation was obtained between concentrations of PM2.5 measured in-situ and PM2.5 estimated from AOD measurements. An increase of ozone concentrations over 130 µg/m^3 was observed at the in-situ station during both dust cases selected. The correlation between dust concentration and ozone concentration is, however, smaller.

Starting from the aerosol concentrations measured at Illmitz, split for each time interval according to the concentrations of PM2.5 modelled, the source-receptor sensitivity was computed using the Lagrangian transport model FLEXPART, run in backward mode for a transport time of five days for.several receptor heights, ground level and 1500 m (850 hPa level), 3000 m (700 hPa level) and 5500 m (500 hPa level). The source-receptor sensitivity shows the likely source of the aerosol is the Sahara desert.

We obtained a correlation coefficient between PM2.5 derived from AERONET and ozone concentrations measured at Illmitz of 0.71 for the first case and 0.75 for the second case. The correlation coefficient between the Angstrom exponent (AE) and ozone concentration was 0.15; as the AE depends on the aerosol size, it is not possible to establish a relation between aerosol size and ozone concentration.

In conclusion, the surface ozone and PM concentrations in Austria are strongly influenced not only by local, anthropogenic aerosols but also by long-range transported aerosols and ozone: air pollution is a global problem, requiring global solutions.

Keywords: Dust, ozone, particulate matter, aerosol optical depth, Lagrangian transport model.

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