Impact of Long-range Transport of Dust on In-situ Measurements of Particulate Matter and Ozone – Case Study: Austria

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Introduction

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 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.

Methodology

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. The period selected was 28 May – 25 June 2017.

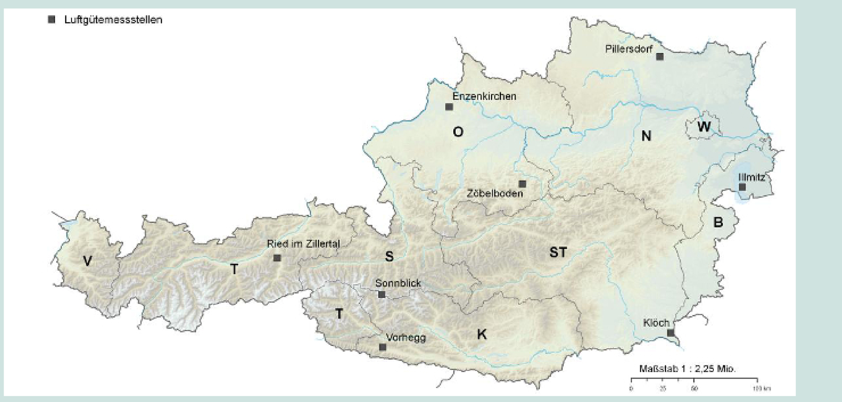
The cases of long-range transport of mineral dust over Austria were identified analysing the aerosols optical properties [1] (aerosol optical depth AOD at 500 nm, Angstrom exponent AE, single-scattering albedo) and aerosol size distributions retrieved from sun-photometers measurements from AERONET stations from and close to Austria: Vienna_BOKU, Vienna_UNIVIE, Munich, Leipzig. When the measurements were not available, the properties have been retrieved from MODIS satellite data.

Multiple linear regression was used to estimate the surface PM2.5 mass concentration from the AOD at 500 nm and the profiles of temperature and humidity. The regression coefficients were computed for four consecutive days, starting one day before the dust event occurs. The meteorological fields were taken from ECMWF's ERA-Interim reanalysis, with a spatial resolution of 0.5°x 0.5°, 61 vertical levels from the surface to 150 hPa, and a time resolution of 3 h.

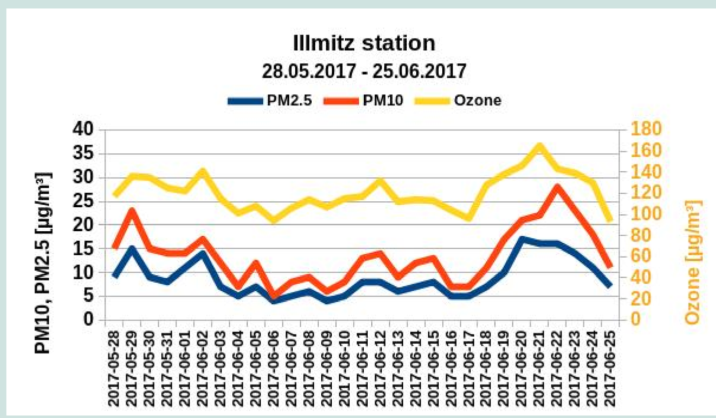
The source-receptor sensitivity was computed using the Lagrangian transport model FLEXPART [2, 3], starting from the aerosol concentrations measured at Illmitz, run in backward mode for a transport time of ten days.

Measurements

In-situ measurements

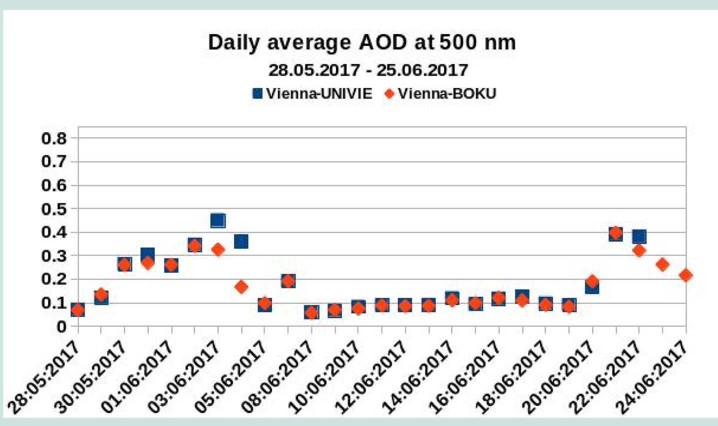


The air quality monitoring network of the Austrian Federal Environment Agency

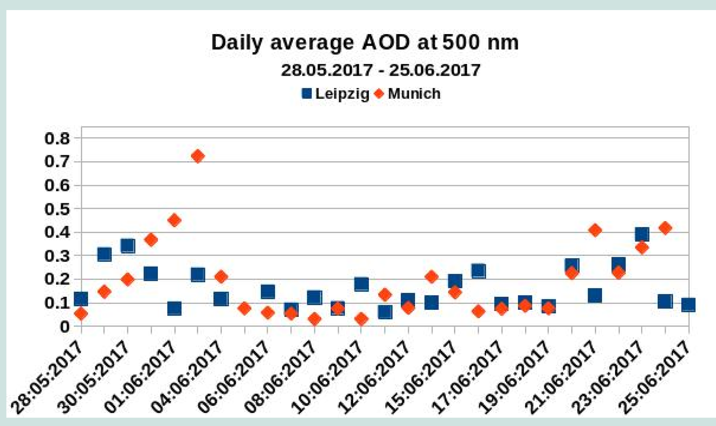


Selected measurements from Illmitz, Austria (47°46′ N, 16°48′ E) station

Sun-photometer measurements

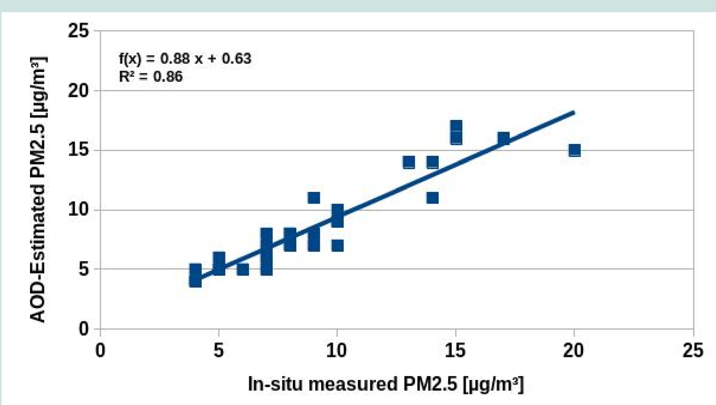


Aerosol optical depth, level 1.5, measured by the Austrian Aeronet stations: Vienna_UNIVIE 48°13′ N, 16°21′ E, alt. 225 m and Vienna_BOKU 48°14′ N, 16°20′ E, alt. 266 m

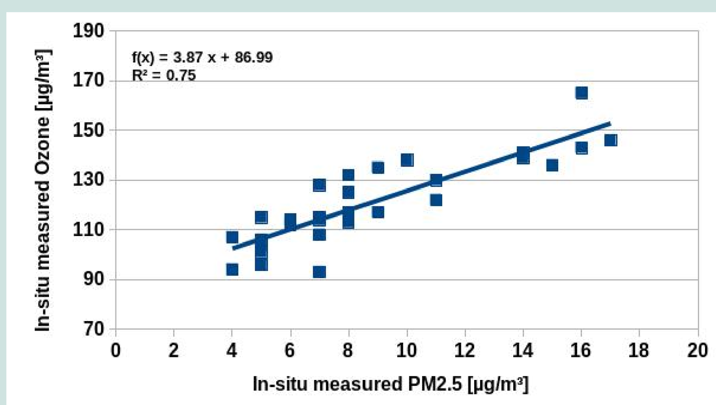


Aerosol optical depth, level 1.5, measured by the German Aeronet stations: Leipzig 51°21′ N, 16°21′ E, alt. 125 m and Munich University 48°9′ N, 11°34′ E, alt. 533 m

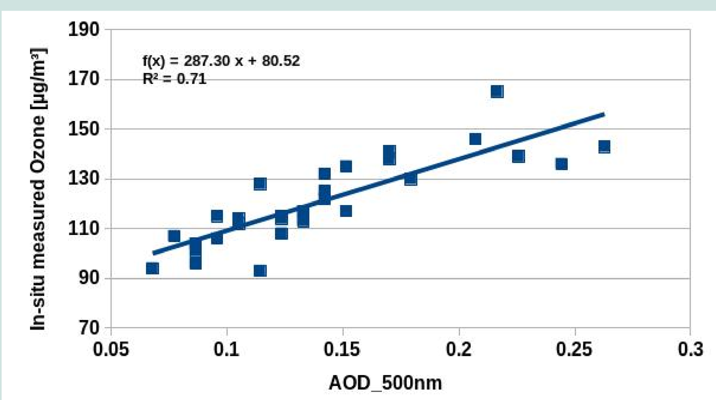
Correlations of in-situ and sun-photometer measurements



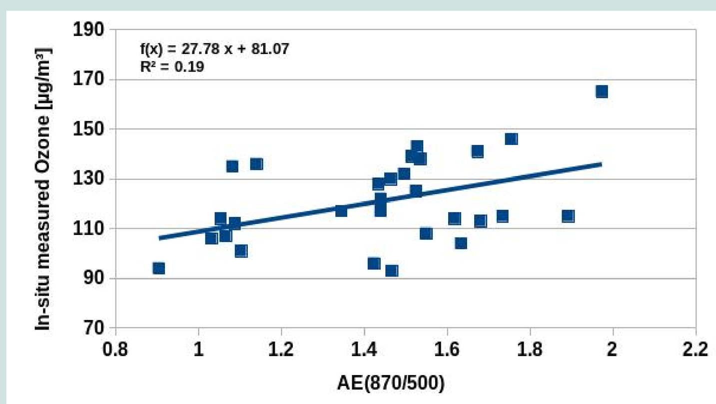
Correlation of PM2.5 concentrations measured at Illmitz station and of the PM2.5 concentrations estimated from the AOD measured at Vienna Aeronet stations for the period 28.05.2017 – 25.06.2017



Correlation of the PM2.5 and Ozone concentrations, both measured in-situ at Illmitz station for the period 28.05.2017 – 25.06.2017



Correlation of AOD values for the wavelength 500 nm retrieved from Vienna Aeronet stations and Ozone concentrations measured at Illmitz station for the period 28.05.2017 – 25.06.2017



Correlation of AE computed from the solar radiance for two wavelengths (870 nm and 500 nm) retrieved from Vienna Aeronet stations and Ozone concentrations measured at Illmitz station for the period 28.05.2017 – 25.06.2017

References

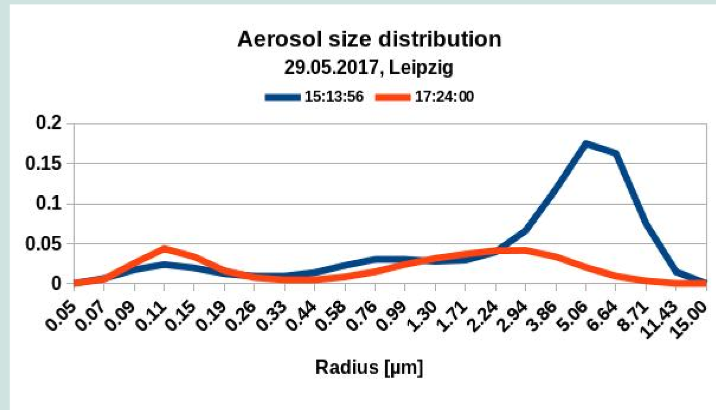
[1] Oleg Dubovik, Brent Holben, Thomas F. Eck, Alexander Smirnov, Yoram J. Kaufman, Michael D. King, Didier Tanré, and Ilya Slutsker. Variability of Absorption and Optical Properties of Key Aerosol Types Observed in Worldwide Locations. *Journal of the Atmospheric Sciences*, 59(3):590–608, Feb 2002.

[2] P. Seibert and A. Frank. Source-receptor matrix calculation with a Lagrangian particle dispersion model in backward mode. *Atmospheric Chemistry and Physics*, 4(1):51–63, Jan 2004.

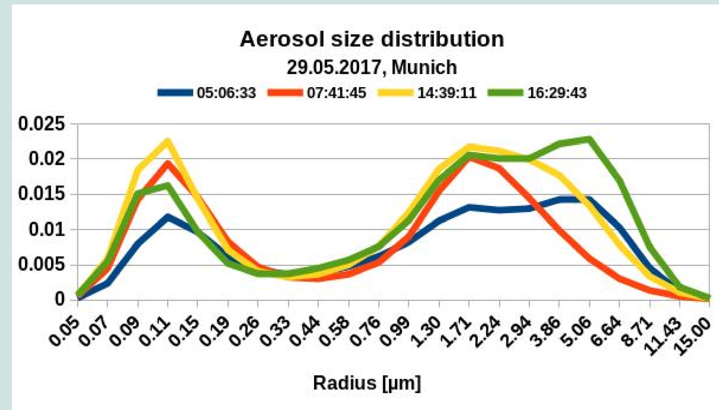
[3] A Stohl, C Forster, A Frank, P Seibert, and G Wotawa. Technical note: The Lagrangian particle dispersion model FLEXPART version 6.2. *Atmospheric Chemistry and Physics*, 5(9):2461–2474, Sep 2005.

Analysis cases

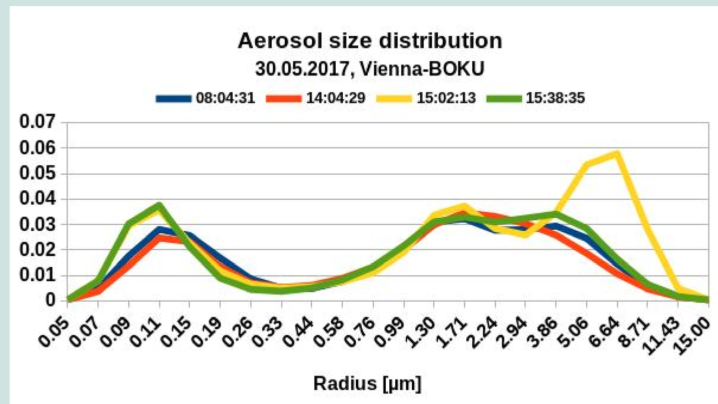
Case 1: 29.05 – 30.05.2017



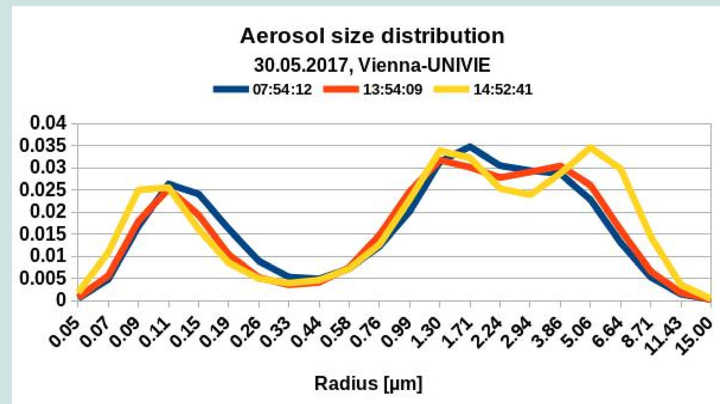
Aerosol size distribution, level 1.5, measured by the Leipzig Aeronet station on 29.05.2017



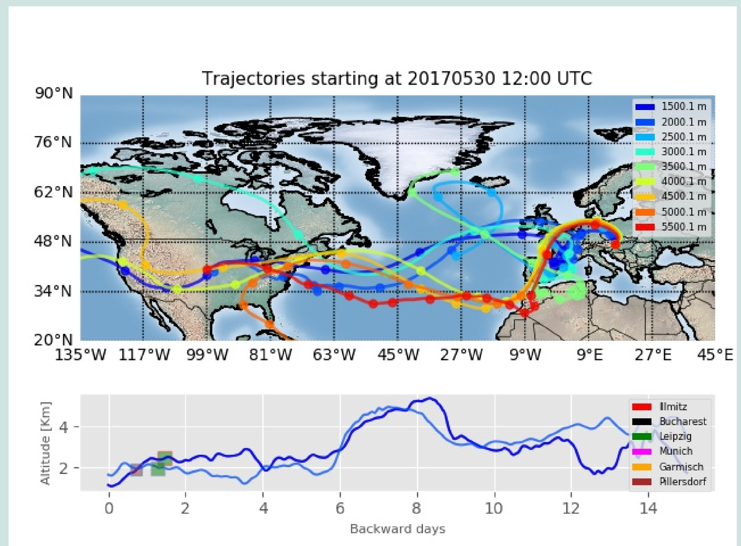
Aerosol size distribution, level 1.5, measured by the Munich Aeronet station on 29.05.2017



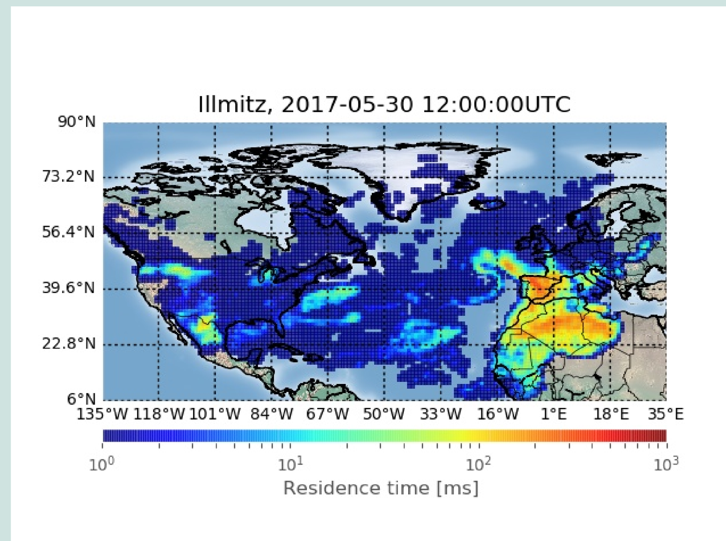
Aerosol size distribution, level 1.5, measured by the Vienna_BOKU Aeronet station on 30.05.2017



Aerosol size distribution, level 1.5, measured by the Vienna_UNIVIE Aeronet station on 30.05.2017

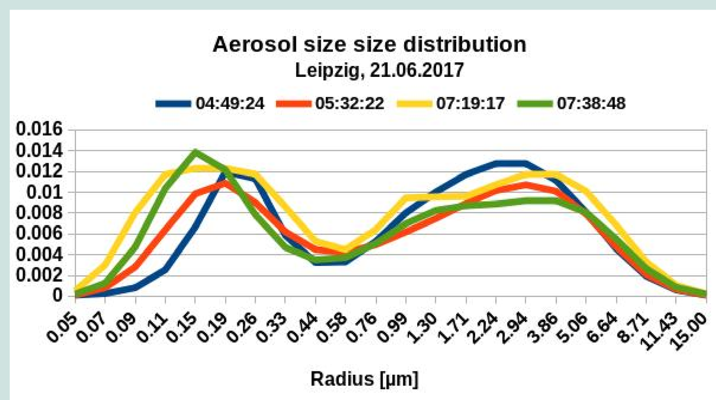


FLEXTRA trajectories of the aerosols computed for Illmitz, starting from 30.05.2017 12:00 UTC, run in backward mode for 14 days; 9 vertical layers, ranging from 1500 m – 5500 m with a spatial resolution of 500 m

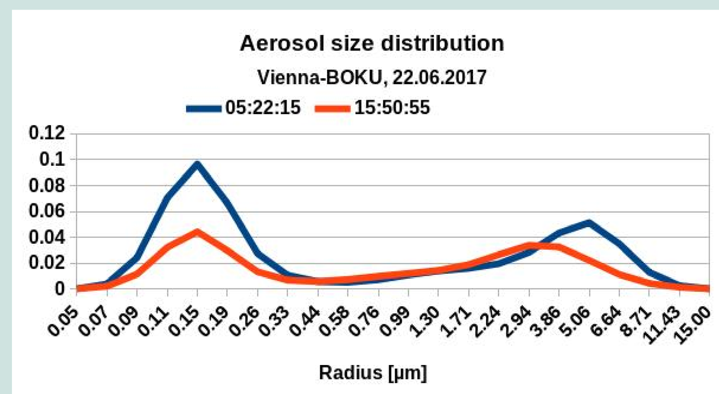


Source-receptor sensitivity computed using FLEXPART starting from 30.05.2017 12:00 UTC. The response functions are computed hourly, 10 days backward, on a 1°x 1°grid. Only the planetary boundary layer was used, considered to extend from surface to 2000 m

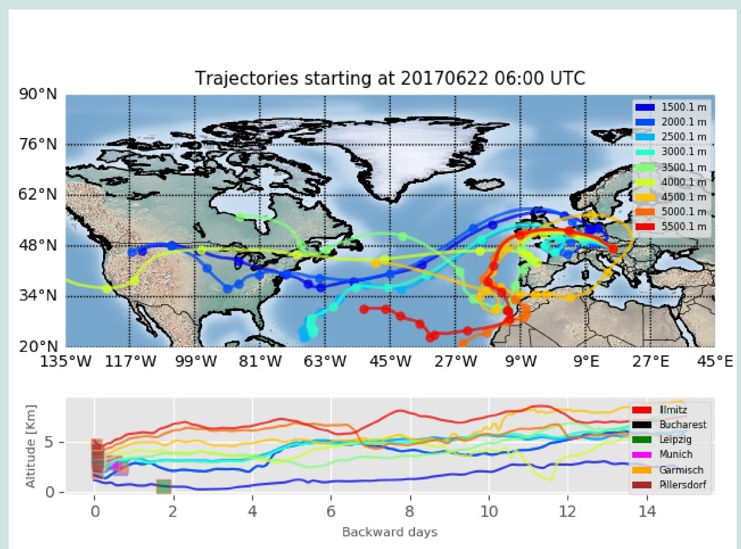
Case 2: 21.06 – 22.06.2017



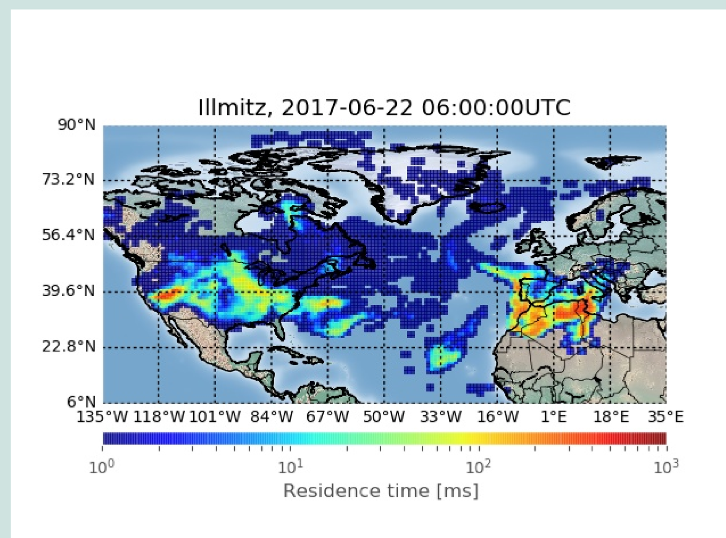
Aerosol size distribution, level 1.5, measured by the Leipzig Aeronet station on 21.06.2017



Aerosol size distribution, level 1.5, measured by the Vienna_BOKU Aeronet station on 22.06.2017



FLEXTRA trajectories of the aerosols computed for Illmitz, starting from 22.06.2017 06:00 UTC, run in backward mode for 14 days; 9 vertical layers, ranging from 1500 m – 5500 m with a spatial resolution of 500 m



Source-receptor sensitivity computed using FLEXPART starting from 22.06.2017 06:00 UTC. The response functions are computed hourly, 10 days backward, on a 1°x 1°grid. Only the planetary boundary layer was used, considered to extend from surface to 2000 m

Conclusions

- Two cases of long-range transport of mineral dust over Austria were identified in the analysed period using measurements from AERONET stations from and close to Austria: Vienna_BOKU, Vienna_UNIVIE, Munich, Leipzig.
- An increase of ozone concentrations over 130 $\mu g/m^3$ was observed at the in-situ station during both dust cases selected.
- For both cases, the source-receptor sensitivity shows that the likely source of the aerosol is the Sahara desert. In the second case, the North American desert has also an important contribution to the total concentration of dust recorded over Austria.
- We obtained a correlation coefficient between PM2.5 derived from AERONET and ozone concentrations measured at Illmitz of 0.75.
- The correlation coefficient between the Angstrom exponent (AE) and ozone concentration was 0.19; 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.

Supported by Austrian Science Fund FWF, Project M 2031, Meitner-Programm. We thank the PI investigators and their staff for establishing and maintaining the four AERONET sites used in this investigation.