Size segregated particle mass concentration and chemical composition in an agrarian region in Saxony

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Summary

The international field experiment INTERCOMP 2000 took place at the research station Melpitz of the IfT in Leipzig from April-04 to April-14-2000. The community of scientists, who are dealing with collection and analysis of particulate matter of the atmospheric aerosol, uses a lot of different tools and methods for sampling, weighing and analysis of particulate matter. Depending on the equipment and the scientific goals PM_{10}, $PM_{2.5}$, PM_1 and multiple size samplers are in use. The techniques of sample preparation and chemical analysis are quite different.
To compare the data from the different sites and groups this inter-comparison experiment should be the basis for the future work in particle measurements. During 10 measurement days a concerted collection followed by individual chemical analysis or on-line analysis of each partner should be a stock of samples characterised by different methods to compare our techniques and discuss advantages or disadvantages. Eight groups of scientists from the AEROSOL community have met at the IfT research station Melpitz:

The measuring site and sampling techniques

The research station Melpitz is an ideal place because the flat old meadow offered identical conditions to all participants. Because long range data sets for meteorological conditions, trace gas concentrations and particle mass concentration exists, the period for the INTERCOMP experiment in spring 2000 can be class in a period of more as eight years. During this time the particle mass concentration decreased at the Melpitz site. In the last years the concentration decrease stopped and winter concentration maxima, caused from local sources (individual coal heating systems and obsolete industry) are not any longer observed. Measurements of particle concentration in different size classes (PM_1, $PM_{2.5}$ and PM_{10}) shows differences in the seasons. During the inter-comparison measurements for different sampling techniques for trace gases and typical meteorological parameters were available and a background characterisation for the mentioned days was possible. Back trajectories allow the description of the long range transport of air masses.

Long term observations 1993 – 2001 for particle mass concentration and chemical composition

The background concentration of particles was measured using virtual impactors continuously at the IfT research station in Melpitz (Altitude 87 m, Latitude 51°32' N, Longitude 12°54' E) in the downstream plume of the Leipzig conurbation (Heintzenberg *et al*., 1998, Müller 1999, Spindler *et al*., 1999). The station is located on a flat meadow surrounded by agricultural land For further description of the Melpitz site see Spindler *et al.*, 2001.
Since 1993 particle filter samples were collected daily using a modified PM10 high volume sampler (HV, Anderson Samplers Inc., Atlanta, USA) The filters are quartz fibre from

Munktell Filter, Grycksbo, Sweden. In the result for Melpitz an eight year daily quantification of the particulate matter fraction PM_{10} is available (Figure 1).
Since 1999 particles have been collected also as weekly samples on filter packs for PM_{10}, $PM_{2.5}$ as well as PM_1 (two inlets) by using the "Partisol 2000" low flow (LV) air sampler (Rupprecht and Patashnik Co. Inc., Albany, USA, Figure 2). The filters for the three impactors are 47 mm diameter Teflon filters (Millipore, Eschborn, Germany, Type 470 and 3 µm pore size. The second PM_1 impactor act in parallel operation and was used for OC/EC collection on quartz filters. The carbon content of the PM_1 fraction was determined with a thermographic method using Ströhlein C-mat 5500 carbon analyzer separating the OC (650 °C, nitrogen) and EC (650 °C, oxygen). In the result an 2.5 year study for particle concentration fraction PM_{10}, $PM_{2.5}$ and PM_1 (additional with the OC and EC content) is available (Figure 2). In both time series the INTERCOMP period was highlighted. The course of daily particle mass concentration PM_{10} shows a declining trend from 1993 to 2001. The highest values have been observed in the winters 94/95 and 96/97. Also for the winters 97/98, 98/99 and 99/00 pronounced concentration peaks were observed. A reason for the decreasing particle concentration is the decreasing number of individual coal heating systems in the conurbation and the surroundings. In the winters high pressure systems with a transport of dry continental air masses, small mixing height and low wind velocities promote concentration peaks. In the last two winter no typical concentration peaks exist, the reason can be the low particle concentrations in combination with more westerly wind situations observed in central Europe. All samples were analysed by ion chromatography for the content of ionic constituents.

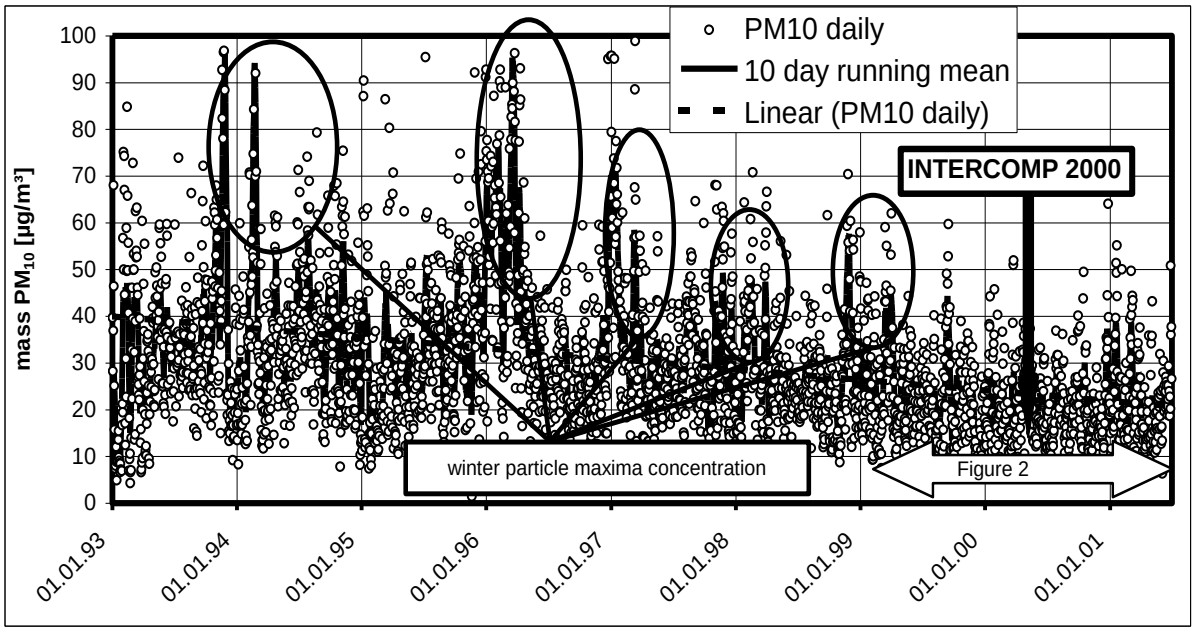

Figure 1: Daily particle concentration (HV) PM_{10} at Melpitz

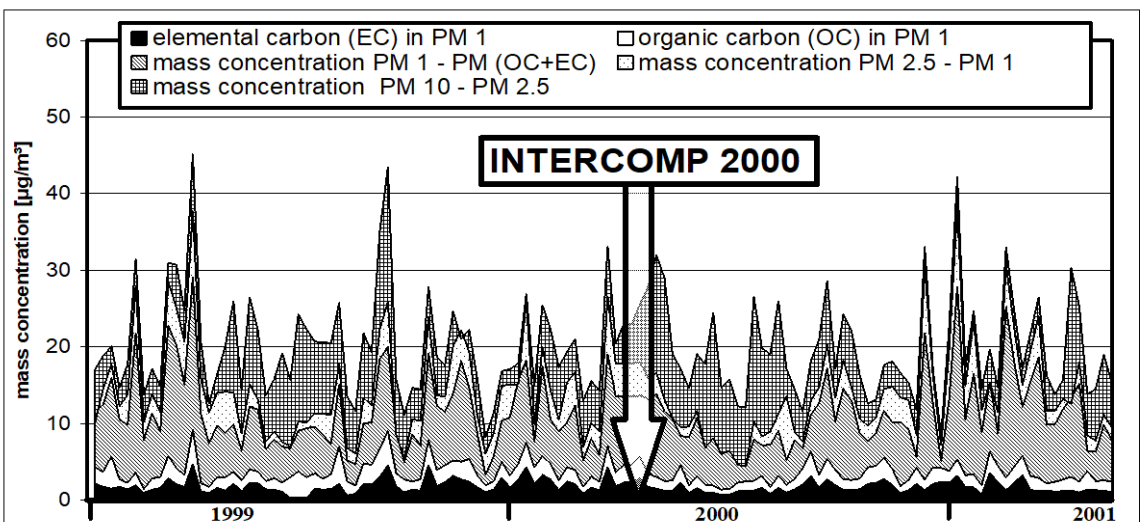

Figure 2: Weekly particle concentration (LF) fraction PM_{10}, $PM_{2.5}$ and PM_1 (additional with the OC and EC content), the weeks 29,31,41 (1999), 14,15 (2000) and 12 (2001) are interpolated

In Figure 2 the influence of surface wetness is clearly recognisable. In the summertime more coarse particles (PM_{10}-$PM_{2.5}$) exists. The summer 2000 starts early, straight after the INTERCOMP experiment in Mai. The mean mass distribution for the period 1999 up to 2001 is: 11.2 µg m^{-3} for particles PM_1, with a part of water soluble ions of 57.5 %, 2.8 µg m^{-3} for particles ($PM_{2.5}$ – PM_1), with a part of water soluble ions of 38 % and 6.0 µg m^{-3} for particles (PM_{10}– $PM_{2.5}$), with a part of water soluble ions of 17.5 %.

Size segregated particle composition (PM10, PM2.5, PM1)

During the INTERCOMP experiment daily filter samples (8:00 to 8:00 o'clock, MEZ) were collected with the "Partisol 2000" sampler (LF) as an exception. In these samples the content of water soluble ions was determined (Figure 3). For two days four back trajectories per day (NOAA, USA) are plotted in Figure 3 as an example for the characterisation of source areas of air masses. The air mass (06-Apr; 07-Apr 00) is from the North Atlantic region, non polluted air transported with high wind velocity to the Melpitz site. The samples show a very low particle mass and the content of NH_4^+, NO_3^- and especially SO_4^{2-} is low. The air mass (11-Apr 00) contains pollution from the East European region transported with moderate wind velocity to Melpitz. The sample has a high particle mass concentration and contains a striking part of the ions SO_4^{2-}, NO_3^- and NH_4^+. For the INTERCOMP period different meteorological periods can be derived from back trajectories:

1. North Atlantic non polluted air (06-Apr; 07-Apr)
2. North Atlantic slightly polluted air (08-Apr; 09-Apr)
3. East European influenced polluted air (10-Apr; 11-Apr)
4. West European influenced air (04-Apr; 05-Apr; 12-Apr; 13-Apr)

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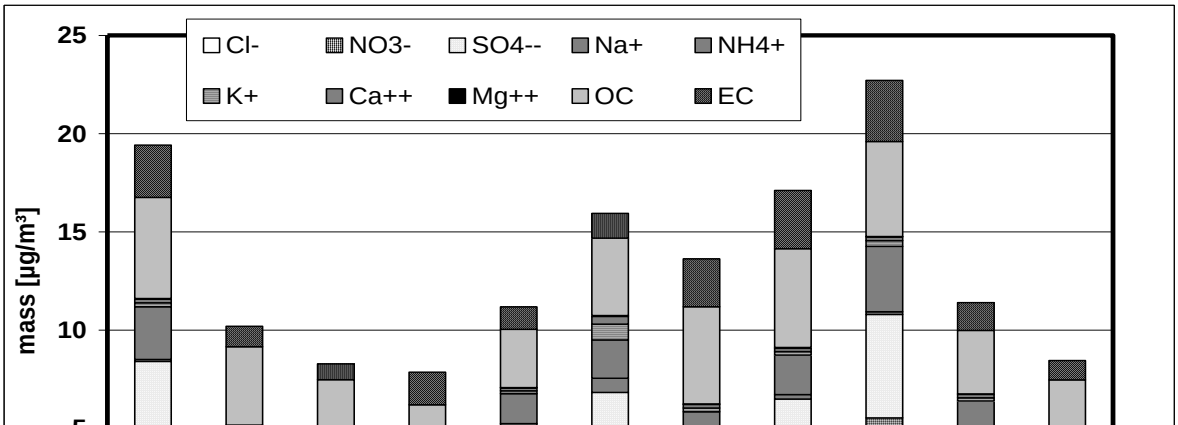

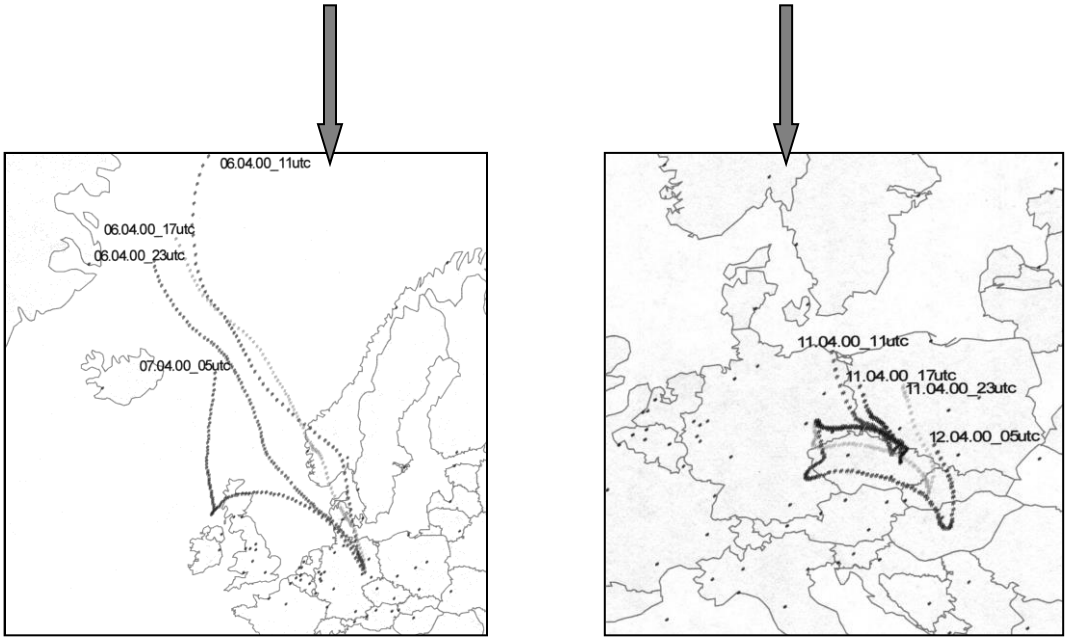

Figure 3: Daily PM_1 filter samples (LF) and exemplary back trajectories for two days

References

Müller, K. (1999): A 3-year study of the aerosol in Northwest Saxony (Germany). *Atmos. Environ*. **33**, 1679-1685

Spindler, G., K. Müller, H. Herrmann (1999): Main Particulate Matter Components in Saxony (Germany). *ESPR - Environ. Sci. & Pollut. Res.* **6**, 89-94

J. Heintzenberg, K. Müller, W. Birmilli, G. Spindler, A. Wiedensohler (1998): Mass-related aerosol properties over the Leipzig Basin. *J. Geophys. Res*. **103D**, 13.125-13.135

G. Spindler, U. Teichmann, M.A. Sutton (2001): Ammonia dry deposition over grassland – Micrometeorological flux-gradient measurements and bi-directional flux calculations using an Inferential Modell. Q.J.R.Meteorol.Soc. **127**, 795-814