SIZE-SEGREGATED CHEMICAL PARTICLE CHARACTERIZATION IN WINTER 2003 AT THE IFT-RESEACH STATION MELPITZ (GERMANY)

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Motivation and Experimental

Aerosols are stable suspensions of solid and liquid particles in the troposphere. Particles can be emitted directly (primary particles) or can be formed as result of chemical reactions (secondary particles). The physical size distribution and chemical composition of particles shows a strong variability, this emanates from different complex sources. Tropospheric particles influence the radiation balance (e.g. Heintzenberg et al. 1998), are in interaction with trace gases (e.g. Usher et al. 2003) and can provoke negative human health effects (Dockery and Pope, 1994). Quality standards for tropospheric particles are defined (EU-Commission, 1999). The particles have, dependent on their aerodynamic diameter, different tropospheric live times . Particles in the "Nucleation Mode" are primarily formed (D_p < 20 nm), they grow by coagulation and condensation to particles in the "Aitken Mode" (D_p= 20 to 100 nm). Primary emitted soot particles exists also in this size range. These particles grow more by coagulation, condensation and influenced by chemical liquid phase processes to fine particles in the size range (D_p = 0.1 to 1µm) and can be removed from the troposphere by rain. Coarse particles (D_p = 1 to 100 µm) emanate from mechanical processes and resuspension by turbulence. These particles sediment near their sources. For a chemical size segregated characterization particles were sampled over 24 hours (start was 10:00 MEZ) in five size classes (BERNER low pressure impactor with the cut-off sizes 10, 3.5, 1.2, 0.42, 0.14, and 0.05 µm, compare Figure 1) and analysed for mass and the content of water-soluble ions and total carbon. The particle mass concentration was determined gravimetrically (at 50% relative humidity, 20 °C), conditioning time: 24 hours (Mettler AT 261 Delta Range balance). The concentration of water-soluble ions was detected by ion chromatography (Metrohm, Switzerland). Total carbon (TC) was quantified as sum of organic (OC) and elemental (EC) carbon by a thermographic method applying a Ströhlein C-mat 5500 carbon analyzer. For a complex size-segregated physical-chemical characterization of aerosol in typical urban background a joint project between the Umweltbundesamt (UBA) and IfT was designed (UBA code 351 01 031) for two years. The new project starts in July 2004 and is based on results (some are shown here) of a joint pilot study (UBA code 351 01 022) carried out at Melpitz site in winter 2003 for tests of the sampling technique and investigation of the appropriateness of this place.

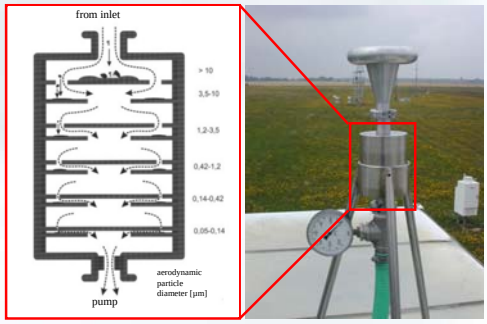

Fig. 1: Five-stage low-pressure cascade impactor (BERNER type), flow rate 4.5 m³/h at Melpitz site

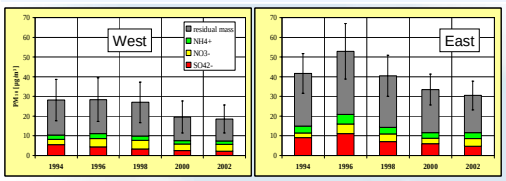

Fig. 3: Comparison of two year means from daily samples 1993 to 2002 (high volume sampler, Sierra Andersen, PM_{10}), for wind direction East and West (at least 16 hours in a 90° sector, 41 % of data are for West and 17 % for East).

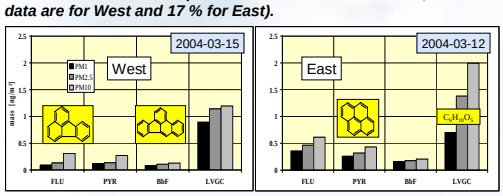

Fig. 4: Comparison of concentration of organic species at two days in spring for source direction West and East (high volume sampler DIGITEL PM_1, $PM_{2.5}$ and PM_{10})
FLU, Fluoran-thene; PYR, Pyrene; BbF (combustion), Benzo- (b)-fluoranthene (gasoline); LVGC, Levoglucosan (biomass burning).

The IfT-research station – wind direction and PM-concentration

The research station of the IfT is situated near the village Melpitz in the vicinity of the city Torgau in the river Elbe valley (87m above sea level, 51°32' N and 12°54 ' E) and is one point in the observational network of the UBA, see Figure 2. The station is located on a flat meadow. Under the dominating wind direction from southwest humid air masses from the Atlantic crossing parts of western Europe and important parts of Germany before reaching Melpitz. The second important wind direction maximum is east. Hence, during high-pressure conditions dry air masses are transported over long distances to Melpitz, often with moderate wind velocity and without precipitation. The main source regions for these air masses are Poland, Belarus, Ukraine and the north of the Czech Republic. In these areas coal heated power plants with little exhaust treatment, old industry and older cars still exist. Both wind directions (southwest and east) are the chief cause for different concentrations of chemical species in the particles, compare Figure 3 with results for mass and content of mean ions in PM_{10} for the decade 1992 to 2002, Spindler et al. 2004. With backward trajectories source regions for particles can be assigned, see Figure 4 as an example with concentration of organic species for combustion, biomass burning and gasoline use in PM_1, $PM_{2.5}$ and PM_{10}.

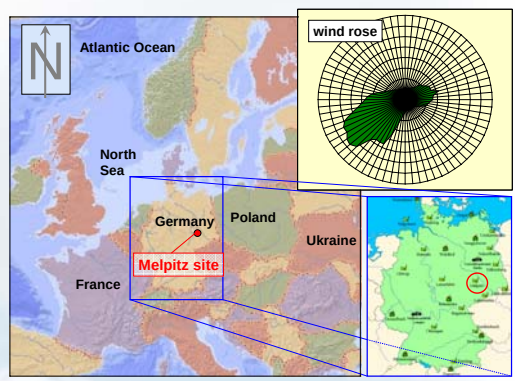

Fig. 2: Location of the IfT-research station in Europe, wind rose (1992 to 2001, base 5minute means) and overview of the UBA measuring network in Germany (Melpitz highlighted)

Some results of a joint pilot study in November and December 2003

The IfT-research station as one point in the UBA network and was tested for the suitability for the use of the complex particle measurement technique in the field and the exposure for a relatively representative physical chemical characterization of particles in Germany. In a pilot study measurements with the BERNER impactor took place. Results for the 24 hour impactor measurements were separated by air stream directions from tree source regions (indicated by 96h backward trajectories): North Atlantic, West Atlantic and West Europe and from the continent during easterly wind direction, respectively (Figure 6). Figure 5 shows the comparison of two days with an air stream from Atlantic and with continental air stream. The particle mass concentration shows highest amounts for the continental air mass. The highest particle, ion or TC mass concentration found in the air mass from the continent. Air masses with the source region Northern Atlantic show marginally lower masses as with source region Western Atlantic and Western Europe. Therefore it is possible to distinguish for the Melpitz site two main source regions in the future.

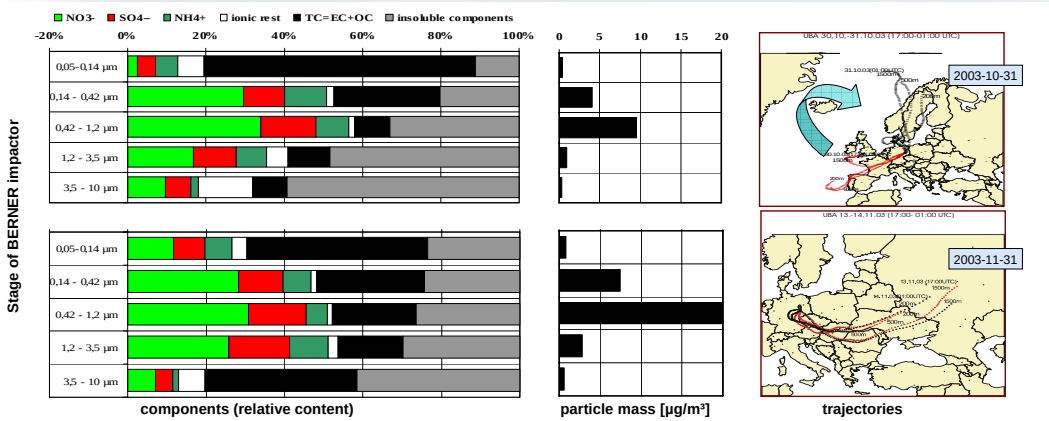

Fig. 5: Comparison of two days with air stream from Atlantic and with continentel air stream, respectively. 96 h Backward trajectories characterize the source regions. The particle mass concentration and the relative content of water soluble ions and TC measured with five stage BERNER impactor are quite different. Particles on stage 2, 3 and 4 are from long-range transport.

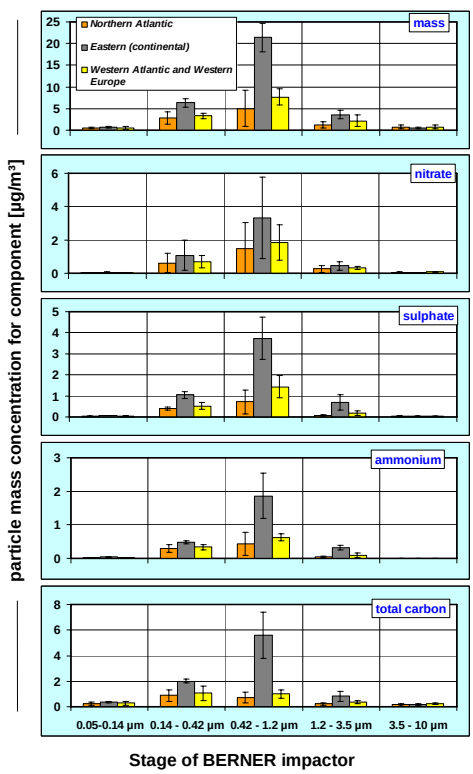

Fig. 6: Mass concentration and concentration of water soluble ions (NO_3^-, SO_4^{2-} and NH_4^+) and total carbon in particles sampled with the five stage BERNER impactor, distinguished by air streams from three source regions (for each region three 24 h samples averaged). The source regions were detected using 96 h backward trajectories.

References:
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