Nucleation mode particles in the Karlsruhe city plume, the COPS / TRACKS - Lagrange experiment

W. Junkermann[1], R. Hagemann[2] and B. Vogel[2]

[1]Forschungszentrum Karlsruhe, IMK-IFU, Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany
[2]Forschungszentrum Karlsruhe, IMK-TRO, 76021 Karlsruhe, Germany

Keywords: nucleation, size distribution, airborne particles

Within the COPS/TRACKS (Kottmeier et al., 2008) campaign in the Rhine valley and northern Black Forest an airborne Lagrange experiment was performed to investigate the fate of a single city plume and its chemical aging during transport over remote areas of the Kraichgau. Measurements of aerosols and aerosol size distributions were performed using an ultralight aircraft equipped with fast condensation particle counters, scanning mobility particle sizers and optical particle counters for the characterisation of the whole spectrum of particle sizes from ultrafine aerosols to coarse particles.

An aerosol plume of nanometer size particles was detected with a source region above the city of Karlsruhe and aging and growth of the particles during three hours transport time. The temporal evolution of size distributions within this plume was generally in agreement with the behaviour of size distributions of nucleation events with a subsequent growth of about 5 nm/h (Laaksonen et al, 2005) but the diurnal timing of the particle generation was several hours delayed compared to typical nucleation events observed elsewhere (Wu et al, 2008). Though nucleation events have occasionally been reported to happen later during the day the weather patterns during the campaign rather favoured early morning nucleation.

We use a 1-D version of the comprehensive model system COSMO-ART (Vogel et al., 2009) to test individual hypothesis that could explain the unexpected nucleation time shift behaviour of the observed temporal development of the size distributions. We found that either a direct emission of nanometre size particles (< 5 nm) or a strong source of SO_2 would be required to explain the observations. Sufficient emissions of ultrafine particles have not been reported up to now neither from traffic exhaust, nor from city emissions or from polluted rural conditions (Wu et al. 2008). An elevated source of SO_2 in our model simulations produced rapidly new particles with a similar temporal evolution of the size distributions as observed. SO_2 emission from a nearby power plant thus might be responsible for the particle plume.

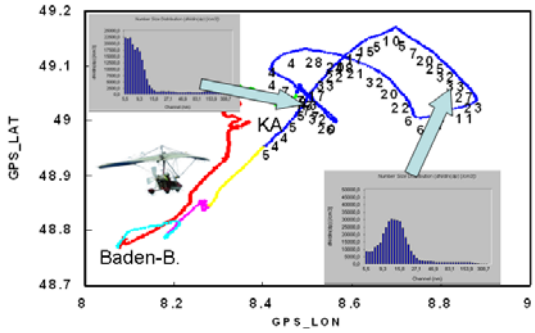

Fig. 1, Flight track, size distributions and total number of particles > 10 nm (/1000) during the Lagrange flight. Particle numbers outside the plume were ~ 4-6000 / cm3.

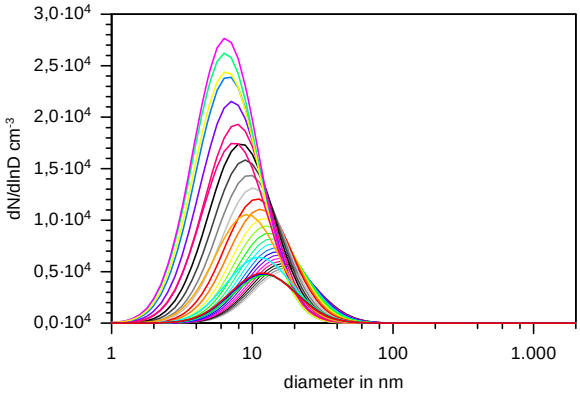

Fig. 2, Simulated temporal evolution of the size distribution with five minutes time intervals.

Wu, Z., Hu, M., Lin, P., Liu, S., Wehner, B., Wiedensohler, A., (2008), Atmos. Environ., 42, 7967-7980.
Kottmeier Ch. et al., (2008), Meteorol. Z., 17, 931-948.
Laaksonen, A., Hamed, A. Joutsensaari, J., Hiltunen, L., Cavalli, F., Junkermann, W., Asmi, A., Fuzzi S., and Facchini,M.C, Geophys. Res. Lett., 32, L06812, 10.1029/2004GL022092, (2005)
Vogel, B., H. Vogel, D. Bäumer, M. Bangert, K. Lundgren, R. Rinke, T. Stanelle, (2009) submitted to APCD.