Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-556-SC1, 2016

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Vertical and horizontal variation of aerosol number size distribution in the boreal environment" *by* Riikka Väänänen et al.

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Received and published: 1 September 2016

The manuscript describes results of regional scale flight experiments in the area of Hyytiälä, the location of the SMEAR II field site. Airborne measurements of aerosol size distributions are combined with concurrent ground based measurements during two intensive field campaigns in 2013 and 2014. The results compare well with previous experiments during the EU project QUEST (O'Dowd et al, 2009) showing a similar high spatial variability of ultrafine particle number concentrations. Also it is obvious that the majority of the enhanced ultrafine particle number concentrations are found in the planetary boundary layer. Compared to O'Dowd et al, who used for most of the flights 'only' two counters with different cutoff sizes to identify ultrafine particles between 3 and 10 nm, the current size distribution measurements allow a by far more detailed analysis.

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Discussion paper

The authors discuss the limitations of a single aircraft making point measurements and either vertical or horizontal flight patterns and also the problems of averaging such data while due to the high variability most of the information is contained in individual flight patterns or individual flying days. A major result is that the size distributions aloft typically show the lowest size mode in a range of 10 – 20 nm. This is also typical for a few recent airborne nucleation mode plume studies (Junkermann et al, 2011, 2016, Junkermann and Hacker, 2015)

The manuscript gives a nice overview over results of more than 100 flight hours, however, it leaves some questions open. There are several recent publications on more detailed airborne measurements of nucleation mode particles available, see below. Why is the horizontal distribution that patchy? Why don't we see particles in the lowest size bins in the airborne results? The smallest particle mode detected during the airborne measurements is not in the lowermost size bins but mostly larger in a range of $\sim$ 10-20 nm. According to Boy and Kulmala (2002) and Kulmala et al, (2012) this is an indication that the observed particles are not produced locally but, that they are advected from somewhere else. However, where do they come from? The aircraft is than far downwind of the place where particles are generated, see for examples the long distance airborne measurements with similar SMPS size distributions and spatial extend of particle plumes from anthropogenic sources. Directly at or over a NP source area or within an aging plume with high sulphur content the SMPS size distributions should show a major mode in the smallest size bins (biogenic particles, Junkermann et al, 2009; sulpur rich plume, Junkermann and Hacker 2015).

Can we learn from size distributions and HYSPLIT transport model about the origin of the new particles or their precursors? For the fast processes happening with NPF it's not only important where the airmass comes from but rather what is happening during transport on the backtrajectory within the last 24 or 30 hours. Either an anthropogenic source with 4-8 nm emission is considered (Junkermann et al, 2011), than 20 nm particles are about four growth- hours old and the spatial distribution is narrow or gas

to particle conversion (NPF) is considered, than, assuming a growth time of $\sim$ 4 hours up to sizes of 4 nm (Kulmala et al, 2013) and further continuous growth of $\sim$ 4 nm/h, 20 nm 'new' particles should be a at least 10 hours old and the location of initial production thus may be far more than a hundred km upwind. Even further away, when growth occurs only at daytime. However, than the high spatial variability is not in agreement with the data as plume dispersion would produce a wider distribution. The HYSPLIT (GDAS meteorology) airmass backtrajectory for March 28 directly overpasses the Kola Peninsula $\sim$30 hours before arrival at Hyytiälä. Other anthropogenic sources might be closer. And, anthropogenic sources can emit sulphur-compounds and particles into the residual layer at night.

Please also include the winds at flight altitude into the graphics. The winds only at the surface are misleading in a context or airborne experiments. HYSPLIT may be used to derive winds along the trajectory as well.

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