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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observations of turbulence-induced new particle formation in the residual layer" *by* B. Wehner et al.

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We really appreciate the helpful comments and suggestions of the reviewers! Thanks!

Comments: Airborne aerosol measurements are known to be challenging. Has the performance of these measurements in the ACTOS platform tested earlier and how? Please provide some information in this regard.

Answer: These helicopter-borne measurements were performed in heights below 2 km. In these heights the pressure is still high enough that the commercial TSI CPCs can be operated without any modifications (see manual 3762). The SMPS was build like other well-characterized instruments, just optimized in terms of weight, power consumption, and data acquisition. This instrument has been compared several times with

well established instruments in IfT labs, such as DMPS. In general they show a good agreement in particular above 10 nm. Below the sampling error is generally high under ambient conditions. Also the OPC fits well at the upper end of the SMPS and also with other TMPS, see example: Figure 1 below.

The plot shows one-hour average number size distributions from two IFT-TDMPS-systems (both labeled TDMPS 1 here are in fact different systems) and the ACTOS-SMPS. The agreement above 10 nm is reasonably good, below 10 nm the SMPS shows a bit lower concentrations. One reason might be that the TDMPS systems operate with 20 l sheath air within the short DMA while our DMA uses 10 l only. This increases the losses due to diffusion. Furthermore, the TDMPS systems use UCPCs below 30 nm, using a much lower sampling flow resulting in a worse counting statistics. Thus, uncertainties below 10 nm in particular at low concentrations are high. We think, the comparison shows a reasonable agreement for the SMPS range and a perfect agreement for the OPC range.

We added in the text: Both, SMPS and OPC have been compared under different conditions with well-characterized reference-instrumentation at IfT, such as Twin Differential Mobility Particle Sizer (TDMPS). The measurements showed a good agreement within the range of measurement uncertainties.

NAIS appears to be a very new instrument. How reliable is it? Has its performance been tested?

Answer: The NAIS measurements have been performed using calibrated, inter-compared instrument. The instrument took part in a calibration and inter-comparison workshop before and after the field measurements (Asmi et al., 2009; Gagné et al., manuscript in preparation). The (N)AIS is a relatively new instrument suitable to measure nanometer-sized ions and also particles in the size range below 3 nm with a good performance for mobility and concentration measurements (Asmi et al. 2009).

Asmi et al. (2009) performed mobility calibrations (determined the experimental trans-

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fer functions), concentration calibrations and flow calibrations. The (N)AISs detected similar concentrations as reference instruments at concentrations corresponding to particle formation events, whereas the mobilities were slightly overestimated.

How many instruments like that there are in operation and are they comparable to each other?

Answer: In the same workshop all the ion spectrometers were inter-compared. During the calibration workshop, the number of the (N)AIS instruments in the world was only 12 and 10 of them took part in the calibrations and inter-comparison. During 2008 and 2009 all these ion spectrometers were operating in 12 field sites across Europe within the EUCAARI project (Manninen et al. 2010 submitted to ACP).

For the inter-comparison, the instruments were compared in field-like conditions. Both Asmi et al. (2009) and Gagné et al. (2010 manuscript in preparation) reported that all instruments agreed sufficiently in terms of particle number concentration and size. NAIS compares well with other aerosol instruments also on field conditions (Kulmala et al., 2007; Manninen et al., 2009).

We included in the text: 'The NAIS used here took part in a calibration and inter-comparison workshop before and after the field measurements and agreed sufficient with other instruments (Asmi et al., 2009).'

The authors showed that in their measurements, nucleation occurred in distinctive layer above a ground and when this air was mixed down, also increases in ground-level particle concentrations were observed. As a result, the authors made a strong point that great care should be taken when interpreting nucleation events observed at the ground level. It is very rare that ground-level measurements are accompanied by sufficiently accurate remote sensing other methods to reveal whether ground measurements have affected by mixing from above. Do the authors have any recommendation on how to distinguish between nucleation taking place close to ground and that taking place above the ground using solely ground measurements? For example, does it help to

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have an instrument of particle detection limit below a few nm? Please add some advice here.

Answer: That is really a good question; we were thinking and discussing a lot. However, we cannot give a clear answer after this individual case study, but some speculation should be given here. One special feature on May 13, 2008 was that we did not see a typical new particle formation day with a banana-shaped contour plot from ground based aerosol measurements. Here, the NPF was measured immediately at larger diameters which means that the particles have been formed somewhere else and grown particles reached the measurement site. This transport could generally be horizontally or vertically. Thus it would be nice to have any vertical measurements available allowing conclusions about the thickness and development of the mixing layer. If the appearance of such a particle burst (no continuous growth from smallest diameters) coincides (maybe with a slight time shift) with the removal of the nocturnal inversion it is very likely that the newly formed particles have been transported vertically. A measurement at the smallest detectable diameters may help to prove this idea: If the NPF event starts at the ground station with smallest diameters of a few nanometers, the particles are really fresh and nucleated in the nearest environment. Over horizontally homogeneous terrain, horizontal advection requires a region with preferred conditions with NPF combined with some horizontal transport. Thus, we conclude that if a particle burst occurs (not at smallest detectable sizes, no banana-shape) over horizontally homogeneous terrain a vertical transport of newly formed particles is a probable explanation. However, this is just speculation and should not be published in a scientific paper yet. More similar studies are required to draw any general conclusion.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 327, 2010.

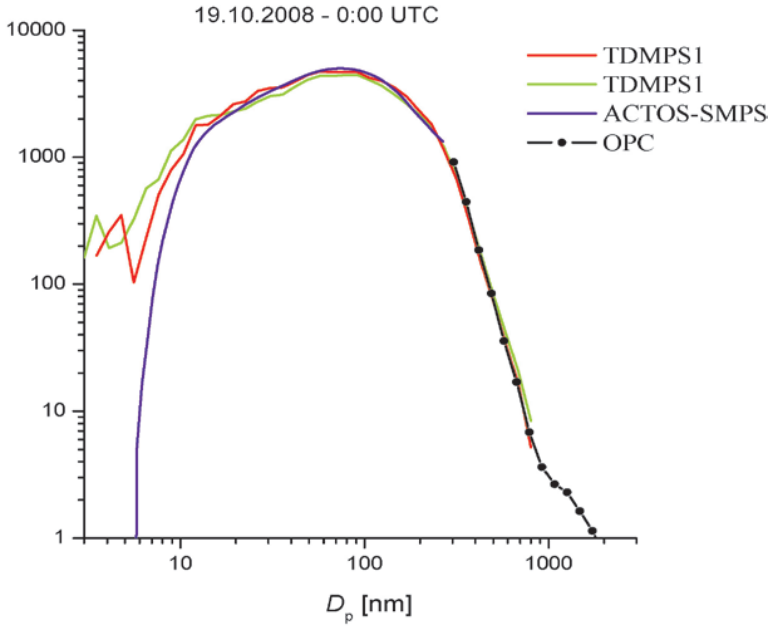

Fig. 1. One-hour average number size distributions from two IFT-TDMPS-systems (both labeled TDMPS 1 here are in fact different systems) and the ACTOS-SMPS.

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