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

B. Wehner et al.

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Received and published: 4 May 2010

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

The results are intriguing and actually some of the first I know of where co-located aerosol and meteorological measurements have been performed in a relatively stationary air mass situation. These are precisely the sort of measurements we need to better understand the relationships between meteorological and aerosol physicochemical processes like new particle formation. I commend the authors for designing a very nice study.

The findings are actually consistent with previous airborne aerosol measurements I made in 1998 over Philadelphia, USA. Although my previous results are not nearly as

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comprehensive as those presented here, at both the AAAR conference in 2000 and the EAC in Leipzig in 2001 I showed results from simultaneous measurements of nanoparticle size distributions (5-50,000nm) and a variety of gasses that could potentially act as particle precursors (SO₂, H₂O₂, Ozone, water vapor). We observed very interesting 'bursts' of the smallest particle sizes at the boundary between the developing mixed layer and the nocturnal residual layer during the late morning hours (around 10 am local time). We never observed the bursts during afternoon flights. We speculated that turbulent mixing could be playing a role, but did not have concurrent turbulence data to substantiate our claim.

Answer: I remember your talk in Leipzig 2001, that really fits to our results. Also to those from the SATURN campaign 2002, where we also observed new particles near the inversion above the developing boundary layer.

One concept that still isn't clear to me: If we assume that 5nm particles could already be several hours old, given the back trajectories shown in Fig. 2, wouldn't the air mass within which formation actually occurred have been ~100km away? The statement on page 13 that the similarity of the vertical profiles supports local production compared to vertical transport makes sense, but I don't see how horizontal advection can be ruled out if the atmosphere was simply strongly stratified and very stable in the nocturnal/residual boundary layer above the developing mixed layer. Furthermore, if the size distributions for diameters smaller than 20 nm suffered from poor counting statistics, doesn't this suggest that nucleation, if it did occur locally, was relatively weak, or that the nucleation occurred some distance away?

Answer: Right, horizontal advection cannot be excluded in this case. The horizontal wind speed within the interesting layers is 5 m/s in maximum, resulting in less than 40 km as an upper estimate. Only vertical transport can be excluded for sure. We modified one sentence: . . .are caused by locally restricted new particle formation (NPF) events at those heights including horizontal transport, rather than. . .

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I would like to recommend reducing the amount of detail described at several points in the paper, particularly if the details are not explicitly connected with proving or disproving a hypothesis. At times throughout the paper it is difficult to follow the very detailed description of the boundary layer structure (for example most of page 12) - it would be helpful in several of these situations to either remove the discussion or end the detailed discussion with some kind of summary statement explaining why such detail is important - what is the point relative to your hypothesis that turbulence is playing a role in new particle formation?

Answer: This is correct, we explained and described the vertical stratification very detailed because it is the most important part of the study. From the first view the profiles did not look very special but a deeper look shows a number of features which help to understand the occurrence of new particles. Therefore, we will explain why these details are necessary and added one paragraph to subsection 3.3.

We added: One unique aspect of these observations was the high resolution of the vertical profiles of thermodynamic, turbulence, and aerosol properties. The purpose of this section is to provide a detailed view of that structure and therefore illustrate the kind of vertical heterogeneity that may contribute to new particle formation.

With respect to the Richardson number discussion relative to new particle formation. Were data from other days analyzed as well to explore whether similar turbulence parameter profiles were observed without simultaneous new particle formation?

Answer: Not yet, there were days without NPF and others with NPF which need to be analyzed.

Could the vertical cloud chamber, or some other nucleation chamber at IfT be used to explore particle formation under controlled turbulence conditions?

Answer: No, there is no controlled turbulence possible, which is really hard to realize. We do feel that development of laboratory chambers with controllable turbulence would

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be a fruitful endeavor for atmospheric research.

Given that the diurnal boundary layer development process and turbulent mixing between the developing mixed layer and the residual layer occurs around the globe, would the authors like to speculate on the potential magnitude of this process as a global new particle source?

Answer: No, this would not have any scientific background in my opinion (at least not yet). We observed one event at a single location. During this campaign we found in total 3 days with this kind of new particle formation, but also 3 days with very similar meteorological conditions without any particle bursts. Thus, we still do not understand the process and necessary conditions which would be essential for such a global estimate.

Details: Page 11 line 17 end parentheses is missing.

Answer: Yes, has been added now.

Page 12 line 20 '..of the following thick..' is somewhat unclear - do you mean 'The lower boundary of the developing particle-laden layer..'?

Answer: The reviewer Dave Covert suggested 'The lower boundary of the more heavily particle-laden layer..' which has been included in the text.

In Fig. 8 I don't see the red lines for number concentration, I see black solid lines and black dotted lines.

Answer: I realized that shortly after paper submission... The caption has been changed to solid and dotted lines.

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

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