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Atmospheric Chemistry and Physics Discussions

Interactive comment on "New particle formation in the western Yangtze River Delta: first data from SORPES-station" *by* E. Herrmann et al.

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In response to Referee #2

The referee notes that 26 publications in ten years make for a "crowded field". To get a feel for this crowdedness, we did another informal search for "nucleation SMEAR kulmala" covering 2003-2013. This represents just part of the work of one group in Finland. The search yielded 60 hits. Similarly, a search for "hyytiala" (=Hyytiälä) should find research connected to merely one site. This search produced 160 hits. So, while we agree on the number 26, we have to disagree on the referee's conclusions. Indeed, considering China's sheer size and its manifold environments, much more research is needed to reach an understanding that could even remotely compare to the understanding that we have of nucleation in Europe and North America. Especially after

Wang et al. (2011) found formation rate and sulfuric acid to be connected by exponents as big as 7 which far exceeds typical observations so far (1...2) and strongly suggests that our knowledge of particle formation cannot be simply exported to significantly different environments such as for example China with its highly polluted air. The revised manuscript adds pieces of evidence to this picture.

However, to put our manuscript into perspective, we have added a short "review" of the bulk of those 26 articles (in section 1), identifying typical research foci to date (Beijing, Hong Kong, urban in general) and certain shortcomings (few long-term observations, size range often limited to 10nm), more clearly expressing which present gaps our manuscript addresses.

The manuscript presents the longest and most comprehensive data set on aerosols in the YRD to date. It is the first work to report on particles as small as 1 nm in China. The revised version presents a detailed analysis of the behavior of air ions during nucleation, documenting how neutrally formed particles acquire charges over time. Far less than 1% of particles, however, are formed with a charge, leaving ion-induced nucleation an only marginal role. The revised manuscript goes on to estimate sulfuric acid concentrations with the latest proxies by Mikkonen et al. (2011) and looks into the role of sulfuric acid during early particle growth. A closer investigation finds that McMurry's particle formation criterion is ultimately in disagreement with our observations, prompting the development of an empirical parameter based on our observations. In a similar fashion, the nucleation rate is parameterized.

In short, the revised manuscript considers the role of ions in nucleation in great detail. A new NPF criterion is developed (in a strictly numerical approach based on measurements), and the nucleation rate expressed in terms of a basic set of observations. Significant changes and additions have been made in previous sections 1, 4, 5, and partly 6, a re-structuring has merged chapters 3, 4, and 5.

To comment on the single points the referee raised:

1. This confusing statement does indeed not mean anything and has therefore been removed.

2. Figures have been revised according to these technical comments.

3. The data represent total ions at all times (except where otherwise noted), i.e. negative + positive. This was defined already in section 3.2 and has now been extended by an explicit note.

4. We believe that our discussion of the role of ions and the continuous development of the aerosol population over many hours make a strong point for nucleation on site.

5. Yes, J2 is calculated from J6, as laid out in the Nature Protocol by Kulmala et al. (2012). The parameters used are growth rate and condensational sink. We have reason to believe that this method represents an extensively published, time-honored and indeed standard approach (as it is indeed taken from a "manual") and thus not included the formula in the manuscript. Anyways, the older figure 4 (a particle formation event in AIS) has now been replaced by one showing ais and dmps data, supporting the point of a continuously evolving particle population.

6. We do not understand how that first part about boundary layer lifting relates to a process starting at 4 a.m. during winter, but we have nevertheless improved the figure according to the referee's suggestion.

7. Indeed. Accordingly, these sections have been completely overhauled using the Mikkonen proxy and adding much numerical detail on nucleation probability and rate. See general comments in this response, and section 3 in the revised manuscript.

8. Referring to point 4 in this response and section 3 in the revised manuscript, we believe we have made a very strong point that nucleation indeed occurs on site. In fact, one could say that this is the first manuscript from China to go below 3 nm, so this is indeed the first time that nucleation has been observed directly. As for comparing RH and the likes to the nucleation rate: nucleation depends on sulfuric acid, sulfuric

acid proxies are typically constructed from RH and the likes, thus it seems quite logical to express the nucleation rate in terms of those values in order to (a) deduct a useful empirical parameterization of the nucleation rate or (b) to see if we can learn anything about the relation of sulfuric acid and nucleation rate which in turn might tell us something about the particle formation process.

9. Conclusions have been updated as a result of a largely re-worked section 3 (now including former sections 4 and 5) with new, strictly numerical approaches to describe nucleation probability and rate.

In conclusion we would like to thank referee #2 for his insightful comments which have helped us to improve the manuscript. Significantly, as we believe.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 1455, 2013.