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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Atmospheric data over a solar cycle: no connection between galactic cosmic rays and new particle formation" *by* M. Kulmala et al.

Anonymous Referee #2

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1 General Remarks

The authors report about an impressive 12 year time series of particle size distribution measurements (0.003 - $\sim$1 μm particle diameter) measured at the SMEAR II site in Hyytiälä between 1996 and 2008 by a DMPS instrument. This time series is statistically analysed for particle formation events. The occurence of particle formation events is correlated with the cosmic ray induced ionisation intensity (CRII), with the result of little to no correlation between new particle formation and CRII in the boundary layer at Hyytiälä. Since particle formation and subsequent particle growth to sizes necessary for a particle to act as liquid phase cloud condensation nucleus (CCN) are necessary

for an influence on cloud formation, this is an indication that CRII does not influence low level cloud formation. In order to attribute this result, the authors analyse number size distributions of neutral and ionised clusters (0.8 - 40 nm diameter) for the underlying nucleation rate. These cluster size distributions were measured by Neutral cluster and Air Ion Spectrometers (NAIS) at Hyytiälä, Hohenpeissenberg (Germany), and Melpitz (Germany) during periods of 2008 . They find that the contribution of ionised nucleation to the total nucleation rate is typically less than 10% at these boundary layer sites, and larger only in cases of very low particle formation rates, which confirms the previously drawn conclusion.

In the next step, the authors analyse NAIS measurements conducted onboard the research aircraft Falcon, scanning the whole tropospheric column. Also here, they find a low fraction of the nucleated particles to originate from ionised clusters. By using a CRII model, it is stated that the CRII throughout the whole tropospheric column is equally influenced by solar intensity fluctiations. It is estimated that the changes of the upper tropospheric CCN concentration due to CRII fluctuations amount to less than 1% by using the CRII variation across the solar cycle (15%) and the fraction of particles produced by ion-induced nucleation at this altitude (10%, measured with an NAIS onboard the Falcon). This result is used to extend the conclusion, no influnce of CRII on cloud cover, to the whole tropospheric column.

The possible influence of cosmic rays on cloud cover is an ongoing, controversely discussed topic, and this article makes an important contribution to this discussion by using innovative experimental techniques. However, the authors may want to consider to restrict their conclusions to the boundary layer and low-level, liquid-phase clouds:

1. The authors show convincingly that they don't observe any significant correlation between CRII and the occurence of particle formation events at the SMEAR II site over a period of 12 years. The authors then generalise this finding to the whole tropospheric column. This extension may be misleading since formation of low-

level liquid phase clouds and formation of upper tropospheric ice clouds are very different processes. While a particle's ability to act as liquid-phase CCN is largely a function of its size (Dusek et al., 2006), the nature of ice nuclei (IN) is a matter of ongoing investigation. Only a small fraction of the particles available in the upper troposphere will act as IN (e.g. Twohy and Poellot, 2005), and the formation of ice-clouds is often limited by the availability of IN (Spichtinger et al., 2002). While particles formed from CRII induced nucleation may be a small fraction of the total particle burden in the upper troposhere, it may actually be charged particles that serve as IN.

2. The lack of correlation between CRII and particle formation events in the boundary layer, measured over a whole solar cycle, is a very convincing argument for the point the authos's want to make. The conclusion for the tropospheric column however is based only on one aircraft field campaign. In order to make a similar convincing point for the tropospheric column, another aircraft campaign in the opposite phase of the solar cycle would be helpful.

3. The conclusion for the tropospheric column is based on aircraft-based NAIS measurements, which is a rather new technique. Neither in this article nor in the article quoted for the airborne NAIS are possible aircraft inlet effects on the cluster charge distribution discussed. An aircraft inlet, decelerating the sample by roughly two orders of magnitude, can be seen as a type of nozzle. It is a well-known experimental fact that a nozzle may change the charge distribution of particles in a sample. It is not certain that such an effect is relevant for airborne NAIS measurements, but the author's should certainly investigate this possibility.

2 Other comments

Section 2.1.1: The full size range covered by the DMPS at Hyytiälä should be mentioned.

section 2.2: It should also be mentioned when and how long a NAIS was located at Hyytiälä.

p. 21537, ll. 20ff.: The article should be in general understandable without consulting the quoted literature. The particle nucleation rates J should therefore be properly introduced and explained. The reference to Figure 7 should probably a reference to Figure 8.

p. 21538, ll. 4 - 9: Before drawing conclusions from Figure 9, the general features visible in the figure should be described.

Table 2: The particle growth rate GR mentioned in this table should be introduced and defined somewhere in the article.

References

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Twohy, C. H., Poellot, M. R., 2005. Chemical characteristics of ice residual nuclei in anvil cirrus clouds: evidence for homogeneous and heterogeneous ice formation. Atmos. Chem. Phys. 5, 2289 – 2297.