

Interactive comment on “No statistically significant effect of a short-term decrease in the nucleation rate on atmospheric aerosols” by E. M. Dunne et al.

Anonymous Referee #3

Received and published: 22 August 2012

The authors used a global aerosol microphysics model (GLOMAP) to determine whether a 10-day (per month) reduction of 15% in the nucleation rate could generate a statistically significant response in aerosol concentrations and optical properties. Based on their statistical analysis of the modeling output, the authors found no statistically significant response in concentrations of particles with diameters larger than 10 nm (CN10), in cloud condensation nuclei (CCN) with diameters larger than 70 nm, or in the Angstrom exponent. The authors concluded that the effect of short-term decreases in cosmic ray ionization (associated with Forbush decrease) on global aerosol and cloud properties should be undetectable.

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The impacts of cosmic ray ionization change associated with solar activities on aerosol formation and cloud properties have been quite controversial. This manuscript contributes to the topics by presenting a separate study using a global aerosol model with size-resolved microphysics. The topic is suitable for ACP. I recommend the publication of this manuscript in ACP after the following comments are properly addressed and manuscript revised accordingly.

Main comments

1. The authors decreased nucleation rates by 15% for 10 days for each month. The aerosol changes that have been analyzed are monthly mean or annually mean values. On an annual mean base, the effective change of nucleation rates between perturbed and controlled cases is $15\%/3=5\%$. It is necessary to point this out in the text and abstract.
2. Figure 8b. Based on the shown values, I assume that Fig 8b gives the percentage difference. The authors reduced the nucleation rates by 15% for every grid box. Fig. 8b shows that the changes in CN10 are negative in some locations while positive in other locations. The patterns appear to be random. Why the systematic reduction in nucleation rates didn't lead to a systematic change in CN10? Are the fluctuations in CN10 change random for all months and layers? To help the reader to better understand your modeling results, please provide figures (probably as supplementary materials) showing spatial variations (both horizontal distribution for surface and zonal average figures) of sulfuric acid vapor concentration, nucleation rate, CN10 and CCN for unperturbed case, along with the differences between perturbed and unperturbed cases.
3. Page 15381. You assumed that 2.5% of Sulfur emitted as primary sulfate. The primary sulfate emission has been widely used to parameterize the sub-grid plume scale sulfate particle formation and growth. If cosmic ray ionization affects nucleation, it should also affect the sub-grid sulfate particle formation. Have you tested how the primary sulfate emission assumption may affect your results?

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4. Section 2.1. You used BHN of Vehkamäki et al (2002) for free troposphere nucleation and empirical formula of Sihto et al (2006) for BL nucleation. Was the empirical scheme applied to global BL or limited to continental BL? How much the value of pre-factor (you used $2E-6$ s⁻¹), which has large uncertainty, might affect your results and conclusions? In addition, laboratory studies (Hanson and Lovejoy, J. Phys. Chem. A, 110, 9525–9528, 2006) have shown that the BHN of Vehkamäki et al. (2002) overpredicted the BHN rates by about three orders of magnitude under the typical conditions of free troposphere. How sensitive are your results to the uncertainties in nucleation schemes?

Other comments:

5. Abstract. You mentioned twice about “observed correlation between short-term . . . properties”. However, in the Introduction and Discussion you questioned the existence of the correlation. If you think the correlation does not exist, you may want to modify the abstract to reflect this.

6. End of Section 1. It would be helpful to insert a short paragraph to describe the main objectives of this work and key differences to previous studies.

7. Page 15393, line 14. This statement is not necessarily true. Because of the lower sulfuric acid vapor concentration and higher ionization rate in the free troposphere, the effect of ionization rate change on particle concentration could be weak or opposite in sign.

8. Section 3.2.2. “Figure 4” should be “Figure 8”. Also “(a)” and “(b)” were not marked in the figure.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 15373, 2012.