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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cosmic rays, aerosol formation and cloud-condensation nuclei: sensitivities to model uncertainties" *by* E. J. Snow-Kropla et al.

Anonymous Referee #1

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Summary of manuscript

The manuscript presents a model study of the response of aerosol in the troposphere to variations in atmospheric ionization, such as occurring in the course of the decadal solar cycle, or due to Forbush decreases. The role of uncertainties in primary aerosol emissions, aerosol precursor emissions, and in the description of aerosol microphysical processes for the results (the response of aerosol to changes in atmospheric ionization) are investigated. A global chemical transport model with detailed, interactive aerosol microphysics is used for this purpose, with prescribed meteorology.

The authors show that larger aerosol particles, which are more likely to form cloud drops than smaller aerosol particles, show a very modest response to changes in atmospheric ionization in the course of the decadal solar cycle. This result bears negatively upon a proposed causal link between variations in galactic cosmic ray intensity and global cloud cover. Similarly, the simulations show a very modest response of the Ångström exponent (on the global scale) to variations in atmospheric ionization, in contrast with other recently published works.

General comments

The presented work and its results are well described and discussed, and provide new insights on the topic. The manuscript is written in a transparent style, with few exceptions where text passages need clarification or rewording. Some scientific matters where additional explanations or minor corrections are needed are listed in the following. The figures are nicely done. Please check for typos.

Specific comments

Page 2698, line 1: *The flux of cosmic rays to the atmosphere has been observed to correlate with cloud and aerosol properties.*
"... has been observed ..." implies in scientific terms a little disputed fact, which the correlation of galactic cosmic ray intensity and cloud cover is not; a host of mutually inconsistent results has been published on the topic. "... has been reported ..." would reflect this better.

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Page 2700, line 9: *... the ion fields near clouds are strengthened by cosmic rays. The stronger field affects the collection of unactivated aerosols by cloud droplets ...*
This description of the near-cloud mechanism is incomprehensible. What does "strengthening of ion fields near clouds by cosmic rays" mean?

Page 2700, line 17: *... explaining the observed correlations between cosmic rays and clouds ...*
”reported”, in contrast to ”observed” would better reflect the disputed status of the correlation.

Page 2701, line 21: *The observed 5–10 day delay in the minimum of aerosol and cloud values after the minimum in the cosmic ray flux by Svensmark et al. (2009) is evidence for the ion-aerosol clear-sky mechanism.*
The delay is consistent with the clear-sky mechanism, but by no means evidence.

Page 2703, line 22: *SOA is assumed to be non-volatile and is condensed onto the aerosol surface area.*
Secondary organic aerosol does not condense onto aerosol surface area.

Page 2708, line 15: *...the modelled accumulation mode may be too large on average.*
Please, clarify whether the accumulation mode consists of too many or too large particles.

Page 2710, line 16: *The competition between these three phonomena* [sic] *lead to some regions showing increases of CCN with cosmic rays and some regions showing the opposite.*

- This is a plausible explanation for the patterns seen in Figure 6, but can you

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provide some supporting evidence for it?

- The model runs cover March, June, September and December, with a prescribed meteorology. Can you exclude the possibility that the patterns seen in Figure 6 are a result of the specific meteorology in these months?
- Is there a strong variation in the patterns seen in Figure 6 between the months?
- Would the same patterns be obtained from averaging a 12-month run?

Page 2714, line 1-10: This passage describes in detail the content of Figure 8, but it could be shortened to its most relevant portions.

Table 1: Simulation "CHARGE": Is the sulfuric acid condensation rate charge-enhanced for all sub-10 nm particles, or only for those particles that formed from a gas phase ion? If the former is the case, can that approach be justified?

Figure 8: The change from solar maximum to minimum in CN10 in the "ALL" simulation is always smaller than in the "LoPE" simulation over land areas (Fig. 8 b). This is explained on page 2713 line 19-24:

The change in CN10 between solar-maximum and solar-minimum is less for the ALL case than for the LoPE case for all surface locations. This is because the additional SOA and charge-enhanced growth cause a decrease in the ability of nucleated particles to grow to 10nm when primary emissions are reduced (the relative increase in the coagulation sink from the extra SOA and charge-enhanced growth is larger when primary emissions are reduced).

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However, over the land areas (with the exception of the tropics), the change from solar maximum to minimum in CN80 is *LARGER* in the "ALL" simulation compared to the "LoPE" simulation (Fig. 8 c). Is this consistent with the above explanation, and is this behavior of C10 and C80 consistent?

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 2697, 2011.

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