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Atmospheric Chemistry and Physics Discussions



*Interactive comment on "*

# Air pollution control and decreasing new particle formation lead to strong climate warming" *by* R. Makkonen et al.

**R. Makkonen et al.**

risto.makkonen@helsinki.fi

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"-P25995 L7 and P25998 L11: What is your present-day source of SOA? Many global models are on the low end of SOA estimates (10-30 Tg yr-1), while the actual amount may be much more (100 Tg yr-1) (Spracklen, D. V., Jimenez, J. L., Carslaw, K. S., Worsnop, D. R., Evans, M. J., Mann, G. W., Zhang, Q., Canagaratna, M. R., Allan, J., Coe, H., McFiggans, G., Rap, A., and Forster, P.: Aerosol mass spectrometer constraint on the global secondary organic aerosol budget, Atmos. Chem. Phys. Discuss., 11,

5699-5755, doi:10.5194/acpd-11-5699-2011, 2011. ) The model may be much more sensitive to a 50% future increase in SOA if the present-day SOA was higher in the model. Please comment on this. "

The emissions of biogenic precursors for SOA are difficult to constrain. The present-day monoterpene emissions from LPJ-GUESS are in the low-end of estimates with 30 Tg(C)/year. Furthermore, we apply a yield of 0.15 to form SOA from the monoterpene emission, and there is no source of SOA from isoprene in the current model. Taking these into account, the modeled SOA is in the low-end of values in literature. However, it is difficult to say how a higher base level (and possibly higher absolute increase in future) would affect the results. An increase in BVOC emission helps nucleated particles to grow, but also increases condensation sink, lowering particle nucleation rates (O'Donnell, 2011). We are looking at this issue in an ongoing study. We have improved the description of SOA in the manuscript.

"-The sensitivity to grid-scale nucleation is tested. What about the sensitivity to primary emissions or sub-grid (plume-scale nucleation)? For example, the ECHAM-HAM model assumes that all sulfuric acid formed in sub-grid anthropogenic SO2 plumes goes into forming large accumulation-mode particles (500 nm), which adds aerosol mass, but does little to change aerosol/CCN number concentrations. Nucleation can occur under some conditions in these plumes (Stevens, R. G., Pierce, J. R., Brock, C. A., Reed, M. K., Crawford, J. H., Holloway, J. S., Ryerson, T. B., Huey, L. G., and Nowak, J. B.: Nucleation and growth of sulfate aerosol in coal-fired power plant plumes: sensitivity to background aerosol and meteorology, Atmos. Chem. Phys. Discuss., 11, 24765-24812, doi:10.5194/acpd-11-24765-2011, 2011.). The global effect of plume-scale nucleation is still very uncertain as is the uncertainty in size and mass emission rates of other primary aerosols. Please comment on their potential importance to your conclusions. I don't think your main conclusion of the strong reduction of cooling will change, however, the exact strength of the reduction may change (not obvious to me whether it would be stronger or weaker)."



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We have tested the sensitivity of our results to primary emission size by comparion primary radii used by Stier et al. (2005) and Dentener et al. (2006). Stier et al. (2005) and our study apply emission radii that are doubled in size compared to those in Dentener et al. (2006) for both natural and anthropogenic emissions. The change in primary emission size radii by a factor of 2 (leading to factor of 8 in number emission) has far less effect for the global average CCN than nucleation. Also, an increase in the primary emission number could lead to a decrease in CCN due to competition of available particle growth. The number of particles emitted from the "primary sulfate" in our study is small, since ship-, industrial and powerplant emissions are attributed to accumulation and coarse modes. Taking into account plume nucleation from SO2 would increase number concentrations from anthropogenic emissions, possibly increasing the contrast between pre-industrial and present-day. We have included discussion of primary emission size and plume nucleation in the revised manuscript.

"-P25993 L1: Can you give more detail on what RCPs are? "

The RCPs ("Representative Concentration Pathways") are a set of pathways provided for the global modeling community (Moss et al., 2010). They are tools for the scenario development process for the IPCC AR5. Recently, the RCPs have been covered in several papers, see for example the special issue on RCPs in Climatic Change (Volume 109, Numbers 1-2). The description of RCPs is extended in the revised manuscript.

"-P25994 L4: “THE aerosol module is coupled...” -P25997 L12: There is a missing reference in the “()” "

The technical corrections are applied in the revised manuscript.

References used in the author’s response:

Dentener, F., Kinne, S., Bond, T., Boucher, O., Cofala, J., Generoso, S., Ginoux, P., Gong, S., Hoelzemann, J. J., Ito, A., Marelli, L., Penner, J. E., Putaud, J.-P., Textor, C., Schulz, M., van der Werf, G. R., and Wilson, J.: Emissions of primary aerosol and



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Moss RH, Edmonds JA, Hibbard KA, Manning MR, Rose SK, van Vuuren DP, Carter TR, Emori S, Kainuma M, Kram T et al: The next generation of scenarios for climate change research and assessment. Nature 463:747–756, 2010.

O'Donnell, D., Tsigaridis, K., and Feichter, J.: Estimating the direct and indirect effects of secondary organic aerosols using ECHAM5-HAM, Atmos. Chem. Phys., 11, 8635-8659, doi:10.5194/acp-11-8635-2011, 2011.

Stier, P., Feichter, J., Kinne, S., Kloster, S., Vignati, E., Wilson, J., Ganzeveld, L., Tegen, I., Werner, M., Balkanski, Y., Schulz, M., Boucher, O., Minikin, A., and Petzold, A.: The aerosol-climate model ECHAM5-HAM, Atmos. Chem. Phys., 5, 1125-1156, doi:10.5194/acp-5-1125-2005, 2005.

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