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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Climatic effects of 1950–2050 changes in US anthropogenic aerosols – Part 2: Climate response" *by* E. M. Leibensperger et al.

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We thank the reviewer for their valuable comments and suggestions. Their input has improved the clarity and content of the manuscript.

Referee's comments are in plain text, our responses are **boldface**, and changes to the manuscript are ***italicized***.

The manuscript by Leibensperger et al investigates the climate response of changing US anthropogenic aerosols emissions for the timeperiod 1950-2050. The US anthropogenic emissions applied in this study and the associated radiative forcings are described in an accompanying manuscript. The authors conclude that during 1970-1990,

when aerosol emissions peaked over the US, surface temperature were reduced in central and eastern US by 0.5 – 1.0 deg C due to the direct and indirect aerosol effect. They also highlight that future aerosol emission reductions will cause only little further warming (0.1 degC), as present day aerosol emissions sources are already low.

The topic is interesting and fits well into the scope of ACP. The manuscript is clearly structured and very well written. I recommend publication of the manuscript after some minor revisions. In the following I list points the authors may want to address in a revised version of the manuscript.

In the introduction the authors cite model studies in which a regional radiative forcing caused a strong regional climate response and contrast these with studies in which the regional aerosol radiative forcing leads to less localized response pattern (page 24131, line 9). This is mentioned again in the results section (page 24138, line 19). The studies cited here use all very different modeling approaches. While Levy et al., 2008 for example investigated the transient climate response with a coupled climate model (similar to the present study), Kloster et al., 2009 investigated the equilibrium climate response to aerosol radiative forcing. The response pattern will be different as in an equilibrium response feedback processes operating on longer time scale are accounted for as well. This should be discussed more in detail in a revised manuscript and should be moved from the introduction section into the result section.

The comparison with Fischer-Bruns et al., 2010 (page 24138, line 24) is also just of limited value as Fischer-Bruns et al. 2010 show results in an equilibrium state which is different from the transient response modeled here.

We agree that experimental setup is an important factor and have added the following text to the Conclusions:

Relating aerosol radiative forcing to regional climate change is challenging. There are many model uncertainties involved in the mechanisms of

aerosol-cloud interactions, the response of the hydrological cycle, the lateral transport of heat in the ocean (the Q-flux parameterization used here does not allow for change in that transport), and other aspects of the climate model. Multi-model analyses are needed to address the robustness of results (National Research Council, 2005). Our ability to reproduce observed 1950-2010 temperature trends lends some confidence to our conclusions.

Page 24142 line 22: compared the simulated sensitivity of surface temperature to changes in aerosols forcing to the climate sensitivity of the model defined as the equilibrium global temperature response to a doubling of atm. CO2 concentrations. These numbers are not comparable as they mix transient with equilibrium response and global with regional response. The model applied here uses a q-flux ocean to simulate transient climate response to transient varying forcing. This is different from GCM studies that use a full ocean model. The authors should explain how only considering the response of the ocean mixed layer might impact the results.

We have removed the discussion of the global climate sensitivity. We now mention the importance of ocean representation in the conclusions section as outlined above.

The model runs applied prescribed precalculated aerosol concentration fields. The impact of changes in climate on aerosol deposition processes and subsequently on the atmospheric aerosol load were in this study not considered. This should be mentioned in the conclusion section. Also from the introduction it was not clear that aerosol concentration fields are prescribed.

In our view, the change in source amounts will dominate any change in aerosol abundances caused by the perturbed climate. We have added the following text to Sect. 2.2:

The use of archived monthly mean aerosol distributions as input to our

climate simulations does not allow for feedbacks of changing climate on aerosol concentrations. These feedbacks are likely very small relative to the source driven aerosol perturbations implemented here, considering that both models and observations indicate little direct sensitivity of aerosol air quality to climate change (Jacob and Winner, 2009; Tai et al., 2011). The use of monthly mean aerosol concentrations does not introduce significant bias in the calculation of the direct radiative effect (Koch et al., 1999), but it may affect the aerosol indirect due to the nonlinear relationship between aerosol amount and cloud droplet number (Jones et al., 2001) as seen in Eq. 1.

Page 24131, line 24 states that aerosol radiative forcing is used. This was confusing. For the future aerosol emissions the authors applied an upscaling based on the SRES A1B scenario I was wondering how this compares to the new RCP scenarios.

We have added the following text to make it clearer that aerosol abundances from GEOS-Chem, and not radiative forcing values, are used in the GCM:

Here we use the 1950-2050 time series of US aerosol concentrations from Leibensperger et al. (submitted) to conduct 1950-2050 transient climate simulations with the NASA Goddard Institute for Space Studies (GISS) GCM 3 (Rind et al., 2007).

And in the Conclusions:

. . . ***including our best estimates of time-dependent greenhouse gas concentrations and aerosol distributions (Leibensperger et al., 2011)*** . . .

We also have added the following to Sect. 2.2 regarding emission scenarios:

The A1B scenario provides a radiative forcing for the 21st century comparable to the more recent RCP6 scenario from the IPCC (Moss et al., 2010).

In general the conclusion section could be shortened. It repeats many of the statements made in the result sections.

We have made the summary in the conclusion more concise. Some additional discussion (discussed above) has been added but the section is shorter in total.

New References:

Jacob and Winner, Atmos Environ, 43, 51, 2009
Jones et al., JGR, 106, D17, 20,293, 2001
Koch et al., JGR, 204, 23,7999, 1999
Koch et al., J Climate, 24, 2693, 2011
Moss et al., Nature, 463, 747, 2010
NRC, Radiative forcing of climate change: Expanding the concept and addressing uncertainties, 2005
Tai et al., ACPD 11, 31031, 2011

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