Atmos. Chem. Phys. Discuss., 11, C15067–C15075, 2012
www.atmos-chem-phys-discuss.net/11/C15067/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Climatic effects of 1950–2050 changes in US anthropogenic aerosols – Part 1: Aerosol trends and radiative forcing" *by* E. M. Leibensperger et al.

E. M. Leibensperger et al.

eleibens@mit.edu

Received and published: 3 February 2012

We thank Referee #1 for their valuable comments and suggestions. Their input has improved the manuscript.

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

The paper presented by Leibensperger and colleagues summarizes in a clear and well documented way a study on US radiative forcing, its recent history and prospects. It is of interest for ACP readers and should be published after (seriously taken) minor revision. Especially some of the discussions with policy relevance should be reconsidered.

The documentation of the basic model results is also lacking.

General remarks 1) Introduction: The motivation why the study concentrates on the US and its emissions is not very well laid out. Why is "The US (is) an interesting testbed to analyze the climate implications of environmental regulations" as stated by the authors? Sorry to insist, but it would be interesting to put this in perspective to a global model analysis done by other groups.

The goal of this work is to connect US anthropogenic aerosol sources with changes in climate. This is particularly policy relevant since ongoing regulations are reducing US anthropogenic aerosol sources following large increases before 1980. This effort differs from the global analyses in that it focuses solely on the US.

This section of the Introduction now reads:

The need to integrate air quality and climate change mitigation objectives in environmental policymaking is increasingly recognized (National Research Council, 2005; Raes and Seinfeld, 2009; Penner et al., 2010). This is particularly the case for aerosols since air quality improvements potentially come at the cost of warming. Previous studies have investigated the climate effects of global aerosol sources (Shindell et al., 2008; Chen et al., 2010; Koch et al., 2011), but understanding the effects of national sources is most useful to policymakers. The US is an interesting testbed to analyze the climate implications of environmental regulations since the historical period from 1950 to present has witnessed a reversal of aerosol trends, increasing until 1980 and then decreasing, with regulations in place to enforce continued decrease in the future.

Would the authors be ready to argue more explicitely, that it is useless to regulate BC in the US? What implications for BC emission standards in the world if this would become US policy?

We have shown that the present day (2010) direct radiative forcing of US anthropogenic BC is relatively small regionally and globally. We have added the following to Sect. 4:

The climate benefit of reducing US BC emissions is further complicated when considering the effects of co-emitted aerosol species and cloud interactions (Bauer et al., 2010; Chen et al., 2010a; Koch et al., 2010; Unger et al., 2010).

And to the Conclusions:

We have confidence in this result because of the ability of the model to reproduce observed BC concentrations in the US in 2010 (20% low bias). Although our radiative forcing estimate does not include the semi-direct associated with cloud evaporation (Koch and Del Genio, 2010), transient-climate simulations presented in Leibensperger et al. (2012) confirm the climate insensitivity to present-day anthropogenic sources of BC in the US.

The influence of US policy on the policies of other countries is beyond the scope of this work. However, we have added the following to point out that regulation in other regions can still provide both air quality and climate benefits:

This conclusion merely reflects the relatively small magnitude of BC emissions from the US and does not challenge the argument that decreasing global BC emissions would have significant benefit for both air quality and climate (Jacobson, 2002; Bond, 2007; Grieshop et al., 2009). In particular, an important regional climate benefit could be achieved in Asia, where BC sources are much larger than in the US (Lu et al., 2011).

2) How uncertain are the emission scenarios used? Is the scenario IPCCA1B used to derive the future evolution of emissions still a valid assumption in view of recent work on new IPCC scenarios? How much differ the emissions against other published work?

Emissions are a source of uncertainty and we discuss problems with emissions

and their trends in our comparison to observations in Sect. 3. The A1B scenario we have used is similar to the newer RCP6.0 scenario for SO_2 and BC in the US, but less comparable to NO_x. We have added the following text mentioning this:

The decline of US anthropogenic SO_2 and BC in the A1B scenario is comparable to those in the more recent RCP6.0 scenario from the IPCC AR5 (Moss et al., 2010). All RCP scenarios decrease global SO_2, NO_x, BC, and POA and US NO_x emissions more rapidly than the A1B scenario.

3) I think the paper misses some supporting material on emissions, global burdens, optical depth and direct radiative forcing for the major aerosol species for the decades under investigation. Which part of all that is anthropogenic? I suggest a table being added with such basic model characterization. Examples why I think the work is not fully traceable in its present form: The authors mention: "The global mean tropospheric lifetime of sulfate in the model is 4.0 days". Is that derived from sulphate burden and total deposition?

All of the radiative forcing discussed in this work is anthropogenic. We have added a table compiling many of the characteristics suggested by the reviewer. Please see the table in the supplement to this response. We have also edited our statement about the lifetime of sulfate:

The global mean tropospheric lifetime of sulfate in the model (computed as the ratio of global burden to deposition) is 4.0 days, comparable to other sulfate models (Schulz et al., 2006).

Also the emissions seem to be a mix of different inventories. It is thus not possible to see which emission history was used for the US and globe. AOD per species would allow to better compare the forcing to other model results. The anthropogenic fraction is important to understand the BC forcing history.

The most relevant emissions are from EDGAR (SO_2 and NO_x) and Bond et al.

(2007; BC and POA). Table 1 displays 2010 emission totals and the proportion of which is from the US. We also have made this clearer by adding the following to the caption of Fig. 1:

SO_2 and NO_x emissions are from EDGAR (van Aardenne et al., 2001; Oliver and Berdowski, 2001). BC and POA emissions are from Bond et al. (2007). All emissions are extended past the year 2000 following the IPCC A1B scenario.

4) Chapter4 "By 2010 we find that the radiative forcing from anthropogenic US aerosol sources has decreased to -0.03Wm-2 globally, amounting to just 8% of the total from worldwide anthropogenic sources (-0.36Wm-2), reflecting the rapid decline of emissions in the US and growth in Asia (Fig. 1)."

=> The comparison of regional to global forcing, given as percentage, should be separated for BC and the scattering aerosol. If BC forcing would have increased in the US, then the total US forcing would decline to 0 Wm^{-2} and the importance of the US forcing would be numerically close to zero %. This is misleading for forcing discussions, where absorbing and scattering aerosol components contribute to total anthropogenic aerosol forcing.

This information is now available in the table. We have additionally added the following to Sect. 4:

The decline of the US contribution to the global mean aerosol radiative forcing results largely from decreasing sulfate aerosol (+0.07 W m^{-2}) with a smaller opposing role for decreasing black carbon (-0.01 W m^{-2}).

5) In the end of chapter 4 the authors state: "Thus most of the climate response from controlling US anthropogenic sources should have already been realized. Second, the present-day radiative forcing from BC is small (and even less if external forcing is assumed), weakening the argument of a “win-win” scenario for public health and climate from controlling BC emissions." This is a little quickly written. => Which anthropogenic

sources do you mean? (GHGs as well? Open fires?)

We mean anthropogenic aerosol sources. We have clarified this:

Thus most of the climate response from controlling US anthropogenic aerosol sources should have already been realized.

=> Is it really important whether aerosol RF in 1980 was much higher than that for present day when discussing future policy choices? A discussion of present day forcing uncertainty and the future scenario should be added.

We compare present day RF to 1980 as a reference for expected climate change due to further reductions.

In Sections 4 and 5 we discuss the uncertainty of our forcing estimates due to differences between simulated and observed aerosol trends and amounts. We now compare our emissions to the more recent RCP scenarios in Sect 2.1 as mentioned above.

=> Which present day BC forcing do you mean? That of US-BC for the globe? What is the BC global forcing in the model (see also my suggestion for a table added)? Who suggested a win-win scenario "just" for the US?

We were referring to the BC forcing from the US. We have clarified this:

Second, the present-day (2010) radiative forcing from US anthropogenic BC is small (and even less if external forcing is assumed), so that emission controls targeting BC provide only limited climate benefit. These emission controls would benefit public health but are not an effective ‘win-win’ scenario for both US public health and climate.

The global anthropogenic and US anthropogenic BC RF are now listed in Table 1.

Specifically I’d like to suggest also the following changes/clarifications:

xx Regarding multiple mentioning of forcing "over the eastern US (east of 100W)":
=> please add to regional foring information always global values. E.g. put in parentheses always behind the regional forcing also the global forcing. Radiative forcing has a global significance (since climate effects spread) and it is can be misunderstood if only the local forcing values are mentioned.

Global values for 2010 are now presented in Table 1. We have also added mention of global values within the text.

xx"The small positive radiative forcing from US BC emissions (+0.3Wm-2 over the eastern US in 2010) suggests that an emission control strategy focused on BC would have only limited climate benefit."
=> What of the global BC forcing does this value of 0.3 Wm^{-2} represent? First - what is the global BC forcing from the US? Second - what is the global anthropogenic BC forcing in the model used here. I believe these are two numbers are crucial here for underpinning whether and US BC emission strategy would have benefits. Please include this info also in the abstract.

The global BC forcing presented here is +0.30 W m^{-2} (internal mixture) and the US contributes 5% of this. We have added this to Sect. 4 and the abstract.

Sect. 4: ***We see that the US contributes only 5% of the global mean anthropogenic radiative forcing from absorbing aerosols (global mean: +0.30 W m^{-2}) while providing 6.3% of the forcing from scattering aerosols (global mean: -0.83 W m^{-2}).***

Abstract: ***The small positive radiative forcing from US BC emissions (+0.3 W m^{-2} over the eastern US in 2010, 5% of the global forcing from anthropogenic BC emissions worldwide) suggests that a US emission control strategy focused on BC would have only limited climate benefit.***

xx "It has been argued that decreasing BC emissions (and hence aerosol absorption)

could provide a “win-win” strategy for air quality and climate change mitigation (Jacobson, 2002; Bond, 2007; Grieshop et al., 2009)."
=> It should be mentioned here that these papers probably did not have US emissions in mind. Since the sentence before this one the US is explicitly mentioned the reader is misguided.

Our intention is to point out that such a “win-win” strategy does not apply to the US. The cited papers are all general and do not focus on specific regions. As a result, their general conclusion has influenced US policymakers. As mentioned above, we clarify the issue of regions outside the US in the Conclusions:

This conclusion merely reflects the relatively small magnitude of BC emissions from the US and does not challenge the argument that decreasing global BC emissions would have significant benefit for both air quality and climate (Jacobson, 2002; Bond, 2007; Grieshop et al., 2009; Shindell et al., 2012). In particular, an important regional climate benefit could be achieved in Asia, where BC sources are much larger than in the US (Lu et al., 2011).

Added references:

Bauer, S. E., Menon, S., Koch, D., Bond, T. C., and Tsigaridis, K.: A global modeling study on carbonaceous aerosol microphysical characteristics and radiative effects, Atmos Chem Phys, 10, 7439-7456, doi: 10.5194/acp-10-7439-2010, 2010.

Jacobson, M. Z.: A physically-based treatment of elemental carbon optics: Implications for global direct forcing of aerosols, Geophys Res Lett, 27, 2, 217-220, 2000.

Koch, D., Bauer, S. E., Del Genio, A. D., Faluvegi, G., McConnell, J. R., Menon, S., Miller, R. L., Rind, D., Ruedy, R., Schmidt, G. A., and Shindell, D.: Coupled aerosol-chemistry-climate twentieth-century transient model investigation: Trends in short-lived species and climate response, J Climate, 24, 2693-2714,

doi: 10.1175/2011JCLI3582.1, 2011.

Lu, Z., Zhang, Q., and Streets, D. G.: Sulfur dioxide and primary carbonaceous aerosol emissions in China and India, 1996-2010, Atmos Chem Phys, 11, 9839-9864, doi: 10.5194/acp-11-9839-2011.

Moss, R. H., Edmonds, J. A., Hibbard, K. A., Manning, M. R., Rose, S. K., van Vuuren, D. P., Carter, T. R., Emori, S., Kainuma, M., Kram, T., Meehl, G. A., Mitchell, J. F. B., Nakicenovic, N., Riahi, K., Smith, S. J., Stouffer, R. J., Thomson, A. M., Weyant, J. P., and Wilbanks, T. J.: The next generation of scenarios for climate change research and assessment, Nature, 463, 747-756, doi: 10.1038/nature08823, 2010.

Shindell, D. T., Levy, H., Schwarzkopf, M. D., Horowitz, L. W., Lamarque, J.-F., and Faluvegi, G.: Multimodel projections of climate change from short-lived emissions due to human activities, J Geophys Res-Atmos, 113, D11109, doi: 10.1029/2007JD009152, 2008.

Shindell, D., Kuylenstierna, J. C. I., Vignati, E., van Dingenen, R., Amann, M., Klimont, Z., Anenberg, S. C., Muller, N., Janssens-Maenhout, G., Raes, F., Schwartz, J., Faluvegi, G., Pozzoli, L., Kupiainen, K., Höglund-Isaksson, L., Emberson, L., Streets, D., Ramanathan, V., Hicks, K., Kim Oanh, N. T., Milly, G., Williams, M., Demkine, V., and Fowler, D.: Simulataneously mitigating near-term climate change and improving human health and food securtiy, Science, 335, 183-189, doi: 10.1126/science.1210026.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C15067/2012/acpd-11-C15067-2012-supplement.pdf

---