Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-486-RC2, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Multi-model Impacts of Climate Change on Pollution Transport from Global Emission Source Regions" *by* Ruth M. Doherty et al.

Anonymous Referee #3

Received and published: 18 July 2017

Review of

Multi-model Impacts of Climate Change on Pollution Transport from Global Emission Source Regions

by Doherty et al.

Overview.

The authors compare present-day day air pollution transport patterns with projected end-of-21st-century conditions. For this purpose, seasonally-averaged volume mixing ratio fields of an artificial tracer simulated by four chemistry-climate-model of the

ACCMIP project are inter-compared. The tracer has a 50-day lifetime and is emitted using present-day anthropogenic and biomass burning CO emissions. The authors find a general decrease in tracer concentrations in the troposphere and an increase near the tropopause in the simulation of all models. The authors attribute this mainly to reduced convection in the tropics and an increase in tropopause height. The results agree across the four models and also with previous studies.

General comments

The work is a scientifically sound study of the impact of climate change. Decrease in convective activity, increase in tropopause height as well as weakening but increase in extend of the Hadley circulation is a climate response simulated by many CCMs. Showing the impact on concentration patterns as presented in the study is a step further in understanding the impact of these circulation changes.

The relevance and novelty aspect of the study could be enhanced by elaborating in more detail the agreement but also the disagreement with the studies from the literature, many of them mentioned in the introduction. Please include this in the conclusion section.

The presented study focuses a lot on the tropics. But changes in the transport to the Arctic is also an important aspect given the impact of black carbon on the radiative forcing. For example Orbe et al. (2015) and (2013) find enhanced pole-ward transport towards the Arctic. It would be good if the results of the current study would report more on the change in the poleward transport. Also, please show maps from 90S - 90N and do not omit the high latitudes.

To avoid misunderstandings, the authors should discuss more clearly the limitations of the study because of the use of the artificial tracers: i.e. no impact of the photochemistry (loss by OH and production by VOC) or the precipitation patterns (deposition), and , most importantly, no change in the emissions.

The end-of-century volume mixing ratios appear overall lower than the volume mixing ratios of the present day runs. But the total burdens should be the same (p6 l1). It would be good if you could confirm the mass conservation and explain in more detail how the burden was redistributed. A comment on the mass conservation of the SL-advection scheme of STOC-HadAM3 might also be helpful.

The mechanism for the increase in tracer mixing ratios below the tropopause should be better explained. Is it simply because of the higher tropopause (i.e.the increase occurs near the present day tropopause) or do differences in stratosphere-troposphere exchange also play a role. Once it is established that the tropopause is higher from the GCM run, it is somewhat a trivial finding that tropospheric mixing ratio for primary tracers are increased at the same height.

Specific comments:

P 1 L 24 , I think the weaker Hadley cell is a result of the GCM calculations, i.e. a given for this study So please consider rephrasing " .. in turn reflect . . ." to " . . . causes . . . "

P1 L25 Please add a sentence on the mechanism of increase in tracer because of increase in tropopause height.

P2 L19-L27 This is more relevant for ozone and not so much for transport of primary pollutants. Consider shortening or omitting it.

P3 L 17 Is this response in ozone caused by transport ? If not please omit.

P3 L 23 Please discuss the impact of changes in stratosphere-troposphere exchange for the tracer transport

P3 L31 Please add also Orbe et al. (2013)

P4 L29 Please add also information about the different convection schemes of the 4 models

P5 L19 Please state the temporal resolution of the GFED 2 data

P7 L4 Please add a discussion here how the present-day CO tracers compare to actual CO. The NH CO maximum occurs in April, which seems not the case for tracer.

P7 L5 It is not clear that lower values do not deserve consideration. The changes could be even stronger. Please elaborate on this. MAM is the maximum of present day CO.

P7 L23 Please clarify if this is the thermal present-day tropopause or the tropopause for the respective time slice. How does the thermal tropopause relate to a "tracer" tropopause?

P8 L9 Please discuss also the changes at high latitudes. (see Orbe et al. 2013)

P8 L17 From all ACCMIP models or only the four discussed here ?

P8 L18 For the present-day or end-of-century runs ?

P8 L20 Please provide more explanation for the up to factor 4 differences in the convective fluxes by the models. Is it driven by the meteorological input (i.e. T profile) or the specifics of the parametrisation.

P8 L21 Is there any indication, which of the models simulates more realistic mass fluxes.

P9 L9 Please discuss also the increase in convection north of 60 N in DJF shown in Figure 6.

P10 L10 Please provide a plot of the increase in the thermal tropopause height between present-day and end-of-century or give some numbers in pressure and height.

P10 L15 Please discuss Fig 11 in more detail. Is the conclusion based on the fact that dotted and solid blue lines overlap more than the respective green lines? I am not sure if this is actually the case especially for the the tropics.

P10 L21 The weaker across-the-tropopause gradient is an interesting finding. It should be mentioned more clearly in the paper, i.e. the conclusions.

P11 L18 Please discuss also the response in the Arctic (compare with Orbe et al. (2013, 2015)) and the hemispheric gradient (Holzerand Boer, 2011)

P11 L22 Please mention that you found a weaker across-the-tropopause gradient (if this is the case)

Figures 4,5, 8 etc. please show maps from 90S-90N

Figure 1 add to caption "for different seasons"

Figure 2, please use either present-day or REF not both

Figure 11, please mention that the distance is from the respective tropopause for each time slice.

Literature: Orbe, C., M. Holzer, L. M. Polvani, and D. Waugh (2013), Air-mass origin as a diagnostic of tropospheric transport, J. Geophys. Res. Atmos. 118, 1459–1470, doi:10.1002/jgrd.50133

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-486, 2017.