

Anonymous Referee #1

Received and published: 5 August 2010

General Comments

Koffi et al. use global chemistry-climate simulations to calculate the influence of transport (aircraft, road, ship) emissions on global ozone distributions. This work quantifies the effects of transport emissions for the present day and future, accounting for changes in climate and emissions. For the present day, road emissions are found to be the most significant source of ozone (from transport emissions). In the future, aircraft and ship emissions are increasingly important as road emissions are significantly reduced. The net global change in ozone from the transport sector is dependent on the future scenario used, since they have different predictions for aircraft and ship emissions. In total, climate change reduces the impact of transport sector emissions on global ozone, but climate change can have significant positive or negative effects over regions. The regional response is dependent on altitude and season. The manuscript is well organized and generally well written. I suggest publication in ACP after the following concerns and corrections are addressed.

Specific Comments

I have one suggestion and numerous smaller comments:

I'm curious how the change in column ozone translates to radiative forcing. I suggest presenting the radiative forcing from each transport mode and discussing how climate change would affect the forcing, which is similar to the change in ozone column already presented. This would make the changes in ozone particularly useful to policymakers.

We agree that radiative forcing is a key point for policy decision and that's why it is the topic of many forthcoming papers (see hereafter) based on these results. However, this point is beyond the scope of this study which aims to focus on the impact of transport on ozone concentrations. Radiative forcing is for example discussed in Myrhe et al. 2010, which deals with the radiative forcing (RF) due to changes in ozone and methane caused by the transport sector, as calculated using results from the present study and from four other global atmospheric chemistry models. The results show that the net RF of O₃ and CH₄ combined (i.e. including the impact of CH₄ on ozone and stratospheric water vapour) is positive for ROAD (16(±13) mWm⁻²) and AIR (6(±5) mWm⁻²) traffic sectors and is negative for SHIP (-18(±10) mWm⁻²) sector in all five models. This reference (already cited in the conclusion) has been updated.

Reference: Myhre G., K.P.Shine, G.Rädel, M.Gauss, I. S.A. Isaksen, Qi Tang, M.J. Prather, J. E. Williams, P. van Velthoven, O. Dessens, B. Koffi, S. Szopa, P. Hoor, V. Grewe, J. Borken-Kleefeld, T.K. Berntsen, J.S. Fuglestedt, *Radiative forcing due to changes in ozone and methane caused by the transport sector, Atmospheric Environment, accepted.*

Two other multi-model analyses (Hodnebrog et al., personal communication) are still in preparation. They will include future RF calculations for (i) B1 (aircraft+shipping) and B1ACARE (aircraft) scenarios and (ii) for a so-called A1 "high" scenario (road) using the results of the same five models.

Page 15763: Is this version of the model the same as was used by Cariolle et al. (2009), which is mentioned on page 15759, line 25? If it is not, these plume effects should be listed later as an uncertainty in the results section.

The version used in the present study does not take into account the plume effects. This has been precised as follows:

New sentence P15764 Line 1

Unlike Cariolle et al. (2009), the plume effects from the transport emissions are not taken into account in the present study.

Page 15763, lines2-6: Does the model predict a change in tropopause height or is it fixed at 150 hPa? If the tropopause is allowed to shift there could be an artificial increase in ozone in the upper troposphere.

The model does predict a change in the tropopause. Therefore, despite a prescribed stratospheric ozone climatology, the stratosphere to troposphere exchange can be modified in case of climate change. To clarify this, the text has been modified (p15764, line 4) as follows:

Initial sentence:

This climatology is deliberately kept fixed at present-day values in all simulations in order to isolate the effects of tropospheric chemistry and climate change to changes in the chemical composition of the stratosphere.

Final sentence:

This climatology is deliberately kept fixed at present-day values in all simulations in order to isolate the effects of tropospheric chemistry and climate change to changes in the stratospheric chemistry. Regardless the prescribed stratospheric ozone, the stratosphere to troposphere exchanges are affected by changes in the vertical circulation across the tropopause.

Page 15764: The authors correctly point out the importance of using realistic emissions. At the same time, I'm curious how well the model compares to observations when using realistic emissions. A full evaluation is not necessary, but there should at least be a citation specifically referring to previous model-observations comparisons.

The following section has been added p15764 Line 7

The LMDz-INCA chemical results were compared to many other global CTMs or GCMs, and to observations during the international exercises HTAP and Photocomp. The related papers show a response (in term of sensitivity to emissions) of LMDz-INCA which is quite similar to the ensemble mean of the results for ozone (Stevenson et al., 2006). Comparisons with ozone surface network (Ellingsen et al., 2008) show a systematic positive bias for all the models, partly due to misrepresentation of NO_x gradient close to the sources. Reidmiller et al. (2009) and Fiore et al. (2009) tried to discriminate the climatological feature of ozone measured by the castnet (USA) and emep (Europe) networks before comparing with global models. LMDz-INCA showed in these studies a fairly good agreement for ozone with US stations. More recently, Jonson et al. (2010) compared 12 models involved in the HTAP experiment to ozone sonde measurements and concluded that the global models have far more difficulty in accurately reproducing ozone variability in the free troposphere. As stated by Shindell et al. (2006), all the global models show large under-estimates of Northern Hemisphere extra-tropical CO, while typically performing reasonably well elsewhere. An evaluation of the performance of the global chemistry transport and chemistry-climate models involved within the QUANTIFY project has also been performed (Schnadt et al., 2010), using observations from the long-term programme MOZAIC, as well as from the SPURT, CONTRACE II, and TROCCINOX campaigns. In accordance with the previous conclusions, the ozone concentrations are shown to be over-estimated at northern midlatitudes by the present version of LMDz-INCA and the other models, whereas CO is significantly underestimated by all models throughout the troposphere, at northern midlatitudes and in the subtropics. No systematic bias is obtained for the NO_x concentrations

in the upper troposphere and lower stratosphere between LMDz-INCA simulations and the different observation campaigns.

New references

*Ellingsen, K., Gauss, M., Van Dingenen, R., Dentener, F. J., Emberson, L. Fiore, A. M., Schultz, M.G., Stevenson, D. S., Ashmore, M.R., Atherton, C. S., Bergmann, D. J., Bey, I., Butler, T., Drevet, J., Eskes, H., Hauglustaine, D.A., Isaksen, I. S. A., Horowitz, L. W. , Krol, M., Lamarque, J. F., Lawrence, M. G., van Noije, T., Pyle, J., Rast, S., Rodriguez, J., Savage, N., Strahan, S., Sudo, K., Szopa, S., and Wild, O.: Global ozone and air quality: a multi-model assessment of risks to human health and crops, *Atmos. Chem. Phys. Discuss.*, 8, 2163-2223, 2008.*

*Jonson, J.E., Stohl,A., Fiore,A.M., Hess, P., Szopa, S., Wild, O., Zeng, G., Dentener, F.J., Lupu, A., Schulz, M.G., Duncan, B.N., Sudo, K., Wind, P., Schultz, M., Marmer, E., Cuvelier, C., Keating, T.J., Zuber, A., Valdebenito, A., Dorokhov, V., De Backer, H., Davies, J., Chen, G.H., Johnson, B., Tarasick, D. W., Stubi, R., Newchurch, M.J., von der Gathen, P., Steinbrecht, W. and Claude, H.: A multi-model analysis of vertical ozone profiles, *Atmos. Chem. Phys.*, 10 (12):5759-5783, DOI 10.5194/acp-10-5759-2010, 2010*

*Reidmiller, D. R., Fiore, A. M., Jaffe, D. A., Bergmann, D., Cuvelier, C., Dentener, F. J., Duncan, B. N., Folberth, G., Gauss, M., Gong, S., Hess, P., Jonson, J. E., Keating, T., Lupu, A., Marmer, E., Park, R., Schultz, M. G., Shindell, D. T., Szopa, S., Vivanco, M. G., Wild, O., and Zuber, A.: The influence of foreign vs. North American emissions on surface ozone in the US, *Atmos. Chem. Phys.*, 9, 5027-5042, 2009.*

Page 15770, line 6: It's unclear what the " preliminary LMDz-INCA simulations" are. I am assuming the versions in Hoor et al. (2009), but this should be explicitly mentioned.

Reference added.

Page 15770-15771, also Figures 2-4: It's not clear to me what is learned from presenting a transport mode as being x% of transport emissions' impact. I think it's important to explain why this information is important (is it because all transport emissions are lumped together in the later climate simulations?). It might be clearer to present the absolute impact of each mode.

In Figure 1, we show the total absolute impact of the transport sector for the ozone column, the surface ozone and the zonal mean ozone. The respective contributions of the three transport modes are then provided in % of the total impact in Figures 2, 3 and 4, respectively. Coming back to Figure 1 gives an idea of the corresponding absolute perturbations, which are also provided here and there in the text.

The following sentence has been added p 15770 line 13 (before the description of Figure 2 to 4) to explain why it is important to show the transport mode contributions in % of total impact of transport emissions:

Future changes in ozone production by the transport sector will strongly depend on the respective contributions of the different transport modes (see for instance Dahlmann et al. 2009). Therefore, it is important in terms of mitigation options, to quantify the present and the future respective contributions of each of them.

Technical Corrections

Page 15756, line 11: "a moderate" rather than "amoderate"

Page 15756, line 13: "a drastic" rather than "adramatic"

Page 15756, line 15: "a very" rather than "avery"

Page 15756, line 18: "a similar" rather than "asimilar"

Page 15756, line 21: “a significant” rather than “asignificant”
Page 15757, line 16: “very sensitive” rather than “very sensitivity

Corrected

Page 15758, line 21: Dalsoren and Isaksen (2006) is not specifically about shipping

This reference has been removed.

Page 15760, line 27: "are sensitivity rather than prediction" rather than

Corrected

Page 15765, final paragraph: I was confused by this paragraph. I suggest comparing emissions through relative terms (twice as much, 50

Confusing, indeed! It has been clarified as follows:

Initial text

The resulting QUANTIFY 2000 final emissions from road (9.1 TgNO_x(N)/yr, and 15 Tg NMHC/yr, 110 Tg CO) are significantly higher than QUANTIFY preliminary ones (6.85 Tg N/yr, and 10 Tg NMHC/yr, 73 Tg CO) used in Hoor et al. (2009). They are closer for NO_x, but still lower for CO and NMHC compared to previous assessments. For comparison, the road traffic emissions adopted by both Matthes et al. (2005) and Niemeier et al. (2006) are 9 Tg (N)/yr and 36 Tg/yr for NO_x and NMHC, respectively. For CO, they, respectively used 237 Tg/yr and 196 Tg/yr, i.e. about twice the emissions used in the present study.

Final text

The resulting QUANTIFY 2000 final emissions from road (Table 1) are 33%, 50% and 51% higher than QUANTIFY preliminary ones (Hoor et al., 2009) for NO_x, NMHC and CO, respectively. They are closer for NO_x, but still lower for CO and NMHC compared to previous assessments. For comparison, the road traffic emissions adopted by Matthes et al. (2005) and Niemeier et al. (2006) for NMHC and CO are about twice the emissions used in the present study.

Page 15767, line 23: Six sets of experiments, not five.

Corrected

Page 15768, line 3: “which leads to” rather than “which lead to”

Corrected

Page 15768, line 22: “The first three” rather than “The three first”

corrected

Page 15768, line 24: “Like the emissions change” rather than “Likewise the emissions change”

corrected

Page 15769, lines 19: “traffic emissions” should be “transport emissions”

The whole sentence has been modified as follows (according to comments from Reviewer 2)

Initial sentence (Page 15769, lines 18-20):

It must be emphasized here that the ozone perturbation due to traffic emissions is not included in the climate perturbation, i.e., ozone changes do not feedback on climate.

Final sentence:

It must be emphasized here that the present (experiments A to E) and future (experiment F) climates are forced using HadGEM1 simulation outputs, and therefore, that the changes in the tropospheric chemistry simulated in this study do not feedback on climate.

Page 15774, line 19: The transport NO_x emissions listed here do not match Table 1.

Initial text

(from 0.8 to 3.3 Tg(N).yr⁻¹)

Final text

(from 0.85 to 3.3 Tg(N).yr⁻¹),

Page 15774, line 25: "scenario A1B" rather than "scenario A1"

corrected

Page 15776: The final paragraph of section 4.2.2 doesn't particularly fit in the B1 ACARE section. Perhaps it'd be better in the previous section?

This paragraph ends the whole section 4.2. It has been reduced, as well as section 4.2.2, following Reviewer 2 request (see answers to Reviewer 2).

Page 15776, line 21: Should the year be 2100 rather than 2010?

Corrected

Page 15776, line 25: Simulations G and H are not listed in Table 2.

Corrected to : "Simulations E and F"

Page 15778, line19: "ozone production efficiency" rather than "production ozone efficiency"

Page 15779, line 1: "impact of future transport emissions" rather than "impact of future traffic emissions"

Page 15779, line 11: I believe the applicable results of the simulation using 2003 met data is in Fig. 1b.

Page 15779, lines 13-14: Two references to Fig. 10c, I believe the latter should be 10b.

Above corrections page 15778 and 15779 done

Page 15779, lines 26- : I don't understand this sentence.

Initial text

While very similar patterns for the impact of transport emissions on ozone are predicted with and without the climate change, the latter showing slight but significant positive and negative effects, according to the location and the season, on the ozone change. A climate-induced increase of up to +0.6DU.

Final text

While very similar global patterns for the impact of transport emissions on ozone are predicted with and without the climate change, significant positive or negative climate-induced changes are simulated according to the region, altitude and season. An increase of up to +0.6 DU.

Page 15781, line 10: "magnitude as the" rather than "magnitude than the"

Corrected

Page 15790-15791: Matthes citation is listed twice.

Corrected

Page 15794, Table 1: I think the source "Total Traffic" would be better labeled "Total Transport." If possible, it'd be best to bold-face "Total transport," "Total" and "Transport contribution" so that they stand out more.

Modified as requested

Page 15795, Tabel 2: I think the last sentence of the caption is meant to say "The first three years have been: : :"

Corrected

Page 15806, Figure 9: The lower two panels showing changes in CO are never discussed in the paper. Are they necessary?

They are removed in the reviewed version.

All figures: The figures could be improved by darkening/thickening the continental outlines, graph axes and the line indicating the tropopause.

If they could be somewhat improved doing so, it would require more time than allotted to redo all of them.