

Interactive comment on “Key drivers of ozone change and its radiative forcing over the 21st century” by Fernando Iglesias-Suarez et al.

Anonymous Referee #1

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Review of “Key drivers of ozone change and its radiative forcing over the 21st century” by F. Iglesias-Suarez et al.

General Comments

This is an interesting and generally well-constructed paper that presents new results and is well worthy of publication. However, several things about the paper confused me, and I think must be clarified before it is accepted for publication. These are listed in detail below, but can be broadly summarised as follows. The paper is about modelled ozone changes between 2000 and 2100, but after reading it I am unclear how the major influence of changing anthropogenic emissions is included (the focus is on changes in climate, lightning, ozone-depleting substances, and methane). I think they must change, based on some of the text, and comparisons to other studies, but I can't work

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out how they are handled from what is written in the text. There are a few other things that I find a bit confusing, but I think if the authors can address the specific comments below the paper will be good for publication.

Specific Comments

P2 I4-6: Do changes in the stratosphere account for 47% of the overall RF for both 1750-2000 and 2000-2100?

P2 I15: 90% by mass.

P2 I19: It is difficult to agree that ozone is ‘the main’ concern for climate change and air quality (CO₂ and PM are probably more important!) – suggest change to ‘an important’.

P2 I26: Delete comma after although.

P2 I30: “BDC is the wave-driven factor” – rephrase.

P3 I13: ODS (not ODSs).

P3 I18: troposphere (not stratosphere).

P3 I21-24: Clarify – do reductions in O₃ photolysis mean more tropospheric O₃?

P4 I1: to -> with.

P4 I4: lower -> reduced.

P4 I9: What about aircraft NO_x?

P5 I15-17: Aren't higher latitudes than the tropics more strongly influenced by stratospheric influx of O₃?

P5 I27-29: Sentence unclear – reword.

P6 I8: i.e. -> e.g. (also following lines 9 and 11).

P6 I19-23: Unclear – reword.

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P7 I19: Is CH₄ an ODS? (I don't think so.)

P7 I27-28: It may have been recommended by CCMI, but I don't really understand why the O₃S tracer can't also be lost by O₃ dry deposition (like any ozone molecule). Can you clarify why? This seems like an odd approach. I see you apply a correction factor – I guess to account for this.

P8 (This should be somewhere in the model description or experimental set-up): Is ozone coupled radiatively to the climate model? I assume it is, and this means that any changes in ozone generate changes in meteorology. This should be made clear, as it has important implications for how the results are interpreted.

P8 I10: There is a minor inconsistency in your naming/approach – 1990-2009 is used to represent 2000; 2080-2099 is used to represent 2100. Why not nominally 2090? Actually on the next line you say each experiment is 20 years with only the last 10 years used – so 2000-2009 or the 2000s and 2090-2099 i.e. the 2090s?

P8 I14: You use MACCity anthropogenic emissions, but don't make it clear if they are held fixed at year 2000 levels or if they change between 2000 and 2100 (RCP8.5). This needs to be clear as it is also very important.

P8 I19 phases

P8 I23: Clarify if land-use is changing in these runs – if so this would have implications for, e.g., BVOC emissions, etc.

P10 I4: I think Section 3 belongs within the "Results", rather than prior to it. It contains some results!

P10 I7: a 25%

P10 I19: the annual mean

P10 I23: small bias of total column O₃? Clarify.

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P10 I31: 20 N/S -> 20N – 20S

P11 It should be made clear that there is a large difference between a "Radiative Effect" and a "Radiative Forcing".

P11 I12: "Nevertheless" seems misleading. Just because the present-day RE is small it doesn't follow that the RF is small. Indeed the tropospheric O₃ RF (pre-industrial to present-day) peaks in the sub-tropics.

P11 I16: As already mentioned – we've already had some results.

P11 I19 . . . shows modelled annual. . .

P11 I20-21: We present results from adding. . .

P11 I23: "expected" sounds a bit presumptive. A similar pattern to that found previously?

P11 I27: chemistry -> chemical

P12 I19: (non-lightning) climate-induced

P13 I16: weighted by latitudinal area (?)

P13 I24: Clarify the origin of the quoted plus/minus value. Is it +/- 1SD from inter-annual variability? (as stated p10 I25) If so, please say explicitly how you calculated this – 10 years of data from run 1 and 10 years of data from run 2 – is it just based on the difference between years 1, 2, etc.? Or is it something more sophisticated? I'm not quite sure what this value really represents, and you use it to justify the significance of particular results later, so it should be clear.

P14 I7: partly associated

P14 I17: larger -> higher

P14 I31: . . . distribution of changes. . .

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P15 I7: ...global forcing between 2000 and 2100... This seems to be the combined RF of CLIMATE+LIGHTNING++O3-RECOVERY+++METHANE. But does it include changes in (other) anthropogenic emissions (i.e. NO_x, CO, etc.)? Clarify.

P15 I21: NB changes in the methane lifetime occur on OH timescales (seconds). Impacts on CH₄ concentrations are felt on decadal timescales. Rephrase.

P15 I25 It would be better to quote these imposed CH₄ concentrations in Section 2.2.

P15 I28: ...global mean methane...

P16 I19-20: Clarify – is this small negative forcing just the long-term CH₄-related O₃ component (I think so?) or the (CH₄+O₃) net RF?

P16 I23: I'm struggling to find the corresponding ACCMIP value in Stevenson et al – specify the table or figure in that paper? Did ACCMIP report directly equivalent results?

P18 I16: Clarify – are you changing anthropogenic emissions? Also, it must be really clear that whenever you say 2100 you mean 2100 under the RCP8.5 scenario.

P19 I13: I think the number in Stevenson et al. (2013) is 600 +/- 30% (i.e. 180) W/m²?

P19 I22: Is a whole column NRF sensible? The large difference relative to Gauss a few lines later reinforces that it probably is not sensible.

P20 I5: leaves -> alone produces a small positive...?

P20 I10: which may be -> which are?

P20 I31: RCP8.5 scenario

P21 I10-14: So the global average column O₃ is OK, just its spatial distribution isn't?

Table 1: What happens to anthropogenic trace gas emissions? Do they all follow RCP8.5 or are they kept at 2000? Clarify: by 2100 you mean 2100 RCP8.5 (for climate and CH₄) – but what scenario for ODS?

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Table 2: Possibly clarify CLIMATE does not include any climate-change related changes in LNO_x.

Table 3: Clarify that these are RFs for 2100 RCP8.5 relative to year 2000.

Figure 2: It took me a little while to work out that (a) shows CLIMATE-CNTRL; (b) shows +LIGHTNING-CLIMATE; (c) shows ++O₃-RECOVERY - +LIGHTNING; and (d) shows +++METHANE - ++O₃-RECOVERY. Is that correct? This should somehow be made clearer.

Figure 3: The ZM right panels would probably be better if they all shared the same x-axis scale. Also the dashed and dotted grey lines on these are hard to see.

Figure 4: Units are W m⁻² / DU.

Figure 5: I was confused by the extra 1750-2000 overall forcing on the total bar. Also clarify that the total bars are simple sums of the four bars above – is that right? What about changes in anthropogenic emissions 2000-2100 RCP8.5? Are they somehow included here, or definitely not? I'm confused.

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