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” byy 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...
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 l4-6: Do changes in the stratosphere account for 47% of the overall RF for both 1750-2000 and 2000-2100?

P2 l15: 90% by mass.

P2 l19: 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 l26: Delete comma after although.

P2 l30: “BDC is the wave-driven factor” – rephrase.

P3 l13: ODS (not ODSs).

P3 l18: troposphere (not stratosphere).

P3 l21-24: Clarify – do reductions in O3 photolysis mean more tropospheric O3?

P4 l1: to -> with.

P4 l4: lower -> reduced.

P4 l9: What about aircraft NOx?

P5 l15-17: Aren’t higher latitudes than the tropics more strongly influenced by stratospheric influx of O3?

P5 l27-29: Sentence unclear – reword.

P6 l8: i.e. -> e.g. (also following lines 9 and 11).

P7 l19: Is CH4 an ODS? (I don’t think so.)

P7 l27-28: 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 l10: 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 l14: 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 l19 phases

P8 l23: Clarify if land-use is changing in these runs – if so this would have implications for, e.g., BVOC emissions, etc.

P10 l4: I think Section 3 belongs within the “Results”, rather than prior to it. It contains some results!

P10 l7: a 25%

P10 l19: the annual mean

P10 l23: small bias of total column O3? Clarify.
P10 l31: 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 l12: “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 l16: As already mentioned – we’ve already had some results.

P11 l19 . . . shows modelled annual . . .

P11 l20-21: We present results from adding . . .

P11 l23: “expected” sounds a bit presumptive. A similar pattern to that found previously?

P11 l27: chemistry -> chemical

P12 l19: (non-lightning) climate-induced

P13 l16: weighted by latitudinal area (?)

P13 l24: Clarify the origin of the quoted plus/minus value. Is it +/- 1SD from inter-annual variability? (as stated p10 l25) 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 l7: partly associated

P14 l17: larger -> higher

P14 l31: . . . distribution of changes . . .
P15 l7: ...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. NOx, CO, etc.)? Clarify.

P15 l21: NB changes in the methane lifetime occur on OH timescales (seconds). Impacts on CH4 concentrations are felt on decadal timescales. Rephrase.

P15 l25 It would be better to quote these imposed CH4 concentrations in Section 2.2.

P15 l28: ...global mean methane...

P16 l19-20: Clarify – is this small negative forcing just the long-term CH4-related O3 component (I think so?) or the (CH4+O3) net RF?

P16 l23: 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 l16: 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 l13: I think the number in Stevenson et al. (2013) is 600 +/- 30% (i.e. 180) W/m2?

P19 22: Is a whole column NRF sensible? The large difference relative to Gauss a few lines later reinforces that it probably is not sensible.

P20 l5: leaves -> alone produces a small positive...?

P20 l10: which may be -> which are?

P20 l31: RCP8.5 scenario

P21 l10-14: 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?
Table 2: Possibly clarify CLIMATE does not include any climate-change related changes in LNOx.

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.