

Interactive comment on “Potential of future stratospheric ozone loss in the mid-latitudes under climate change and sulfate geoengineering” by Sabine Robrecht et al.

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This study by Robrecht et al. focuses on analysing the conditions over which heterogeneous chlorine activation and its subsequent effect on ozone concentration in the mid-latitudes might happen if stratospheric aerosols injections are applied. To do so, the authors use both direct simulations results from CESM1(WACCM) and box-model simulations from the Chemical Lagrangian Model of the Stratosphere (CLaMS). While the impact is found to be rather minimal, the analyses presented in this paper are very nicely described, are scientifically robust and definitely of interest to the scientific community. The paper is of high quality and deserves publication on ACP. I have some

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minor suggestions that I list below, and after they are addressed the manuscript can be accepted promptly.

General remark: Throughout the entire manuscript, the authors define the RCP8.5 cases as the “climate change” cases, whereas the GLENS geoengineering scenario is defined as “geoengineering scenario”. They also are not always consistent with the names they use to define the two scenarios. I think that’s not entirely correct, as a definition, and could be a bit misleading. Would climate change under RCP8.5? Of course, as a consequence of high GHGs mixing ratios. But contrasting “climate change” with geoengineering gives the impression that what GLENS (and geoengineering in general) does is “cancels out” climate change. It doesn’t, and plenty of GLENS studies have shown that, while smaller than those produced by the warming alone, geoengineering does produce some changes in the surface climate. So, for clarity, I would suggest the authors use a more precise definition for the RCP8.5 scenario (i.e. “increased surface warming”). Even just calling it “RCP8.5” would be better.

Page 1 Line 3: no comma after “Especially” Line 16: comma after furthermore Line 17: “has been” discussed? Line 29: I would suggest also citing some of the results from CCMI, for instance discussing the sensitivity of ozone changes to various ODSs and GHGs, Morgenstern et al. (2018)

Page 4 Line 22: focusing with just one s

Page 5 Line 23: maybe better to specify it’s “surface” temperatures that GLENS tries to manage? Line 30: would be emitted by the end Line 31: in CESM1(WACCM), yes, but other models need to inject upward to 20 Tg-SO₂ to get the proper AOD (see Timmreck et al. (2018) and references therein). So either specify that that’s what WACCM needs, or that there’s a range of uncertainty in this.

Page 6 Table 1: I think the names of the scenarios should be more consistent between experiments, as I said before. First of all, the 2010-2020 period is still under RCP8.5, since the emissions do vary even in that decade between the RCPs. Second, if C2040

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is defined as “Climate Change following the RCP8.5 emission pathway” (although here I would use “surface temperatures increase”), then consistently F2040 should be defined as “Sulfate geoengineering to maintain temperatures at C2010 levels” (but it’s actually 2010-2030, so it should be more specific) and similarly for F2090. Or another idea could be to have a column for “Underlying Emission Scenario” (that is always RCP8.5), a column for “Global T increase” (that would be > 0 for the C simulations and ~ 0 for the F simulations) and a column for “Stratospheric SO₂ injected” (that would be $= 0$ for the C simulations and $\gg 0$ for the F simulations). This would give the reader unfamiliar with GLENS an estimate at a glance of the amount of warming and of intervention that it’s being considered here. Overall, the authors are free to do as they wish, but I strongly suggest making this table more useful to the reader.

Line 15 or thereabout: is the spatial range chosen for a specific purpose (i.e. we have measurements over that area) or just as an example because (clearly) considering the entire latitudinal band would be too much calculations? From reading further on, it is clear it is the former, so it should be specified in here too.

Page 7 Line 3: no “in” before “the focus of this study”

Page 8 Table 2: “For a better overview in this paper, the pressure ranges are allocated to a pressure level” I find this phrase very hard to parse, even if I can catch the meaning. Should be rewritten. Line 5: “tropospheric character” doesn’t really mean much. Maybe “characteristic”?

Page 12 Lines 2-5: If the “higher ozone smog production” is a result of RCP8.5 emissions, shouldn’t the same also be observable in GLENS, given the underlying emissions are the same? Later, on line 5, should specify that the BDC changes transporting more air downward are true at the considered latitudes, not everywhere.

Page 14 Line 17: no comma after “range”

Page 18 Line 1-2: the HCl absorption by the liquid aerosols is an interesting point.

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Some mention of the fact that this has been observed and discussed for volcanic eruption could be of interest to the reader (see Tabazadeh and Turco, 1993) to back up this point.

Page 21 Line 1: “at” lower latitudes than “at” higher. . .

Line 15-16: The use of commas in this phrase makes it a bit hard to follow: I suggest a slight change below “Since no mixing is allowed in the box-model runs, the conditions that yield chlorine activation are not disturbed within 10 days”

Line 17: maybe “conservation” is a clearer term than “maintenance”?

Line 34: this makes it sound like the geoengineering scenario in GLENS prescribes a reduction of ODS. That reduction is prescribed in the underlying RCP scenarios, more in general. This is especially confusing considering the authors sometimes use GLENS to identify the geoengineering scenario, sometimes both future scenarios.

Page 23 Line 26: “are” summarized

Page 25 Line 6: are reduced “by” 2K

Page 26 Line 4: “even though” is better here, otherwise “despite the fact that”

Line 30: “Despite the”

Page 27 Line 1: Except “for”

Throughout the Discussion session, is hard to understand what the authors mean by GLENS. The geoengineering scenario? The RCP8.5 one? Should be clarified.

Page 29 Line 19: “In our study, only air masses that are close to the tropopause are considered”

Page 31 Line 15: “few ozone” is not really correct. “Not much”, or “scarcely any” would be more correct. Also, “due to” (or “as a consequence of”) instead of “caused by” Line 28: no comma after showed

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References

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