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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sulfate geoengineering: a review of the factors controlling the needed injection of sulfur dioxide" *by* Daniele Visioni et al.

Anonymous Referee #2

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Review

The paper summarizes geoengineering studies that discussed stratospheric SO2 injections into climate models. The paper focusses only on a few studies. There are not that many studies in recent years that actually injected a fixed amount of SO2 into the stratosphere. However, various studies used prescribed aerosol distributions. Those also contribute to the question of needed injections of sulfur dioxide. Therefore, I would recommend to extend this study to more papers, as listed below to justify the word "review" in the title. Also, I do not understand the last section of the paper and numbers in Table 1, and I think it needs more explanation. Specific comments are listed below:

Abstract: I disagree that the described technique would be planned for a timeframe of a few decades, while implementation of global measures of GHG emissions is achieved.

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Discussion paper

This technique would likely have to be applied during and after global measures are implemented, and for a much longer period of time if aiming for temperature stabilization, since temperatures will still continue to rise after mitigation efforts have started. See for example Sanderson et al., 2016 (doi: 10.1002/2016GL069563), Tilmes et al., 2016 (doi:10.1002/2016GL070122); depending on the mitigation efforts, solar geoengineering may be required for a very long period of time.

Line 10: It will be very difficult to fine-tune amounts of sulfur dioxide emissions based on models, due to the range of climate sensitivity and differences in the response of surface temperatures to volcanic aerosols. All the different studies can do, is outline important factors that control the amount of sulfur dioxide to be injected.

Page 2, Line 8. As commented above, it is misleading to assume that this technique would only be used between 2020 and 2070.

Page 2, Line 21. Why would you only focus on the G4 type studies, why not extend this? Besides, there are other earlier studies that used fixed amounts of SO2 injections, Rasch et al., 2006, and studies that prescribed sulfate aerosols based on fixed amounts of SO2 injections, including Rasch et al, 2008 (doi:10.1029/2007GL032179), Tilmes et al., 2009 (doi:10.1029/2008JD011420), Tilmes et al., 2012 (doi:10.5194/acp-12-10945-2012). Those and others may be included in the review.

Line 26: You can also add Niemeier et al., 2011 (doi:10.1002/asl.304), and Niemeier et al., 2013 (doi:10.1002/2013JD020445).

Page 3: Direct forcing of stratospheric sulfate: References in the first paragraph are very old and by now there are more recent papers describing that the cooling effect after Mt. Pinatubo was actually much smaller (at most 0.3 C), IPCC 2015, Canty et al., 2013 (doi:10.5194/acp-13-3997-2013). Also the radiative forcing seems to be largely overestimated in the study by Minnis et al., 1993.

Page 3, Line 28: The range in radiative response was likely due to the differences

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in AOD of the models. However, even with the same AOD distribution, models may have very different radiative responses, see for example Neely et al., 2015 (doi:10.5194/gmdd-8-10711-2015), just comparing 2 CESM versions with different radiation schemes.

Page 3, Line 13: please change to “a series of factors”

Section 2.2.1 Ozone. This section only summarizes findings from one paper, this is not a review. Heckendorn et al., 2009 (doi:10.1088/1748- 9326/4/4/045108) and Tilmes et al., 2009 (doi:10.1029/2008JD011420), have discussed changes in ozone due to solar geoengineering.

Page 5, Line 13: Do the numbers -1.1 to -2.1DU include the model that did not consider heterogeneous chemistry? How do those numbers compare to earlier studies? Same for the RF, what models are included in this number?

Section 2.2.3. Do you mean “Upper tropospheric ice”?

Page 8, Line 12; Please note, tropospheric UV shows a net reduction in the tropics, correctly stated in the text. However, this is not the case of mid- and high latitudes. Methane lifetime is mostly influenced from OH changes in the tropics, therefore the methane lifetime is increased with geoengineering.

Line 23: typo: today’s, also what do you mean by today’s levels, what period?

Could you explain the numbers given in Section 2.3 and Table 1?

For example, to offset certain levels of RF, one would need to identify how much sulfur injection is required, which is model depended. For instance, Niemeier and Timmreck, 2015, calculated an efficiency of 0.30 – 0.35 W/m2 per TgS injection. Since 5TgSO2 are equal to 2.5 TgS, this results in about 0.3*2.5 = 0.75 W/m2 per 5 Tg SO2 injection. Can you do the same calculations for the other studies? It is not clear how you get to the value of -1.45 W/m2 +/- 0.65 in this study.

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Also, for example the RF of RCP 4.5 between 2020 and 2070 is about 2.2-2.3 W/m2. Where does the number in Table 1 (0.8 W/m2) come from? If the RF needs to be set off by geoengineering in 2070, much more forcing is required than 0.8 W/m2.

For the cirrus forcing, why do you only state one number for cirrus impacts and not the lower number from Pitari et al., 2016b? Particle sizes from sulfate geoengineering are likely not large enough to have any significant effect, while dust particles have a larger effect. In Table 1, at least give a range for cirrus cloud effects.

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