

Interactive comment on “Sulfate Geoengineering Impact on Methane Transport and Lifetime: Results from the Geoengineering Model Intercomparison Project (GeoMIP)” by Daniele Visionsi et al.

Anonymous Referee #2

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General Comments:

This study used ULAQ-CCM and GEOSCCM to study the CH₄ transport and lifetime change under sulfate injection geoengineering. The ULAQ-CCM and GEOSCCM simulation used prescribed SSTs from CCSM-CAM4. There are only a few studies working on sulfate geoengineering impact on atmospheric chemistry, and this one is important to better understand how injected sulfate aerosol will change the stratospheric circulation and CH₄ chemistry. It is a good fit for ACP. However, more clarifications are needed.

C1

More detailed model description are needed. It is not clear whether the models have land model coupled, and whether CH₄ emission is prescribed. Better explain the experiment design, such as why use two sulfate injection amounts?

There are too many figures and tables, maybe it is better to move some of them to supplemental materials, which will also make the main text more focus on its own logistic flow.

Specific comments:

Page 1:

-Line 3: sulfate aerosol reflects and scatters the incoming solar radiation. Reflection effect should be much larger than the scattering effect in terms of increasing the planetary albedo and cooling the surface.

Page 2:

-Line 3: Please change the citation format to (Kravitz et al., 2011), and change the format through the whole manuscript.

-Line 9: delete “at visible and UV wavelengths”. Solar radiation is the short wave radiation.

-Line 11: change the sentence to “ a reduction of the global surface air temperature from 0.5 K (Soden et al., 2002) to 0.14 K using detrended analyses (Canty et al., 2013)”

-Line 16: please reorganize this sentence “First of all, . . .infrared wavelengths”

-Line 27: what does “a heightened exchange between the stratosphere and the troposphere” mean? The altitude change of tropopause?

-Line 28: change sentence to “. . .fluxes injects more stratosphere air into the troposphere, which dilute the troposphere concentration of such gases”

-Line 29: what is “the horizontal eddy mixing of UTLS tropical mixing ratios with the

C2

extra-tropics"? please reorganize.

Page 3:

-Line 11 - 16: move the experiment description to session 2, and add more details of the experiment design, such as what is G4? Why there are two injection amount (5/8 Tg SO₂/yr)

-Line 25-30: CCSM-CAM4 is used to provide the SST of RCP4.5 and G4 for further simulations with ULAQ-CCM and GEOCCM. Need to emphasize this. Since there are two injection amounts, maybe you should use different name for them?

Page 4:

-Line 3: what is MBC and FBC? Description needed when first appear. What's the difference among the three ULAQ-CCM experiments? How MBC and FBC make a difference?

-Table 1: Tilmes et al. (2016) used CCSM-CAM4-CHEM, which includes stratosphere and troposphere chemistry, and performed REFC1 and REFC2 experiment. You mentioned that the G4 experiment has been done with CCSM-CAM4 without interactive chemistry. This reference might be wrong for your 8Tg SO₂ injection case? The CCSM-CAM4 is 40 levels? In Tilmes et al. (2016), it is 26 levels (FR) or 56 levels (SD). Why use different amount of injected SO₂ in GEOCCM and ULAQ-CCMc relative to others? Table 1: in ULAQ-CCMc and GEOCCM, RCP4.5 SSTs are used. Does the land temperature response to the sulfate injection? In that case, would there be inconsistent between the land and the ocean?

- general question for model description: in ULAQ-CCM and GEOCCM, is the CH₄ emission prescribed? Or the two models have interactive land with dynamic vegetation and agriculture, CH₄ emission is interactive with the climate? Do those two models have no ocean, and that why they need the SSTs from CCSM-CAM4?

Page 6:

C3

-Line 2: could you explain why ULAQ-CCM has a large bias over the polar region, especially in MAR? -Figure 1: why TES has much higher CH₄ concentration than HALOE on both 100 hPa level and the vertical profile? Please use subscript number in chemical formulas, such as CH₄. Please make this change through all plots.

-Line 12: change "significant" to "significant"

Page 7:

-Figure 2: in the figure caption, please change to "(a) and (d) 60S-90S and 60N-90N, (b) and (e) 30S-60S and 30N-60N, and (c) and (f) 30S-30N". Delete "units are ppmv". The plot itself shows the unit.

Page 9:

-Table 4: instead of confidence interval, maybe standard deviation is easier to see? (e.g. ± 0.003)

Page 10:

-Line 2: change to "model values"

-Line 8: delete "by knowing this"

-Line 10: change to "We looked at"

-Line 11: change to "Table 5 compares the coefficient. . ."

Page 11:

-Figure 4: please make sure that the tile font size is the same.

Page 13:

-Line 1: would result from MBC include both the dynamic change and the tropospheric CH₄ concentration change? Would it be better to put results from MBC and FBC together, and the difference will demonstrate the dynamic change?

C4

-Line 8: it might be better to change the sentence to something like “In the latter two model simulations, RCP4.5 SSTs are used, whereas ULAQ-CCM(a) is driven by G4 SSTs.”

-Line 11: delete “where SSTs in G4 are unchanged with respect to RCP4.5.”

Page 14:

-Line 20: why “missing chemical processes in the upper troposphere in GEOSCCM” only affect CH₄? N₂O shows similar change in two models.

-Line 33: there is no zonal vertical plot showing the comparison between GEOSCCM and ULAQ-CCM9c)

Page 15:

-Figure 6: does the difference between GEOSCCM and ULAQ-CCMc in (c) and (d) also come from the difference in QBO?

-Figure 6: the difference between ULAQ-CCMa and ULAQ-CCMc in (a) and (b), is that from the gas concentration change from the troposphere or from the tropical surface temperature difference?

-Line 1: Why showing ULAQ-CCMa and b? do those two runs both use SSTs from G4 simulation, and ULAQ-CCMc uses SSTs of RCP4.5? if the purpose is to compare SSTs in G4 and RCP4.5, then it is a comparison between ULAQ-CCM(a),(b) and ULAQ-CCM(c).

-Line 4: in Figure 9b, isn't the global averaged surface temperature back to RCP4.5 level around 2080? Then it is 10 years not 20 years.

-Line 5: the warming in North Atlantic Ocean under G4 is because the cooling in that region under RCP4.5. Please look at IPCC report, and there are observations showing the cooling in that region.

C5

Page 16:

-Line 8: why comparing ULAQ-CCMa and GEOSCCM? ULAQ-CCMa simulates 8Tg SO₂/yr injection, and used SSTs of G4, GEOSCCM simulates 5Tg SO₂/yr injection, and used SSTs of RCP4.5.

Page 17:

-Figure 8: please add the pressure level on y-axis as well.

-Figure 8: figure 6 shows that the vertical mass flux in GEOSCCM is much larger than in ULAQ a and c as a result of QBO, why here the stratosphere CH₄ concentration is much stronger in ULAQ? Is that because the troposphere CH₄ concentration is much higher in ULAQ than in GEOSCCM?

-Figure 8: why there are strong reduction of CH₄ and N₂O under G4 in lower stratosphere over the south pole relative to RCP4.5 using ULAQ?

-Line 6: how was the lifetime calculated?

Page 18:

-Figure 9: In (b) G4 global averaged surface temperature returns back to RCP4.5 level around 2.80, but in (a) the red dashed line (2080-2089) shows a large negative number, with a global average close to -0.5 K. How could that be?

Page 19:

-Figure 10: the red and blue bars are overlapped.

Page 20:

-Figure 11: the red and blue bars are overlapped.

Page 21:

-Line 8-9: delete the repeat sentence.

C6

-Line 17: what does $2 \times 10^2 \text{ cm}^{-3}$ mean? Should it be 2×10^3 ?

Page 22:

-Figure 12: what does Pressure Altitude mean? Add pressure level in y-axis.

-Line 4: 10-30%

Page 23:

-Line 1: how about over the mid-high latitude regions, UVB increases as a net result, which enhances the production of OH. In Figure 15, does the green color over pole regions on the surface mean positive or negative?

-Line 3: 1.5-2.0%

-Line 4: unit of latitude.

-Line 8: not scattering increases albedo, reflection is the main reason.

Page 27:

-Line 6: The relative long life time makes the CH₄ concentration needs a longer time to return back to the RCP4.5 level after termination. But why the lifetime of CH₄ need a long time to back to RCP4.5 level? Could you please explain more? How the atmospheric dynamics, the UVB, OH (which are related to the CH₄ lifetime) changes after the termination?

Page 29:

-Line 6: please change to "we have described that an injection of 5-8 Tg of SO₂ per year would have effect on large scale. . ."

-Line 6-8: reorganize this sentence, maybe break into two sentences.

Page 30:

-Line 1 and Figure 18: "a decrease in tropospheric UV" will be misleading. Figure 14

C7

shows the reduction in only in tropics, and there is an increasing over mid-high latitude.
-Please discuss the uncertainty of this study, and what could be improved in future studies.

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C8