This paper presents a modeling study where an Earth System Model (CESM-CAM4) was used to examine the response of terrestrial photosynthesis in the context of climate intervention by geo-engineering. The author conducted 2 experiments. In a first experiment (G4SSA), stratospheric sulfate aerosols are injected to counteract global warming from anthropogenic activities assuming a RCP6.0 baseline scenario. An increase of up to +3.8 PgC/year in plant gross primary productivity during the geo-engineering period is reported for G4SSA. In the second experiment (G3S), the authors ran a simulation with reduced solar constant to counteract the global warming from anthropogenic activities assuming the RCP4.5 baseline scenario. In this later experiment, the plant gross primary productivity is virtually unmodified compared to the RCP4.5 control run. Despite using different baseline scenario references between the two experiments, the authors conclude that the increase in the land carbon sink in the G4SSA experiment could be attributed to the diffuse light fertilisation effect introduced by the stratospheric sulfate aerosols. Indeed, aerosols not only reduce the quantity of radiation reaching the surface, but also modify its quality, increasing the diffuse component that supposedly benefits plant growth despite the reduction of total radiation.

General comments:

Overall, this paper is well written and the subject is relevant for a publication in ACP. Moreover, this paper is trying to address one of the scientific question for which the GeoMIP experiments were specifically designed for - i.e. impact of geo-engineering on the carbon cycle - making the publication of this paper in the ACP - GeoMIP special issue even more appropriate. I appreciate that the paper was initially tailored to be a letter to be submitted to GRL which explains the short format. However, despite the authors making overall reasonable scientific points throughout the manuscript, the reader is left with the feeling that the results presented here may lack robustness due to a very short analysis and a discussion / conclusion that remains quite general. It would be better to further evaluate the contribution of the other impacts of geo-engineering on the C-cycle to put in context the diffuse light fertilisation effect identified in this study. I would support the publication of this paper after considering some of these comments.

Specific comments:

- Why not run G3S with RCP6.0 as a baseline scenario? This would partially help to disentangle the increase in GPP due to the cooling effect and the increase due to the diffuse fertilisation effect.
- It would be interesting to discuss in more details the individual contribution of the climatic variables (T, precip, Rad, CO2, …) that control the observed changes in photosynthesis (e.g. Beer et al., 2010 DOI: 10.1126/science.1184984)
- In Fig 3, could you indicate the area where changes are statistically significant?
- In atmospheric radiative transfer models, the optical properties of anisotropic scatterers such as aerosols are usually rescaled to provide a better estimate of the total fluxes which are ultimately used to calculate the atmospheric heating rates. This, however, introduces biases for the direct and diffuse components of radiation. Indeed, a fraction of the diffuse radiation that is scattered in the incident direction is then reallocated to the direct beam. In your study, have you considered recalculating the best estimate of surface diffuse radiation (i.e. total radiation with rescaling minus direct radiation without rescaling) to use in the land surface scheme. If so could you comment on the uncertainties that this could introduce ?
- As you correctly mentioned the absence of nitrogen limitation in your simulations means that the increase in photosynthesis for G4SSA is an upper limit estimate. I thought that CLM has a configuration with nitrogen limitation that doesn't require to run with the nitrogen scheme. Why not try also running with this to provide a lower estimate of the photosynthesis increase (if any) for G4SSA?

- This is a naive question but is this stratospheric SO2 injection great enough to lead to the formation of acid rain, which ultimately could affect plant physiology?
- As you mentioned, the reduction of surface temperature in a geo-engineered climate should reduce the heterotrophic transpiration therefore reducing a source of carbon for the atmosphere. Why not have look at this parameter in your simulation?
- You mentioned that the carbon cycle was not allowed to feedback in your simulation (concentration driven run with prescribed CO2). But does the vegetation be allowed to evolve and compete or this is fixed as well? Dynamic vegetation is important as this allows the land surface type to adjust to changes in climate rather than retaining potentially uncompetitive, poorly adapted plant species.

Technical corrections:

- **Page 25628, line(s) 4-5:** "*we conducted climate model simulations with the Community Earth System Model, with the Community Atmospheric Model …*". This should be reformulated to make it less confusing.
- **Page 25628, line(s) 14-16**: "*This beneficial impact of stratospheric sulfate geoengineering would need to be balanced by a large number of potential risks in any future decisions about implementation of geoengineering.*" Add "the" before "*implementation*". In my opinion, this sentence doesn't really add anything to the abstract and could be removed.
- **Page 25628, line(s) 18-19**: change "*to manipulate*" by "for manipulating"
- **Page 25628, line(s) 24-25**: change "*how this proposed …*" by "the way in which this proposed …"
- **Page 25628, line(s) 26**: replace "*such as*" by "including"
- **Page 25629, line(s) 6-7**: replace "have not been comprehensively studied yet" by "have not yet been comprehensively studied"
- **Page 25629, line(s) 12**: change "*rate, which was mainly due*" by "rate. This was mainly due"
- **Page 25629, line(s) 15**: change "*volcano eruptions*" by "volcanic eruptions"
- **Page 25629, line(s) 21**: change "*by the continents*" by "by terrestrial vegetation"
- **Page 25630, line(s) 2**: add comma before "together" and after "effect". Replace "*may*" by "would likely"
- **Page 25631, line(s) 9**: replace "*especially*" with "particularly"
- **Page 25631, line(s) 12-14**: "*The terrestrial total solar radiation (not shown) also has a slight increasing trend from 2004 to 2089, which is opposite with the global surface solar radiation trend"*. Note that in the land-surface community, the "global radiation" usually refers to the sum of diffuse and direct radiation at surface. You may want to reformulate this sentence in order to avoid ambiguity (e.g. replace terrestrial by averaged over land and global by averaged globally). Also, add "surface" after "terrestrial total" for consistency.
- **Page 25631, line(s) 14-15**: change "*There are two reasons: first*" into "There are two reasons for this, first". Replace semi column by coma at "*; and second,* ". Change "*increasing*" by "increase".
- **Page 25631, line(s) 16**: Change with "Averaged visible diffuse radiation (300–700 nm) over land"
- **Page 25631, line(s) 24**: change "*Therefore although the total*" for "*Therefore, while the* "
- **Page 25632, line(s) 2**: replace "*larger*" by "greater"
- **Page 25632, line(s) 2-3**: "*The photosynthesis rate increased 23 % in 1992 compared with an unperturbed year (1997) (Gu et al., 2003)*". Wasn't this result just for Harvard forest?
- **Page 25632, line(s) 14-15**: replace "*since*" by "because". I wouldn't say that the absorption of diffuse radiation is "more homogeneously". It is the distribution of radiation that is more

homogeneous within the canopy for diffused light conditions, hence, more light to be absorbed is available for shaded leaves. Remove the "*also*" in "*and also more efficiently*". Replace "*photosynthesis capacity*" with "photosynthetic capacity"

- **Page 25632, line(s) 18**: remove coma at the end of "*load exceeds a certain level,* "
- **Page 25632, line(s) 22**: replace "*which is the maximum ratio*" by "this is the max…"
- **Page 25632, line(s) 24**: replace "*indicating that*" with "therefore"
- **Page 25632, line(s) 29**: change for "… increase is limited by the amounts of soil nutrients such as …"
- **Page 25633, line(s) 4-5**: Rephrase this with something like: "Photosynthesis is most efficient at an optimal temperature that depends on plant type and CO_2 …"
- **Page 25633, line(s) 7**: "*there might be extreme*" replace "might be" to "is likely to be"
- **Page 25633, line(s) 16**: use "largely" or "primary" instead of "*mostly"*
- **Page 25633, line(s) 17**: "*photosynthesis rate is almost all over*" replace "all" with "entirely"
- **Page 25633, line(s) 23**: "will significantly help to bring more carbon" replace "*will* with "would"
- **Page 25634, line(s) 4**: "Since the two climate interventions", remove "since"
- **Page 25634, line(s) 5-6**: change for "have different assumptions and with different reference runs (RCP6.0 and RCP4.5) and have different …"
- **Page 25634, line(s) 7-9**: stop sentence here: "*concentrations, we cannot evaluate*". "concentrations. We cannot, therefore, evaluate". The rest of the sentence is awkwardly phrased, ("*exact fraction of the enhancement of diffuse radiation contribution to the increasing …*"), please correct that. Don't start next sentence with "*But*"! You can say: "When comparing the global averaged photosynthesis change (Fig 2) with the cooling effect, the diffuse …"
- **Page 25634, line(s) 12**: Delete "*briefly"*
- **Page 25634, line(s) 13**: remove coma after "*our simulations*"
- **Page 25634, line(s) 13-16**: This sentence is too long and quite messy. Reorder it and start with listing the assumptions (no Nutr. Lim., area, G4SSA …) and then write the result.
- **Page 25634, line(s) 18**: change "*estimated*" with "estimate"
- **Page 25634, line(s) 20**: change "*which were contributed by both diffuse*" for "this was the result of both …"
- **Page 25634, line(s) 22**: replace "*effective"* with significant
- **Page 25634, line(s) 22-23**: "Volcanic" instead of "*volcano"*
- **Page 25634, line(s) 22 to Page 25635, line(s) 2**: From "*This enhanced land carbon*
- ... " until the end of the Results section; As you don't do the simulations that allow the carbon cycle to feedback on the climate, I would recommend to move this paragraph to the discussion and develop it to make a stronger argument.
- **Page 25635, line(s) 4**: "*Although the calculation here*" too informal
- **Page 25635, line(s) 6**: "*geoengineering might trigger*". Change "*might"* to "would"
- **Page 25635, line(s) 12-13**: "*the cooling effect also suppresses soil respiration, which reduces carbon emissions as much as increasing of the carbon sink*". Do you mean that the cooling effect decreases the soil respiration to the same quantity as it increases the carbon sink or do you mean it does the two simultaneously?
- **Page 25635, line(s) 16-17**: "*Therefore, if we include the reduction of heterotrophic respiration due to the cooling effect*". Isn't soil respiration a diagnostic from CLM that you could look at in the G3S and its control simulations for instance?
- **Page 25635, line(s) 23 to Page 25636, line(s) 4**: "*The ocean covers most of Earth…*". Maybe you should remember the relative contribution of the ocean and the land in removing Carbon from the atmosphere to strengthen the significance of your study results.

- **Page 25636, line(s) 1**: correct "*The ocean model we used does simulate*" with "…we used simulates"
- **Page 25636, line(s) 5-8**: Reverse the construction of the sentence in order not to end on a negative note - i.e. start by commenting on the hesitation about geo-engineering and then terminate with the main result from your study.
- **Page 25636, line(s) 16**: change "*understanding*" to "understand"