Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-711-RC1, 2016

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Shortwave radiative forcing and feedback to the surface by sulphate geoengineering: Analysis of the Geoengineering Model Intercomparison Project G4 scenario" *by* Hiroki Kashimura et al.

Anonymous Referee #1

Received and published: 15 August 2016

Kashimura et al. determine the shortwave radiative forcing at the surface of stratospheric sulfur injection (SAI) and it's changes due to clouds. They use results of experiment G4 of the geoengineering model intercomparison project, constant injection of 2.5 Tg(S)/y, of six different models for the study. They apply a single-layer model of short-wave (SW) radiation to estimate the feedbacks caused by the reduced incoming SW radiation due to the scattering sulfate aerosol layer. This is a strong simplification but it allows to differentiate between different cloud feedbacks.

It is important to know the rate of SW reduction at the surface to estimate the impact

of geoengineering. The single-layer model provides information on the impact of SAI on clouds and the study highlights the differences between the models. A comparable study has not previously been performed. I recommend the publication of this work after considering the following remarks.

General:

Kashimura et al. concentrate on SW radiation. However, stratospheric sulfate aerosols absorb long-wave (LW) radiation, which heats the stratosphere. This reduces the efficiency of SAI. The injection rate, necessary to counterbalance a certain anthropogenic forcing, is determined by the top of atmosphere forcing imbalance, not by the SW radiation at the surface. Therefore, the LW absorption is important and the role of LW radiation needs to be discussed. The relevance for the presented results should be described in more detail.

A second aspect which is not or only shortly discussed is the meridional distribution of the aerosols. The two models coupled to an aerosol microphysics show most probably different distributions. This has a clear impact on the forcing (English et al.(2013), Niemeier and Timmreck (2015)). The importance of the particle size is not mentioned et all. Scattering of SW radiation decreases with increasing particle size (Pierce et al. (2010)). Is the particle radius similar in the models prescribing the AOD? Do the two aerosol models simulate similar AOD?

These aspects will not change the presented results but may provide some additional explanation of differences.

Introduction:

Line 16: Rasch (2008) and Robock (2008) do not use full aerosol microphysics. E.g. Rasch (2008) prescribe the aerosols. There are several more recent studies available: e.g. Heckendorn et al. (2009), Pierce et al (2010), English et al (2013), Niemeier and Timmreck (2015) all with full aerosol micro-physics. They may provide information of the LW impact.

Impact of LW radiations, particle size and meridional distribution might be discussed in the introduction.

Methods: Page 5 end of the page: *'effect on the absorption rate is negligible'.* The absorption in the near infrared should be discussed prior to this point.

Results: Line 6: *'for a few decades'* Please be a bit more specific.

Line 17: You discuss at the end the problem of comparing ensemble mean data to single model results. This came to my mind already here.

Page 8:
Line 10: *'except MIROC-ESM-CHEM-AMP'* Why?

Line 22: cooling and heating effect: You may better name it positive and negative forcing.

Line 26: How are the modes of the aerosol module set up? Do you use the same mode width as described in Sekiya (2016)? The injection strength under geoengineering conditions is smaller compared to a volcanic eruption. This may cause

Line 28/29: Why do they differ? Horizontal distribution, particle size?

Line 33: I would expect that the average over time of the AOD is similar between the ensemble members. You may explain this better if you show a zonal mean of the AOD for the two models and, in case they differ, the ensemble members.

Page 9:
1st sentence: *'varies from....'* between the models.

Page 10:
Line 3 and 4: You list many regional details. Can we trust the model in this detail?

Line 31: The difference in meridional distribution of the aerosols are an notable aspect. However, this is important in modeling because the model results differ. So the different

results show possible behavior of nature. Which of them represents nature best is another question.

Page 10/11:
Do the results agree with previous studies?

Discussion:

Page 11:
Line 18-20: You may add references.

Page 12:
Line 10 to 15: This is a serious concern. Would your results differ when you use one simulation of each model, e.g. always r1? You can test this to give a less broaden statement here.

Figure 7:
Line thickness differs in the zonal mean plot. Does this show ensemble mean and single results? Please note it somewhere.

You hatch regions were the models agree. Do you mean disagree? The hatching is so strong that it would make no sense to hatch the regions were the models agree.

What do you mean with *'The color tone shows the horizontal distribution'*?

References

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