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Interactive comment on "The impact of increases in South Asian anthropogenic emissions of SO_2 on sulfate loading in the upper troposphere and lower stratosphere during the monsoon season and the associated radiative impact" *by* Suvarna Fadnavis et al.

Anonymous Referee #1

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Review of the paper: "The impact of increases in South Asian anthropogenic emissions of SO2 on sulfate loading in the upper troposphere and lower stratosphere during the monsoon season and the associated radiative impact", by S. Fadnavis et al., Atmos. Chem. Phys. Discuss., acp-2019-81, 2019.

This study focuses on the impact that rapidly increasing anthropogenic emissions of SO2 in South Asia may have on the distribution of UTLS sulfate. This is an important

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topic and the manuscript deserves publication on ACP, after two major points (in my opinion) have been correctly addressed in the revised version.

Major points

1) The most important conclusions of the present study (changes in ATAL and related radiative forcing both at the surface and TOA, as well as feedback processes on UTLS dynamics and clouds) are based on the model calculated distribution of sulfate aerosols following the increasing anthropogenic SO2 emissions at the surface over South Asia. This distribution is not only determined by local convective uplift, but also by the lower stratospheric coupling of aerosol transport and microphysics. From this point of view, the quasi-biennal oscillation (QBO) plays a major role in determining the rate of large-scale isentropic transport from the tropics to the extratropics. A different SO2 and SO4 lifetime in the tropical reservoir may, in turn, affect the aerosol size distribution, thus modulating the sedimentation rate and the strat-trop exchange. Nothing is said in the manuscript on how the QBO is treated in the model simulations. Internally generated? External nudging? What is the different level of sulfate export from the tropical reservoir during E/W phase years? I think the authors should clarify and produce some evidence of the model predicted variability in the horizontal gradient of the sulfate loading between tropics and extratropics (maybe in the supplementary material). Some recent studies have focused on this topic, looking at model simulations for SO4 aerosols from sulfate geoengineering (e.g., Aquila et al., 2014; Visioni et al., 2018). It is true that in this latter case, as well as for aerosols from major tropical volcanic eruptions (e.g., Pinatubo; Trepte and Hitchman, 1992) the aerosols are located a few kilometrs above those convectively uplifted from the surface, but the QBO impact on the latitudinal transport of aerosols in the lower stratosphere should be significant, anyhow. The link between tropical UTLS sulfate (convectively uplifted from South Asia) and its poleward transport is mentioned in several places in the manuscript (lines 22-23, 77-79, 309-314, 321-325, 344-345, 398-399, 450-453) and is one of the key points in the discussion. For this reason, the QBO effects need to be addressed. 2) Proper

acknowledgment of previous works in the literature is needed. The authors cite the review paper of Kremser et al. (2016), but they should do the same for the SPARC assessment of stratospheric aerosol properties (ASAP, 2006), as well. Here, in the uncertainties section of Chapter 6, a detailed discussion is made on the potential impact of future trends of stratospheric sulfate aerosols due to increasing anthropogenic sulfur emission in South Asia. A citation to SPARC-ASAP would be appropriate, for example, at lines 76-77 and line 287.

Minor points

Both in the abstract (line 19) and in the conclusions (line 447) the authors write: "…experiments with SO2 emissions enhanced by 48% over South Asia…". For the reader, it is not clear (mainly in the abstract) with respect to what the emissions are enhanced by 48%. Later on in the text this is made clear (lines 210-213).

Line 66: "economy and agricolture" instead of "economy, agricolture".

Line 78 and 399: "poleward" is one word, not two.

A reference is missing at line 202: "AMIP (add reference) sea surface temperature…".

Line 340: is likely to be caused.

Lines 370-371: Ozone absorption of the increasing diffuse radiation by sulfate aerosols may also play a role.

At line 443 the Kuebbeler et al. (2012) citation is not appropriate for the cirrus cloud formation response to volcanic eruptions, but it should be moved at line 444 together with Visioni et al. (2018). On the other hand, the effects of non-explosive volcanic eruptions on UTLS aerosols and cirrus ice clouds were explored in Pitari et al. (2016).

References

Aquila et al.: Modifications of the quasi-biennial oscillation by a geoengineering perturbation of the stratospheric aerosol layer, Geophys. Res. Lett., 41, 1738–1744, 2014.

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Pitari et al.: Sulfate aerosols from non-explosive volcanoes: chemical-radiative effects in the troposphere and lower stratosphere, Atmosphere, 7, 85, doi:10.3390/atmos7070085, 2016.

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