

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2020-1255

Anonymous Referee #2

Referee comment on "Impact of regional Northern Hemisphere mid-latitude anthropogenic sulfur dioxide emissions on local and remote tropospheric oxidants" by Daniel M. Westervelt et al., Atmos. Chem. Phys. Discuss.,
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This study documents the impact of anthropogenic SO₂ emissions from China, Europe and the US, on tropospheric oxidants in the GFDL AM3 model. The authors test this by conducting individual simulations where the SO₂ emissions in each region are systematically switched off. They find SO₂ emissions and subsequent formation of sulphate aerosols lead to a decrease in OH and HO₂, increase in NO_x and a decrease in ozone. Changes in concentrations are focussed predominantly in the northern hemisphere. The chemical effect, via heterogeneous uptake of these species by aerosol particles dominates over the photolysis effect, whereby aerosols alter the photolysis rates of O₃ and NO₂. This is a pertinent and timely study given current strategies to improve air quality, particularly in Asia and ensuring all atmospheric chemistry aspects and pollutants impacting this are considered. It is a well-written piece of work and clearly laid out.

I therefore find it suitable for publication in ACP subject to some minor comments which should be addressed prior to publication.

Minor comments:

- Does the model include nitrate, and if so how does this impact sulfate formation and subsequent impact on oxidants?

- The changes in surface ozone (of the order of 3 ppb/year), this would equate to less than 10% or so of the surface ozone in the source regions studied here and is likely well within the model standard deviation. Can the authors comment on the role of the model uncertainty/variability on the significance of these results and potential implications for AQ. Indeed, in L199/200 the authors refer to clean air technologies driving up O₃ by "a

few ppb" in summertime. A comment on the relative significance of these changes for local air quality should be provided.

- L147: how much of the reduction in OH is attributed to the heterogenous uptake of sulphate by HO₂ versus increase sink via oxidation of SO₂+OH? Can the authors separate out these contributions to OH loss. The analysis presented focus on the radiative effect (via changes in photolysis) and the chemical effect (heterogeneous uptake) but what about the additional aerosol oxidation chemistry that is also taking place and how that impacts the oxidant concentrations?

Technical comments:

L21: The sentence "Regional SO₂ emissions increasing the NO_x lifetime as the heterogeneous sink on sulfate aerosol declines" is confusing as the sink on sulfate of OH, NO₃ and N₂O₅ are increased which leads to the reduction in NO_x sinks. Please rephrase.

L132: for the presence of --> due to the presence of

L134: The zeroing of 2015 emissions --> the zeroing of 2015 **SO₂** emissions

L138/9: from a zeroing of China SO₂ --> the increase in sulphate clearly doesn't come for the zeroing of the emissions, suggest the statement is rephrased.