Comment on acp-2022-274

**Anonymous Referee #3**
**Referee comment on "Enhanced sulfur in the UTLS in spring 2020" by Laura Tomsche et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-274-RC1, 2022**

**1) comments from referee**

This manuscript provides an overview of the BLUESKY mission during the 2020 COVID-19 lockdown in Europe. The authors present interesting measurement results of $SO_2$ and $SO_4^{2-}$, along with other trace gases and aerosols, at UTLS, which have the potential to be an important reference to future chemistry and modeling development. The authors have revised the manuscript with more discussions based on the comments from previous reviewers.

In addition to the comments from previous reviewers, I'm particularly interested in how wildfires contribute to $SO_2$/$SO_4^{2-}$ profile changes. Although the authors cited previous studies that demonstrated smaller amount of $SO_2$ released from wildfires compared to that from volcanic eruptions, this wouldn't necessarily represent the BLUESKY case since the meteorological conditions may be different between 2019 and 2020. Based on the 2020 EU JRC wildfire report (https://ec.europa.eu/commission/presscorner/detail/en/ip_21_5627), there were still significant wildfire events in Europe, especially in Germany, during May 2020. If those wildfires were intense enough, $SO_2$ and $SO_4^{2-}$ at UTLS could be influenced. The authors should provide sufficient evidence to convince readers how these "local" wildfires, in addition to long-range transport $SO_2$ from other continents, didn't contribute significantly to the $SO_2$ and $SO_4^{2-}$ profile changes during the BLUESKY mission. Additional discussion about wildfires can help improve the manuscript.

1a) **author's response**

We thank the reviewer for the comments. We revised the manuscript and added details on wildfires and how they contribute or not to the mixing ratios of SO2 and SO42- in the UTLS. In particular, we discussed that "local", i.e. European, fires had probably very low impacts on the May/June 2020 UTLS. Explanations are in section 4 and 5 for SO2 and SO2-, respectively.

1b) **manuscript changes**

L312-316: "In contrast, the trajectories do not indicate local transport from the central European PBL to the UT, hence the transport of $SO_2$ from wildfires in Germany in May 2020 (European Commission, 2021) to the UT seems negligible. Even if the transport of the smoke was via self-lofting (Ohneiser et al., 2021), i.e. absorption of sunlight leads to warming of the ambient air and thus lifting of the smoke, the transport is slow and so $SO_2$ might already been transformed to $SO_4^{2-}$ before reaching the UTLS and does not contribute to the elevated $SO_2$ in the UT. Moreover, …"

L388-393: "Ohneiser et al. (2021) discussed self-lofting as a potential transport pathway in the UTLS for these Siberian fires in the absence of strong vertical motion in July 2019. The smoke plume could raise and reach the UT and further ascent into the LS. During the slow ascent, the emissions alter chemically, in the case of $SO_2$, it is transformed to $SO_4^{2-}$. Finally, the $SO_4^{2-}$ could have contributed to the enhanced $SO_4^{2-}$ in the LS. Further, wildfires in central Europe in May 2020 (European Commission, 2021) could also have undergone this self-lofting process as the trajectories do not indicate uplift over Europe and thus might additionally have contributed to elevated $SO_4^{2-}$ in the UTLS."

**Minor comments:**

**2) comments from referee**

Ln 22, 124, 125, 128, 353, 358, 359. Keep the number expression consistent. A thin space is suggested before and after the plus-minus sign.

2a) **author's response**

-> done L22, L12, L125, L127, L359, L364, L365

**3) comments from referee**

Ln 55. "(46°N, 0.8 Tg $SO_2$)" is suggested.

3a) **author's response**

-> done L56

**4) comments from referee**

Ln 59. Typo: "important source of stratospheric aerosol are intense wildfires, ..." should be "is" instead of "are."

4a) **author's response**

-> done L59

**5) comments from referee**

Fig. 1 The bottom axis at 0 longitude seems to have an additional character embedded.

5a) **author's response**

-> updated Figure 1

**6) comments from referee**

Ln 64. You may want to spell out COVID at its first appearance in the text. Also, be consistent with using COVID-19 or COVID19 in the manuscript.

6a) **author's response**

-> done L63 and used COVID-19 (L280, L283)

**7) comments from referee**

Ln 128. Lower case of N for “nitrous.”

7a) **author's response**

-> done L128

**8) comments from referee**

Ln 132. This sentence should be combined with the previous sentence.

8a) **author's response**

-> done L130

**9) comments from referee**

Ln 137. A proper citation/reference to the GDAS dataset is mandatory.

9a) **author's response**

-> done L137

**10) comments from referee**

Ln 159. May replace “will follow” with “is presented.”

10a) **author's response**

-> done L160

**11) comments from referee**

Fig.2 caption. “… Plotted are a) $SO_2$, …, and f) altitude across longitudes ##°W–##°E.”

11a) **author's response**

-> done L164/165

**12) comments from referee**

Fig. 3 caption. Superscripts for $25^{th}$ and $75^{th}$, be consistent with how they are used in the main text.

12a) **author's response**

-> done L199

**13) comments from referee**

Ln 205. “… 310 K and 340 K; above the chemical tropopause the sum increases up to …”

13a) **author's response**

-> done L207

**14) comments from referee**

Ln 395. Typo: “were” instead of “where.”

14a) **author's response**

-> done L386