

Atmos. Chem. Phys. Discuss., author comment AC2  
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## Reply on RC1

Youwen Sun et al.

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Author comment on "The drivers and health risks of unexpected surface ozone enhancements over the Sichuan Basin, China, in 2020" by Youwen Sun et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-664-AC2>, 2021

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### Response to Referee #1:

Thanks very much for your comments, suggestions and recommendation with respect to improve this paper. The response to all your comments are listed below.

The authors use high resolution nested-grid GEOS-Chem simulation, the eXtreme Gradient Boosting (XGBoost) machine learning method and the exposure–response relationship to determine the drivers and evaluate the health risks of the surface O<sub>3</sub> enhancements over the Sichuan basin (SCB) in May-June 2020, which are in contrast to an overall reduction in surface O<sub>3</sub> level across China. The authors first use the XGBoost machine learning method to correct the GEOS-Chem model-to-measurement O<sub>3</sub> discrepancy over the SCB, where large discrepancies between measured and modelled surface O<sub>3</sub> are found due to the complex terrain. The relative contributions of meteorology and anthropogenic emissions changes to the unexpected surface O<sub>3</sub> enhancements are then quantified with the combination of GEOS-Chem and XGBoost models. In order to assess the health risks caused by the unexpected O<sub>3</sub> enhancements over the SCB, total premature death mortalities are estimated.

The paper concluded that the unexpected changes in meteorology combined with the complex basin effect enhance downward transport of O<sub>3</sub> from upper troposphere, enhance biogenic emissions of volatile organic compounds (VOCs) and nitrogen oxides (NO<sub>x</sub>), speed up O<sub>3</sub> chemical production, and inhibit the ventilation of O<sub>3</sub> and its precursors, and therefore account for the surface O<sub>3</sub> enhancements over the SCB in May-June 2020. The total premature mortality due to the unexpected surface O<sub>3</sub> enhancements over the SCB has increased by 89.8% in May-June 2020 vs. 2019.

With a thoroughly review of this study, I would like to classify it as a very interesting and creative study. It is well written, structured, and its topic fits well in the scope of ACP. I believe that the results of this study could be of interest to the general atmospheric science community and should be in the literature. I recommend for publication after minor revisions.

**Response:** All your comments listed below have been addressed. Please check the point by point response as follows.

### General comments:

**Comment [1-1]:** The authors use the XGBoost machine learning method to correct the GEOS-Chem model-to-measurement O<sub>3</sub> discrepancy over the SCB and then use the discrepancy corrected model to quantify the relative contributions of meteorology and anthropogenic emissions changes to the unexpected surface O<sub>3</sub> enhancements. This is a nice concept and I like it. However, this method used in present work can only separate the total meteorology or anthropogenic driven influences. For each individual meteorological or anthropogenic influence, the analysis is qualitative. As a result, I would suggest the authors to consolidate the analysis for the influence of each individual meteorological or anthropogenic factor. For example, as the community comments from Dr. Heini Wernli mentioned, the differences are on the order of 0.1 PVU (1 potential vorticity unit = 10<sup>-6</sup> K m<sup>-2</sup> kg<sup>-1</sup> s<sup>-1</sup>) for PV, which is very small, how the authors conclude from Fig. 6a that “the meteorology-induced surface ozone increase is mainly attributed to significant increases in temperature and downward potential vorticity” (p. 14 line 4). In addition, there are still some grammatical errors need to be corrected. I list part of them as bellow. I hope one of the authors with good command of English can go through the manuscript in detail or the ACP copy-editing service at the publication stage can help to correct all the glitches.

**Response:** In the revised version, we have double checked the analysis for the influence of each individual meteorological and anthropogenic factor. We have followed the suggestions of prof. Heini Wernli and removed the analysis for the potential vorticity. As a result, all concerns arise from the PV discussions are gone. Since we only performed very few analysis for the PV in the study, all revisions are minor. Instead, we have compared and analyzed the difference in vertical transport velocity at the PBLH between 2020 and 2019. We concluded that there is no strong evidence for the change in the horizontal transport from other regions (Figure 1(b) in supplement of this response letter) and the vertical transport from the free troposphere to the surface (Figure 2(a) in supplement of this response letter) over the SCB in May-June 2020 vs. 2019. In addition, we have corrected all grammatical errors listed below and one of the authors with good command of English have gone through the manuscript in detail to address the rest errors. Please check the marked up file for details.

#### **Detailed comments:**

**Comment [1-2]:** Page 2, line 23, “Depending which ...” should be “Depending on which ...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-3]:** Page 3, line 15, “be applicable ...” should be “be applied...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-4]:** Page 3, line 19, “model mechanism...” should be “model mechanisms...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-5]:** Page 3, line 19, “discrepancy...” should be “a discrepancy...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-6]:** Page 3, line 38, “fourth largest...” should be “fourth-largest...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-7]:** Page 4, line 4, “highly industrialized region...” should be “highly

industrialized regions...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-8]:** Page 4, line 16, “After removing unreliable measurements with the filter criteria used in Lu et al. (2020)”. Please add the data filter criteria to the supplement.

**Response:** We have included the data filter criteria in the revised version (see section S1 in supplement of this response letter). Please check the marked up file for details.

**Comment [1-9]:** Page 4, line 41, “3-hour interval...” should be “3-hour intervals...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-10]:** Page 5, equation (1) should be divided into equations (1), (2), (3).

**Response:** Done. Please check the marked up file for details.

**Comment [1-11]:** Page 6, line 14, “a10-fold” should be “a 10-fold”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-12]:** Page 6 equations (4) and (5), the definitions of XG\_Emis and XG\_Met are missing.

**Response:** We have included the statement “where the acronyms are similar to those in equations (1) and (2) but for GEOS-Chem-XGBoost method” in the revised version. Please check the marked up file for details.

**Comment [1-13]:** Page 8, line 32, “relative poorer...” should be “relatively poorer...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-14]:** Page 9, line 1, “each individual model...” should delete “individual”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-15]:** Page 9, line 1, “which offer...” should be “which offers”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-16]:** Page 10, line 19, “slightly with...” should be “slightly from...”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-17]:** Page 12, line 38, “Table S4 and S5” should be “Tables S4 and S5”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-18]:** Page 13, line 20, “largest populations” should be “the largest populations”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-19]:** Page 14, line 13, “in May-June 2020” should be “during May-June in 2020”.

**Response:** Done. Please check the marked up file for details.

**Comment [1-20]:** Figures 1, 6, 7 should add the corresponding latitude and longitude.

**Response:** We have included latitude and longitude information in Figures 1, 6, and 7 .  
Please check the marked up file for details.