# Review of egusphere-2023-1452 "The impact of El Niño–Southern Oscillation on the total column ozone over the Tibetan Plateau" by Yang Li et al.

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## General comments

The manuscript of "The impact of El Niño–Southern Oscillation on the total column ozone over the Tibetan Plateau" by Yang Li et al. focuses on the effect of the ENSO on total column ozone (TCO) above the Tibetan Plateau (TP). Through analysis of the aggregated long-term satellite data C3S, the chemical transport model TOMCAT, and the water vapor and ozone dataset SWOOSH, the authors present statistical significant relations of positive TCO anomalies above the TP during El Niño and vice versa for La Niña events. These anomalies are robustly found in all presented datasets.

This study is definitely relevant and suits the scope of ACP well and is a welcome addition for the atmospheric community. The manuscript itself is mostly well written and understandable. However, there are parts, that are less well described and early conclusions that cannot be followed in the current state of the article. Hence, a **major revision** of this article are needed before a recommendation for publishing can be made.

In particular, the authors only look at correlations of different parameters and jump to the conclusion of a causation. The whole mechanism of the TCO increase described in the conclusion is not well supported by the findings of the study and could be argued for in different order as well. The ENSO is leading the TCO anomaly but it is not clear if the cooling of the troposphere or the lowered geopotential height of the 150 hPa level is the next step in the mechanism. Since only the correlations are shown, this conclusion cannot be drawn.

Furthermore, the increase of the TCO is argued by the reduction in tropospheric height and a subsequent "change in the relative amounts of ozone–poor tropospheric and ozone–rich stratospheric air in the profile". While this is true for the relative amounts of air, it is not necessarily for the TCO. The TCO can only increase if there is an influx of stratospheric, ozone-rich air from other regions. This is not talked about although it is the center point of this study.

In general, the authors should either rephrase their claims or increase their evidence for the presented mechanism. In the current state, the stated causation is not evident.

Following are specific and technical comments with citations from the manuscript given in italics.

## Specific comments

- l 57 ff: There is no mention abut the atmospheric part of the ENSO, i.e., the SO part. Add a sentence describing this as well.
- l 99: how many vertical levels does your data span between 1000 and 0.01 hPa?
- l 122:*which is calculated according to cross correlation function (Chatfield, 1982)*: probably an article missing (a or the?), but the cross correlation function should be described by a bit more detail. Or the sentence should be rephrased for better understandability.
- l 224: *±1.2% percentage change (i.e., anomaly divided by climate mean) of TP TCO* You stated that your dataset has an accuracy of about 2%, which would render this change to be within the expected error if found in an individual case. Please comment on the this discrepancy within the text. Since you use composite events, the errors are canceling to some extent. Do you have a feeling to what extent?
- l 225 ff: *To further clarify the influence of ENSO on TP TCO, we use regression method to remove the ENSO signal from TP TCO and then perform composite TCO during El Niño and La Niña years. Without considering the ENSO signal on the TP TCO, both C3S data and TOMCAT simulation show that there is no significant TCO anomalies over the whole TP during El Niño and La Niña years (not shown).* As it is, this section gives no new information since it basically reads as: if we remove the linear relation,

we find no longer a linear relation. Please describe how you removed the ENSO signal. This should be a physically justified approach for the separation. If it is actually a regression separation, remove this part.

- Fig. 3: There is a shaded region mentioned for the stat. significance, but not shown. Change this to state something like: 'There is no region, where the anomaly is statistically significant beyond the 90% confidence level.' in the caption.
- l 243 ff: although the altitudes of 100–50 hPa agree with your vertical shift hypothesis, the Ozone profiles between 200–100 hPa show a different slope for El Niño and La Niña. This might not only be related to a vertical shift but a compression/stretching of the profile for Niño and La Niña, respectively?
- l 270 ff: *Therefore, a decrease of tropopause height (TH) will tend to replace ozone–poor tropospheric air by ozone–rich stratospheric air in the UTLS region ...* This would only be true, if there is horizontal flow of from surrounding areas towards the TP. In other words, a constant Stratopause would be expected and/or an opposite TCO anomaly adjacent to the TP. The Ozone has to come from somewhere. Please add on this question for a more detailed description of this process. As it is right now, your point is not self-sufficient.
- l 331 f: *That is, the tropospheric temperature will warm (cool) when the rising (falling) GH150 causes the increased (decreased) air column thickness.* This sounds too much like a cause and consequence where only correlation is seen. Please rephrase this sentence accordingly.
- l 339 f: *According to equation (3), this implies that the El Niño (La Niña) events favour the decreased (increased) air thickness and thus contributes to the cooling (warming) tropospheric mean temperature (Figures 8).* 'Contributes' is more than you can claim here, I would say it is 'associated with' since you only found the correlation.
- l 351 f: *... there is a strong negative correlation (–0.56) between Niño 3.4 and temperature associated with air thickness.* While it is very convincing that the air thickness is related to whether there is a El Niño or La Niña, the correlation to Niño 3.4 is not as convincing. Did you have a look at other indices and their correlation to the air thickness? And what about the non-ENSO events in the same periods, do they fall close to the center point in this diagram, or are they scattered on the vertical axis? Please comment on this in the text.
- l 378 f: *...with and without ENSO signal...* should be '...with and without QBO signal...' if I'm not mistaken.
- l 393 ff: *Thirdly, such a TH decrease tends to cause a change in the relative amounts of ozone–poor tropospheric and ozone–rich stratospheric air in the profile, which increases the partial column ozone in the UTLS...* See above. The partial column ozone will change for a fixed pressure interval, but for the TCO, there needs to be an influx (or source) of Ozone adjacent to the column. The process described here is not clear. The main question I'm left with is: where is the additional Ozone in the TCO stemming from?

## Technical comments

- l 67: since the satellite era → during the satellite era
- l 104: of area averaged of SST anomalies (SSTA) → of area averaged SST anomalies (SSTA)
- l 104 f: consider adding a reference to the website here
- l 106 f: *As the SWOOSH spans from 1984 to the present, its anomalies are with respect to the period 1984–2021.* consider rephrasing this for better understanding
- l 131 f: *In view of the fact that the relationship between the positive and negative ENSO phases may not be linear (An and Jin 2004), we consider El Niño and La Niña events should be analyzed separately.* remove 'should be analyzed' or 'we consider'
- l 187: presentation → representation
- sec 3.1: use *lead-lagged* (or *lagged-lead* if you prefer this) consistently in your text and captions
- l 247: remove *Such*
- l 250: remove *, whose results are consistent with Figures 5a and 5d.* Since its only a zoom it is not only consistent but identical. No need to clarify after stating it's a zoom.