

## ***Interactive comment on “Stratospheric impact on the Northern Hemisphere winter and spring ozone interannual variability in the troposphere” by Junhua Liu et al.***

### **Anonymous Referee #1**

Received and published: 16 November 2019

Overview: This paper uses modeled and observed ozone to examine the interannual variation of the impact of stratospheric ozone on tropospheric concentrations and is restricted to mid to high latitudes in the NH during winter and spring. The authors conclude that the model well reproduces the interannual variations in tropospheric ozone, except over North America following the eruption of Mt. Pinatubo. They infer that the STE was too strong over NA after the Pinatubo eruption. The paper will be suitable for publication, but I recommend revision prior to acceptance, after the authors have considered the questions noted below.

Question 1: The authors state that the stronger and deeper stratospheric contributions

C1

in the tropospheric O<sub>3</sub> variability shown by the model is related to the ozonesondes being closer to the polar vortex in winter over NA than over Europe. This doesn't make sense to me. Does it mean that you're effectively comparing apples and oranges, in that you're looking at different meteorological regimes when looking at your NA data vs your European data? The text makes it sound like the ozonesondes are somehow controlling what the model does.

Question 2: The Orbe 2017 paper referenced talks about multiple version of a replay simulation, and discusses various deficiencies in the large-scale transport depending on how the simulation was done. Which one of the runs discussed in the Orbe paper is this study using? Or, because it seems this is a higher horizontal resolution run than discussed in Orbe et al, 2017, is it something completely different? My concern is that the Orbe paper talks about potential issues (i.e., regarding age of air in particular) regarding the replay simulations, so have you picked a version of the model that would best represent overall transport?

Question 3, discussion of figure 4 tropospheric comparison. The authors states that the phase is in agreement but the magnitude is underestimated by the model for the observed anomalies. (and, do you calculate the anomalies from the individual stations and then average, or from the averaged ensemble of 17 stations? This should be stated before the figure is presented.) I think really you mean sign is in agreement rather than phase. I also don't see that in general that the absolute value is underestimated by the model. At 700 mb, the model and obs don't agree on the sign for the period from 2012-2015. At 400 mb, they don't agree on the sign for 1990-end of 1991. At 400 mb, there is an underestimate sometimes, and an overestimate from 1997-2001. I also don't understand the statement that both obs and simulations show the largest interannual variations in winter and spring. Am I supposed to be able to discern that from Figure 4? Perhaps that statement shouldn't be made until you've presented figure 5. And, in the caption of figure 4, please say what the red and black numbers are supposed to mean.

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Question 4, discussion of figure 5. The authors state that, for 200 mb, the IAV is larger over NA than Europe, and larger in spring than winter. These appear to be qualitative statements. Do you have a way to calculate a value for IAV (i.e., perhaps the standard deviation of your anomalies)? It would then be possible to apply some sort of statistical test to assess whether there really is a regional or seasonal difference.

Question 5, The author's state that the correlation between polar winter 150 mb temps and 200 mb ozone anomalies being lower in spring is "consistent with our understanding of the impact of temperature variations on the formation of polar stratospheric clouds and polar vortex isolation with reduced transport of o3 from the tropics at low temperatures....". I personally don't follow this at all. Are you trying to explain why there is a correlation, or why the correlation is different between winter and spring?

Question 6, I think you need a quantifiable definition of what you mean by IAV in order to compare where it is larger or smaller in different seasons or in different regions. The paper is written as though IAV is the same as the deviation (anomaly) from the seasonal mean. One then has to determine the interannual variations from looking at wiggles in anomaly plots.

Question 7: Discussion of Table 3, Please explain how, from looking at the correlation coefficients in Table 3, that one concludes that 27% of the NA interannual variation is related to 200 mb changes in winter.

Question 8: Discussion of Figure 6, Mt Pinatubo erupted in June 1991. Your 700 mb DJF NA plot shows a large difference between the red, black and green lines for 1990. What are you defining as the "Pinatubo period" and do you keep 1990 in your re-calculations of strato3-o3 correlation when you say you omit the Pinatubo period?

Question 9: around line 260-265 it states that anomalies in strato3 diverge from simulated o3 near the end of the period, and looking at figure 5, that seems to be around 2012. Do precursors really become significantly important only in the past decade?

C3

Question 10: If you separate the analysis more finely than simply Europe vs NA, and compared comparable latitudes, do you come to the same conclusions? How different are Madrid and Wallops? Your NA comparison includes more high latitude stations than your European one does. Is it longitude you're finding differences between, or latitude?

Question 11: On line 306, replace "changes" with "relationship" Your plot shows snapshots of winter and spring 1993, not differences (or changes).

Question 12: Final paragraph, the implication here is that the underlying meteorology was deficient over NA in the early period, but perhaps not over Europe. What would be the reason for that? And, can you look at any other fields in the model/sonde comparisons to assess whether this is the issue (maybe tropopause pressure, or the temperature from the radiosonde that flew with the ozone sonde?

specific comment: please change "amplitude" on line 194 to "magnitude".

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