Comments on the manuscript" Influence of Atmospheric Circulation on the Interannual Variability of Transport from Global and Regional Emissions into the Arctic" by Zheng et al.

The manuscript is well written. It reports the influence of global and regional emissions on the Arctic. It is suitable for the Journal and can be published. I suggest minor changes before publication.

Thanks for your comments!

In the introduction section, the references used are old. Recent references should be mentioned. There are several papers on trajectory analysis of atmospheric transport to the Arctic. The results from these studies are also interesting.

We will add a few sentences (see below) in the introduction to discuss the utility of back trajectory analysis in understanding the transport into the Arctic.

"The observed concentration of trace gases and aerosols is influenced by emission, transport and removal processes. One way to disentangle their respective roles, specifically to isolate the role of long-range atmospheric transport, is the back-trajectory analysis which is often carried out with reanalysis or model meteorological fields to identify source regions of trace gases or aerosols in the Arctic. Such back-trajectory analysis has been applied to understand how variability in emissions and transport modulates Arctic aerosol and trace gases (e.g., Huang et al., 2010; Hirdman et al., 2010; Schmeisser et al., 2018; Leaitch et al., 2018), chemistry processes along the transport into the Arctic (e.g., Matsui et al., 2011; Gilardoni et al., 2023), as well as comparing with aircraft measurements (e.g., Willis et al., 2019; Schulz et al., 2019)."

The results presented in the study are based on WACCM6 model simulations. There may be biases in model transport processes that vary with the model. It will affect the atmospheric circulation. You may mention it.

We will revise the sentence regarding the caveats of model simulations as "The detailed structures of the teleconnection patterns influencing the transport into the Arctic may be model dependent and could differ from observations due to model biases." This will emphasize the possible biases in the model.

A schematic depicting overall results is needed since the result section is descriptive and quantitative.

Thanks for the suggestion! A schematic is quite helpful to visualize our results. The schematic figure below summarizing how circulation anomalies modulate the transport from different emission regions will be added to the revised manuscript.

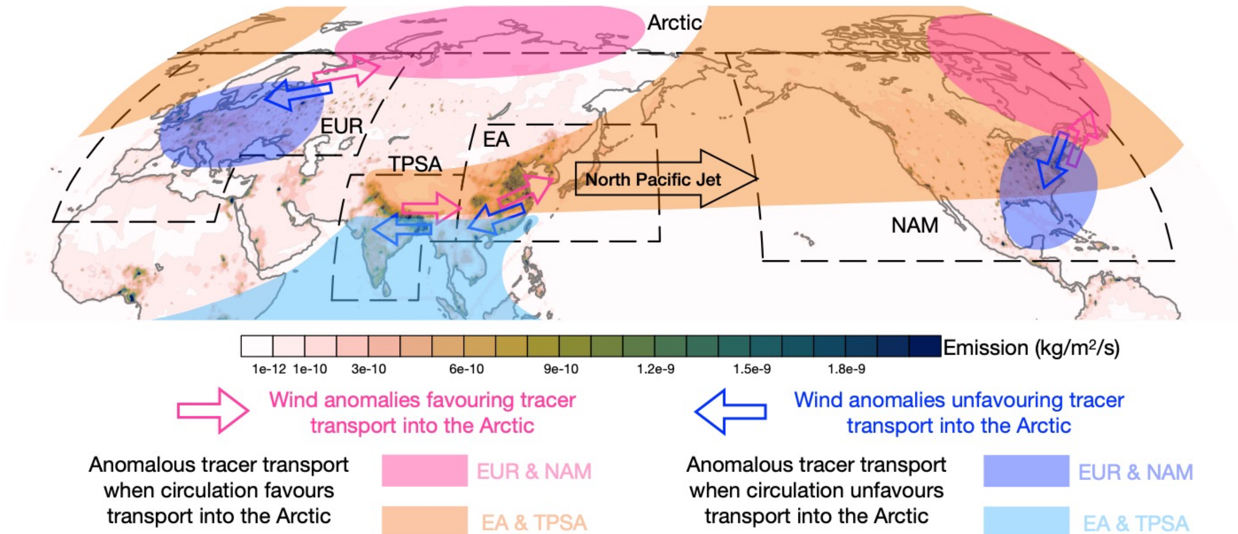

Figure R1: Schematic figure summarizing the atmospheric circulation anomalies that modulate the tracer transport into the Arctic from major emission regions. The shading in the background layer shows surface emission (kg/m^2/s) similar to Figure 1 (values smaller than 1e-12 are not shown). The solid black lines depict the boundary of the major emission regions, including EA, TPSA, EUR and NAM. The dashed black lines represent the boundary of the Arctic region (70°N). The magenta and blue arrows show the wind anomalies favouring and unfavouring tracer transport into the Arctic for different emission regions, respectively. The magenta and orange shadings show the anomalous tracer transport (positive anomaly of column tracer mass) associated with circulation favouring tracer transport into the Arctic. Similarly, the blue and cyan shadings represent the anomalous tracer transport associated with circulation unfavouring tracer transport into the Arctic. The transport anomalies are summarized from the results for winter in Figure 7.

Conclusion section is lengthy. Concise bullets points of the important results should be given.

Following the reviewer's suggestion, we summarized the findings from the EOF analysis into 4 major points (see below), which will be included in the revised manuscript.

- For regional emitted tracers in both summer and winter as well as the global emitted tracer in winter, the first EOF of each tracer not only captures the most important mode of spatial variations in the Arctic but also explains almost all the interannual variability in Arctic tracer mass associated with that particular tracer.

- The spatial patterns of the first EOFs for different regional tracers exhibit significant similarity, with a poleward versus equatorward shift of the tracer distribution. The transitions of these shifts in distribution are consistently located over the regional emission regions, meaning that the circulation (horizontal wind) over the emission regions drives almost all the interannual variability of Arctic tracer mass for a regionally emitted tracer. This is further confirmed by the associated atmospheric circulation patterns as poleward and eastward wind over the emission region favours transport into the Arctic. Fig. 13 shows a schematic diagram summarizing the circulation anomalies and the associated tracer column mass anomalies that favour or unfavour the transport into the Arctic.

- The EA and TPSA tracers make the largest contributions to winter GLB EOF1. The EUR and NAM tracers, despite their large contribution in climatology, make smaller contributions. The atmospheric circulation associated with winter GLB EOF1 corresponds to an equatorward shift of the midlatitude jet when a higher amount of GLB tracer is transported into the Arctic. This is consistent with the findings in Yang et al., (2019) and Yang et al., (2020). This shift of the jet is likely driven by the SST anomalies in the tropics and subtropics.

- Large scale teleconnection patterns, such as the AO and the Eurasian pattern, corresponding to GLB EOF2 and EOF3 in winter, spatially redistribute tracer mass in the Arctic and modulate the transport of different regional tracers into the Arctic, as different regional tracers sometimes compensate for each other in their contribution to Arctic tracer mass from year to year. The NAO drives the variability of the EUR tracer transport in both winter and summer, which is consistent with previous studies.