

**Review of the manuscript entitled “Stretched polar vortex increases mid-latitude climate variability during the Last Glacial Maximum” by Zhang et al.**

**Summary:**

The observation data and numerical modelling have suggested that the Arctic stratospheric polar vortex (SPV) is playing role in inter-seasonal variability and predictability of the winter climate over Eurasia and North America. By analysing PV changes in the PMIP paleo-simulations, the author explored the PV changes and its influences on climate variability during the glacial climate. The results show that under LGM conditions, the PV stretched toward the Laurentide ice sheet increased the possibility of cold air outbreaks into mid-latitudes. This finding provides an explanation to the observed extreme winter cooling and long-stand inter-model spreads. The paper is well-written. I recommended to published it with the following minor revision.

**Comments:**

Line 10: The abbreviation of polar vortex PV could be confused with PV of potential vorticity, suggested change to SPV.

[Done](#)

Line 18: should be “was beyond...”

[Done](#)

Line 86: Table 1 was not included. Should be Table S1?

[Yes, it is supposed to be Table S1, which has been fixed.](#)

Line 102: Present AWI-ESM resolution in the form of grid numbers, like for the other models.

[done](#)

Lines 122-132: add unit of gpm to VSI? like -1000 gpm and 70 gpm

[done](#)

Line140: Further specify that ERA5 is shown in black line. For instance, “This overall pattern fits the ERA5 re-analysis data, as shown by the similar shape of 250 gpm contour (black line in Fig. 1).

[Thanks for this comment on improving the clarity. We have included this in the revised version.](#)

Line 172-174: “...previous climate models results found that the stratospheric polar vortex itself can be either colder or stronger with increasing GHG depends on the strengthen amplitude of the troposphere originated planetary waves (Baldwin et al., 2003). The expression is not very clear, please clarify.

We mean that the wave activity flux plays a key role in determining the SPV strength. In this revised version, we decided to stay away from GHG increase case discussion as that can be a quite complicated issue. So this sentence has been replaced by “Previous studies have demonstrated that wave activity flux is the key to determine strength of troposphere-stratosphere interaction (Baldwin et al., 2003; Jones and Cohen, 2011; Polvani and Waugh, 2004).”

Line 211: “warm-cold-warm-cold pattern” sound weird, do you mean dipole between mid- and high latitudes?

yes, that is exactly what we mean. We have rephrased the sentence by following this comment.

Figure 3: add confident level to the figure.

Done for the figure 3.