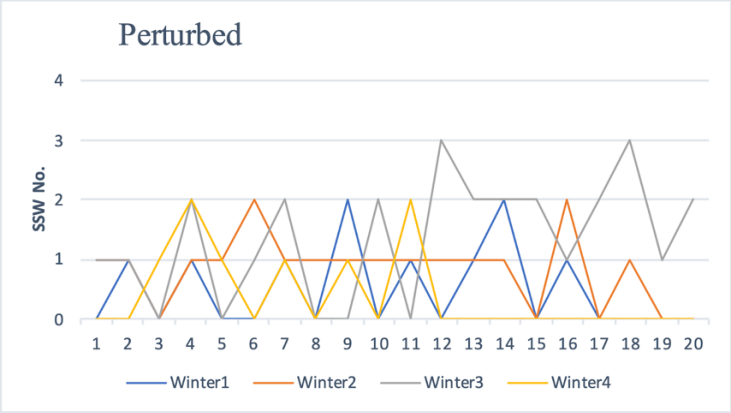
Response by authors

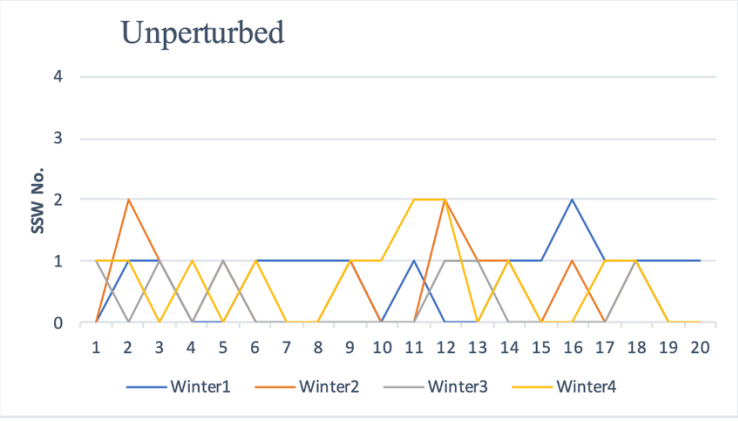
We thank Reviewer #2 for their appreciation of our study and for their helpful comments on the discussion paper. We are convinced that a revision of our manuscript that addresses the Reviewer's criticism on methodological and presentation aspects of our study is feasible. Specifically, we plan to revise the manuscript as outlined in the following.

Concerning the Reviewer's skepticism about the substantial increase in SSWs in the third post-eruption winter, in the revised manuscript we will support our analysis with an additional figure that illustrates the number of SSW events in individual realizations and an improvement of original Figure 3 showing a time series of the stratospheric wind for individual realizations. The figure shown below (Figure 1R) provides a glimpse on the distribution of SSW events in individual realizations (x-axis) and for the first four post-eruption winters (DJF1-4), for the cpl and control experiments. The figure shows that whereas the fraction of cpl realizations with at least one SSW event in winter 3 is the same as in winter 2 (70%), the fraction of cpl realizations with more than one SSW event in winter 3 (50%, so half of the realizations) is unmatched in other winters, both in cpl and control experiments. In the revised manuscript we will support this comparative analysis with statistical tests (ranksum).

a)



b)



c)

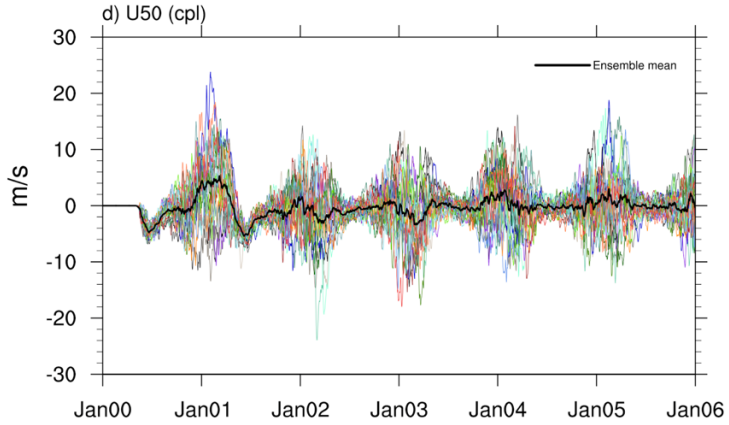


Figure 1R: *a)* The number of SSW occurrences (y axis) during the first 4 post-volcanic winters (x axis) for each of the ensemble members of the cpl experiment. The fraction of ensemble members having more than 1 SSW per winter increases to 50% (10 ensemble members) in winter 3 compared to only 10% (2 ensemble members) for winters 1 and 2. Winter 4 is shown only as an additional comparison. *b)* The same as *a)* but for the control experiment. c) Anomalies (cpl minus control) of the stratospheric zonal winds at 50hPa (U50) at 70-80° N for each ensemble member (colored lines) and the ensemble mean (black curve). A more consistent U50 decrease is detected in winter 3 compared to winter 2 where a single realization causes a sharp drop in U50 (light-blue line).

In the revised manuscript, we will also better describe the mechanism responsible for the enhancement of SSW occurrence in the third post-eruption winter. Our focus will be on surface anomalies in the North Pacific/Western North American sector, where anomalous land-sea temperature gradients are suggested to contribute to the strong upward wave flux detected.

We plan to address the issue on the different aerosol lifetime for high-latitude eruptions compared to tropical ones in the revised version by adding a clarification on this matter in the Methods and Discussions chapters and compare our forcing with other related studies on high-latitude eruptions/aerosol injections. However, we do want to stress here that our experiment is designed around a longer-lasting aerosol injection, unlike the experiments in Toohey et al. (2019), with maximum values spanning in total 5 months that could potentially counteract part of this decrease.

We also appreciate the comment about improving the EP and Plumb flux analysis, which is central to our study. In a revised version of the manuscript we will better connect to existing literature and cite all the references suggested by the Reviewer. Especially we will dig deeper into the mechanism by, e.g., adding an analysis to assess a) the role of the eddy feedback parameter in the increased upward EP flux at the surface and b) the role of wave-eddy interactions regarding our detected stratospheric circulation/polar vortex response (preliminary results also point to a potential role of land-sea surface temperature gradients in the North Pacific/North American sector). As

a result, we will improve Discussions with respect to the above comment and take into consideration putting our results in context with DallaSanta et al. (2019) and/or Bittner et al. (2016) as the Reviewer mentions, both of which are highly relevant (see also Smith et al. 2022).

Finally, and in light of the comments from both Reviewer #1 and #2, we agree on altering the title to better represent and describe the content of this manuscript as well as to restructure the results section of the paper (see Author response to Reviewer #1 for details). Regarding the specific comments by Reviewer #2, in the revised manuscript we will account for each of the suggestions and the clarification requests.

References

Smith, D. M., Eade, R., Andrews, M. B., Ayres, H., Clark, A., Chripko, S., ... & Walsh, A. (2022). Robust but weak winter atmospheric circulation response to future Arctic sea ice loss. *Nature communications*, *13*(1), 727.