Dear authors,

we appreciate the manuscript by Ewa Bednarz and colleagues and we are convinced it will make an interesting contribution to the Hunga-Tonga literature. After having gone through the manuscript in detail, we wish to encourage some additional analysis with respect to Kuchar et al (2025). We would encourage the authors to examine in more detail the atmospheric-only simulations (HUNGA_fix) even though the climatological SSTs may dampen the surface response.

It appears that HUNGA_fix has the potential to represent the top-down mechanism suggested in Kuchar et al (2025), i.e. the influence of lower-mesosphere cooling on the stratospheric polar vortex via decreased temperature gradient. Because of HTHH-MOC (Zhu et al., 2024), there is access to the presented simulations which allowed us to reproduce Fig. 2 from Kuchar et al (2025), see Fig. C1 below. As you can see most of the features such as the mesospheric cooling at lower latitudes (Fig. C1a), which has the potential via the thermal wind relation to weaken the polar-night jet, are represented by the HUNGA_fix simulation. Consequently, we observed an increase in polar temperature progressing downward and the associated cooling aloft (Fig. C1b). However, the statistical significance at higher latitudes is rather limited possibly due to the use of monthly means. Note that Fig. C1 shows the evolution of temperature for the winter 2023/2024 in contrast to 2022/2023 used in SOCOLv4 in Kuchar et al (2025). As discussed therein, the mechanism suggested and simulated by SOCOLv4 above should be valid for the winter of 2023/2024 and the following winters if the lower-mesospheric cooling is persistent and strong enough due to the excess WV. This difference has been attributed to the overly fast transport of water vapour in SOCOLv4 and differences in the experiment protocol.

We also reproduced Fig. 9 to assess the detectability of the NH stratospheric vortex in the early winter (Fig. C2a), late winter (Fig. C2b) and March only (Fig. C2c) in SOCOLv4. Similarly, we cannot detect any statistically significant signal beyond the envelope of potential responses in the early and late winter based on our sample size. However, when we assess the responses only in March 2023 we see an emerging negative response in zonal-mean zonal wind at 65°N and 50 hPa. This suggests that emerging signals on a monthly basis may be detected even with a limited sample size. Accordingly, we would like to suggest further exploring the detectability of signals for the winter 2023/2024 as done in Figs. 9 and S5.

Best regards

Ales Kuchar, Timofei Sukhodolov, Eugene Rozanov, Gabriel Chiodo, Harald Rieder

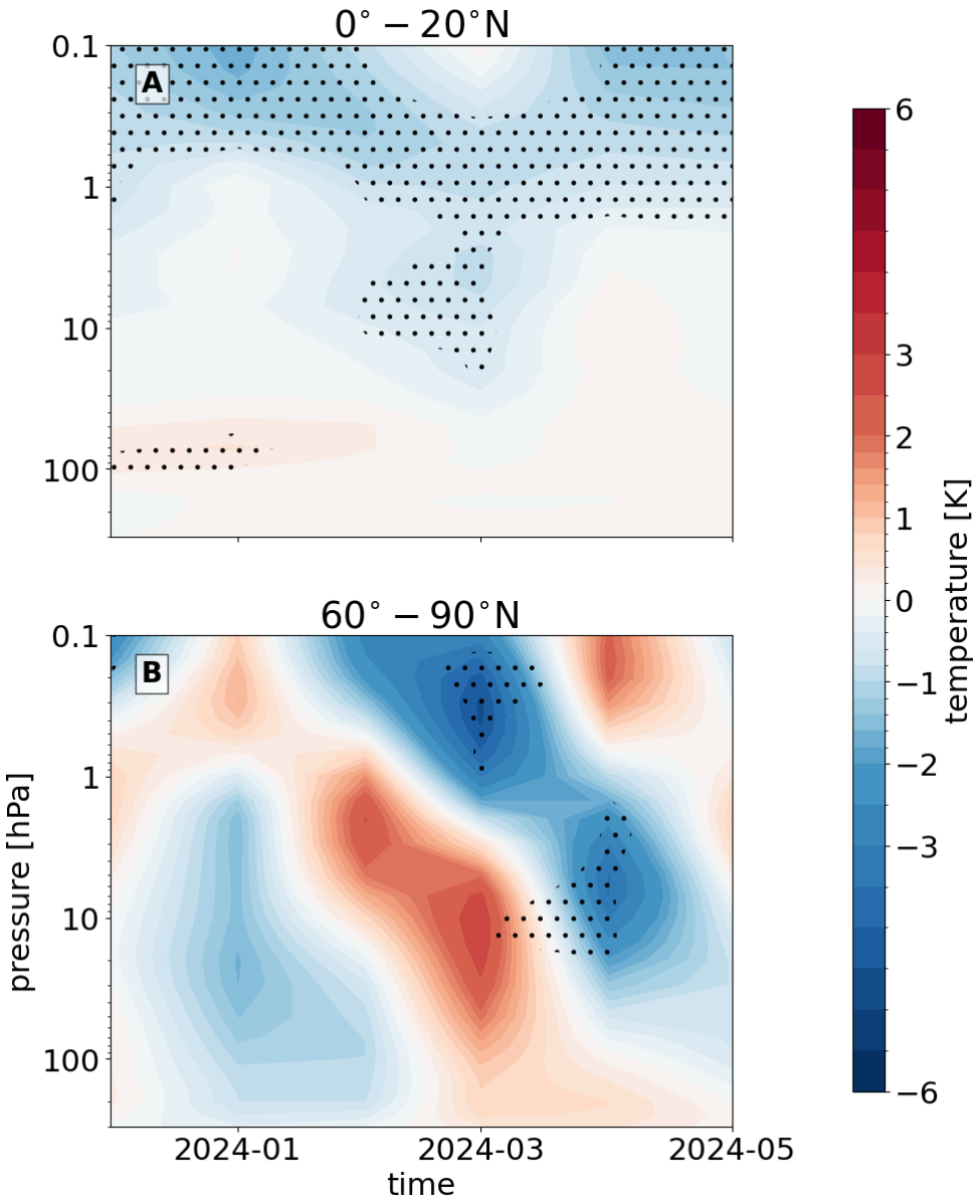

Figure C1 *Weighted zonally averaged temperature averaged over 0 -20° N (a) and 60 -90° N (b) monthly anomalies for 202312-202405 in WACCM (HUNGA_fix). The anomalies are expressed as the differences between the simulations with and without HT forcing. The 2σ statistical significance from a t test is indicated by the dots.*

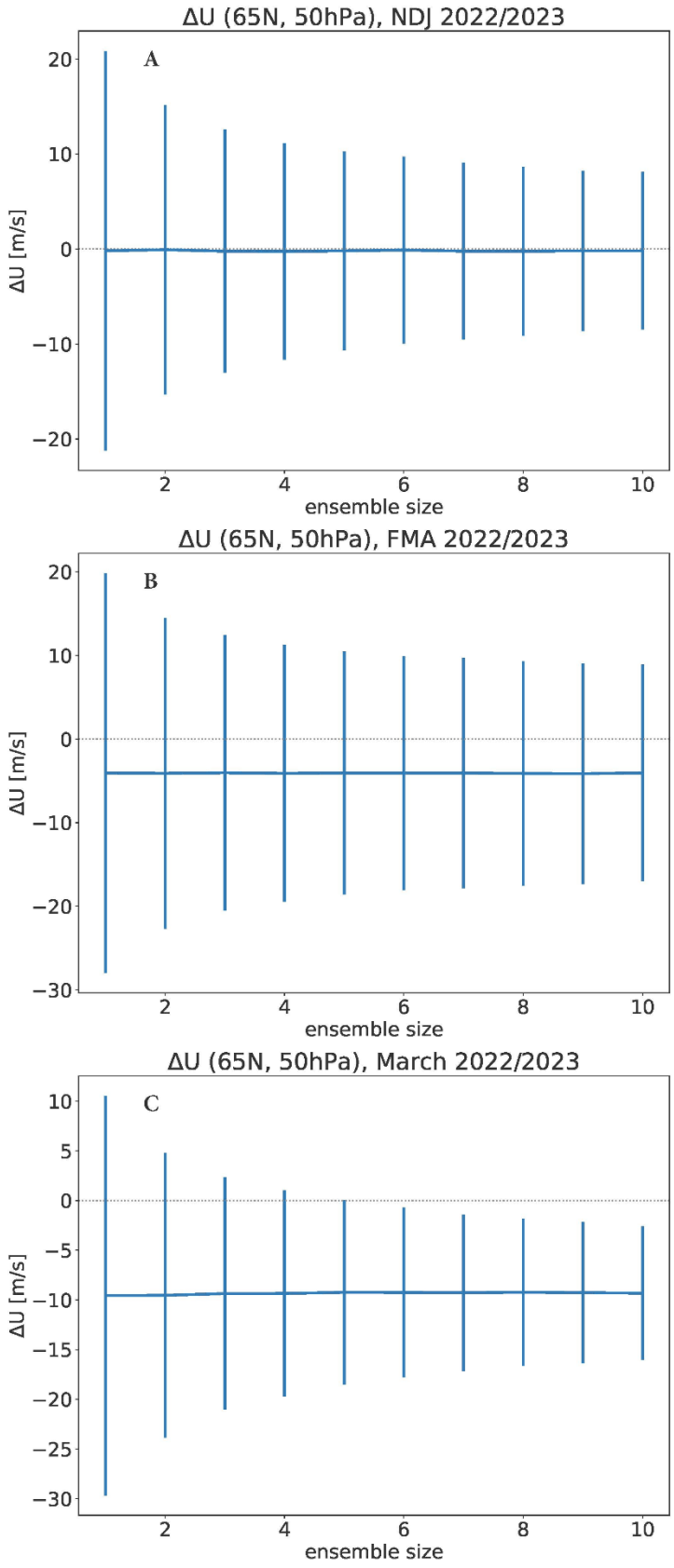

Figure C2 *Detectability of the NH stratospheric vortex in the early winter (A), late winter (B) and March only (C) in SOCOLv4 based on daily means. Error bars represent +/- 2 standard deviation of the possible responses obtained by randomly subsampling the ensemble with replacement to obtain 2000 artificial samples of each different ensemble size.*

References

Kuchar, A., Sukhodolov, T., Chiodo, G., Jörimann, A., Kult-Herdin, J., Rozanov, E., and Rieder, H. H.: Modulation of the northern polar vortex by the Hunga Tonga–Hunga Ha'apai eruption and the associated surface response, Atmos. Chem. Phys., 25, 3623–3634, https://doi.org/10.5194/acp-25-3623-2025, 2025.

Zhu, Y., Akiyoshi, H., Aquila, V., Asher, E., Bednarz, E. M., Bekki, S., Brühl, C., Butler, A. H., Case, P., Chabrillat, S., Chiodo, G., Clyne, M., Falletti, L., Colarco, P. R., Fleming, E., Jörimann, A., Kovilakam, M., Koren, G., Kuchar, A., Lebas, N., Liang, Q., Liu, C.-C., Mann, G., Manyin, M., Marchand, M., Morgenstern, O., Newman, P., Oman, L. D., Østerstrøm, F. F., Peng, Y., Plummer, D., Quaglia, I., Randel, W., Rémy, S., Sekiya, T., Steenrod, S., Sukhodolov, T., Tilmes, S., Tsigaridis, K., Ueyama, R., Visioni, D., Wang, X., Watanabe, S., Yamashita, Y., Yu, P., Yu, W., Zhang, J., and Zhuo, Z.: Hunga Tonga-Hunga Ha'apai Volcano Impact Model Observation Comparison (HTHH-MOC) Project: Experiment Protocol and Model Descriptions, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-3412, 2024.