Comments from Anonymous Referee #1

General comments:

In the present paper, the authors investigate a potential link between the 2022 Hunga Tonga eruption and noctilucent clouds (NLC) activity in the southern and northern hemisphere. The authors have used Microwave Limb Sounder (MLS) measurements of water vapor and temperature in the mesopause region to analyze the development of the mesopause environment and how it has reacted on the 2022 Hunga Tonga eruption. Also, the authors have used Ozone Mapping and Profiling Suite - Limb Profiler (OMPS-LP) measurements to obtain information on NLC activity from 2013 to 2024 in both the SH and the NH. The authors have found a slight increase in water vapor mixing ratio in January-February 2024 by about 1 ppmv between 70°S - 80°S up to an altitude of 83 km. However, no clear signal was observed for the NLC occurrence frequency in the analyzed space and time domains. At the same time, the authors speculate that this slight increase in the H2O amount in the beginning of 2024 in the SH could potentially be caused by the additional water vapour from the 2022 Hunga Tonga massive eruption. Besides, the authors have found a slight increase in the water vapour in the polar summer mesopause region in the NH during the 2024 NLC season. At the same time, the anomalous warming in the NH mesopause during the second half of the 2024 NLC season has been observed that has hindered the NLC formation, and thus masking a potential link between the 2022 Hunga Tunga eruption and the 2024 NLC activity in the NH.

I have found the present paper to be very interesting to the atmospheric community. I recommend the present paper for publication after minor revisions which are outlined below.

We would like to thank the reviewer for taking the time to assess our manuscript and think that their comments resulted in its improvement. We will address all of the reviewer's comments in the following paragraphs.

Specific comments:

Line 11: "To summarise, the volcanic water vapour seems to need two years to reach the summer polar mesopause region."

Please make it clearer here that two years are needed for the volcanic water vapour to reach the summer polar mesopause region from the lower mesosphere.

Thank you for raising our awareness to this aspect. We are, however, hesitant to provide a specific atmospheric region as the starting point for the H_2O transport. As you correctly mentioned, there are reports of the visible plume reaching 57 km altitude (Proud et al., 2022). Nevertheless, there are also indications that the plume only shortly reached this overshooting height before it collapsed. MLS data and model simulations by Niemeier et al. (2023) indicate, that the main part of the plume descended in the first two weeks and remains between 20 - 40 hPa until October 2022. Because of this complex behavior we rephrased the sentence to "To summarise, based on analysis performed in the study, we show that the volcanic water vapour needs two years to reach the summer polar mesopause region".

Reference:

Simon R. Proud, Andrew T. Prata & Simeon Schmauß (2022),The January 2022 eruption of Hunga Tonga-Hunga Ha'apai volcano reached the mesosphere. Science378,554-557. DOI:10.1126/science.abo4076

Niemeier, U., Wallis, S., Timmreck, C., van Pham, T., & von Savigny, C. (2023). How the Hunga Tonga—Hunga Ha'apai water vapor cloud impacts its transport through the stratosphere: Dynamical and radiative effects. Geophysical Research Letters, 50, e2023GL106482. https://doi.org/10.1029/2023GL106482

Lines 23-24: "Two years later, in June 1885, first sightings of noctilucent clouds were reported (Backhouse, 1885; Leslie, 1885; Schröder, 1999)."

Please add here the paper by Tseraskii (1887) who observed, photographed and estimated the NLC altitude for the first time already in June 1885.

We added the paper by Tseraskii (1887) as suggested.

Lines 185-186: "They found that in polar regions (that are already cold enough for NLCs during summer time) mesospheric clouds are more sensitive to water vapour than changes in temperature."

Here it is worth mentioning the paper by Pertsev et al. (2014) which clearly demonstrated the sensitivity of NLC to the relative humidity of the mesopause region. At the same time, it should be mentioned that Dalin et al. (2023) showed that a combination of lower mesopause temperature and water vapor mixing ratio maximum at middle latitudes was the main reason for frequent and widespread occurrences of NLC seen around the globe at middle latitudes in the 2020 summer.

We agree and added "The sensitivity of NLCs to the relative humidity of the mesopause region was also confirmed by Pertsev et al. (2014). Moreover, Dalin et al. (2023) showed that a combination of low mesopause temperature and a maximum in water vapor mixing ratios was the main reason for the frequent and widespread occurrences of NLCs seen at NH mid-latitudes in the summer of 2020." to the text.

Lines 204-205: "Similarly, the final launch of the space shuttle was associated with unusually bright NLCs (Stevens et al., 2012)."

Here it is worth mentioning the paper by Dalin et al. (2013) which clearly demonstrated the direct formation of NLC in the rocket exhaust trail.

We agree and added "and Dalin et al. (2013) even demonstrated the direct formation of NLCs in the exhaust trails of Soyuz rockets." to the text.

Additional references:

Dalin, P., H. Suzuki, N. Pertsev, V. Perminov, N. Shevchuk, E. Tsimerinov, M. Zalcik, J. Brausch, T. McEwan, I. McEachran, M. Connors, I. Schofield, A. Dubietis, K. Černis, A. Zadorozhny, A. Solodovnik, D. Lifatova, J. Grønne, O. Hansen, H. Andersen, D. Melnikov, A. Manevich, N. Gusev, V. Romejko: The strong activity of noctilucent clouds at middle latitudes in 2020. Polar Science, 35, 100920, https://doi.org/10.1016/j.polar.2022.100920, 2023.

Dalin, P., Perminov, V., Pertsev, N., Dubietis, A., Zadorozhny, A., Smirnov, A., Mezentsev, A., Frandsen, S., Grönne, J., Hansen, O., Andersen, H., McEachran, I., McEwan, T., Rowlands, J., Meyerdierks, H., Zalcik, M., Connors, M., Schofield, I., Veselovsky, I.: Optical studies of rocket exhaust trails and artificial noctilucent clouds produced by Soyuz rocket launches, JGR-Atmospheres, 118, 14, 7850-7863, https://doi:10.1002/jgrd.50549, 2013.

Pertsev, N., Dalin, P., Perminov, V., Romejko, V., Dubietis, A., Balčiunas, R., et al.: Noctilucent clouds observed from the ground: sensitivity to mesospheric parameters and long term time series. Earth, Planets and Space, 66(1), 1–9, https://doi.org/10.1186/1880 5981 66 98, 2014.

Tseraskii, V. K.: Astronomichesky fotometr i ego prilozhenia (Astronomical photometer and its applications). Doctoral Dissertation, Mathematical Proceedings, XIII, Section 21, 626–631, 1887 (in Russian).

We would like to thank Anonymous Referee #1 for their time and for providing comments on our manuscript.