The study focuses on water vapour transport mechanisms driven by lightning-induced deep convection in the Third Pole region, a global lightning hotspot where UTLS (upper troposphere and lower stratosphere) water vapour exchange significantly impacts climate. The research addresses critical regional and global climatic implications.The combination of multi-source data (TRMM-LIS, ERA5, AIRS, MLS) with km-scale ICON-CLM modeling and Lagrangian tracking creates a robust "observation-reanalysis-model" validation framework, demonstrating methodological advancement.The logical and the results are reasonable. The structure is clear, and the writing is well. However, there are some concerns about this study.

Response: We sincerely thank the reviewer for their thoughtful and encouraging feedback. We greatly appreciate your recognition of the scientific significance of our study, particularly in addressing water vapour transport mechanisms in the Third Pole region and their climatic implications through the use of multi-source data and high-resolution ICON-CLM simulations.

1.Lightning datasets (TRMM-LIS, ISS-LIS) span long periods, but the impact of temporal discrepancies (TRMM: 1995–2015; ISS-LIS: 2019–2020) on result consistency requires clarification.

Response: We thank the reviewer for raising this important point. We have clarified the use of TRMM-LIS (1998–2015) and ISS-LIS (2019–2020) datasets in the revised manuscript (Data and Methodology section; line numbers 70-80 in revised manuscript). While these datasets span different periods, they share consistent detection capabilities through the similar LIS instrument. TRMM-LIS is used to assess long-term regional lightning patterns, while ISS-LIS supports recent event selection and model evaluation. Since they serve distinct purposes: climatology vs. case-specific validation. The difference in temporal coverage does not compromise the consistency or validity of our results.

2.Incorporate recent (post-2023) observational studies on deep convection in the Third Pole (e.g., ground-based radar or satellite retrievals) to enhance timeliness.

Response: We thank the reviewer for this insightful suggestion. We agree that integrating recent (post-2023) observational studies would enhance the relevance of our work. However, we found that post-2023 ground-based radar studies or satellite retrievals specifically focused on deep convection over the Third Pole are currently limited, and most ground-based radar datasets over the Third Pole region remain inaccessible in the public domain.

Although we are involved in a few ongoing collaborative efforts to analyze event-based satellite observations, these studies are still in preparation and are not yet available for citation. Furthermore, the combined analysis of lightning (as a proxy for deep convection) and UTLS water vapor transport representation in high-resolution regional climate models remains largely unexplored over the Third Pole in recent literature. Given these limitations, and the specific focus of our study on evaluating km-scale ICON-CLM simulations for the 2019–2020 period.

3. Correlation analysis (e.g., Table 2) shows the highest lightning-UT water vapour correlation over the Tibetan Plateau ($r = 0.78$). Whether the region's low lightning frequency (<4 flashes/km²/year) affects statistical significance?

Response: We thank the reviewer for raising this important point. While the average lightning density over the Tibetan Plateau is relatively low (<4 flashes/km²/year), our analysis focuses on a spatially extensive region (90–105°E, 30–35°N), which represents the core lightning-active zone within the Plateau (as shown in Supporting Figure 1). Over this large area, flash density accumulates to over 3 million lightning flashes during the TRMM-LIS observation period (1998–2014), ensuring a robust sample size for statistical analysis. Therefore, the observed correlation ($r = 0.78$) remains statistically significant despite the seemingly low flash density. We have clarified this point in the revised manuscript (Line numbers 154–157 in revised manuscript).