Review of the paper
Müürsepp et al. — *The role of radiation in the Northern Hemisphere troposphere-to-stratosphere transport* (submitted to *EGUsphere*)

General Comments

This is a well-written and important paper that examines, from a Lagrangian perspective, the physical processes responsible for potential vorticity (PV) modification during troposphere-to-stratosphere transport (TST), especially during crossings of the 2 PVU dynamical tropopause. Using ERA5-based trajectories together with the diabatic heating rates provided by the reanalysis, the authors quantify the contributions of shortwave and longwave radiation as well as other diabatic processes to PV formation, and compare these with PV tendencies derived directly from ERA5 and interpolated along the trajectories. The residual between the two is interpreted as the contribution from dynamical–dissipative effects. The scientific questions (Q1–Q4) are clearly formulated, thoroughly addressed, and well-summarized in the conclusions. The analysis itself and the high quality of the figures are convincing. The dominant role of clouds and/or strong vertical humidity gradients in producing radiative PV rates is somewhat unexpected but physically plausible and well supported by the results.

I have only two major points and a few minor issues listed below.

Major Comments

- The total PV change along a trajectory results from both diabatic processes (radiation, latent heating, etc.) and dynamical–dissipative processes (turbulence, wave breaking). In the paper, the radiation-induced PV increase of 1 PVU is linked to a modification of the potential temperature, as expected for a diabatic process. However, the magnitude of the associated cross-isentropic motion is not quantified. Classical conceptual descriptions (e.g. Holton et al., 1995) often emphasize idealized, nearly isentropic pathways for troposphere–stratosphere transport, with PV changes occurring by crossing the tropopause. As I began reading the manuscript, I hoped for a quantitative estimate of the actual $\Delta\theta$ along the radiatively dominated TST trajectories. This seems straightforward to compute from the trajectory data already available. Are the typical $\Delta\theta$ values of order 1 K, 5 K, or 10 K? Including a brief summary of these values would greatly help interpret the physical significance of the radiatively driven PV changes.

- You state that 84% of the identified TST trajectories show a positive radiative PV contribution, and that in about 8% of all cases radiation dominates the PV increase prior to TST (i.e. $\Delta PV_{rad} > 0.5$ PVU). Interpreting these numbers in reverse implies that, for the majority of trajectories, the second term in Eq. (1)—the contribution from dynamical–dissipative processes—is dominant. As much as I appreciate the clarity of your analysis, the manuscript currently gives the impression that radiation is the primary mechanism of PV formation during TST. A clearer statement emphasizing that dynamical–dissipative processes dominate in most cases (with radiation being important but not generally leading) would help balance the interpretation. This clarification would not diminish the relevance of your radiative analysis; rather, it would strengthen the overall message by placing the radiative contribution in the correct dynamical context.

Minor Comments

- L24
  "The amplitude of the net transport is small compared to the upward and downward transports, and in the climatological mean it is upward in the tropics and downward in the extratropics."
  I would suggest clarifying that the **net mass exchange exhibits a pronounced seasonality**, and that its amplitude is small compared to the gross upward and downward fluxes. A revised formulation could note that, despite this small net signal, the climatological mean shows upward transport in the tropics and downward transport in the extratropics.

- Eq. (3)
  The equation could be written more compactly by using a single summation and grouping the PVR terms in parentheses.

- Figure 1
  This figure is important for understanding the methodology. However, the radiative contribution in this example is very small and confined to a short period (approximately 16–22 h), making it a non–radiation-dominated case. A gentler introduction—also in the caption—would help guide the reader. I recommend explicitly using the accumulated PV notation (APV) in the caption to maintain consistency with the text.

- Figure 2 and related text
  The definition of the categories used in Fig. 2 should be introduced at the beginning of Sect. 3, so that the reader understands them before encountering the figure. It may also be useful to include a brief reminder of the category definitions directly in the figure caption.

- Figures 5 and 6
  The examples shown in Figs. 5 and 6 should ideally be connected more clearly. For instance, selecting cases with similar TST durations (or another consistent criterion) would make it easier for the reader to relate the subpanels of Fig. 5 to the corresponding subpanels of Fig. 6.