Reply to Anonymous referee #3

The authors appreciate the valuable comments on the manuscript which led to a significant improvement. Referee comments are given in bold, the answers in standard font. Changes to the text are in italics.

Generally, we note that we revised most of the figures based on suggestions from the three referees. We also changed some of the acronyms of our experiments. Moreover, we included three more figures (new Figures 9, 15, and 16 in the revised manuscript) and based on questions and comments from Sebastian Schemm and George Craig we included a new section (Section 5 in the revised manuscript) in which results from LC2 experiments are discussed.

Specific comments

In Fig. 6, comparison between RAD and BMP is very interesting. As authors mentioned, both RAD and BMP show large ΔN2 values near the tropopause, while only RAD shows significant PV change near the tropopause. BMP show minimal change in PV, and this strongly supports authors idea that BMP's contribution on ΔN2 is largely due to upward motion (which is likely forced well below the tropopause). Further contrasting the two experiments in the text (around beginning paragraph in P21510) may be beneficial.

We extended the discussion around Fig. 6. Especially, we explicitly note that the altitude of the maximum diabatic PV change is closely related to the altitude where the water vapor gradient changes significantly below and across the tropopause. We further related this PV change to results given in another study (Chagnon et al., 2013) and we explained more specifically why there is hardly a change in PV evident in the domain mean for BMP. This is because in BMP the changes in PV do not occur always at the same altitude relative to the tropopause and occur on relatively small scales. In contrast, in RAD the PV change occurs on larger scales and almost on the same altitude (relative to the tropopause) at the respective time steps.

Related to Fig. 9, the early increase of N2 in BMP RAD TRUB CONV SURF experiment is interesting, but is it only attributable to radiation process? This could also be due to direct effect of enhanced upward motion (mass flux could be interpreted this way too). Could you clarify which one contribute more? If this is not straightforward, mentioning the both possibilities of radiation and updraft (direct effect) may lead the discussion to be a more balanced.

In lines 5-12 on page 21513 of the discussion paper we state that convective processes are most responsible for the earlier increase in N^2 in BMP RAD TURB CONV SURF. This is further supported by Fig. 9e (in the revised manuscript Fig. 10e) where we show the temporal evolution of the cloud base mass flux which serves as an indicator for convective activity.

First paragraph in P21514 (and Fig. 11): The initial importance of updraft and time behavior of TIL seems interesting. However, this paragraph and figures are complex and difficult to understand unless read it several times. For example, Fig 11 has 12 panels, but not all the figures are necessary for the discussion. Further simplification will be helpful for readers (maybe comparison of two contrasting experiments, BMP vs RAD?).

Thanks for pointing this out. We rephrased the corresponding paragraph on page 21514. However, we would like to keep the number of sub-panels for all simulations of the second part of our discussion (section 4). We think the full set of panels is useful for the reader to follow our discussion. We want to point out that the convergence of the vertical wind due to the large scale flow or small scale disturbances is of further importance for the formation and maintenance of the TIL during the life cycles.

Technical comments

P21505 L7: The abbreviation QADI sounds somewhat misleading. Although the saturation adjustment process is the most simple one, it gives enough latent heating as authors shows in Fig. 5b. In that sense, it is far from adiabatic process.
We changed QADI to BMP SATAD.

P21506 L11: BMP, RAD) → '('BMP, RAD) or may rephrase as "we compare results from the first four life cycle experiments (BMP, RAD, TURB, and REF)
We changed the sentence as suggested.

P21509 L7: "which increases the convergence of isentropic surfaces" the vertical gradient of isentropic surfaces"?
We rephrased the sentence to:
“Consequently, also the air above is slightly lifted, thereby increasing the vertical gradient of potential temperature, resulting in enhanced static stability above the tropopause.”

P21509 L12: "Fig.6a and Fig.6b" do not match with Fig. 6; maybe Fig.6 (left panels) and Fig.6 (right panels)?
Correct, changed accordingly to left and right panels.

P21514 L25: feedback feedback → feedback
Corrected as suggested.

P21517 L14: "sharpening" is sometimes used for stronger TIL; this may be misleading. Could you rephrase this?
We removed this part of the sentence.

P21517 L27: relative → relatively
Corrected as suggested.

Table 1: Experiment names are confusing if you break it into two lines. Putting indent for the second line could be helpful.
Thanks for pointing this out. We changed some of the long acronyms and now use shorter ones. In one case two lines where still necessary (BMP RAD NOCRF) where we used an indent at the beginning of the line.

Figure 13: This figures are somewhat redundant. Showing just one good example may be clearer.
The redundancy is reduced by showing Fig. 10 (new Fig. 11) at 120 hrs as suggested by George Craig, so Figure 13 (new Fig. 14) is at least unique at 144 hrs after simulation start. We want to keep the number of sub-panels to show that this feature is not only related to one specific combination of physical processes but always evident when the turbulence parameterization is turned on.

P21524 Fig1 caption: 0.002 is too small, maybe typo?
Correct, this should be 0.02.

References:
Chagnon, J. M. Gray, S. L., and Methven, J.: Diabatic processes modifying potential vorticity in a North Atlantic cyclone, Q. J. Roy. Meteor. Soc., 139, 1270–1282, doi:10.1002/qj.2037, 2013.