Reply to reviewer's comments #1

Summary

Using an idealized aquaplanet model, the authors investigate the changes of storm track in response to uniform global warming downstream of a midlatitude SST front. They found a local enhancement of eddy kinetic energy (EKE) downstream of SST front, and attribute the EKE enhancement to the internal baroclinic conversion from eddy available potential energy (EAPE). By analyzing the EAPE budget, they further show that the EAPE enhancement downstream of SST front is due to change of baroclinic conversion efficiency. They also provide the response of several life cycle characteristic of extratropical cyclones using tracking algorithm.

Recommendation

Several prior studies have examined the overall poleward shift of storm track without the presence of diabatic forcing, but less attention has been paid to the local increase of storm track downstream of SST front. I believe this study brings an important contribution to storm track response by considering the local SST-front effect. The results are novel and robust. I thus recommend the authors to perform a minor revision by considering the comments listed below.

Reply: We would like to thank the reviewer for the positive evaluation of our study and the helpful comments. In the revised manuscript we have given more emphasis to the local minimum of EKE increase in region 3, which turns out to be largely related to changes in stationary waves, as well as to some extent reduce baroclinic conversion.

Minor comments:

(1) In the abstract, the authors suggest a tripolar pattern of storm track under global warming, with a poleward shift of storm track, enhance EKE downstream of the SST front and a regionally reduced EKE increase at polar latitudes. The local minimum of EKE in polar region in Figure 2 (label 3) is much less obvious than the other two characteristics (labels 1 and 2). Moreover, less attention has been paid to explain this response in the main text. I thus suggest the author to either revise the abstract or add more discussions on the storm track response in the polar region.

Reply: The local minimum of EKE in the polar region you are referring to indeed has a weaker amplitude than the anomalies 1 and 2. Nevertheless, it is a common feature of the storm track response that appears in global warming scenarios in various climate models as well as in aquaplanet simulations with a localized SST front. Furthermore, the minimum in region 3 is also evident in 300 hPa wind speeds (Fig. R1a). Hence, we still think it is worth being mentioned in the abstract. However, we do agree that the changes leading to the reductions of EAPE and EKE in region 3 have insufficiently been discussed in the original manuscript.

The reasons for the minimum in region 3 are twofold: Reduced baroclinic conversion and advection anomalies. Considering external and internal baroclinic conversions, we find local minima the region in question (Figs. 3c and 6c). These minima are, however, less pronounced than the minima in EAPE and EKE themselves, suggesting that other processes might be relevant too. A key difference between the warmed and control simulations is the amplification

of a stationary wave pattern downstream of the front. This pattern comprises a strengthened trough downstream and poleward of the SST front, extending about 90° eastward, as well as an amplified ridge between 90°E and 180°E (Fig. R1b). This pattern results in enhanced poleward advection of EKE and EAPE between the stationary trough and ridge (at about 90°E) and reduced advection just north of the SST front. The latter contributes to the existence of the minimum in region 3.

In the revised manuscript, we include Fig. R1 as Fig. D1 and include a new subsection 3.4 discussing the aforementioned changes of stationary waves and their implications for the advection of EAPE and EKE. Furthermore, we also explicitly point out the local minima in external and internal baroclinic conversion in region 3.

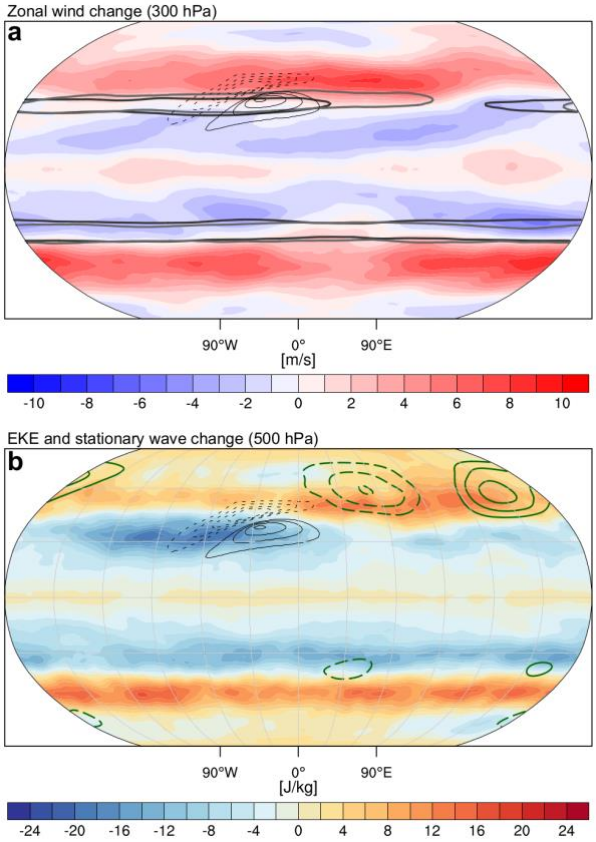

Figure R.1: (a) Wind speed difference at 300 hPa between the Qobs control run with SST front in the Northern Hemisphere and uniform warming by 4 K at the surface, as well as the 40 m s^{-1} wind speed contour in the control (black) and the warmed simulation (gray). (b) EKE (color) and geopotential difference at 500 hPa (defined as deviation from the the zonal mean; green solid indicate positive and dashed negative values; +/- 200, 400, and 600 m 2 s −2). Additionally shown in both panels is the 2-m temperature after removing the zonal mean (black solid contours indicate positive and dashed negative values; starting at +/- 2.5 K in steps of 0.5 K).

(2) Lines 55-60: The sentence is too long and hardly to understand the logic behind it.

Reply: Thanks for pointing out. We agree that this sentence was too convoluted, and we have rephrased it as follows.

However, there is evidence that diabatic heating within storms tends to amplify their growth rates (e.g., Kuo et al., 1991; Davis et al., 1993; Stoelinga, 1996; Chang et al., 2002; Schemm et al., 2013). At the same time, transient diabatic processes, including surface fluxes, have been found to reduce eddy available potential (EAPE) and, thus, the reservoir from which eddy kinetic energy (EKE) can be generated (Ulbrich and Speth, 1991; Chang and Zurita-Gotor, 2007; Marcheggiani and Ambaum, 2020).

(3) Line 84: I don't understand why you use "an otherwise" here, maybe delete that?

Reply: We agree that "otherwise" is unnecessary and we have removed the word.

(4) Line 90-92: I suggest the author to revise this sentence. Maybe from the perspective of EAPE/EKE budget analysis?

Reply: We have rephrased the sentence as:

The response is described in terms of changes of the eddy energy cycle, that is EAPE and EKE, and the associated tendencies, including baroclinic, barotropic, and diabatic conversions, as well as the baroclinic conversion efficiency.

(5) Line 121: remove "the" before "there is no seasonality…"

Reply: Done.

(6) Lines 123 and 124: the EKE represents eddy kinetic energy. Please add the word "energy" after "eddy kinetic" in the two places.

Reply: Thanks, we have corrected this.

(7) Figure 4: It is perhaps better to highlight the key region of conversion efficiency downstream of SST front in Figure 4. This is helpful for the reader to understand that the downstream enhancement of baroclinic conversion is caused by the conversion efficiency instead of baroclinicity or eddy total energy.

Reply: We agree and have marked the region with a star.