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Interactive comment on "SST fronts along the Gulf Stream and Kuroshio affect the winter climatology primarily in the absence of cyclones" *by* Leonidas Tsopouridis et al.

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The paper explores the role that SST gradients in the Gulf Stream and Kuroshio play in extratropical cyclones in the two main storm tracks of the Northern Hemisphere. Surprisingly, the paper focuses mainly on the low-pressure systems that reach their maximum intensity over the Gulf Stream or Kuroshio, even though the largest changes in cyclone frequency in the experiments occur well downstream of either the Gulf Stream or Kuroshio (Fig.4).

My major comments are as follows:

1. The finding that cyclones play a secondary role in forming strong sensible and latent heat fluxes is only true for the low-pressure systems which have their centres in the selected areas, i.e. right over the oceanic currents. However, anomalous turbulent fluxes may not be associated with the cyclones with centres in the selected boxes. Tilinina et al. (2018; https://doi.org/10.1175/MWR-D-17-0291.1) showed that extreme fluxes over the Gulf Stream are linked to regions of cyclone-anticyclone interaction (usually associated with strong winds and large air temperature anomalies) when they are located above the ocean current. The finding by Tilinina et al. implies that the atmospheric circulation plays an important role in creating strong turbulent fluxes. While systems that have their centres within the selected boxes may, indeed, not be associated with strong air-sea fluxes, I believe that the paper should focus on a different subset of cyclones, i.e., those that are located $\sim$ 1000-3000 km to the north or north-east of the Gulf Stream or Kuroshio). This is in agreement with the area of the largest changes of cyclone activity shown in Fig.4.

2. I do not feel comfortable with the idea of using SST fronts from CNTRL for analysis of the smoothed runs. I believe that fronts should be objectively identified in all runs. This is particularly important in the Pacific, where SST fronts can hardly be seen in the the SMTHK experiments. As the classification of cyclones in this paper is based on the location relative to the SST front, in those cases when an SST front in SMTH cannot be detected, the type of cyclones cannot be defined. That said, given my first comment on the subset of cyclones that may be particularly affected by the the SST gradient, I am not sure that a classification based on the location of cyclone centres relative to the ocean current is particularly important. Fig. 5 shows that there are hardly any statistically significant differences between those types, not to mention the differences between SMTH and CNTRL runs.

3. Finally, it will be interesting to assess how much changes in heat fluxes, precipitation, etc. scale with a change in the SST gradient. It is mentioned multiple times that smaller reduction in the SST gradient in the Kuroshio region led to smaller corre-

sponding changes in the atmospheric circulation. The question I want to raise here is if similar reductions in the SST gradient in those basins lead to comparable response. Or, alternatively, how stronger/weaker smoothing affects the same region.

Overall, the question raised in the paper ('how SST currents influence extratropical circulation?') is very intersting and existing simulations may shed light on it; however, in my opinion, the analysis should focus more on the systems downstream of the Gulf Stream and Kuroshio. Importantly, based on earlier publications and some plots in the submitted manuscript, I believe that such approach will change the main finding (and the title!) of the paper showing that SST gradients affect atmospheric cyclones.

Other comments:

Title: In the current version of the manuscript, it is, indeed, shown that the atmospheric conditions change stronger in the absence of cyclones over the ocean currents. However, as I said in the above, if more analysis is done on cyclones in the the storm track areas, the title may need to be changed.

l.90: Instead of just saying 'to the questions raised above', it is worth repeating the main questions here.

Data: I could not find the time resolution of the data used.

l.97: Why the period of integration ends in 2001? Considering the coarse SST resolution in ERA-Interim prior to 2002, selection of the time period needs to be justified.

l.114: Give a more detailed description of how the jet was detected.

l.104: Explain what is meant by "1-2-1 running mean"

l. 123: following a comment above, 3 consecutive time steps for the minimum life time of 12 hr comes from nowhere. I'd mention here that 12 hours is less than more often used threshold of 24 hours (i.e., five 6-hour time steps), applied in Neu et al. (2013; https://doi.org/10.1175/BAMS-D-11-00154.1) and adopted in many recent studies on

extratropical cyclones.

l.124, 144: I presume that you require that the cyclone centre, not just any point of the cyclone area, passes over the Gulf Stream or Kuroshio regions?

l.159: Also refer to Fig. 2a,b for the SST gradient.

Fig. 3: what are the units used to show the distribution of the SST fronts and jet axis? The caption says 'km of line/ 100km**2'. It suggests that the SST front is represented by a line, not by an area where the SST is above a 2 or 1.25K/100km (this indicates again, that the method used to define the SST front needs to be better described in Section 2.2, see my earlier comment). Explain how you got km of line per a unit area. Why not showing the frequency of the SST values above a threshold instead?

As I do not quite understand the units in Fig.3, I am not sure how to interpret higher jet distribution values over the Pacific. The text says that the jet is 'stronger', does that mean that it is present more often or that it is wavier?

l. 172: How do you know that it is the jet that affects the cyclones, not the other way round? More importantly, how does this section answers the question raised at the start of the paragraph (on the impact of the upper-level circulation on cyclones)? I only see a comparison of statistics at the upper and low levels.

l.179-187: As the Pacific jet is located further south compared to the Atlantic jet, it is hard to shift it more equatorward. Secondly, from my point of view, the magnitude of changes in two basins is very comparable despite of the smaller smoothing in the Pacific.

l. 188-191: Again, I do not see larger changes in the cyclone activity in the Atlantic. The patterns in the Atlantic and Pacific are slightly different, but this may be a result of the different location of the SST front/jet axis, as well as difference in the shape of continents. Moreover, I see a shifted storm track activity in the Atlantic or Pacific, however, basin-wide it does not seem to be weaker as opposed to the Southern ocean mentioned in the text.

l.192: The differences in the Atlantic are also shifted between the upper and lower levels, less than in the Pacific, but in the same direction. It will be interesting to add cyclone frequencies in the middle of the troposphere (e.g., 500hPa).

Fig. 5: If you keep this plot in the revised manuscript, could you estimate if the difference between lines (i.e., between mean values for the different cyclone types at every time step) are statistically significant and mark the time steps when the mean value for a given type is significantly different from the other two types? I would recommend focusing the discussion on significant results.

l.250, Fig.6: I am not sure if Fig 6 is worth showing. As the cyclone classification in this paper is based on the location relative to the SST front, the mean SST in the cyclone area is somewhat prescribed.

l.256: In line with my earlier comments, the statement that weaker SST gradients in the Pacific are not strong enough to affect cyclone development, points to the fact that, perhaps, the SST threshold for the Pacific regions should be increased. Ideally, I think, they should be identical (even if the Atlantic threshold is decreased).

l.303: As I said in the major comments, cyclones that have centres over the oceanic currents are not expected to cause strong heat fluxes.

l. 307, Section 3.4.2: In line with my Major comment 1, it will be interesting to show how much precipitation changes with cyclones most affected by the SST change. (however, the increased precipitation over the ocean currents may be associated with another subset of cyclones, not those that are related to the increased heat fluxes)

l.313: Does smoothed SST in the Atlantic lead to a reduced separation distance between the maximum in large-scale and convective precipitation? If that does not happen, then explain why smaller SST gradients in the Pacific are responsible for more collocated precipitation maxima in the Pacific.

l.323: the largest shift in cyclones occurs downstream of the selected regions, however, the precipitation changes most significantly within the black boxes. I think it should be discussed in the text.

l.349: specific humidity can be affected by cyclones over the central part of the Notrh Atlantic. Besides local change in evaporation over the ocean currents, changes in characteristics of the extratropical cyclones downstream of the Gulf Stream and Kuroshio may modify the intensity of warm conveyor belts. There is also an increase in the relative humidity in the south-east corner of the Pacific basin, most likely associated with a southward shift of the storm track.

Fig. 7-10: Indicated statistical significance of the differences.

l.395: The pattern in the Atlantic (jet, cyclone frequency) suggests negative NAO in the smoothed runs.

l.400: I like the hypothesis here. However, in my opinion, the jet response in the Pacific is mainly associated with a strong increase in cyclone frequency in the Bay of Alaska (Fig.4c). A well developed cyclonic circulation will increase (decrease) the wind speed to the south(north) of its centre. This low pressure system may also be responsible for the moisture advection from the central Pacific to north-east (Fig. 9f). Interestingly, cyclones over the Kuroshio are associated with an intensified subtropical jet.

Minor comments:

l.6: I'd replace the 'intensification' with 'intensity', unless you really want to stress the process of deepening, rather than the maximum strength of the systems.

l.14: change 'states' to 'state'

p.1, l17: and throughout the paper: change to 'regions' as the Gulf Stream and Kuroshio are two independent regions (as opposed to, e.g., the Kara and Barents Sea)

l.102: Introducing SMTHG and SMTHK, it is worthwhile mentioning the Gulf Stream and Kuroshio, respectively, instead of the North Atlantic and Pacific. Otherwise, it is not immediately obvious what K and G stand for.

l.145: replace ‘intensification’ with ‘intensity’.

l.199: Perhaps, ‘classification’ sounds better.

l.341: Did you mean that precipitation should shit equatorward in case of a reduced SST gradient? l376: change to ’40%’

It will be good to show lon/lat values for the gridlines (at least once in the beginning).

Fig. 1, caption: Remove the first ‘(a)’ from the caption. In c (and the following figures), make clear that it is SMTHG minus CNTL. The caption should mention black solid lines.

Fig.2, b, e: Why did you choose to show the SST gradient in 0.5K/100km instead of K/100km?

Fig.7-10: I do not think I understand the last sentence in the captions. What kind of scaling was applied? In this case please describe in the Methods.

Fig. 3: On my screen the ‘orange’ colour scale looks nowhere near to orange, I’d call it pale red. Perhaps, change the scale a little bit.

Fig. A1, panels b and e: The range of values in the colour scale is too big and yellow shading is hard to see against the white background. The colour scale does not match either Fig. 2a or 2d, so I do not see why you chose such large range.

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