

Response to Anonymous Referee #2

This manuscript assesses whether extreme hurricane seasons can be attributed to ocean warming and changes to circulation patterns. The authors develop a novel statistical model that utilizes daily weather patterns and average SSTs and find that increases in Atlantic SSTs have led to a higher likelihood that the North Atlantic will have extremely active hurricane seasons (or more extreme hurricanes). This paper is worthy of publication after some major changes to the delivery. There are a few areas worth mentioning.

1. I think the manuscript needs to be placed in the context of the literature. The authors cite a few papers related to the topic but there are many others. See my comments below.

We thank the reviewer for the concrete suggestions and will incorporate them in the revised manuscript.

2. I think the organization of the supplement needs some work. It included a large amount of information and introduced figures in a nonintuitive order. See my comments below.

We agree that the supplementary information could be organized and structured more meaningfully.

Minor Comments:

- Line 49: If the data are available, I'd recommend including 2019 and 2020 in your dataset.

We will do so in the revised manuscript.

- Line 53: Are the grid cells used to average those that are directly around (nearest0-neighbor) or is there a farther extent used for the average? Please clarify this in the text. And what is the temporal resolution of the data you used to average back out to daily? Did it start as daily data?

We would clarify this as follows in the revised manuscript:

"In order to remove the direct influence of TCs in the reanalysis data we replace an area of 9°x9° around the center of the storm with an average of the 16 grid-cells that lie outside of this 3x3 grid-cell square around the storm center."

The original data is sampled on a 6-hourly frequency. We will clarify this in the revised manuscript.

- Why are the tropical north Atlantic tropical storms being taken from a slightly larger area than the SST data? It would make more sense to have the same region unless there is a reasonable explanation for why it should remain different. It should be mentioned in the text.

We agree that this inconsistency should be explained in the text. While we want to study all tropical storms in the Atlantic basin, most of the storms form over a smaller region, the so called main development region (MDR). This region is commonly used in the literature and we would like to stick to this region as it reflects quite well the relevance of SSTs on TCs in the Atlantic.

We initially used a region for storm selection (fig. S3) to filter out extratropical cyclones. In the revised manuscript we will not use this region anymore and instead use the storm classification from IBTrACS to filter out extratropical cyclones.

- Figure S3 and S7 could be greatly improved. There are no axes labels, north arrows, scale bars. I think the authors should spend some time here.

We will improve both figures including grid lines and coordinate labels on the axes.

- Line 55: check acronym for ITrACS (which should also be spelled out completely for first use).

Well noted.

- What is your definition of an event? Is it all storms over 34 kts? 64 kts? Please add to text.

In the initial version, we included all storms for the ACE calculation. In the revised version we will only include storms above 34 kts and will clarify this in the text.

- How many storms does your analysis include? Please add near line 64.

In the revised manuscript we will include the years 2019 and 2020. With those years, the analysis will include 806 storms. We will include this information in the revised manuscript.

- Where are you getting your equation for ACE? Please cite.

We will cite Bell et al. 1999 in the revised manuscript.

- You use many acronyms without introducing them first – WMO, NOAA, IBTrACS. Please look through and introduce the first and then use them again after that. Just helps to make the reading a bit easier.

Thank you for pointing that out. We will introduce all acronyms in the revised manuscript.

- Your supplementary material figure order isn't intuitive. I'm getting S7 in the text before S1.

We will restructure the supplementary material in a more meaningful way.

- Figure 1 – I love this! I think you made an excellent figure and a great way to visualize the variables across time. Once this is published, I'll be using this in my hurricane class. Nicely done!

Thanks a lot! We would be happy if you use it.

- I'm not sure I understand the purple arrow placement on Figure 2. Can you add something to the text that describes this figure to guide a reader how to use it.

The purple arrow implies that one input for the intensity calculation is the intensity of the storm on the day before. This input can not directly be related to SSTs or weather patterns. We will clarify this in the figure caption.

- Line 116: extent, not extend

Well noted.

- Paragraph 112-115: I'm not sure I understand the choices you have made for the duration. At the very least, this section needs to be cited for support about why the duration assumptions are

made. Even better would be a sensitivity to test to understand how sensitive your model output is to different assumptions. This is also applicable to your intensity discussion.

Please see the comment 6 comments below that starts with: “Disregard my comment above about sensitivity testing...”

- Line 134: too not to

Well noted.

- Lines 112-135 need to be better cited. There are many publications that can be used to show support for these things. Trepanier (2020) in atmosphere utilizes local SSTs in the North Atlantic to estimate the probability of extreme hurricane winds throughout the basin. This is applicable to support your choices here.

We agree that a citation for this paragraph was missing and thank the reviewer for suggesting this reference. We will include it in the revised manuscript.

- Line 153: Did your data start with 1979 as previously stated or 1982? Please check this.

We thank the reviewer for pointing out this inconsistency. When starting the clustering exercise for the weather patterns, we were working on the available ERA5 data at that time which was 1979-2018. Later on we decided to use SSTs from the DOISST data set from NOAA, which only starts in 1982. In a revised manuscript we would consistently use the period 1982-2020 (or even 2021) for each part of the analysis.

- In Figure 3, what is your neutral year?

Thanks for pointing out this inconsistency! The neutral year (cyan in fig. 3) is 2009. We will change the figure caption and the text accordingly.

- It is interesting that ACE has the highest correlation and storm formation has the least. This could be related to the way you defined storm formation (and duration) but it could also be related to the notion that SST more predominantly affects intensity and less the formation of storms. Perhaps worth mentioning.

We thank the reviewer for sharing this interpretation. In our view, this mainly shows that with weather patterns and SSTs we can adequately estimate the potential for seasonal TC activity which appears to be easier than emulating storm formations. In that sense, the intensification component of the emulator can be seen as control instance that won't allow seasons to become highly active if SSTs are cool even if for some reason the emulator produced a high number of storms. Consequently, one could think that including SSTs into the storm formation component could improve the skill of the emulator, but there is no clear evidence for the effect of SSTs on storm formation numbers and our sensitivity analysis suggests, that including SSTs in the storm formation component does not improve the emulator. In the revised manuscript we will elaborate more on this aspect.

- Disregard my comment above about sensitivity testing. I see you did this in the supplementary. Kudos and thanks for that. I still think it needs additional citations, though, pretty much throughout this whole thing.

We agree with the reviewer and will add references for the assumptions underlying the three components of the emulator.

- The supplement is difficult to follow and dense. As I was finishing this review, I noticed Reviewer 1 commented. I completely second this individual's 2nd main comment. The amount you have in the supplement looks to be enough for another manuscript. It should be easy to follow and directly relate to the text. You may reconsider restructuring it.

We totally agree with both reviewers and will restructure the supplement.

- Figure 6 caption description – I think you mean vertical line, not horizontal

Thank you!

- Since 2019 and 2020 are not represented in here, as I noted earlier, can your emulator be used to estimate the number of storms, etc., for those two seasons? Can you put the known conditions in and see if it produces a similar ACE, duration, etc. for those that aren't in the data set? Could be an interesting addition to the work.

We will include those years for the analysis of the revised manuscript.

- What are you hoping someone does with this emulator? Can you provide a little broader impact context to the discussion?

We are hoping that this emulator can be used to further investigate the influence of potential changes in atmospheric circulation patterns on hurricane activity. One major challenge in tropical cyclone research is that TCs are not well reproduced in common climate models. Applying this emulator to projections of weather patterns and SSTs from a comprehensive ensemble of climate models could help to better estimate how atmospheric circulation changes resulting from global warming might affect TC activity.