Assessment of ENSO-TC Relationship in the HighResMIP Models

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1. Introduction

- El Niño Southern Oscillation (ENSO) modulates Tropical Cyclone (TC) Activity.
- ENSO conditions can impact the formation, intensity, duration, and location of TCs.
- El Niño events are warm SST anomalies (above 0.5°C for observational analysis), La Niña are cool SST anomalies (below -0.5°C for observational analysis).
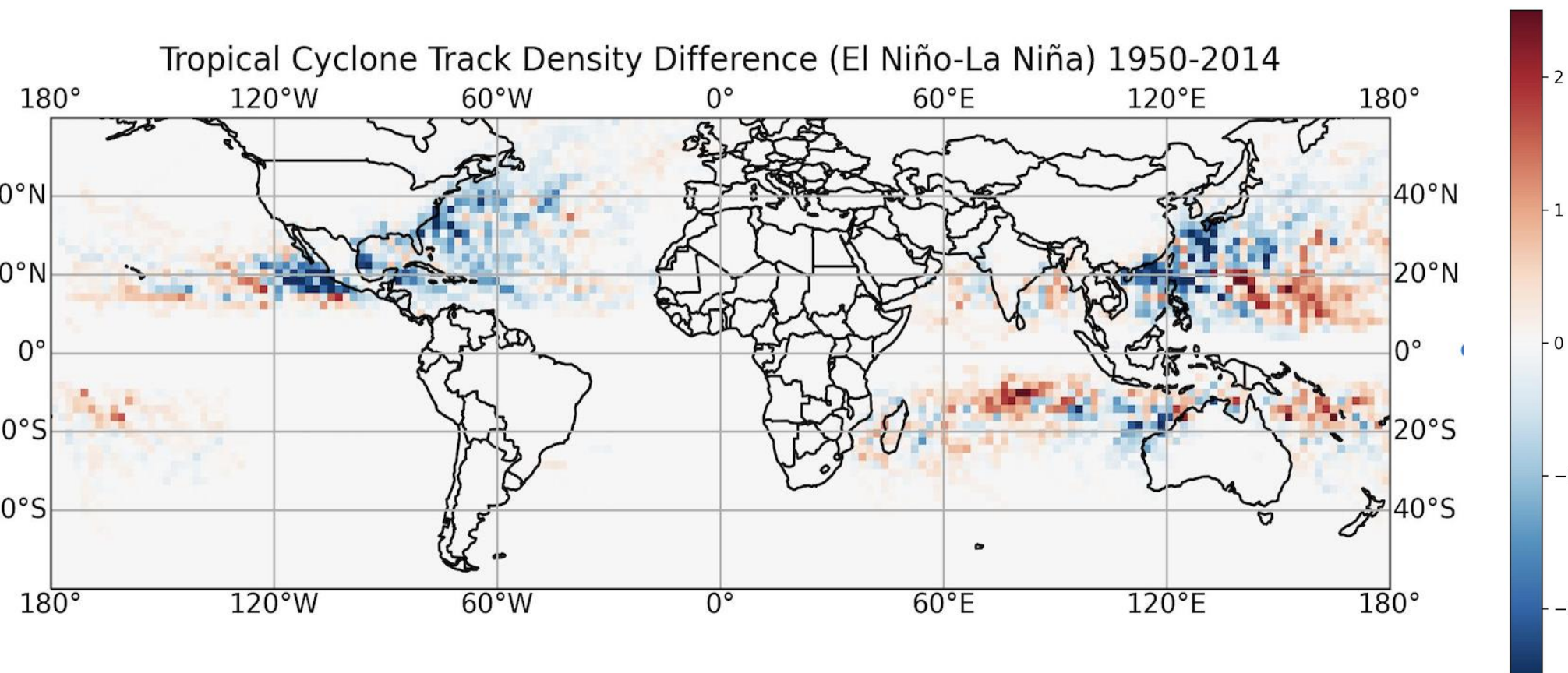

Fig 1: Observed TC track density difference between El Niño and La Niña events. ENSO events were determined using ASO definition for Northern Hemisphere and JFM for Southern Hemisphere. TC tracks for each ENSO phase were summed and normalized by dividing by number of events in each ENSO phase.

- Observed track density difference between El Niño and La Niña show the different response of basins to ENSO, e.g. NA basin is more active during La Niña events.

2. Motivation

1) Analysis of ENSO-TC historical relationship in high resolution climate models simulations.
2) Examine if and how the ENSO-TC relationship is changing due to anthropogenic climate change in HighResMIP models.
- HighResMIP is a subset of CMIP6 models run at high resolution for historical and future periods.
- Model simulations' ability to reproduce the ENSO-TC relationship evaluated by comparing it to historical relationship.
- Historical and future model simulations compared to determine if the ENSO-TC relationship is changing with anthropogenic climate change.

7. References

Roberts, M. J., et al. (2020). Impact of model resolution on tropical cyclone simulation using the highresmip–primavera multimodel ensemble. *Journal of Climate*, *33*(7), 2557–2583. https://doi.org/10.1175/JCLI-D-19-0639.1

Roberts, M. J., et al. (2020). Projected Future Changes in Tropical Cyclones Using the CMIP6 HighResMIP Multimodel Ensemble. *Geophysical Research Letters*, *47*(14). https://doi.org/10.1029/2020GL088662
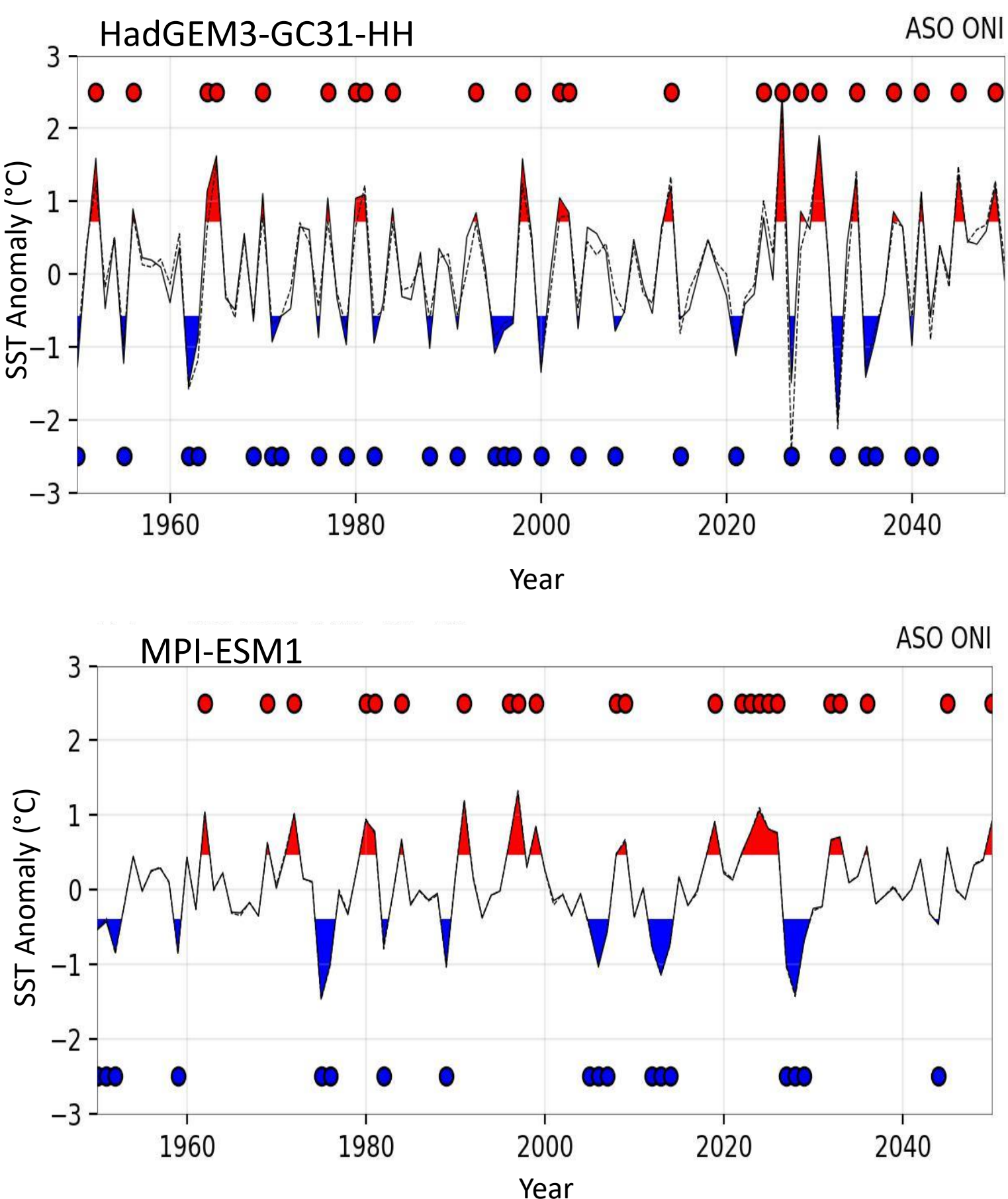
3. ENSO Characteristics in Models

Fig 2: SST anomalies for two of the six models evaluated between 1950-2050.

- SST anomalies calculated using a custom box method, which selects the area in the Equatorial Pacific with the greatest variation in SST.
- Threshold for ENSO events is based on the standard deviation of the SST anomalies of each model (0.75x the standard deviation of the SST anomalies in the custom box).
- Difference in both frequency and magnitude of events between models examined using figures.
- Models typically were able to reproduce frequency of El Niño events more accurately than La Niña events.

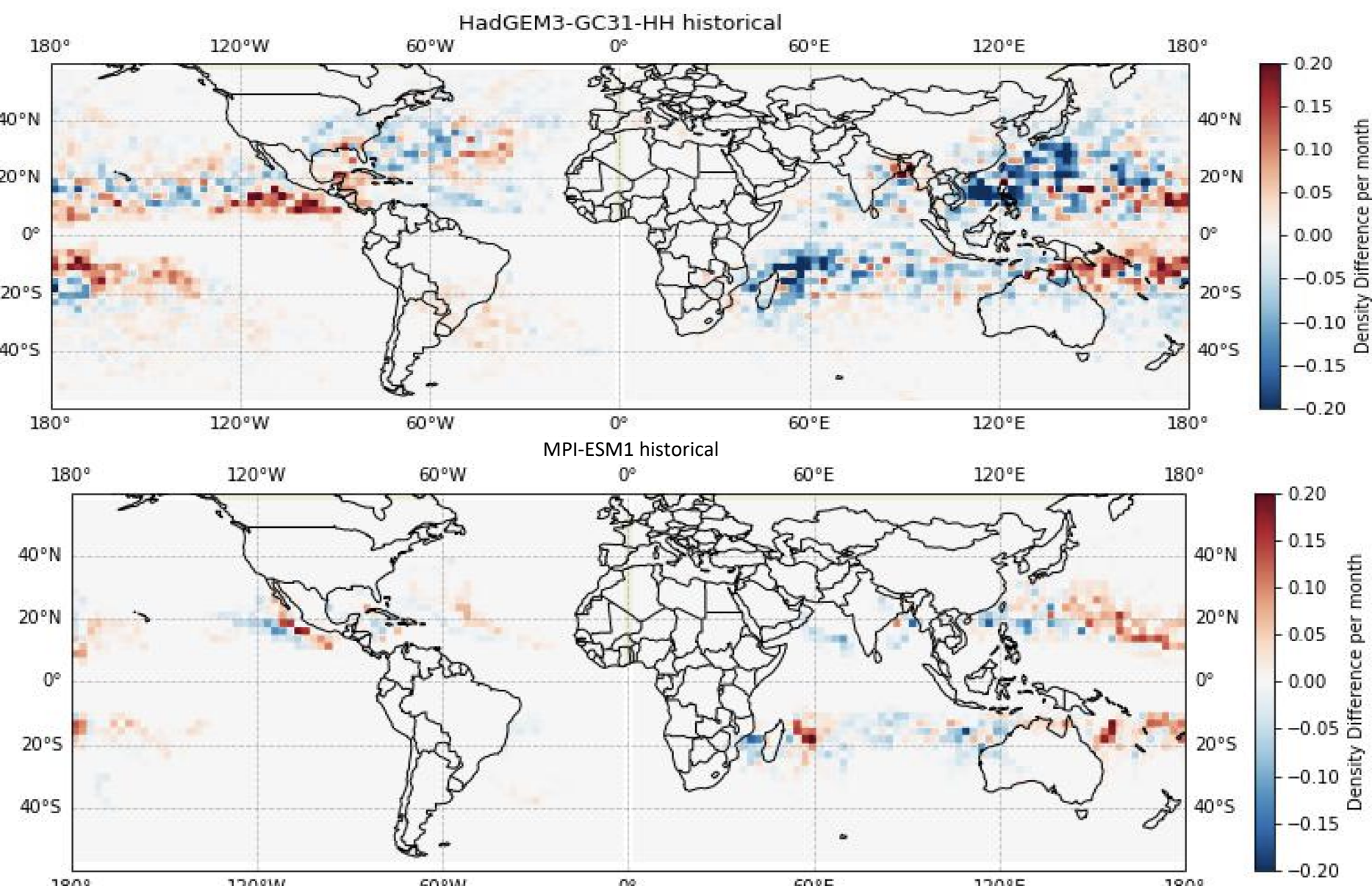## 4. ENSO-TC Relationship in Models-Historical

Fig 3: Track Density difference (El Niño-La Niña) for HighResMIP models in two of the six historical simulations evaluated. Differences are normalized for the number of ENSO events in each model.

- Varying skill of ENSO-TC relationship reproduction across basins for all six model simulations.
- Considerable difference in ENSO-TC relationship simulation between the six models.

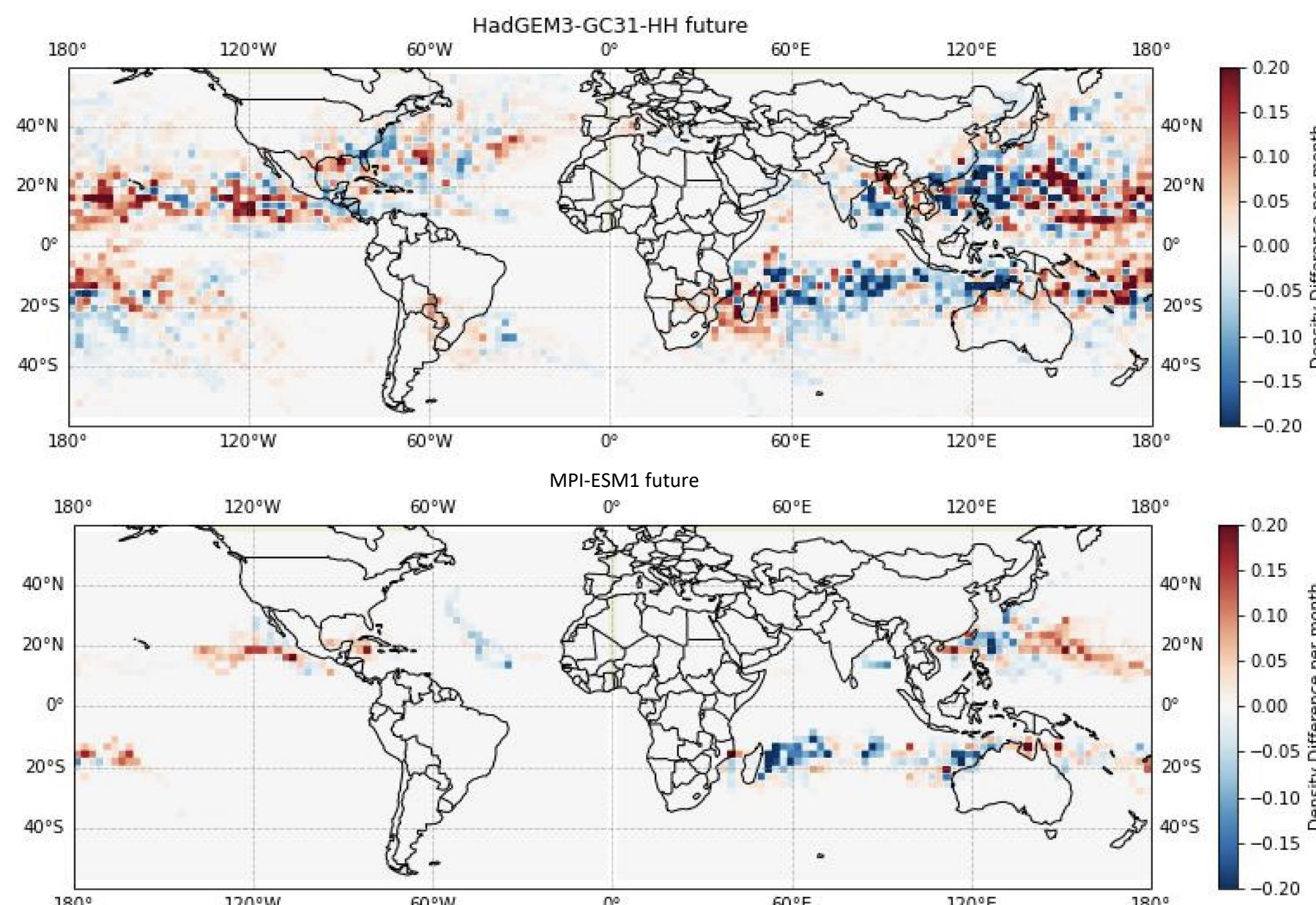## 5. ENSO-TC Relationship in Models-Future

Fig 4: Track Density difference (El Niño-La Niña) for HighResMIP models in two of the six future simulations evaluated. Differences are normalized for the number of ENSO events in each model.

- Appearance of increased ENSO-TC activity for each future simulation compared to corresponding historical simulation for the six models.
- Differences in ENSO-TC relationship in specific basins for future simulation compared to historical simulation.

6. Summary

- HighResMIP model simulations investigated vary in skill of ENSO simulation frequency. Models more accurately simulated El Niño than La Niña.
- Ability of the models to reproduce the ENSO-TC relationship was evaluated by comparing it to historical relationship. Variation in skill of simulation across basins.
- Large differences in the ENSO-TC relationship across models. For example, more ENSO-TC activity across all basins in HadGEM3-GC31-HH model compared to MPI-ESM1 model.
- There are differences in the ENSO-TC relationship between the historical and future model simulations. The next step will be to determine the statistical significance an agreement among all the HighResMIP for these differences.