1. Motivation

- Tropical cyclone paths have been extended meridionally in recent decades (ref. 1).
- Tropical cyclones (TC) developing over the ocean threaten society when they approach land.
- The mean distance of TC location from the closest shoreline at lifetime maximum intensity (LMI) is getting shorter in the recent 40 years (ref. 2, fig.1).

As only one realization, the cause is unclear; external forcing vs natural variability.

External forcing:
- Impact on global spatial distribution of TC (ref. 3).
- Hadley Cell expansion (ref. 1).

Natural variability:
- Pacific Decadal Oscillation (PDO) changes the atmospheric circulation (ref. 2).
- ENSO impacts the TC genesis and intensity over the western North Pacific (ref. 4).

Aim of this study: identify the cause of the observed LMI trend through a multi-model data analysis.

2. Data and method

- We analyzed outputs of high-resolution global multi-model ensemble simulations prepared by the PRIMAVERA project according to the CMIP6 HighResMIP protocol (ref.5, table 1).
- TC tracking data are publicly available for the models (ref. 5), reanalysis (ref. 6), and observation (IBTrACS; ref. 7).

We calculate the instantaneous distance using these tracking data and discuss the reproducibility of the trend in LMI distance on the following assumption:

- AGCM ensemble mean captures SST forcing.
- CGCM ensemble mean captures external forcing (global warming).

3. Results

3-1. Simulated annual mean time series of the LMI distance

- AGCM: Significant trend is reproduced for both MME and 4/10 simulations (Figs. 2a, 3a, 3c).
- CGCM: No significant trend for MME, and the time-evolution is very different from each other.

Importance of natural SST variability on the LMI trend, not global warming.

3-2. Association of the LMI distance trend with SST variability; IPO

- SST anomaly associated with the global-mean LMI distance (Fig. 4a) anomaly shows a similarity to the natural SST variability pattern known as Inter-decadal Pacific Oscillation (IPO, fig. 4b, ref. 8)
- Correlation between the detrended LMI distance and IPO for AGCM (fig.4c) is 0.67 (p<0.01).
- IPO shows a negative trend during 1981-2020 (fig. 4c).

3-3. Process at work in variations of LMI distance; TC genesis locations

- Trends of LMI distance and the genesis distance are highly correlated for both global and Pacific averages (Fig. 5).
- The global mean trends reflects the Pacific basin. In the Pacific basin, the mean annual TC genesis number in IBTrACS (1981-2020) is 59.7, which is 70.1% of the entire globe (85.2).
- For IBTrACS, the genesis-distance trend explains 80.8% of the LMI-distance trends for the global domain and 73.1% for the Pacific domain.
- Due to the closer location of TC genesis to land, the LMI locations also became closer.

3-4. Association between the TC genesis distance and IPO

- Focusing on the Pacific basin, IPO strongly influences the decadal-scale variation in the location of TC genesis locations, which was found through the observation, AGCM, and CGCMs (Fig.6).
- This association plays a vital role in variations of LMI distance.

4. Summary

- Our HighResMIP data analyses revealed that the cause of the recent tendency of TCs approaching coasts is the natural SST variability known as IPO, not the global warming.
- IPO impacts on the TC data locations over the Pacific basin, thereby influences the LMI distance.
- The observed LMI trend is not expected to continue in the future.

4.1. Observations and reanalysis data used in this study. Resolution indicates the atmospheric grid spacing at the equator.

4.2. Observed annual-mean LMI distance and its 5-year running mean.

4.3. Observed annual-mean LMI distance and its 5-year running mean.

References