Sea Surface Temperature at Tropical Cyclone Genesis across Ocean Basins: Distribution and Evolution

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Introduction

- **Mechanisms of tropical cyclone (TC) genesis** are still not clear, leading up to uncertainty in future projections of TC activity.
- Warm **sea surface temperature (SST)** is thought to influence TC activity—frequency, intensity, rainfall—such that global warming leads to expectation of changes in TC activity.
- There is a degree of consensus concerning the projected response of the **global** TC genesis rate to climate change; however there is no agreement about the projected **regional** changes [1] and there are some discrepancies in trends of potential intensity [2].
- Recent studies have re-examined the **hypothesis of a SST threshold** for tropical cyclogenesis [3, 4] on a global scale.
- While trends for SST during tropical deep convection have been established [5], the **long-term trends for SST** at the time of tropical cyclone genesis have not been previously documented.

Methods

Tropical cyclone **genesis** is the moment when the maximum sustained wind first reaches 18 m s^{-1}.

The 5 basins with most TC activity are examined between 1982 and 2013: North Atlantic, West Pacific, East Pacific, South Pacific and South Indian.

SST$_G$: SST at the time of TC genesis.

SST$_S$: SST averaged over the main development region of each basin during its tropical cyclone season (i.e., months of main TC activity).

SST$_{conv}$: SST at the location where there is tropical deep convection—i.e., where the Outgoing Longwave Radiation (OLR) is smaller than 240 Wm^{-2}—over ocean basins.

The probability distribution functions (PDF) are obtained by dividing the SST range in bins of 0.5°C, overlapping by 0.49°C, and computing the percentage occurrence for each SST bin.

The time series are annual-mean values and the trends are obtained by linear regression. The determination of the 95% confidence interval and the statistical significance of the trend take into account autocorrelation of the time series.

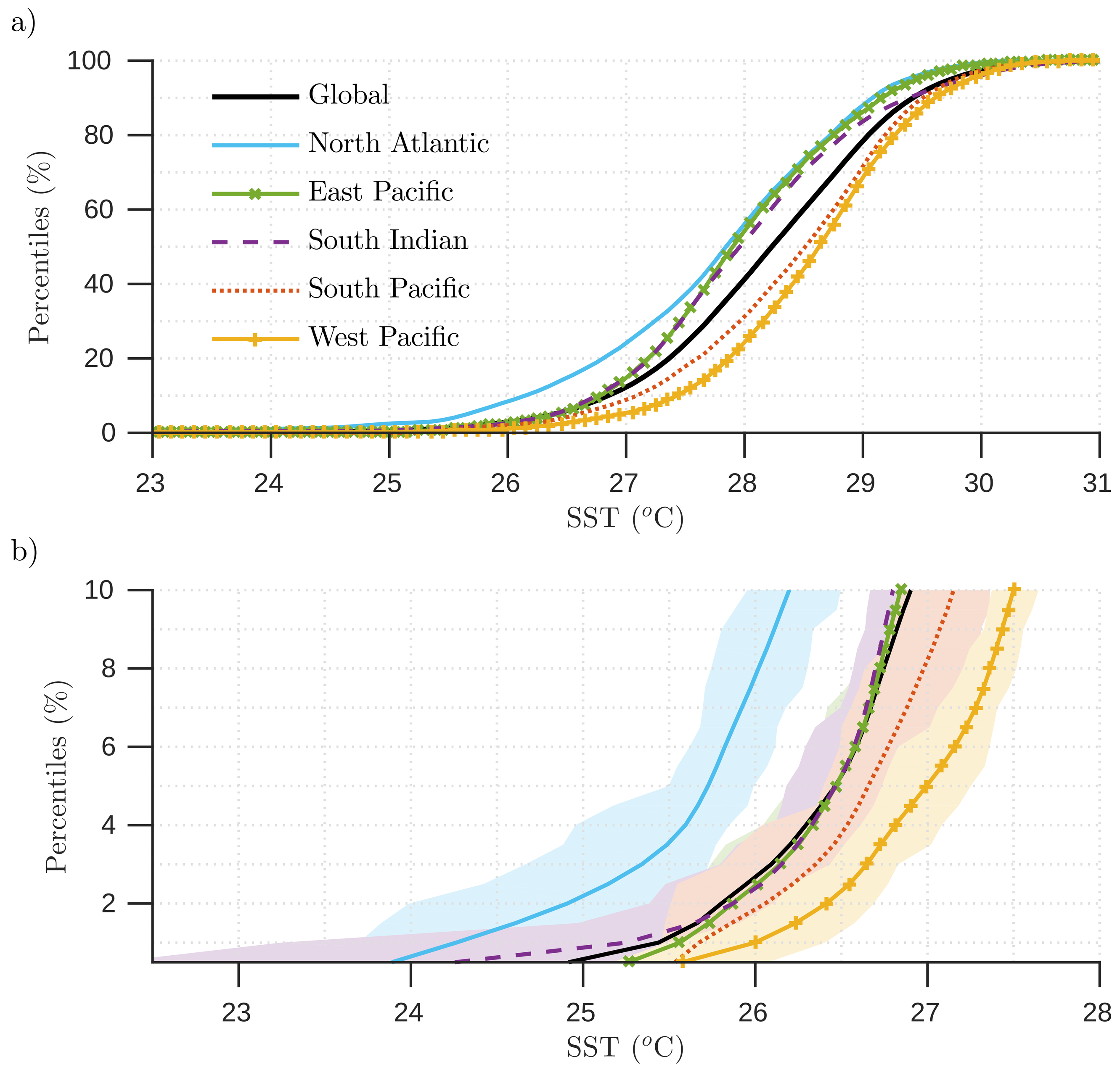

Figure 1: Cumulative distribution of the SST observed at the time of TC genesis (SST$_G$), for each ocean basin separately (colored lines indicated in the legend) and for the globe (thick black line) for (a) the full distribution and for (b) the lowest percentiles with 95% confidence interval (shaded).

Distribution of SST$_G$ and SST$_S$

- Distribution of SST$_G$ **varies across ocean basins**, with different values of mean and standard deviation.
- Distributions of SST$_G$ are nearly **symmetric** and close to those of the summer environment (SST$_S$), except for the East Pacific basin.
- The peak of SST$_G$ occurrences is generally slightly colder than the most frequent observed SST$_S$, and the standard deviation is slightly smaller for SST$_G$ than for SST$_S$.
- Within each basin, SST$_G$ and SST$_S$ span the **same range**.

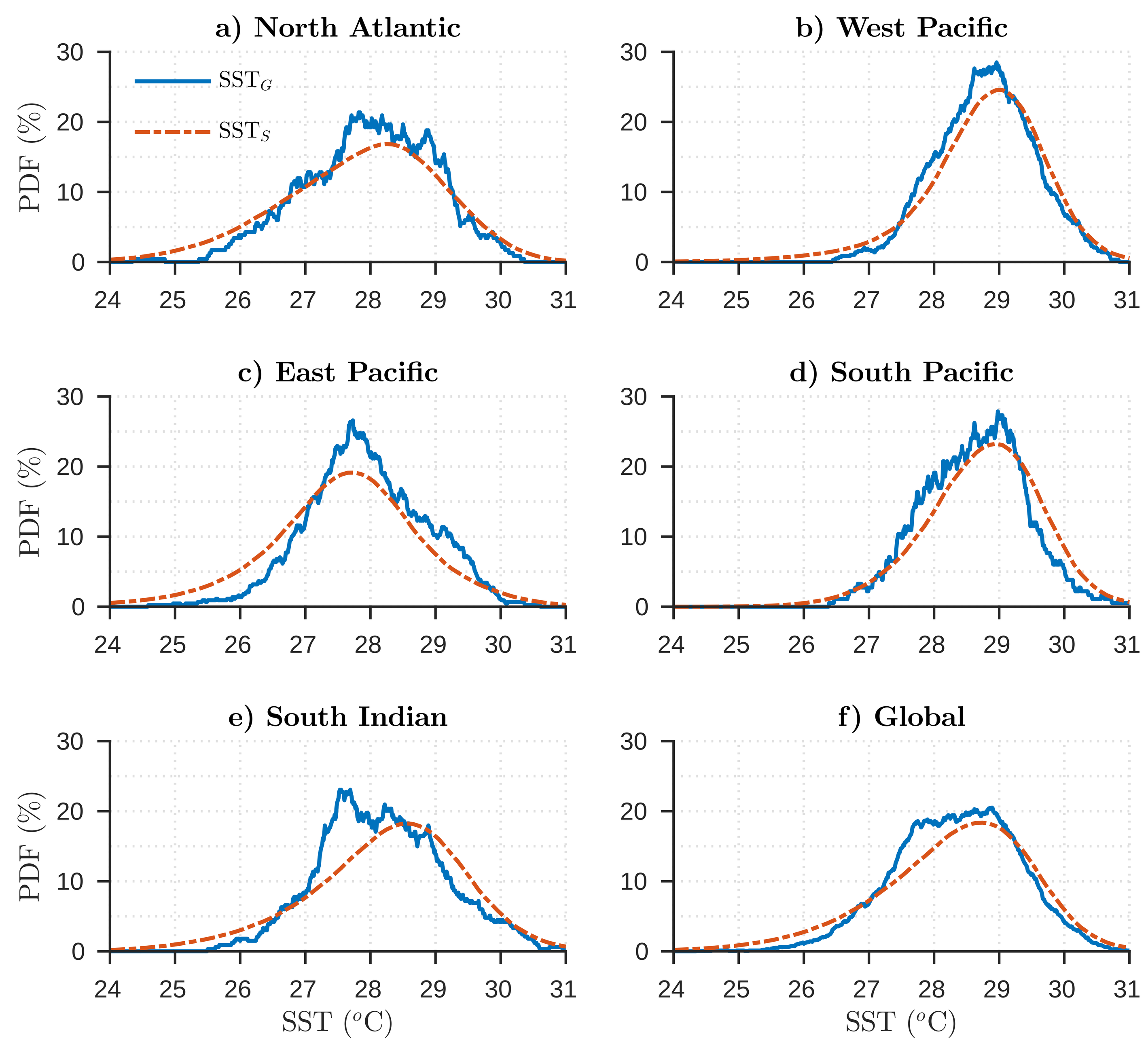

Figure 2: Probability distribution functions of SST at TC genesis (SST$_G$) (full line) and of SST observed during the TC season (SST$_S$) for each basin (dash-dotted line): a) North Atlantic, b) West Pacific, c) East Pacific, d) South Pacific, e) South Indian, f) Global.

Data

- International Best Track Archive for Climate Stewardship (IBTrACS) database [6] for TC tracks (v03r06).
- Optimum Interpolation Sea Surface Temperature (OISST) data set [7] for daily SST values.
- NOAAs Climate Data Record (CDR) Program, [8] for daily OLR values (version 1.2).

References

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Observed long-term trends

- SST$_G$, SST$_S$, and SST$_{conv}$ show **similar year-to-year variations**, except in 1995 for SST$_G$.
- SST$_G$, SST$_S$, and SST$_{conv}$ show **comparable, significant long-term trends** of approximately 0.2°C per decade.
- Same results hold with HadISST data set, but with different absolute values of the trends.

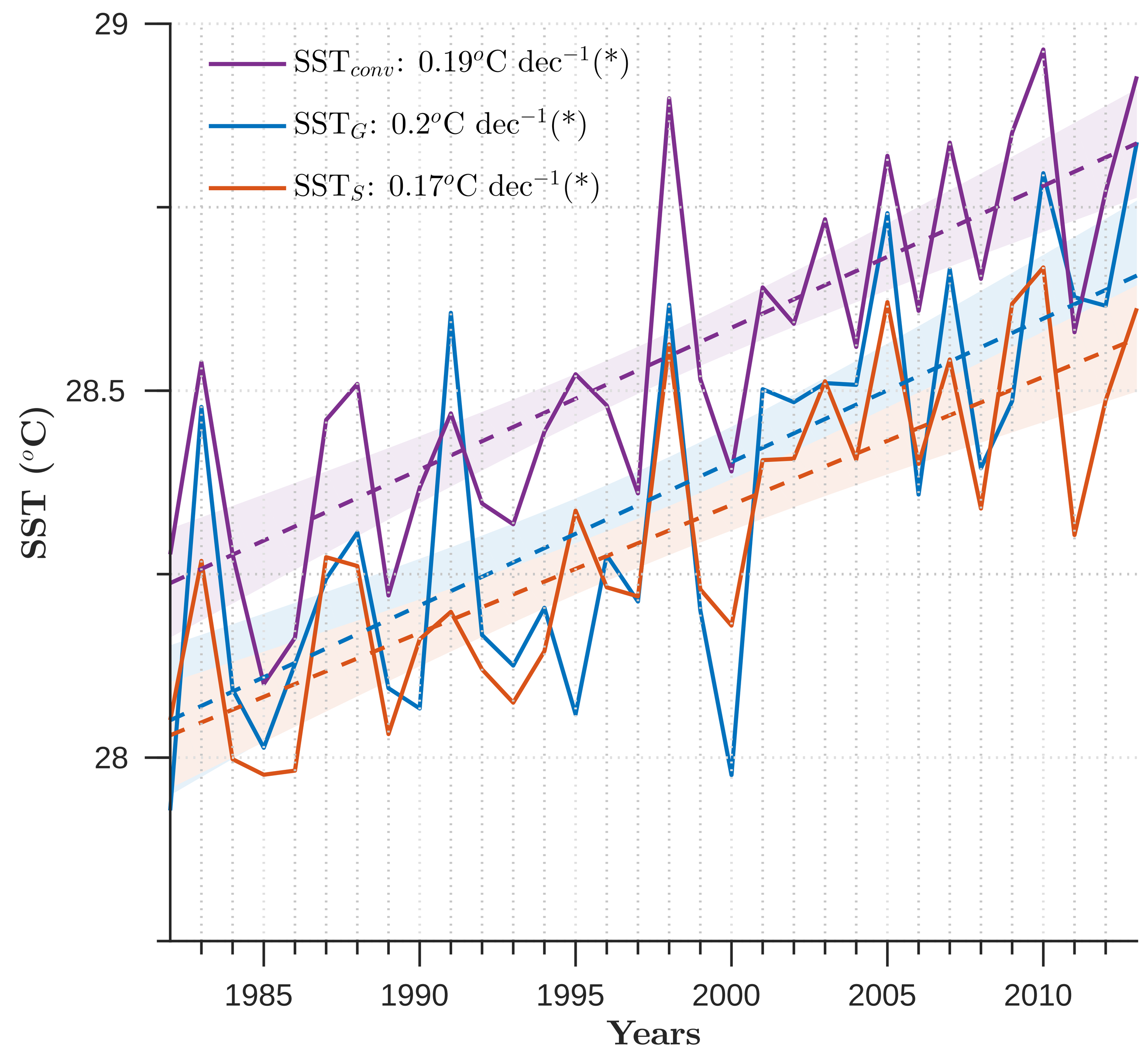

Figure 3: Time series of SST at TC genesis (SST$_G$), SST at location of tropical deep convection events (SST$_{conv}$), and summer-environment SST (SST$_S$), averaged over the 5 basins with the most TC activity. For each curve the linear trend (dashed lines) and the 95% confidence interval (shaded area) are also shown.

Conclusions

- Differences between basins in SST at TC genesis indicate that an **apparent global threshold SST for TC genesis arises from climatologically colder basins**.
- SST bounds for TC genesis are set by the **climatological bounds of the basin**.
- **Increasing SST favors TC genesis for SSTs colder than the mean SST**$_S$ of the corresponding basin, while the likelihood of genesis is insensitive to SST for warmer SSTs.
- Similarities between SST$_G$, SST$_S$ and SST$_{conv}$ indicate that **SST in and of itself is not a good predictor for TC genesis**.
- **SST**$_G$ **and SST**$_{conv}$ **generally reflect mean SST in summer environment**, and the long-term trend is attributable to anthropogenic climate change.

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For further information please see [9] or contact cecile.defforge@mail.mcgill.ca