147. THE DISTRIBUTION AND EVOLUTION OF SEA SURFACE TEMPERATURE AT TROPICAL CYCLONE GENESIS ACROSS OCEAN BASINS

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1 Introduction

The mechanisms of tropical cyclone (TC) genesis are still not clear, however some environmental factors such as warm sea surface temperature (SST) are thought to be favorable to TC genesis.

Since 1948, it has been commonly accepted that the development of tropical cyclones requires a minimum threshold SST of 26°C (Palmen, 1948; Gray, 1968). While it is understood that multiple environmental factors are important for TC genesis, recent studies have focused only on the SST and have re-examined the hypothesis of a SST threshold for tropical cyclogenesis (Dare and McBride, 2011; Tory and Dare, 2015). They analyzed the distribution of SSTs at the time of TC genesis (hereafter referred as SST_G), with TC genesis being defined as the first time the maximum sustained wind reaches 18 m s^{-1}. The recent studies confirmed the value of 25.5°C as a "threshold", as 98% of the TCs develop over warmer SSTs.

While existing studies examined the global SST_G distribution, we performed a basin-by-basin analysis for five of the most active basins. The following sections describe the data and methodology used to analyze the SST_G distributions and present results of the comparison between the basins. The results show that SST_G distributions are close to normal distributions with different values of the mean and standard deviation for each basin and that they generally reflect the corresponding basin-mean SST distribution over the summer season.

2 Data

We use the tropical cyclones track information from the International Best Track Archive for Climate Stewardship (IBTrACS) database (Knapp et al., 2010) which is comprised of data from 11 tropical cyclone centers since 1842, including the position, the wind speed and the ocean basin every 6 hours of the storm track. The IBTrACS database also indicates the nature of the storm (tropical, subtropical, extratropical, etc.), which is determined by the individual meteorological organizations for each basin.

The storm tracks are combined with the Optimum Interpolation Sea Surface Temperature (OISST) dataset (Reynolds et al., 2007) from the National Oceanic and Atmospheric Administration (NOAA). It provides daily mean values of SST with a horizontal resolution of 0.25°, from 1982 to the present.

3 Methodology

The present study is performed over the 33-year period from 1982 to 2014. All the storms which developed during this period are filtered in order to study only those which reach tropical cyclone intensity in the Tropics.

Consistent with previous studies, the storms that are not labeled as "tropical" in the IBTrACS database and those that developed at latitude poleward than 35° are excluded (Dare and McBride, 2011; Tory and Dare, 2015). We also used more objective methods which only consider the latitude at the time of TC genesis and define the boundaries of the Tropics accordingly to dynamical criteria. However, it appears that SST_G distributions are not sensitive to the method used to exclude non-tropical storms, so only the one using IBTrACS labels is presented here.

For the selected tropical cyclones, we look for the SST at the location and time of genesis, performing linear interpolation in time. The SST is averaged over a horizontal square of 1.5° of longitude and 1.5° of latitude following McTaggart-Cowan et al. (2015). The storms are sorted according to the basin in which they developed and the five most active basins are examined here: North Atlantic, West Pacific, East Pacific, South Pacific and South Indian. All the values of SST_G are sorted into bins of 0.5°C and the percentage oc-

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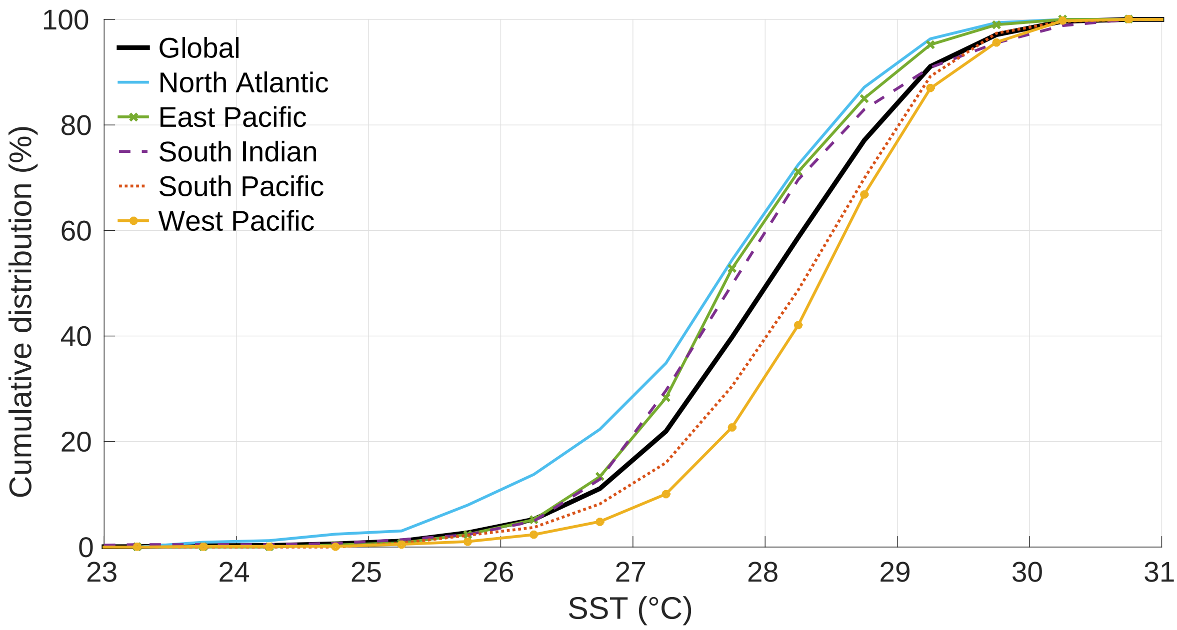

Figure 1: Cumulative distribution of the SST at the time of TC genesis (SST_G), for each ocean basin separately (colored lines indicated in the legend) and for the globe (thick black line)

currences of each SST_G bin is computed.

The surface temperatures of each basin during its 33 summer-seasons are also studied, hereafter referred as SST_S. The summer-season and the spatial extent of each basin are defined in Table 1 (Wing et al., 2015). As in our analysis of SST_G, the values of SST_S are sorted in bins of 0.5°C and percentage occurrences are examined.

Table 1: Spatial and temporal extent of the summer season for each basin

Basin	**Longitude**	**Latitude**	**Summer months**
NA	265°- 340°E	10°- 28°N	July to October
WP	110°- 170°E	5°- 25°N	June to November
EP	190°- 270°E	8°- 20°N	June to October
SP	135°- 220°E	8°- 20°S	January to April
SI	40°- 130°E	5°- 20°S	December to April

4 Results

Figure 1 shows the cumulative distributions of SST_G for each ocean basin separately. It also shows the global distribution of SST_G (thick black line), reproducing the results of Dare and McBride (2011) and Tory and Dare (2015). All the basins show different characteristics regarding SST_G, with North Atlantic being the coldest basin and West Pacific the warmest one. The SST_G values of the lowest percentiles correspond to the SSTs under which TC genesis is very unlikely. These values differ between the basins and the global values for percentiles smaller than 10% are colder than all the individual basins, except the North Atlantic one. The East Pacific and South Indian basins also have cold values of low percentiles, though slightly warmer than the global values. This figure highlights the differences between the basins' SST_G distributions and illustrates that the global distribution erases these basins' specificities. In particular, the cold tail of the global distribution is influenced by the cold SST_G events in the climatological coldest basins. Therefore, a SST "threshold" derived from the global distribution of SST_G does not adequately represent warmer basins such as West Pacific.

Figure 2 shows the probability density function (PDF) of the SST_G for each basin (solid line) and

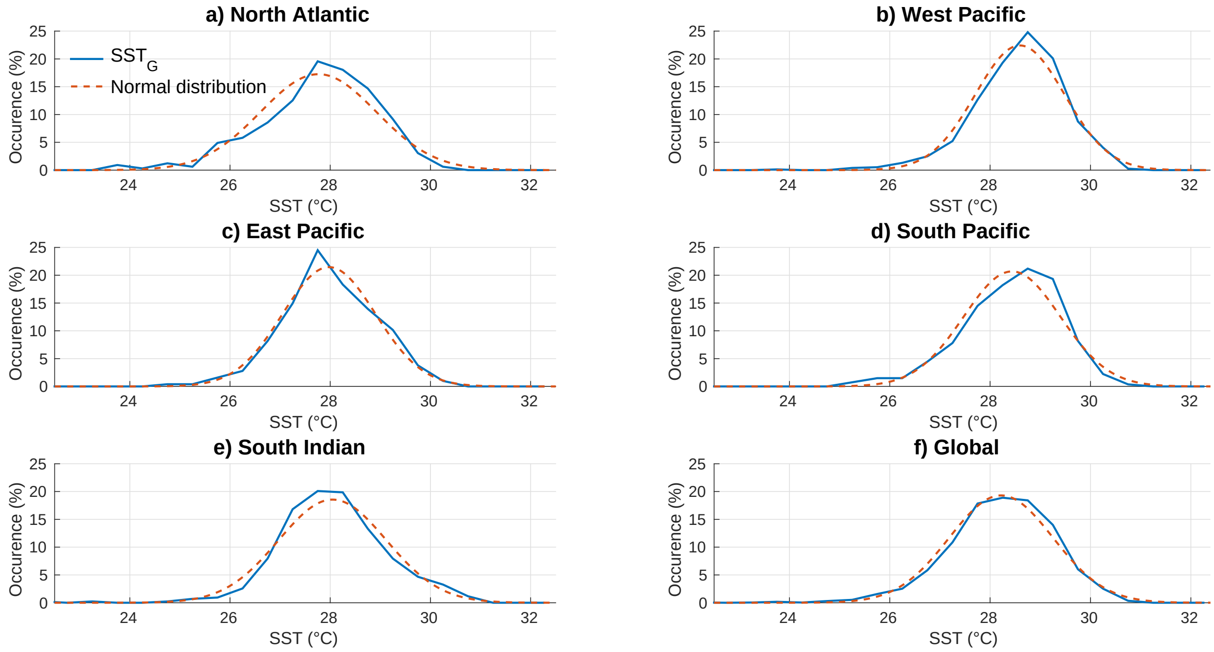

Figure 2: Probability distribution function of SST_G (thick line) and the corresponding normal distribution (dashed line): a) North Atlantic basin, b) West Pacific basin, c) East Pacific basin, d) South Pacific basin, e) South Indian basin, f) Global

the corresponding normal distribution estimated using the basin's sample mean and sample standard deviation (dashed line). For each basin the two distributions are quite similar. In addition to showing that the mean value of SST_G varies by approximately 1°C between the basins, this figure shows that SST_G occurrences increase smoothly with SST in the cold tail of the distribution.

Figure 3 shows the PDF of SST_G for each basin and the PDF of SST_S. In the East Pacific basin, genesis at cold SST is less likely, while in other basins, such as the West Pacific, the distribution of SST_G is shifted to colder temperatures relative to the summer-season SST distribution. The similarities between the SST_G and SST_S distributions, except for the East Pacific basin, suggest that the warm and cold bounds of the SST_G distribution are set by the climatological bounds of the basin's SST. It also indicates that during summer season, when the other parameters influencing TC genesis are also favorable, the probability of TC genesis is comparable over the range of environmental SSTs.

5 Conclusions

This study of the distribution of SST at TC genesis shows that all the basins have their own characteristics. The differences between the basins suggest that an apparent global threshold SST for TC genesis arises from the climatological colder basins, in particular the North Atlantic basin which accounts for the coldest genesis events. The fact that TC genesis occurs over different ranges of SSTs, according to the basin considered, also indicates that the covariance of SST with other environmental parameters which are important for TC formation (e.g., vertical shear and humidity) differs between the basins.

The similarities between the occurrences of the SST at the time of TC genesis and the SST observed during the entire summer season, for all the basins except East Pacific, implies that for each basin there are comparable probabilities of TC genesis for all the SSTs encountered during its summer season.

In subsequent research, we will assess the long-term trends in the SST at times of genesis.

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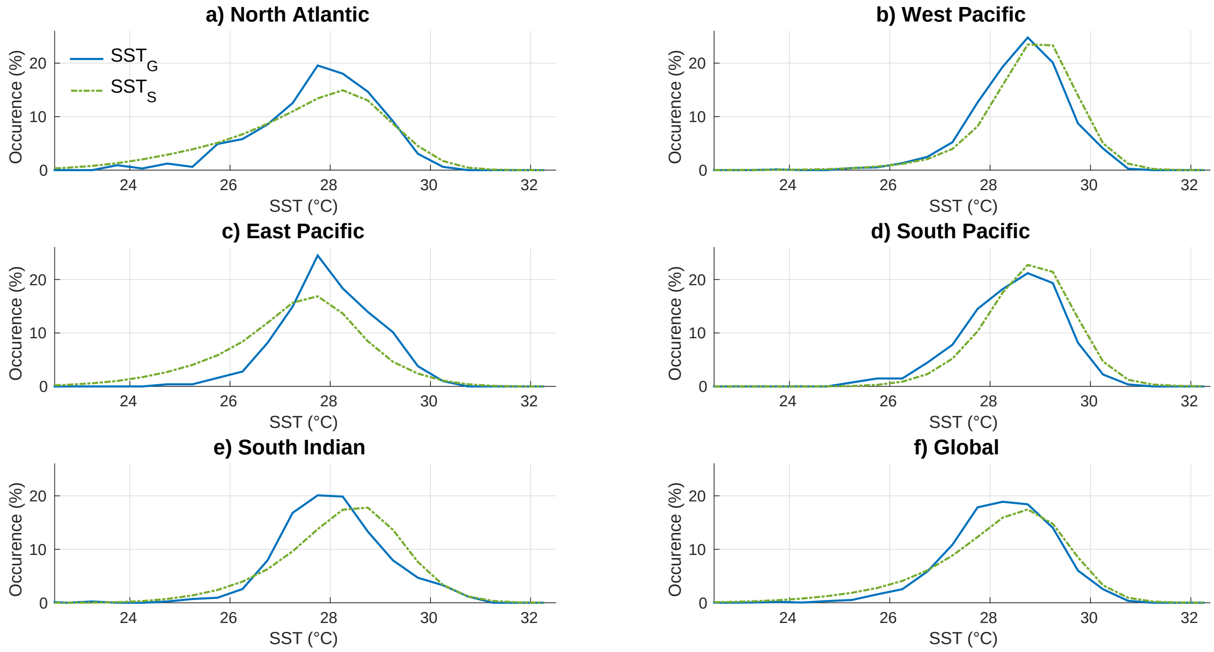

Figure 3: Probability distribution function of SST_G (thick line) and of the SST observed during the summer-season (SST_S) for each basin (dash-dotted line): a) North Atlantic basin, b) West Pacific basin, c) East Pacific basin, d) South Pacific basin, e) South Indian basin, f) Global

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