An Analysis of the Relationship Between Cyclogenesis Latitude and Sea Surface Temperature Anomalies

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ABSTRACT

Because cyclones can cause large scale destruction to human infrastructure, it is necessary to develop models that can effectively predict their occurrences. Though current research points at a poleward migration of yearly average cyclogenesis latitude in the Pacific region, developed trendlines of the shift cannot accurately predict seasonal cyclogenesis variability. In this investigation, I attempted to develop a new method that could predict yearly variability in cyclogenesis latitude during the cyclone off-season (months between consecutive cyclone seasons) using sea surface temperature (SST). The goal was to create a model that would achieve a balance between climatic prediction and immediate prediction. In such a scenario, both the level of accuracy and time span prior to storm occurrence are satisfactory enough to minimize physical damage. Additionally, the amount of weather data to analyze would be minimized by decreasing the time span to the off-season. To perform correlations between SSTs and cyclogenesis latitude, average latitudes of positive SST anomalies (regions of above average temperature) during the cyclone off-season (months between consecutive cyclone seasons) were calculated through the development of a Python algorithm. This algorithm could extract pixel coordinates from SST images by identifying color values that correspond to positive SST anomalies. This analysis was performed solely in the Northeast Pacific region. Moderate to strong non-linear relationships were found to exist, more apparent when averages were weighted in favor of larger positive anomalies.

Introduction:

Current research in tropical meteorology points towards the possibility of a poleward shift in the average yearly location of cyclone location of maximum intensity (LMI) in the Pacific Ocean [3]. This poleward trend was also discovered for yearly cyclogenesis latitude [2]. Sources such as the National Oceanic and Atmospheric Administration attribute this climatic shift to the expansion of the tropics [3]. This term refers to an increase in the size of the region with tropical-like weather [1].

Though these findings are noteworthy, the development of merely a trend line will not aid in predicting yearly variability of tropical cyclogenesis. It is important to study factors that contribute to seasonal variability in order to improve the accuracy of immediate cyclone prediction, not just long-term cyclone prognostication. Being able to predict whether the average cyclogenesis latitude of one year will be higher or lower than the previous year is an important step forward in achieving this goal. Previous research already points at the possibility of sea surface temperature (SST) anomalies playing a major role in the variability of yearly cyclogenesis patterns [4].

The aim of this investigation was to expand on current speculations by determining whether the analysis of Northeast Pacific SSTs during the cyclone off-season (December to April) will help to predict future tropical cyclogenesis patterns. Doing so had the potential to provide cyclone models with the ability to roughly predict average cyclogenesis latitudes of future storm seasons prior to their occurrence. This aids in statistically communicating a potential storm threat prior to its occurrence, an outcome that would be highly favored by individuals advocating for better storm preparation [7].

Procedure:

Genesis latitudes of individual cyclones were obtained for the years 1980-2018 from the Weather Underground and NOAA database [8]. Genesis was defined as the first point at which a cyclone has a windspeed greater than or equal to 30 knots. Averages of the individual latitudes for each year were calculated and a table of values was created.

Sea surface temperature map image paths were collected for the months of December through April (off-season for Pacific cyclones) from the available years of 1996-2018. This was performed by saving SST maps from the NOAA database as image files [6]. An absolute path of the image was then used by an algorithm developed using Enthought Canopy for analysis. The code utilized a getpixel function to extract coordinates of regions based on RGB values that corresponded to different temperature anomalies.

The strength of relation between the average latitude of a certain SST threshold in a given off-season and the average cyclogenesis latitude of the subsequent year was then determined by calculating the correlation coefficient for common functions, a process facilitated by Microsoft Excel [5].

The overall analysis experienced alterations such as the application of different weighting schemes to SST anomalies. These changes were made to the process with the hopes of strengthening the relationship between SST anomalies and seasonal cyclogenesis variability.

Results/Conclusions/Further Research:

When performing an unweighted analysis of average off-season SST latitudes and average cyclogenesis latitude, a non-linear polynomial relationship was found as the best fit. The R-value for this relationship was slightly above 0.5, deeming it as a moderate correlation. To potentially strengthen this correlation, the average SST latitude value was adjusted to favor specific elements pertaining to the variable. The first change was the span of time that the average would represent. The average SST latitude was derived solely from the month of April (last month of the off-season). But this change weakened the relationship with cyclogenesis, dropping the R-value to below .01. Another change was the addition of a weighting scheme that would alter the SST average in favor of either higher positive anomalies or smaller positive anomalies. When the average off-season SST latitude favored smaller anomalies, the best relationship also was a non-linear polynomial relationship, but the R-value was not very different from the original unweighted analysis. When larger anomalies were favored, the best relationship once again was a non-linear polynomial relationship, but the R-value did increase. The same weighting scheme was performed for years that consisted of extreme positive anomalies and years that consisted of moderate positive anomalies. Both groups produced an R-value that fell between .6 and .9, indicating a strong correlation.

These results confirm that in the Northeast Pacific, SST anomalies possess potential to predict seasonal variability in cyclogenesis latitude. It also seems that the orientation of larger anomalies has a more significant role in this variability. To build of these studies, the same analysis can be performed in other ocean regions to determine whether this relationship has broader applications. Additionally, more weather variables tied to cyclogenesis can be analyzed to further improve seasonal prediction

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