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Western Tropical North Pacific: A Climatology

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Abstract

Sea surface temperature data have shown that the area of highest temperatures of the North Pacific, always in the western tropics, increases in spring and summer by expanding northward. Thirty years of ship-injection temperatures are used here to document the year to year SST fluctuations for a given month and the month to month variations for a given year of the large surface area of the western tropics during the warming seasons. Some of the fluctuations are significantly large and may therefore be real. Thus the previously hypothesized exportation of warm surface water northward out of the western tropics at the end of every summer may deliver variable amounts of oceanic heat to mid- and higher latitudes from one year to another. A possible connection with mid-latitude weather changes on time scales of months to years is briefly stated.

Keywords

North Pacific, Western Tropics, High SSTs Area

1. Introduction

Climatology here means a study of SSTs over 30 consecutive years from the mid-1940s into the mid-1970s. There is only one ocean where this can be done: the North Pacific. With help from an enormous data base, which has positive as well as negative characteristics, it is possible to obtain new and interesting information. Positive is the 30 year coverage, quite extensive. Negative, from the point of view of the geography chosen, is the limitation to latitudes greater than or equal to 20 N. Since the western tropics is the heat source supplying two northward flowing warm surface currents, the permanent one connected to the Gulf of Alaska, the other transient one moving to the west of the permanent flow and occurring every summer, each current having width and length scales large enough to affect the weather [1], it is important to learn as much as possible about this huge body of water with the warmest surface temperatures of the whole ocean.

As the wide warm surface currents flow north, they heat the atmosphere from below causing locally relatively

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high sea level pressure. That hypothesis is based in part on direct measurements of water and air properties gathered on an oceanographic ship that sailed right through the warm current off California and the North Pacific High on top of it, along 35 N in March and April of 1976 [2]. Once generated high sea level pressure over the mid-latitude ocean can affect the weather which comes within its sphere of influence and later enters North America by moving east and crossing the west coast. Thus one of the main goals of the decade-long NORPAX Program at the Scripps Institution of Oceanography is becoming a bit closer to being reached, all be it long after the Program has come to an end.

Widths of about 4000 km and sluggish speeds of 10 - 20 cm/sec for the warm surface currents exiting the western tropics are not disadvantageous when it comes to delivering heat to the atmosphere at mid-latitudes. Contrast this situation with the Gulf Stream, which is very thin, very fast, meanders about, and probably has less detectable effect on the air above it.

Year to year variations of SST for a given month and month to month variations for a given year within the western tropical North Pacific therefore become valuable to explore in the context of potential relations to changes in the weather that might be experienced by the USA. They are described and discussed next.

2. Data Displays

Ship-injection temperatures have been combined into five degree latitude/longitude squares and one month intervals that cover most of the North Pacific north of 20 N and coast to coast. Namias estimated that 20 years of such data would contain about 8 million individual observations [3]; then the 30 years of data used here should include 12 million, a prodigious amount of data by oceanographic standards. Informally this unpublished SST data set is known as the Namias-Scripps surface temperatures.

Between latitude 20 N and the 26 C temperature contour all the five degree squares have been added up for each month and averaged over 30 years. **Figure 1** shows the mean number of squares for those months during the warming season, in which the number increases from month to month (February through September). One sees in **Figure 1** the growth or swelling of the surface area containing temperatures equal to or greater than 26 C.

There is a consistency between the main feature of **Figure 1** and what can be noticed in the North Pacific section of the classic sea surface temperature atlas of the world (H. O. 225), which is also based on ship-injection temperatures [4] [5]. Differences in the two data sources are: 1) the atlas has coverage all the way to the equator whereas the Namias-Scripps SSTs stop at 20 N, and 2) above 20 N the atlas has far fewer data per unit area and per month. Also the grid on which the atlas is constructed consists of one degree latitude/longitude squares instead of five degree squares. As a consequence 26 C water never vanishes in February as might be mis-interpreted from **Figure 1**; the area just shrinks to between the equator and about 20 N in the winter.

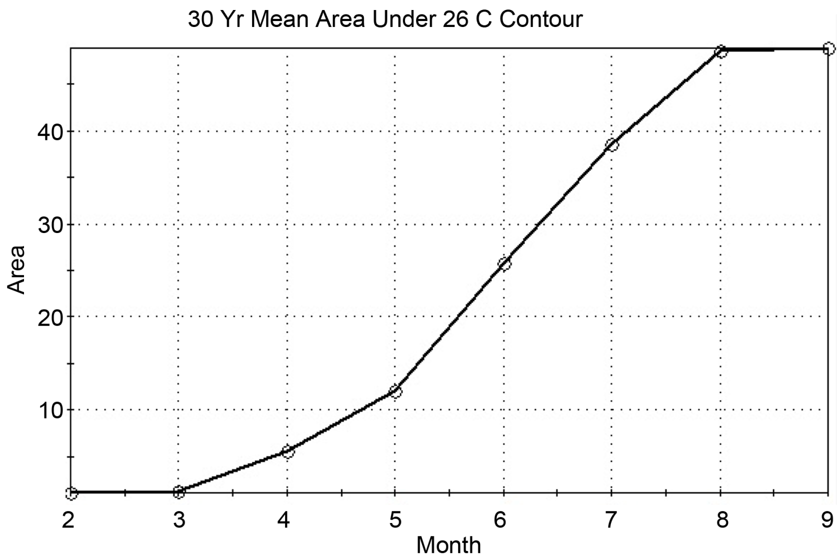

Figure 1. 30 years average number of five degree latitude/longitude squares with SSTs greater than or equal to 26 C at and north of 20 N plotted against month from February (2) to September (9).

Before the condensation took place in **Figure 1**, which suppressed much of the variability by averaging, the numbers displayed in **Figure 2** were already worked out of course. Since a figure like **Figure 2** has never been shown before, probably, what should the thinking about it be? No pre-conceived notions occurred to me. Also first impressions are usually not helpful and there has been no time for intuition to build. At any rate, the increase in the mean number of squares with the advance of the season from May to August is apparent in **Figure 2**, but the main features of interest now are the variations about the means.

One objective approach to understanding the variations better is to compute standard deviations. For the year to year variations, looking horizontally across **Figure 2**, they are 2.7, 2.4, 3.6, and 3.2 corresponding to the months May through August. For the months February, March and April (not shown) they are 1.7, 1.9 and 2.7, and for September (not shown) it is 2.9 [fractions of a five degree square are a result of the calculation; they don't make a lot of sense and should probably have been rounded up or down as the case may be to the nearest whole five degree square].

According to **Figure 2** some of the year to year fluctuations are within one standard deviation for a given month but there are quite a few exceptions, which might suggest that those variations are real. For example, near the beginning of the record for August a couple of year to year changes are between 10% and 20% of the mean. In other words, a 5 to 10 five degree square difference between one year and the next could amount to a significantly different quantity of heat being transported north [for discussing heat content areas can be turned into volumes by multiplying them by 100 m, over which more than 90% of the sun's radiation penetrating the sea surface is absorbed]. Someday there may be a way to independently check the variations.

3. Month to Month Changes

By reading the graph (**Figure 2**) vertically the month to month changes for a given year can be seen. How the area of warmest temperatures expands in spring and summer is that the contours move north. In the tropics a northward shift of SST isotherms very likely means that warm surface water itself is moving north, because heat exchange with the atmosphere is expected to be small there. Then if the speed of northward flow has the right magnitude, one might hope to occasionally find a positive or negative anomaly propagate upward in **Figure 2** from May to August. Unfortunately, the "right" speed is about five degrees of latitude in one month, which is a bit faster than the contours move. Average northward speeds of the 26 C contour during spring and summer are more in the range of 10 latitude degrees in three months.

Nevertheless, there are hints of this conjectured northward movement going on in **Figure 2**. For example, in

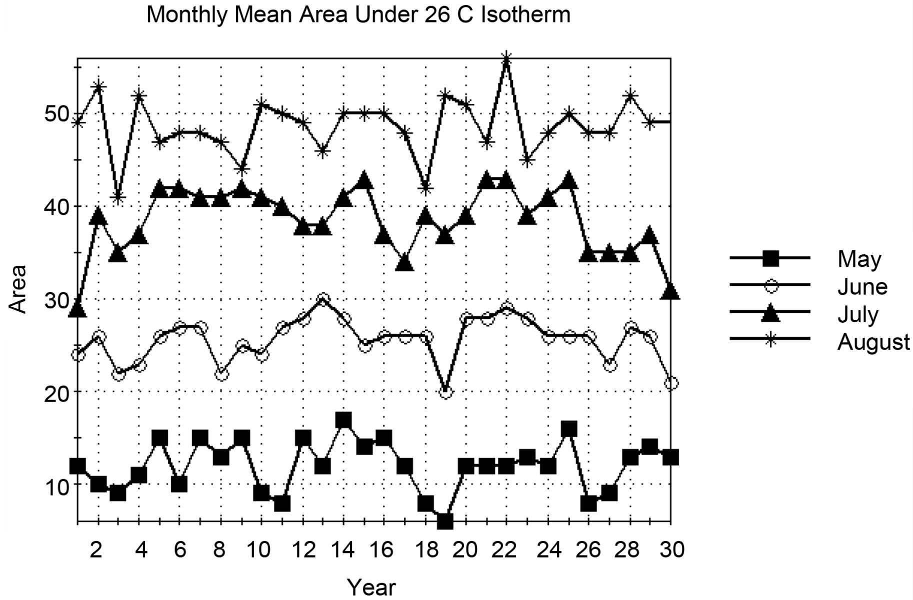

Figure 2. Monthly number of five degree latitude/longitude squares with SSTs greater than or equal to 26 C at and north of 20 N plotted against year from 1947 (1) to 1976 (30) for months May, June, July and August on the same scale consecutively with May on the bottom and August on top.

years 3, 27, and 30 positive or negative anomalies line up vertically in all four months, and in years 13, 19, 22, and 25 three out of four anomalies line up. If there is a connecting link between variations between different months of particular year, then that lends credibility to their reality. Supposing that some fluctuations are real, the mystery is: how do they arise? This question can be viewed against the background of the sun's motion, which is as smooth and regular as clockwork.

4. Discussion

Among the various extensions possible of the above exploration some may be more fruitful than others. For example, standard deviations computed vertically in **Figure 2** in a few cases are comparable to those already obtained horizontally (listed above), so this approach was not completed. Also the data series that ends at 30 years in **Figure 2** has a couple of more years that could be added to it, but then the series came to an end and there has been no attempt to update it or make it current. Whether or not more years of fluctuations would make them more understandable is open to debate.

One aspect of the variations that extends them some credence is that the thing that is varying is an integral quantity of temperature or heat, because a good number of five degree squares have been added together to make an area (or volume). For August more than 50 squares have been combined.

Where the irregularities stem from might be related to any variable process that interferes with the incoming solar rays penetrating the ocean's surface. Clouds come to mind, which can appear in different types and amounts at different times and locations. Clouds also influence the long wave radiation leaving the ocean.

In addition, it should be pointed out that in the records of **Figure 2** not hard to fine are patches where up to three years in a row show virtually no change from one year to the next for a given month.

5. Conclusion

Thirty years of ship-injection temperatures are used to depict the year to year variations for a given month and the month to month changes for a given year in the sea surface area containing the highest temperatures of the North Pacific. Most likely such a display has not been carried out before. The study focuses on the western tropics and the warming seasons, spring and summer. Although an independent check on the fluctuations is not possible at present, some of them are significantly large and could be real. Implications are discussed for variations from one year to another in the oceanic heat in the surface layer exported out of the tropics to middle and higher latitudes at the end of every summer.

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