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NW Indian Ocean's SSTs Are Bi-Seasonal

Kern E. Kenyon

4632 North Lane, Del Mar, USA

Correspondence to: Kern E. Kenyon, kernken@aol.com

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ABSTRACT

Two independent atlases agree that in the northwest Indian Ocean the sea surface temperatures cool down markedly in the spring and also that they have a significant double seasonal cycle, unlike any other ocean in both cases. Horizontal advection is proposed to play an important part in causing these unusual features to occur.

1. INTRODUCTION

Recently a study of the sea surface temperatures of the northwest Indian Ocean revealed that, following the expected mid-winter minimum, maximum values occurred over the largest area in May, after which the sea surface cooled down significantly [1]. No other northern hemisphere ocean behaves this way, so an explanation is urgently needed. As discussed before, the monsoon winds are unable to be the major cause for the simple reason that the timing is not right: sea surface cooling starts before the winds do. Just when the sun is busily pumping, more energy per unit area and per unit time into the top 100 m of the ocean, that is when this cool down takes place. Indeed a puzzle.

Since a classical world atlas of sea surface temperatures (H. O. 225) was used to obtain this puzzling observation, based on ship-injection temperatures taken earlier than 1944, one might wonder about the reality of the result coming from these measurements. Consequently, the main objective of what follows is to provide a totally independent check on the spring cooling and also to confirm that this cooling is part of a double seasonal signal occurring during the period of one year. Available hypotheses to account for that fact are lacking also. In addition, I am not aware that the SSTs of any southern hemisphere ocean exhibit a double seasonal variation as distinctive as shown in **Figure 1**.

2. DATA COMPARISON

Figure 1 compares the same operation made on two different sets of sea surface temperature data from different atlases. First, the northwest Indian Ocean is defined for convenience to be that body of water north of the equator and west of 80 E, which is just a little east of the big southern tip of India. For each month the percentage of the sea surface area in which the temperature equals or exceeds 80 F in one atlas is compared to the percentage of the area in which the temperature equals or exceeds 27˚C (80.6 F) in the

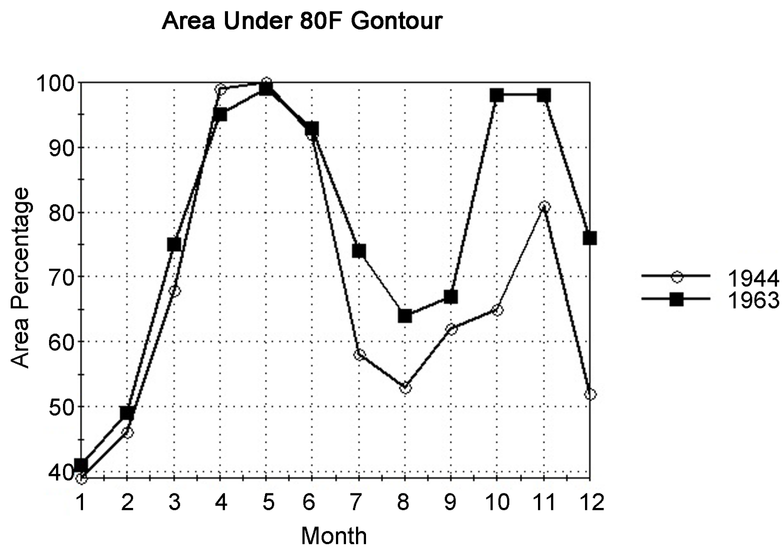

Figure 1. Vertical axis: percentage of the surface area of the northwestern Indian Ocean in which the sea surface temperature equals or exceeds 80 F for the 1944 data and equals or exceeds 27 C for the 1963 data. Horizontal axis: months (January = 1, etc.).

other atlas [temperature contours in one atlas are in degrees F, the other atlas uses degrees C].

Source #1: World Atlas of Sea Surface Temperatures, H. O. 225, constructed from all the ship injection temperatures that could be found for several years leading up to the date of publication, 1944 [2]. Totals of individual measurements are not given for any ocean. Source #1 data in **Figure 1** here were published before [1] but a couple of corrections to errors in the lower values have been made now that do not affect qualitative features before or after the corrections.

Source #2: Oceanographic Atlas of the International Indian Ocean Expedition [3], Chapter 1, Distribution of Properties at the Sea Surface. SST charts were compiled from all available ship injection temperatures for the single year 1963. Totals of individual observations average about 6000 per month over the twelve months for the whole Indian Ocean. Source #2 data in **Figure 1** have not been published previously in the manner chosen here.

Agreement between the two curves in **Figure 1**, separated in time by roughly 20 years, is fairly good considering the non-uniformity of the observations in space and time, and the fact that the accuracy of the thermometers involved is only about 1 F. Reality of the spring cool down and of the bi-seasonal variation in SSTs are thereby enhanced. As closely as can be expected from the data at hand, there are six months between the two maxima as well as between the two minima in **Figure 1**.

3. DISCUSSION

As far as the spring cooling is concerned, both atlases agree in suggesting that the cooling begins at the east coast of Africa (Somalia) and then spreads east and north from there. Earlier it was proposed that the origin of the lower temperature water is in the southern Indian Ocean and that it is pushed across the equator in the northern spring by a large-scale horizontal pressure gradient, related to the large-scale north/south temperature gradient, in the surface layer [1]. Work in the future will be needed to try to substantiate this claim because existing data may not be adequate.

Still to ponder are answers to questions surrounding the presence of the second maximum in **Figure 1** during October and November. If advection is the primary mechanism by which the area percentage is increased in these two months, then there are two ways that this can happen: relatively warm water can be brought into the northwest basin from the east or from the south. The opening to the east (80 E) is considerably smaller, so the equatorial opening might be more favorable, assuming that the advection components normal to the cross-sections are comparable. Such hypothetical statements must be checked up on, and of course, there could be other physical heating methods to investigate by which the area of the high SSTs can be greatly increased over the period of one or two months.

Reference [3] contains, in addition to displays of sea surface properties, a large number of vertical hydrographic sections, mainly north/south and east/west, that have great intrinsic value. These sections have been reviewed more than once to see if they might shed some light on leftover questions that I have. For example, from an east/west vertical section of temperature made in October-November along the equator, can it be inferred that there was flow of warm water crossing the equator in the surface layer within a particular band of longitudes and either north or south? Probably not for several reasons. One is that neither of the two vertical sections along the equator in the atlas took place in either of those months, not even close.

Since the areas enclosed within the 80 F contours can drop from 100% to 40% of the total surface area of the NW Indian Ocean in just a couple of months, according to **Figure 1**, in the midst of strong solar heating, then for horizontal advection to be effective the classically narrow western boundary current option is probably not a logical solution to the problem of explaining how this could happen.

A reader may have noticed that the correspondence between the two curves in **Figure 1** is better for the first six month than it is for the second six months. Whether or not any significance can be attached to that difference is not known at this time.

4. CONCLUSION

The spring cool down of the sea surface in the northwestern Indian Ocean appears to be real. Also the double seasonal variation of SSTs in this ocean body appears to be real. These conclusions come from comparing monthly charts of two independent atlases, in both cases based on ship-injection temperatures, but one set containing data available before 1944 and the other set using data for the single year 1963 only. Horizontal advection is proposed to be involved in the cause of the two unusual features, which have not been found in any other ocean.

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