Heat Content and Cyclogenesis Anomalies in the South Pacific

The 1982-83 warm season in the South Pacific was marked by a strong anomaly in the geographic distribution of the origins of tropical depressions. Following the World Meteorological Organization (WMO) rules, tropical depressions are classified as tropical storms for maximum mean wind speeds between 16 and 32 m s^{-1}, and as hurricanes for wind speeds above 32 m s^{-1}.

Meteorological files from 1940 to mid-1982 show that, among the 431 recorded depressions, 84% originated west of the dateline and only 16% occurred east of it. For the same period, only one hurricane formed east of 150°W, in February 1976. Sketchy data from the beginning of the century indicate that in January 1903 and March 1905 depressions which hit French Polynesia may have been born east of 150°W; these storms closely followed the moderate El Niño events of 1902 and 1905. Of the fifteen tropical storms and hurricanes of the 1982-83 season, eight formed east of 180°, and five among these east of 150°W. This is another unique characteristic of the current climate perturbation. A previous statistical study for the period 1956-78 (Donguy *et al.*, 1979) had already indicated that, during the warm seasons following an El Niño year, about twice the regular rate of formation of tropical depressions was observed east of the dateline (Table 1). This was attributed in part to the shift of the heat content of surface waters toward the central Pacific. This shift has been described for the 1957, 1972, and 1976 El Niño events from existing cruise and XBT data (Hénin and Donguy, 1980).

TABLE 1 (*Eldin and Donguy*)

Zonal distribution (numbers and percentages) of the origins of tropical depressions for 1956-78 (from Donguy et al., 1979), and for 1982-83 in the South Pacific.

130°E 180° 160°W 130°

"Pre-El Niño" warm seasons, 1956-1978	134 83%	28 17%	
1957-58, 1965-66, 1972-73, 1976-77, 1977-78 warm seasons	34 69%	16 31%	
1982-83 warm season	7 47%	2 13%	6 40%

For the 1982-83 event, much more temperature data is available, allowing a more detailed description of the distribution and evolution of the heat content. This data consists mainly of XBT casts made from merchant ships participating in the joint France-U.S. network operated since 1979. They are supplemented by measurements made near French Polynesia by the French Navy in April 1983, and the results of two cruises of the R/V *Melville* between Tahiti and the equator in February and March 1983 (data kindly provided by C. C. Eriksen).

We will use here a definition of heat content taken by meteorologists as a good indicator of the available energy for ocean-atmosphere interchange, *i.e.*, the thermal energy above the 26° isotherm depth, or 60 m, whichever is shallower (Gray, 1976). This quantity is expressed by the average temperature between the surface and the chosen depth, a method filtering the effect of adiabatic movements of the isotherms (Stevenson and Niiler, 1983).

The variations of heat content from November 1982 to April 1983 are shown in Figure 1, together with the zones of cyclogenesis for each month. In November and December 1982, the maximum heat content zone extends from 140°E to eastward of 160°W and north of 10°S, as was observed at the end of 1976 (Hénin and Donguy, 1980). Three tropical storms form above this zone. By January 1983, the heat pool has recessed toward the southwest, regaining its normal seasonal position. It is noteworthy that at the same time, other XBT data at 0°, 100°W show a lifting of the thermocline, although the SST does not decrease; also, the Southern Oscillation Index begins to increase (CAC, 1983). These features looked like precursors of the resumption of normal climatic conditions. However, scarce data east of 160°W does not allow heat content determination in this region. Three depressions take place this month, two of them associated with the western maximum of heat content. By February 1983, a strong warming of the central Pacific is observed, and the westernmost heat pool continues to weaken. Three hurricanes and one tropical storm form this month, evenly distributed around 10°S from 160°E to 140°W. Although all the depressions are not associated with the heat pool in the east, the maximum cyclonic activity occurs during this month, when the global heat content of the whole South Pacific is at a maximum. During the following two months, the heat content weakens progressively from the southwest. Five hurricanes will still appear, four of them east of the dateline.

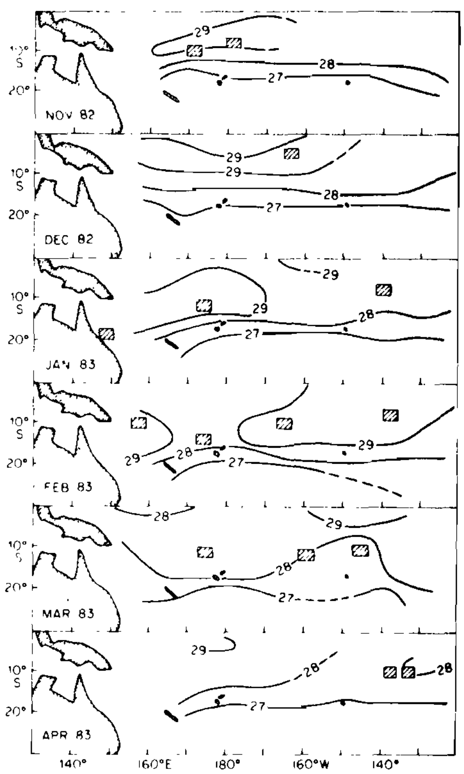

FIGURE 1 (*Eldin and Donguy*)
Evolution of the upper ocean heat content from November 1982 to April 1983, expressed as the mean temperature between the surface and the shallower of 60 m and the 26°C isotherm depth. Shaded rectangles represent zones of cyclogenesis.

A comparison with the monthly SST and SST anomaly charts published by NOAA does not show a better local correlation of cyclogenesis with SST than with heat content. For a given latitude, depressions do not always appear in the region of maximum SST or positive anomaly.

Many parameters which are not readily accessible to continuous monitoring, such as the vertical shear of the wind field or the vertical gradient of atmospheric temperature, play an important role in cyclogenesis. These parameters are also strongly modified during and after an El Niño event. Moreover, depressions themselves are part of the process of energy transfer from the ocean to the atmosphere. This energy is then redistributed to the ocean by the atmospheric circulation. This highly nonlinear process explains why a local relationship between a given amount of heat content or a given SST and cyclogenesis cannot be found.

It seems certain that perturbations in the magnitude and position of the maximum heat content in the South Pacific are tied to the perturbations in cyclogenesis. A more complete study is being undertaken from filed records to try to understand more precisely the origin of cyclogenesis anomalies following El Niño events.

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