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RELATIONSHIP BETWEEN ENSO AND SOUTHERN OCEAN WATERS (PRELIMINARY REPORT)*

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Abstract: ENSO (El Niño/Southern Oscillation) has been studied in the tropical Pacific Ocean. In the tropical Atlantic also we can find El Niño type analogous to the Pacific ENSO. But the frequency of El Niño type appearance in the Atlantic is less than in the Pacific. As there are lower values of standard deviation for meteorological data on the tropical Atlantic than on the Pacific, we may estimate more stable meteorological conditions for the tropical Atlantic. One reason for it may be due to lower water temperature in the South Atlantic compared in the same latitude. The mechanism involving low water temperature in the South Atlantic must be studied in the near future.

1. Introduction

El Niño is the famous phenomenon which shows abnormaly high water temperatures along the coasts of Ecuador, Peru and Chile. Recently it has been elucidated that El Niño is not a local phenomenon influencing the sea water along the Pacific coast of South America but it corresponds to the extensive phenomenon affecting whole tropical Pacific Ocean.

As the Southern Oscillation proposed by WALKER (1923, 1924) has been studied in intimate connection with El Niño (an example of the Southern Oscillation is a seesaw phase between air pressures in the tropical Indian Ocean and in the tropical South America), the ENSO has become of great interest as a large-scale air-sea interaction. A number of coupled ocean-atmosphere models have been proposed to simulate the tropical aspect of ENSO (*e.g.*, ANDERSON and MCCREARY, 1985; PHILANDER *et al.*, 1984). The dynamical analysis of global structure of ENSO has been carried out by meteorologist or oceanographer (*e.g.*, YAMAGATA, 1986; YASUNARI, 1987a, b).

In this paper the authors indicate only the different points about ENSO cycle in the Pacific and Atlantic Oceans on the basis of several meteorological and oceanographical data.

2. Frequency of ENSO

We can obtain ENSO data in the Pacific from several papers (*e.g.*, RASMUSSON and

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CARPENTER, 1982; KOUSKY *et al.*, 1984; WHYSALL *et al.*, 1987). According to these data, the appearance of ENSO in the Pacific Ocean is very frequent, that is, eight ENSOs have been found from 1957 to 1986. On the other hand, El Niño type in the Atlantic Ocean appears no more than four times from 1933 to 1986 (SHANNON *et al.*, 1986). The cause of frequent occurrence of ENSO in the Pacific is difficult to explain sufficiently but the variance of meteorological data in both oceans may give a clue to the cause.

3. Variances of Meteorological Data in the Two Oceans

We can get easily some meteorological data at stations facing the tropical Pacific and Atlantic Oceans (refer to Fig. 1 for the location of stations). By comparing the

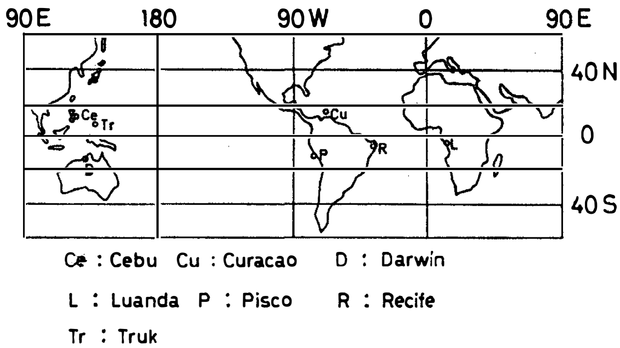

Fig. 1. Positions of meteorological stations in the tropical Pacific and Atlantic Oceans.

Table 1. Ratios of standard deviation and coefficient of variance of meteorological data between tropical Pacific and Atlantic Oceans.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual mean
Air pressure													
Cebu	1.84	1.75	1.41	1.37	0.99	1.56	1.58	1.93	1.33	2.61	1.80	1.91	1.68
Curacao	1.84	1.77	1.41	1.39	0.99	1.56	1.59	1.94	1.34	2.62	1.80	1.91	1.68
Darwin	1.53	1.78	1.97	1.30	1.79	1.20	0.95	1.25	1.35	1.53	0.83	2.33	1.48
Recife	1.54	1.79	1.98	1.31	1.80	1.20	0.95	1.25	1.35	1.54	0.83	2.34	1.49
Pisco	1.28	1.21	1.50	1.38	1.29	1.77	1.21	0.71	1.02	0.70	1.01	1.42	1.21
Luanda	1.28	1.21	1.50	1.38	1.29	1.77	1.22	0.72	1.02	0.70	1.01	1.42	1.21
Air temperature													
Cebu	1.12	1.06	1.21	1.29	1.29	1.99	1.23	2.05	1.59	1.00	1.12	0.77	1.31
Curacao	1.11	1.06	1.19	1.24	1.24	1.98	1.27	2.09	1.64	1.03	1.14	0.77	1.31
Darwin	1.35	1.00	1.28	1.26	2.00	3.08	1.96	2.09	2.46	1.61	1.26	0.76	1.57
Recife	1.28	0.96	1.20	1.16	1.86	2.99	1.89	1.91	2.17	1.41	1.11	0.68	1.55
Pisco	1.46	1.30	4.21	1.99	1.96	1.91	1.40	1.06	1.47	0.89	1.00	1.90	1.71
Luanda	1.73	1.54	5.07	2.49	2.57	2.40	1.75	1.36	1.93	1.20	1.36	2.31	2.14
Wind velocity													
Truk	1.11	0.80	1.16	1.19	1.58	1.13	3.47	2.79	3.43	2.88	0.90	1.15	1.80
Curacao	1.26	0.86	1.40	1.50	2.20	2.05	16.13	15.07	62.52	17.26	1.42	1.29	10.24

Upper; ratio of standard deviation
Lower; ratio of coefficient of variance

meteorological data at the geographically similar located stations facing the tropical Pacific and Atlantic, standard deviations of air pressure, air temperature and wind velocity are studied to understand the meteorological variance in both oceans. The ratios of standard deviation and coefficient of variance are shown in Table 1, respectively (ratio is given as Pacific/Atlantic). Every ratio is much larger than 1, especially the ratio of coefficient of variance about wind is considerably large (annual mean is about 10). This fact means that variations of meteorological data in the Pacific are remarkably larger than in the Atlantic. In other words, the meteorological disturbances in the tropical Pacific are more active than in the tropical Atlantic.

Studying the occurrences of typhoon and hurricane, we never find the appearance of hurricane in the South Atlantic (refer to Fig. 2). This fact also indicates that meteorological conditions in the tropical Atlantic are more stable than in the tropical Pacific.

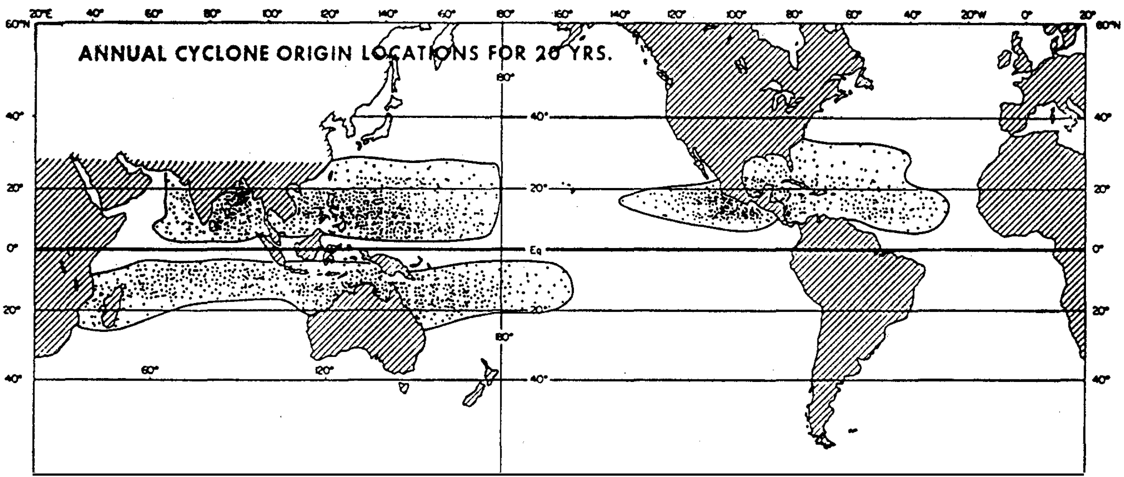

Fig. 2. Occurrence positions of tropical cyclones over world oceans from 1957 to 1977 (after GRAY, *1979).*

Table 2. Surface values of water temperature (T: °C) and salinity (S: ‰) in the Pacific and Atlantic Oceans.

	N. Pacific		N. Atlantic	
Lat. (N)	*T*	*S*	*T*	*S*
30–20	23.38	34.88	24.16	36.47
20–10	26.42	34.29	25.18	35.62
10– 0	27.29	34.85	26.66	35.67
	S. Pacific		S. Atlantic	
Lat. (S)	*T*	*S*	*T*	*S*
0–10	26.01	35.25	25.18	36.11
10–20	25.11	35.55	23.16	36.59
20–30	21.35	35.57	21.20	36.15
30–40	16.98	35.00	16.90	35.24
40–50	11.16	34.36	8.68	34.64
50–60	5.00	—	1.76	—
60–70	−1.30	—	−1.30	—

After SVERDRUP *et al.* (1947).

4. The Cause of Stable Meteorological Conditions in the South Atlantic Ocean

In the case of scanty heat supply to the lower layer of atmosphere, this atmosphere may continue to be stable. In general, water temperatures in the South Atlantic are lower than in the South Pacific as the same latitude (refer to Table 2). In Table 2 it is seen that the lower atmosphere on the South Atlantic receives less heat energy from the sea surface than on the South Pacific. Especially, water temperatures in high latitude

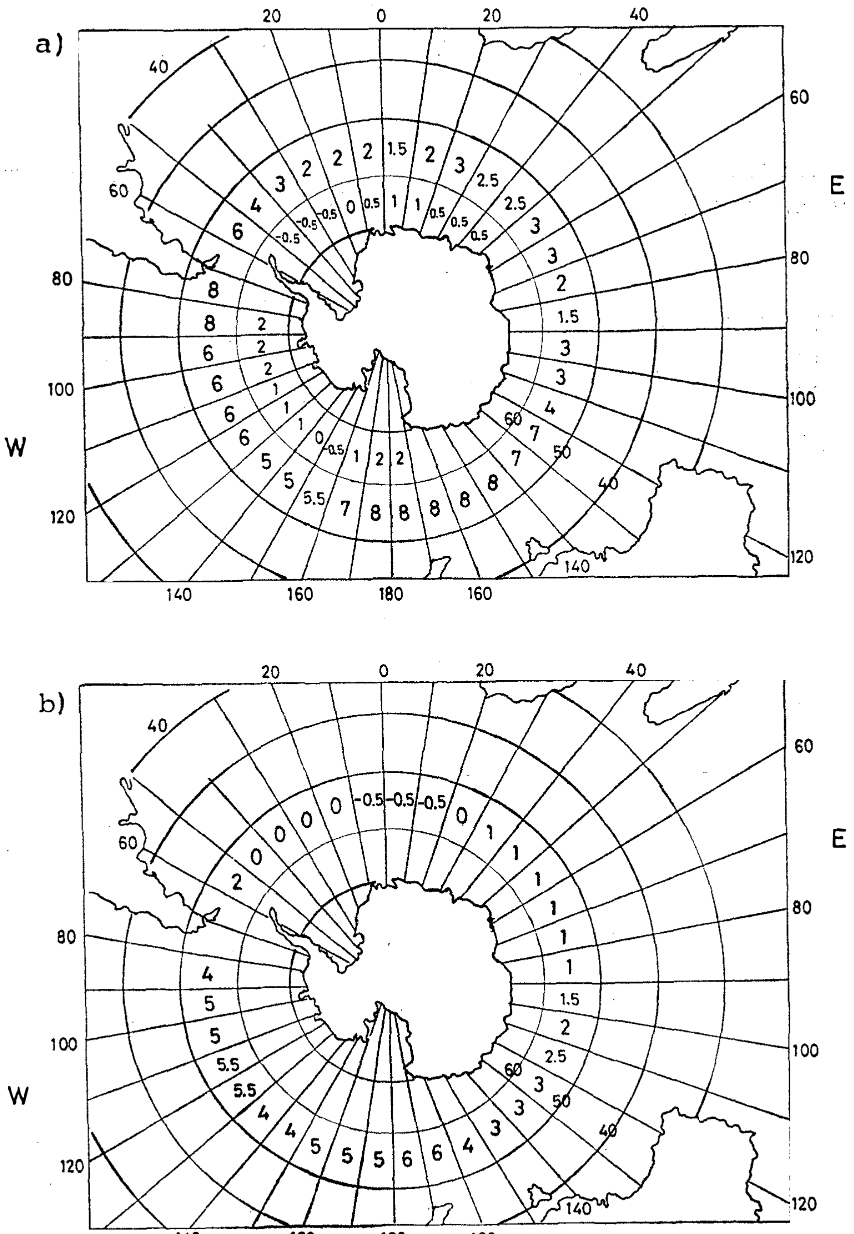

Fig. 3. Surface water temperature by 10° square in the Southern Ocean (modified after some maps of GORDON and MOLINELLI, 1982). a: January–February–March; b: July–August–September.

of the South Atlantic are considerably lower than in the same latitude of the South Pacific. The low water temperature tendency in the Atlantic may indicate a possible source of low water temperature in high latitude of the South Atlantic.

To find the source of cold water around the Antarctic Continent, the oceanographical study in the Weddell Sea may be important because there are dominant cold water masses near and in the Weddell Sea (refer to Fig. 3).

5. Future Problem

Concerning the difference of ENSO appearance in the Pacific and Atlantic Oceans, low water temperature in the South Atlantic may play the leading role. If low water temperature extension in the South Atlantic can be attributed to the water masses in the Weddell Sea, the mechanism of northward extension of cold water mass must be studied in the near future. This is to study the difference of heat transport in the Pacific and Atlantic sections of the Southern Ocean.

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