Reprint 310

Some Impacts of El Niño and La Niña Events on the Weather of Hong Kong

W. L. Chang
Hong Kong Observatory

Abstract - An attempt is made to identify and summarize the broad patterns of impacts of El Niño and La Niña on Hong Kong. It is found that recent years in which El Niño occurred have about half the normal number of typhoons affecting Hong Kong. In contrast, years immediately following La Niña onset tend to see more than the usual number of typhoons. El Niño onset years or the years immediately following onset are likely to be wetter than usual in Hong Kong, so do springs coinciding with a mature phase of the El Niño. El Niño onset years or the years immediately following onset tend to be warmer on the whole. However, the linkage between El Niño/La Niña events and their impacts is not one to one.

1. Introduction

The 1997-1998 El Niño, the strongest since 1982-1983, spawned immense concern and interest in governments, the scientific community, the media and the public alike. El Niño, Spanish for male infant, originally refers to the warming of the waters off the coast of Peru which takes place around Christmas every year. Occasionally this warming becomes particularly intense and prolonged. Nowadays El Niño has come to be identified with these episodes of exceptional warming.

El Niño is characterized by low pressure over the equatorial Pacific and high pressure over the Indian Ocean, weak easterly trade winds, falling sea levels in the western equatorial Pacific and rising sea levels in the eastern equatorial Pacific.

La Niña, Spanish for the female infant, is the extreme opposite of El

Niño albeit the characteristics of two phenomena are not always entirely symmetrical. La Niña occurs less frequently than El Niño and has been less studied. No two El Niño or La Niña events are exactly identical. A list of recent years in which El Niño/La Niña occurred is shown in the Appendix.

Since the late 1970s there has been a tendency for more El Niño and fewer La Niña events. The interval between the two strongest El Niño events this century is only 15 years. Typically it should be 30 to 40 years. Trenberth and Hoar (1997) suggests that these changes are unlikely to be due to natural variability alone. McPhaden (1999) suggests other natural atmospheric cycles such as the Pacific Decadal Oscillation (PDO), the Madden-Julian Oscillation (MJO) or the chaotic nature of the atmosphere might also have a role to play. The possible influence of global warming has also been raised. However, a consensus on this has yet to be reached.

El Niño and La Niña events are closely linked to the Walker Circulation and the Southern Oscillation (SO). This relationship is addressed in the accompanying paper by Lau (1999). It is therefore not dwelt upon here except to note for completeness that El Niño events are also called El Niño-Southern Oscillation (ENSO) or warm events, and La Niña cold events.

This paper tries to identify and summarize the broad patterns of anomalies in tropical cyclone activity, rainfall and temperature in Hong Kong in years in which El Niño or La Niña is active. The purposes are to contribute to the global database on the likely influences of El Niño and La Niña, and to generate local 'analogues' or 'templates' on potential impacts for promoting public awareness as well as the planning of activities by different user groups in the community. For completeness, mention is also made of the relationship between El Niño events and mean sea levels in Hong Kong during the two strongest warm events.

2. Impacts of El Niño and La Niña - general aspects

When El Niño or La Niña occurs, the atmospheric circulation is modified by the unusually warm or cold waters then prevailing over the equatorial Pacific. The effect of this modification is translated into anomalous weather patterns felt worldwide in a phenomena known as 'teleconnections'. The global impacts of El Niño and La Niña are shown schematically in Figure 1a and 1b. Generally, the effects of La Niña are not mirror images of and are less pronounced than those of El Niño. Also, as El Niño/La Niña changes only the probability of occurrence of different weather patterns (Webster and Palmer, 1997), impacts may vary from event to event.

The International Seminar on the 1997-1998 El Niño held in November 1998 in Guayaquil, Ecuador estimates that the mortality resulting from the 1997-1998 episode exceeded 21 000, and economic loss ranged between US$14-33 billion (World Meteorological Organization Circular Letter, 10 December 1998). Some 2 000 lives were lost in the 1982-1983 episode, and damages came to US$8-13 billion (WMO, 1997).

These human and economic losses underline the importance of understanding the phenomena and its impacts to allow steps to be taken in advance to enhance preparedness, mitigate damage and develop management and response strategies.

Many initiatives have been launched with the above purposes in mind. Counted among them are the Tropical Ocean Global Atmosphere - Tropical Atmosphere Ocean (TOGA-TAO) array of buoys set up in the equatorial Pacific to observe and give early warning of the onset of El Niño/La Niña. There is also the establishment of the IRI (International Research Institute) and multi-national programmes such as CLIPS (Climate Information and Prediction Services) and CLIVAR (Climate Variability). The reader is referred to Pietrowicz (1997) for an account of the TOGA-TAO array, Saulesleja and Olsson (1997) for CLIPS and Burns (1998) for CLIVAR.

3. Some impacts on Hong Kong

3.1 Tropical cyclone activity

Climatology suggests that in years immediately following El Niño onset, the tropical cyclone season over the western North Pacific and the South China Sea is likely to start late. Hong Kong Observatory's best-track analysis shows that in 1973 the first tropical cyclone did not form until 1 July, in 1983 24 June and in 1998 8 July. The number of tropical cyclones in these years are below the normal of about 31, being 23, 26 and 20 respectively. Similarly, the number of typhoons are respectively 11, 8 and 6 vis-a-vis the normal of 16. This is consistent with Chan (1985)'s findings.

Also, as shown in Figure 2a and 2b, in El Niño onset years such as 1982 and 1997 less than the usual number of tropical cyclones will make landfall over the south China coast.

Likewise in Hong Kong, tropical cyclones tend to come late in El Niño onset years or the years immediately following onset. The latest start of tropical cyclone season in Hong Kong since 1946 occurred in 1998 when the first signal was not hoisted till 9 August on account of the passage of Severe Tropical Storm Penny. The previous record was 1997 when the Standby Signal No. 1 was hoisted on 31 July for Typhoon Victor.

Climatology also shows that El Niño onset years or the years immediately following onset will mostly see normal or below normal number of typhoons affecting Hong Kong. Especially in recent years the number of such typhoons is about half the normal number of 4. 1992, 1997 and 1998 all recorded only 2 typhoons.

In contrast, records suggest that in years immediately following La Niña onset, Hong Kong is likely to be affected by an above average number of typhoons. There were 8 in 1974 and 6 in 1989. At the time of writing 1999 has already witnessed the passage of Typhoon Leo in April/May and of Typhoon Maggie in June.

3.2 Rainfall

3.2.1 Annual rainfall

In Hong Kong, El Niño onset years or the years immediately following onset tend to be wetter than usual. This is shown in Table 1 below.

The two years with the highest rainfall, 1982 and 1997, coincided with the years of onset of the two strongest El Niño events this century. 1972, ranked seventh in Table 1, can be recalled as the year in which excessive rainfall in June caused disastrous landslips at Kotewall Road and Po Shan Road as well as in Sau Mau Ping.

Table 1 also shows that of the 10 wettest years in Hong Kong since 1947, 6 coincided with either years of El Niño onset or the years immediately following its onset. Two (1973 and 1995) occurred in years with La Niña following El Niño.

A symmetrical behaviour does not seem to exist with regard to La Niña. Of the 10 driest years in Hong Kong since 1947, only 3 coincided with La Niña onset years or the years immediately following its onset (1954, 1956, 1988).

It is interesting to note that 1963, the driest year since 1947, occurred in an El Niño onset year. This attests to the non-linearity and non-uniqueness of the atmospheric response to El Niño mentioned in Section 2 as well as illustrates some of the difficulties in trying to link impacts to El Niño/La Niña.

Table 1. The 10 wettest years since 1947 in Hong Kong and their relation to El Niño/La Niña activity.

year	*ranking*	*annual rainfall (mm)*	*nature of year*
1997	1	3343.0	El Niño onset
1982	2	3247.5	El Niño onset
1973	3	3100.4	La Niña onset following decline of El Niño
1975	4	3028.7	year following La Niña onset
1957	5	2950.3	El Niño onset
1983	6	2893.8	year following El Niño onset
1972	7	2807.3	El Niño onset
1959	8	2797.4	
1995	9	2754.4	La Niña onset following decline of El Niño
1994	10	2725.6	El Niño onset

3.2.2 Spring (February to April) rainfall

The springs of 1983, 1992 and 1998 are all wetter than usual. The rainfall recorded is respectively 840.1 mm, 877.4 mm and 446.1 mm. They are correspondingly the second highest, the highest and ninth highest on record since 1947. All three springs coincided with a mature El Niño in the equatorial Pacific.

This link was first demonstrated by Lam (1993). He attributed it to moist and stronger than usual southwesterlies rising above weak pulses of cold continental air over the south China coast. The enhanced southwesterlies originate from an anomalous anticyclone over the Philippines, this anticyclone itself being a manifestation of the anomalous Walker Circulation resulting from El Niño.

Again, there does not seem to be a symmetrical tendency for springs to be drier in years immediately following La Niña onset. Spring rainfall in Hong Kong was near normal in 1974 and 1989, but 27% below normal in 1999.

3.3 Temperatures

3.3.1 Annual mean temperatures

Globally, the mean temperature in 1998 is 0.66 °C above the long term average of 13.8 °C, making it the warmest year since instrumental record began some 119 years ago and breaking the record set previously in 1997. El Niño is the main reason for the warmth of 1997 (WMO, 1998). Its lingering effect in 1998 as well as the unprecedented warmth of the Indian Ocean are factors contributing to the temperature record that year (NOAA, 1999).

Comparatively, 1982 and 1983 do not rank amongst the warmest years in terms of the global mean temperature. This is probably attributable to the eruption of El Chichon in March/April 1982. The volcanic ash from the eruption would have blocked sunlight and offset any warming.

Consistent with the global tendency, 1998 is the warmest year ever in Hong Kong, and 1997 is co-ranked fifth. This is shown in Table 2.

Table 2. 10 warmest years since 1947 in Hong Kong and their relation to El Niño/La Niña activity.

year	*ranking*	*annual mean temperature (°C)*	*nature of year*
1998	1	24.0	La Niña onset following decline of El Niño
1966	2	23.8	year following El Niño onset
1994	**3**	**23.6**	**El Niño onset**
1991	4	23.5	El Niño onset
1977	5	23.4	year following El Niño onset
1987	5	23.4	year following El Niño onset
1997	**5**	**23.4**	**El Niño onset**
1963	6	23.3	El Niño onset
1973	**6**	**23.3**	**La Niña onset following decline of El Niño**
1996	6	23.3	year following La Niña onset

Table 2 also shows that 3 of the 10 warmest years are also amongst the wettest as appearing in Table 1 (1994, 1997, 1973), and that El Niño onset years or the years immediately following onset tend to be warmer on the whole.

3.3.2 Mean spring (February to April) temperatures

Lam (1993) found that wet springs with El Niño activity are likely to be cooler than usual. There seems to be no clear signal of an association between mean spring temperatures and La Niña.

4. Relationship between local sea levels and El Niño

As noted in the Introduction, when El Niño occurs, sea levels tend to rise in the eastern equatorial Pacific and fall in the western equatorial Pacific. This is due to the weakening of the southeasterly trade winds during El Niño events. Under normal conditions these trade winds would drive the waters westwards and thereby raising the water levels in the western equatorial Pacific.

It would seem that local sea level records also reflect these anomalies (Cheng, 1988). This can be seen in Fig. 3 which shows the deviations of monthly mean sea levels from their long-term (19-year) means during the course of the 1982-1983 and 1997-1998 El Niño events. For both events the records show a definite dip in mean sea levels towards the end of the onset year when the El Niño events are attaining or have attained maturity. The 1982-1983 anomaly is the more pronounced.

5. Predicting El Niño and La Niña events

Several models have been developed to forecast the evolution of sea surface temperatures (SST) as indicators of the onset and decline of El Niño/La Niña.

The two main categories of models in this regard are statistical models which use regression techniques and empirical orthogonal functions, and coupled atmosphere-ocean models which simulate air-sea interactions through advanced computational techniques. Barnston, Glantz and He (1999) finds that the two categories of models have comparable skills, and though not perfect, they do yield usable and helpful guidance.

The TOGA-TAO array provides an important source of observational data for the initialization, improvement and verification of these models. These data and models have enabled the 1997-1998 El Niño to be the first such event which is observed and forecast from onset to demise [News and Notes, Bulletin of the American Meteorological Society, March 1999].

The increased ability to predict SSTs also paves the way for predicting temperature and precipitation anomalies on a seasonal basis. This is done through ensemble forecasting (see the review by Palmer and Anderson, 1994) in which a model is run many times using slightly different initial conditions. The predicted value is given by the ensemble mean. Several centres have now made their experimental seasonal forecast products available to the international community.

Enquiries from the local community have given impetus for the Hong Kong Observatory to begin exploring the feasibility of formulating local seasonal forecast advisories by making reference to guidance from the above centres, local climatology and other relevant information.

6. El Niño/La Niña and the Media

The media can help to disseminate information effectively and widely, educate the public and promote awareness. Kuhnel (1998) amongst others has identified the media as a new 'stakeholder' in the El Niño/La Niña discipline. Press coverage of El Niño and La Niña events was also an agenda at the La Niña Summit held in Colorado in July 1998 where the perspectives of the press [headlines and soundbites] vis-à-vis those of the scientific community were discussed.

As elsewhere in the world, the 1997-1998 El Niño attracted much public interest. This is reflected in the great attention the media paid to the subject. To assist the printed and electronic media convey an informed and balanced view to the community, officers of the Hong Kong Observatory undertook many interviews. Features articles were written for the press as well.

A section on El Niño has been constructed on the Observatory's Homepage to provide easy access by the media and the public alike to the latest development on El Niño/La Niña events. Presently a television programme on El Niño/La Niña is also in preparation.

7. Conclusions

Some of the weather anomalies in Hong Kong associated with El Niño/La Niña events in respect of tropical cyclone activity, rainfall and temperature are identified. Although no two events are entirely alike and neither are the impacts, these anomalies are not without common features and they could serve as a broad analogue to the potential impacts of El Niño/La Niña on Hong Kong.

Acknowledgements

The results reported in this paper represent a summary of the work of many colleagues, especially that of Mr. C. H. Au. Their assistance and contributions are gratefully acknowledged.

References

Barnston, Anthony G., Michael H. Glantz, and Yuxiang He, 1999: Predictive skill of statistical and dynamical climate models in SST forecasts during the 1997-98 El Niño episode and the 1998 La Niña onset. *Bull Amer. Meteor. Soc.*, **80**, 217-243.

Burns, Richard F, 1998: CLIVAR — Climate prediction from past, present ..the future. *Sea Technology*, **39**, 29-43.

Chan, J. C. L., 1985: Tropical cyclone activity in the northwest Pacific in relation to the El Niño/Southern Oscillation phenomenon. *Mon. Wea. Rev.*, **113**, 599-606.

Cheng, T. S., 1988: El Niño and sea level changes. Presented at 'Future Sea Level Rise and Coastal Development', University of Hong Kong, April 1988.

Lam, C. Y., 1993: El Niño/Southern Oscillation and spring weather in Hong Kong. *HKMetS Bulletin*, **3,** 3-13.

Lau, K. M., 1999:

McPhaden, Michael J., 1999: The child prodigy of 1997-1998. *Nature*, **398**, 559-562.

NOAA, 1999: *Climate of 1998 —Annual Review (12 January 1999)*.

Palmer, T. N., and L. T. Anderson, 1994: The prospects for seasonal forecasting —A review paper. *Q. J. R. Meteorol. Soc.*, **120,** 755-793.

Piotrowicz, Stephen R., 1997: TOGA observing system and GOOS. *Sea Technology*, **78**, 39-44.

Saulesleja, Andrej, and Lars E. Olsson, 1997: Climate Information and Prediction Services —CLIPS. *World Meteorological Organization Bulletin*, **46,** 21-24.

Trenberth, Kevin E., and Timothy J. Hoar, 1997: El Niño and climate change. *Geophys. Res. Lttrs.*, **24**, 3057-3060.

Trenberth, Kevin E., 1997: The definition of El Niño. *Bull Amer. Meteor. Soc.* **78**, 2771-2777.

Webster, Peter J., and Timothy N. Palmer, 1997: The past and future of El Niño. *Nature*, **390,** 562-564.

WMO, 1997: El Niño Update, December 1997. World Meteorological Organization, Geneva.

WMO, 1998: Press release WMO No, 610, 20 January 1999. World Meteorological Organization, Geneva.

Table A1. Years in which El Niño* occurred.

Onset year	*Second year*	*Third year*
1951	1952	
1953		
1957	1958	
1963	1964	
1965	1966	
1968	1969	1970
1972	1973	
1976	1977	
1977	1978	
1979	1980	
1982	1983	
1986	1987	1988
1991	1992	
1993		
1994	1995	
1997	1998	

Table A2. Years in which La Niña* occurred.

Onset year	*Second year*	*Third year*
1950	1951	
1954	1955	1956
1956		
1964	1965	
1970	1971	1972
1973	1974	
1974	1975	1976
1984	1985	
1988	1989	
1995	1996	
1998	1999	

* based on Trenberth (1997)

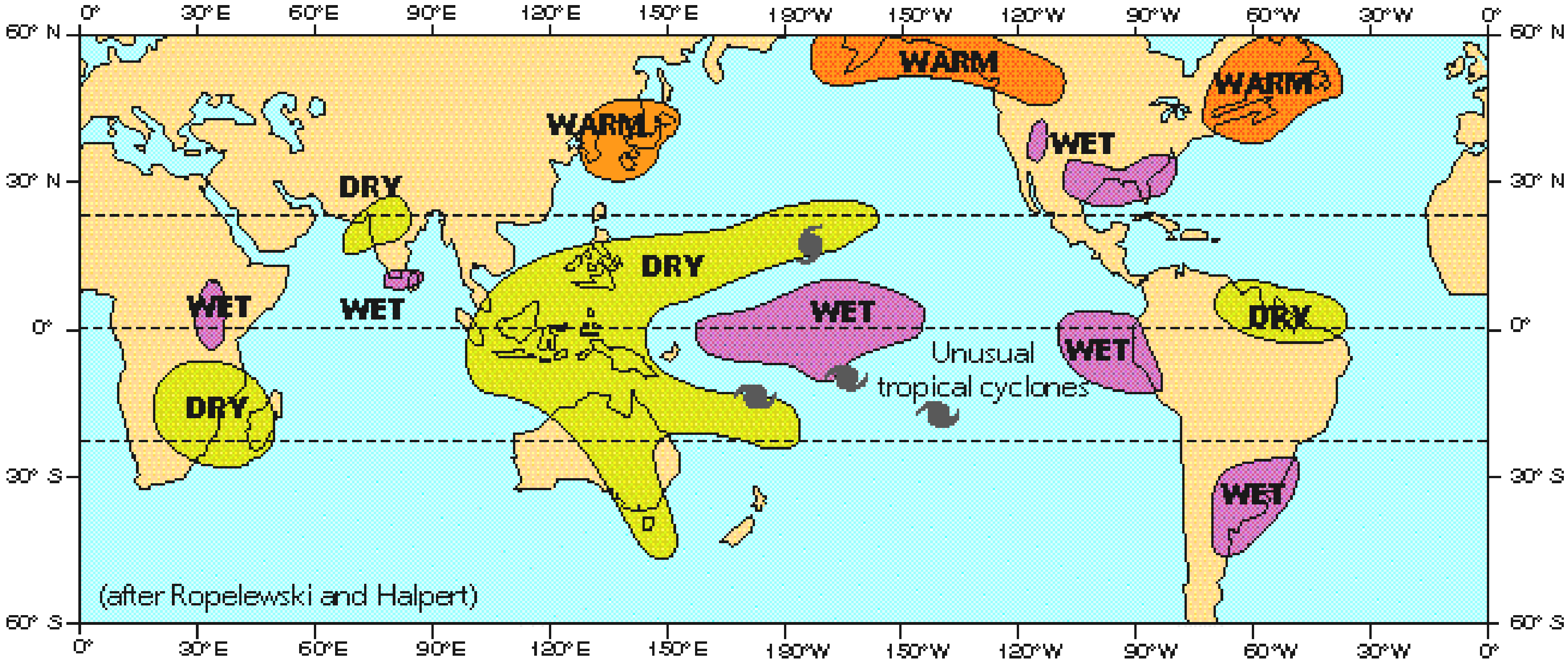

Figure 1a. The global impacts of El Niño. (Adopted from Plan for the Global Climate Observing System, GCOS-14(WMO/FD-No.681), Version1.0, May1995)

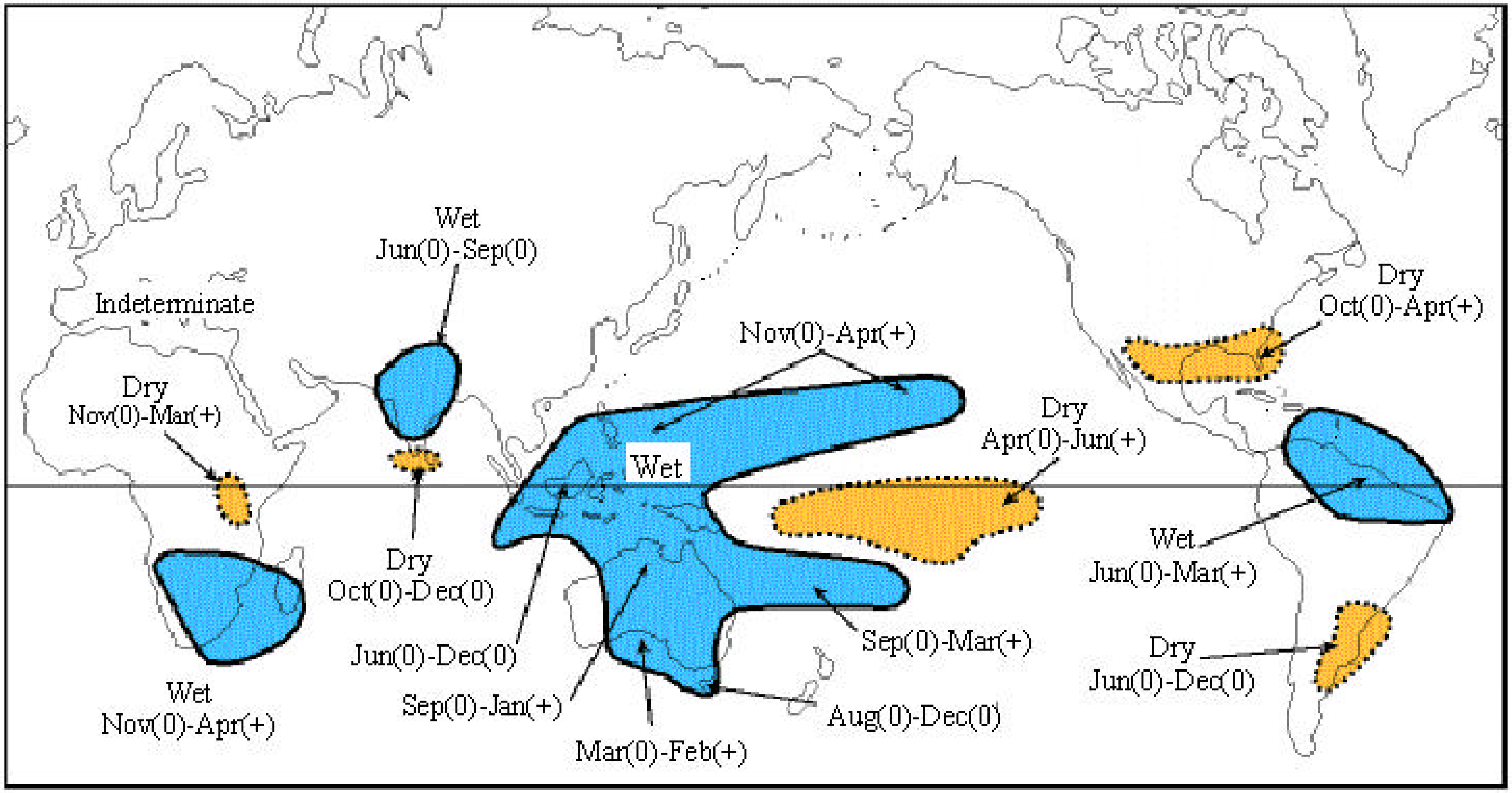

Figure 1b. The global impacts of La Niña. In the map, (0)=Year of La Niña Onset and (+)=Year Following La Niña Onset. (Adopted from the Summary Report for Workshop on 'Review of the Causes and Consequences of Cold Events: A La Niña Summit' held on 15-17 July 1998, Boulder, Colorado, USA)

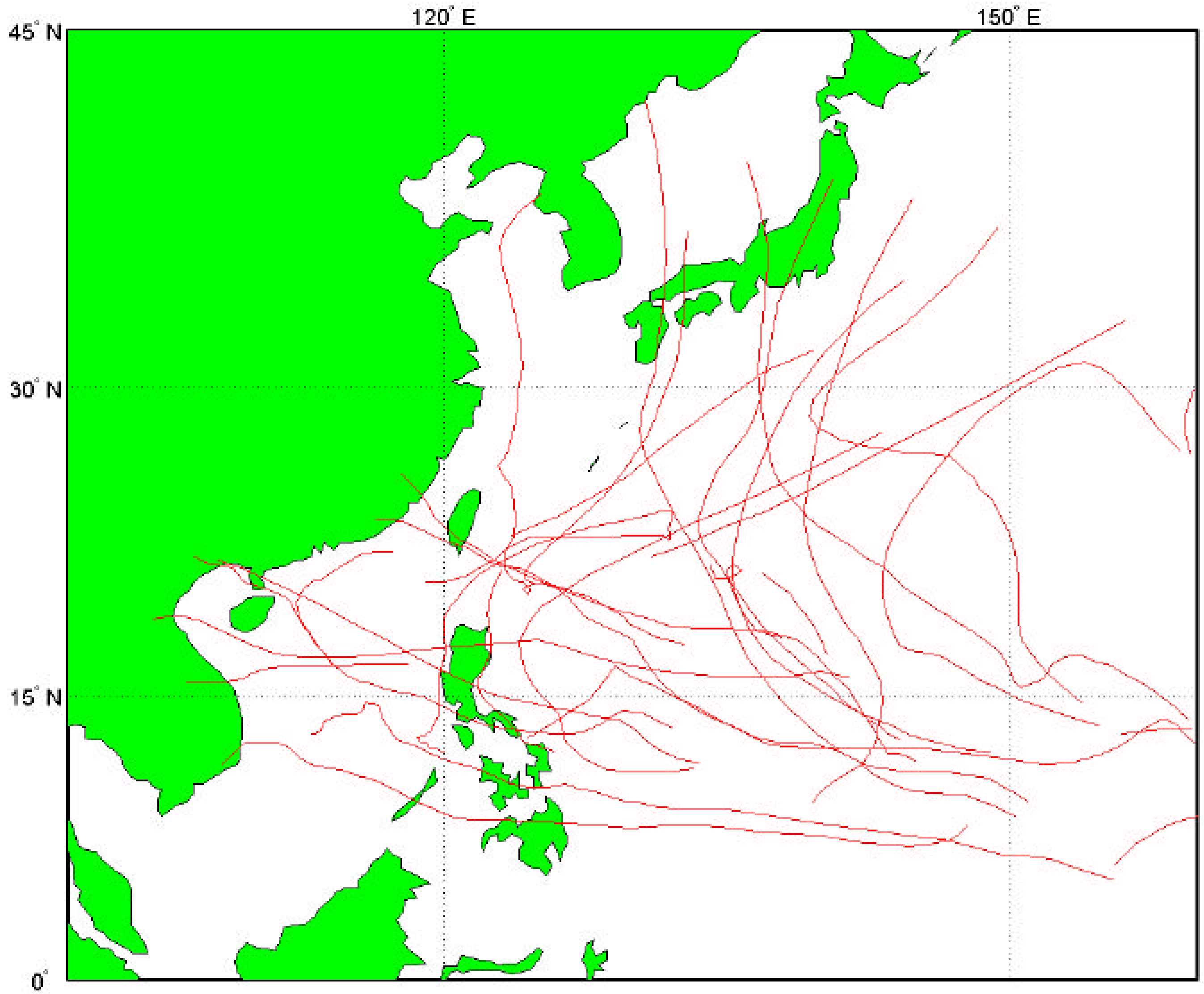

Figure 2a. Tracks of tropical cyclones in 1982.

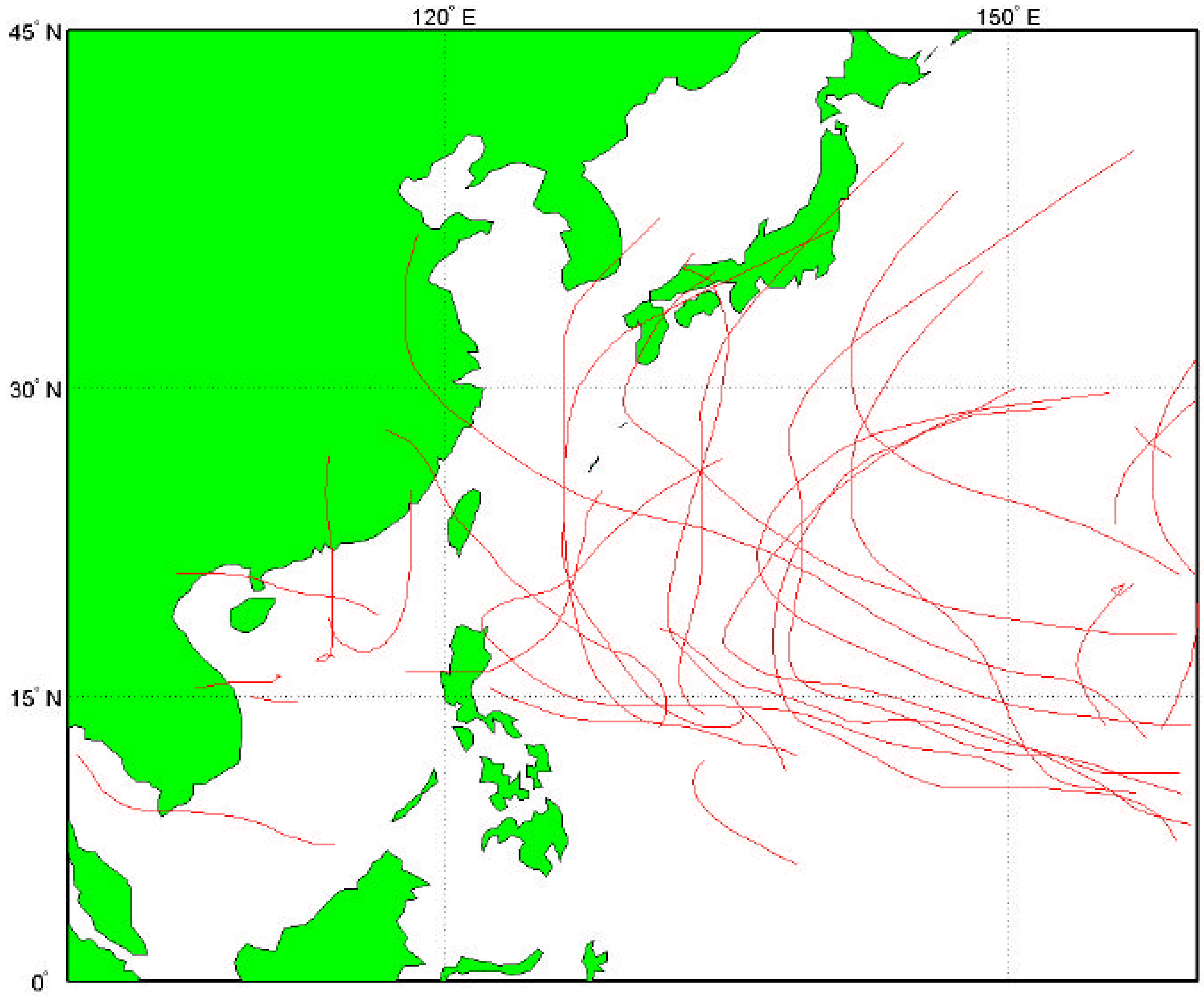

Figure 2b. Tracks of tropical cyclones in 1997.

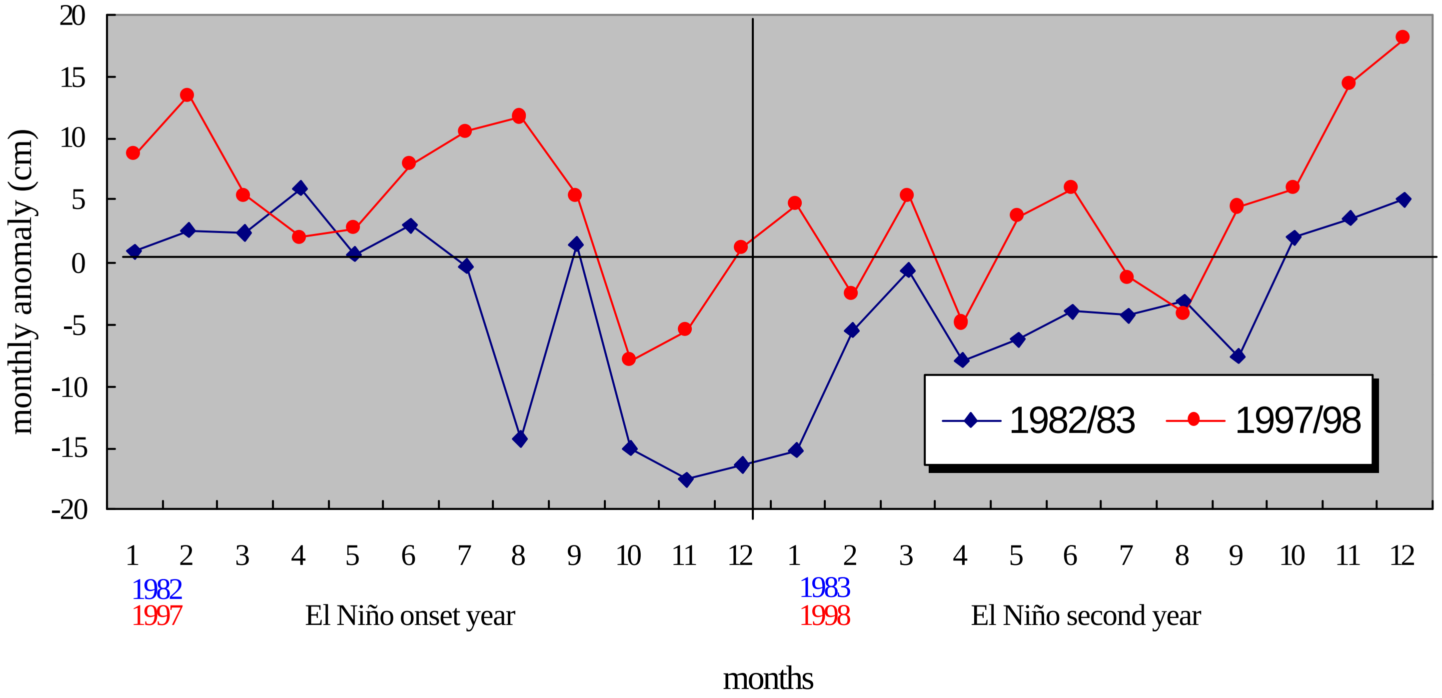

Figure 3. Monthly sea level anomaly at North Point/Quarry Bay, Hong Kong
(anomaly is based on the mean from 1980 to 1998)