

On Long-Term Variations of Typhoon Activities in Taiwan

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Abstract

This article discusses the ultra-long (> 30 years), the interdecadal, and the interannual variations of the invaded-typhoon activities in Taiwan. A long-term decreasing trend in annual total invaded typhoons is noted on the ultra-long time scales. For the interdecadal variations, the activities of invaded typhoons were gradually suppressed since 1960's, reaching an inactive period in 1970's, and then slowly moved into a more fluctuated phase after mid-80's. The evolving tendency of typhoon activities over Taiwan is similar to that over the western North Pacific areas, which in turn may have a certain association with the interdecadal variations of tropical sea-surface temperature anomalies (SSTAs). The shorter interannual variations of invaded-typhoon activities are related to the ENSO cycles in that the annual frequency was noticeably reduced in the abnormal-SSTA years, especially in the extremely cold ones. It is interesting to note, however, that the storms tend to be more intensified in warm years than in cold years.

1. Introduction

Taiwan is in the main tracks of non-recurred western North Pacific (WNP) typhoons. The data of typhoon activities around Taiwan have been documented since 1897, and may also be used as indication of interannual variations of the non-recurred WNP typhoons. Here, a typhoon is regarded as a tropical cyclone that reaches the intensity of a tropical storm (whose near-the-center maximum wind ≥ 17.2 m/s or 34 kts) and beyond (CWB 1994). Special focus has been put on the so-called invaded typhoons that had caused loss of lives and/or damages of properties in Taiwan, regardless of they made landfall or not (Hsiao 1993; CWB 1994).

Figure 1 shows the time series of invaded typhoons in Taiwan from 1897 to 1995. In general, there are about 3–4 invaded typhoons in Taiwan per year. However, the yearly total can be as many as eight in some years (1914), while as few as none in others (1941 and 1964). It thus shows that the year-to-year variations of the invaded-typhoon activity can be pronounced. By applying the auto-correlation and harmonic analysis to the data (1897–1992), with the fundamental period being set to 108-year, three major climate-scale oscillations, centered respectively at the periods of near 34, 7 and 3 years, have been identified (Fig. 2; from Hsiao 1993). The following discussions will focus on the variations of the invaded-typhoon activities comparable to these three time periods, namely, the ultra-long (≥ 30 -year), the interdecadal (7–10 years), and the shorter interannual variations.

2. Ultra-long variations

While the climatological grand mean (1897–1995) shows about 3.5 events per year, a long-term decreasing trend seems to be evidenced from successive 30-year means, showing 4.2 times per year in 1901–30, 3.4 in 1931–1960, and 3.1 in 1961–1990. It is also noted that there were at least 2 invaded typhoons yearly prior to 1936 (except in 1897: only once), and at least 3 in the period of 1916–1932. On the other hand, there were at most 4 episodes only per year between 1963–1980, and at most 3 in the last 9 years of the same period. This may suggest a real decreasing trend, but it may also be affected by a slight change of the definitions in invaded typhoons in 1962 (CWB 1994).

3. Interdecadal variations

For the data homogeneity, our scope of study on the interdecadal variability of invaded-typhoon activities in the Taiwan area is restricted to the last 34 years (i.e., 1962–95). It is noticed that the distribution of annual invaded typhoons becomes bi-modal during this period (Fig. 3). The major peak is still concentrated at 3 events per year, whereas the secondary peak at 1. The maximum number of annual invaded typhoons were noted to be four in 60s', three in 70s', five in 80s', and six in 90s', showing the year-to-year variations become aggravated recently, especially after the late 80s' (Fig. 1). Such a

trend is somewhat coincident with the evolving tendency of yearly total tropical storms (including typhoons) over the WNP (Fig. 4), according to both the JTWC (1993) and the JMA (1993). It is interesting to learn that the sea-surface temperature anomalies (SSTAs) over the NINO-West region (130–150°E, 0–14°N) are generally colder (than normal) in 70s', warmer in 80s', but become colder again in early 90s'. In addition, the SSTAs over the NINO-3 region (150–90°W, 4°S–4°N) show a similar interdecadal trend as over the NINO-West region in the 70–80s', but continue to be warmer in the early 90s' (Fig. 5). Therefore, it might be worthwhile to explore the relationship among the interdecadal variations of typhoon activities in the vicinity of Taiwan, over the WNP, and the SSTAs over the tropical Pacific.

4. Interannual variations

As to the interannual variability of invaded-typhoon activities in the Taiwan area, its association with the ENSO events has been investigated by local researchers recently (Chang 1994, 1996a, 1996b). The change of definition in invaded typhoons is not as crucial to these short-term climate scales as the longer temporal scales mentioned above, so the records prior to 1962 can also be included in the discussion. It is found, by using the data in 1949–95, that the yearly total invaded typhoons can be influenced by the ENSO cycles. From the 47-year record, it is noted that 11 out of 13 years with 2 yearly invaded typhoons or fewer are those years with either an El Niño (September–December mean NINO 3 SSTA ≥ 0.5 °C; including 1983) or a strong La Niña event (≤ -1 °C), while 11 out of 12 years with 5 or more are the near normal (or slightly cooler) years (Fig. 6). Furthermore, the SST-normal years are almost all with at least 3 annual invaded typhoons (23 out of 25), while those associated with either an El Niño or a La Niña are at most 4 invaded typhoons yearly (21 out of 22). It is thus concluded that the invaded-typhoon activities in the Taiwan area are more active during the normal SST years than during the abnormal years, especially the cold ones. Besides, while the effects of warming or cooling tropical SSTAs to the annual invaded-typhoon activities are similar, the corresponding effects to the storm intensity are different. The statistics (since 1958) show that the invaded typhoons tend to be more intensive in the El Niño (or warm SSTA) years, while weaker in the La Niña (or cold SSTA) years (Fig. 7). This may be partly due to the eastward (westward) shift of the storm formations over the WNP areas in the warm (cold) years (see e.g., Lander 1994), so that the storms have a longer (shorter) developing time over the open-water surfaces before reaching the Taiwan area.

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5. Reference

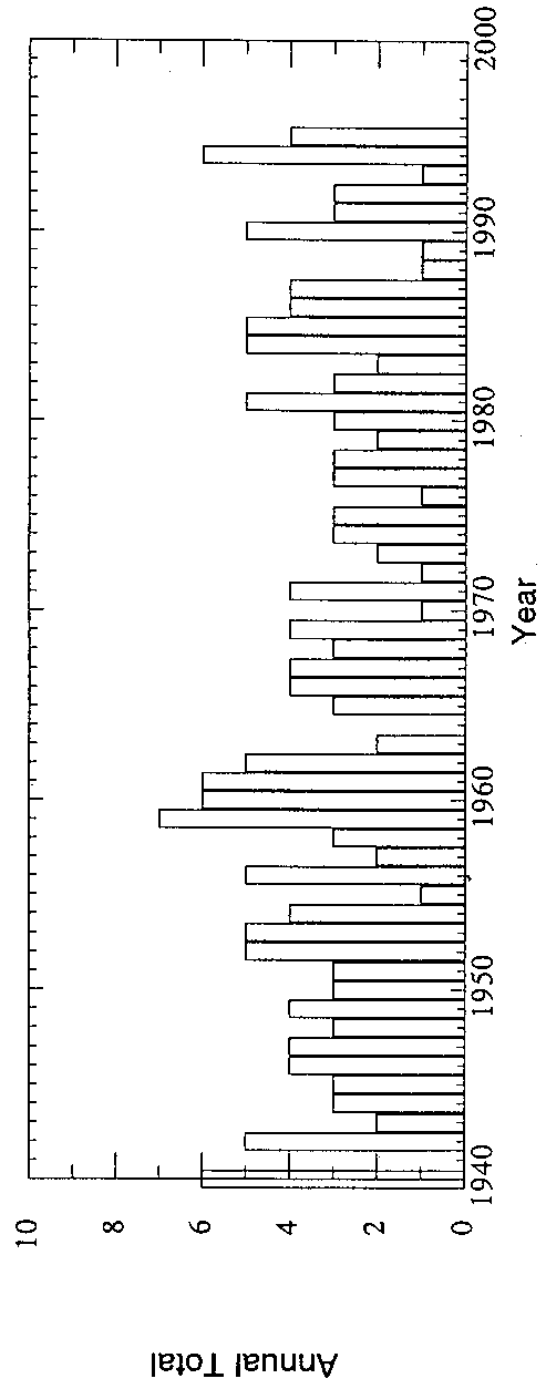
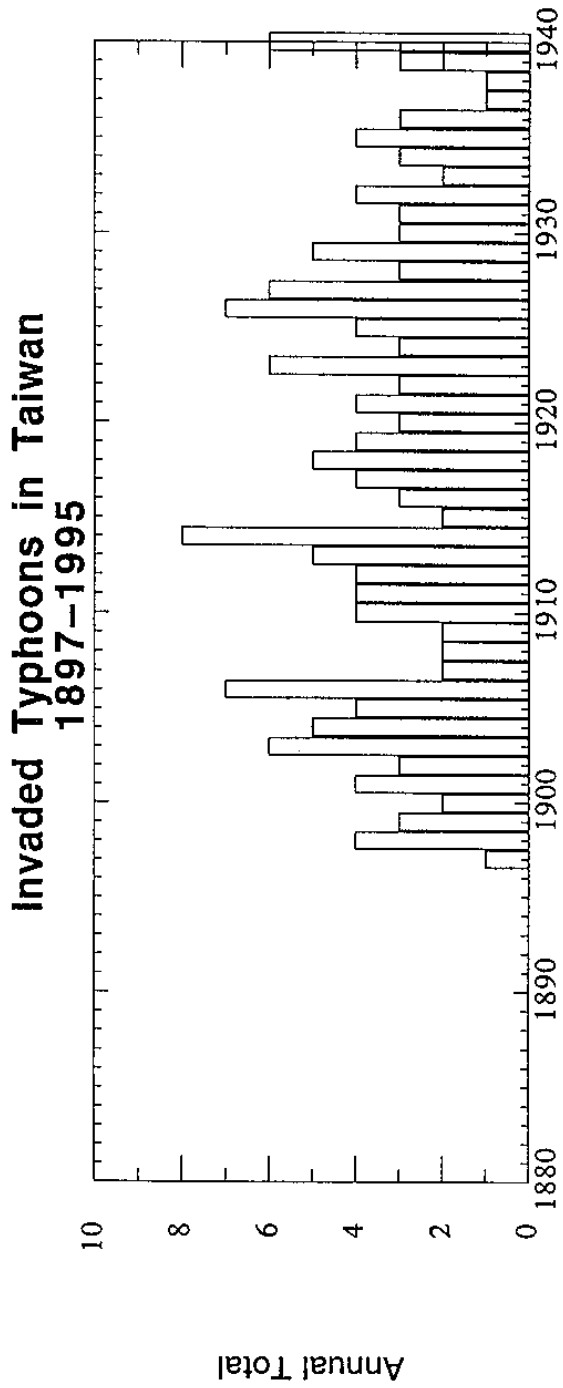


Fig. 1 Time series of annual total invaded typhoons in Taiwan in 1897-1995.

Autocorrelation and Harmonics Analyses 1897–1991

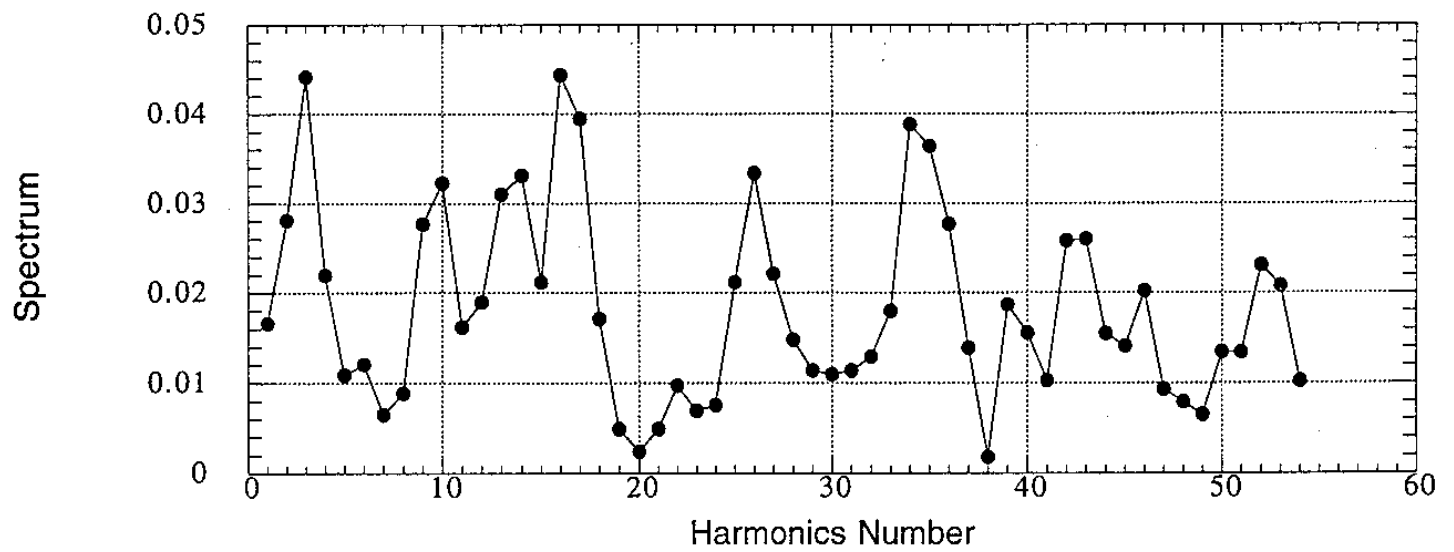
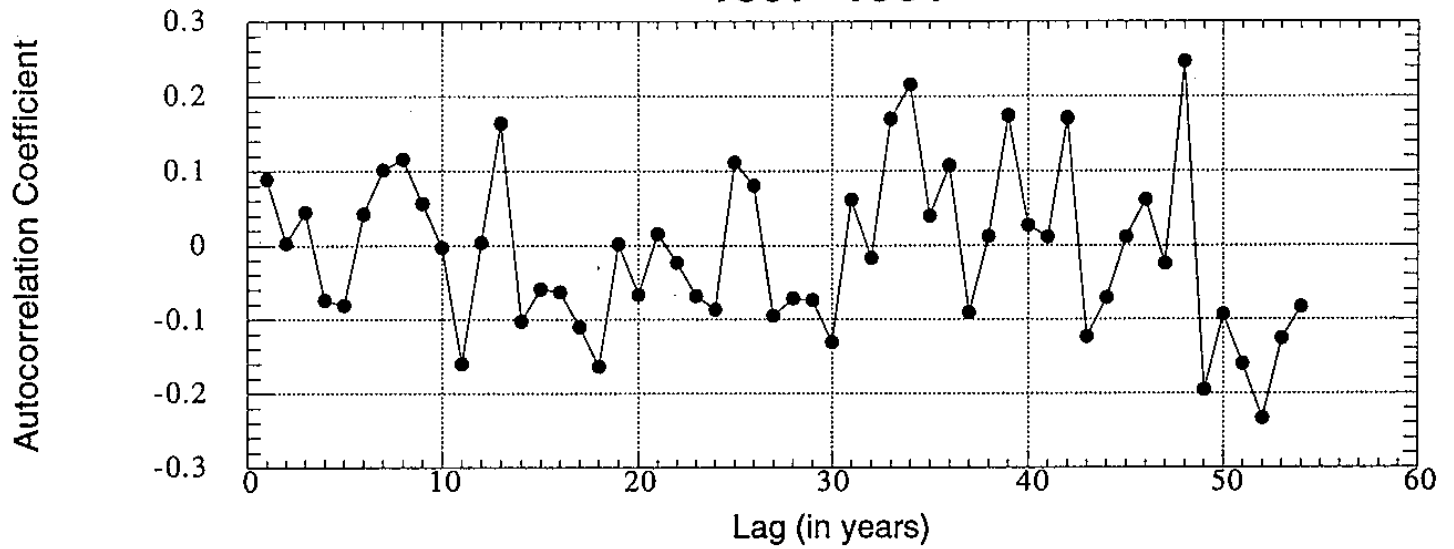
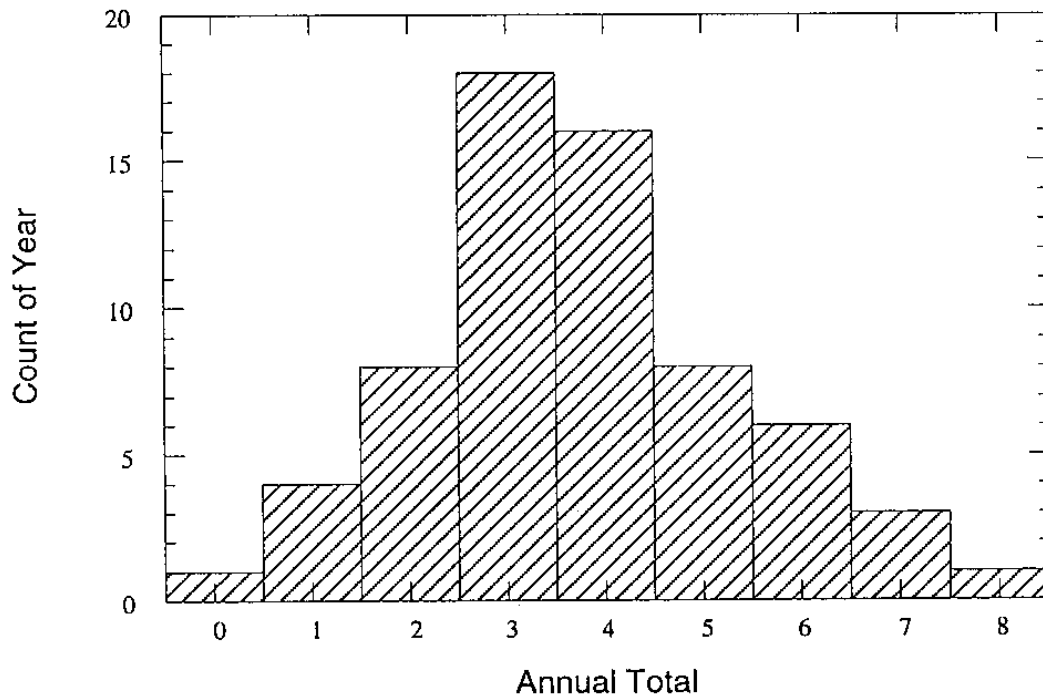


Fig. 2 (a) Auto-correlation coefficients and (b) its harmonics spectrum of the annual total invaded typhoons in Taiwan in the period of 1897–1992 (after Hsiao 1993, his Fig. 10b).

**Distribution of Annual Invaded Typhoons
(1897–1961)**



**Distribution of Annual Invaded Typhoons
(1962–1995)**

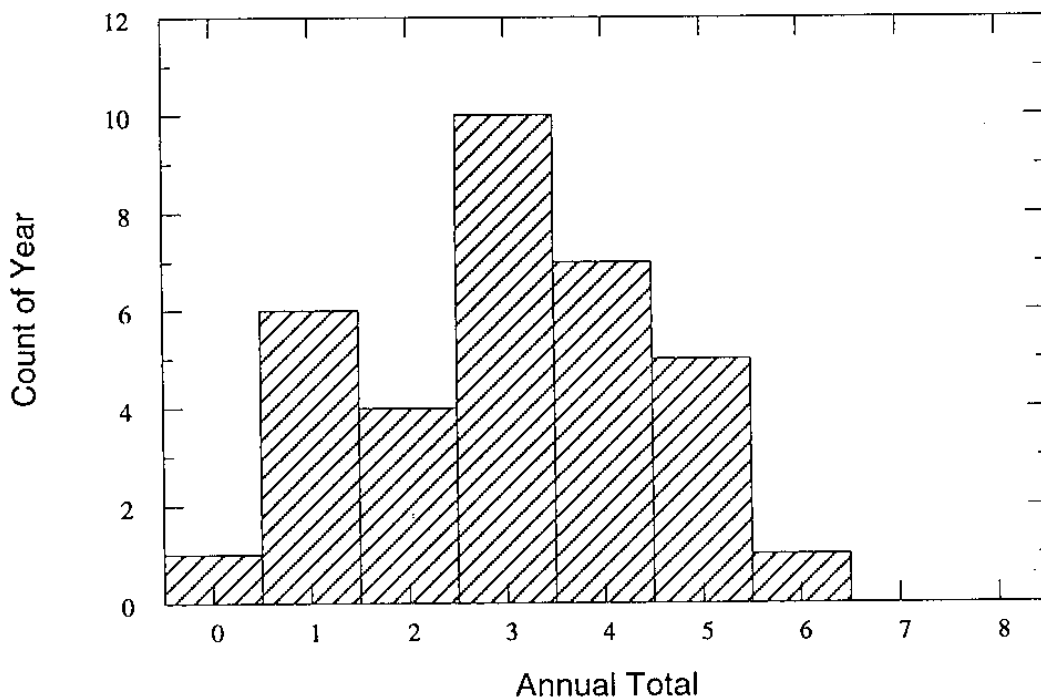


Fig. 3 Distributions of annual total invaded typhoons in Taiwan in the periods of (a) 1897–1961, and (b) 1962–1995.

$\langle TY+TS \rangle$ in 1959-93 (JTWC)

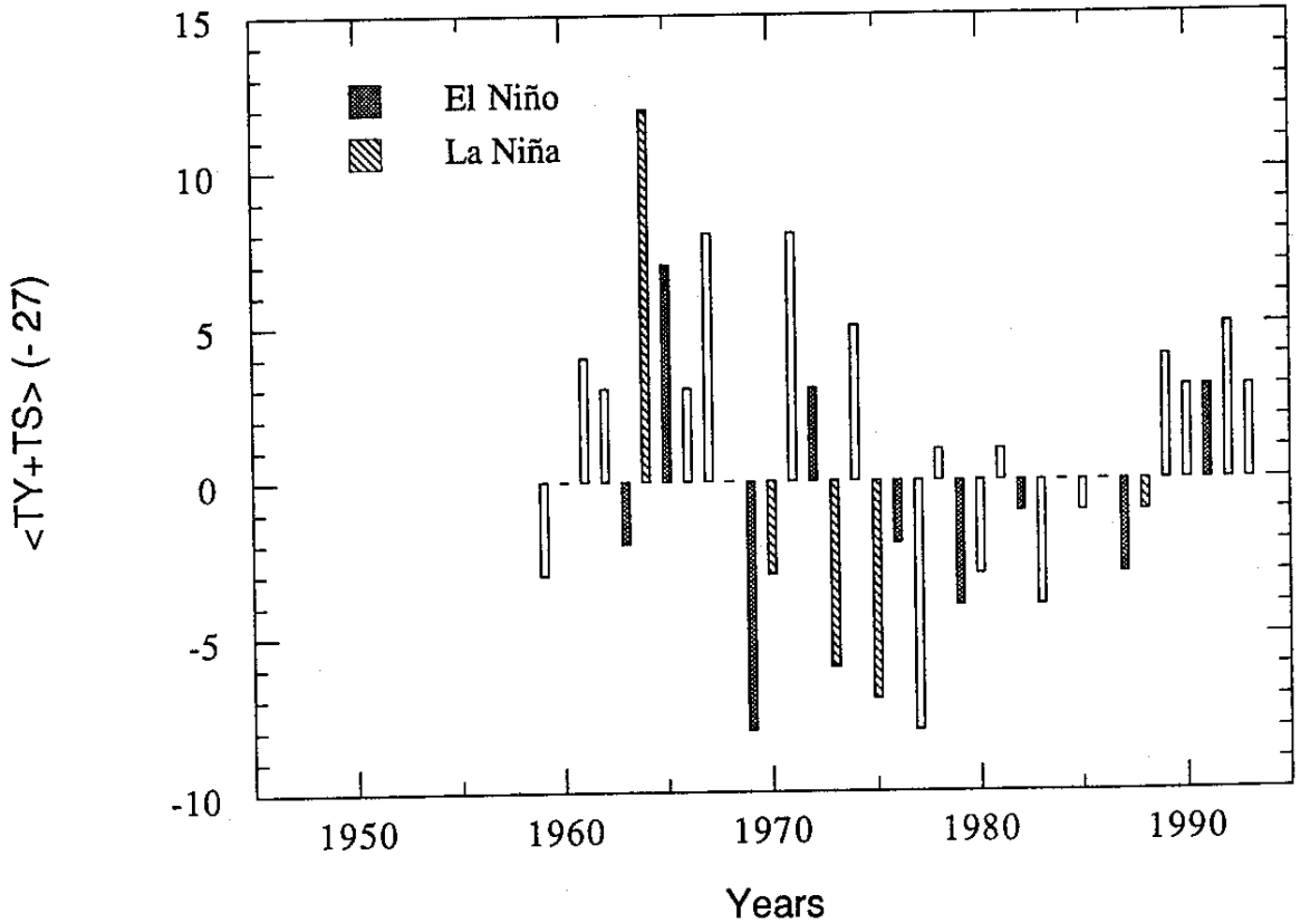


Fig. 4 Time series of annual total tropical cyclones over the WNP areas that reach at least tropical-storm intensity in 1959-1993.

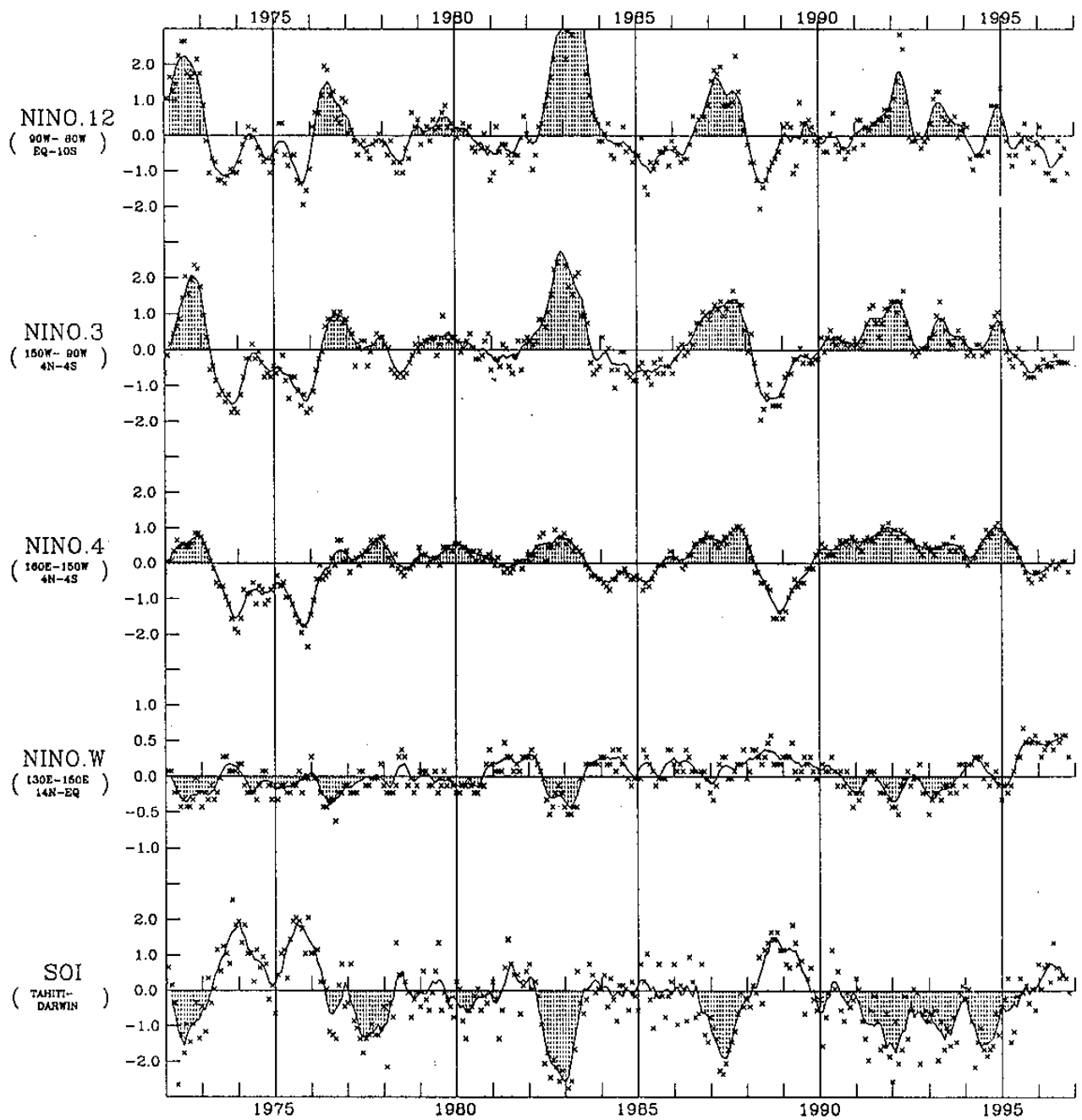


Fig. 5 Time series of ENSO indices since 1972: (a) NINO 1+2, (b) NINO 3, (c) NINO 4, (d) NINO West, and (e) SOI. (The x's represent monthly values, and the curves indicate 5-month running-mean values.)

<ITYs> in 1949–95

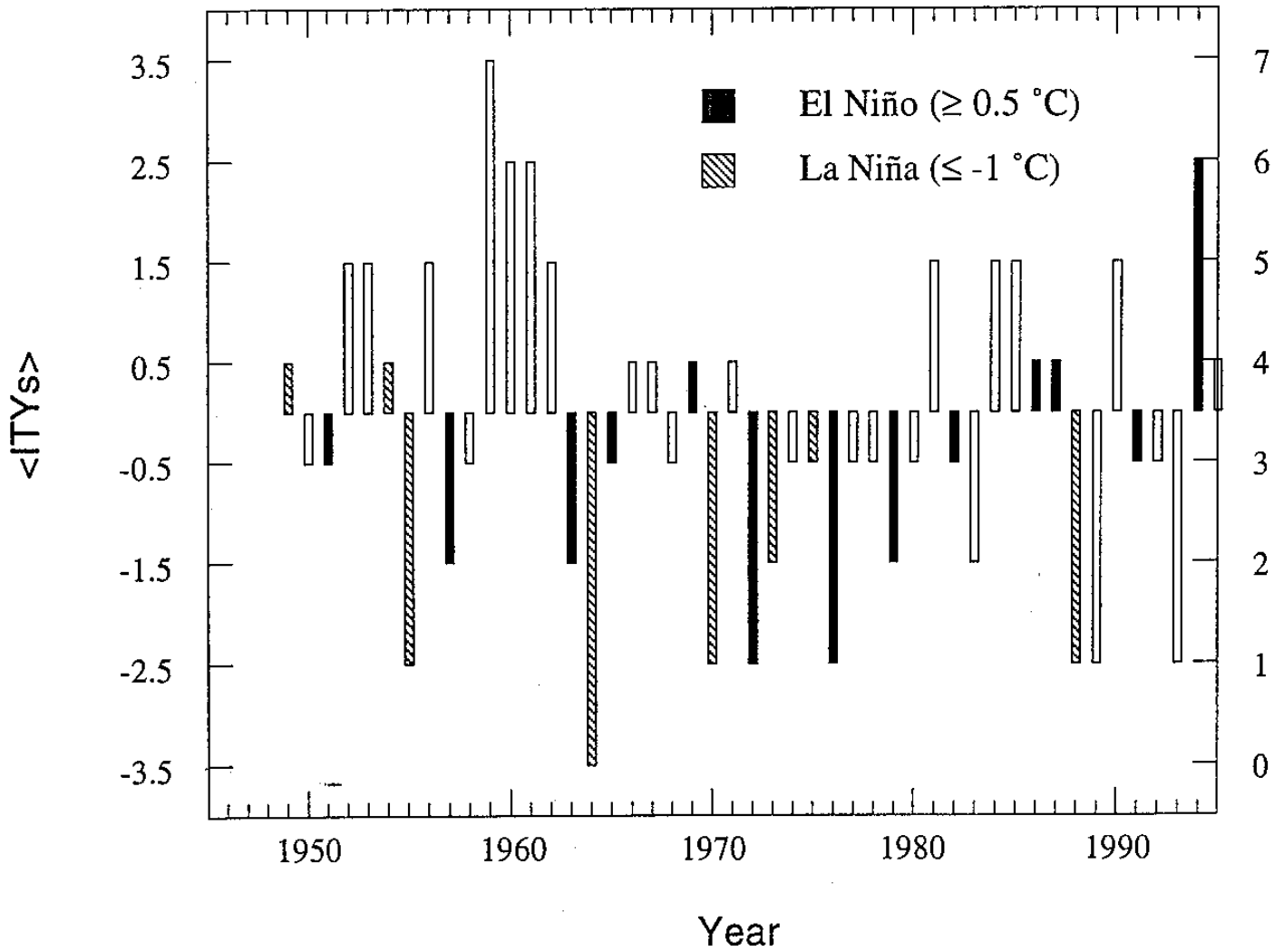


Fig. 6 Time series of <ITYs> (i.e., annual total invaded typhoons in Taiwan) in the period of 1949–1995, categorized by El Niño, La Niña, and normal (and slightly cooler) years (see text for details).

Distributions of Storm Intensity (1958–95)

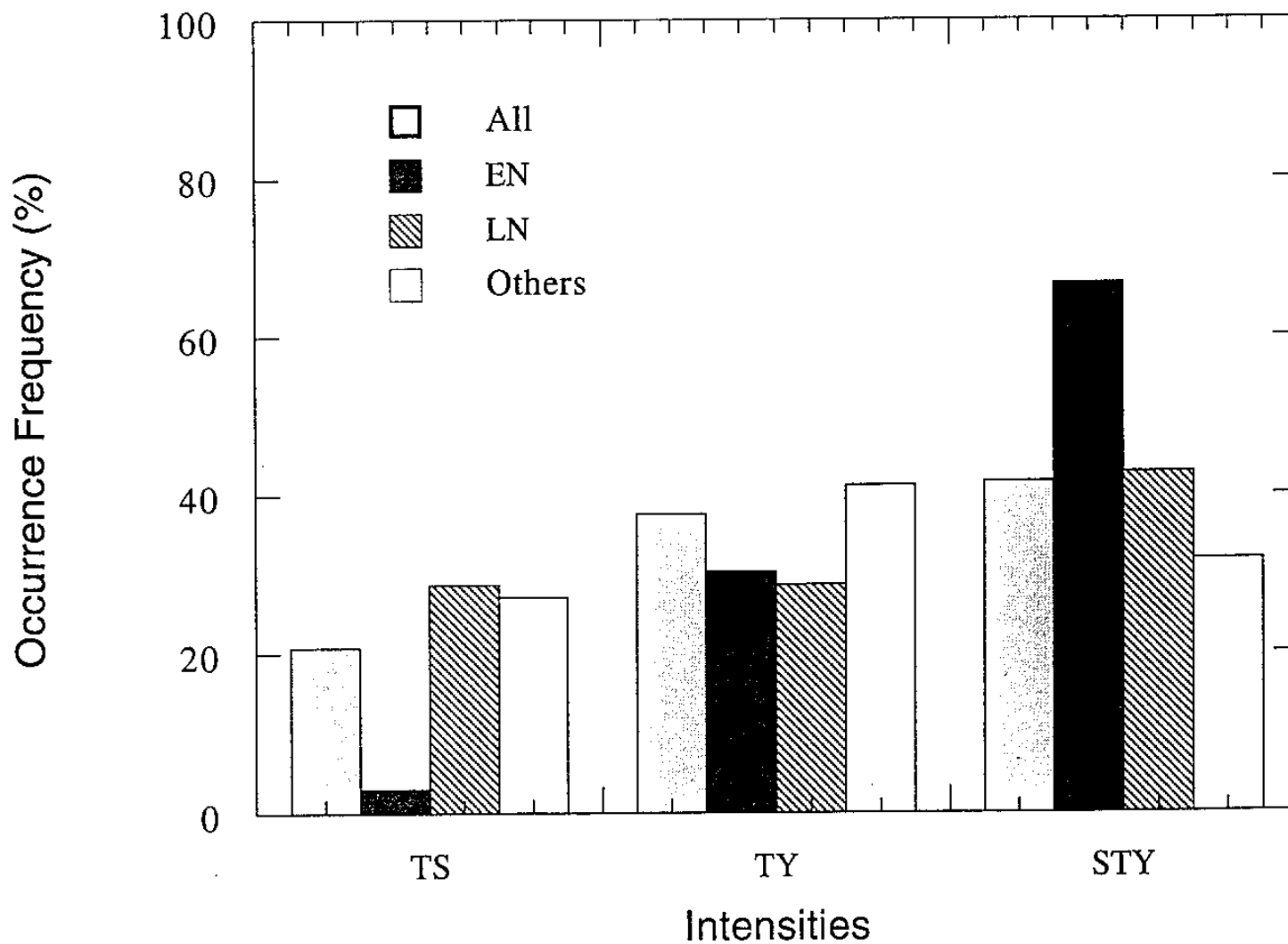


Fig. 7 Distributions of invaded-typhoon intensity in the period of 1958–1995 for all cases (light shading), the El Niño (EN) cases (dark shading), the La Niña (LN) cases (hatching), and the remaining cases.