NOTES AND CORRESPONDENCE

A Further Extension of the Tahiti–Darwin SOI, Early ENSO Events and Darwin Pressure

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ABSTRACT

An extension of the Tahiti minus Darwin Southern Oscillation Index (SOI) from 1882 back to 1876 is reported following the recovery of early Darwin mean sea-level pressure data spanning the period 1865–81. As a result, we are able to compare, for the first time, the major 1877–78 and 1982–83 ENSO events on the basis of this commonly used index. Early Darwin and Jakarta data are also examined in terms of a measure of the Australian response to documented El Niño and/or ENSO events in 1866, 1868, 1871, 1873, 1874 and 1875.

The SOI during the 1877–78 ENSO event has a similar temporal response to that in 1982–83, but the index is slightly weaker than in the recent event. Examination of documentary evidence confirms the severity of the drought conditions that affected the Australian continent during the 1877–78 ENSO, and shows that this response is in line with the wider Indo-Pacific impacts reported in the literature. Earlier El Niño phases in 1868 and 1873 are not resolved distinctly in either the Darwin or Jakarta pressure data. This appears to illustrate that El Niño event histories do not always indicate wider ENSO influences in the Indo-Pacific basin, particularly during weak to moderate phases.

1. Introduction

Interest in extending historical and early instrumental records of the El Niño–Southern Oscillation (ENSO) phenomenon has grown following concerns about low-frequency fluctuations in ENSO and its possible modulation by the greenhouse effect (R. J. Allan 1989; B. J. Allen 1989; Allen et al. 1989; Brookfield 1989; Baker-Blocker and Bouwer 1984; Cooper et al. 1989; Elliot and Angell 1988; Enfield 1988, 1989; Hamilton and Garcia 1986; Hanson et al. 1989; Lindesay and Vogel 1990; Nicholls 1988, 1989; Quinn et al. 1987; Whetton and Baxter 1989; Whetton et al. 1990; Whysall et al. 1987). In seeking to understand the longer term variability and influence of this near-global, ocean–atmosphere phenomenon, attempts have been made to distinguish between wider ranging ENSO phases based on related eastern hemisphere events (such as Indonesian east monsoon droughts, deficient Indian summer monsoon rainfall and weak Nile floods) and more localized El Niño events, which influence only the immediate South American region (Quinn 1990). Although recent appraisals of Southern Oscillation Indices (SOIs), El Niño and ENSO events by Quinn et al. (1978), Quinn et al. (1987), Quinn and Neal (1990), Quinn (1990) and Wright (1975, 1977, 1984, 1989) have extended these signatures at least back into the middle of the 19th century, the most widely used SOI based on Tahiti–Darwin mean sea level pressures is available only from 1882. This date marks the earliest Darwin mean sea level pressure data hitherto available; Tahitian mean sea level pressure data have been recovered back to 1876 by Ropelewski and Jones (1987).

A consequence of this situation has been that studies have had to document the severity of the 1877–78 ENSO, believed to be similar to the massive 1982–83 event, without recourse to the Tahiti–Darwin SOI (Kiladis and Diaz 1986; Quinn et al. 1978; Quinn et al. 1987; Quinn and Neal 1990; Quinn 1990). However, recent examinations of the meteorological records contained in publications of the Adelaide Observatory (Todd 1879–1910; Griffiths 1910) and held in the Northern Territory Branch of the Australian Archives (Peel 1881) has led to the recovery of Darwin mean sea-level pressure data from 1865 to 1881. These sources also record significant barometer type and cistern height changes not documented in the widely cited data references. In this note we present these data and discuss their use in extending the Tahiti–Darwin SOI back to 1876, and thus provide a further index with which to contrast the 1877–78 and 1982–83 ENSO events.

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2. Data

Prior to the formation of the Commonwealth Bureau of Meteorology in Australia in 1908, meteorological observations were the responsibility of each of the Australian states. Meteorological records for Darwin in the Northern Territory were compiled under the jurisdiction of the South Australian Government. Consequently, we found early Darwin data in yearly reports by the Adelaide Observatory in South Australia (Todd 1879–1910; Griffiths 1910). These publications provided data for the period from 1876 to 1907, and overlap with compilations by the Smithsonian Institution (1944), the Australian Bureau of Meteorology (personal communication 1990) and Hunt (1918) after 1881. However, we have discovered that the earliest mean sea level pressure data for Darwin are contained in a journal by Peel (1881) and begin in March 1869. Earlier pressure data from January 1865 to July 1866 are also documented in this publication for a location near Darwin (Adams Bay). Unfortunately, we found these observations to be of dubious quality in the light of correspondence between the Darwin observer and Todd, the South Australian Government Observer, Postmaster-General and Superintendent of Telegraphs (Peel 1881). Details of the observational practices and corrections that were made to the mean sea level pressure data are provided in the Appendix.

3. Results and discussion

We have established the reliability of the Darwin data prior to 1882 by cross checking with Jakarta records (Fig. 1), while known Tahitian pressures were contrasted with those at Santiago in Chile (not shown). Examination of the five-month running means of Darwin and Jakarta pressures (Fig. 1) show that these data are aligned closely from 1876 to 1882. However, we have far less confidence in the Darwin records back to 1869. It was hoped that missing Tahitian data for the first six months of 1877 (Ropelewski and Jones 1987) could be approximated by pressures observed at Santiago. However, given the poor correlations between these stations in Ropelewski and Jones (1987) this proxy was rejected.

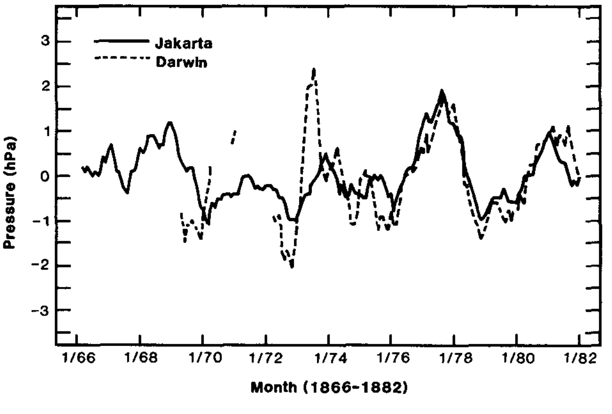

FIG. 1. A five monthly running mean of Darwin and Jakarta mean sea level pressure anomalies (hPa) from 1866 to 1882.

a. *SOI extension to 1876*

As a result of the availability of both the Tahiti and Darwin mean sea level pressure data back to 1876, the Tahiti–Darwin SOI can now be calculated for the period from 1876 to 1881 (Table 1). In this table, the index is calculated according to the method attributed to Troup (1965), where anomalies of monthly Tahiti minus Darwin pressure differences are standardized by the standard deviation of the Tahiti minus Darwin series. Missing SOI values from January to June 1877 (Ropelewski and Jones 1987) are due to the absence of data from Tahiti, while the missing December 1881 value is due to the absence of data from Darwin.

Any comparison with the only other long-term SOI of Wright (1989) is not entirely satisfactory, as the Tahiti–Darwin SOI presented here is on a monthly basis while that of Wright is deduced seasonally and is based on his earlier "area averaged" principal component derived index (Wright 1975, 1977). Nevertheless, there is a broad consensus in terms of the "onset and cessation" of most + and − SOI phases. The − SOI episodes in 1877–78 and 1880–81 are associated with strong and moderate El Niño events respectively in the historical classification of these features by Quinn et al. (1978). The more recent studies of Quinn et al. (1987) and Quinn and Neal (1990) grade the 1877–78 El Niño as very strong. Although they still designate the 1880–81 episode as being of moderate intensity, the areal extent of data covering this event is limited. Finally, Quinn (1990) provides a compilation of near-global, historical ENSO events, and lists very strong ENSO conditions in 1877–78 and moderate ENSO conditions in 1880–81.

It must be remembered that El Niño severity indices are based on information from the South American sector, and thus do not always indicate the existence of wider and significant ENSO conditions in Australasia, especially if the events are in the range of weak to moderate (Quinn 1990). As noted in Deser and Wallace (1987), indicators of El Niño are most sensitive to climatic conditions in late winter to early spring, so that lists of El Niño years do not necessarily coincide with the years indicative of basinwide ENSO events. Correlations between ENSO events and rainfall, show that widespread precipitation deficiencies and drought usually affect northern and eastern inland Australian regions (National Climate Centre 1988). During very pronounced ENSO episodes such patterns can extend over most of the Australian continent.

TABLE 1. Monthly values of the Tahiti–Darwin SOI (Troup's form of the index) from 1876 to 1881 (positive values are underlined, negative values are in bold typeface).

	J	F	M	A	M	J	J	A	S	O	N	D
1876	10.8	10.6	**−0.7**	7.9	6.9	14.2	**−5.2**	11.8	10.5	**−7.9**	**−2.8**	**−4.3**
1877	—	—	—	—	—	—	**−9.5**	**−7.6**	**−16.5**	**−16.0**	**−12.3**	**−13.9**
1878	**−9.4**	**−22.9**	**−14.7**	**−8.2**	2.5	**−3.2**	14.8	12.4	17.5	11.7	14.4	16.6
1879	12.1	14.1	10.8	10.9	2.5	13.5	20.2	21.5	18.7	16.1	9.3	**−6.8**
1880	10.3	7.2	11.8	4.3	12.1	7.2	1.4	13.6	8.1	5.4	6.8	**−3.2**
1881	**−7.9**	**−6.6**	0.7	**−0.1**	**−3.4**	**−4.6**	**−5.2**	**−10.6**	**−12.9**	**−24.4**	6.8	—

b. The 1877–78 and 1982–83 ENSO events

According to studies such as Kiladis and Diaz (1986), the 1877–78 ENSO is the closest in character and magnitude to the 1982–83 event. In fact, the importance of the 1877–78 event was perhaps realized at the time, in that a request was made in 1878 by Sir Henry Blandford, the first Director of the Indian Meteorological Service, for information regarding the high atmospheric pressures throughout the Indo-Pacific region in 1877 (Todd 1881:XXVIII). This reference was our initial source of Darwin pressures from 1876 to 1877.

In Fig. 2, we are able for the first time to compare the Tahiti–Darwin SOI for these two major and protracted ENSO events. An inspection of the indices alone certainly suggests a similar evolution and cessation of the events, although from sea surface temperatures and other surface pressure records Kiladis and Diaz (1986) suspect that the 1982–83 ENSO ceased much later and more rapidly across the Pacific. With the absence of SOI values for the first half of 1877, it is difficult to compare the early stages of the events. However, we suspect that the 1877–78 event may even have begun by the austral spring of 1876. Comparison of SOI magnitudes in the two events seems to suggest that the 1982–83 ENSO was more intense during its peak phase. This alone may support some of the conclusions of Kiladis and Diaz (1986) concerning the moderate nature of the manifestations of the 1877–78 event over Australia. However, it is in turn very much at odds with the magnitude of the wider impacts noted throughout the Indo-Pacific basin and pressure anomalies detailed at other Australian stations (Berlage 1966; Hildebrandsson 1897; Lockyer and Lockyer 1902, 1904; Lockyer 1906; Schove and Berlage 1965; Walford 1878; Walker 1910).

Contrary to the findings in Kiladis and Diaz (1986), the influence of the 1877–78 ENSO on widespread environmental conditions in Australia is quite marked in historical accounts, with indications that the event had begun in late 1876. A major drought affected mainland Australia in 1877–78 (Walford 1878, p. 479). According to this source and Foley (1957), massive livestock losses occurred in Australia. Severe drought conditions and much reduced river flow were reported from each of the Australian colonies during the period 1876–78 in the climatic summaries of Hunt (1911, 1914, 1916, 1918, 1929) and Russell (1886). It would seem that in most regions the drought was 'broken' by abundant and widespread rainfall across the eastern half of the Australian continent in February–March 1878 (Foley 1957; Hunt 1911, 1914, 1916, 1918; Walford 1878).

During the 1982–83 ENSO event, drought conditions prevailed over the eastern half of the Australian continent following the failure of winter and spring rainfall in 1982 and the late and poor summer monsoon season in 1982/83 (Martin 1983; Gibbs 1984). Thus analogies between the 1877–78 and 1982–83 droughts, are best in the states of Queensland, New South Wales, Victoria and South Australia. Nevertheless, mean sea level pressure data for Perth in Western Australia suggest that pressure anomalies were higher in June to October 1877 than in 1982. This would tend to support documentation of severe drought conditions

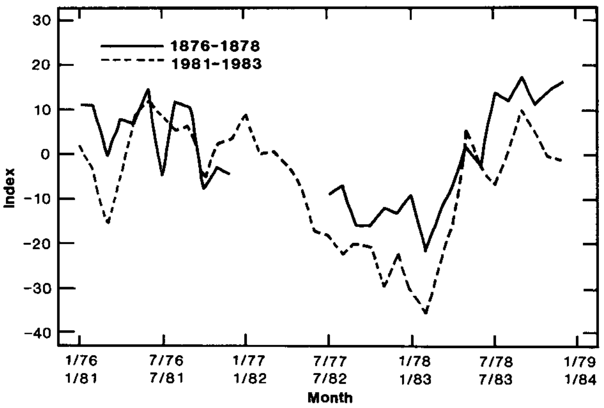

FIG. 2. A comparison of monthly values of the Tahiti–Darwin SOI (Troup's form of the index) for the 1877–78 and 1982–83 ENSO events. The index is plotted for these events and the year before each of them.

cation. In fact in this text, the cistern was said to be at a height of 97 feet from 1882 to 1920. As a result, Darwin mean sea level pressure records in the Smithsonian Institution (1944) and Hunt (1918) references prior to June 1895 are approximately 1 hPa higher than those in Todd (1879–1910). However, this does not discount the possibility that the pre-June 1895 cistern height given in Todd's journals may have been in error due to poor leveling of the site, as was noted for the early records from the stations farther south at Daly Waters and Alice Springs in the 1885 volume of the Todd (1879–1910) reference. Nevertheless, it would appear that the correction needed to bring Darwin and Jakarta pressure data into alignment prior to 1898 must take into account both a documented cistern height change in 1895 and a confirmed barometer change in 1898.

The possibility of problems in the record resulting from the earlier cistern height change around 1878–79 is more difficult to quantify, as no other Darwin dataset is available to cross check it. If not taken into account in reductions of pressure to mean sea level, this change would amount to a 0.3 hPa anomaly in the pressure records. However, such an anomaly was not evident in cross checks with Jakarta records (Fig. 1) and the data was left unchanged.

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