4.11 VARIATIONS IN THE SOUTH PACIFIC CONVERGENCE ZONE AND INFLUENCES AND INFLUENCES ON SOUTH PACIFIC CLIMATE

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1. INTRODUCTION

The South Pacific Convergence Zone (SPCZ) is a dominant feature of the atmospheric circulation in the south west Pacific (Kiladis et al., 1989; Vincent, 1994). It is characterized by a band of low-level convergence, cloudiness and precipitation lying from the west Pacific warm pool south-eastwards towards French Polynesia (Figure 1). It shares some characteristics with the Inter-Tropical Convergence Zone (ITCZ), which lies just north of the Equator, but is more extratropical in character along much of its length, especially east of the Dateline *(*Trenberth, 1976).

The SPCZ is a relatively broad feature, its location related to a southern tropical and subtropical maximum of sea-surface temperature (SST), precipitation, cloudiness, low-level convergence and minimum outgoing long-wave radiation (OLR) (Kiladis et al., 1989). To the west, it is linked to the ITCZ over the Pacific warm pool. To the east, it is maintained by the interaction of the trade winds and transient disturbances in the midlatitude westerlies emanating from the Australasian region.

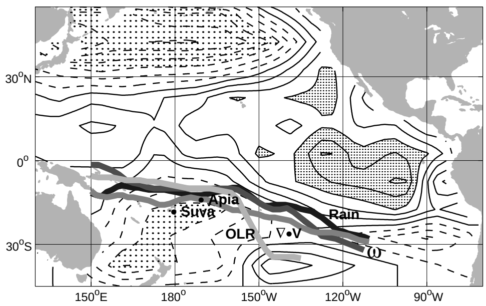

Figure 1. The South Pacific Convergence Zone (SPCZ) and its relationship to the pattern of the Interdecadal Pacific Oscillation (IPO). The mean November to April location of the SPCZ during 1958-1998 is shown by four different indices: a line of maxima in rainfall (Rain), one of maxima in low-level convergence (∇·V), one of maxima in 500 hPa vertical motion (ω) and one of minima in outgoing long-wave radiation. The background contours show the IPO as an EOF of low-pass filtered SST anomalies.

The location of the SPCZ varies systematically with ENSO-related expansion and contraction of the west Pacific warm pool (Trenberth, 1976). Such movements can result in very large precipitation anomalies on either side of the mean location of the SPCZ (Salinger et al., 1995), as it moves northeast during El Niño events and southwest during La Niña events. Its mean location also varies with the polarity of the Interdecadal Pacific Oscillation (IPO), a ~15-30 year time scale fluctuation in SST and circulation across the whole Pacific basin (Power et al., 1999; Salinger et al., 2001). As a result of these movements the SPCZ modulates both variability and trends in South Pacific climate.

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2. SPCZ VARIABILITY

The location of the SPCZ may be defined in terms of extremes of cloudiness (OLR), low-level convergence, or related quantities as in Figure 1. For further analysis the SPCZ is defined here as the maximum of convergence calculated from monthly mean reanalysis 10 m winds. For each Nov-Apr season, the mean SPCZ location at each longitude was taken as the position of the maximum convergence between 0 and 30°S.

High-quality station mean sea-level (msl) pressure data from South Pacific Island sites were used (Collen, 1992) to define a proxy index of SPCZ position. Two stations with reliable records, Suva, Fiji (18°9′S, 178°26′E) and Apia, Samoa (13°48′S, 171°47′W), were chosen to define the SPCZ position (Figure 2). The SPCZ position index (SPI) was calculated as the normalized Nov-Apr difference in msl pressure between Suva and Apia, based on the period 1961-90. It defines the latitude of the SPCZ between longitudes 180 and 170°W.

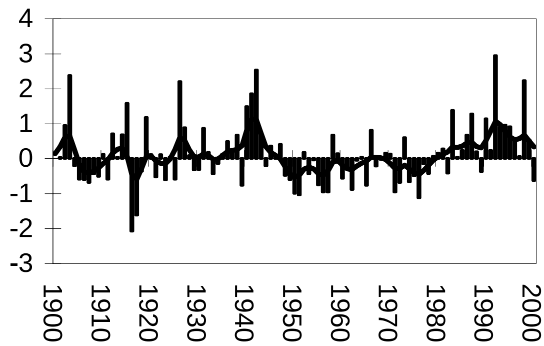

Figure 2. A bar graph of the SPI (overlaid with padded 9 point binomial filter) over the period 1900-2000.

Table 1 investigates this further using an analysis of variance (ANOVA) of the relationship between the Nov-Apr SPI and the corresponding IPO and SOI. It confirms that the SPI, and thus the SPCZ position is significantly related both to the state of the IPO and ENSO during 1891-2000. This shows that the SPCZ tends to move northeast in the warm phase of both oscillations (positive IPO and negative SOI). Thus, the SPCZ is furthest southwest during La Niña episodes with a negative IPO, and furthest northeast during El

Niño episodes with a positive IPO. These movements of the SPCZ modulate South Pacific climate variability.

Table 1 shows Percentage p-values (probabilities that the calculated F-statistics could have arisen by chance) for one- and two-way fixed effect ANOVA of the SPI, using terciles of the SOI and IPO index as effects, Nov-Apr 1891-2000, were adjusted to take account of serial correlation.

	Terciles	SOI	SST IPO	NMAT IPO
1-way ANOVA	All	0.037	0.0014	0.00049
1-way ANOVA	1 and 3	0.019	0.0020	0.0019
2-way ANOVA	All	13	0.52	0.21
2-way ANOVA	1 and 3	13	7.6	6.8

3. SPCZ AND SOUTH PACIFIC CLIMATE TRENDS

Three phases of the IPO have been identified during the 20th century: a positive phase (1922 – 1944), a negative phase (1946 – 1977) and another positive phase (1978 – 1998). These phase changes have resulted in displacement of the SPCZ firstly southwest, then northeast. Climate data are analysed for the two most recent periods to describe the influence of the movement of the SPCZ (northeast) on decadal climate trends. Temperature (hundredths °C) and rainfall

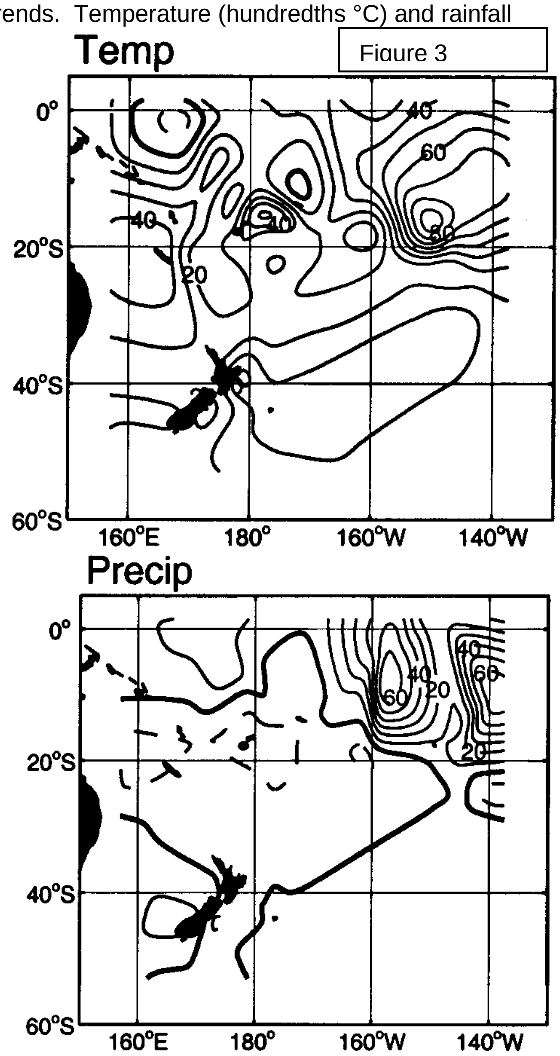

Figure 3

(percent) changes shown in Figure 3. Solid lines represent increases, and dashed lines decrease. Annual surface temperature increased significantly southwest of the South Pacific Convergence Zone (SPCZ) at a rate similar to the average Southern Hemisphere warming. Northwest of the SPCZ temperature increases were less than, and northeast of the SPCZ more than, the hemispheric warming in surface temperature. Increases of annual precipitation of 30 percent or more occurred northeast of the SPCZ, with smaller decreases to the southwest, associated with a movement in the mean location of the SPCZ northeastwards.

4. CONCLUSIONS

The SPCZ is a very important determinant of South Pacific climate producing variability from interannual to multidecadal time scales. Its location plays a key to climate anomalies and shifts. On interannual timsescales it moves northeast during El Niño events and southwest during La Niña events causing increases (decreases) in rainfall anomalies to the north east (south west) during El Niño events and the opposite during the La Niña phase of the Southern Oscillation. On the decadal time scale in positive phases of the IPO the SPCZ moves northeast, and in the negative phase, southwest. The northeast (southwest) displacement in the positive (negative) IPO phase changes decadal averages of temperature and precipitation in the South Pacific, with the northeast (southwest) of the region warming more (less) rapidly and rainfall increasing (decreasing). The SPCZ location modulates regional warming trends observed (Folland et al., 1997]) and provides a major discontinuity for multidecadal climate trends in the South Pacific.

5. REFERENCES

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