4.8 THE INTERDECADAL PACIFIC OSCILLATION: MODELING AND OBSERVATIONS

A. Brett Mullan*, C.K. Folland[+], B. Bhaskaran, M.J. Salinger and J.A. Renwick
National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand
[+]Hadley Centre for Climate Prediction and Research, Met. Office, United Kingdom

1. INTRODUCTION

The Interdecadal Pacific Oscillation (IPO), which can be regarded as the Pacific-wide manifestation of the Pacific Decadal Oscillation that has been described for the North Pacific (Zhang *et al*., 1997), is a mode of sea surface temperature (SST) variability that provides a major source of decadal climate variability in the South West Pacific (Fig. 1). This quasi-symmetrical picture of SST variations about the equator for the IPO is supported by recent research (eg., McPhaden and Zhang, 2002). An abrupt change in circulation in the North Pacific was observed around 1976, marked by a southward shift and intensification of the Aleutian Low, lower SSTs in the Pacific around 45°N, and a coincident shift in the background state of the tropical Pacific. This shift included increases in SST over the central and western tropical Pacific, and an eastward displacement of the region of persistent convection.

Such tropical changes might be expected to influence ENSO behavior. Indeed, during the positive IPO period (post 1976/77), El Niño events were often stronger and more persistent, and the developing El Niño warm anomaly in SST tended to propagate eastward rather than westward.

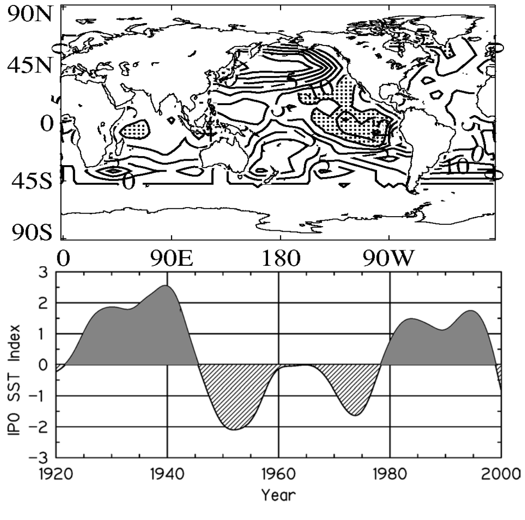

Fig. 1. Third EOF of global low-pass filtered SSTs with positive anomalies shaded (upper), and associated time series (lower), identified as Interdecadal Pacific Oscillation in analysis of Folland *et al*. (1999).

The decadal change in ENSO behavior has been explained by Wang and An (2002) in terms of how ENSO responds to the eastward displacement of SST gradient, zonal wind stress and thermocline slope associated with the background (IPO) climate shift. However, the changed "background" state is, in part, a consequence of the changed ENSO behavior, and so there is considerable debate about cause and effect. A number of theories have been advanced to explain the mechanism of Pacific decadal variability (see Kleeman *et al*., 1999, for a recent summary), and the linkage between midlatitude and tropical anomalies. The source of the forcing (midlatitude versus tropical), and whether the variations are random or partly deterministic, are issues yet to be resolved.

2. DATA SETS

Both observed and model-generated datasets have been analyzed to try and characterize IPO variations and their interaction with ENSO. Observed data consist of the NCEP/NCAR reanalyses (particularly of precipitation and low-level divergence) and the MetOffice HadISST1.1 global SSTs. A series of GCM experiments have been carried out at NIWA, using the HadAM2b version of the Unified Model forced by specified SSTs. A "control" run, forced by observed SSTs for 1960-1995, has been analyzed, along with a set of four anomaly experiments (each of 20 years) that represent the four combinations of SST anomalies at the ENSO and IPO extremes. The positive IPO experiments have the pattern of Fig. 1 (scaled to two standard deviation amplitude in the SSTs, but no signal outside the Indo-Pacific Oceans) added to either the El Niño or La Niña anomaly (again expressed as a two standard deviation amplitude from a high-frequency EOF analysis of global SSTs (Folland *et al*., 1999)).

3. SOUTH PACIFIC CONVERGENCE ZONE

The shifts in the position of the South Pacific Convergence Zone (SPCZ) occurring on the interannual timescale associated with ENSO have been well documented. The SPCZ lies further northeast during El Niño, and further southwest during La Niña, relative to its long-term mean position. However, it is also possible to show that the IPO affects the SPCZ in a similar fashion (Folland *et al*., 2002).

**Corresponding author address*: A. Brett Mullan, NIWA, P. O. Box 14-901, Kilbirnie, Wellington, New Zealand; e-mail: b.mullan@niwa.co.nz

Beginning with the NCEP 10-m winds over 1958-1998, the location of the SPCZ can be diagnosed from the first divergence minimum (ie, convergence maximum) north of 30°S over the sector 165°E to 105°W. The 40 years (Nov-Apr 1958/59 to 1997/98) conveniently divide into two equal parts at the IPO phase change point. Each group of IPO years is then divided into two again according to the value of the SOI. Statistics of the SPCZ positions can then be determined for each 10-year group of SOI/IPO combination (Fig. 2).

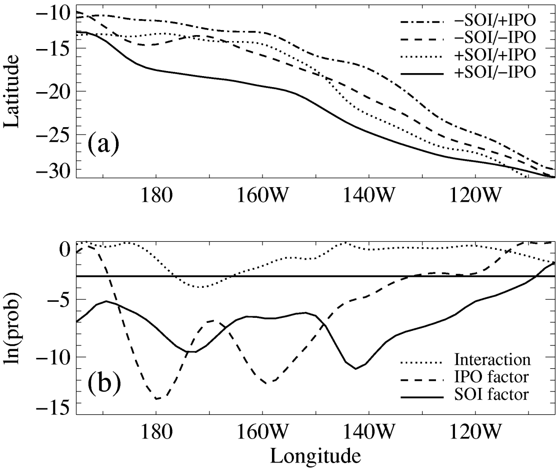

Fig. 2. (a) Mean SPCZ latitude as a function of longitude for different polarities of ENSO and IPO. (b) Natural logarithm of two-way ANOVA p-values (probability that the F-statistic could have arisen by chance). Values below the horizontal line (log of 0.05) are significant at the 5% confidence level.

Warmer conditions in the eastern tropical Pacific (either El Niño or positive IPO years) have a similar effect of moving the SPCZ northeastwards. Moreover, the ANOVA analysis in Fig. 2b suggests that the ENSO and IPO factors are largely linearly independent in their effect on the SPCZ location.

4. TELECONNECTIONS

The IPO also appears to modulate teleconnections with ENSO in a geographically-varying way. A number of studies have been reported in the literature (Gershunov and Barnett, 1998, for the USA, Power *et al.,* 1999, for Australia).

The model experiments show SST anomalies associated with the positive IPO phase tend to reinforce the El Niño pattern of teleconnections, and conversely the negative IPO phase reinforces the La Niña pattern. This supports the observation-based conclusion of Gershunov and Barnett (1998). However, the IPO differences tend to be more subtle in the South Pacific. The leading EOF of seasonal mean sea-level pressure (ie, the “ENSO seesaw”) from the 1960-1995 control run shows the eastern Pacific center of action is closer to Tahiti during the negative IPO (and in this sense the SOI is a slightly better ENSO index in the negative IPO period). This leads to stronger interannual variability in the SPCZ during the negative IPO phase. The ENSO/IPO anomaly experiments indicate eastern Australia is drier during negative IPO El Niño events than during positive IPO El Niño events, supporting the finding of Power *et al.* (1999) that SOI correlations with Australian rainfall are stronger during negative IPO.

5. SUMMARY

This paper describes ongoing studies of Pacific decadal variability, which affects mean climate and ENSO teleconnections. Diagnosis of the SPCZ location from observed data suggests that the IPO affects the South Pacific Convergence Zone movement independently of ENSO. The latitudinal shift with IPO change is large east of about 150°W considering the SST increase is much smaller for positive IPO than for El Niño periods. Model experiments provide some agreement with observed changes in ENSO teleconnection patterns with change in IPO. The eastward shift in zonal gradients in the Pacific associated with the positive IPO phase, and the effect of this on the SPCZ, seems to be a key feature to understanding decadal climate variability in the southwest Pacific.

6. REFERENCES

Folland, C.K., Parker, D.E., Colman, A.W. and Washington, R., 1999: Large scale modes of ocean surface temperature since the late nineteenth century. *Beyond El Niño. Decadal and interdecadal climate variability*, A. Navarra, Ed., Springer-Verlag, 73-102.

Folland, C.K., Renwick, J.A., Salinger, M.J., and Mullan, A.B., 2002: Relative influences of the Interdecadal Pacific Oscillation and ENSO on the South Pacific Convergence Zone. *Geophys. Res. Letts.*, **29**(13), 10.1029/2001GL014201, 21-1–21-4.

Gershunov, A. and Barnett, T.P., 1998: Interdecadal modulation of ENSO teleconnections. *Bull.Amer. Meteor. Soc*., **79**, 2715-2725.

Kleeman, R., McCreary, J.P., and Klinger, B.A., 1999: A mechanism for generating ENSO decadal variability. *Geophys. Res. Letts*., **26**, 1743-1746.

McPhaden, M.J. and Zhang, D., 2002: Slowdown of the meridional overturning circulation in the upper Pacific Ocean. *Nature*, **415**, 603-608.

Power, S., T. Casey, C. Folland, A. Colman and V. Mehta., 1999: Interdecadal modulation of the impact of ENSO on Australia, *Climate Dynamics,* **15**(5)*,* 319-324.

Wang, B. and An, S.I., 2002: A mechanism for decadal changes of ENSO behaviour: roles of background wind changes. *Climate Dynamics*, **18**, 475-486.

Zhang, Y., Wallace, J.M., and Battisti, D.S., 1997: ENSO-like interdecadal variability: 1900-93. *J. Climate*, **10**, 1004-1020.