International workshop on the South Pacific Convergence Zone, Apia, Samoa, August 24-26, 2010

The South Pacific Convergence Zone (**SPCZ**) in the south-west Pacific produces the largest rainfall band in the southern hemisphere and one of the largest bands in the world. In fact during November-April rainfall associated with the SPCZ forms the single most prominent rainfall feature in global precipitation (Figure 1). At this time of the year the SPCZ extends from north-east Papua New Guinea through the Solomon Islands, Tuvalu, Niue and the Cook Islands to the southeast. The SPCZ tends to move towards the north-east during southern winter and El Niño, and towards the south-west during southern summer and La Niña. These changes in position have a profound influence on climate (e.g. rainfall, winds, and tropical cyclone frequencies) and life in most of the nations in the southwest Pacific.

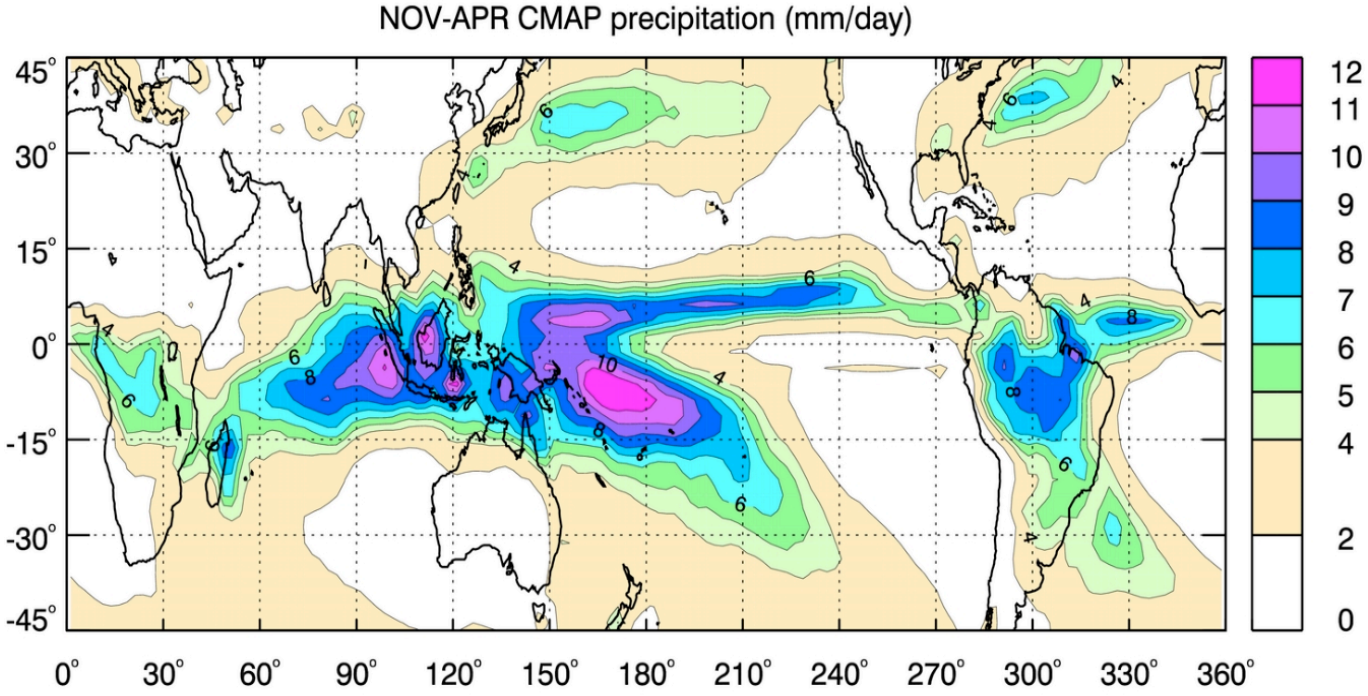

Figure 1. November–April average precipitation (mm/day) in the CMAP precipitation data set (Xie and Arkin, 1997) during 1979-1999.

Despite the importance of the SPCZ to the region and its prominence in the general circulation of the southern hemisphere, the SPCZ has been relatively little studied compared with convergence zones in the northern hemisphere. The first international workshop on the South Pacific Convergence Zone (**SPCZ**) was held in Apia, Samoa on August 24-26, 2010, bringing together 30 experts from Australia, the Cook Islands, Fiji, France, India, New Caledonia, New Zealand, Samoa, the Solomon Islands, Tonga, Tuvalu, the U.K. the U.S. and Vanuatu. The purpose of the workshop was to review what is known about the SPCZ, to identify key gaps in our understanding of the SPCZ and to raise awareness of the need for more research on the SPCZ. It showcased recent advances in our understanding of the SPCZ and the exciting opportunities there are for further research in many areas. We discussed:

- the structure and other characteristics of the SPCZ;
- the impact of the SPCZ on the region;
- the underlying physics of the SPCZ;

- variability in the SPCZ, from synoptic through to interdecadal and longer time-scales;
- our ability to simulate the SPCZ using climate models; and
- the impact of global warming on the SPCZ.

Here is a brief summary of some of the issues discussed.

The meeting highlighted numerous examples of the way in which seasonal, interannual and interdecadal changes have a profound influence on climate in the region. An example was given by Ariete Balesisolomone (Fiji Meteorological Service), who showed that rainfall peaks in Fiji during December-February when the SPCZ tends to lie close by to the north of Fiji and that rainfall tends to be much lower during June-August when the SPCZ shifts northeast well away from Fiji.

Mathieu Lengaigne and colleagues examined atmospheric fields over the South Pacific and showed that tropical cyclogenesis is promoted south of the SPCZ. So when the SPCZ shifts south-west in response to La Niña, genesis is enhanced over the Coral Sea. Sunny Seuseu showed that at the same time the frequency of tropical cyclones tends to decrease further east near Samoa. Scott Power showed consistent results: decadal changes in the number of severe tropical cyclones making land-fall over eastern Australia since the late 19th century are remarkably coherent with decadal changes in an index for the position of the SPCZ over the same period.

Christophe Menkes and Mathieu Lengaigne described work they had done with Emmanuel Vincent and colleagues highlighting that the behaviour of the SPCZ during three large El Niño events was quite different to the behaviour of the SPCZ during other El Niño events. During 1982/83, 1991/92, and 1997/98 the SPCZ became much more zonal in orientation than it usually is. This was related to a large eastward expansion of the warm pool during these events which abruptly altered the position of atmospheric anomalies in the region. They also discussed the implications these changes have for tropical cyclogenesis and how global warming might influence tropical cyclogenesis in the future.

Representatives from several National Meteorological Services from small island countries across the region (Cook Islands, Fiji, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu) described impacts of the SPCZ on their country and extreme events associated with changes in the SPCZ. During La Niña years the SPCZ shifts closer to Vanuatu and Fiji and this increases rainfall and flood risk in those countries. Arona Ngari pointed out that the SPCZ tends to lie between the northern and southern Cook Islands. This gives rise to very different El Niño-Southern Oscillation impacts in the two regions. During El Niño the SPCZ tens to move north-east bringing more rain to the northern group but less to the southern group. This shift also exposes the Cooks to an increased risk of tropical cyclone. This is a particularly serous risk for countries like the Cooks, which have many low lying inhabited atolls. The SPCZ tends to weaken and move away from the Solomon islands (Lloyd Tahini) and Tonga (Moleni Tu'uholokai) during June-August, and this reduces rainfall in both countries though more so in Tonga. Moleni also described an extreme rainfall event that occurred in Tonga on February 8, 2008. This event was connected to synoptic activity and the SPCZ. It brought 289.2mm of rainfall in 12 hours and caused record flooding. Hilia Vavae showed that the SPCZ tends to lie to the north-east of Tuvalu and that rainfall in the islands of Tuvalu tends to increase substantially towards the north-east i.e. towards the centre of the SPCZ.

Changes in rainfall across the island groups was graphically illustrated by Drew Lorrey using a new regional station data set he and his colleagues across the region have assembled.

George Kiladis, Adrian Matthews and Matthew Widlansky discussed variability in the SPCZ on synoptic and intraseasonal time-scales. Matthew showed there is more intraseasonal variability in the tropical (western) portion of the SPCZ than there is in its eastern subtropical portion, and George showed that the near-equatorial western portion of the SPCZ is more affected by equatorially-trapped atmospheric waves. George also showed that variability originating in the northern hemisphere can influence the SPCZ by exciting equatorial waves, while Adrian highlighted the importance of southern hemisphere mid-latitude Rossby waves to variability in the SPCZ, after they refract near longitudes passing through the east coast of Australia. Both Adrian and George emphasized the role of upward motion ahead of upper-level extra-tropical Rossby wave troughs in forcing precipitation within the higher latitude/eastern portion of the SPCZ, and the fact that precipitation occurs in regions where the upper level flow is divergent, consistent with theory. Matthew also presented evidence that zonal gradients in the sea-surface temperature drive zonal gradients in the 200hPa winds (U), and that in places where U decreases moving eastward this tends to slow Rossby waves down, and accumulate their energy. This drives ascending air that causes convection in the presence of moisture, thereby helping to set the position of the SPCZ in the east.

Jerry Meehl discussed decadal timescale variability of Pacific climate over the past century and possible causes. Jerry presented observational and modelling results which suggest that small changes in external forcing, in this case insolation associated with the 11-year solar cycle, can be amplified by the climate system to give a response that in some respects is similar to a low amplitude La Niña event, which includes a south-westward shift in the SPCZ. He also showed that internally generated decadal variability associated with the Interdecadal Pacific Oscillation produces south-westward shifts of the SPCZ when the tropical Pacific is anomalously cool, and north-eastward shifts when it is anomalously warm.

Jo Brown, Wenju Cai and Francois Delage examined the ability of models to simulate the SPCZ and presented preliminary projections for the 21st century. While most CMIP3 models exhibit an SPCZ, but such models all tend to have an SPCZ which is too zonal in orientation. They also presented projections for the future behaviour of the SPCZ under global warming. Cai showed that most of the models that were able to simulate the zonally orientated El Niño events described above tended to exhibit a small equatorward shift in the SPCZ between 150-170˚W during the 21st century under global warming.

Alex Ganachaud described work he had done with his colleagues examining the impact of the SPCZ on the south-west Pacific Ocean and how this impact changes under global warming. Their work indicates that the SPCZ is crucial in driving the South Equatorial Counter Current (SECC), and that modelled changes in the SPCZ under global warming dramatically reduce the volume transport of the SECC by 50%, and contract the SECC towards the west by 1000km.

The participants also discussed areas where key uncertainties exist in our understanding of the SPCZ. Key gaps include: a more detailed history of the advancement in our understanding of the identification and understanding in of the SPCZ, increased understanding of the reasons why the SPCZ exists, especially the role of orographic forcing, air-sea coupling and synoptic variability. The extent to which air-sea coupling is important to the existence of the SPCZ and the extent to which local coupling is important to changes in the SPCZ is largely unknown.

Jim Renwick and Matthew Widlansky briefly described some of the early history in our understanding of the SPCZ. Ensuing discussion highlighted the need for a more detailed description

of the historical development of our understanding in the characterisation and understanding of the SPCZ than is currently available.

Anne Juillet-Leclerc highlighted the importance of producing palaeo-reconstructions of climate linked to the SPCZ so that modern variability can be placed in a much longer perspective.

Gilles Bellon and Matthew highlighted the need to use simplified atmospheric models to improve our understanding of the cause and variability of the SPCZ. Moleni Tu'uholokai pointed out that regional modelling has the potential to improve our understanding of synoptic activity in and around the SPCZ.

Other interesting topics covered at the workshop included sea-level rise and palaeo reconstructions of climate. For example, Axel Timmermann showed that regional contrasts in sea-level rise over the Pacific were largely driven by driven by regional contrasts in projected wind-stress changes. In particular, he demonstrated that future climate change projections using a multi-model-ensemble of CMIP3 climate models simulate intensified Ekman pumping in an area that roughly overlays the SPCZ. In this area increased upwelling of colder water will weaken the rate of global mean sea-level rise by 10-20% over the next century. Scott Power showed that while climate models exhibit a weakened Walker circulation in response to global warming, global warming tends to make the Southern Oscillation Index increase and not decrease, highlighting that natural variability has played a major role in recent climatic change over the South Pacific.

Workshop presentations are available from http://cawcr.gov.au/meetings/fd/SPCZ_Workshop_2010.php.

Acknowledgements
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Reference

Xie, P. and P.A. Arkin, 1997: Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bull. Amer. Meteor. Soc.*, **78**, 2539–2558.