

# INTERANNUAL VARIABILITY OF TROPICAL CYCLONE GENESIS POSITIONS AND TRACKS OVER THE FIJI REGION

Savin S. Chand \* and Kevin J. E. Walsh  
Department of Earth Sciences, The University of Melbourne, Victoria, Australia

## 1. INTRODUCTION

The southwestern tropical Pacific (SWTP) islands, such as Fiji, Samoa and Tonga (hereafter referred to as the FST region; defined as the area between 5-25°S latitude and 170°E-170°W longitude) are highly susceptible to calamitous impacts of extreme meteorological events, particularly those associated with tropical cyclone (TC) activity. One of the most dominant climatic processes affecting TC activity over the FST region is the El Niño Southern Oscillation (ENSO) phenomenon (Mimura et al. 2007).

A study was carried out in the FST region, using Joint Typhoon Warning Center (JTWC) best track data, to determine the variations in tropical cyclone genesis positions and their subsequent tracks during different phases of ENSO. Over the 36-year period from 1970/71 to 2005/06, 122 cyclones are observed to be either forming in the defined region or immediately outside and eventually drifting in. TC formation is defined here as the first track point in the JTWC database and is used interchangeably with genesis and development throughout the paper. More details can be found in Chand and Walsh (2009).

## 2. GENESIS POSITIONS

The Kernel Density Estimation (Bowman and Azzalini 1997) was used to objectively generate spatial distribution of TC genesis positions in each ENSO phase as well as for all TCs. KDE is a non-parametric technique whereby a density function or kernel can be used to construct a smooth probability density estimate of the observed data.

Taking all TCs together (Fig. 1a), there is a large spread in the TC genesis positions. Areas between 6-18°S latitude and 165°E-170°W longitude span 75% of the total genesis, with the highest density north of the Fiji islands. A similar spatial distribution is observed for El Niño and neutral conditions (Figs. 1b and 1d respectively). During the El Niño phase, however, genesis is enhanced east of the dateline extending from north of the Fiji islands to northwest of the Samoa region, with highest density centered on around 10°S, 180°. TC genesis is suppressed west of the dateline and south of Samoa. During neutral years, maximum genesis occurs immediately north of the Fiji islands with enhanced genesis occurring south of Samoa. The TCs that affect FST region during El Niño are mainly formed within the defined domain, whereas in neutral conditions TCs forming as far west as 165°E longitude can affect the FST region.

During the La Niña phase, there are fewer TCs forming within the study domain than during El Niño and neutral years (i.e. approximately 50% less).

The genesis positions during La Niña phase (Fig. 1c) are displaced south of 12°S latitude, with maximum density centered around 15°S, 170°E and south of Fiji. This indicates that during La Niña events, countries like the Fiji islands and Tonga fall within the mean TC genesis zone with little or no genesis around Samoa.

## 3. TRACK CLUSTERING

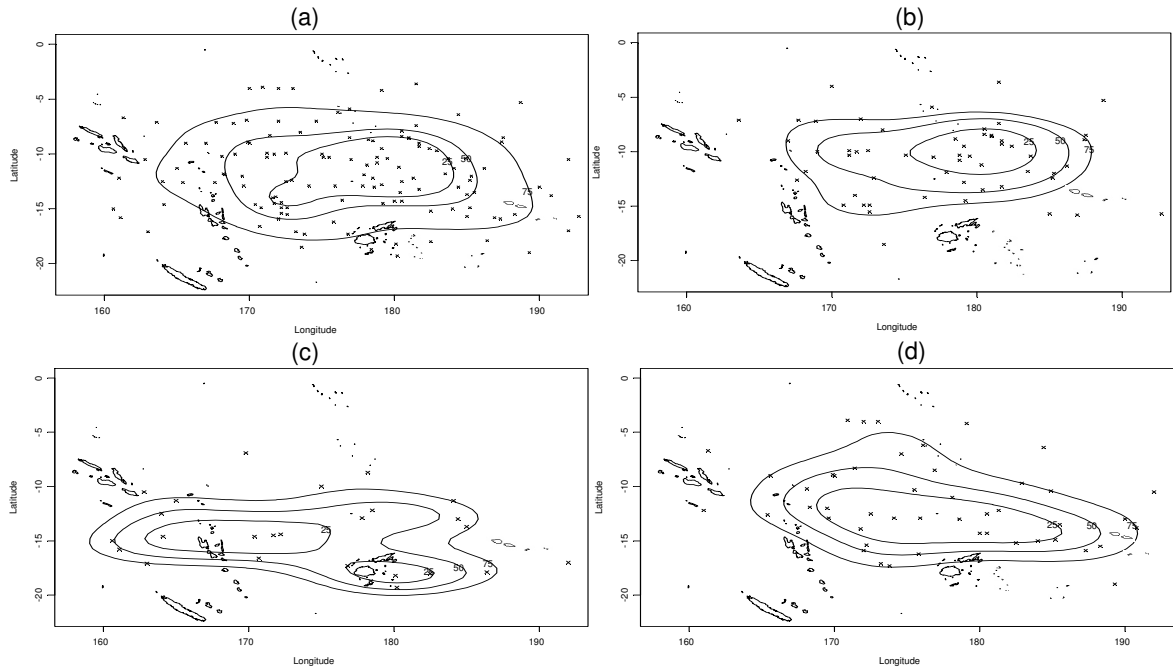
The TC tracks over the FST region were examined for relational behaviors in their track-types using the cyclone-track clustering technique developed by Gaffney (2004). The technique is based on a finite mixture model that accommodates cyclone tracks of different lengths and can objectively cluster TC tracks of different trajectory shapes and locations.

The TC tracks over the FST region are conveniently described using three separate clusters. Two distinct types of TC motions, namely, "straight" (associated with clusters 1 and 2) and "recurver" (associated with cluster 3) types are identified (Fig. 2a). Climatologically, these results indicate that the Fiji islands lie along the path of both straight moving cyclones associated with cluster 1, as well as those of recurving ones associated with cluster 3. The Tonga region has a high risk of impact with cyclones associated with cluster 1, which also passes over the Fiji islands. The cyclones associated with clusters 1 and 3 pose little or no threat to Samoa but those associated with cluster 2, however, can have serious impacts. The recurving cyclones can largely affect areas west-southwest of the Fiji islands.

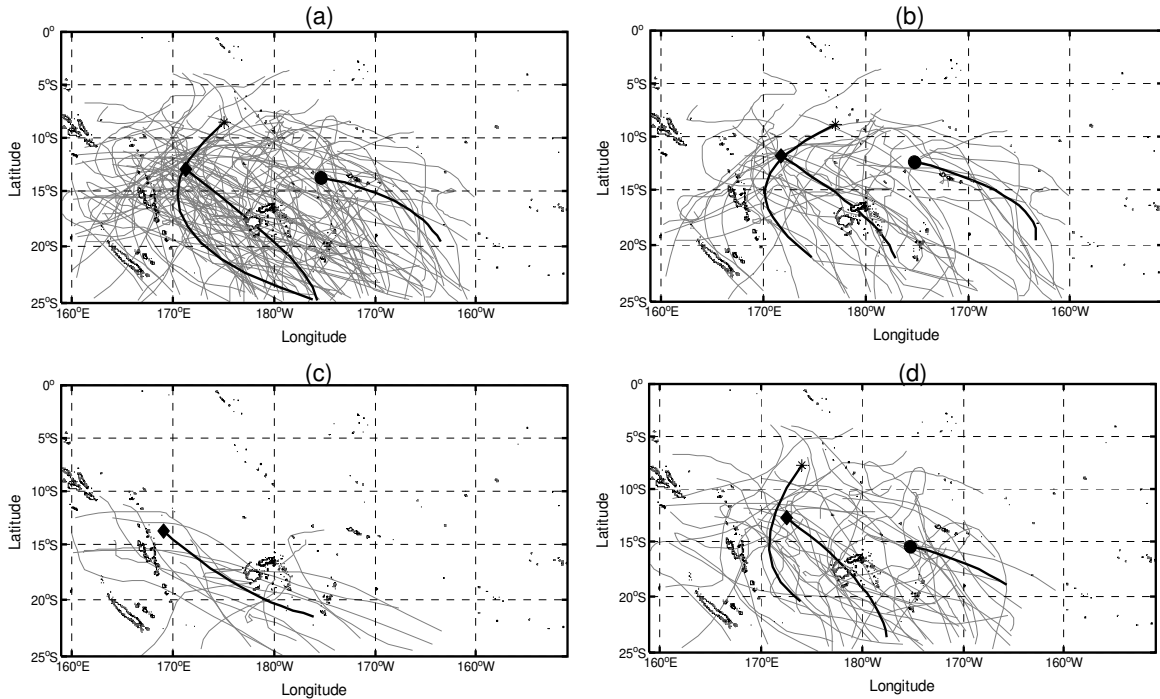
The TC tracks during different phases of ENSO are also examined. Most of the cyclones forming in cluster 1 during the El Niño years (Fig. 2b) pass over the northern part of the Fiji islands into the Tonga region and those that form east of the dateline associated with cluster 2 pass over the northern parts of the Samoa region. The cyclones forming north of 10°S in cluster 3 follow a recurving trajectory to the west-southwest of the Fiji islands. The TCs that form during the counterpart La Niña phase (Fig. 2c) are characteristic of cluster 1, while those forming in clusters 2 and 3 are very few and therefore not included in the analysis. The mean regression curve associated with TCs forming during La Niña years in cluster 1 indicates that most of these TCs pass over the southern parts of the Fiji islands into the Tonga region. A southward displacement is evident in the TC track regimes during La Niña periods relative to the corresponding mean TC track in the El Niño phase. The TC tracks during neutral years (Fig. 2d) are spread over all three clusters with slightly more genesis in cluster 1 than in clusters 2 and 3. Tracks here show substantial similarity to those in the El Niño phase except with a slight poleward displacement.

---

\* Corresponding author address: Savin S. Chand, School of Earth Sciences, The University of Melbourne, 3010, Victoria, Australia. E-mail: schand@pgrad.unimelb.edu.au



**Fig. 1.** Genesis positions of TCs between 1970/71-2005/06 for (a) all seasons, (b) El Niño phase, (c) La Niña phase and (d) neutral phase. Contours labeled 25, 50 and 75 contain 25%, 50% and 75% of the total observations respectively.



**Fig. 2.** TC tracks (gray) and respective mean regression curves associated with each cluster for (a) all TCs, (b) El Niño, (c) La Niña and, (d) neutral phases. The initial positions of mean regression curves marked with a diamond represents cluster 1, a circle represents cluster 2 and an asterisk represents cluster 3.

#### 4. SUMMARY

The TC genesis positions show large regional variations associated with ENSO phases over the Fiji islands, Tonga and Samoa. When examined in relation to the large-scale environmental conditions (namely 850-hPa relative vorticity, 200-hPa divergence and environmental vertical wind shear; not shown), strong relationships could be established. These results suggest that the seasonal TC genesis in the FST region is favored when the aforementioned large-scale environments have the following seasonal-average thresholds: (a) 850-hPa cyclonic relative vorticity between  $-8$  and  $-4$  ( $\times 10^{-6} \text{ s}^{-1}$ ), (b) 200-hPa

atmospheric divergence between  $2$  and  $8$  ( $\times 10^{-6} \text{ s}^{-1}$ ) and (c) environmental vertical wind shear between  $0$  and  $8 \text{ m s}^{-1}$ . The TC tracks over the FST region take three distinct paths with substantial local variations during different phases of ENSO. These characteristics paths largely depend on mean wind flow regimes between 700 and 500-hPa levels.

#### 5. REFERENCES

Bowman, A. W., and A. Azzalini, 1997: Applied smoothing techniques for data analysis: the Kernel approach with S-Plus illustrations. Oxford University Press., 193 pp.

Chand, S. S., and K. J. E. Walsh, 2009: Tropical cyclone activity in the Fiji region: spatial patterns and relationship to large-scale circulation. To appear in *Journal of Climate*.

Gaffney, S. J., 2004: Probabilistic curve-aligned clustering and prediction with regression mixture models. Ph.D. thesis, University of California, Irvine, CA, 281 pp. [Available online at [http://www.ics.uci.edu/~sgaffney/papers/sgaffney\\_thesis.pdf](http://www.ics.uci.edu/~sgaffney/papers/sgaffney_thesis.pdf).]

Mimura, N., L. Nurse, R. F. McLean, J. Agard, L. Briguglio, P. Lefale, R. Payet and G. Sem, 2007: Small islands. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 687-716.