## 2C.4 CHARACTERISTIC FIELDS ASSOCIATED WITH TROPICAL CYCLONE FORMATIONS

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### 1. Introduction

Tropical cyclone (TC) formation remains to be one of the unresolved problems in tropical meteorology, and its prediction is still a great challenge to forecasters. The difficulties come from the fact that the large-scale environment and the mesoscale disturbances are interacting in complicated ways such that determining which side is the dominating factor is not always possible. Variability in the atmospheric circulation (e.g., the El Niño Southern Oscillation that affects the large-scale flow and the intraseasonal oscillations that may modulates the spatial/temporal distributions of mesoscale disturbances) further increases the difficulty to understand and predict the variability in TC activity.

However, it is believed that individual TC formations are following some characteristic physical processes when the large-scale environmental parameters and mesoscale features are examined together. Therefore, the purpose of this study is to extract these characteristics so that a knowledge base is available when considering and forecasting subsequent formation cases.

### 2. Large-scale characteristics

Cheung (2004) examined six large-scale environmental parameters associated with 405 TC formations in the western North Pacific during 1990–2001 computed from the NCEP/NCAR reanalyses with 2.5$^o$ latitude/longitude resolution. These parameters included the sea-surface temperature, 200-850-hPa zonal and meridional vertical shear, 500-700-hPa average relative humidity, convective available potential energy (CAPE), and 200-hPa divergence.

These parameters had quite consistent values with near-Gaussian distributions in almost all the cases examined (Figs. 1-5). The mean values (standard deviations) of these domain-averaged distributions are 28.9$^o$C (0.8 $^o$C), -3.2 m s$^{-1}$(7.5 m s$^{-1}$), -2.3 m s$^{-1}$(5.3 m s$^{-1}$), 61.8% (11.3%), 1184.1 J kg$^{-1}$ (206.4 J kg$^{-1}$), and 5.2 x 10$^{-6}$ s$^{-1}$ (3.8 s$^{-1}$) respectively. Base on these distributions of values, a formation potential area is defined in which a location possesses environmental parameters within the thresholds (one standard deviation from the mean value of them found above) of favorable formations. In general, the seasonal cycle of the six environmental parameters is consistent with the seasonal TC activity, except that the formation potential area seems to be too large in the early season months. This can be inferred from the moderate correlation between the observed monthly TC occurrence frequency and the total formation potential area, which indicates the regions where all the favorable environmental conditions are satisfied. The sensitivity of the formation potential area to each of the environmental parameters is also examined. Among the six parameters, the vertical zonal shear and CAPE should play important role in affecting the meridional change of formation positions within a year, as indicated in their respective climatologies. The sensitivity tests also indicate that the zonal shear and relative humidity determine to a large extent the zonal distribution of the formation potential area.

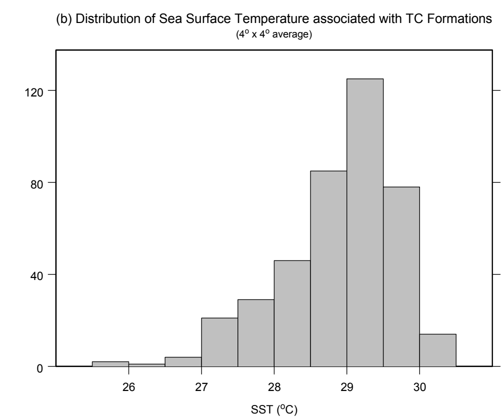


Fig. 1 Distribution of SSTs associated with all the formation cases with 0.5$^o$C intervals.

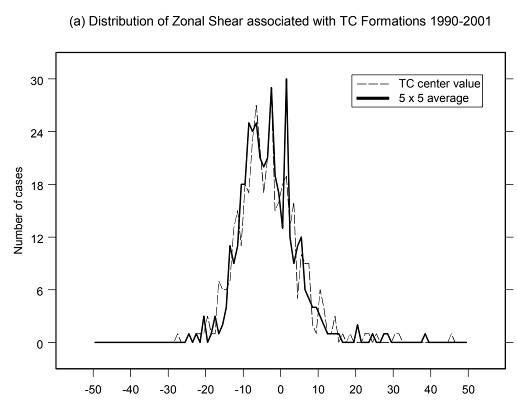


Fig. 2 Distribution of 200-850-hPa (a) vertical zonal shear and (b) vertical meridional shear associated with the 405 tropical cyclone formations during 1990–2001. The counting interval is 1 m s$^{-1}$.

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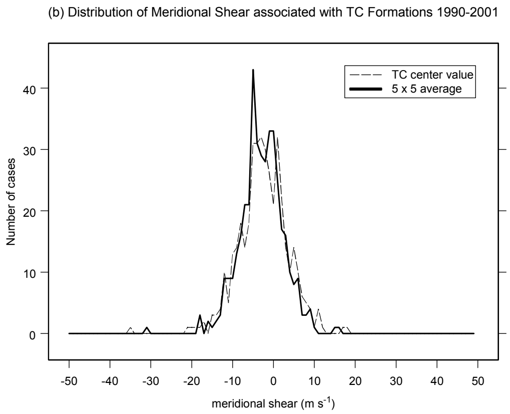


Fig. 2 (continued)

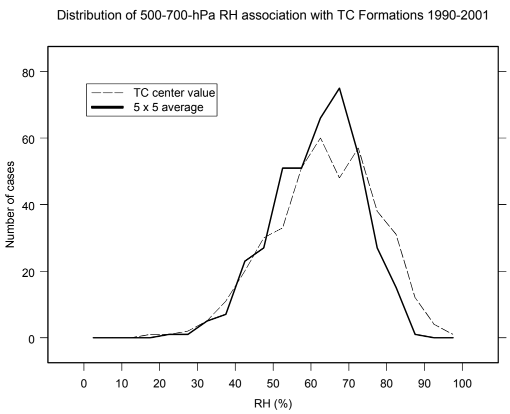


Fig. 3 Distribution of 500-700-hPa relative humidity associated with the 405 tropical cyclone formations during 1990–2001. The counting interval is 5%.

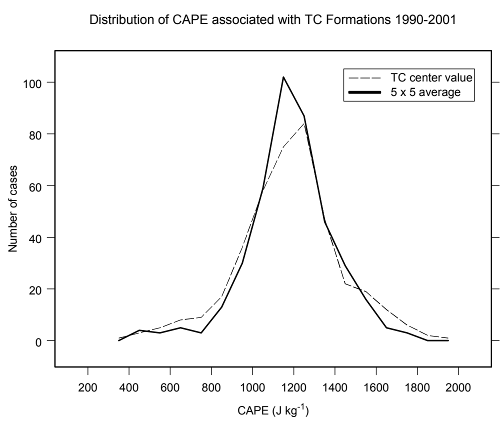


Fig. 4 Distribution of convective available potential energy associated with the 405 tropical cyclone formations during 1990–2001. The counting interval is 100 J $kg^{-1}$.

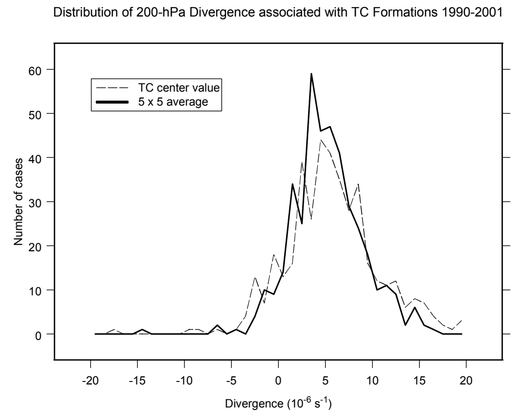


Fig. 5 Distribution of 200-hPa divergence associated with the 405 tropical cyclone formations during 1990–2001. The counting interval is $10^{-6}$ $s^{-1}$.

On a longer time scale, the interannual variability of the environmental parameters is also consistent with that of TC activity, although the correlation between the yearly total formation potential area and the actual TC occurrence frequency is low. This suggests that additional factors might be modulating the TC interannual variability, and hence some extensions to the previous study are necessary.

## 3. Extensions

This study is an extension of Cheung (2004) in two aspects. One is to overcome the limitation of the coarse resolution of the NCEP/NCAR reanalyses by extracting characteristic mesoscale feactures during TC formations. Besides the six parameters mentioned above, the existence (or not) of mesoscale convective systems, and their interactions will also be considered. The second extension is to examine the temporal evolution of the environmental fields and mesoscale features during formations, instead of examining only those features at a specific formation time that often may be ambiguous. Unlike previous individual case studies, objective analysis techniques will be used to produce high-resolution reanalyses for the TC formation cases that incorporate additional observations and satellite products so that mesoscale fields are available for examination. Then the characteristics associated with TC formations will be extracted using linear and nonlinear principal component analysis. The analysis procedure is performed separately for formation cases in different basins to examine different initial disturbances and formation dynamics.

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## References

Cheung, K. K. W., 2004: Large-scale environmental parameters associated with tropical cyclone formations in the western North Pacific. *J. Climate* (in press)