3B.2 COMPARISON OF MULTIDAY CONVECTIVE-ENVIRONMENTAL EVOLUTIONS BETWEEN TC DEVELOPING VS. NON-DEVELOPING DISTURBANCES OVER THE WESTERN NORTH PACIFIC

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1. INTRODUCTION

Tropical cyclone (TC) formation requires a transformation of a pre-existing mesoscale convective system into a warm core vortex with organized convection. While there exists some controversy concerning which part of the mesoscale convective system, convective (Hendricks et al. 2004) or stratiform (Simpson et al. 1997) precipitation region, plays more significant role in TC formation, both pathways emphasize the role of cloud clusters that develop up to the tropopause level. In terms of deep convection as well as convective organization process, the multiple episodes of diurnal convective bursts (hereafter, mCB) are widely understood as a typical preparation for TC formations (Zehr 1992; Davis and Ahijevych 2012). However, quantitative analysis on the relationship between mCB and TC developing and non-developing disturbances has not been explored. We investigate a total of 463 disturbances—80 developing and 383 non-developing—over the western North Pacific from 2007 to 2009 to quantify and compare mCB associated with developing and non-developing disturbances.

2. DATA AND METHOD

2.1 DATA

This study utilizes 6-hourly International Best Track Archive for Climate Stewardship (IBTrACS) data and 3-hourly tropical cloud cluster (TCC) track data (Hennon et al. 2011) as a vortex track reference. For the temporal information of TC formation, we refer to the Joint Typhoon Warning Center best track; their first designation time of tropical depression (13–17 m s^{-1}) is adopted as the TC formation time.

Geostationary satellite (Multifunctional Transport Satellite-1R data is used to distinguish deep convection. Infrared (IR; centered at 10.8 μm) and water vapor (WV; centered at 6.75 μm) channel brightness temperatures are used (Olander and Velden 2009), which are available every hour at 4 km × 4 km horizontal resolutions.

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The atmospheric fields are examined using the Modern Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) dataset. The data is available at three-hourly intervals in 0.5° × 0.625° longitude-latitude resolutions on 42 pressure levels from 1000 hPa to 0.1 hPa.

2.2 METHOD

Since any best track data is available several hours before TC, we obtained five-to-seven-day pre-genesis and two-day post-genesis positions within developing disturbances, and five-day positions within non-developing disturbances by following the 600 hPa MERRA potential vorticity centers. For the initial reference for developing and non-developing disturbances, IBTrACS data and TCC track data are used, respectively.

By following the vortex track, deep convection developed up to the tropopause is identified by taking the difference between IR and WV brightness temperatures. Following the 500-km radius circle relative to the vortex track, an hourly time series of IR–WV < 0 areas is constructed and smoothed using a 7-h running mean. When the IR–WV < 0 areas increment satisfies four thresholds ($\Delta t \geq 6$ h, $\Delta A \geq$ 5,000 km^2, $\max(A) \geq$ 15,000 km^2, and $\Delta A/\Delta t \geq$ 500 km^2 h^{-1}), we defined it as a significant convective burst (CB). If CBs occur for at least two consecutive days, it is then defined as mCB.

3. RESULT

While quasi-diurnal convective bursts in the developing disturbances were occasionally introduced in the preceding studies, the present results identify that 67.5% of the 80 developing disturbance, that is, a majority of TC formation cases, were associated with a mCB prior to the TC genesis. Along with the series of convective bursts, the strength of relative vorticity gradually intensifies from the lower troposphere to the upper troposphere as the vertical wind shear remained barotropic about the vortex center through developing days. Remaining 32.5% of the TC cases, which develop without mCB, show weaker initial vorticity within strong vertical wind shear environment. On one or two days prior to TC formation, convective activity as well as relative vorticity intensification rapidly initiate, which is likely influenced by an arbitrary external forcing.

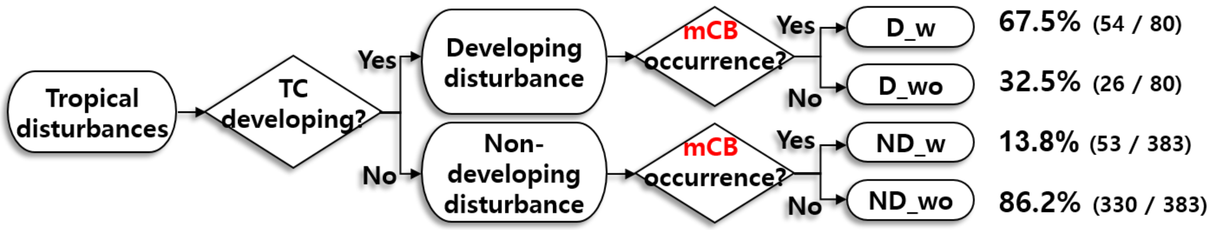

Figure 1. Tropical disturbances classification flow chart. The total 463 (= 80 developing + 383 non-developing) disturbances were classified into four groups: developing disturbances with mCB (D_w) and without mCB (D_w/o), and non-developing disturbances with mCB (ND_w) and without mCB (ND_w/o).

Meanwhile, mCB was also observed in 13.8% of 383 non-developing disturbances, that is 53 disturbances. Intensities of the mid-to-low tropospheric relative vorticity are comparable with that of developing disturbances with mCB on four to five days prior to TC formation. However, vorticity intensification is relatively weaker for non-developing disturbances in consecutive days possibly due to the environments of strong vertical wind shear, and eventually decays. Finally, most (86.2%) of non-developing disturbances are classified as not having mCB. That is, most non-developing disturbances are featured with one-time CB as well as significantly weak relative vorticity.

4. CONCLUSION

This study has explored a relation between successive convective bursts and TC formation by investigating the multiday evolution of convection using continuous observations from geostationary satellite measurements as well as the evolution of atmosphere using reanalysis data. The results show that mCB is a common feature in pre-TC stages, but the influence of vertical wind shear environment is also critical for the initiation of TC-strength vortex. In order to better understand and predict TC formation, further examination of two unique scenarios are required: when apparently unfavorable convection is observed in developing TCs and when apparently favorable convection is observed, but a TC does not develop.

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