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On Tropical Cyclone Formation

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Introduction: The formation (genesis) of tropical cyclones (TCs) is a complicated process that involves interactions among multi-scale circulations. While tropical disturbances exist all the time, only a few of them may develop into TCs. In this study, the daily global analysis from the Navy Operational Global Atmospheric Prediction System (NOGAPS) is examined to understand why some disturbances develop into TCs while others do not. Significantly different characteristics of atmospheric variables associated with developing and nondeveloping disturbances are found. The most important parameter controlling TC formation is vertical wind shear in the North Atlantic (NA) and low-level, large-scale convergence in the western North Pacific (WNP). The result suggests that different cyclogenesis mechanisms may operate for TC formation in the two oceanic basins.

Problem: While there has been a steady improvement in TC track forecasts, little progress has been made in TC genesis forecast in past decades, mainly due to the lack of accurate observations over the ocean and the complicated processes involved in TC genesis. Earlier work[1] suggested six favorable environmental conditions for TC formation. Although there are many tropical disturbances each year in different ocean basins, only a few develop into tropical cyclones. In this study, we trace tropical disturbances that formed TCs eventually and those that did not, to gain more insight into TC formation. The data set we use is NOGAPS daily analysis data with a one-degree resolution. Scenarios for the North Altantic and the western North Pacific are investigated separately to identify possible different characteristics of the developing and nondeveloping disturbances for TC formation in these two basins.

Data and Method: Recent improvement of NOGAPS and its data assimilation system make its analysis a good proxy of real atmosphere. A time-filtering technique is applied to NOGAPS analysis for the 2003 to 2005 period to extract 3- to 8-day period synoptic-scale waves/perturbations and low-frequency (20 days or longer) background fields. A composite map is made in a 20° by 20° domain centered at the maximum low-level (850 mb) vorticity disturbance. For the developing cases, synoptic-scale disturbances are traced back three days before the genesis and composites are made for the genesis day (day 0) and the previous three days (day –1, day –2, and day –3). Disturbances with clear close-circle cyclonic circulation are considered as non-developing cases, and only one composite is made for all of them.

Results and Discussion: Figure 4 shows the composite maps of the vertical shear (200–850 mb) in terms of speed for the developing and nondeveloping cases in the North Atlantic (top) and the western North Pacific (bottom). For the developing disturbances in both the NA and the WNP, there is a gradual buildup of a low shear zone near and north of the perturbation center from day –3 to the genesis day. The composite of the nondeveloping disturbances in the NA shows a very large shear gradient across the center, with a significantly large vertical shear appearing to its south. This is consistent with recent climatology studies[2] that point out that the low vertical shear months of August and September correspond to the most active tropical cyclogenesis in the NA.

Contrasting to those in the NA, the vertical shear in the WNP shows a very different feature. In the WNP, the nondeveloping composite shows a smaller vertical shear than the developing cases. This indicates that the larger vertical shear does not preclude a tropical disturbance from becoming a TC in the WNP. It has been well understood that, in general, larger shear is not favorable for TC formation. The distinction between the characteristics in the NA and the WNP suggests that vertical shear plays a more important role in the NA than in the WNP in the formation of TCs.

Figure 5 illustrates the composite maps for 20-day low-pass filtered 850 mb divergence fields. In the NA, the difference between the developing and nondeveloping cases is small, while there is a distinct larger convergence for the developing cases in the WNP. This suggests that large-scale environmental convergence is important for TC formation in the WNP, while it is less so in the NA.

Composites of other variables show that more moisture at the lower and middle troposphere and larger low-level relative vorticity are common features for both NA and WNP developing disturbances compared to the non-developing cases. We also found that the averaged moving speed is slower in the developing cases than that in the nondeveloping cases in both the NA and the WNP. Another unique feature in the NA is that the developing disturbances are correlated well with the weakening of the upstream 500 mb easterly wind so that less dry air from the Sahara desert is brought into the eastern part of the NA where TCs usually form. A cyclogenesis prediction index based on this study is under development that has the potential to provide useful guidance in the operational forecast of tropical cyclone genesis.

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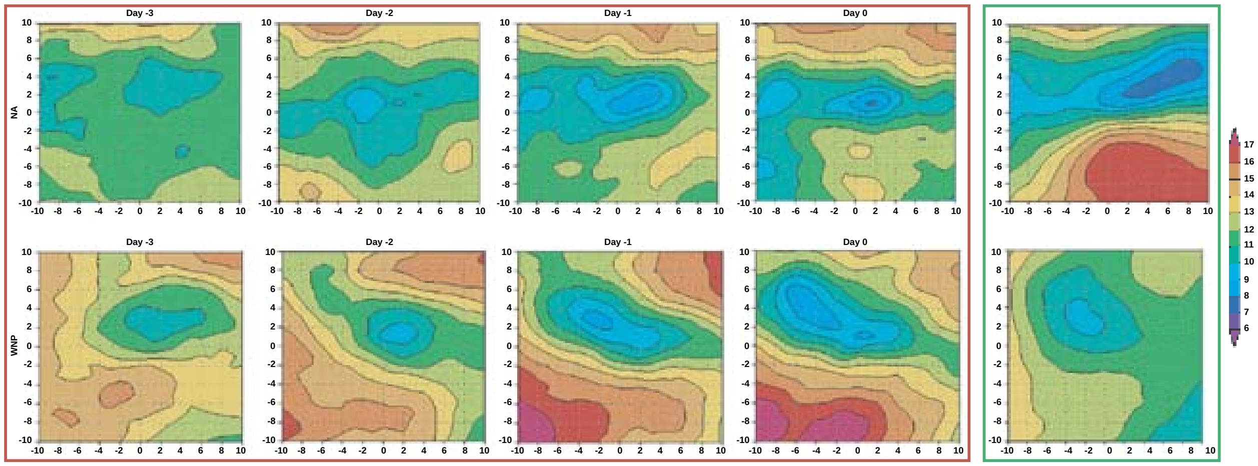

FIGURE 4
Composites of the speed of the vertical shear (200–850 mb) for developing (in red frame) and nondeveloping (in green frame) disturbances in the NA (top) and WNP (bottom). The horizontal domain is a 20° by 20° region centered at the maximum low-level vorticity. Day 0 is the day when the TCs formed, Day –1 is the prior day, and so forth.

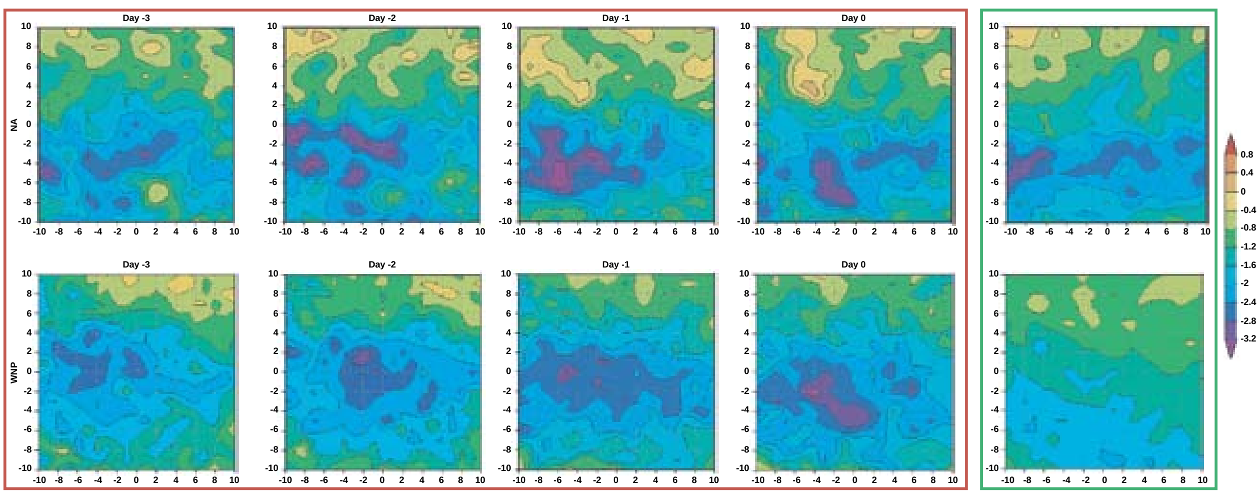

FIGURE 5
Same as Fig. 4, but for 20-day low-pass filtered 850 mb divergence fields.

References

[1] W.M. Gray, "A Global View of the Origin of Tropical Disturbances and Storms," *Mon. Wea. Rev.* **96**, 669-700 (1968).

[2] A.R. Aiyyer and C. Thorncroft, "Climatology of Vertical Wind Shear over the Tropical Atlantic," *J. Climate* **19**, 2969-2983 (2006).

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