6A.1 Development and Breakdown of Reverse Monsoon Troughs in the Western Pacific

Kelly Lombardo*
State University of New York at Albany
Albany, New York

1. INTRODUCTION

The monsoon trough is a persistent lower tropospheric feature in the Western Pacific during the Northern Hemisphere summer. It provides a potential source of low level vorticity for tropical cyclogenesis. Hence, the location and evolution of this feature becomes important for the prediction of tropical cyclogenesis.

Lander (1996) identified the fundamental orientations of the monsoon trough, one of which is known as the reverse oriented monsoon trough. From this, Lander made a comparison between tropical cyclone tracks under the typical monsoon trough and the reverse oriented (SW-NE) monsoon trough. Typically, tropical cyclones moved northwestward due to the presence of the monsoon trough. When the axis of the monsoon trough became reversed, tropical cyclones tended to track more northward. Furthermore, Harr and Elsberry (1995) have identified six primary large-scale wind patterns in the western Pacific utilizing EOF cluster analysis. Several of these patterns resemble the monsoon trough positioned along its various orientations. Once again, locations of tropical cyclogenesis as well as tropical cyclone tracks appear to be influenced by these large-scale patterns.

Considering the above, it seems reasonable that understanding the mechanisms controlling the evolution of the monsoon trough can be crucial in providing some insight to tropical cyclone formation and motion. Toward this end, this study will examine the influence of upper-level synoptic-scale forcing mechanisms on the evolution of the monsoon trough.

2. DATA AND METHODOLOGY

ECMWF gridded analysis have been utilized to examine the occasional reversal in orientation of the monsoon trough. A twenty-day low-pass filter has been applied to the relative vorticity fields for several different summers, in order to highlight the strength and orientation of this feature. From the years examined, the 1988 period illustrates a clear reversal of the monsoon trough as well as its dramatic impact on tropical cyclogenesis. Therefore, this year has been chosen for further investigation.

During the summer of 1988, four periods were selected isolating instances of both the monsoon trough and the reverse oriented monsoon trough. Time-averaged wind and relative vorticity were calculated for each period at two levels, 850 hPa and 200 hPa, to illustrate both the lower-tropospheric and upper-tropospheric large-scale patterns associated with each distinct feature. In the lower troposphere, the location of mean cyclonic vorticity highlights the axis of the monsoon trough.

3. RESULTS

Figure 1 shows the mean winds and cyclonic vorticity at the 850 hPa level. Locations of initial tropical depression development were obtained from the Joint Typhoon Warning Center (JTWC) best track data and plotted as well. Two reverse oriented monsoon troughs are visible in the August mean relative vorticity field. During this period, all instances of cyclogenesis occurred north of 20N and, more interestingly, most tropical cyclones formed within these two large-scale features. Approximately one month later, the monsoon trough returned to its typical climatological position, as shown in figure 2. Again, the regions of cyclogenesis coincide with the orientation of the monsoon trough.

The simultaneous altering of the monsoon trough's axis along with the primary region of cyclogenesis occurs on two other occasions in this year alone. It is evident that a relationship exists between these two phenomena.

Understanding this coexistence requires the examination of upper-tropospheric synoptic-scale features. Mean relative vorticity and wind fields at 200 hPa have been generated for the same two periods illustrated in figures 1 and 2 (not shown).

Between 27 July and 26 August, upper-level mid-latitude troughs repeatedly penetrated into the subtropics. As a result, the interaction between these two regions was tremendously enhanced. This was not the case during the second period. An elongated region of high pressure, an extension of the upper-tropospheric Asian anticyclone, was present over the mid-latitude Pacific Ocean. In addition, the frequency of mid-latitude troughs entering the subtropics decreased. Therefore, the magnitude of such interactions diminished considerably.

One can speculate that the penetration of mid-latitude troughs into the tropics may aid in the demise of the monsoon trough, oriented along the climatological position, and the development of this feature farther to the north. The absence of such disturbances allows the typical monsoon trough to reestablish itself. Further investigation is necessary to better understand these complex interactions and relationships.

* *Corresponding author address*: Kelly Lombardo, Department of Earth and Atmospheric Sciences, State University of New York at Albany, Albany, NY 12222.
e-mail: lombardo@atmos.albany.edu

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5. REFERENCES

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(1)

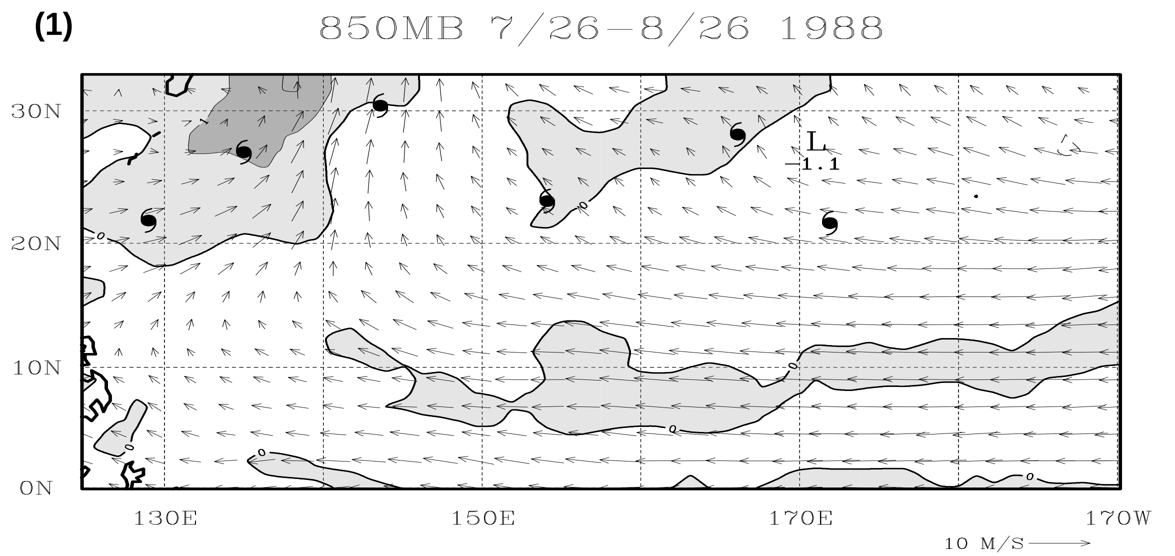

Figure 1: Time-averaged wind and relative vorticity (shaded when cyclonic) for 26 July - 26 August 1988. Locations of initial tropical depression development during each given period have been plotted.

(2)

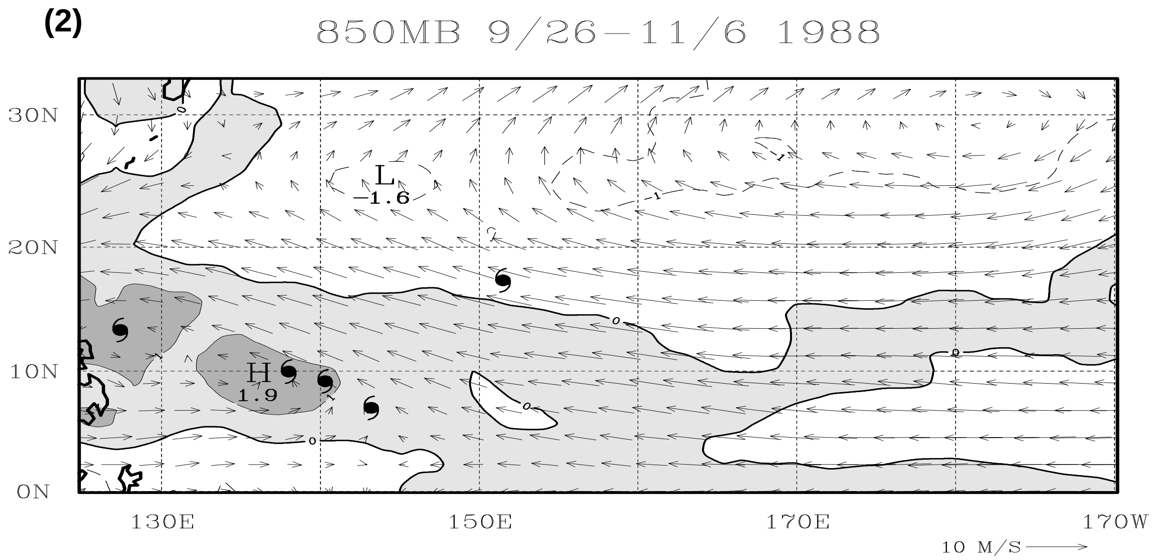

Figure 2: Same as figure 1, but for 26 September - 6 November 1988.