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PARADIGMS OF TROPICAL CYCLOGENESIS IN THE WESTERN PACIFIC

by

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1. INTRODUCTION

In this talk we will focus on the issue of tropical cyclogenesis in the Northwest Pacific, and its relationship to general paradigms of tropical meteorology. Palmer (1951) wrote a classic paper concerning research progress in tropical meteorology up to that time. He defined three schools of thought. The first, the air mass school, misapplied the methods of middle latitudes to the tropics. The second, the "climatological school", noted the persistence of such features as the trade winds and the monsoons, and argued that day-to-day weather could be addressed by making use of monthly or seasonal mean maps that showed these dominant large-scale structures. The third approach, the "perturbation school", noted the presence of synoptic-scale waves. While they accepted the existence of a time-mean flow with distinct large-scale structures, they believed that the behavior of (usually westward-propagating) perturbations was of greater importance for forecasting day-to-day weather than the time-mean flow. At the time of Palmer's paper, the air mass school was largely recognized as incorrect, but a debate continued among the climatological and perturbation schools about what features dominated the tropical weather.

We believe that this debate never ended, and is now being played out in the views of tropical cyclogenesis in the Western Pacific Ocean. In published work on this topic, frequently the discussions revolve around the location and intensity of the monsoon trough. It has been argued that 80% of West Pacific tropical cyclones form within the monsoon trough, and 10% or fewer form in association with westward-moving disturbances (McBride 1995). [We will label these disturbances generically as "waves", although they might not be wavelike during at least part of their history.] It will be argued here that the concept of the monsoon trough, which is an easily definable, unambiguous feature in seasonal mean maps, is much more difficult to apply to the understanding and forecasting of individual tropical cyclogenesis events.

2. EXAMPLES

Recently Wheeler and Kiladis (1999) provided evidence that cloudiness in the tropics and subtropics is heavily influenced by waves that obey linear beta-plane solutions with zero mean flow. Their results suggest that what some viewed as esoteric mathematical solutions are in fact significant players in the *weather* in the tropics and subtropics.

It will be argued that a significant fraction of tropical cyclones in the western Pacific form within amplifying synoptic scale waves that represent various equatorial wave mode solutions (how the genesis occurs within the wave is an interesting but separate question). The prediction of the genesis of these storms a week or more in advance requires one to understand and predict the behavior of waves moving through an inhomogeneous background flow. The background flow is viewed as being driven by slowly varying diabatic heating like that occurring with the Madden-Julian Oscillation (MJO) or other long-period fluctuations.

Dickinson and Molinari (2002) found a large-amplitude mixed Rossby-gravity (MRG) wave packet during 1987 that lasted 5 weeks and spawned three tropical cyclones in the same region, one with each cyclonic gyre within the

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packet as the gyres turned away from the equator in the western Pacific. The wave packet grew within an active MJO, and decayed when the MJO moved eastward away from the packet, whose eastward group velocity was far less than the MJO speed. Aiyyer and Molinari (2003), using idealized shallow-water modeling, argued that the MJO, which was asymmetric with respect to the equator, created a background state favorable for off-equatorial growth of vortices within the MRG waves on the scale of a few hundred km, which is an appropriate seedling for a tropical cyclone.

Lombardo (2004, this conference) found even a more dramatic example of equatorial wave modes influencing tropical cyclogenesis. She will show an equatorial Rossby wave packet in the western Pacific that lasted nearly three months and spawned 11 tropical cyclones. This raises the possibility that once a pattern is established, repeated tropical cyclogenesis in a region might be predictable even a month or more in advance.

Aiyyer (2004, this conference) examined a cluster of five tropical cyclone formations over three weeks in the east Pacific and Gulf of Mexico. Details are in his talk and will not be given here, except to note that whether or not easterly waves spawned tropical cyclones in the east Pacific/Gulf of Mexico was very sensitive to the inhomogeneous background experienced by the waves. In his study the MJO appeared to be responsible for the active and inactive background states.

3. DISCUSSION

In all of the above, westward moving, synoptic-scale disturbances moved through an inhomogeneous background and grew in amplitude. Three wave types were represented: Rossby, mixed Rossby-gravity, and equatorial Rossby. In each event, tropical cyclones formed repeatedly within the cyclonic parts of the wave train. It is not certain what if any role the monsoon trough played in these events. A challenge for our field is to meld the monsoon trough and wave (i.e., climatological and perturbation school) paradigms for tropical cyclogenesis.

Further discussion and examples will be presented in the talk.

4. ACKNOWLEDGEMENT

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