BAROTROPIC DYNAMICS OF TROPICAL CYCLONE MOTION

JOHNNY C. L. CHAN
Dept. of Physics & Mat. Sci., City University of Hong Kong

The movement of tropical cyclones (TCs) is known to deviate from its steering flow, which has been labelled as propagation. It has been proposed, based on barotropic model studies, that the pair of counter-rotating gyres that result from the interaction between the environmental flow and the vortex circulation is responsible for the propagation. This study attempts to verify this hypothesis using the analyses from the Tropical Cyclone Motion Experiment conducted over the western North Pacific in 1990 and to propose a coherent theory of TC motion based on barotropic dynamics.

The results suggest that gyres cannot be identified in some of the cases studied. This is consistent with other modelling studies that demonstrate the masking of such features when the environmental vorticity gradient is significant. For those cases in which gyres are found, their orientation appears to bear no systematic relationship with the propagation vector. This suggests that other factors must be present to steer the TC.

To study further the asymmetric flow associated with the TC, a Fourier analysis is applied. While an azimuthal wavenumber-1 (WN-1), i.e. the pair of counter-rotating gyres, appears in most cases, its amplitude can diminish relative to the WN-2 flow especially when the TC is about to recurve. This demonstrates the importance of the latter in certain situations. A further analysis on the energetics of the flow suggests possible energy exchanges among the various wavenumber components and the environmental flow. It is therefore hypothesized that other wavenumber components may also contribute towards the propagation process. Verification of such a hypothesis is made by computing the various terms in the vorticity equation. Based on these results, a theory of TC motion with only barotropic dynamics is proposed.

Key Words: tropical cyclone, barotropic dynamics