行政院國家科學委員會補助專題研究計畫成果報告

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一、 中文摘要

由三維原始方程模式計算颱風所產生的渦漩在開放的海域內傳播過程。雖然颱風所產生的渦漩能量主要在近海面 250 米水層內，但它仍會向下層海洋以 Rossby 波动傳送能量，因此低壓渦漩有明顯向西北移动的趨勢，同時渦漩的动能及位能在傳遞過程是持續減弱，因此它應沒有能力改变西方邊界流的結構。

關鍵詞：颱風渦漩、西方邊界流

Abstract

From a three-dimensional primitive-equation model, we simulate the propagation of a typhoon-induced mesoscale eddy in an open ocean. Although the eddy energy is confined in the upper 250 m near the surface, it still can leak energy by radiating Rossby waves into the lower ocean. As a consequence, a cyclonic eddy translates toward northwest and loses both its kinetic energy and the available potential energy during its evolution. Therefore, a typhoon-induced cyclonic eddy at low latitude is incapable to affect Kuroshio to the east of Taiwan.

Keywords: Typhoon eddy, Kuroshio, Rossby wave

二、緣由與目的

本計畫的工作是用三維數值模式探討颱風所產生的渦漩在開放的海域自由傳播的過程以及當這類渦漩傳到西方邊界後是否仍有能力改变西方邊界流的結構。由於西方邊界流是大洋中最強的海流，Yang el al. (1999) 報導臺灣東邊外海黑潮变化的過程，提出一个可能的因素就是受到中尺度渦漩的影响，由於黑潮流與渦漩無論在速度或渦度上都不是同級的，它們之間能否有互动是十分值得進一步探討，這也是本計畫的目的。

三、結果與討論

A three-dimensional nonlinear primitive equation model is used in this study. The model basin is a rectangular basin of 300x150 grids in the horizontal plane and 18 layers in the vertical.. The resolution is 0.2^{o} and a time step is 5 minutes. The southern boundary of the ocean is at 10 N and the western boundary of the model basin is at 120 E. A typhoon wind stress anomaly , centered at 150 E, 20 N, is imposed at sea surface for a 4 day period to generate the typhoon-induced eddy .

Figure 1 depicts the evolution of the eddy center for a 360 day period, each mark denotes a 10 day interval.. This eddy propagates primarily northwestward, in contrast to a westward propagation in a two-dimensional reduced-gravity model simulation. Cushman-Roisin et al. (1990) proved that an isolated vortex without a background flow drifts just westward. However, when the eddy can radiates energy into the deep ocean, the eddy can no longer to regard as "isolated eddy", and its drifting velocity has a significant northward component. Matsuura (1995) also demonstrated that a large amplitude upper-ocean vortex can move northward in a two-layer ocean, through the radiation of Rossby waves into the lower layer.

Figure 2 depicts the time history of the kinetic energy and the available potential energy, associated with the eddy motion in the upper 250 m. The continuously loses both the kinetic energy and the potential energy from the eddy is evident. The magnitude of the kinetic and potential energy drops to 1/10 of its original strength in about 180 days. During this period, the eddy can only move about 4 degree, 440 km, north, far less than the 1000 km northward movement of a typhoon-induced cyclonic eddy reported by Lee et al. (2003).

Besides the eddy evolution in a quiescent open ocean, we also simulate the evolution of a typhoon-induced cyclonic eddy with the presence of a wind-driven general circulation. The model ocean is spun up by a climatological wind for five years and then a typhoon wind stress anomaly is imposed for four day period. Figure 3 depicts the horizontal distribution of the temperature and velocity fields at the 25-50 m depth range on day 10 after the onset of the typhoon, centered at 135 E and 16 N. The temperature at the eddy center is about 6 ^{o}C below the surrounding water at this depth level. The background flow in Fig. 3 also depicts the strong western boundary current to the east of Luzon and Taiwan and a loop current in the Luzon Strait. Figures 4 and 5 depict the horizontal distribution of the temperature and velocity fields on day 90 and 180, respectively, at this same depth level. It is quite clear that the eddy decays before it encounters the western boundary current and the Kuroshio has no appreciable change, except that some warm water intrudes westward in the Luzon Strait as the eddy approaching the east of Taiwan. In summary, from our model study, we infer that a strong three-dimensional mesoscale cyclonic eddy can drifts northward through radiating Rossby waves into the lower ocean. Meanwhile, the eddy also loses its energy and decays. It is impossible for such an eddy to affect the Kuroshio to the east of Taiwan. Eddies will die to the east of Kuroshio.

四、計畫成果自評

本年度的計畫目標就是以數值模式來探討颱風所產生的渦漩是否有能力改变西方邊界流。目前已完成三維模式的發展，可以成功的推算渦流在開放海域的傳播過程及渦漩運动到西方邊界後受到邊界流影响而消散的情況，這些結果正在整理中，預期很快就可發表。

五、參考文獻：

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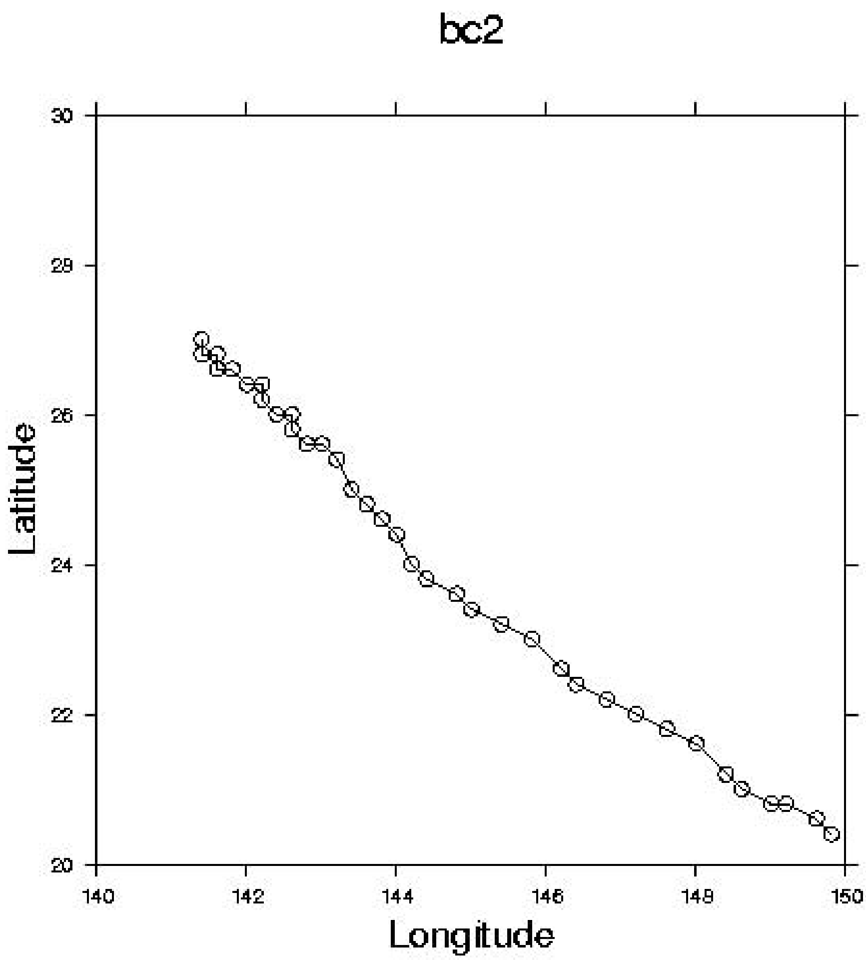

Fig. 1 Evolution of the eddy center associated with a typhoon-induced cyclonic eddy

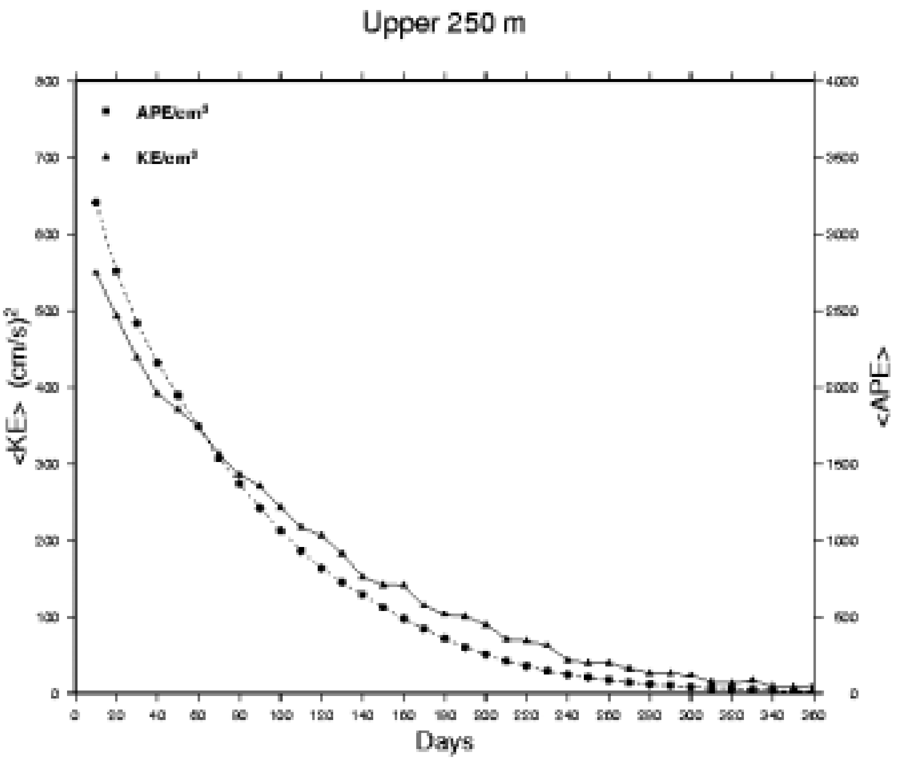

Fig. 2 Time history of the kinetic energy and the available potential energy of the eddy motion in the upper 250 m.

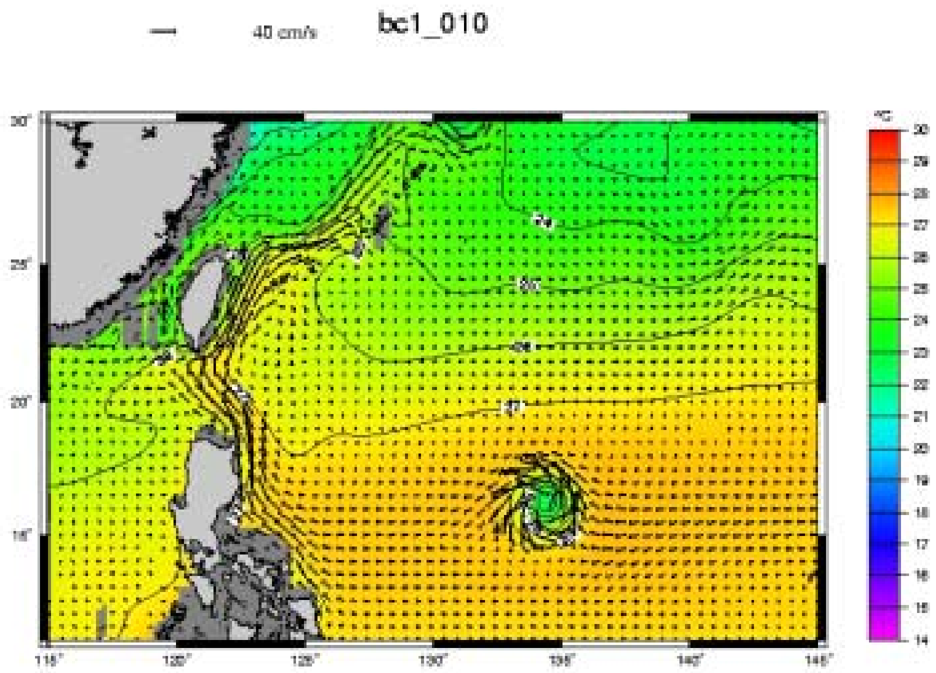

Fig.3 Horizontal distribution of temperature and velocity at 25-50 m depth range at day 10

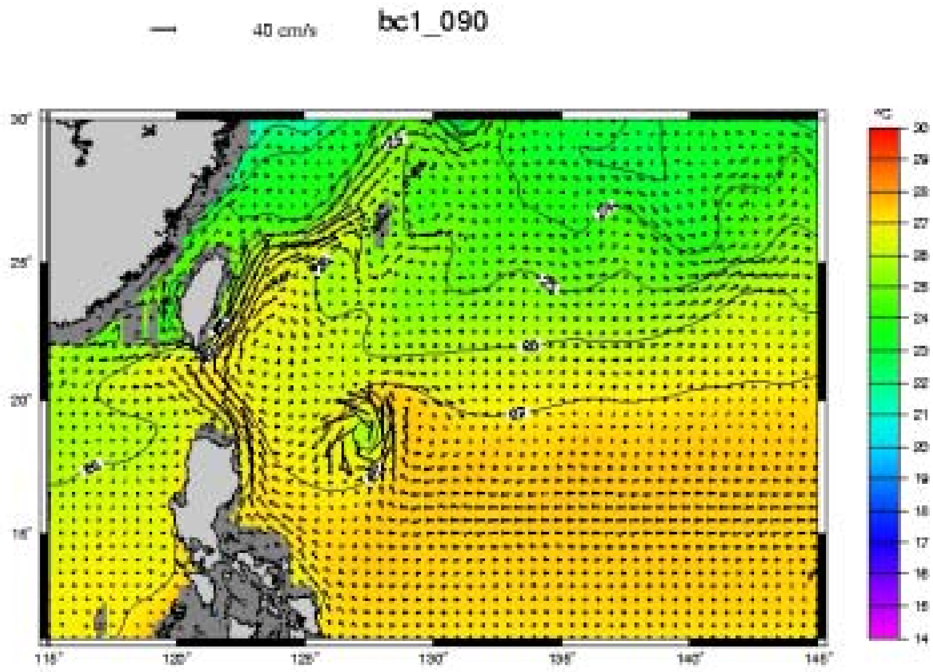

Fig. 4 Horizontal distribution of temperature and velocity at 25-50 m depth range at day 90

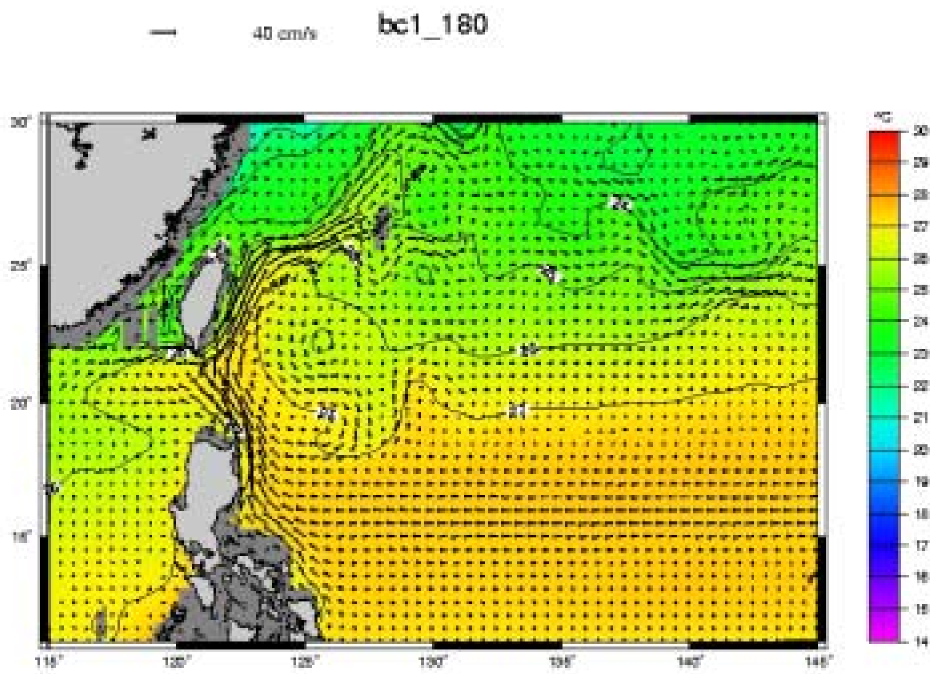

Fig. 5 Horizontal distribution of temperature and velocity at 25-50 m depth range at day 180.