The Birth of Tropical Storms

Forecasting the formation of tropical cyclones has been a challenge in part because of a lack of reliable observations over the ocean. Modern satellite products are now providing a great opportunity for studying and predicting this important meteorological phenomenon. Using QuikSCAT surface-wind and Tropical Rainfall Measurement Mission (TRMM) Microwave Image (TMI) data, **Tim Li** (IPRC) and **Bing Fu** (UH) looked at the formation of tropical cyclones in the western North Pacific during the summers 2000 and 2001. In their analysis, they identified two formation processes: the dispersion of energy of a mature tropical cyclone in the form of Rossby waves, and the energy accumulation of easterly waves in the monsoon confluence region. Of the 34 cyclones studied, 7 were associated with easterly wave propagation and 6 with energy dispersion of a mature cyclone.

An example of the birth of a storm in the wake of Rossby waves of an existing cyclone is seen in Figure 4. On August 1, Tropical Cyclone Jelawat forms, then moves northwest and intensifies. The four panels show the surface wind patterns from August 6 to 9, 2000, associated with Jelawat. (The QuikSCAT daily wind data were subjected to a 3-8 day filter to isolate synoptic-scale signals.) A Rossby wave train forms on August 6 in the wake of Jelawat, a process that continues until August 9 and can be clearly seen in the figure. As the scale of the Rossby wave train contracts, a new tropical cyclone, Ewiniar, forms on August 9.

Motivated by these satellite analyses, **Tim Li**, **Yongti Zhu** (IPRC visitor from the Shanghai Typhoon Institute), **Yuqing Wang** (IPRC), and **Bin Wang** (IPRC) conducted a simulation of tropical cyclone formation associated with the dispersion of energy through Rossby waves. They used the 3-dimensional tropical cyclone model developed by Yuqing Wang, modifying it to allow the cyclone to evolve in a specified summer-mean flow that does not change with time; they initialized the model with a mature tropical cyclone that has developed its Rossby wave train. Two different convective heating schemes (explicit heating scheme and mass-flux scheme) are applied in the model. Their experiment shows that, in the presence of the mean summer monsoon circulation, a new cyclone with realistic dynamic and thermodynamic structures forms in the wake of an existing cyclone (Figure 5). When the model is run again without the summer-mean flow, no tropical cyclone forms, suggesting that the monsoon flow is necessary for the Rossby wave scale contraction.

Tim Li has analyzed also the tropical cyclone formation associated with energy accumulation of easterly waves in the confluence region where the monsoon westerly winds meet the easterly trade winds. He has found, for instance, that four days before Jelawat formed, a kinetic energy perturbation and precipitation signal appeared in the western Pacific around 175ºW to 172ºE. This disturbance continued to move westward and then gave birth to Jelawat at 152ºE. Using the same tropical cyclone model as in the other cyclogenesis simulation, Li and his collaborators were able to also simulate this second tropical cyclone formation process.

The observational and modeling results above have important implications for operational forecasts of tropical cyclones. In a newly funded project supported by the Department of Defense, Li and his colleagues propose to extend the current scope by taking advantage of modern satellite products (such as the Advanced Microwave Sounding Units A and B), which provide in 3-dimensions the spatial-structure and time evolution of temperature and moisture fields of synoptic-scale perturbations over the tropical oceans. These products together with other available datasets, such as QuikSCAT surface winds, are expected to provide detailed tropical wave structures and wave propagation characteristics. By injecting these characteristics into the model's initial fields, the group plans to develop a dynamic approach in order to simulate and predict the birth of tropical storms in the western North Pacific. The findings of this research project should lead to improvements in forecasting the formation of tropical cyclones.

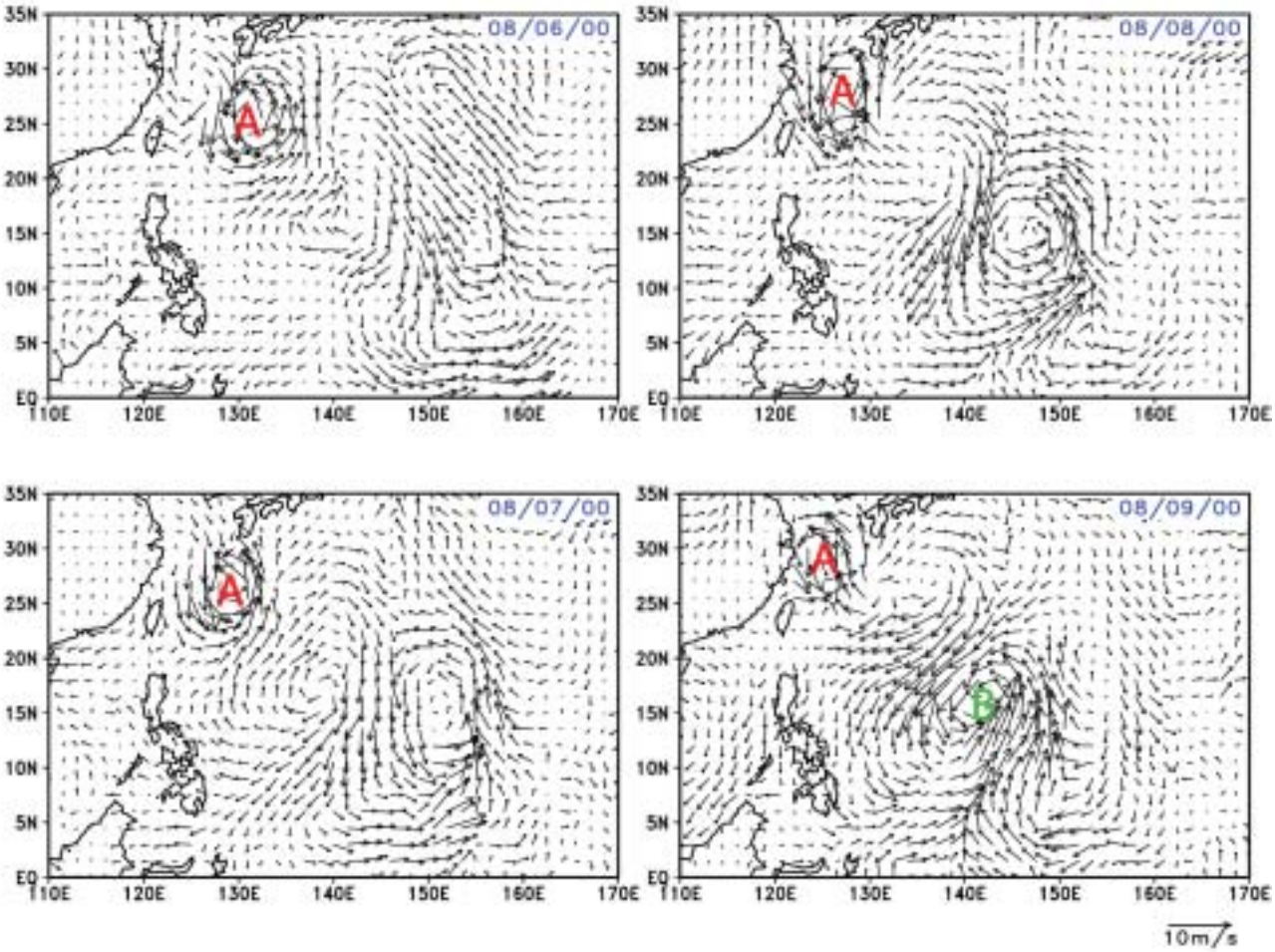

Figure 4. *Time sequence of the synoptic-scale wave train associated with tropical cyclone Jelawat, which formed 1 August 2000. "A" shows Jelawat's center. A new cyclone, Ewiniar, with "B" denoting its center, formed on 9 August 2000 in the wake of the Rossby wave train of Jelawat. A 3-8 day filter has been applied to the QuikSCAT surface-wind data to isolate synoptic-scale signals.*

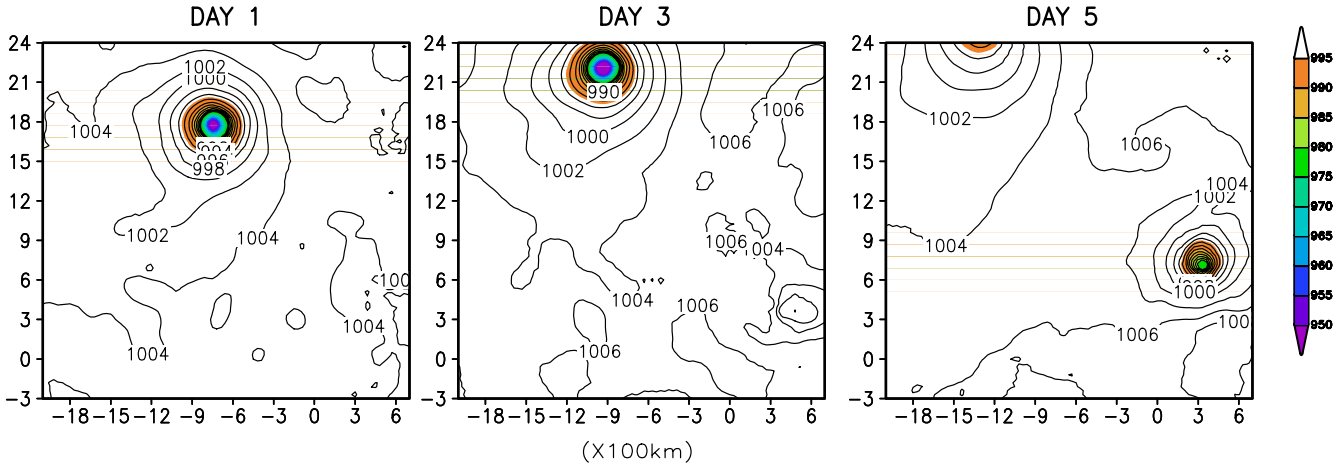

Figure 5. *Time sequence of the surface pressure field obtained from a numerical experiment. A mature tropical cyclone with its Rossby wave train is specified at the outset in an environmental flow similar to the western North Pacific summer monsoon. Five days later a new cyclone with realistic dynamic and thermodynamic structures forms in its wake. The minimum pressure at the center of the new cyclone is about 970 mb.*