Toward the Development of Tropical Cyclone Ensemble Forecast and Cyclogenesis Modeling and Forecast for DoD's Joint Typhoon Warning Center

PI: Tim Li
Department of Meteorology, University of Hawaii at Manoa,
2525 Correa Road, Honolulu, Hawaii 96822
phone: 808-956-9427 fax: 808-956-9425 email: timli@hawaii.edu

CO-PI: Bin Wang
Department of Meteorology, University of Hawaii at Manoa,
2525 Correa Road, Honolulu, Hawaii 96822
phone: 808-956-2563 fax: 808-956-9425 email: wangbin@hawaii.edu

Award Number: N000140310739

LONG-TERM GOALS

The long-term goal is to improve Navy's operational forecast skill for tropical cyclone (TC) track, intensity change, and formation.

OBJECTIVES

The objectives of this project are twofold. First, we intend to apply the latest satellite products into Navy's operational weather forecast models. Our special focus is on the improvement of forecast skills of TC track and intensity change with use of a new TC bogus scheme that incorporates satellite-retrieved 3D temperature products. Secondly, we intend to develop a dynamic approach for tropical cyclogenesis forecast. To achieve it, we intend to simulate cyclogenesis processes in a numerical model and to understand physical mechanisms that give rise to the cyclogenesis.

APPROACH

The key for the first objective is to develop a systematic approach to derive initial asymmetric TC structures based on Advanced Microwave Sounding Unit (AMSU) products. Once 3D temperature fields are obtained, we will further derive asymmetric wind fields based on a nonlinear balance equation for a rotational wind component and an omega equation for a divergent wind component (see Zhu et al. 2002 for detail). We will particularly select special cases (during recent years when the AMSU data are available) in which current operational models had large errors in TC track and intensity forecasts. We plan to use the new initialization scheme to reconstruct better initial TC structures. We will then implement the new initial field into the operational model and conduct forecast experiments. Given a certain bias in satellite retrieving, ensemble forecasts with slightly changed initial conditions are needed in order to understand the sensitivity of the forecast to initial TC structures.

For the second objective, we intend to focus on in what scenarios of synoptic-scale wave patterns and large-scale environment flows a new TC can be simulated or predicted by a sophisticated atmospheric model through wave-mean flow interactions. In particular, we intend to simulate cyclogenesis

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2003**	2. REPORT TYPE	3. DATES COVERED **00-00-2003 to 00-00-2003**

4. TITLE AND SUBTITLE **Toward the Development of Tropical Cyclone Ensemble Forecast and Cyclogenesis Modeling and Forecast for DoD's Joint Typhoon Warning Center**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Department of Meteorology, University of Hawaii at Manoa,,2525 Correa Road,,Honolulu,,HI,96822**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

processes associated with the Rossby wave energy dispersion of a pre-existing typhoon, easterly wave forcing, and synoptic-scale wave trains that are not related to a pre-existing TC.

WORK COMPLETED

This project started from June 2003. The first task we have completed during the past months is the development of a unified code for directly retrieving 3D temperature fields at regular grids from raw, original satellite orbit (AMSU level 1B) data. This includes the filling of gaps between orbiting channels with an optimal interpolation approach and/or use of the NCEP analysis data. This is successfully done through close collaboration with scientists, Drs. F. Weng and T. Zhu, at NOAA's Joint Center for Satellite Data Assimilation.

For the TC genesis study, we have conducted an observational analysis of the Rossby wave energy dispersion and associated cyclogenesis in the western North Pacific during 2000 and 2001 typhoon seasons. We also conducted a set of numerical experiments to simulate tropical cyclogenesis associated with the Rossby wave energy dispersion in a 3D model.

RESULTS

Three-dimensional temperature structures of Super-typhoon Halong during various development phases have been derived based on the code described above. Halong formed in the western North Pacific in 2002. Its asymmetric warm core structures during its mature phase are well reproduced by this automatic analysis tool using the AMSU data.

By analyzing the QuikSCAT surface wind and the Tropical Rainfall Measurement Mission (TRMM) Microwave Image (TMI) precipitation data, we have identified three major cyclogenesis scenarios in the western North Pacific: 1) Rossby wave energy dispersion of a pre-existing TC, 2) energy accumulation of easterly waves in a confluent mean flow, and 3) storm development in a synoptic-scale wave train. During the summer of 2000 and 2001, there were a total of 34 cyclogenesis cases (in which the vortex reaches the tropical storm strength). Among them, 7, 6 and 11 cases are related to the easterly wave forcing, TC energy dispersion and synoptic-scale wave trains, respectively.

Figure 1 shows a scenario of the Rossby wave energy dispersion. It illustrates the time sequence of synoptic-scale wind patterns associated with a named TC Jelawat, which formed on 1 August 2000. During the first few days, Jelawat did not excite any significant Rossby wave train in its wake due to its relatively weak intensity. As it intensified on its northwestward route, a Rossby wave train developed in its wake. A northwest-southeast oriented wave train was clearly seen on August 6, and it had a typical zonal wavelength of 2500 km. A significant feature of this wave train was its rather large meridional length scale as compared with its zonal length scale. Based on non-divergent barotropic vorticity dynamics, we argue that this feature is essential for the eastward energy propagation. A remarkable feature associated with the aforementioned Rossby wave train is its scale contraction, in particular the meridional scale. This is evident from August 7 to 9 as shown in Fig. 1. Following this scale contraction, a new TC named Ewiniar formed in the positive vorticity region of Jelawat's wave train on 9 August 2000. This analysis of the satellite data present convincing evidences for the existence of Rossby wave train induced by a mature TC and the formation of a new TC in the wake of a pre-existing TC.

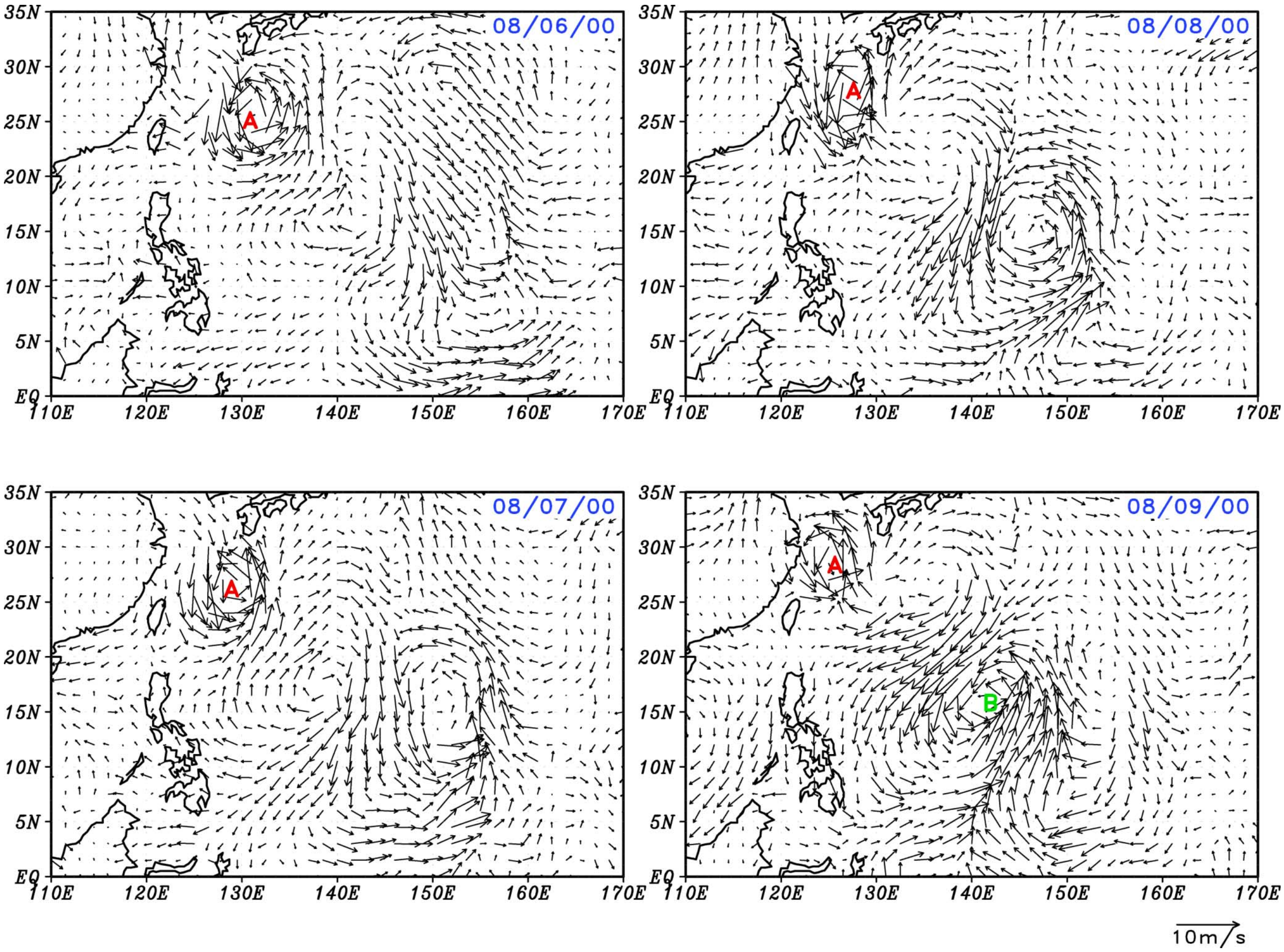

Fig. 1 Time evolution of Rossby wave train associated with the energy dispersion of TC Jelawat as seen from the QuikSCAT surface wind observation. "A" represents the center location of TC Jelawat that formed on 1 August 2000. "B" represents the center location of a new TC named Ewiniar that was generated on 9 August 2000 in the wake of the Rossby wave train of Jelawat.

In addition to satellite data analysis, we have also conducted a numerical investigation to simulate cyclogenesis associated with the TC Rossby wave energy dispersion in a 3D model. A mature TC with its well-developed Rossby wave train is specified initially. Two different heating schemes, one with an explicit convective heating scheme and the other with the mass-flux scheme, are used. In both cases, a new TC was successfully simulated in the wake of the pre-existing TC in the presence of an idealized basic flow similar to the observed summer mean flow in the WNP. The simulated new TC has a minimum central pressure of 970 hPa and realistic dynamic and thermodynamic structures. Currently we are investigating a vorticity budget to understand physical processes that give rise to the cyclogenesis.

IMPACT/APPLICATIONS

The application of the new satellite-retrieved products and the new TC initialization scheme, once proved to be successful, would have a great impact on improving TC track and intensity forecast.

The success in simulating and understanding the physics of TC formation would lead to the development of a dynamically-oriented cyclogenesis forecast system.

RELATED PROJECTS

NSF project (ATM01-19490): Tropical cyclone energy dispersion and self-maintaining mechanisms for summertime synoptic-scale waves in the northwest Pacific. While this NSF project focuses mainly on theoretical aspects of 3D TC energy dispersion and associated cyclogenesis, the current ONR project deals with the application of new satellite data to Navy operational forecast systems in an aim to improve current forecast skills for TC track and intensity change and the development of a dynamic approach for TC formation forecast.

REFERENCES

Zhu, T., D. Zhang, F. Weng, 2002: Impact of the advanced microwave sounding unit measurements on hurricane prediction. *Mon.Wea.Rev*., **130**, 2416-2432.

PUBLICATIONS

The following is a list of submitted manuscripts sponsored in part by this ONR project.

Li, T., B. Fu, X. Ge, B. Wang, and M. Peng, 2003: Satellite data analysis and numerical simulation of tropical cyclone formation. *Geophy. Res. Let. ,* submitted.

Li, T., B. Fu, and F. Weng, 2003: Tropical cyclone formation in the western North Pacific as revealed from the QuikSCAT and TMI data. *Mon.Wea.Rev.*, submitted.