

Tropical Cyclone and Hurricane Landfall Studies

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LONG-TERM GOALS

The long-term goal is to improve understanding of the tropical cyclone structure and motion throughout its evolution from formation, mature stage, and extratropical transition and thereby contribute to improved predictions of the tropical cyclone threat to the Fleet afloat and ashore.

OBJECTIVES

Working with a team of research collaborators, advance understanding of tropical cyclone during all stages using both observations and modeling approaches.

Working with the U.S. Weather Research Project (USWRP), provide scientific leadership to advance understanding and improve prediction of hurricanes threatening landfall on the United States.

APPROACH

Collaborative studies with present and past members of our research team have included studies of tropical cyclone formation (see separate reports by Patrick Harr and Kevin Cheung) and extratropical transition (reports by Harr and Elizabeth Ritchie, now at the University of New Mexico), and tropical cyclone motion prediction (with former team member Les Carr and Mark Boothe).

I have continued to serve as Science Coordinator for the USWRP Hurricane Landfall program and have produced a number of assessments of the status of our understanding and prediction of tropical cyclones throughout the globe. In pursuit of this objective, I also served as Director of the Firth International Workshop on Tropical Cyclones (IWTC-V) during December 2002.

WORK COMPLETED

The collaboration on extratropical transition with Patrick Harr has continued (see his report for details). I have submitted a comment (Elsberry 2003) on two recent articles in the *Monthly Weather Review* that purport to describe an extratropical transition of ex-hurricane Earl.

Another collaboration on tropical cyclone formation with Patrick Harr and Kevin Cheung (see separate reports) has continued both from an understanding and a building/testing of a prototype prediction system.

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Prior collaboration with Les Carr on the development of the Systematic Approach to tropical cyclone track forecasting has resulted in a book chapter (Elsberry and Carr 2002). Continuing collaboration on development of the Systematic Approach in the North Indian Ocean and Atlantic Ocean with Mark Boothe has been reported on in two conference presentations (Boothe, et al. 2003a; Boothe and Elsberry 2003b).

The USWRP Hurricane Landfall (HL) effort has produced an assessment of the hurricane landfall precipitation problem (Elsberry 2002a). A summary of the USWRP HL program was also presented to the WMO World Weather Research Program (Elsberry 2003d). In conjunction with the IWTC-V, a nearly 500-page workbook was edited and published as a World Meteorological Organization Technical Document WMO/TD No.1136 in hard copy and on a CD. I wrote the Topic 1 report on tropical cyclone structure and structure change in that workbook (Elsberry 2002b). I also wrote and/or edited the final report, which is WMO/TD No. 1165 (TMRP No. 68), including the preface, introduction, Topic 1 report, and an Appendix (with C. Velden). The Appendix was then submitted for publication (Elsberry and Velden 2003) in the *WMO Bulletin*.

RESULTS

Extratropical transition of tropical cyclones is a significant forecast challenge for Navy (and civilian) forecasters because of the threat to transiting ships and coastal bases. Under the leadership of Patrick Harr, our research team has contributed to understanding of extratropical transition via both observational and modeling studies (see the Harr and the Ritchie reports). A critical factor in the extratropical transition is the relative contributions of the midlatitude trough and the tropical cyclone (Klein et al. 2002). In some cases, the midlatitude trough is the dominant contributor. In other cases, the tropical cyclone position and structure is a dominant factor. When both circulations contribute in an optimum sense, a major extratropical cyclone results during the re-intensification stage. The modeling study by Ritchie and Elsberry (2003) clarifies the favorable and unfavorable geometrical relationships between the midlatitude trough position and the tropical cyclone position. Collaboration with Elizabeth Ritchie is continuing on modeling aspects and a Taiwan researcher (Stefano Liu) will continue the observational studies of western North Pacific extratropical transition.

One of the results from the Klein et al. (2002) study was that apparent extratropical transition cases exist in which the tropical cyclone is present but actually has no contribution to the extratropical cyclone development. This case is demonstrated by removing the tropical cyclone circulation from the model initial conditions and finding that the extratropical cyclogenesis occurs in the same locations and with the same amplitudes as in the control integration with the tropical cyclone present. This is the basis for the Comment (Elsberry 2003a) in relation to two papers describing a purported extratropical cyclogenesis of ex-hurricane Earl. As in Klein et al., the removal of the Earl remnants from the initial conditions does not change the prediction of an explosive extratropical cyclogenesis off the east coast of Canada. It is important that an accurate record of extratropical transition cases be established for research studies, and also that the archive of the National Hurricane Center be corrected to reflect a dissipation of ex-hurricane Earl and not an unreasonable northeastward track to the extratropical cyclone prediction. These were the purposes for submitting the Comment.

IMPACT/APPLICATIONS

The production of the IWTC-V workbook (WMO 2002) has provided an assessment of the progress in tropical cyclone research and forecasting over the past four years and the opportunities for research and

future requirements for forecasting. The final report for the IWTC-V (WMO 2003) summarizes the discussions and lists the recommendations for WMO programs/activities, for the research community, and for the forecaster community. In that sense, these WMO documents provide a global view of the status and requirements for research in tropical cyclones that supplements the USWRP documents produced in 2002 (e.g., Elsberry 2002). In particular, these documents provide a guideline for future research efforts.

TRANSITIONS

The extratropical transition results has been forwarded to the Joint Typhoon Warning Center (JTWC) and incorporated into their training materials.

RELATED PROJECTS

As indicated in the text above, the Naval Postgraduate School research team includes Patrick Harr, Kevin Cheung, and Mark Boothe. Collaboration with former team member Elizabeth Ritchie is continuing.

SUMMARY

Whereas the focus of our research team in the past has been on tropical cyclone motion understanding and improved track prediction at JTWC, our present focus is on formation and extratropical transition, because these stages in the tropical cyclone life cycle are also important to the Navy for protection of the fleet and possible tactical advantage. In addition, the early stage and extratropical transition stage are when the track prediction errors are largest, so improved understanding of those stages will improve the accuracy of the five-day track forecasts that are required by the Navy.

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