On the observed and modeled development of Hurricane Earl (2010) during rapid intensification

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Introduction

Although tropical cyclone (TC) track forecasting has improved within the last 10 years, intensification forecasting remains difficult. TCs have the potential to cause severe destruction to property and widespread loss of life, so it is important to improve operational numerical weather prediction (NWP) models to mitigate these effects. The intensification problem has resulted in the formation of the Hurricane Forecast Improvement Project (HFIP). Formed by the National Oceanic and Atmospheric Administration (NOAA), HFIP aims to double the accuracy of TC intensity forecasts in 10 years. This study aims to examine the observed and modeled rapid intensification (RI) of Hurricane Earl to determine how it rapidly intensified, which could give insight into how TCs rapidly intensify in reality.

Methodology

- Dropwindsondes are analyzed in the eye, eyewall, and rainband region before, during, and after RI to analyze the evolution of these locations from the onset to close of RI.
- Observed vertical thermodynamic and dynamic profiles are compared to the Hurricane Weather Research and Forecasting (HWRF) System at the mandatory levels in the atmosphere (850 hPa, 700 hPa, 500 hPa, and 200 hPa) to determine the accuracy of the modeled forecast.
- Idealized parabolic warm core structures are created to analyze the relationship between the height and depth of a warm core and the minimum sea level pressure (MSLP).
- Hurricane Earl's warm core is compared to the theory developed to suggest why it rapidly intensified.

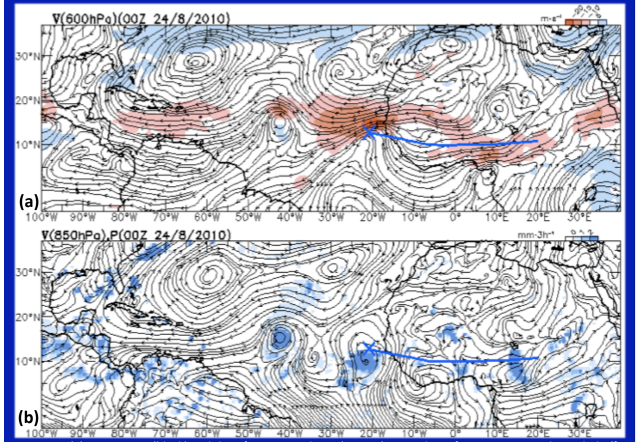

FIG. 1. (a) Trajectories (black) and the African Easterly Jet (orange) at 600 hPa after Hurricane Earl traveled off the coast of western Africa at 0000 UTC on 24 August 2010, (b) Trajectories (black) and 6-hourly accumulated precipitation (blue) at 850 hPa for the same time as (a).

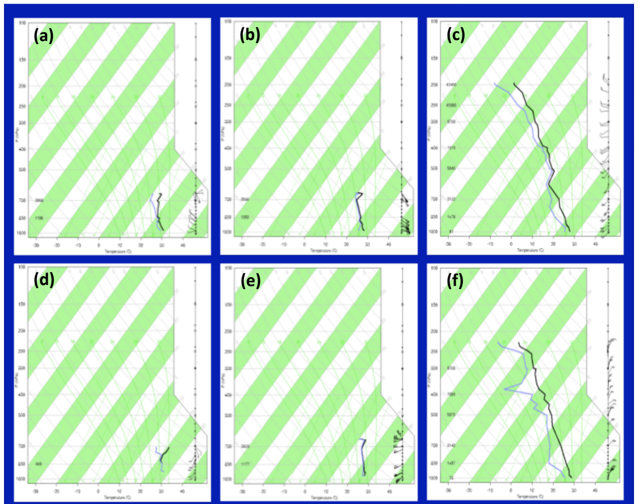

FIG. 2. Representative skew–T log p diagrams in the (a) eye, (b) eyewall, and (c) rainband region during RI and in the (d) eye, (e) eyewall, and (f) rainband region post-RI.

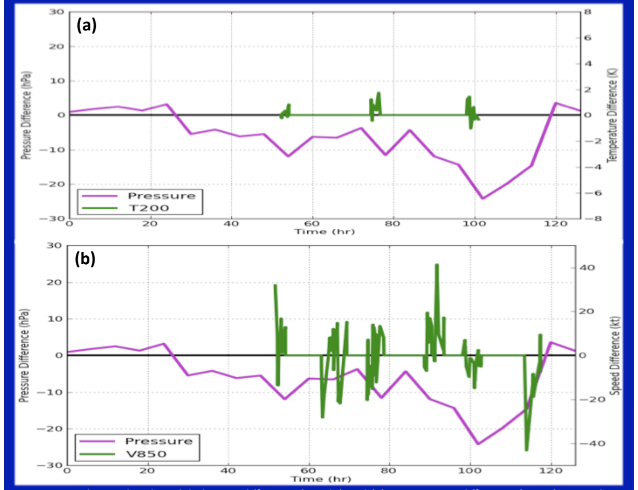

FIG. 3. Observed and modeled MSLP difference (purple) and (a) temperature difference (green) at 200 hPa and (b) wind speed difference (green) at 850 hPa for the 126-hour forecast.

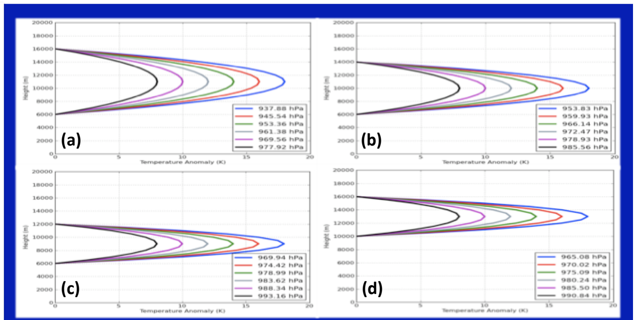

FIG. 4. (a) Idealized parabolic warm cores with a vertical depth from 6000 m to 16000 m, (b) Vertical depth from 6000 m to 14000 m, (c) Vertical depth from 6000 m to 12000 m, and (d) Vertical depth from 10000 m to 16000 m. The resulting MSLP for each parabola is shown.

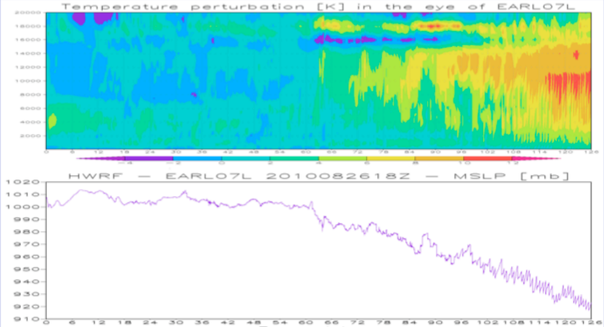

FIG. 5. (top) Hurricane Earl's modeled warm core structure for the 126-hour forecast starting at 1800 UTC on 26 August and (bottom) the resulting MSLP for the same forecast period.

Conclusions

- A defined subsidence-induced dry layer in the eye and a saturated near-surface layer in the eyewall develop after RI. The rainband region is generally more moist during RI.
- Differences in the observed and modeled temperatures, wind speeds, and wind directions at the mandatory levels in the atmosphere do not significantly explain the deviations in the MSLP.
- Hurricane Earl rapidly intensified due to the expanding depth of its warm core.

Acknowledgements. Thank you to my mentors at the Hurricane Research Division (HRD), Drs. S. Gopalakrishnan, T. Quirino, H. Chen, and X. Zhang, for motivating me to pursue this research topic, providing useful HWRF model data, and guiding me through this study. Thank you to Drs. T.-C. Chen, P. Tsay, and Mr. M. Greve for their support, suggestions, and computer programming assistance. Additionally, thank you to HRD's K. Sellwood for providing the dropwindsonde data and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) for supplying the microwave imagery. Most importantly, thank you to the Hollings Scholarship Program for giving me the opportunity to research at HRD.