On the Multiple Intensity Changes of Hurricane Earl (2010)

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Introduction

- Hurricane track forecast has improved considerably over the past several decades
- Intensity forecast has been slower to progress
- Rapid Intensification is a large focus of current research

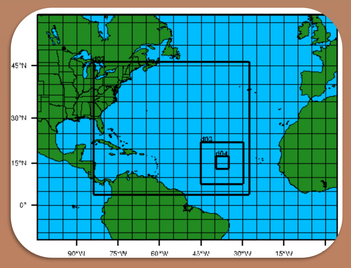
Rapid Intensification (RI) – an increase in the maximum sustained surface wind of at least 30 knots (15.4 m/s) in a 24-hour period (Kaplan and DeMaria 2003)

Objectives

- Evaluate the performance of the model simulation relative to observations
- Examine the intensity and structural changes of Earl, especially the secondary eyewall formation, in relation to RI
- Plan for future studies on hurricane energetics during RI and the secondary eyewall formation

Methodology

- Utilized Weather Research and Forecasting (WRF) Model (ARW Core)
- Initial and boundary conditions obtained from 1°× 1° reanalyses from the National Centers for Environmental Prediction (NCEP)
- Sea-surface temperatures (SSTs) also retrieved from NCEP reanalyses at the model initial time
- SSTs set constant throughout simulation



Model domain configuration; innermost two domains are storm-following nests

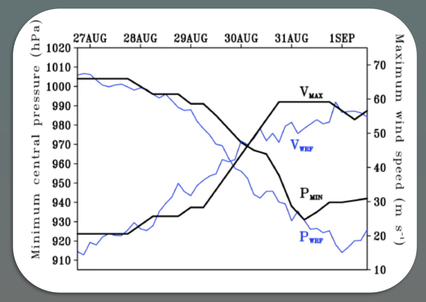
Model Configuration

Grid resolution	27/9/3/1 km (3 and 1 km domains are storm-following nests) 27/9/3 km domains are initialized at 1800 UTC/26 August 1 km domain is initialized at 1200 UTC/27 August
Cumulus Parameterization	Kain-Fritsch scheme is used in 27/9 km domains No cumulus scheme in 3/1 km domains
Planetary Boundary layer	Yonsei University (YSU) scheme
Microphysics	Thompson scheme
Vertical levels	50 vertical levels with a 30-hPa top

Results

Intensity

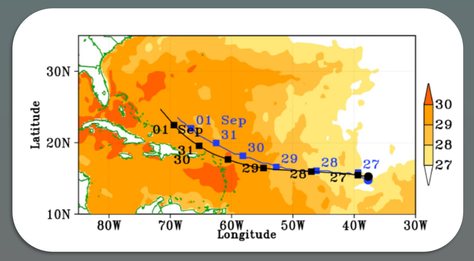
- Simulation is accurate in reproducing the onset of RI, which occurs around 0600 UTC 29 August
- End of RI occurs about 12 hours later in the model than in observations



Comparison of the simulated minimum central pressure (P_{WRF}) and 10 m maximum wind (V_{WRF}) to the NHC best track (P_{MIN}, V_{MAX}); model data is from the 27 km domain

Storm Track

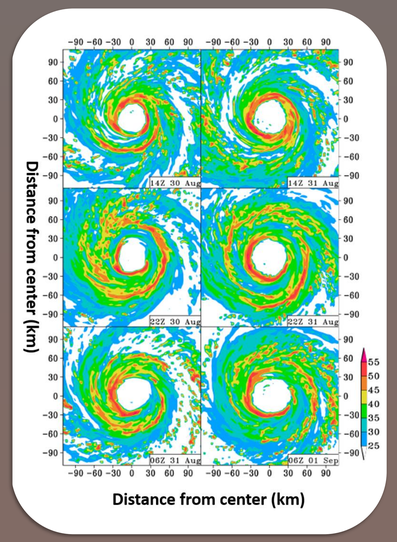
- Model is very accurate in capturing the track between 27 and 29 August
- After 29 August, the simulated path deviates to the east-northeast of the observed track



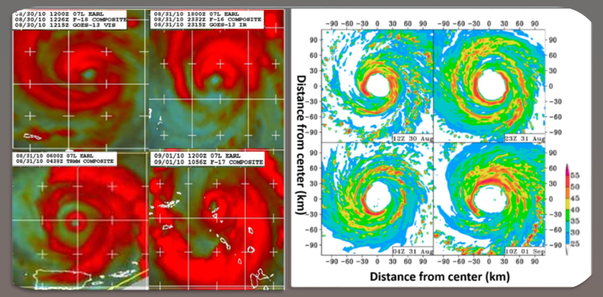
Comparison of the simulated storm track (blue) to the best track/observations (black) superimposed with the model SST (shaded, °C), which is obtained for the model initial time

Structure

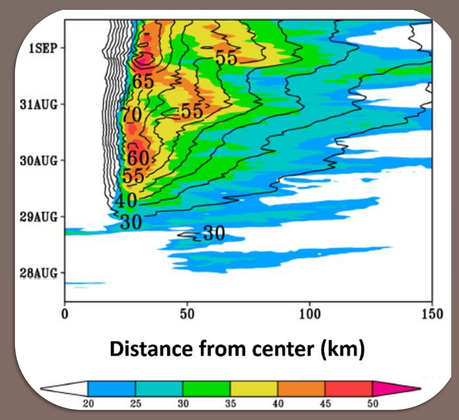
- Simulated storm is able to reproduce the secondary eyewall formation, which begins around 0000 UTC 31 August in the model simulation
- Model is several hours late in forming the double eyewall and about 12 hours late in producing the inner eyewall collapse



Simulated radar reflectivity (shaded, dBZ) at 1.5 km height at the times indicated; obtained from the innermost domain



(Left) microwave satellite imagery of Earl from the Naval Research Laboratory's tropical cyclone webpage, and (right) 1.5 km simulated radar reflectivity (shaded, dBZ) at the times indicated; obtained from innermost domain



Azimuthally-averaged simulated radar reflectivity (shaded, dBZ) and tangential wind (contours, ms^{-1}); obtained from innermost domain

Conclusions

- Simulation is skilled in reproducing the intensity, track, and structural changes of Earl, including the secondary eyewall formation
- Timing of RI onset in the simulation is fairly accurate, although it was late in producing the end of RI

Limitations

- Although the secondary eyewall formation is well reproduced, the low-reflectivity "moat" region between the inner and outer eyewalls is absent
- While this simulation will be used for future studies on energetics associated with RI, the limitations of the simulation should be kept in mind when interpreting results

References

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