The Value of a Basin-Scale Domain to Improve Tropical Cyclone Track Forecasts in HWRF

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1. INTRODUCTION

The effort to reduce tropical cyclone (TC) track errors is one of the Hurricane Forecast Improvement Project (HFIP; Gall et al. 2013) goals, in addition to the broader mission of improving community comprehension of the fundamental and complex processes at work within a TC. One important aspect of HFIP is to improve TC forecasts made by the operational Hurricane Weather Research and Forecasting (HWRF) model, which is updated every year to reflect the latest research advances made by the HFIP community. The HWRF model has been a critical tool to help improve TC track forecasts. However, even as the efforts of HFIP collaborators are integrated into each new version of HWRF, broader shortcomings have been identified with the current system. For example, the operational HWRF features an outer domain that lacks the horizontal expance to capture critical multi-scale interactions that influence TC tracks, especially in greater lead times. In an effort to build a more robust operational HWRF system for the future, a parallel version of the HWRF model, called the basin-scale HWRF (Zhang et al. 2015, in prep.), has been developed in the AOML/IRD. The basin-scale HWRF features a large domain that covers most of the Northeast Pacific and North Atlantic basins and is capable of including several moving nests (i.e., more than one TC).

The goal of this study is to compare the track skill of the 2013 basin-scale HWRF to the track skill of the operational HWRF versions from 2013, 2014, and 2015 in order to assess the value of a basin-scale domain.

2. MODEL CONFIGURATIONS

• The versions of the operational HWRF used in this study are: 2013 operational HWRF (H213), 2014 operational HWRF (H214), 2015 operational HWRF (H215)
• The 2013 basin-scale HWRF (H3HW) is a simpler version of the operational HWRF system that covers close to ½ of the Earth.
• CLIPER5 (CLP5) is used as a baseline to assess track skill.
• GPS Analysis and NHC Best Track are used as observations to compute model errors.

3. TRACK SKILL VERIFICATION

• Retrospective forecasts for each HWRF version for all Atlantic and East Pacific TCs from 2011-2013.
• Track skill is higher in Atlantic basin.
• H3HW produces more skillful tracks than H213 (Fig. 1).
• Importance of the increased vertical levels and model top (Table 1).
• H3HW is competitive with (or more skillful than) H214 and H215.

4. SENSITIVITY TO TC INITIAL LOCATION

• The operational HWRF domain moves from one forecast cycle to the next.
• TC initial location is used as a proxy for the location of the operational HWRF outer domain.
• At 24h, H3HW is more skillful in the East Atlantic compared to H213, H214, and H215.
• At 120h, H3HW is more skillful in the West Atlantic and Caribbean Sea.
• Operational HWRF outer domain boundary is located over the Rocky Mountains.
• This introduces mesoscale errors that may grow to the synoptic scale 3-5 days into the forecast.

5. ISAAC (2012) CASE STUDY

• H215 erroneously turns Isaac to the North.
• H3HW has smaller track errors than H215.

6. LAND SURFACE MODEL SENSITIVITY

• In H215, the land surface model (LSM) is upgraded from the GFDD slab scheme to the Noah LSM.
• A similar upgrade will be present in 2015 basin-scale HWRF (H5HW).
• We test an identical version of H215, except for the LSM, which is reverted to the GFDD slab scheme (H15G).
• For now, we have only run a few Isaac forecast cycles. In future work, we will test the LSM sensitivity for many TCs, but that work will be performed for H5HW.

The track of Isaac is not very sensitive to choice of LSM.

7. CONCLUSIONS

• From 2011-2013, H3HW is more skillful in track forecasts than H213 and is competitive with or better than H214 and H215 track skill scores.
• Track skill scores for the operational HWRF versions (H213, H214, H215) are sensitive to the outer domain location.
• When the operational HWRF boundary is located over topography, as is the case when TCs are initialized in the Western Atlantic and Caribbean Sea, errors are introduced and track skill scores are reduced.
• Boundary-induced errors can grow to the synoptic scale, impact the mid-latitude trough-ridge pattern, and negatively influence TC tracks.
• Forecasts of the mid-latitude trough-ridge pattern improves when the flow over the Rocky Mountains is captured within the H215 outer domain.

• TC propagation speed is an important factor for its interaction with the large-scale environment.
• H215 exhibits weak sensitivity to LSm. More extensive tests will be performed with the latest basin-scale HWRF (H5HW).

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