Evaluation of the MYNN Planetary Boundary Layer Scheme in the Hurricane Weather Research and Forecast (HWRF) system

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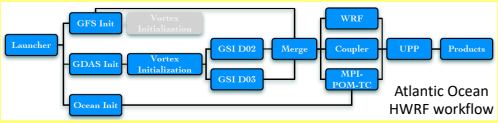
Motivation

- Does replacing the operational Global Forecast System (GFS) Eddy Diffusivity-Mass Flux (EDMF) Planetary Boundary Layer (PBL) scheme with the Mellor-Yamada-Nakanishi-Niino (MYNN) PBL scheme in HWRF provide comparable or better tropical cyclone forecasts?
- How do the temperature, moisture, and mixing vertical profiles in the hurricane eyewall compare between the MYNN and GFS EDMF configurations of HWRF?

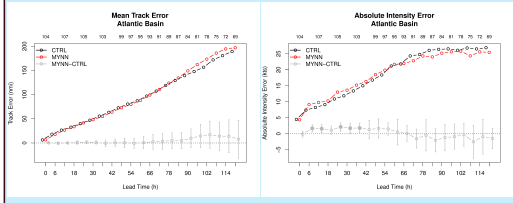
The Hurricane Weather Research and Forecast System

- Nonhydrostatic, coupled mesoscale model utilizing the WRF-NMM core
- 13.5-km parent with storm-centered 4.5- and 1.5-km nests, 75 levels
- Physics: scale-aware SAS cumulus, modified Ferrier-Aligo microphysics, GFS EDMF PBL, GFDL surface layer, RRTMG radiation
- Implemented operationally at NCEP to provide forecast guidance for tropical cyclone track, intensity, and structure.



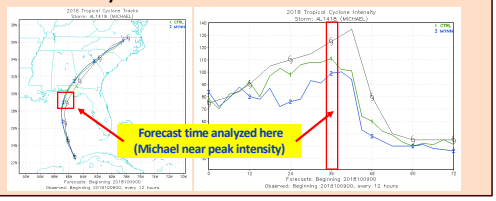
Atlantic Ocean HWRF workflow

Hurricane Track and Intensity Forecast Statistics

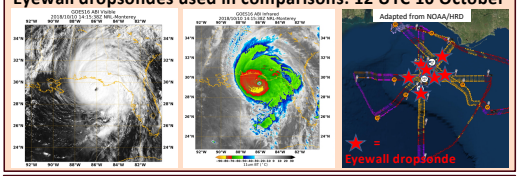


In general, the performance between the HWRF control and HWRF MYNN is comparable, except at early lead times for intensity.

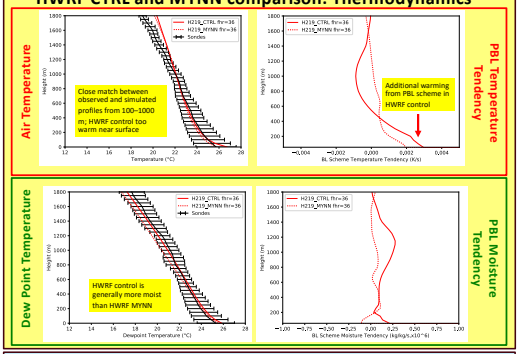
Case study: A HWRF forecast of Hurricane Michael



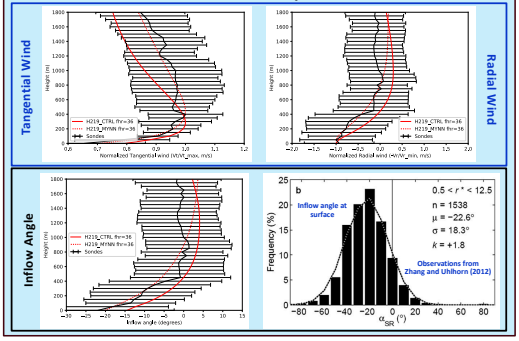
Eyewall dropsondes used in comparisons: 12 UTC 10 October



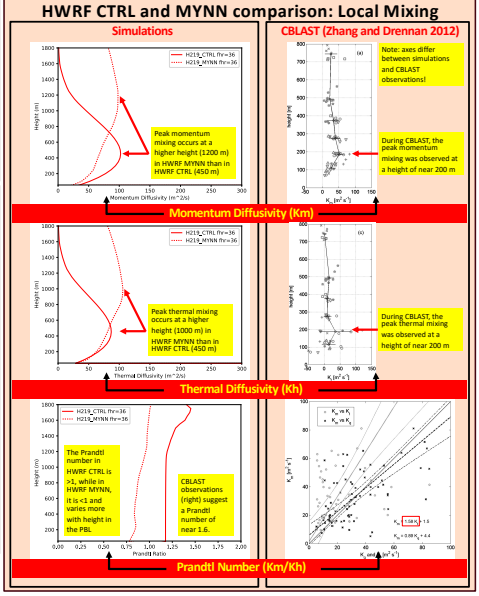
HWRF CTRL and MYNN comparison: Thermodynamics



HWRF CTRL and MYNN comparison: Kinematics



HWRF CTRL and MYNN comparison: Local Mixing



Summary

1. Hurricane track and intensity forecasts produced by HWRF MYNN for three 2018 Atlantic tropical cyclones (Florence, Isaac, and Michael) are generally comparable to the HWRF control forecasts.
2. Analysis of a case study reveals that both the HWRF control and HWRF MYNN produce similar temperature and moisture vertical profiles within the lowest 1 km as compared to observations. However, the lapse rate within the surface layer (< 100 m) in the HWRF control is steeper than the observations.
3. HWRF MYNN produces wind profiles that are more similar to observations than the HWRF control. The height of the peak tangential wind is 400 m in the observations and HWRF MYNN, but 250 m in the HWRF control.
4. Compared to the HWRF control, HWRF MYNN generally has less mixing within the lower half of the boundary layer, but substantially more mixing above it. This contrasts with observations from the Coupled Boundary Layers Air-Sea Transfer Experiment, which shows the peak mixing within the lowest 250 m.

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