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A flow-dependent horizontal mixing length scale and its impact on simulations of Harvey (2017) in HWRF

Weiguo Wang[1], Bin Liu[1], Lin Zhu[1], Zhan Zhang[1], Avichal Mehra[2], Vijay Tallapragada[2]

[1]IMSG at EMC/NCEP/NWS/NOAA, College Park, MD 20740 [2]EMC/NCEP/NWS/NOAA, College Park, MD 20740

Introduction

- Tropical Cyclone (TC) simulations are sensitive to horizontal mixing length scale (L_h)[1][2][3]
- A "constant" L_h is usually used in TC simulations, while observational studies suggested L_h is not a constant at all [4][5].
- A new formation of L_h is proposed and tested in HWRF [6]

Horizontal length scale formulation

Horizontal eddy diffusivity, K_h, :

$$K_h = L_h^2 |D_h|$$

D_h -- horizontal deformation.

Current HWRF:

L_h -- $c\Delta$ (grid size) with c a constant.

New :

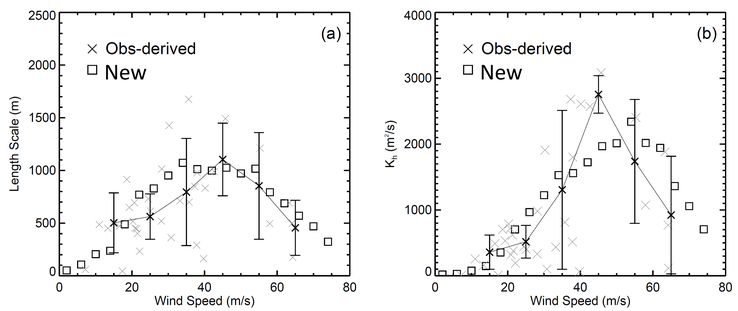
L_h -- $F(L_{h1}, L_{h2})$, a function of length scales of shear and stretching.

HWRF configuration

- Same as operational HWRF in 2017 except DA is turned off.
- Three domains with 18-6-2km; 75 levels in the vertical with top of 10 hpa.
- 3 experiments with different L_h over D3

Experiment	Description
L750	$L_h \approx$ 750 m as in oper HWRF
L2KM	$L_h \approx$ 2 km
LVAR	Flow-dependent L_h

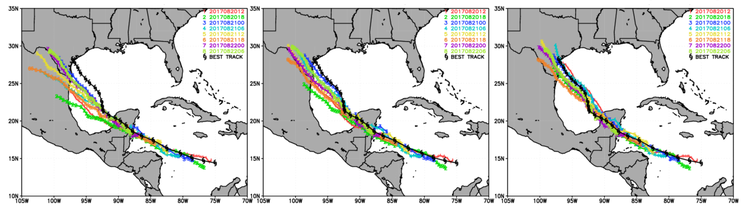
Comparisons with observations



Left: The new length scale is close to that derived from observations[5]. Right: K_h

Composite Tracks of Harvey

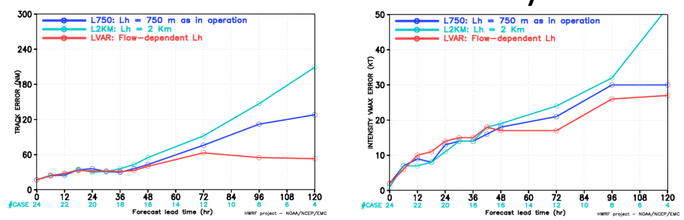
L=2KM L=750m LVAR (new)



New flow-dependent L_h improves 5-day track forecasts of early cycles

Verifications

Track errors Intensity errors



Red lines: New L_h improves both track &intensity for >2 days forecasts

Conclusions

New L_h is closer to obs-derived values and improves Harvey(2017) forecasts.

Reference

[1] Bryan, 2012, MWR; [2] Zhang et al. 2018, WAF; [3] Zhang & Marks,2015,MWR; [4] Bryan & Rotunno, 2009, Mesoscale conf.;[5] Zhang & Montgomery, 2012, JAS; [6] Wang et al. 2020, A flow-dependent horizontal length scale, to be submitted MWR