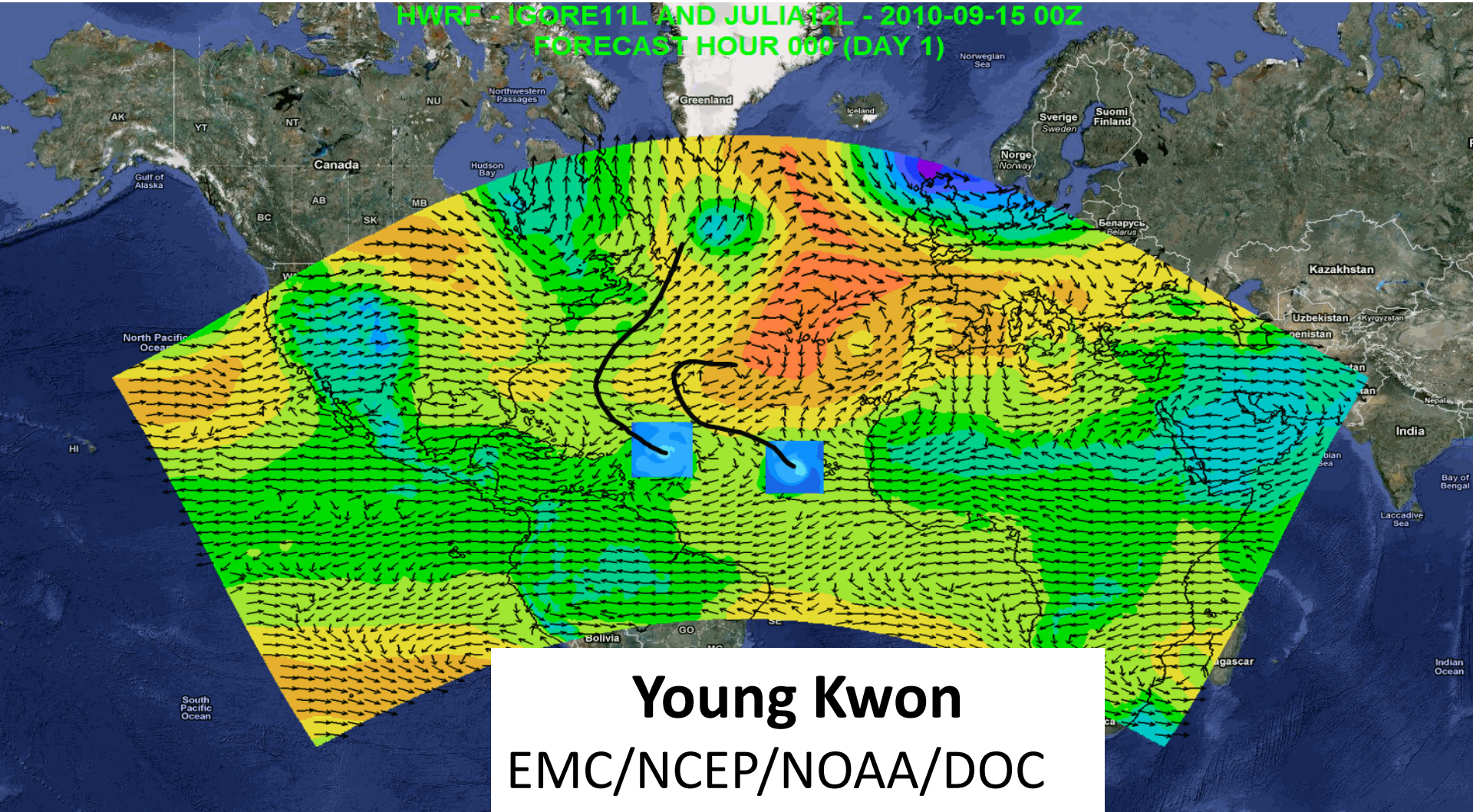
Advancement of the operational hurricane modeling effort in EMC/NOAA and collaboration efforts with research community

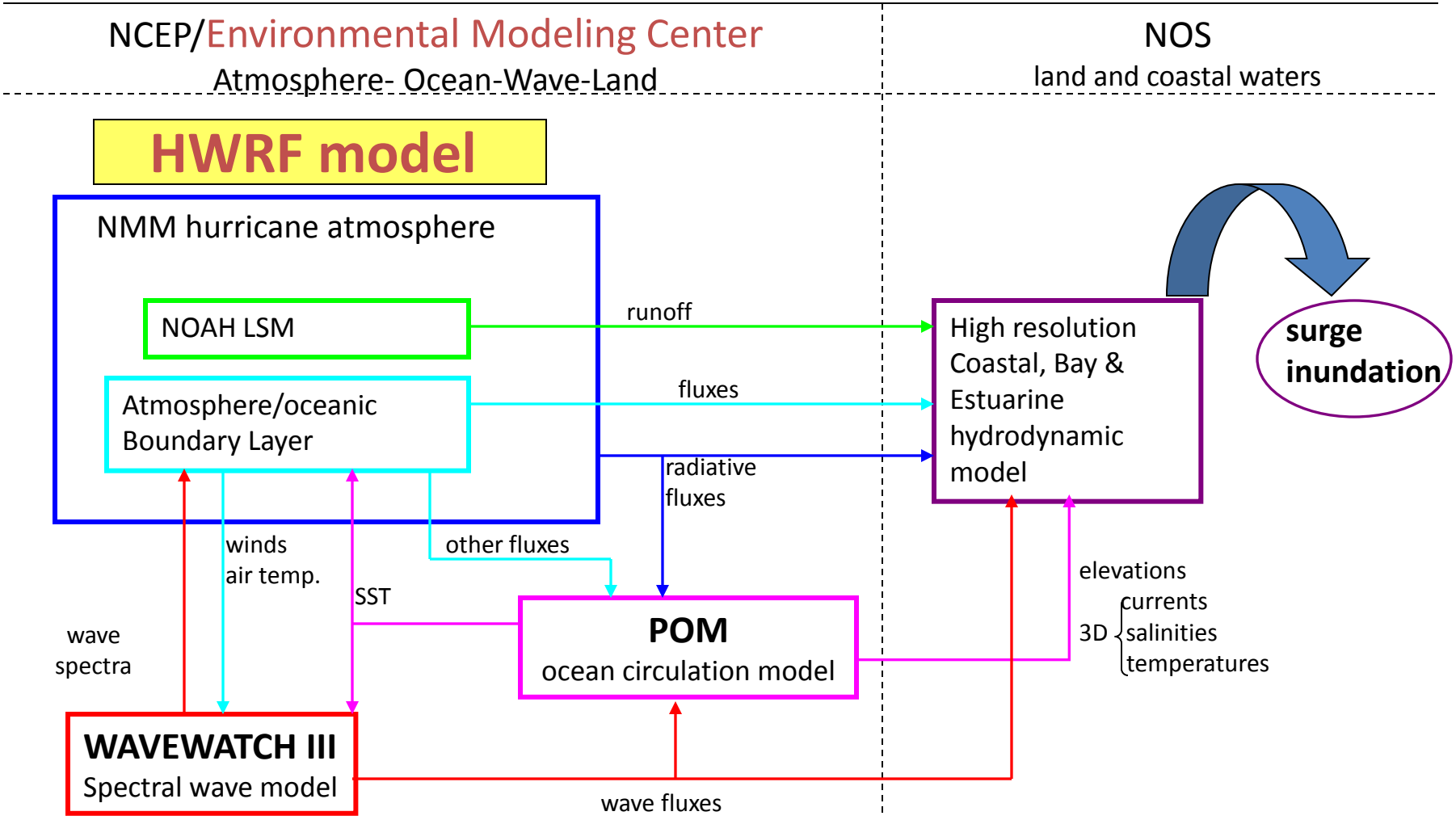


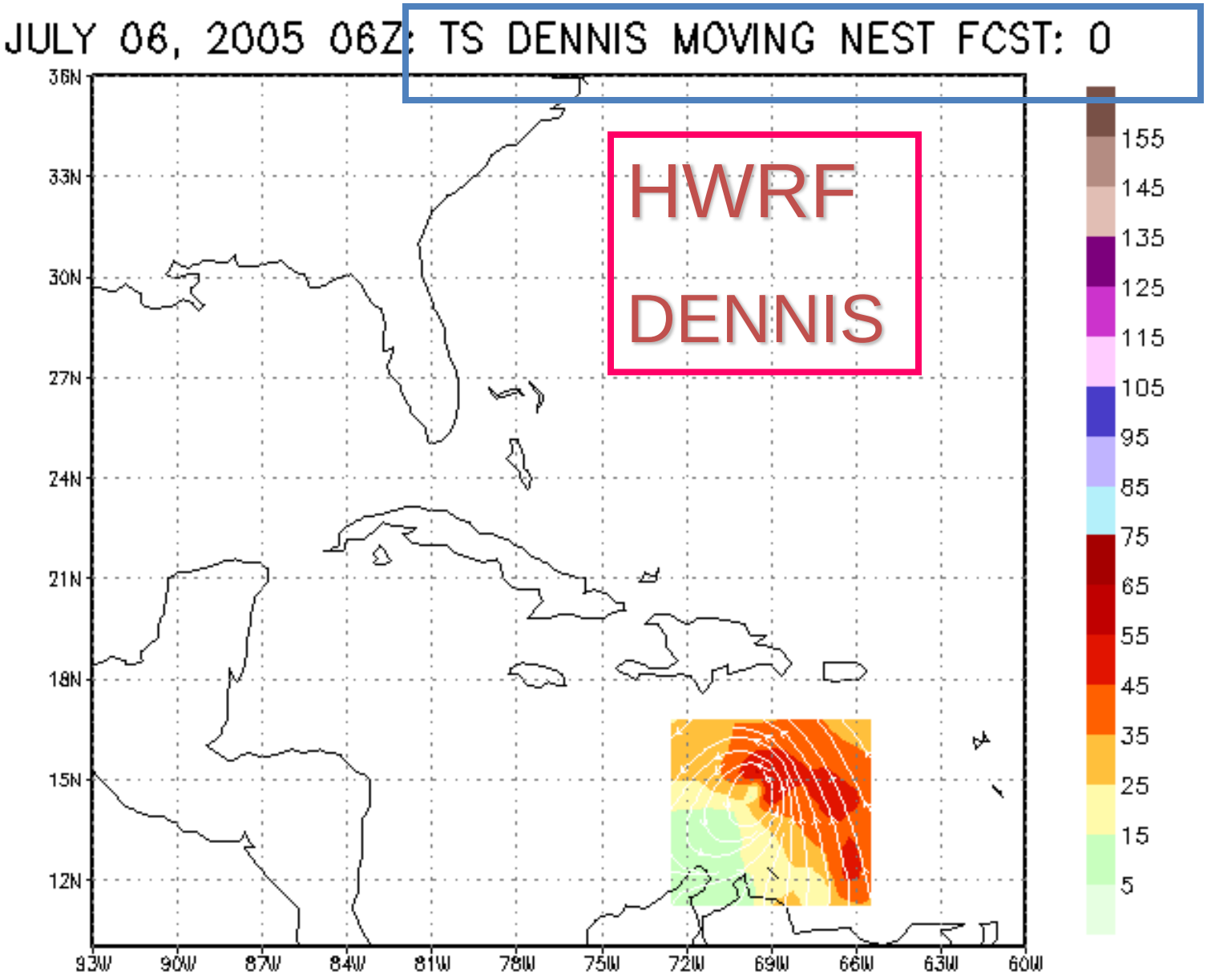
Young Kwon
EMC/NCEP/NOAA/DOC

Contents

1. Introduction of the operational hurricane model (HWRF model)
2. Examples of products
3. HFIP (hurricane Forecast Improvement Project) and community outreach
4. HWRF dynamics and physics
5. Model improvement efforts in EMC

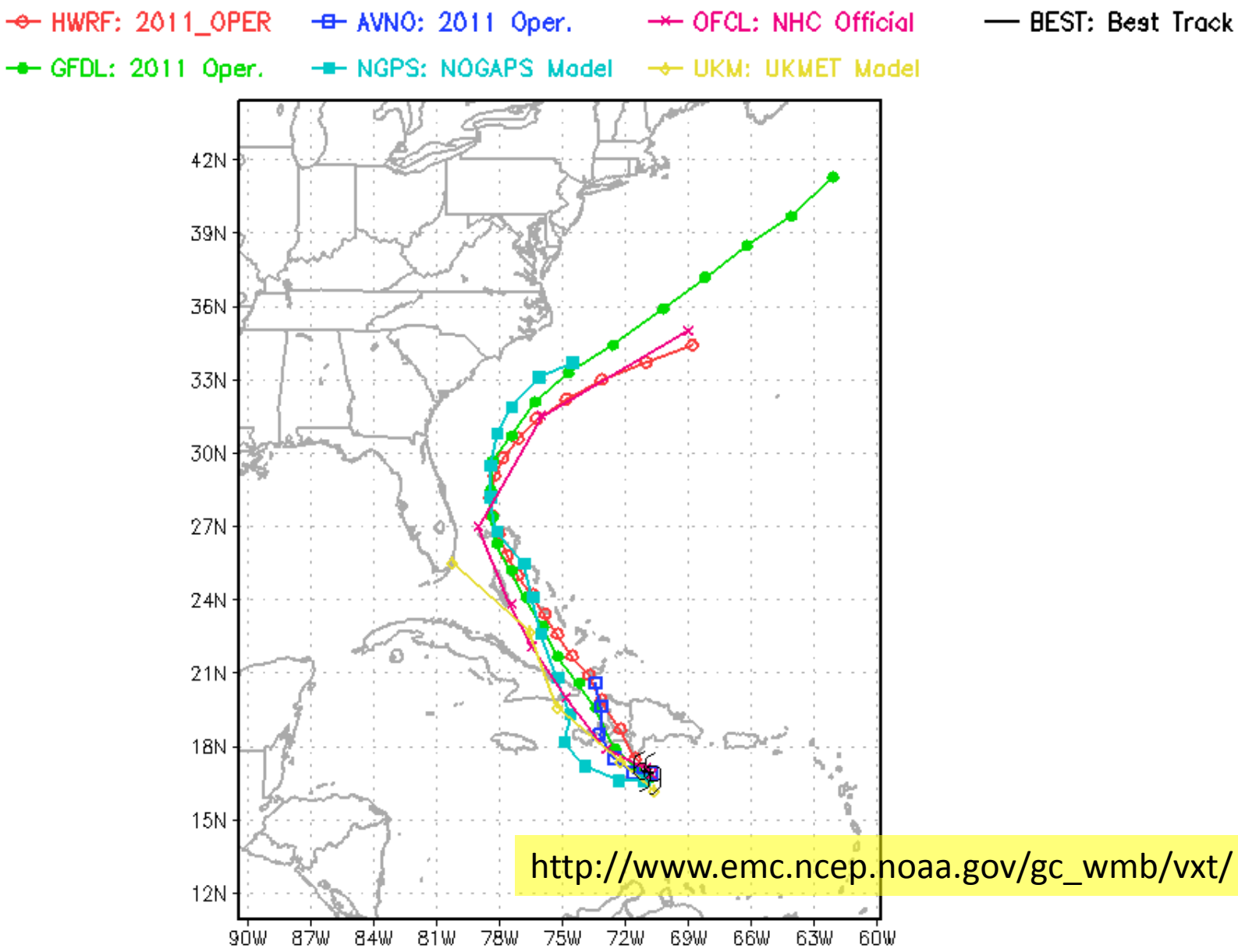
Hurricane-Wave-Ocean-Surge-Inundation Coupled Models




JULY 06, 2005 06Z: TS DENNIS MOVING NEST FCST: 0
HWRF
DENNIS
36N
33N
30N
27N
24N
21N
18N
15N
12N
93W
90W
87W
84W
81W
78W
75W
72W
69W
66W
63W
60W
155
145
135
125
115
105
95
85
75
65
55
45
35
25
15
5

Operational HWRF: 2011 TC Tracks

Storm: EMILY (05L) valid 2011080400



Hurricane Forecast Improvement Project (HFIP)

A 10-year project designed to

(1) provide the basis for NOAA and other agencies to work towards an effort to coordinate national hurricane research needed to **significantly improve guidance for hurricane track, intensity, and storm surge forecasts**

(2) promote the inter-agency and larger research community efforts towards **addressing the challenges posed to improve operational hurricane models**.

Main Goal: reducing the average errors of hurricane track and intensity forecasts at all lead times by 20% within 5 years and by 50% in 10 years

HFIP TEAMS

TEAM	LEADERS
Global Model/Physics	Stan Benjamin (ESRL), John Brown (ESRL)
Regional Model/Physics	Morris Bender (GFDL), Young Kwon (EMC)
Ensembles	Zoltan Toth (ESRL), Carolyn Reynolds (NRL)
Data Assimilation/ Vortex Initialization Team	Jeff Whitaker (ESRL), Bill Lapenta (EMC)
Verification Team	Tim Marchok (GFDL), Barb Brown (NCAR)
Diagnostics	Ed Rappaport (NHC), Mark DeMaria (NESDIS/STAR)
Hurricane Observations	Sim Aberson (AOML), John Knaff (NESDIS/ORA)
Ocean/Wave Models	Hendrik Tolman (EMC), George Halliwell (AOML)

With huge collaborations with EMC/URI/ AOML/GFDL

Timeline of DTC work in Hurricanes

- 2009
  - Obtained HWRF codes
  - Established operational capability in existing repositories: WRF, WPS, WPP
  - Created community code repositories: POM, coupler, tracker, vortex initialization
- 2010
  - HWRF Beta-release, 1st HWRF Tutorial
  - Developed functionally-similar T&E suite
  - Testing for internal consistency, bug fixes
  - Operations: remain V2
- 2011
  - HWRF V3.3a release, 2nd HWRF Tutorial
  - Testing for internal consistency, bug fixes
  - Operations: upgraded to V3.2

Good job of bringing community code and operational codes in sync

With commitment, can keep them in sync as we go forward

http://www.dtcenter.org/HurrWRF/users/downloads/index.php

HWRF Model

Became the nation's operational hurricane model since 2007

HWRF dynamics – wrf-nmm

1. Full compressible equations which split into hydrostatic and nonhydrostatic contributions ($\varepsilon = 1/g\ (dw/dt)$)
2. Horizontal advection: 2nd order Adams-Bashforth
3. Vertical advection: Crank-Nicolson scheme
4. Horizontal grid: Arakawa E-grid (aka rotated lat-lon grid)
5. Vertical coordinate: sigma-pressure hybrid
6. Horizontal diffusion: 2nd order, nonlinear Smagorinsky-type horizontal diffusion

HWRF Physics

1. Convective parameterization: Simplified Arakawa-Schubert Scheme (SAS)
2. Micro physics scheme: Ferrier Scheme (single moment)
3. Boundary layer scheme: NCEP GFS scheme (non-local scheme)
4. Surface layer scheme : MO similarity (Cd: Moon et al, Ch CBLAST)
5. Radiation scheme: GFDL long and short wave radiation
6. Dissipative heating from turbulent flow
7. Ocean coupling: Princeton Ocean Model

Prognostic Variables:

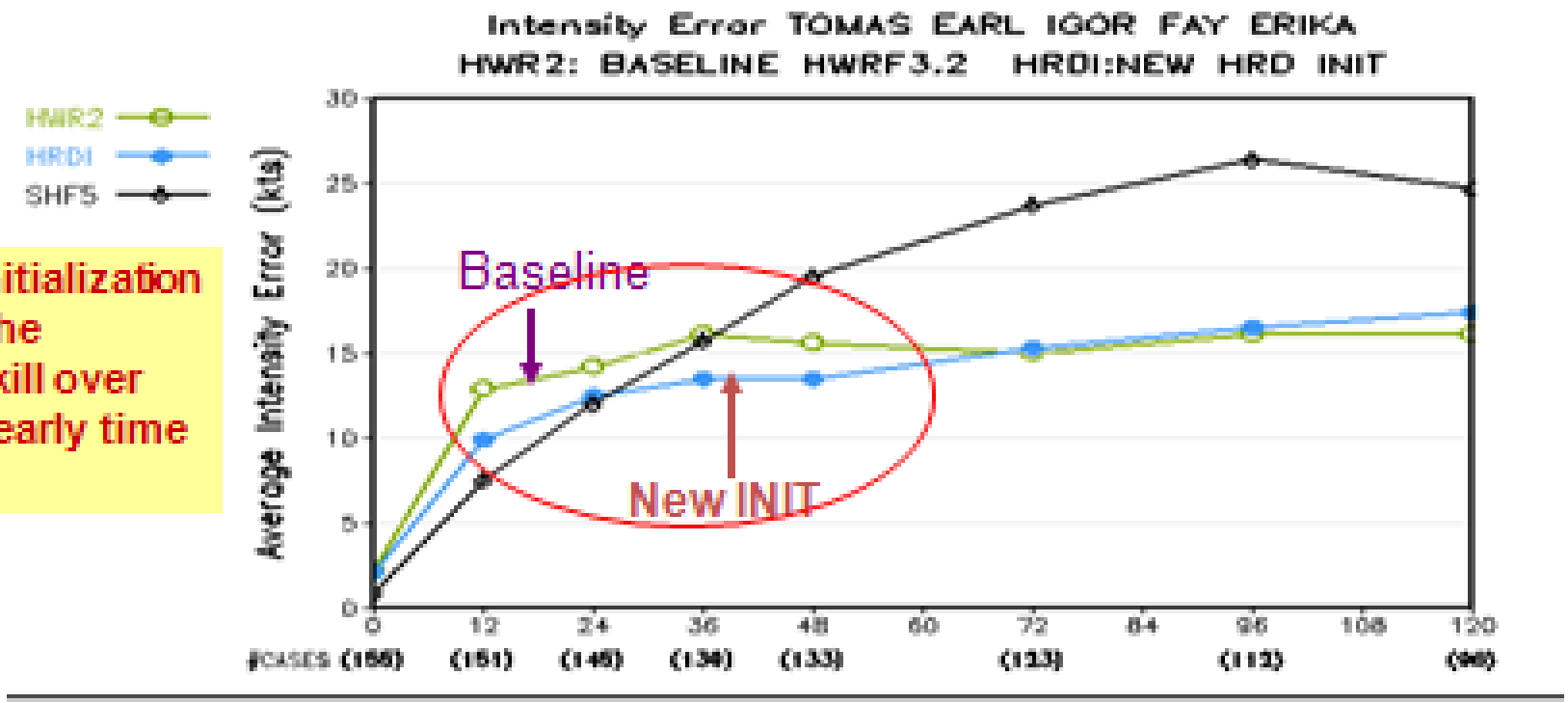
► Mass variables:

- PD – hydrostatic pressure depth (time and space varying component) (Pa)
- PINT – Total pressure (Pa)
- T – Air temperature (K)
- Q – specific humidity (kg/kg)
- CWM – total cloud water condensate (kg/kg) for Ferrier Microphysics (others-all hydrometeo species)
- Q2 – 2 * turbulent kinetic energy (m^2/sec^2)– not used in the current HWRF configuration

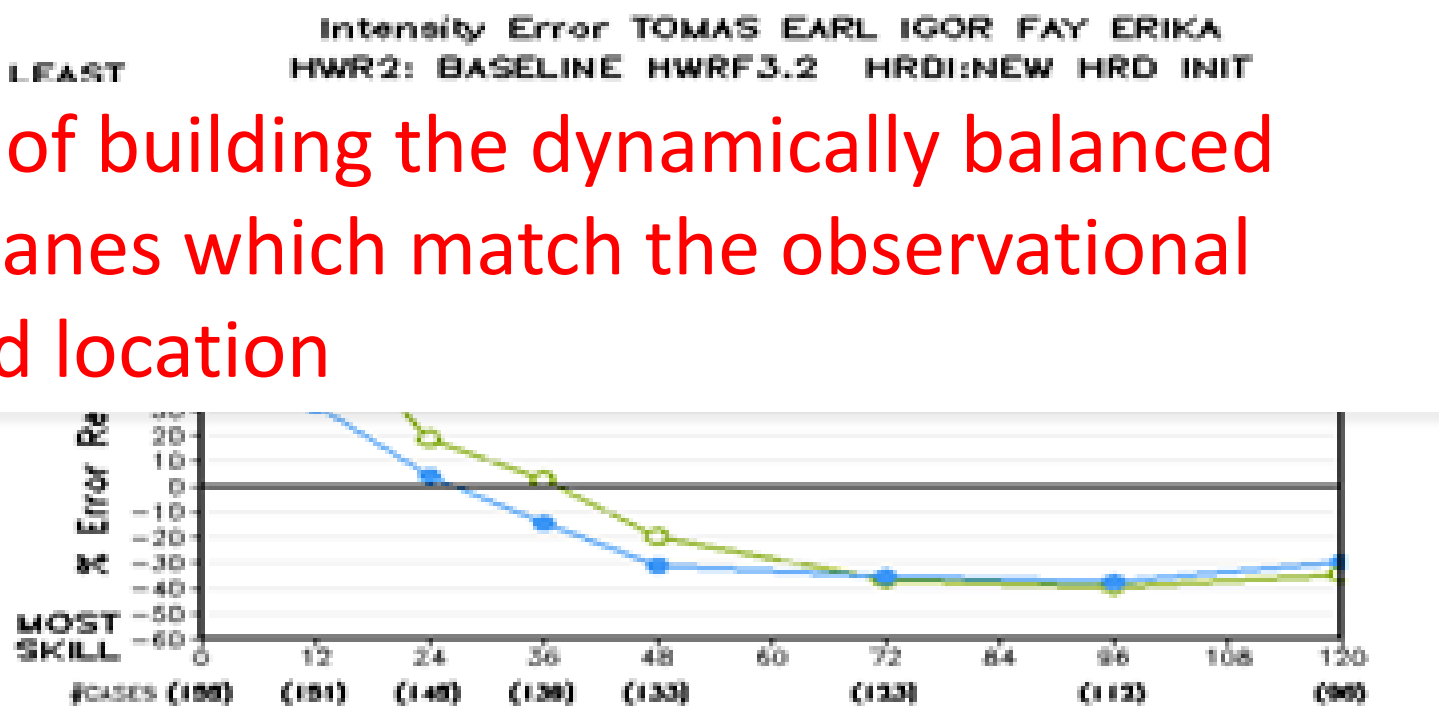
► Wind variables:

- U, V – wind components (m/s)

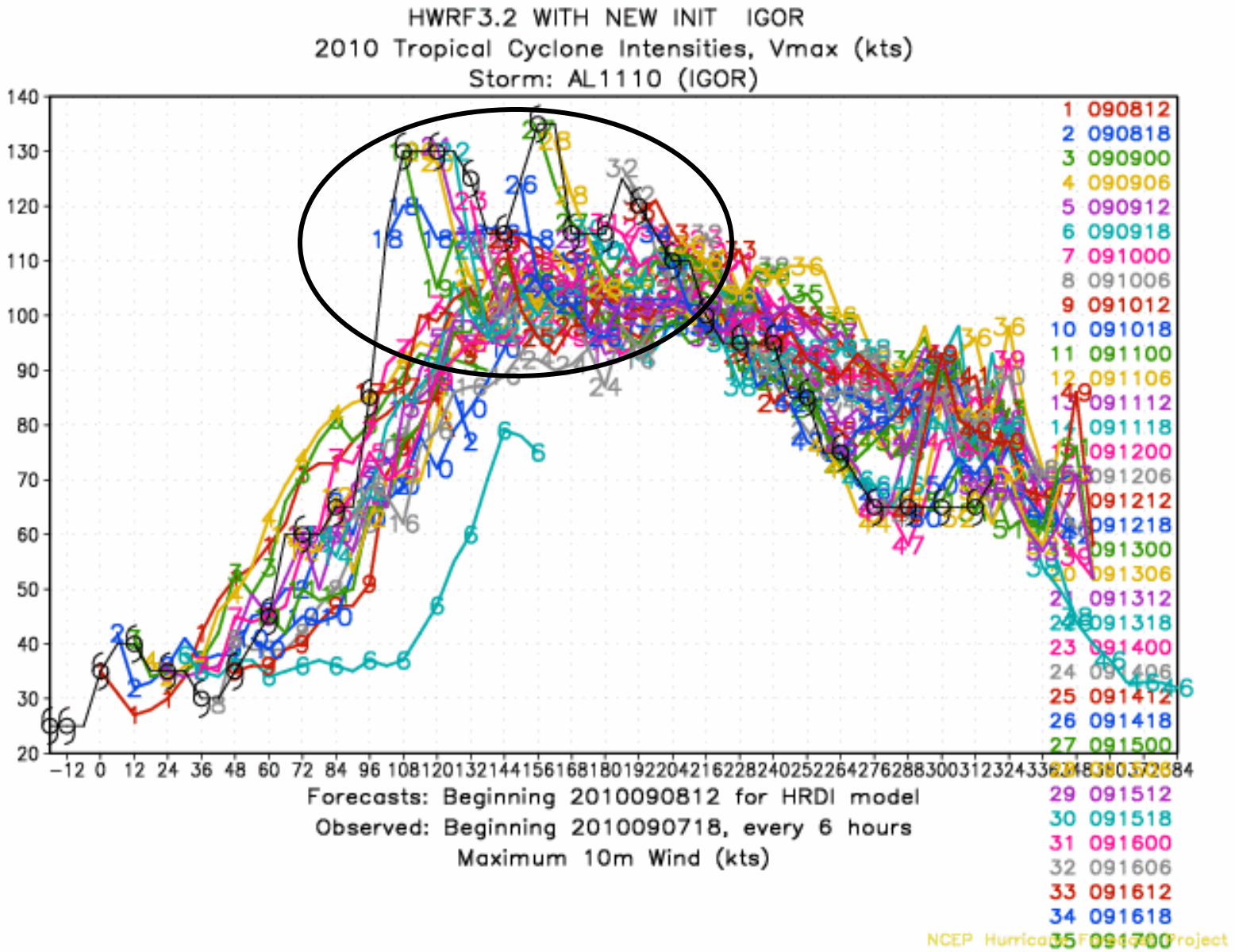
Some examples of EMC's effort to improve the HWRF model performance

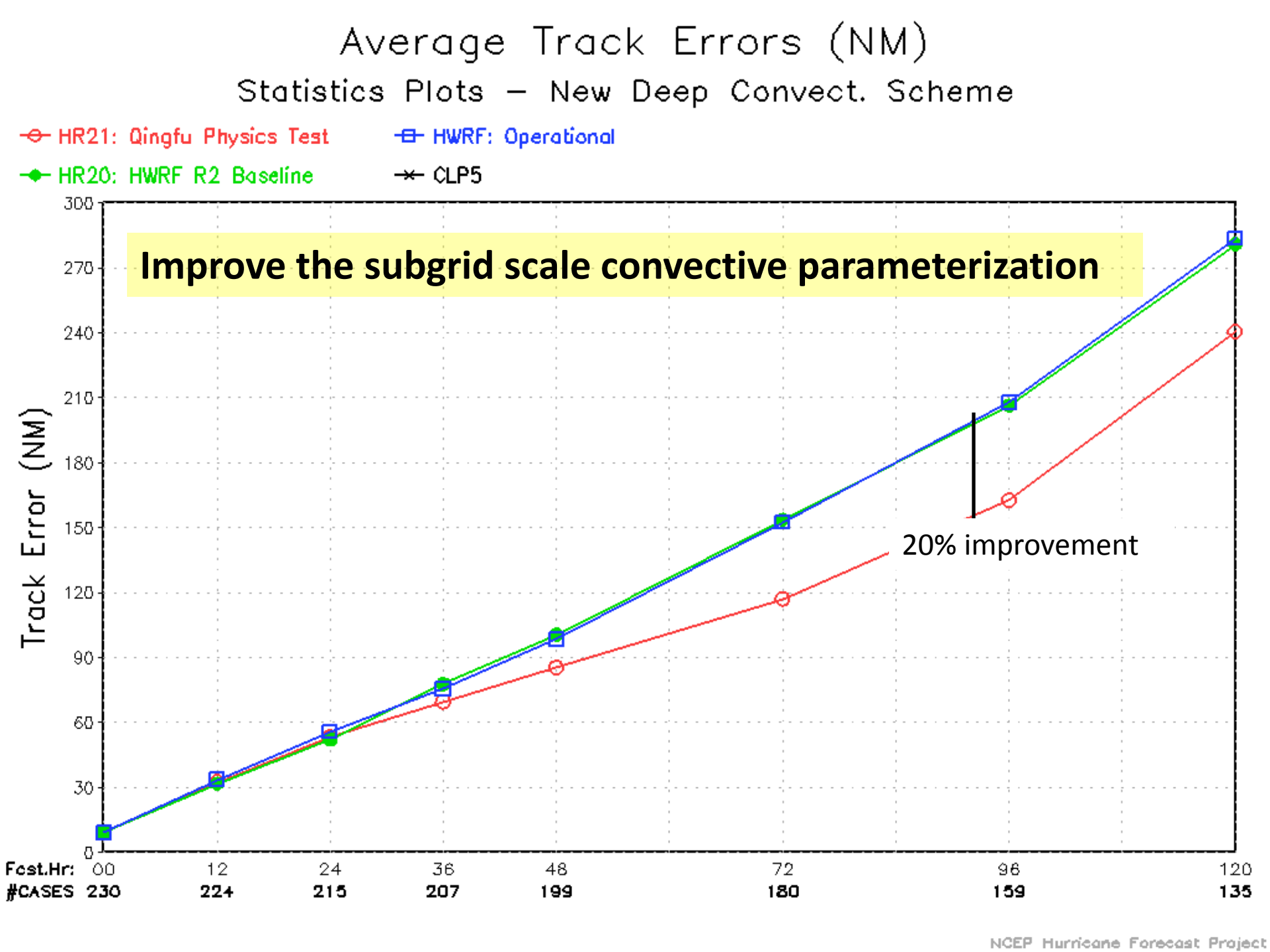


Modified initialization improves the intensity skill over 20% at the early time (0-48hr)



Importance of building the dynamically balanced initial hurricanes which match the observational intensity and location


HWRF3.2 WITH NEW INIT IGOR
2010 Tropical Cyclone Intensities, Vmax (kts)
Storm: AL1110 (IGOR)
140
130
120
110
100
90
80
70
60
50
40
30
20
−12 0 12 24 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240 252 264 276 288 300 312 324 336 348 360 372 384
1 090812
2 090818
3 090900
4 090906
5 090912
6 090918
7 091000
8 091006
9 091012
10 091018
11 091100
12 091106
13 091112
14 091118
15 091200
16 091206
17 091212
18 091218
19 091300
20 091306
21 091312
22 091318
23 091400
24 091406
25 091412
26 091418
27 091500
28 091506
29 091512
30 091518
31 091600
32 091606
33 091612
34 091618
35 091700
Forecasts: Beginning 2010090812 for HRDI model
Observed: Beginning 2010090718, every 6 hours
Maximum 10m Wind (kts)
NCEP Hurricane Forecast Project


Average Track Errors (NM)
Statistics Plots – New Deep Convect. Scheme
HR21: Qingfu Physics Test
HWRF: Operational
HR20: HWRF R2 Baseline
CLP5
Improve the subgrid scale convective parameterization
Track Error (NM)
300
270
240
210
180
150
120
90
60
30
0
20% improvement
Fcst.Hr: 00 12 24 36 48 72 96 120
#CASES 230 224 215 207 199 180 159 135
NCEP Hurricane Forecast Project