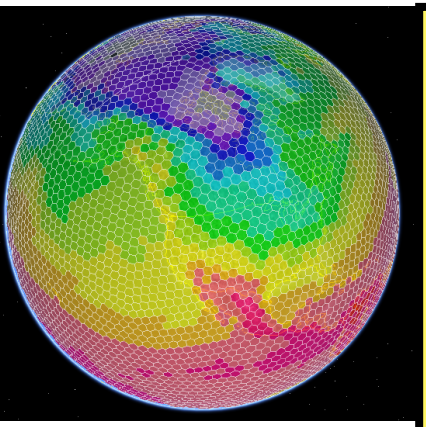

HFIP Global Model/Physics Working Group Report – Nov 2012

Goal:

Advanced global model for improved TC forecasting

Stan Benjamin, John Brown - NOAA/ESRL

+ Mike Fiorino, Jeff Whitaker, Susan Sahm, Ed Szoke, Rainer Bleck, Susan Sahm, Shan Sun, Jian-Wen Bao, Georg Grell, Tom Henderson

Fanglin Yang - NCEP/EMC

Jim Ridout (et al.) - NRL

FIM development

Performance in fall 12 for FIM and ESRL global ensembles

FY13 proposed plans and milestones

Areas of FIM development - 2012

- Horizontal diffusion – Rainer Bleck, Shan Sun
  - 4^{th} order diffusion on icosahedral grid now available.
  - 4^{th} order diff somewhat better for TC intensity
  - 2^{nd} order diff better for 500 hPa AC
- May 2012 GFS physics – Jian-wen Bao, Shan Sun
  - Testing underway for 3 months, not working yet
  - Necessary to allow correct CFS physics specification (primarily for cloud-radiation multi-layer specification
- DCMIP participation – Shan, Rainer, Tanya Smirnova
  - Pressure gradient problem revealed: Janjic PG installed
  - Icos grid approximation issue revealed: Solution (spherical geometry) in development – Ning Wang
- FIM-iHYCOM coupled version – Rainer, Shan
- FIM-EnKF using GSI-EnKF/hybrid structure – Mariusz Pagowski, guidance from Jeff Whitaker

Welco

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Dynamical Core Model Intercomparison Project

DCMIP

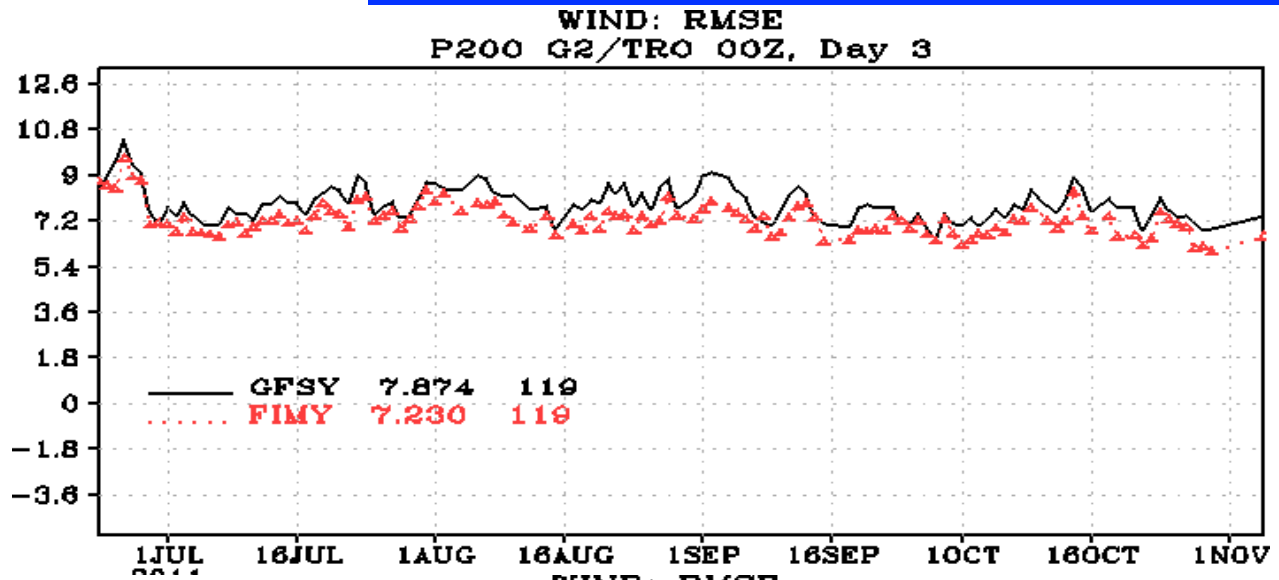
The 2012 Dynamical Core Model Intercomparison Project

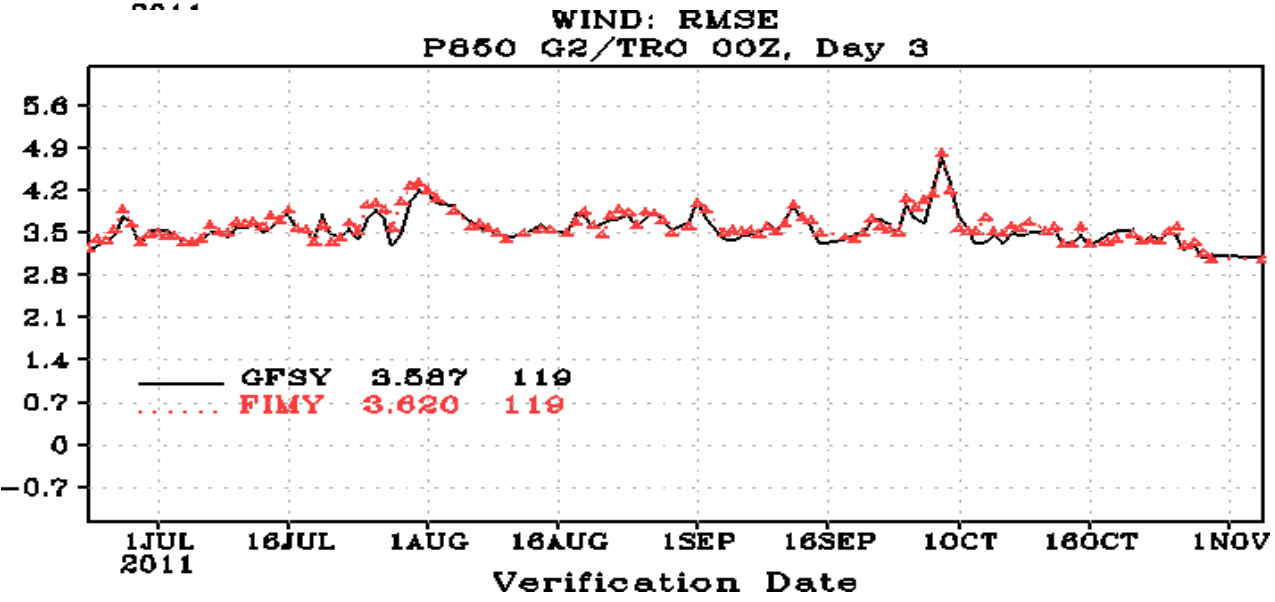
The Dynamical Core Model Intercomparison Project (DCMIP) and associated two-week summer school from 7/30/2012-8/10/2012 highlights the newest modeling techniques for global climate and weather models. Special attention is paid to non-hydrostatic global models and their dynamical cores that now emerge in the General Circulation Model (GCM) community. Such future-generation GCMs allow for high-resolution simulations and offer new pathways for embedded variable-resolution meshes.

The objectives of DCMIP and its summer school are (1) to establish an open-access database via the Earth System Grid that hosts DCMIP simulations for community use, (2) to host about 15 dynamical core modeling groups at NCAR in August 2012 for the hands-on student-run DCMIP model intercomparison project, (3) to establish new non-hydrostatic dynamical core test cases in the community that also include simple moisture processes (4) teach a group of about 40 multi-disciplinary students, postdocs and other young researchers how today's and future atmospheric models are or need to be built, and (5) to hear from keynote speakers who give lectures on modern GCM modeling and evaluation techniques, uncertainty quantification, the lessons-learned from GCM ensembles, the physics-dynamics coupling, innovative computational tools and high-performance aspects. This multidisciplinary two-week summer school and Dynamical Core Model Intercomparison Project (DCMIP) takes place at the National Center for Atmospheric Research (NCAR) in Boulder, CO, USA. The event brings together graduate students, postdocs, atmospheric modelers, expert lecturers and computer specialists to create a stimulating, unique and hands-on driven learning environment.

2011 Tropical wind forecasts – FIM vs GFS, both verified against ECMWF analyses – RMS vector

From http://www.emc.ncep.noaa.gov/gmb/wx24fy/fimy/





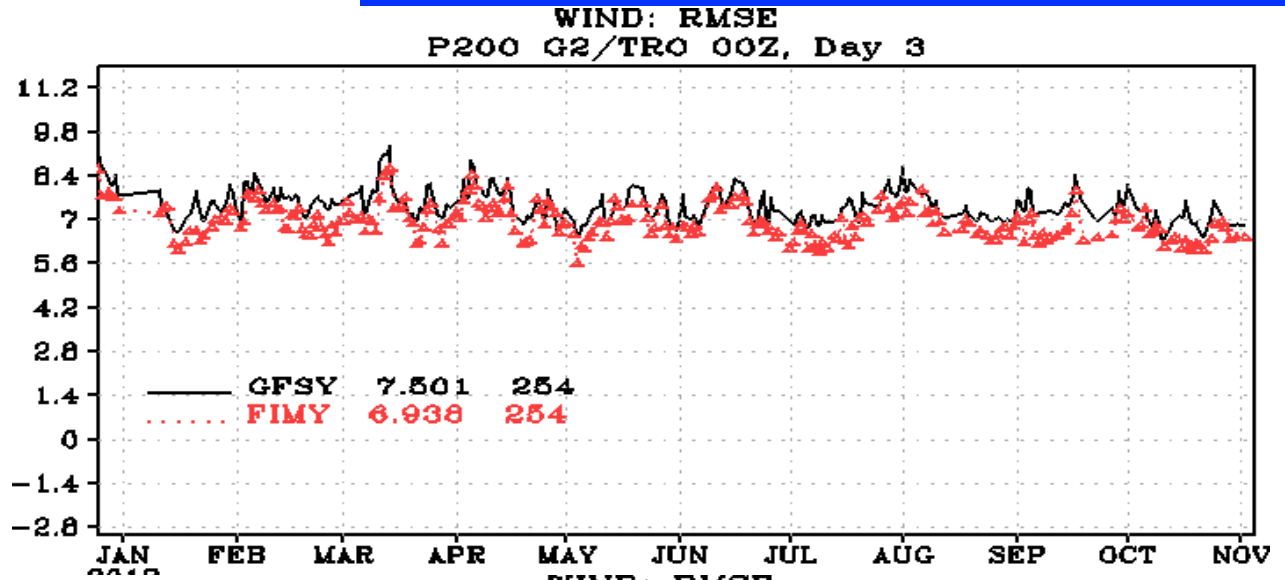
FIM improvement over GFS in tropical upper-level winds (at 200 hPa) is consistent – occurs in every run

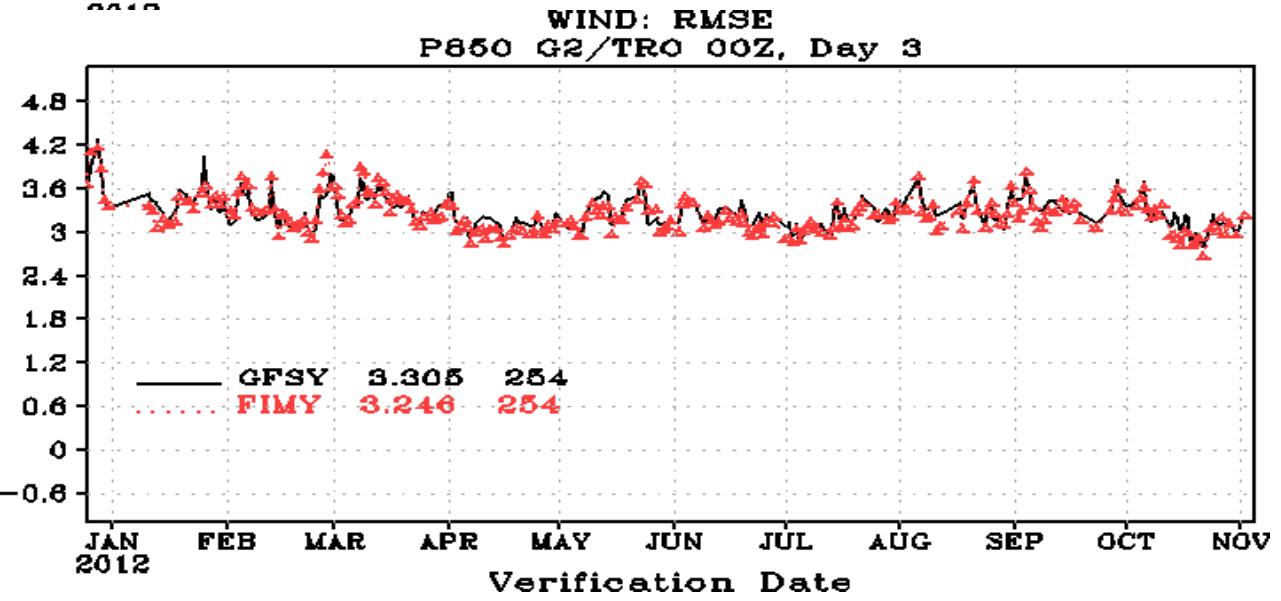
… and little difference in tropical 850 hPa winds

Via collaboration between NCEP/EMC – Fanglin Yang and NOAA/ESRL

2012 Tropical wind forecasts – FIM vs GFS, both verified against ECMWF analyses – RMS vector

From http://www.emc.ncep.noaa.gov/gmb/wx24fy/fimy/





200 hPa tropical winds FIM shows strong improvement over GFS, consistent – occurs in every run

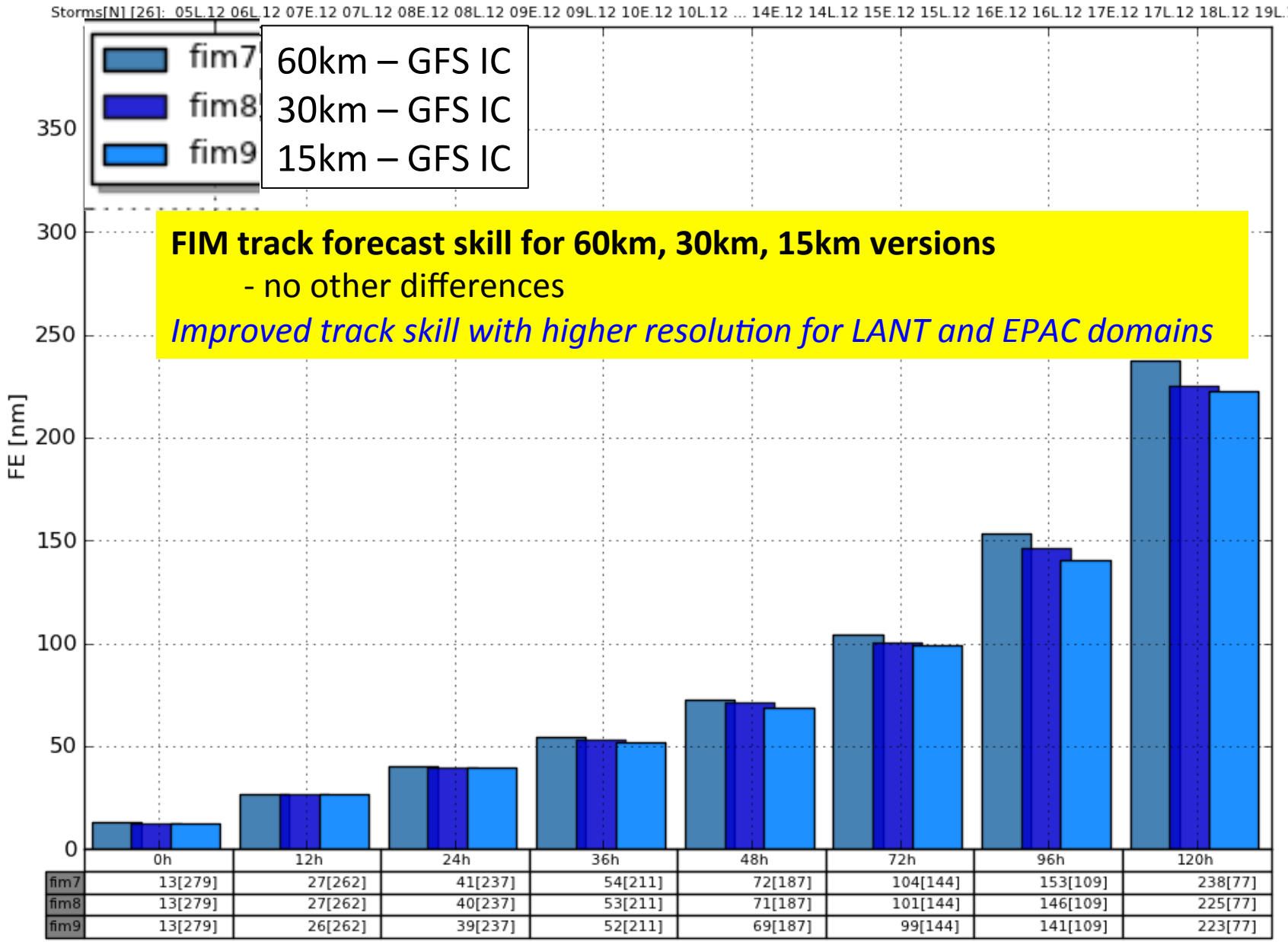
… and slight improvement in tropical 850 hPa winds in 2012

Via collaboration between NCEP/EMC – Fanglin Yang and NOAA/ESRL

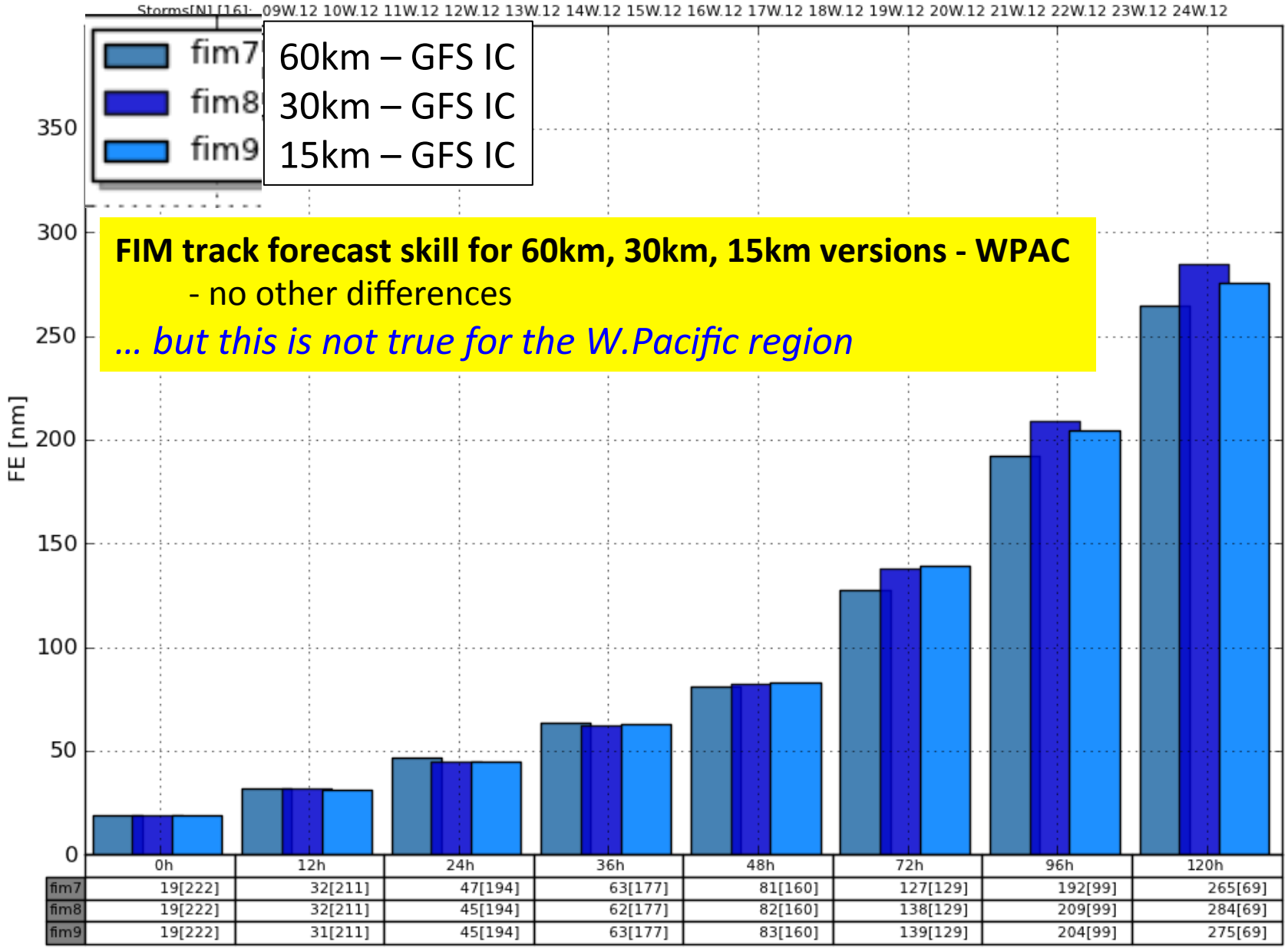
Versions of FIM in real-time runs – Fall 2012

	Resolution	Init conds	Physics	Diffusion	HFIP Stream
FIM	30km	GFS oper	GFS (May 2011, not May 2012)	2nd-order	-
FIM9 -HFIP-tjet	**15km**	GFS oper	GFS	**2nd-order**	1.5
FIM9 - zeus	15km	GFS oper	GFS	**4th-order**	-
FIMens - sjet	30km, 10mem	**GFS-ESRL**	GFS	2nd-order	2.0
FIMX	30km	GFS oper	GFS + WRF-chem, testing of Grell cu	2nd-order	-
FIM7	60km	GFS oper	GFS	2nd-order	-

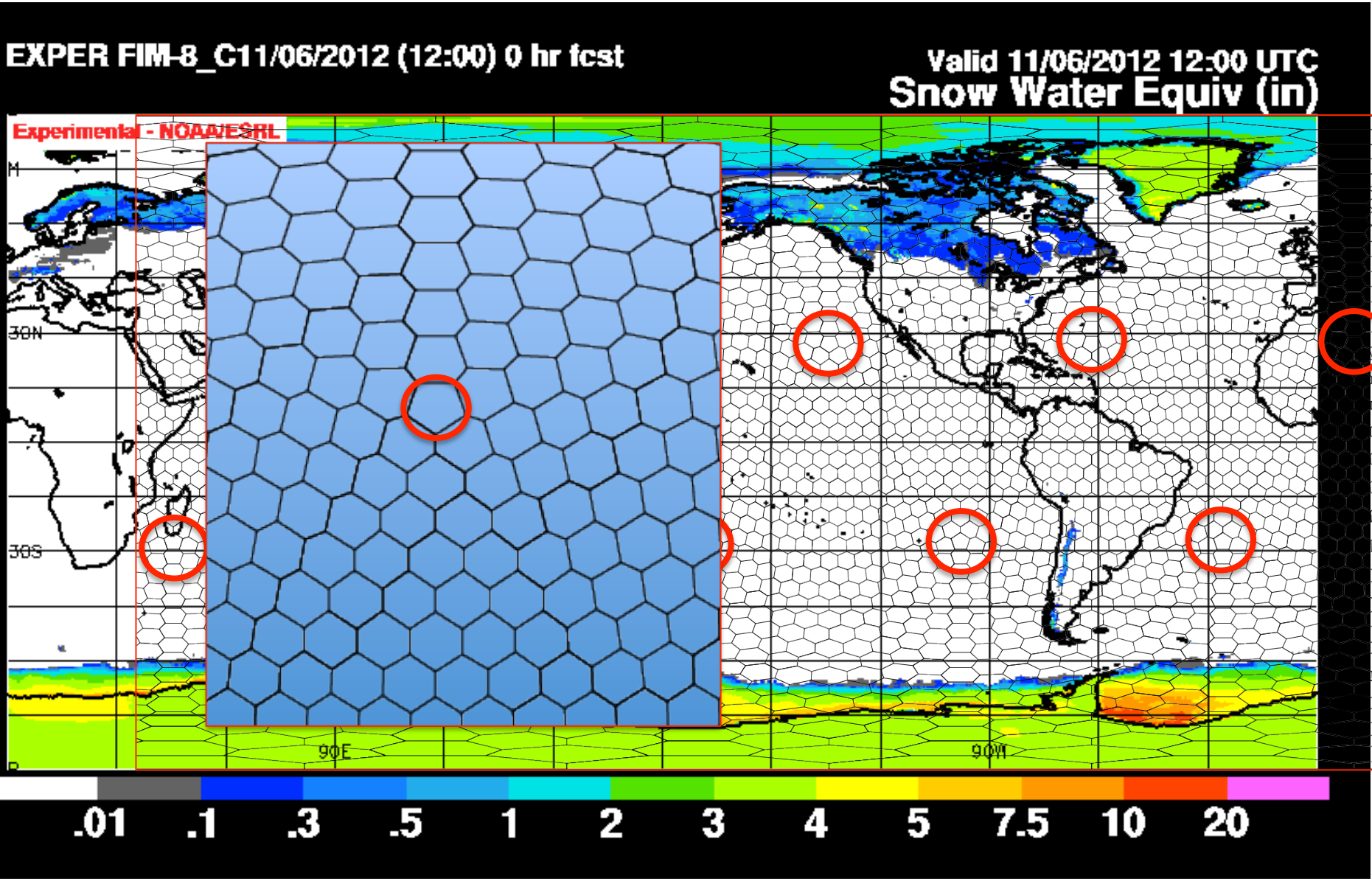
EPAC/LANT FIM7 v FIM8 v FIM9 track error



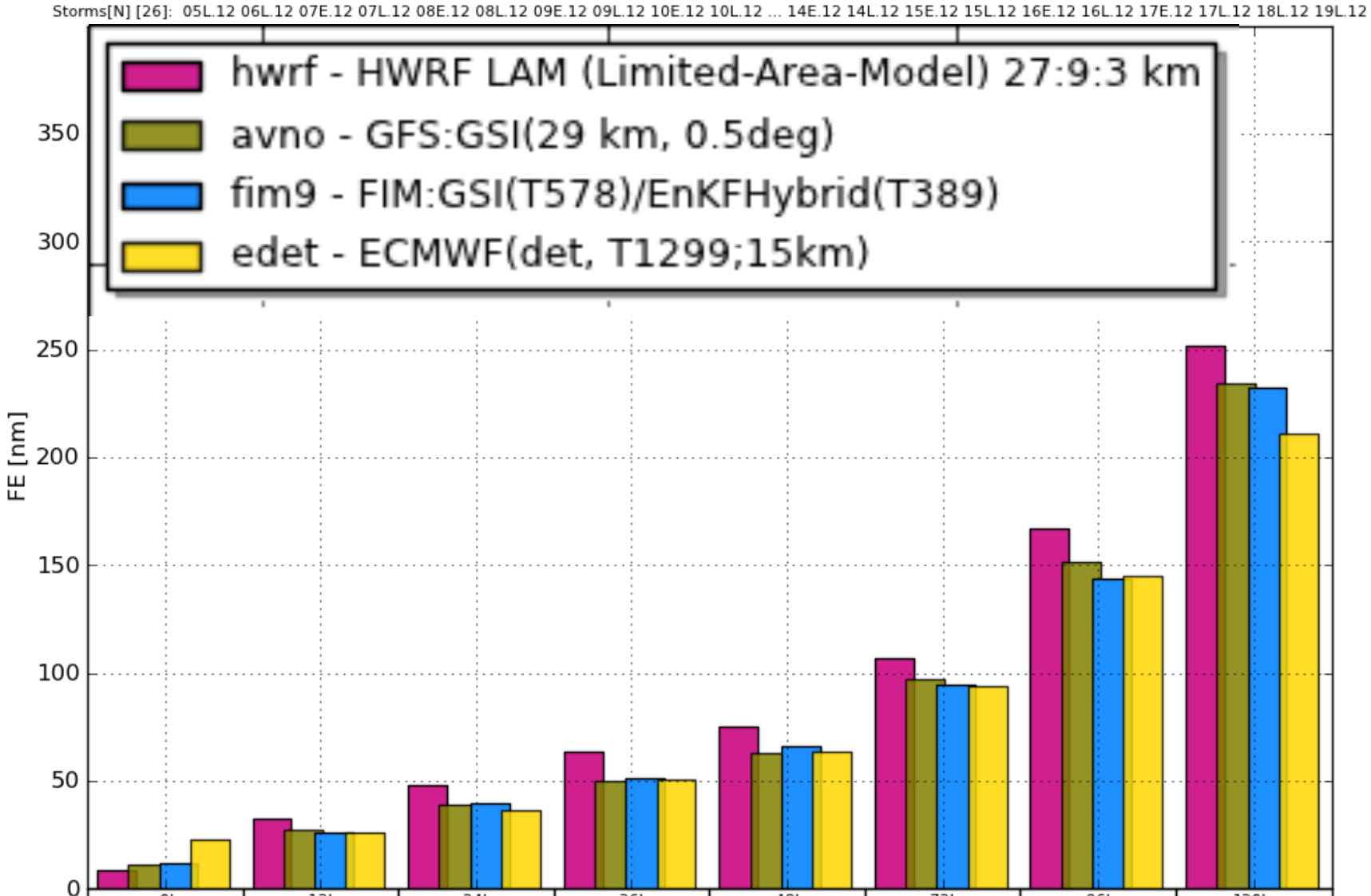
WPAC FIM7 v FIM8 v FIM9 track error



	0h	12h	24h	36h	48h	72h	96h	120h
fim7	19[222]	32[211]	47[194]	63[177]	81[160]	127[129]	192[99]	265[69]
fim8	19[222]	32[211]	45[194]	62[177]	82[160]	138[129]	209[99]	284[69]
fim9	19[222]	31[211]	45[194]	63[177]	83[160]	139[129]	204[99]	275[69]

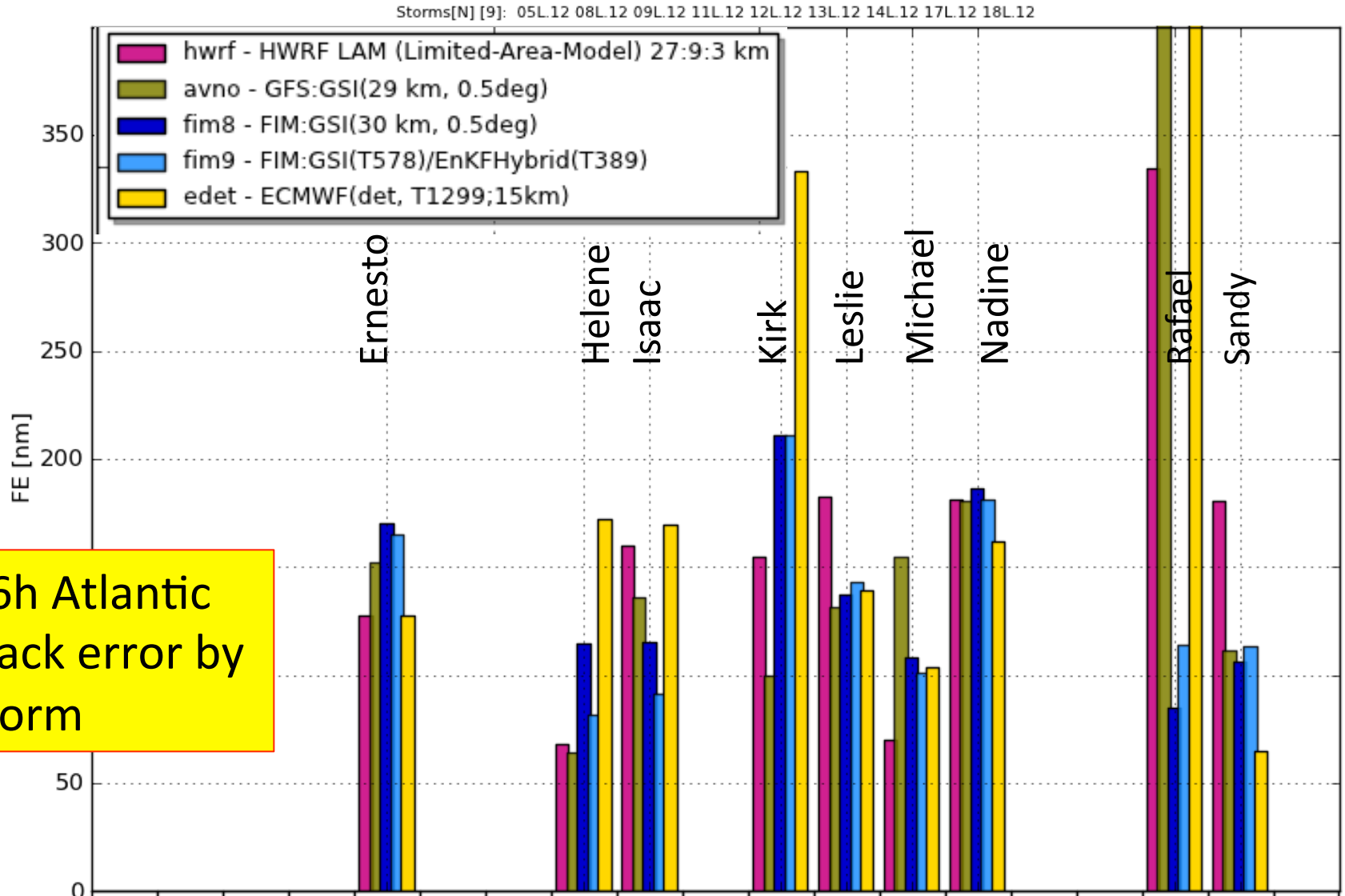

EXPER FIM-8_C11/06/2012 (12:00) 0 hr fcst
Valid 11/06/2012 12:00 UTC
Snow Water Equiv (in)
Experimental - NOAA/ESRL
30N
30S
90E
90W
.01
.1
.3
.5
1
2
3
4
5
7.5
10
20

Full 2012 track errors – Atlantic + E.Pacific basins



	0h	12h	24h	36h	48h	72h	96h	120h
hwrf	9[249]	33[239]	48[218]	63[193]	75[169]	107[133]	167[99]	252[66]
avno	11[249]	27[239]	39[218]	50[193]	63[169]	97[133]	152[99]	234[66]
fim9	12[249]	26[239]	40[218]	51[193]	66[169]	95[133]	144[99]	232[66]
edet	23[249]	26[239]	37[218]	51[193]	64[169]	94[133]	145[99]	211[66]

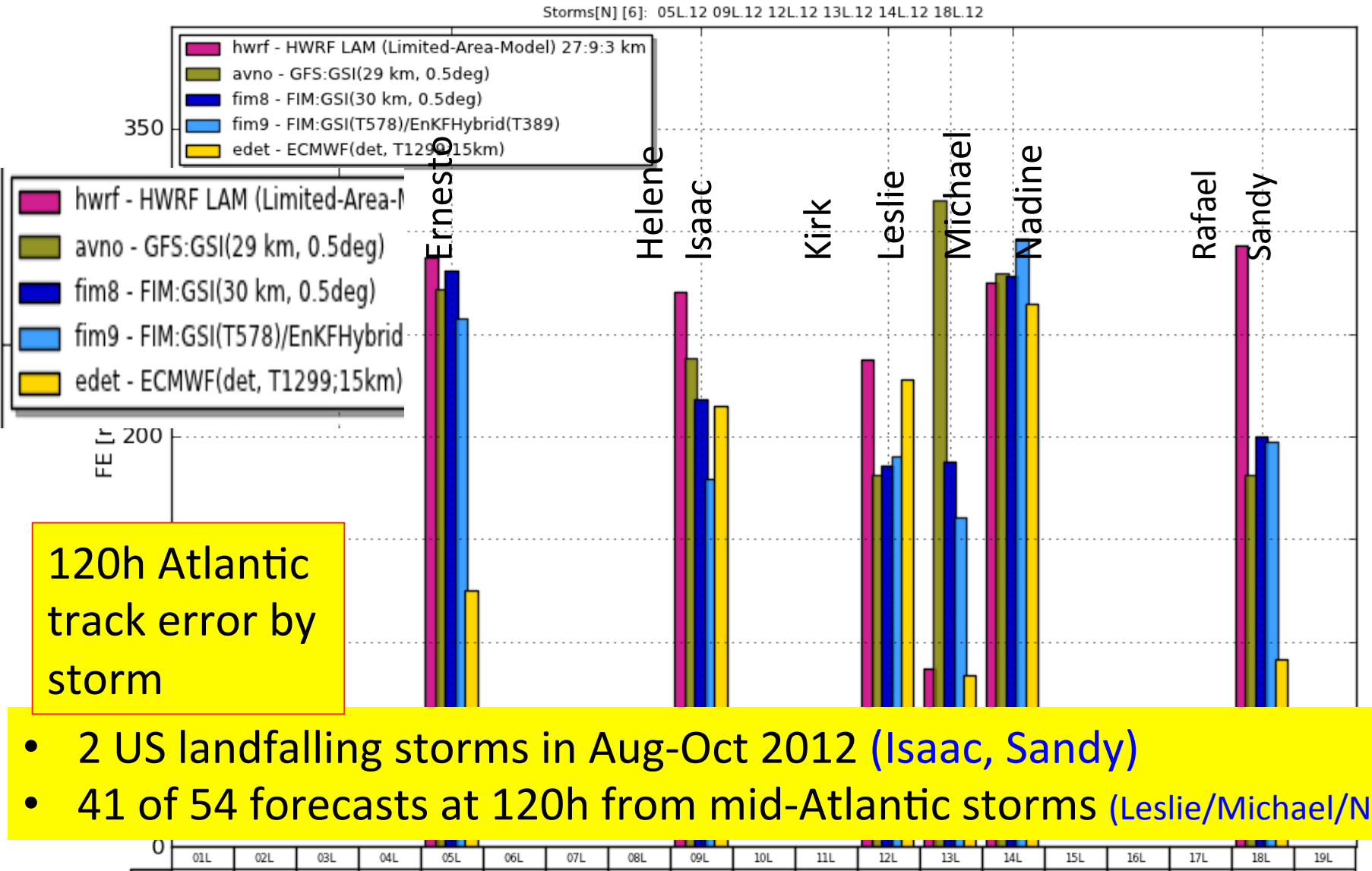
96h LANT 2012 HWRF v GFS v FIM8 v FIM9 v ECMWF track error by storm



96h Atlantic track error by storm

	01L	02L	03L	04L	05L	06L	07L	08L	09L	10L	11L	12L	13L	14L	15L	16L	17L	18L	19L
hwrf					127[7]			68[2]	160[11]		155[2]	182[16]	70[6]	181[29]			335[1]	180[6]	
avno					152[7]			64[2]	136[11]		100[2]	131[16]	154[6]	181[29]			419[1]	112[6]	
fim8					170[7]			114[2]	115[11]		211[2]	137[16]	108[6]	186[29]			85[1]	106[6]	
fim9					165[7]			82[2]	91[11]		211[2]	143[16]	101[6]	181[29]			114[1]	113[6]	
edet					128[7]			172[2]	169[11]		333[2]	139[16]	103[6]	162[29]			417[1]	65[6]	

120h LANT 2012 HWRF v GFS v FIM8 v FIM9 v ECMWF track error by storm

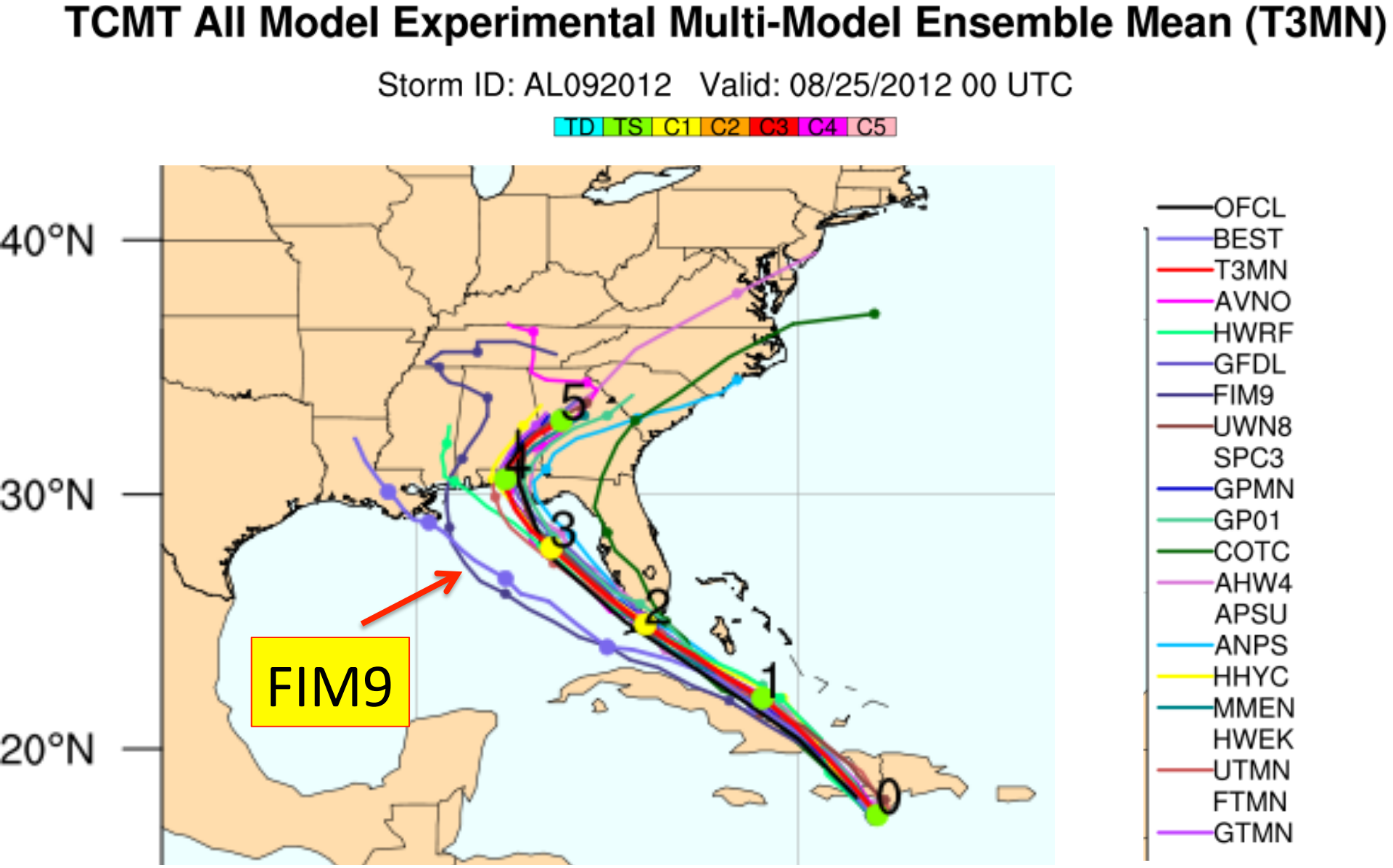


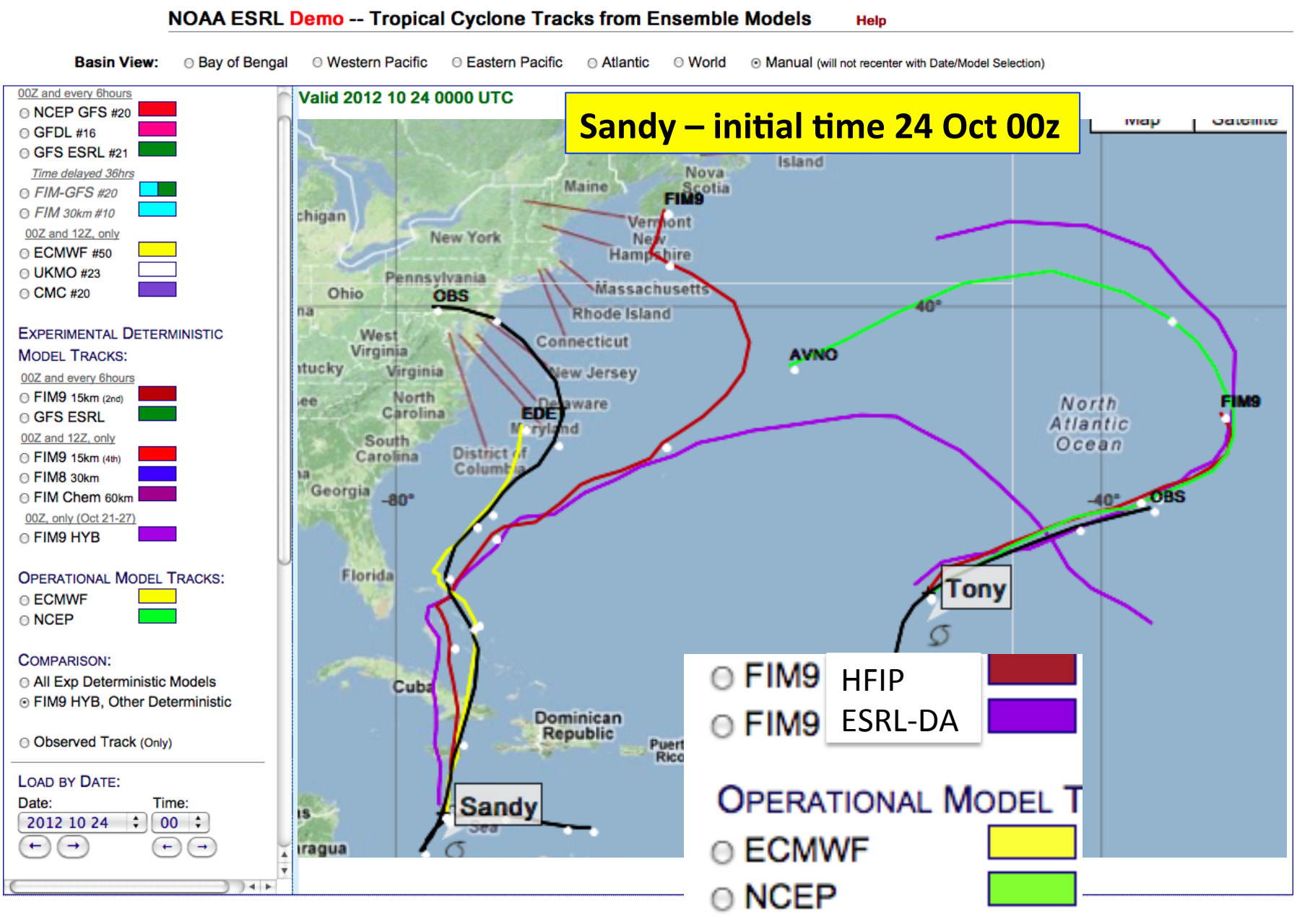
120h Atlantic track error by storm

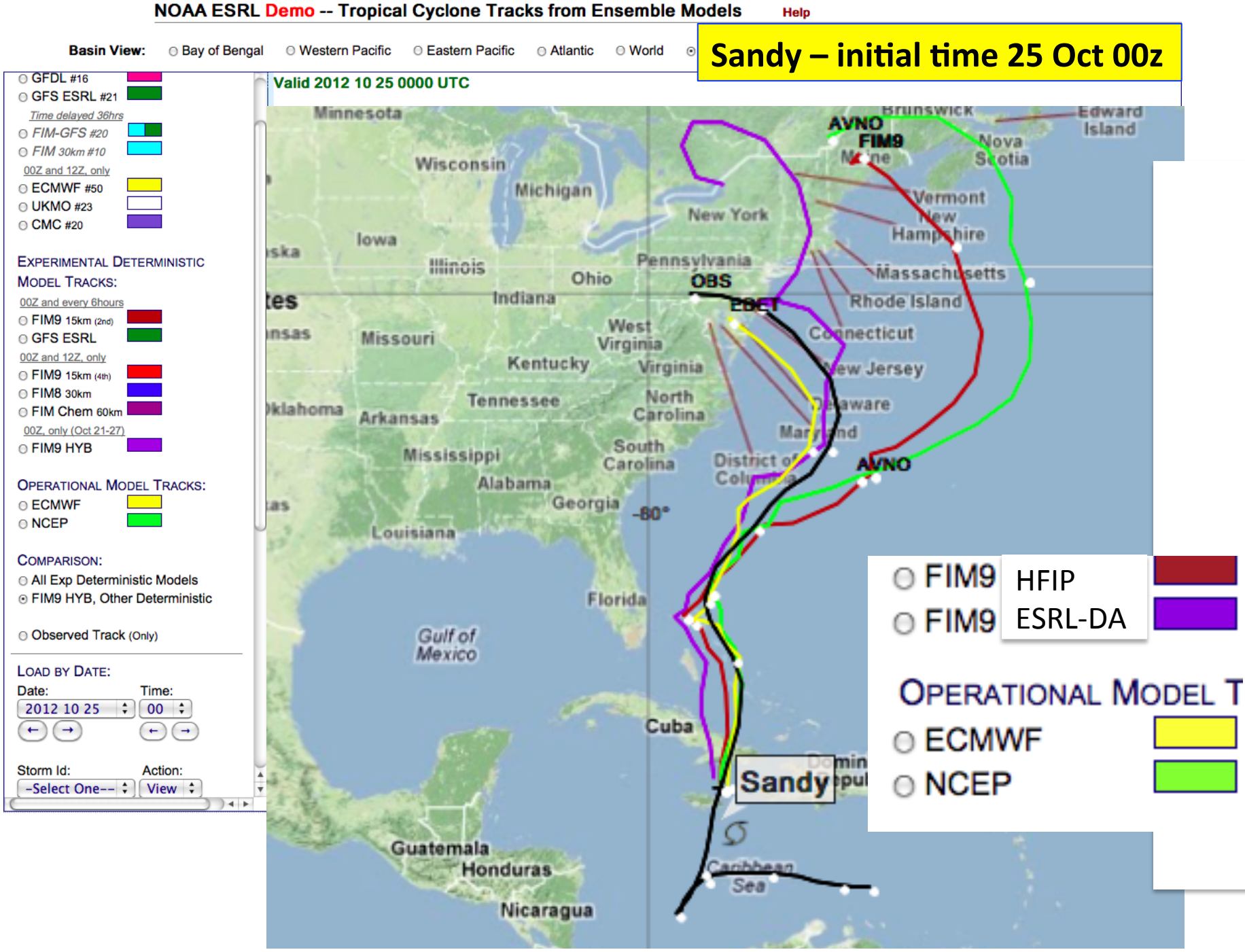
- 2 US landfalling storms in Aug-Oct 2012 (Isaac, Sandy)
- 41 of 54 forecasts at 120h from mid-Atlantic storms (Leslie/Michael/Nadine)

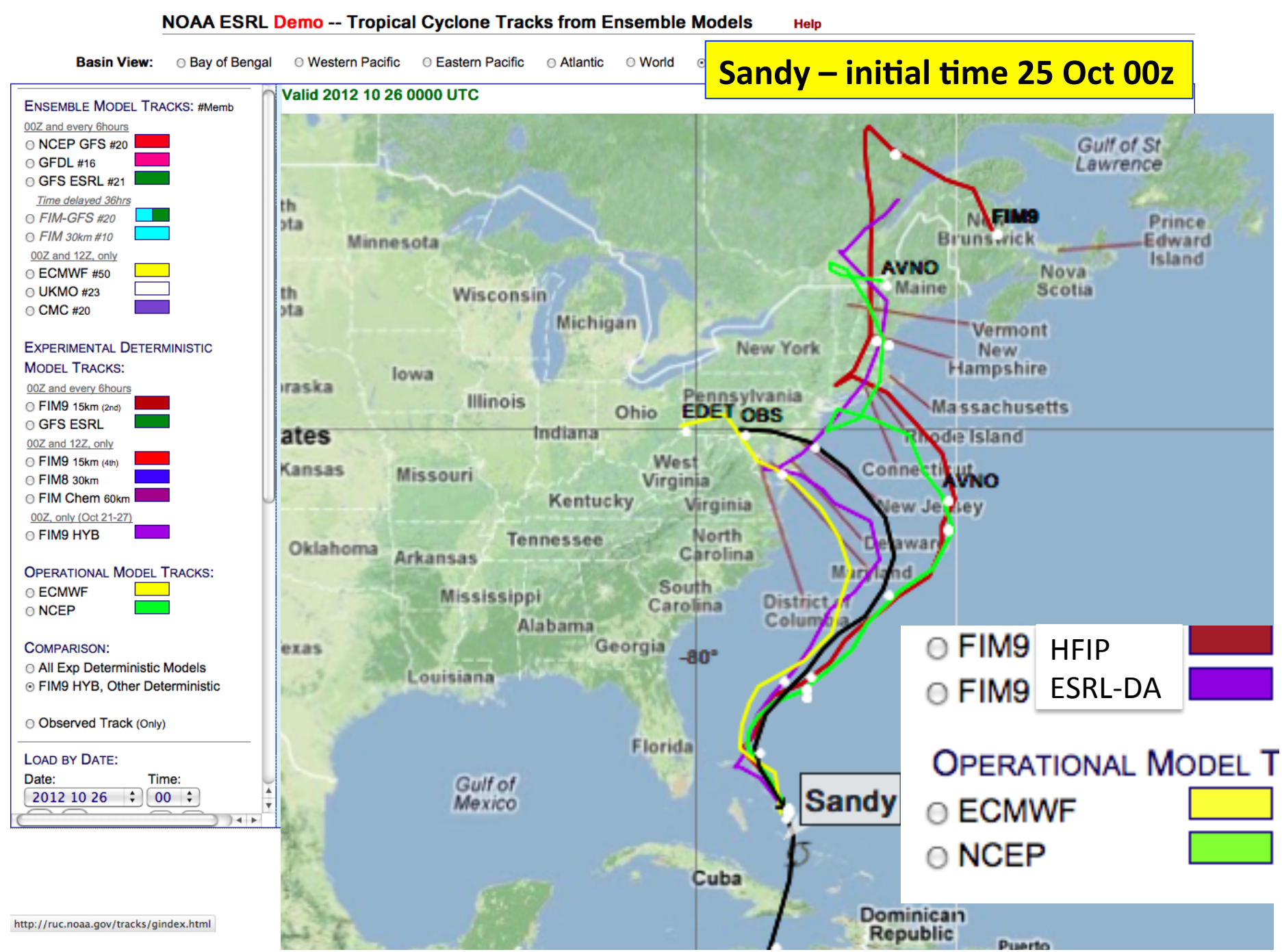
	01L	02L	03L	04L	05L	06L	07L	08L	09L	10L	11L	12L	13L	14L	15L	16L	17L	18L	19L
hwrf					287[3]				270[9]			237[13]	87[3]	275[25]				293[4]	
avno					272[3]				238[9]			181[13]	315[3]	279[25]				181[4]	
fim8					281[3]				218[9]			186[13]	187[3]	278[25]				200[4]	
fim9					258[3]				180[9]			190[13]	161[3]	296[25]				198[4]	
edet					125[3]				215[9]			228[13]	84[3]	265[25]				91[4]	

Isaac forecasts from HFIP




NOAA ESRL Demo -- Tropical Cyclone Tracks from Ensemble Models
Help
Basin View: Bay of Bengal Western Pacific Eastern Pacific Atlantic World Manual (will not recenter with Date/Model Selection)
00Z and every 6hours
NCEP GFS #20
GFDL #16
GFS ESRL #21
Time delayed 36hrs
FIM-GFS #20
FIM 30km #10
00Z and 12Z, only
ECMWF #50
UKMO #23
CMC #20
Experimental Deterministic Model Tracks:
00Z and every 6hours
FIM9 15km (2nd)
GFS ESRL
00Z and 12Z, only
FIM9 15km (4th)
FIM8 30km
FIM Chem 60km
00Z, only (Oct 21-27)
FIM9 HYB
Operational Model Tracks:
ECMWF
NCEP
Comparison:
All Exp Deterministic Models
FIM9 HYB, Other Deterministic
Observed Track (Only)
Load by Date:
Date:
2012 10 24
Time:
00
Valid 2012 10 24 0000 UTC
Sandy – initial time 24 Oct 00z
Maine
Nova Scotia
Island
FIM9
New York
Vermont
New Hampshire
Pennsylvania
Ohio
OBS
Massachusetts
Rhode Island
West Virginia
Connecticut
New Jersey
Virginia
North Carolina
Delaware
EDE
Maryland
South Carolina
District of Columbia
Georgia
-80°
40°
AVNO
North Atlantic Ocean
FIM9
-40°
OBS
Tony
Florida
Cuba
Dominican Republic
Sandy
FIM9 HFIP
FIM9 ESRL-DA
Operational Model T
ECMWF
NCEP
Privacy Policy | Accessibility | Disclaimer | Cont


NOAA ESRL Demo -- Tropical Cyclone Tracks from Ensemble Models
Help
Basin View: Bay of Bengal Western Pacific Eastern Pacific Atlantic World
Sandy – initial time 25 Oct 00z
Valid 2012 10 25 0000 UTC
GFDL #16
GFS ESRL #21
Time delayed 36hrs
FIM-GFS #20
FIM 30km #10
00Z and 12Z, only
ECMWF #50
UKMO #23
CMC #20
Experimental Deterministic Model Tracks:
00Z and every 6hours
FIM9 15km (2nd)
GFS ESRL
00Z and 12Z, only
FIM9 15km (4th)
FIM8 30km
FIM Chem 60km
00Z, only (Oct 21-27)
FIM9 HYB
Operational Model Tracks:
ECMWF
NCEP
Comparison:
All Exp Deterministic Models
FIM9 HYB, Other Deterministic
Observed Track (Only)
Load by Date:
Date: 2012 10 25
Time: 00
Storm Id: -Select One--
Action: View
Minnesota
Wisconsin
Michigan
Iowa
Illinois
Indiana
Ohio
Pennsylvania
New York
Missouri
West Virginia
Kentucky
Virginia
Tennessee
North Carolina
Arkansas
South Carolina
Mississippi
Alabama
Georgia
Louisiana
Florida
Gulf of Mexico
Cuba
Guatemala
Honduras
Nicaragua
Caribbean Sea
Brunswick
Nova Scotia
Edward Island
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
AVNO
FIM9
OBS
EBET
Sandy
-80°
FIM9 HFIP
FIM9 ESRL-DA
Operational Model T
ECMWF
NCEP


NOAA ESRL Demo -- Tropical Cyclone Tracks from Ensemble Models
Help
Basin View: Bay of Bengal Western Pacific Eastern Pacific Atlantic World
Sandy – initial time 25 Oct 00z
Valid 2012 10 26 0000 UTC
Ensemble Model Tracks: #Memb
00Z and every 6hours
NCEP GFS #20
GFDL #16
GFS ESRL #21
Time delayed 36hrs
FIM-GFS #20
FIM 30km #10
00Z and 12Z, only
ECMWF #50
UKMO #23
CMC #20
Experimental Deterministic Model Tracks:
00Z and every 6hours
FIM9 15km (2nd)
GFS ESRL
00Z and 12Z, only
FIM9 15km (4th)
FIM8 30km
FIM Chem 60km
00Z, only (Oct 21-27)
FIM9 HYB
Operational Model Tracks:
ECMWF
NCEP
Comparison:
All Exp Deterministic Models
FIM9 HYB, Other Deterministic
Observed Track (Only)
Load by Date:
Date: 2012 10 26
Time: 00
http://ruc.noaa.gov/tracks/gindex.html
Minnesota
Wisconsin
Michigan
Iowa
Illinois
Indiana
Ohio
Kansas
Missouri
Kentucky
West Virginia
Virginia
Tennessee
North Carolina
Oklahoma
Arkansas
Mississippi
South Carolina
Alabama
Georgia
Louisiana
Florida
Gulf of Mexico
Cuba
Pennsylvania
New York
Maine
Vermont
New Hampshire
Massachusetts
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
Nova Scotia
Prince Edward Island
Gulf of St Lawrence
EDET OBS
AVNO
FIM9
-80°
Sandy
FIM9 HFIP
FIM9 ESRL-DA
Operational Model T
ECMWF
NCEP
Dominican Republic

NOAA ESRL Demo -- Tropical Cyclone Tracks from Ensemble Models

Help

Basin View: ○ Bay of Bengal ○ Western Pacific ○ Eastern Pacific ○ A ction)

Sandy – initial time 25 Oct 00z

○ FIM9 15km (2nd)
○ GFS ESRL

00Z and 12Z, only
○ FIM9 15km (4th)
○ FIM8 30km
○ FIM Chem 60km

00Z, only (Oct 21-27)
○ FIM9 HYB

OPERATIONAL MODEL TRACKS:
○ ECMWF
○ NCEP

◉ Comparison: FIM9 HYB, Other Deterministic

○ Observed Track (Only)

LOAD BY DATE:
Date: 2012 10 27 Time: 00

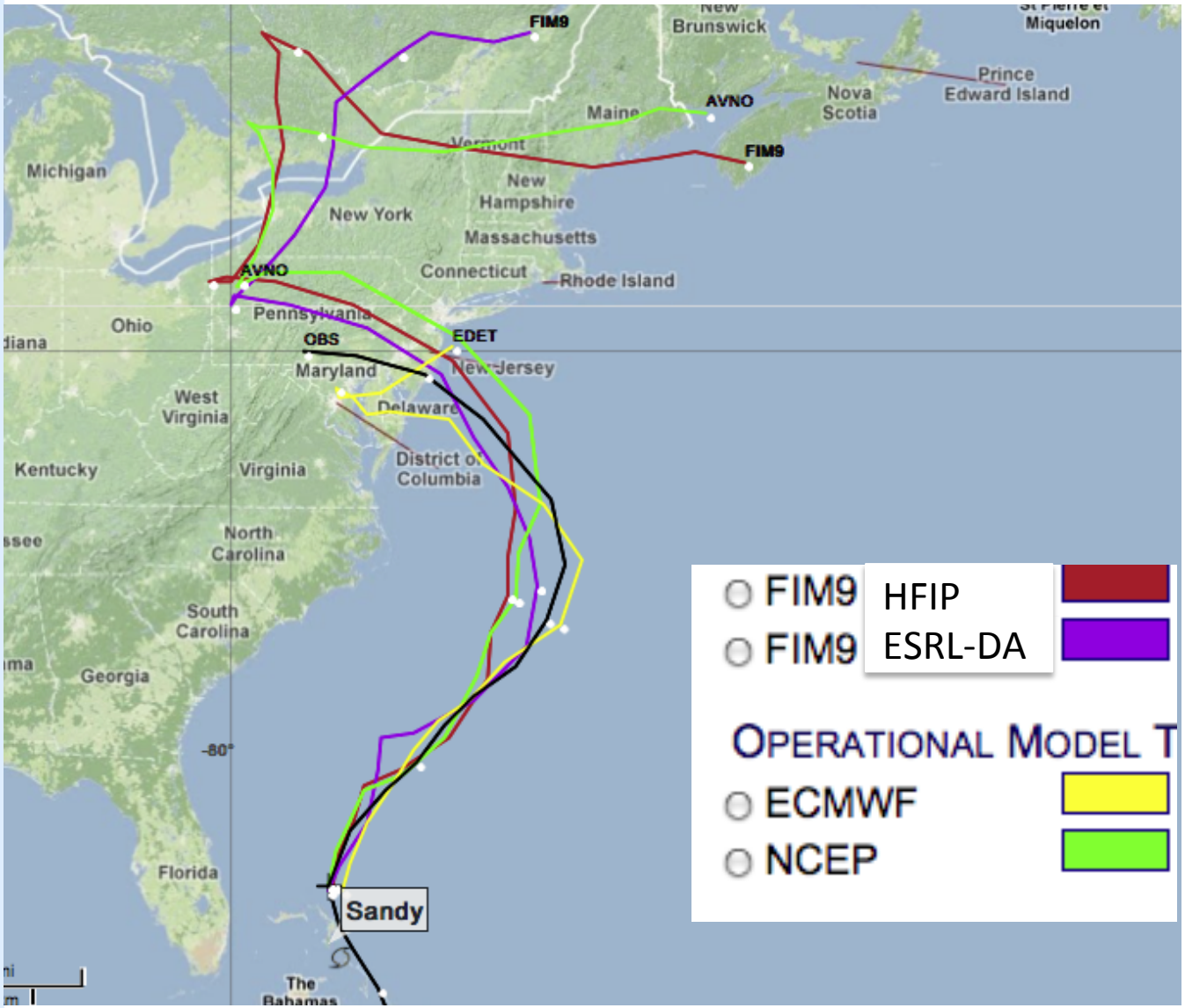
Storm Id: --Select One-- Action: View

Lat Lon Lines: Every 40 deg

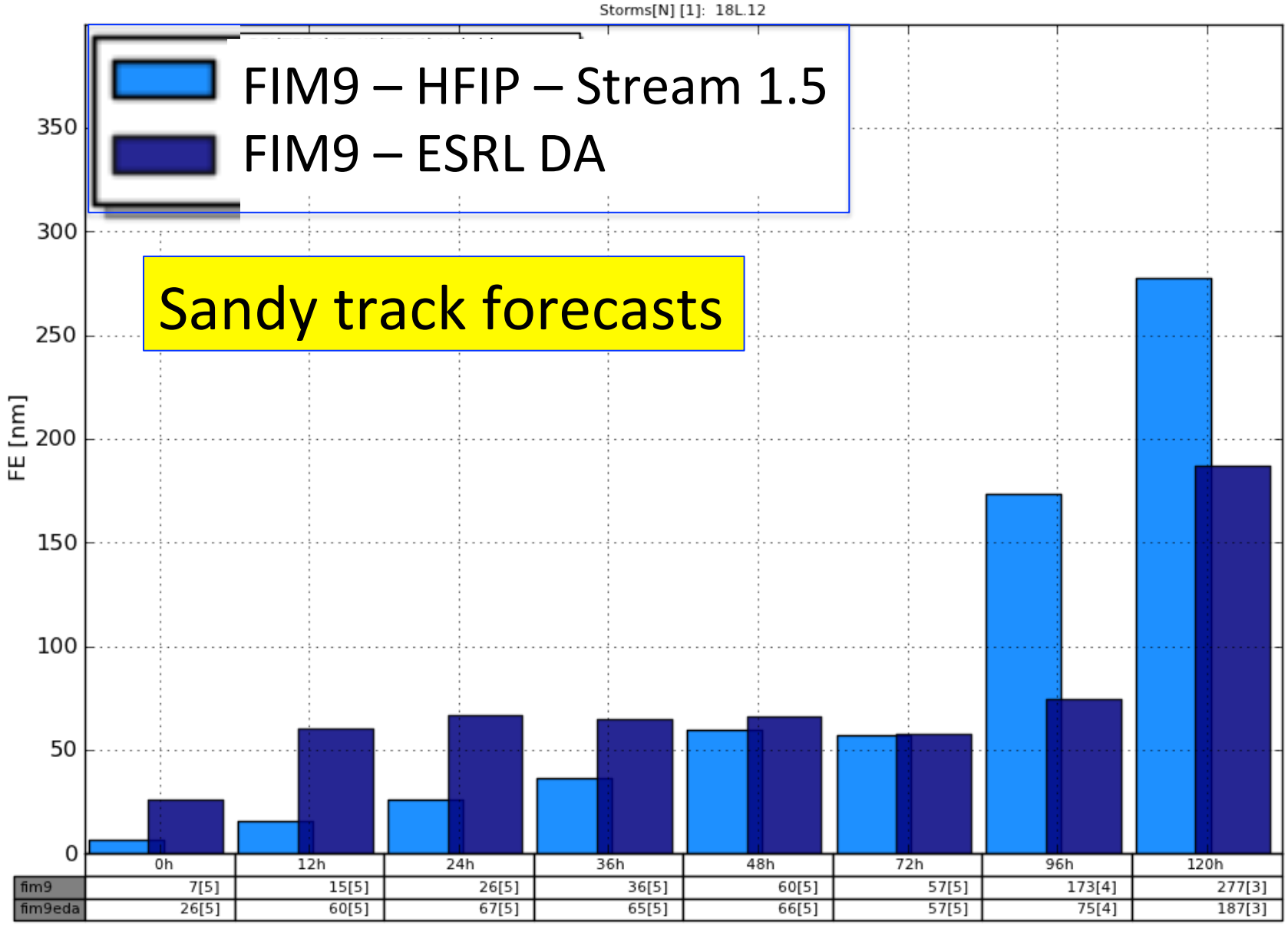
☑ DESCRIPTION

Valid 2012 10 27 0000 UTC
Observed Best Track (black)
Deterministic FIM9 (brown)
Deterministic FIM9-Hyb (violet)
Deterministic ECMWF EDET (yellow)
Deterministic NCEP AVNO (bright green)

Valid 2012 10 27 0000 UTC



18L.2012 - Sandy fim9(NCEP Hybrid DA) v fim9(ESRL Hybrid DA)



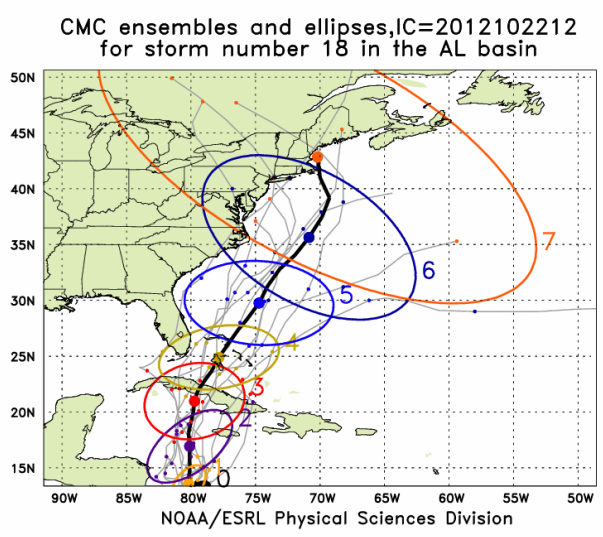
Global ensemble performance for Sandy

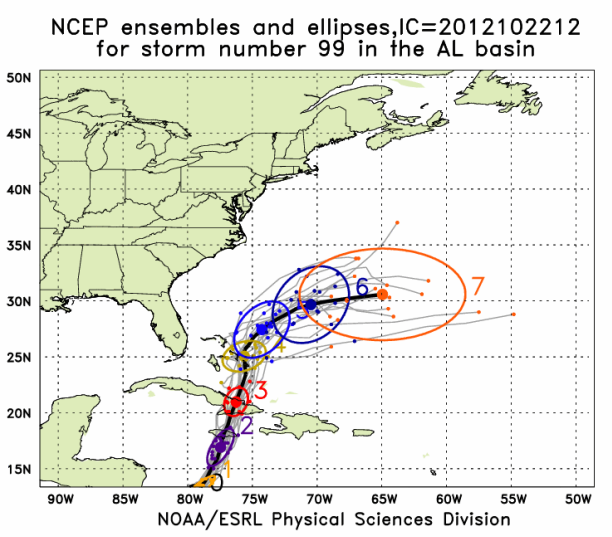
Jeff Whitaker and Phil Pegion

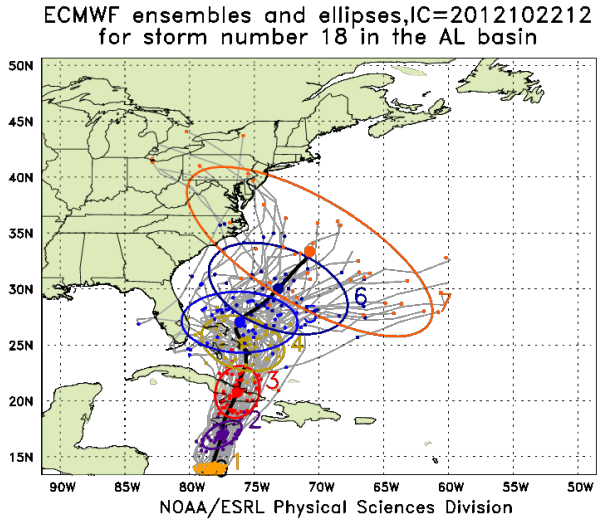
- Track ellipses out to day 7.
- Cumulative probability that the wind will exceed tropical storm force (> 34 kts) at any point during forecast verifying at 2012102912.
- ECMWF, UKMET, Env Canada (CMC), NCEP operational, and HFIP experimental global ensembles are plotted, when available.

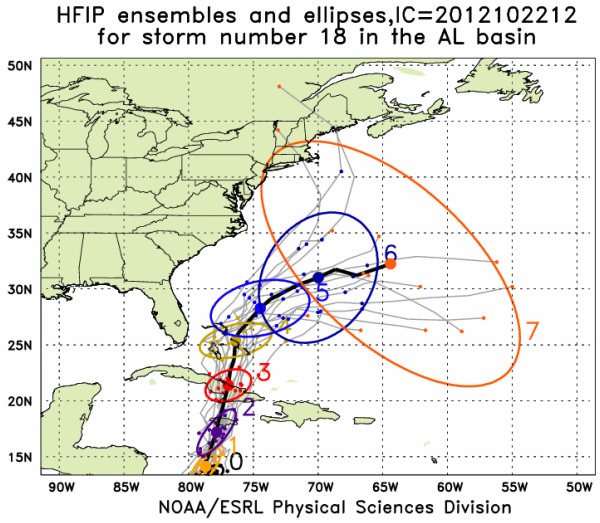
2012102212 initialization

UKMO missing

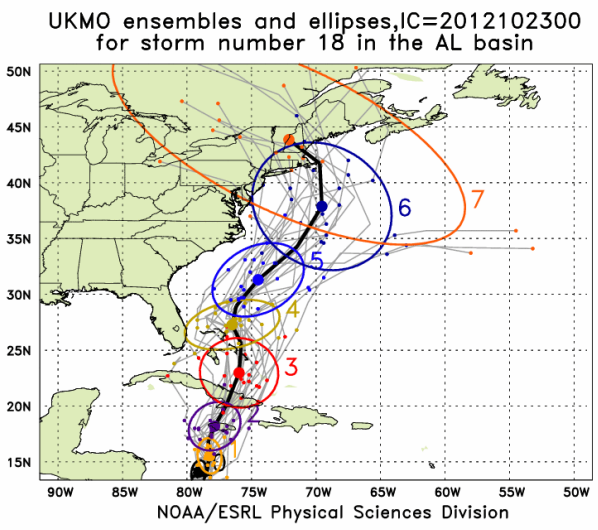


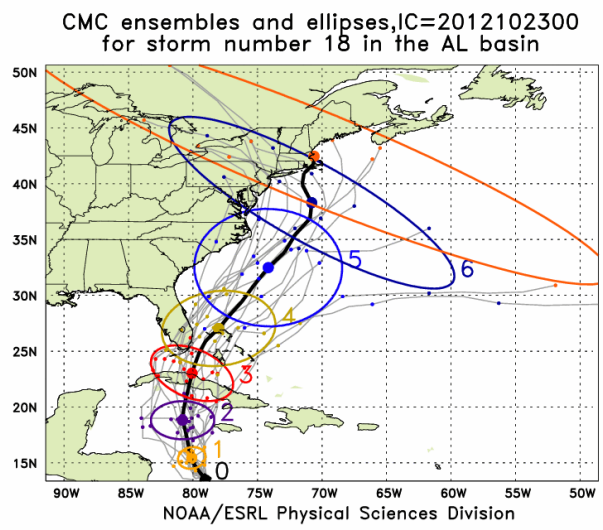


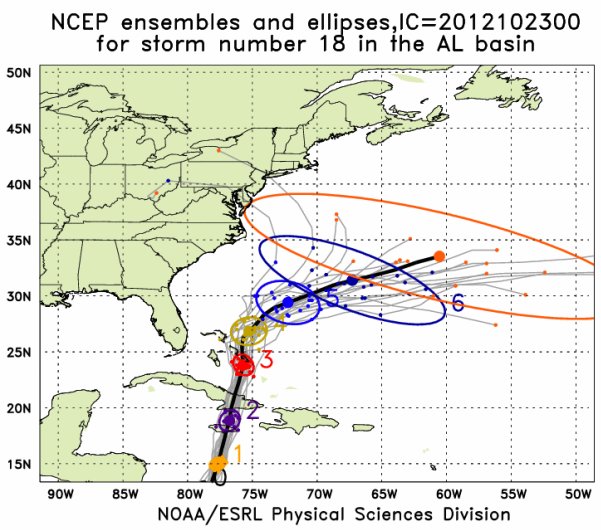


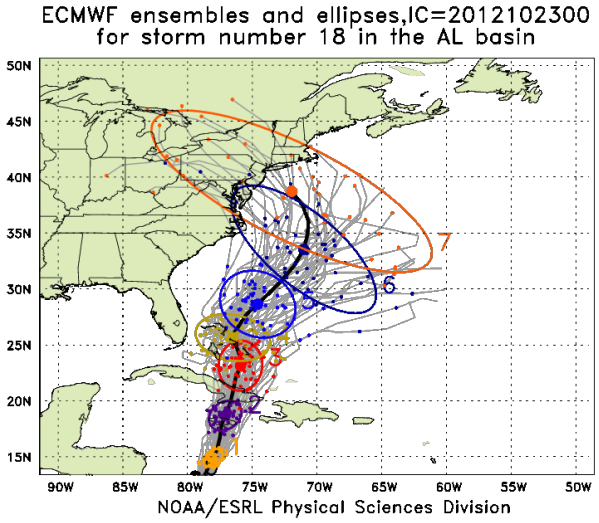


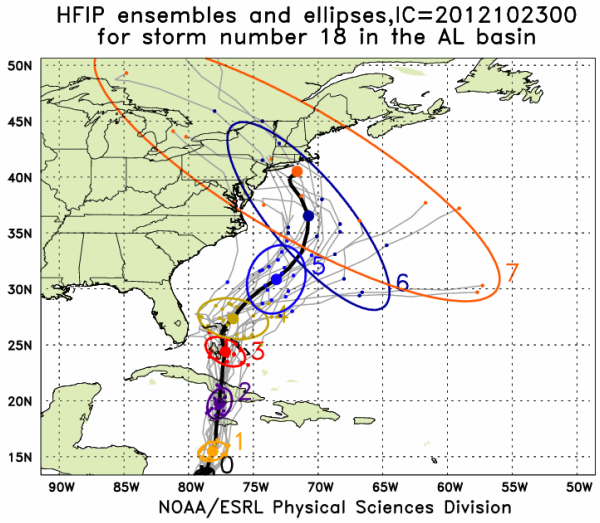
2012102300 initialization



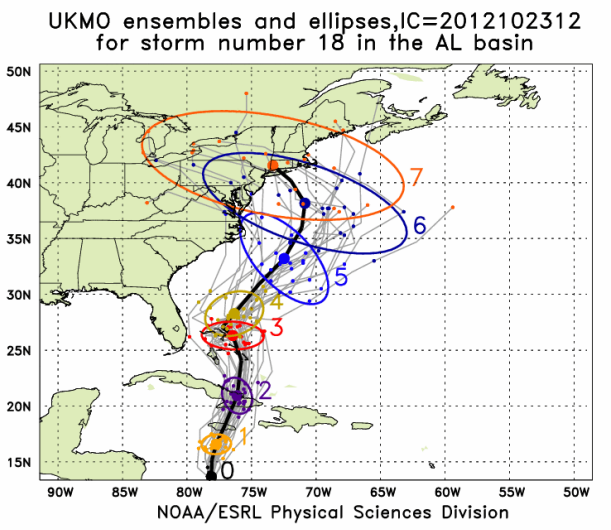


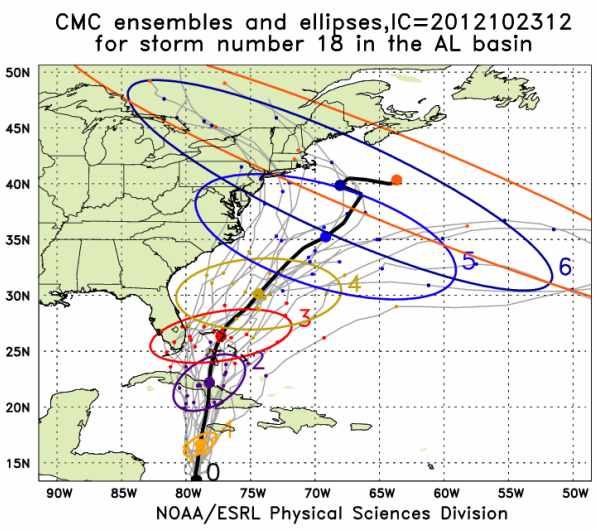


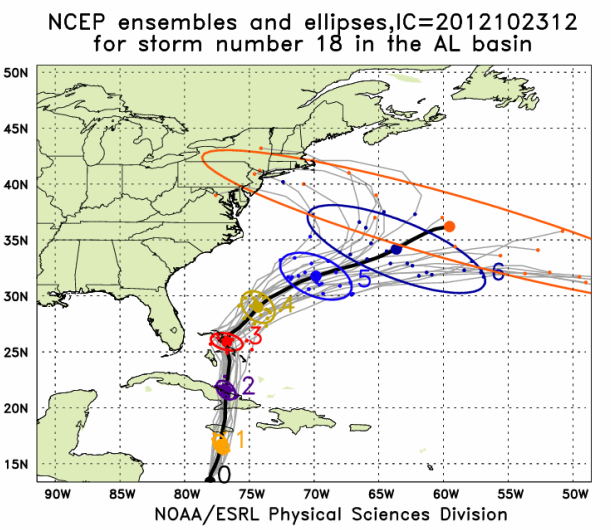


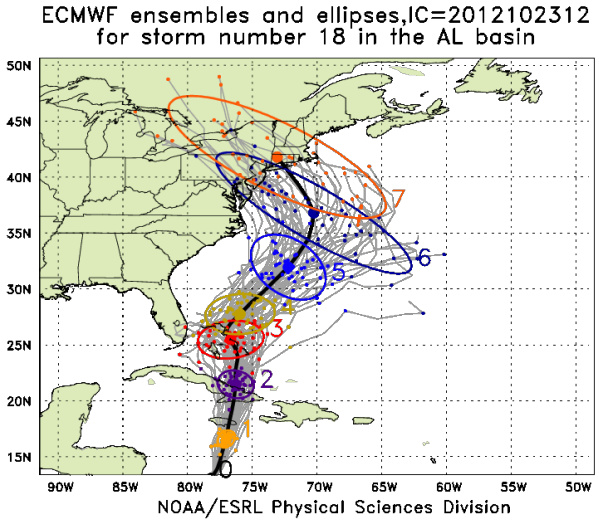


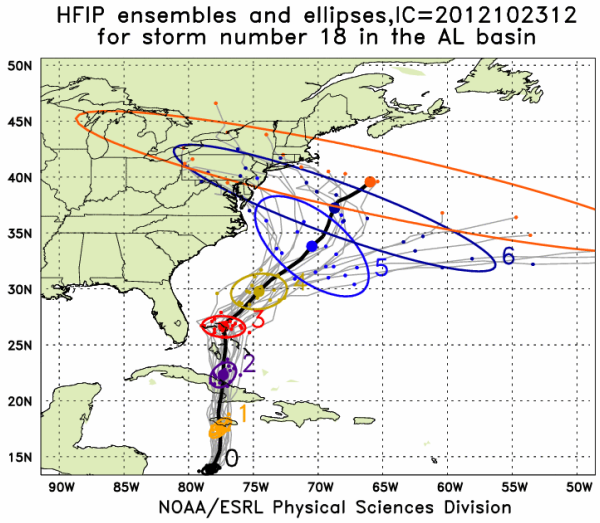
2012102312 initialization



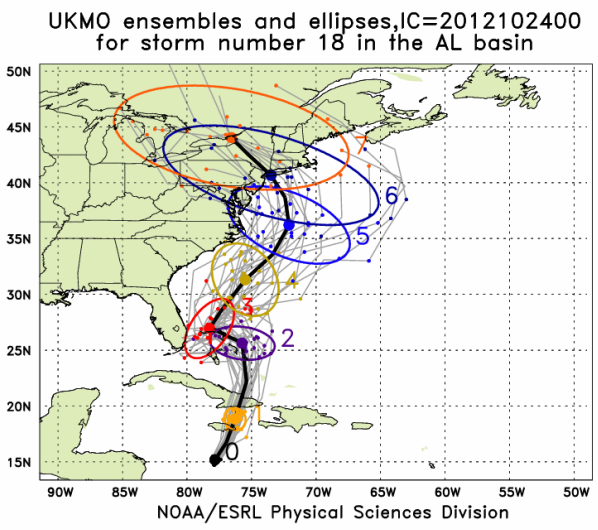


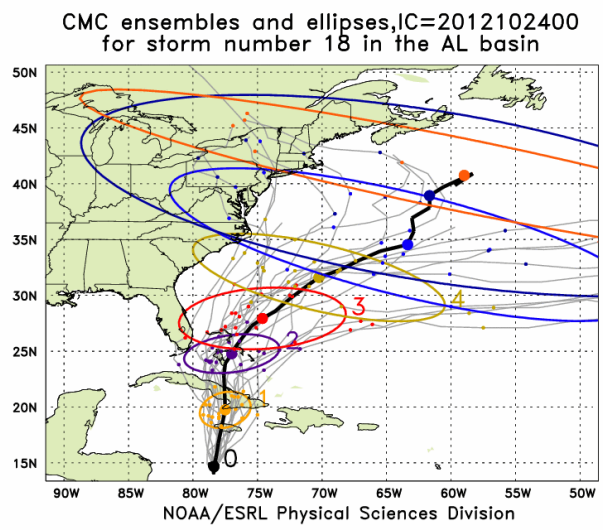


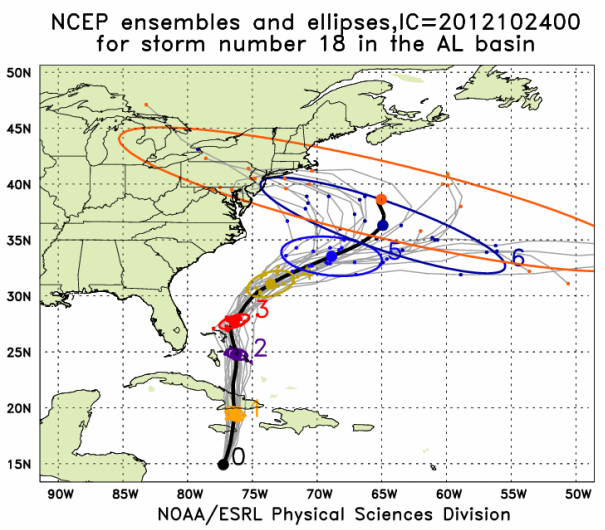


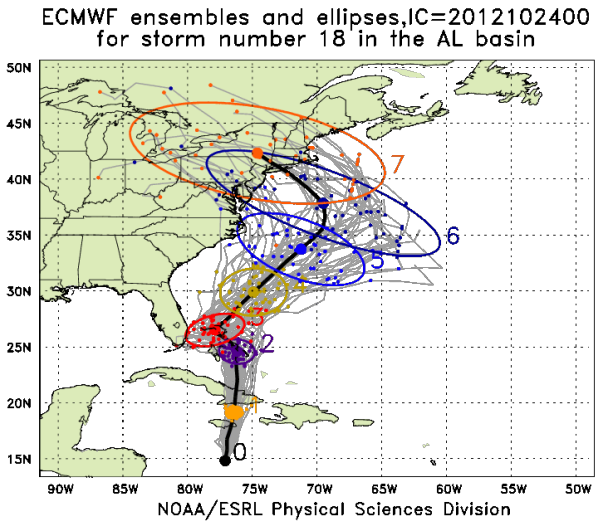


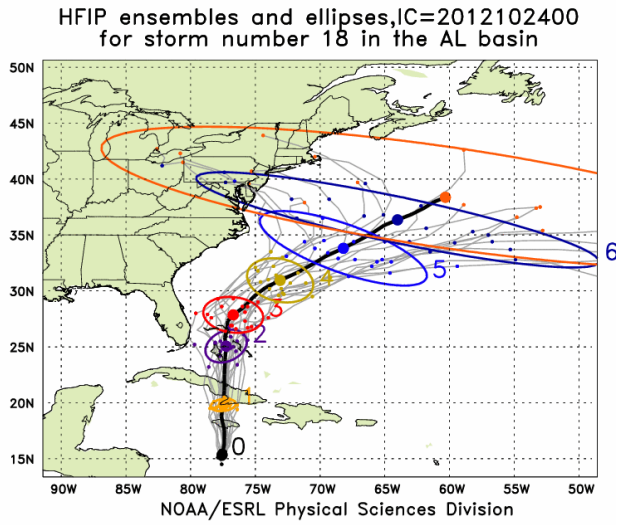
2012102400 initialization



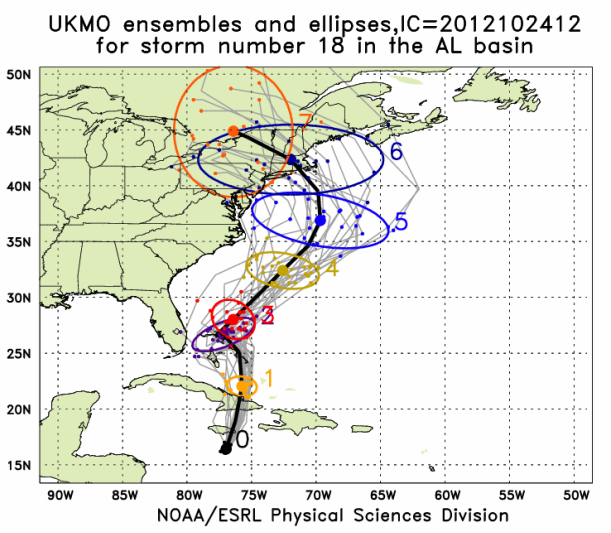


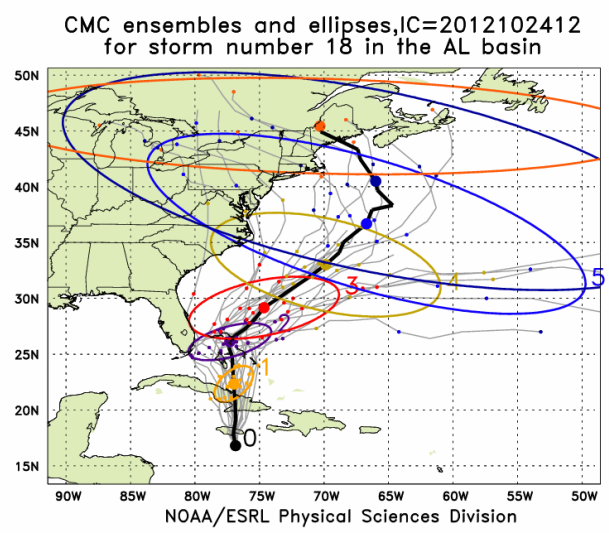


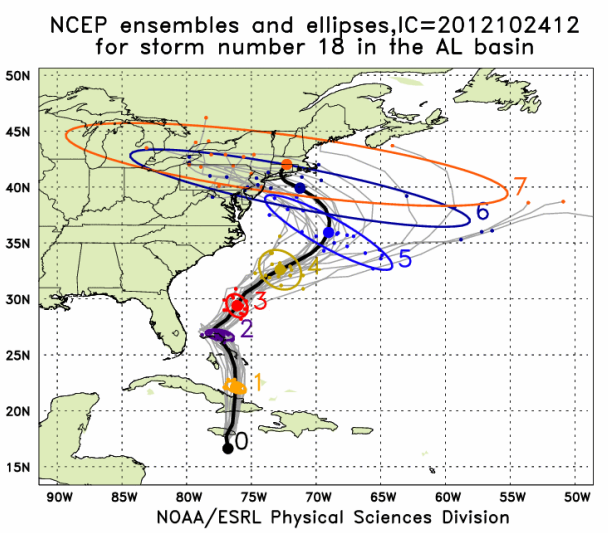


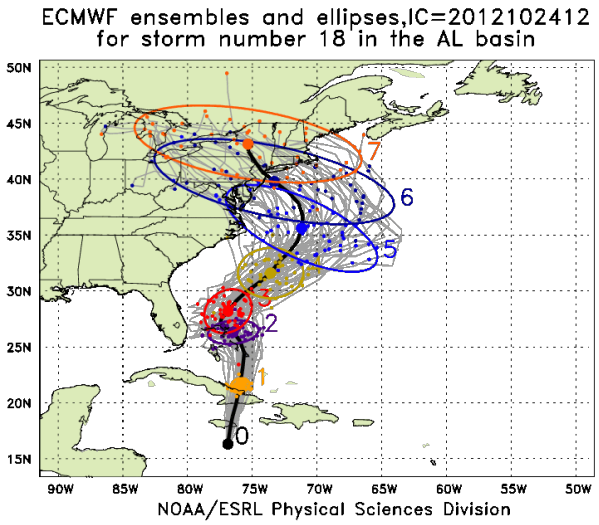


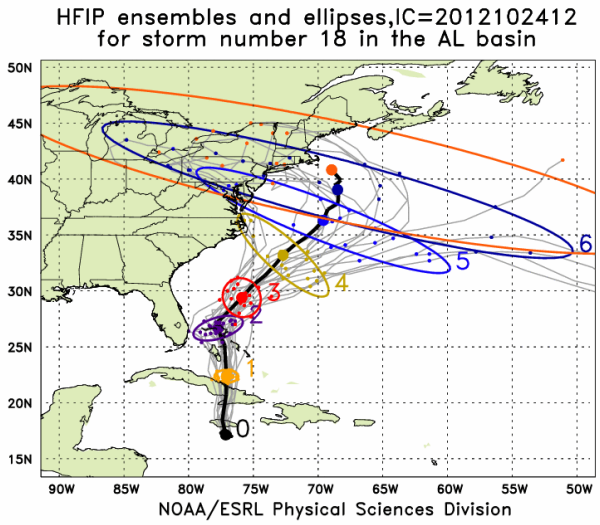
2012102412 initialization



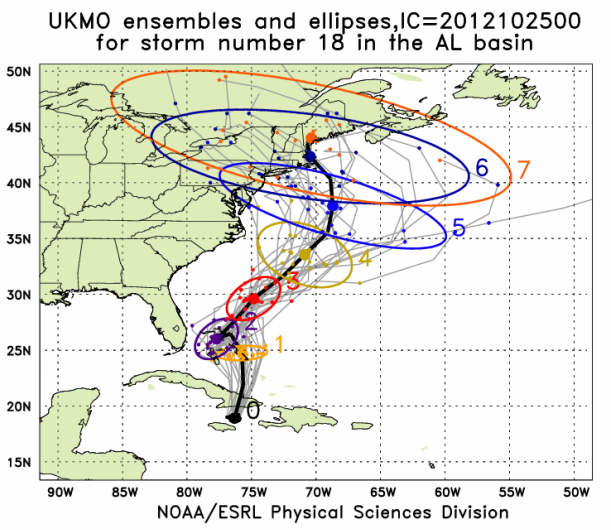


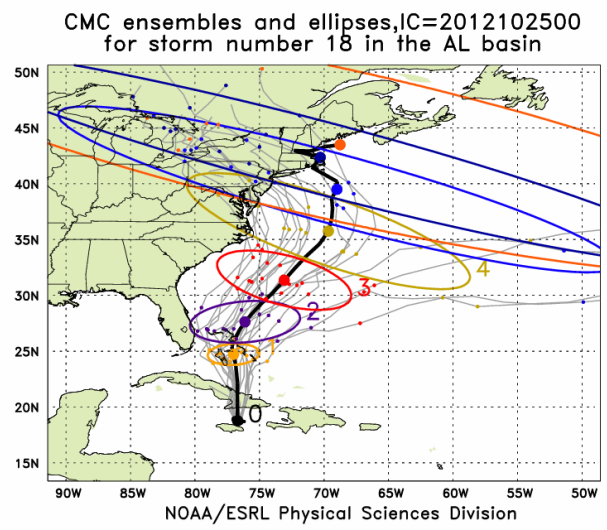


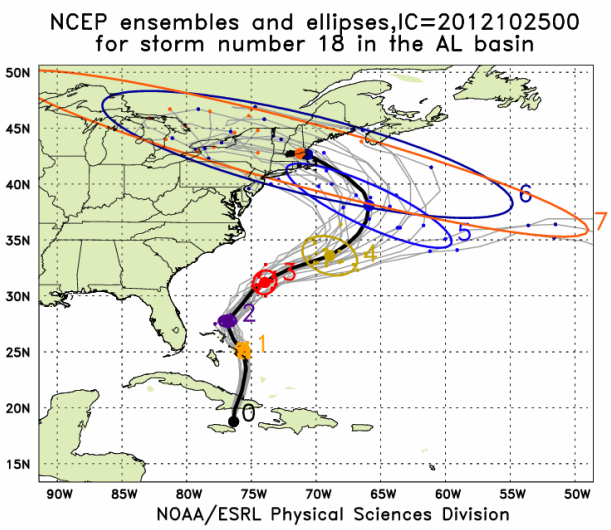


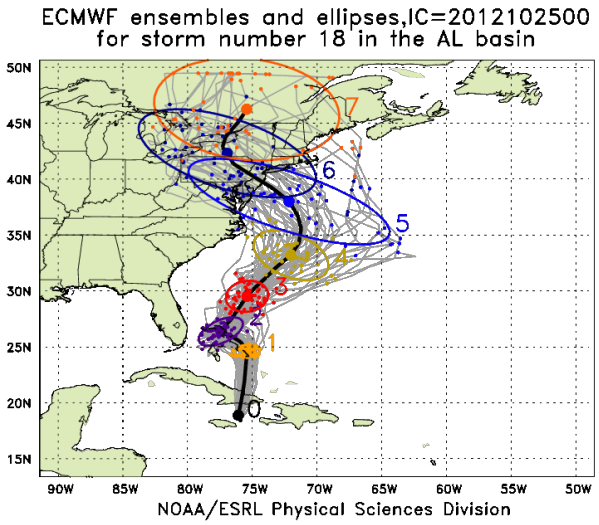


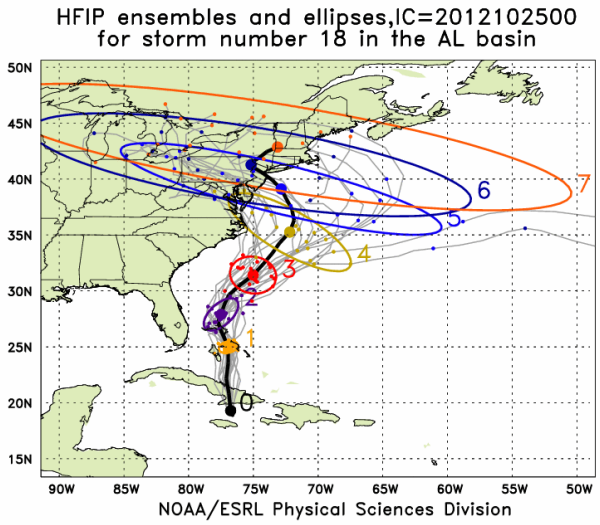
2012102500 initialization



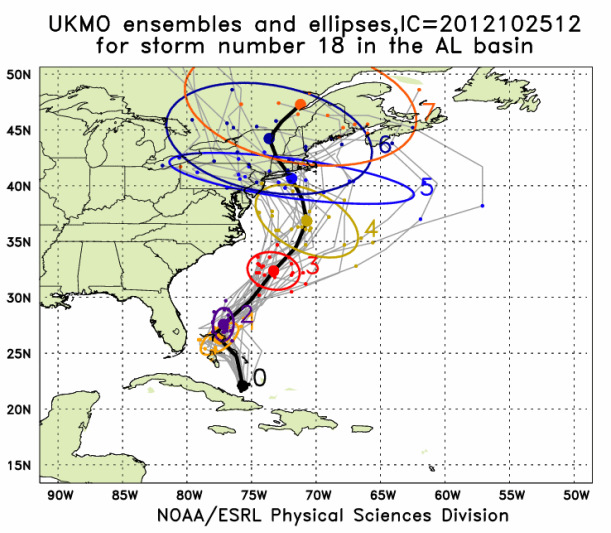


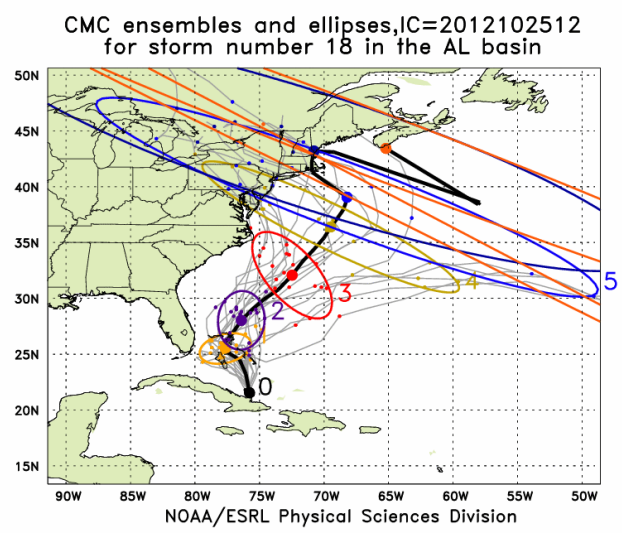


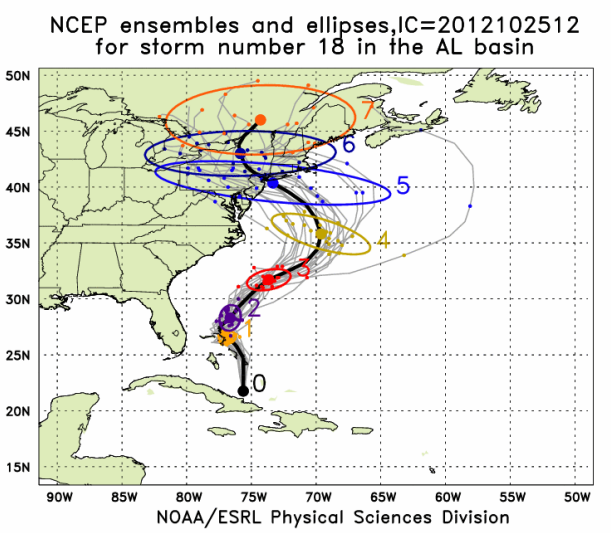


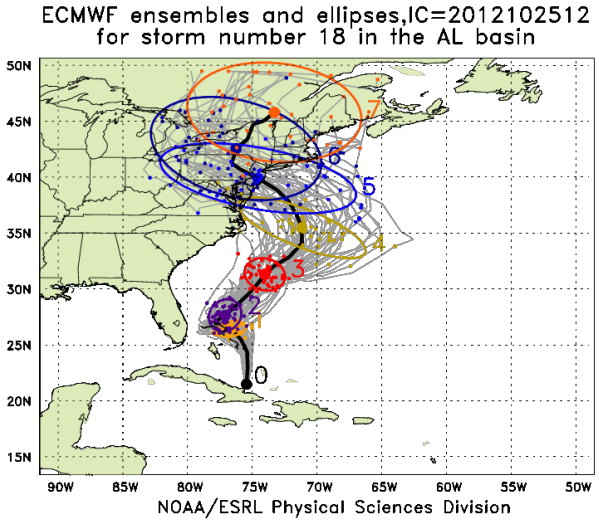


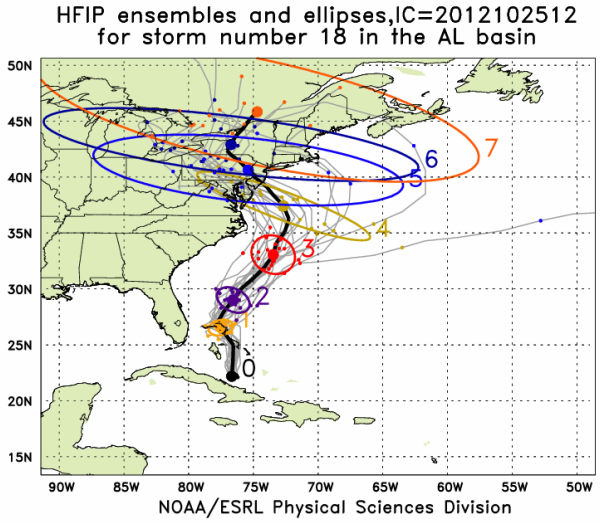
2012102512 initialization



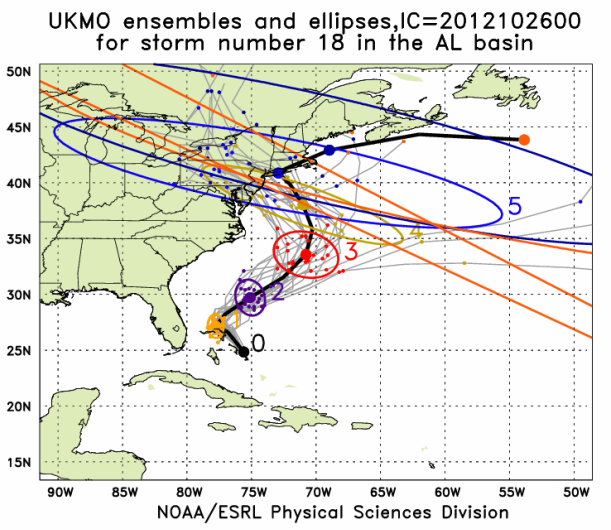




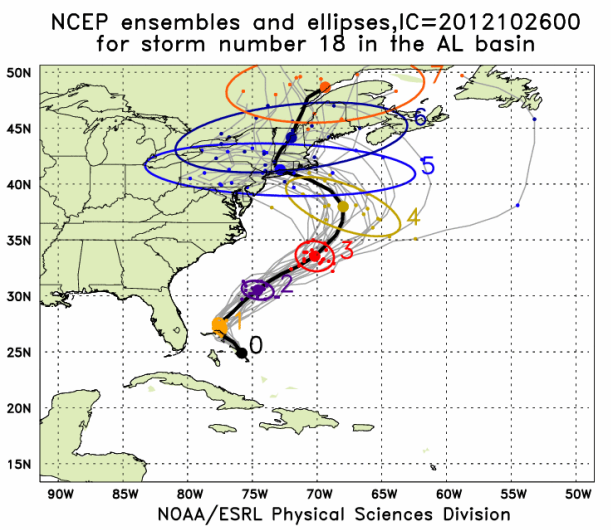


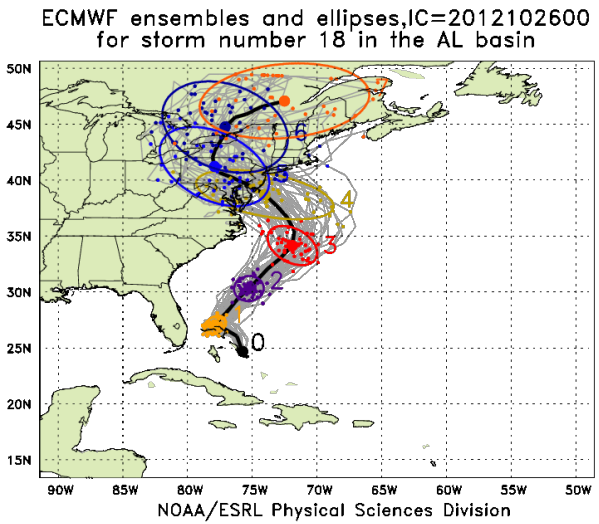


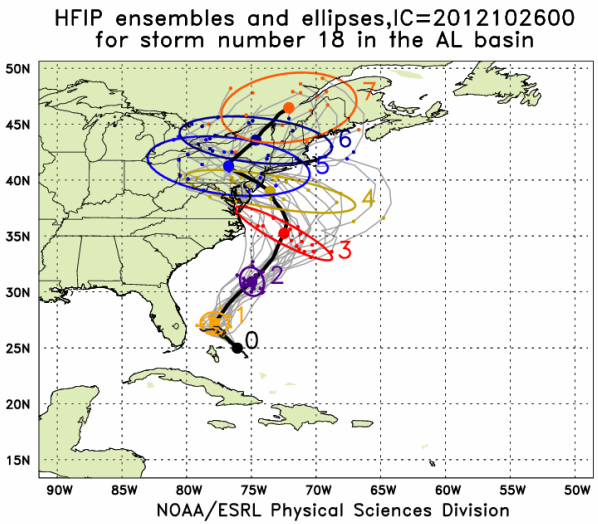
2012102600 initialization



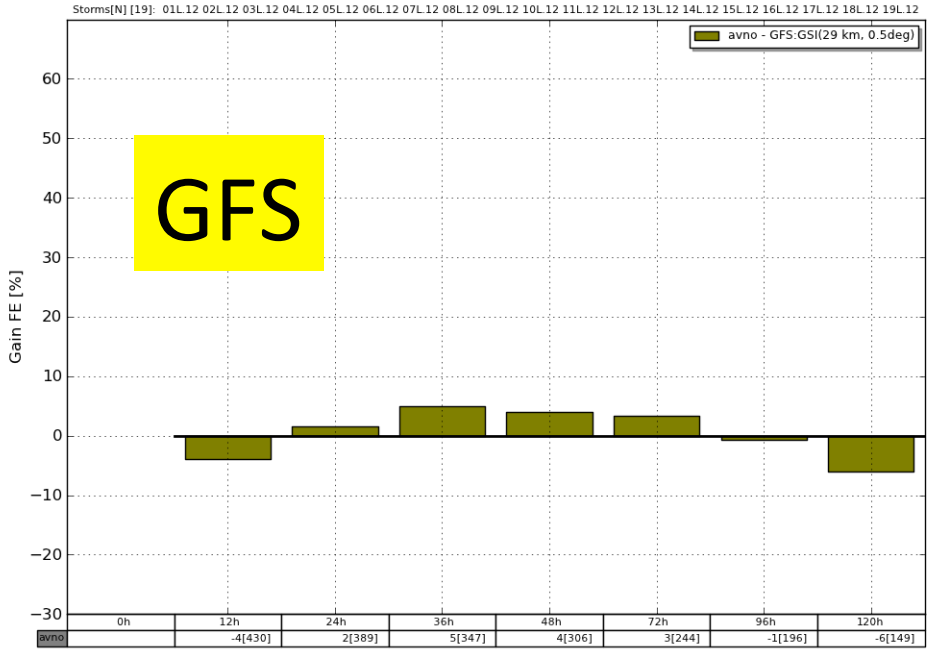
CMC missing



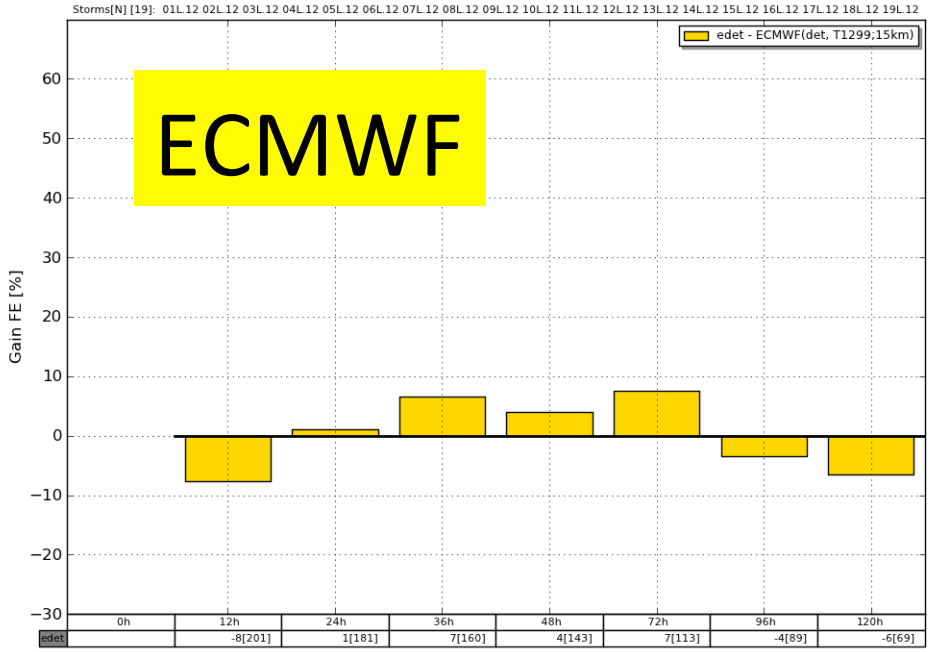




LANT 2012 GFS det v GEFs mean %improve of det v ensemble



LANT 2012 ECMWF det v EPS mean %improve of det v ensemble



Track forecast skill

Percent improvement for deterministic forecast over mean ensemble forecast error

FIM plans for 2013

- Improve accuracy of **FIM numerics** revealed in Dynamic Core Model Intercomparison Project (DCMIP) global model tests
  - Correct pressure gradient
  - Correct grid numerics especially near pentagons including use of spherical geometry rather than plane approximations
- **Data assimilation directly on FIM grid**
  - Builds off GSI-ensemble data assimilation used for GFS
  - Will allow FIM data assimilation cycling
- **Physics**
  - Stochastic physics for FIM ensemble forecasts
  - Test chemistry/aerosol version for TC forecast periods
  - Complete installation of GFS May 2012 physics
  - Perform additional tests of Grell-Freitas convective scheme
- Expand retrospective testing
  - Perform tests for 5-10 year periods, not just 3-12 month periods
- **NCEP** testing for **multi-model ensemble**
- **Single time-step output** for tropical cyclones

NAVGEM Version 1.1

Data Assimilation

- 4D-Var with more Advanced Variational bias correction
- New radiative transfer model CRTM v2 for NPP
- NPP, GPS, SSMIS, UAS, OMPS data sets

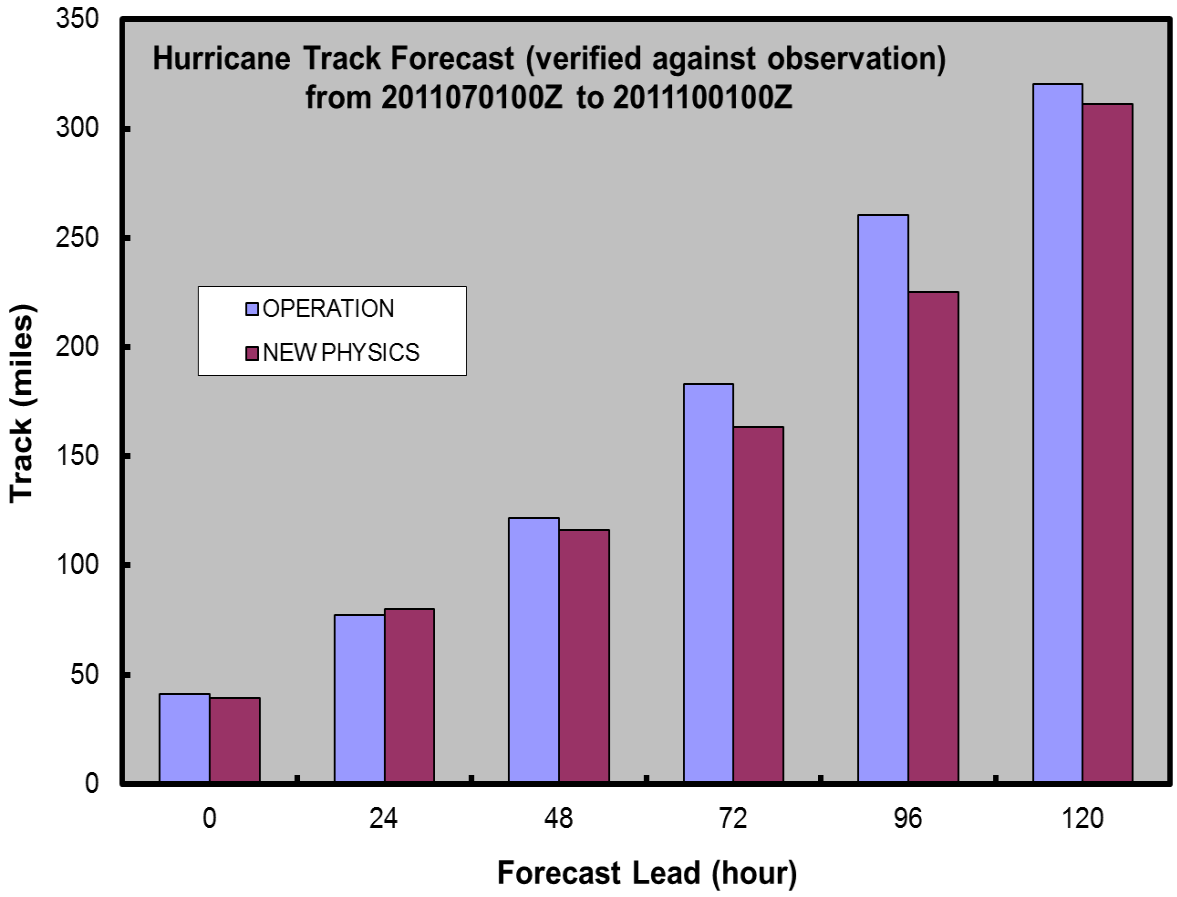
Dynamics

- SL/SI scheme
- Cubic interpolation combining with linear interpolation in the vertical
- Improved BC treatment
- T359L50 (Δx=37km, top at 0.04 hPa or ~70 km)
- Time step = 360 sec

New Physics

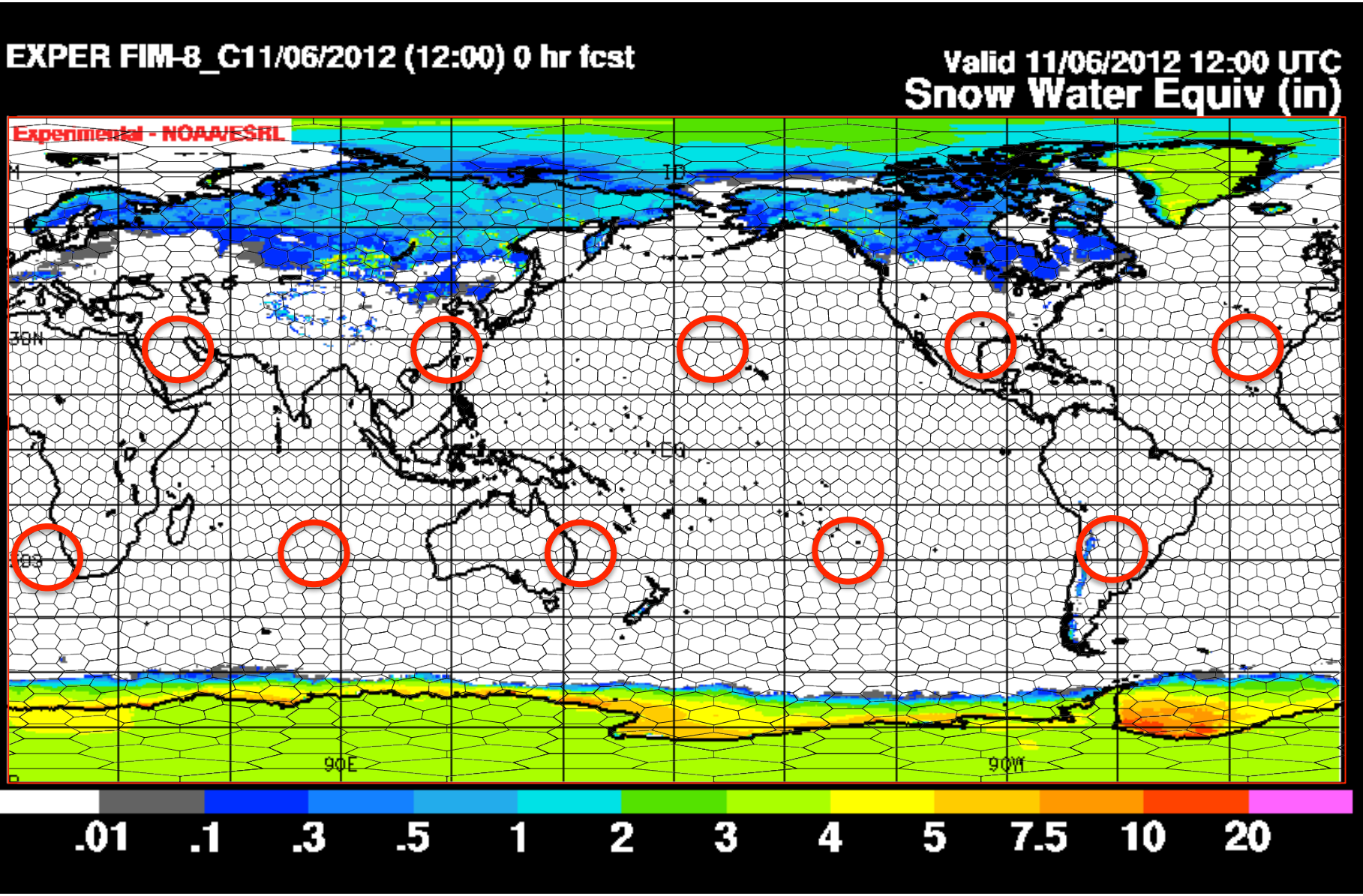
- Simplified Arakawa-Schubert scheme
- Shallow convection
- Prognostic cloud scheme with two species
- RRTMG 4-stream radiation
- Modified cloud fraction scheme
- Modified turbulent mixing scheme

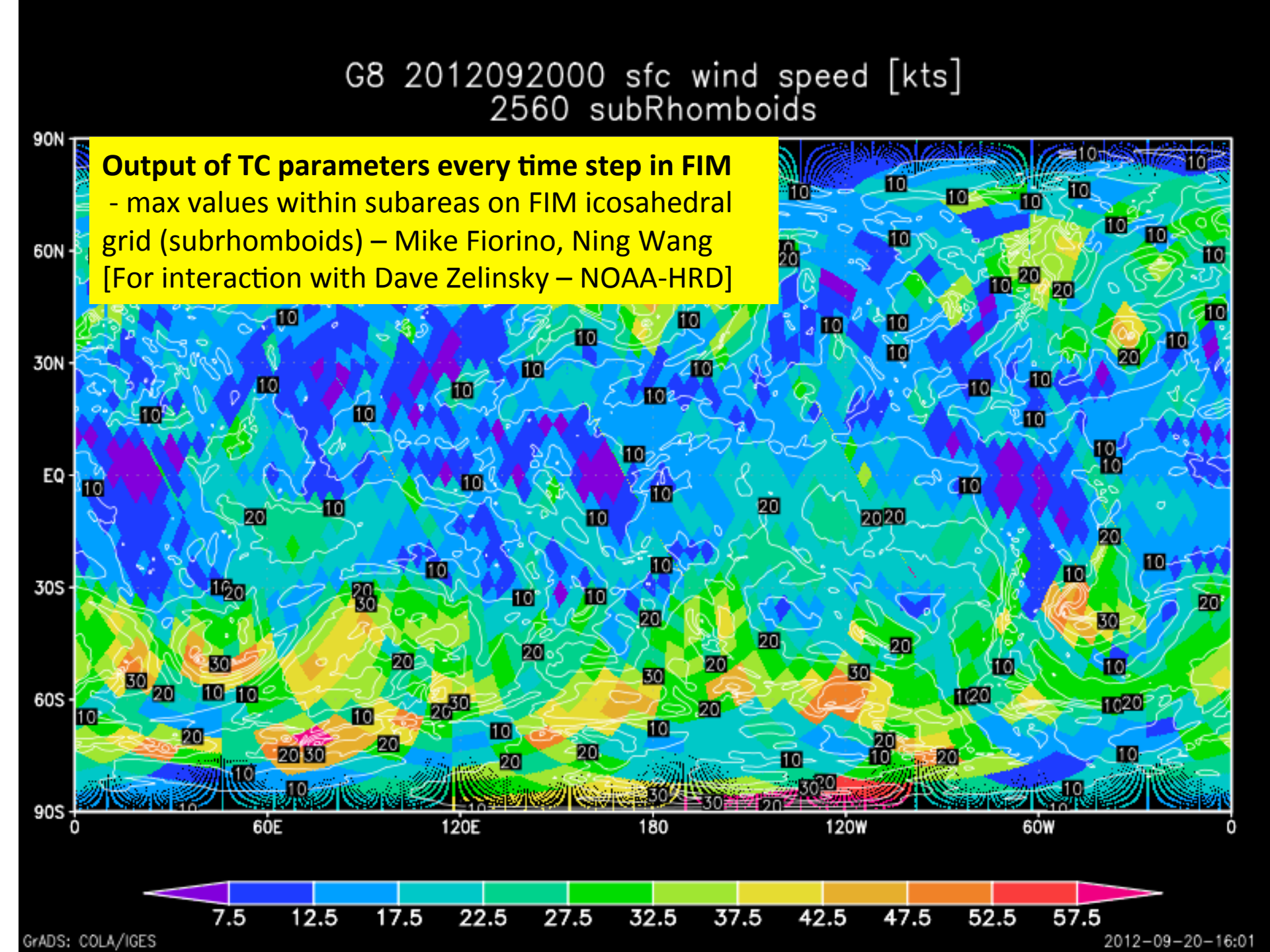
Hurricane Track Forecasts for 2011 TC season
(1 July – 1 October, 2011)



# of storms	
0h	195
24h	157
48h	126
72h	98
96h	75
120h	58

NAVGEM has smaller TC track errors for 2011


EXPER FIM-8_C11/06/2012 (12:00) 0 hr fcst
Valid 11/06/2012 12:00 UTC
Snow Water Equiv (in)
Experimental - NOAA/ESRL
90E
90W
.01
.1
.3
.5
1
2
3
4
5
7.5
10
20

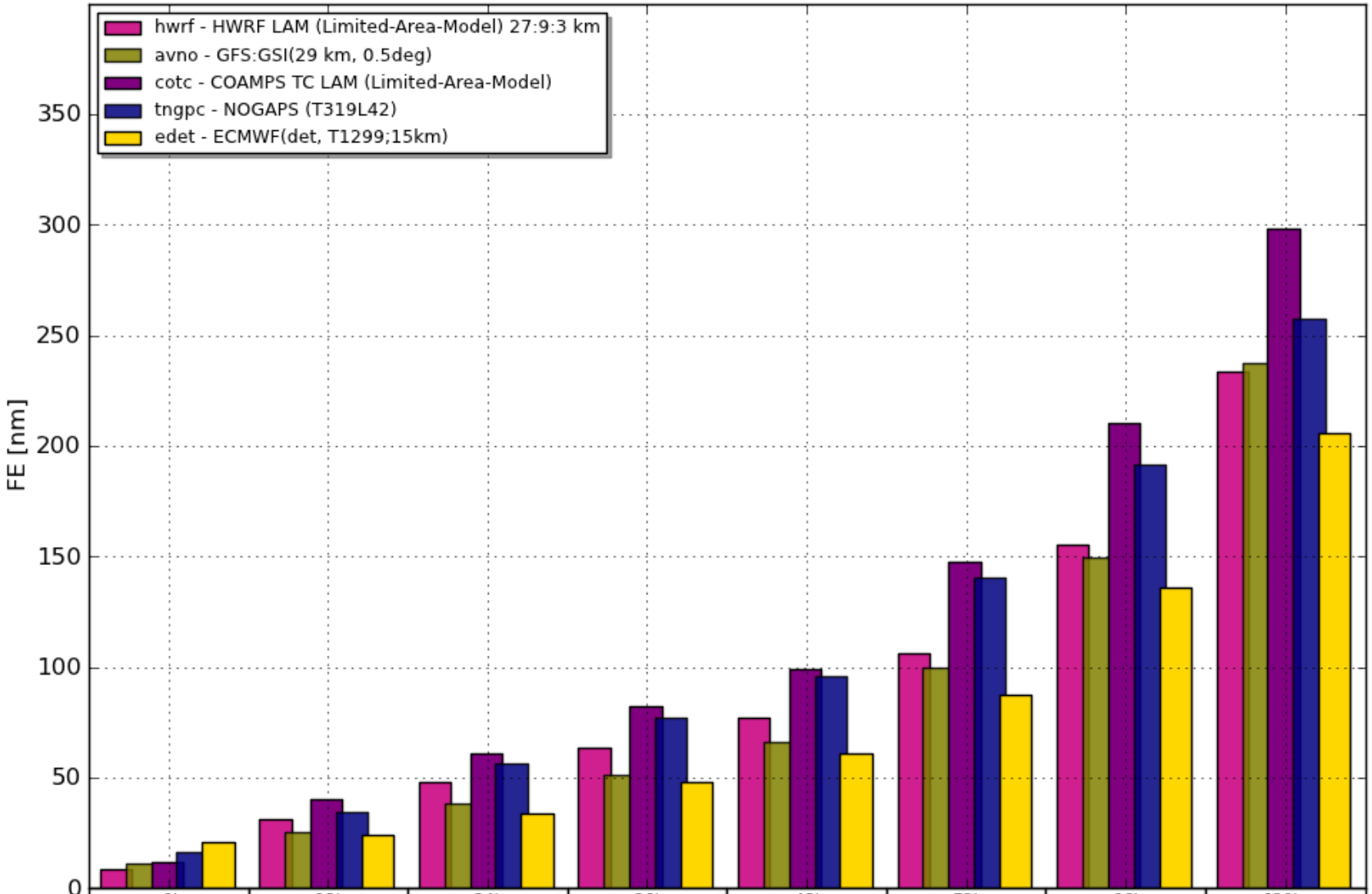

G8 2012092000 sfc wind speed [kts]
2560 subRhomboids
Output of TC parameters every time step in FIM
- max values within subareas on FIM icosahedral grid (subrhomboids) – Mike Fiorino, Ning Wang
[For interaction with Dave Zelinsky – NOAA-HRD]
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
7.5
12.5
17.5
22.5
27.5
32.5
37.5
42.5
47.5
52.5
57.5
GrADS: COLA/IGES
2012-09-20-16:01

Conclusions for HFIP global modeling

- **Progress in tropical cyclone skill from NOAA global modeling toward ECMWF global skill**
  - Equal performance from FIM and GFS to ECMWF for 48h-96h
- Clear improvement in skill from NOAA global models over HWRF
- For 2 US landfall storms:
  - Isaac – best forecasts from FIM
  - Sandy – best forecasts from ECMWF but much improved FIM and GFS forecasting using ESRL higher-resolution hybrid GSI/EnKF data assimilation.
- **Significant global model improvements in pipeline for 2013**
- **Experimental data assimilation gives promise for further improvements in 2013**
  - More work needs to be done to "synchronize" storm positions in control forecast and ensemble with hybrid DA (large initial position errors when relocation turned off, but relocation can degrade TC environment).
  - FIM cycling via ensemble data assimilation
- Need to expand retrospective testing
  - Perform tests for 5-10 year periods, not just 3-12 month periods
  - Statistical significance from 1 or even 3 hurricane seasons is limited

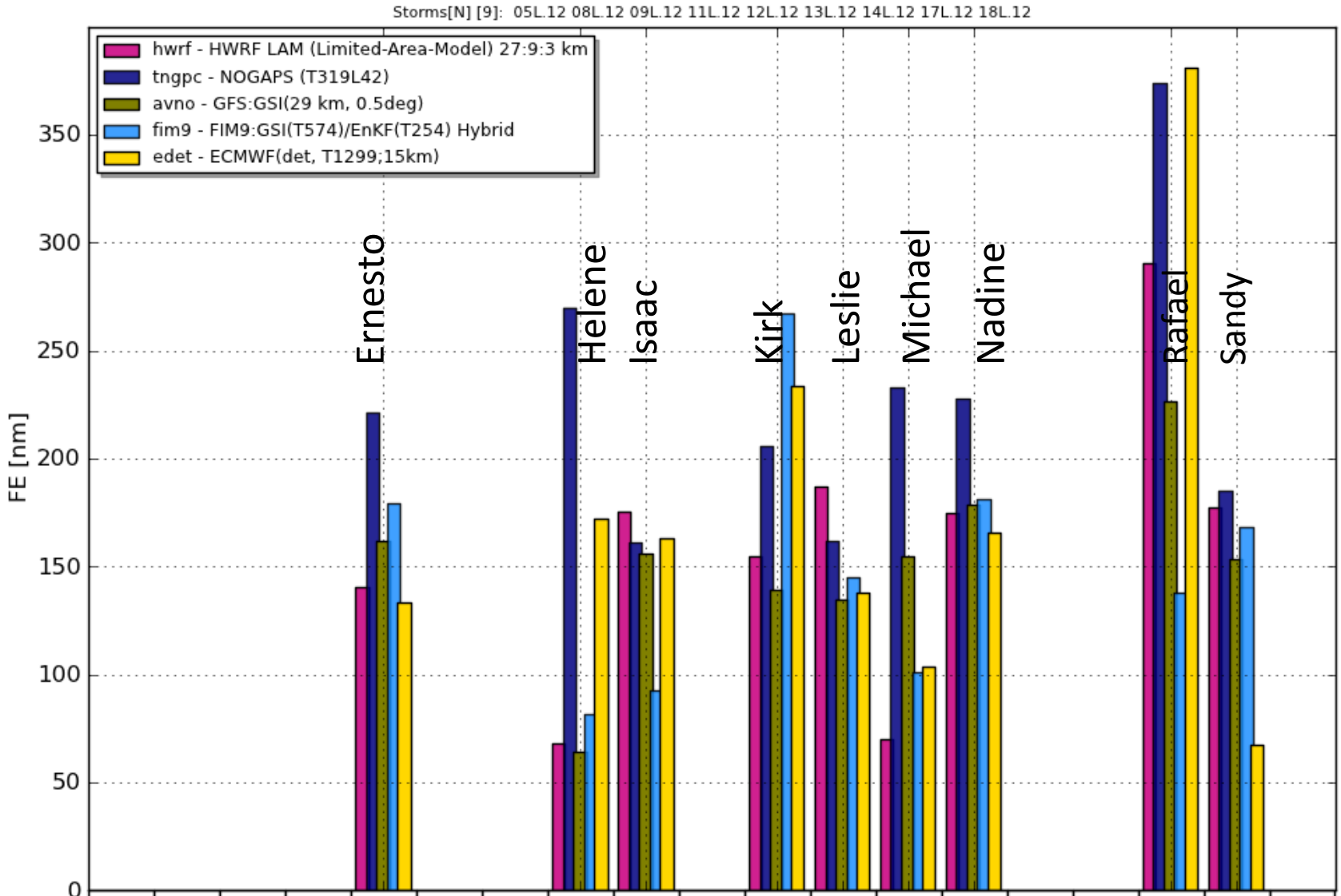
EPAC/LANT 2012 HWRF v GFS v COTC v NOGAPS v ECMWF track error

Storms[N] [22]: 05L.12 07L.12 08E.12 08L.12 09E.12 09L.12 10E.12 10L.12 11E.12 11L.12 ... 13E.12 13L.12 14E.12 14L.12 15L.12 16E.12 17E.12 17L.12 18L.12 19L.12



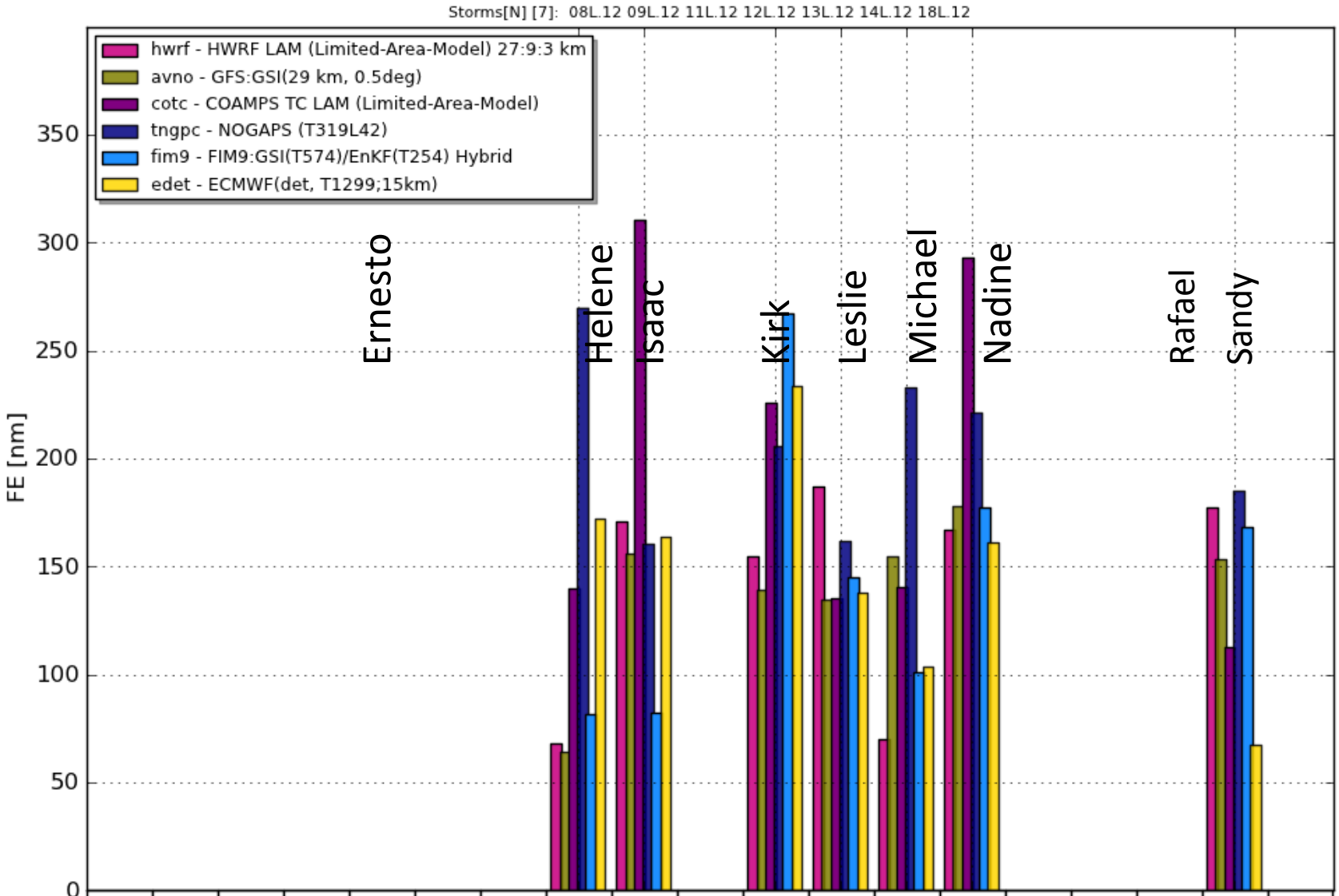
	0h	12h	24h	36h	48h	72h	96h	120h
hwrf	8[191]	31[182]	48[164]	64[144]	77[126]	106[97]	155[75]	234[56]
avno	11[191]	25[182]	38[164]	51[144]	66[126]	100[97]	149[75]	237[56]
cotc	12[191]	40[182]	61[164]	82[144]	99[126]	148[97]	210[75]	298[56]
tngpc	17[191]	34[182]	56[164]	77[144]	96[126]	140[97]	192[75]	257[56]
edet	21[191]	24[182]	34[164]	48[144]	61[126]	87[97]	136[75]	206[56]

96 h LANT 2012 HWRF v NOGAPS v GFS v FIM9 v ECMWF track error by storm



	01L	02L	03L	04L	05L	06L	07L	08L	09L	10L	11L	12L	13L	14L	15L	16L	17L	18L	19L
hwrf					141[5]			68[2]	175[8]		155[1]	187[15]	70[6]	175[26]			291[2]	177[5]	
tngpc					222[5]			270[2]	161[8]		205[1]	162[15]	233[6]	228[26]			374[2]	185[5]	
avno					162[5]			64[2]	156[8]		139[1]	135[15]	154[6]	179[26]			227[2]	154[5]	
fim9					179[5]			82[2]	93[8]		267[1]	145[15]	101[6]	181[26]			138[2]	168[5]	
edet					133[5]			172[2]	163[8]		233[1]	138[15]	103[6]	166[26]			381[2]	68[5]	

96 h LANT 2012 HWRF v GFS v COTC v NOGAPS v FIM9 v ECMWF track error by storm



	01L	02L	03L	04L	05L	06L	07L	08L	09L	10L	11L	12L	13L	14L	15L	16L	17L	18L	19L
hwrf								68[2]	171[7]		155[1]	187[15]	70[6]	167[25]				177[5]	
avno								64[2]	156[7]		139[1]	135[15]	154[6]	178[25]				154[5]	
cotc								140[2]	310[7]		226[1]	135[15]	140[6]	293[25]				113[5]	
tngpc								270[2]	160[7]		205[1]	162[15]	233[6]	221[25]				185[5]	
fim9								82[2]	82[7]		267[1]	145[15]	101[6]	177[25]				168[5]	
edet								172[2]	163[7]		233[1]	138[15]	103[6]	161[25]				68[5]	