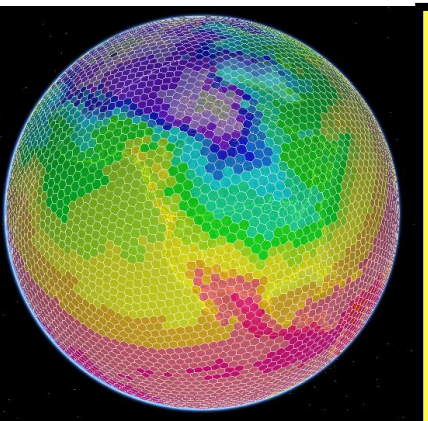
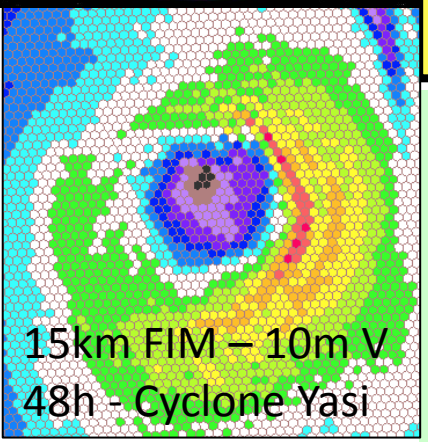




HFIP Global Model/Physics Working Group Report – Nov2011

Goal:

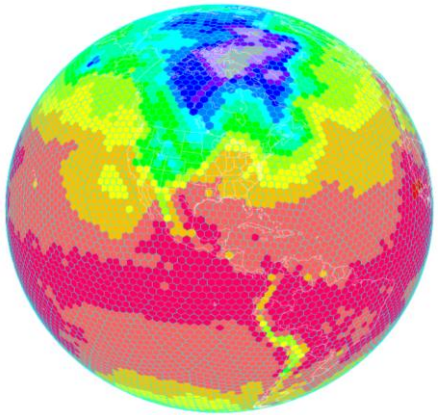
Advanced global model for improved TC forecasting

Stan Benjamin, John Brown - NOAA/ESRL
+Rainer Bleck, Susan Sahm, Shan Sun, J-W Bao,
Georg Grell, Tom Henderson, Mike Fiorino,
Phil Pegion, Jeff Whitaker
Jim Ridout (et al.) - NRL
S.-J. Lin (et al.) - GFDL
S. Moorthi, M. Iredell, Fanglin Yang - NCEP/EMC

FY11 highlights
FIM development and testing
Performance update
FY12 proposed plans and milestones

Hurricane Forecast Improvement Program | NOAA

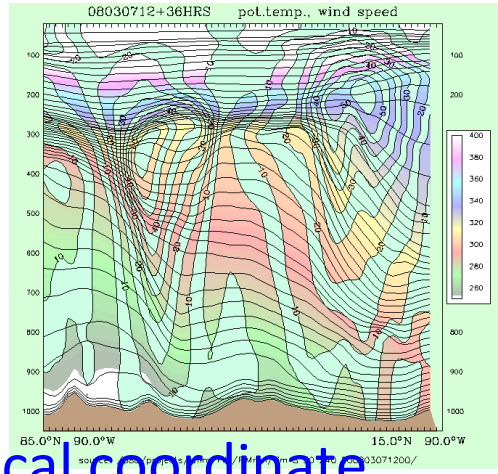
FIM purpose and configurations



Purpose: A next-generation global model for NOAA (candidate for NCEP ops, coupled model research)

Resolution

- Real-time testing at 60km, 30km, 15km resolution - icosahedral horizontal grid
- 64 vertical levels – hybrid θ-σ
- Ptop = 0.5 hPa, θ-top = 2200K



Physics

- Currently GFS physics suite (2010 version)

Initial conditions

- GFS/GSI spectral data to FIM icos hybrid θ-σ vertical coordinate
- Ensemble Kalman using GFS T254 – Jeff Whitaker, ESRL

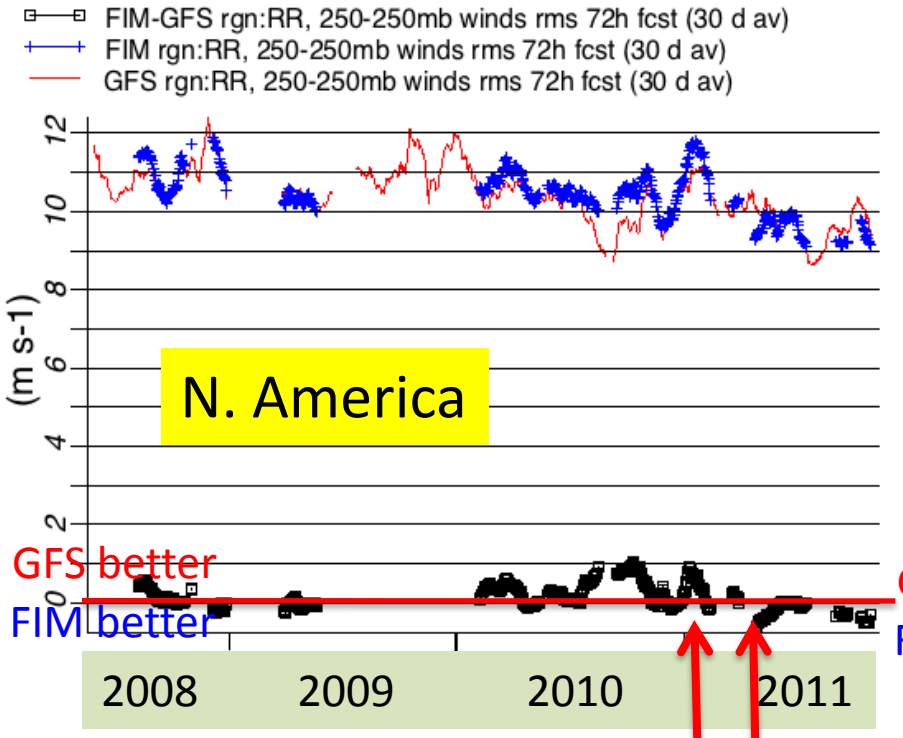
Application at NCEP

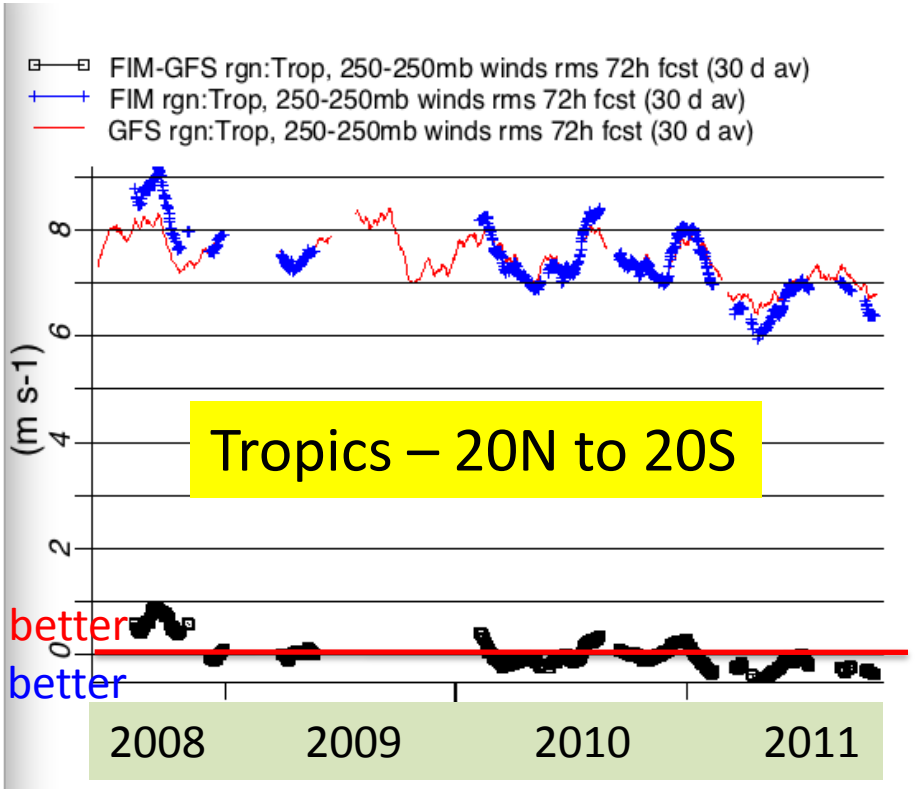
Likely application in GEFS, candidate for future global model

FIM – Most important model changes since 2010 hurricane season

1. Corrected CO2 error – Jan 11
   - Was erroneously set =0 in fall 2010 real-time runs
   - Discovered NCEP "secret" – value of CO2 ppm moved to run-time script with July 2010 version of GFS (instead of inside code as prior to July)
   - Reason for poorer real-time FIM performance in fall 2010 than in 2009
2. Corrected numerical error in flux-corrected transport – Apr 11
   - Outcome from investigation of broader than expected tropical cyclones – focused on Cyclone Yasi (Queensland landfall – 2 Feb 2011)
   - Error would not have been found without HFIP project with TC focus
3. Corrected version recommended for Stream 1.5 by TCMT after 2008/2009/2010 reruns

GFS vs. FIM – 250 hPa winds
72h forecasts verified against raobs

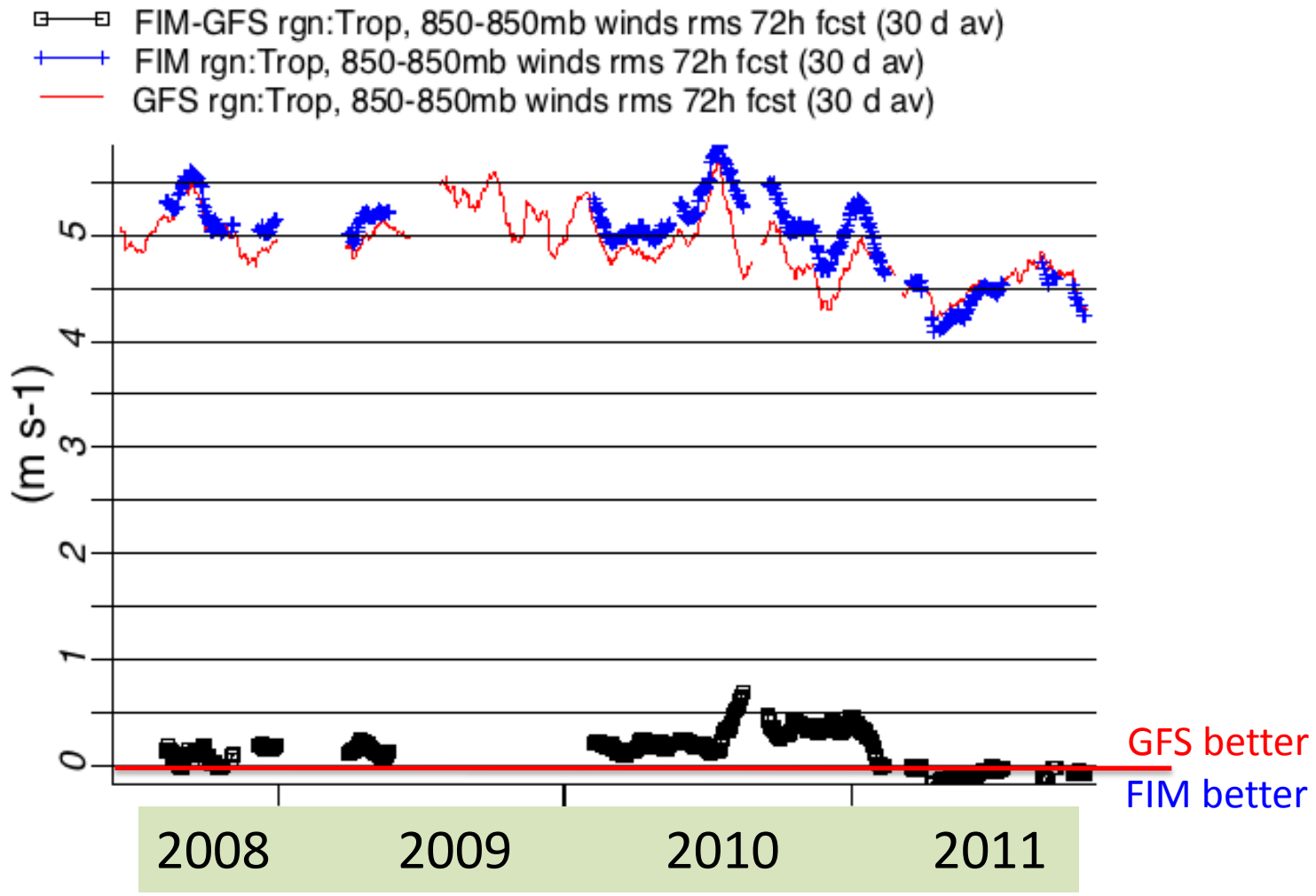




Jan 2011 – CO2 fix

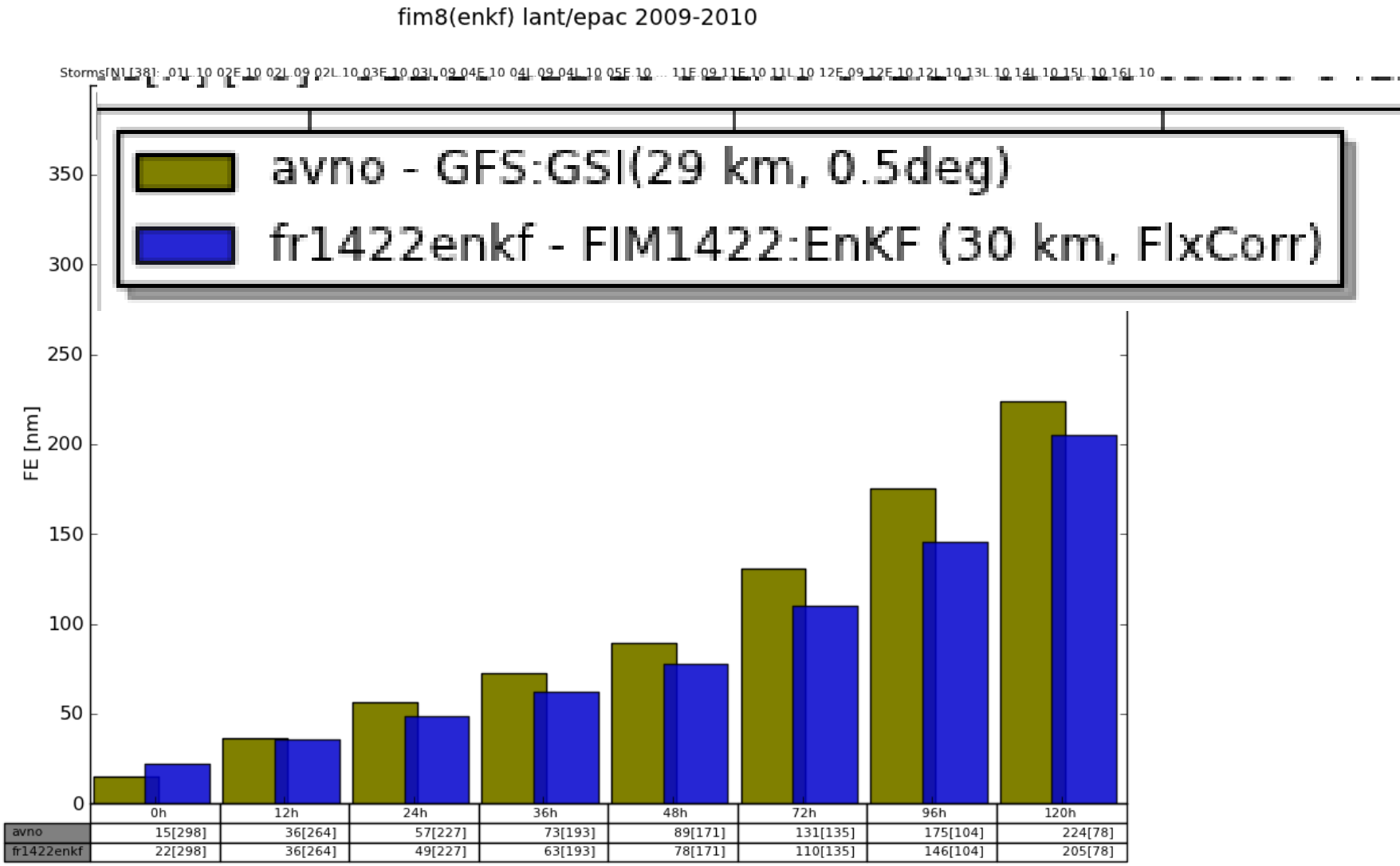
April 2011 – FCT fix

GFS vs. FIM – **850** hPa winds
72h forecasts verified against raobs



2009-2010 reruns with corrected FIM

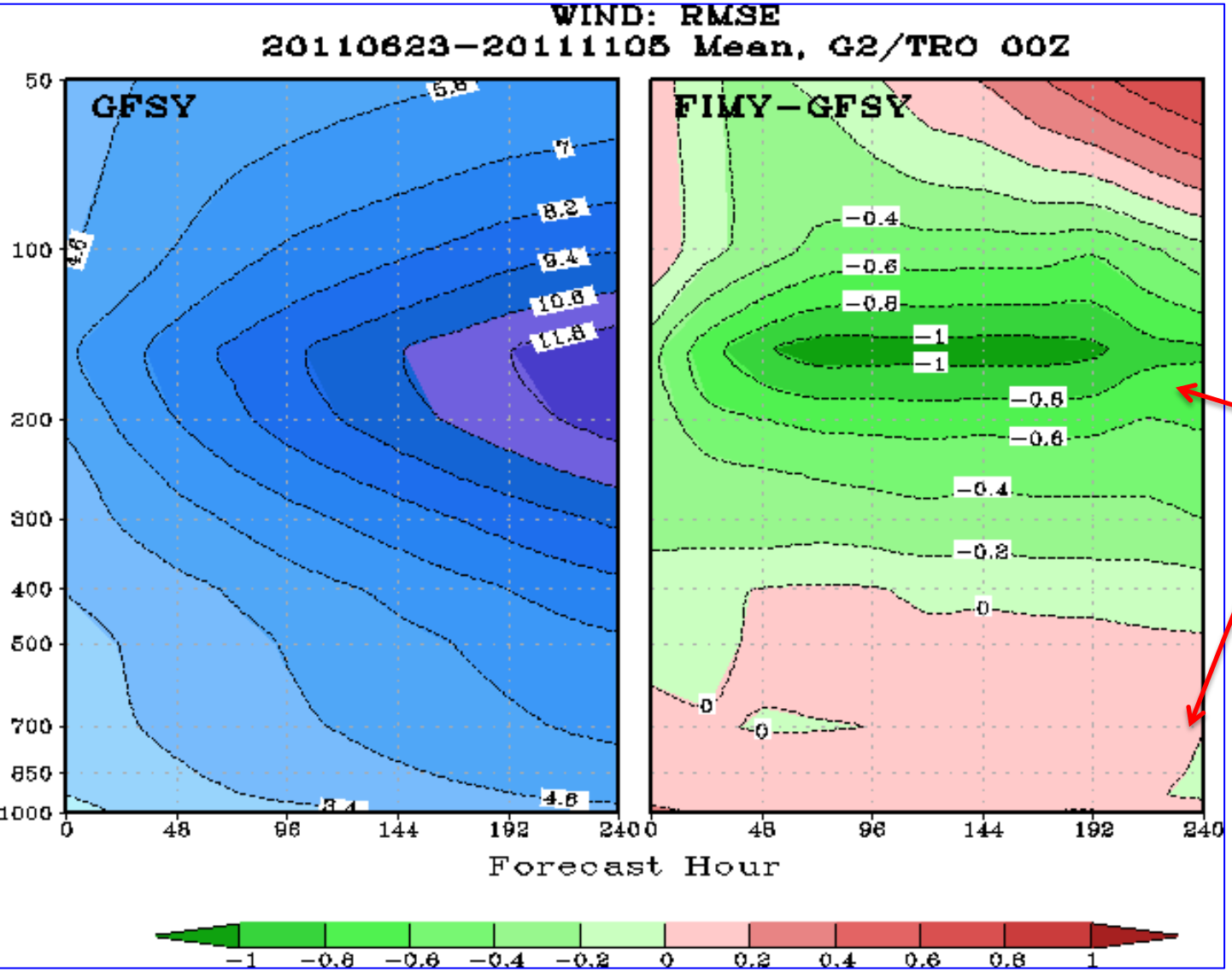
(and with EnKF initial conditions) – LANT/EPAC



	0h	12h	24h	36h	48h	72h	96h	120h
avno	15[298]	36[264]	57[227]	73[193]	89[171]	131[135]	175[104]	224[78]
fr1422enkf	22[298]	36[264]	49[227]	63[193]	78[171]	110[135]	146[104]	205[78]

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

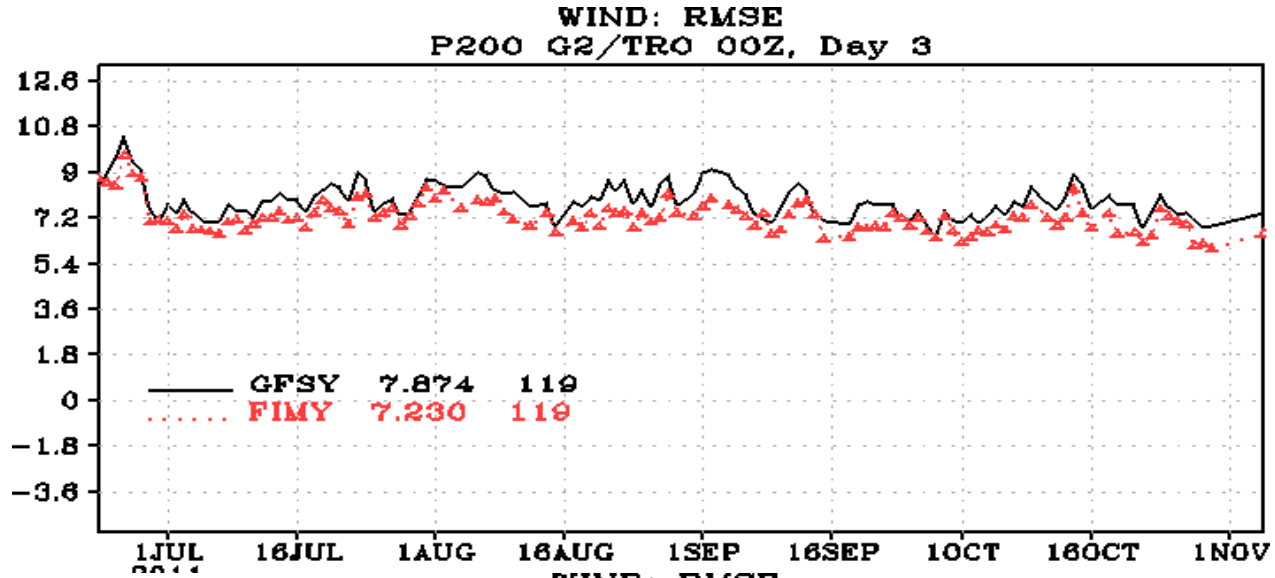
From http://www.emc.ncep.noaa.gov/gmb/wx24fy/fimy/

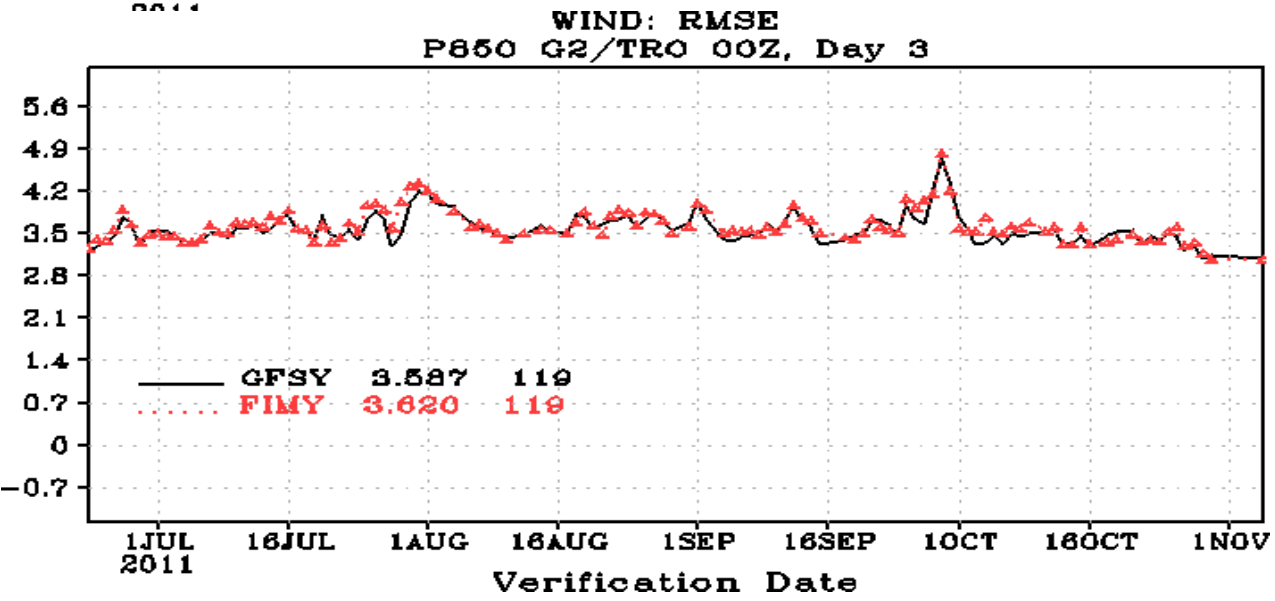


FIM – significant improvement over GFS in tropical upper-level winds (at 200 hPa), little difference in lower troposphere

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

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





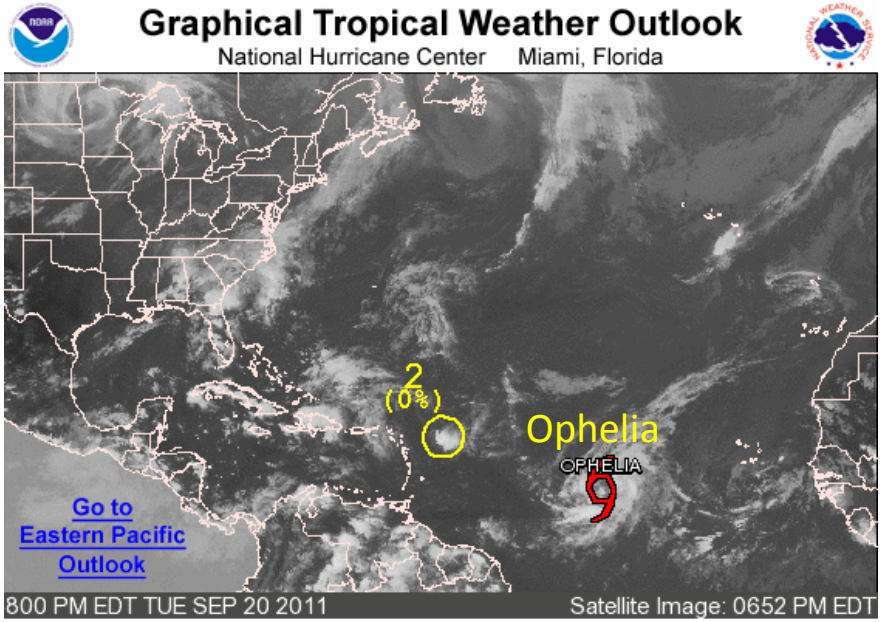
FIM improvement over GFS in tropical upper-level winds (at 200 hPa) is consistent – occurs in every run

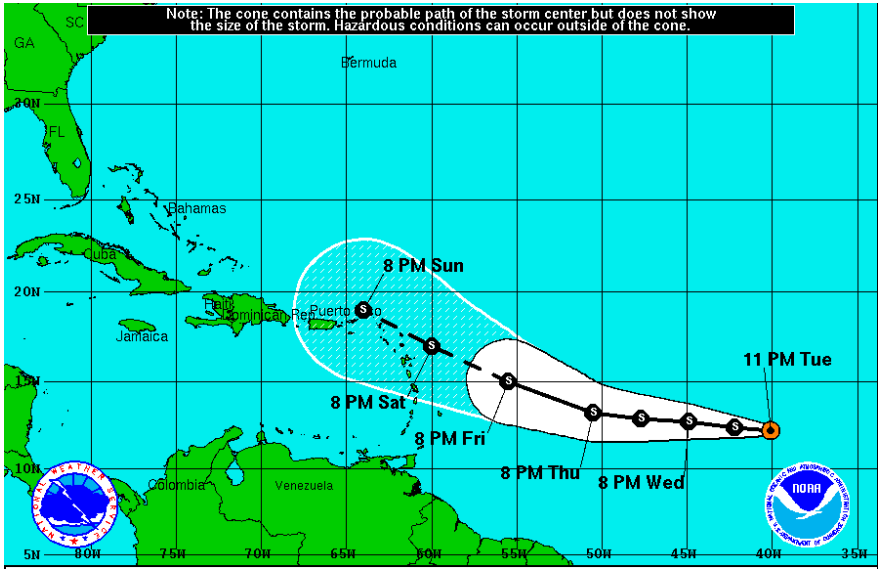
… and little difference in tropical 850 hPa winds

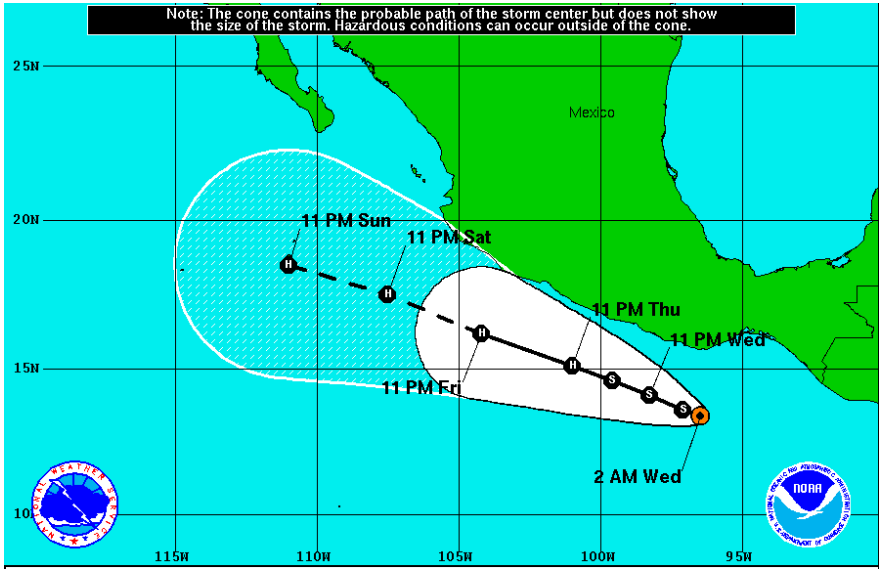
Versions of FIM running – Fall 2011

	Resolution	Init conds	Physics	Stream 1.5
FIM	30km	**GSI**	GFS (July 2010)	No
FIMY - Stream 1.5	30km	**EnKF**	GFS	Yes
FIM9	**15km**	EnKF	GFS	No
FIMX	60km	GSI/cyc chem	GFS + WRF-chem, testing of Grell cu	No
FIM7	60km	GSI	GFS	No
FIMens	60km, 10mem	EnKF	GFS	No
FIMens	27km, 4mem	EnKF	GFS	No

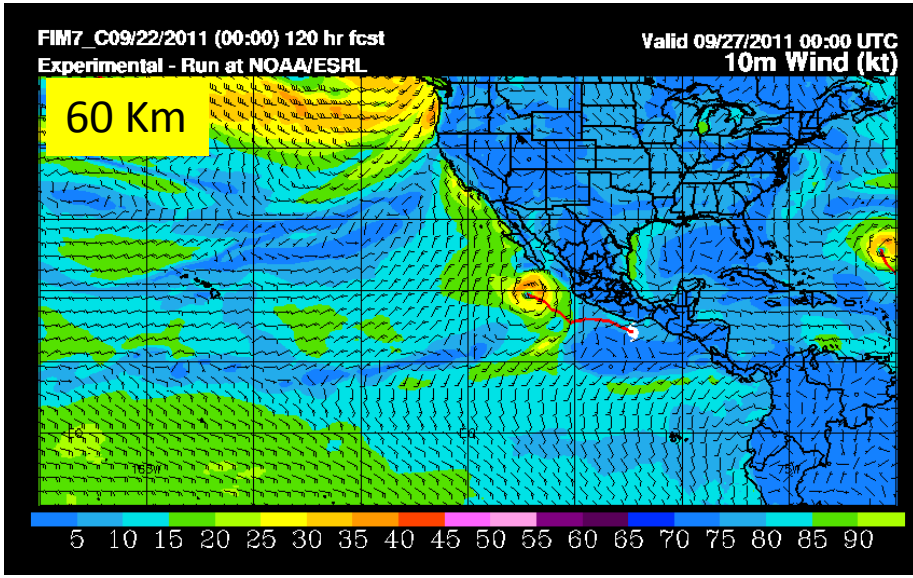
HFIP Global EnKF using GFS and FIM: Ophelia and Hilary
Initialized 00z Wednesday 21 Sep 2011

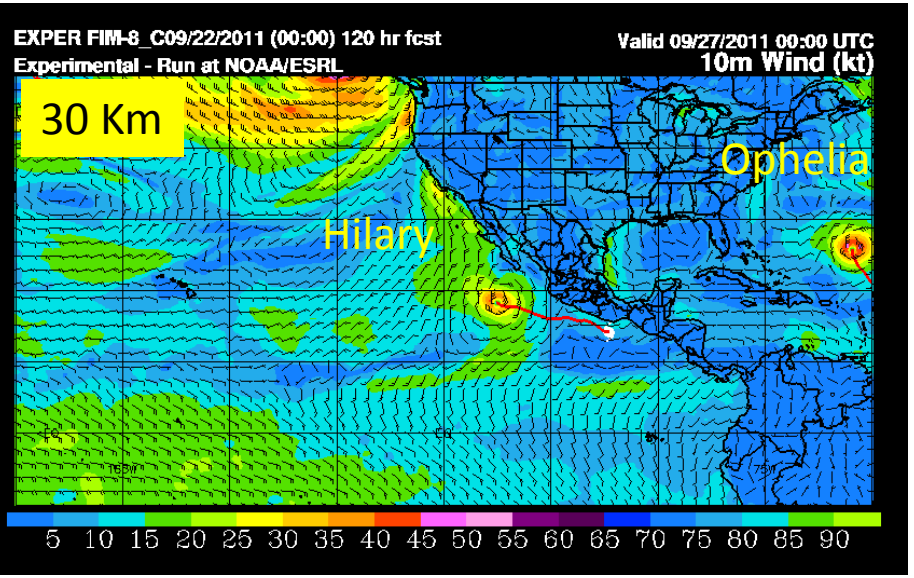




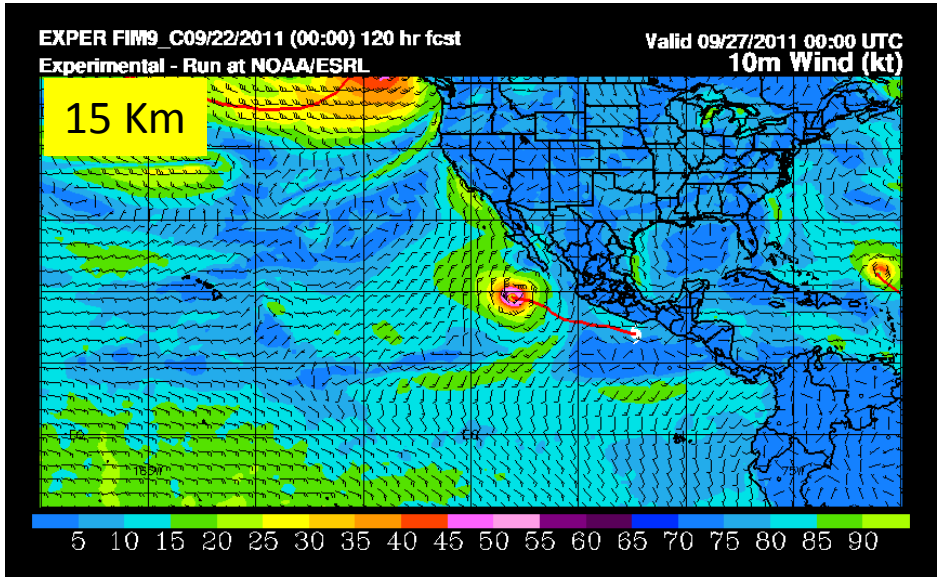


120h 10-m FIM Forecasts from 00Z 22 Sep 2011
Hilary and Ophelia – scale dependence

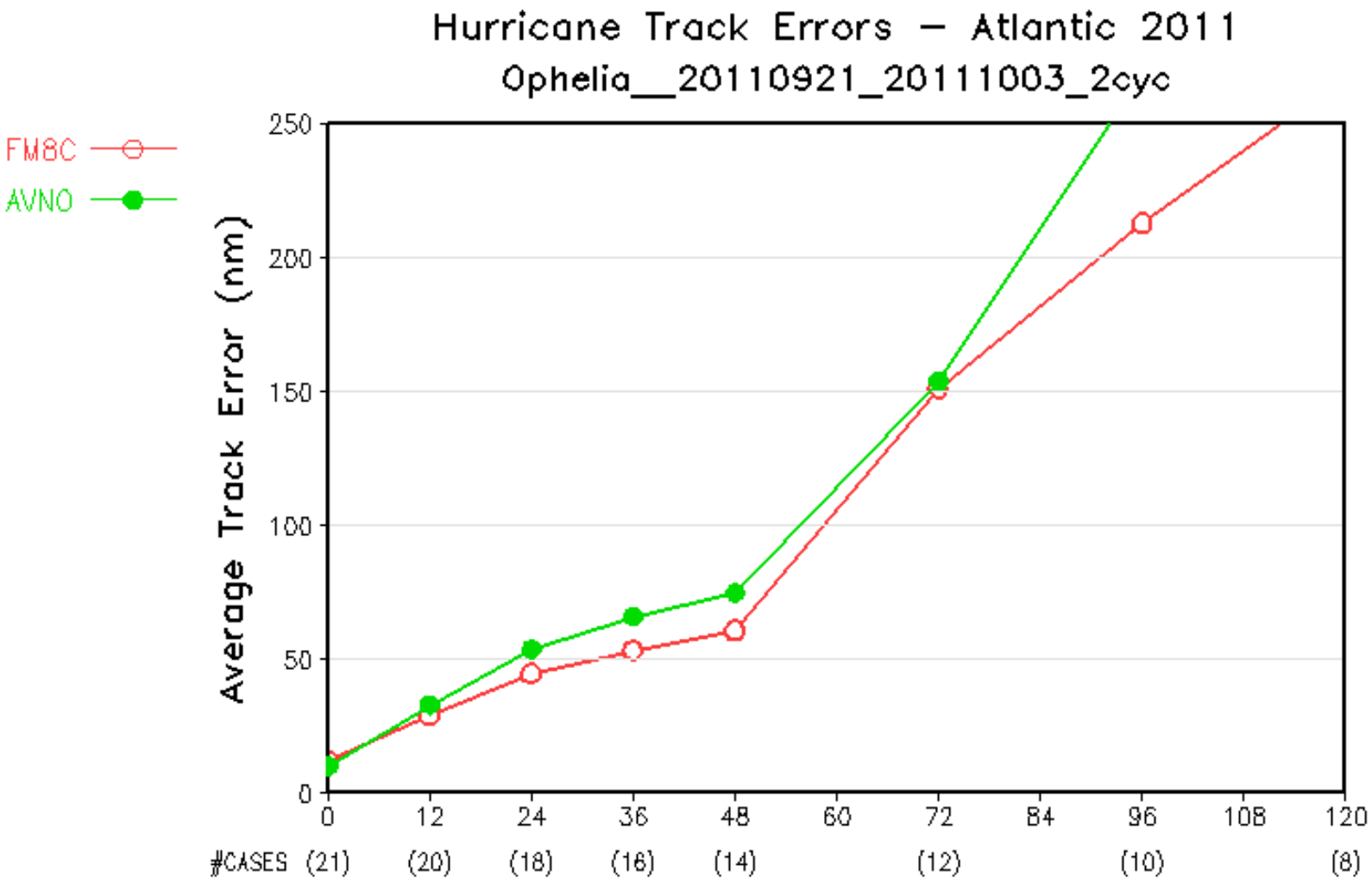




One might expect that the higher resolution runs would produce the smallest, strongest storms. Here, Ophelia is smaller (radius of max wind) at higher resolution, but strongest (in terms of 10-m wind speed) at 30km. Hilary is strongest at 15km, largest, as expected, at 60km.

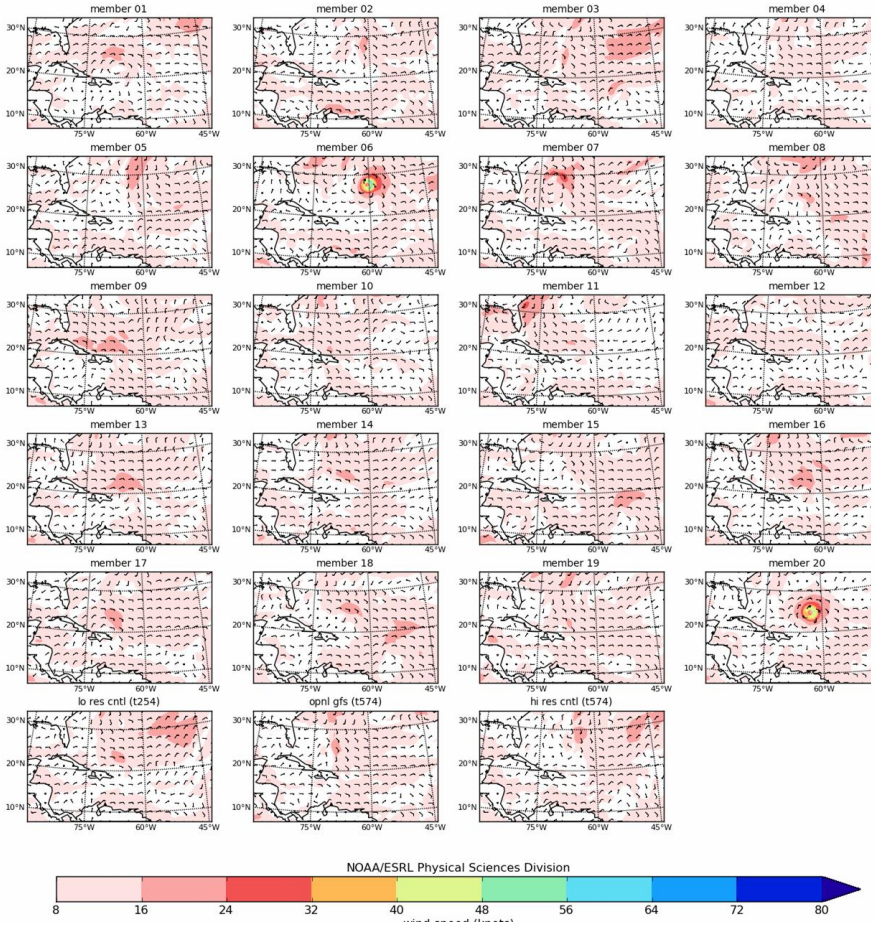


Ophelia – track forecasts

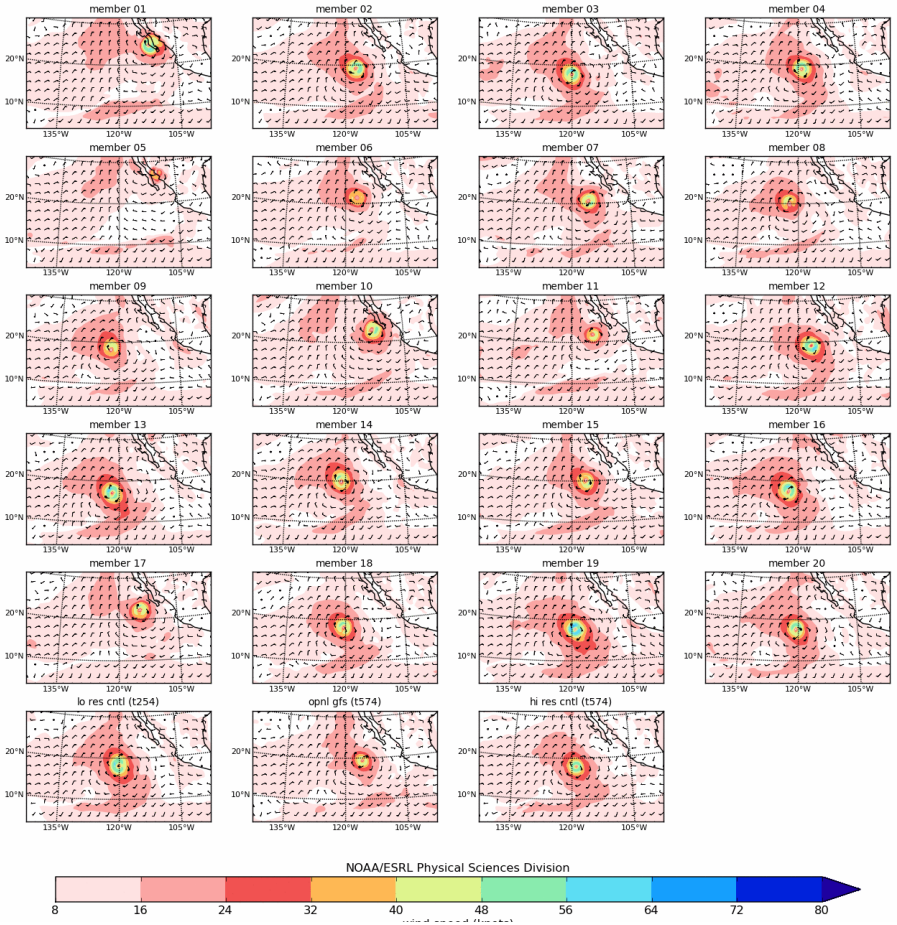


00Z 21 Sep 2011 initial time GFS/EnKF ensemble: contrasting views of Hilary and Ophelia

Only 2 members strengthen Ophelia, while all the members strengthen Hilary, with a couple of members much faster turning it to the NNE.



Ophelia: 168-h valid 00z 28 September

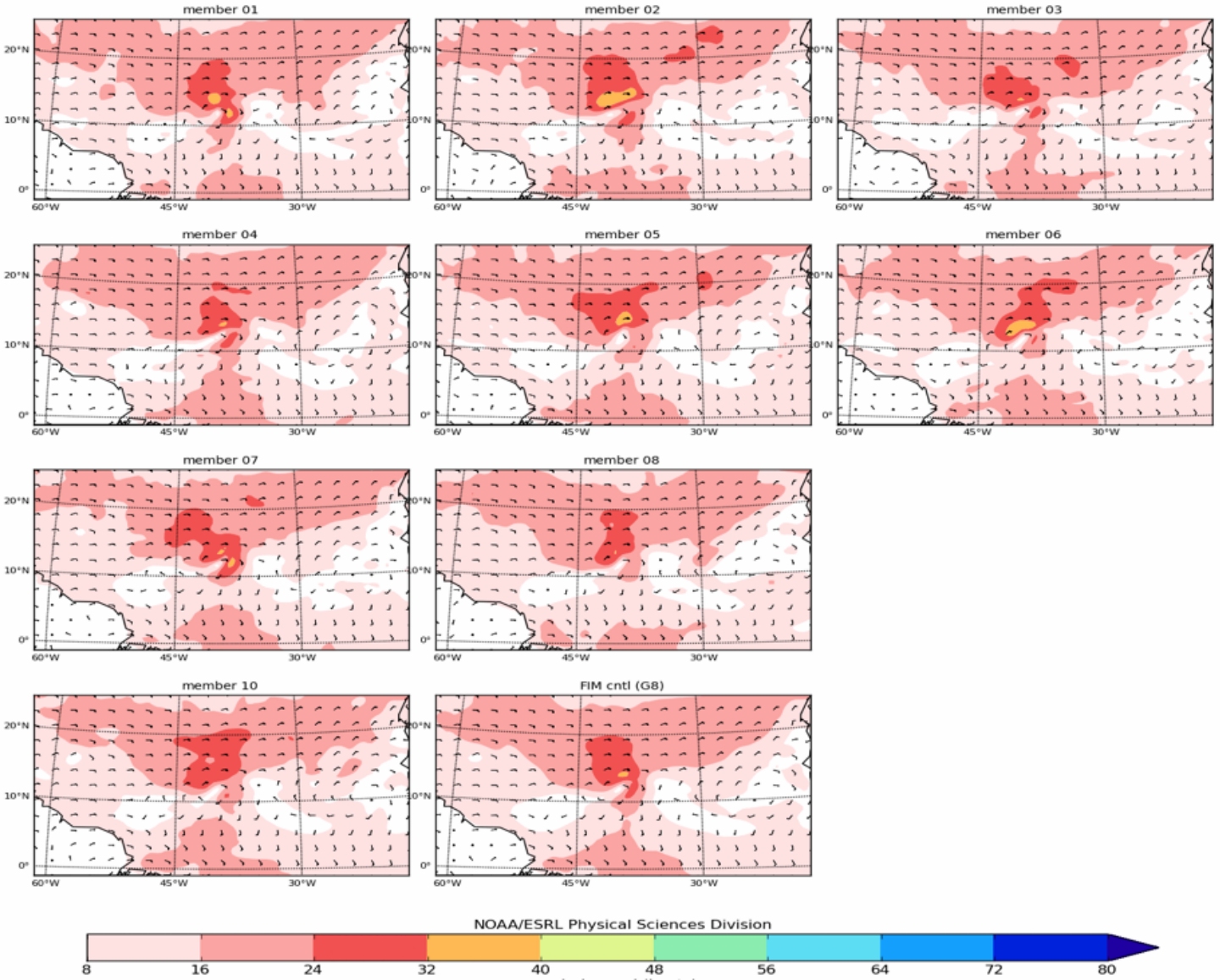


Hilary: 168-h valid 00z 28 September

Example of FIM forecast (Ophelia) Initial time: 00Z 21 Sep 2011

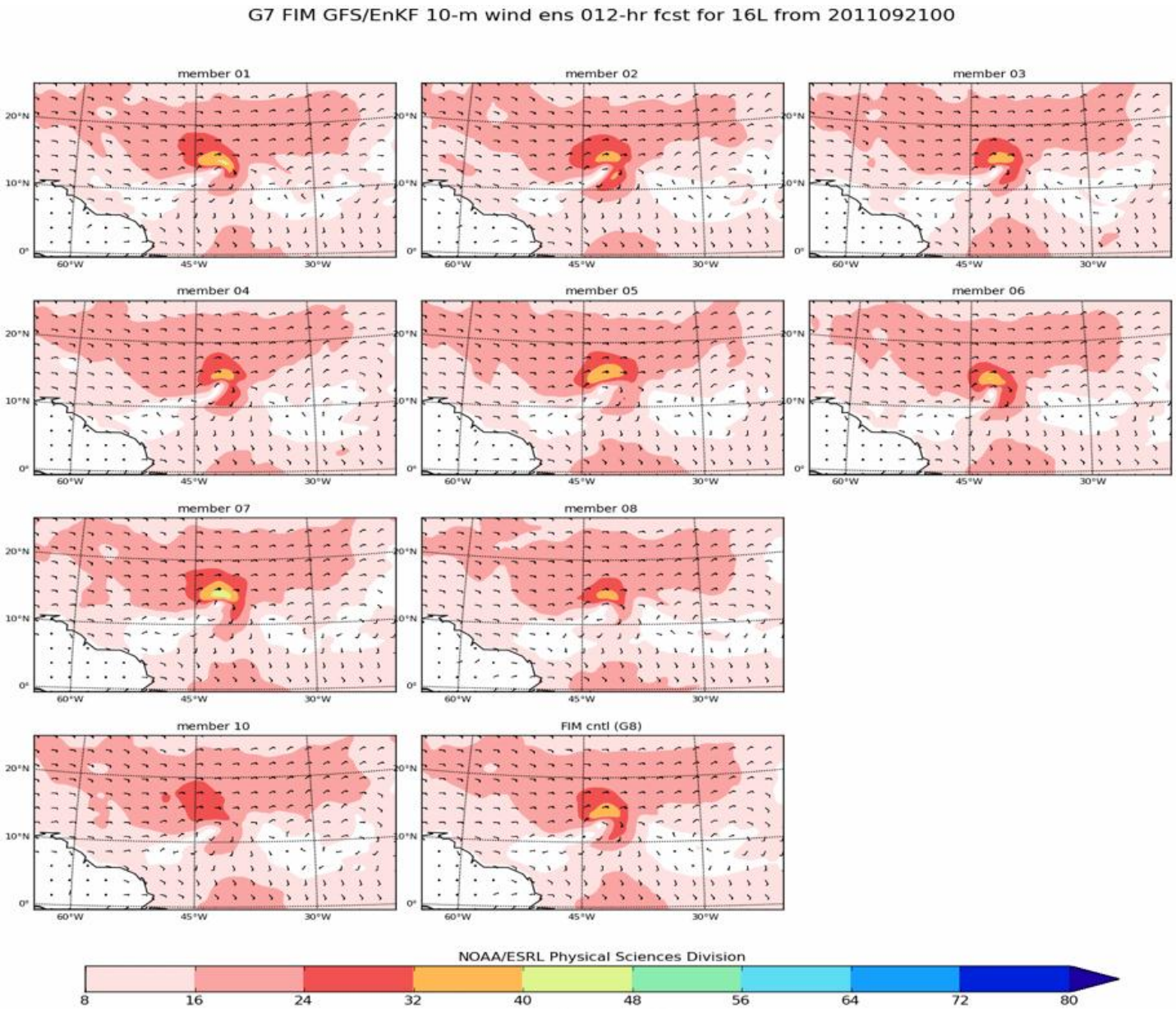
- Ophelia first strengthens in most of the members, then by 120h it has weakened in most members as it passes W of ~ 55W.
- Next few slides show the sequence (every 12h) of the individual 60km FIM ensemble-member forecasts of 10-m wind.
- Lowest image in middle column is from the EnKF-initialized G8 (30-km) run, others are G7 (60km).

00z 21 Sep 2011 initial
10-m wind

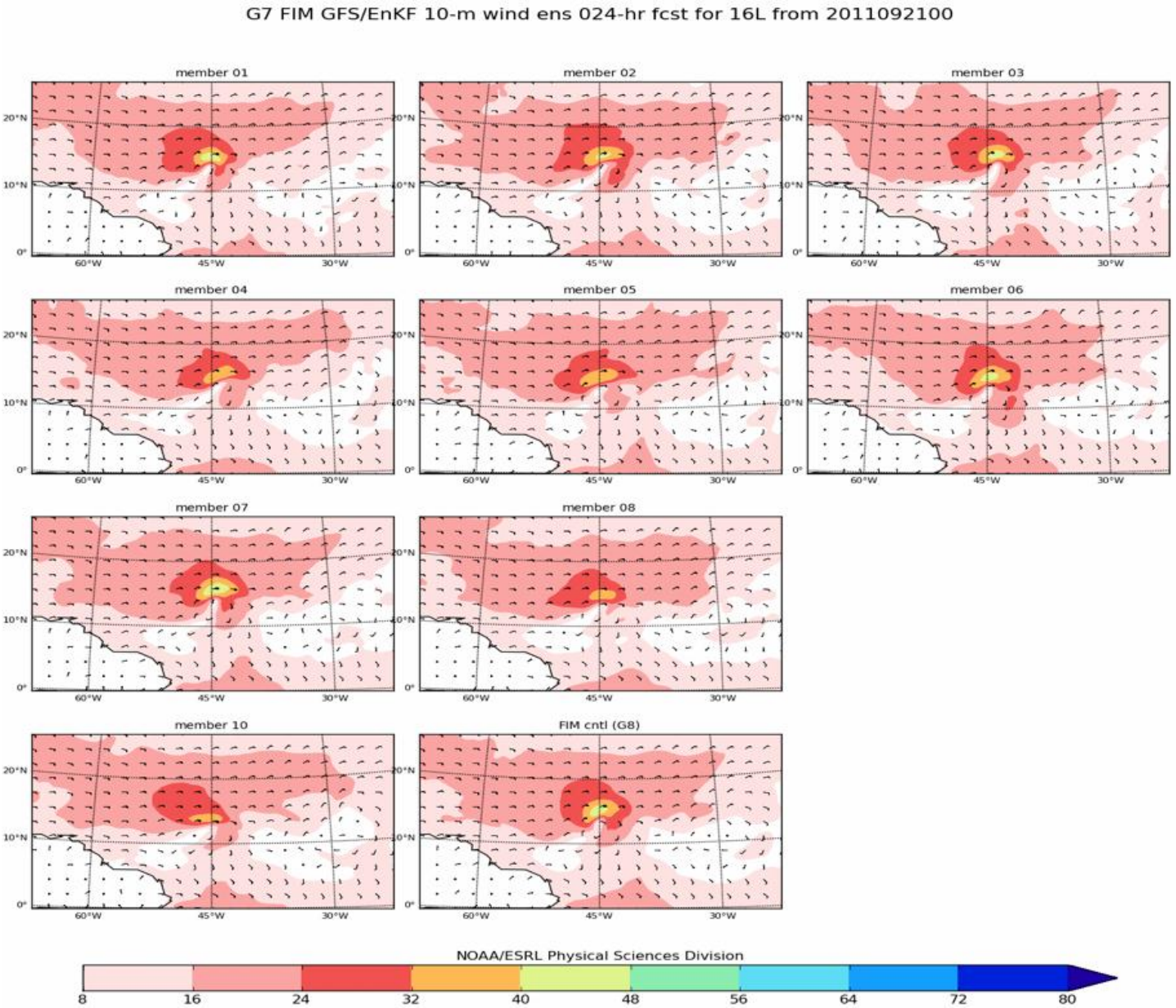


12-h Fcst Valid 12z 21 Sep 2011

10-m wind

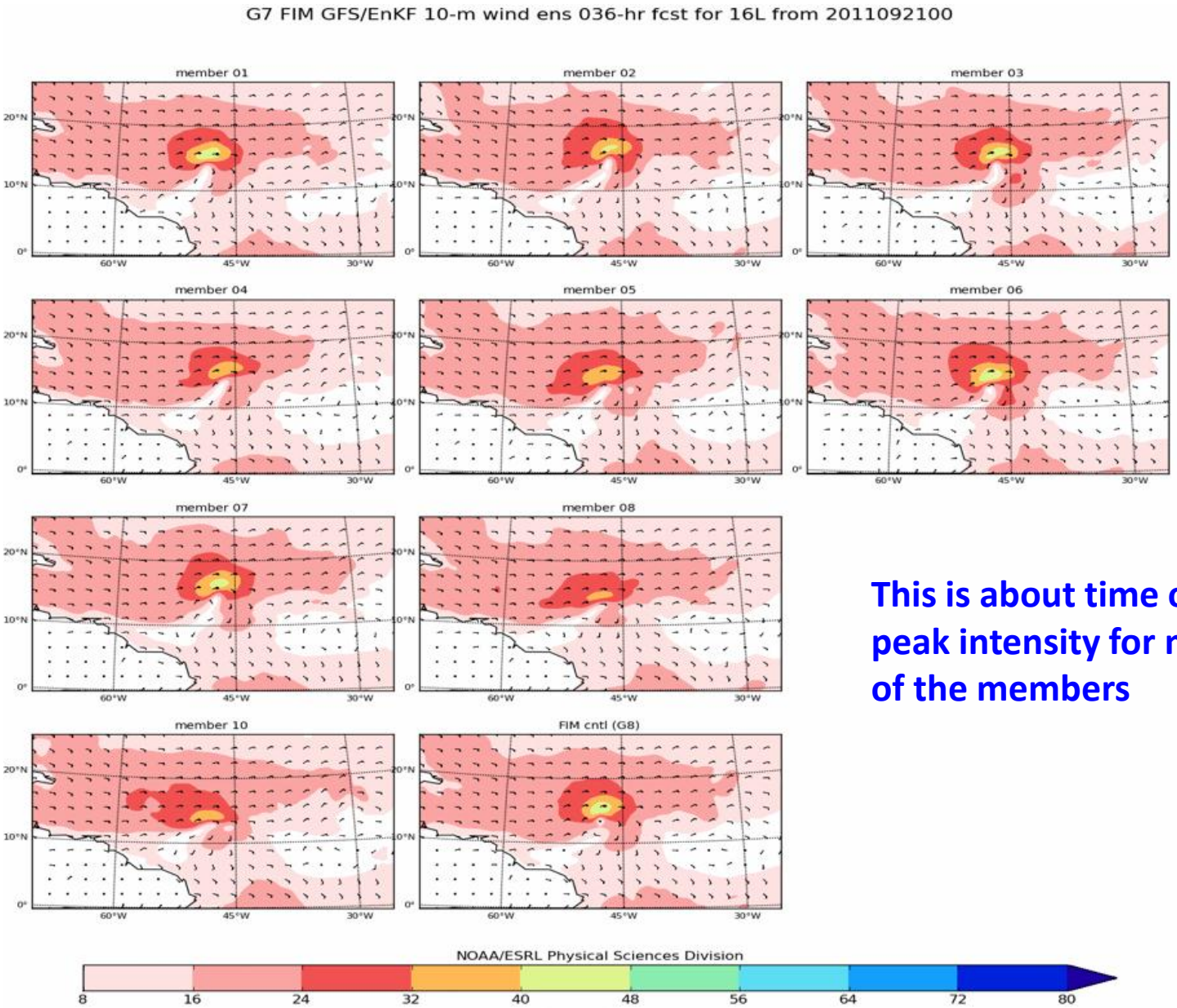


24-h Fcst Valid 00z 22 Sep 2011
10-m wind



36-h Fcst Valid 12z 22 Sep 2011

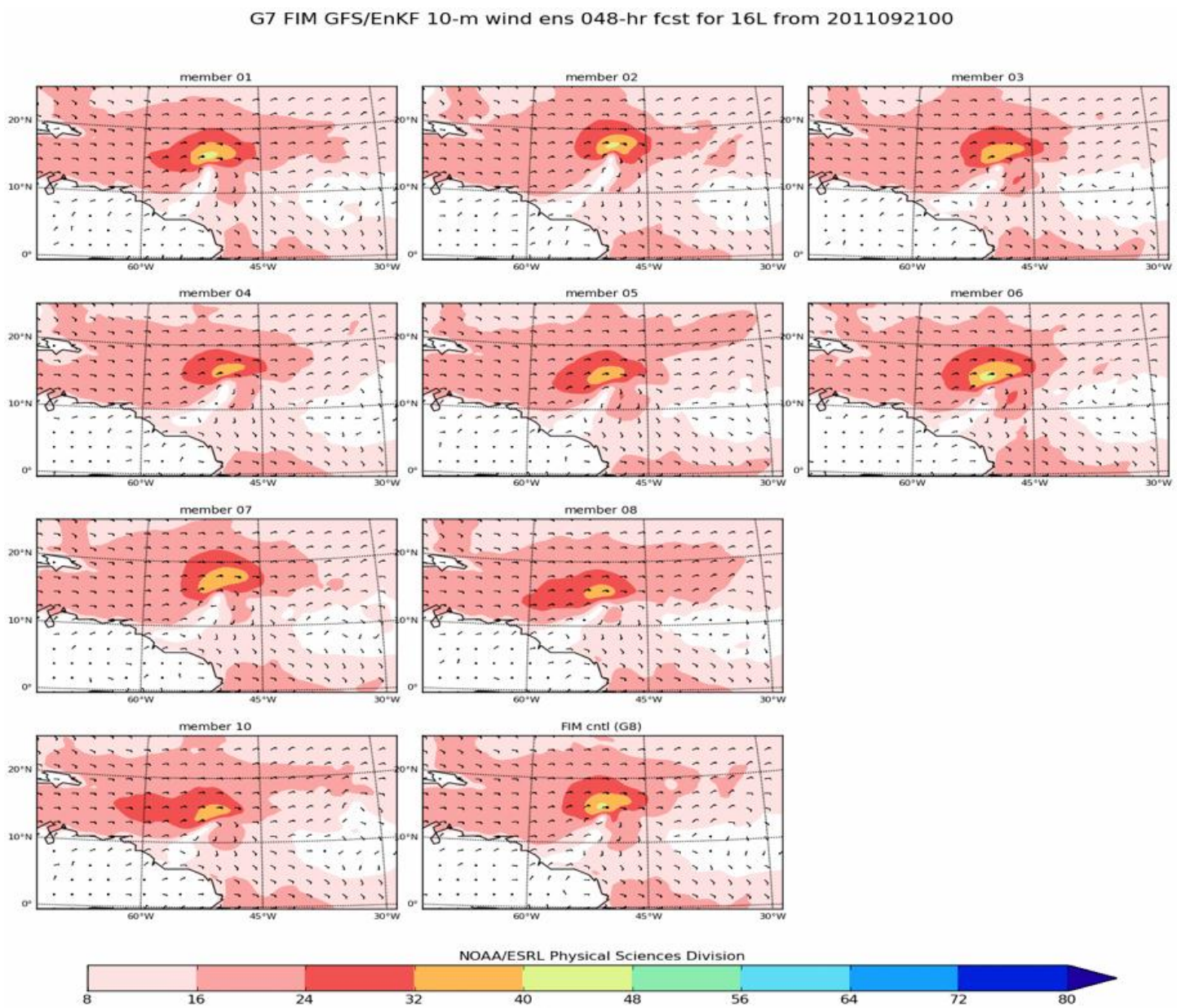
10-m wind



This is about time of peak intensity for most of the members

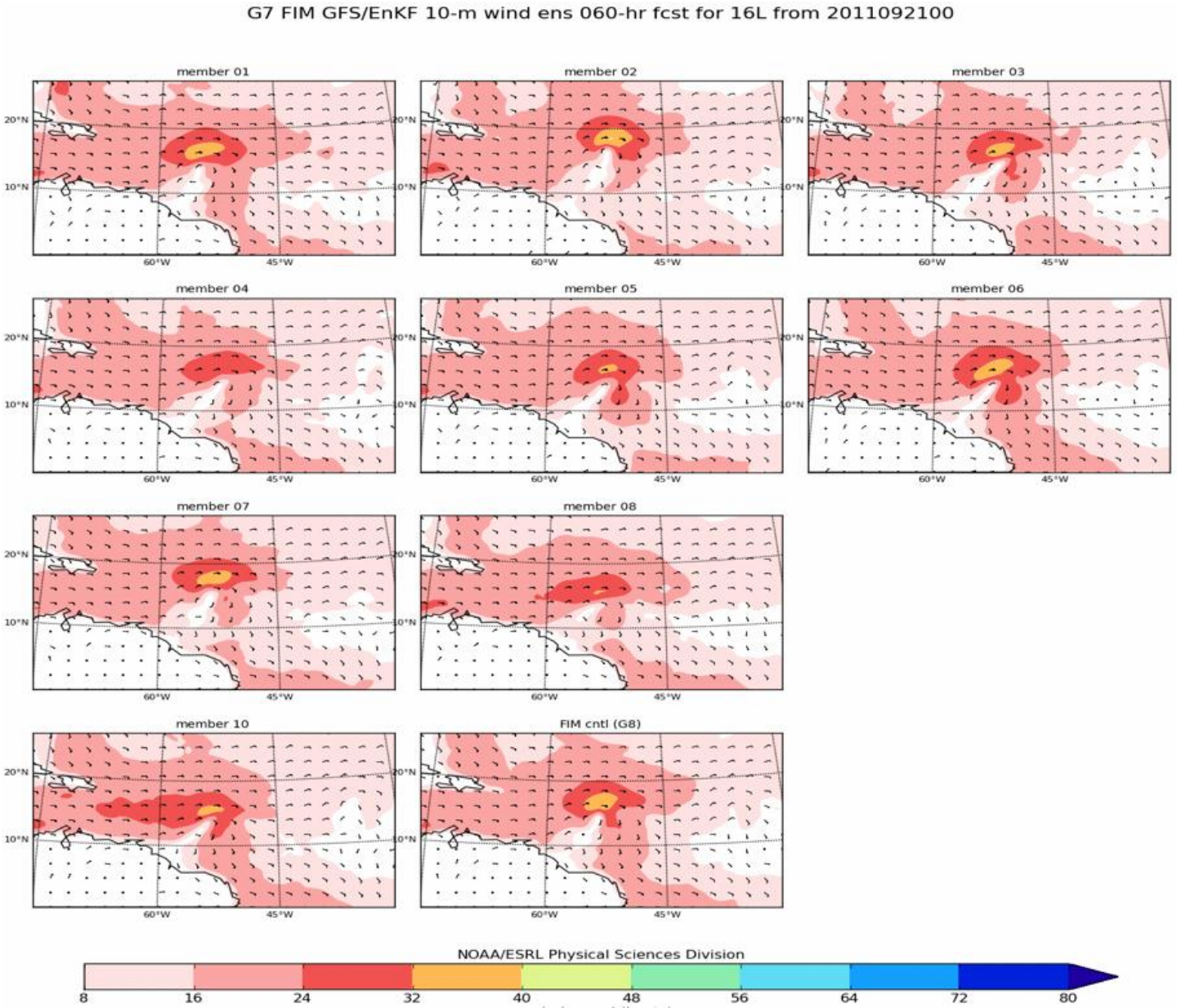
48-h Fcst Valid 00z 23 Sep 2011

10-m wind



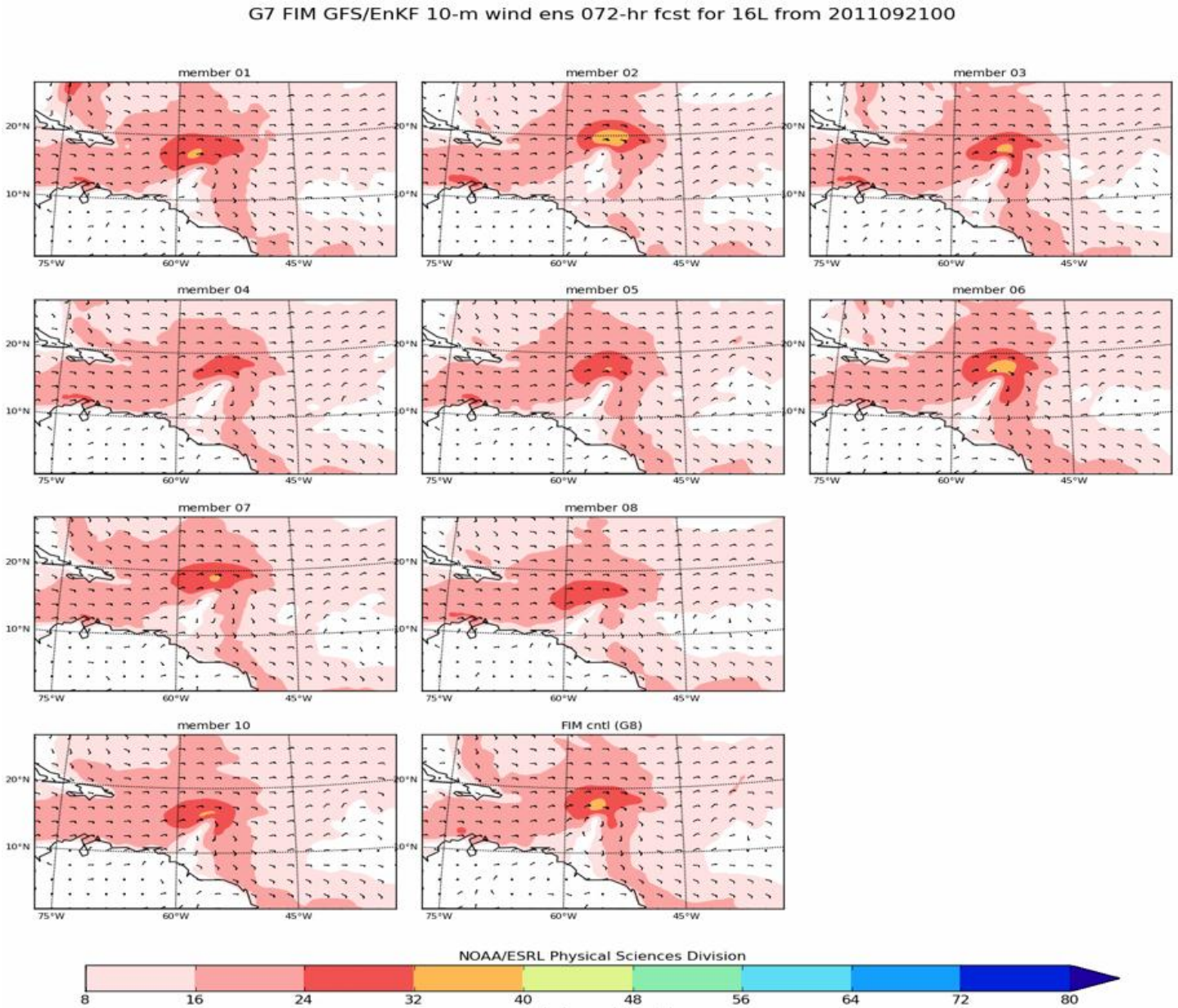
60-h Fcst Valid 12z 23 Sep 2011

10-m wind



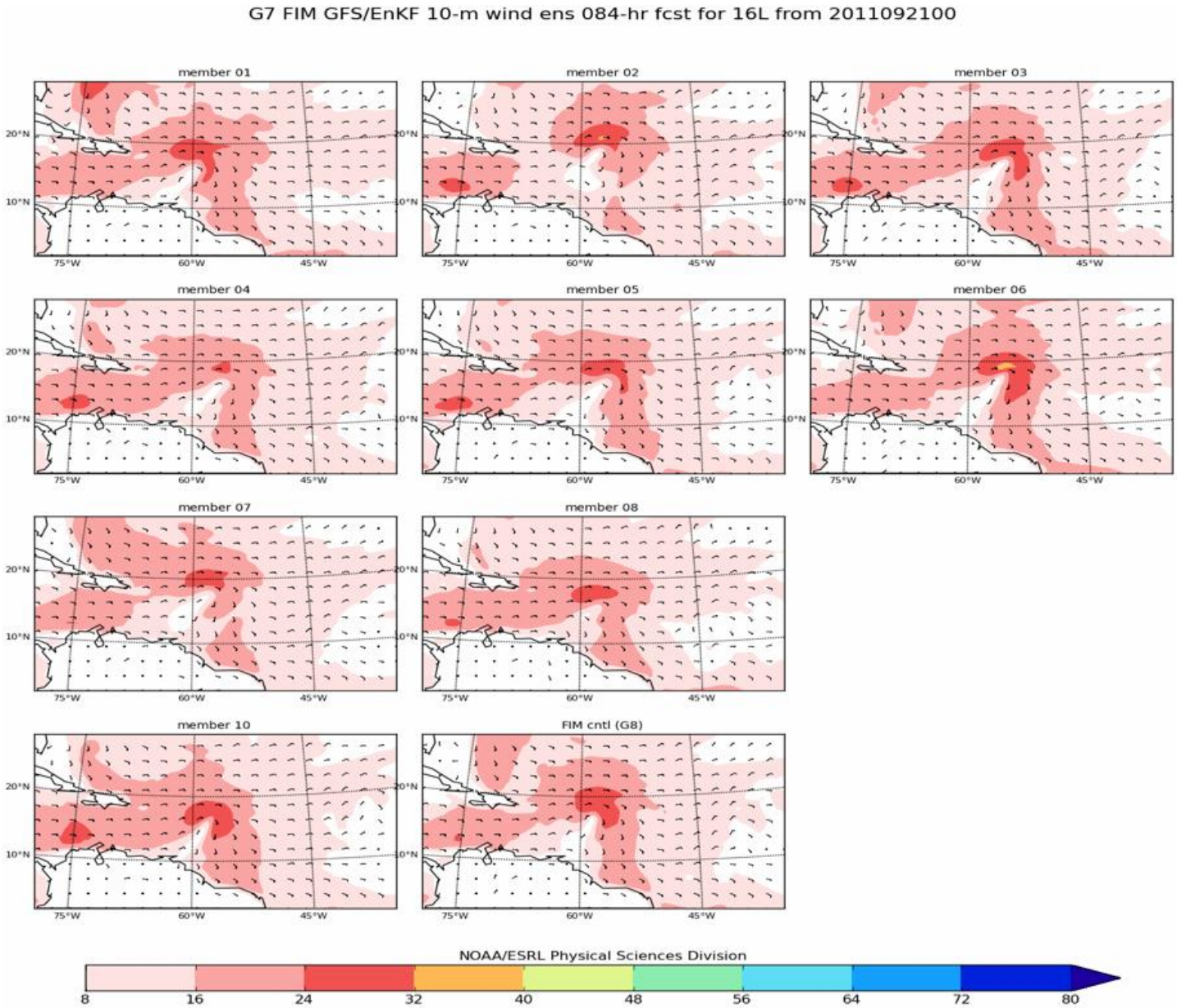
72-h Fcst Valid 00z 24 Sep 2011

10-m wind



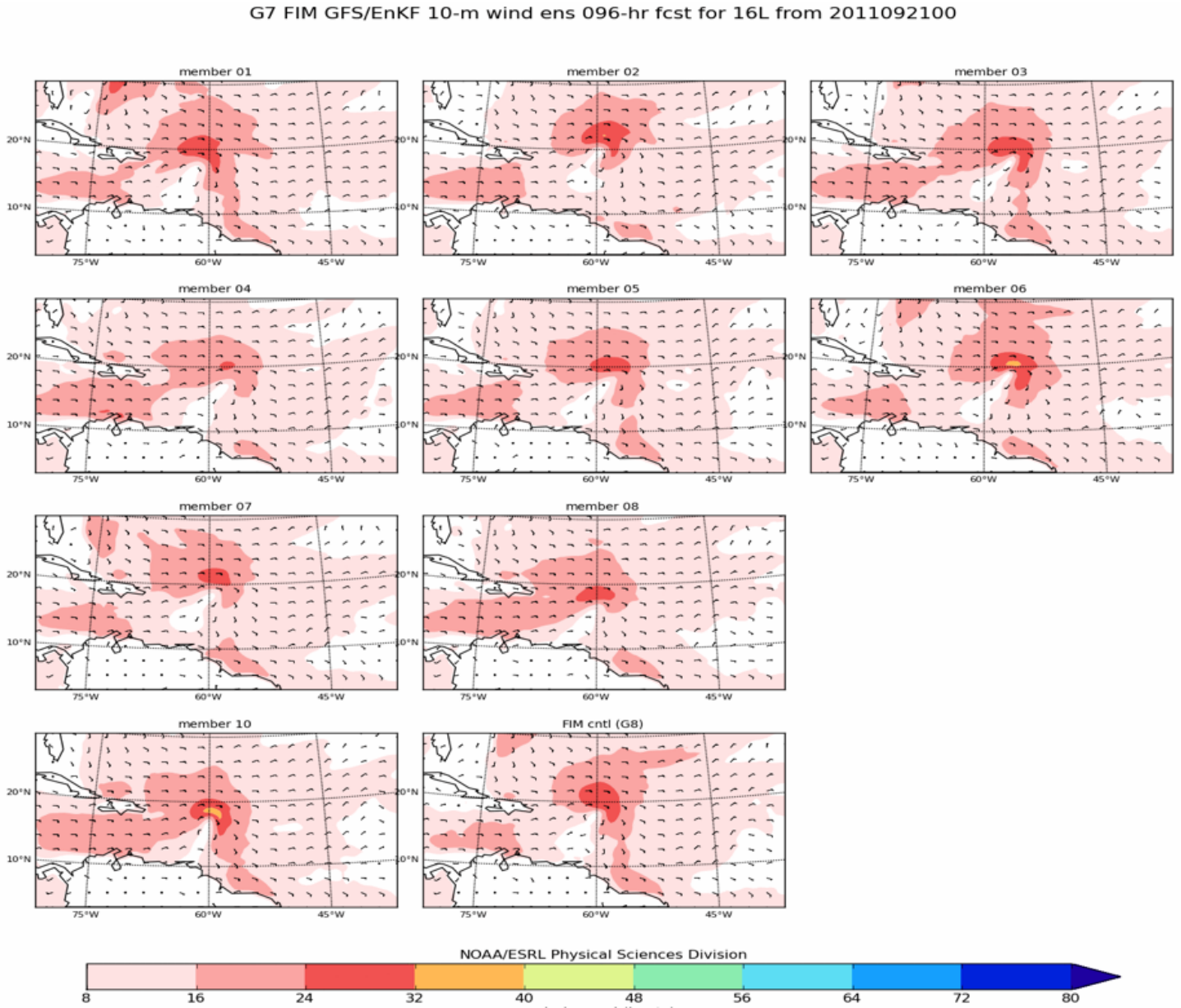
84-h Fcst Valid 12z 24 Sep 2011

10-m wind

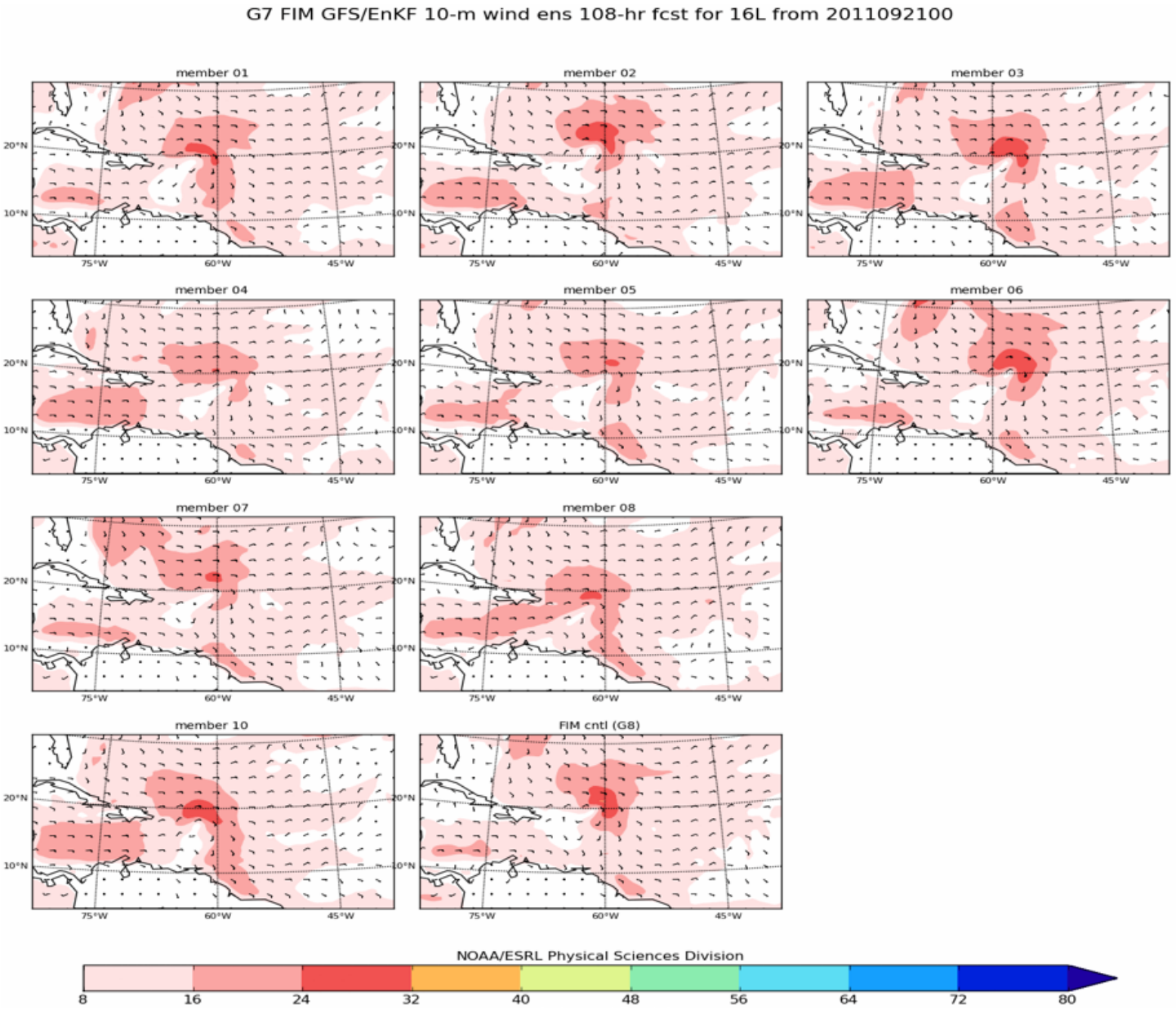


96-h Fcst Valid 00z 25 Sep 2011

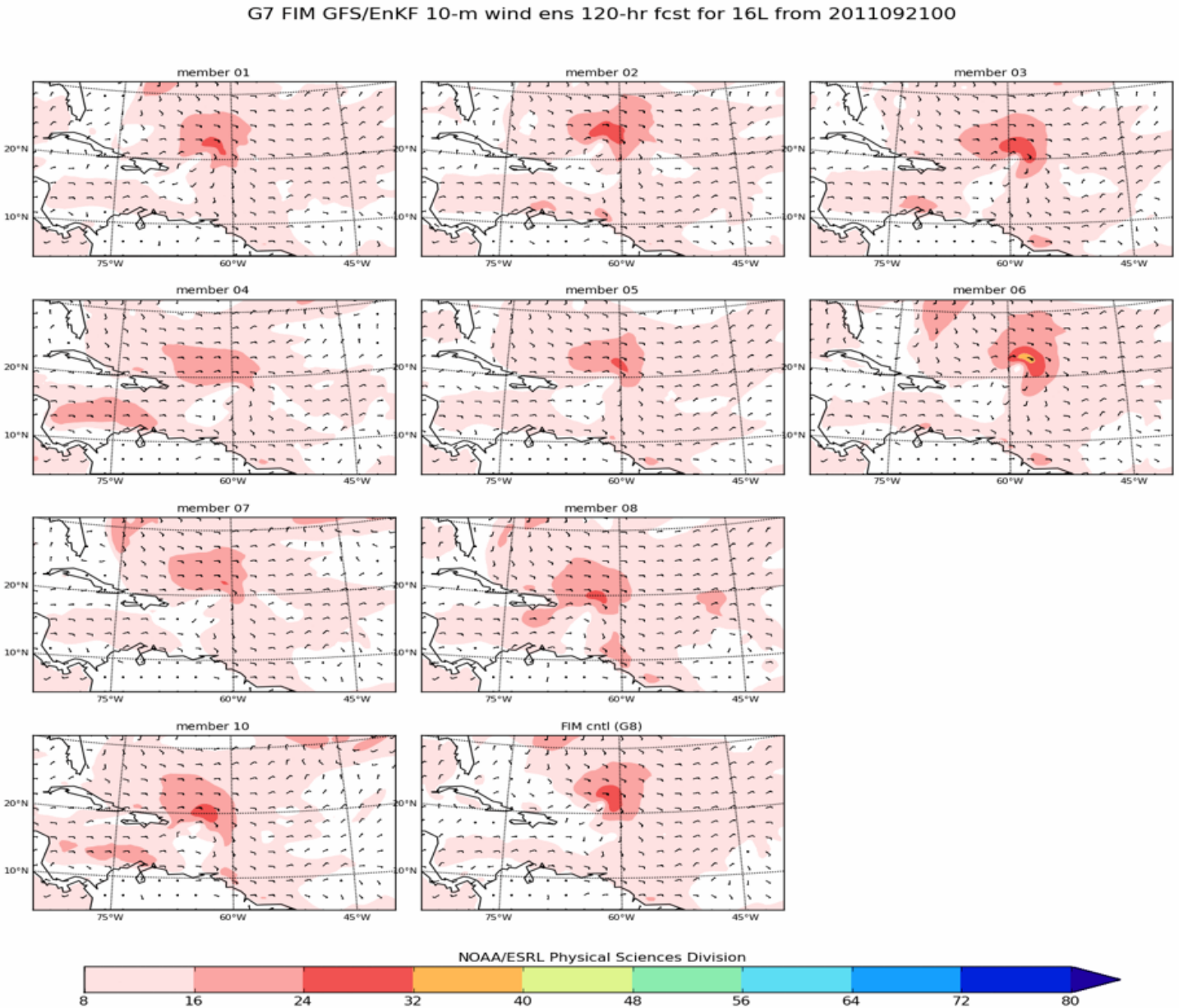
10-m wind



108-h Fcst Valid 12z 25 Sep 2011
10-m wind

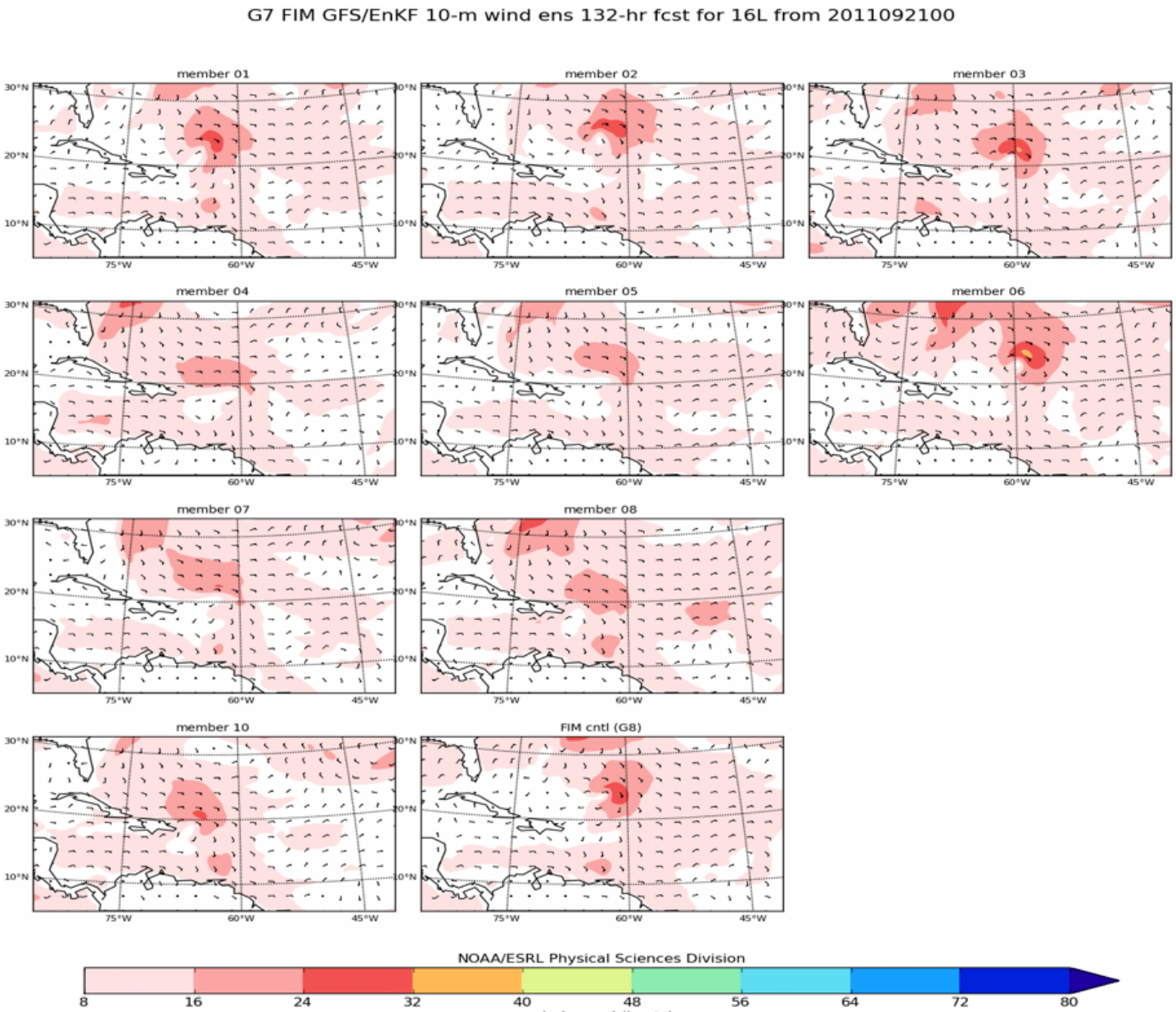


120-h Fcst Valid 00z 26 Sep 2011
10-m wind



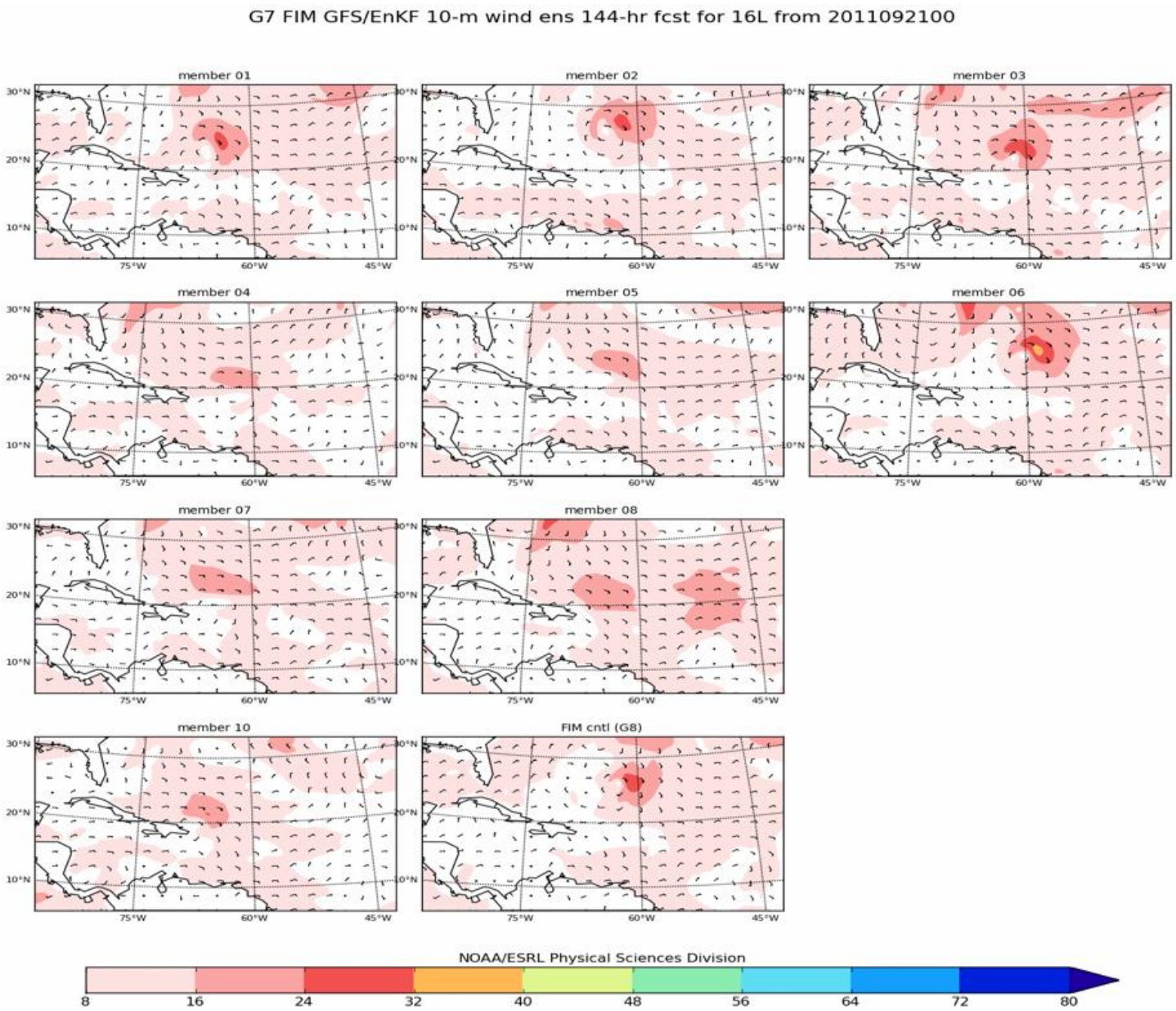
132-h Fcst Valid 12z 26 Sep 2011

10-m wind



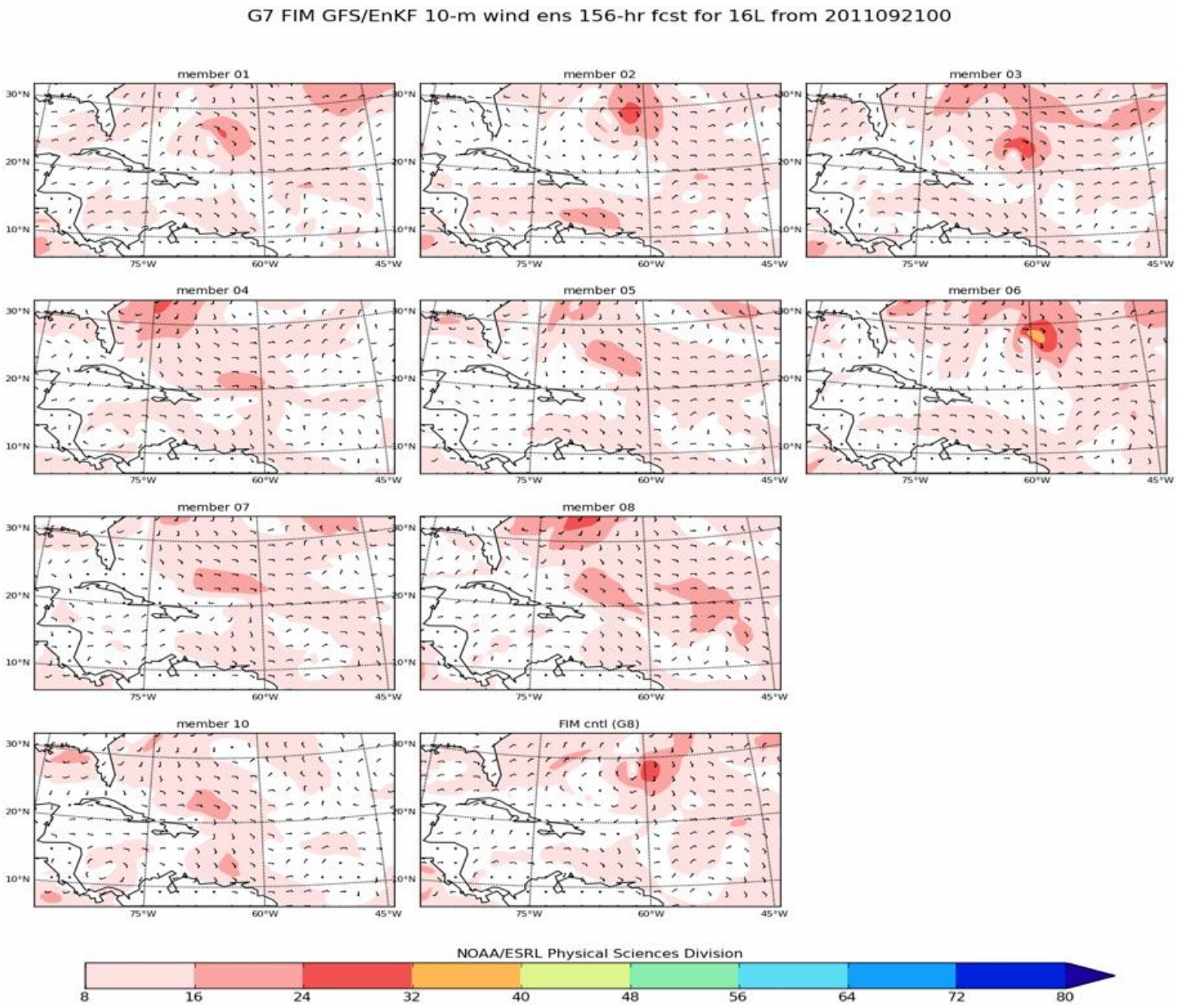
144-h Fcst Valid 00z 27 Sep 2011

10-m wind

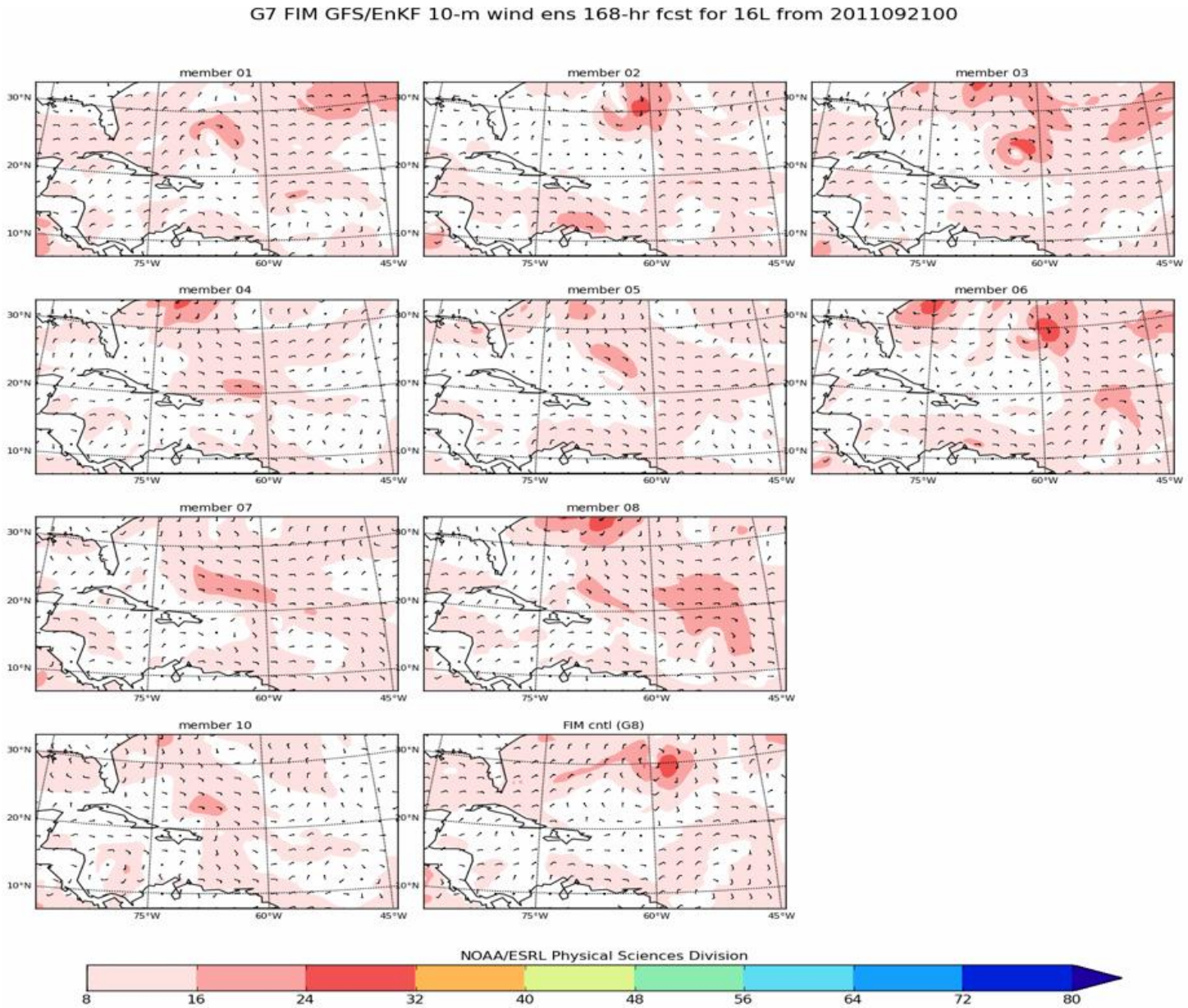


156-h Fcst Valid 12z 27 Sep 2011

10-m wind

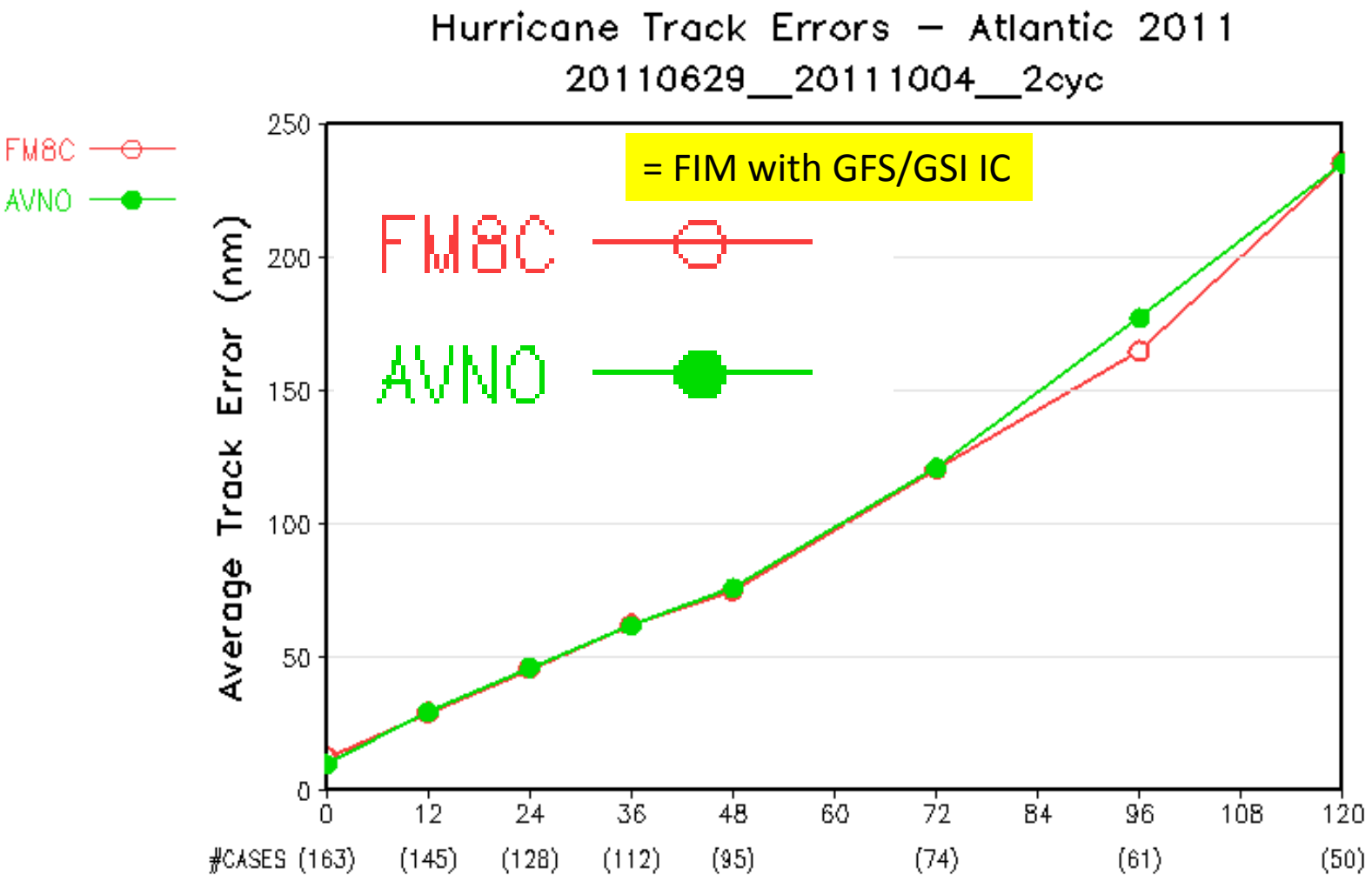


168-h Fcst Valid 12z 27 Sep 2011
10-m wind



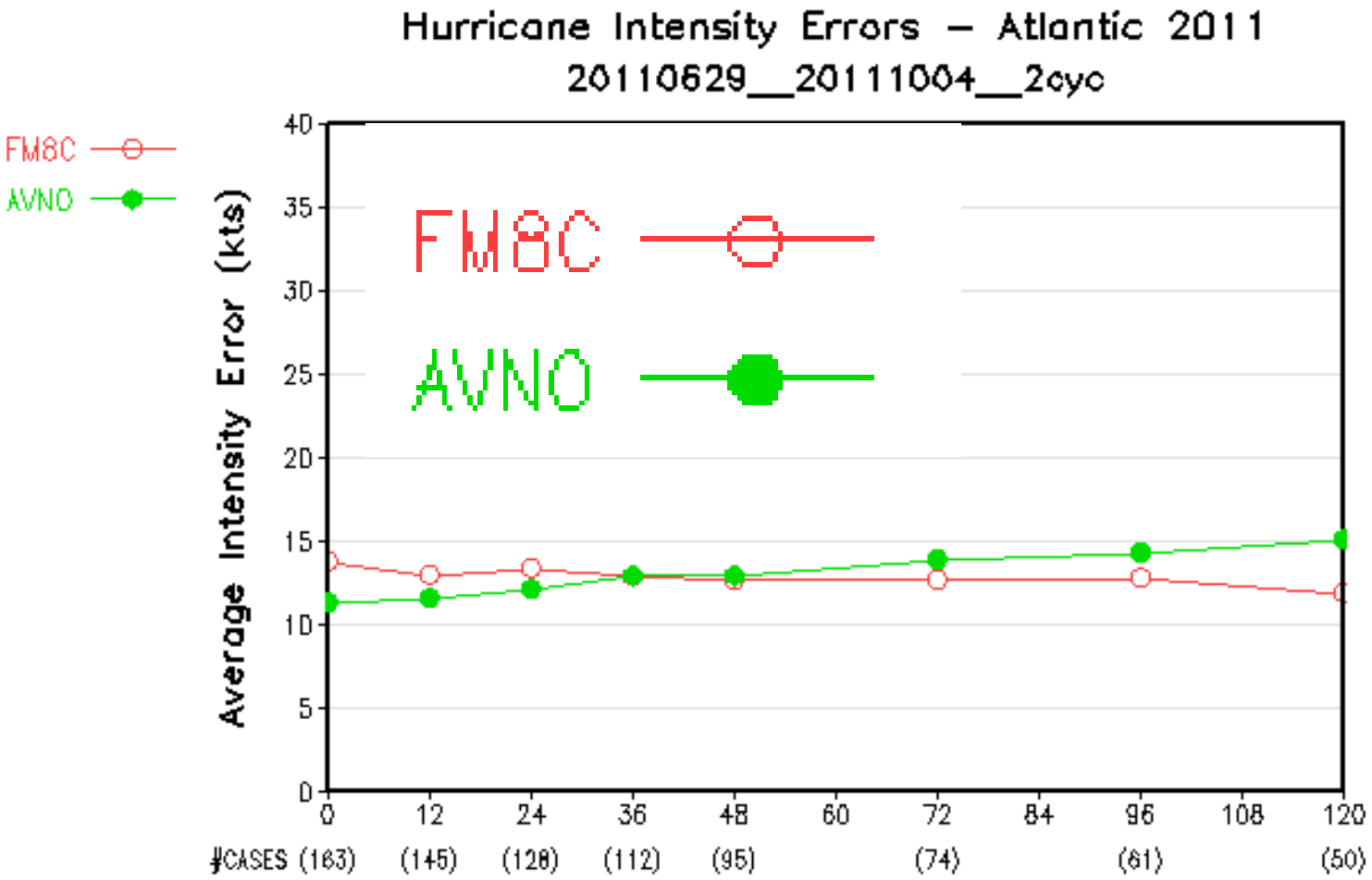
From NCEP verification - http://www.emc.ncep.noaa.gov/gmb/wx24fy/fim

Atlantic – 2011 - track



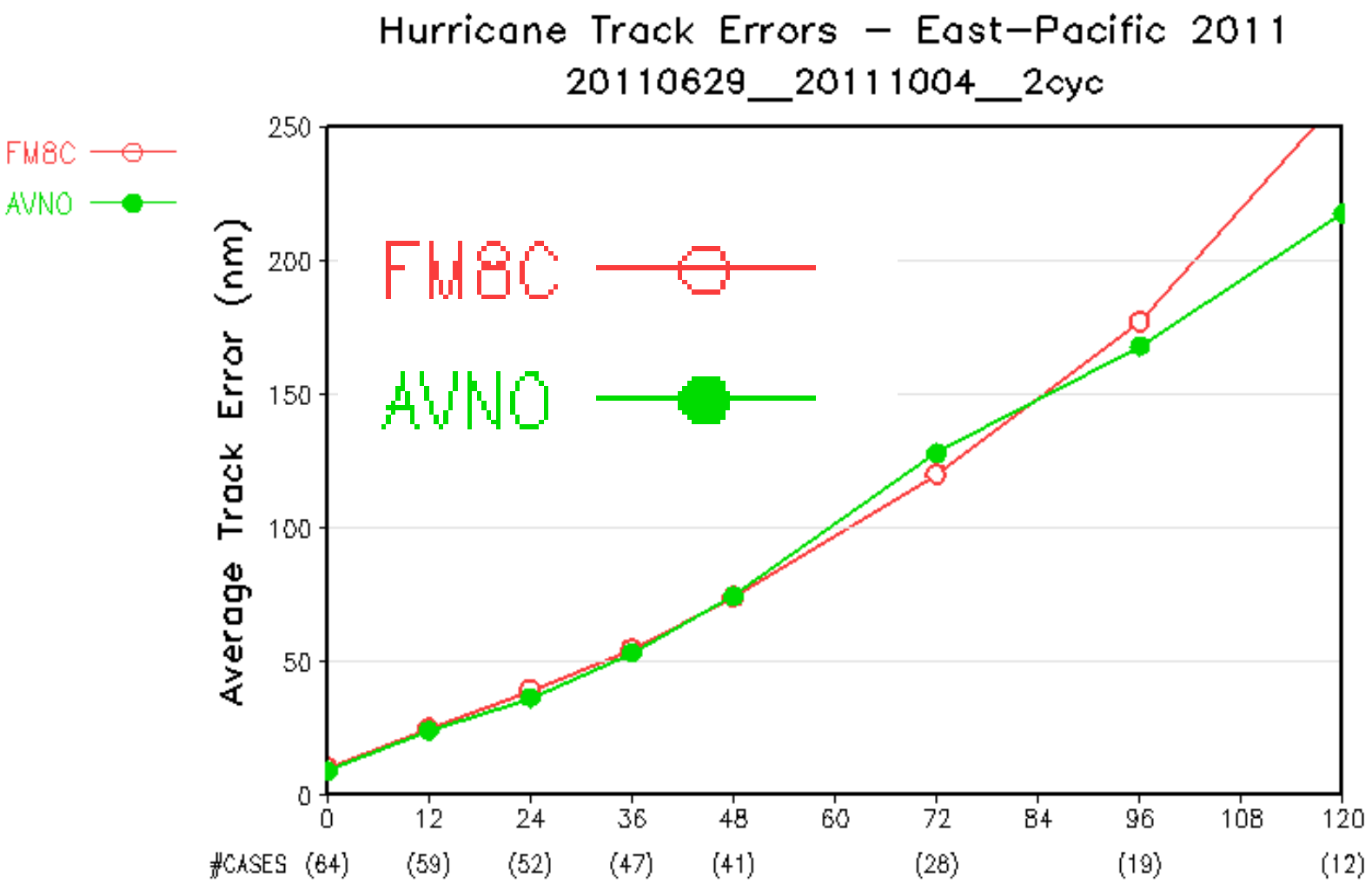
From NCEP verification - http://www.emc.ncep.noaa.gov/gmb/wx24fy/fim

Atlantic – 2011 - intensity



From NCEP verification - http://www.emc.ncep.noaa.gov/gmb/wx24fy/fim

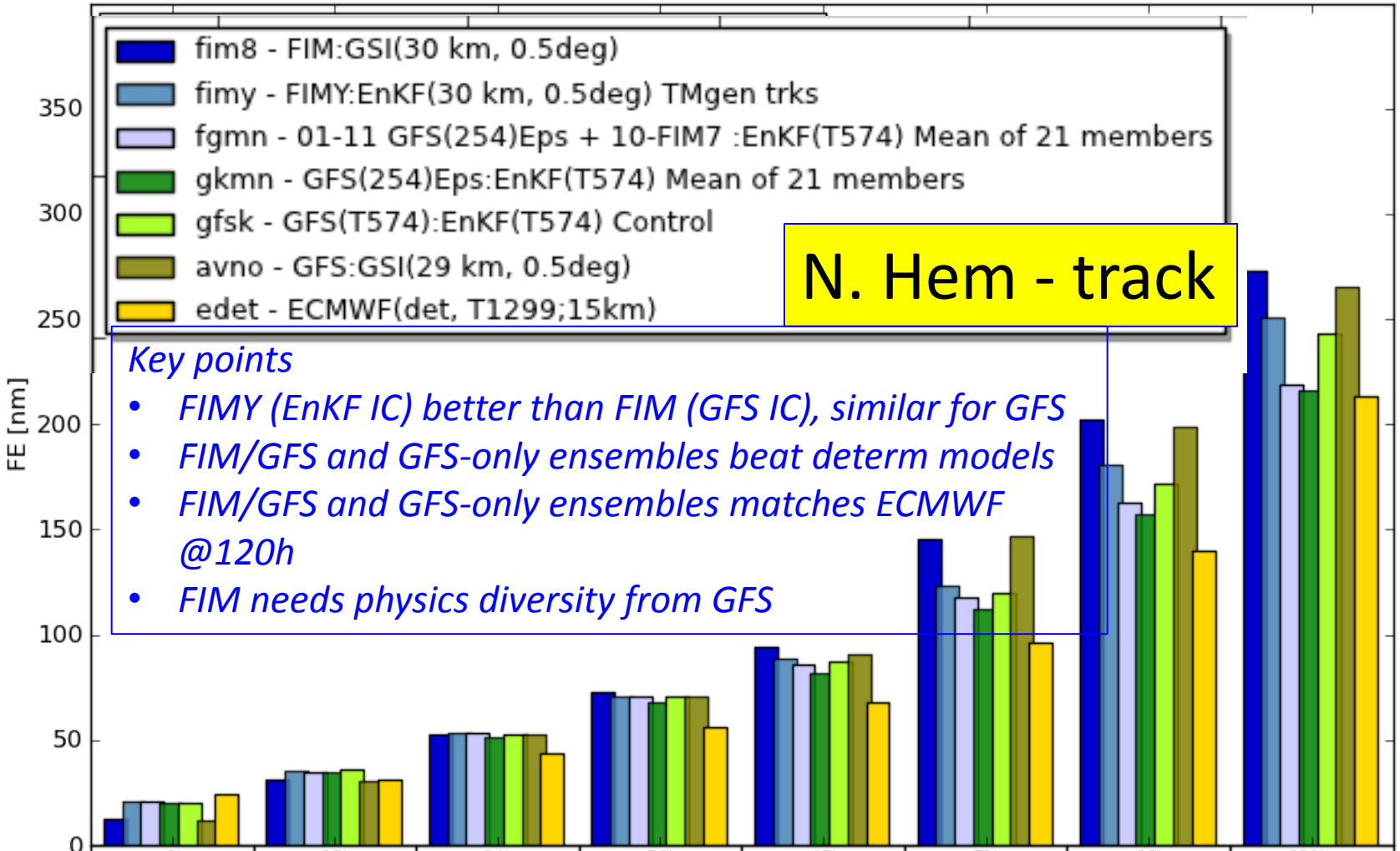
E.Pacific - 2011



HFIP/NOAA Global v ECWMWF :: NHEM 2011

Fiorino stat summary 2011

Storms[N] [31]: 05L.11 06E.11 07E.11 07L.11 08L.11 09E.11 09L.11 10E.11 10L.11 11E.11 ... 16W.11 17L.11 17W.11 18L.11 18W.11 19W.11 20W.11 21W.11 22W.11 23W.11



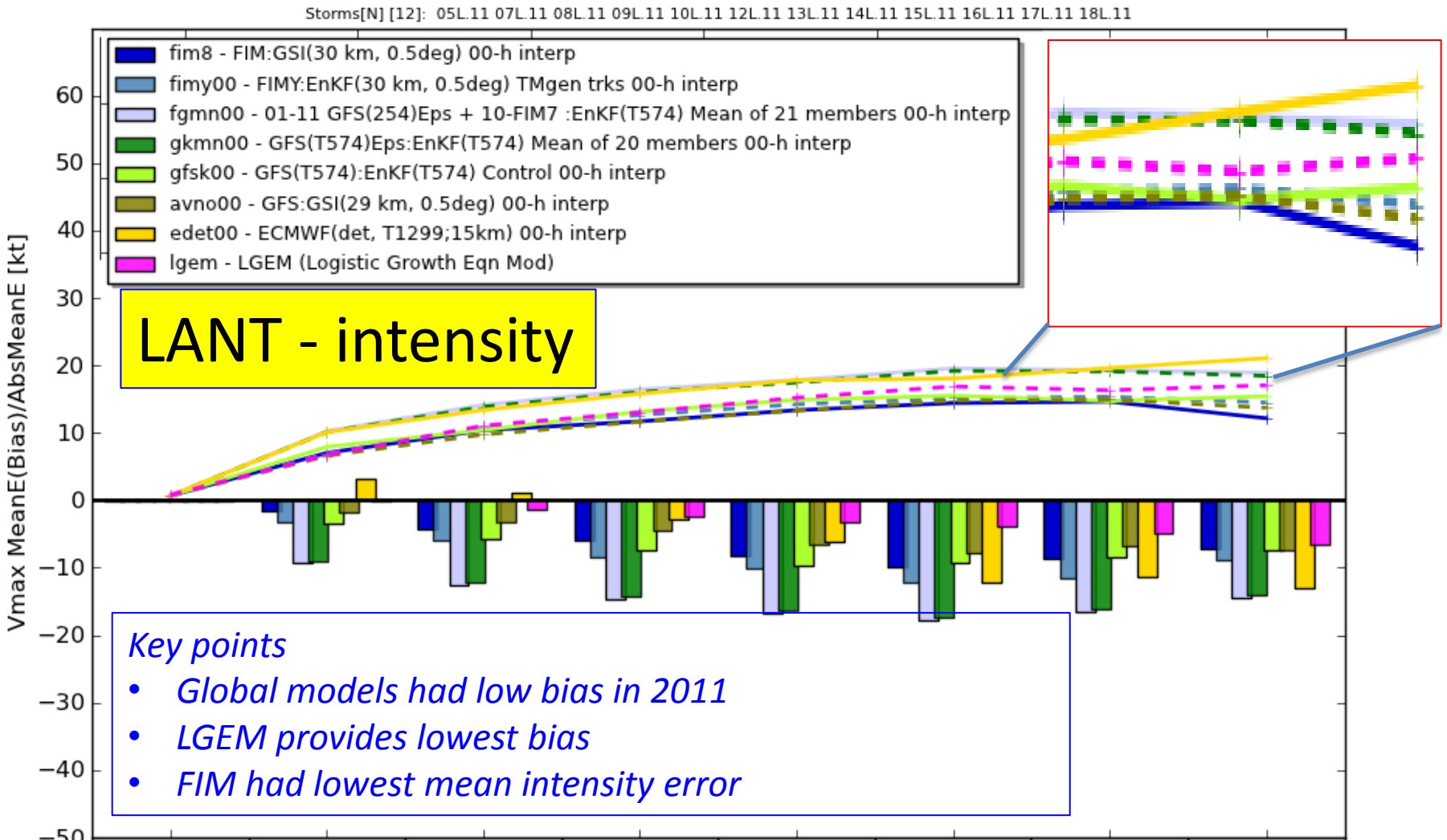
N. Hem - track

Key points

- *FIMY (EnKF IC) better than FIM (GFS IC), similar for GFS*
- *FIM/GFS and GFS-only ensembles beat determ models*
- *FIM/GFS and GFS-only ensembles matches ECMWF @120h*
- *FIM needs physics diversity from GFS*

	0h	12h	24h	36h	48h	72h	96h	120h
fim8	13[287]	31[266]	53[240]	72[212]	94[190]	145[153]	202[115]	273[88]
fimy	21[287]	35[266]	53[240]	70[212]	88[190]	124[153]	181[115]	251[88]
fgmn	21[287]	35[266]	54[240]	71[212]	86[190]	118[153]	163[115]	219[88]
gkmn	20[287]	34[266]	51[240]	68[212]	82[190]	112[153]	157[115]	216[88]
gfsk	20[287]	36[266]	52[240]	71[212]	87[190]	120[153]	171[115]	243[88]
avno	12[287]	31[266]	52[240]	71[212]	90[190]	147[153]	199[115]	265[88]
edet	24[287]	31[266]	43[240]	56[212]	68[190]	96[153]	140[115]	213[88]

Fiorino stat summary 2011



Key points

- *Global models had low bias in 2011*
- *LGEM provides lowest bias*
- *FIM had lowest mean intensity error*

	0h	12h	24h	36h	48h	72h	96h	120h
fim8	1; -0[121]	7; -2[110]	10; -4[98]	12; -6[88]	13; -8[83]	14; -10[70]	15; -9[54]	12; -7[42]
fimy00	1; -0[121]	7; -3[110]	11; -6[98]	13; -8[88]	14; -10[83]	15; -12[70]	15; -11[54]	14; -9[42]
fgmn00	1; -0[121]	10; -9[110]	14; -13[98]	16; -15[88]	18; -17[83]	20; -18[70]	19; -16[54]	19; -15[42]
gkmn00	1; -0[121]	10; -9[110]	14; -12[98]	16; -14[88]	17; -16[83]	19; -17[70]	19; -16[54]	18; -14[42]
gfsk00	1; -0[121]	8; -3[110]	10; -6[98]	13; -7[88]	15; -10[83]	16; -9[70]	15; -8[54]	15; -7[42]
avno00	1; -0[121]	7; -2[110]	10; -3[98]	12; -4[88]	13; -7[83]	15; -8[70]	15; -7[54]	14; -7[42]
edet00	1; -0[121]	10; 3[110]	13; 1[98]	16; -3[88]	18; -6[83]	18; -12[70]	20; -11[54]	21; -13[42]
lgem	1; -0[121]	7; -0[110]	11; -1[98]	13; -2[88]	15; -3[83]	17; -4[70]	16; -5[54]	17; -7[42]

FIM Development at NCEP

Strong progress toward NCEP operational status

- Preliminary tests of FIM done on NCEP CCS
- MOA with NCEP to run FIM as part of Global Ensemble Forecast System (GEFS) under NEMS.
- GSD's Advanced Computing Group worked closely with NEMS developers at NCEP to work out basic NEMS design issues as well as to get FIM under NEMS
- Testing of FIM to start within NEMS GEFS framework at NCEP in next few months
- NCEP doing their own verification now of FIM
- 38-level version of FIM tested – equal performance with L64 – readiness for GEFS. (Fewer levels should fare well with isentropic-hybrid coordinate …. and apparently do)

HFIP Global Model/Physics Team plans for FY12

- FIM - Testing in GEFS under NEMS
- Model enhancements toward efficiency
- Testing of WRF physics (Grell cumulus), other physics
  - Critical for improving tropical cyclone diversity
- Physics – diversity between GFS and FIM should improve multi-model TC ensemble
  - Grell 3-d convective scheme – now in testing
  - FIM-chem with more complex microphysics (2-moment cloud at least) for coupling with aerosol (Saharan dust, sea salt, etc.) – Georg Grell
  - Stochastic physics, other devices to increase ensemble diversity – Jian-Wen Bao, Georg
- Continued development of CFIM (coupled atmosphere-ocean FIM with icos HYCOM)
- Use of long runs for evaluation of FIM TC climate and diagnosis of physics problems
- Continue work toward FIM-based EnKF-hybrid (Phil Pegion, Jeff W)

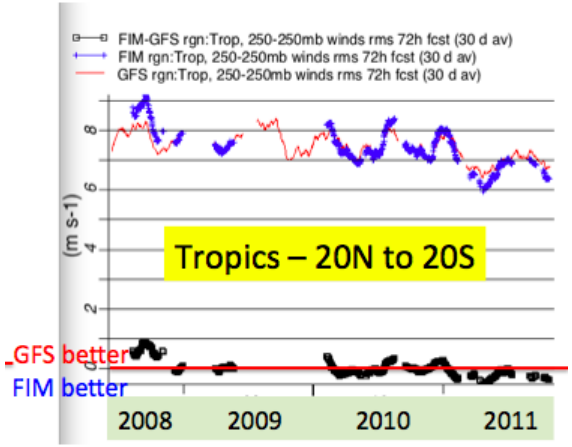
NRL global model progress from NOGAPS to NAVGEM for tropical cyclones

(from Jim Ridout at NRL-Monterey)

- Results for Summer 2010 - reanalysis
  - improved results at 120-hr for NAVGEM vs. NOGAPS
- Results for 2011 (just being assessed)
  - Mixed between NAVGEM and NOGAPS
  - **Overall, TC track errors appear comparable**
  - **Current work is being focused on adjustments to the new physics, particularly the Simplified Arakawa Schubert cumulus scheme.**
  - **Enhancements to the radiation scheme (testing the RRTMG scheme) and incorporation of a prognostic cloud scheme are also in progress.**
  - **The adoption in NAVGEM of semi-lagrangian moisture advection scheme expected to help enable faster transitions to higher resolutions than would be possible with NOGAPS."**

Summary for Global Modeling Progress

- Significant improvement in FIM in last year – 2011 was breakthrough year
  - improvement over GFS in wind forecasts at all levels, especially in tropics
  - Tropical cyclone improvement – achieved Stream 1.5 after successful retro runs and recommendation by TCMT (EnKF initialization – FIMY)
  - FIM "competitive" with GFS for track, best global model for intensity



Proposed 2012 Milestones—ESRL global model and assimilation efforts

1. Develop **improved version of FIM global model ready for testing in 2012 hurricane season**. (improved numerics, improved/diversified physics)

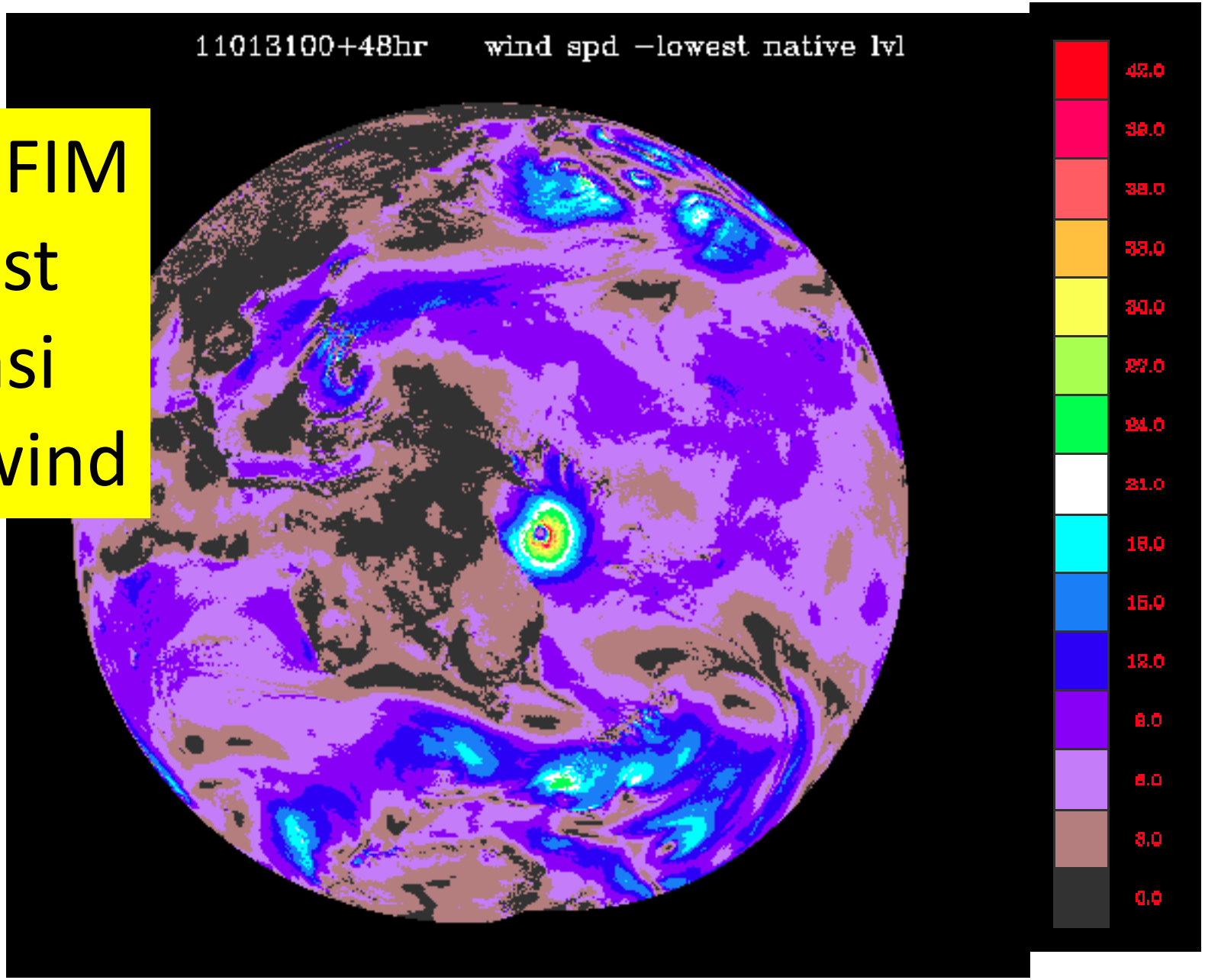
2. **Develop improved version of global ensemble data assimilation ready for real-time operations in 2012 hurricane season**. Collaborate with regional modeling (for initial conditions) and ensemble data assimilation (for lateral boundary condition) efforts (Jeff Whitaker)

3. Conduct **real-time demonstration in 2012 hurricane season of FIM model and GFS model** run in both

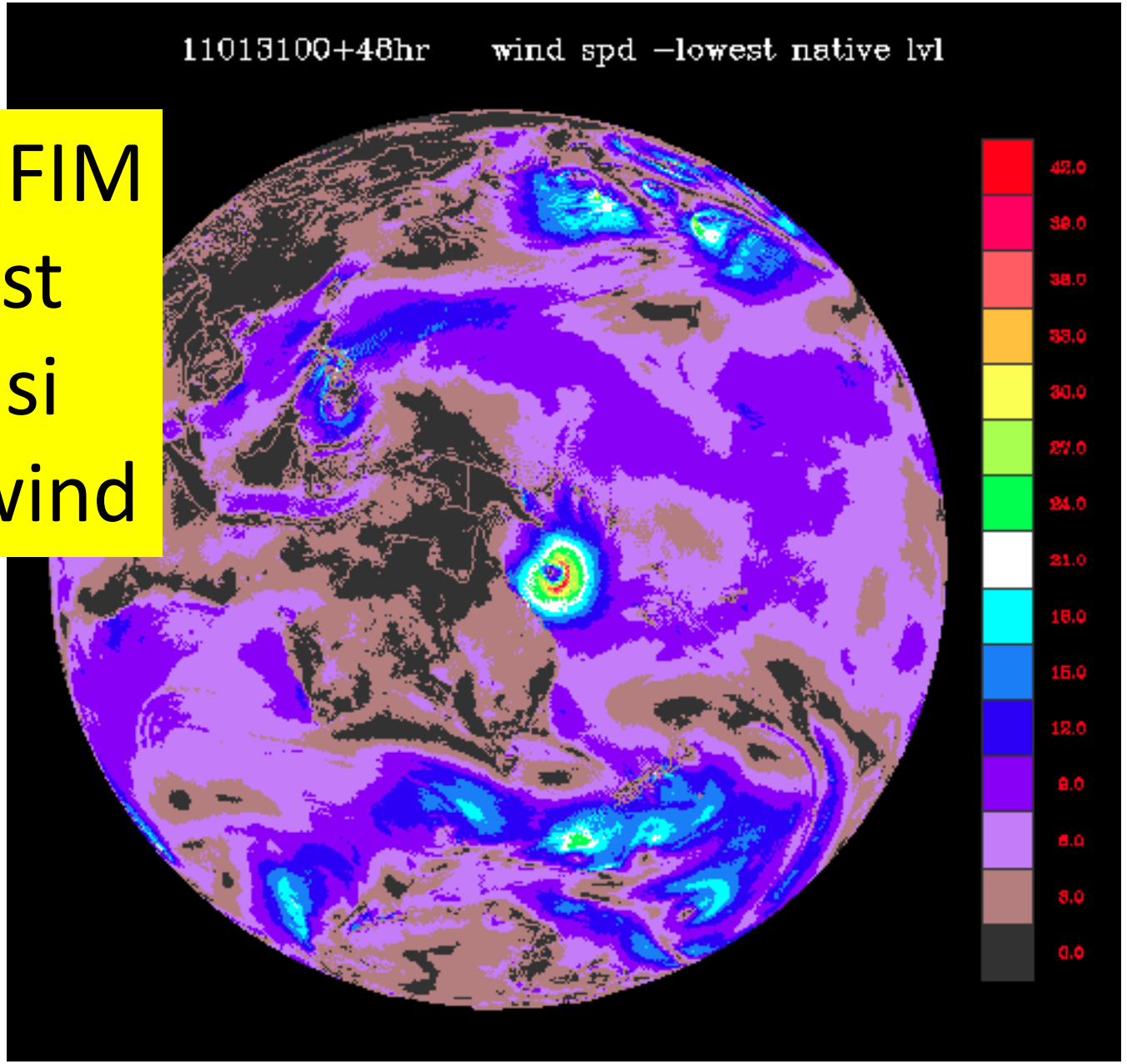
- high-resolution deterministic (10-15km FIM)
- medium-resolution ensemble configurations (down to 27-30km FIM)

--- Initialization with experimental advanced (ensemble / EnKF / hybrid) initial conditions (Jeff Whitaker, Phil Pegion) **for advanced versions of FIM and GFS global models**

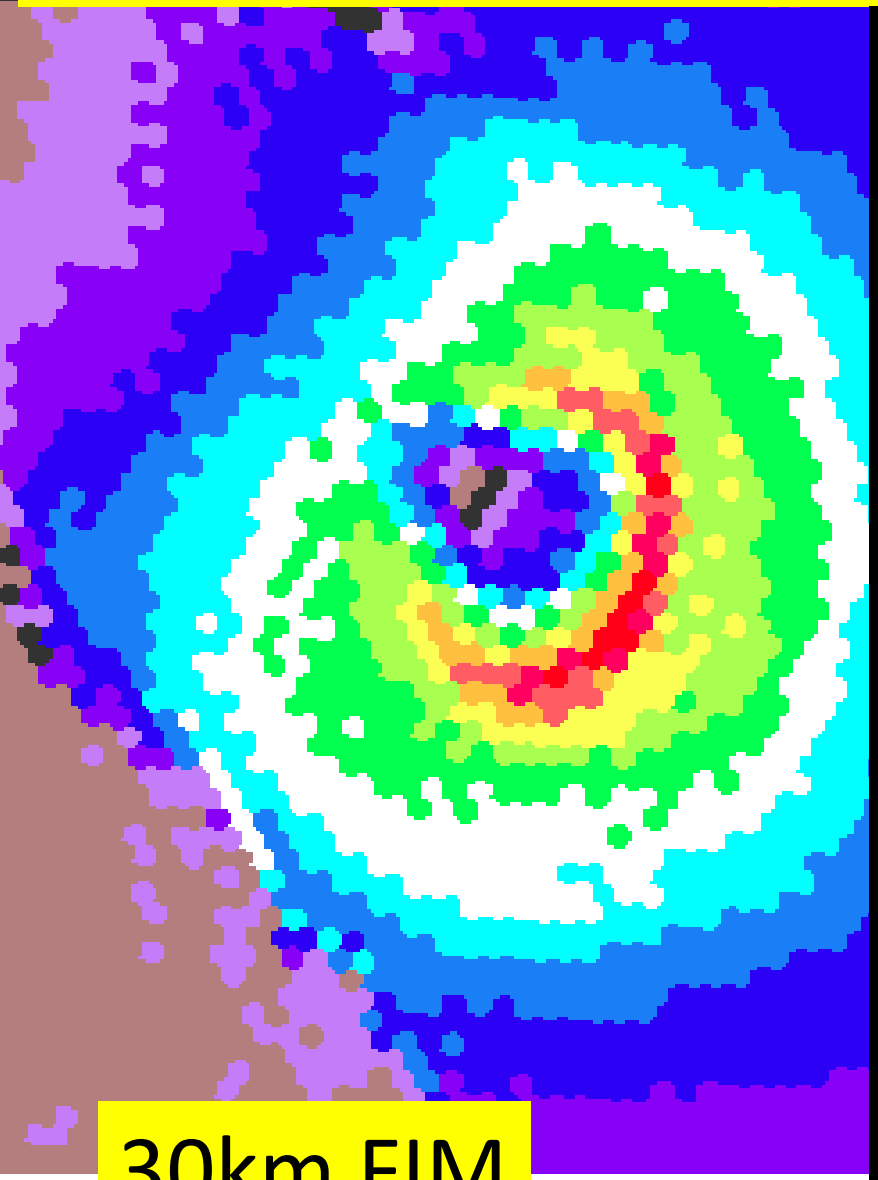
30km FIM
48h fcst
Cyc Yasi
10m wind



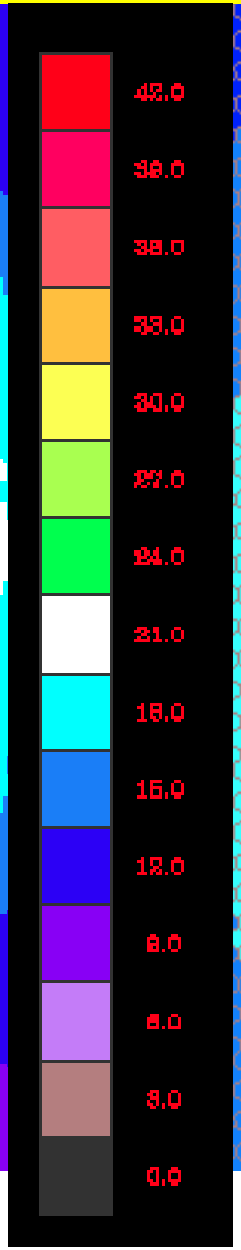
15km FIM
48h fcst
Cyc Yasi
10m wind

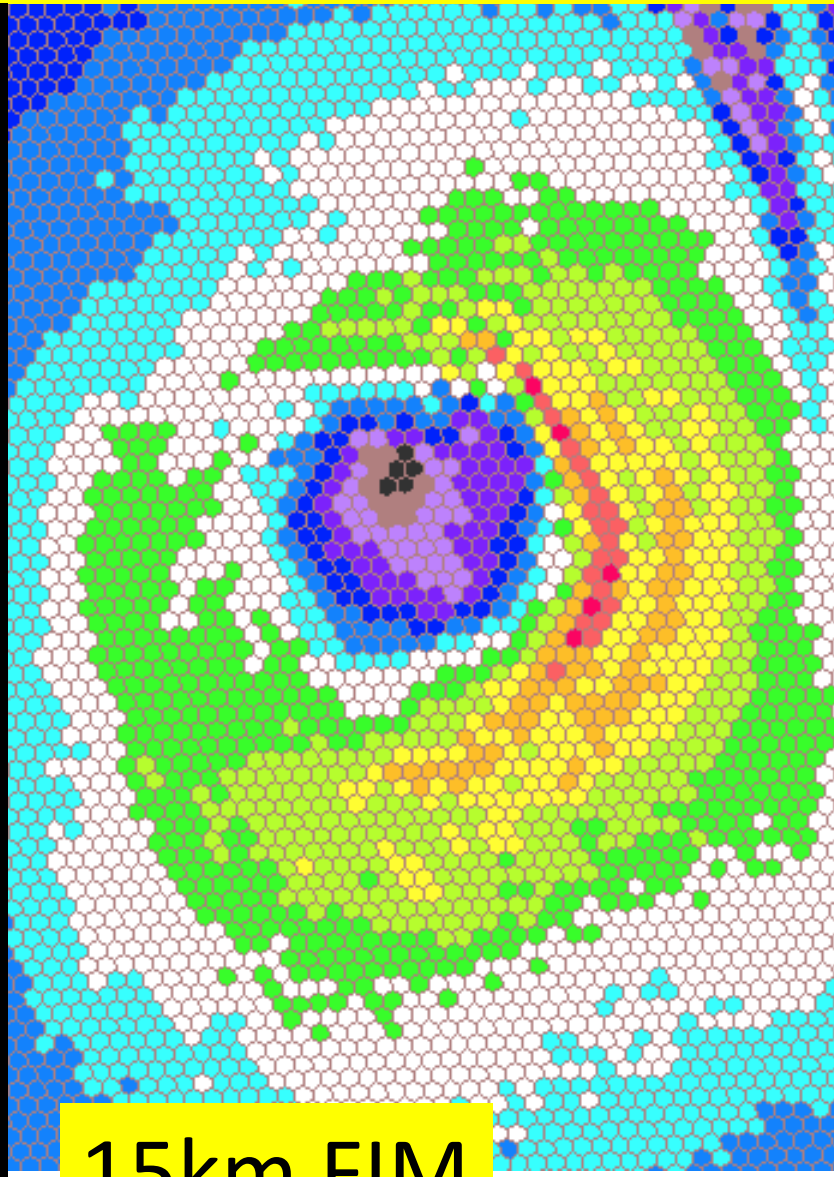


48h fcst - Cyclone Yasi -10m wind (not at same time)



30km FIM





15km FIM