HFIP Joint HWRF/COAMPS-TC/GFDL Multi-Model Regional Ensemble System

HWRF: Zhan Zhang, Jiayi Peng, Samuel Trahan, Weiguo Wang, Vijay Tallapragada
NRL: Jon Moskaitis, Alex Reinecke, Jim Doyle
GFDL: Matthew Morin, Timothy Marchok Morris Bender

HFIP Telecon, July 30, 2014

Outline

- Motivations and Goals;
- Introduction to Three-model High-resolution Regional Ensemble System;
- Verification Results from Retrospective experiments;
- Real Time Ensemble Forecast Products.

Motivations and Goals

- Increase number of ensemble members to take into account more uncertainties in:
  - Large scale environment flows, IC/BC;
  - Vortex intensity and structures at the model initial time;
  - Model physics and dynamics.

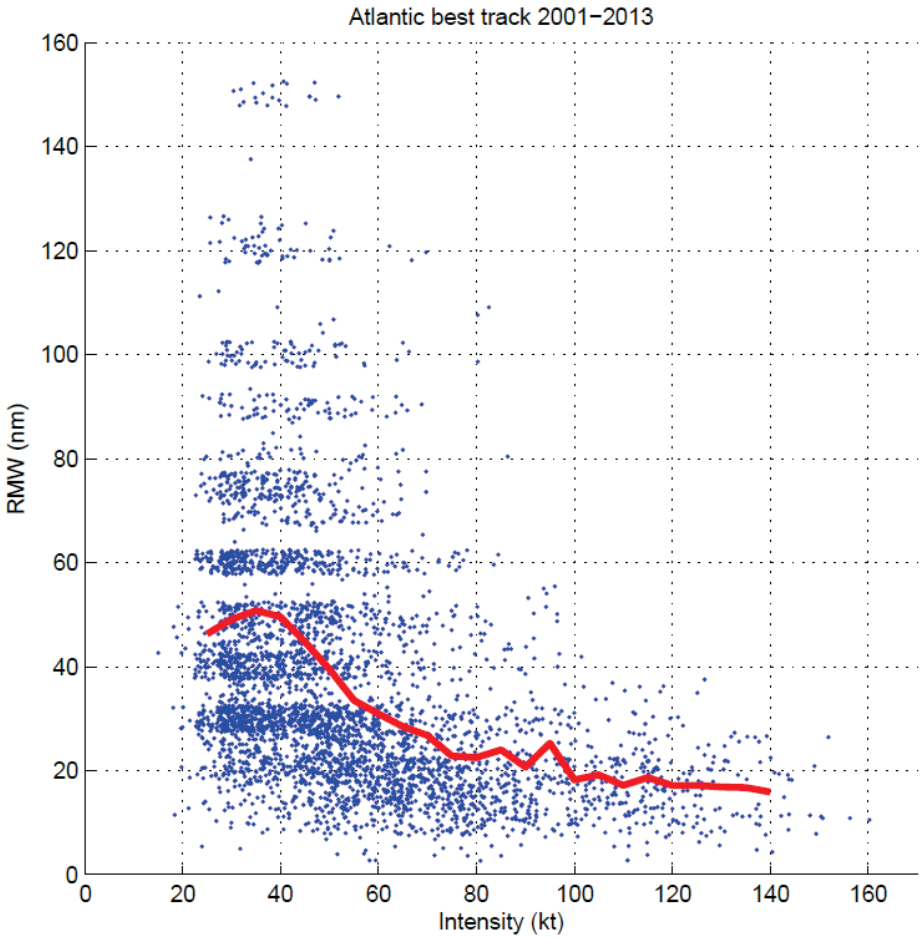
- Provide improved and reliable real time storm track/intensity forecasts and probabilistic forecasts (real time tier1 products will be submitted to TCMT for verification);

- Develop more ensemble probabilistic forecast products based on multi-model ensembles.

2014 COAMPS-TC ensemble Configuration

- Synoptic perturbations:
  - Perturbation drawn from a static covariance
  - Perturb the boundaries
  - Use WRFVAR cv3

- Vortex scale perturbations:
  - Vortex position, max wind, and RMW.
  - Perturbation variance from:
    - Torn and Snyder 2012
    - Landsea and Franklin 2013
  - Max wind and RMW covariance derived from 2001-2013 best track data.
  - Variance's and covariance's depend on TC-vital max wind speed.



2014 GFDL ensemble Configuration

GP00: Control forecast (based on NCEP's 2014 implementation of the GFDL hurricane model)
GP01: Opposite vortex bogussing method of the ensemble control model (i.e., runs unbogussed when the control runs bogussed, and vice versa)
GP02: Increase NHC-observed Vmax 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25%
GP03: Decrease NHC-observed Vmax 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25%
GP04: Increase inner-core moisture by a max of 10%
GP05: Decrease inner-core moisture by a max of 10%
GP06: Increase SSTs by a max of 2°C within the initial extent of the TC
GP07: Decrease SSTs by a max of 2°C within the initial extent of the TC
GP08: Surface physics modification: GFDL 2011 operational formulation of CD & CH (surface drag and enthalpy exchange coefficients)
GP09: Surface physics modification: HWRF 2014 operational formulation of CH (surface enthalpy exchange coefficient)
GPMN: Ensemble mean computed at each lead time where the member availability is at least 4 members (40% threshold)

2014 HWRF ensemble Configuration

- Use 2014 operational deterministic HWRF model except for
  - Less vertical resolution: L43 vs. L61;
  - Smaller D02, D03 domains, same as H213;
  - No GSI due to lack of GDAS data;

- IC/BC Perturbations (large scale): 20 member GEFS.

- Model Physics Perturbations (vortex scale):
  - Stochastic Convective Trigger in SAS: -50hPa to + 50hPa white noise ;
  - Stochastic boundary layer height perturbations in PBL scheme, -20% to +20%;
  - Stochastic initial wind speed perturbations with zero mean and 7% standard deviation, Gaussian distribution.

Retrospective Runs from HWRF/COAMPS-TC/GFDL Ensembles

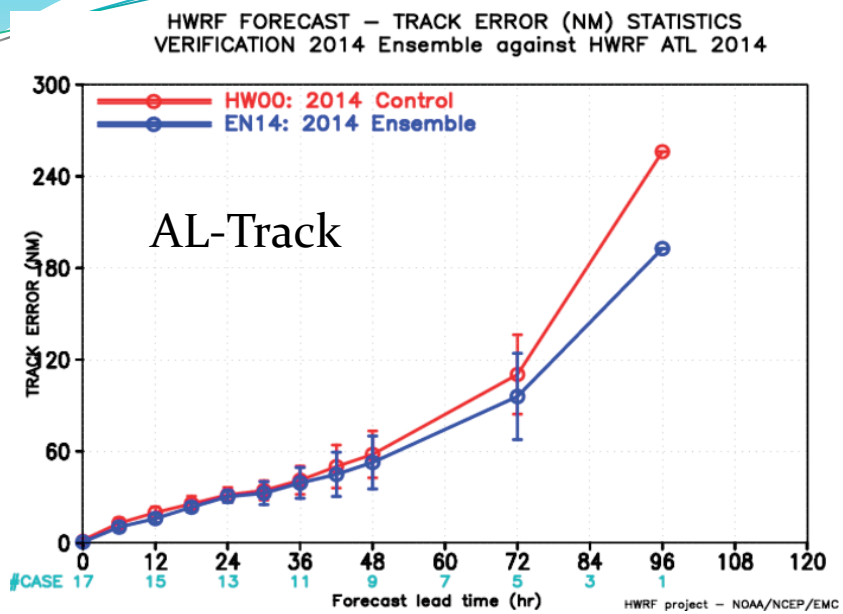
Models	Number of Cycles	Number of Storms
HWRF	520 cycles, 2011-2013, AL and EP	54
COAMPS-TC	210 cycles, 2010-2013, AL	10
GFDL	716 cycles, 2011-2013, AL	43

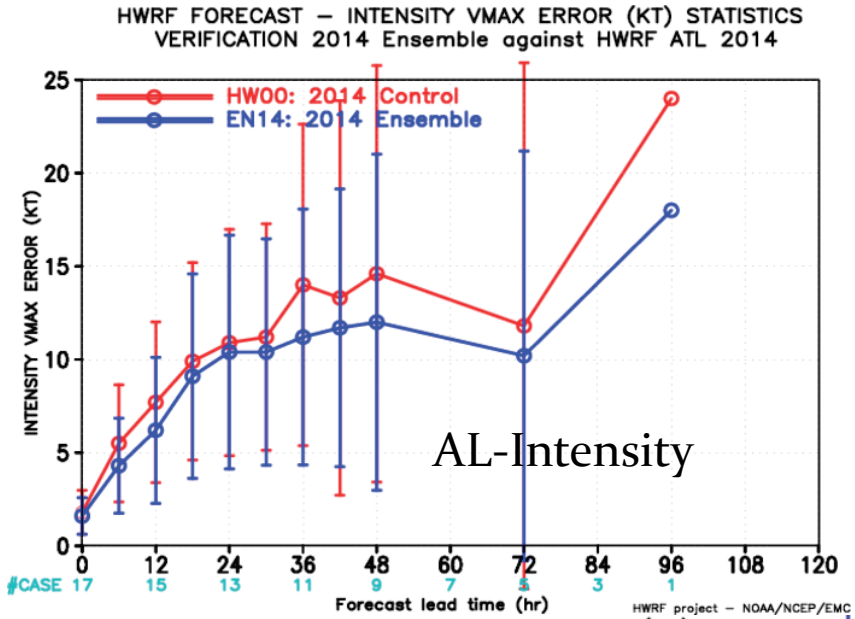
Homogeneous Samples:
(133 Cycles, 8 TC)

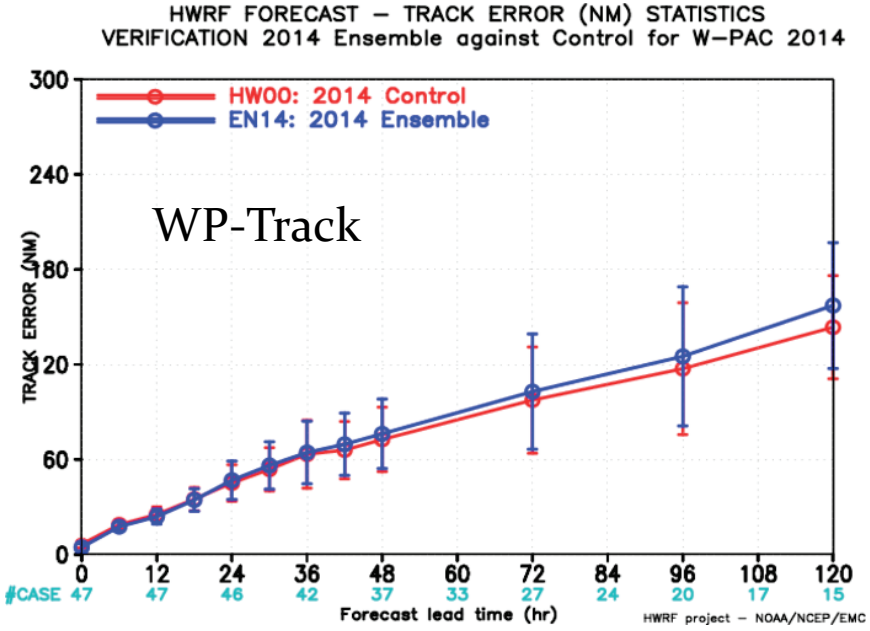
(1) Irene, 2011/09L
(2) Katia, 2011/12L
(3) Ernesto, 2012/05L
(4) Isaac, 2012/09L
(5) Nadine, 2012/14L
(6) Sandy, 2012/18L
(7) Gabrielle, 2013/07L
(8) Humberto, 2013/09L

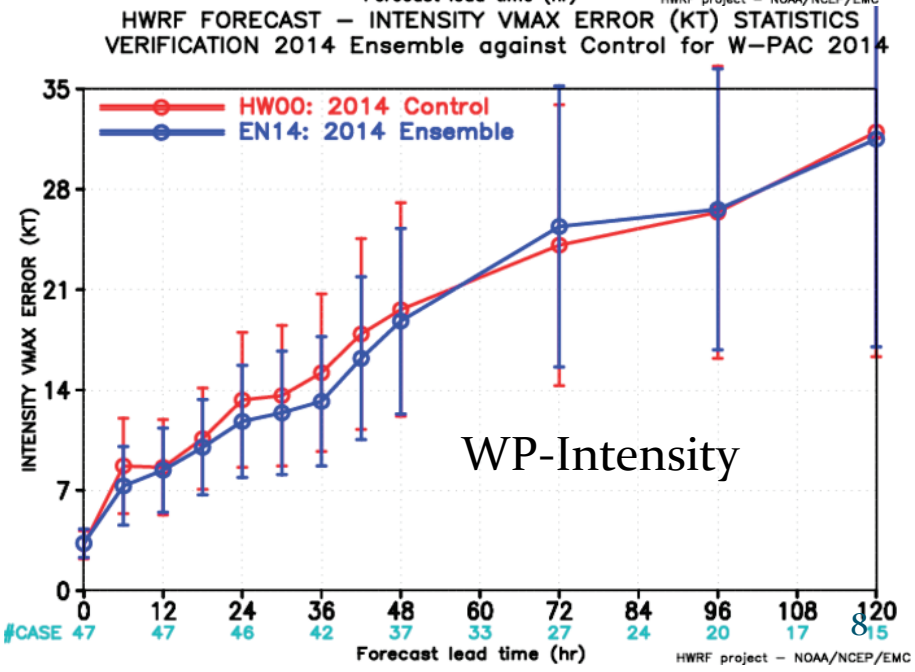
Ensemble mean is computed when the forecasts available from 40% of the total ensemble members.

HWRF-EPS vs. HWRF-deterministic
(2014 Real time)



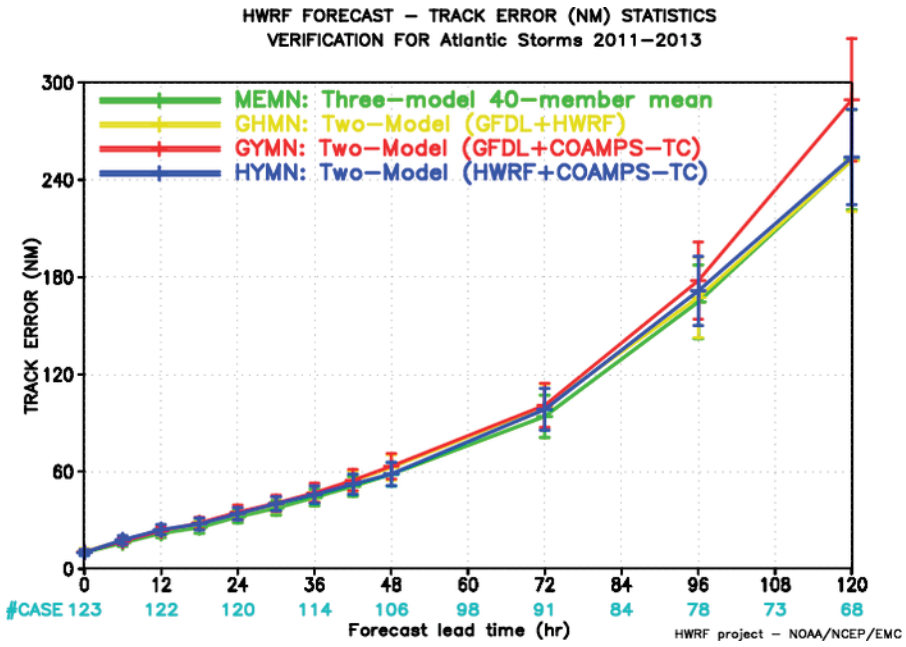




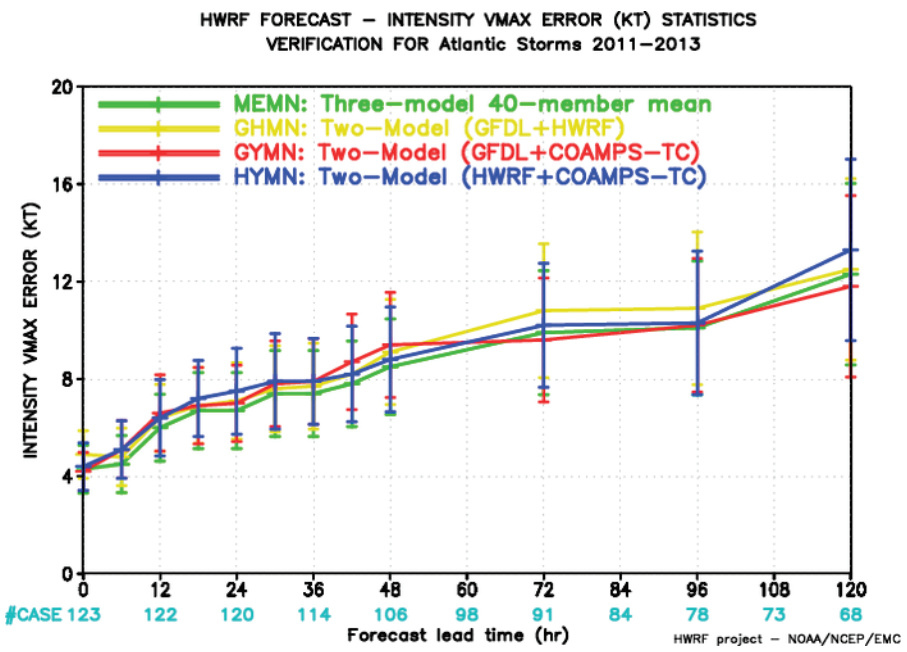


Three Model Ensembles vs. Two-model Ensembles

Track



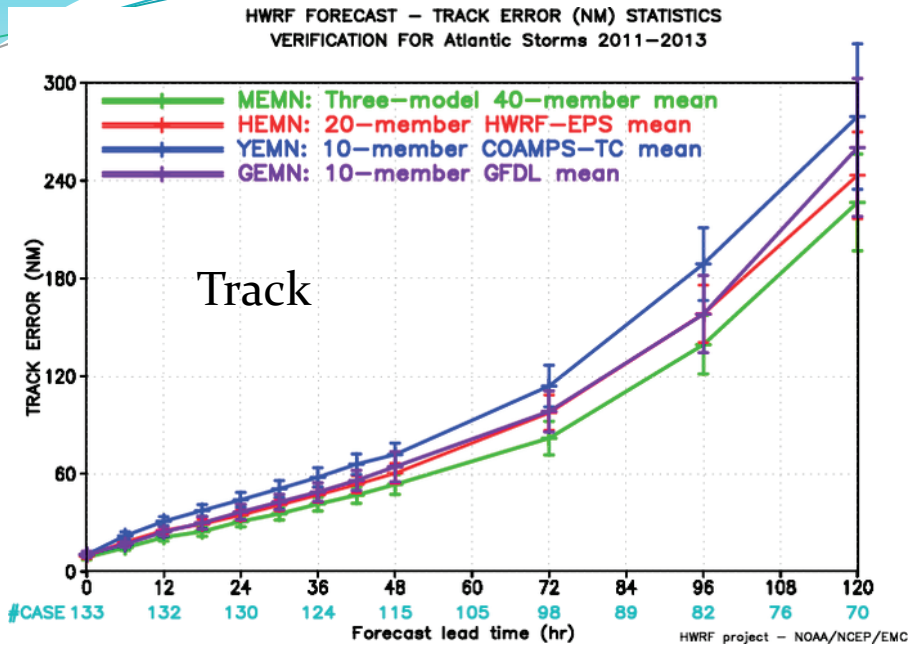
Intensity

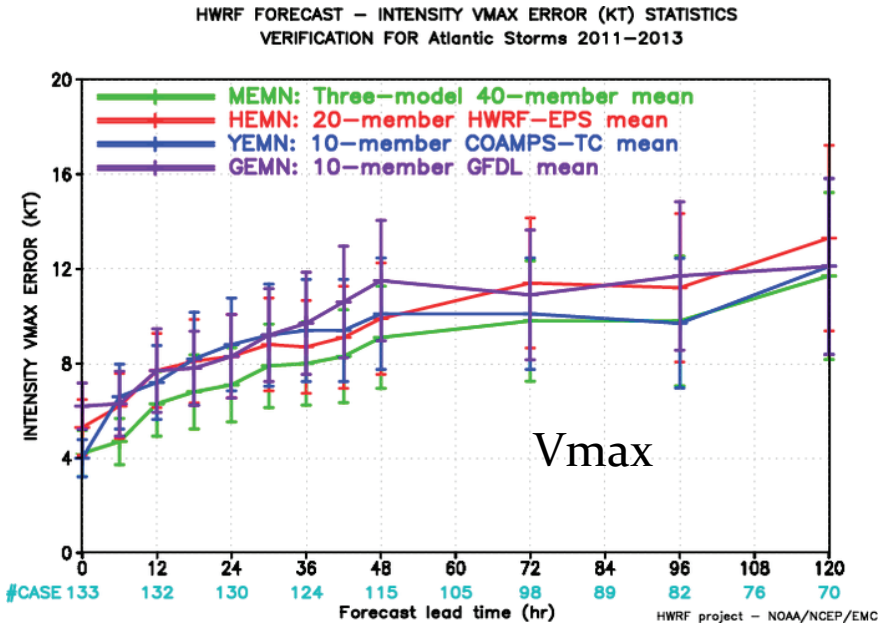


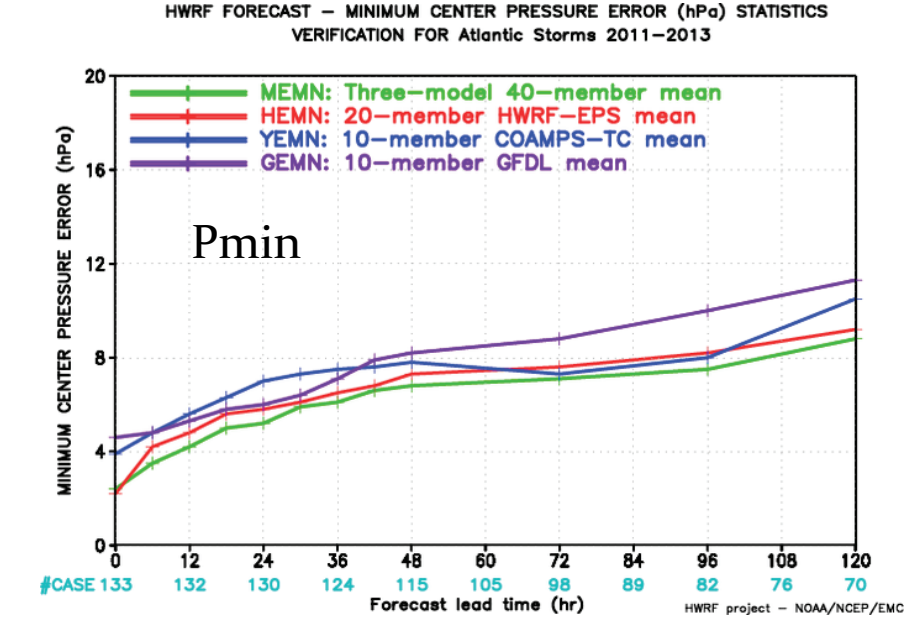
Three-model ensemble is generally better than Two-model ensemble in terms of both track and intensity forecasts at all forecast hours.

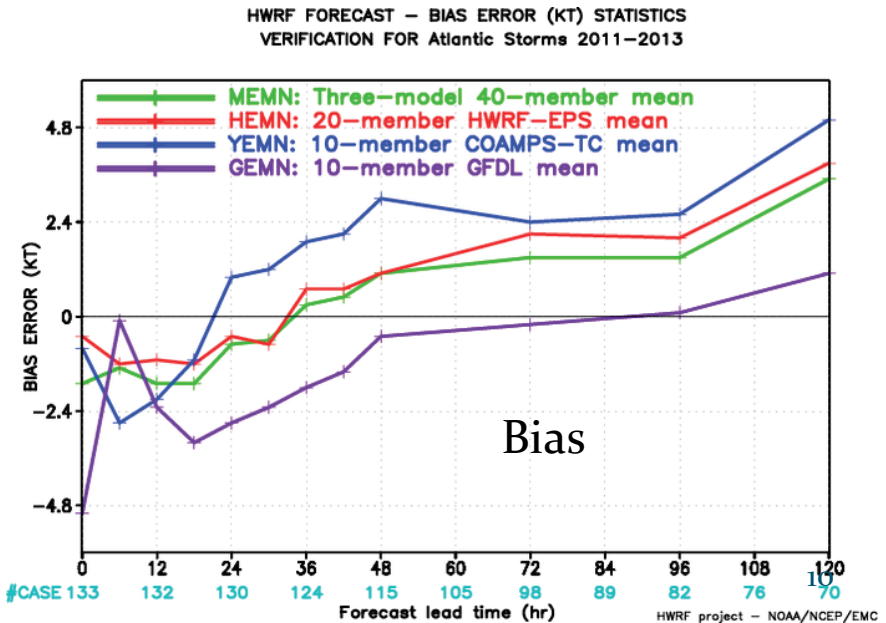
Multi-Model Ensemble Verification

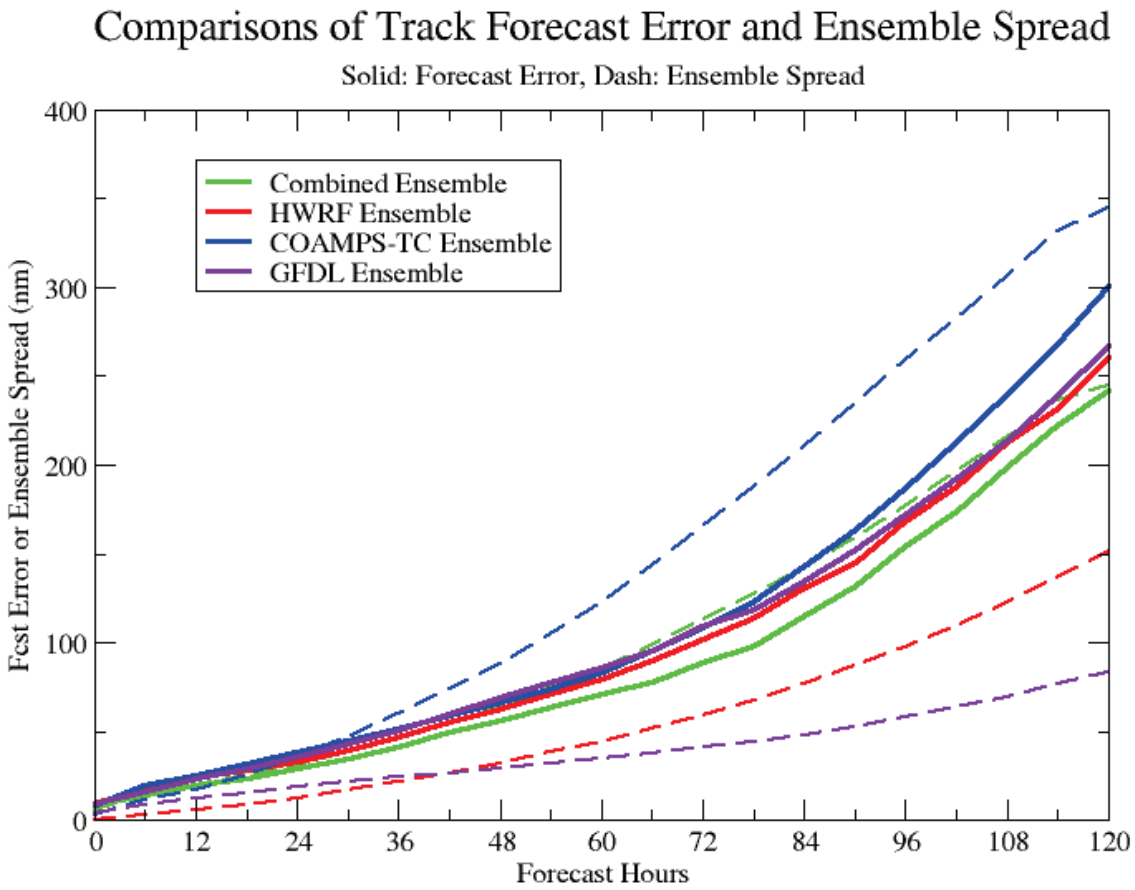
(Retrospective runs 2011-2013)





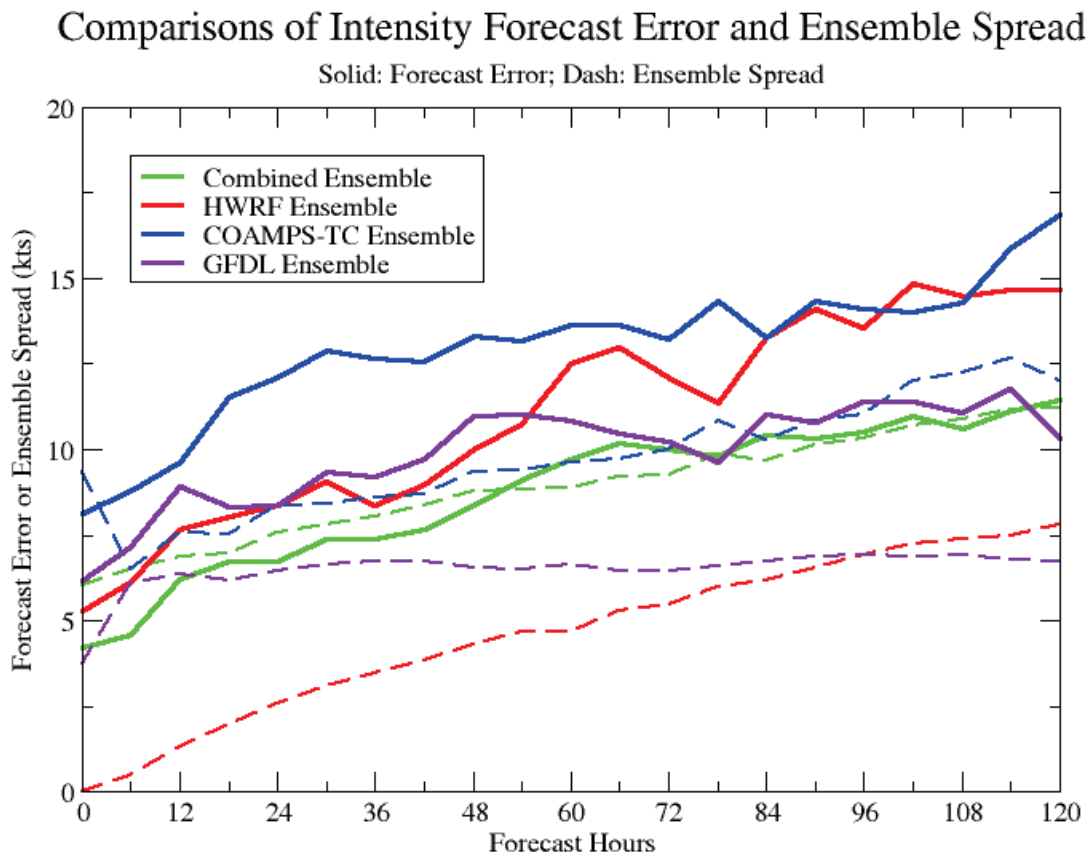






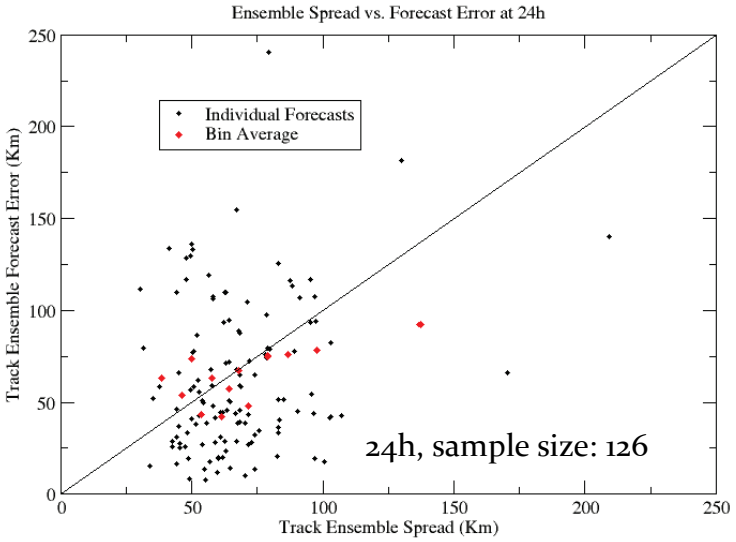
Combined ensemble track forecasts have:

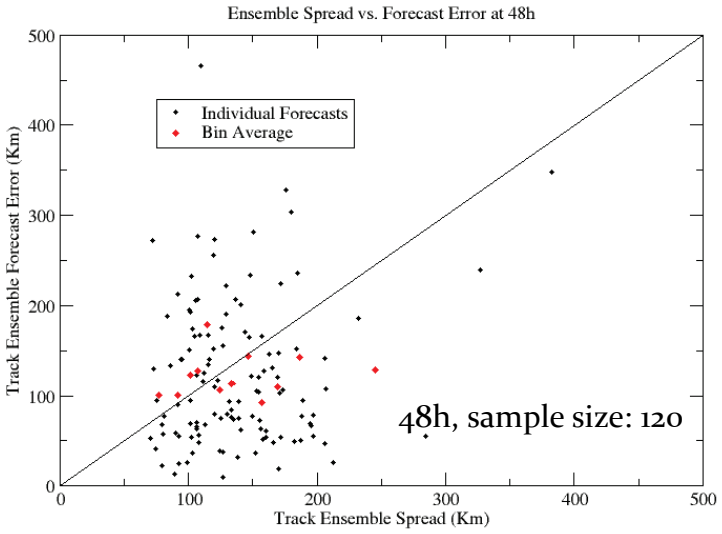
1. lowest track forecast errors;
2. adequate ensemble track spread.

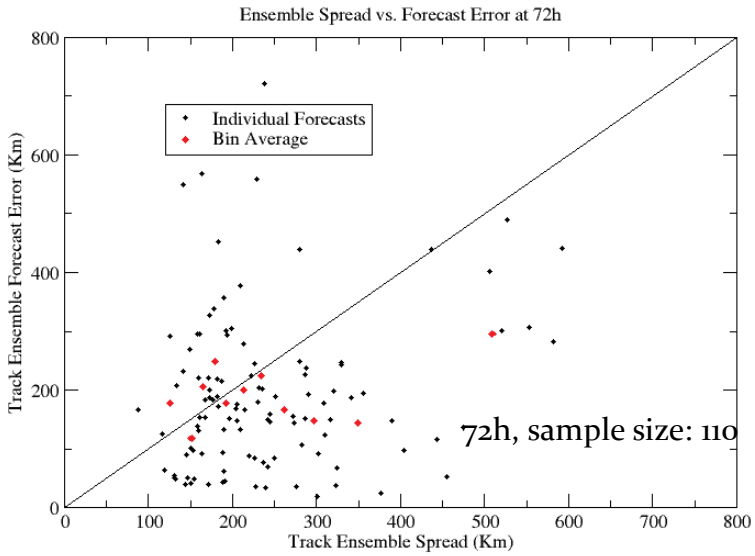


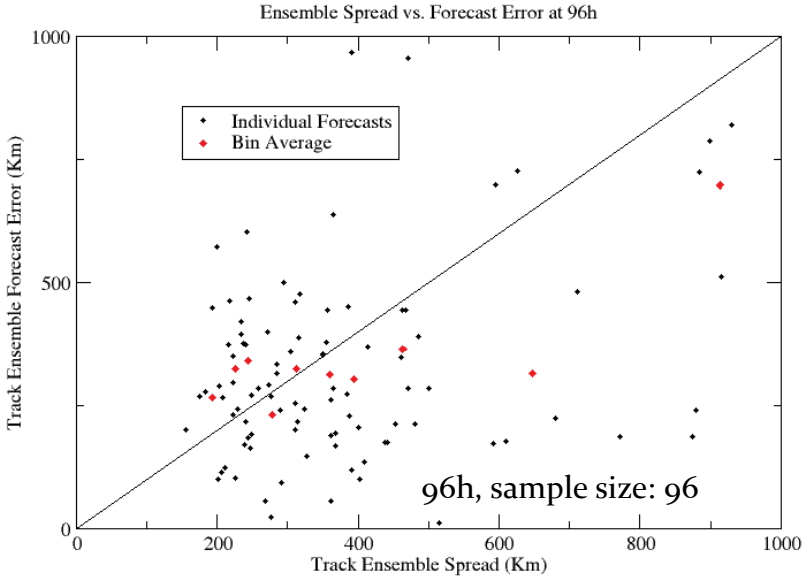
1. Even though HWRF ensemble spread has fast growth rate, it is much smaller than its forecast error because of zero spread at the initial time. This is corrected by adding intensity uncertainties at initial time now.
2. Combined forecast errors are close to the combined ensemble spread.

Relationship between Forecast Error and Ensemble Spread (Track)

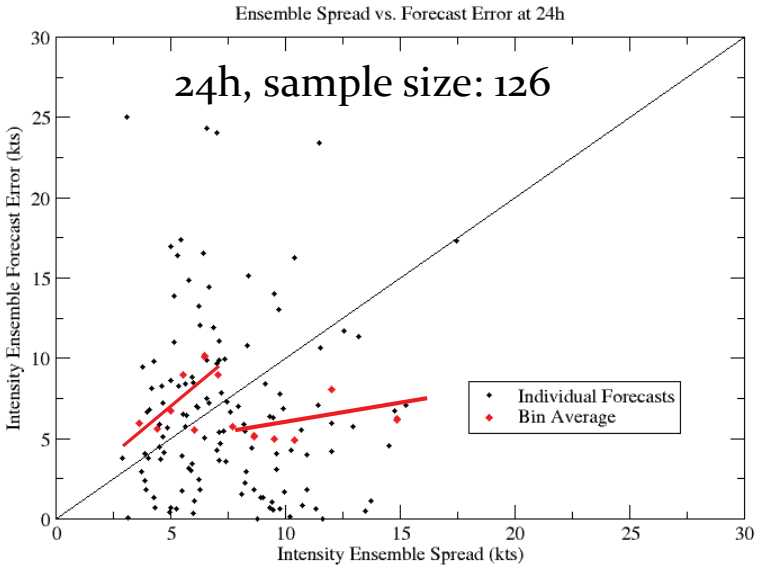


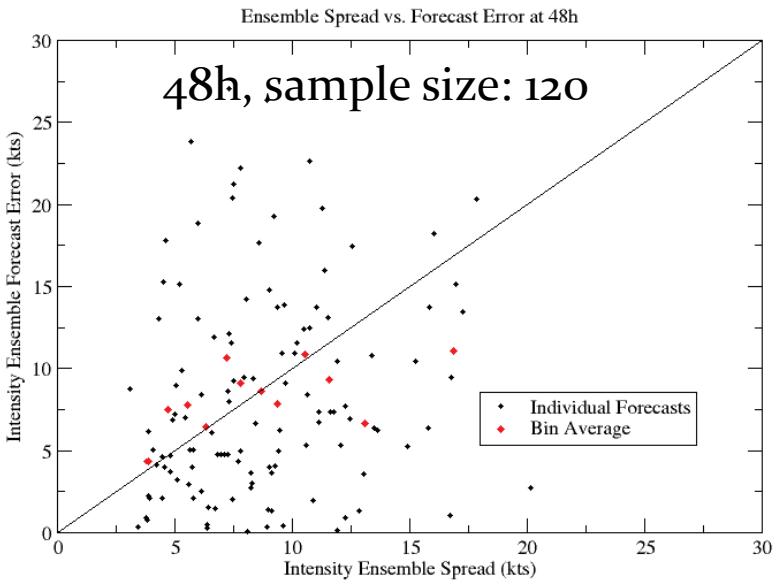


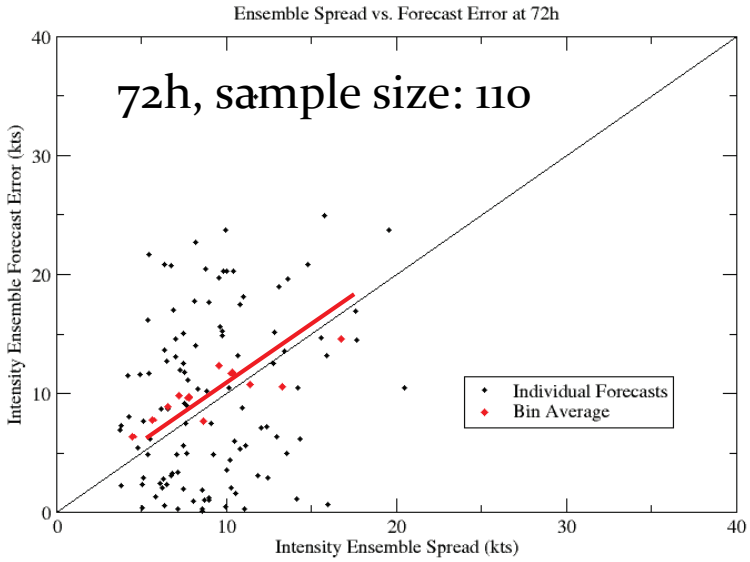


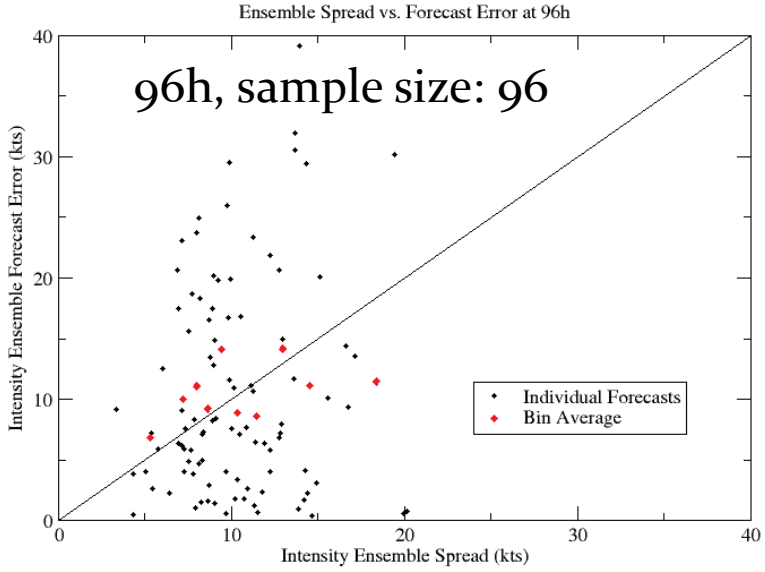


Relationship between Forecast Error and Ensemble Spread (Intensity)

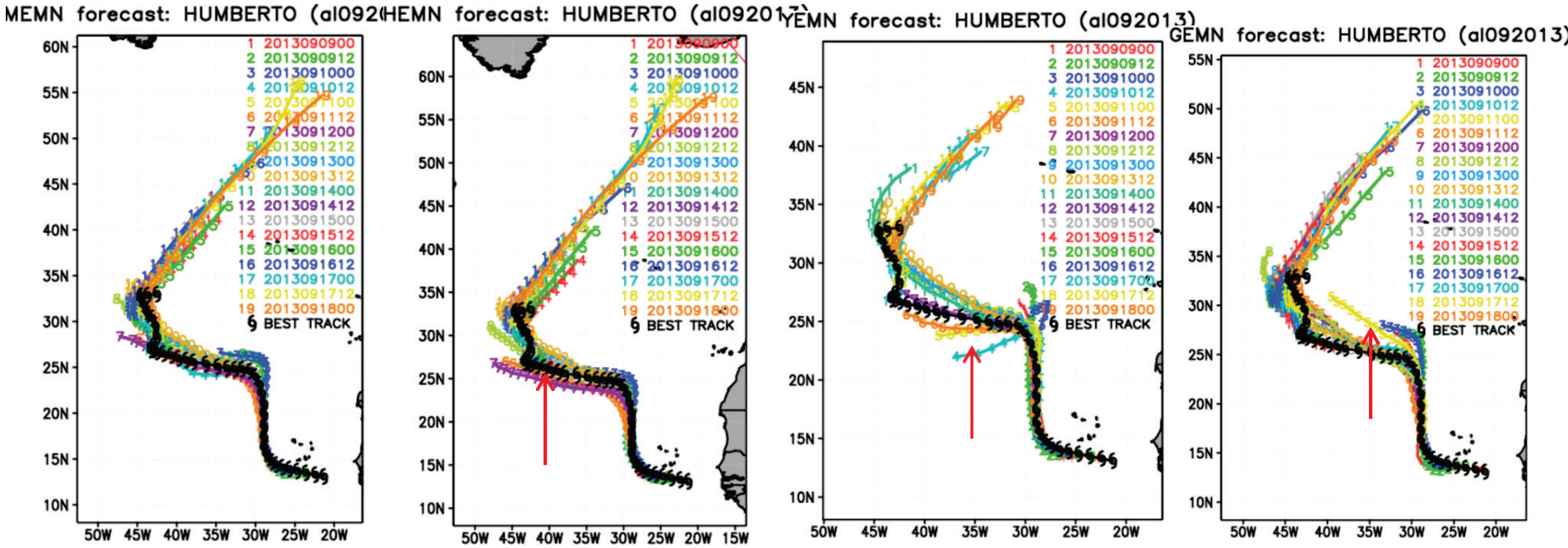






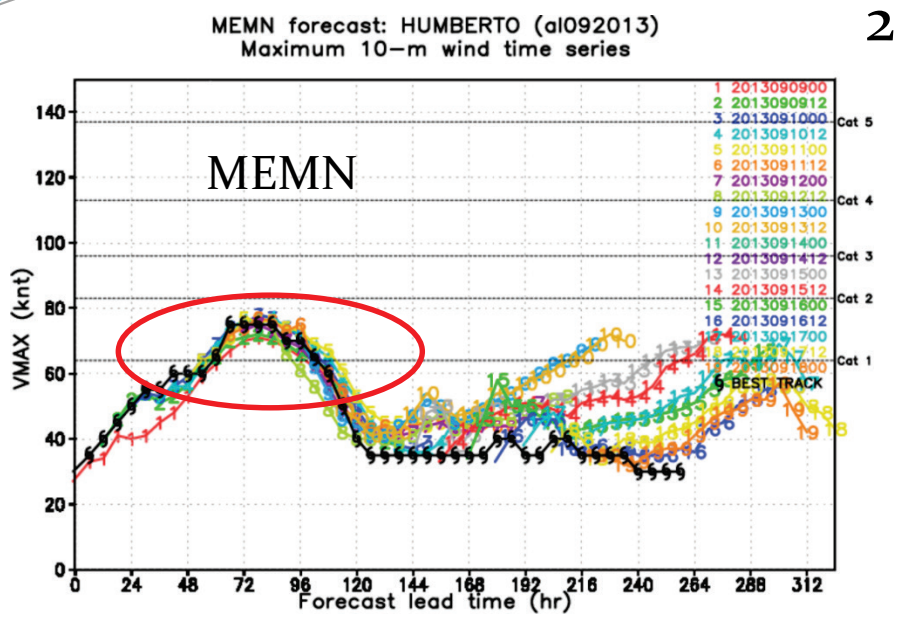


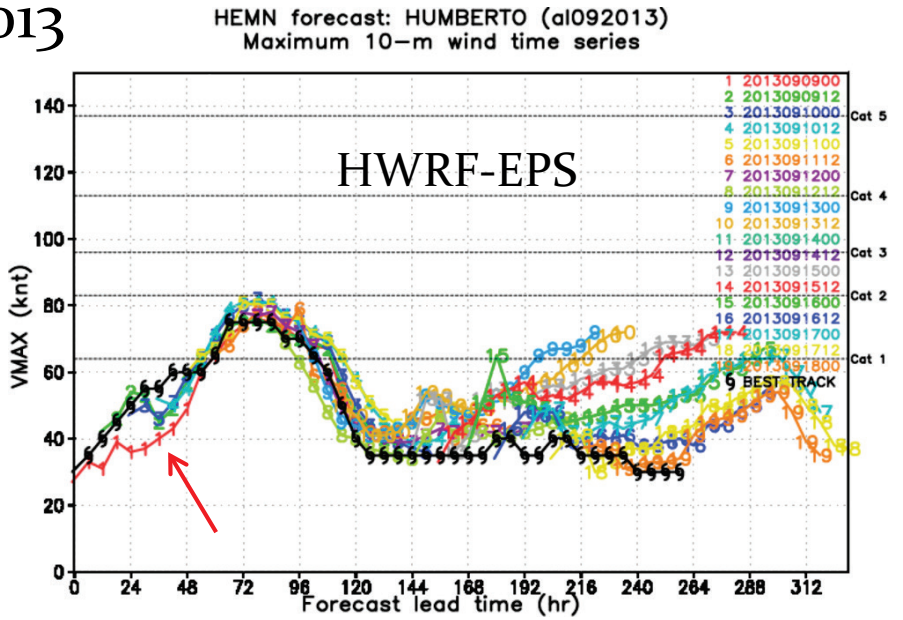
Composite track forecasts for Humberto 09L, 2013

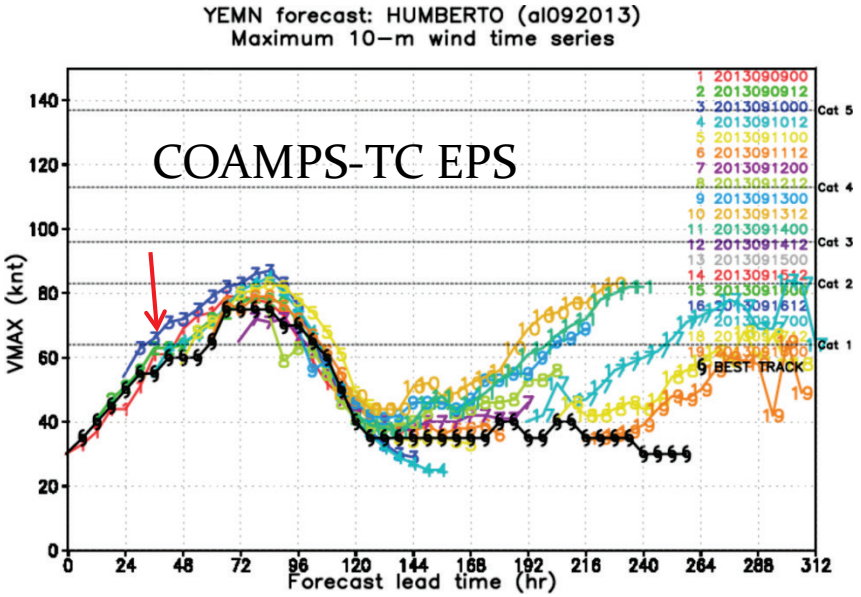


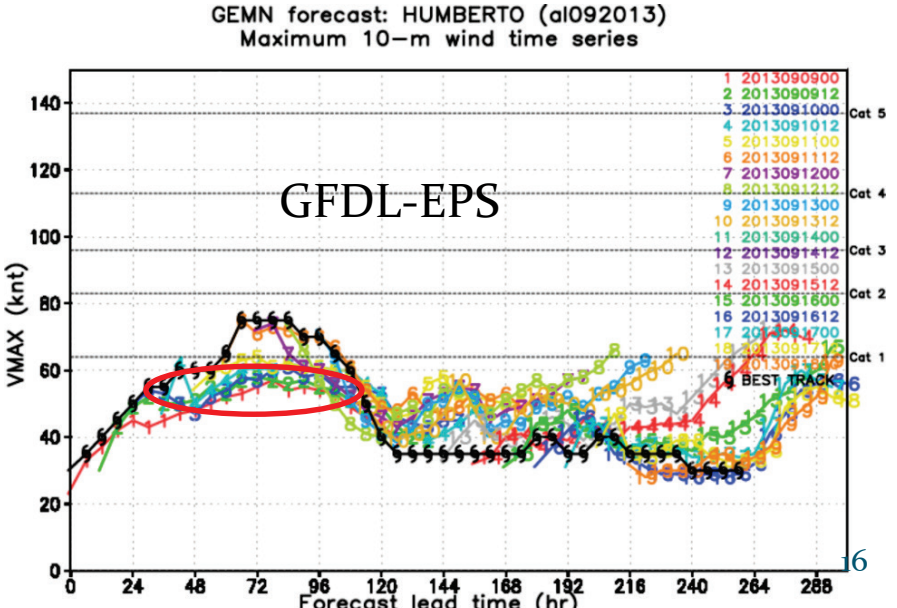
MEMN HWRF-EPS COAMPSTC-EPS GFDL-EPS

Composite intensity forecasts for Humberto 09L, 2013

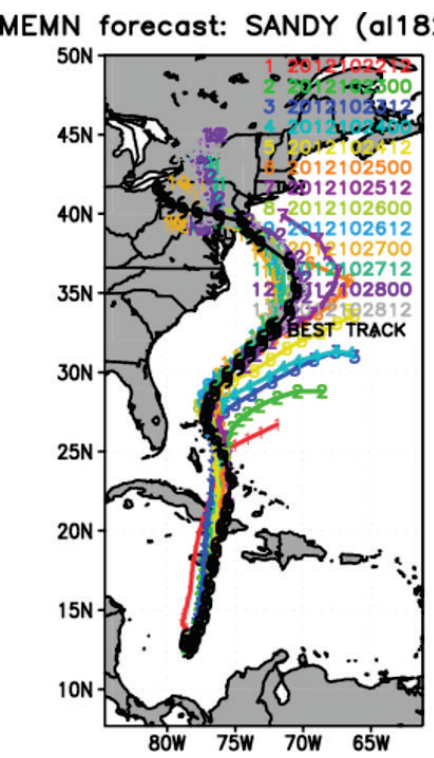




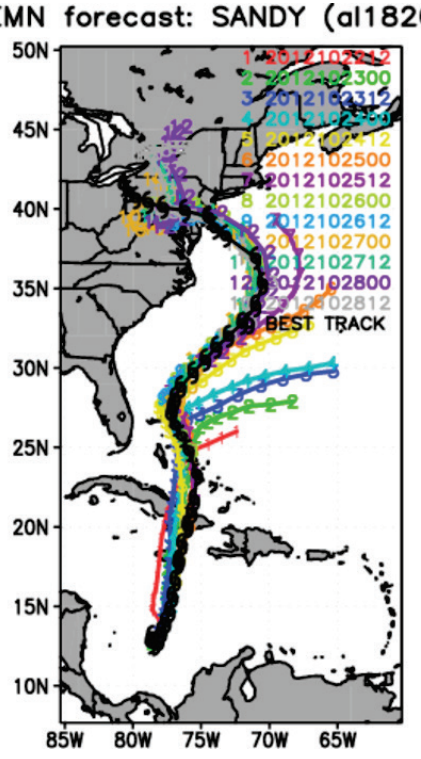




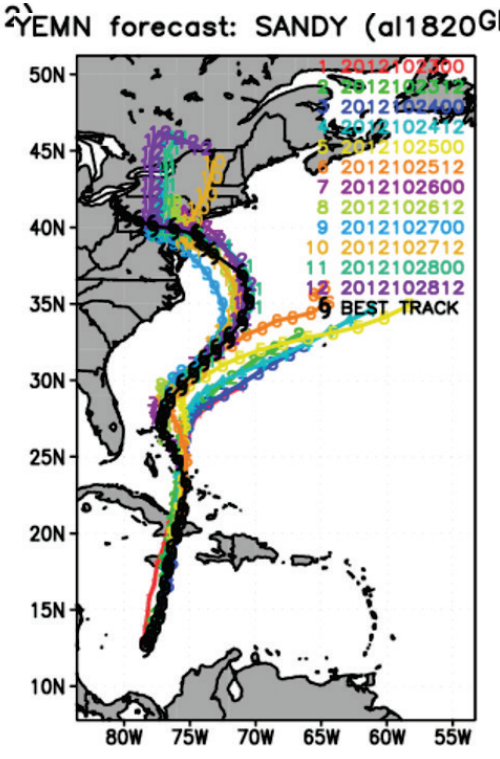
Composite track forecasts for Sandy 18L, 2012



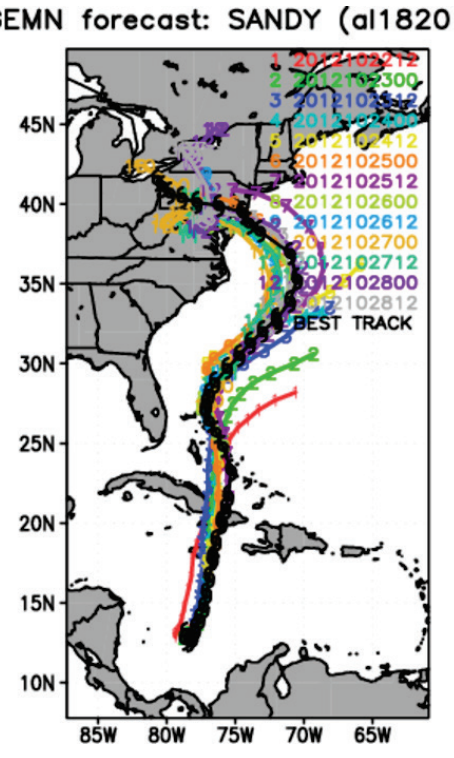
HEMN



HWRF-EPS

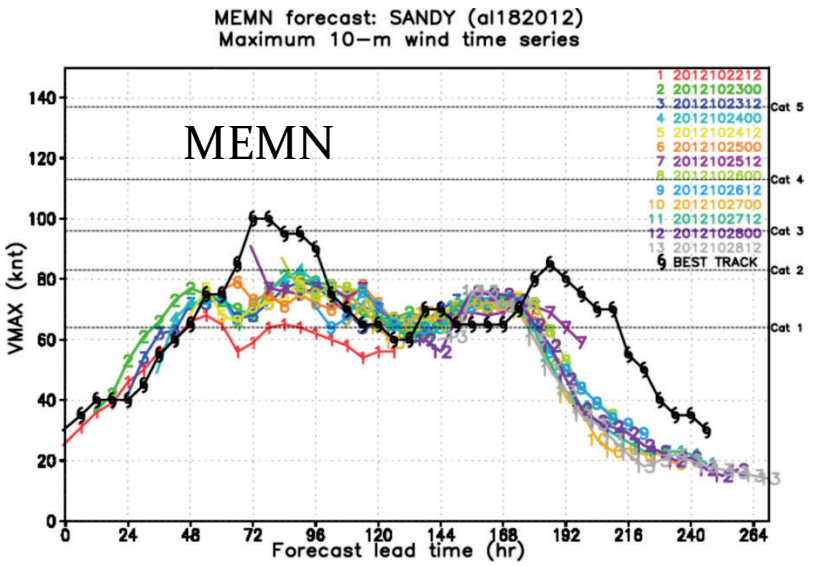


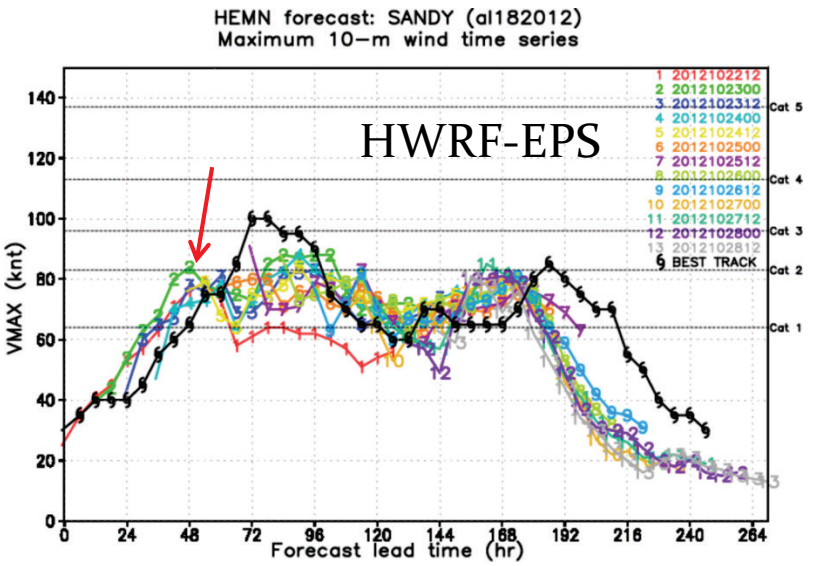
COAMPS-TC EPS

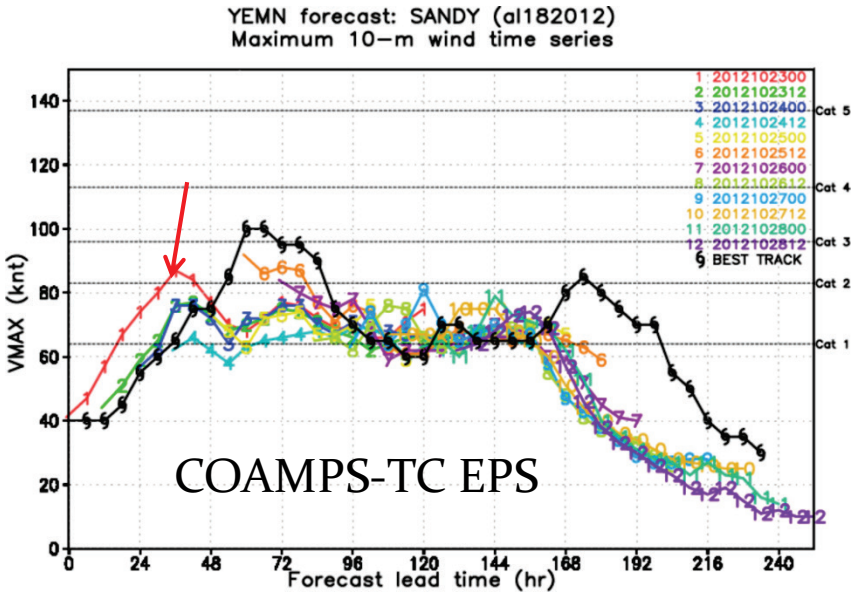


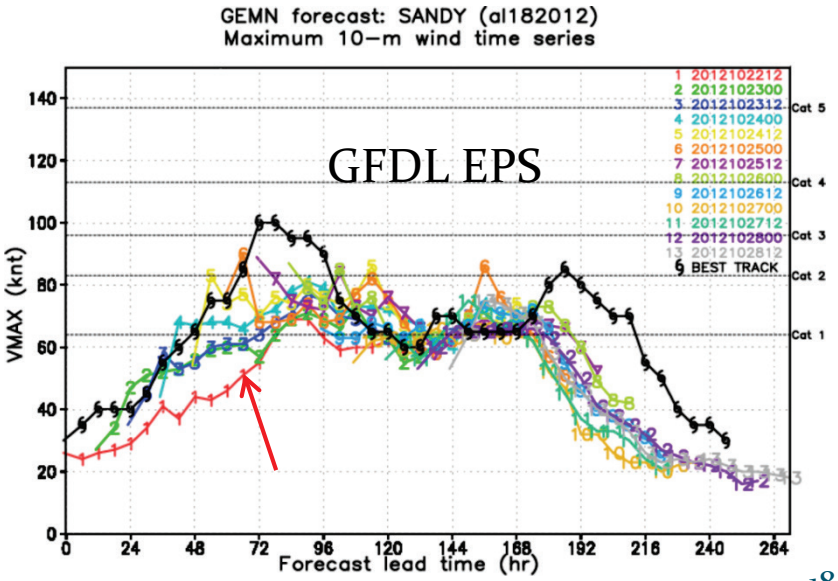
GFDL EPS

Composite intensity forecasts for Sandy 18L, 2012





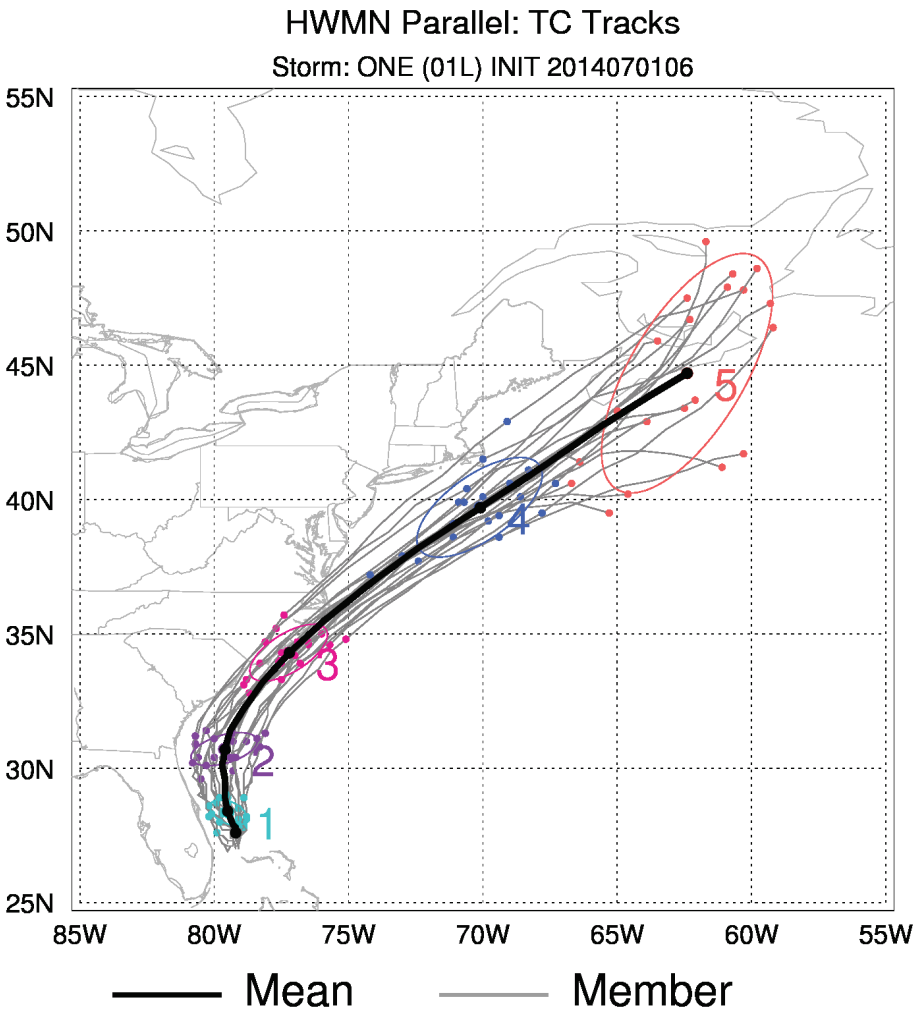




HWRF Ensemble Products

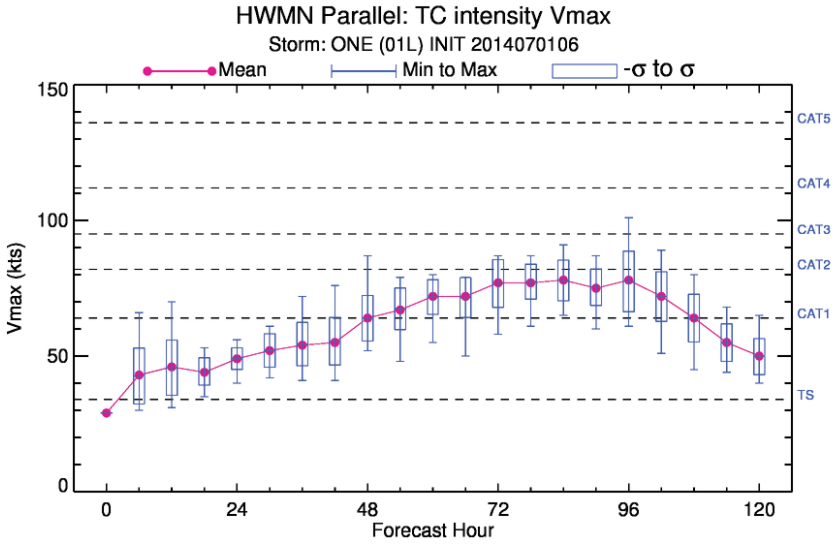
Track Forecasts

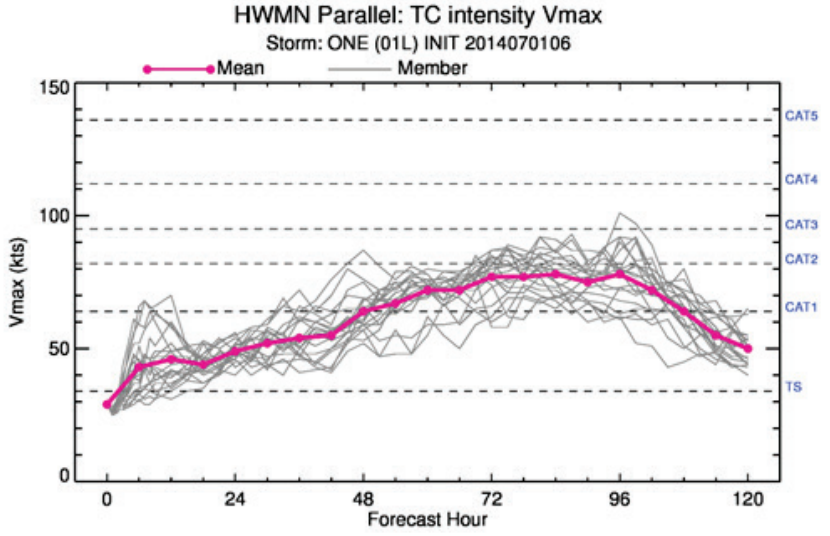
Arthur, 2014070106

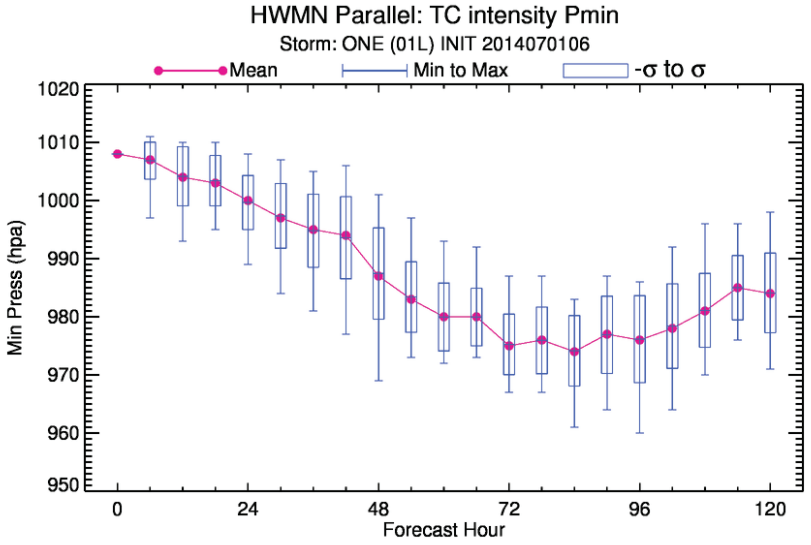


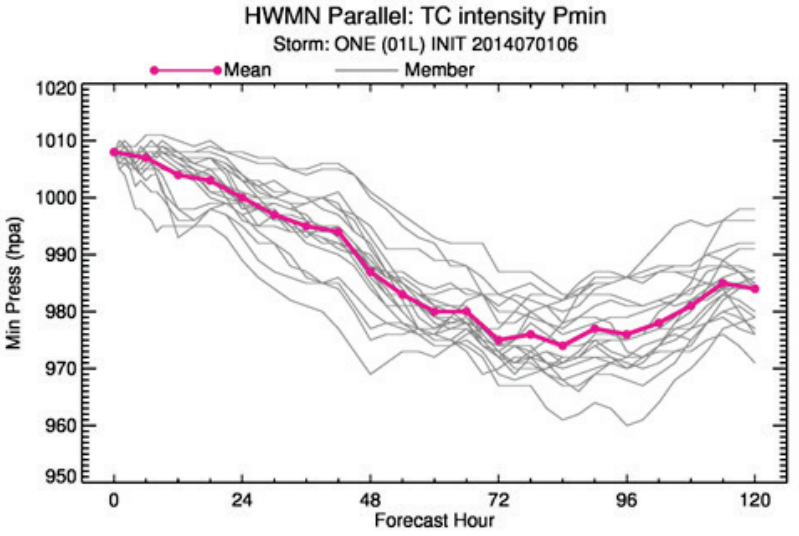
Can be extended to multi-model ensemble products.

Intensity Forecasts





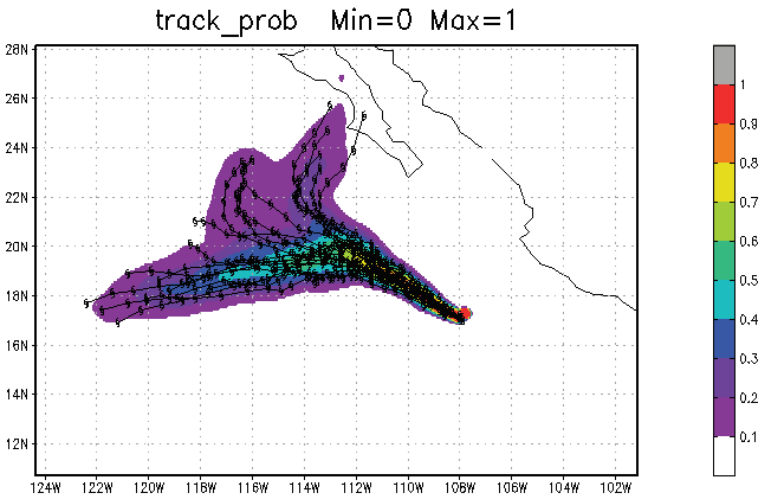




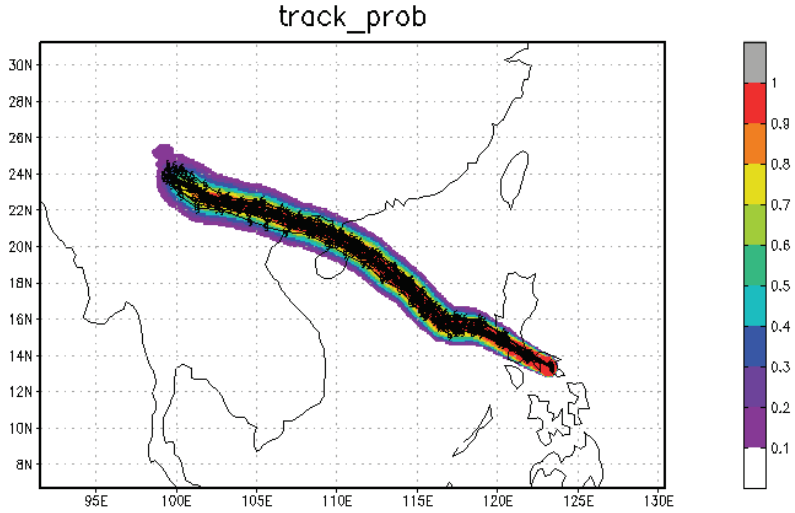
Can be extended to multi-model ensemble products.

Track Probability Forecast based on HWRF-EPS and Deterministic HWRF Forecast Errors

Cristina 03E, 2014061300



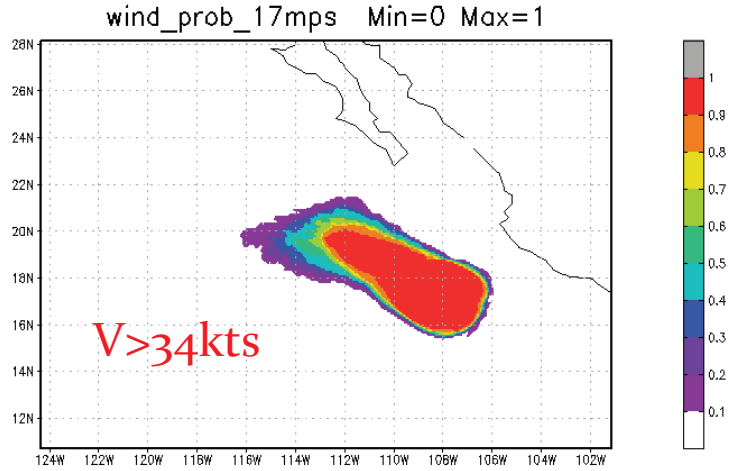
Rammasun 09W, 2014071512

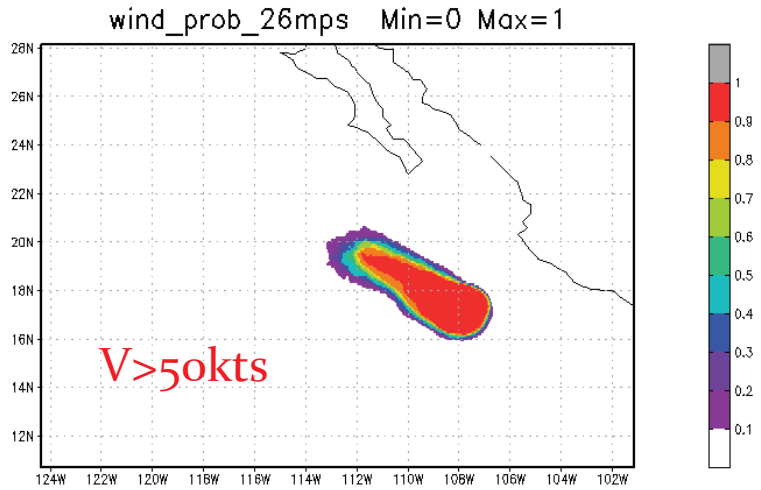


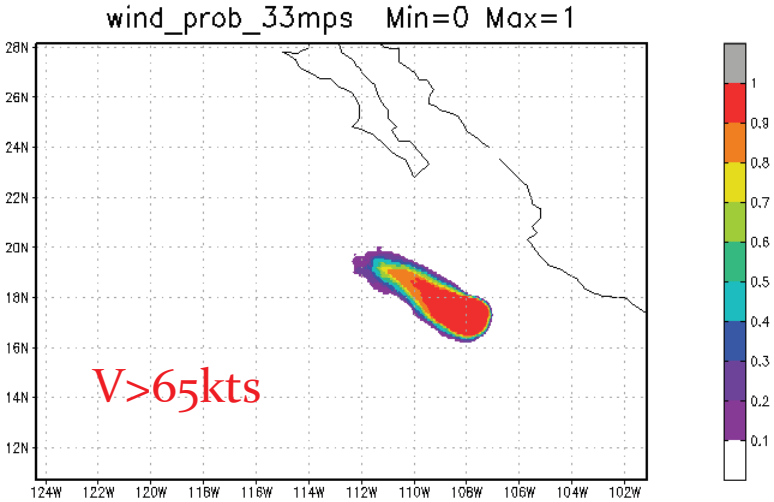
Can be extended to multi-model ensemble products.

Credited to Sam Trahan

Wind Probability Forecasts based on HWRF-EPS at different Thresholds

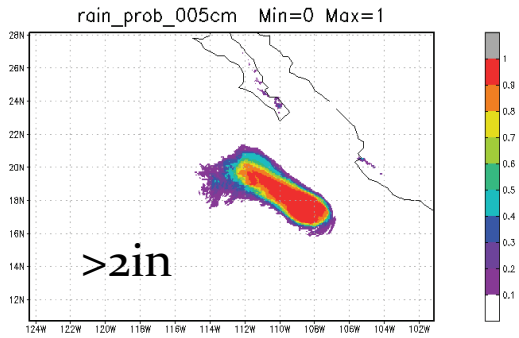


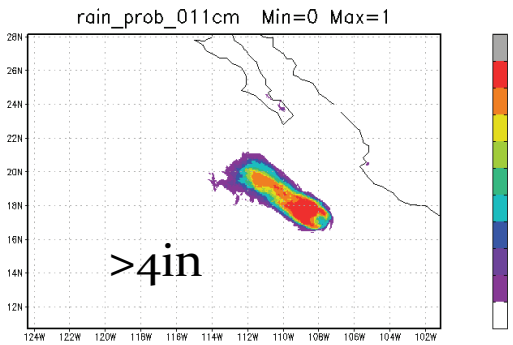


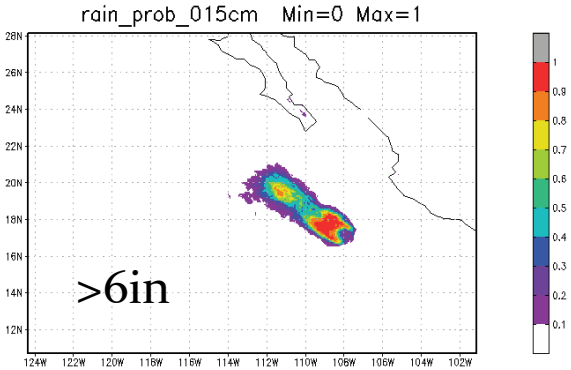


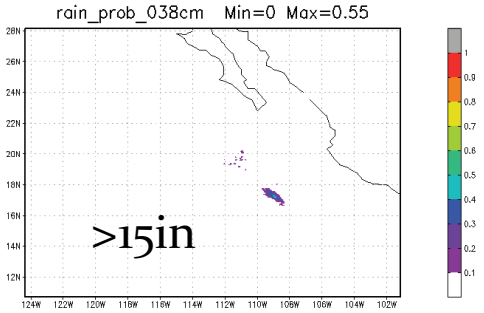
Cristina 03E, 2014061300

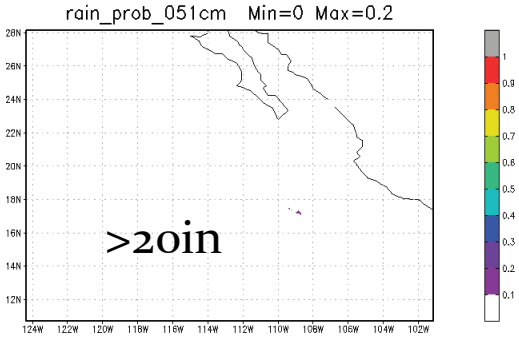
Rainfall Probability Forecast based on HWRF-EPS at different Thresholds

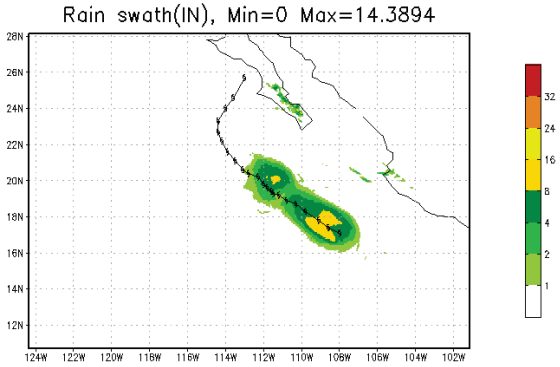








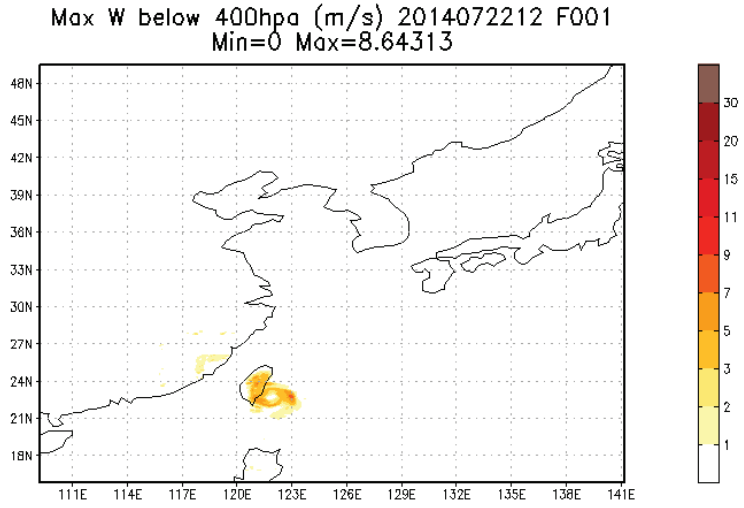


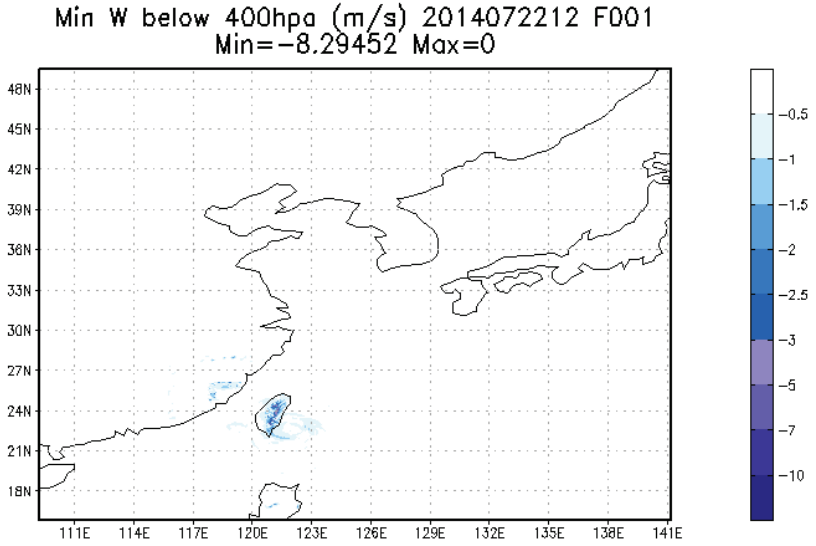


Cristina 03E, 2014061300

Credited to Sam Trahan

Hourly Ensemble Max/Min Vertical Velocity (m/s)



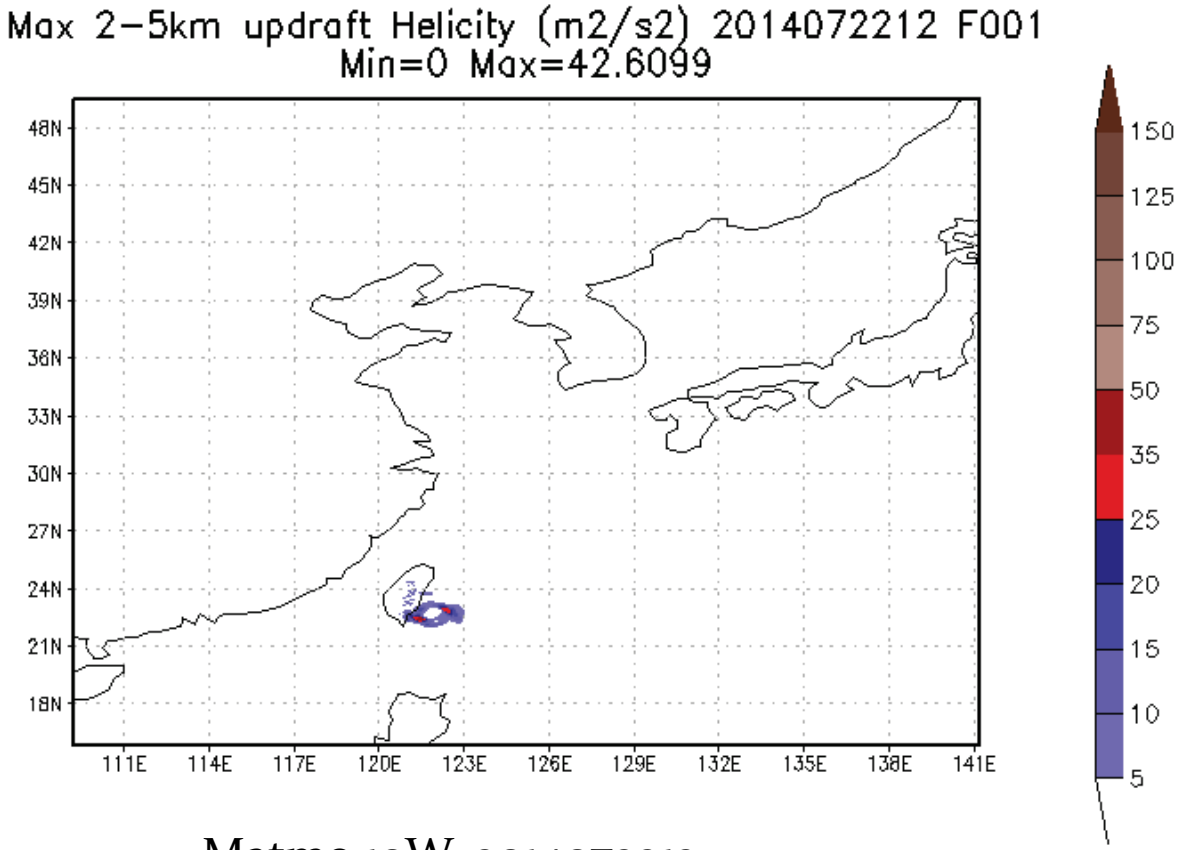


Matmo 10W, 2014072212

Useful for tornado forecast guidance for landfalling storms

Credited to Sam Trahan

Hourly Ensemble Updraft Helicity (m^2/s^2)



Matmo 10W, 2014072212

Useful for tornado forecast guidance for landfalling storms

Credited to Sam Trahan

Summary

- Combined HWRF/COAMPS-TC/GFDL ensemble system takes into account most of uncertainties that are important to model hurricane track/intensity forecasts;

- Combined ensemble system provided improved track/intensity forecasts, compared to the forecasts from each individual ensemble system;

- Combined ensemble system has adequate forecast error and ensemble spread relationship;

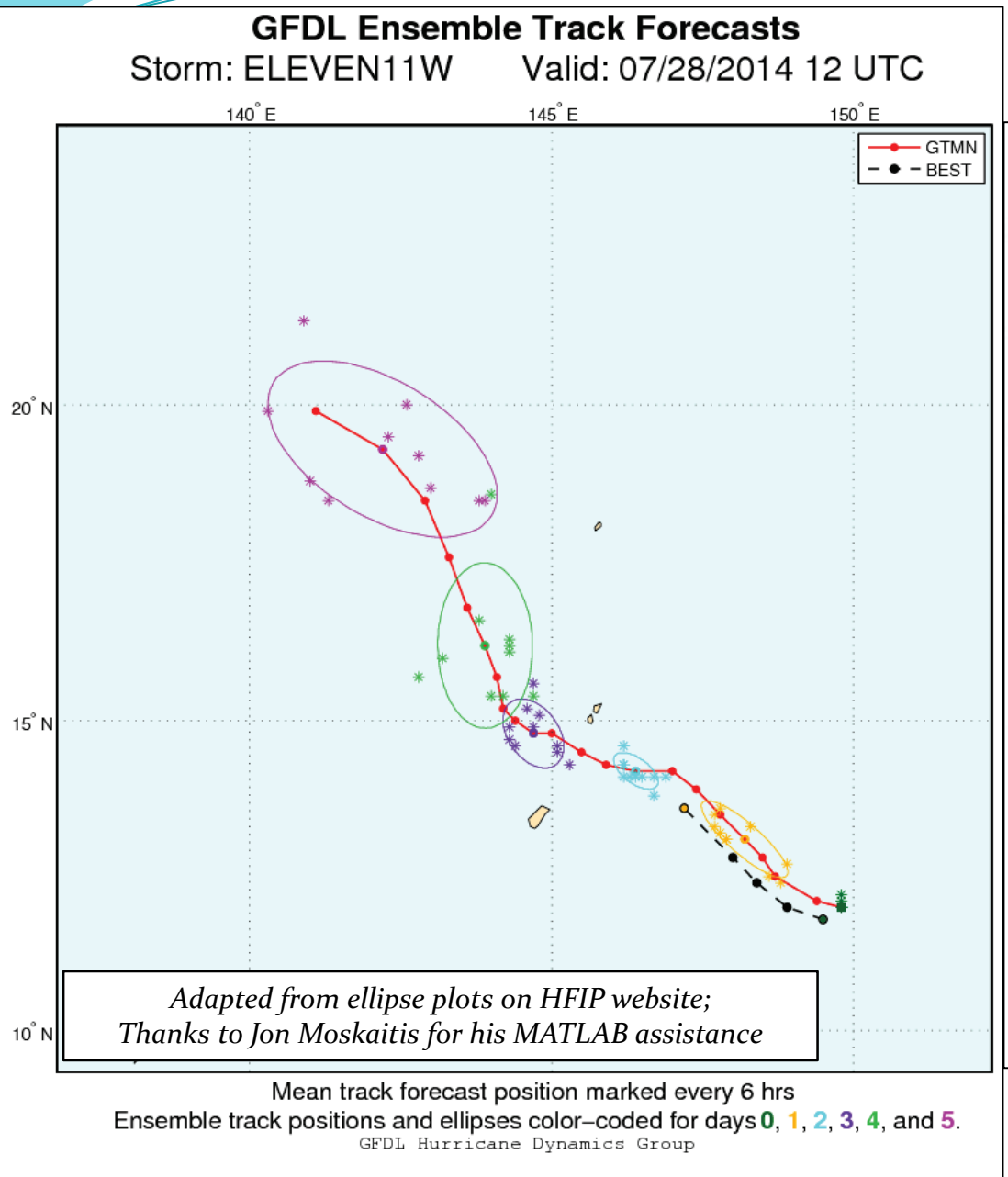
- More ensemble products can be developed based on the combined ensemble system.

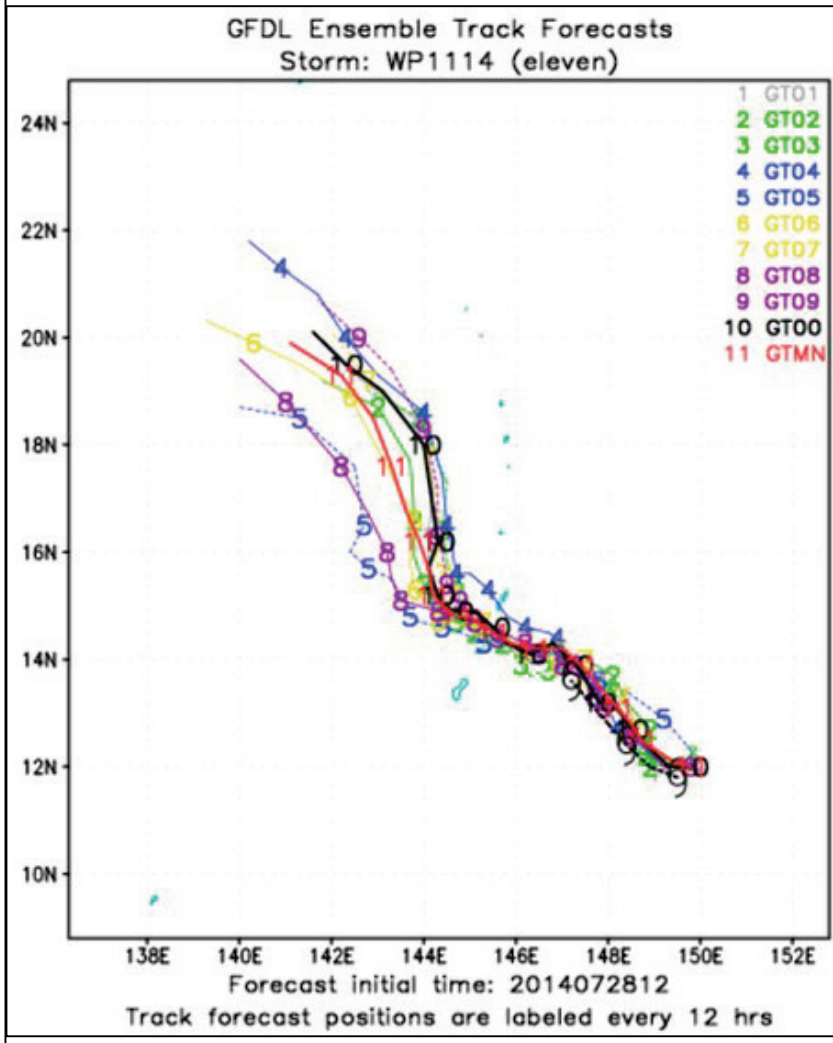
COAMPS-TC
Slides provided separately

GFDL Ensemble Products

http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/

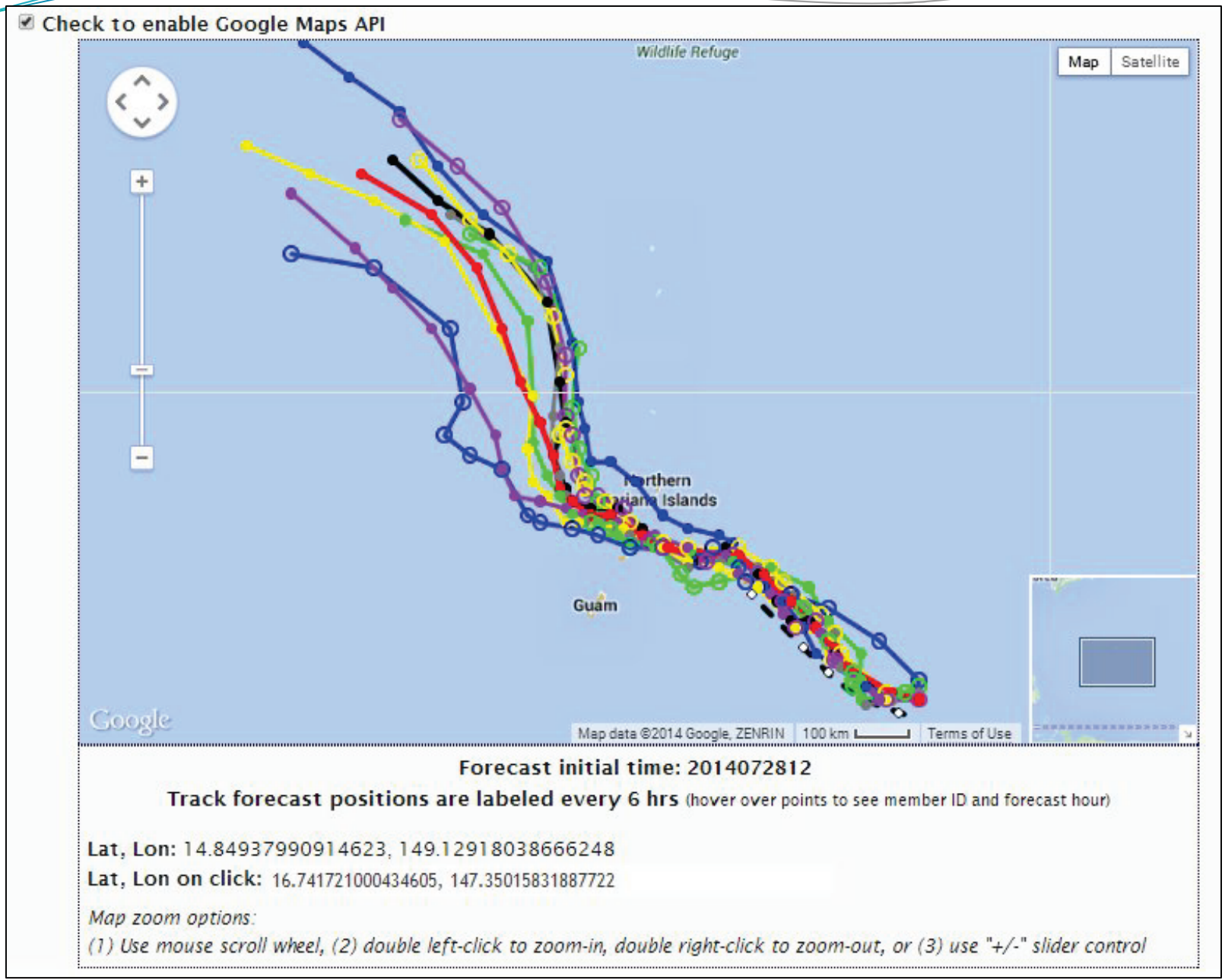
Track Forecasts





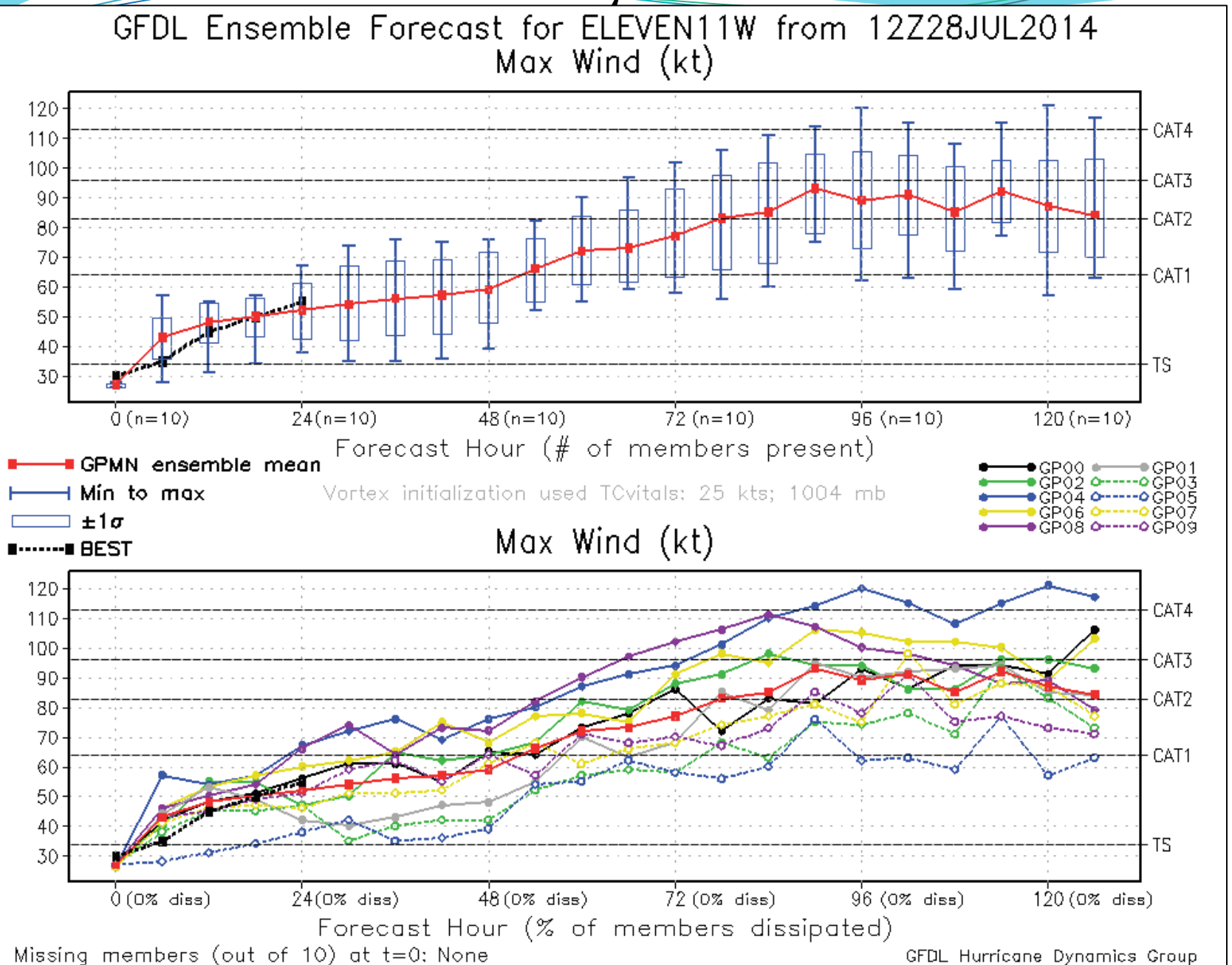
http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/

Track Forecasts



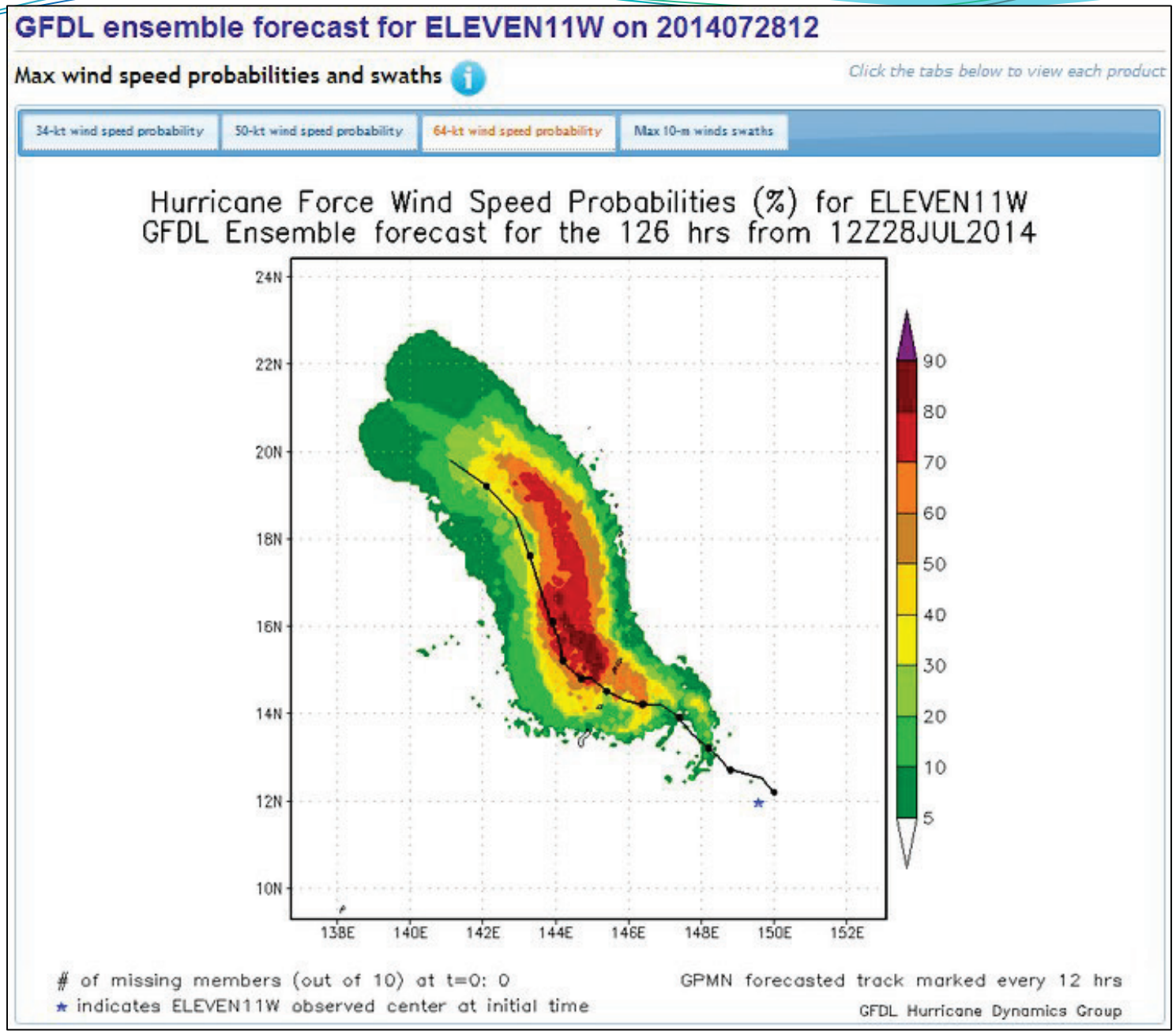
http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/

Intensity Forecasts



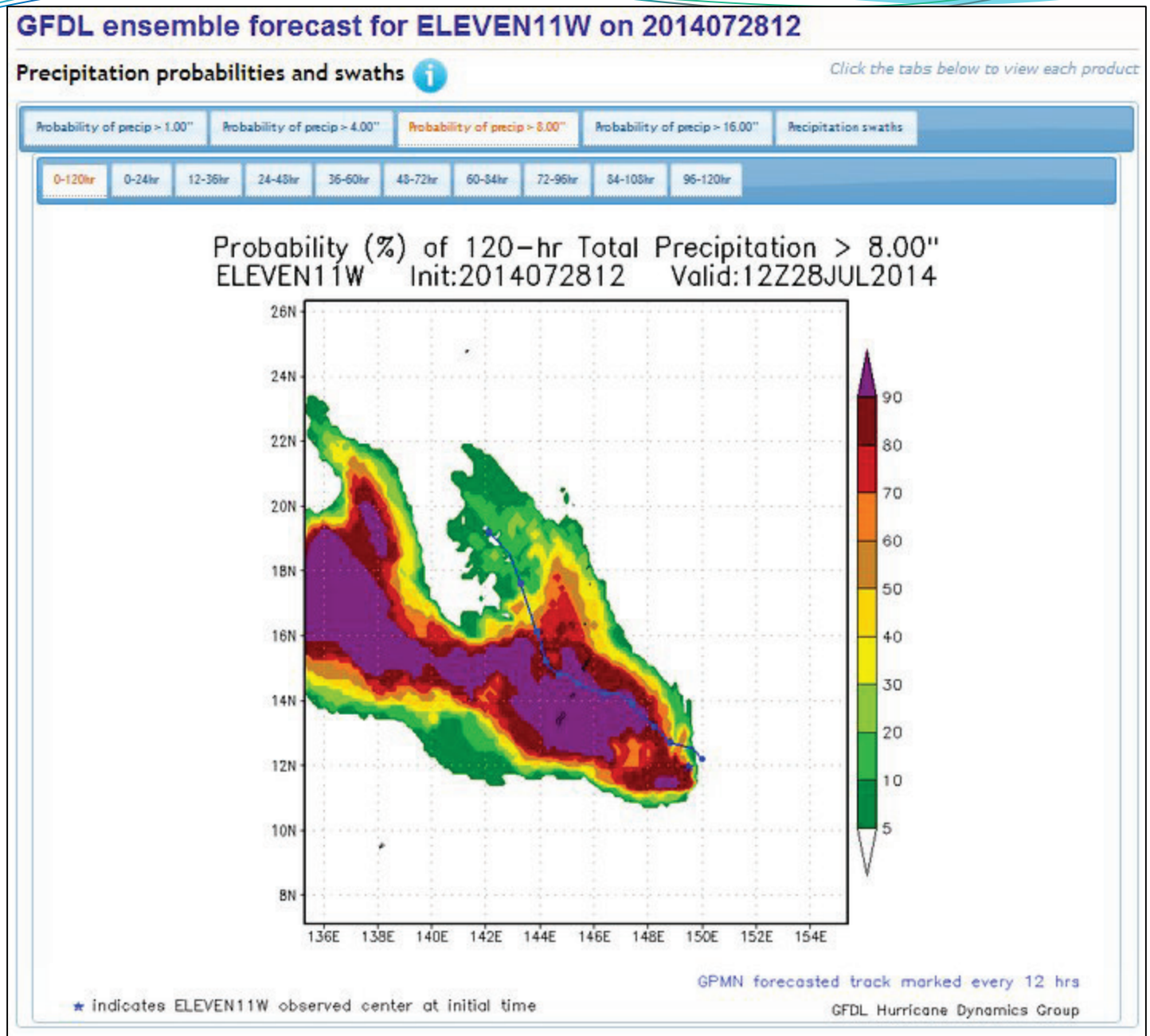
http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/

Wind Probability Forecasts Based on GFDL-EPS



http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/

Rainfall Probability Forecast Based on GFDL-EPS



http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/

Other GFDL-EPS Products