HFIP ENSEMBLE TEAM UPDATE

•Develop more reliable and useful automated probabilistic numerical guidance for hurricane track, intensity, structure, rainfall, storm surge, and other associated weather elements through improved ensemble forecasting systems and improved post-processing methods

•Work closely with HFIP ***Data Assimilation Team*** on development and use of ensemble-based data assimilation techniques for initializing ensemble predictions

•Work with ***Verification Team*** on developing and using ensemble/probabilistic measures

•Work with ***Applications/DiagnosticsTeam*** to develop ensemble/probabilistic products

1. **NCEP**
2. **ESRL/PSD**
3. **GFDL**
4. **ESRL/GSD**
5. **NRL**

NCEP Ensemble Team Report

Yuejian Zhu, Jiayi Peng and Jun Du

October 2012

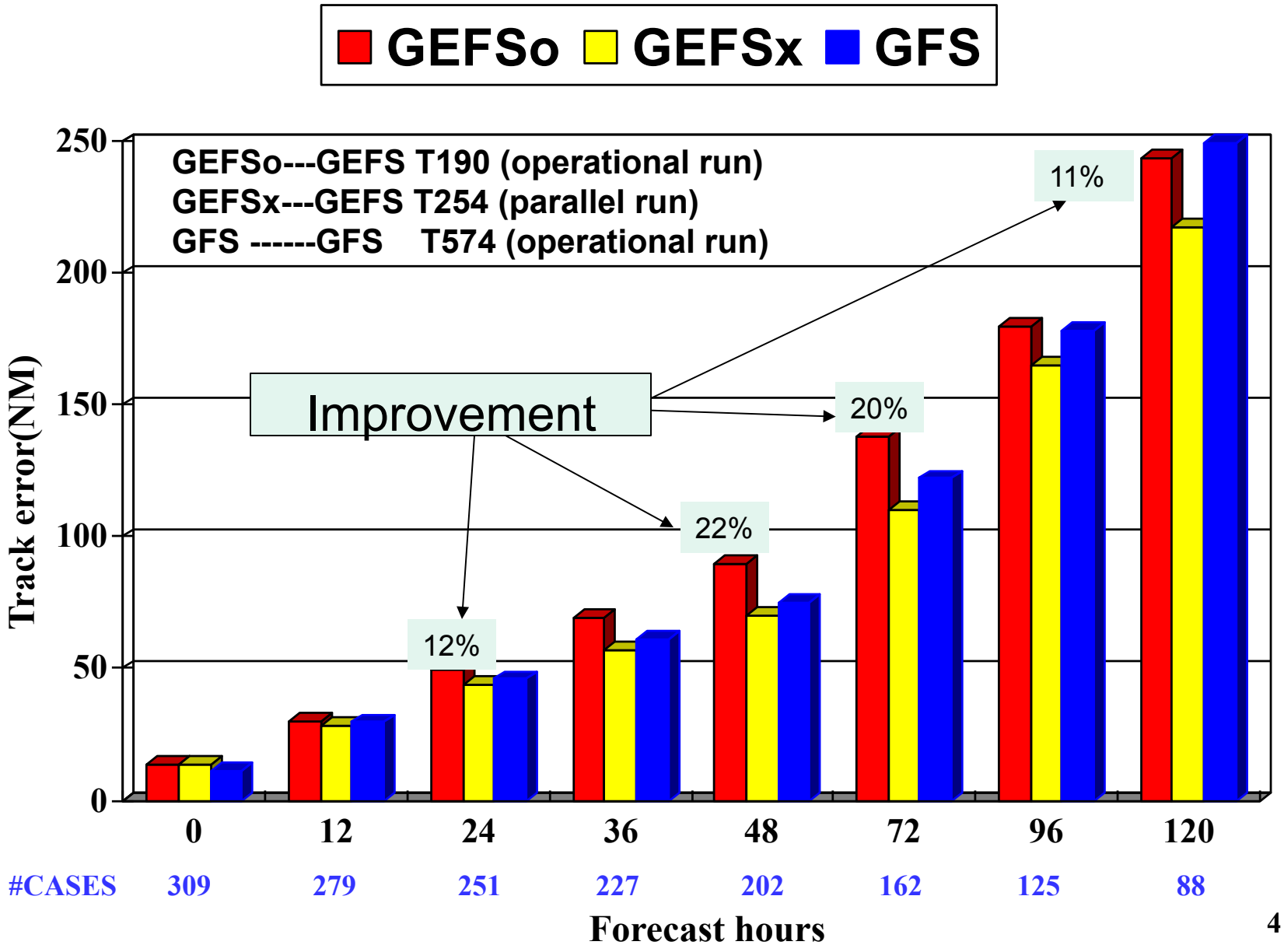
GEFS Implementation – 02/12/2012

- Model and initialization
  - Using GFS V9.01 (current operational GFS) instead of GFS V8.00
  - Improved Ensemble Transform with Rescaling (ETR) initialization
  - Improved Stochastic Total Tendency Perturbation (STTP)
- Configurations
  - T254 (55km) horizontal resolution for 0-192 hours (from T190 – 70km)
  - T190 (70km horizontal resolution for 192-384 hours (same as current opr)
  - L42 vertical levels for 0-384 hours (from L28)

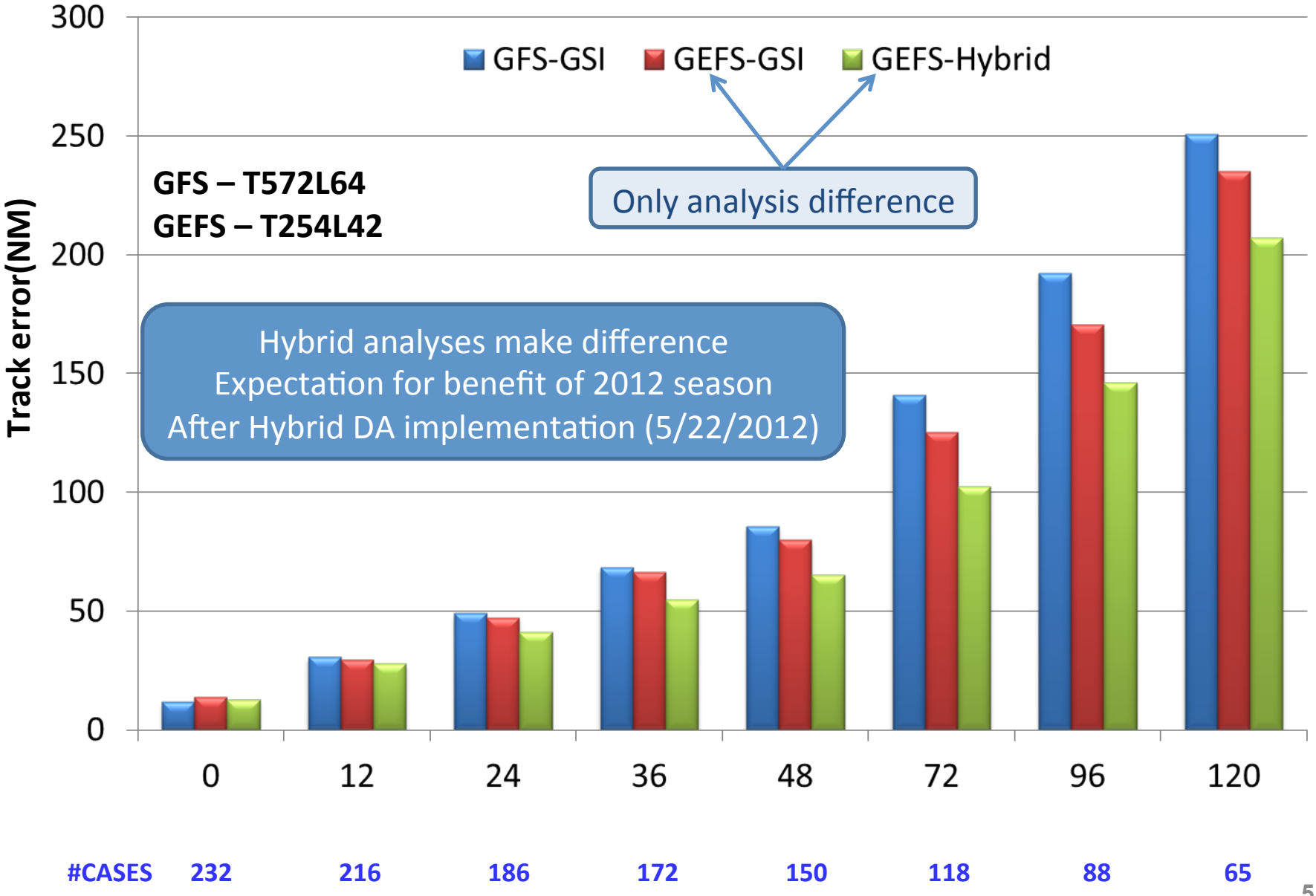
SREF Implementation – 8/21/2012

- Model Change
  - Model adjustment (eliminate Eta and RSM legacy models and add new NEMS-based NMMB model)
  - Model upgrade (two existing WRF cores from v2.2 to version 3.3)
  - Resolution increase (from 32km/35km to 16km)
  - All models run with 35 levels in the vertical and 50 mb model top.
- IC diversity improvement
  - More control ICs (NDAS -> NMMB, GDAS -> NMM, RAP blended @ edges w/GFS -> ARW)
  - More IC perturbation diversity (blend of regional breeding and downscaled ETR)
  - Diversity in land surface initial states (NDAS, GFS, and RAP).

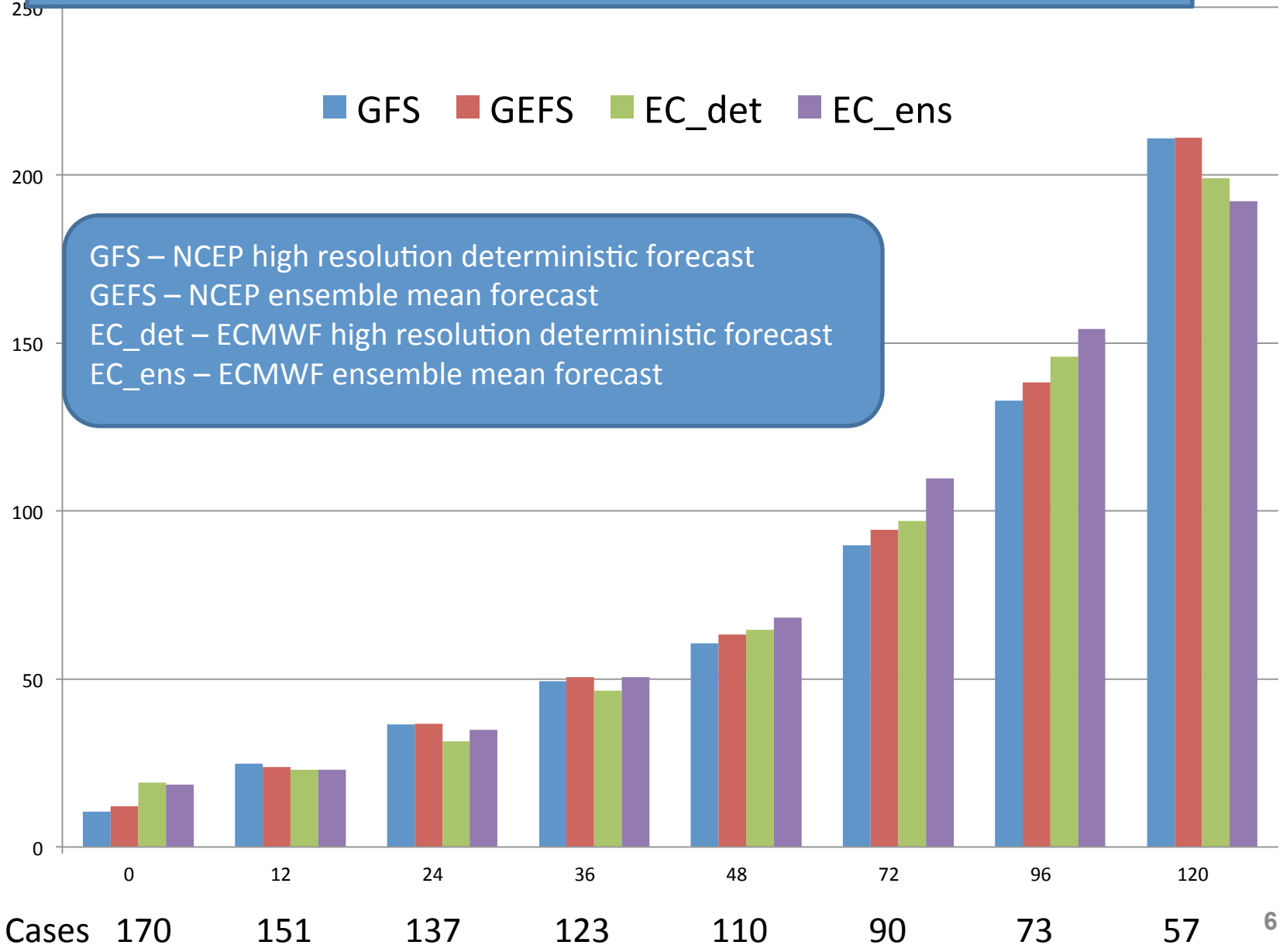
Atlantic, AL01~19 (06/01~11/30/2011)



AL01-18,EP03-12, WP08-23 (07/01-10/25/2011)

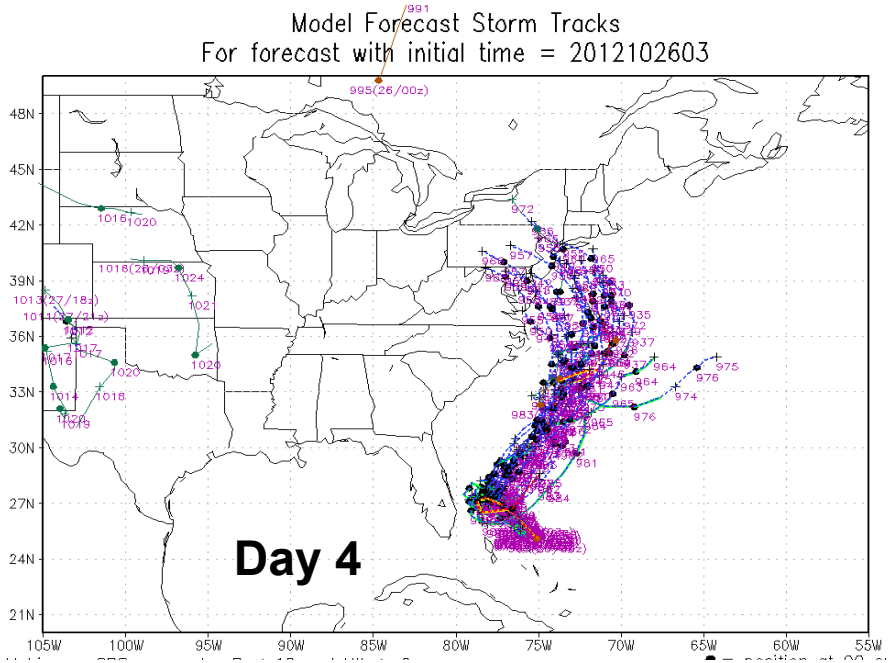


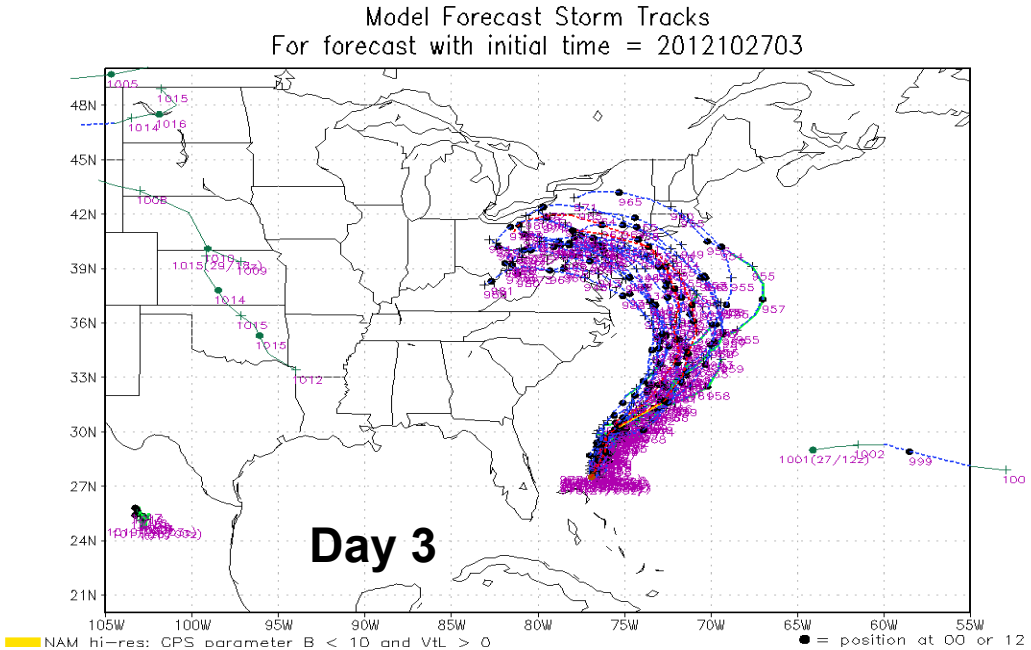
Atlantic Basin 2012 season (05/01~09/30/2012)

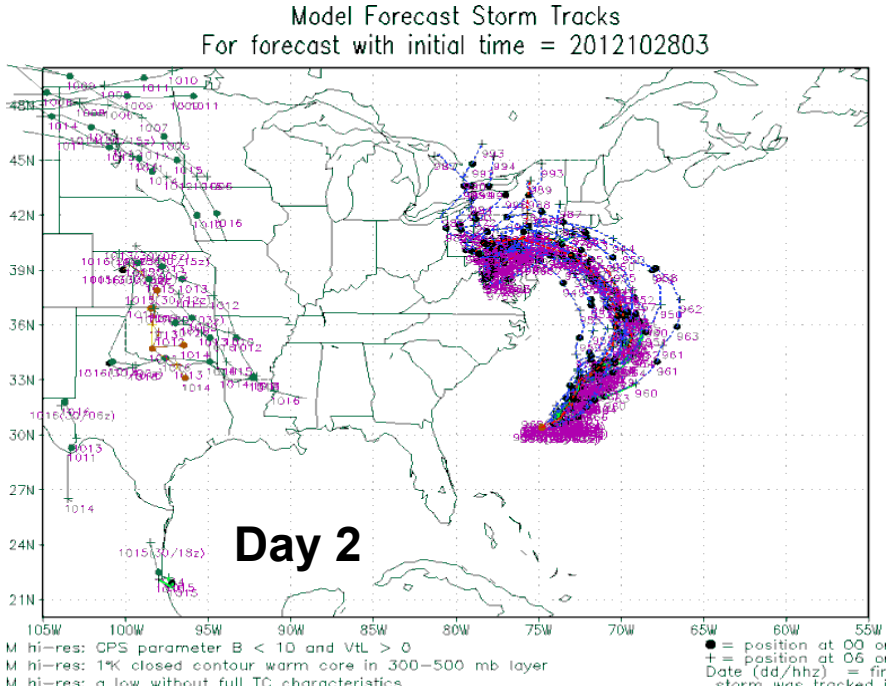


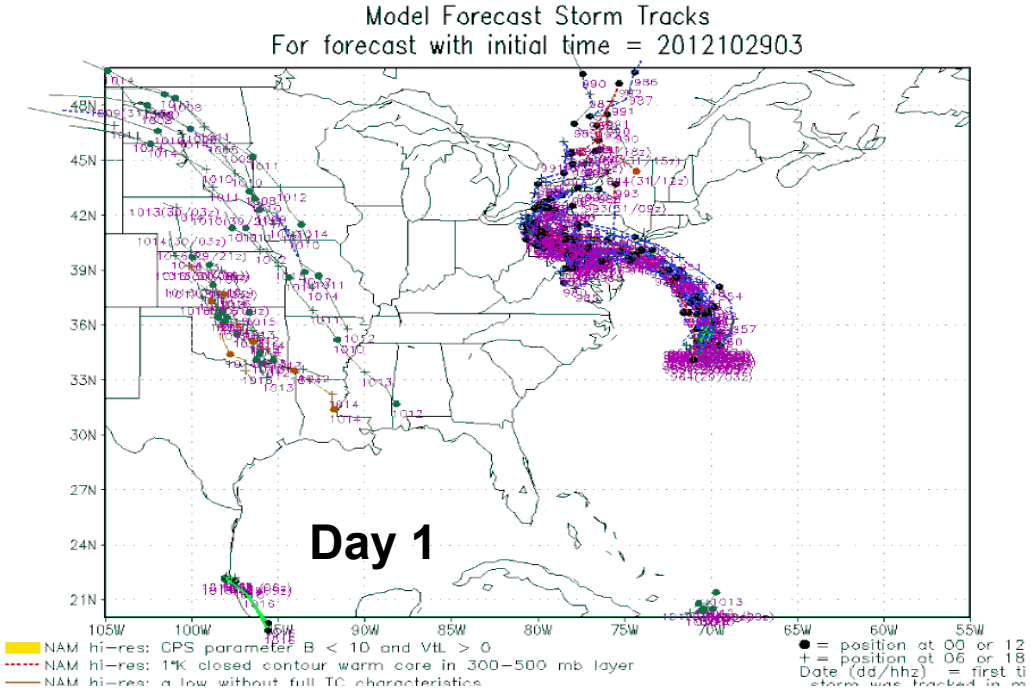
Cases	170	151	137	123	110	90	73	57

NCEP SREF Track Forecasts of Hurricane Sandy (landfall near Atantic City, New Jersey, 00z, Oct. 30, 2012)

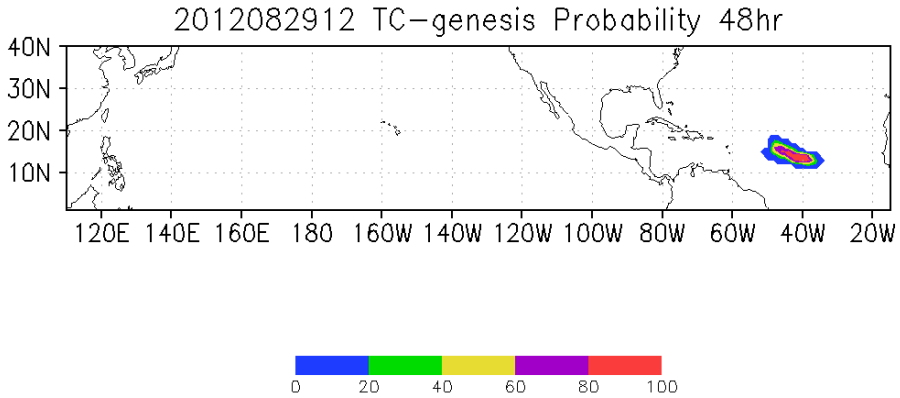


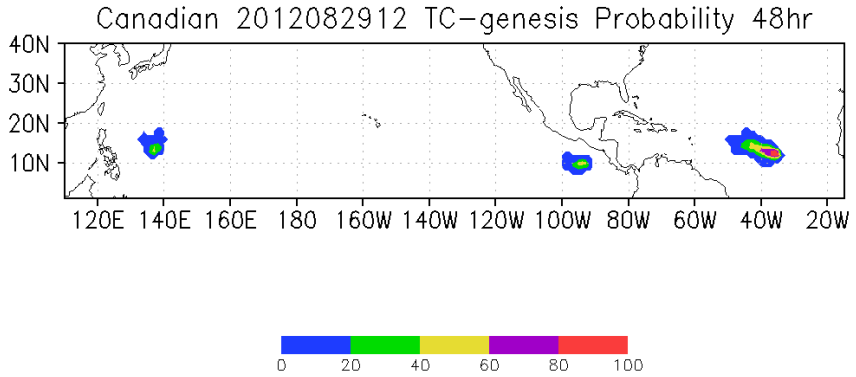


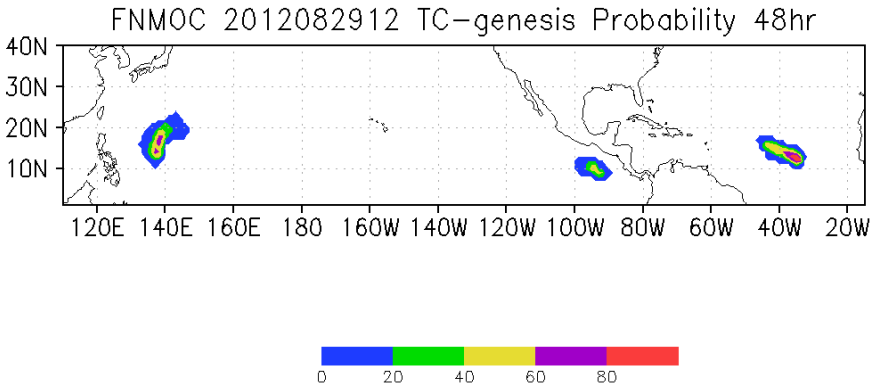


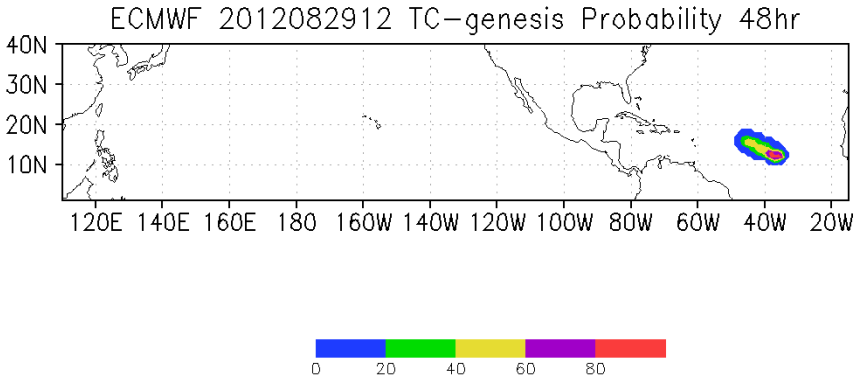


TC genesis probability forecasts from NCEP GEFS, Canadian, Navy and ECMWF ensemble forecast systems(AL12)









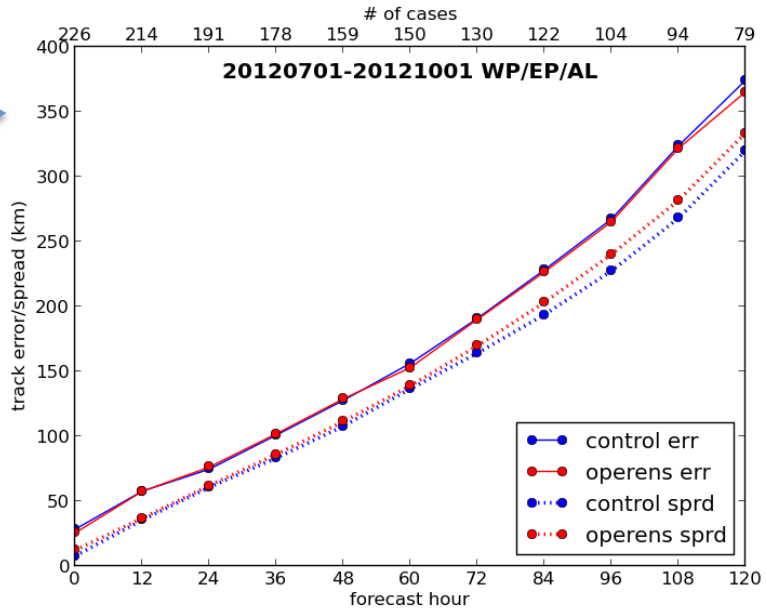
Stochastic Physics testing in GFS ensemble

Jeff Whitaker, Phil Pegion and Tom Hamill

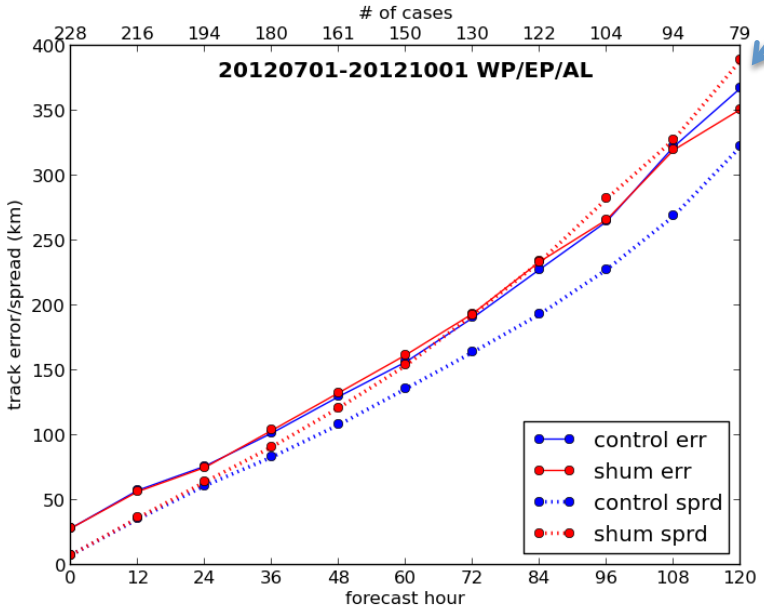
- 3 methods tested and compared to operational NCEP scheme
  - SPPT (ECMWF scheme 'stochastically-perturbed physics tendencies')
  - VC (vorticity confinement, similar to stochastic backscatter but simpler)
  - SHUM (stochastic perturbations to boundary layer specific humidity)
- Ensemble forecasts run at T254L42 every 00UTC from 1 June to 1 Oct 2012 from operational NCEP initial conditions.
- Operational NCEP scheme and SPPT have little impact on TC ensemble forecasts
- SHUM has a large impact on track spread, VC reduces intensity bias.

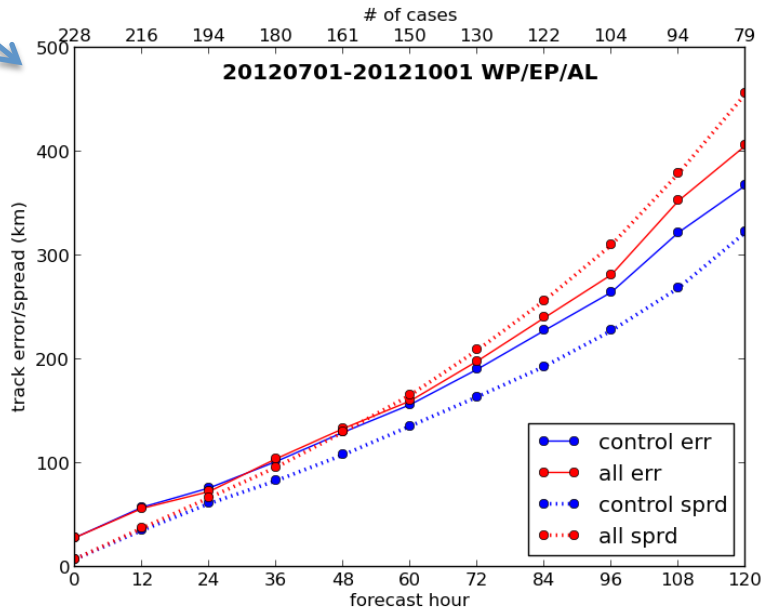
Track Forecast Error/Spread

'control' has no stochastic physics.
'operens' is operational scheme.
Operational scheme has a small impact on track spread.



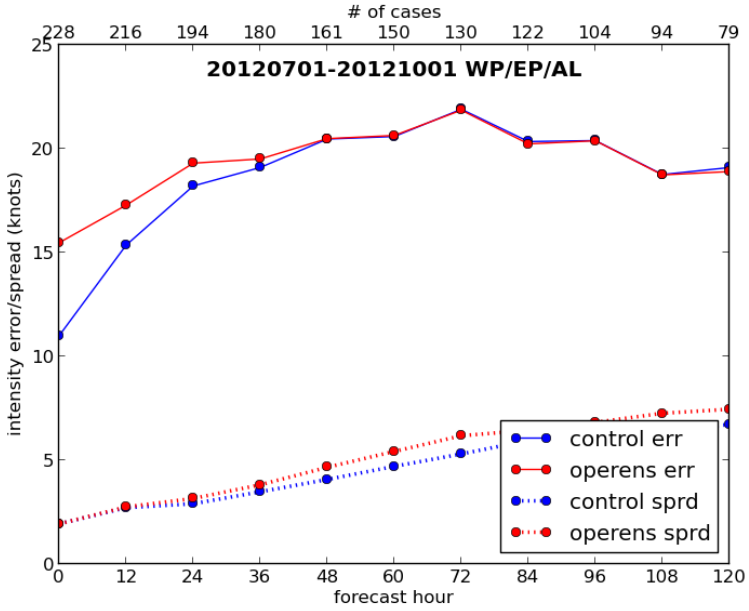
'SHUM' has a large impact on track spread.
'ALL' = SHUM+SPPT+VC has a bit too much spread, slightly degraded error.
Perturbed PBL humidity scheme produces well-calibrated track forecasts – other schemes do not produce enough track spread.



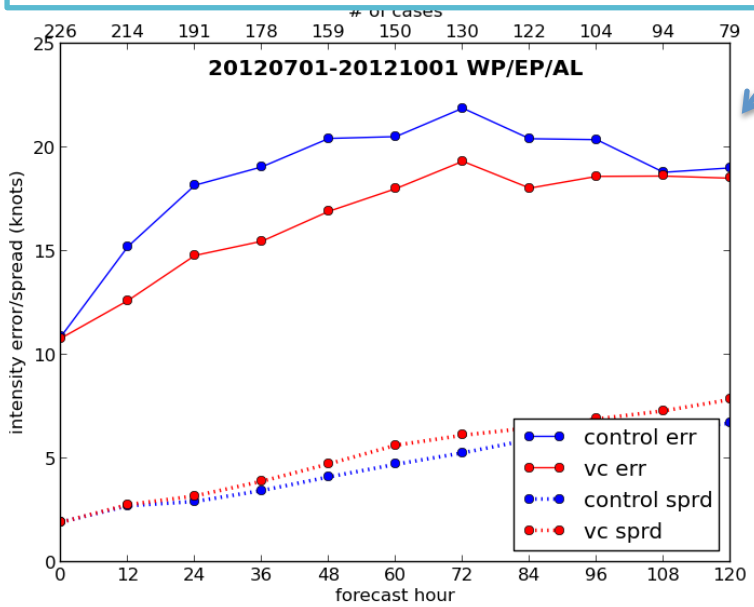


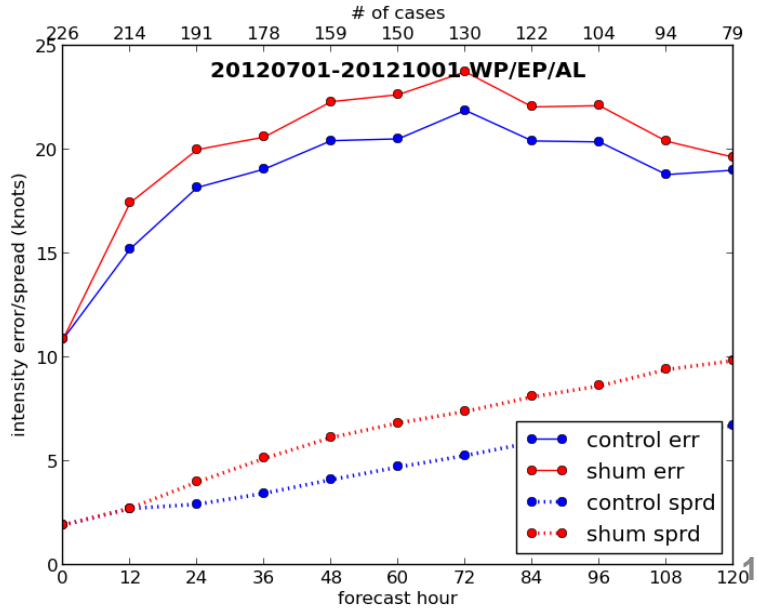
Intensity Forecast Error/Spread

'control' has no stochastic physics.
'operens' is operational scheme.
Operational scheme has a small impact on intensity spread.

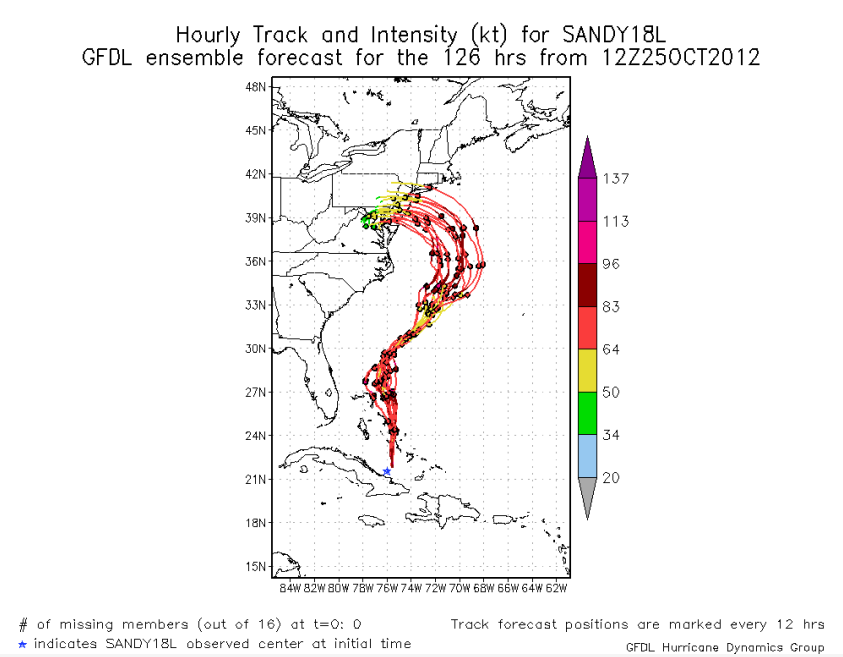


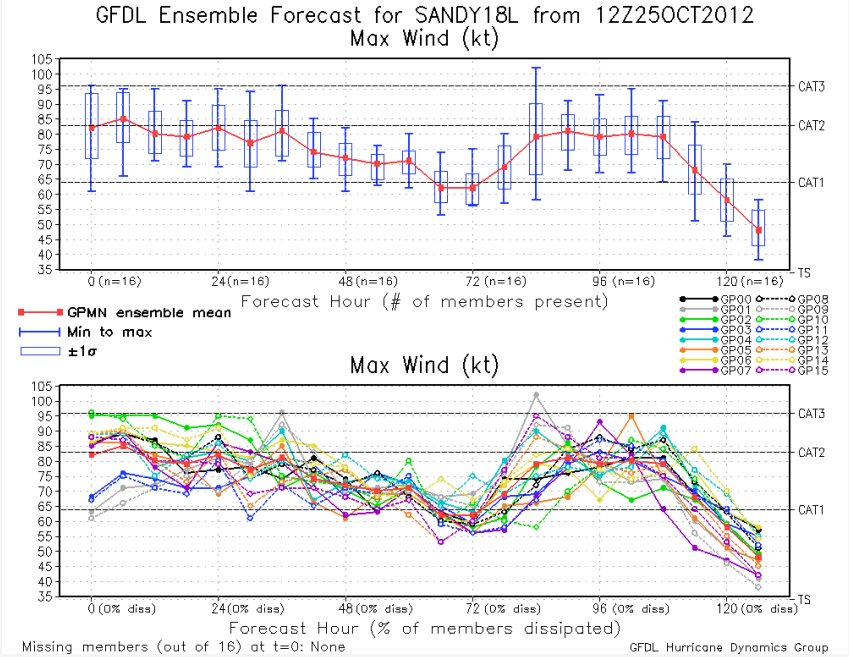
'SHUM' has a large impact on intensity spread, 'VC' and 'SPPT' have comparable but small impacts.
'VC' reduces intensity error, mainly by reducing bias (makes TCs stronger). 'SHUM' alone increases intensity error, but combination of 'VC' and 'SHUM' (not shown) has reduced error relative to control.
Combination of VC and SHUM improves both the ens. mean error and the spread/error calibration.





GFDL Hurricane Model Ensemble Performance During the 2012 Atlantic Season

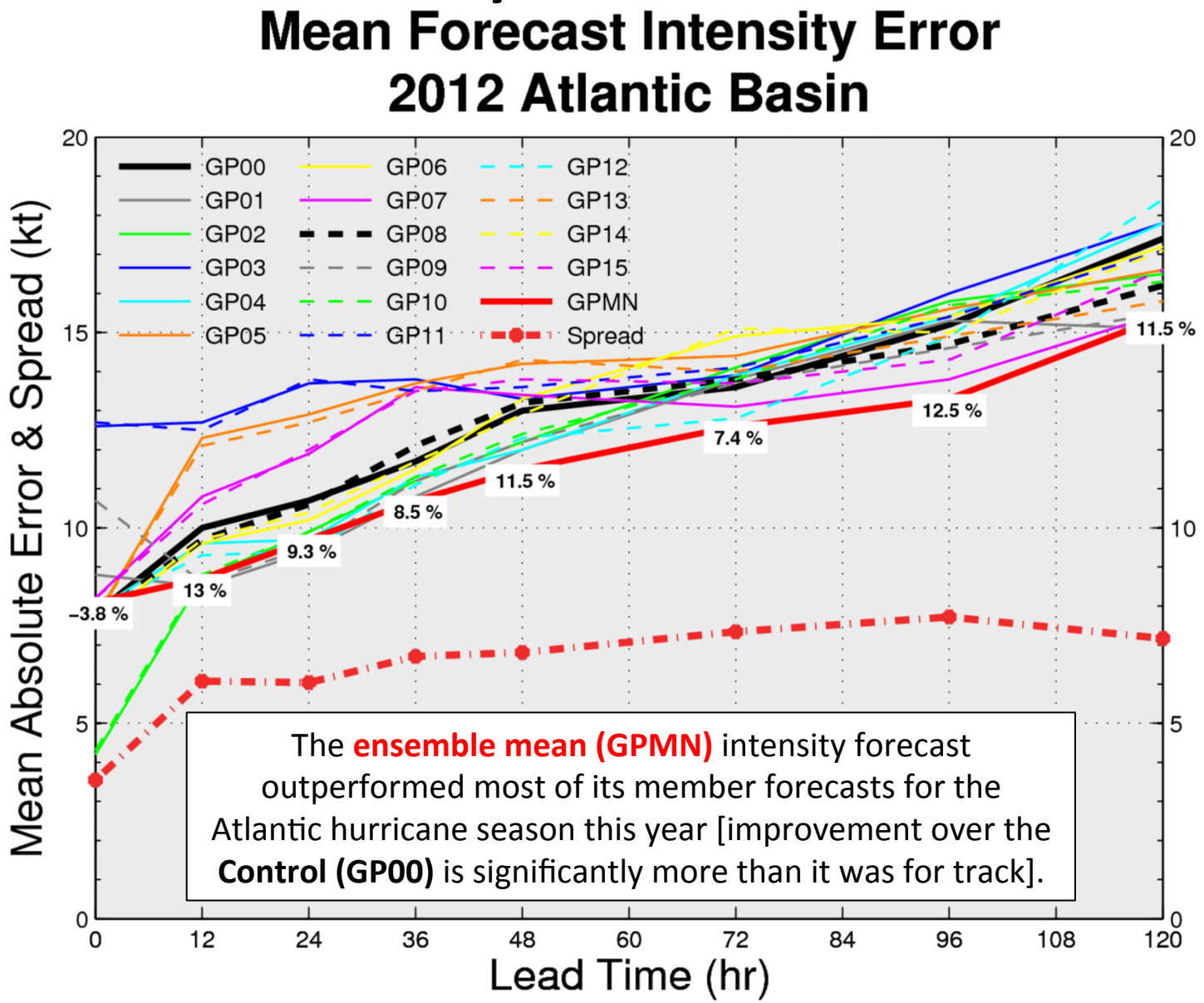




Tim Marchok (NOAA / GFDL)
Matt Morin (DRC® HPTG / GFDL)
Morris Bender (NOAA / GFDL)

Contribution to HFIP Ensembles Team Presentation
28 November 2012

Results: Intensity Forecast Verifications



GPMN improvement (%) over the Control is noted in the white text boxes

GFDL Geophysical Fluid Dynamics Laboratory

ENSEMBLE PRODUCTS PAGE | ABOUT THE GFDL HURRICANE ENSEMBLE | HFIP HOME PAGE | ABOUT GFDL

GFDL Hurricane Model Ensemble

Products browser

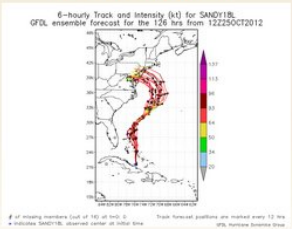
1.) Select a storm: SANDY18L

2.) Select a date: 2012102512_SANDY18L

3.) Select a product:

4.) Click: View products

Forecast preview



GFDL ensemble forecast for SANDY18L on 2012102512

Disclaimer: These are experimental research products and are not intended to replace the official forecasts issued by the National Hurricane Center and/or National Weather Service.

Click here for a printer-friendly display of all GFDL ensemble products for this forecast.

List of most recently added forecasts:

Use the 'Products browser' to load the graphics for a particular forecast

- INVEST90E_2012110406: Added on Sun Nov 04 08:24 EST 2012
- ROSA17E_2012110400: Added on Sun Nov 04 01:36 EST 2012
- ROSA17E_2012110318: Added on Sat Nov 03 20:21 EDT 2012
- ROSA17E_2012110312: Added on Sat Nov 03 14:33 EDT 2012
- ROSA17E_2012110306: Added on Sat Nov 03 08:27 EDT 2012
- ROSA17E_2012110300: Added on Sat Nov 03 02:39 EDT 2012

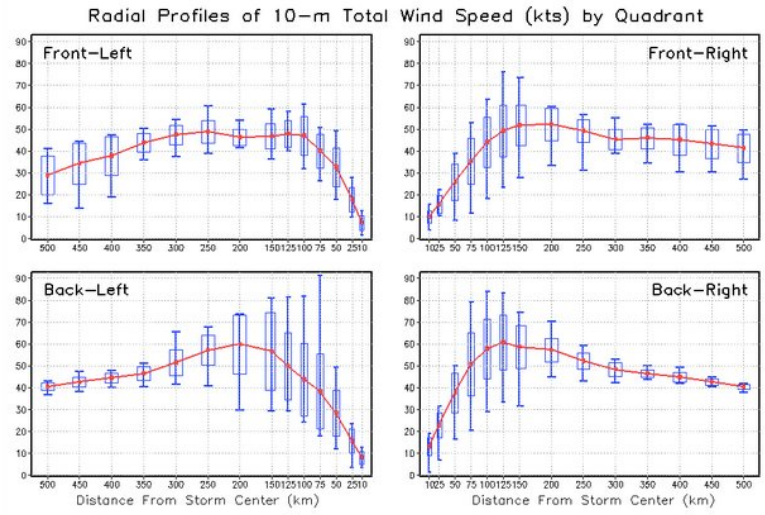
10-m wind structure

Click the tabs below to view each product

TC-relative total winds | Earth-relative total winds

data1.gfdl.noaa.gov/hurricane/gfdl_ensemble

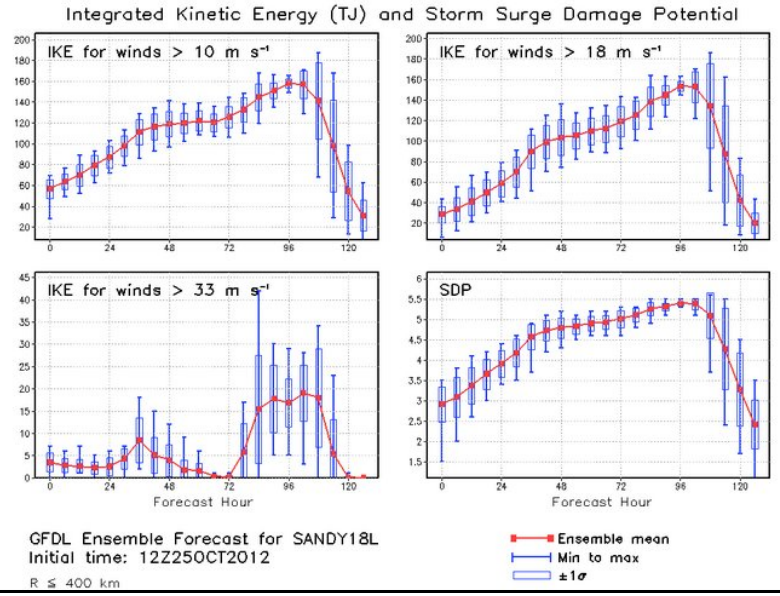
0 hrs | 24 hrs | 48 hrs | 72 hrs | 96 hrs | 120 hrs



Integrated kinetic energy and surge damage potential

Click the tabs below to view each product

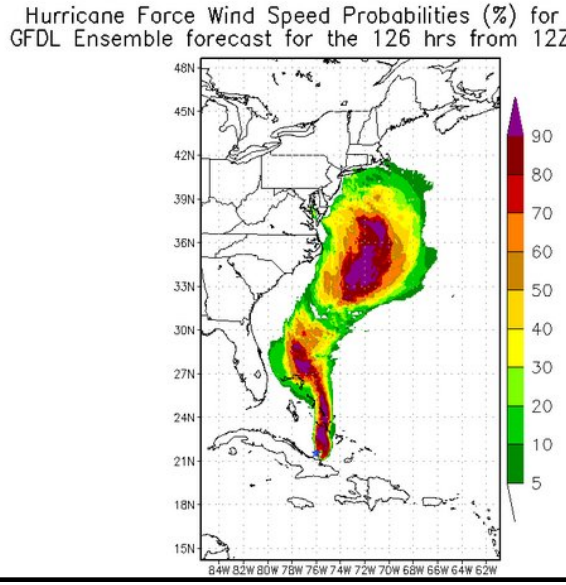
IKE and SDP box plots | IKE and SDP spaghetti plots



Max wind speed swaths and probabilities

Click the tabs below to view each product

34-kt wind speed probability | 50-kt wind speed probability | 64-kt wind speed probability | Max 10-m winds swaths



Dynamical Downscaling of Global perturbations for HWRF

Brian Etherton

Methodology

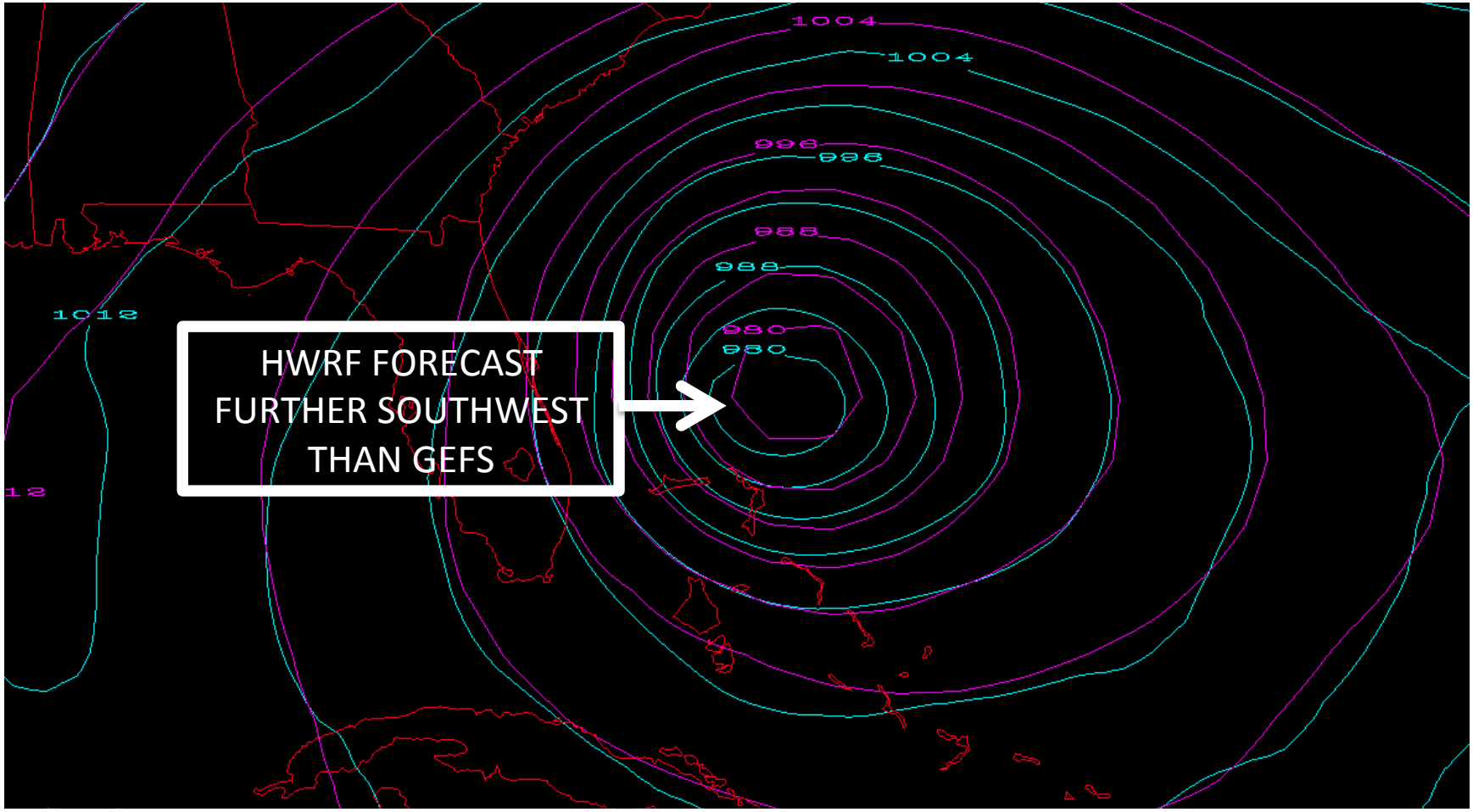
- To produce initial conditions for HWRF, take the 6-hour HWRF forecast and add onto it the analysis increment from the GENS

$$X_a^L = X_f^L + (X_a^G - X_f^G)$$

- An alternative way of viewing this is adding on the difference between the GENS and HWRF forecasts that had the same initial conditions to the GENS analysis

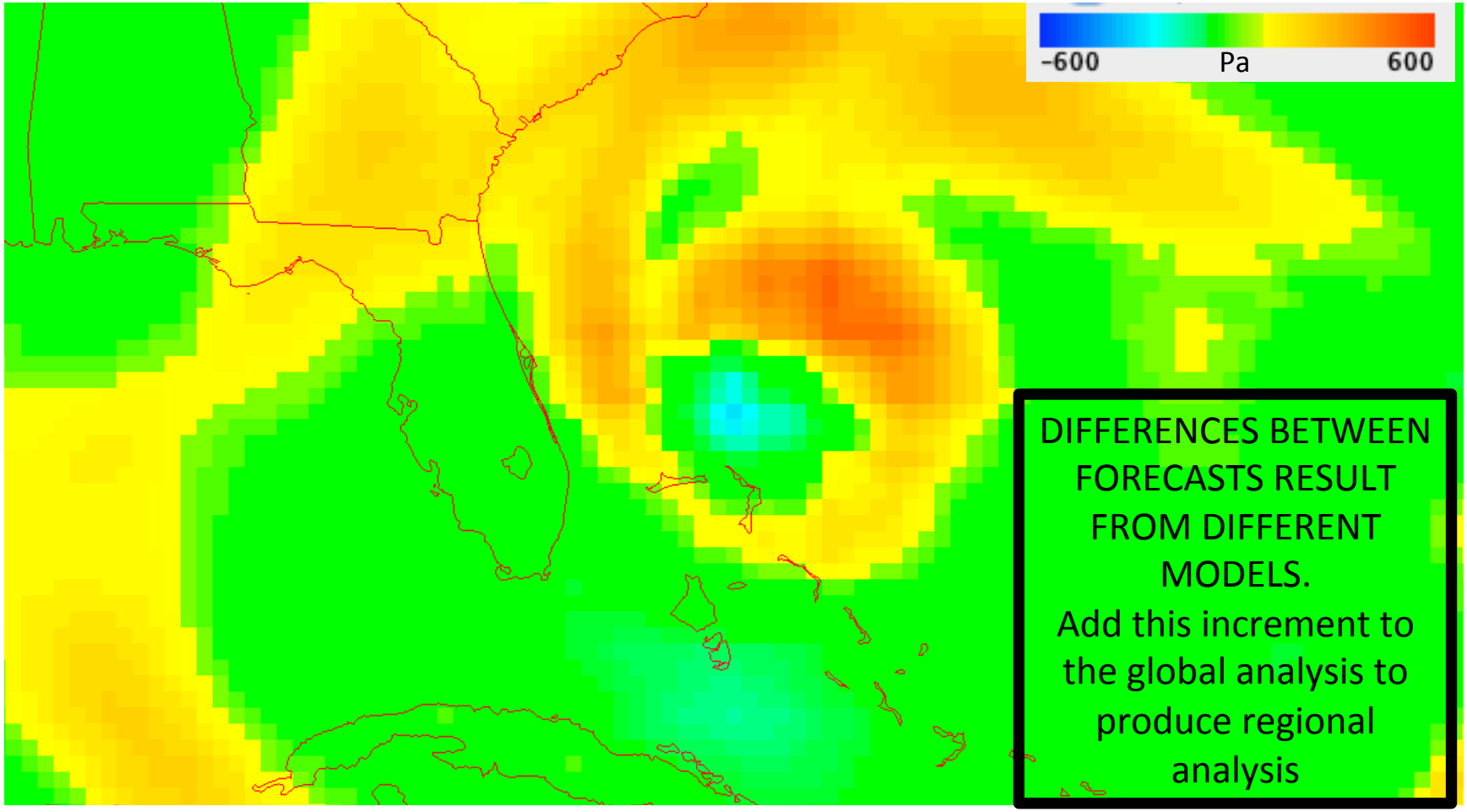
$$X_a^L = X_a^G + (X_f^L - X_f^G)$$

Difference Between HWRF and GEFS



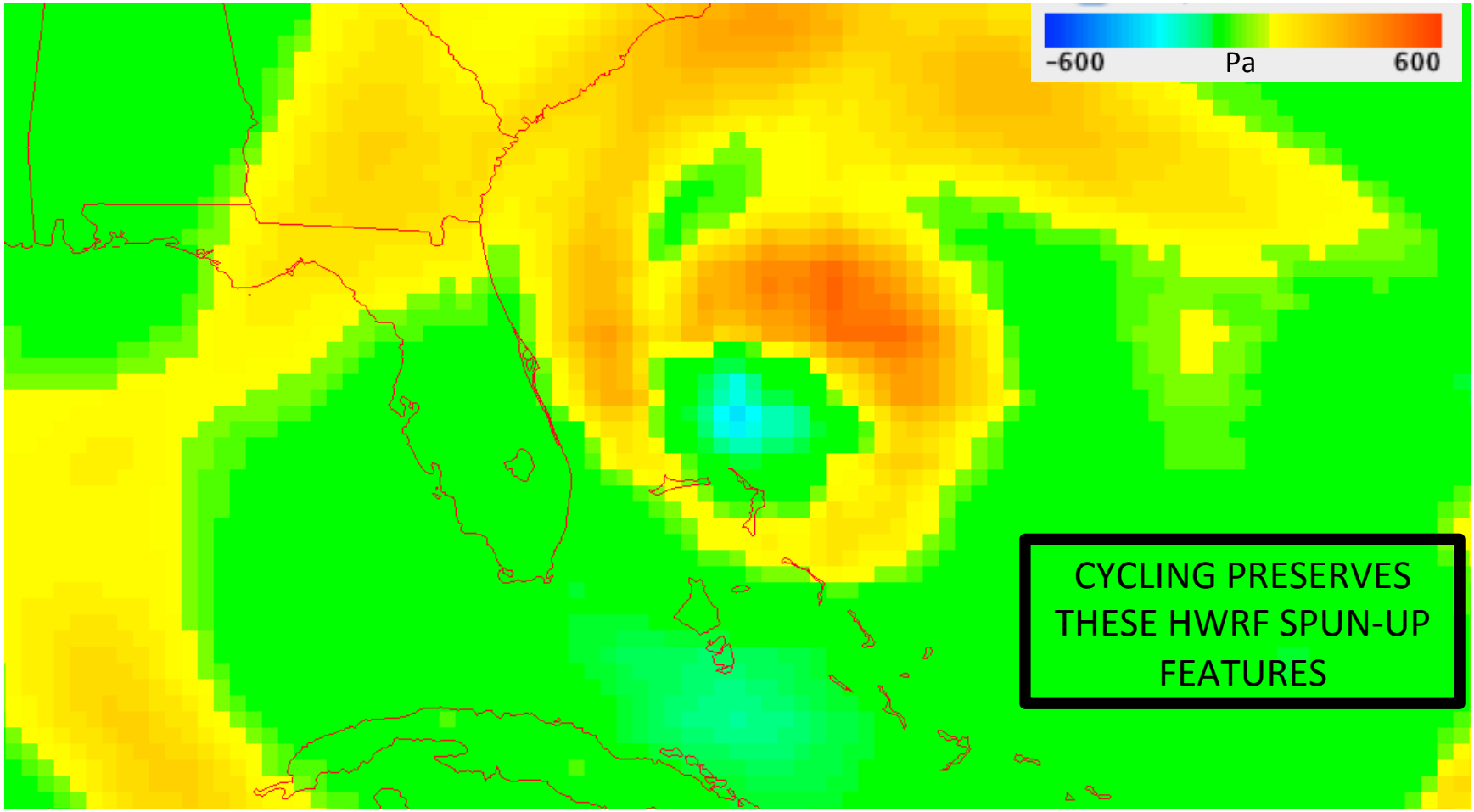
CYAN = HWRF 6-hour FORECAST, PINK = GEFS CONTROL 6-hour FORECAST
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference HWRF and GEFS forecasts



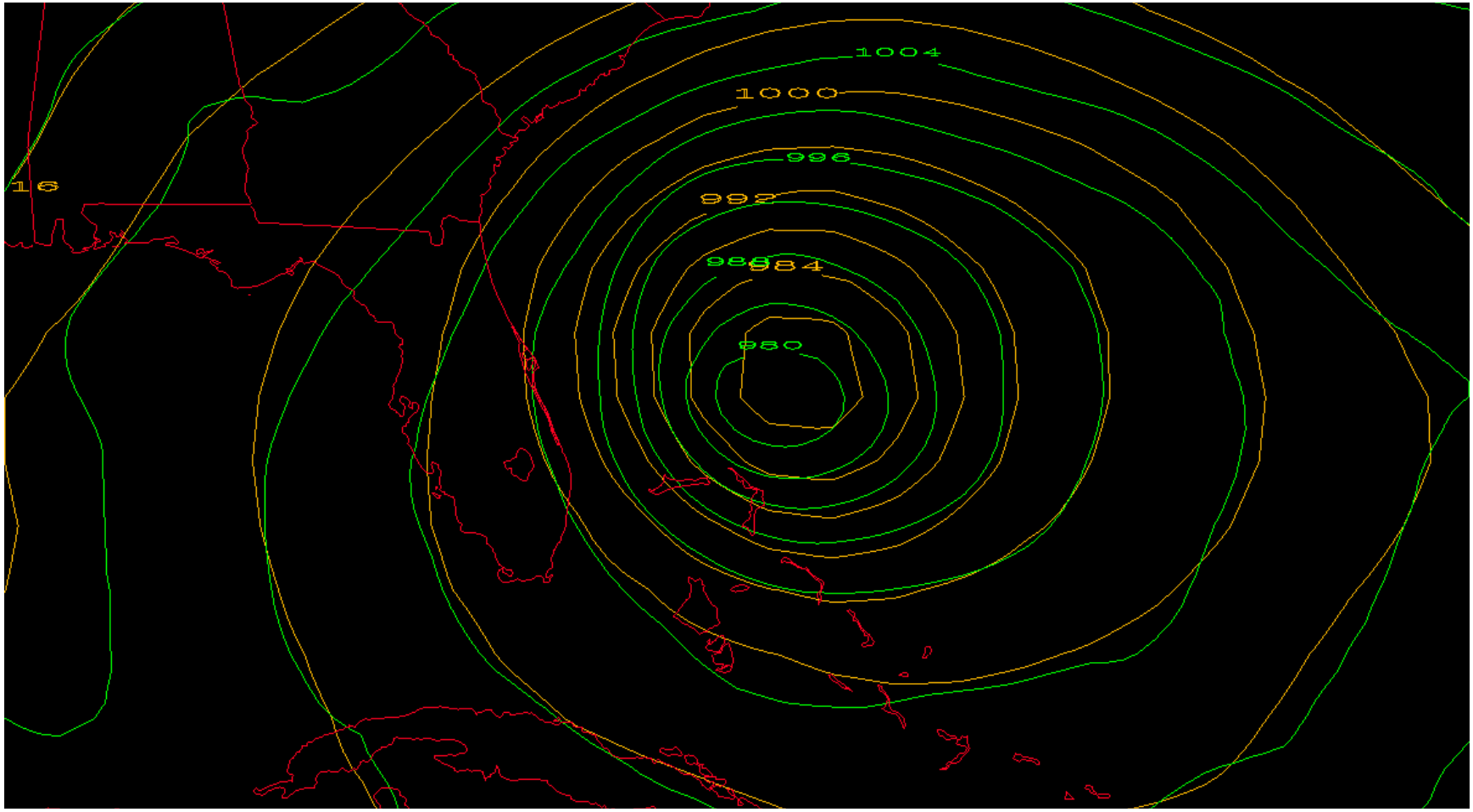
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

HWRF Initial Conditions: Cycled v GEFS



ANALYSIS TIME = 2012102706

HWRF Initial Conditions: Cycled v GEFS



GREEN = HWRF INITIAL CONDITION, YELLOW = GEFS CONTROL ANALYSIS
ANALYSIS TIME = 2012102706

Notes

- Most limited area models drift from the global model over time.
  - In our approach, ¼ of the ensemble is 'cold started' each 6-hours (so all members are cold started once per day).
- Technically simple to implement
  - A combination of wgrib, wgrib2, copygb, and cnvgrib was all that was needed for this approach.

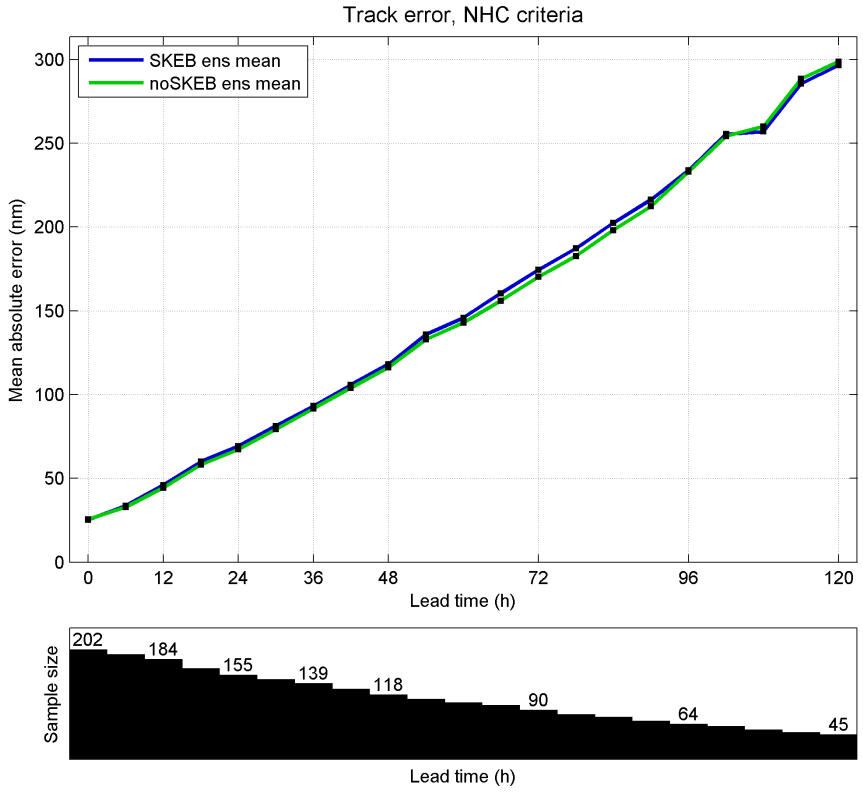
NRL Global Ensemble Research

NOGAPS Ensembles

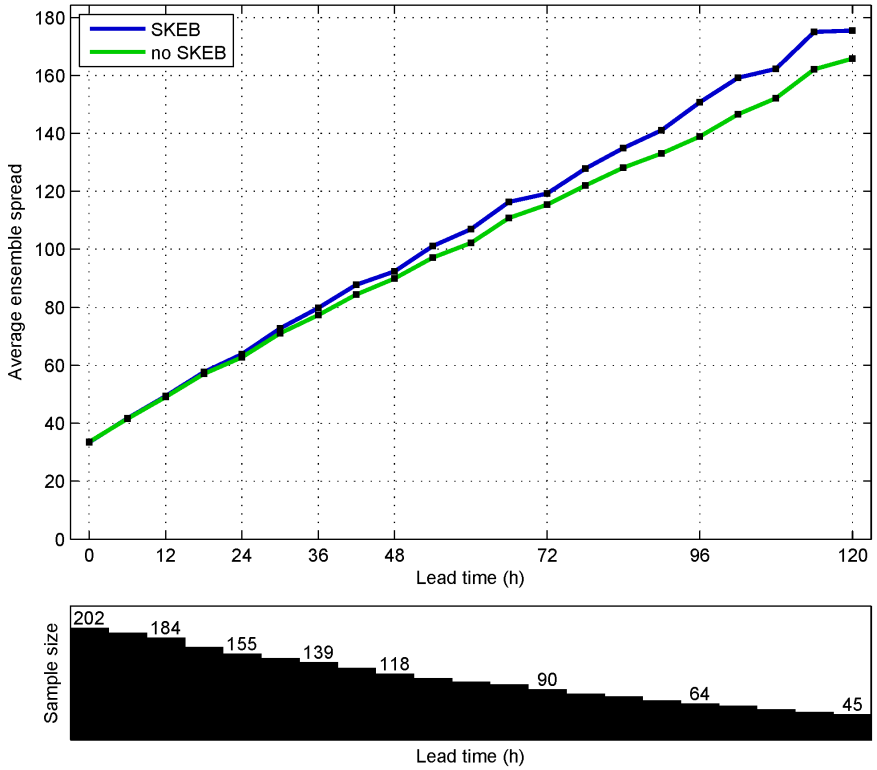
- 20 members, 10-d forecasts, once daily, T319 (42-km), for 2010 and 2011 Seasons.
- Banded ET initial perturbations with (SKEB) and without (noSKEB) stochastic kinetic energy backscatter
- Compare ensemble mean, control member, and “OPER” tropical cyclone (TC) track errors

Track forecast error and spread:
SKEB vs. noSKEB

Ensemble Mean Track Error



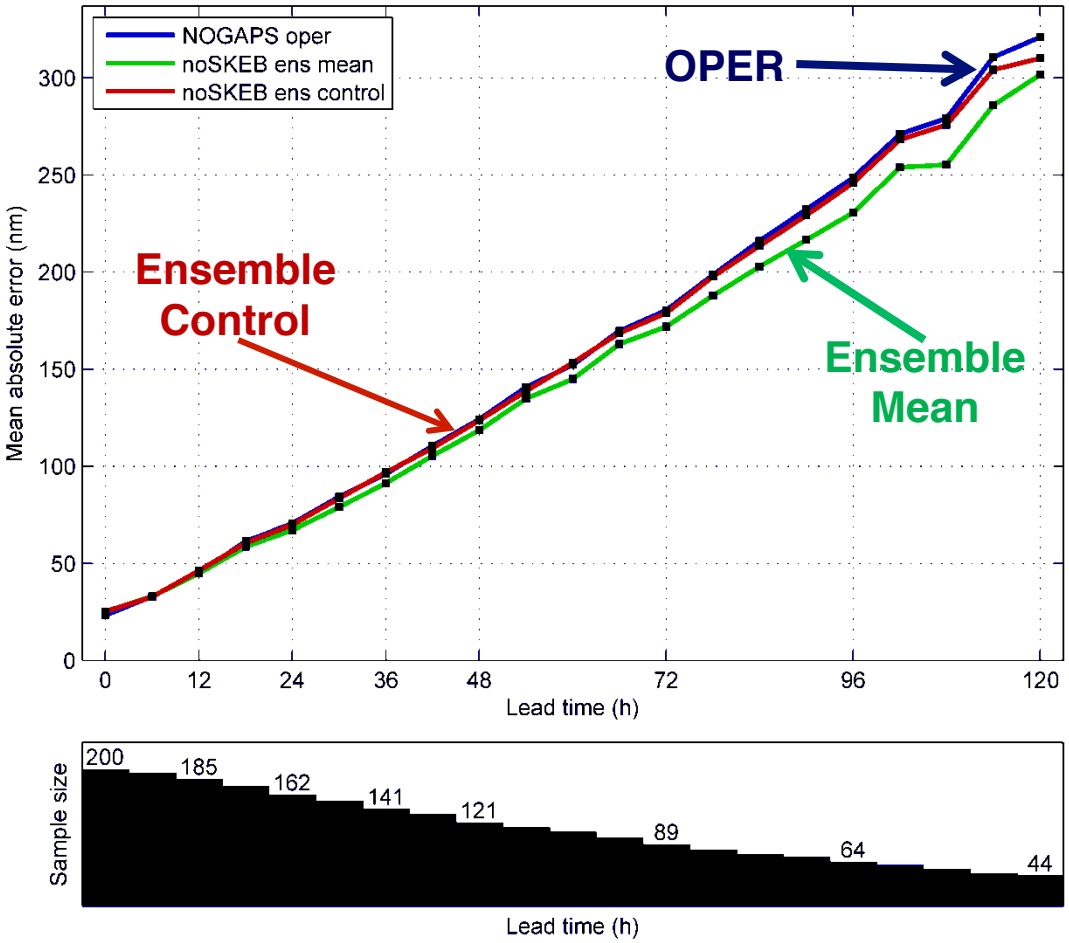
Ensemble Spread



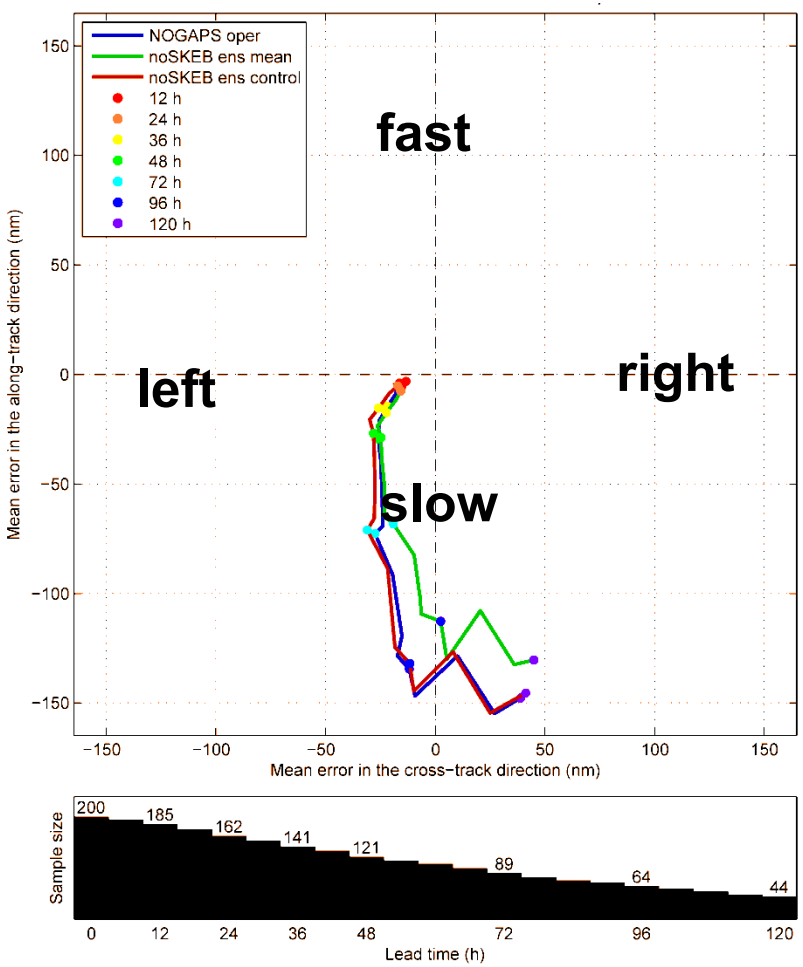
SKEB does not have an appreciable impact on ensemble mean track error (left), but does increase spread (right)

NRL Real-time Ensembles

Mean Absolute Track Error

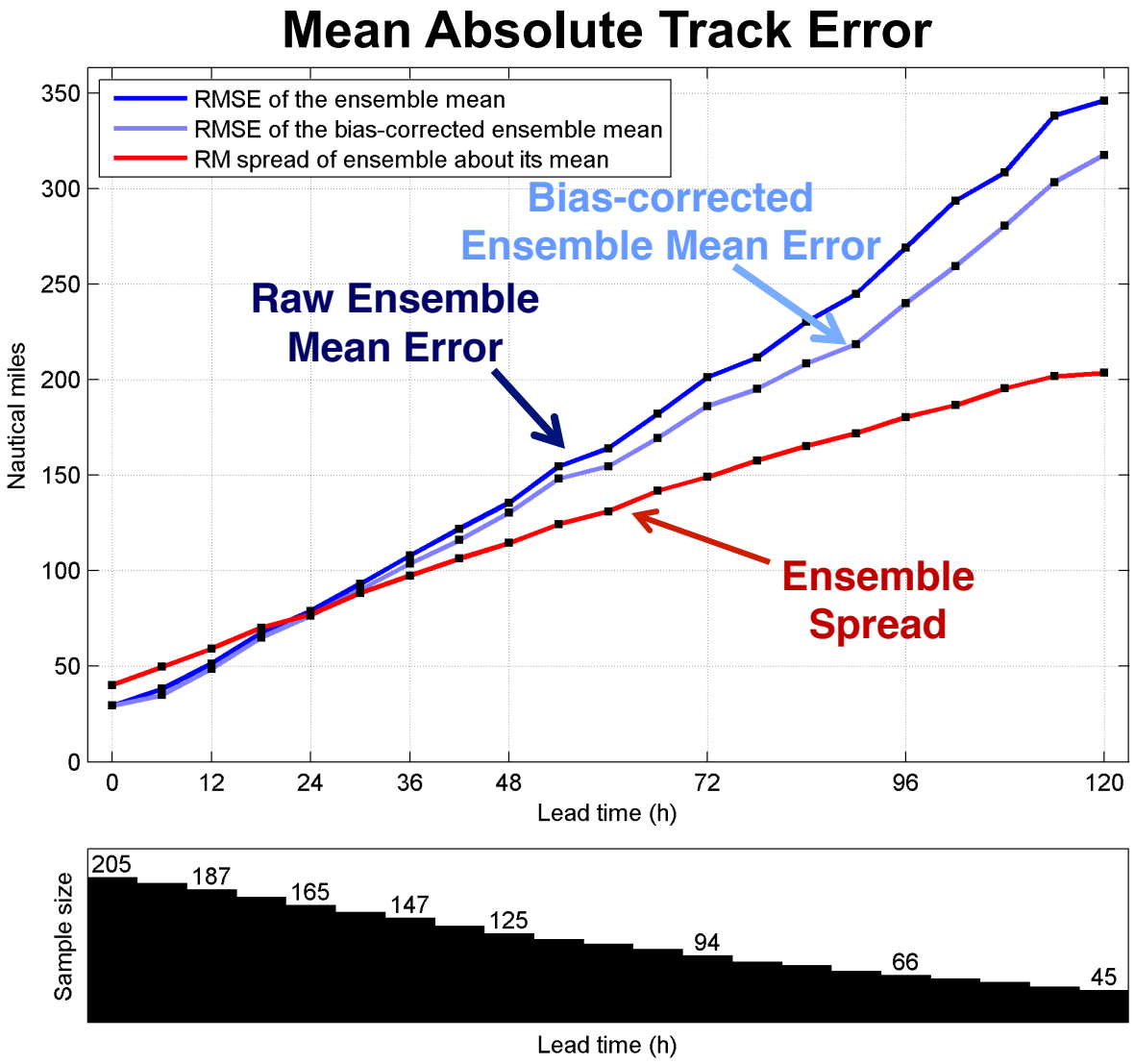


Track Bias



Ensemble mean slightly better than control member and operational forecast. All forecasts are slow.

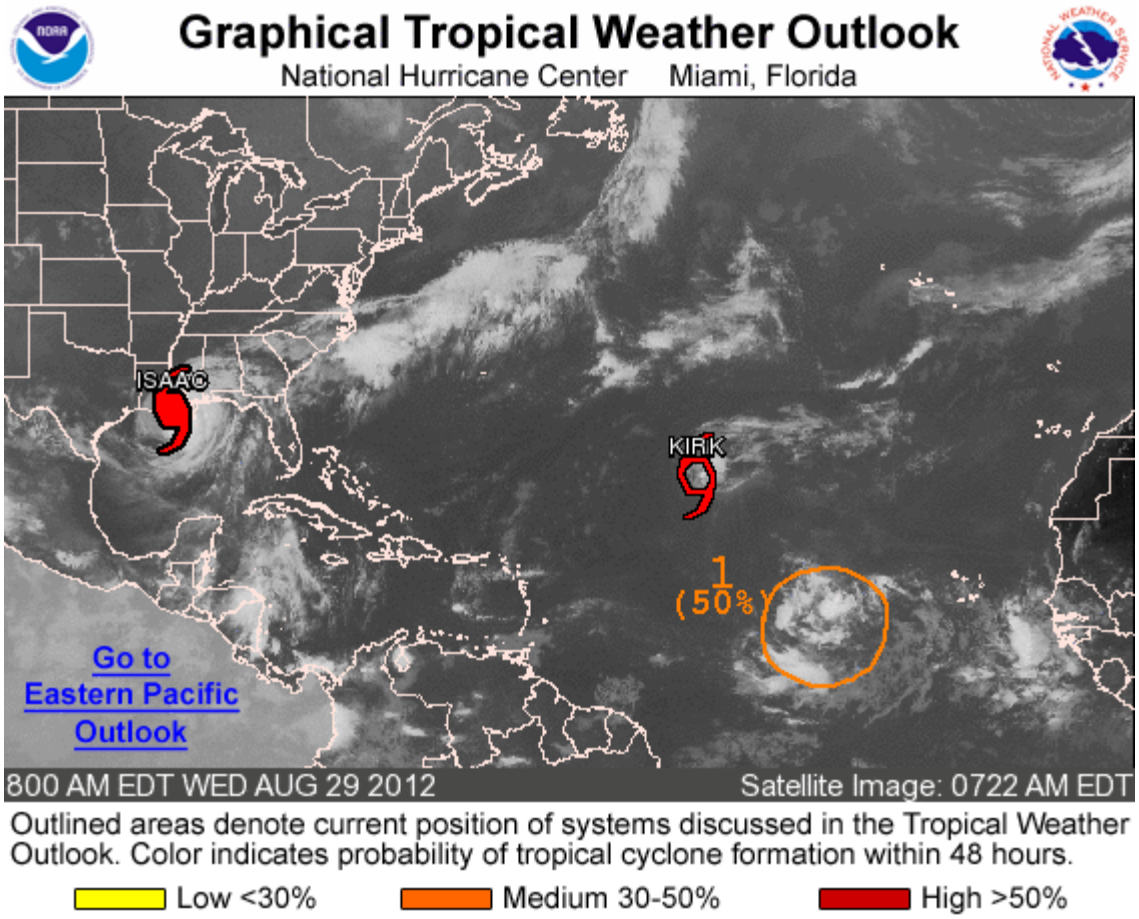
High-resolution Real-time Ensembles



After 24 hours, ensembles are under-dispersive (ensemble spread less than ensemble mean error). Removing the cross and along-track biases reduces track error.

NCEP/EMC Extra Slides

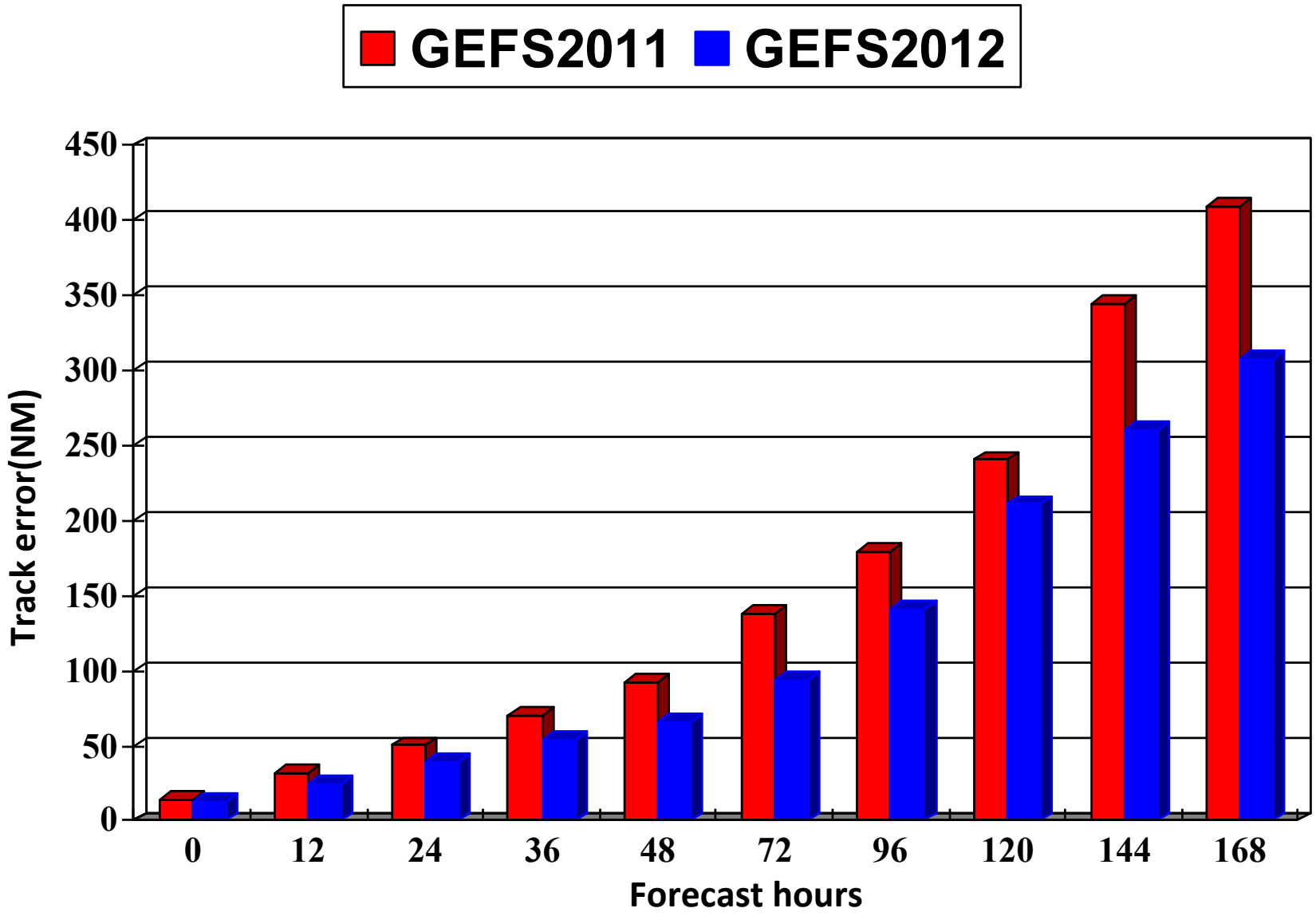
NHC Hurricane Genesis Probability Forecasts at 08/29/2012 12z.
It will form AL12 (Leslie) at 08/30 06z.



Summary

- NCEP upgraded both regional and global ensemble forecast systems during past year.
- 2012 hurricane season should be benefited from both GEFS upgrade (02/12/2012) and Hybrid DA implementation (05/22/2012)
- Ensemble mean track errors are significantly reduced through increasing resolutions, upgrade of model, and improving initial perturbations (and analysis, too).
- Ensemble mean track forecasts are closed to (or better than) GFS high resolution deterministic forecast, closed to ECMWF ensemble mean and high resolution deterministic forecast
- EMC is producing real time ensemble track forecast for multi-model ensembles
- EMC is producing strike probability maps for hurricane based on multi-model ensembles
- EMC is experimentally producing real time hurricane genesis for various ensemble systems. The evaluation will come up later.

NCEP GEFS operational track forecast – Atlantic Basin



CASES-2011:	393	356	314	274	238	182	141	98	71	49
CASES-2012:	421	381	339	297	259	201	164	133	113	92

GFDL Extra Slides

2012 Ensemble Membership

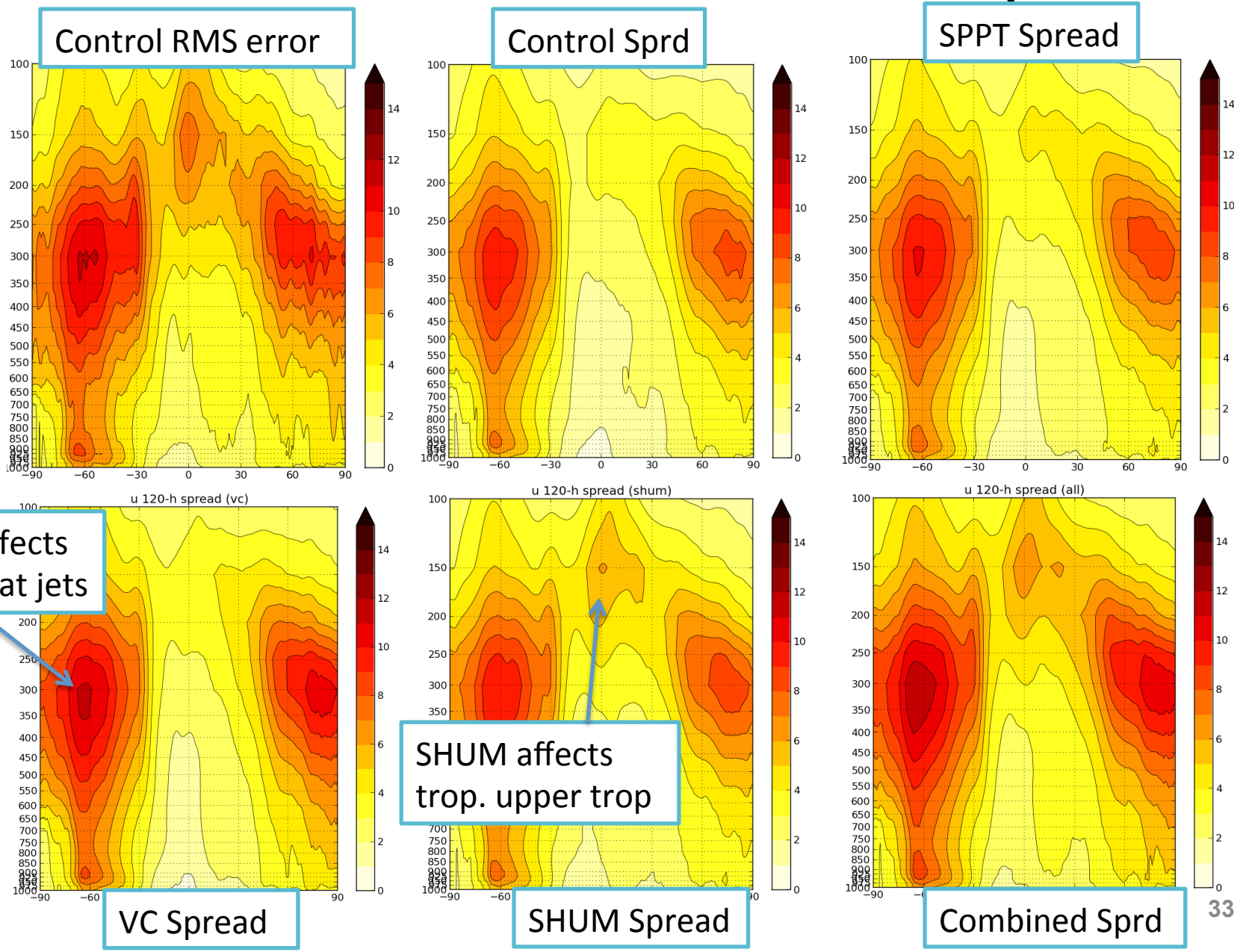
*GP** members represent ATCF output from GFDL's (internal) vortex tracker, while GT** represents HFIP community (external) vortex tracker output.*

The global model used for initial and boundary conditions is noted in brackets.

ATCF ID	Description
GP00/GT00	Control forecast (same model as NCEP 2012 operational GFDL) [GFS deterministic]
GP01/GT01	Unbogussed forecast using the 2012 control model [GFS deterministic]
GP02/GT02	Increase NHC-observed V_{max} 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25% [GFS deterministic]
GP03/GT03	Decrease NHC-observed V_{max} 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25% [GFS deterministic]
GP04/GT04	Modification to increase inner-core moisture by a max of 10% [GFS deterministic]
GP05/GT05	Modification to decrease inner-core moisture by a max of 10% [GFS deterministic]
GP06/GT06	Increase SSTs by a max of 1°C within the initial extent of the TC [GFS deterministic]
GP07/GT07	Decrease SSTs by a max of 2°C within the initial extent of the TC [GFS deterministic]
GP08/GT08	Control forecast for the NCEP ensemble-based members [NCEP GEFS mean]
GP09/GT09	Unbogussed forecast using the 2012 control model [NCEP GEFS mean]
GP10/GT10	Increase NHC-observed V_{max} 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25% [NCEP GEFS mean]
GP11/GT11	Decrease NHC-observed V_{max} 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25% [NCEP GEFS mean]
GP12/GT12	Modification to increase inner-core moisture by a max of 10% [NCEP GEFS mean]
GP13/GT13	Modification to decrease inner-core moisture by a max of 10% [NCEP GEFS mean]
GP14/GT14	Increase SSTs by a max of 1°C within the initial extent of the TC [NCEP GEFS mean]
GP15/GT15	Decrease SSTs by a max of 2°C within the initial extent of the TC [NCEP GEFS mean]
GPMN/GTMN	**Ensemble mean computed at each lead time where the member availability is at least 6 members (40% threshold)**

ESRL/GSD Extra Slides

Time-mean zonal-mean 5-d zonal wind spread

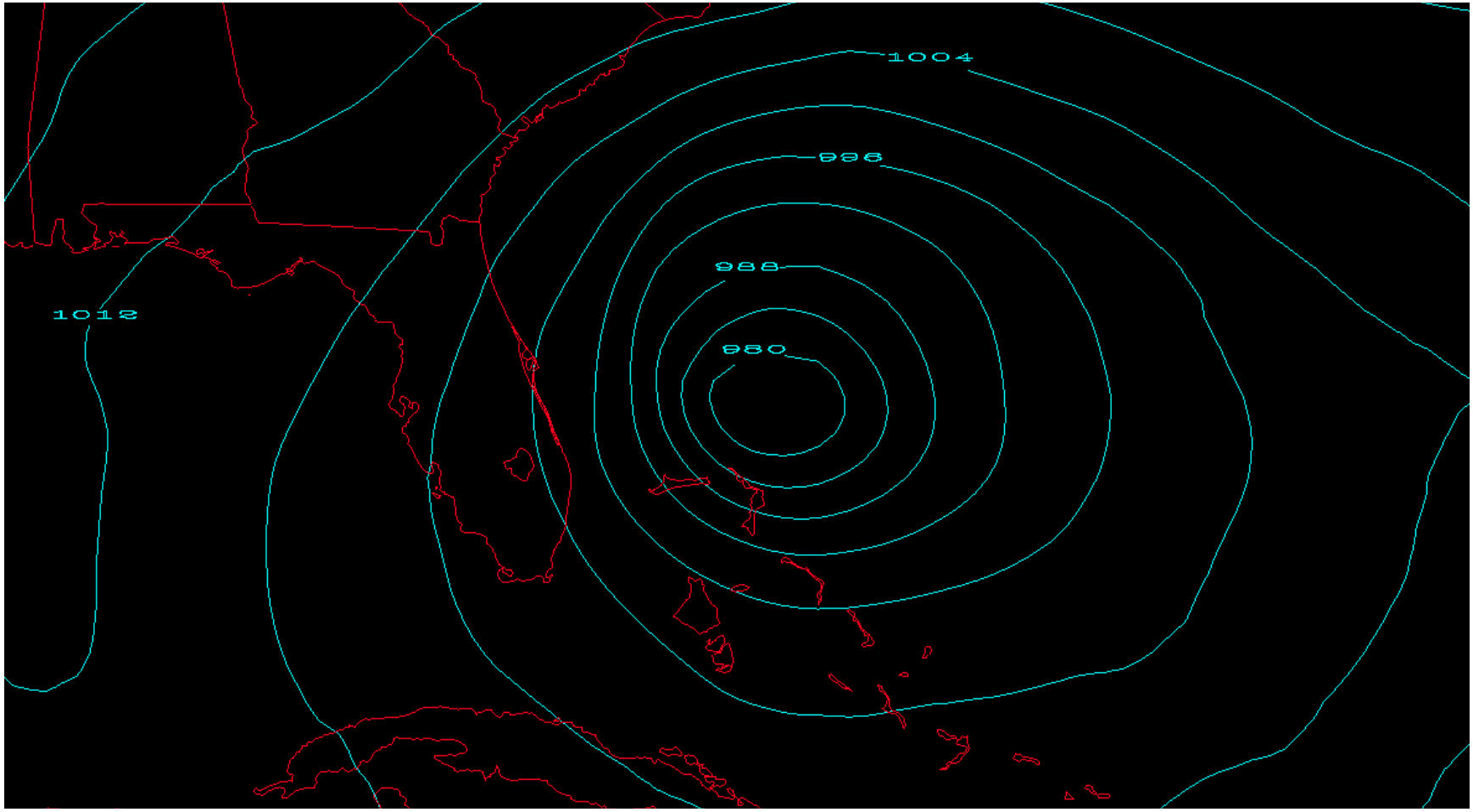


ESRL/PSD Extra Slides

Dynamical Downscaling of Global perturbations for HWRF

Brian Etherton

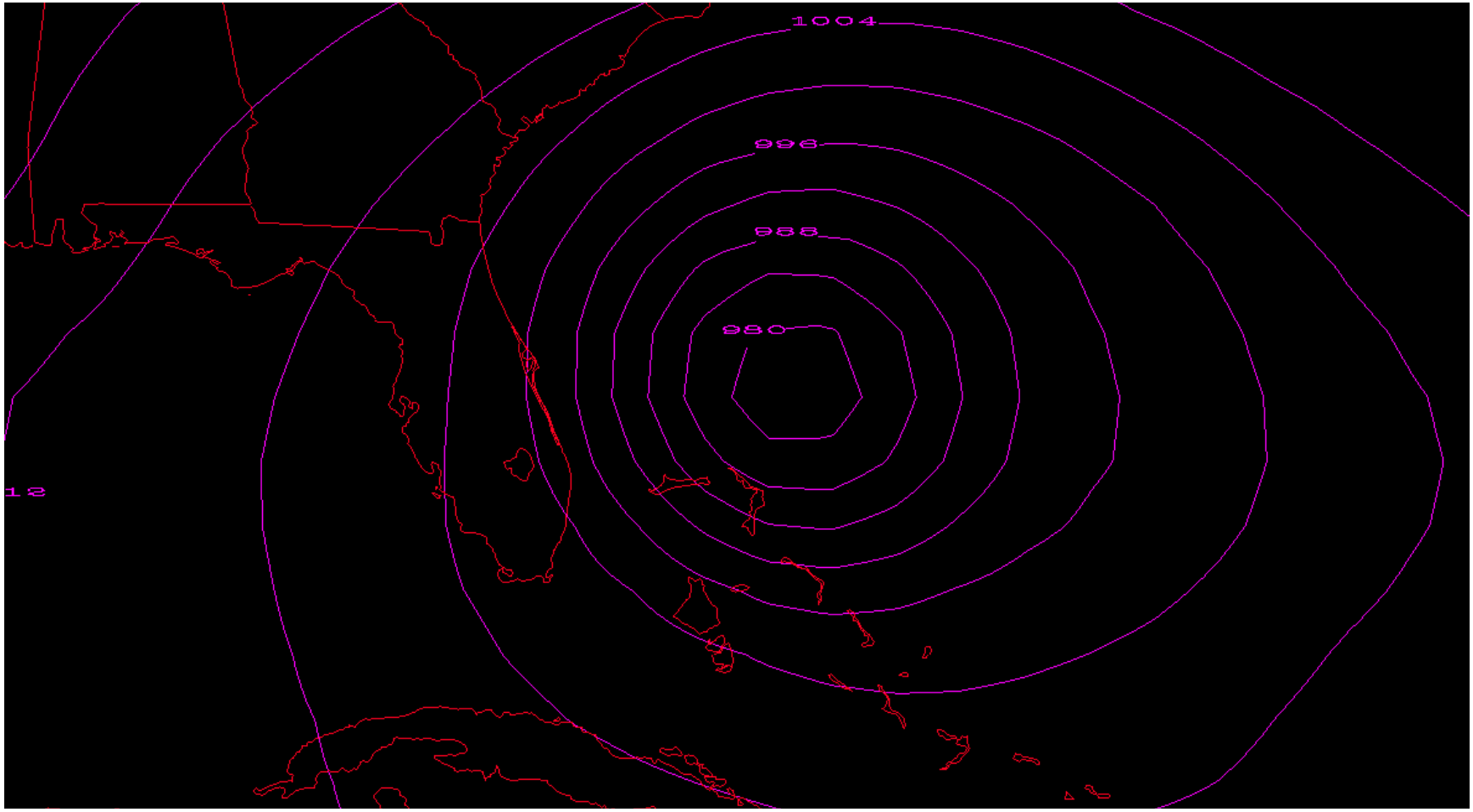
6-hour forecast from HWRF



INITIALIZED FROM GEFS CONTROL

INITIAL TIME = 2012102700 VALID TIME = 2012102706 MODEL = BASIN SCALE HWRF

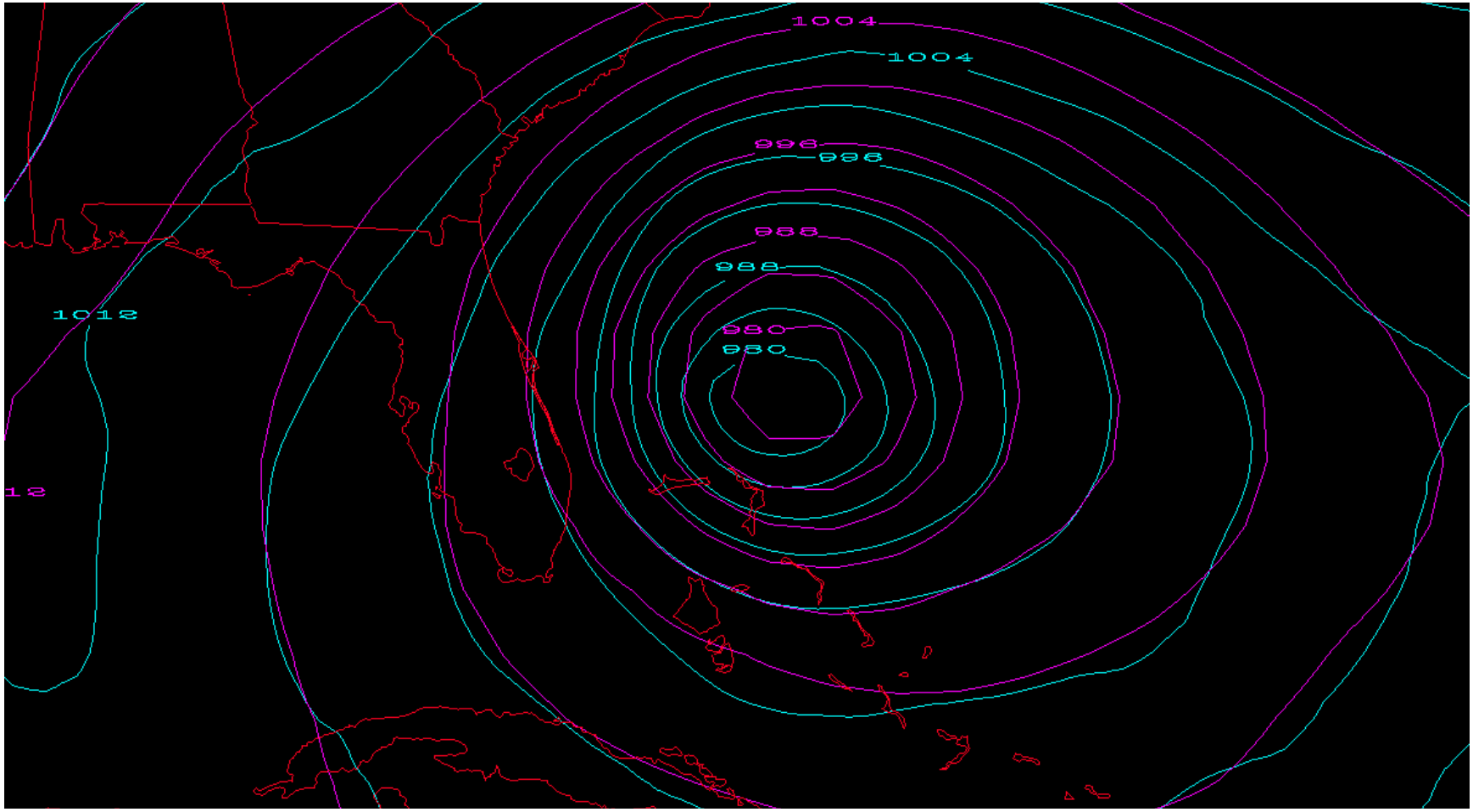
6-hour forecast from GEFS



INITIALIZED FROM GEFS CONTROL

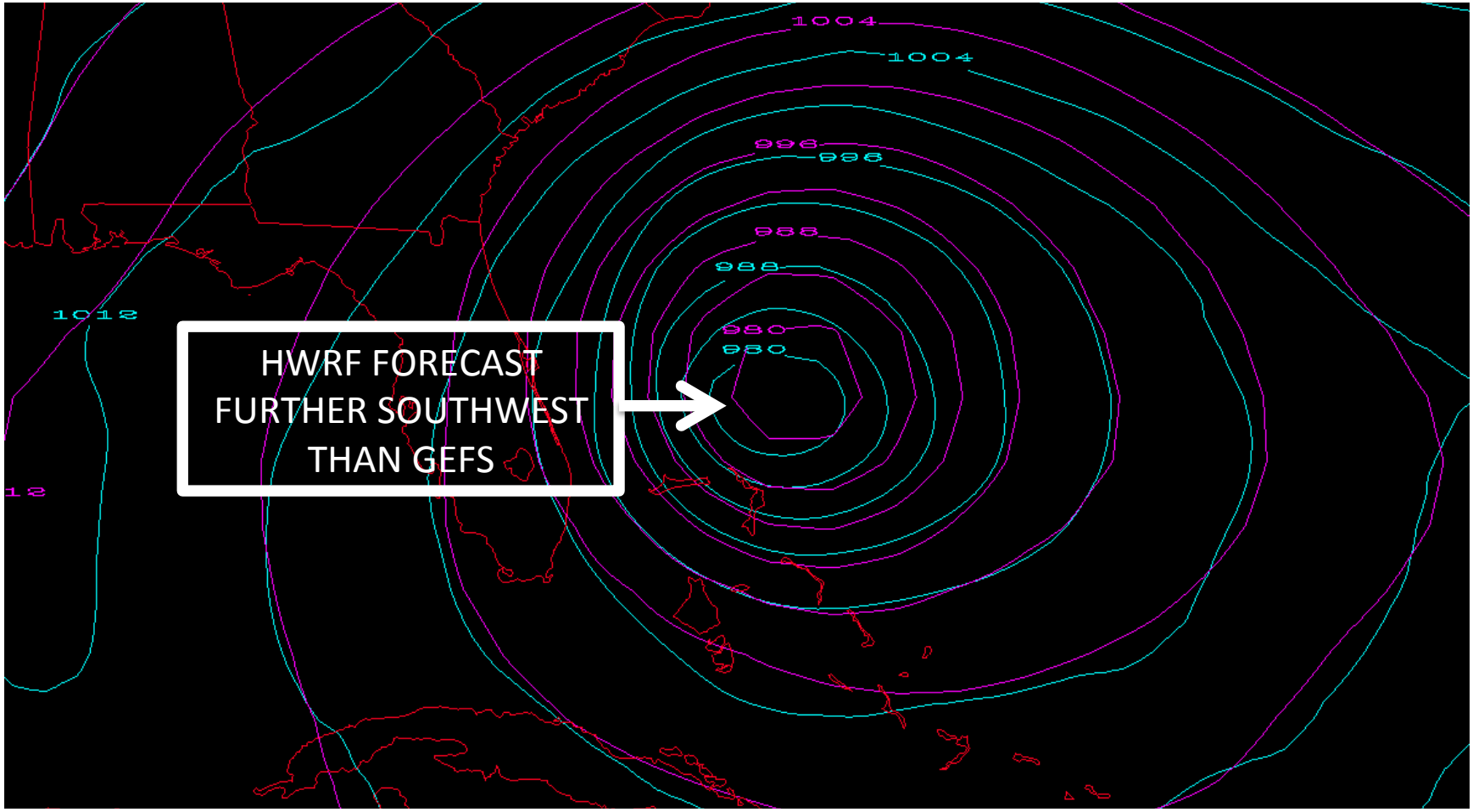
INITIAL TIME = 2012102700 VALID TIME = 2012102706 MODEL = GEFS (control)

Difference Between HWRF and GEFS



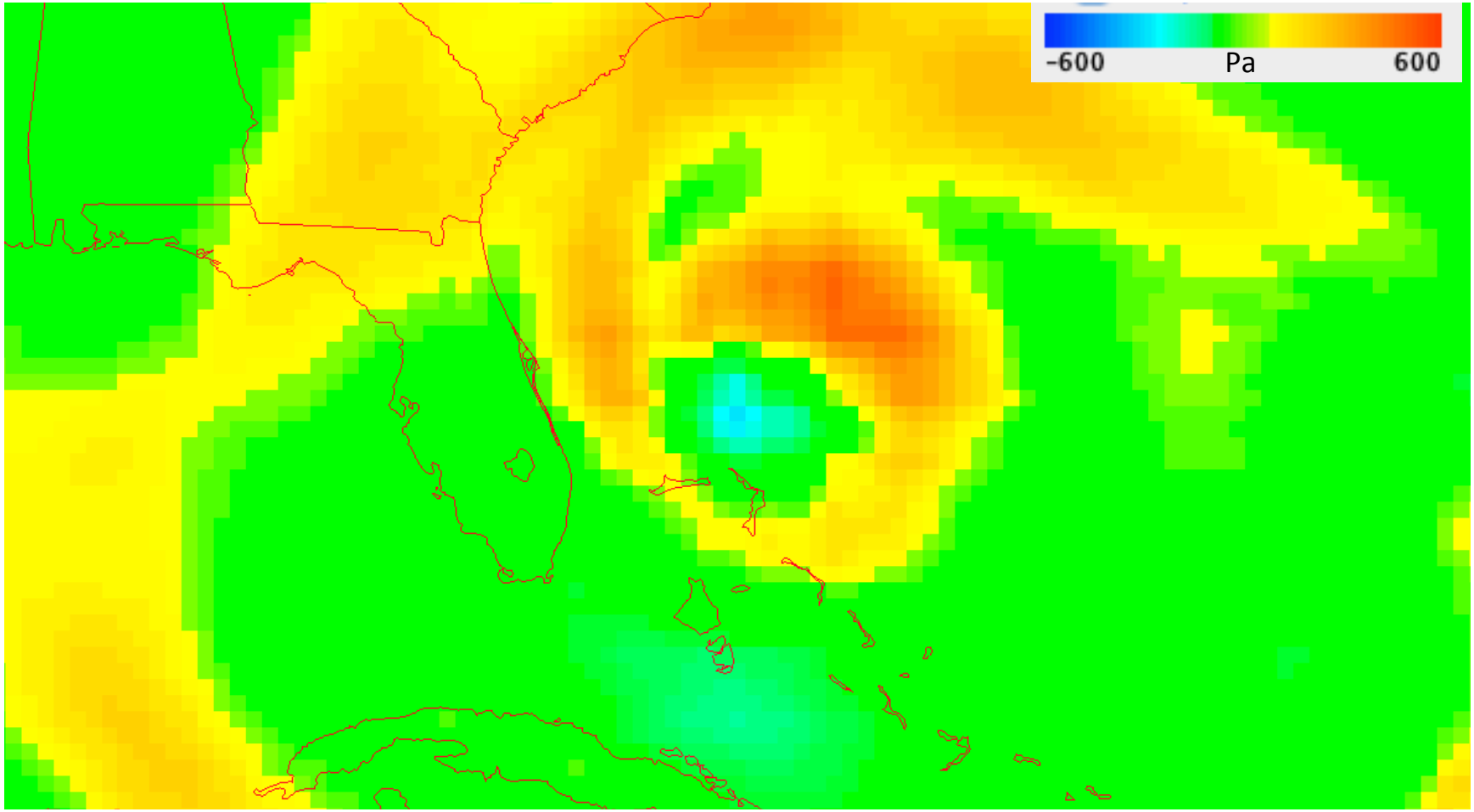
CYAN = HWRF 6-hour FORECAST, PINK = GEFS CONTROL 6-hour FORECAST
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference Between HWRF and GEFS



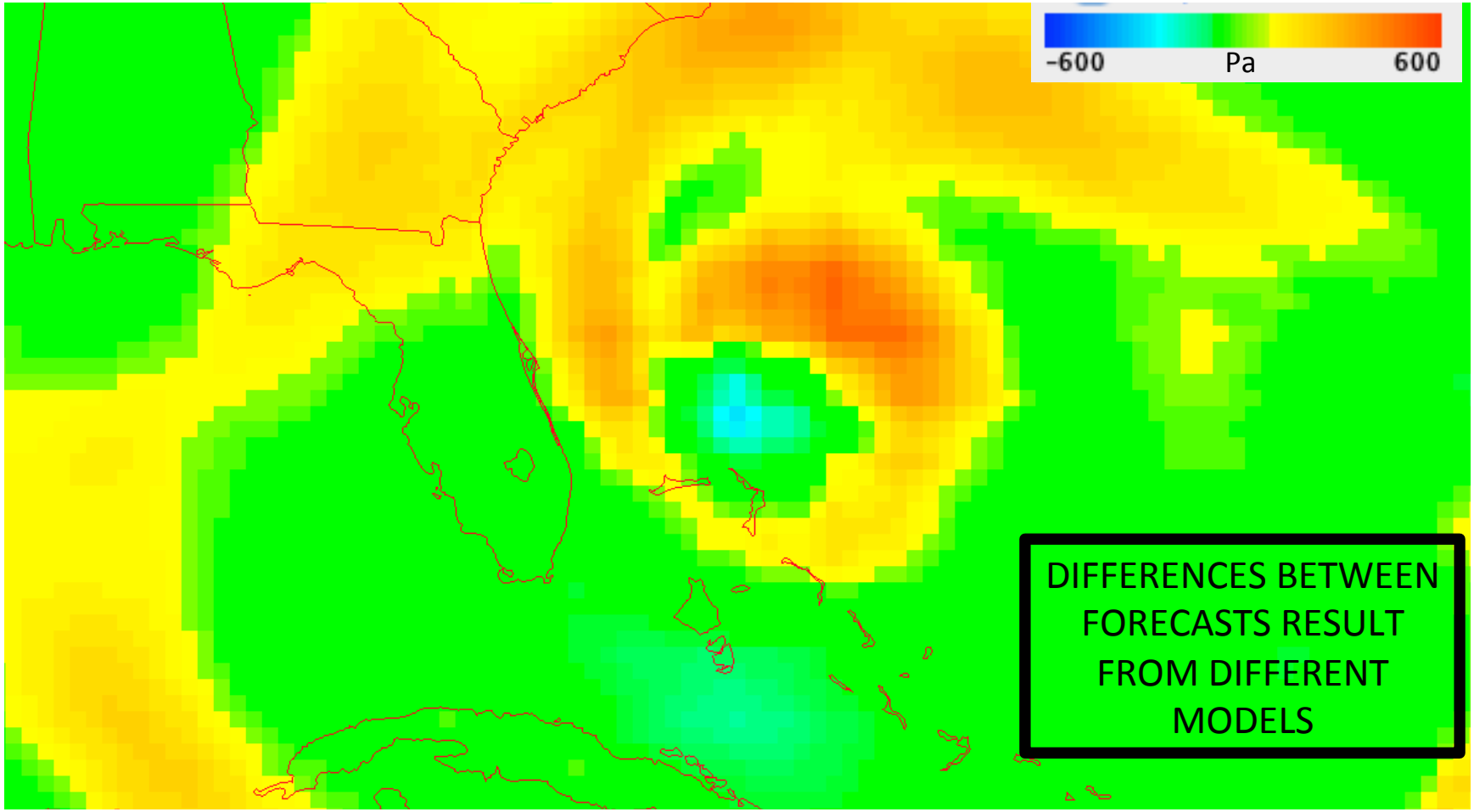
CYAN = HWRF 6-hour FORECAST, PINK = GEFS CONTROL 6-hour FORECAST
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference HWRF and GEFS forecasts



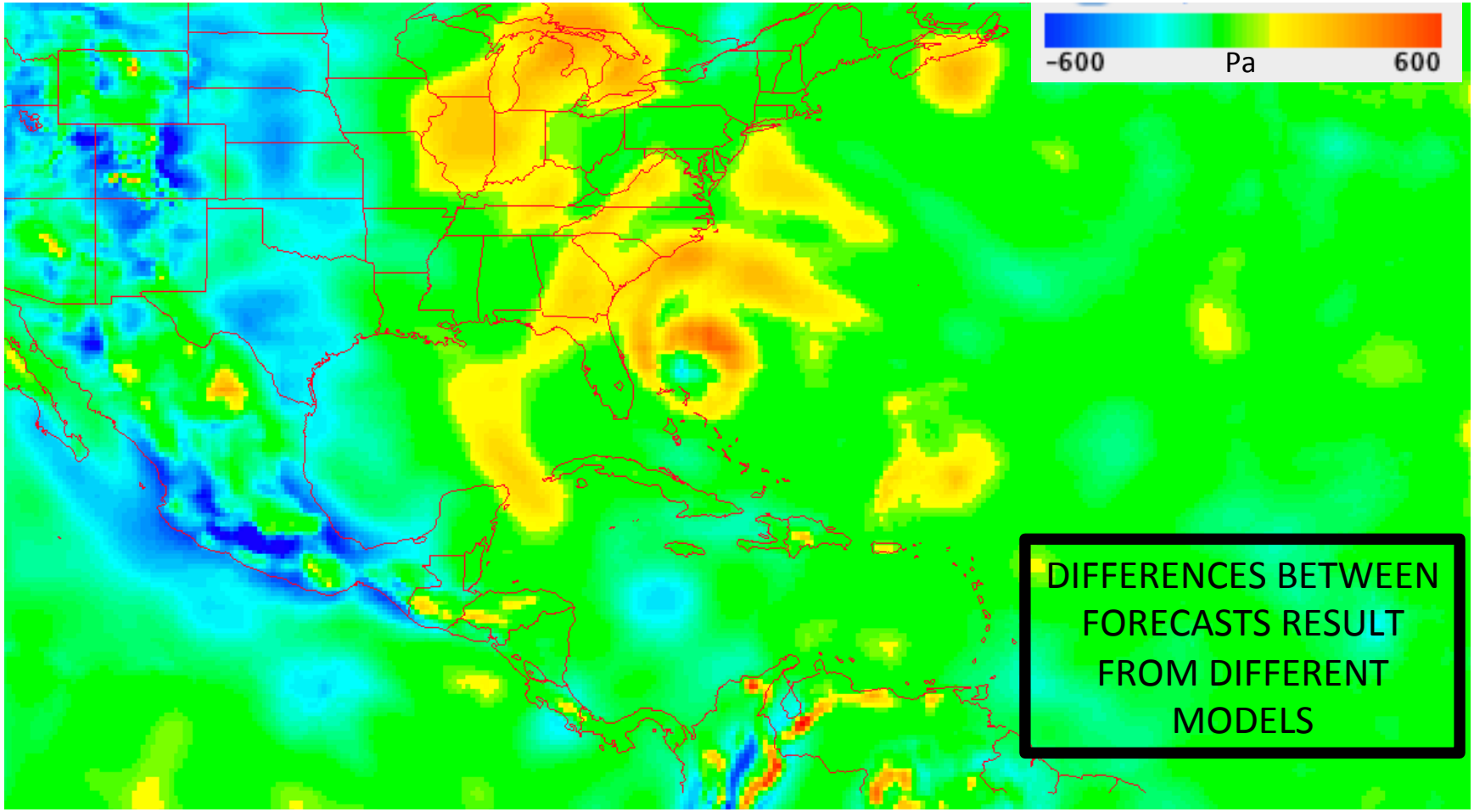
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference HWRF and GEFS forecasts



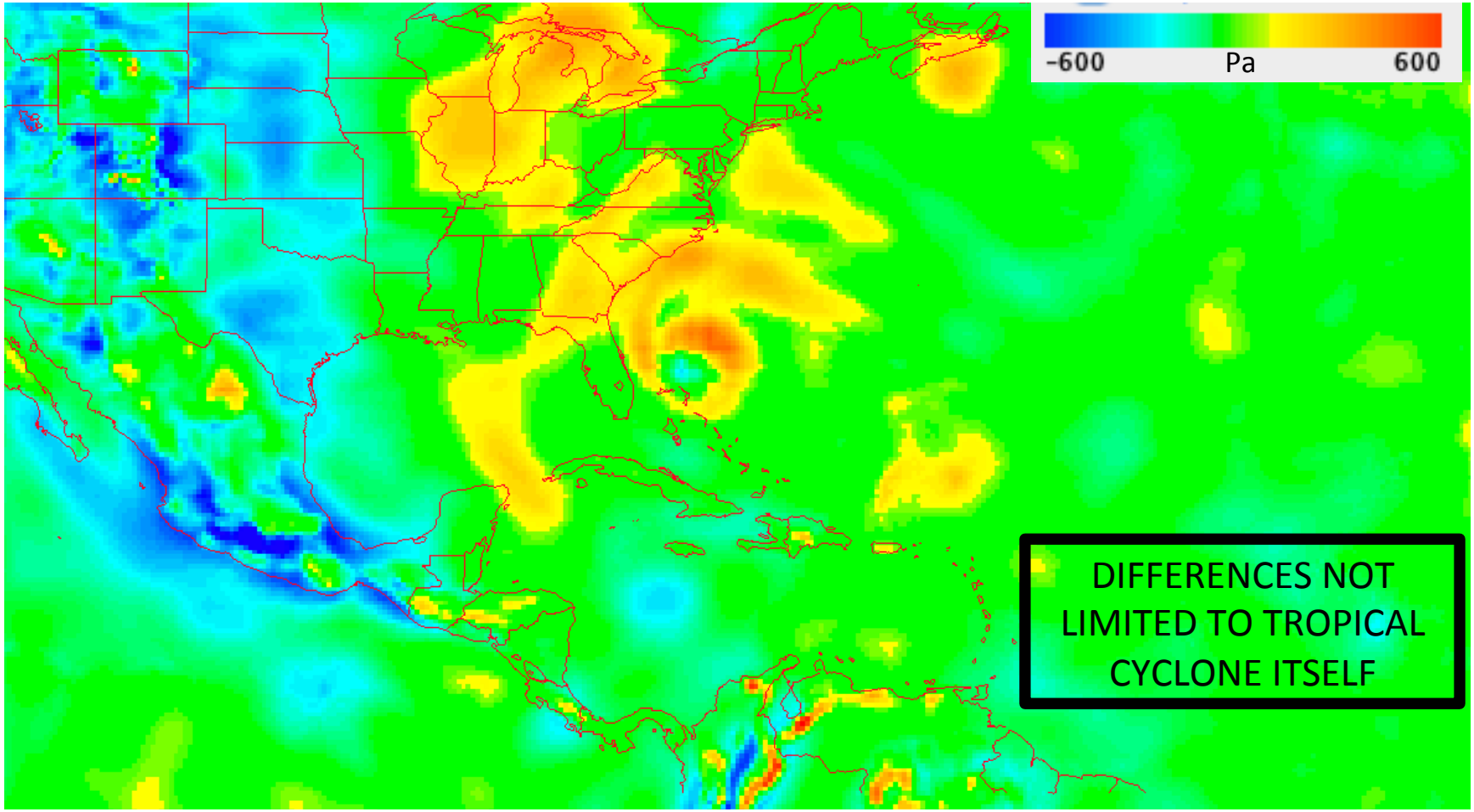
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference HWRF and GEFS forecasts



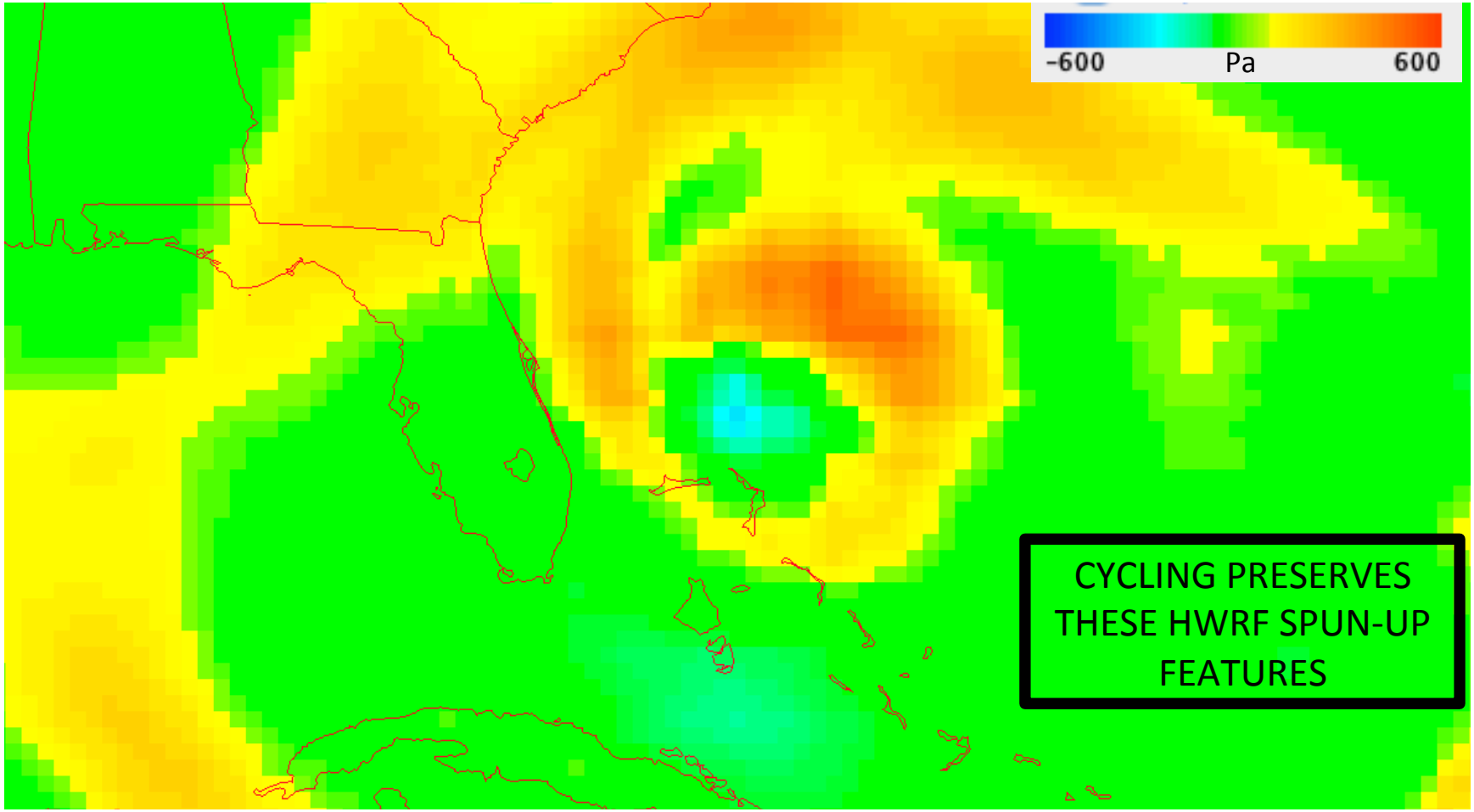
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference HWRF and GEFS forecasts



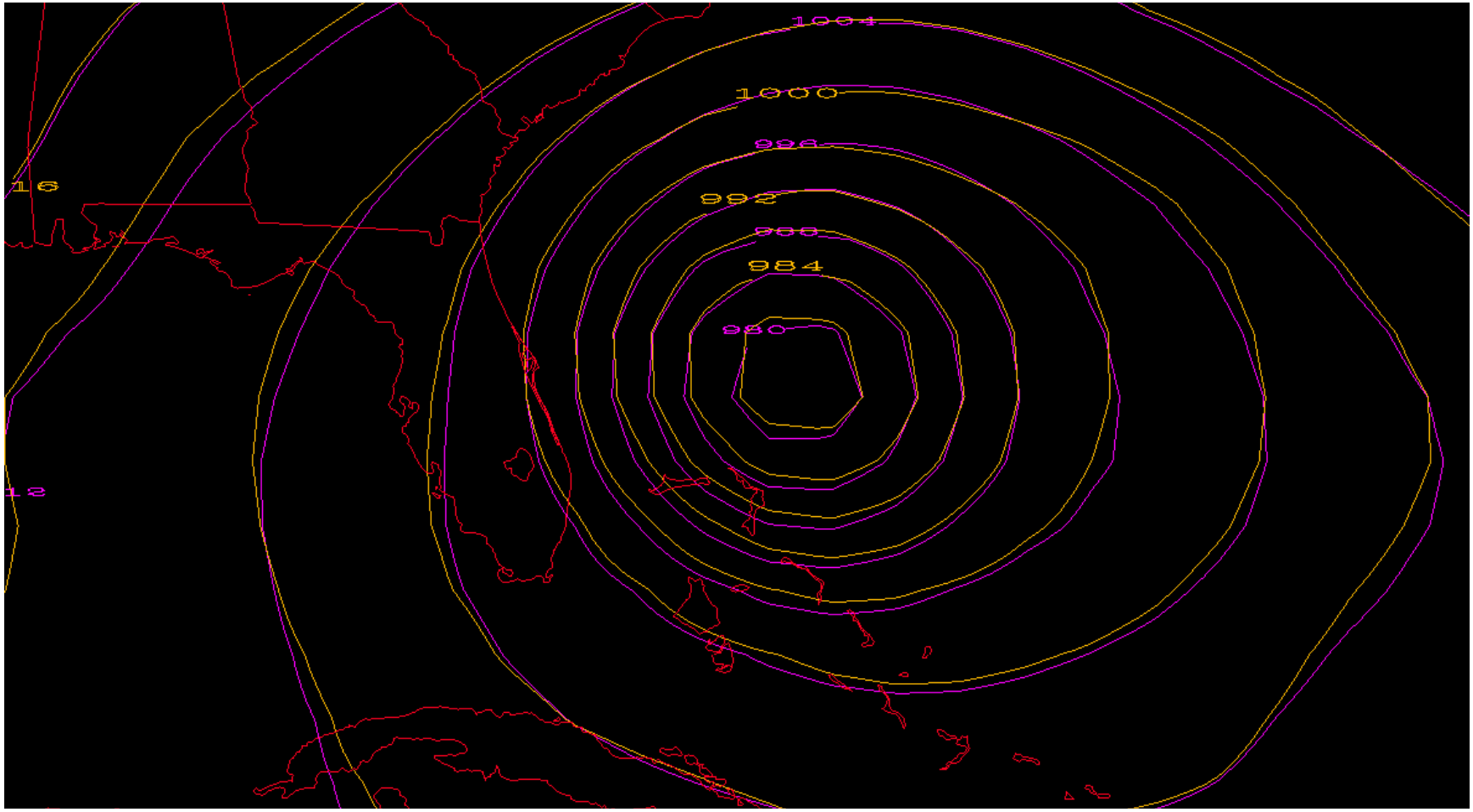
INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

Difference HWRF and GEFS forecasts



INITIAL TIME = 2012102700 VALID TIME = 2012102706 SAME INITIAL CONDITIONS

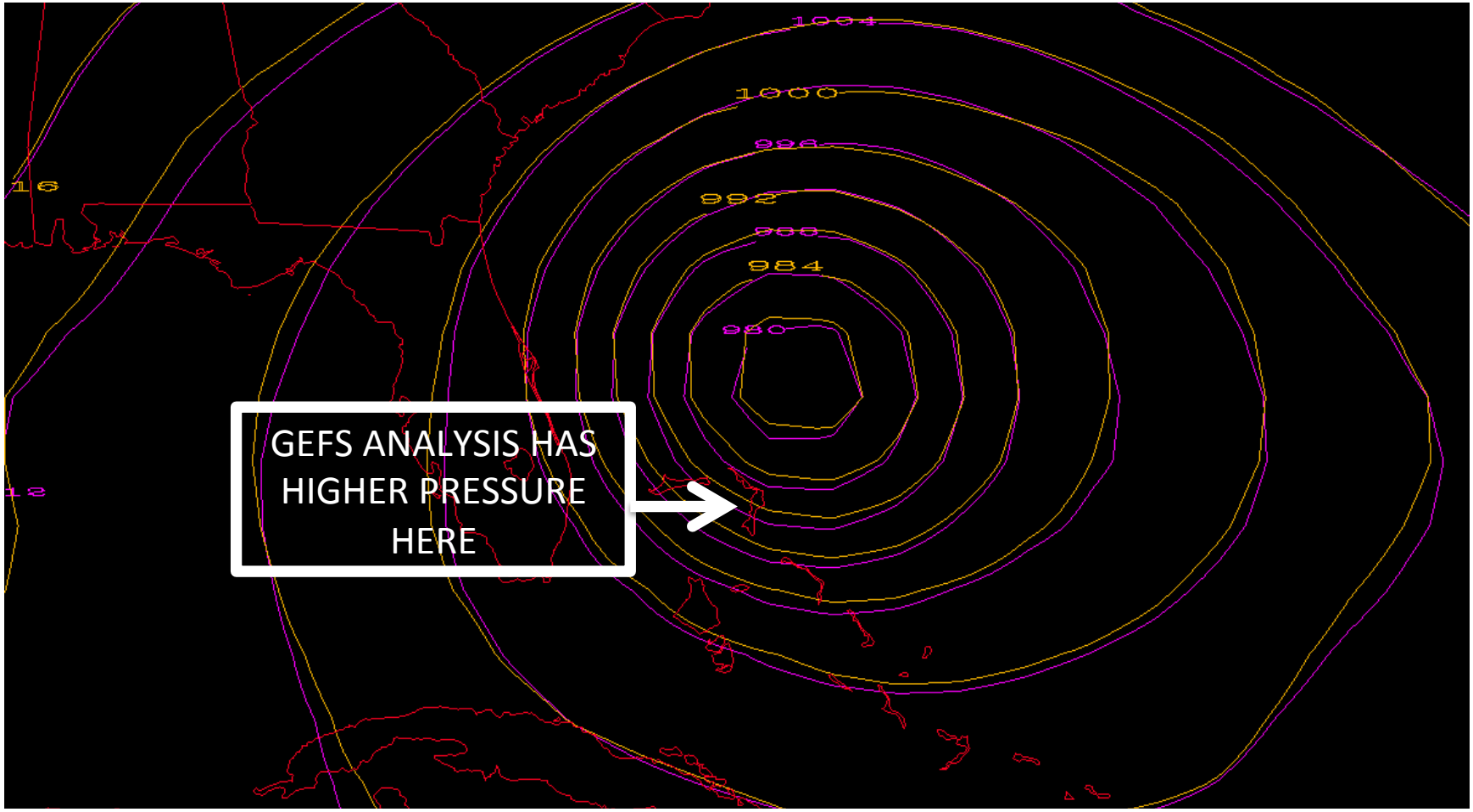
GEFS Analysis and Forecast



ORANGE = GEFS CONTROL ANALYSIS, PINK = GEFS CONTROL 6-hour FORECAST

ANALYSIS TIME = 2012102706 FORECAST INITIAL TIME = 2012102700 VALID TIME = 2012102706

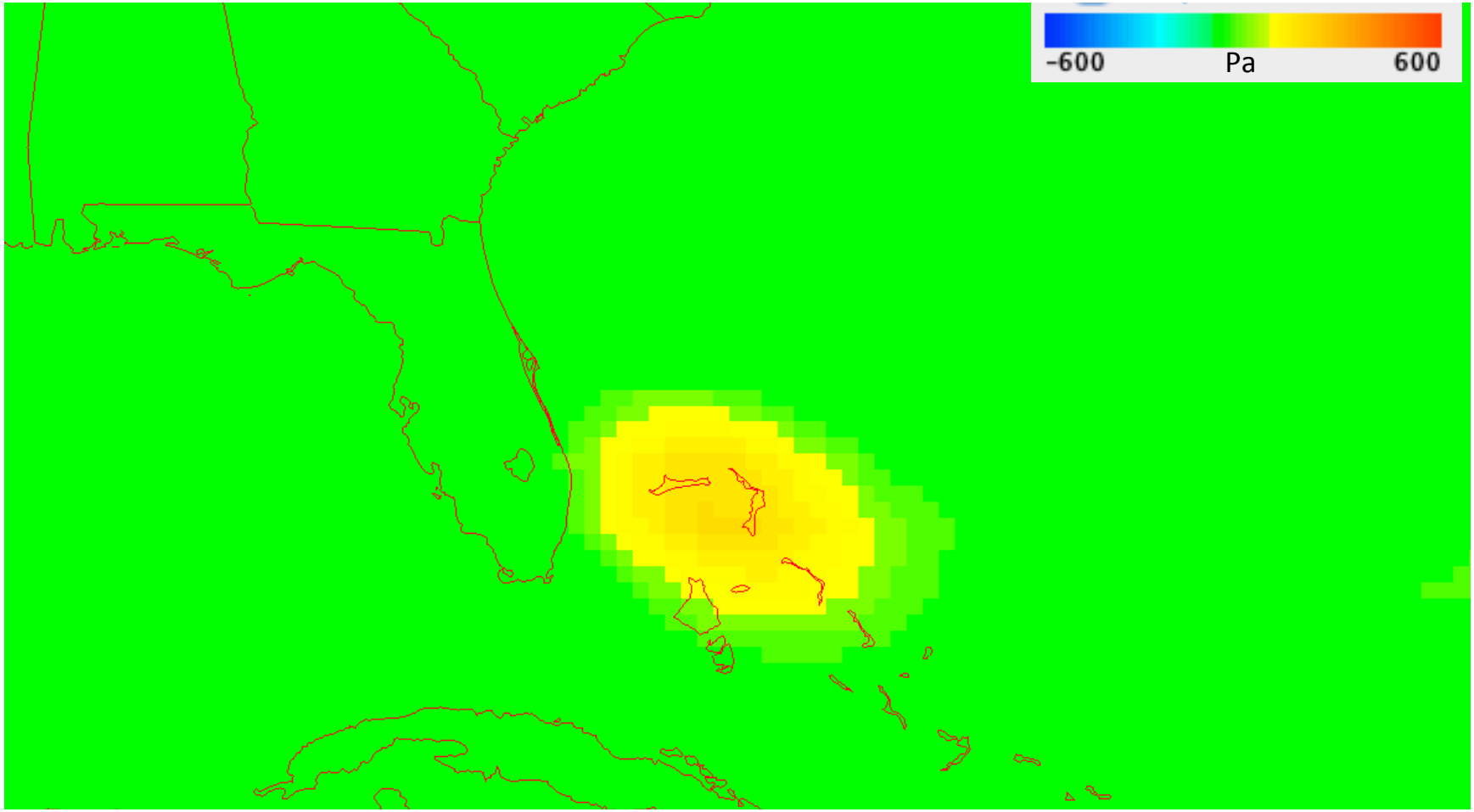
GEFS Analysis and Forecast



YELLOW = GEFS CONTROL ANALYSIS, PINK = GEFS CONTROL 6-hour FORECAST

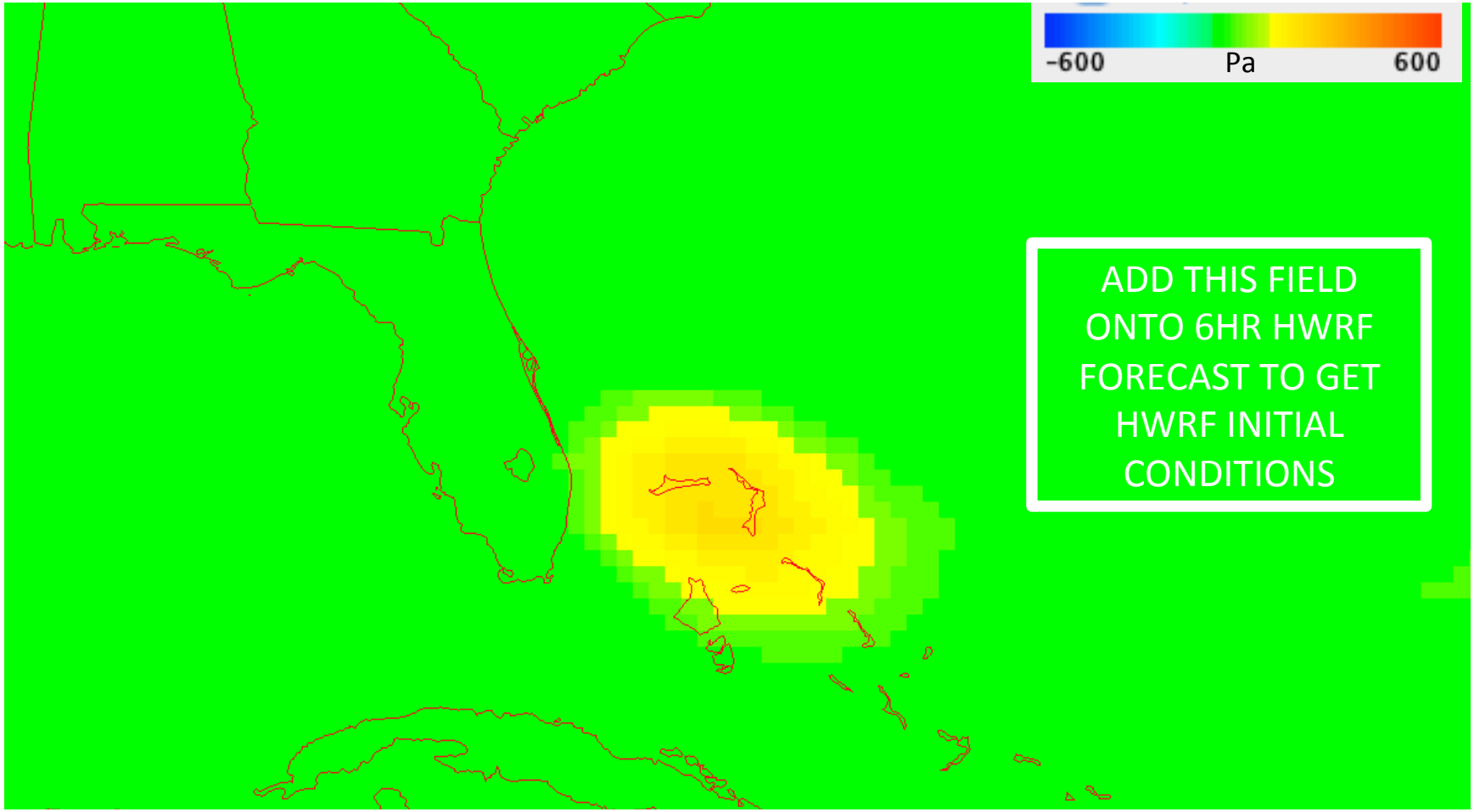
ANALYSIS TIME = 2012102706 FORECAST INITIAL TIME = 2012102700 VALID TIME = 2012102706

Difference GEFS Analysis and Forecast



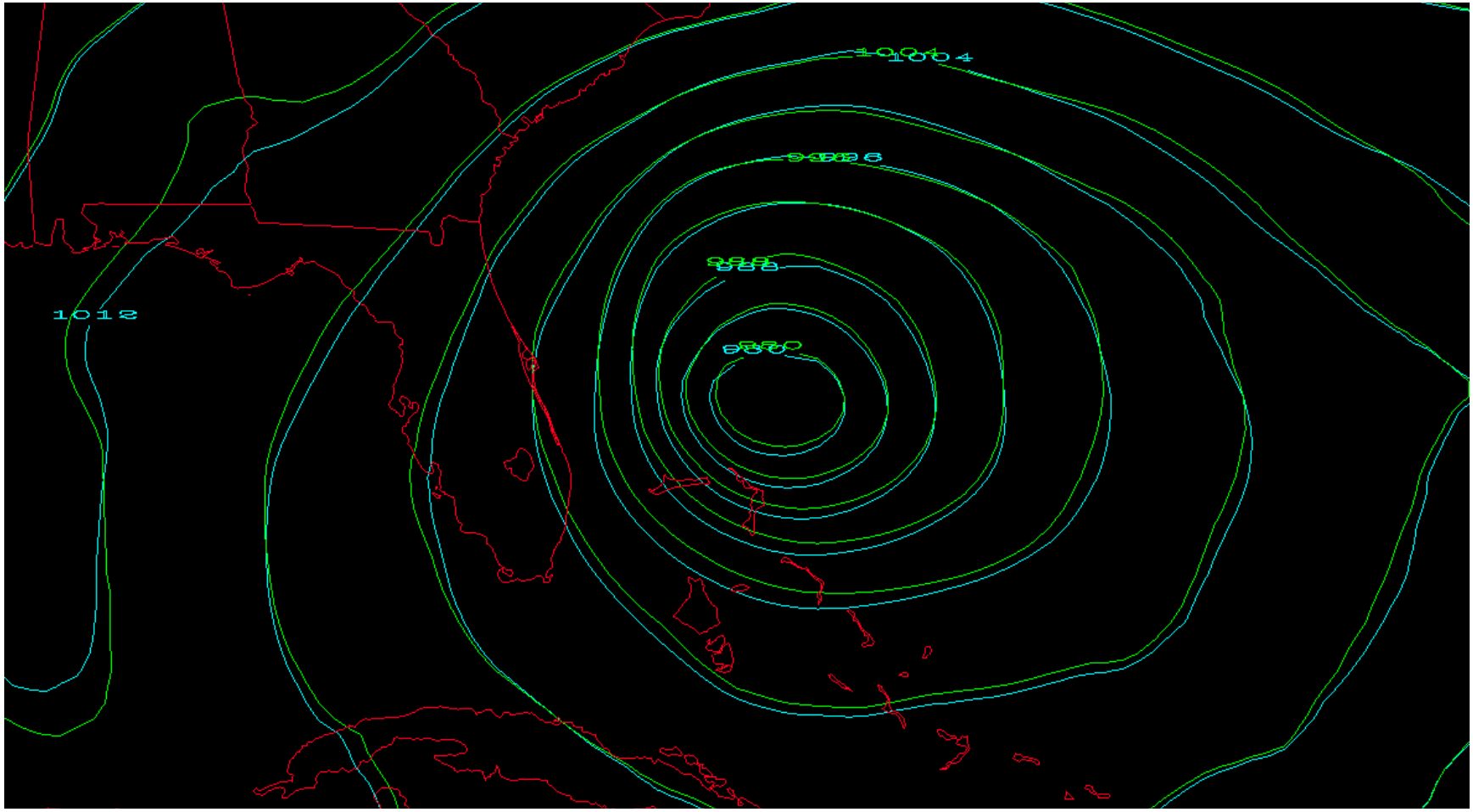
ANALYSIS TIME = 2012102706 FORECAST INITIAL TIME = 2012102700 VALID TIME = 2012102706

Difference GEFS Analysis and Forecast



ANALYSIS TIME = 2012102706 FORECAST INITIAL TIME = 2012102700 VALID TIME = 2012102706

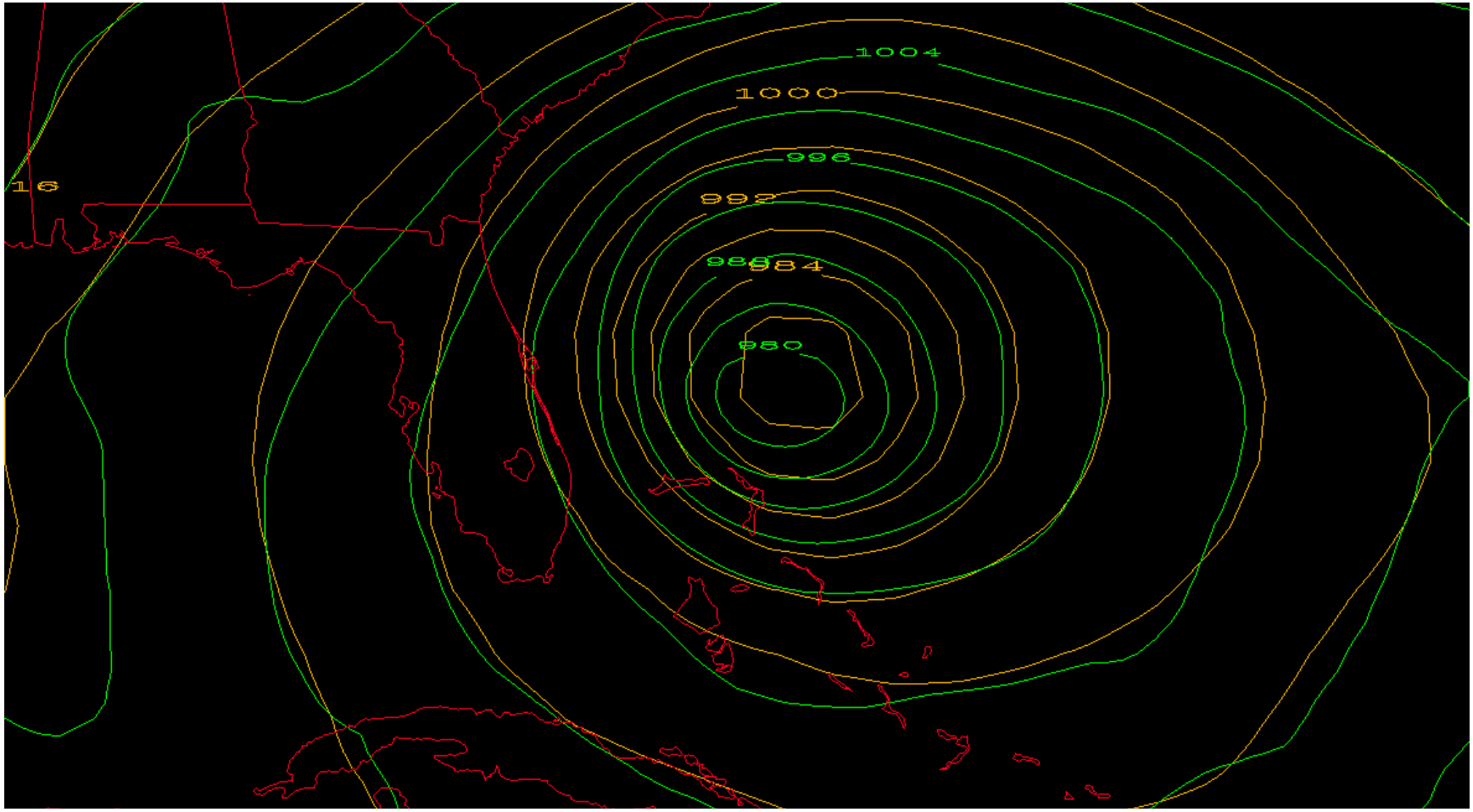
HWRF Initial Conditions and Forecast



GREEN = HWRF INITIAL CONDITION, BLUE = HWRF 6-hour FORECAST

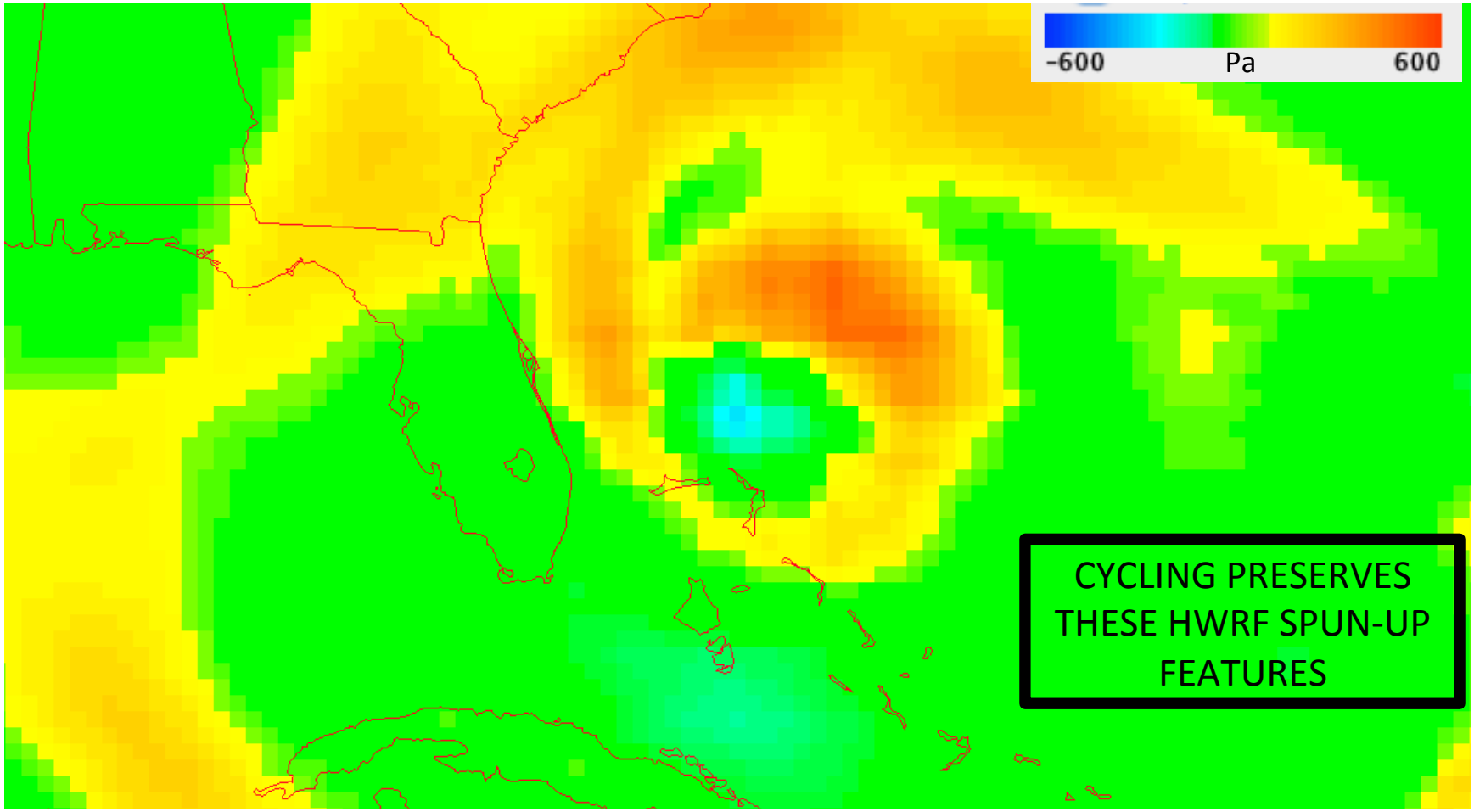
ANALYSIS TIME = 2012102706 FORECAST INITIAL TIME = 2012102700 VALID TIME = 2012102706

HWRF Initial Conditions: Cycled v GEFS



GREEN = HWRF INITIAL CONDITION, YELLOW = GEFS CONTROL ANALYSIS
ANALYSIS TIME = 2012102706

HWRF Initial Conditions: Cycled v GEFS



ANALYSIS TIME = 2012102706