A First Look at Hurricane Sandy

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NOAA SAB
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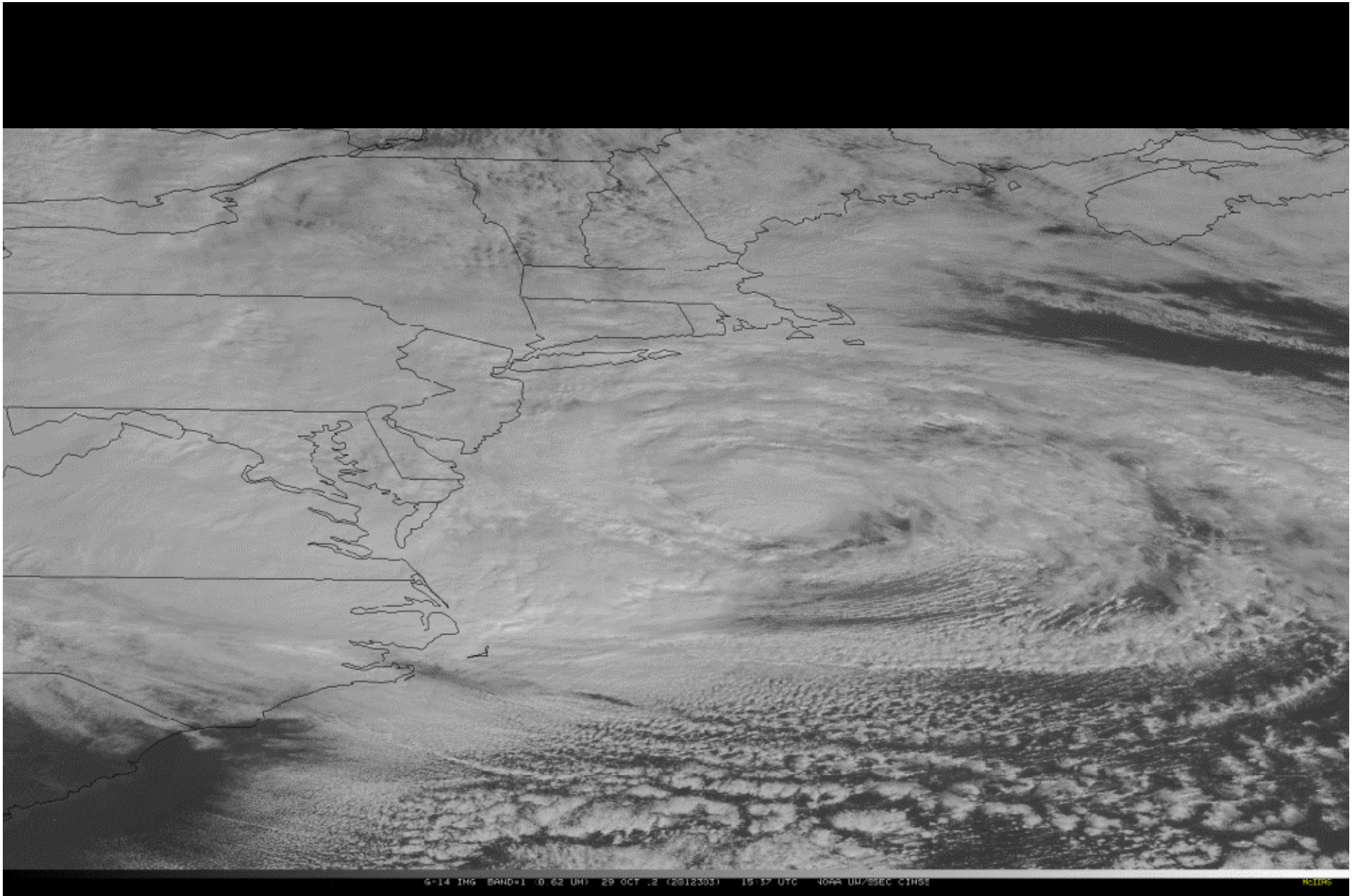
"Where America's Climate, Weather, Ocean and Space Weather Services Begin"

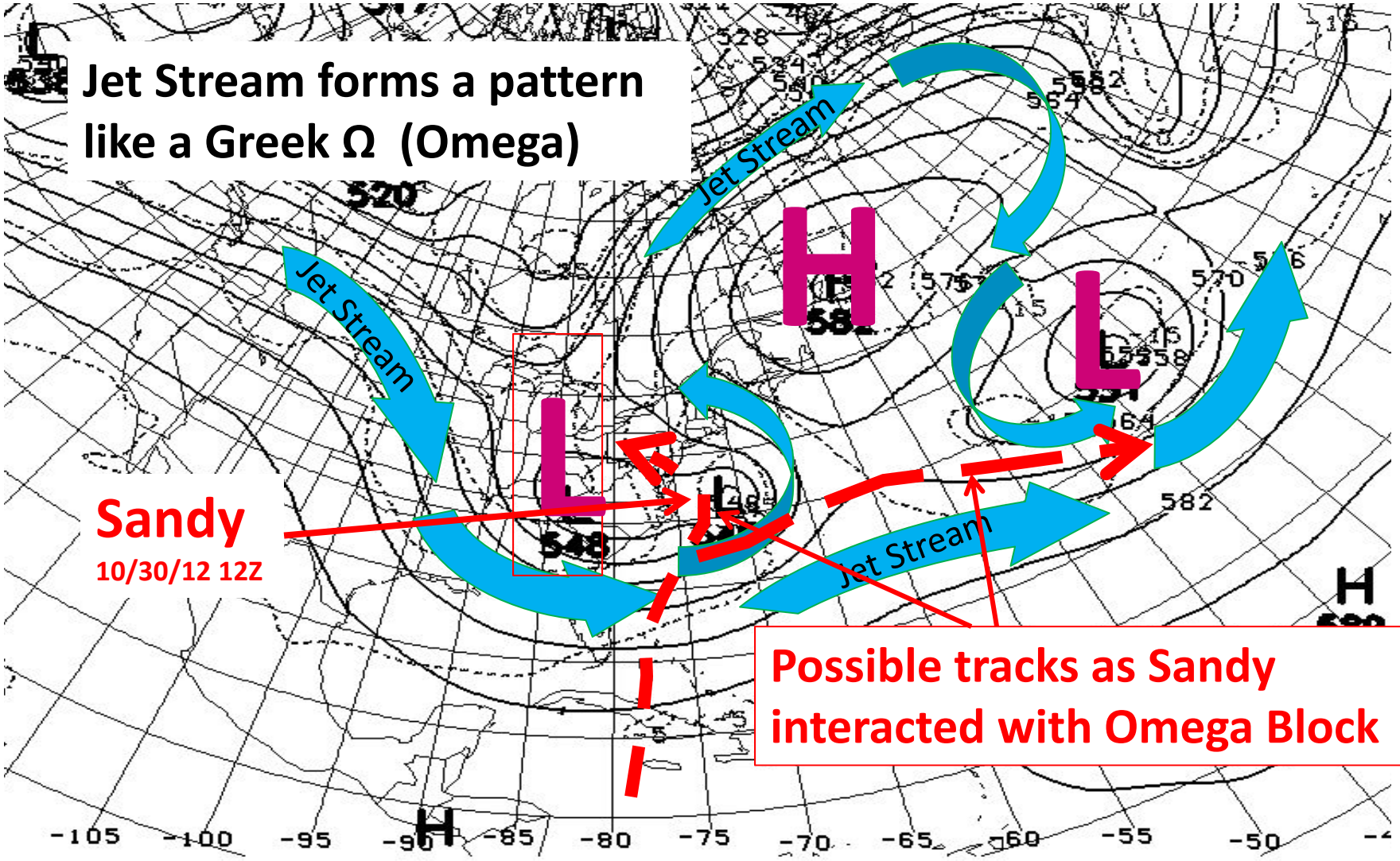
Outline

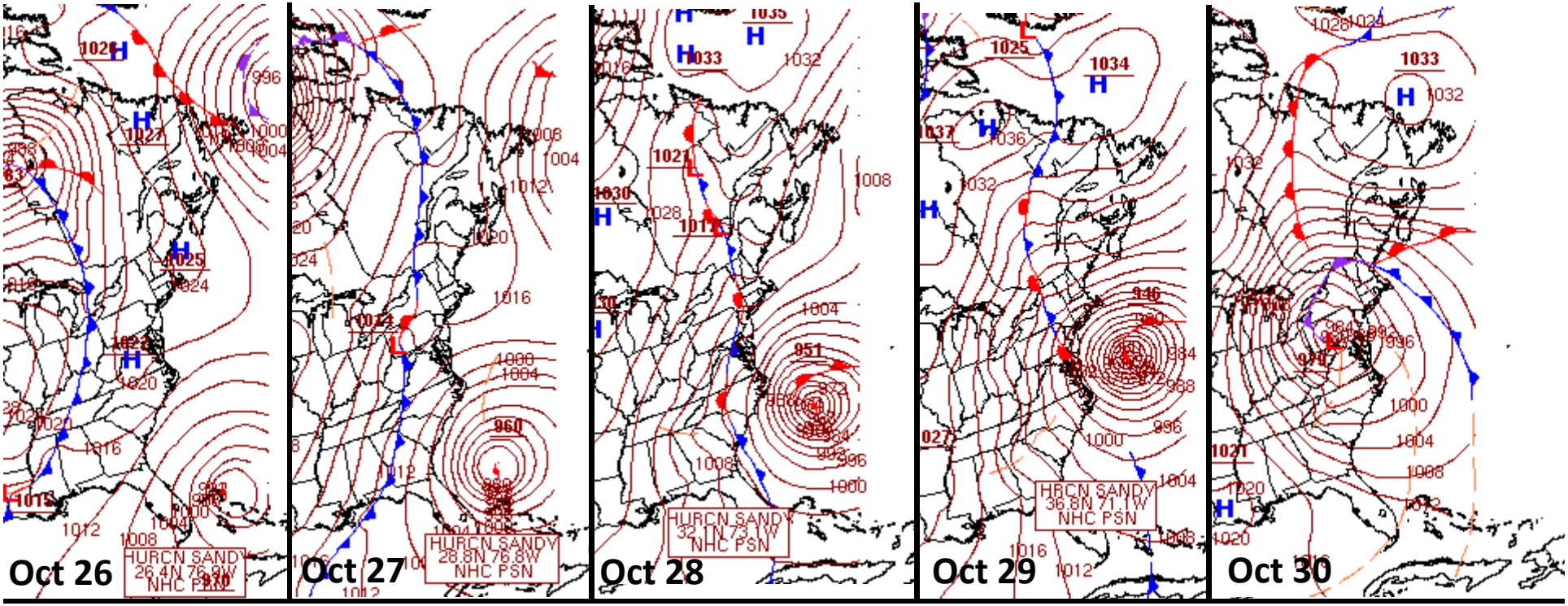
- Some Basic Characteristics of Sandy
- Forecasts for Sandy
  (from the forecaster perspective)
- Initial Look at Models used by Forecasters
- Verifications
- Issues/Challenges – Ongoing Experiments
- Summary



Hurricane Sandy – GOES-14 SRSO – October 29, 2012 1430-1530 UTC

Jet Stream 10/30/12 12Z (Blue)
Uncertainty in Sandy's track

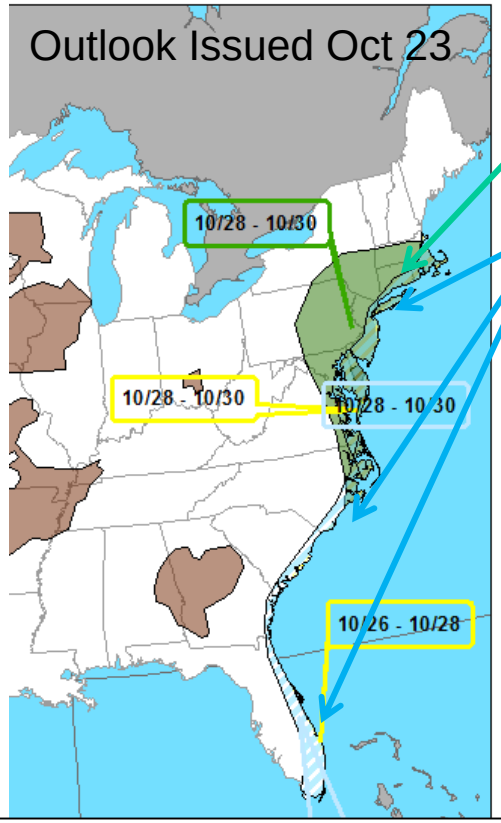




Surface Analysis: Friday October 26 – Tuesday October 30, 2012

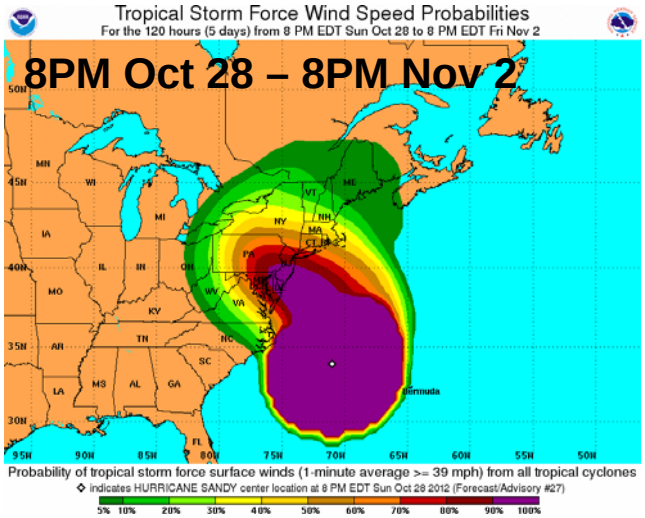
Forecasts for Sandy
(from the Forecaster Perspective)

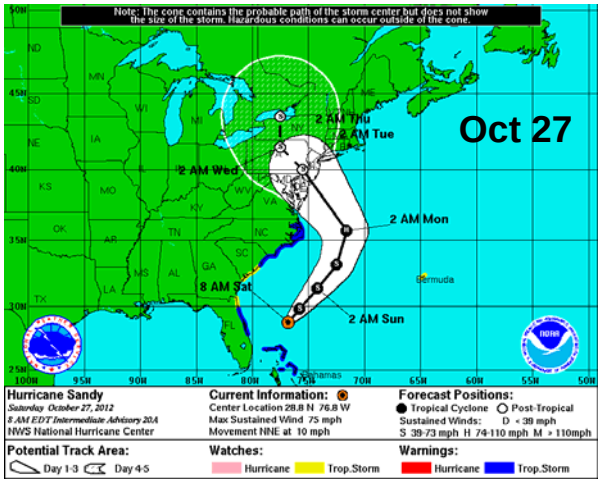
Hurricane Sandy: Collaborative Forecast Process

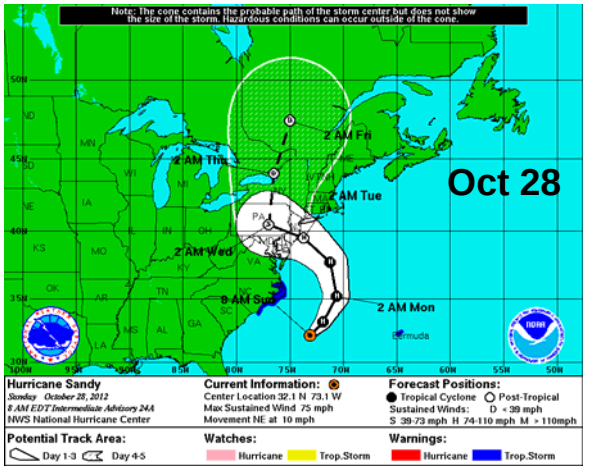


- CPC – Outlooks, Hazards Chart, 5 days in advance

- NHC – Hurricane Track/Intensity Forecasts; Wind Speed Probabilities

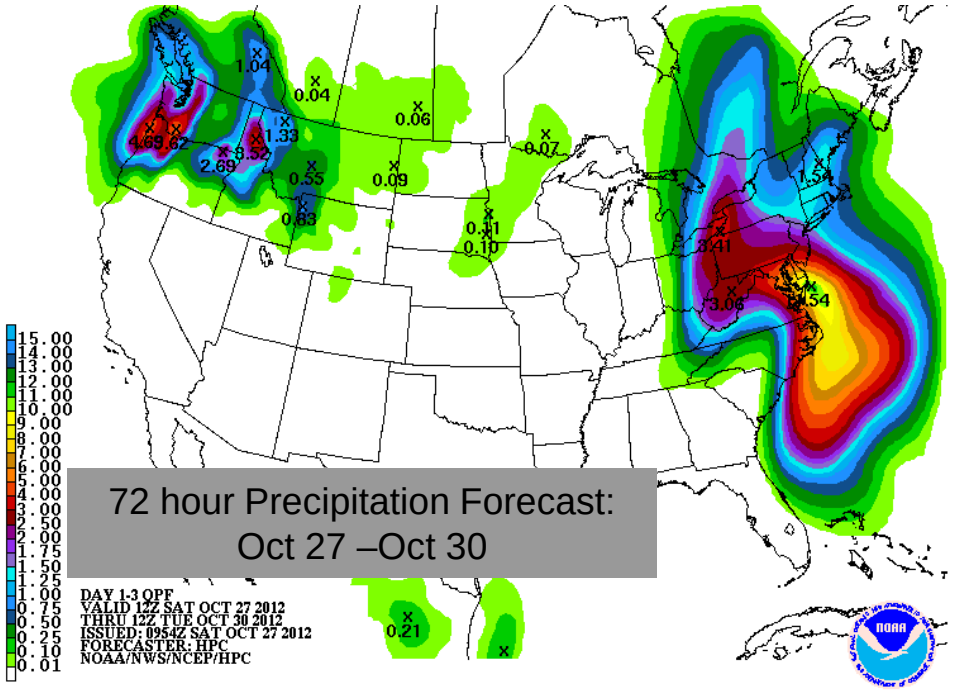




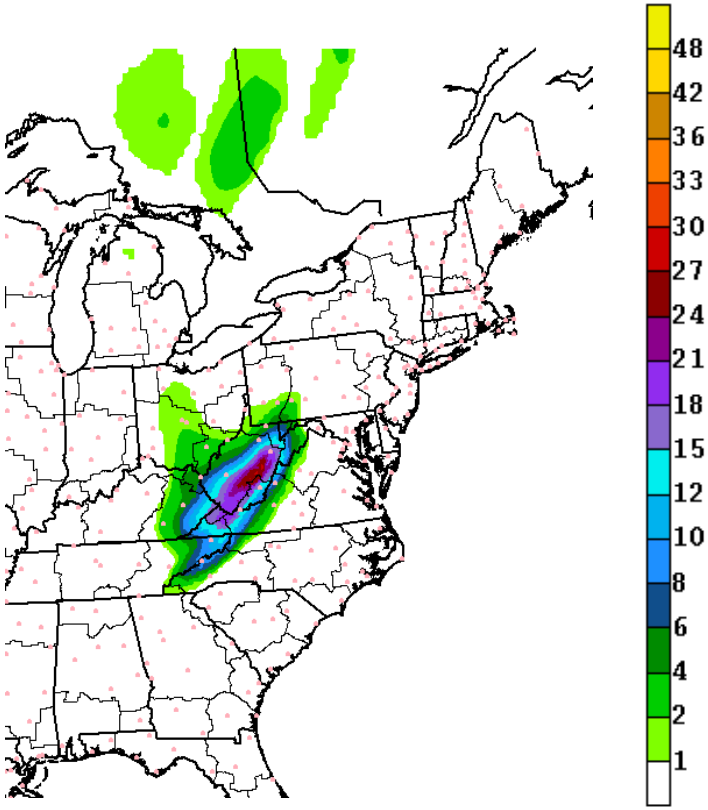


Hurricane Sandy: Collaborative Forecast Process

- HPC – QPF and Winter Weather Desk Snow forecasts



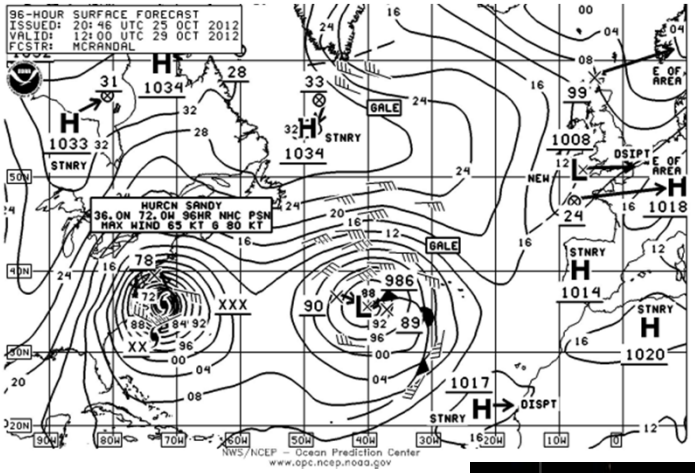
72 hour Precipitation Forecast: Oct 27 –Oct 30



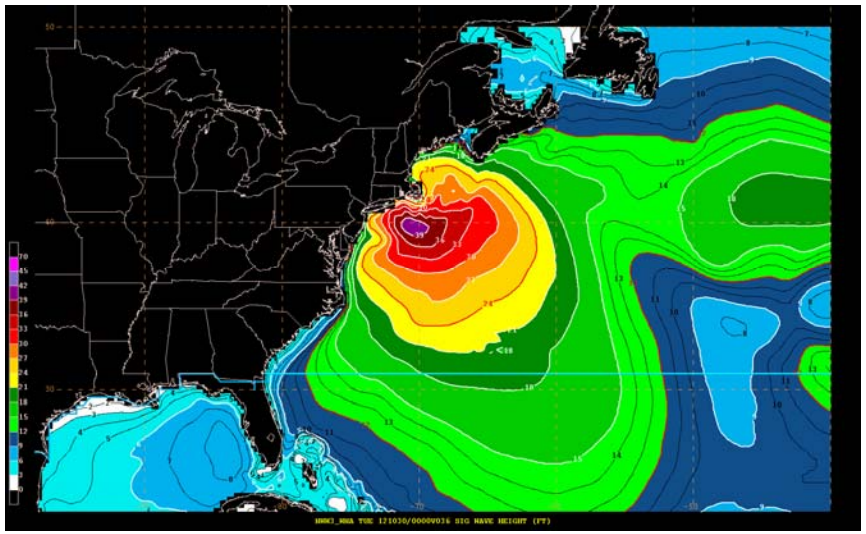
3 day Snow Total: valid Oct 28-Oct 30

Hurricane Sandy: Collaborative Forecast Process

- OPC – 96 hour surface chart



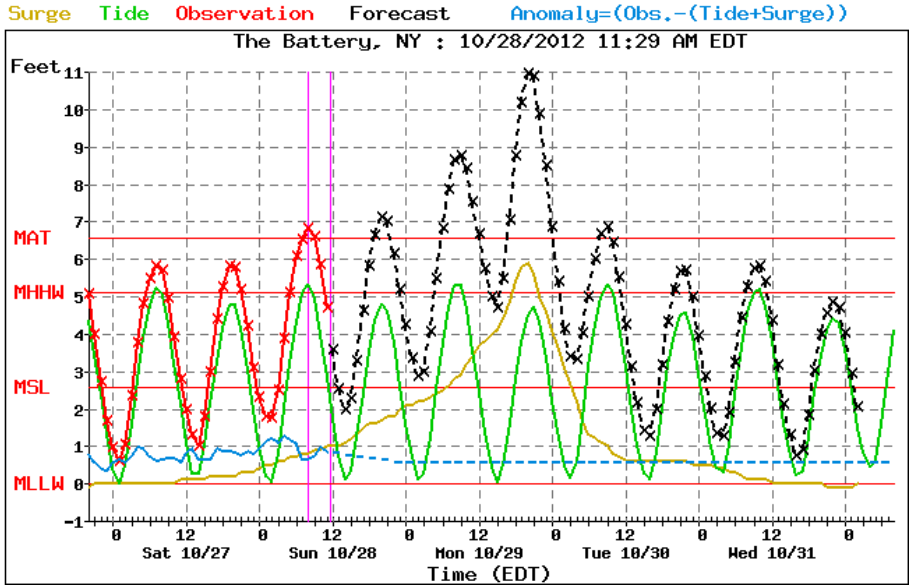
- EMC – Wave Model forecasts

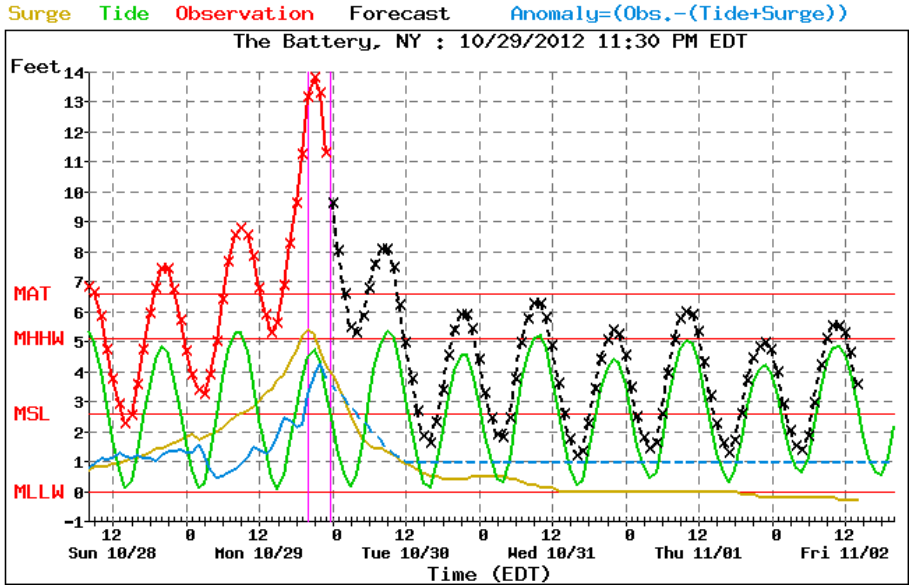


36 hour wave height forecast (ft)

Hurricane Sandy: Collaborative Forecast Process

MDL NWS Surge Forecast:
Forecasts were coordinated among OPC, NHC, local WFOs

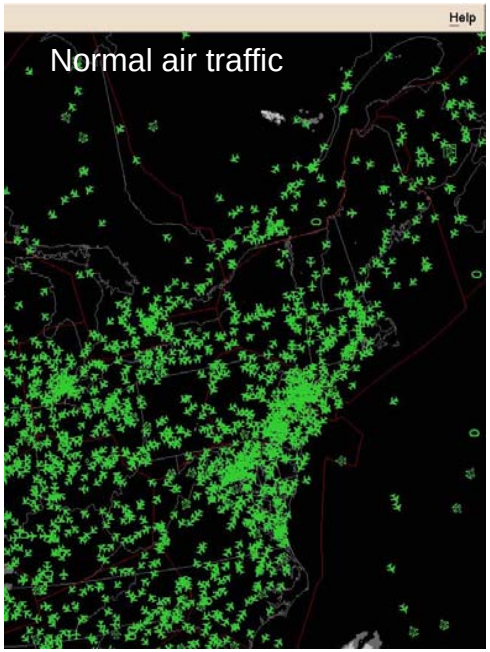


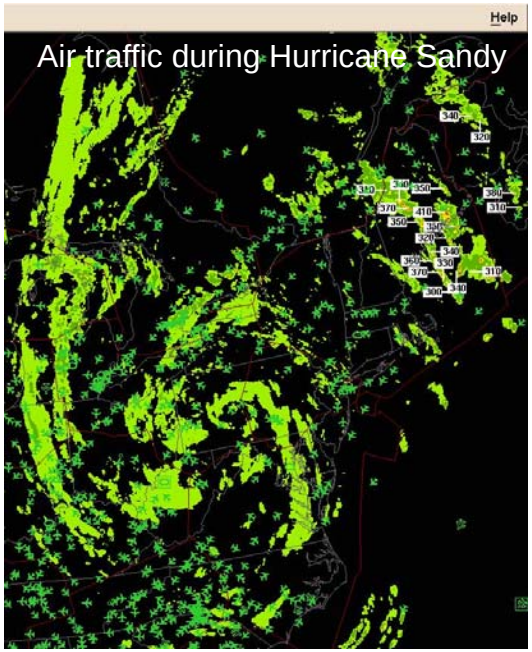


"Life Threatening" statements issued Sunday morning by NHC and called into NYC Emergency Operations Center;
NYC initiates evacuations and shut down of public transportation shortly thereafter

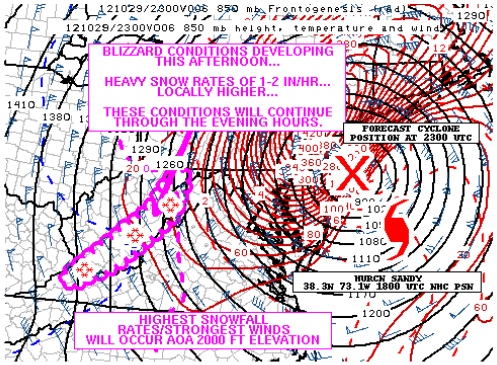
Hurricane Sandy: Collaborative Forecast Process

- AWC – briefings for FAA staff: current weather, timing of impacts at facilities and airports, outlooks for recovery, coordinated with WFOs and CWSUs





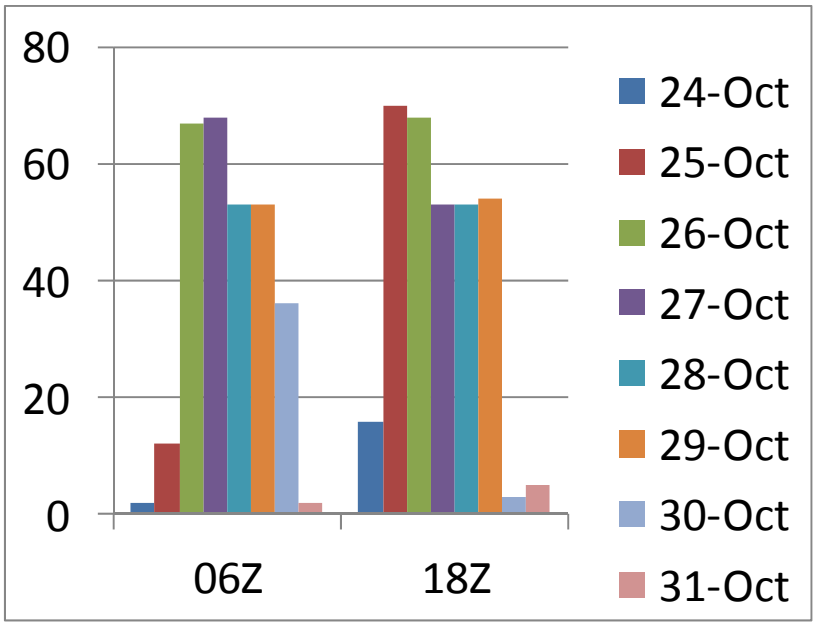
- SPC – Mesoscale Discussion highlighting blizzard conditions in the Appalachians



SPC MCD #2091

Hurricane Sandy: Collaborative Forecast Process

- NCO – Coordinated extra radiosonde deployment with WFOs over an 8 day period
  - received over 600 additional soundings



- Supercomputer operations

Hurricane Sandy: Collaborative Forecast Process

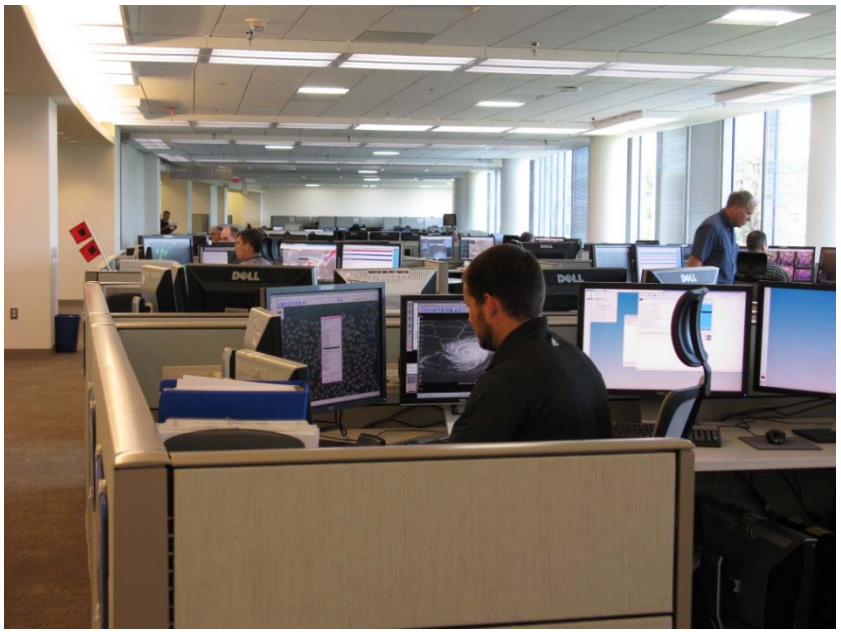
Communication Strategy

- Forecaster collaboration across All NCEP Centers, WFOs and Other NOAA LOs (NESDIS, NOS, OMAO)
  - Specific local forecasts issued by WFOs
  - All special messages and linkages to local emergency centers through WFOs
  - Seamless Consistent Message to Emergency Decision Makers and Public

Hurricane Sandy: Collaborative Forecast Process

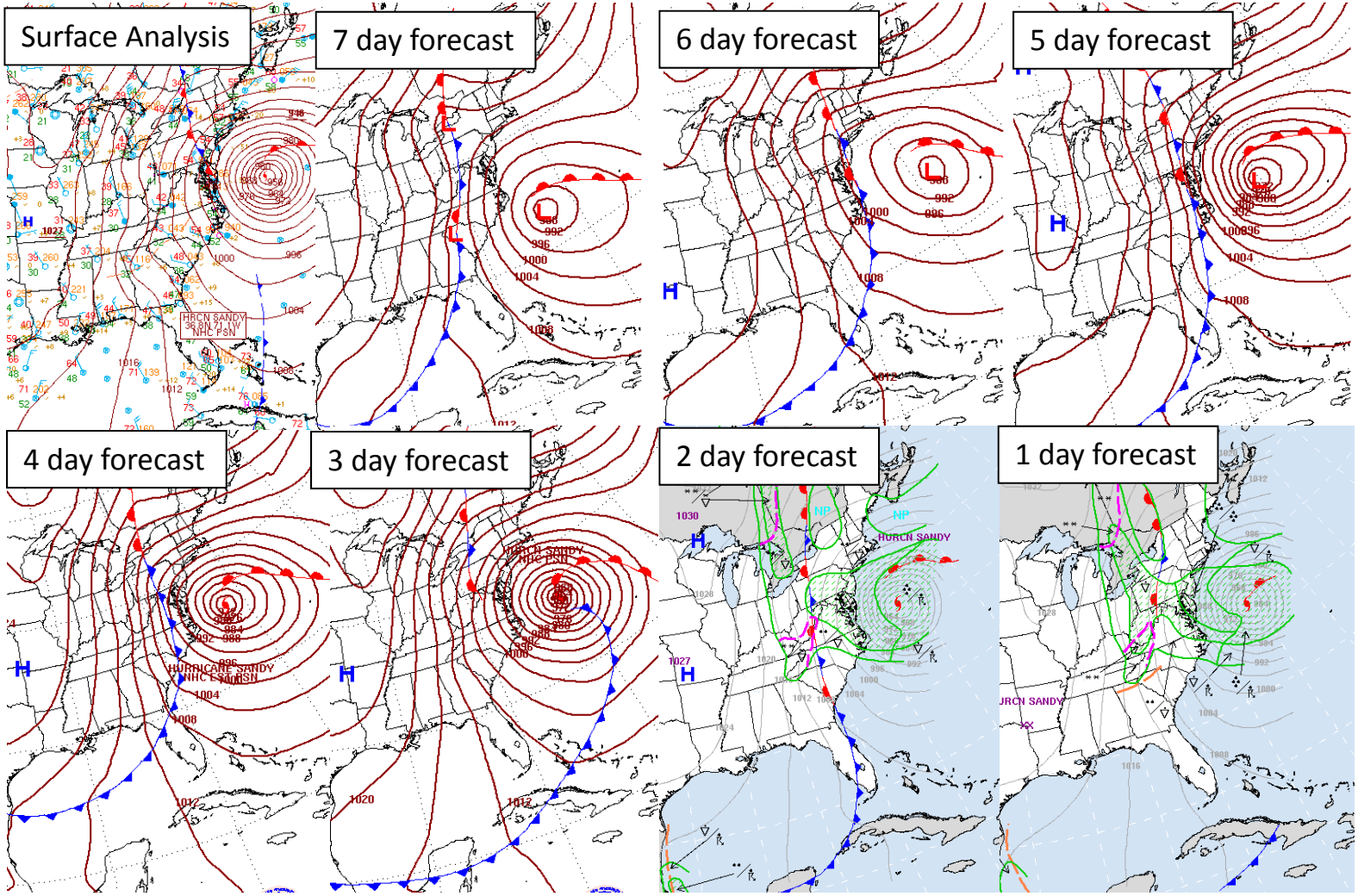
Communication Strategy

- Messaging Focused on ***Impact-***Based Decision Support Services
  - Unique nature of storm (tropical to extratropical transition
  - Large area affected by strong winds
  - East to west track toward NJ
  - Record surge/inundation in NJ→ NYC→ SE New England
  - Record blizzard in Appalachian Mountains & WV
  - Threats emphasized particularly dangerous storm – "worst case scenario" compared to the Perfect Storm

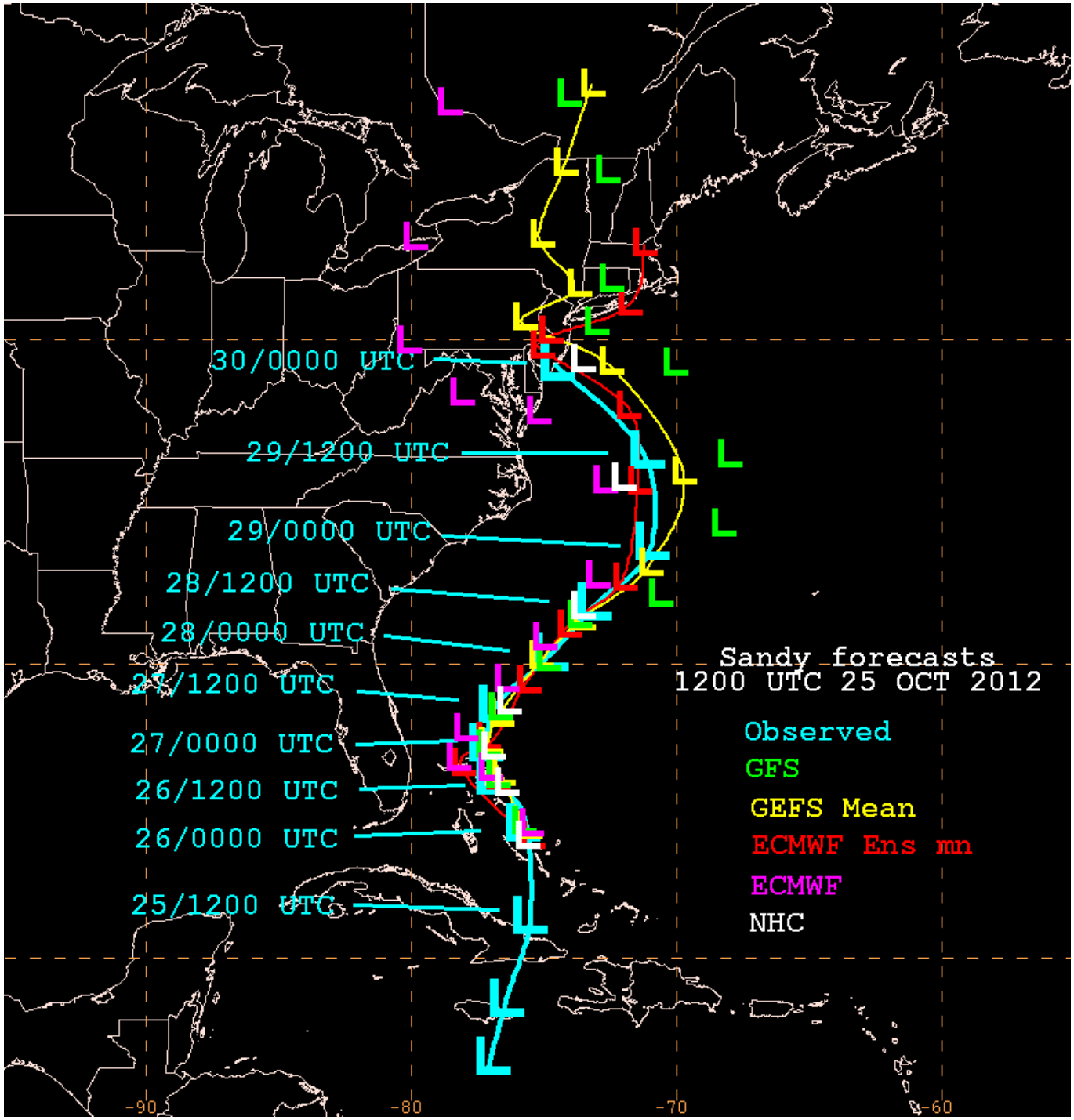


Initial Look at Models Used by the Forecaster

Hurricane Sandy: All Charts Valid 12Z October 29, 2012

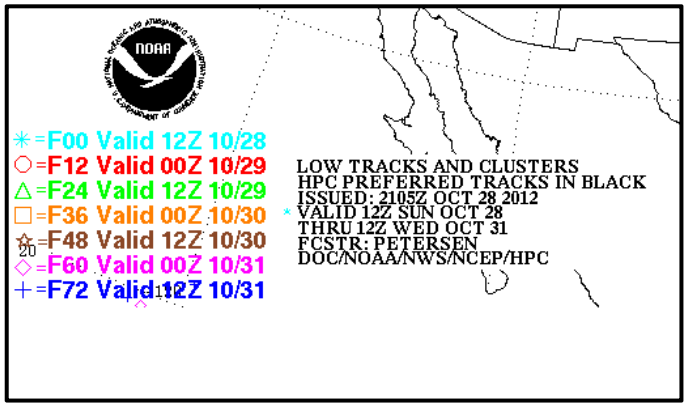


Forecasters Use Ensemble Means for Official Track Forecasts

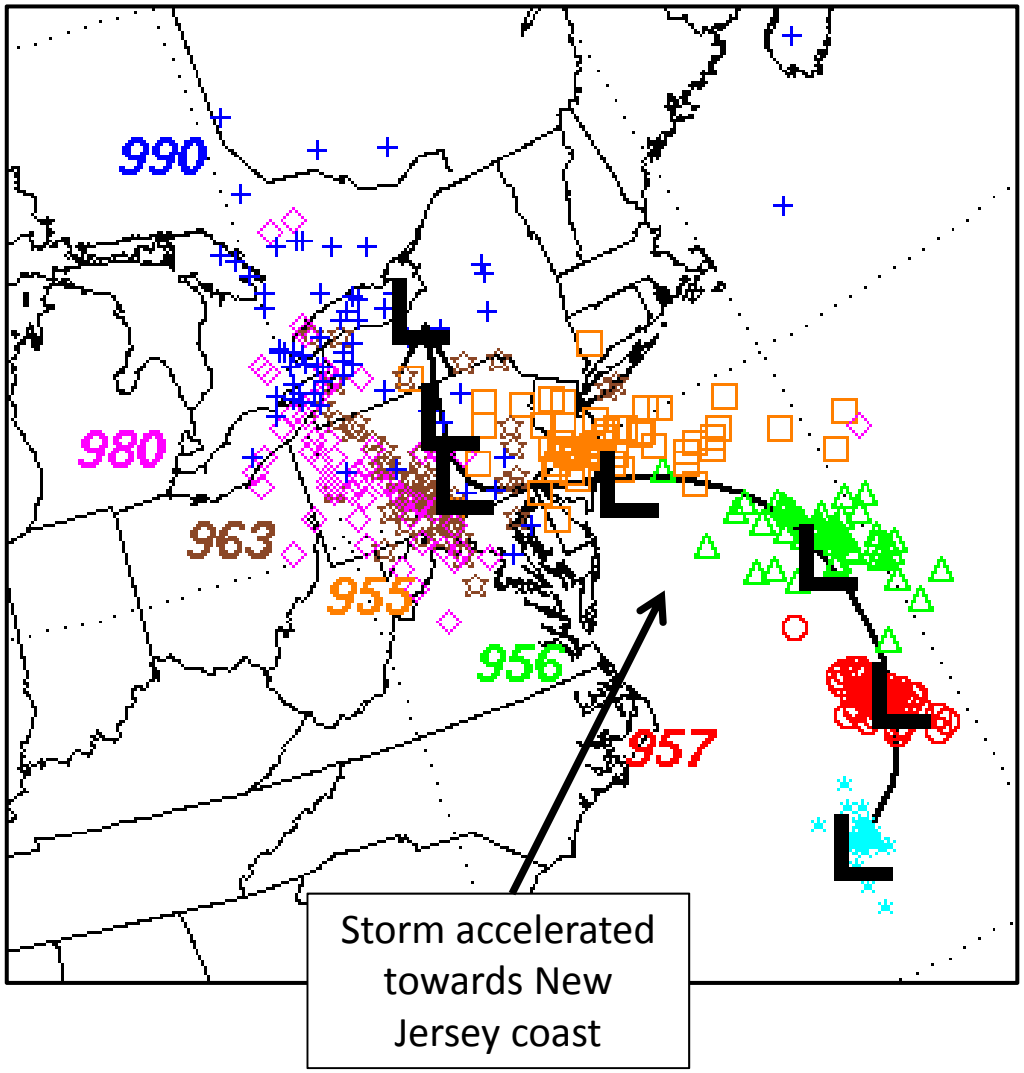


Low Track Forecast – 1.5 days prior to landfall

* Note the ensemble spread at each forecast time.

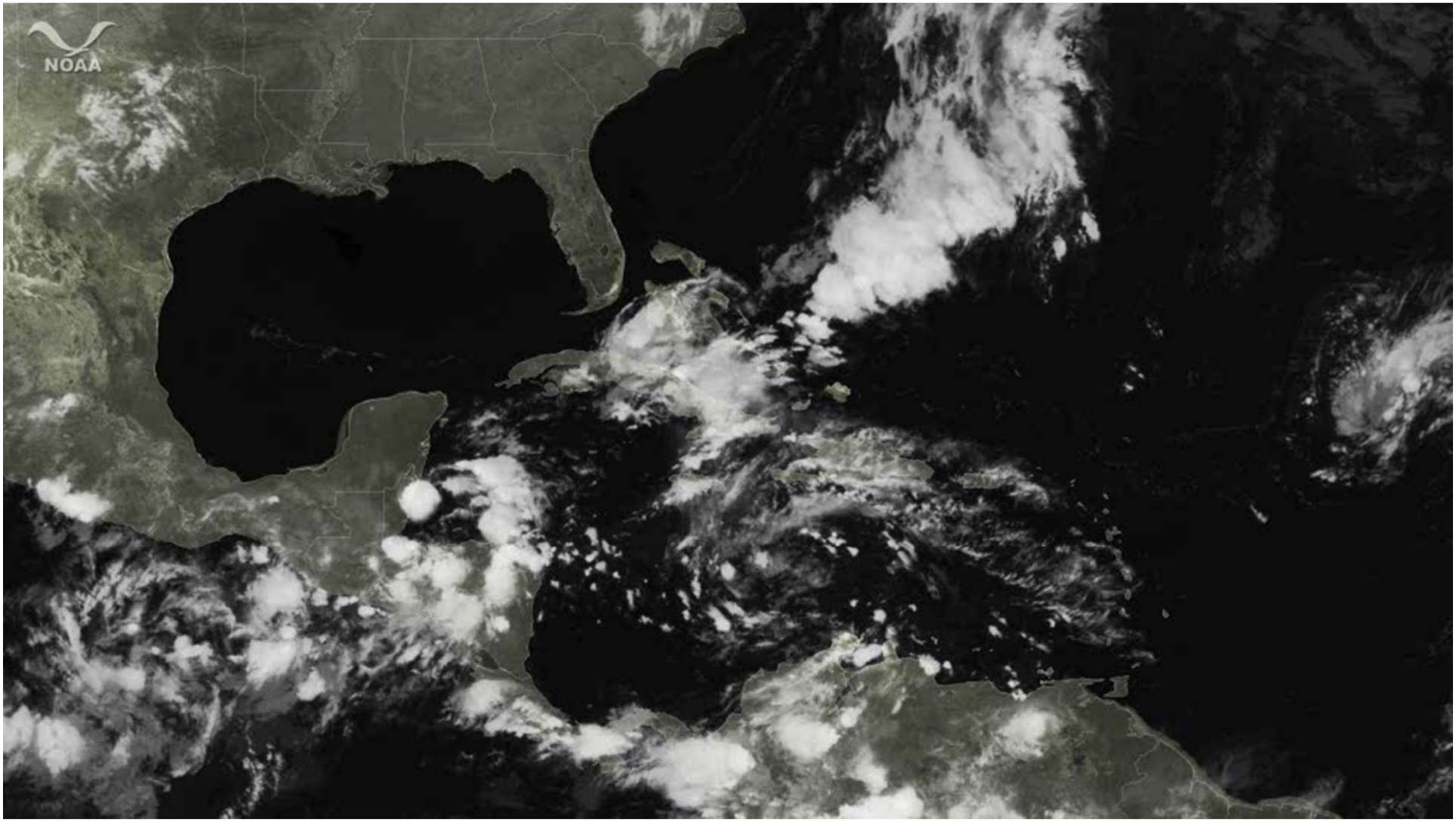


- Acceleration of storm - only model that hinted at this within 24 hours of landfall – SREF
- Is acceleration a function of the interaction of Sandy with the extratropical trough? The blocking ridge? Both?



Verification

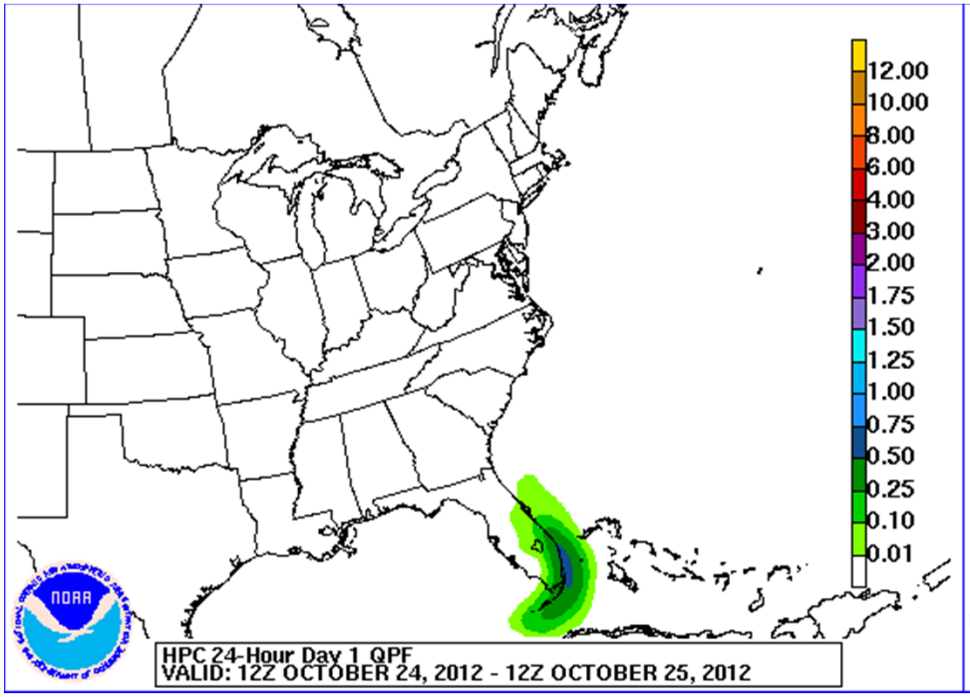
Hurricane Sandy
October 21, 2012 0345Z through October 31, 2012 1315Z



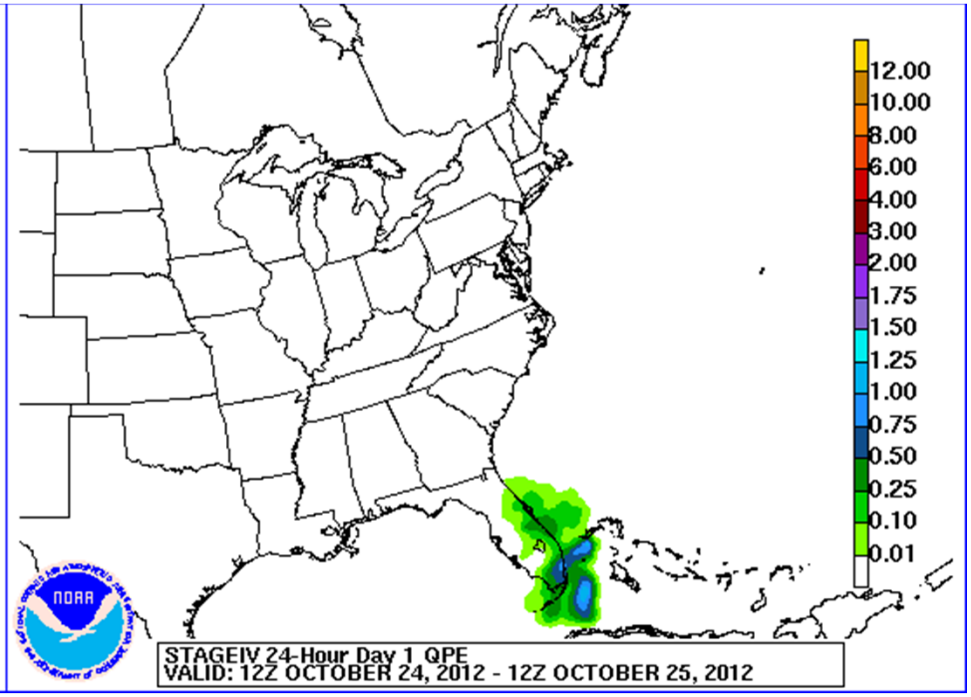
National Hurricane Center's 5 day forecast track issued at 11 a.m. EDT on Thursday, October 25

Hurricane Sandy Precipitation

HPC Forecast

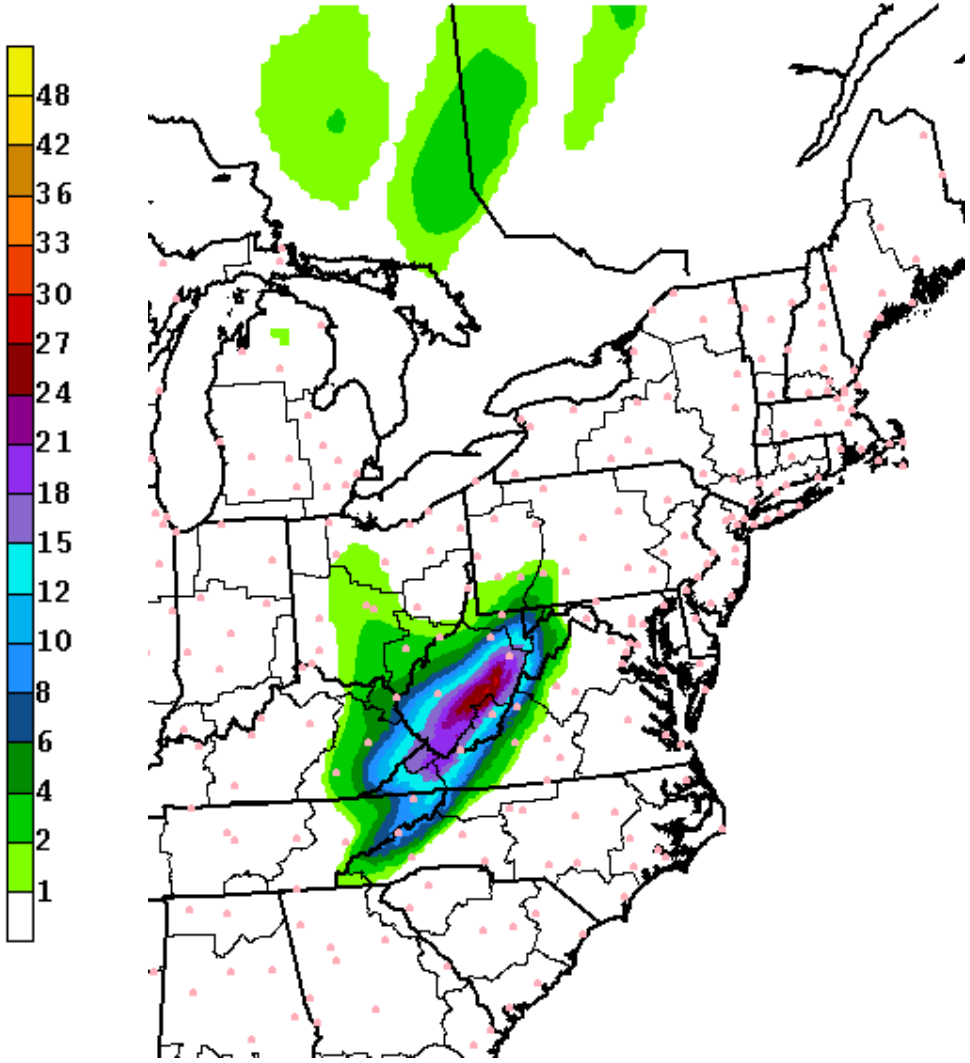


Verification



October 24 – November 1, 2012

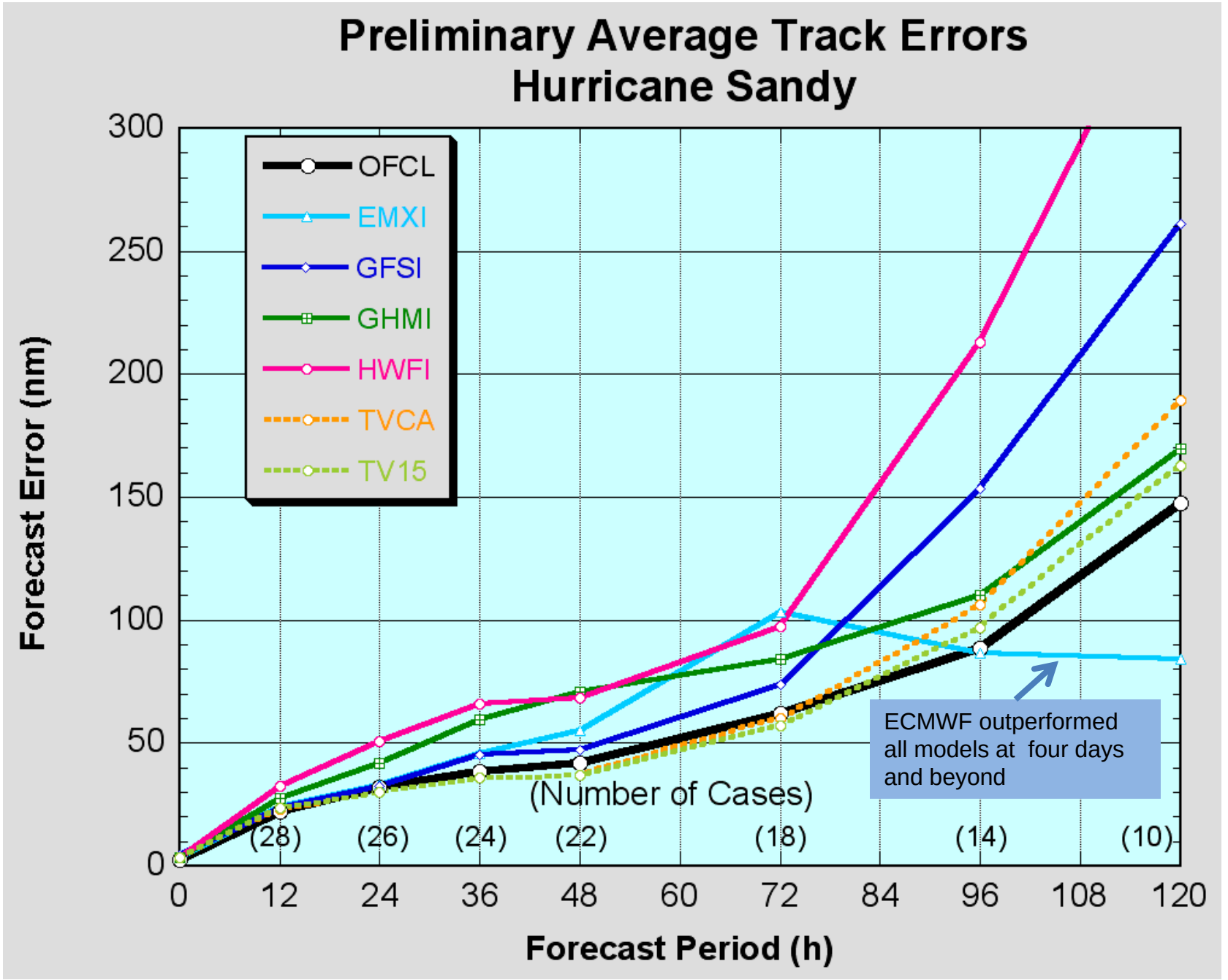
3 day Snow Total: valid Oct 28-Oct 30



Snow Totals (Inches)

...WEST VIRGINIA...	
CLAYTON 2 NNW	33.0
QUINWOOD	29.0
DAVIS	28.0
FLAT TOP	28.0
HUTTONSVILLE 5 WSW	28.0
CRAIGSVILLE	26.0
ALEXANDER	24.0
ALPINE LAKE	24.0
KITZMILLER	24.0
MINGO 2 SSE	24.0
NETTIE	24.0
TERRA ALTA	24.0
BAYARD	22.3
BEVERLY	21.0

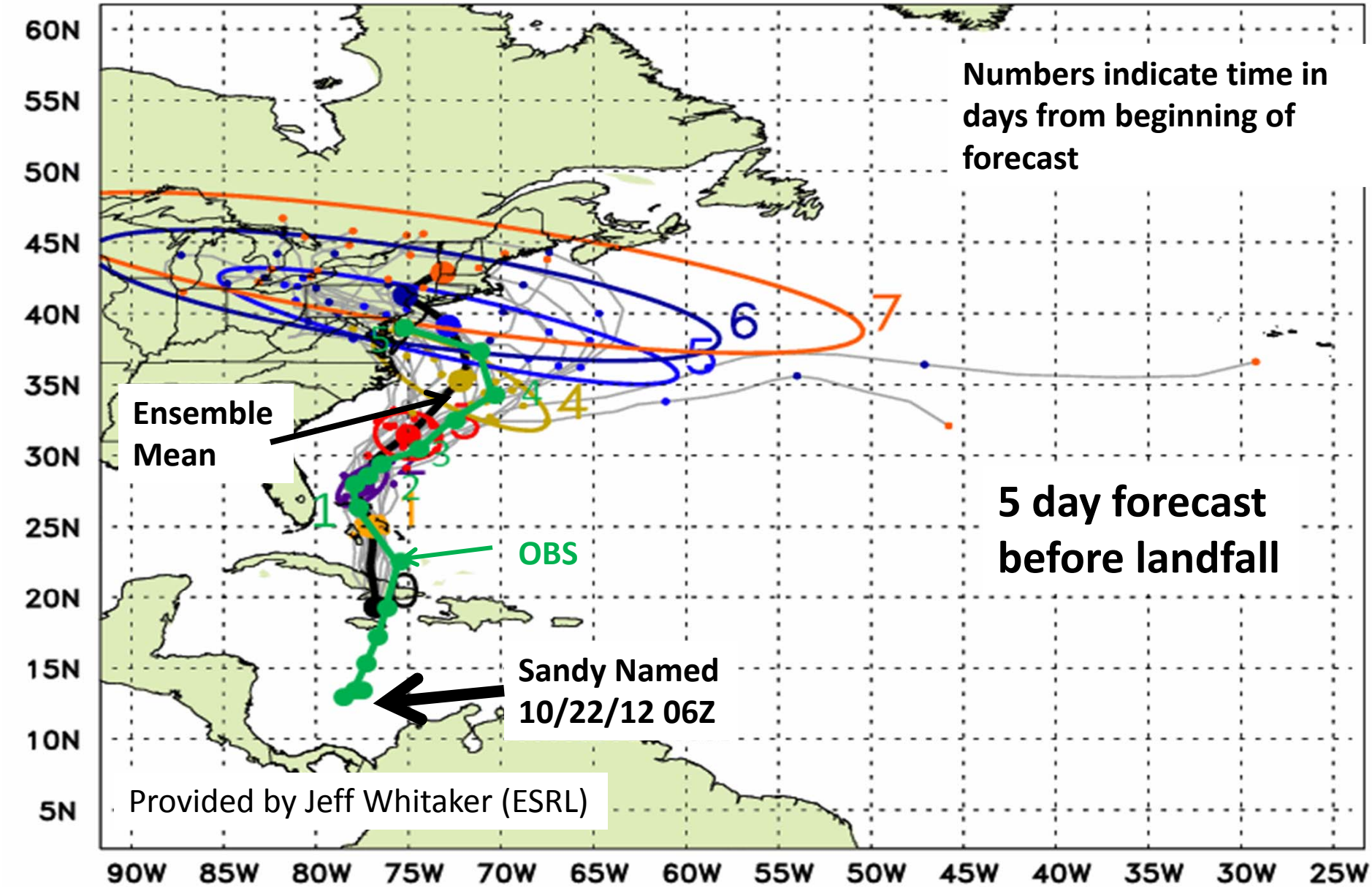
Issues/Challenges – Ongoing Experiments


Preliminary Average Track Errors
Hurricane Sandy
Forecast Error (nm)
300
250
200
150
100
50
0
OFCL
EMXI
GFSI
GHMI
HWFI
TVCA
TV15
(Number of Cases)
(28)
(26)
(24)
(22)
(18)
(14)
(10)
0
12
24
36
48
60
72
84
96
108
120
Forecast Period (h)
ECMWF outperformed all models at four days and beyond

Some Ongoing Experiments

- Higher Resolution Ensemble Forecasts
- Data Denial Experiments

Higher Resolution HFIP Global Ensemble Forecast for Hurricane Sandy from 00Z Thursday 10/25/12 (8pm EDT Wednesday 10/24/12)

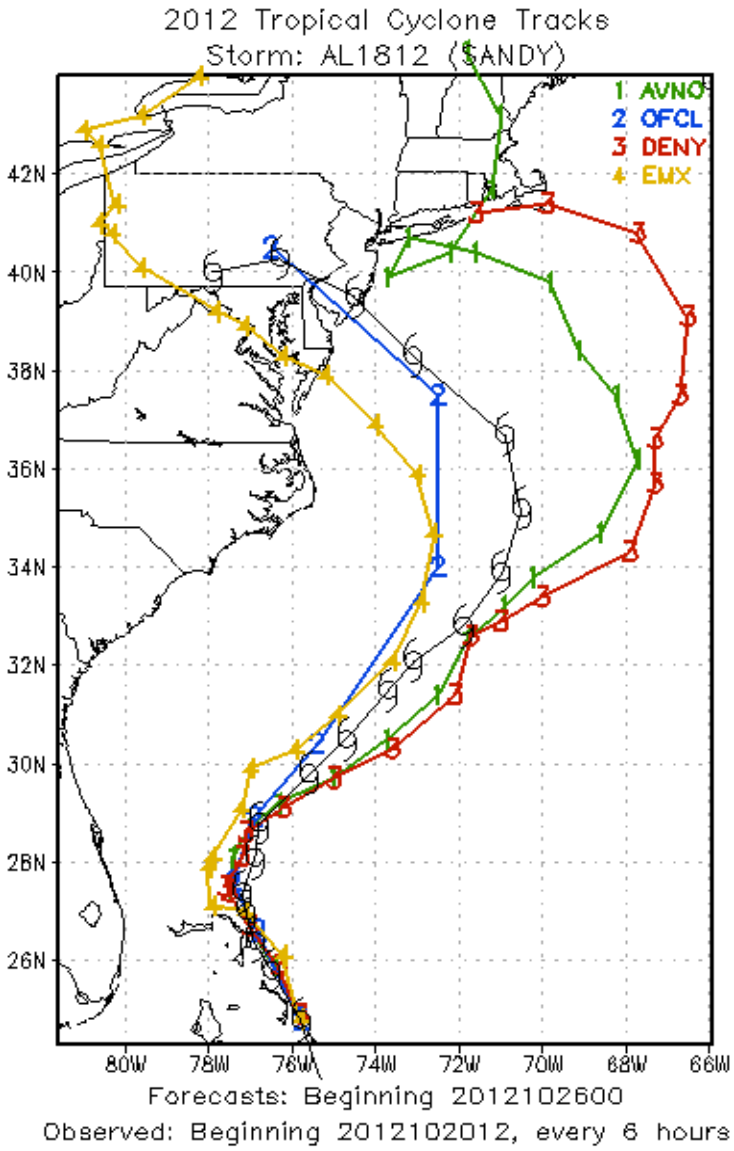


Sensitivity Experiments

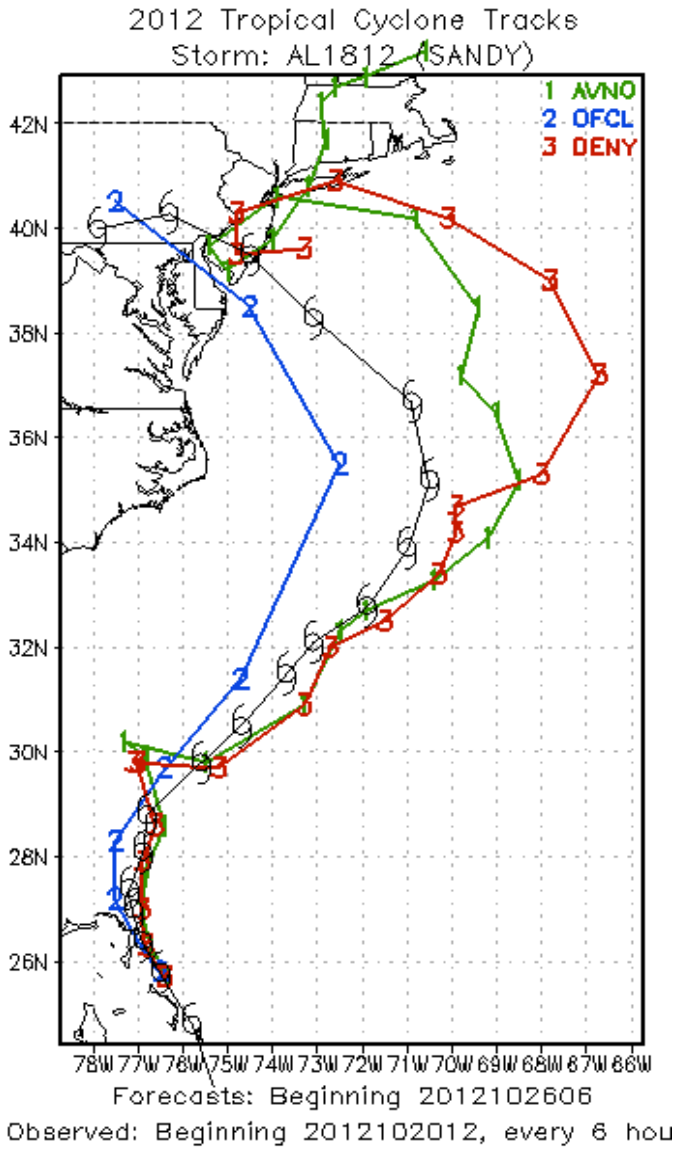
- Special raobs launched at 06 and 18Z (615 over 8 days)
- The supplemental radiosondes were assimilated in the operational GDAS/GFS 06 and 18Z cycles

- A data denial experiment with and without the special soundings was carried out using the operational configuration of the NCEP GDAS/GFS to review impact on track, speed and run-to-run consistency
  - Excluding the 06 and 18Z CONUS radiosonde data
  - Initialized using the operational GFS initial conditions at 18Z 25 Oct 2012
  - Last cycle executed was 12Z 30Oct2012
  - Fully cycled with data assimilation

2012102600 cycle

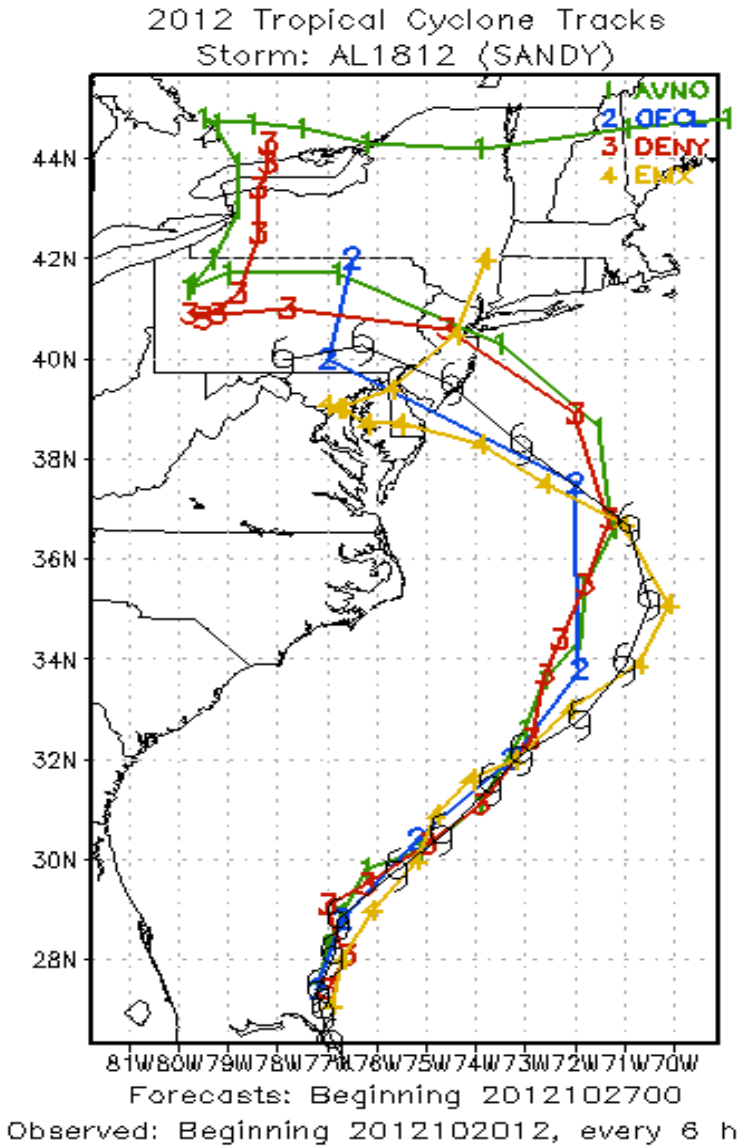


2012102606 cycle

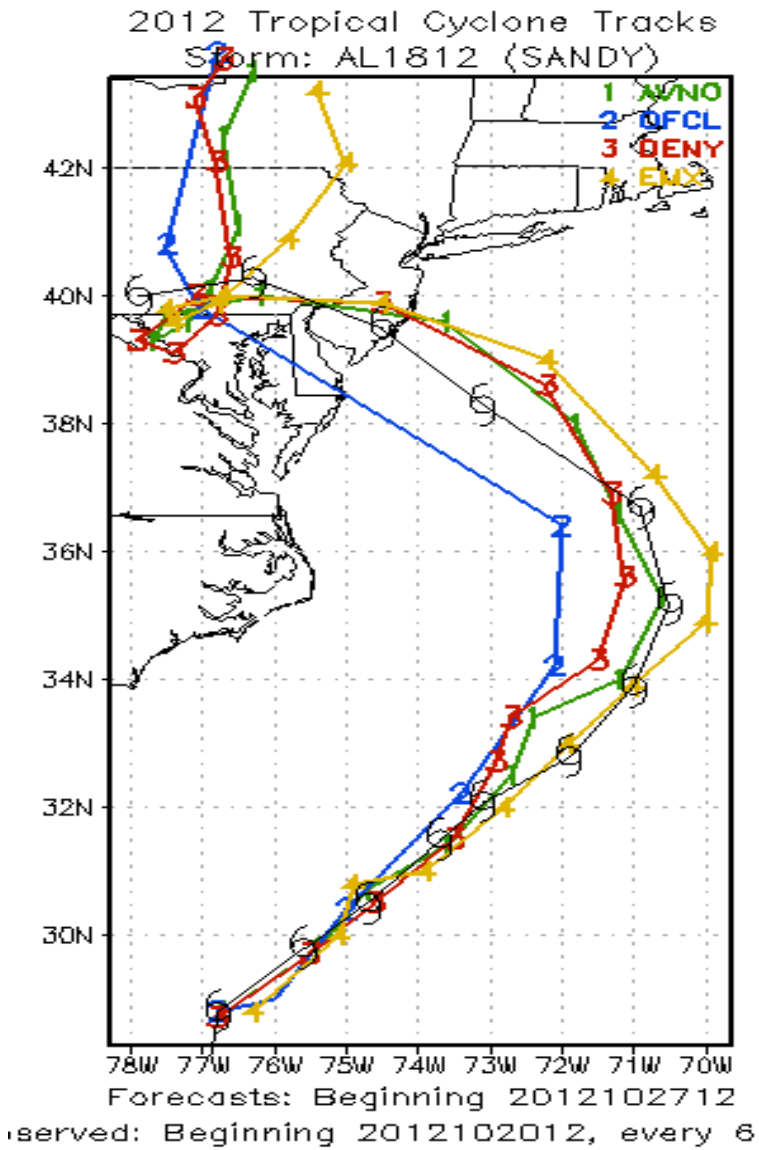


Track Forecasts

2012102700 cycle



2012102712 cycle



Track Forecasts

Surge Issues

- Surge forecast heavily dependent on track/fetch
- Model forecasts for NYC and surrounding areas were record setting but still under-forecasted
- Model calibration needed for extratropical systems affecting NYC: still ongoing

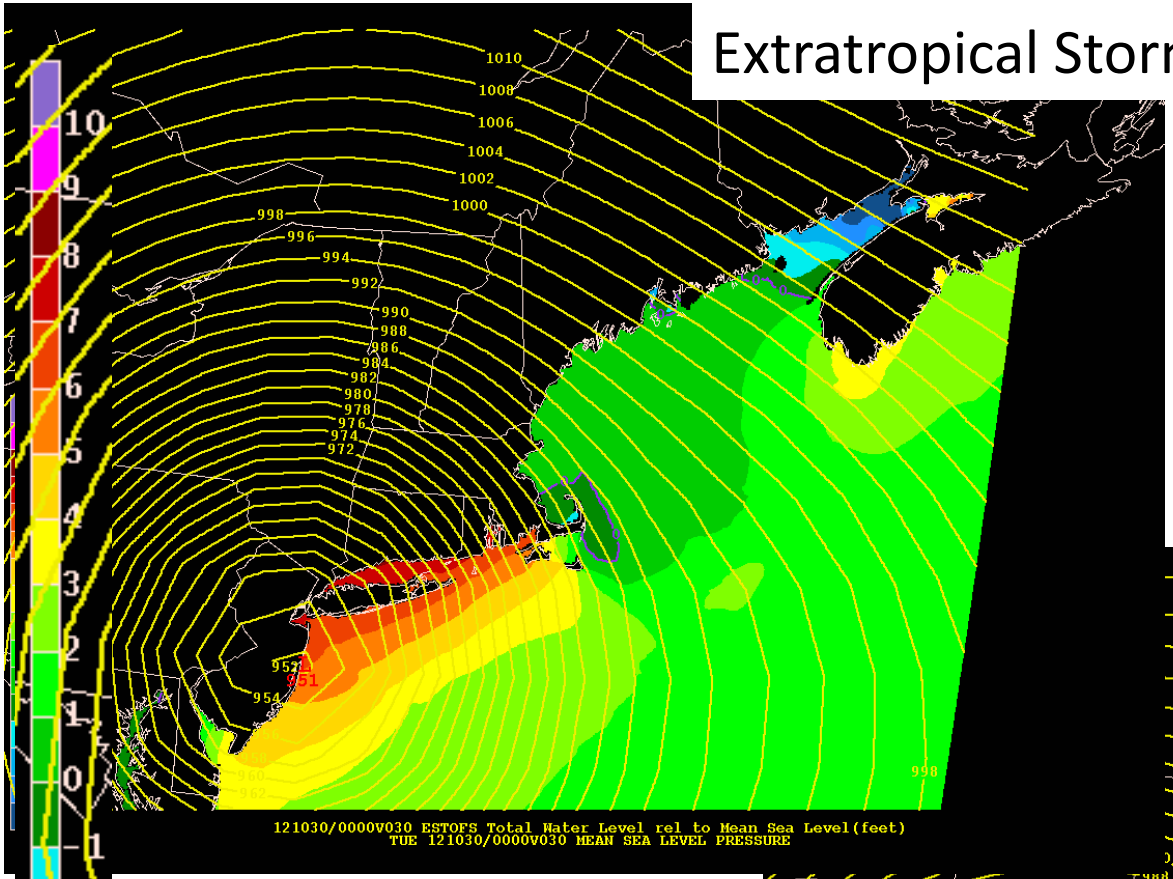
Summary

- Forecasts were generally based on ensemble model approach (from U.S., Europe and Canada). ECMWF higher resolution deterministic and ensemble models provided first alert (7+ days in advance) with remarkable accuracy
  - Be careful with overgeneralizations, GFS has very good track forecasts for 2012 season
- Beginning Thursday – Friday: NOAA/NWS communicated/coordinated all forecasts with FEMA/emergency management community; NHC provided briefings to the White House
- Media coordination started on Friday and continued through the event
- Conveyed consistent forecast message on the historic nature, unique characteristics and destructive potential for this storm
  - Westward track
  - Large size
  - Destructive surge (historic levels)
  - Tropical – extra tropical transition
  - Heavy precipitation
  - Record setting blizzard conditions
  - Evacuations initiated 60-72 hours in advance

- The forecasts saved lives!
- Primary model issue: ongoing HFIP research points to enhanced resolution for deterministic and ensemble systems

Appendix

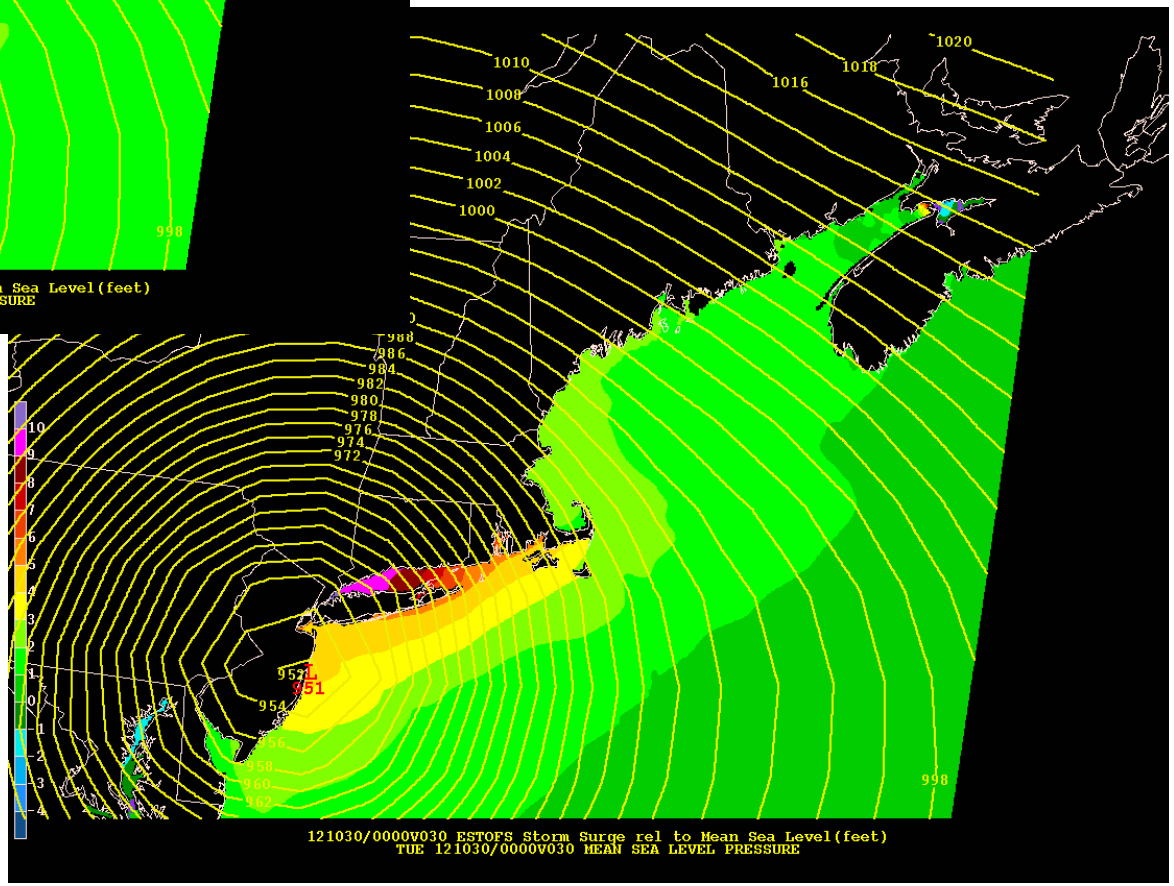
Extratropical Storm Surge



Extratropical Surge and Tide Operational Forecast System (ESTOFS)
Total Water Level (feet)
30 hour forecast
Initial time: 2PM Sunday, Oct 28

A collaboration between the NOAA/NOS/Coast Survey Development Lab and NOAA/NCEP

Extratropical Surge and Tide Operational Forecast System (ESTOFS)
Storm Surge relative to MSL(feet)
30 hour forecast
Initial time: 2PM Sunday, Oct 28



Higher Resolution HFIP Global Ensemble Forecast for Hurricane Sandy from 00Z Tuesday 10/23/12 (8pm EDT Monday 10/22/12)