EMC Change Control Board Briefing

Upgrades to the Global Wave Ensemble Forecasting System

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Presentation Outline

- Overview
  - Quad Chart/Charter Overview
    - Quad chart
    - System description
    - Primary customer base
    - System changes
    - Expected benefits
  - Pre-implementation test results
  - IT and compute resources tally
  - Issues & Risks
  - Remaining Schedule

Global Wave Ensemble System Upgrade

Project Status as of 08/08/2013

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Project Information and Highlights

Lead: Hendrik Tolman, Henrique Alves, EMC and Chris Magee, NCO

Scope: Significant upgrade that introduces:

- Spatial resolution upgrade;
- Reintroduce hindcast phase using perturbed analyses;
- Physics upgrade (new wind input and wave dissipation);
- Reconcile output of standard integral wave parameters to what is available from other wave models;

Expected Benefits:

1. Improve longer range global wave prediction.
2. Expand reliability of longer range forecasts of hurricane waves.
3. Compliance to charter for expanding combined NCEP/FNMOC wave ensembles including Environment Canada.

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Scheduling

Milestone (NCEP)	Date	Status
EMC testing/ EMC CCB	Jan 2014	Completed/Ongoing
Initial Code Delivery to NCO	TBD	
Technical Information Notice Issued	TBD	
Initial Test Complete	TBD	
CCB approve parallel data feed	TBD	
IT testing begins	TBD	
IT testing ends	TBD	
Parallel testing begun in NCO	TBD	
Real-Time Evaluation Ends	TBD	
Management Briefing	TBD	
Implementation	TBD	

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Issues/Risks

Issues: (1) Change in physics may affect downstream dependency in combined wave ensembles.

Risks: (1) Combined ensembles deteriorate statistics.

Mitigation: (1) Determine statistical treatment to attenuate unwanted results.

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Finances

Associated Costs:

Funding Sources: EMC Base: T2O 3 man-months NCO Base: 1 man-months for implementation, 1 man-month annually for maintenance

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Charter Overview

- When is upgrade scheduled: FY14Q3 (April 2014?)
- System description: NCEP Global-Scale Wave Ensemble System (NGWES)
  - 21 Members
  - Forcing: GEFS + MMAB hires ice analysis
- Primary customer base
  - OPC, NHC, FNMOC, Environment Canada
- Cycles/day: 4 daily cycle [00,06,12,18]Z
- Interdependencies in production suite:
  - Upstream: GEFS (grib2 + BiasCorr), GFS (SST), ICE Analysis (from GFS grib2)
  - Downstream: NFCENS

Charter Overview

What's being changed in the system

- A new physics package for wave growth and dissipation
  - Operational in multi_1 and GLW
- Higher resolution spatial and spectral grids
- Reintroduction of hindcast phase
  - -24h cycle: GEFS 80-member initialization cycle
- Name change: MENS to GWES
  - Global Wave Ensemble System

Charter Overview

What's being changed in the system

- Expansion of field outputs
  - Current: U10, Hs, Tp, DirP, DirM
  - Upgrade, added: partitioned Hs, Tm, DirM (3 first partitions)

- Reduction, then expansion of point outputs
  - WW3 style point output, reduced from 152 to 94 locations
    - Some points off the grid, some old inactive buoys
  - Ensemble bulletins at 383 points, most multi_1 buoy or WFO locations (ex points not covered by grid, ~120 points left out)

Charter Overview

New Product: statistics bulletin

Location : 46001 (56.31N -148.02W)
Model : NCEP Global Wave Ensemble System (GWES)
Cycle : 20140127 t00z UTC

day hour	Hs avg (m)	Hs spr (m)	Tp avg (s)	Tp spr (m)	U10avg (m/s)	U10spr (m/s)	P(Hs>) 1.00m	P(Hs>) 2.00m	P(Hs>) 3.00m	P(Hs>) 5.50m	P(Hs>) 7.00m	P(Hs>) 9.00m
27 00	2.98	0.00	7.91	0.00	13.40	0.26	1.00	1.00	1.00	0.00	0.00	0.00
27 06	3.97	0.06	8.90	0.03	16.10	0.31	1.00	1.00	1.00	0.00	0.00	0.00
27 12	4.00	0.07	9.90	0.04	11.40	0.43	1.00	1.00	1.00	0.00	0.00	0.00
27 18	3.70	0.08	10.00	0.08	12.30	0.86	1.00	1.00	1.00	0.00	0.00	0.00
28 00	4.53	0.14	9.49	0.09	17.90	0.48	1.00	1.00	1.00	0.00	0.00	0.00
28 06	6.20	0.17	10.90	0.22	19.80	0.28	1.00	1.00	1.00	1.00	0.00	0.00
28 12	7.78	0.24	13.00	0.27	19.90	0.67	1.00	1.00	1.00	1.00	1.00	0.00
28 18	7.39	0.29	14.00	0.15	13.80	1.48	1.00	1.00	1.00	1.00	0.90	0.00
29 00	6.28	0.23	13.80	0.20	11.40	1.08	1.00	1.00	1.00	1.00	0.00	0.00
29 06	5.27	0.21	13.20	0.15	11.40	1.24	1.00	1.00	1.00	0.21	0.00	0.00
29 12	4.56	0.23	12.30	0.26	11.30	1.52	1.00	1.00	1.00	0.00	0.00	0.00
29 18	4.38	0.26	11.80	0.17	10.10	1.93	1.00	1.00	1.00	0.00	0.00	0.00
30 00	3.96	0.29	11.40	0.20	8.55	2.15	1.00	1.00	1.00	0.00	0.00	0.00
30 06	3.58	0.32	11.00	0.22	8.53	1.87	1.00	1.00	1.00	0.00	0.00	0.00
30 12	3.21	0.28	10.60	0.17	7.10	2.13	1.00	1.00	1.00	0.00	0.00	0.00
30 18	2.83	0.21	10.20	0.11	5.34	1.93	1.00	1.00	1.00	0.00	0.00	0.00
31 00	2.48	0.16	9.93	0.11	4.38	1.74	1.00	1.00	1.00	0.00	0.00	0.00
31 06	2.19	0.14	9.71	0.10	4.23	2.16	1.00	1.00	0.95	0.00	0.00	0.00
31 12	1.93	0.13	9.44	0.11	4.04	2.19	1.00	1.00	0.32	0.00	0.00	0.00
31 18	1.81	0.26	9.86	2.55	4.43	2.73	1.00	1.00	0.14	0.00	0.00	0.00
01 00	2.13	0.80	11.90	3.46	4.24	1.45	1.00	1.00	0.42	0.00	0.00	0.00

Hs : Significant wave height
Tp : Peak period
U10 : Wind speed at a height of 10m above the surface
avg : Average of ensemble members
spr : Spread (standard deviation) of ensemble members
P(Hs >): Probability of Hs exceeding given threshold

NOAA/NWS/NCEP Marine Modeling and Analysis Branch, 20140127

Charter Overview

Expected benefits to end users

- Improve longer range global wave prediction.
- Compliance to charter for expanding combined NCEP/FNMOC wave ensembles including Environment Canada.
- Expand reliability of longer range forecasts of hurricane waves.

Charter Overview

Expected benefits to end users

On Wed, Aug 7, 2013 at 9:33 AM, Jose-Henrique Alves <henrique.alves@noaa.gov> wrote:
Hi Scott

We are planning a wave ensemble upgrade. The idea is to increase spatial resolution fron 1x1 to 0.5x0.5 def, increase spectral resolution and upgrade physics. There may be a chance to increase forcing from 6h GEFS to hourly. Do you see any benefits to NHC of this upgrade? Please give me an idea of current usage at NHC of the wave ensembles and if the upgrades will impact the current usage, expand etc.

Thanks
Henrique

On 08/07/2013 02:26 PM, Scott Stripling - NOAA Federal wrote:
Henrique

Good news! Yes the higher resolutions will certainly benefit us, although I am not sure how the increased temporal resolution will impact the model output. The increased spatial resolution will certainly provide more accurate output across the Atlc basin near and in the lee of both the Caribbean and Bahamas Islands, and potentially capture Hmax values in smaller scale systems. Across the Pacific, it turns out that most of our warnings for our High Seas areas actually occur with gap wind events near the coasts, where the global model resolution has been insufficient to accurately capture these events. TC's wave fields in both basins will also improve with the changes. So, a resounding YES is the answer!!

Thanks for the heads up. I will g**et back to you soon on the Sandy paper.**
Scott

Charter Overview

Heads up on IT and compute resources

- Infrastructure: code is fully compliant to EE
  - Since transition from CCS to WCOS
- No AWIPS dependency
- Will require significant increase in compute resources + disk space
  - Last upgrade was in 2008: a lot of catching up…
  - Impacts from physics, Higher spectral/spatial resolution, larger number of output points, added bulletins
  - Numbers coming in a few slides

Charter Overview

Heads up on IT and compute resources

- Initial request during kickoff was challenged by NCO and EMC
- Optimization team formed: Farid Parpia, Hendrik Tolman and Henrique Alves
- Based on initial input by Farid on code bottlenecks
  - Runtime tweaking allowed 20% reduction of run time (40min ➔ 30 min)
  - WAVEWATCH III has been using only ½ node due to memory restrictions in WCOSS relative to the CCS
  - Inclusion of OMP directives for using whole node
    - Directives on source terms ➔ 25% reduction of run time
    - Directives on propagation ➔ 5% reduction of run time
- Final optimization: reduction of node usage:
  - Start: 210 for 40 min
  - End: 147 for 34 min

Pre-Op Test Results

Two major changes impacting quality of output

1. Science/Code Changes
   - New physics package
   - Tolman & Chalikov (1996) -> Ardhuin et al (2010)
   - Goodies: previous CCB's for multi_1 and GLW...

2. Spatial resolution increase
   - From 1° x 1° to 0.5^ox0.5^o
   - New grid, from 79.5^oS to 79.5^oN (now at 80^oS to 80^oN)
     - 79.5 is the magic number for CFL t-step = 450 (superstition?)

Pre-Op Test Results: Bulk

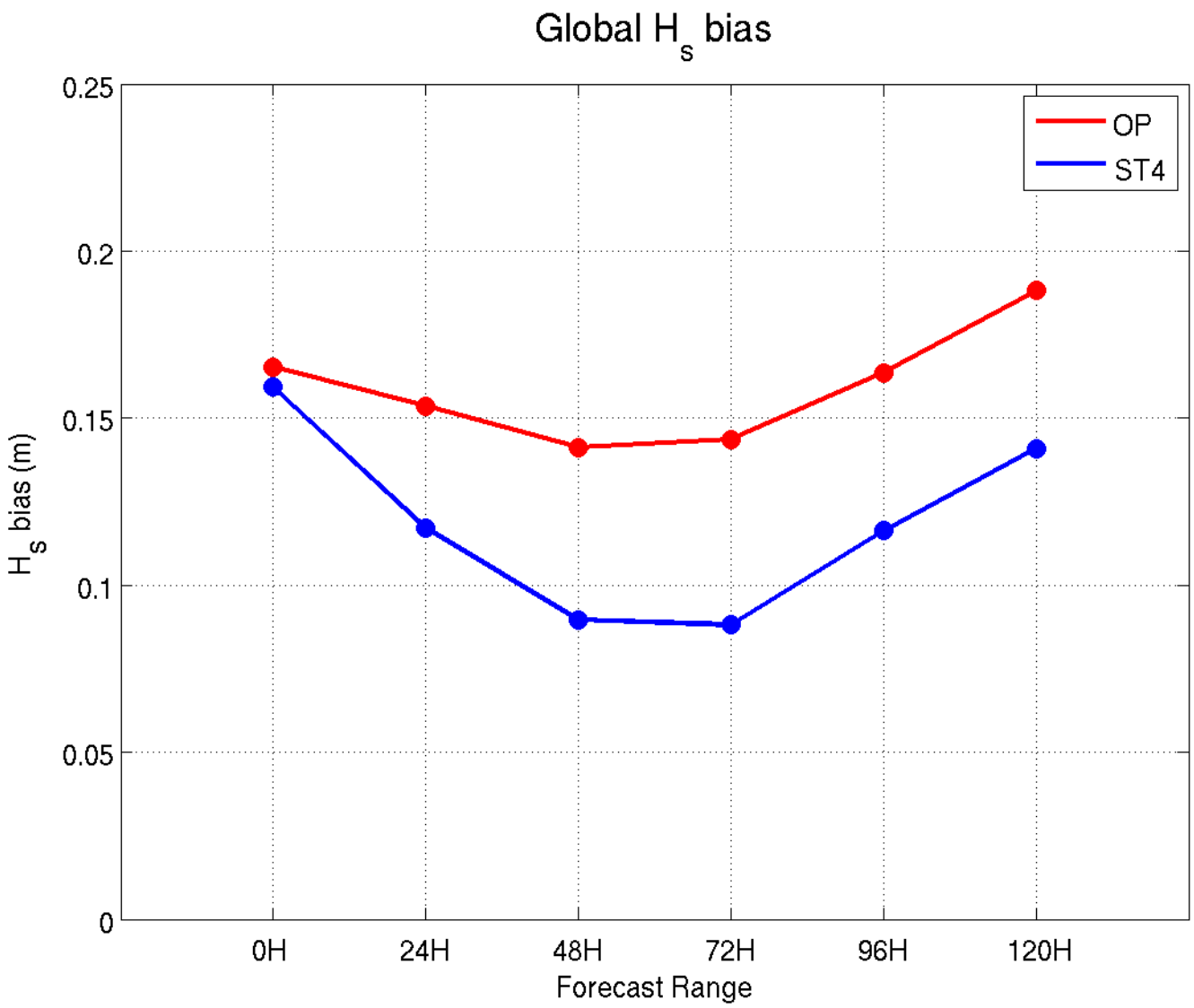
- Altimeter Hs Observations from J-1, J-2, EnvSat, Cryosat from GlobWave (Ifremer)

- 6 months global forecast (Mar-Aug 2012)
  - Physics upgrade validation
  - Operational ST2 vs Upgrade ST4 physics

- 2 ½ months global forecast (Mar-mid-May 2012)
  - Validation of impact from higher resolution grid

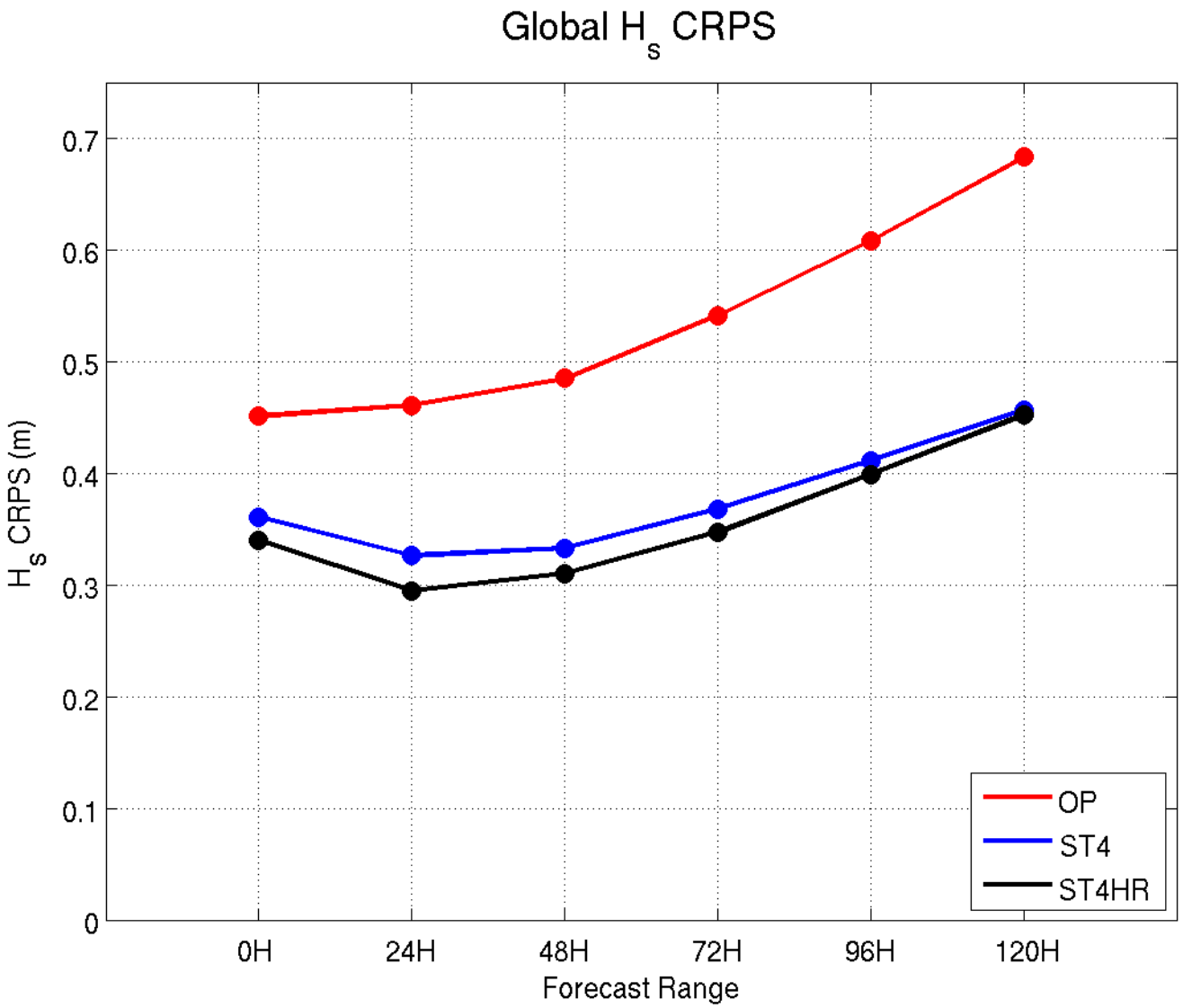
Pre-Op Test Results: Bulk

Physics upgrade validation



Pre-Op Test Results: Bulk

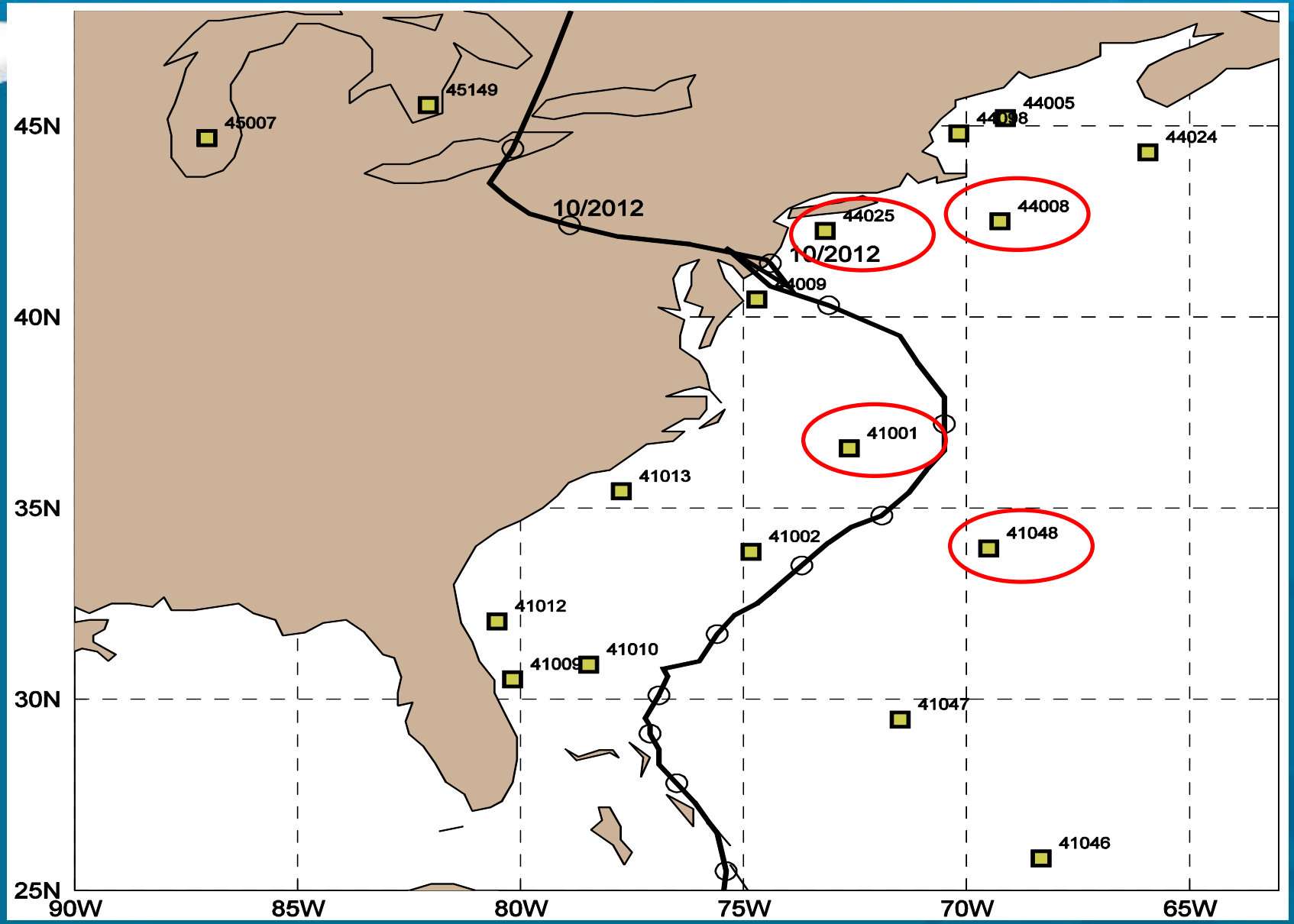
High resolution grid upgrade validation



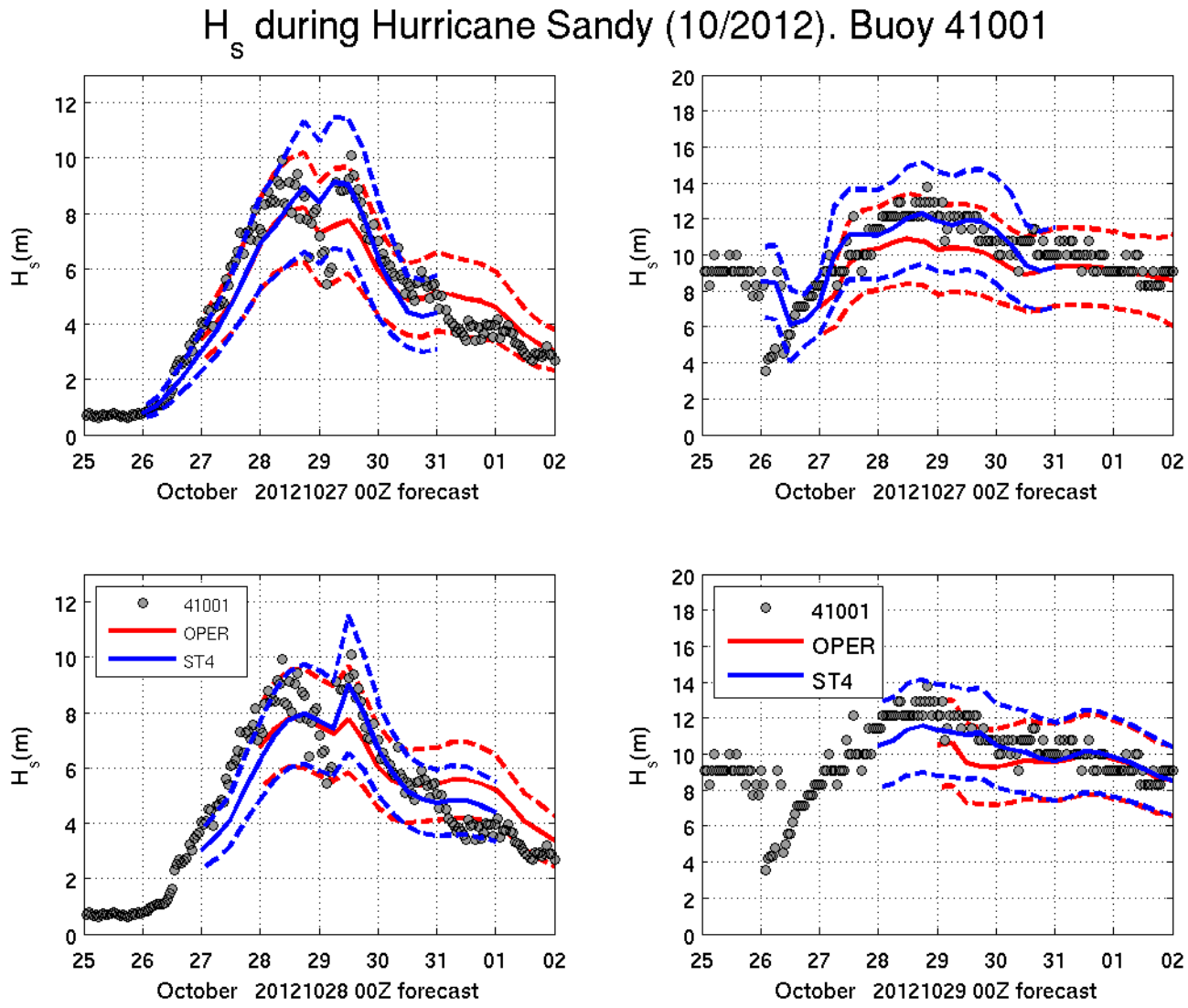
Pre-Op Test Results: Sandy

- Hurricane Sandy: end of Oct 2012
- 23 buoys recorded Hs > 6m
- Selected 4 buoys with Hs > 9m
  - Closest to track
- Validation in 3 steps
  - Physics, keeping resolution equal to Op (1x1)
  - Resolution, keeping source-terms equal to Upgrade
  - Physics and resolution ➔ Operational vs. Upgrade

Pre-Op Test Results: Sandy



Pre-Op Test Results: Sandy



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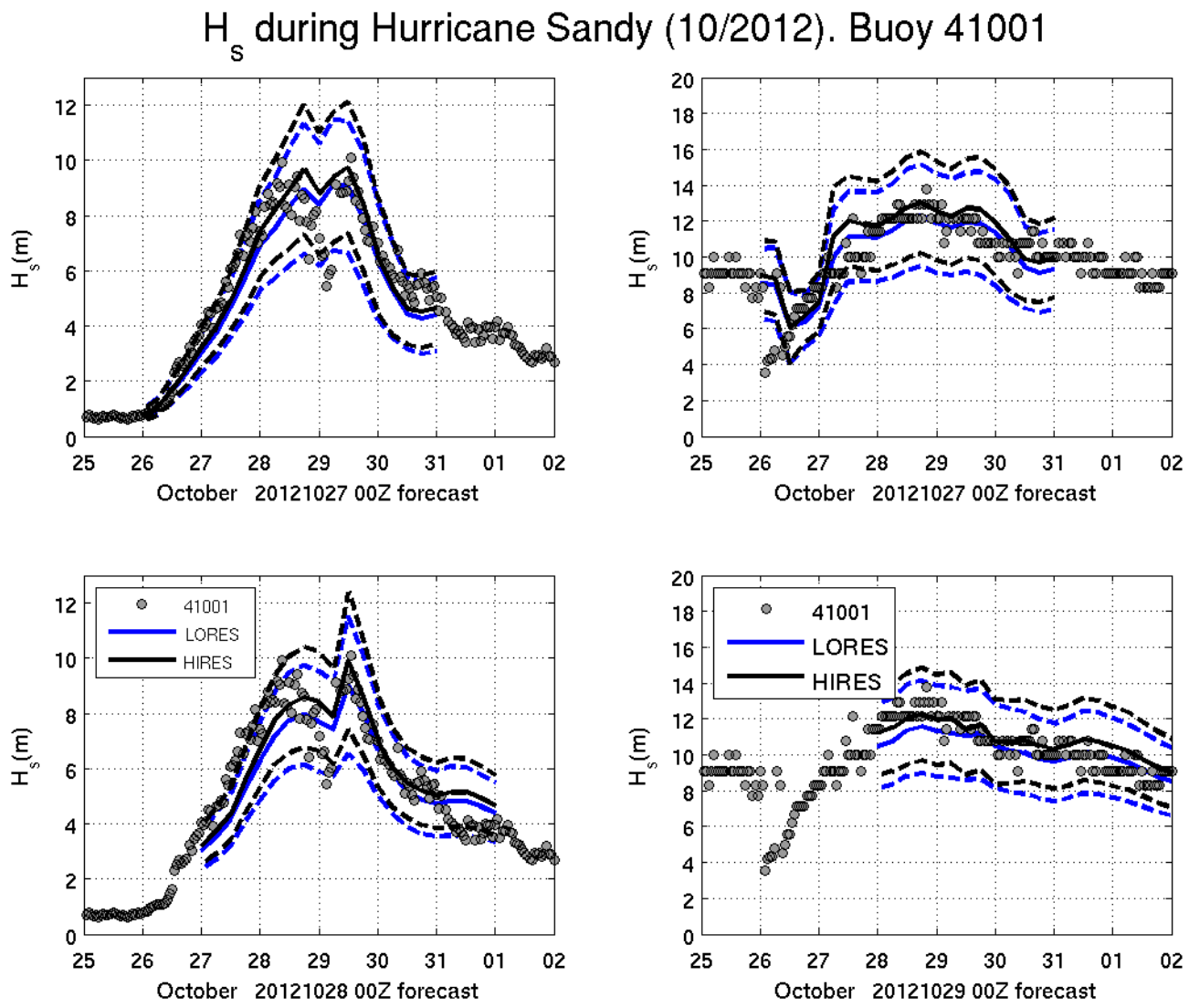

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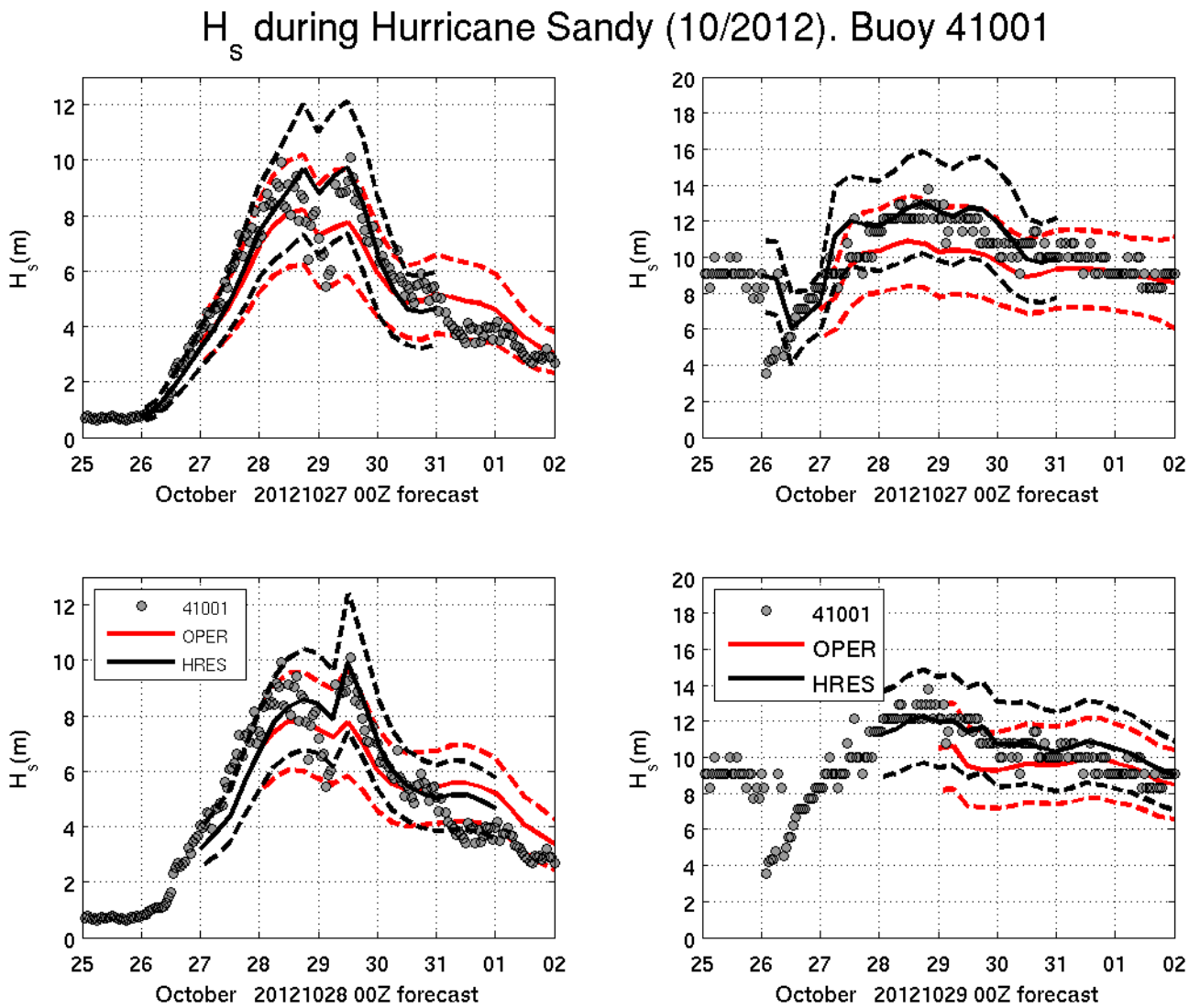

And… The Numbers

Issues impacting computer resource requirements

- Higher spatial resolution
  - 1x1 to 0.5x0.5 => 2x in X, 2x in Y = 4x
  - Three-tier grid
  - Single grid
  - Extend to 86N (EC) or to 80N (from effective 77.5N)?
- Higher spectral resolution:
  - 24 x 25 (600) to 50 x 36 (1800) = 3x
    - Delta f 10% to 7%
  - 24 x 25 (600) to 44 x 36 (1800) = 2.6x
    - Delta f 10% to 8%
- Potential demand increase of 10x to 12x
- Objective was to keep simulations under one hour

And… The Numbers

VER	STEP	RUN TYPE	# JOBS	CPU	SPAN	NODE	TOT NODE	RUN TIME
V2.1.3	PREP	OPERAT	21	2	2	SHRD	(2)	30 sec
	FORECAST		21	16	16	1	21	11 min
	POST		21	16	16	1	21	2 ½ min
	STAT		1	16	16	1	1	2 min
V3.0.0	PREP	UPGRADE	1	21	16	2	2	2 - 5 min
	FORECAST	3-GRID NF=50	21	80	8	10	210	1h 30 min
	FORECAST	1-GRID NF=50	21	80	8	10	210	1h
	FORECAST	1-GRID NF=45	21	80	8	10	210	40 min
	FORECAST	1-GRID, NF=45 MPI+OMP HYB	21	56	8	7	147	34 min
	POST	UPGRADE	21	32	16	2	42	5 min
	STAT	UPGRADE	1	96	16	6	6	10 min

And… The Numbers

Issues impacting disk space requirements

- Higher spatial resolution
- Higher spectral resolution
- Output rate changed from 6h to 3h
- Added new parameters to fields output files
- Added new files to represent point output (stats)
  - Bulletins matching output locations from multi_1
  - Time-series (station files) as above (replacing current station files)

And… The Numbers

STEP	FILE	OP (Mb)	N FILES	TOTAL (Mb)	NEW (Mb)	N FILES	TOTAL (Mb)
PREP	Moddef_ice	240	1	240	269	1	269
	Moddef_pnt	0.06	1	0.06	34	1	34
	Moddef_wnd	2.1	1	2.1	37	1	37
	Moddef_wave	2	1	2	43	1	43
	Times	0.01	21	0.21	0.01	21	0.21
	Wind	30	21	630	34	21	714
	Ice	35	1	35	36	1	36
	sst	0.25	1	0.25	0.25	1	0.25
FORECAST	Outgrd	640	21	13440	1100	21	23100
	Outpnt	255	21	5355	151	21	3171
	Restart	105	21	2205	992	21	20832
	Log	0.02	21	0.42	0.04	21	0.84
POST	Bulltar	4.5	21	94.5	3	21	63
	Spectar	240	21	5040	250	21	5250
	Grib2	30	21	630	136	21	2856
STATS	Mean grib1	7	1	7		1	0
	mean grib2	5	1	5	60	1	60
	Spread grib1	7	1	7		1	0
	Spread grib2	5	1	5	60	1	60
	Probab grib1	38	1	38		1	0
	Probab grib2	17	1	17	200	1	200
	Bulltar				12	1	12
	Timeseriestar				6	1	6
TOTAL/CYCLE				27753.54			56744.3

IT Requirements

Overall Summary

- Product generation requirements/changes/dataflow
  - Physics change
  - Changes in spectral resolution and number of points
  - Changes in spatial resolution, number of output parameters and output step of binary and grib2 gridded data files
  - Elimination of grib1 data
  - Inclusion of new products (stats bulletins and time series)
- Downstream dependencies
  - No AWIPS delivery concerns
  - Combined NCEP/FNMOC Wave Ensemble Product
    - Initially generate old resolution files, upgrade when FNMOC ready
- TIN in preparation.

Outlook

Remaining Schedule

- Initial Code Delivery to NCO: Feb 2014
- TIN Issued: Early March
- Assign Evaluators: Early March
- Initial Test Complete: Early March
- CCB approve parallel data feed:
- IT testing begins:
- IT testing ends
- Parallel testing begun in NCO
- Real-Time Evaluation Ends
- Management Briefing
- Implementation: Early FY14Q3?