Nearshore Wave Prediction System (Pre-) Kick-off Briefing

André van der Westhuysen, Roberto Padilla, Hendrik Tolman (NCEP)

Nicole Kurkowski (OST); John Kuhn (OCWWS);

Pablo Santos, Alex Gibbs, Joe Maloney (WFO-MFL), Doug Gaer, Jack Settelmaier (SRH); Ray Ball (WFO-MOB); Troy Nicolini, Sten Tjaden, Brian Garcia (WFO-EKA); Donnie King, Scott Kennedy (WFO-MHX), Carlos Anselmi (WFO-SJU), Eric Lau (PRH), Carl Dierking (WFO-JUN), Jim Nelson (WFO-ARH)

Jeffrey Hansson (USACE/CHL), Eve-Marie Devaliere (NESDIS/STAR), Joe Long and Hilary Stockdon (USGS)

Internal presentation to NCO, Aug 21, 2014

US Army Corps of Engineers®

USGS science for a changing world

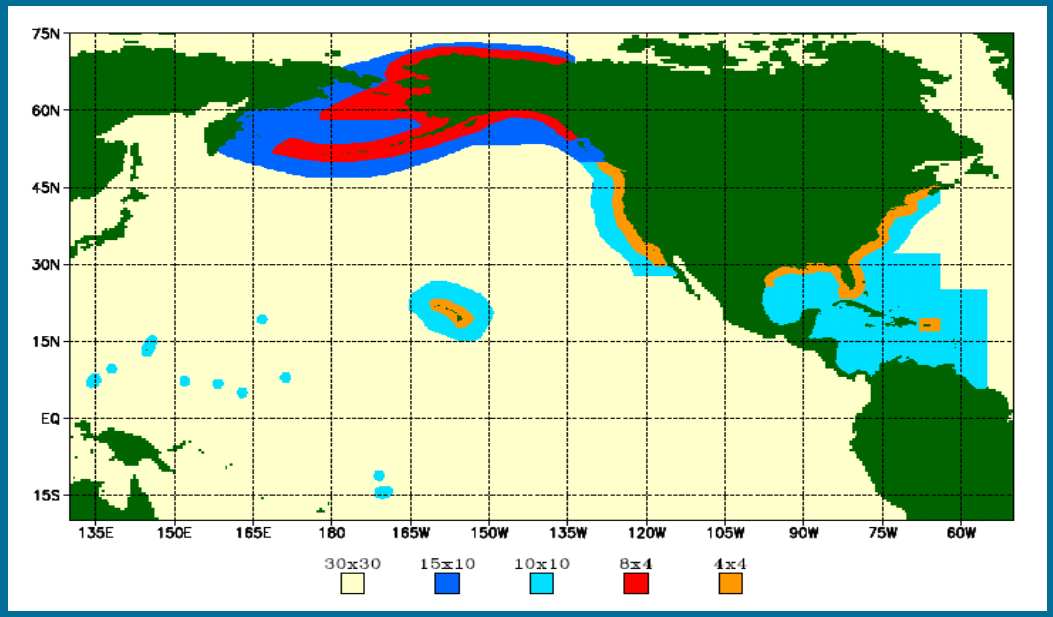
Outline

1. Motivation for implementation
2. Overview of CONOPS
3. High-level system architecture
4. Charter and Implementation planning
5. Timeline

- App A: Detailed system description
- App B: Future additions (Phase 2 implementation)

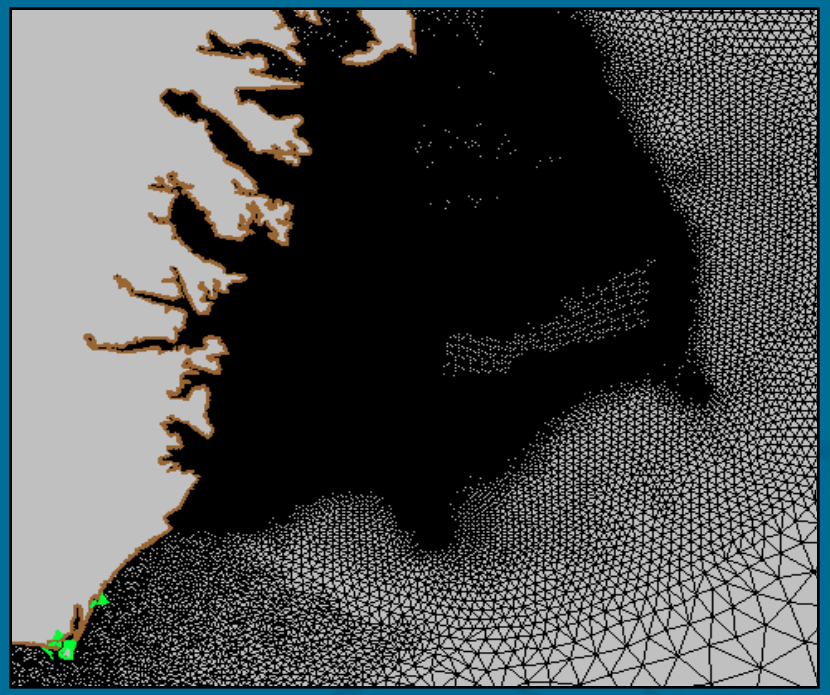
Motivation for implementation

Current WW3 global grid mosaic



Max. coastal resolution = 4 arc min (7.5 km)

Desired nearshore application

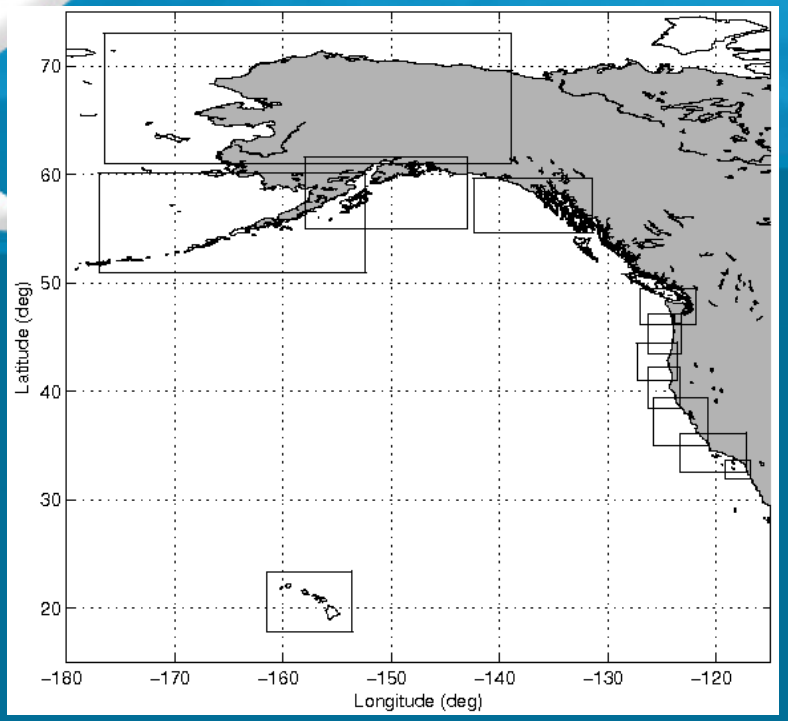


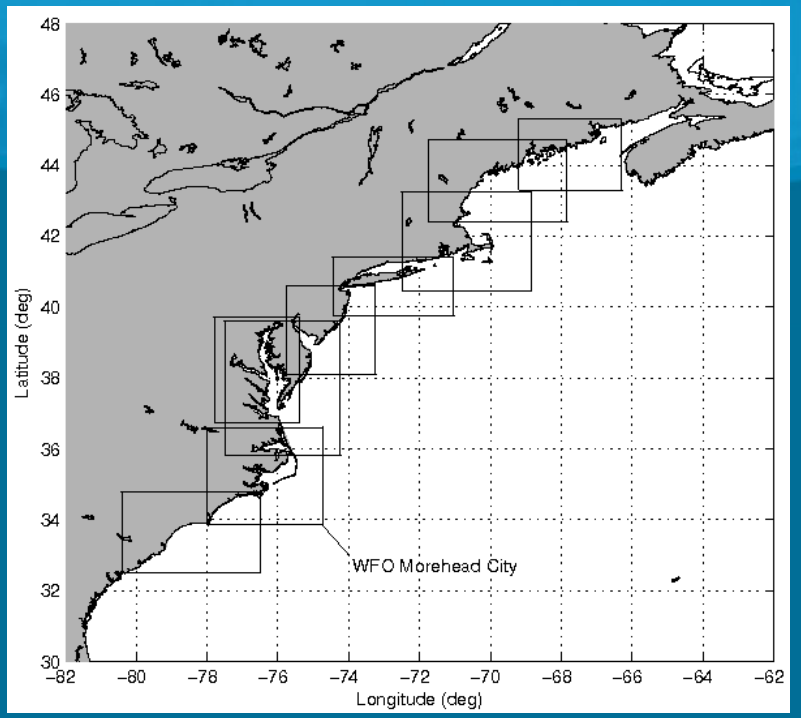
Required nearshore resolution < 500 m

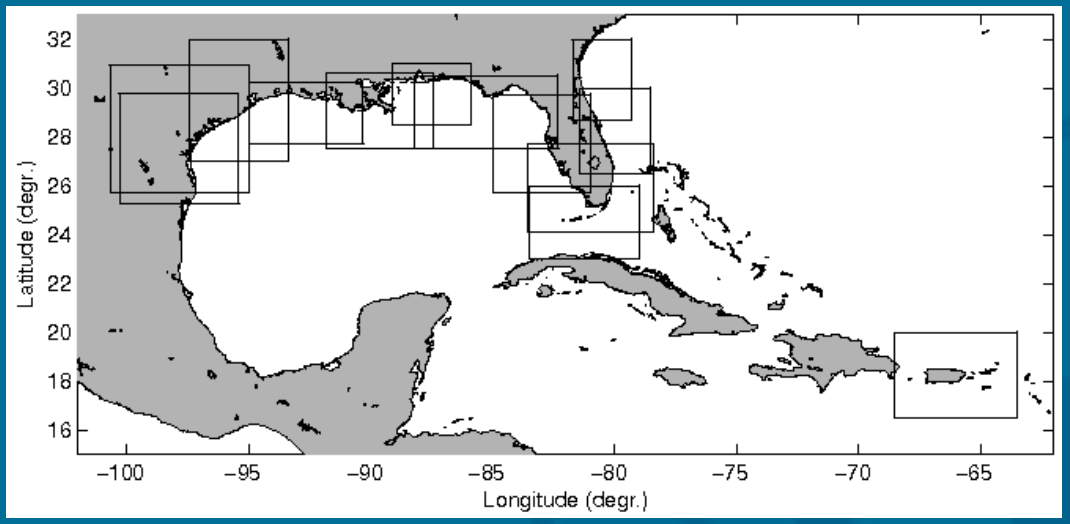
The Nearshore Wave Prediction System (NWPS)

- Run routinely/on-demand, using SWAN or nearshore WW3
- Driven by forecaster-developed winds from GFE (AWIPS2), and other NCEP forcings (e.g. WW3, RTOFS/ESTOFS).
- Intended to include in the AWIPS2 baseline for sustainability.
- Address region-specific physical processes in the nearshore (wave-current interaction, ice interaction, vegetation, etc.).
- Include wave partitioning (separate wave field into component systems).
- Future two-way coupling to coastal circulation model (ADCIRC).

NWPS grids for coastal WFOs





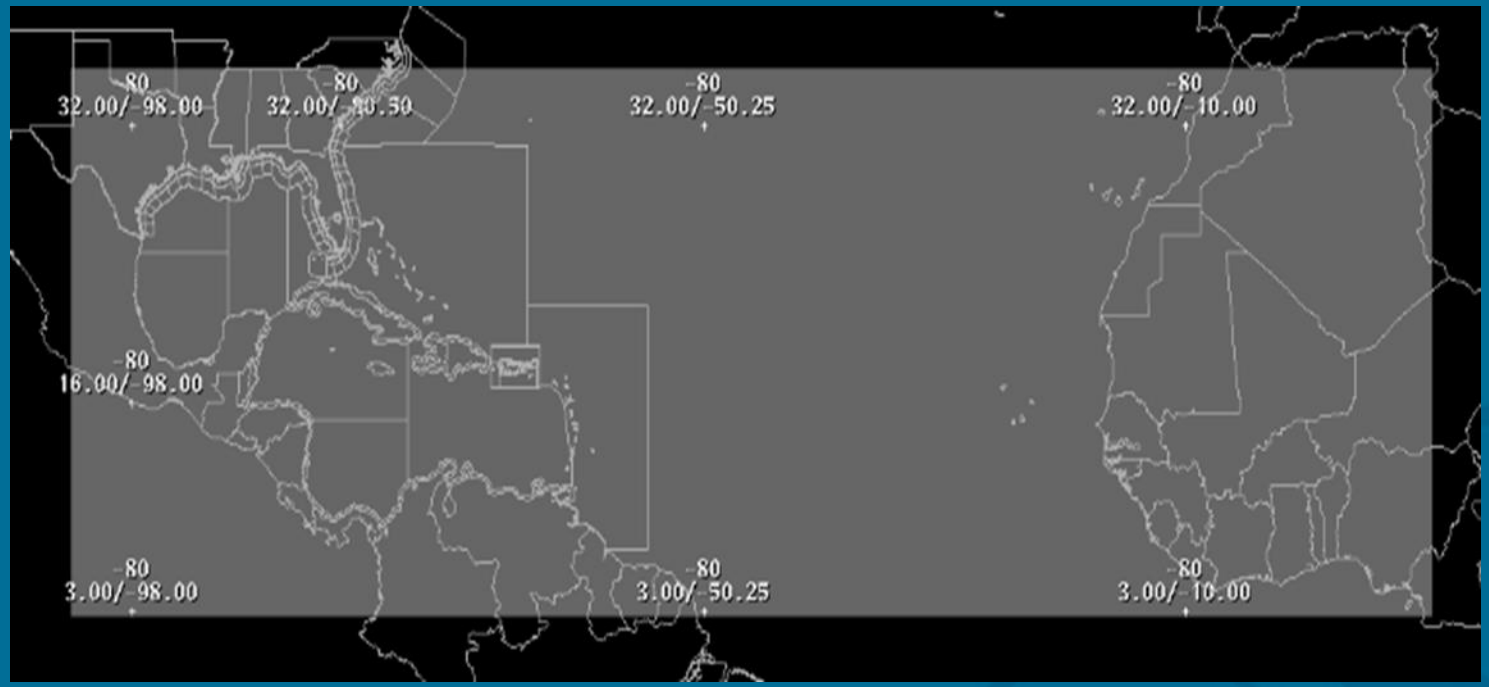


NHC/TAFB's local NWPS domain

Run operationally on a 24-core cluster at NHC. Future candidate for WCOSS (along with an OPC domain)

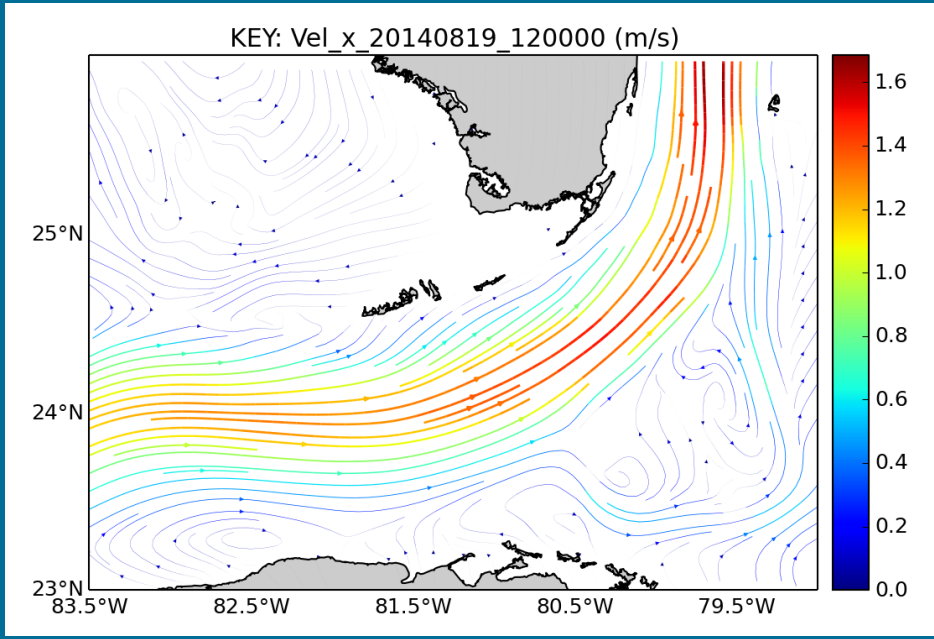
Model Domain:

SW LAT= 3.00
SWLON= -98.00
NELAT= 32.00
NELON= -10.00

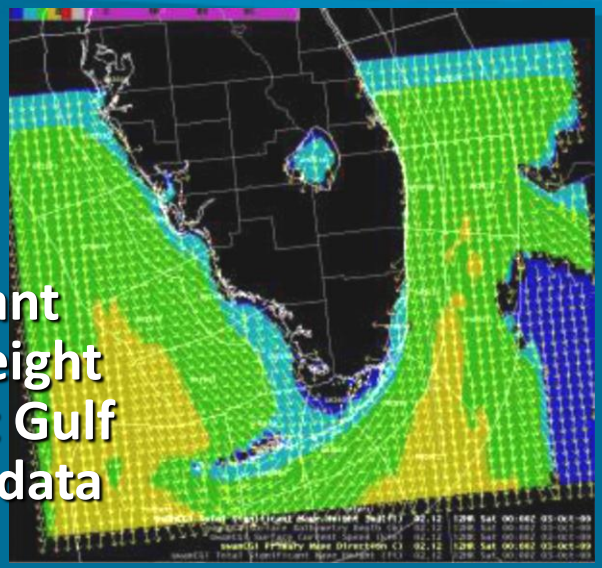


Forcings: Surface currents

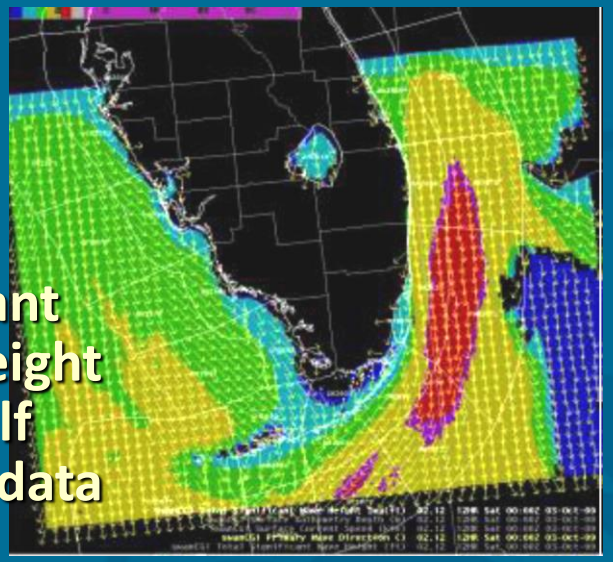
RTOFS Global output of Gulf Stream



Significant wave height without Gulf Stream data



Significant wave height with Gulf Stream data

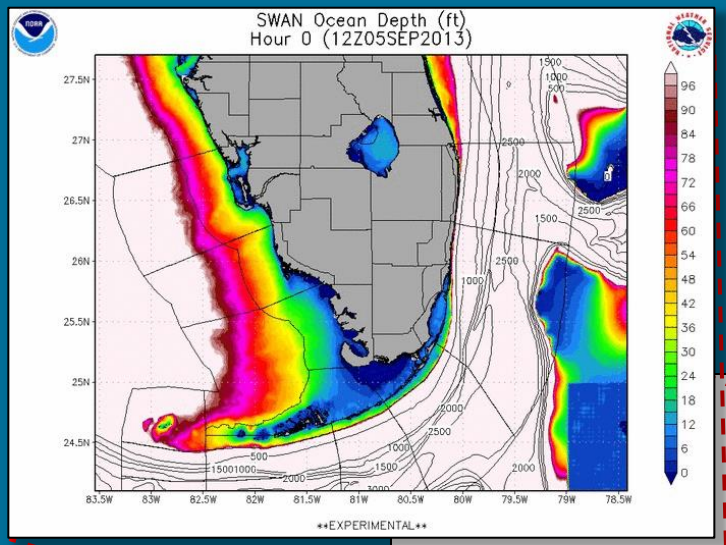


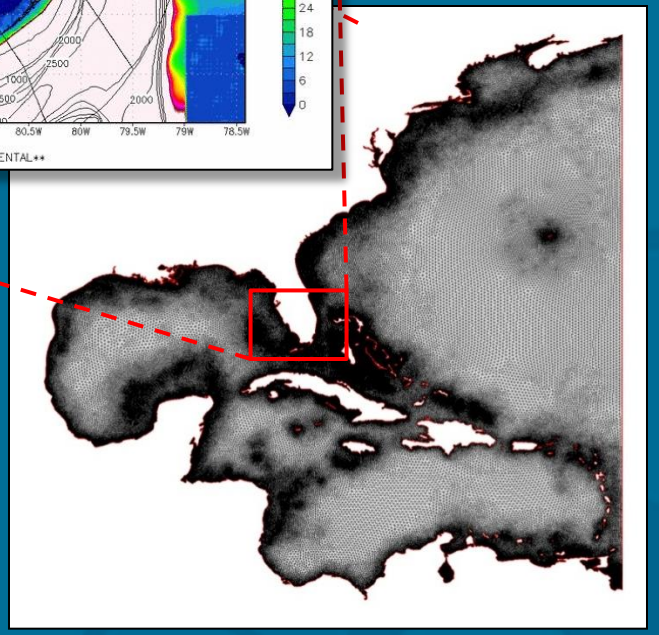
(Settelmaier et al. 2010)

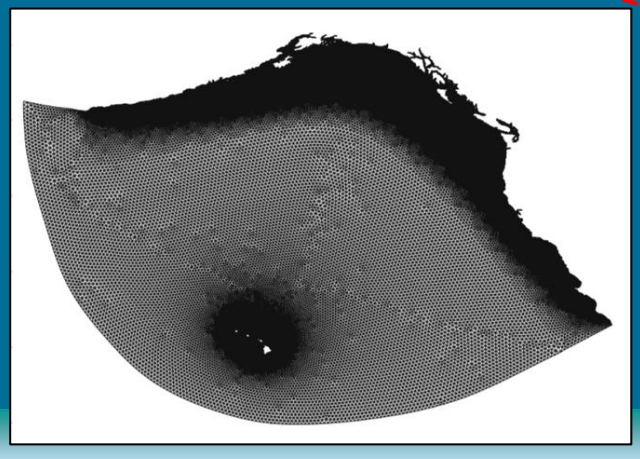
Forcings: Water levels, Extra-tropical
Surge & tides from ESTOFS Atlantic and Pacific

Based on East Coast 2001 tidal database grid (EC2001)

- Coastal resolution ≈ 3-5 km
- Barotropic ADCIRC model
  - *Tidal boundary forcing at 60º W*
  - *Tidal forcing from TPXO 6.2 global tide model*
  - *Meteorological forcing from GFS (wind shear, inverse barometric effect)*
- **ESTOFS Pacific to be added**

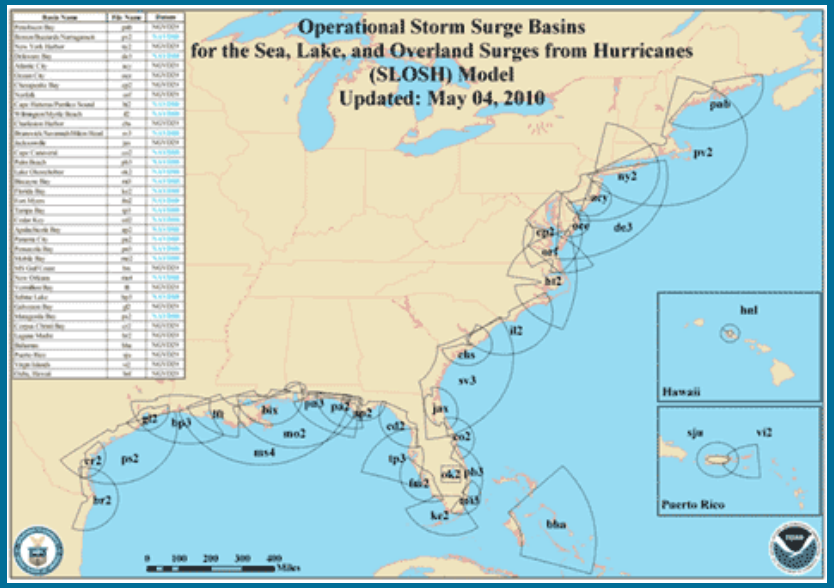


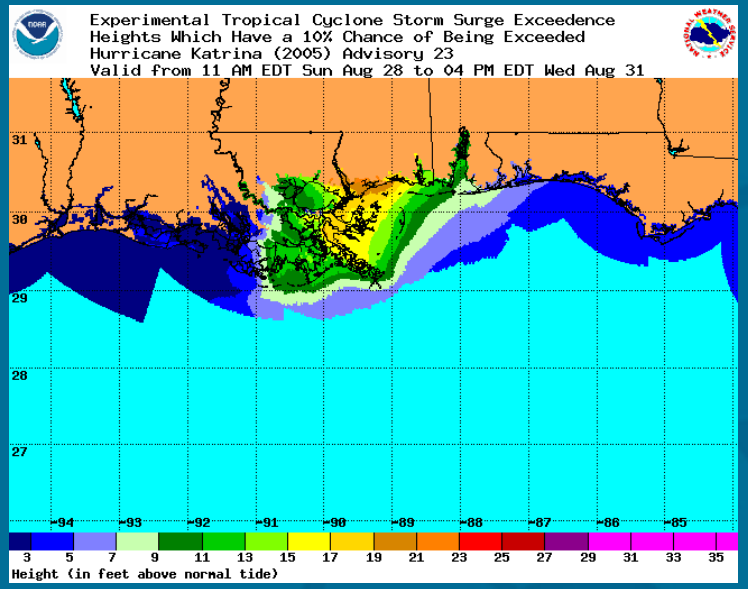




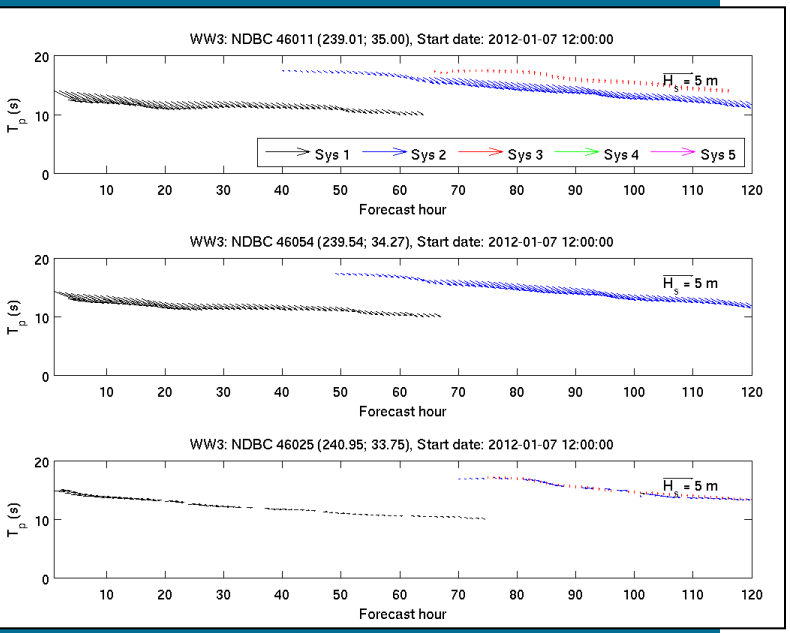
Forcings: Water levels, Tropical
Surge level and tide from P-Surge 2.0

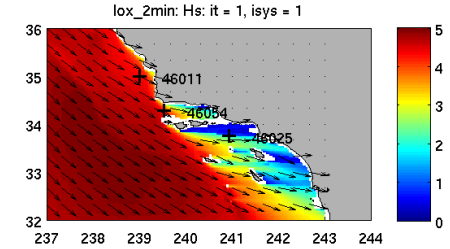
- During tropical events, uncertainty in the forcing necessitates a probabilistic approach
- Probabilistic surge computation can be incorporated in a deterministic NWPS run by using P-Surge results for a pre-defined exceedance (10-50%)
- To resolve tides, time step should ideally be 1 h or less.

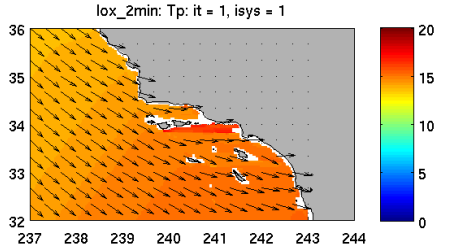


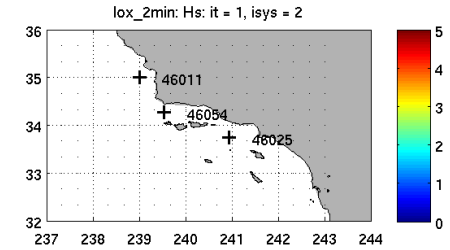


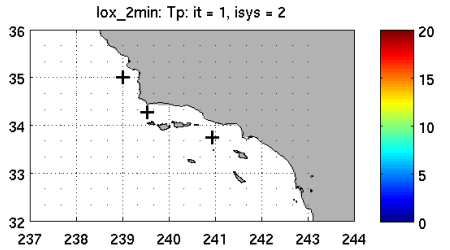
Post-processing: Wave system tracking

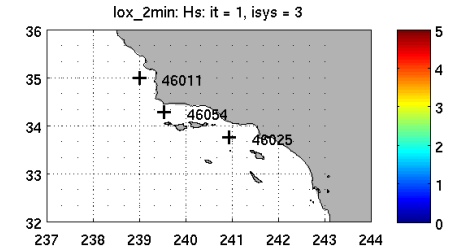


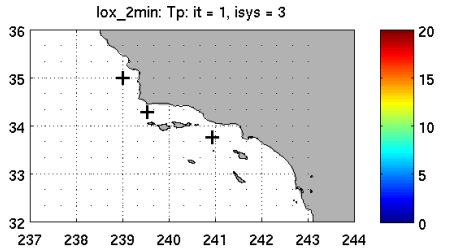


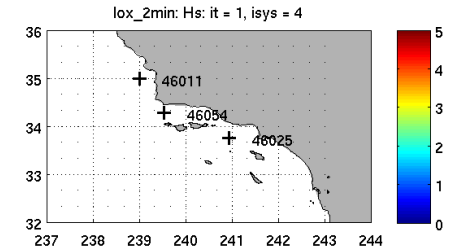


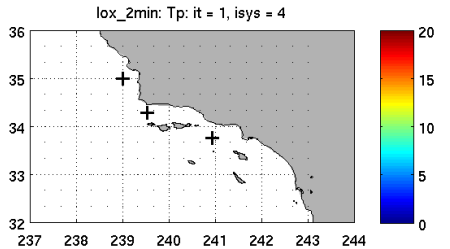


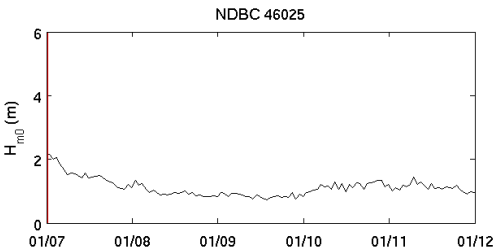


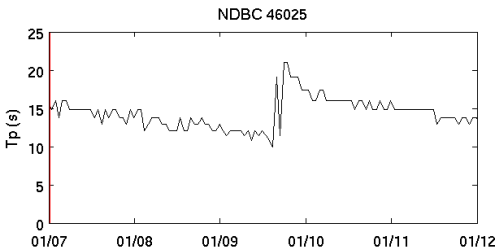


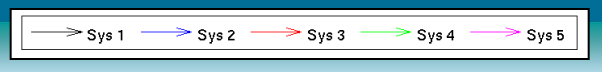




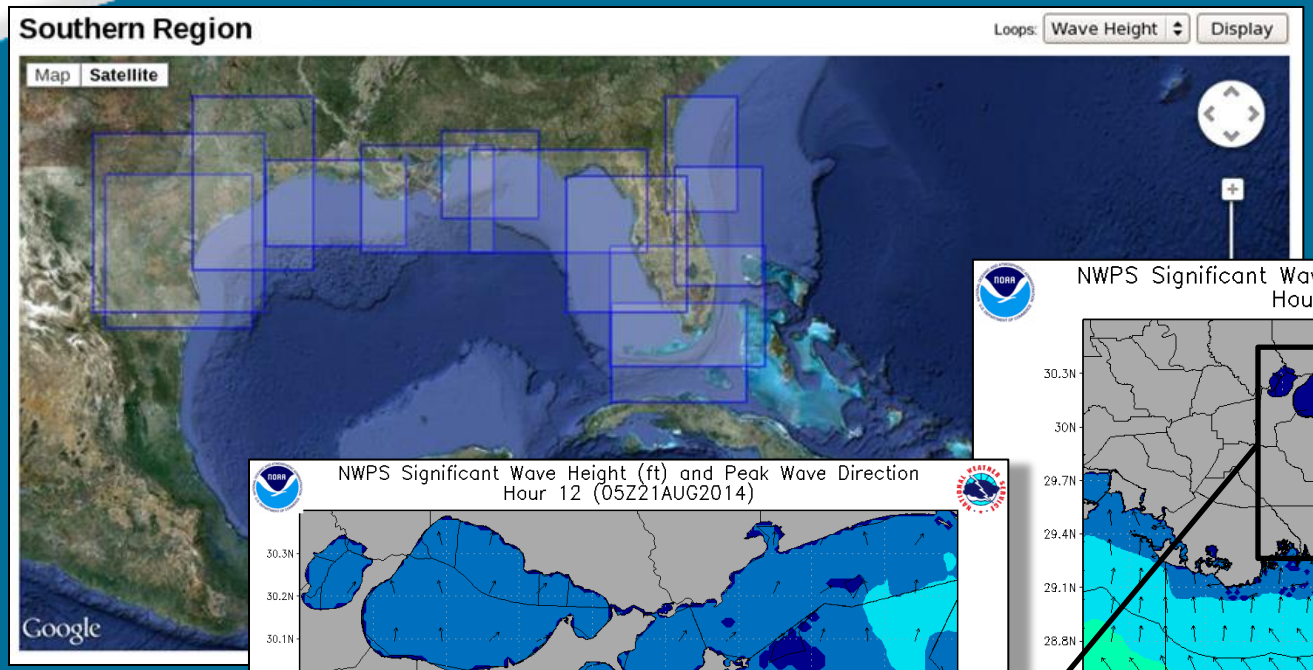




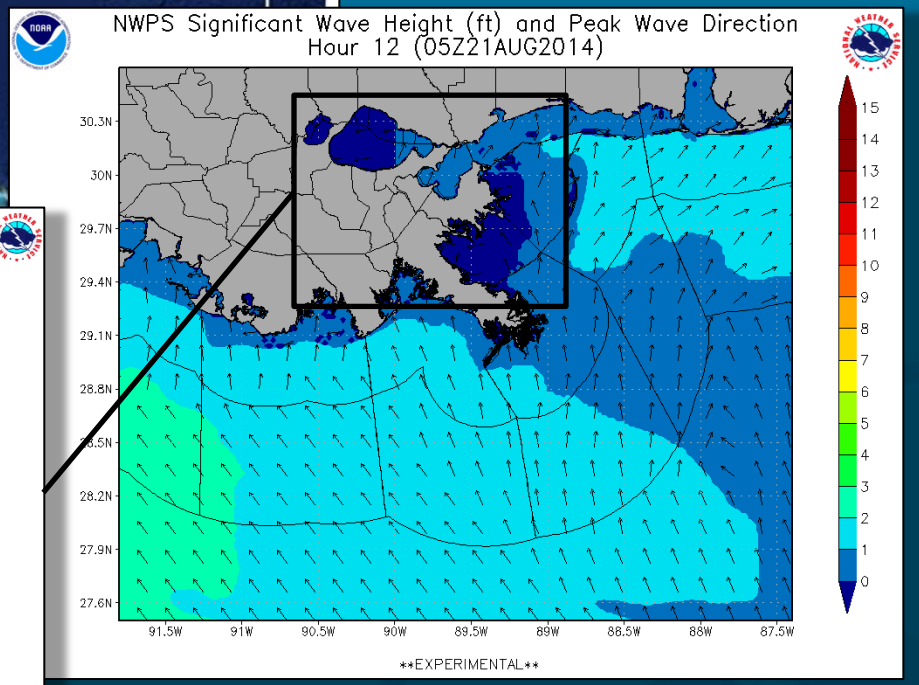


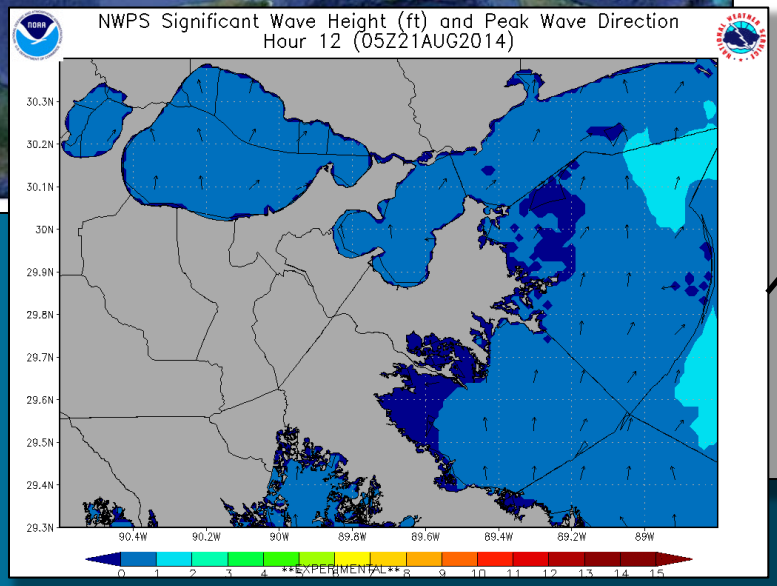


Example output for WFO New Orleans



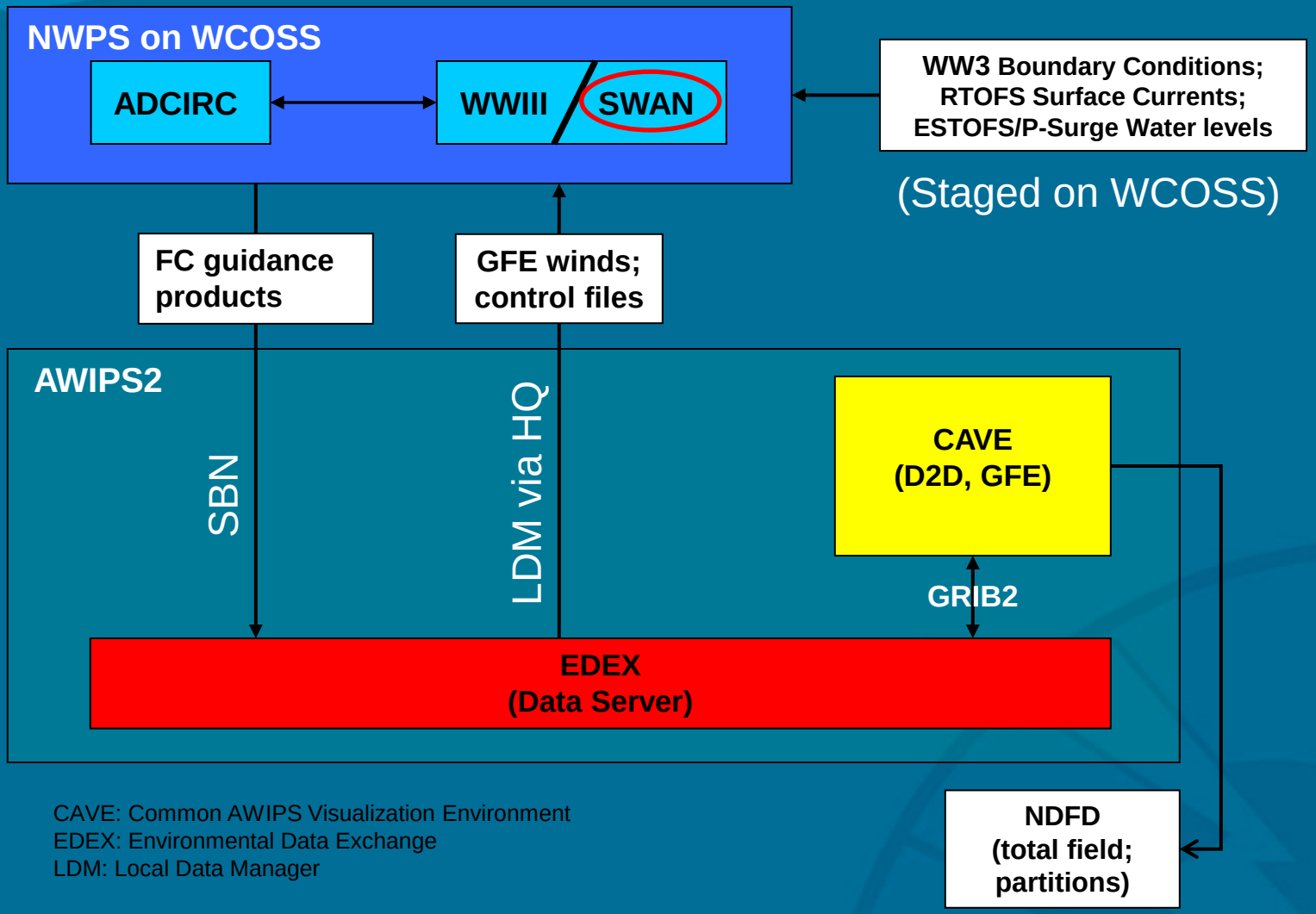
WFO LIX, CG1





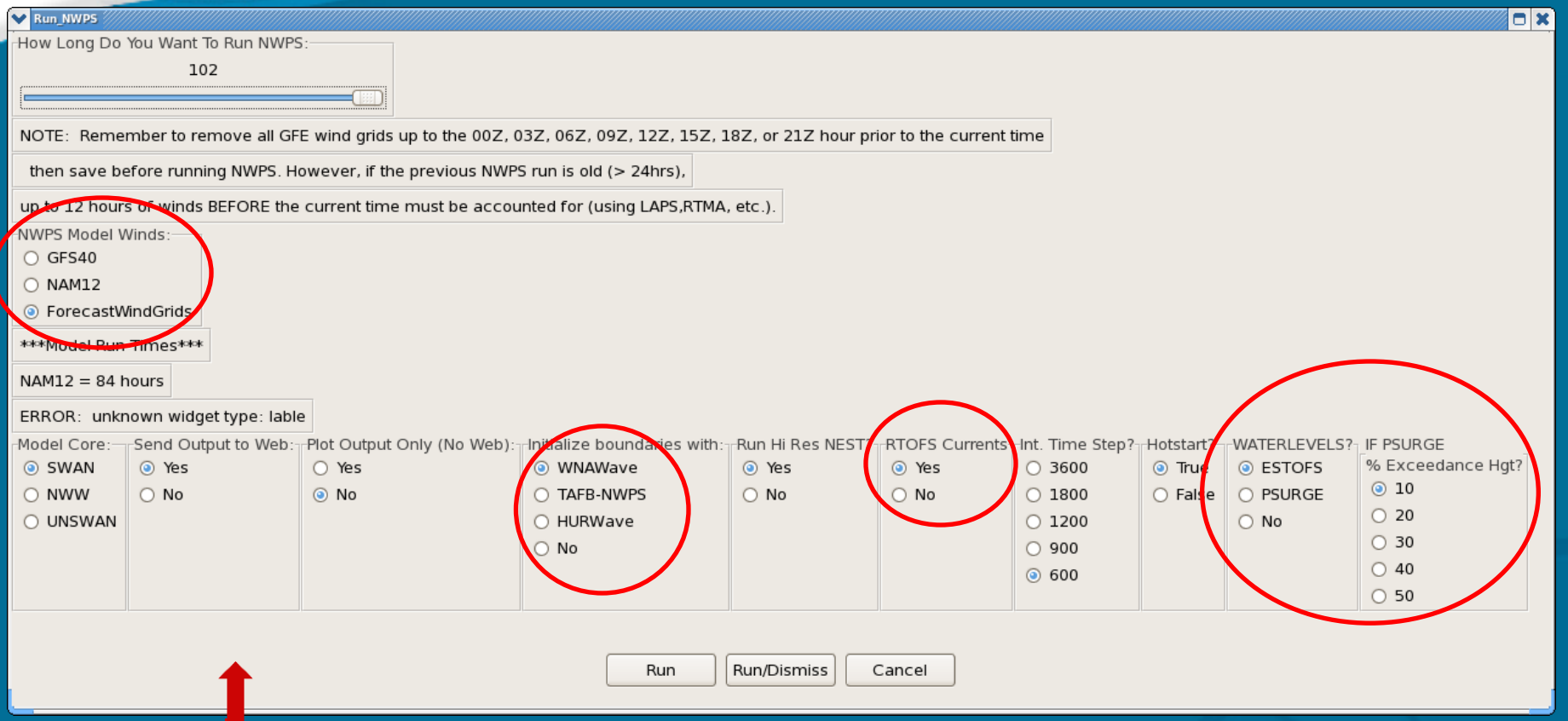
CG2

High-level system architecture



CAVE: Common AWIPS Visualization Environment
EDEX: Environmental Data Exchange
LDM: Local Data Manager

NWPS User Interface (AWIPS2 v14.4.1)



GRID file (GFE winds, text file)

DOMAIN file (9.6 kB text file)

CONTROL file (1 kB text file)

Size = ~2 Mb zipped

Example DOMAIN and CONTROL files

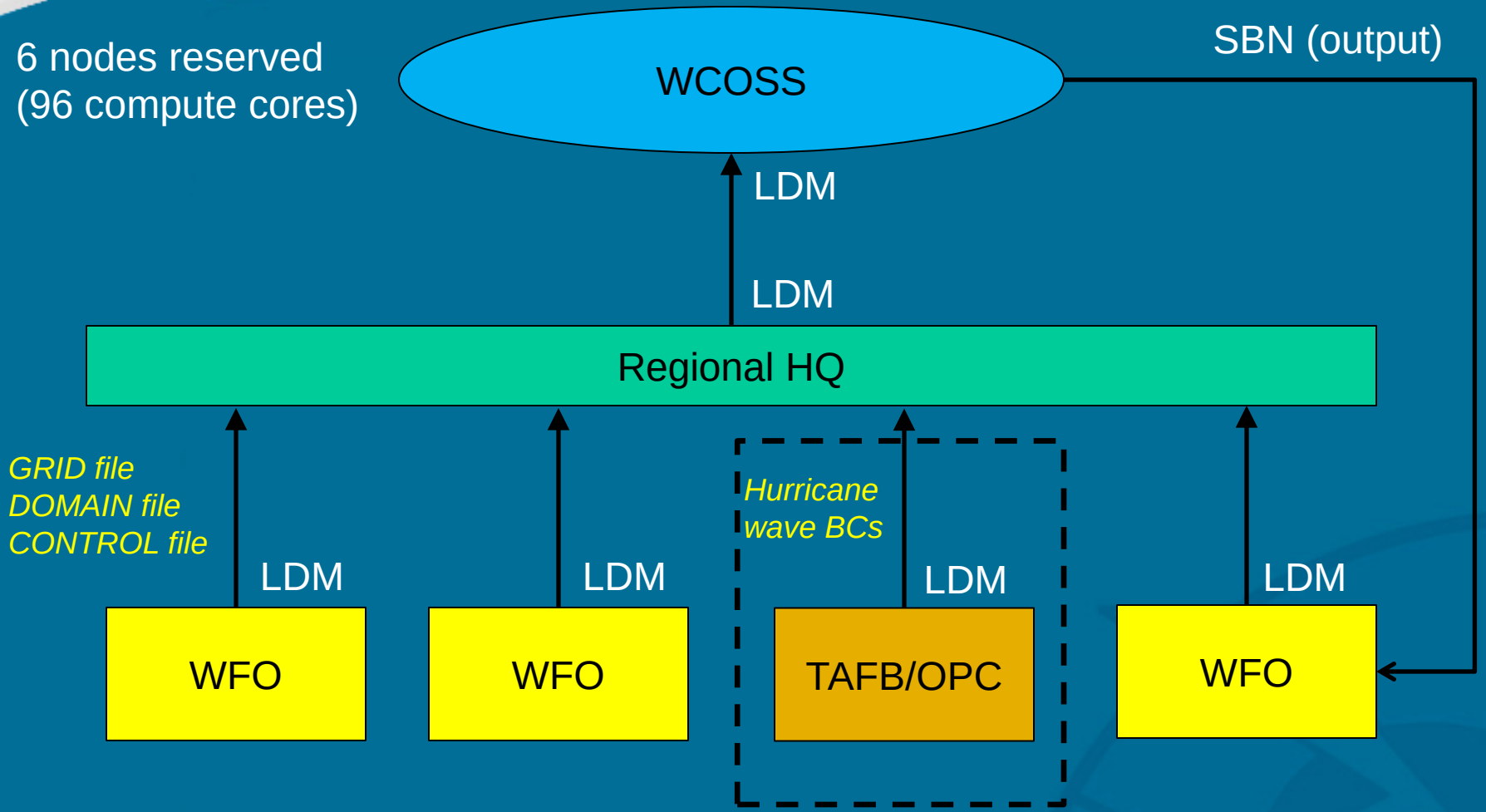
```
#------------------------------------------------------------------------
# Domain File
# Original Author(s): Roberto Padilla-Hernandez,Douglas Gaer,
# Alex Gibbs, Pablo Santos,Tony Freeman
# File Creation Date: 06/01/2012
# Date Last Modified: 02/01/13
#
# Version control: 1.33
#
# Support Team:
#
# Contributors:
#
# ------------------------------------------------------------------------
# --------------------- Description and Details ------------------------
# ------------------------------------------------------------------------
#
# File used to setup a geographical domain for SWAN and WW3
#
# ------------------------------------------------------------
#========================================================================
#                                    MFL                                 =
#  GEOGRAPHICAL DOMAIN, GEOGRAFICAL RESOLUTION AND OUTPUT TIME STEP      =
#========================================================================
export SITEID="MFL"
export REGIONID="SR"
export NELAT="27.70"
export NELON="-78.41"
export SWLAT="24.10"
export SWLON="-83.54"
#export RES="1.8"
export RES="6"
export TSTEP="3"
```

DOMAIN file

```
ssh ${SSHARGS} ldad@ls1 echo "$RUNLEN:$WNA:$NEST:$GS:$WINDS:$WEB:$PLOT:$DELTAC:$HOTSTART:$ESTOFS:$CORE >
/data/ldad/nwps/input/inp_args" 2>&1 | tee -a $logfile
```

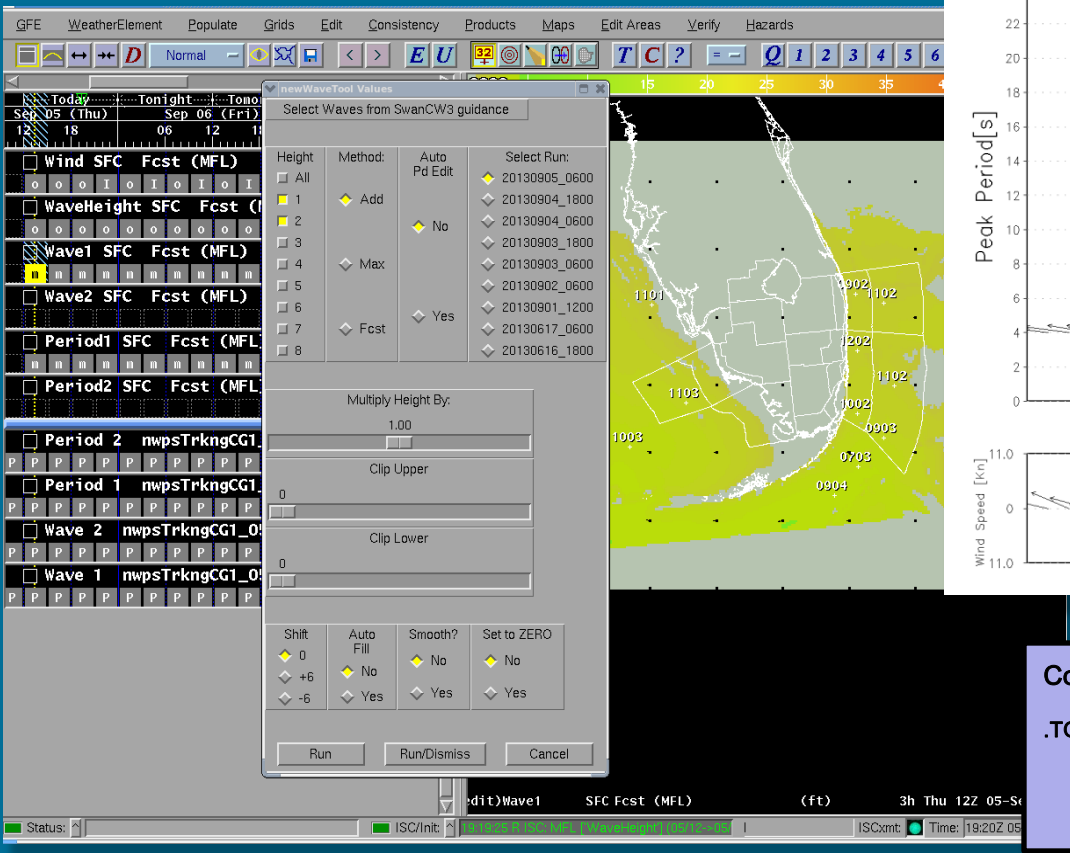
CONTROL file (produced in AWIPS)

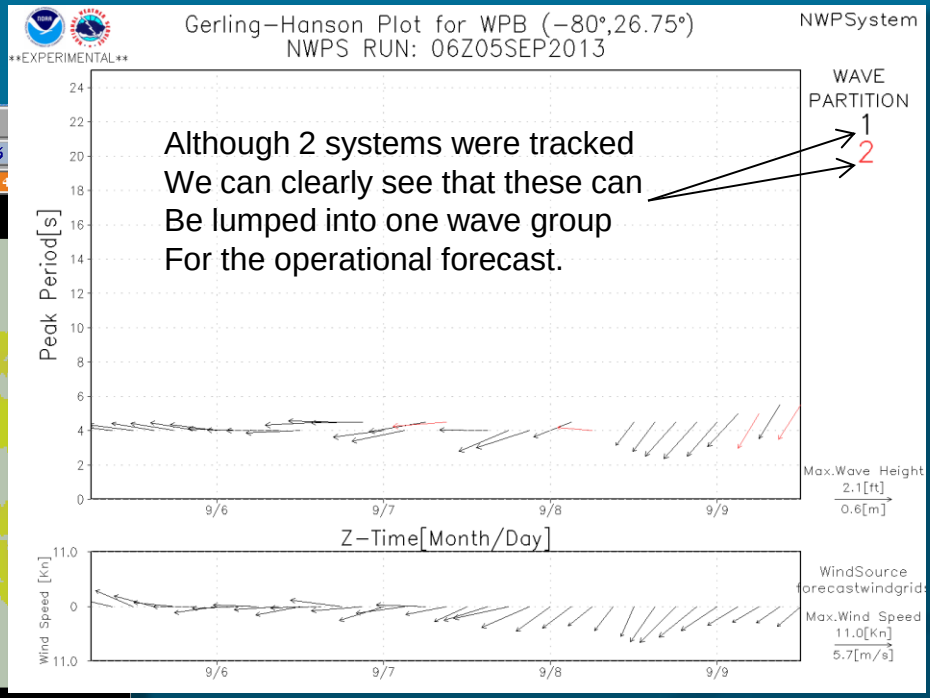
Data upload and run triggering



Guidance in GFE, incl. tracking output

WAVE1-2: Height + Direction





Coastal Waters Forecast Example:

.TODAY...EAST WINDS AROUND 10 KT. SEAS EAST 1 TO 2 FT AT 4 SECONDS.

I/O sizes

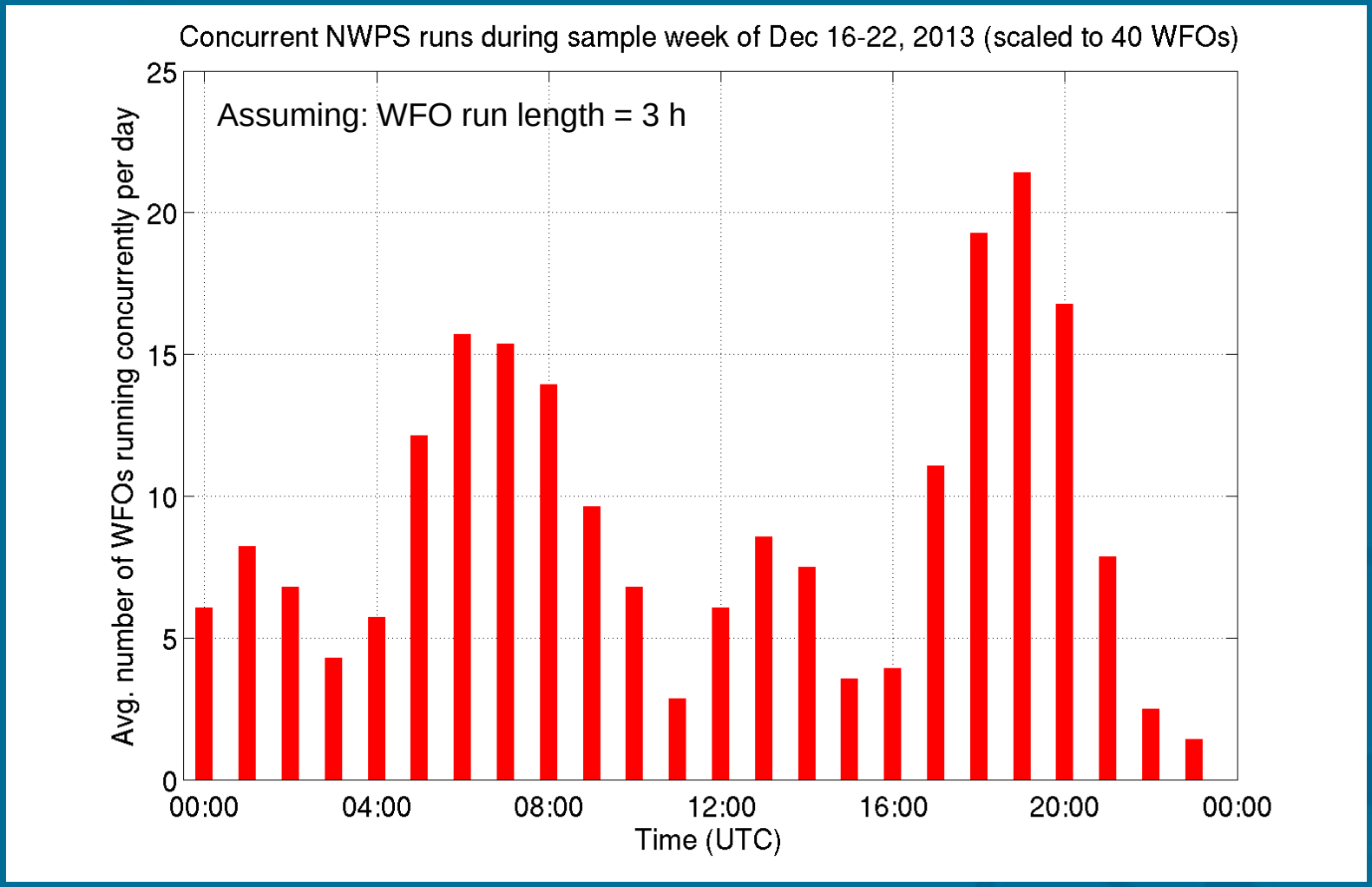
Sample input files (WFO Miami)

```
total 33456
-rw-r--r-- 1 ifps fxalpha  2064319 Feb 26 05:59 201402260558_WIND.txt.gz
drwxrwxr-x 2 ifps fxalpha   466944 Feb 26 06:03 estofs
drwxrwxr-x 2 ifps fxalpha     4096 Sep 25 21:56 gfswind
drwxrwxr-x 3 ifps fxalpha    20480 Feb 26 08:46 hotstart
drwxrwxr-x 2 ifps fxalpha     4096 Sep 25 21:56 latestWNAFiles
drwxrwxr-x 2 ifps fxalpha     4096 Sep 25 21:56 ndbc
drwxrwxr-x 2 ifps fxalpha    81920 Feb 26 06:03 rtofs
drwxrwxr-x 2 ifps fxalpha     4096 Feb 26 06:01 wave
drwxrwxr-x 3 ifps fxalpha     4096 Sep 25 21:56 webGet
drwxrwxr-x 2 ifps fxalpha     4096 Feb 26 06:03 wind
-rw-r--r-- 1 ifps fxalpha 31585868 Feb 26 05:59 Wind_File
```

Sample output files (WFO Miami, CG1 and nested CG2 domains). Can be up to 5 domains

```
-rw-rw-r-- 1 ifps fxalpha 30365335 Feb 25 19:36 CG1/mfl_nwps_CG1_20140225_1800.grib2
-rw-rw-r-- 1 ifps fxalpha 27611115 Feb 26 07:01 CG1/mfl_nwps_CG1_20140226_0600.grib2
-rw-rw-r-- 1 ifps fxalpha 32992715 Feb 25 20:15 CG2/mfl_nwps_CG2_20140225_1800.grib2
-rw-rw-r-- 1 ifps fxalpha 29334515 Feb 26 07:38 CG2/mfl_nwps_CG2_20140226_0600.grib2
```

System load analysis



Charter (preview)

a. **Scope of changes**: New implementation

b. **Development Testing**

i. Testing completed: Preliminary testing field/Dev machine

ii. Preparation of scripts and jobs: Initial WCOSS implementation completed (see "Detailed system description").

iii. Operational IT testing during last implementation: N/A

iv. Standards followed: ECflow, alerts, output, cleanup, monitoring, ~~mirroring~~.

c. **Parallel Evaluation Recommendations**

i. Completed evaluation outside of EMC: Beta testing of WFO version.

ii. Length of time: 30-day proposed – one WFO each in SR and ER

iii. Recommended evaluators: WFO Miami & WFO Morehead City

Implementation planning

a. **CPU and Disk**

i. Current CPU and Disk requirements: 2 cycles/day. 8 cores per WFO, for 3 hours = 168 cores total (see load distribution graph). 96 cores reserved through Sandy Supplemental. 150 Mb disk space per WFO (CG1-CG5). Total of 5.6 Gb per cycle.

ii. Change in CPU and Disk requirements: N/A

iii. Retaining output on WCOSS: Proposed: 7-day archive

iv. Additional output to RUNHISTORY job: ???

v. Network handling of bandwidth: TBD

b. **Post-production and Products**

i. Any new products?: Yes. CG1-CG5 GRIB2 fields for each WFO (Hsig, Tp, Dir, Wind, Water level, Surface current, Partition fields). GEMPAK development required.

ii. Dissemination: Via SBN-AWIPS: 150 Mb per WFO/cycle

Implementation planning (2)

c. **Library changes:** TBD

d. **Downstream Dependencies**

i. List all downstream model dependences: Empirical rip current and wave runup models.

ii. List all downstream product dependences: Coastal Marine forecasts and warnings. Rip current and runup forecasts. Ship routing forecast.

iii. List all other dependent variables: None

e. **Data Flow requirements**

i. New WMO headers (featuring WFO tag) to be encoded. Proposed encoding shared with NCO/SIB.

Nearshore Wave Prediction System (NWPS) V1.0.0

Project Status as of 06/24/2014

G

Project Information and Highlights

Lead: Hendrik Tolman, EMC and Chris Magee, NCO

Scope:

1. Centralized implementation of NWPS that is currently run locally at a number of coastal WFOs.
2. Involves separate implementations for approx. 20 WFOs, using shared basic scripting.
3. Novel on-demand run triggering.

Expected Benefits:

1. Resolution of coastal wave model guidance improved from 4 arc-min (with ww3 multi_1) to at least 1 arc-min.
2. Wave guidance consistent with forecaster-developed wind fields.
3. Improved economy of scale of centralized computing compared to distributed computing.

G

Scheduling

Milestone (NCEP)	Date	Status
Initial EE setup (NCO Support)	01/31/15	
EMC testing complete/ EMC CCB approval	02/28/15	
Code delivered to NCO	02/28/15	
Technical Information Notice Issued	03/31/15	
CCB approve parallel data feed	03/31/15	
Parallel testing begun in NCO	03/31/15	
Real-Time Evaluation Ends	04/30/15	
IT testing begins	05/01/15	
IT testing ends	05/31/15	
Management Briefing	06/15/15	
Implementation	06/30/15	

G

Issues/Risks

Issues: Additional computing capacity required; Multiple implementations (each of approx. 20 WFOs).

Risks: Implementation and testing may take longer than usual; On-demand run capability is yet untested.

Mitigation: Funding secured for 4 additional nodes (through Feb 2017). Funding a dedicated SPA for 8 months to work with EMC: An initial testing period of Sept-Nov 2014 is added up-front to test on-demand run capability. Actual implementation and testing occurs during Mar-Jul 2015.

G

Finances

Associated Costs:

1) $250,000 - Applied to IBM Task Order 4 to augment WCOSS by 6 nodes (approx 1%)
2) $147,180 - To hire dedicated SPA for extended testing and implementation period (Sept-Nov 2014, Mar-Jul 2015)

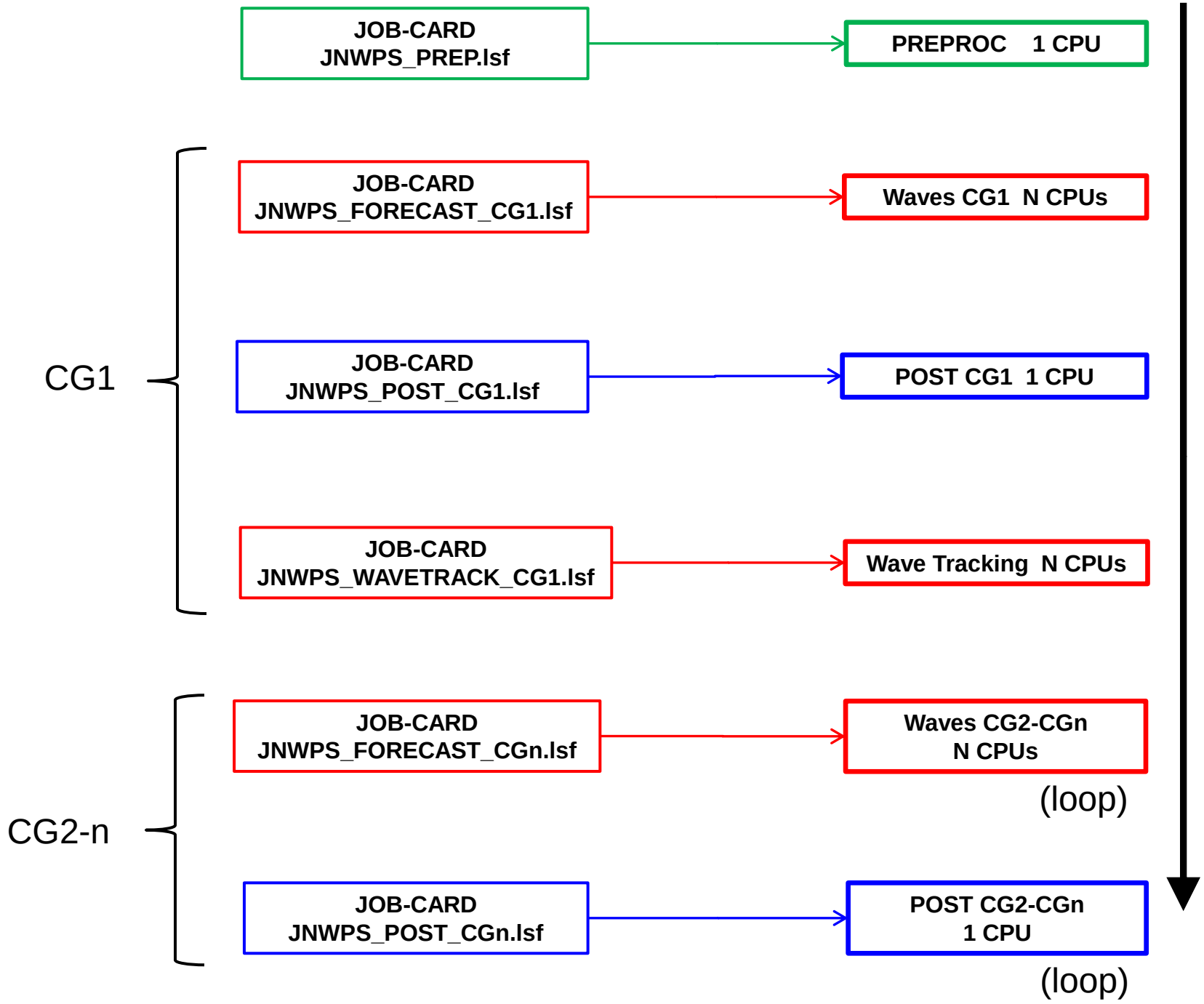
Funding Sources: Sandy Supplemental; OST development funding.

R Management Attention Required | Y Potential Management Attention Needed | G On Track

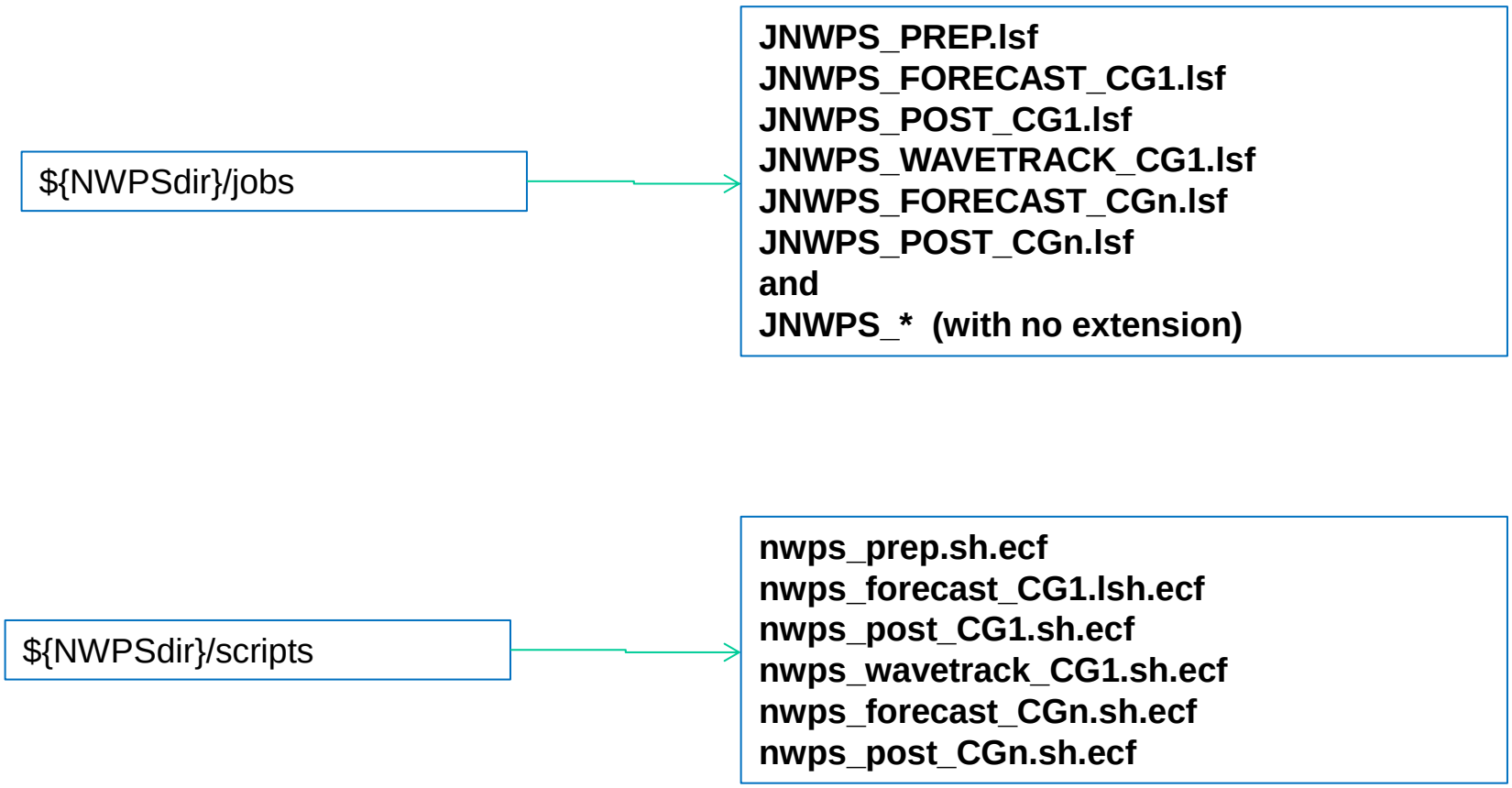
WCOSS implementation schedule

	Jul 14	Aug 14	Sep 14	Oct 14	Nov 14	Dec 14	Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15
Finalize initial WCOSS development	✓											
Developer testing on WCOSS, incl. data upload, run triggering												
Initial EE setup (NCO Support)												
Code delivered to NCO												
TIN issued; CCB approves parallel data feed; 30-day parallel testing at NCO												
IT testing at NCO												
Management Briefing & implementation												
AWIPS2 build v14.4.1												

Appendix A:
Detailed system description


JOB-CARD
JNWPS_PREP.lsf
PREPROC 1 CPU
CG1
JOB-CARD
JNWPS_FORECAST_CG1.lsf
Waves CG1 N CPUs
JOB-CARD
JNWPS_POST_CG1.lsf
POST CG1 1 CPU
JOB-CARD
JNWPS_WAVETRACK_CG1.lsf
Wave Tracking N CPUs
CG2-n
JOB-CARD
JNWPS_FORECAST_CGn.lsf
Waves CG2-CGn
N CPUs
(loop)
JOB-CARD
JNWPS_POST_CGn.lsf
POST CG2-CGn
1 CPU
(loop)

Two new subdirectories, were made following WW3 structure



JNWPS_PREP.lsf 1 CPU

```
#!/bin/bash

#BSUB -J JNWPS_PREP
#BSUB -oo JNWPS_PREP.out
#BSUB -q "dev"
#BSUB -W 00:10

export job=JNWPS_PREP
export
NWPSdir=/marine/save/nwps/model
```

```
$NWPSdir/jobs/JNWPS_PREP
```

JNWPS_PREP.sh.ecf

```
${NWPSdir}/bin/run_nwps_wcoss.sh --runlen 36  --nest --winds gfs --
domainsetup ${NWPSdir}/domain_setup/domains/MFL   --deltac 600 --plot --
wavemodel swan

echo "Pre-process completed"
exit 0
```

JNWPS_FORECAST_CG1.lsf 8 CPUs

```
#!/bin/bash

#BSUB -a intel
#BSUB -J JNWPS_FORECAST_CG1
#BSUB -oo JNWPS_FORECAST_CG1.out
#BSUB -x
#BSUB -n 8
#BSUB -R "span[ptile=8]"
#BSUB -q "dev"
#BSUB -W 00:20
```

```
$NWPSdir/jobs/JNWPS_FORECAST_CG1
```

JNWPS_FORECAST_CG1.sh.ecf

```
${NWPSdir}/bin/nwps_coremodel_CG1.pl
```

JOB CARDS has the following description

```
#BSUB -a intelmpi                <------ Run with Intel MPI
#BSUB -J JWAVE_NWPS        <------ Name of the run
#BSUB -oo JWAVE_NWPS.out   <---- Log for system output (-o to
append;                                  -oo to overwrite)
#BSUB -eo JWAVE_NWPS.out   <---- Log for system errors (-e to
append;                                  -eo to overwrite)
#BSUB -x                            <------ Exclusive use of node
#BSUB -n 8                         <------ Number of cores to use in run
                                          (should be same as mpirun -n ...)
#BSUB -R [ptile=8]                <----- Number of cores used in node (out
of 32 logical cores)
#BSUB -W 3:00       <----- Maximum wall time in HH:MM
#BSUB -q "dev"      <----- Which queue you are running in (dev, debug,
etc.)
```

JNWPS_POST_CG1.lsf 1 CPU

```
#!/bin/bash

#BSUB -J JNWPS_POST_CG1
#BSUB -oo JNWPS_POST_CG1.out
#BSUB -q "dev"
#BSUB -W 00:10

export
NWPSdir=/marine/save/nwps/model
$NWPSdir/jobs/JNWPS_POST_CG1
```

JNWPS_PREP.sh.ecf

```
${NWPSdir}/bin/run_posproc_CG1.sh
echo "Post-process completed"
exit 0
```

JNWPS_WAVETRACK_CG1.lsf 8 CPUs

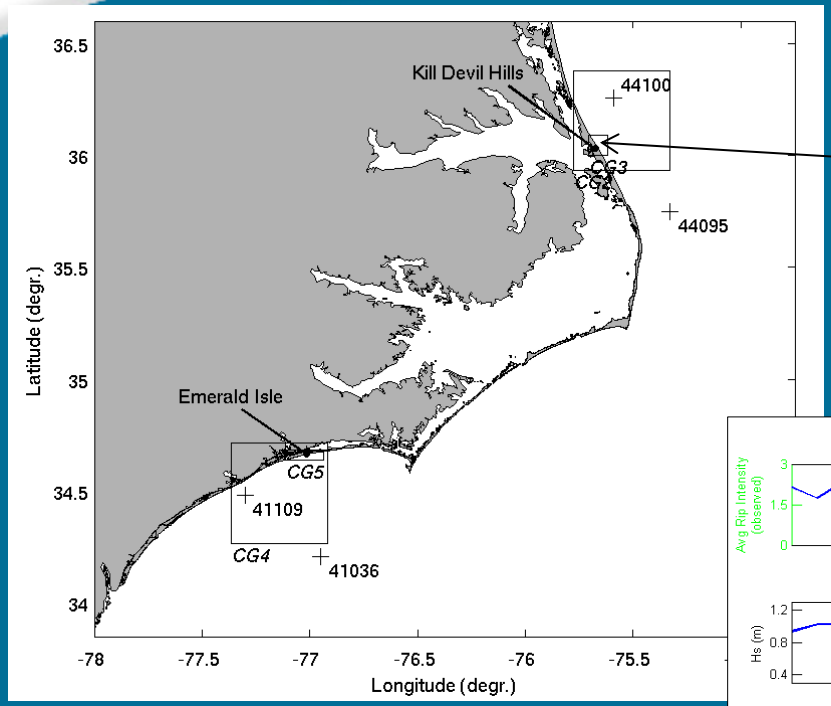
```
#!/bin/bash

#BSUB -a intel
#BSUB -J JNWPS_WAVETRACK_CG1
#BSUB -oo JNWPS_WAVETRACK_CG1.out
#BSUB -x
#BSUB -n 8
#BSUB -R "span[ptile=8]"
#BSUB -q "dev"
#BSUB -W 00:20

export NWPSdir=/marine/save/nwps/model

$NWPSdir/jobs/JNWPS_WAVETRACK_CG1
```

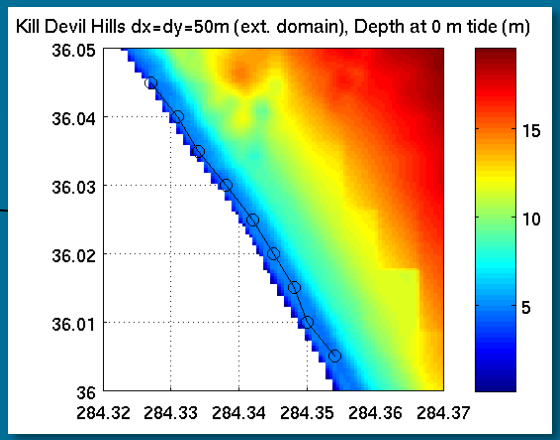
JNWPS_FORECAST_CG1.sh.ecf

```
${NWPSdir}/bin/nwps_wavetrack_CG1.sh
```

Appendix B:
Future Additions
(NWPS Phase 2 implementation)

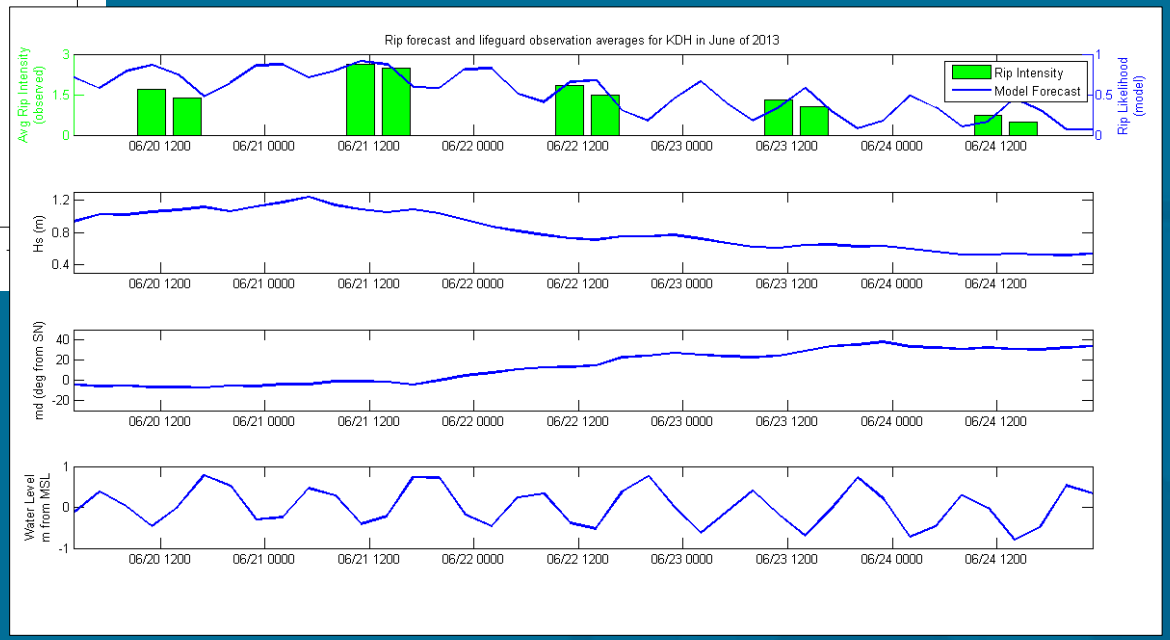
Post-proc: Empirical rip current guidance





$$\pi(x) = \frac{e^{g(x)}}{1 + e^{g(x)}}$$

$$g(x) = 1.05 + 3.51\ln(Hs) - 0.027|\theta| + 0.42\text{Ep} - 1.70\eta$$

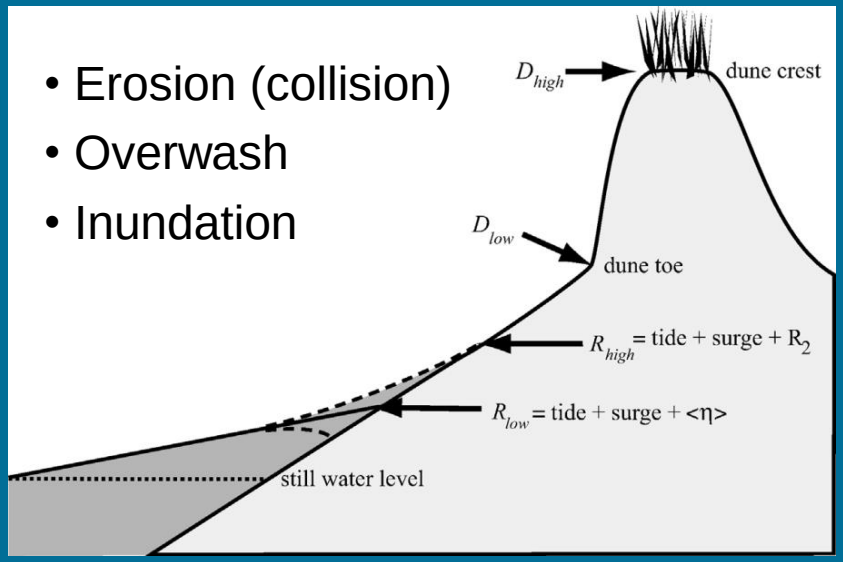


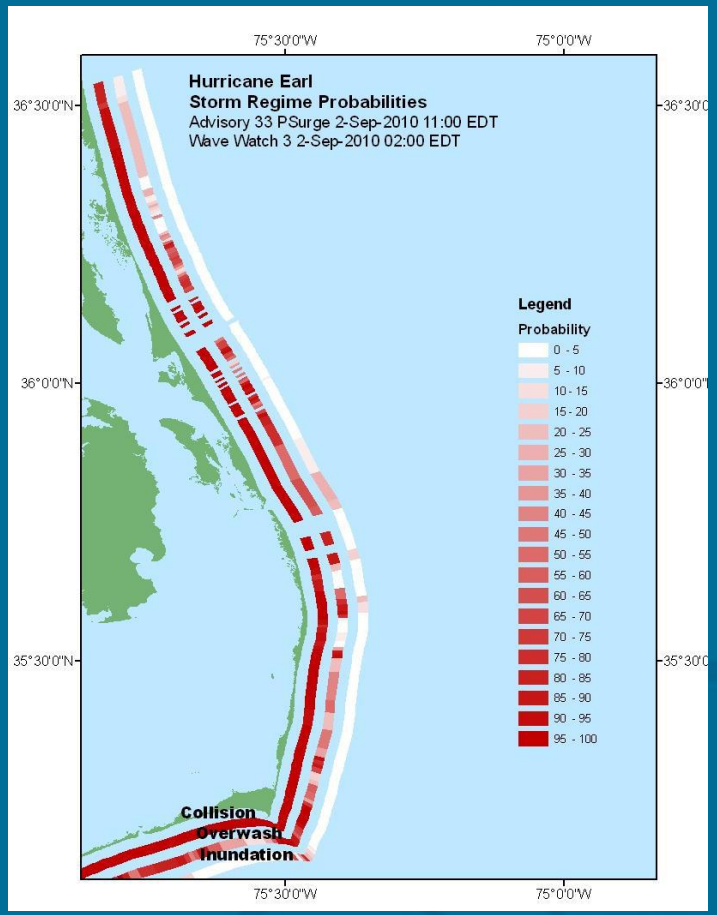
Post-proc: Empirical wave runup guidance

2% exceedence value for wave runup:
(Stockdon et al. 2006, 2007)

$$R_2 = \text{Setup} + \text{Swash}/2$$
$$= 1.1\left(0.35\beta_f (H_0 L_0)^{1/2} + \frac{[H_0 L_0 (0.563\beta_f^2 + 0.004)]^{1/2}}{2}\right)$$

- Erosion (collision)
- Overwash
- Inundation

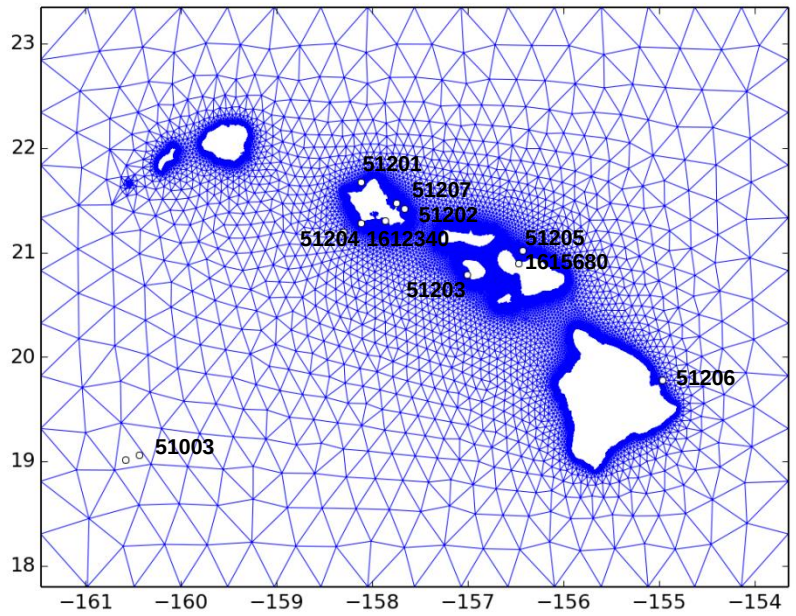


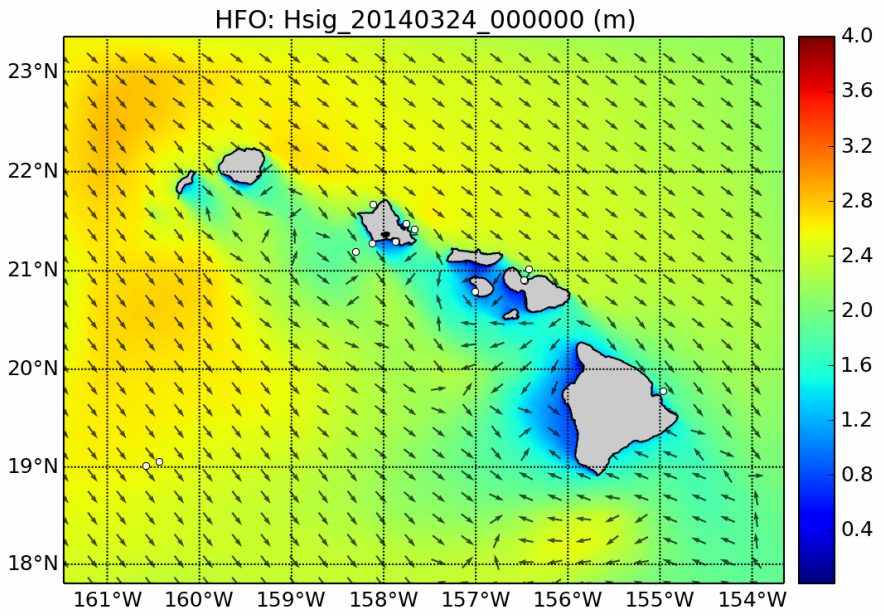


(Stockdon et al. 2006)

USGS science for a changing world

Unstructured meshes





Vertices: 78,622
Offshore resolution: 0.5 deg
Nearshore resolution: 100 m

Forecast length: 96 h
Logical CPUs: 8
Walltime: 00:53:10