Nearshore Wave Prediction System
v1.0.0
CCB Meeting

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

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

Internal presentation to EMC, June 9, 2015
Outline

1. Quad chart
2. Need for nearshore wave guidance
3. NWPS system design
4. Input, output and data flow
5. System loading and Validation
6. Implementation schedule
Nearshore Wave Prediction System (NWPS) V1.0.0
Project Status as of 05/29/2015

Project Information and Highlights

Lead: Hendrik Tolman, EMC and Becky Cosgrove, 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.

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.

Issues/Risks

Issues:

Risks:

Mitigation:

Implementation shifted by 2 quarters to allow additional development and testing. Sandy implementation milestone (FY15Q4) unaffected.

Scheduling

<table>
<thead>
<tr>
<th>Milestone (NCEP)</th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial coordination with SPA team</td>
<td>01/31/15</td>
<td>In progress</td>
</tr>
<tr>
<td>EMC testing complete/ EMC CCB approval</td>
<td>02/28/15 → 06/09</td>
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<tr>
<td>Code delivered to NCO</td>
<td>02/28/15 → 06/09</td>
<td></td>
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<tr>
<td>Technical Information Notice Issued</td>
<td>03/31/15 → 07/01</td>
<td></td>
</tr>
<tr>
<td>SPA begins prep work for 30 day test</td>
<td>03/02/15 → 06/02</td>
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<tr>
<td>30-day evaluation begins</td>
<td>03/09/15 → 07/01</td>
<td></td>
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<tr>
<td>30-day evaluation ends</td>
<td>04/07/15 → 08/01</td>
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<tr>
<td>IT testing ends</td>
<td>03/27/15 → 07/31</td>
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<tr>
<td>Management Briefing</td>
<td>04/24/15 → 08/15</td>
<td></td>
</tr>
<tr>
<td>Implementation (2 pilot offices, MFL &amp; BOX)</td>
<td>04/28/15 → 09/01</td>
<td></td>
</tr>
<tr>
<td>Implementation (remaining 20 offices in SR&amp;ER)</td>
<td>09/30/15</td>
<td></td>
</tr>
</tbody>
</table>

Finances

Associated Costs:
1) $250,000 - Applied to IBM Task Order 4 to augment WCOSS by 4 nodes (approx 1%). A continuous (24 h) reservation of these 4 nodes is required for this on-demand system.
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.

AWIPS changes: An NWPS run configuration GUI and additional nearshore wave products have been added to builds 14.4.1 and 15.1.1.
WAVEWATCH 3 Multi_1
global grid mosaic

- Max. coastal resolution = 4 arc-min (7.5 km)
- Forced by GFS

Nearshore downscaling

- Req. resolution = 500 m - 1.85 km
- Forecaster wind fields (GFE)
• Run on-demand, using open-source wave model SWAN.
• Driven by forecaster-developed winds from GFE (AWIPS2), and other NCEP forcings (e.g. WW3 BCs, RTOFS/ESTOFS).
• Included in the AWIPS2 baseline for sustainability.
• Addresses region-specific physical processes in the nearshore (wave-current interaction, ice interaction, vegetation, etc.).
• Includes wave partitioning (separates wave field into component systems). In future: rip current and wave run-up guidance.

* WFO-based pilot project (WFO Eureka) transitioned to NCEP
* Sandy Supplemental Milestone FY15Q4
Model configuration

- Spectral wave model SWAN v40.81, enhanced with wave partitioning (similar to WW3 v4.18).
- Wave system tracking from WW3 v4.18 (IBM optimized).
- Experimental rip current guidance (Dusek and Seim, 2013).
- **Source terms, deep water (SWAN default):** Komen et al. (1984), as recalibrated by Rogers et al. (2003).
- **Source terms, shallow water (SWAN default):** JONSWAP bed friction, Battjes and Janssen (1978) depth-induced breaking, LTA triads.
- Run length = 102 h, 2 cycles/day. Initiated on-demand by WFOs.
- Grid resolution: 1.8 km resolution outer grid (CG1), with optional nests typically at 500 m resolution (CG2-5).
NWPS grids for coastal WFOs
NWPS Architecture (WFO view)

NWPS on WCOSS

SWAN + Wave Tracking

Guidance products

GFE winds + domain/control files

WW3 Boundary Conditions; RTOFS Surface Currents; ESTOFS/P-Surge Water levels

(Staged on WCOSS)

AWIPS2

SBN

LDM via HQ

CAVE (D2D, GFE)

EDEX (Data Server)

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

NDFD (total field; partitions)
AWIPS User Interface (v14.4.1/v15.1.1)

Run_NWPS Values

- How Long Do You Want To Run NWPS: 102
- Model Start Time:
  - 20150212_1200
  - 20150212_1800
  - 20150212_0400
  - 20150212_0600
  - 20150213_0000
  - 20150213_1200
  - 20150213_1800

- Local or NCEP:
  - Local
  - NCEP

- Model Core:
  - SWAN
  - NWW
  - UNSWAN

- Send Output to Web:
  - Yes
  - No

- Plot Output Only (No Web):
  - Yes
  - No

- Boundary Conditions:
  - WNAWave
  - TAFB-NWPS
  - HURWave
  - No

- Run Hi Res NEST:
  - Yes
  - No

- RTOFS Currents:
  - Yes
  - No

- Model Time Step:
  - 1200
  - 900
  - 600
  - 300

- Hotstart:
  - True
  - False

- Waterlevels:
  - ESTOFS
  - PSURGE
  - No

- If PSURGE
  - % Exceedance Hgt:
    - 10
    - 20
    - 30
    - 40
    - 50

[OK] [Cancel]
Data input (from each WFO via LDM)

1. GFE wind file (GRIB2)
   (produced in AWIPS)

2. DOMAIN file (txt)

3. CONTROL file (txt)
   (produced in AWIPS)

Size = ~2 Mb zipped/WFO site
Data input (Staged on WCOSS)

1. WAVEWATCH III boundary spectra (txt)

2. RTOFS surface current fields (txt)

3. ESTOFS water levels (txt)
   (Extra-tropical conditions)

4. P-Surge water levels (txt)
   (Tropical conditions)
Post-processing: Wave system tracking
Guidance in GFE for producing forecast
NWPS Architecture (Regional view)

4 nodes reserved (96 compute cores)

WCOSS

LDM

SBN (output)

NCWCP

GRID file
DOMAIn file
CONTROL file

Hurricane wave BCs

DBNet

TAFB/OPC

LDM

WFO

LDM

WFO

LDM

WFO

LDM

WFO
NWPS_prepoc

1. Configuration
2. Setup
3. Pre-process all input fields

NWPS_PROC1

for 1, NumGrids {
   Wave Model
}

CG1

CG2-CGn

NWPS_PROC2

for 1, 1 {
   Wave Tracking
}

NWPS_post

for 1, NumGrids {
   Graphic Process(%CG);
}

Archive And Cleanup

Architectural Diagram:

- NWPS_prepoc
  - Configuration
  - Setup
  - Pre-process all input fields

- NWPS_PROC1
  - for 1, NumGrids {
    - Wave Model
  }
  - CG1
  - CG2-CGn

- NWPS_PROC2
  - for 1, 1 {
    - Wave Tracking
  }

- NWPS_post
  - for 1, NumGrids {
    - Graphic Process(%CG);
  }
  - Archive And Cleanup

Architectural Details:

1. NWPS_prepoc:
   - Configuration
   - Setup
   - Pre-process all input fields

2. NWPS_PROC1:
   - for 1, NumGrids {
     - Wave Model
   }
   - CG1
   - CG2-CGn

3. NWPS_PROC2:
   - for 1, 1 {
     - Wave Tracking
   }

4. NWPS_post:
   - for 1, NumGrids {
     - Graphic Process(%CG);
   }
   - Archive And Cleanup

CPU Utilization:

- 1 CPU
- 8CPUs
- n CPU
### Scheduling of jobs (single WFO)

**NODE X**

<table>
<thead>
<tr>
<th>CPU</th>
<th>Prep</th>
<th>CG1 run</th>
<th>CG1 Post</th>
<th>CG1 (&quot;0&quot;) Trk</th>
<th>CG2 run</th>
<th>CG3 run</th>
<th>CG3 run</th>
<th>CG4 run</th>
<th>CG2-4 Post</th>
<th>Final Output</th>
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</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

**Legend:**
- Prep: Preparation phase
- CG1 run: CG1 run phase
- CG1 Post: CG1 post run phase
- CG2 run: CG2 run phase
- CG3 run: CG3 run phase
- CG4 run: CG4 run phase

**Time:**
- Intermediate Output
- Final Output
## WCOSS resources (single WFO)

### Resource usage summary:

<table>
<thead>
<tr>
<th>Application</th>
<th>CPU time</th>
<th>Max Memory</th>
<th>Average Memory</th>
<th>Num of CPUs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREP</strong></td>
<td>3:33 min:sec</td>
<td>62 MB</td>
<td>33.64 MB</td>
<td>1</td>
</tr>
<tr>
<td><strong>FORECAST CG1</strong></td>
<td>40:17 min:sec</td>
<td>511 MB</td>
<td>497.56 MB</td>
<td>8</td>
</tr>
<tr>
<td><strong>POST CG1</strong></td>
<td>9:38 min:sec</td>
<td>1540 MB</td>
<td>302.05 MB</td>
<td>1</td>
</tr>
<tr>
<td><strong>WAVETRACKING CG1</strong> (Incl. Post-processing)</td>
<td>21:22 min:sec</td>
<td>3329 MB</td>
<td>162.97 MB</td>
<td>8</td>
</tr>
<tr>
<td><strong>FORECAST CGn</strong></td>
<td>Variable, WFO depend.</td>
<td>Variable</td>
<td>Variable</td>
<td>8</td>
</tr>
<tr>
<td><strong>POST CGn</strong></td>
<td>Variable, WFO depend.</td>
<td>Variable</td>
<td>Variable</td>
<td>Up to 4</td>
</tr>
</tbody>
</table>

**Estimated avg total per WFO:** 2h25min; 3.4GB RAM
Scheduling of all jobs (per node)
WCOSS resources (all WFOs, estimate)

Concurrent NWPS runs during sample week of Dec 16-22, 2013 (scaled to 23 WFOs)

Assumption: WFO run length = 2.5 h
Data output

1. **GRIB2 files** with all parameters, per WFO per grid (CG1-5), with **WMO Headers**
2. **PNG files** with wave partition time series (Gerling-Hanson plots)
3. **PNG files** with wave spectra
4. **PNG files** with wave fields
5. **Text files** with wave, water level and rip current output (MFL, MHX, TBW)

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Total GRIB2 volume (23 WFOs, all domains) = 1.6 GB/cycle ~ 2x /day -> SBN
Total PNG volume = 964 MB/cycle (18,866 files) ~ 2x /day -> EMC’s Polar
Web graphics on EMC’s Polar

http://innovation.srh.noaa.gov/nwps/
Validation at nearshore NDBC buoys

GFE winds: $U_{10}$

NWPS/SWAN: $H_{\text{sig}}$

Operational runs at SR WFOs:
2014/10/11-2015/05/20
Implementation schedule

- Code delivered to NCO – Jun 9, 2015
- SPA begins prep work for 30 day test – Jun 9, 2015
- TIN issued – Jul 1, 2015
- 30-day evaluation begins (MFL & BOX) – Jul 1, 2015
- IT testing ends – Jul 31, 2015
- 30-day evaluation ends (MFL & BOX) – Aug 1, 2015
- Management Briefing - Aug 15, 2015
- Implementation (MFL & BOX) – Sept 1, 2015
- Implementation (remaining 21 offices in SR & ER) – Sept 30, 2015