Marine Models

Michael Buchanan
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• NOAA’s WaveWatch III (WW3)

• Simulating WAVes Nearshore (SWAN)

• Nearshore Wave Prediction System (NWPS)
  • Includes WW3 and SWAN

• TAMUCC-CBI’s Artificial Neural Network (ANN)

• NOS’s Northern Gulf of Mexico Operational Forecast System (NGOFS)

• Global Real Time Ocean Forecast System (RTOFS)

• Extratropical Surge and Tide Operational Forecast System (ESTOFS)

• MDL’s ExtraTropical Storm Surge Model (ETSS or ET-SURGE)

• MDL’s Sea Lake and Overland Surges from Hurricane (SLOSH)
WaveWatch III

- NOAA’s 3rd generation wave model.
- Runs 4 times a day.
- Output through 180 hours for every 3 hours.
- 3 different resolutions:
  - $1/2^\circ$ or 30 arc-minutes
  - $1/6^\circ$ or 10 arc-minutes
  - $1/15^\circ$ or 4 arc-minutes
- Uses GFS Winds.
- **Western North Atlantic (WNA)** regional domain.
  - Boundary conditions from the Global WW3.
Regional Western North Atlantic

4 arcmin
Regional Western North Atlantic 10 arcmin in GFE
Regional Western North Atlantic
4 arcmin in GFE
WW3 Variants

- **HURricane Wave Model (HURWave)**
  - Blend of GFS & HWRF winds.

- **Global Ensemble Ocean Wave Forecast System (GEOWaFS)**
  - 1 control member (GFS winds) and 20 perturbed members from the GEFS.

- Combined **NCEP/FNMOC Wave ENSembles (NFCENS)**
  - GEOWaFS and Navy Wave Ensembles.

- **Nearshore WaveWatch (NWW)** is not yet operational.
Global Wave Ensemble based on GEFS
NCEP/FNMOC Wave Ensemble

Ensemble Mean (contour, m) & Spread of Hs

Valid 2016/03/07 18z
Simulating WAves Nearshore (SWAN)

- 3rd generation wave model developed in the Netherlands.

- Geared towards the “nearshore”.
Nearshore Wave Prediction System (NWPS)

- Uses the SWAN model as its core.

- **Local and NCEP** runs at:
  - 0040, 0340, 0940, 1240, 1540, 2140Z

- Uses our winds from GFE.
  - NWPSwind element

- 30-40 minutes to run model and post-process.

- High-resolution (~1 arcmin) wave guidance:
  - Significant Wave Height
  - Primary Wave Period
  - Primary Wave Direction
  - Swell Height
**Run_NWPS GFE Procedure**

**How Long Do You Want To Run NWPS:** 102

<table>
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<tr>
<th>Model Start Time:</th>
<th>Local, NCEP, or Both:</th>
<th>Model Core:</th>
<th>Send Output to Web:</th>
<th>Plot Output Only (No Web):</th>
<th>Boundary Conditions:</th>
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**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**

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NWPS NCEP runs
http://www.nco.ncep.noaa.gov/pmb/spa/nwps/

- Operational on WCOSS since 2/9/16.
- Ability to process NCEP runs in 16.2.1.
  - ~May
- Ability for backup WFOs to process NCEP runs in 16.2.2.
  - ~Summer
If the WCOSS run fails...

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2016 Skywarn Storm Spotter Training Schedule

Texas A&M Corpus Christi will begin a Bachelor of Science program in Atmospheric Science in the Fall of 2016

Today

Very Warm Conditions

- Partly cloudy skies
- Cold front moves through with northerly winds this afternoon

Show Caption
Tropical Storm Karen
October 2013

Time Karen Entered Gulf
~30 Hours
Estimating Tropical Cyclone Swell Arrival Time with NWPS

- Period of deep water waves: 11 seconds
- Deep Water Wave equation:
  - Speed = 1.56 * Period
  - Speed = 1.56 * 11
  - Speed = 17 kts
- Time = Distance/Speed
  - Time = 662 nm/17 kts
  - Arrival Time = ~ 39 hours
NWPS Swell Height
NWPS Significant Wave Height in GFE

NWPS Period in GFE

NWPS Swell Height in GFE
NWPS Wave 4
Period in GFE
TAMUCC-CBI’s Artificial Neural Network Water Level Forecasts (ANN)

- One of the “more accurate” water level forecasts.
- Uses NAM winds.
- Tidal/Water levels in the Coastal Bend are forced mostly by wind.
  - Small astronomical influence
National Ocean Service’s **Northern Gulf of Mexico Operational Forecast System (NGOFS)**

- **Finite Volume Coastal Ocean Model (FVCOM)**
- Uses NAM winds.
- Inputs from RTOFS, ETSS, ADCIRC, USGS, and CO-OPS.
- Runs 4 times a day.
- Produces 0-48 hour forecasts of:
  - Water Levels
  - Currents
  - Water Temperature
  - Salinity
Global Real Time Ocean Forecast System (RTOFS)

- Based upon a global Hybrid Coordinates Ocean Model (HYCOM) at 1/12° resolution.
- Runs once a day.
- 2-day nowcasts.
- 6-day forecasts.
- Outputs variables such as:
  - **Currents (Used by NWPS)**
  - Water Temperature
  - Salinity
  - Sea Surface Height
  - Ice Thickness/Cover
  - Mixed Layer
Global RTOFS GS Location for 25-Feb-2016
12°C isoth at 400m and SSH

NAVOCEANO for North Wall Hausdorff: NaN° Modified Hausdorff: NaN°
NAVEASTOCEANCENT for 01-MAR-16 North Wall Hausdorff: 4.97° Modified Hausdorff: 1.19°

For the Hausdorff metrics, the RTOFS front was trimmed to approximately the region of the Navy fronts.
RTOFS Gulf Current Forecast
Extratropical Surge and Tide Operational Forecast System (ESTOFS)

- Uses the ADCIRC model.
- Runs 4 times a day out to 180 hours.
- 2.5 km resolution.
- Uses GFS winds and pressure.
- Outputs:
  - Storm Surge Plus Tide (Used by NWPS)
  - Storm Surge
  - Tide
- NOT to be used for Tropical Cyclones.
ESTOFS Tide in GFE

ESTOFS Storm Surge in GFE
MDL’s ExtraTropical Storm Surge (ETSS or ET-SURGE)

- Based upon SLOSH.
- Runs 4 times a day out to 96 hours.
- 5 km resolution.
- Uses GFS winds and pressure.
- Outputs Storm Surge only.
  - Areal
  - Point
- NOT to be used for Tropical Cyclones.
ETSS Point Output
http://slosh.nws.noaa.gov/etsurge/

Port Aransas, TX: 03/01/2016 3:19 PM CST

Feet relative to MSL

HAT 2
MHHW 1
MSL 0
MLLW -1
ETSS Storm Surge in GFE
MDL’s SLOSH

- **Sea, Lake, and Overland Surges from Hurricanes**
  - Began in the late 60s/early 70s.
  - Estimate storm surge from historical, hypothetical, and/or predicted hurricanes.
  - Factors affecting storm surge are incorporated.
  - Run on specific basins.
Factors Affecting Storm Surge

- Intensity
- Size (Radius of Maximum Winds)
- Central Pressure
- Forward Speed
- Angle of Approach
- Width and Slope of Shelf
- Shape of Coastline
- Local Features
  - Bays, rivers, islands, sounds, inlets
Operational Storm Surge Basins for the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Model
Updated: June 1, 2014
SLOSH Strengths

- Flow through barriers, gaps, and passes.
- Inland inundation.
- Overtopping of levees.
- Astronomical tide.
- Computationally efficient.
- Ensemble Approach.
SLOSH Limitations

- Does not account for Wave action.
  - Wave Setup or Runup

- Does not account for Freshwater Flow.
  - Rivers
  - Rainfall

- **Total Water = Storm Surge + Tides + Waves + Freshwater Flow**
SLOSH Products

- Maximum Envelopes Of Water - MEOWs
- Maximum Of the MEOWs - MOMs
- Probabilistic Storm Surge - P-Surge
Maximum Envelopes of Water (MEOW)

User selects:
1) Category (Cat 3)
2) Landfall direction (wnw)
3) Forward speed (15 mph)
4) Initial tide (High)

[Map showing coastal areas with water levels indicated, including a box highlighting 13.8 ft.]
Maximum of the MEOWs (MOMs)

User selects:
1) Category (Cat 3)

14.7 ft.
Probabilistic Storm Surge (P-Surge)

- Based on the official NHC forecast.
- Incorporates cross-track, along-track, and intensity historical errors.
- Incorporates different storm sizes.
- Potentially, thousands of hypothetical storms are produced.
Cross-Track Error
P-Surge Products

• **Probability product**
  • Probability of storm surge greater than \( X \) feet.

• **Exceedance product**
  • Storm surge value exceeded by \( Y\% \) of storms.
Inundation

- (Storm Surge + Astronomical Tide) - Elevation = \textbf{Inundation}

Storm Tide

- (15 ft Storm Surge + 1 ft Tide) - 10 ft Elevation = \textbf{6 ft Inundation}

- \textbf{Probabilistic Hurricane Inundation Surge Height} - \textbf{PHISH}
Vertical Datums for Bob Hall Pier

Difference between NAVD88 and MSL Across W Gulf is ~ 0.50 foot
Storm Surge Plus Tide
10% Exceedance Height (NAVD88)
Inundation 10% Exceedance Height (AGL)
Probability $>3$ feet of Storm Surge Plus Tide
When is P-Surge Available?

- Whenever a hurricane watch/warning is in effect.
  - Some tropical storm watch/warnings, too.

- Available 30 minutes after the NHC advisory.
  - 430 AM/PM CDT.
  - 1030 AM/PM CDT.
How do I interpret P-Surge?

Why is P-Surge better than using a single deterministic solution?
Actual Hurricane Track 30 mi. E of -12 hr. Advisory Forecast Track

TRACK FORECAST

ACTUAL TRACK

133 mph, 933 mb.
Real-time (Deterministic) SLOSH run shows limited surge threat to Pensacola area

Surge Based on NHC - 12 hr. Advisory
Probabilistic product shows considerable surge threat to Pensacola area.
Actual storm caused highest surge in Pensacola area
Questions?