NOAA's Recent Test, Evaluation, and Operational Use of Microwave Radar Water Level Sensors

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Center for Operational Products and Services (CO-OPS)

MTS TechSurge: Technical Support for Coastal Resiliency

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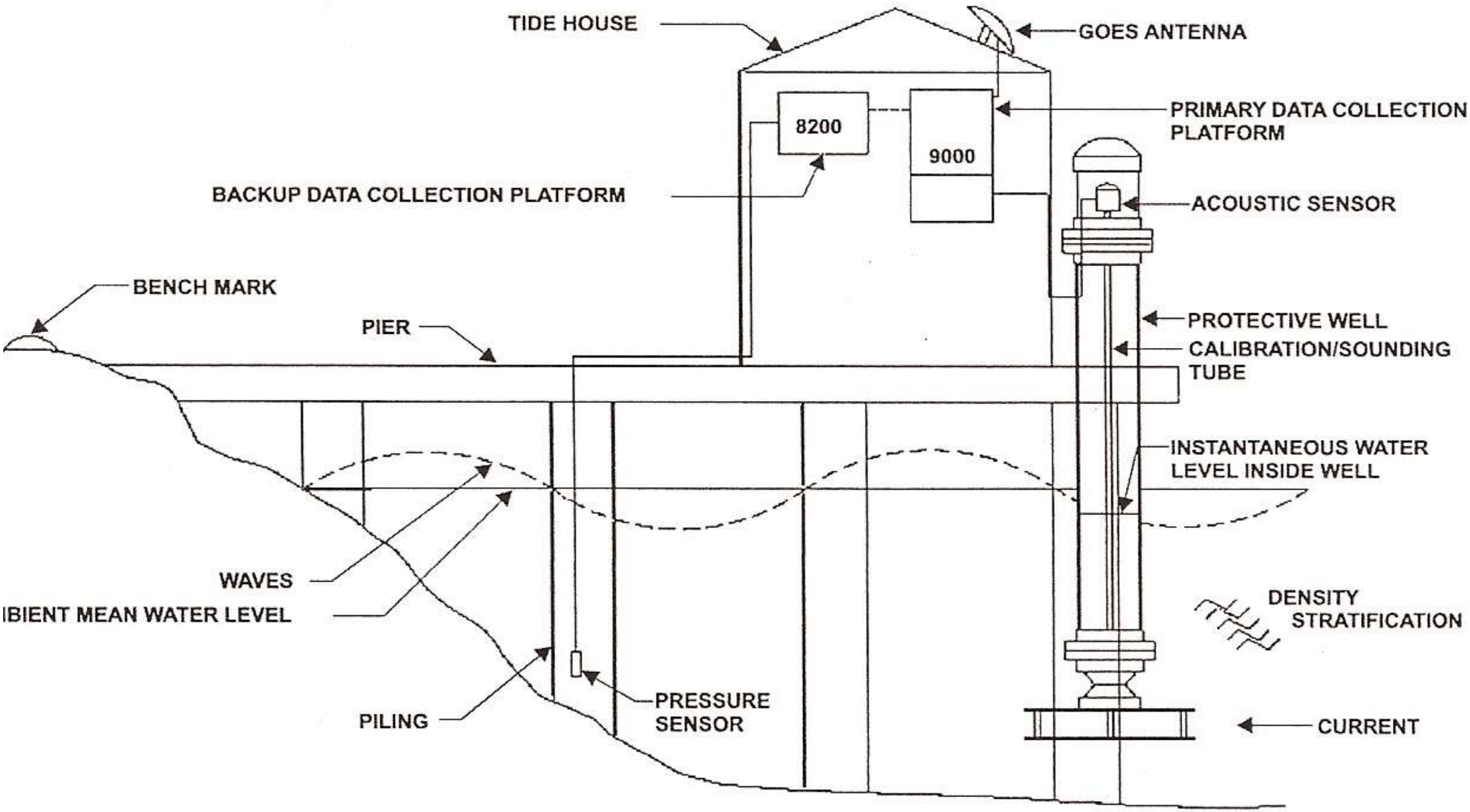
NOAA/NOS/CO-OPS

- **Center for Operational Oceanographic Products and Services**
  - ***Monitor and assess the U.S. coastal environment***
  - ***Distribute real-time ocean/met observations, analysis products, forecasts***
    (CO-OPS website: tidesandcurrents.noaa.gov)

- **Three major coastal observatory systems**
  - ***National Water Level Observation Network (NWLON)***
  - ***Physical Oceanographic Real-Time Systems (PORTS®)***
  - ***National Current Observation Program (NCOP)***

Typical NWLON Water Level Station



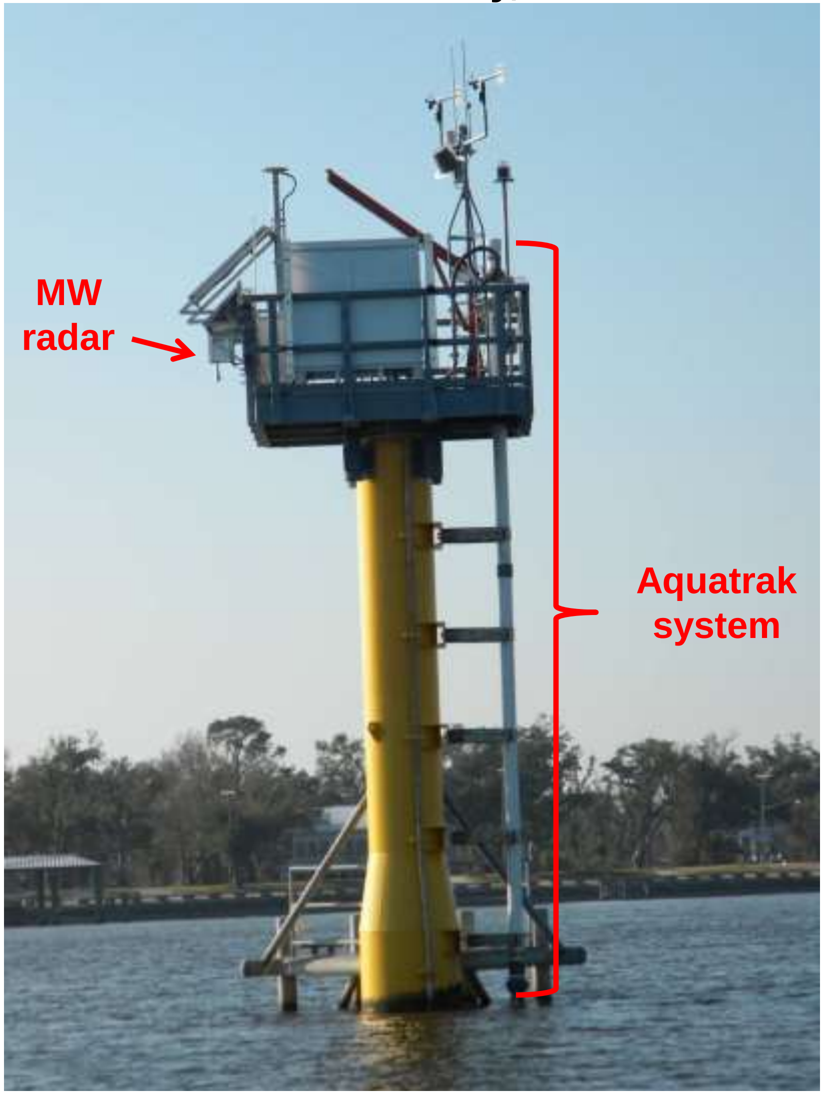
Advantages of Microwave Radar Technology

Aquatrak ®
acoustic sensor

Waterlog ®
microwave radar

Signal spread angle: 10º
Signal freq: 26 GHz
Pulse freq: 3.579545 MHz
Pulse period : 280 ns
Pulse width: 0.8 ns

NWLON 'Sentinel' station,
St. Louis Bay, MS



Background - *CO-OPS and Microwave Radar Water Level Sensors (MWWL)*

2000 – 2005 – Background research, development, and testing with MW radar bridge clearance measurement system for PORTS® ('Air Gap'). Declared operational 2005.

2005 -2008 – Air Gap system evolves, market survey of available MW radar sensors for water level continues. Related work conducted throughout the GLOSS community monitored.

2008 – 2010 - 4 COTS MW radar sensors selected, series of lab and field tests conducted. 4 field test sites: 1) Duck, NC 2) Port Townsend, WA 3) Fort Gratiot, MI 4) Bay Waveland, MS

Mar 2011 – Analysis and results of phase I MW radar water level testing reported. Results support transition to operations.

Jul 2011 - CO-OPS 1st operational MW radar water level systems installed in Mobile Bay, AL.

Sep 2011 – MWWL Transition to Operations Planning (TOP) committee formed. Detailed transition plan for 210 long term water level stations developed.

Oct 2011 – August 2013 – MW radar introduced at 21 different operational NWLON and PORTS® stations.

Aug 2013 – present – Phase II testing - 4 field sites in at NWLON stations in mid-high energy wave environments.

2014 - onward– 10-20 MWWL installed per year planned

2005, first gen 'Air Gap' , LA PORTS®

Phase I Lab and Field Testing
2008 - 2011

Laboratory Tests
- *Range verification*
- *Time response*
- *Wave tank*
- *Temperature chamber*
- *Waveguide*

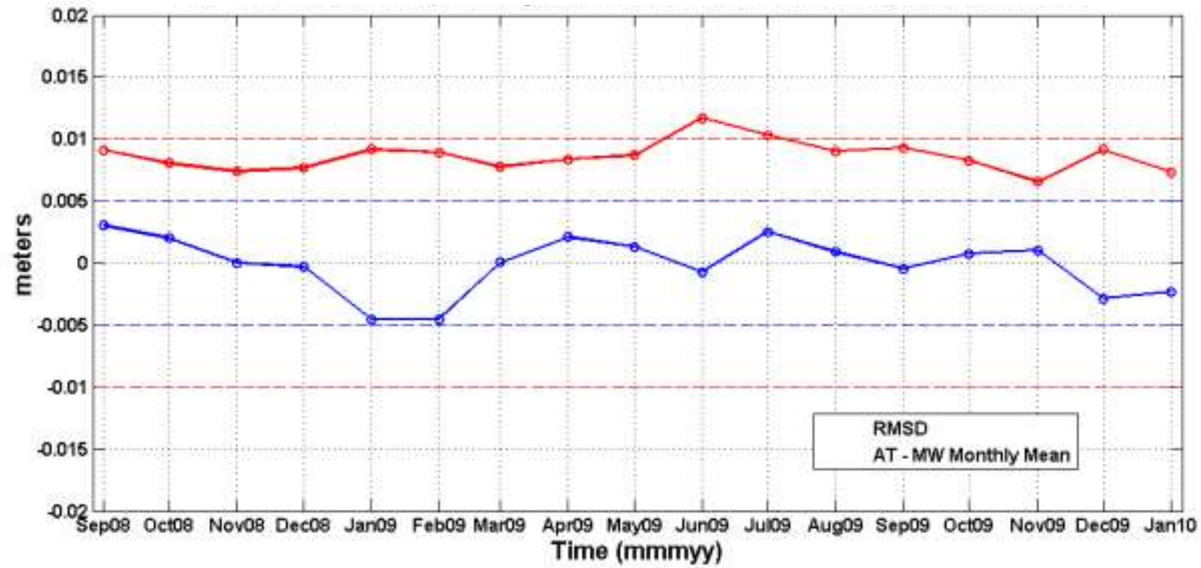
Five Field Tests
- *Port Townsend, WA*
- *Fort Gratiot, MI*
- *Bay Waveland, MS*
- *Money Point, VA*
- *Elizabeth River, VA*

Results from 2008 – 2011 support operational use in enclosed, low wave energy environments.

Wave Tank at NSWC, Carderock, MD

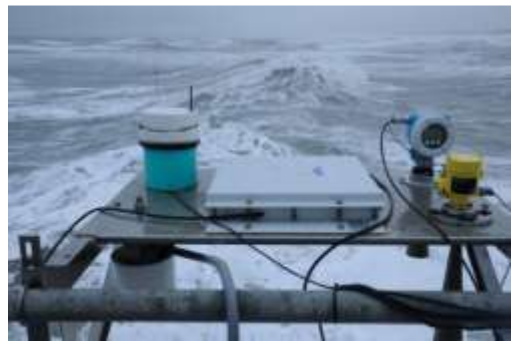
Temperature Chamber USGS HIF, Stennis, MS

Port Townsend - 18 month series of MWWL – NWLON average monthly differences,(blue) and RMSD (red)



Phase II Field Testing

- 2008-2011 test results included MWWL data collected at only one high wave energy environment – the NWLON station at USACE FRF, Duck, NC.
- Until recently, understanding measurement capabilities in high and intermediate wave energy environments was very limited.



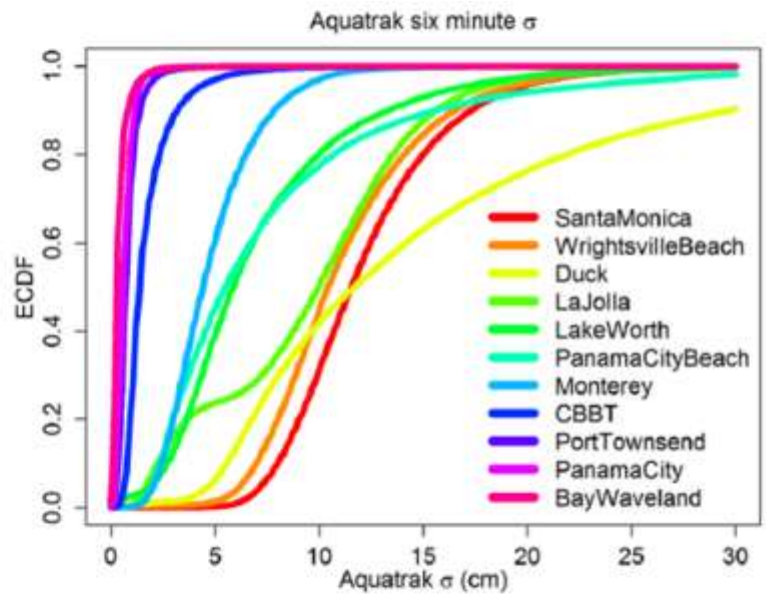
Phase II testing at 4 additional sites in medium-to-high wave energy regimes started Sep ’13.

Lake Worth, FL

Monterey, CA

La Jolla, CA

Duck, NC (reinstalled)



Phase II Field Test Results

Results from 1st several months of data at all 4 of the phase II field sites indicate:

- The majority of Aquatrak vs MWWL water level differences are due to systemic errors in the Aquatrak system including:
  - *Temperature induced speed-of-sound errors.*
  - *Wave & current induced hydraulic pressure errors.*
  - *Bouyancy driven water level resonance.*

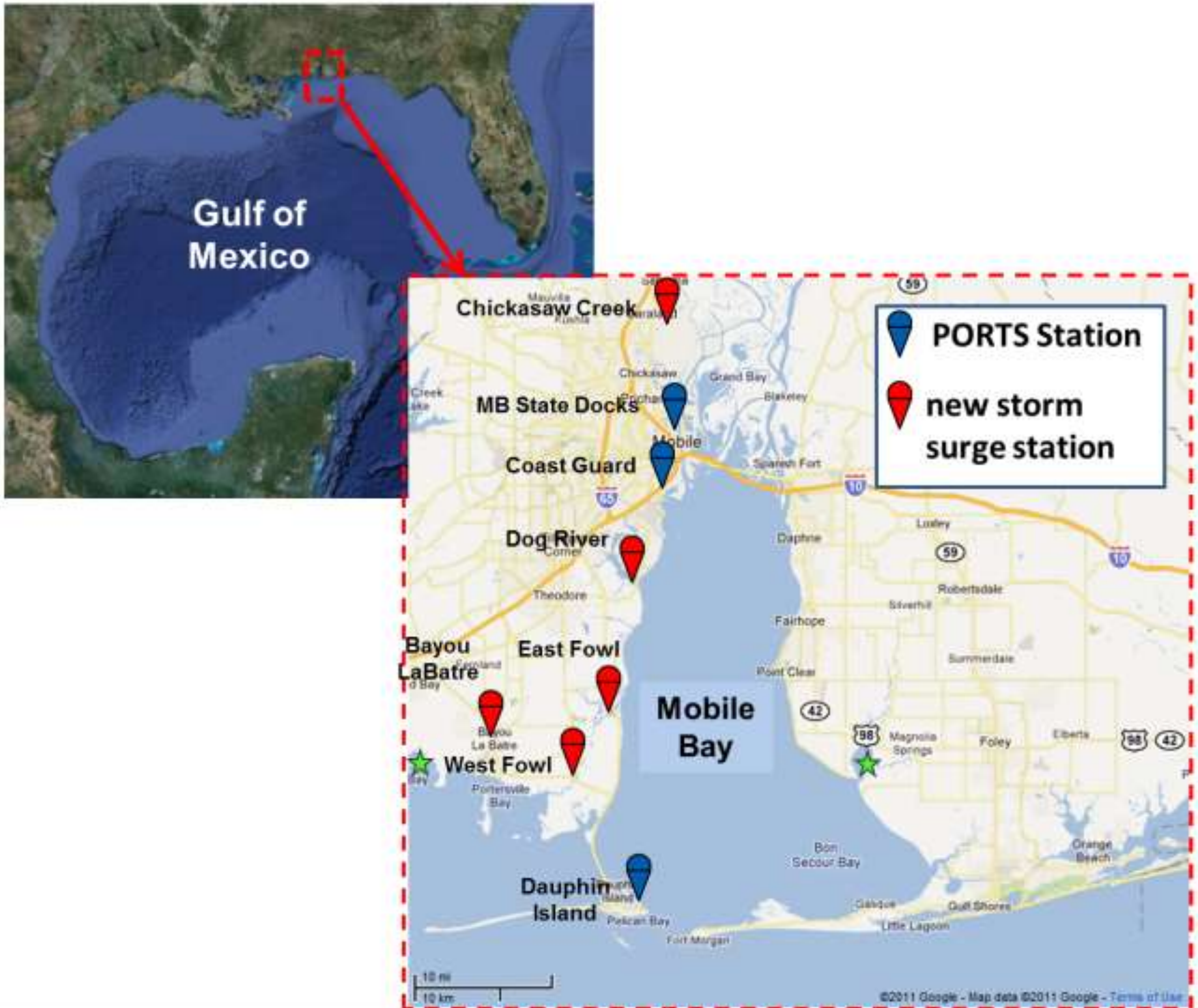
- MWWL captures water level variability with higher fidelity than the Aquatrak when waves are present.

- Further work is needed to attribute infragravity response differences, and differences that deviate from the draw-down model when waves are large.

- When temperature or wave forcings are present, the microwave sensor is a more accurate water level sensor than the Aquatrak.

1st Operational Installation – Mobile Bay

- CO-OPS 1st operational installations completed in July 2011, Mobile Bay, AL
- 5 new stations installed + 3 existing PORTS® stations – ***total of 8 stations***



1st Operational Installation – Mobile Bay

3 new stations atop bridges – ***Dog River, East Fowl River, West Fowl River***

2 stations on elevated platforms – ***Chickasaw Creek, Bayou LaBatre***

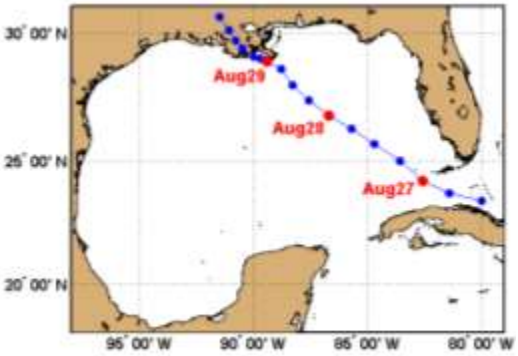
Bridge Installation
Dog River

Elevated Platform
Chickasaw Creek

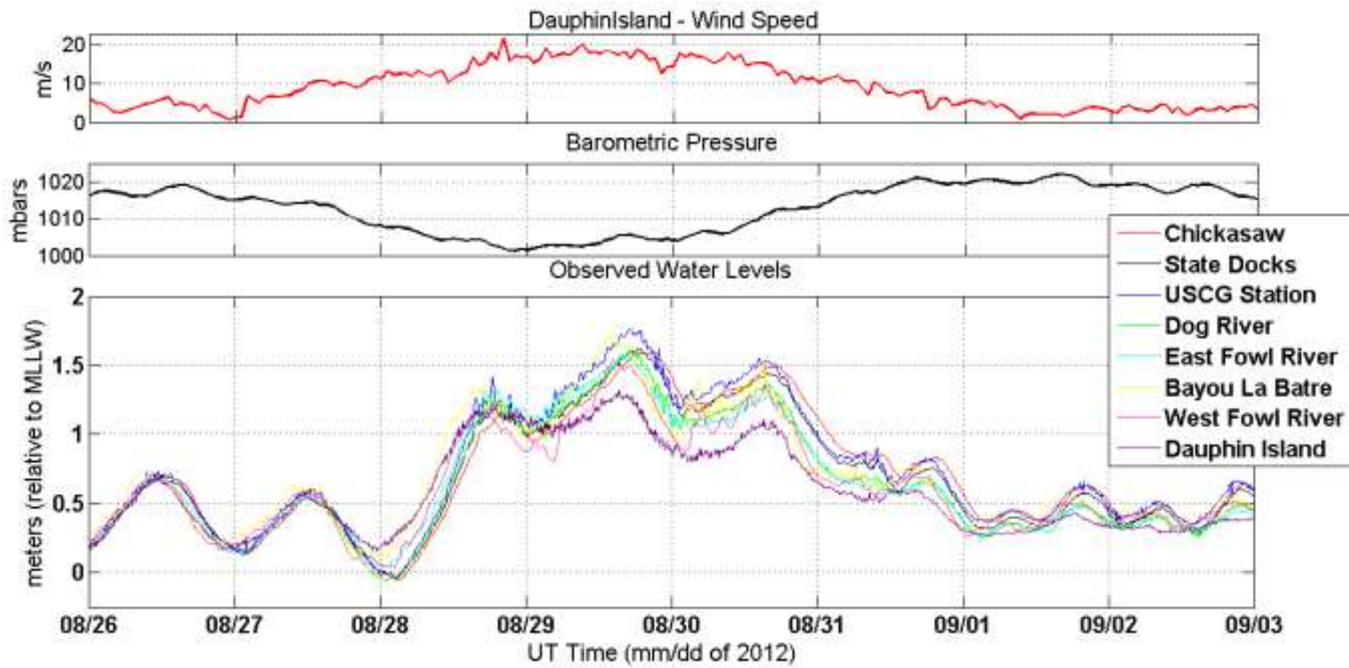
Example Storm Surge - Passage of Hurricane Isaac

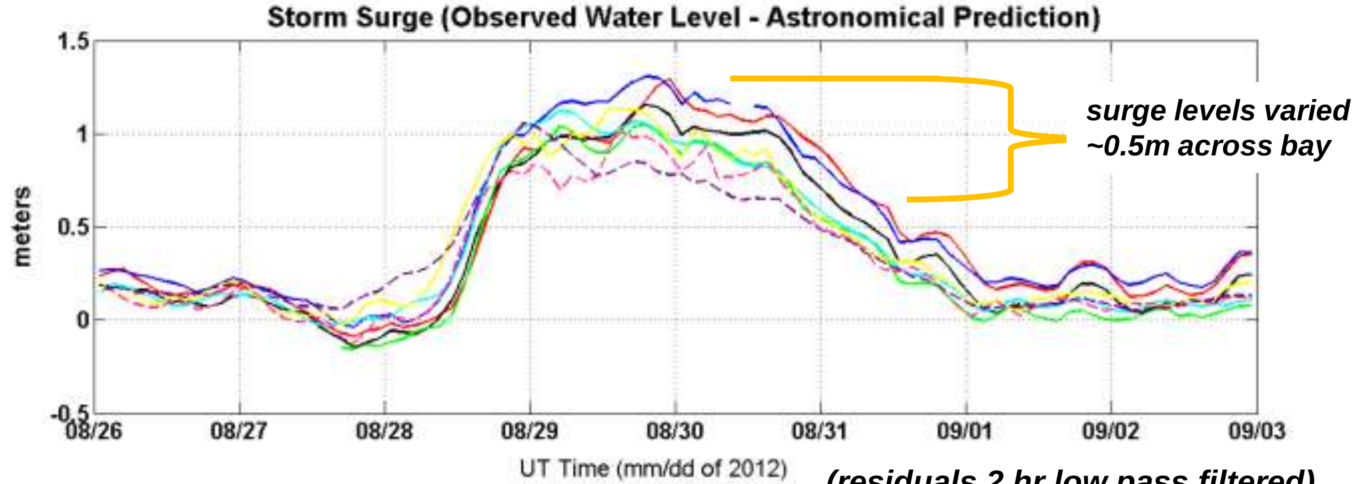
Aug 26 – Sep1, 2012

Storm Track (NOAA\NWS\NHC)



NASA Satellite Image 08/28/2012





(residuals 2 hr low pass filtered)

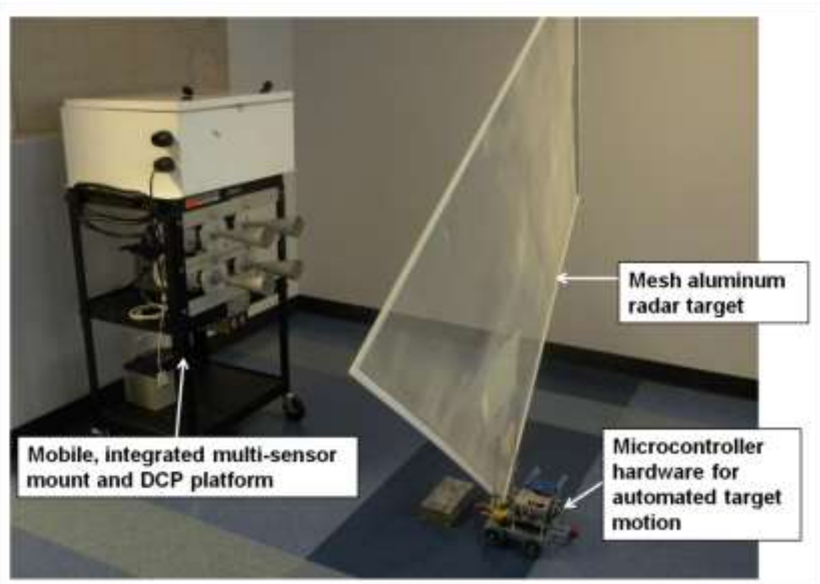
Supporting Transition to Operations

Pre-installation laboratory verification testing

5 step lab verification test procedure established:

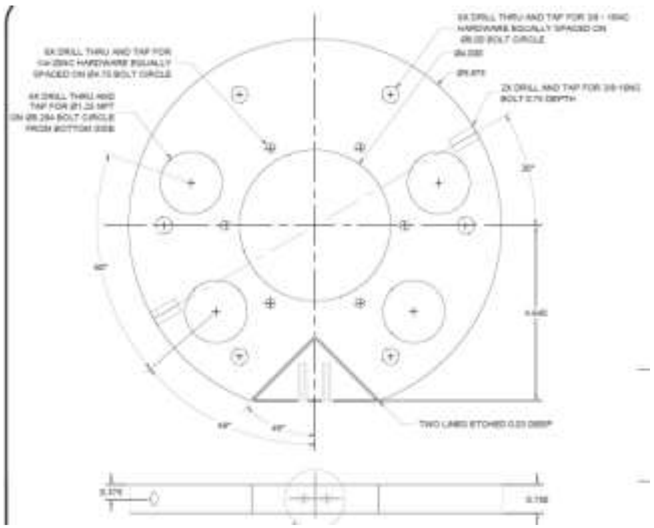
1) *Fixed Target - Resolution Verification*
2) *Sensor Offset Derivation*
3) *Time Response Verification*
4) *Dynamic Tanks Testing*
5) *Range Accuracy Verification (1-10 meters)*

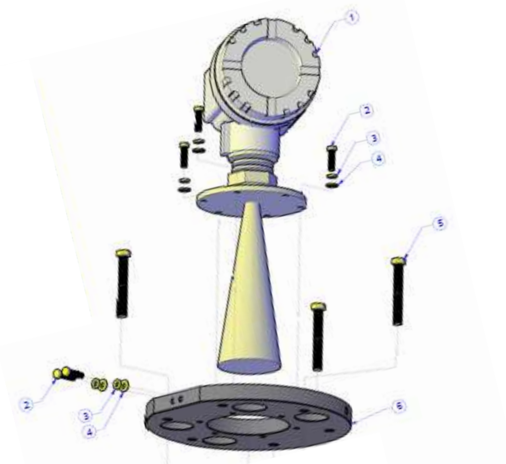
Continuing work to develop an automated & permanent test facility (Chesapeake, VA)

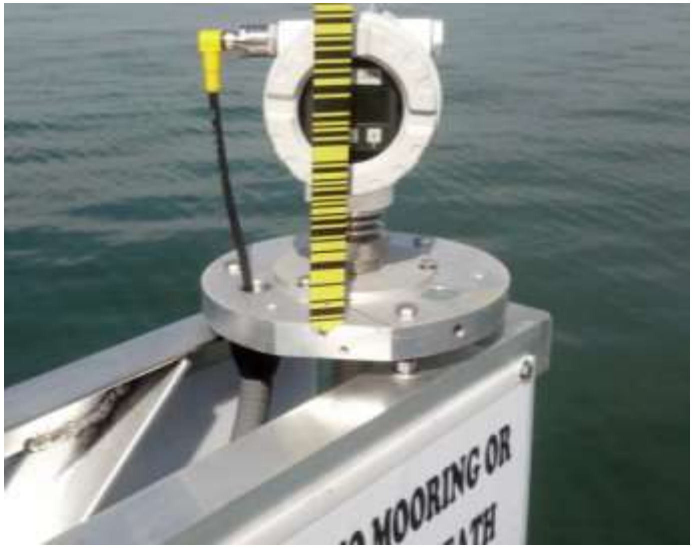


Supporting Transition to Operations

Continued development of mounts and survey methods







Transition to Operations Status

Since 2011, CO-OPS has transitioned MWWL sensors to operations in 3 categories of applications:

1. *Existing long-term NWLON stations.*
2. *Temporary stations supporting hydrographic survey and VDatum*
3. *Newly constructed or rebuilt stations (NWLON and PORTS)*

Since 2011, MWWL sensors have been installed at:

- *More than 20 short term stations (hydrographic and VDatum support)*
- *6 existing long term NWLON stations for 1 year overlap*
- *6 new long term stations*

10-20 NWLON stations per year planned to receive MWWL upgrade ; 3 year cycle per station.

- *Year 1- Equipment purchase, recon and design*
- *Year 2 – Installation of MWWL sensor and collection of 1 yr overlapping data record*
- *3rd year – Removal of legacy primary sensor and components (well)*

Summary

MWWL sensors offer many advantages for long term, water level observatories.

- *Small size, remote sensing, simple installation and maintenance.*
- *Low cost, low power*
- *Potential to measure non-directional wave stats*

CO-OPS phase I lab and field testing (2008-2011) led to preliminary transition to operations across NWLON and PORTS®, in low wave energy environments.

CO-OPS 1st operational MWWL installations were completed in Mobile Bay, AL, Jul 2011. Resulting network has provided valuable/unique observations across the bay.

Phase II field testing commenced Aug'13 (4 sites) to better understand MWWL sensor performance in mid-to-high energy wave environments.

1st Phase II test results show most Aquatrak vs MWWL water level differences are due to systemic errors in the Aquatrak; when temperature or wave forcings are present, MWWL is the more accurate sensor of the two.

CO-OPS continues to transition MWWL technology across NWLON with plans to install ~ 10-20 new systems per year.

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