High Accuracy Positioning Supports Ecosystem Science & Sea Level Change Impacts in the Gulf Coast and Beyond

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Why Millimeters Matter

• Small changes in elevation and sea levels can lead to large changes in flooding
  – Flooding causes damage to coastal communities and built infrastructure (e.g. roads, houses)
  – Changes in frequency and duration of inundation in natural environments can damage critical ecosystems
Why Millimeters Matter

• Most vertical changes occur on the scale of millimeters per year
  – subsidence
  – eustatic sea level rise
  – sedimentation & erosion
  – decomposition
  – biomass accumulation
- Processes can combine to cause centimeter per year scale changes

Subsidence
-6 mm/yr

Eustatic Sea Level Rise
+3 mm/yr

Grand Isle, LA
9.24 +/- 0.59 mm/yr

Source: NOAA
Why Millimeters Matter

• Small changes in elevation and sea levels can lead to large changes in flooding
• Most vertical changes occur on the scale of millimeters per year

Coastal habitats change in response to changing water levels
To better understand mechanisms of change, and to better respond to a changing environment, we need to be able to connect our habitat observations to local water levels at the millimeter scale
The National Spatial Reference System

• “Passive” marks
The National Spatial Reference System

- “Passive” marks
- Continuously Operating GPS Reference Stations (CORS)

Land Elevation Trend $= 1.1 \text{mm/yr}$
The National Spatial Reference System

- “Passive” marks
- Continuously Operating GPS Reference Stations (CORS)
- Gravity
- Hybrid Geoid
Vertical Datums & Reference Surfaces
Why Millimeters Matter

Correct height: correct hydrology → productive marsh

Surface too low: too much flooding → plant death → mud flat
National Water Level Observation Network (NWLon)
National Water Level Observation Network (NWLOMN)
<table>
<thead>
<tr>
<th>Elevation Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>PID: AT0687</td>
</tr>
<tr>
<td>VM: 817</td>
</tr>
<tr>
<td>Station ID: 8761724</td>
</tr>
<tr>
<td>Epoch: 2002-2006</td>
</tr>
<tr>
<td>Date: Mon Jan 21 22:23:22 EST 2013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Depth (feet/meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHHW</td>
<td>1.06 feet (0.322 meters)</td>
</tr>
<tr>
<td>MHW</td>
<td>1.05 feet (0.320 meters)</td>
</tr>
<tr>
<td>MSL</td>
<td>0.53 feet (0.163 meters)</td>
</tr>
<tr>
<td>MTL</td>
<td>0.53 feet (0.161 meters)</td>
</tr>
<tr>
<td>MLW</td>
<td>0.01 feet (0.003 meters)</td>
</tr>
<tr>
<td>MLLW</td>
<td>0.00 feet (0.000 meters)</td>
</tr>
<tr>
<td>NGVD29</td>
<td>-0.36 feet (-0.112 meters)</td>
</tr>
<tr>
<td>NAVD88</td>
<td>-0.65 feet (-0.198 meters)</td>
</tr>
</tbody>
</table>

- MHHW 0.322 m (above arbitrary station datum)
- NGVD 29 -0.112 m
- NAVD 88 -0.198 m

21 cm difference
8 cm difference
Problems with Subsidence

• Published elevations on “static” marks can be suspect over time.

Subsidence on bench mark W 191 in Biloxi MS from 1991 to 2009 (\approx 8 \text{ mm yr}^{-1})
Problems with Subsidence

Published elevations on "static" marks can be suspect over time.

NGS forces you to "accept risk" to get published heights.

Datasheets can be retrieved for one or more PIDs up to a limit of 200 PIDs.

In the box below type in one or more PIDs or load the PIDs from a file. (Max PIDs allowed = 200)

Warning

I have chosen to include suspect heights in my query as defined by NGS which currently includes parts of TX, LA, MS, AL, FL. I understand that these marks may be located in known or suspected areas that experience significant vertical motion due to subsidence, uplift, or other tectonic vertical motion. I also understand that in dynamic areas such as these, NGS warns against using superseded heights as control.

I understand the risk  CANCEL MY REQUEST
Problems with Subsidence

- Published elevations on "static" marks can be suspect over time.
- NGS forces you "accept risk" to get published heights.
- Concept of "epoch" tells you how old data are.

SURVEY DATASHEET (Version 1.0)

- PID: AT0685
- Designation: 8761724 TIDAL 11
- Stamplag: 11
- Stability: Monument will probably hold position well
- Setting: Massive retaining walls
- Mark Condition: 0
- Description:
  - Observed: 2007-10-13T13:29:00Z
  - Source: OPUS - page2 1209.04

- LAT: 26° 15' 33.27912" ± 0.001 m
- LON: -98° 57' 27.08133" ± 0.003 m
- MSL HT: -23.052 ± 0.003 m
- X: 4128.344 ± 0.003 m
- Y: -5585828.197 ± 0.002 m
- Z: 3008526.928 ± 0.002 m
- ORTHO HT: 0.922 ± 0.012 m

- SPC: 1702(L.A.S)
  --NORTHING: 3241665.357m 83578.743m
  -EASTING: 795651.723m 1133712.207m
  -CONVERGENCE: 1.48883859° 0.68792263°
  -POINT SCALE: 1.00006785 1.00000764
  -COMBINED FACTOR: 1.00006237 1.00001126

Contributed by:
- John Oswald and Associates, LLC

Directions:
- To here (nearest road)
Problems with Subsidence

- Published elevations on “static” marks can be suspect over time
- NGS forces you to “accept risk” to get published heights
- Concept of “epoch” tell you how old data are
- Reference surfaces and datums need to be considered
So how do I get new & updated high accuracy positions?

• Height Modernization
  – Specialized survey techniques based on GPS but also combines leveling
  – Numerous states have successfully run “Height Mod” projects to update their heights
  – This is especially attractive for extending heights to areas not amenable to leveling (islands, wetlands)
So how do I get new & updated high accuracy positions?

2012 Gulf Coast Adjustment: up to 10 or more cm differences!
So how do I get new & updated high accuracy positions?

• Large, regional leveling campaigns – Long distance ensures consistent heights within area of interest – Repeat observations along existing level lines allow vertical rate determination – Connections to tidal bench marks allow for better modeling of regional sea surface topography (important in hydrodynamic models and datum transformation tools)
Sentinel Site Initiative

- National program to establish long term coastal ecosystem monitoring sites
- National Estuarine Research Reserve System (NERRS)
- National Park Service
- Regional Cooperatives
Sea Level Rise

Water Level Station

All observations on same vertical datum

Bench Marks with Geodetic Control (NAVD88, etc.)

Geodetic connection assures known gauge stability

Initial Wetland Surface

Surface Elevation Table (SET)

Depth of SET measurement integration

Deep Subsidence

Upland

Subsided Wetland Surface
NERRS Sentinel Site Initiative
Where do I start?

- NGS provides guidelines, training, and tools
  - Online webinars available from our website [ngs.noaa.gov](http://ngs.noaa.gov[science and education])
Where do I start?

• NGS provides guidelines, training, and tools
  – Online webinars available from our web site ngs.noaa.gov [science and education]
  – Corbin Training Center
Where do I start?

• Tidal Datums Training (NGS, CO-OPS, NERRS)
Where do I start?

- NGS provides guidelines, training, and tools
  - Online webinars available from our website ngs.noaa.gov
  - Corbin Training Center
  - NGS State/Regional Advisors
Guidelines (examples)

• For experienced technicians / surveyors
  – High accuracy geodetic leveling
  – High accuracy GPS-derived positioning
  – Height Modernization
Guidelines (examples)

• For technical professionals
  – Geospatial infrastructure for Sea Level Change Sentinel Sites
  – GPS-based heights on SETs
  – Tidal Datums Computations
  – SET guidelines
Ask a Surveyor!

• Florida: David Newcomer (david.newcomer@noaagov)
• Mississippi: Denis Riordan (denis.riordan@noaa.gov)
• Texas: Cliff Middleton (cliff.middleton@noaa.gov) & Daniel Prouty (dan.prouty@noaa.gov)
Questions?
Obtain CORS locations from CORS Map

www.ngs.noaa.gov/CORS/
Datasheet retrieval (NGS Integrated Database)

Data in the NGS IDB include both leveled heights and GSP derived positions.

The data have gone through a rigorous quality assurance and control process.
Note where to find orthometric height (NAVD88), and how it was obtained (via first order, class I leveling – the highest accuracy order/class)
This allows you to retrieve published positional information that has been obtained via GPS.

http://www.ngs.noaa.gov/OPUS/view.jsp
OPUS-DB Datasheet Retrieval
DSWORLD is a user-contributed software, available from NGS (http://www.ngs.noaa.gov/PC_PROD/PARTNERS/index.shtml) to retrieve data from both the NGS IDB and OPUS-DB. It can plot the data on Google Earth®.
Marks will be plotted in Google Earth®, and by clicking on a mark, you will get a pop-up box with identifying information and the link to the datasheet.