USGS Coastal 3DEP – Coastal National Elevation Database (CoNED) Status Report

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USGS

What is the 3D Elevation Program?

A call for action to…

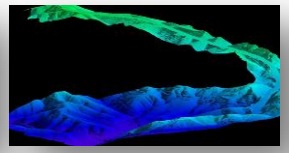
- Accelerate the acquisition of high quality light detection and ranging (lidar) data in the conterminous U.S. (CONUS), Hawaii, and the U.S. Territories; and interferometric synthetic aperture radar (ifsar) data in Alaska
- Completely refresh the National Elevation Dataset (NED) with new lidar and ifsar elevation data products and services
- Leverage collaboration among federal, states, local and tribal partners to systematically complete national 3D elevation data coverage in eight years
- Raise governance to the executive level and build on the structure already in place at the operational level under the National Digital Elevation Program (NDEP)
- Increase the overall investment in 3D elevation to $146 million annually to return more than $690 million annually in new benefits


Natural Resource Conservation


Infrastructure Management


Flood Risk Mitigation


Precision Farming


Land Navigation and Safety


Geologic Resources and Hazards Mitigation

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National Enhanced Elevation Assessment

At a Glance

- Sponsored by the National Digital Elevation Program (NDEP) and funded by USGS, NGA,FEMA, NRCS and NOAA to:
  - Document national requirements for lidar and ifsar data
  - Estimate the benefits and costs of meeting these requirements
  - Evaluate multiple national program scenarios considering data quality, update frequency, geographic coverage and to optimize benefits
- 602 mission-critical activities that require enhanced elevation data were identified by:
  - 34 Federal agencies and 50 states
  - A sampling of local governments, tribes, private and not-for profit organizations
- **A national program has the potential to generate $1.2 billion to $13 billion in new benefits each year**

Benefits for Top Business Uses

Rank		Annual Benefits	
		Conservative	Potential
1	Flood Risk Management	$295M	$502M
2	Infrastructure and Construction Management	$206M	$942M
3	Natural Resources Conservation	$159M	$335M
4	Agriculture and Precision Farming	$122M	$2,011M
5	Water Supply and Quality	$85M	$156M
6	Wildfire Management, Planning and Response	$76M	$159M
7	Geologic Resource Assessment and Hazard Mitigation	$52M	$1,067M
8	Forest Resources Management	$44M	$62M
9	River and Stream Resource Management	$38M	$87M
10	Aviation Navigation and Safety	$35M	$56M
:			
20	Land Navigation and Safety	$0.2M	$7,125M
	Total for all Business Uses (1 – 27)	**$1.2B**	**$13B**

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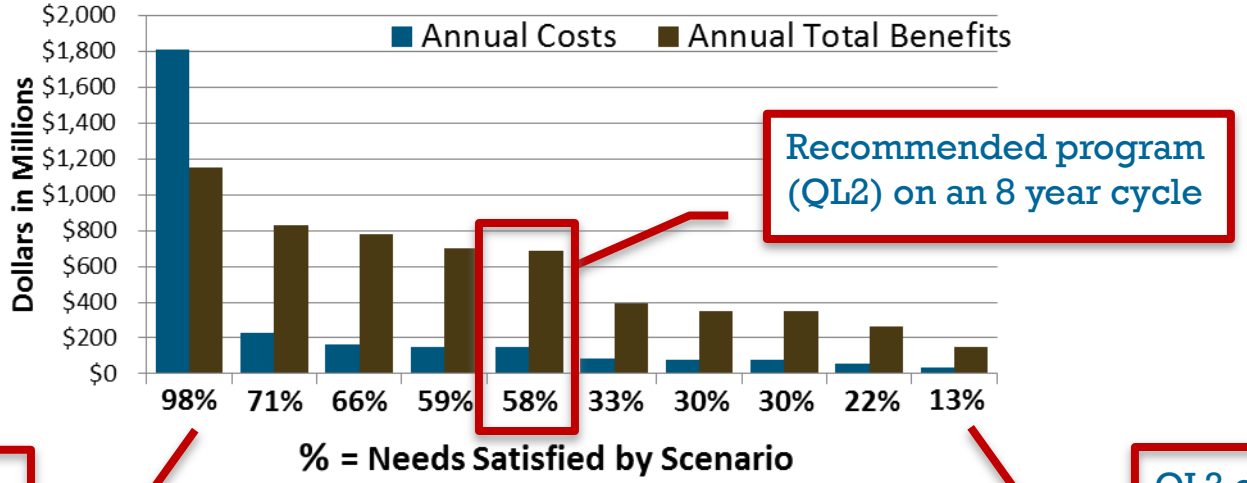
National Program Recommendation

Multiple Scenarios Considered

- Average annual costs: $146M
- Average annual benefits: $690M
- Average annual net benefits: $544M
- Benefit Cost Ratio - 4.7:1
- Total Benefits Satisfied: 58%



Recommended program (QL2) on an 8 year cycle

Highest quality level (QL1) on an annual cycle

QL3 on a 25 year cycle (closest to existing program)

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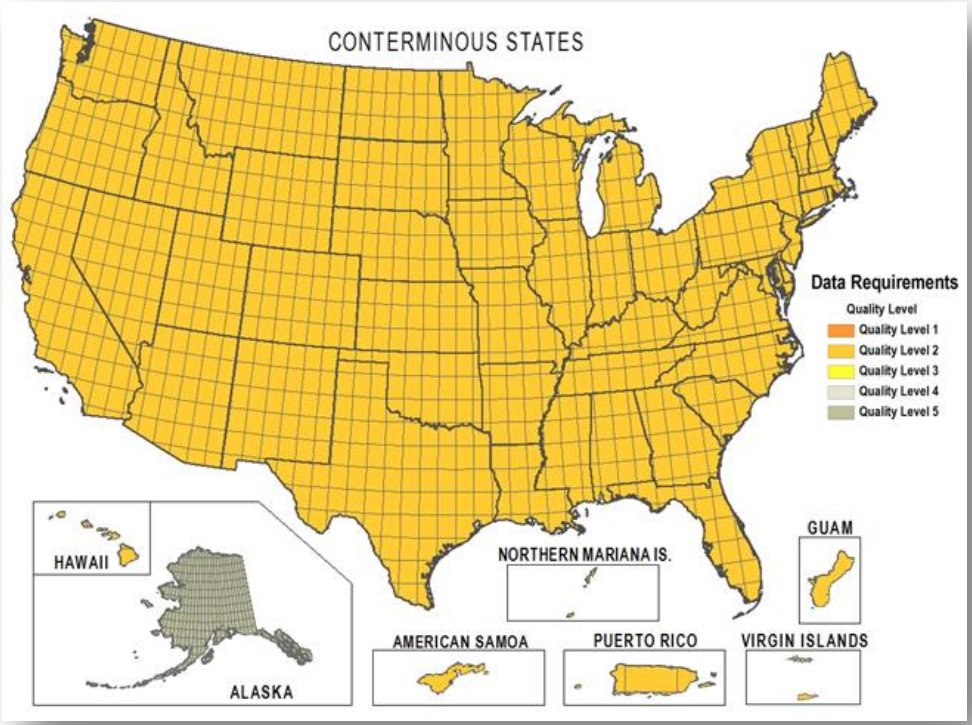
3D Elevation Program (3DEP)

Recommended Uniform Higher Quality



- QL2 lidar data for the conterminous United States, Hawaii, and the territories on an eight-year cycle (compared to QL3 commonly acquired to date)
- QL5 ifsar data for Alaska
- Lidar point cloud data and other products to be publically accessible
- Goal to be operational in early 2015

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3D Elevation Program

Quality Levels

Quality Level	Source	Vertical Accuracy RMSEz	Nominal Pulse Spacing (NPS)	Nominal Pulse Density (NPD)	DEM Post Spacing
QL1	Lidar	10 cm	0.35 m	8 points/sq. meter	1 meter
QL2	Lidar	10 cm	0.7 m	2 points/sq. meter	1 meter
QL3	Lidar	20 cm	2.0 m	0.7 points/sq. meter	3 meters
QL4	Imagery	139 cm	5 m	0.04 points/sq. meter	5 meters
QL5	Ifsar	185 cm	5 m	0.04 points/sq. meter	5 meters

3DEP Products and Services

Initial Products

Product	Planned Coverage on Release Date	Source(s)	Planned Product	Planned Availability and Product Release Dates
1 meter DEM	Partial Coverage U.S. and some Territories	Lidar	Tiles (TBD) by download	The National Map in January 2015 (new data) and TBD for pre-2014 data
5 meter DEM	Partial Alaska	Ifsar	Tiles (TBD) by download	Earth Explorer in October 2013, from The National Map in April 2014
1/9 arc-second DEM - legacy	Partial Coverage U.S. and some Territories	Lidar, Ifsar, Photogrammety	15 min block by download	The National Map now
1/3 arc-second DEM	CONUS, HI, some Territories, partial Alaska	Lidar, Ifsar, Photogrammety	1x1 degree block by download	The National Map now
1 arc-second DEM	CONUS, HI, AK and U.S. Territories	Lidar, Ifsar, Photogrammety	1x1 degree block by download	The National Map now
2 arc-second DEM	Alaska	Lidar and Ifsar, Photogrammetry	1x1 degree block by download	The National Map now
Elevation Point Query	CONUS, HI, some Territories, AK	1/3 arc-second, 1 arc-second in AK	Application service	The National Map now
Hillshade	CONUS, HI, some Territories, AK	1/3 arc-second, 1 arc-second in AK	Viewing service	The National Map now
5 to 120 foot Contours	CONUS, HI, some Territories, AK	1/3 arc-second, 1 arc-second in AK	1 degree block by download and viewing service	The National Map now

3DEP Products and Services

Source Data

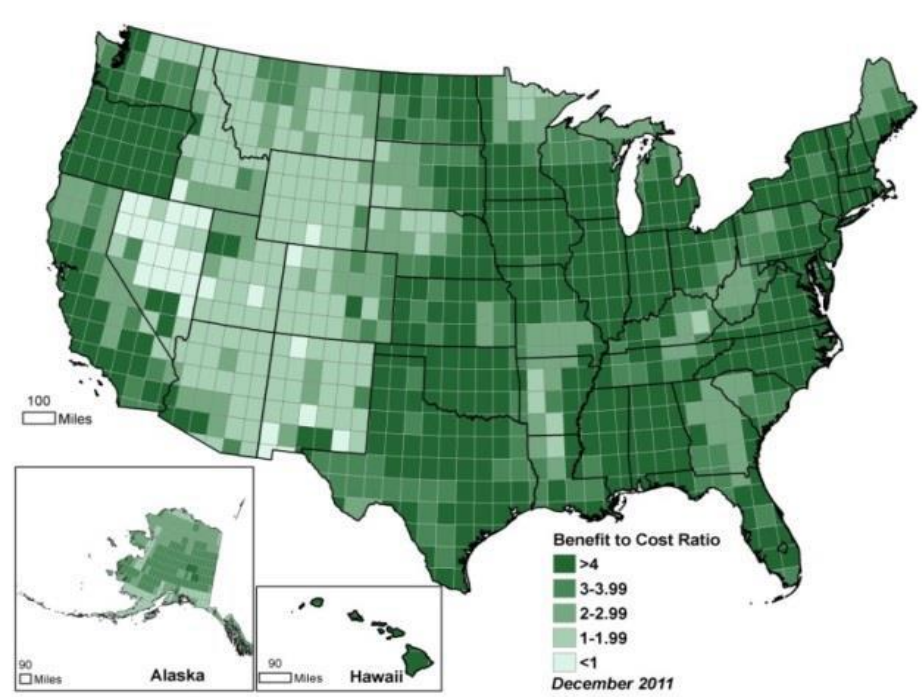
Source Data	Planned Coverage on Release Date	Source(s)	Planned Product	Planned Availability and Service Release Dates
Lidar Full Point Cloud - Unclassified	Partial Coverage – U.S.	Lidar – QL1, QL2, QL3	Project areas by special request	EROS by special request now (pre-2014 data) NGTOC now (data acquired 2014 and later)
Lidar Full Point Cloud - Classified	Partial Coverage – U.S.	Lidar - QL1, QL2, QL3	Project tiles by download	Earth Explorer now. The National Map in October 2014
Ifsar Digital Surface Model	Partial Coverage – Alaska	Ifsar – QL5	Project tiles by download	Earth Explorer now, The National Map in January 2015
Orthorectified Ifsar Intensity Image	Partial Coverage – Alaska	Ifsar – QL5	Project tiles by download	Earth Explorer now, The National Map in January 2015
Source resolution DEM	Partial Coverage U.S. and some Territories	Lidar, Ifsar	Project tiles by download	The National Map now (new data) and TBD for pre-2014 data

3DEP Budget Outlook

USGS Component

- **FY14 President's Budget** – USGS 3DEP increase of $9M plus $1M for Alaska ifsar; Omnibus resulted in $760K increase for Alaska and $1M in USGS Coastal Marine Geology for Coastal National Elevation Dataset
- **Endorsements** – 3DEP was endorsed or received letters of budget support from:
  - American Association of State Geologists (AASG)
  - American Association of Photogrammetry and Remote Sensing (ASPRS)
  - Association of State Floodplain Managers
  - Coalition of Geospatial Organizations (COGO)
  - Management Association of Private Photogrammetric Surveyors (MAPPS)
  - National Geospatial Advisory Council (NGAC)
  - National Society of Professional Surveyors (NSPS)
  - National States Geographic Information Council (NSGIC)
- **FY15 President's Budget** – USGS 3DEP $5M, Alaska Mapping $236K, Ecosystems: Columbia River $350K and Puget Sound $450K
- **National Academy of Public Administration (NAPA) report** - The November, 2013 report entitled **"FEMA Flood Mapping: Enhancing Coordination to Maximize Performance"** included the following recommendation:

  "The Office of Management and Budget should use the 3DEP implementation plan for nationwide elevation data collection to guide the development of the President's annual budget request."

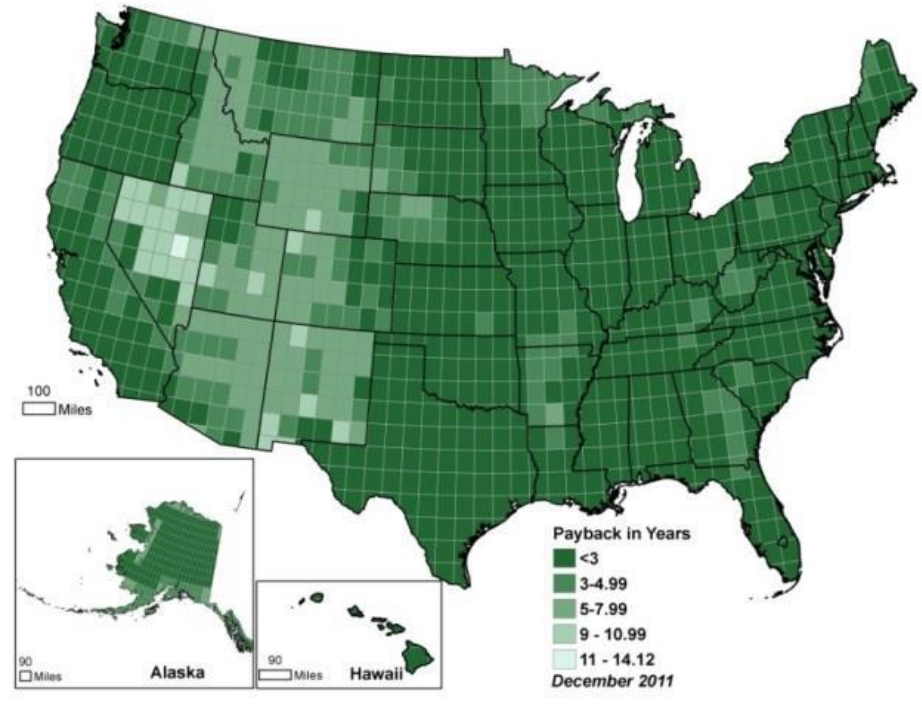


The National Enhanced Elevation Assessment determined that coastal zone lidar mapping investments have a:

- High benefit to cost ratio
- Short payback time

Two Outcomes of the National Enhanced Elevation Assessment:

- Initiation of the 3D Elevation Program
- Redefinition of the CoNED Project as the coastal component of the 3DEP



Regional (to national) coastal zone lidar collection and assimilation for scientific (and other) applications:

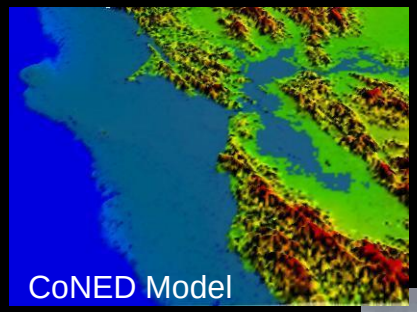
The Coastal National Elevation Database Applications (CoNED) Project

Goal: To systematically construct the coastal component of the 3DEP as topobathymetric elevation models first built over key coastal regions with highly vulnerable infrastructure and natural resources.

Alaskan North Slope

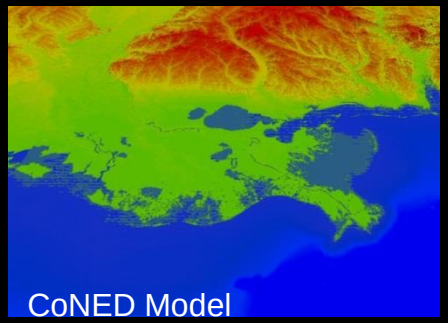
Hx Sandy Impact Northeast Region

San Francisco Bay

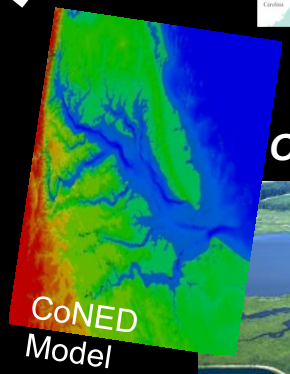


Resilience Issues:
Earthquakes
Tsunamis
Sea Level Rise
Habitat Quality

Northern Gulf of Mexico



Resilience Issues:
Wetland Loss
Storm Surge
Sea Level Rise

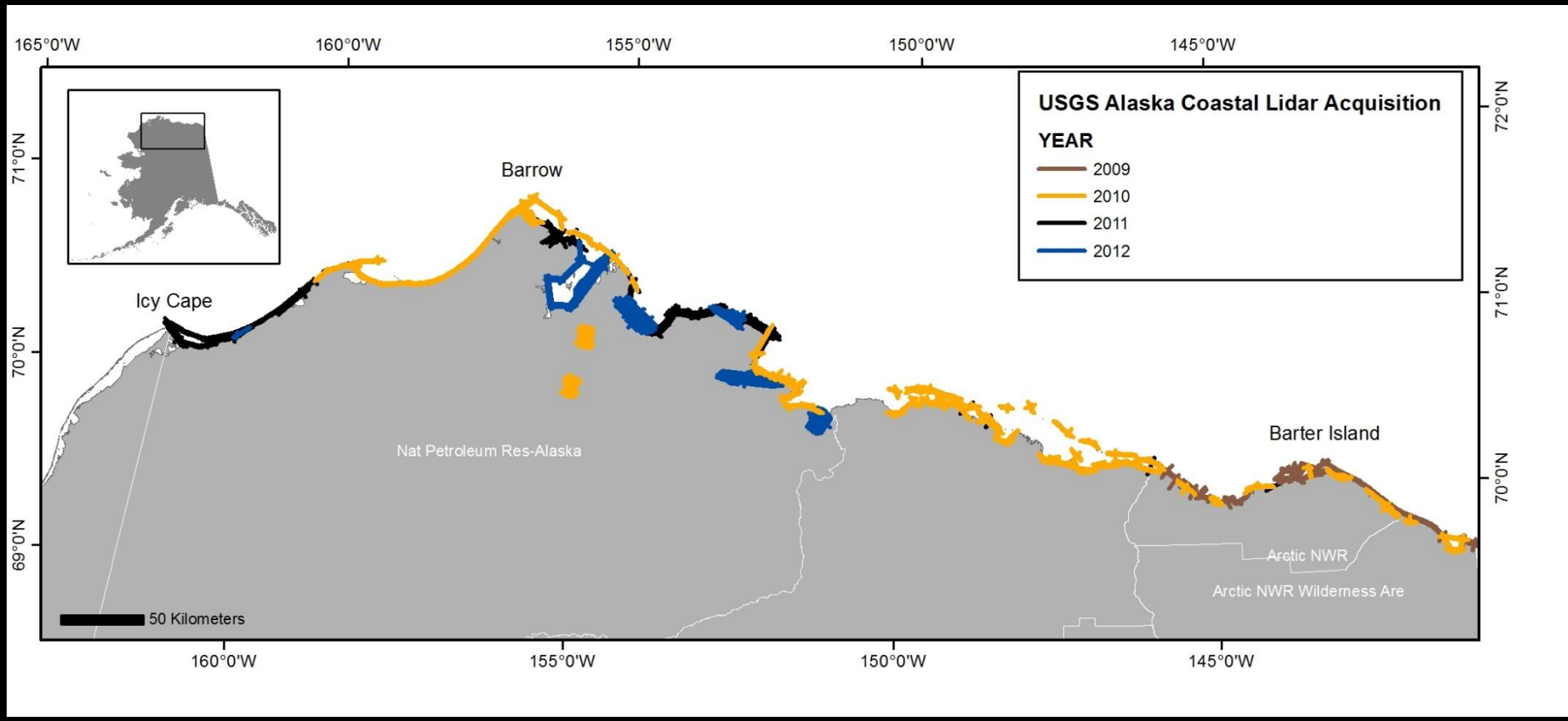


Chesapeake Bay

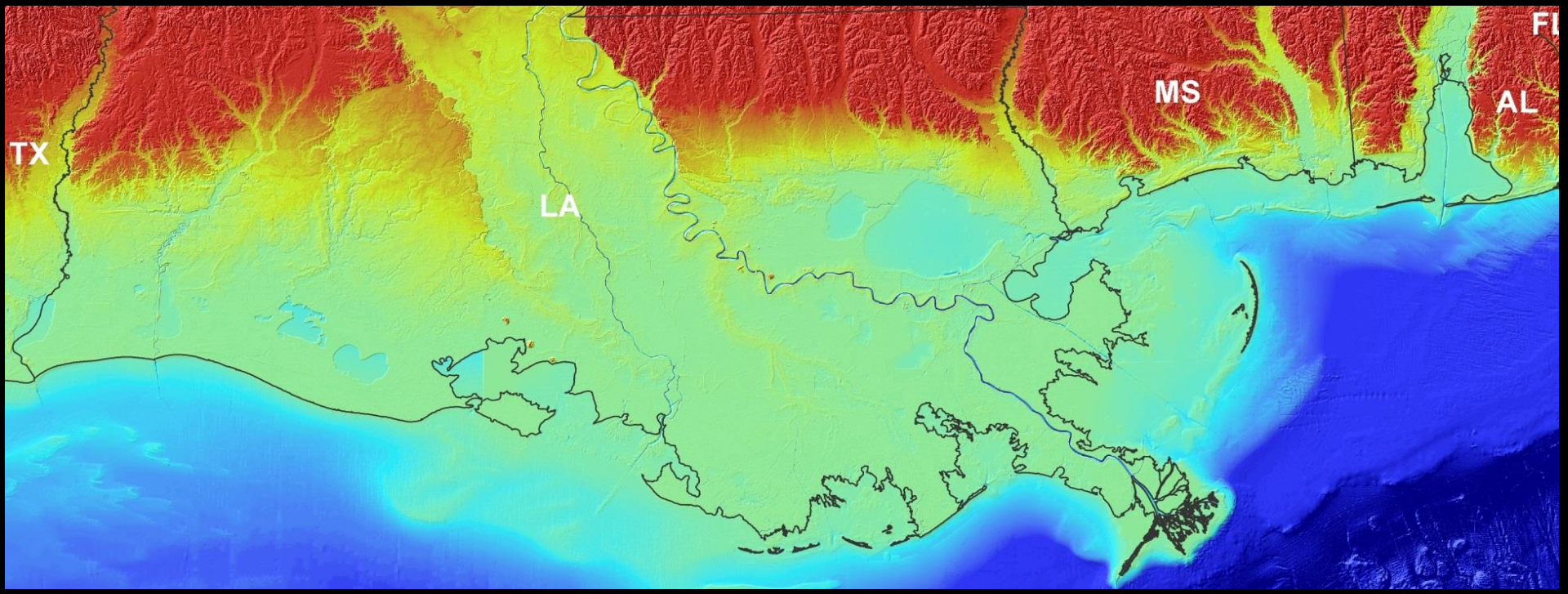
Resilience Issues:
Water Quality
Habitat Quality
Sea Level Rise

Alaskan North Slope CoNED Progress

- **7,119 line-km (~ 11 K km^2) acquired between 2009 and 2012**
- **Icy Cape to the US-Canadian Border**
- **Mainland coast and barrier islands (limited delta and estuary ; FWS-ALCC)**
- **Waterline to approximately 1.5 km inland; 2-4 overlapping passes**
- **~ 1m point spacing, 30 cm vertical accuracy (0.14 RMSE)**
- **Funding : *USGS NGP, CMG Program, Alaska Science Center; USFWS-ALCC; BLM***



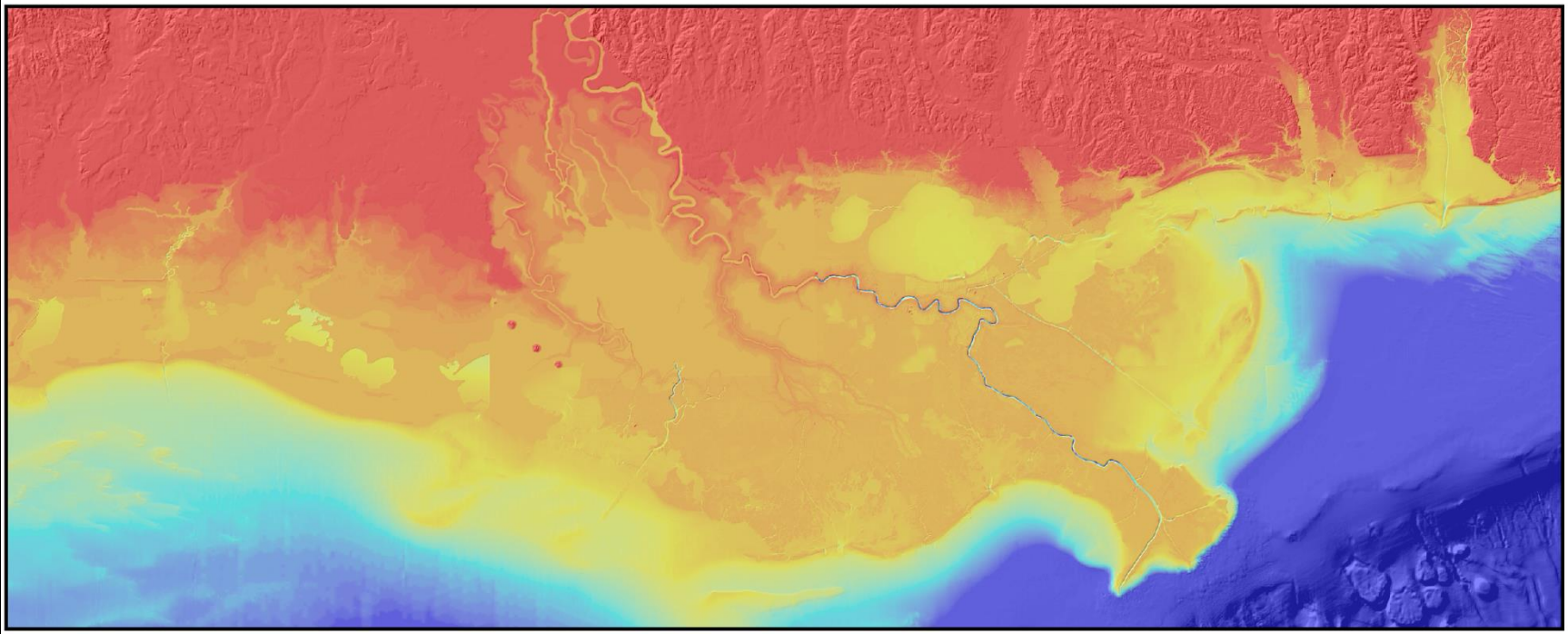
Louisiana CoNED Version 1.0



Integrated Topobathymetric Model:

Raster Size = 65 Gigabytes, 82,842 rows X 206,733 columns
Elevation Range: -2358 to 171 meters NAVD88
Temporal Date Range: 1888 - 2013
Incorporates over 150 separate topographic and bathymetric datasets

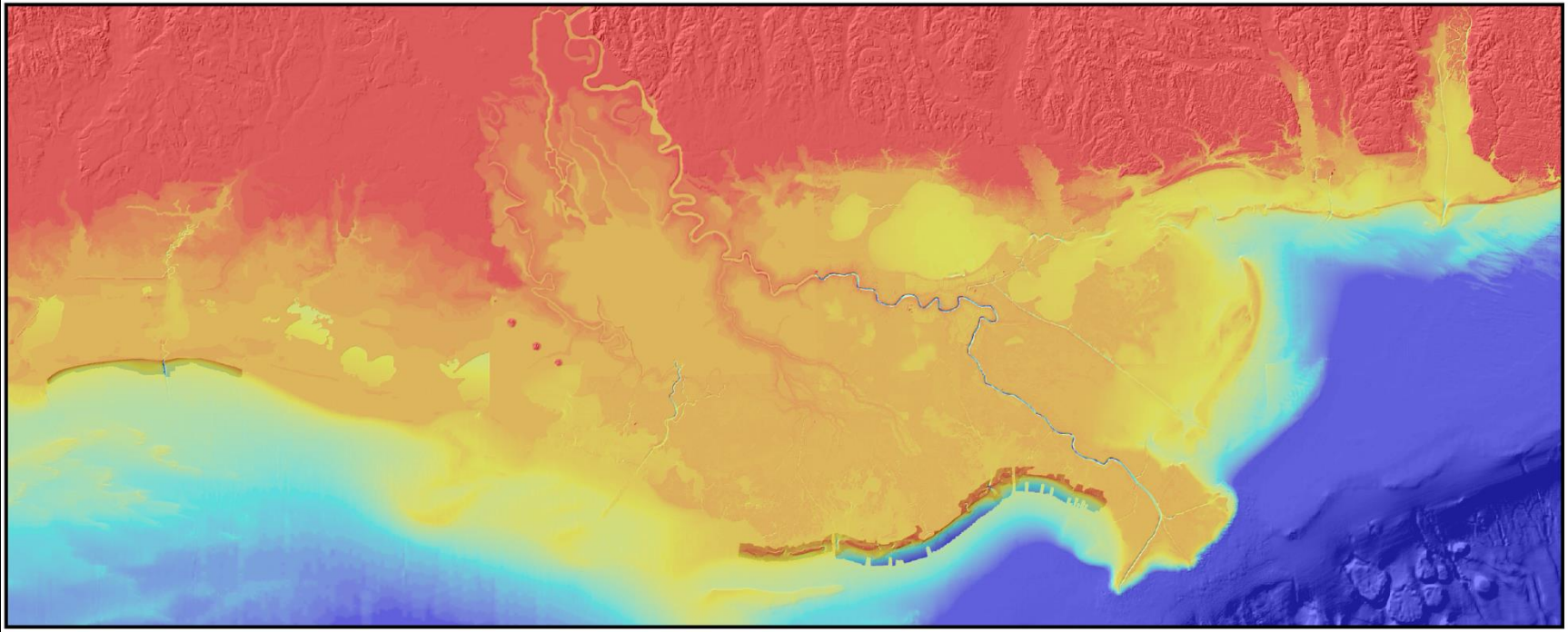
Southern Louisiana Topobathymetric Elevation Model Data Sources



9) NOAA low & medium res topobathy

USGS

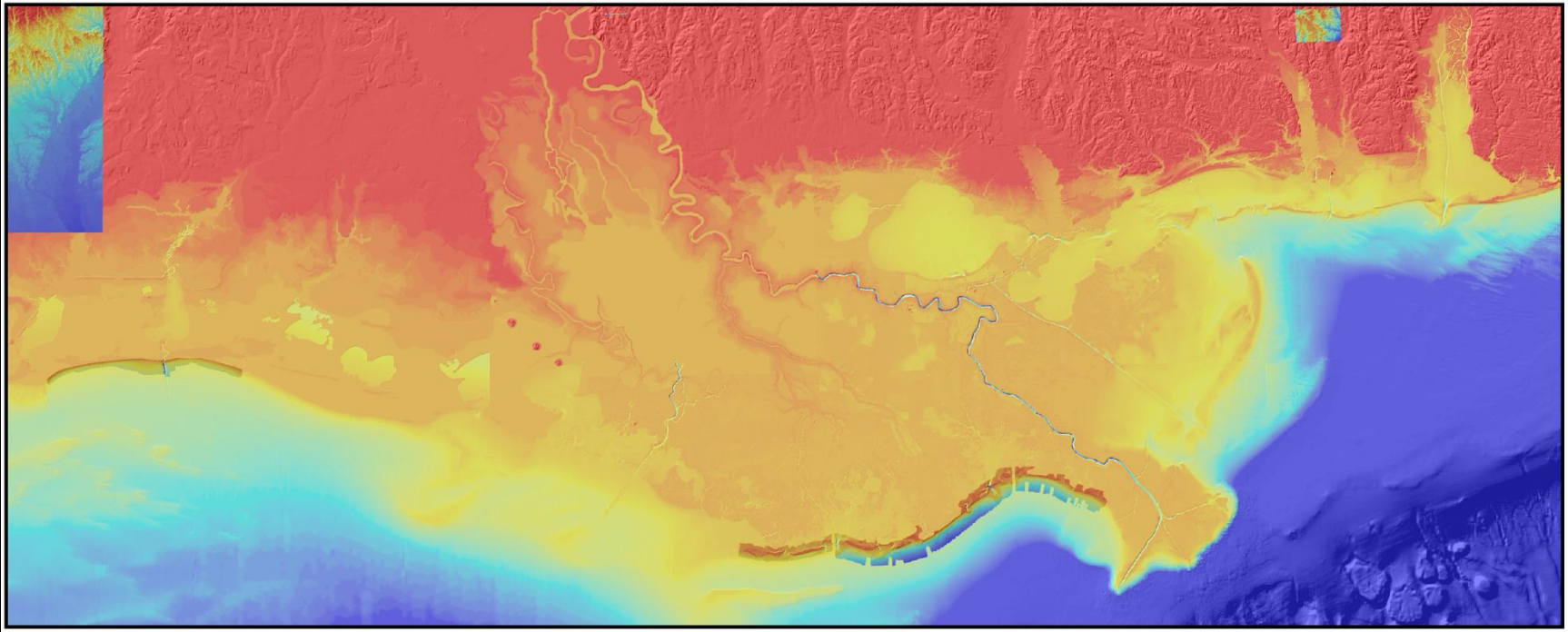
Southern Louisiana Topobathymetric Elevation Model Data Sources



8) BICM bathy
9) NOAA low & medium res topobathy

USGS

Southern Louisiana Topobathymetric Elevation Model Data Sources



7) NED 1/3"
8) BICM bathy
9) NOAA low & medium res topobathy

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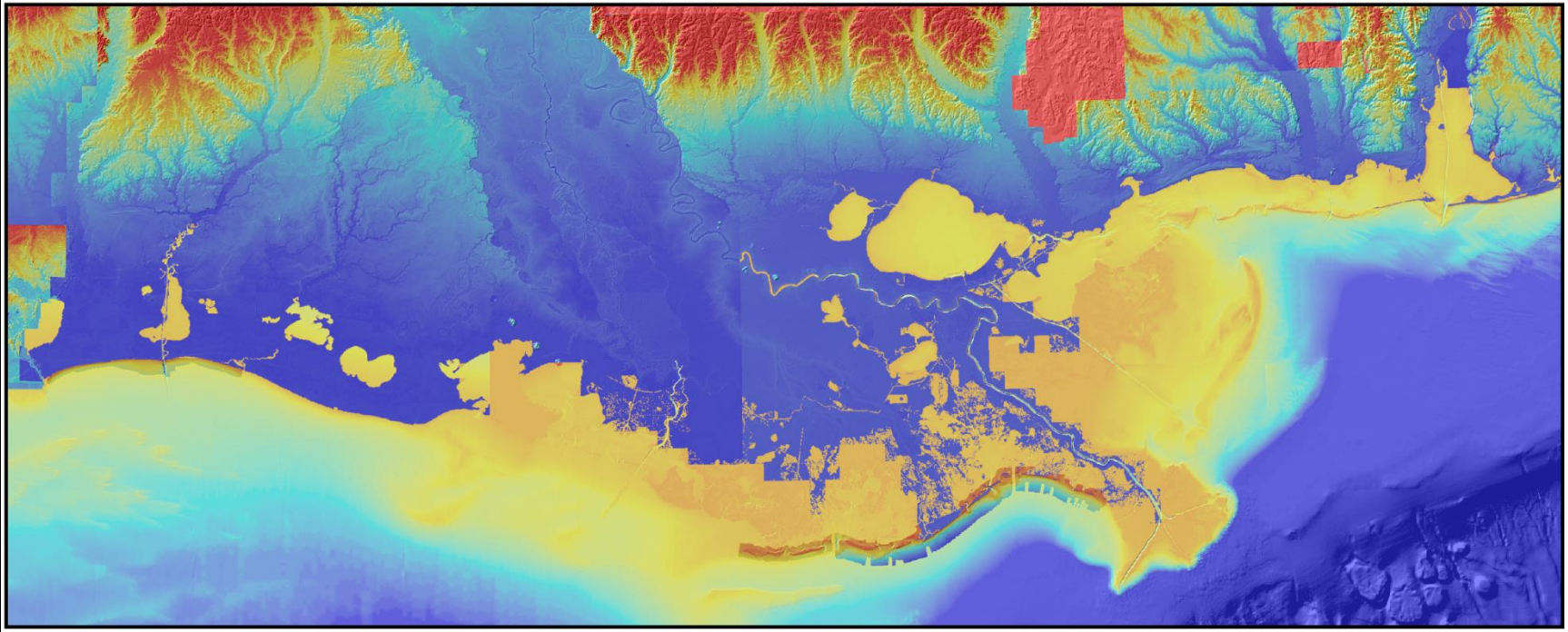
Southern Louisiana Topobathymetric Elevation Model Data Sources



6) NED 1/9" & lidar mosaics
7) NED 1/3"
8) BICM bathy
9) NOAA low & medium res topobathy

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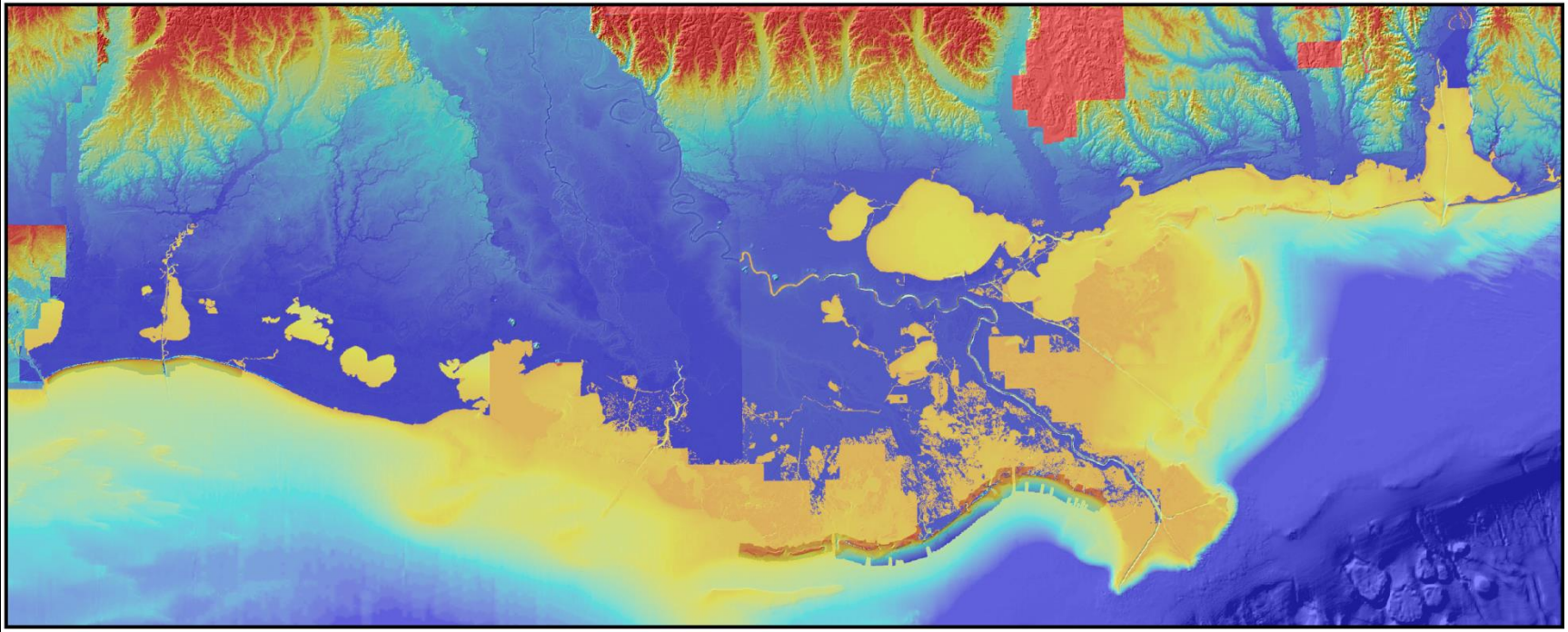
Southern Louisiana Topobathymetric Elevation Model Data Sources



5) BICM topo
6) NED 1/9" & lidar mosaics
7) NED 1/3"
8) BICM bathy
9) NOAA low & medium res topobathy

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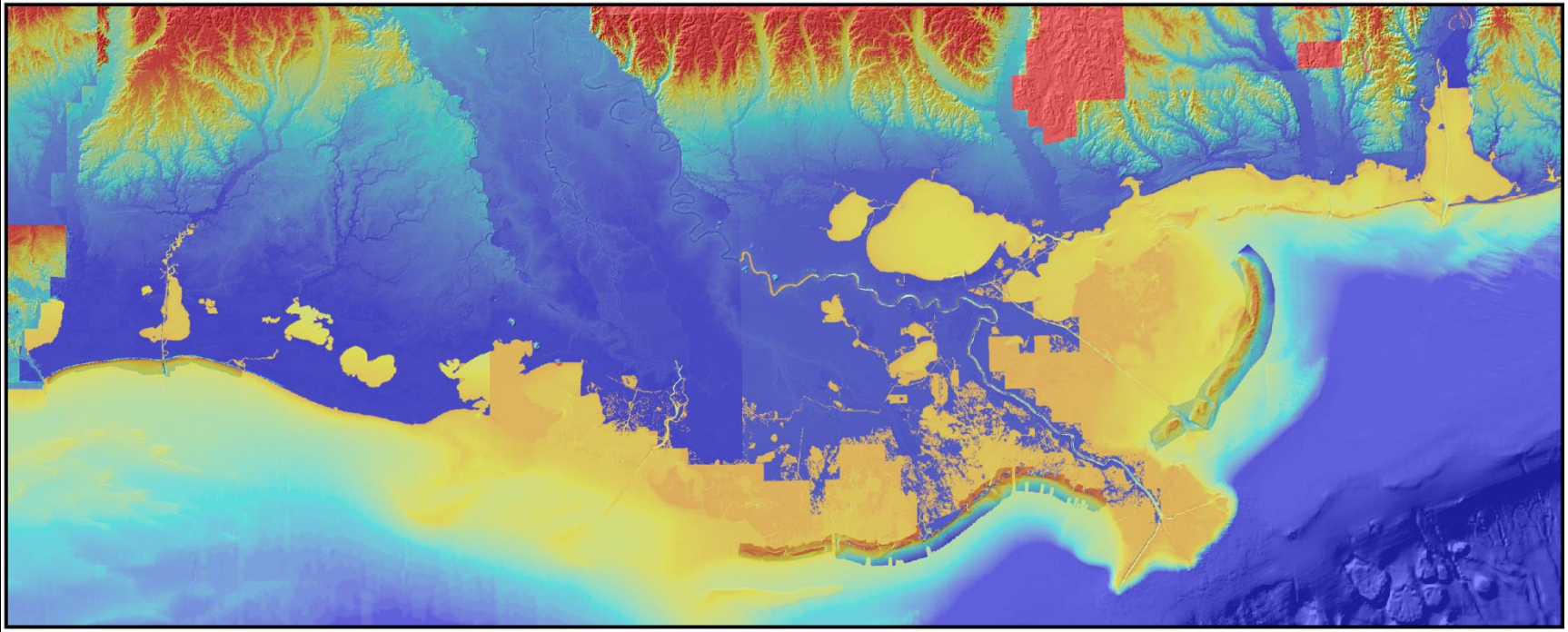
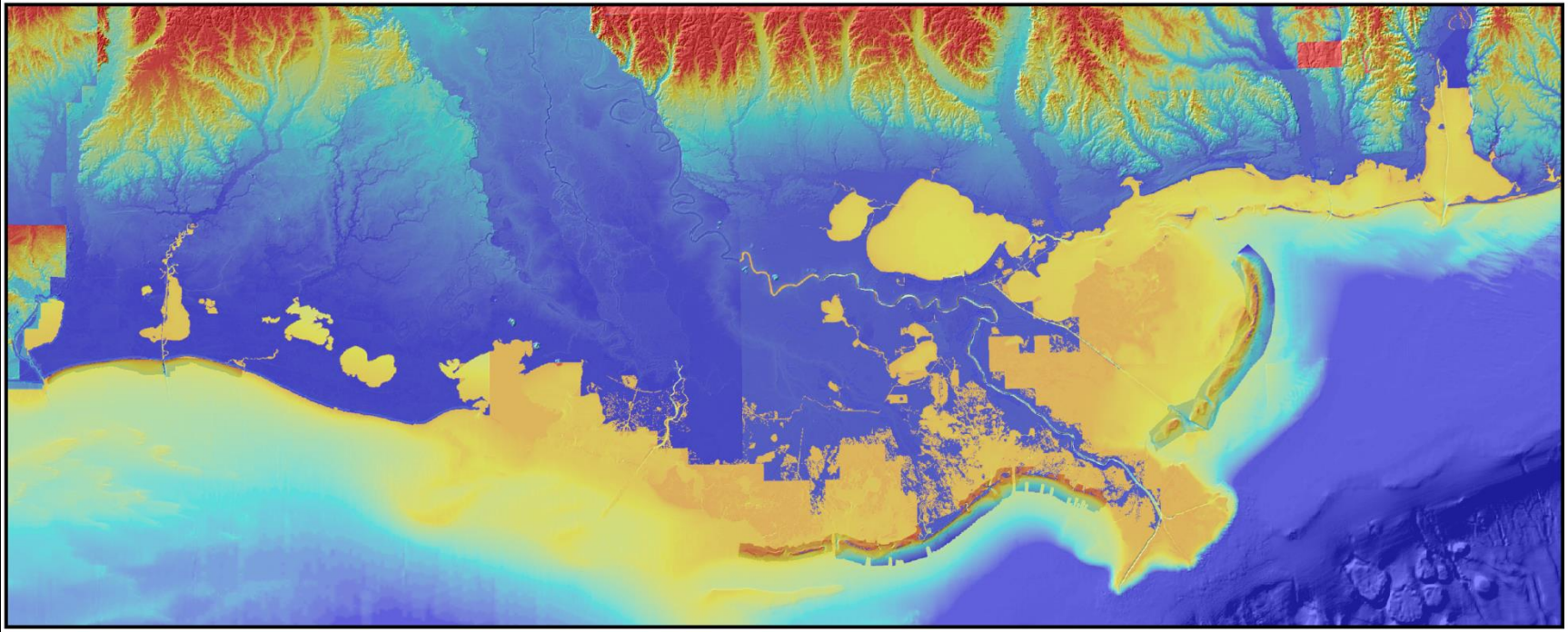
Southern Louisiana Topobathymetric Elevation Model Data Sources



4) Chandaleur Islands
5) BICM topo
6) NED 1/9" & lidar mosaics
7) NED 1/3"
8) BICM bathy
9) NOAA low & medium res topobathy

USGS

Southern Louisiana Topobathymetric Elevation Model Data Sources



3) Lidar mosaic
4) Chandaleur Islands
5) BICM topo
6) NED 1/9" & lidar mosaics
7) NED 1/3"
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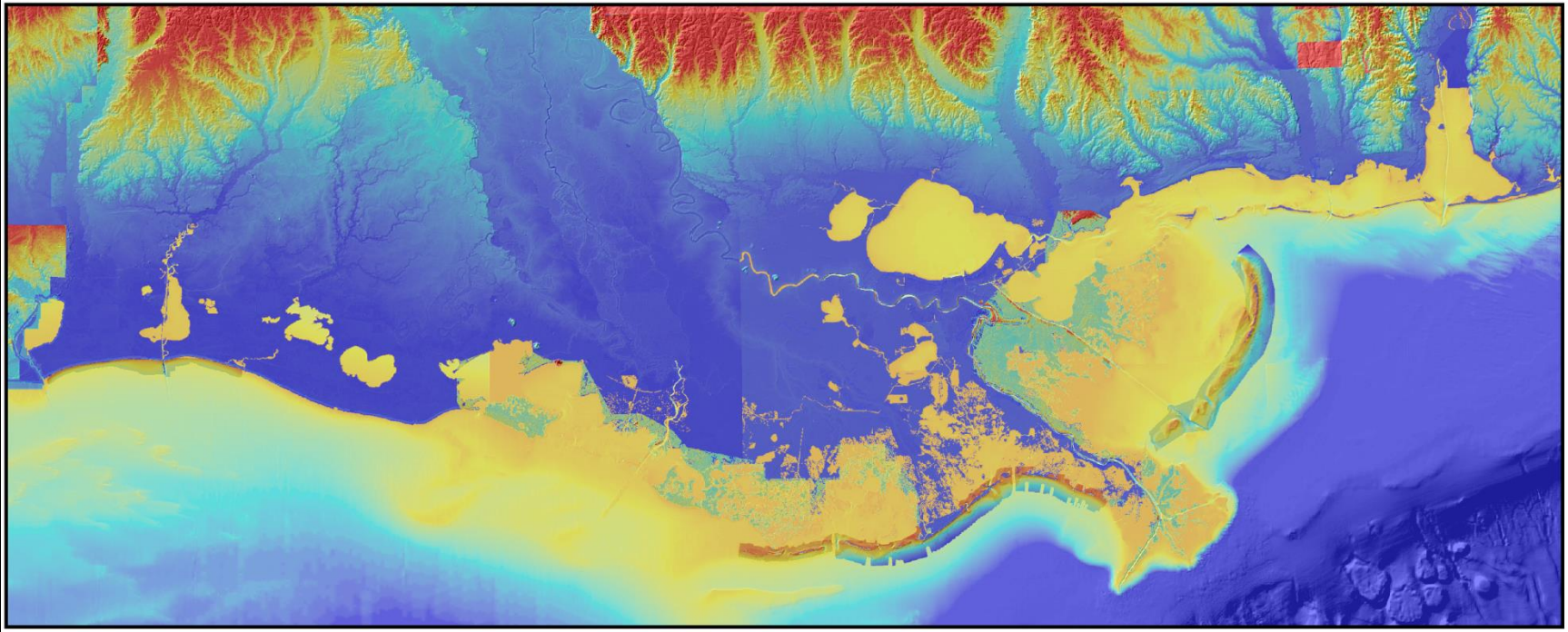
Southern Louisiana Topobathymetric Elevation Model Data Sources



2) ARRA
3) Lidar mosaic
4) Chandaleur Islands
5) BICM topo
6) NED 1/9" & lidar mosaics
7) NED 1/3"
8) BICM bathy
9) NOAA low & medium res topobathy

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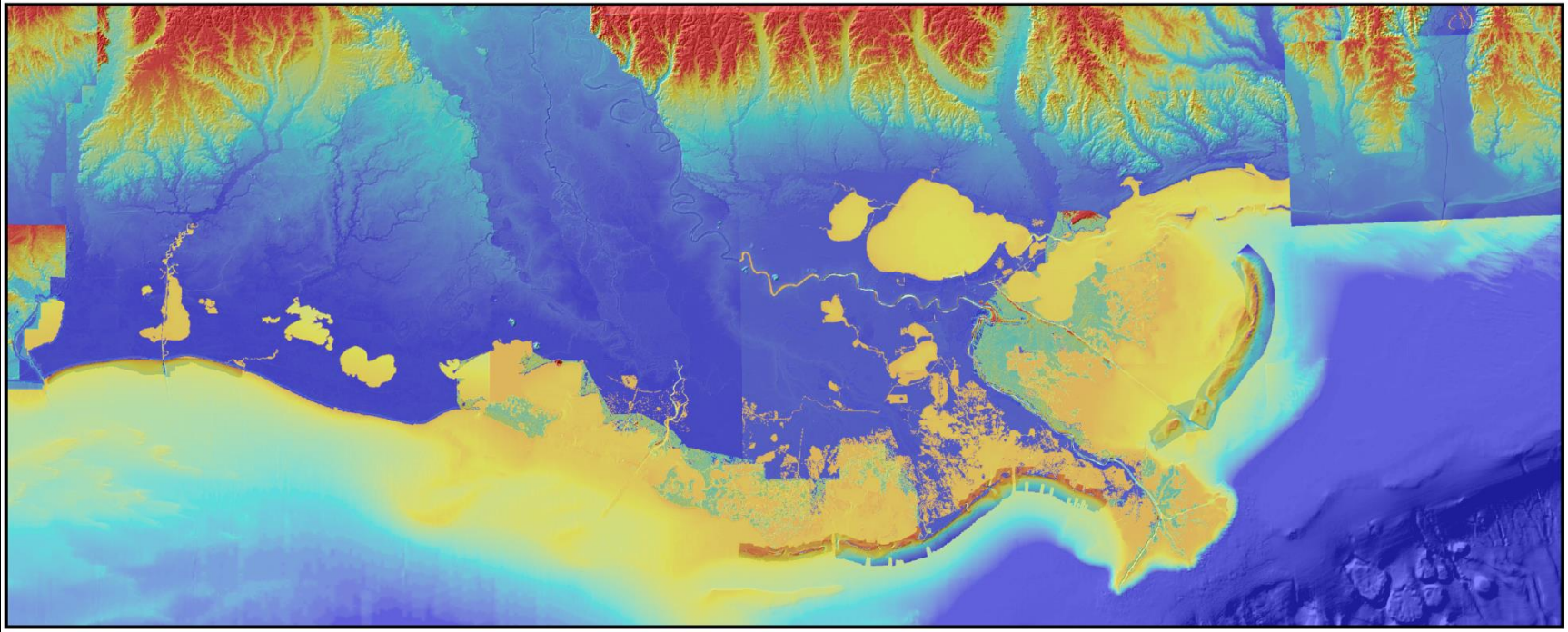
Southern Louisiana Topobathymetric Elevation Model Data Sources



1) Mobile Bay topobathy
2) ARRA
3) Lidar mosaic
4) Chandaleur Islands
5) BICM topo
6) NED 1/9" & lidar mosaics
7) NED 1/3"
8) BICM bathy
9) NOAA low & medium res topobathy

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Specifications of the LA CoNED Topobathymetric Elevation Model Version 1.0

- Horizontal datum / projection – NAD83, UTM
- Vertical datum – NAVD88 (Geoid12A)
- Vertical Accuracy: Recent Lidar - 9.25 cm RMSE (ie, 3DEP QL2)
  Older Lidar – 15 cm RMSE (but variable)
- Cell size – 3 meter
- Nesting – Consistent resampling, cell alignment (pixel edge), and aggregated resolutions
- Updating – Spatially Referenced Metadata
- Gap-filling / interpolation – Terrains and empirical bayesian kriegging
- File format – GeoTIFF

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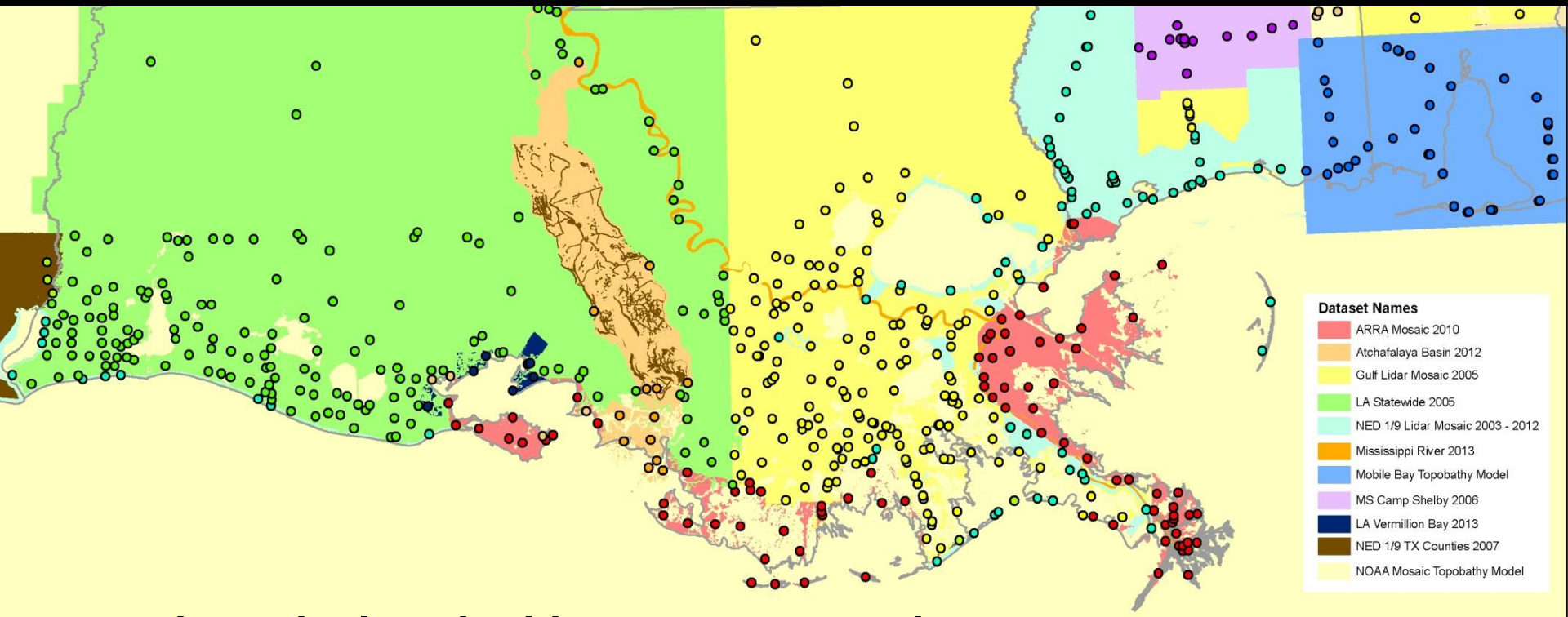
Validation of the LA CoNED Version 1.0



GPS Points Displayed With Data Set Footprint

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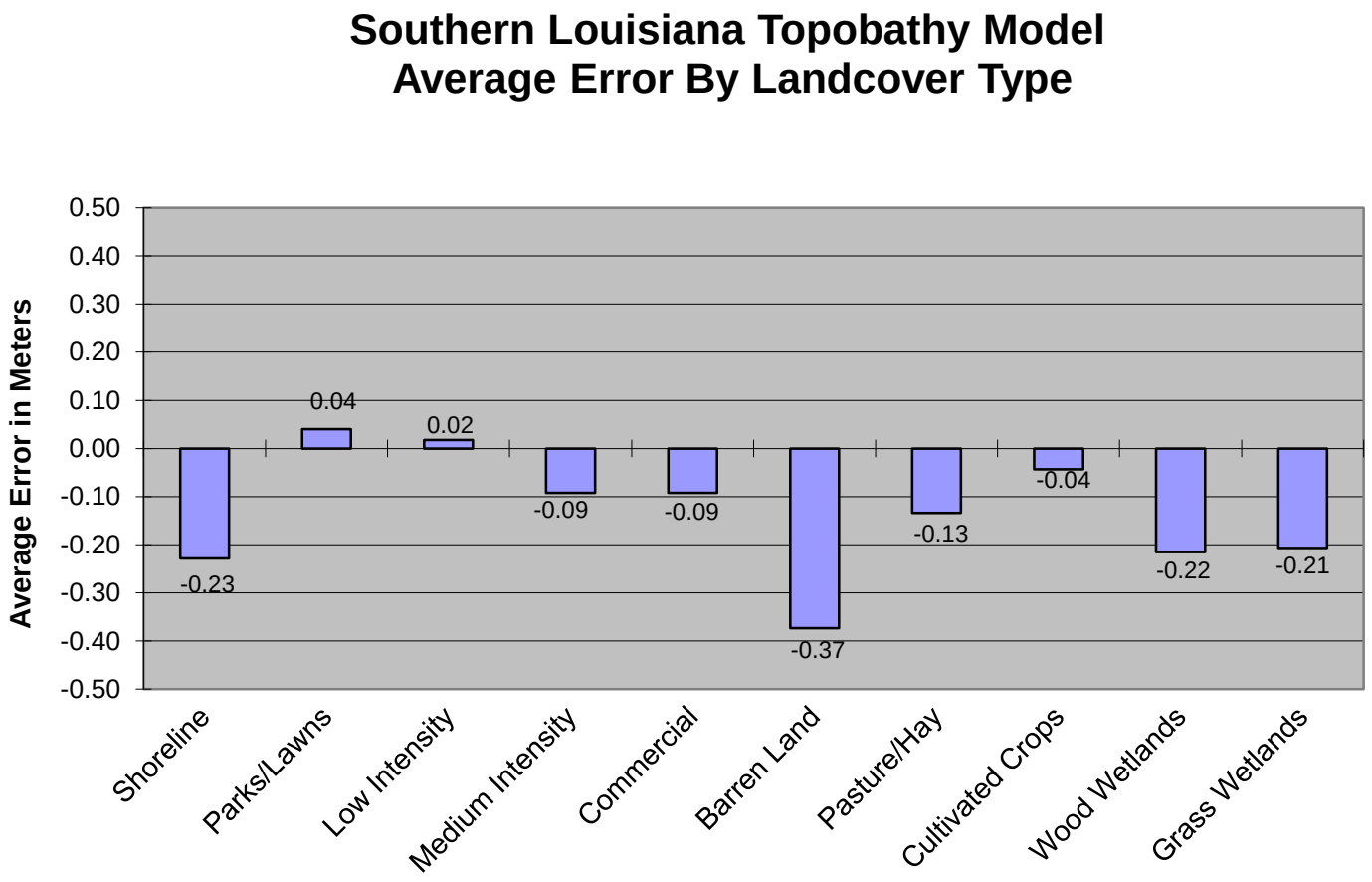
Average Error By Landcover Type



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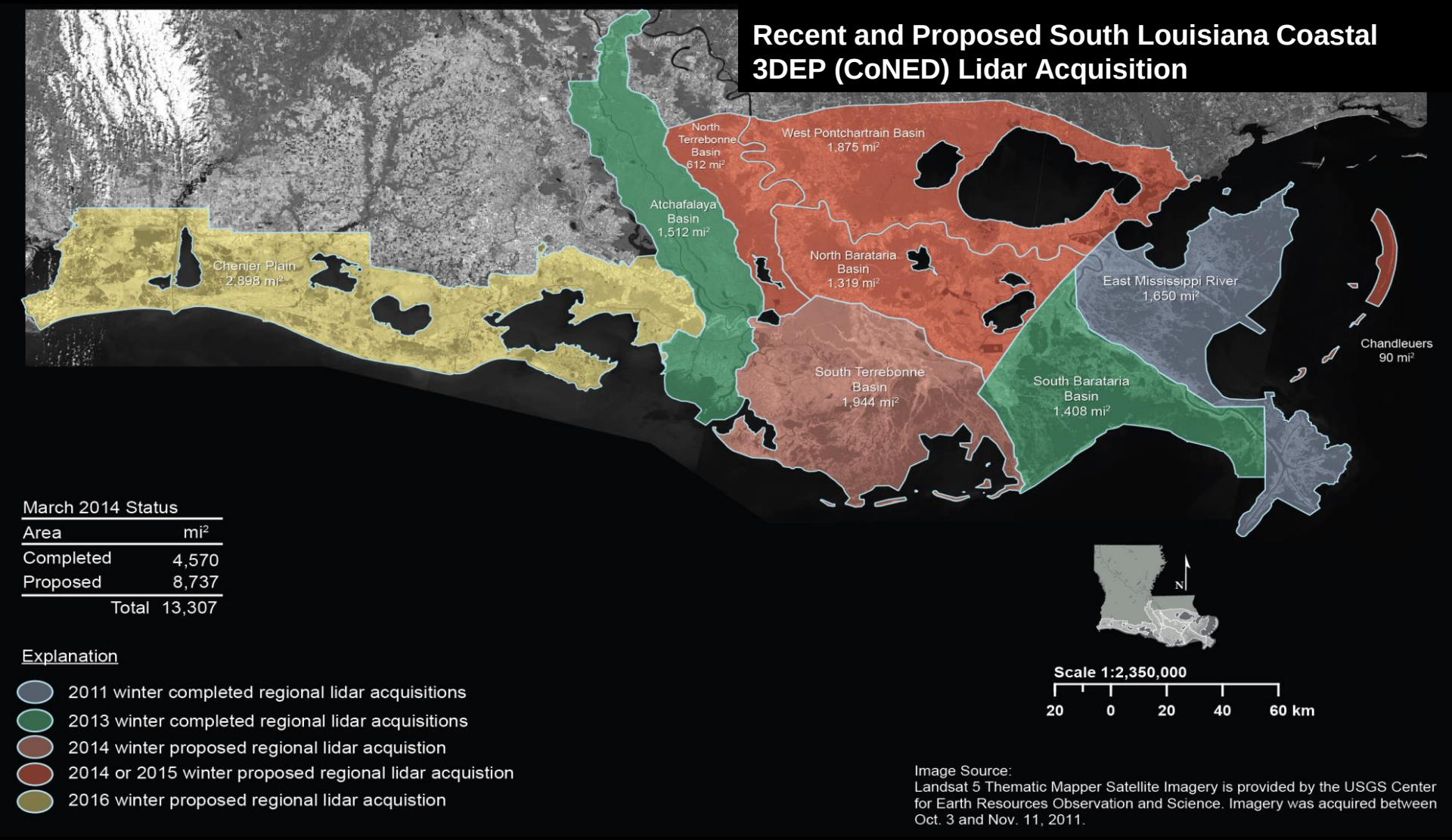
Plans to Construct LA CoNED Version 2.0



LA CoNED Version 1 Incorporates Mississippi River Bathymetry: Inland Bathymetry will be Emphasized in LA CoNED Version 2

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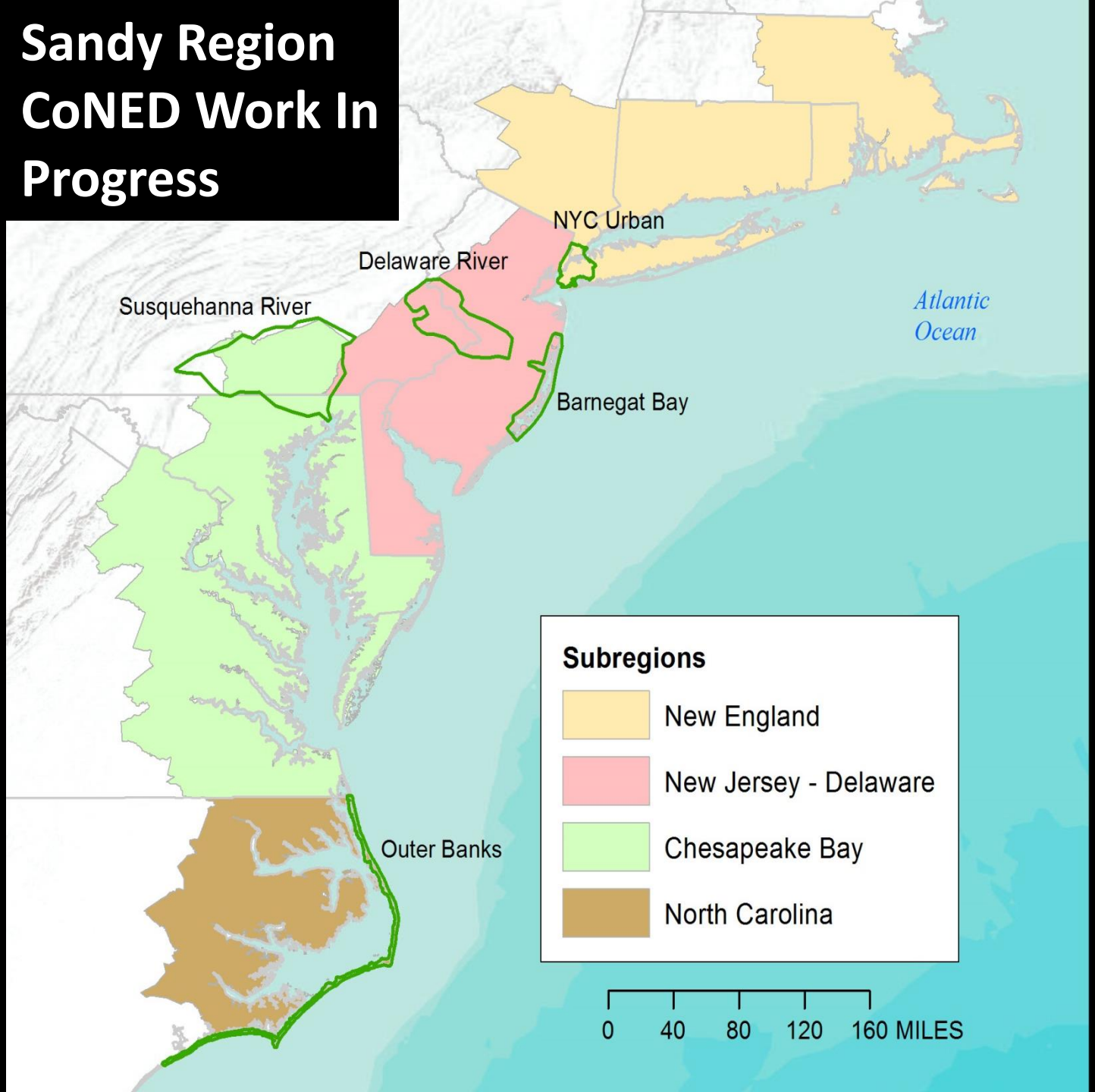
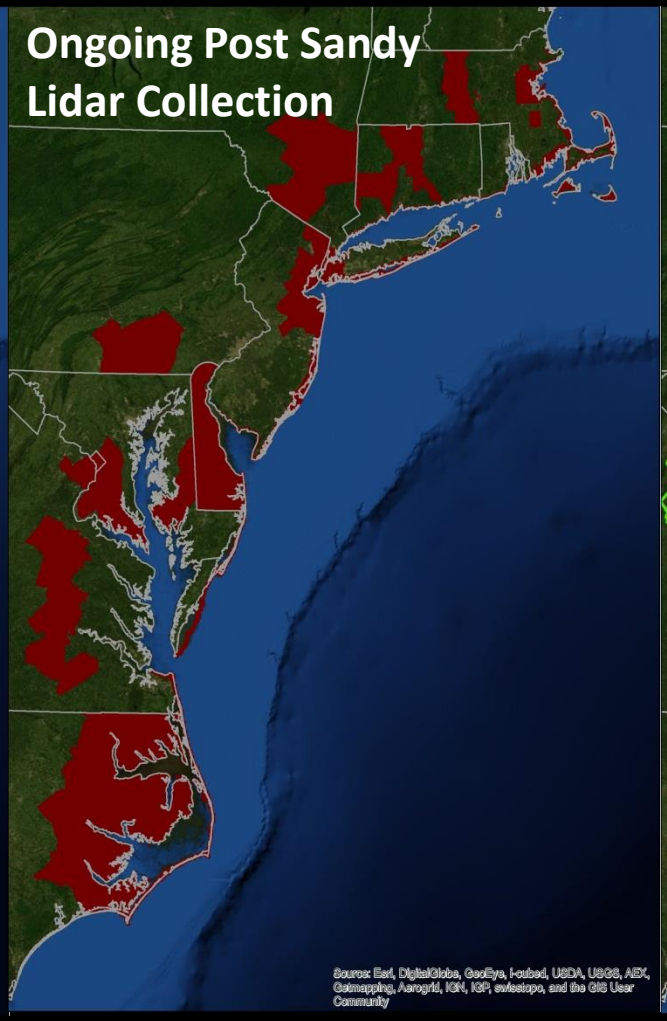
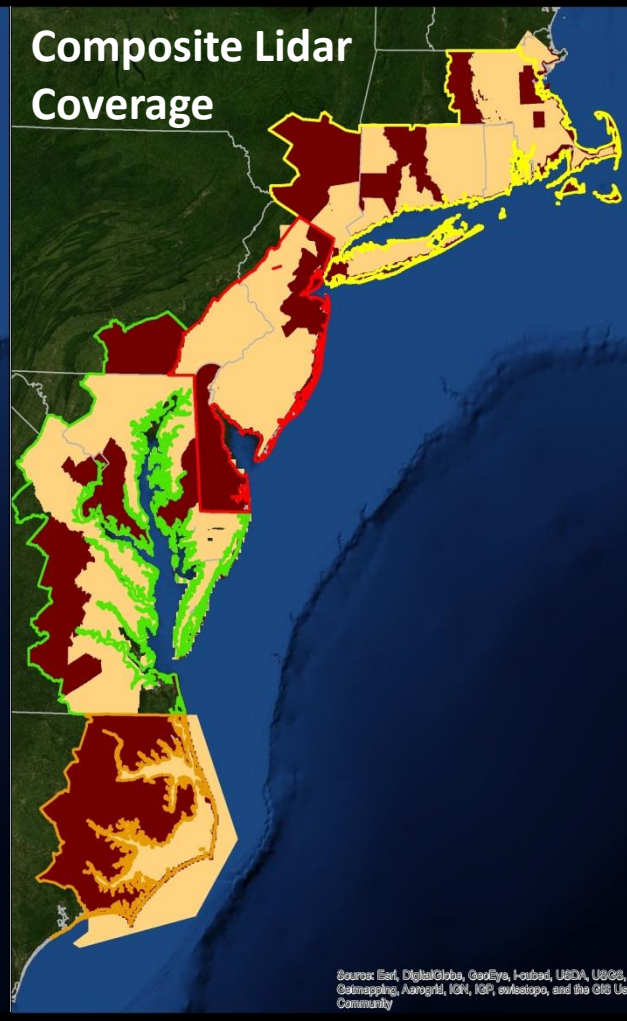
Sandy Region CoNED Work In Progress



Lidar Data Coverage for the Sandy CoNED Task





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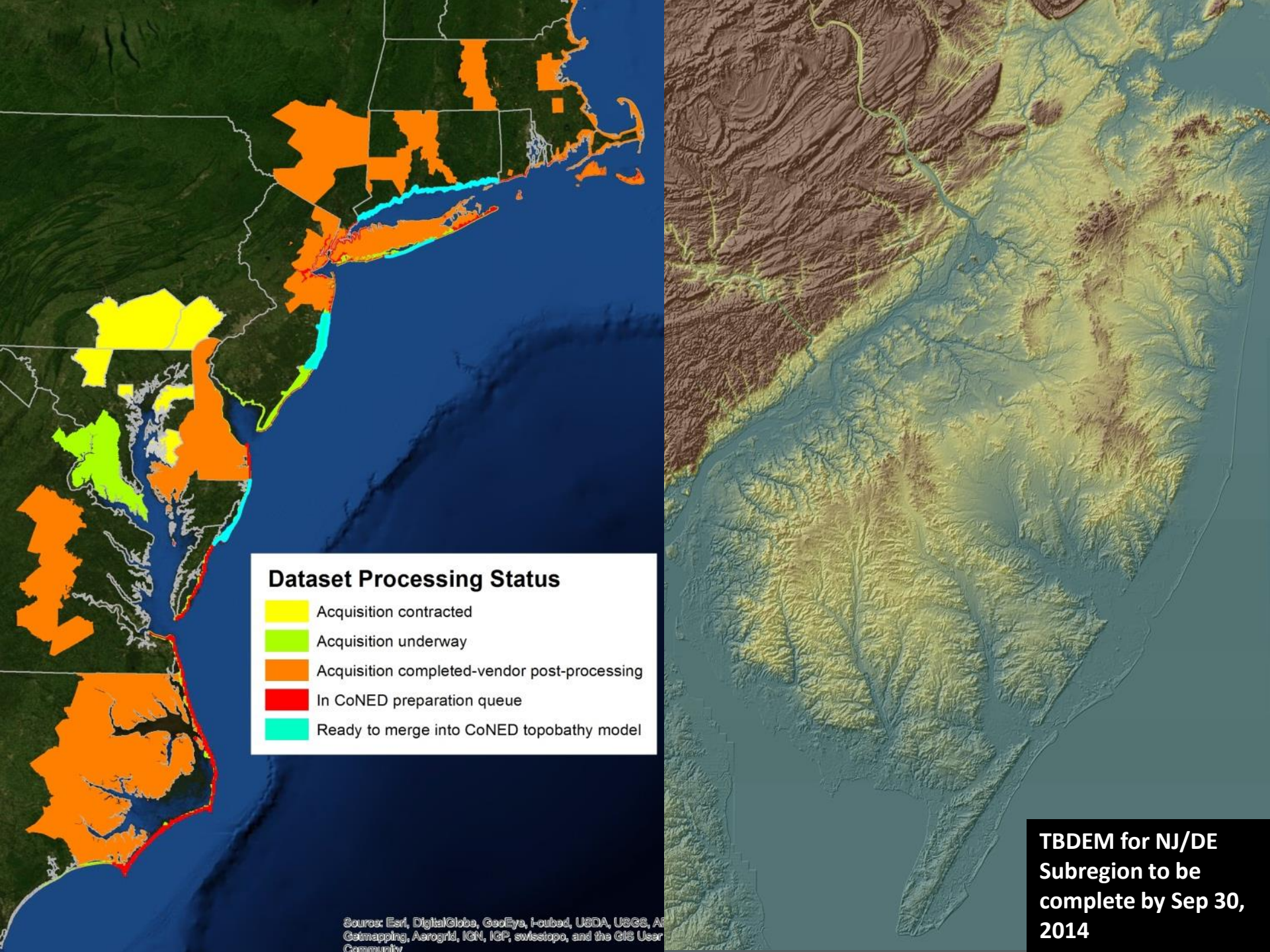
Dataset Processing Status
Acquisition contracted
Acquisition underway
Acquisition completed-vendor post-processing
In CoNED preparation queue
Ready to merge into CoNED topobathy model
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AE
Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User
Community
TBDEM for NJ/DE Subregion to be complete by Sep 30, 2014

Specifications of the Sandy Region CoNED Topobathymetric Elevation Models Now Under Construction

- Horizontal datum / projection – NAD83, UTM
- Vertical datum – NAVD88 (Geoid12A)
- Vertical Accuracy: Post Sandy Lidar - 9.25 cm RMSE (ie, 3DEP QL2)
  Pre Sandy Lidar – 15 cm RMSE (but variable)
- Cell size – 1 meter
- Nesting – Consistent resampling, cell alignment (pixel edge), and aggregated resolutions
- Multi-temporal database – Outer Banks Focal Area only
- Hydro-enforcement – River Focal Areas only
- Updating – Spatially Referenced Metadata
- Gap-filling / interpolation – Terrains and empirical bayesian kriegging
- File format – GeoTIFF

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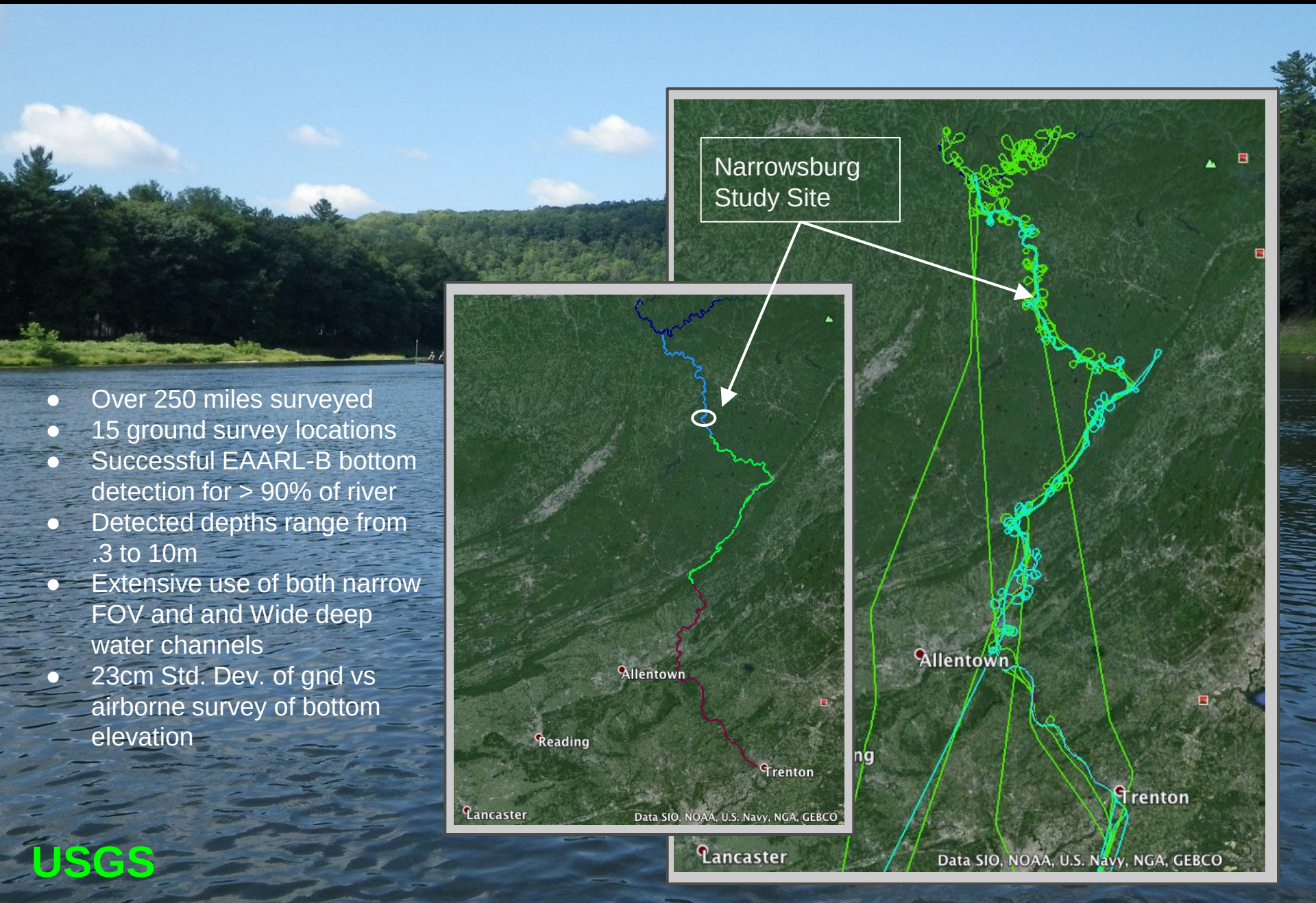
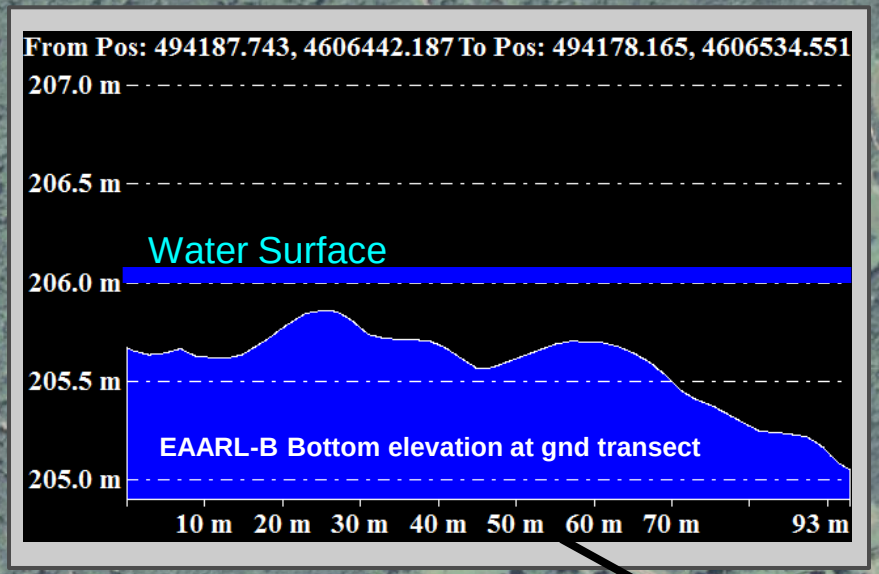
Delaware River EAARL-B Survey



- Over 250 miles surveyed
- 15 ground survey locations
- Successful EAARL-B bottom detection for > 90% of river
- Detected depths range from .3 to 10m
- Extensive use of both narrow FOV and and Wide deep water channels
- 23cm Std. Dev. of gnd vs airborne survey of bottom elevation

USGS

Narrowsburg, Pa. Site 5 of 15



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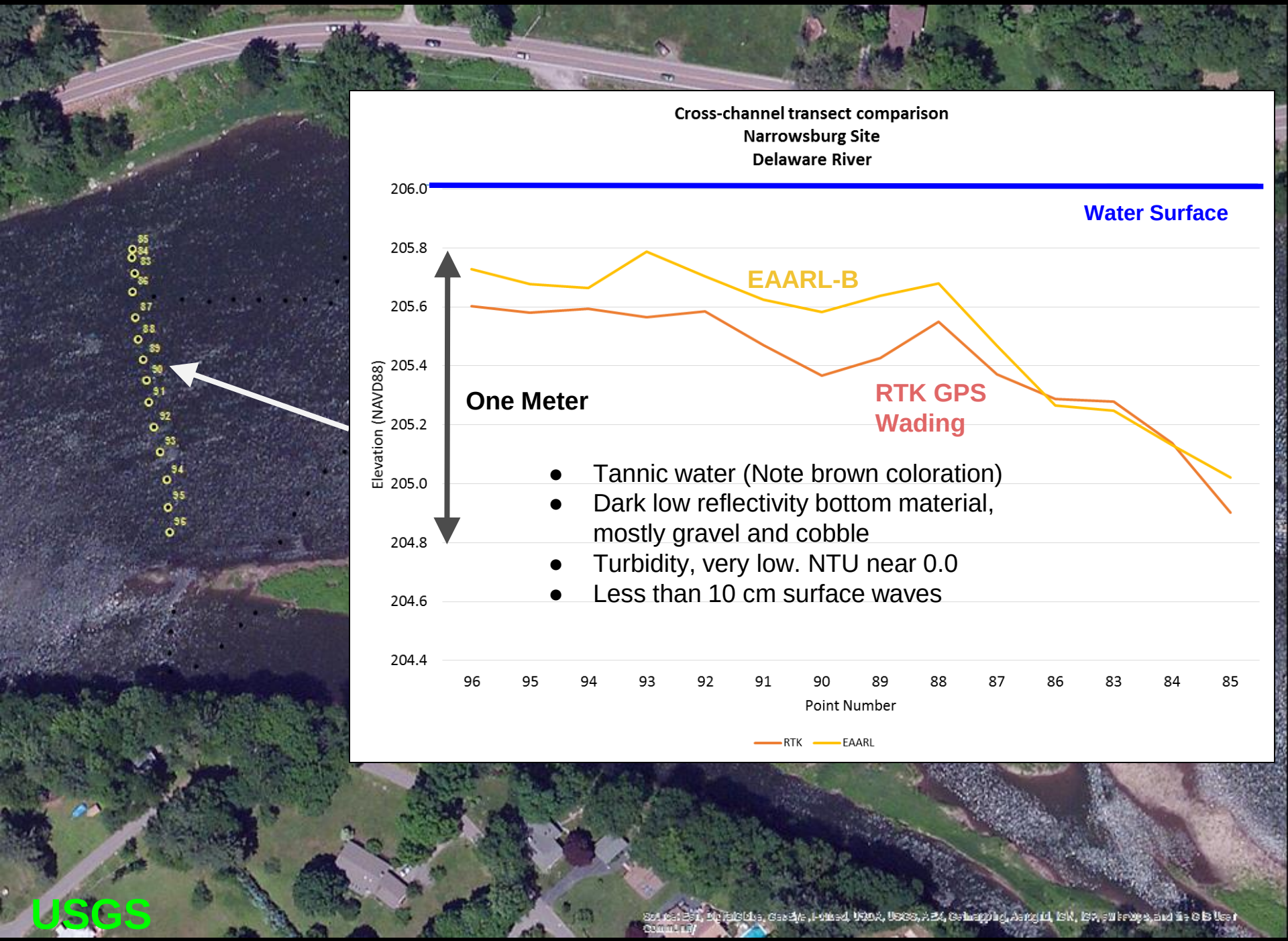

Cross-channel transect comparison
Narrowsburg Site
Delaware River
206.0
205.8
205.6
205.4
205.2
205.0
204.8
204.6
204.4
Elevation (NAVD88)
Water Surface
EAARL-B
RTK GPS
Wading
One Meter
Tannic water (Note brown coloration)
Dark low reflectivity bottom material, mostly gravel and cobble
Turbidity, very low. NTU near 0.0
Less than 10 cm surface waves
96 95 94 93 92 91 90 89 88 87 86 83 84 85
Point Number
RTK
EAARL
USGS

EAARL-B & Ground truth Site 5 of 15

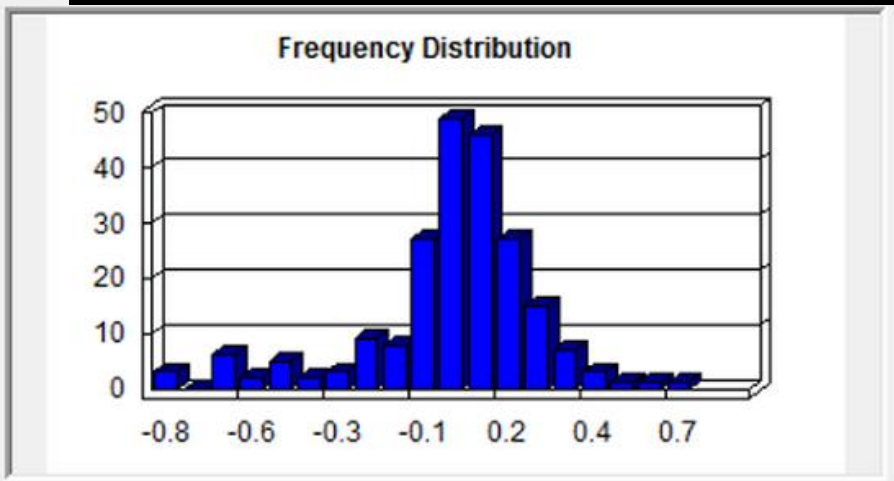
Statistics of nars_topobathy_extract_bed_points

Field

HgtDiff

Statistics:

Count:	215
Minimum:	-0.8076
Maximum:	0.72027
Sum:	9.50601
Mean:	0.044214
Standard Deviation:	0.236428
Nulls:	0

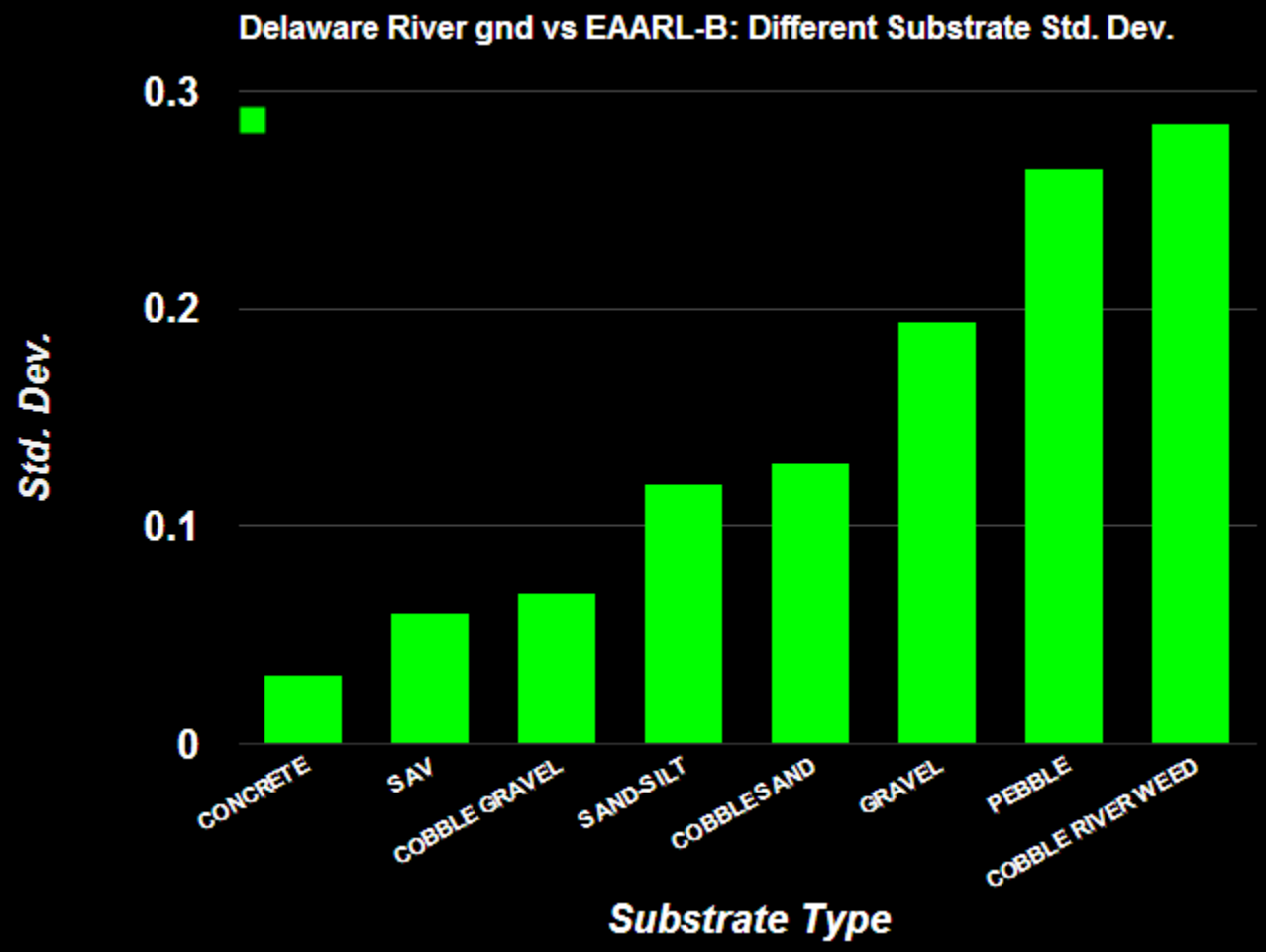


NARS

USGS

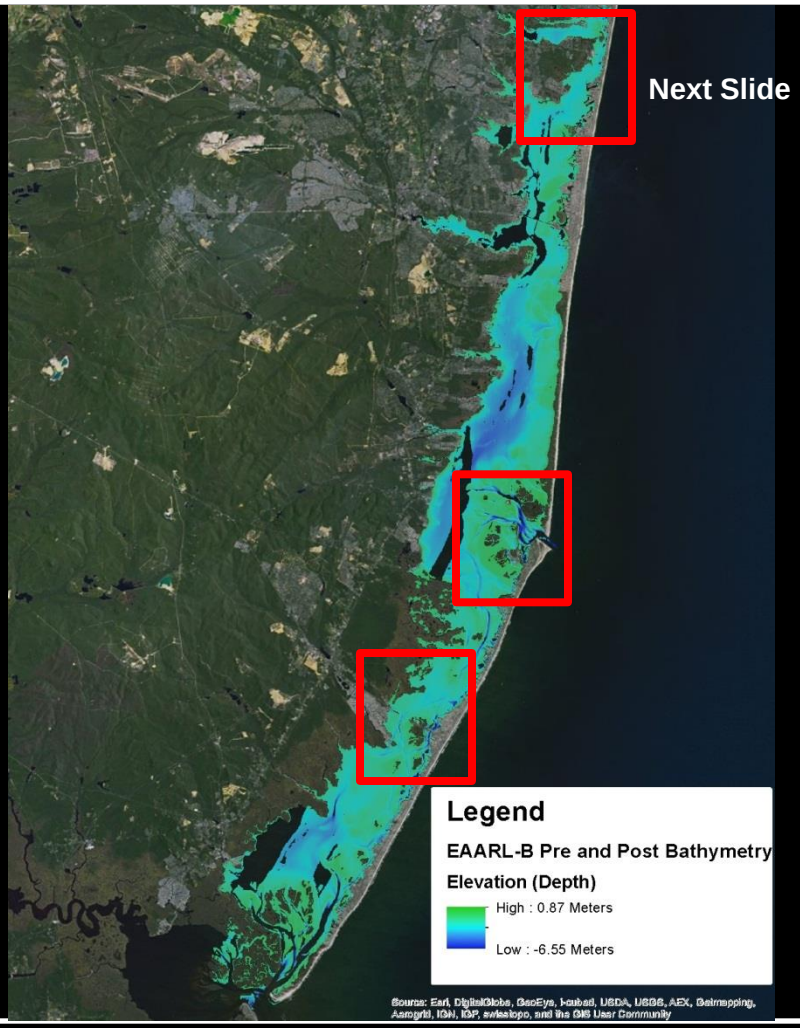
Comparison of EAARL-B with Ground Truth Difference by Substrate Type

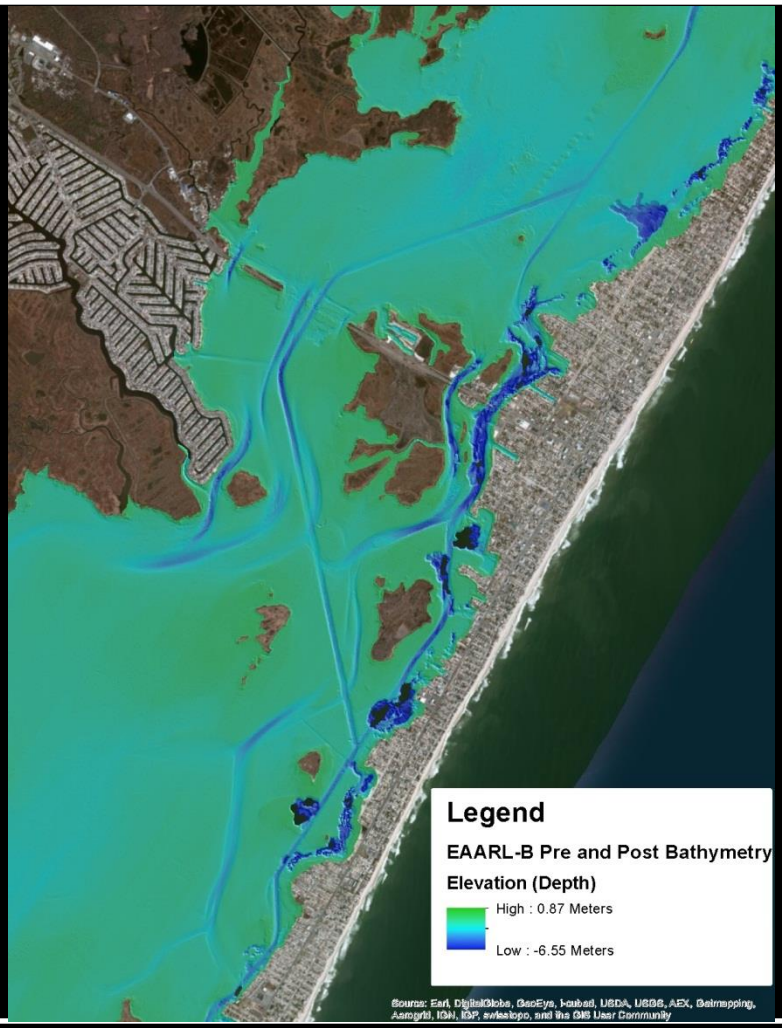
~23.6 cm overall Std. Dev.



USGS

EAARL-B Bathymetry for Barnegat Bay





USGS

Simultaneous Narrow & wide FOV on each Laser pulse

Pre Hurricane Sandy, Barnegat bay, Mantoloking NJ:

The EAARL-B captures both small and wide fields-of-view for every pulse.

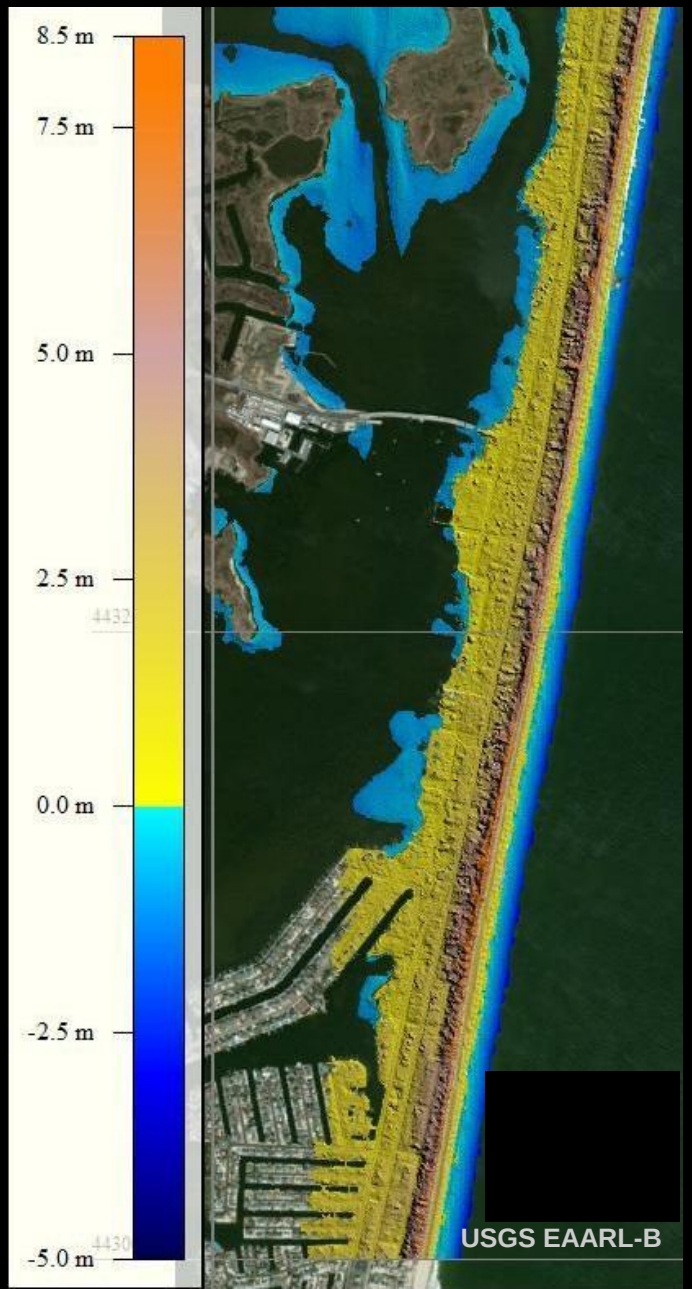
~5 NTU turbidity during survey.

Scattering by suspended sediment and surface wave action severely limits the depth capability of systems with only small foot prints.

The small footprint is adversely affected by small changes in turbidity.

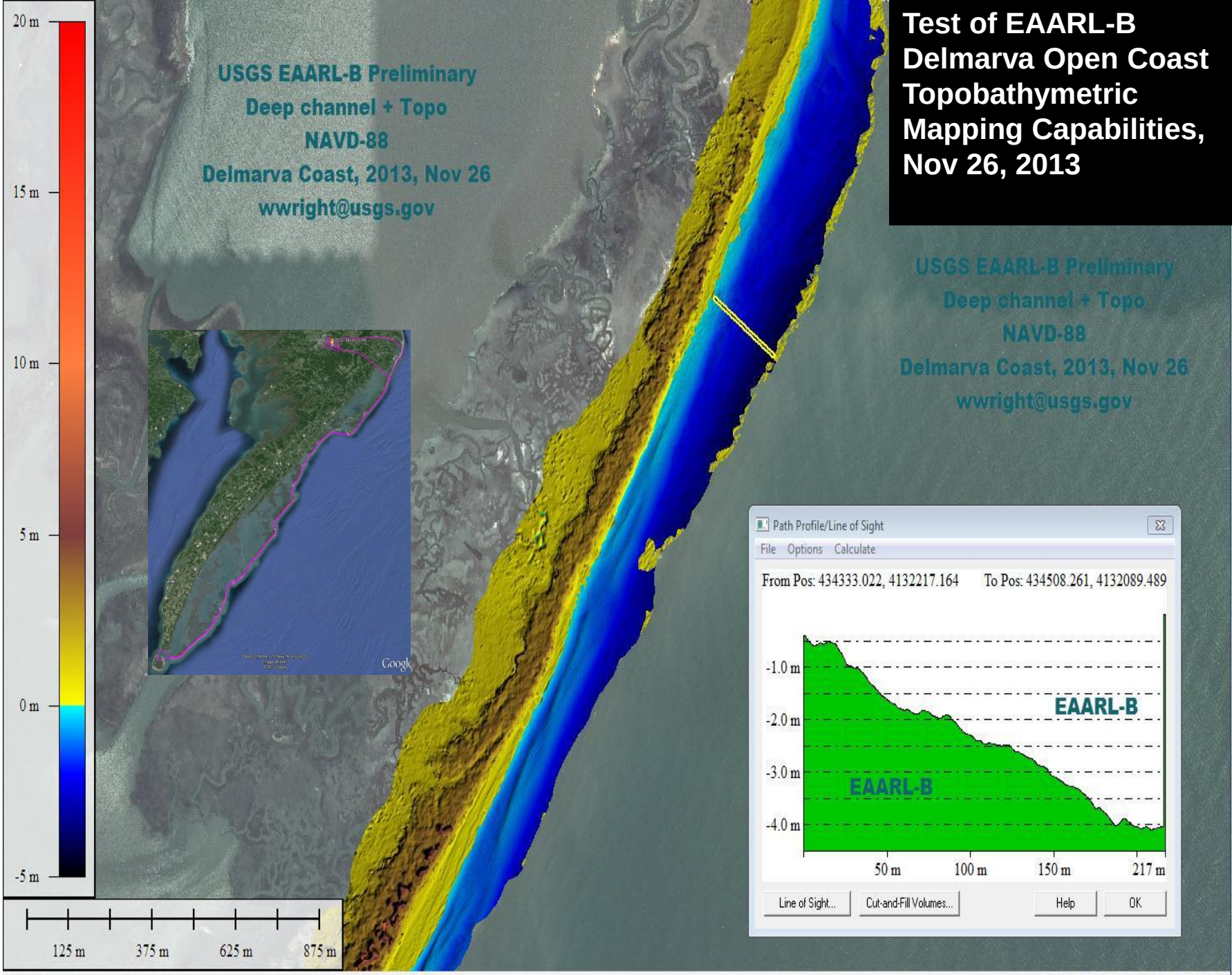
Systems with only large foot prints have difficulty in shallow water (< 2m).

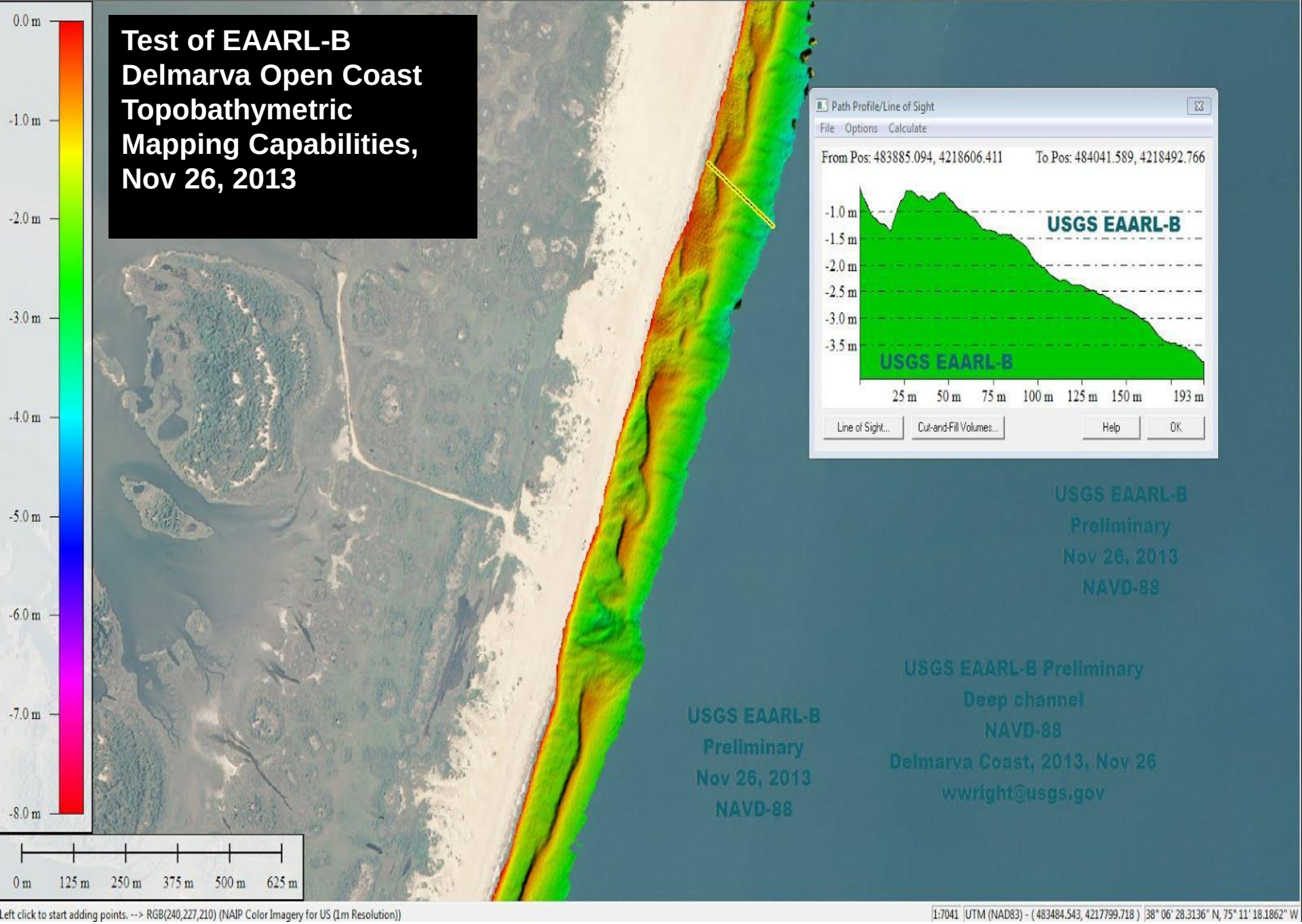
The EAARL-B combines scattered energy from all three beamlets into one large foot print while simultaneously retaining waveforms from the original three beamlets.



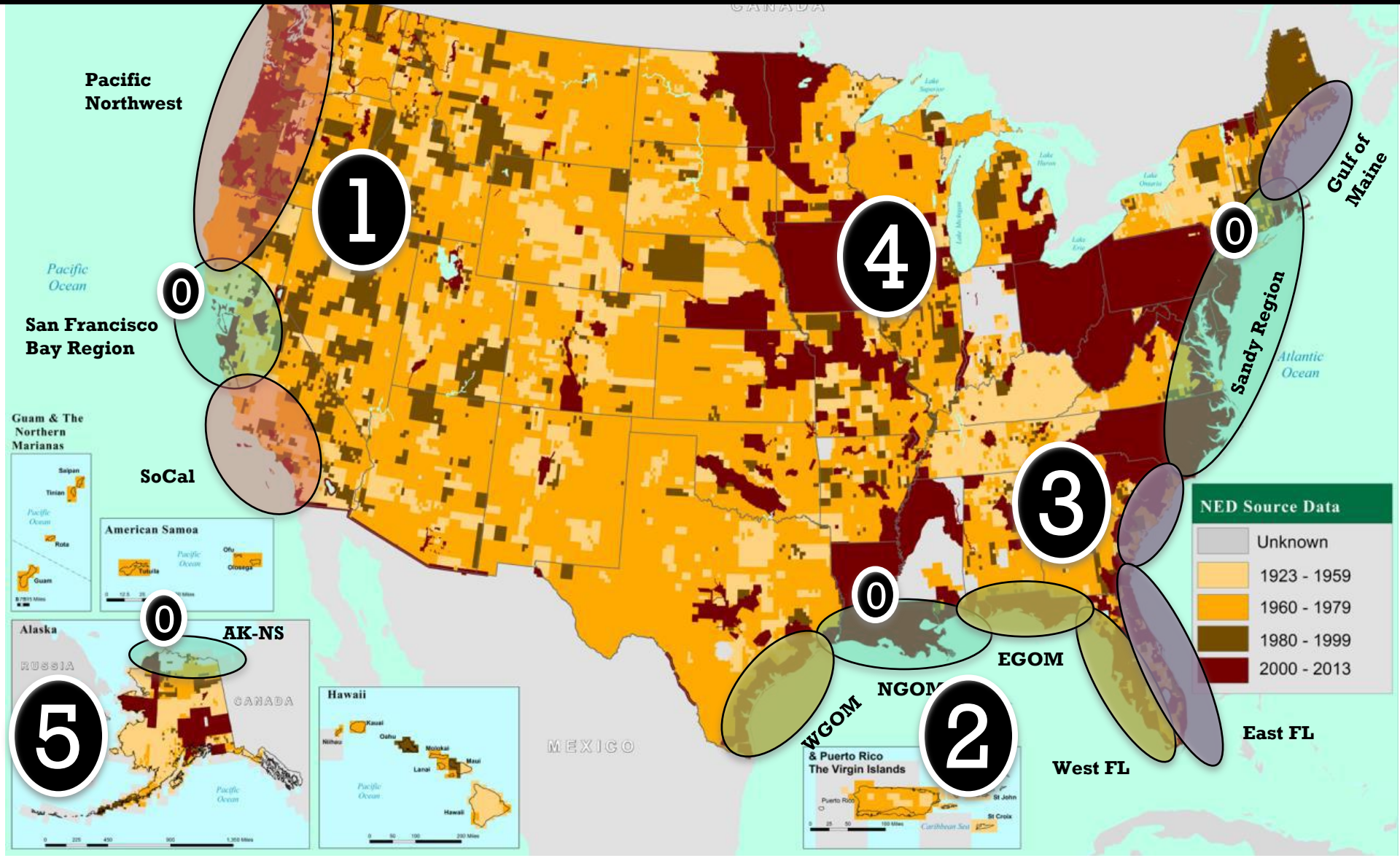
USGS

Test of EAARL-B Delmarva Open Coast Topobathymetric Mapping Capabilities, Nov 26, 2013



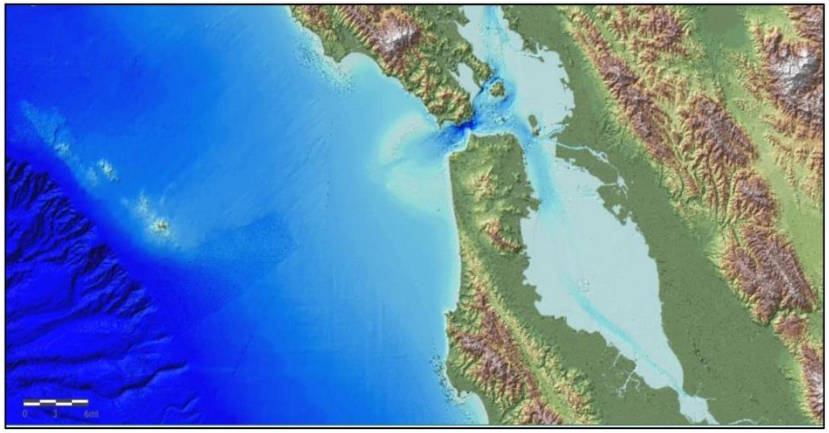

Test of EAARL-B Delmarva Open Coast Topobathymetric Mapping Capabilities, Nov 26, 2013
0.0 m
-1.0 m
-2.0 m
-3.0 m
-4.0 m
-5.0 m
-6.0 m
-7.0 m
-8.0 m
0 m
125 m
250 m
375 m
500 m
625 m
Path Profile/Line of Sight
File Options Calculate
From Pos: 483885.094, 4218606.411
To Pos: 484041.589, 4218492.766
-1.0 m
-1.5 m
-2.0 m
-2.5 m
-3.0 m
-3.5 m
USGS EAARL-B
USGS EAARL-B
25 m
50 m
75 m
100 m
125 m
150 m
193 m
Line of Sight...
Cut-and-Fill Volumes...
Help
OK
USGS EAARL-B
Preliminary
Nov 26, 2013
NAVD-88
USGS EAARL-B Preliminary
Deep channel
NAVD-88
Delmarva Coast, 2013, Nov 26
wwright@usgs.gov
USGS EAARL-B
Preliminary
Nov 26, 2013
NAVD-88
Left click to start adding points. --> RGB(240,227,210) (NAIP Color Imagery for US (1m Resolution))
1:7041
UTM (NAD83) - (483484.543, 4217799.718)
38° 06' 28.3136" N, 75° 11' 18.1862" W

Proposed Sequencing of Lidar Collection Focus and Coastal 3DEP Construction Over the Next Decade:



Call for Manuscripts for a **Journal of Coastal Research** Issue on:

Advances in Topbathymetric Mapping, Models, and Applications



Detailed knowledge of temporally-varying subaerial and submerged topography is needed by scientists and policy-makers in heterogeneous coastal zones with high-energy physical processes, complex habitats, steep ecological gradients, focused societal infrastructure investments, and concentrated human populations vulnerable to a range of inundation hazards. The latest topographic and topographic-bathymetric (topobathymetric) lidar systems offer greatly enhanced littoral zone mapping capabilities and facilitate generation of merged multi-sensor coastal zone elevation models with continuous but varied resolution keyed to ecosystem zonation. Recently launched satellite sensors combined with radiative transfer modeling is improving the ability to derive bathymetry from multispectral and hyperspectral imagery where conditions permit. Efficient new methodologies are being developed to allow the assimilation of disparate and voluminous multi-sensor, multi-temporal topographic and bathymetric data sets to create seamless, regional-scale topobathymetric digital elevation models (TBDEMs). In parallel, coastal science and coastal zone management communities are devising original applications of these TBDEMs in coastal wetlands mapping and monitoring, storm surge and sea level-rise modeling, benthic habitat mapping, coral reef ecosystem mapping, and a host of related activities.

This Special Issue of the Journal of Coastal Research is intended to serve as a forum for researchers to communicate findings on the following broad topics: 1) capabilities of green laser lidar instruments or multispectral imagery to capture dense submerged elevation data under varying turbidity, depth, and substrate reflectance conditions, 2) capabilities of green laser lidar instruments to map ephemeral and morphologically-complex sedimentary structures and benthic habitats, 3) methods for the merging of multi-source elevation data to create seamless cross-shoreline TBDEMs keyed to coastal ecosystem zonation, 4) the application of seamless cross-shoreline TBDEMs within the hydrodynamic modeling and forecasting of tsunamis, storm surge, and flood inundation, 5) the application of cross-shoreline TBDEMs within the prediction of sea-level rise inundation and associated economic costs.

Submission Deadline:

August 31, 2014

Guest Editors: John C. Brock, Dean Gesch, Christopher E. Parrish, and C. Wayne Wright

Please contact one of the Guest Editors if you intend to submit a manuscript (contact info on next page).

Call for Manuscripts for a **Journal of Coastal Research** Issue on:

Advances in Topbathymetric Mapping, Models, and Applications

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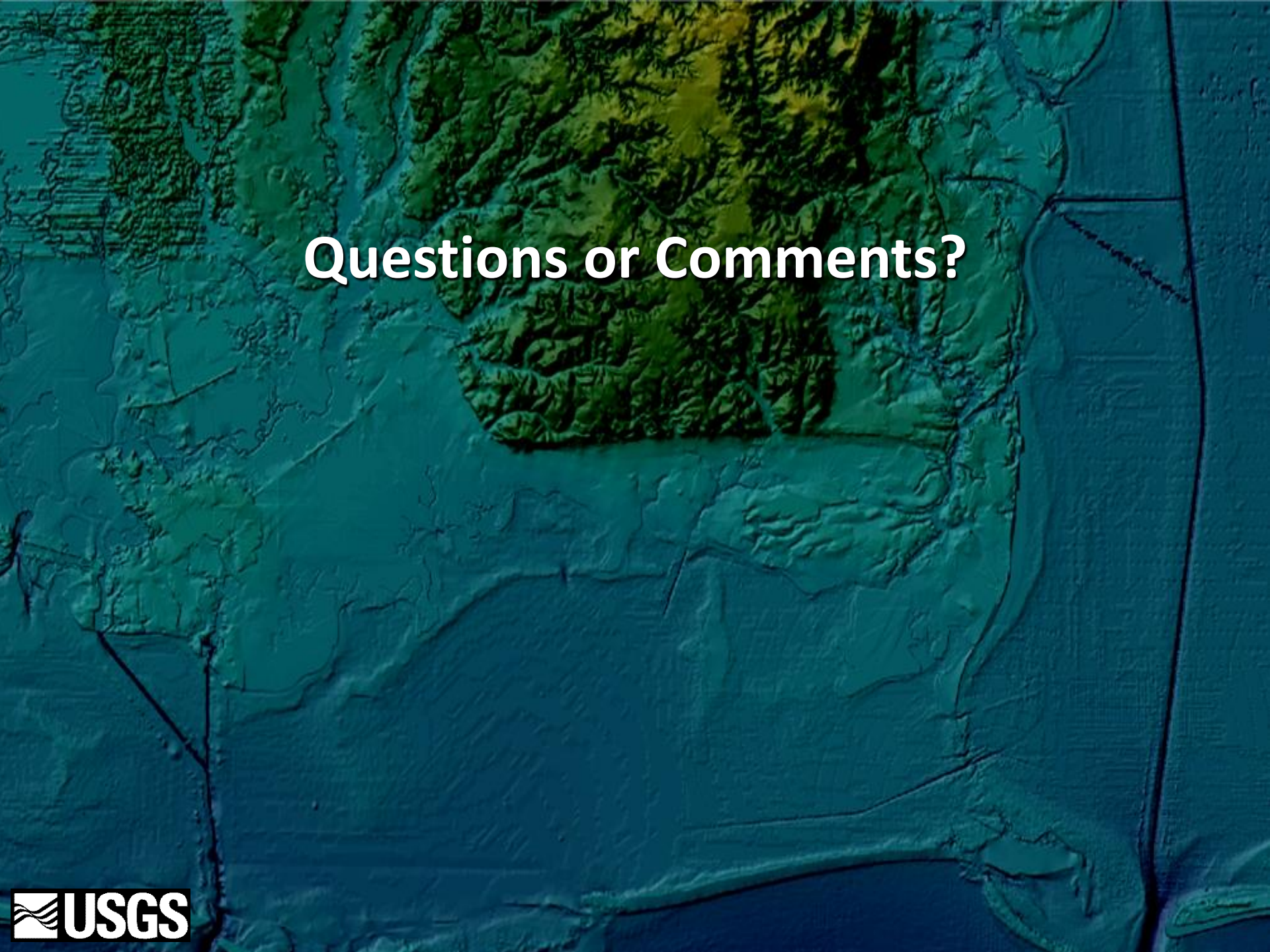
Questions or Comments?