Lidar – The Gift That Keeps Giving

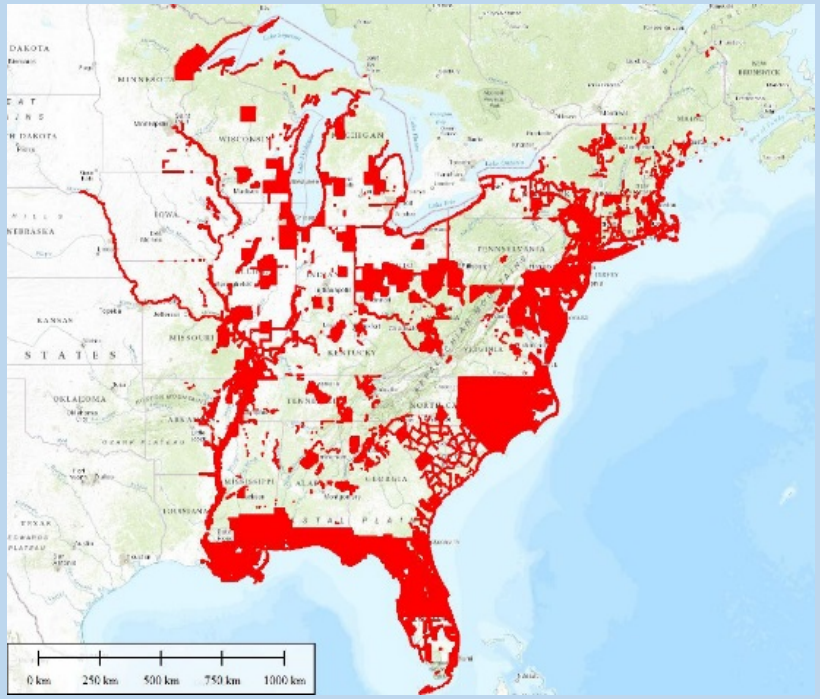
Building on Decades of Good Data

Geoscience Consultants, LLC.

GEOSCIENCE CONSULTANTS

Lidar – The Gift

- Time - Approaching/Reached milestone of 20 years of data
- Quantity - Repeat coverage of many coastal areas is becoming statistically favorable (i.e., 3 or more independent coverages)
- Time to change our QA SOP's – or not?
- Couple of practical examples to explore use of time and data

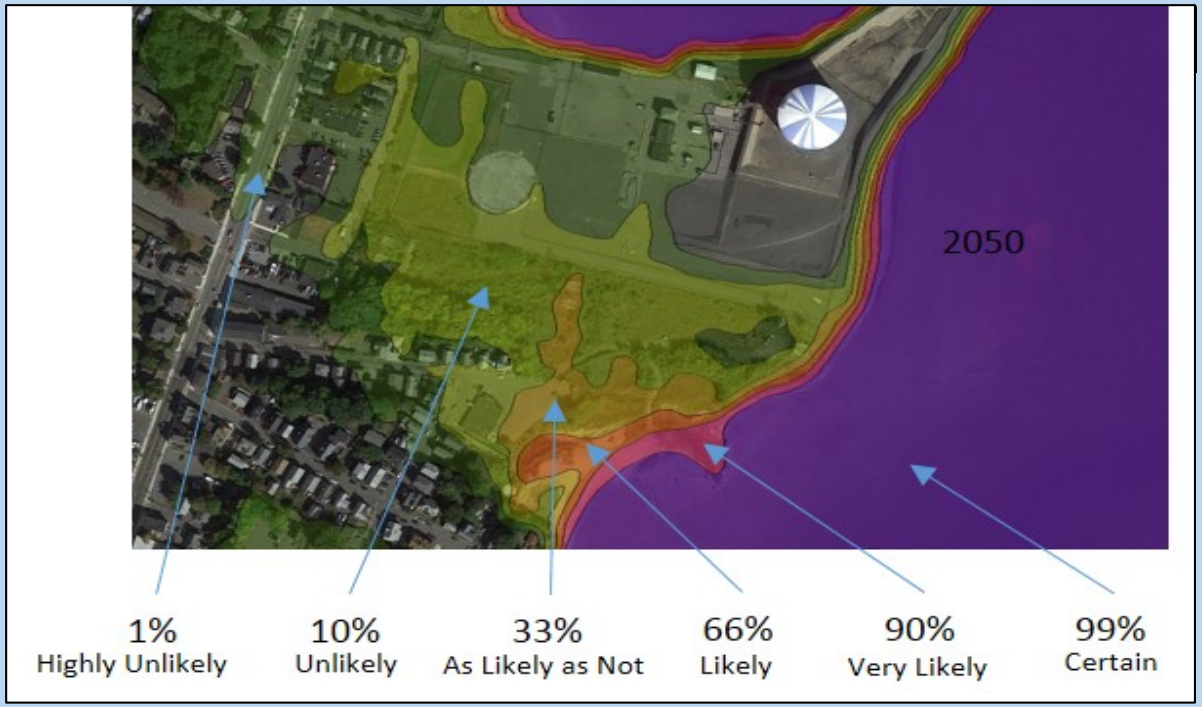


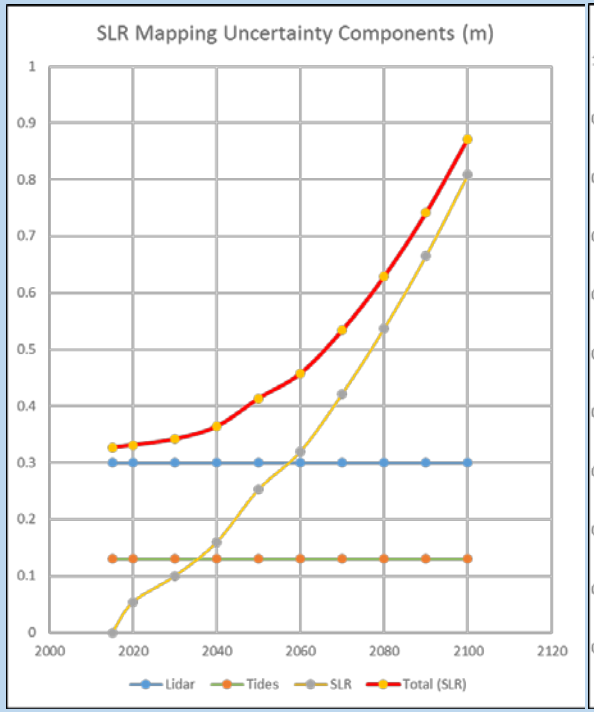
Overview of Example Uses

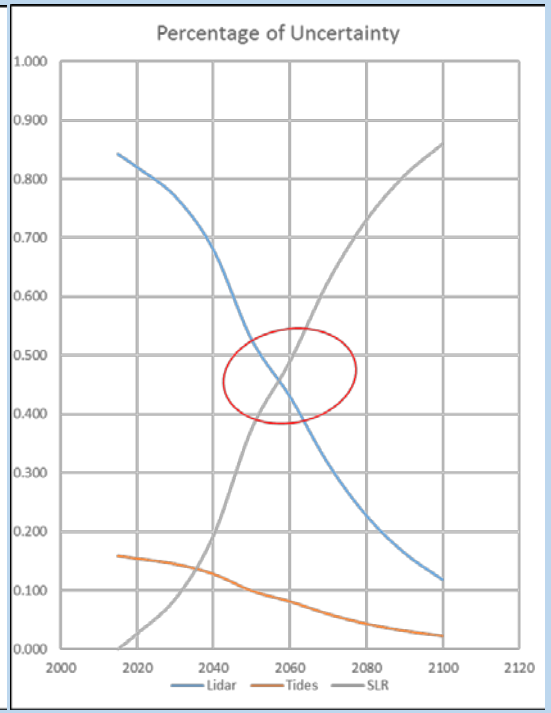
- Rationale/Logic
  - Years of GCP Collection and Error Assessment
  - Wealth of Coastal Lidar Available
- Primary Needs
  - Improved Error Values for Modeling
  - Increased Local Confidence in Error Assessment
  - QA/QC for New Collection Techniques (i.e., UAV's)
- Other Uses
  - Vertical Marsh Change (Marsh Renourishment)

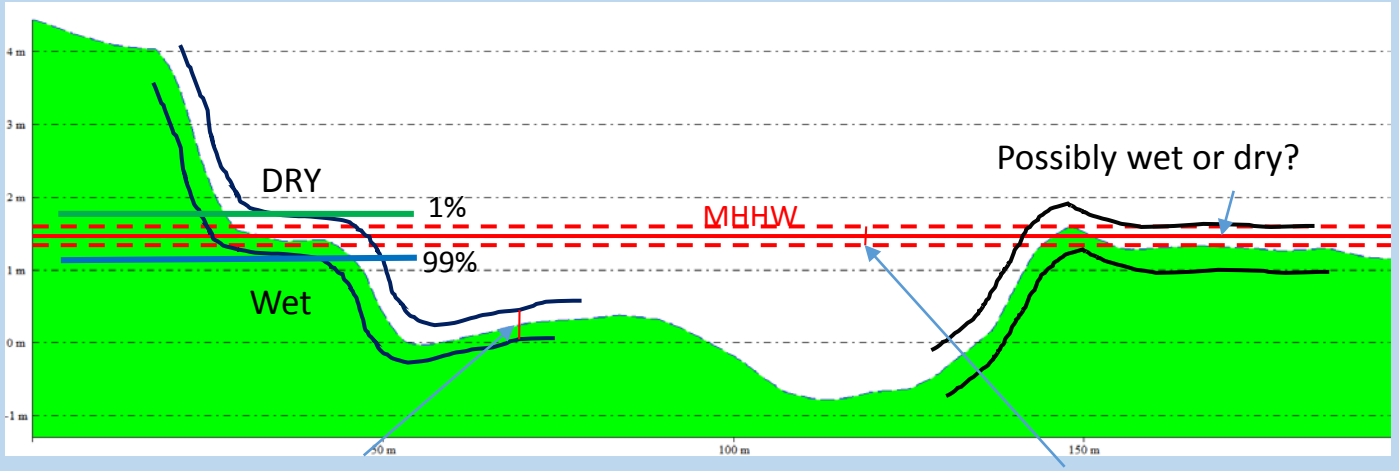
Need – Local Error Modeling

- Lidar error is an important factor in SLR error budget until 2050.
- Single value used across all land covers at present.
- Use of Data Quantity







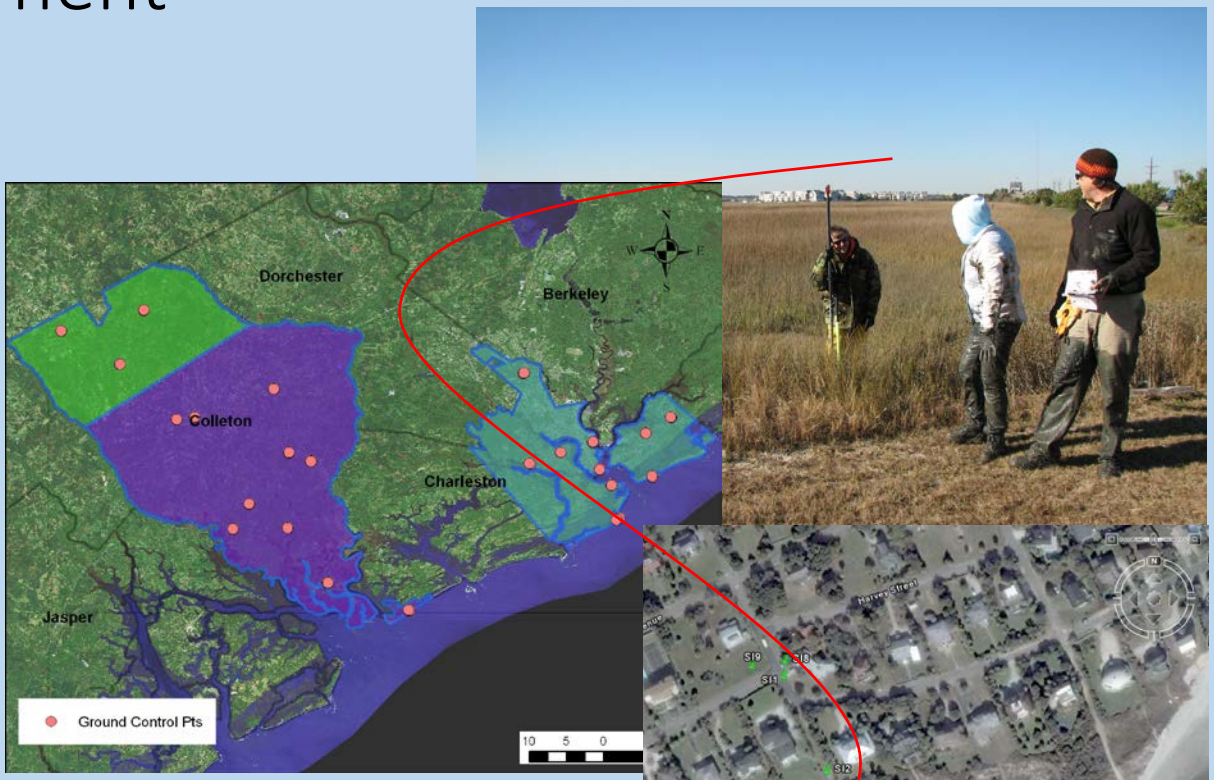


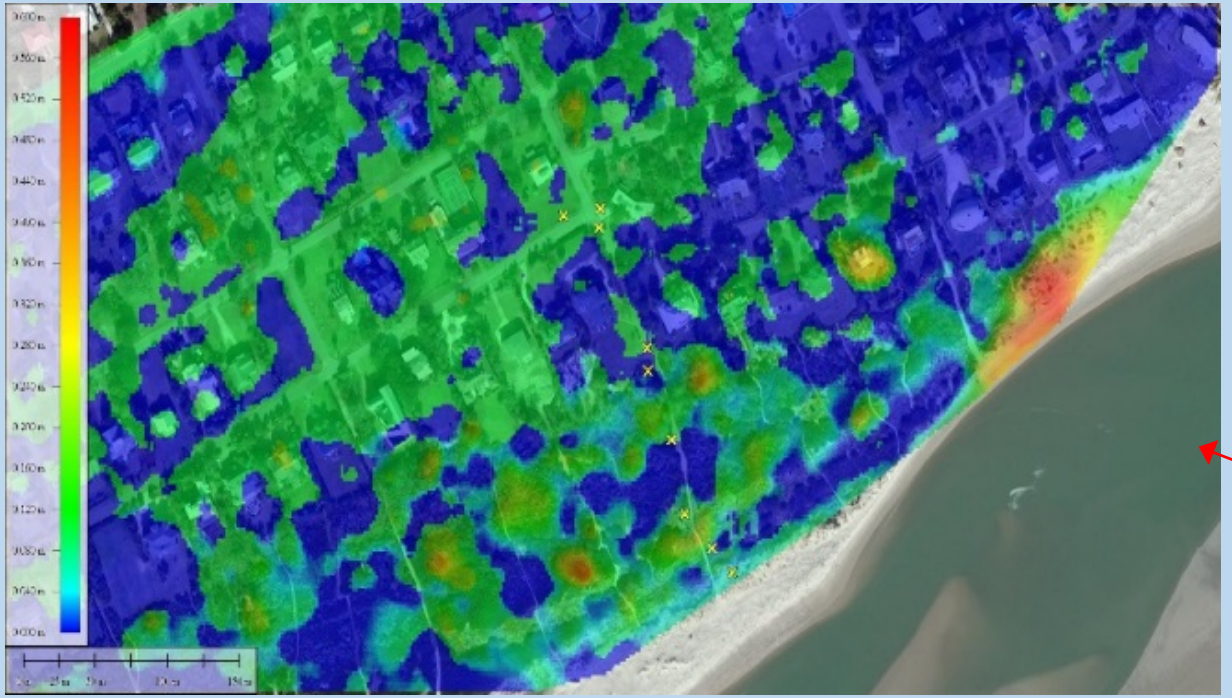
Error in Lidar DEM (RMSE)

Error in Tidal Surface (MCU)

Goal – Improved Spatial Error Assessment

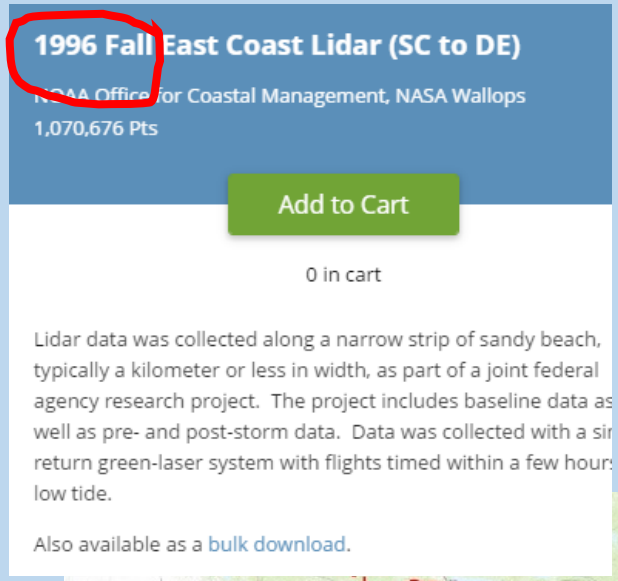
- Move from GCP's to Ground control surfaces (GCS's)
- Develop spatial accuracy metrics using 10's of millions of points

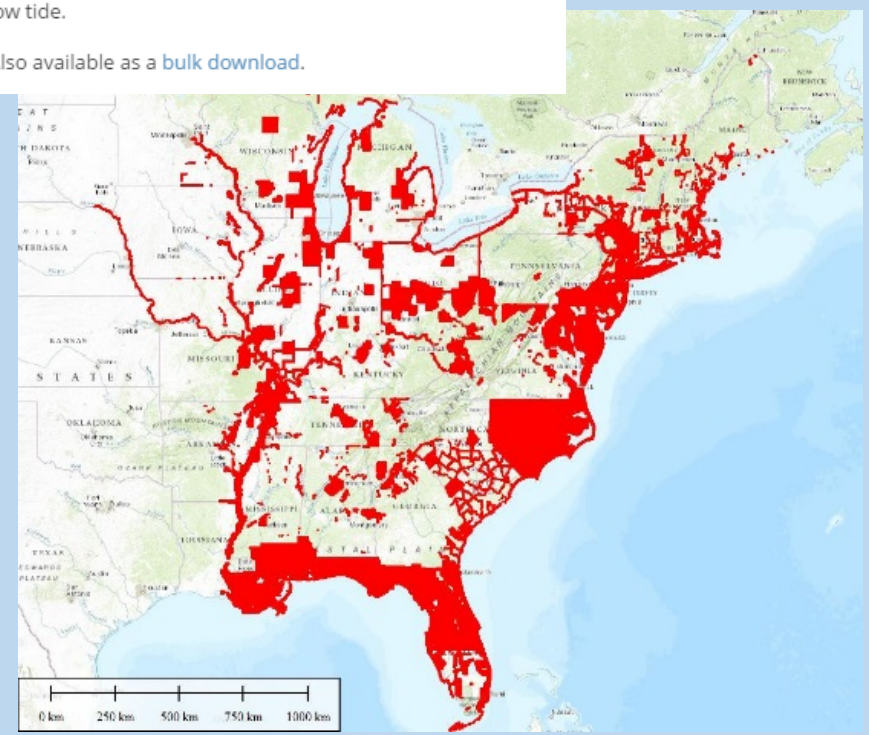




A Pipe Dream or Attainable, Some Logic

- We (I mean you) have worked hard for 20 years collecting and making Lidar data available (true)
- There is re-occurring coverage (true)
- We have ground truth'ed and tested it (true?)
- 90% + of the surface is static at the time/levels used by most people (?)
- **If true: there are trustworthy measurements for about every meter in many locations - and we, potentially, have a lot (!!) of GCP's at our disposal.**





BIG Questions

1. We have tested existing data enough?
2. 90% + of Coverage is Static at the Time/Levels Used Most Often?
   - i.e., there are places that are as they were 10 or 15 yrs ago (streets, parking lots, lawns)

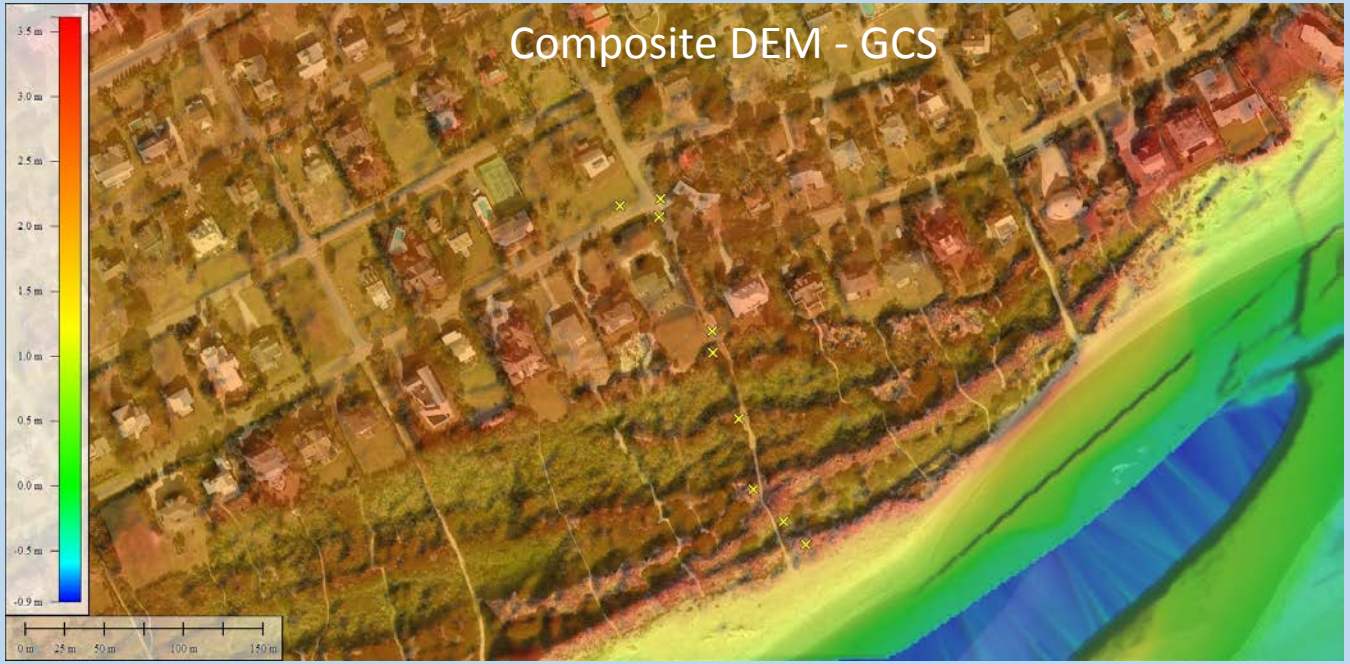
What We Have

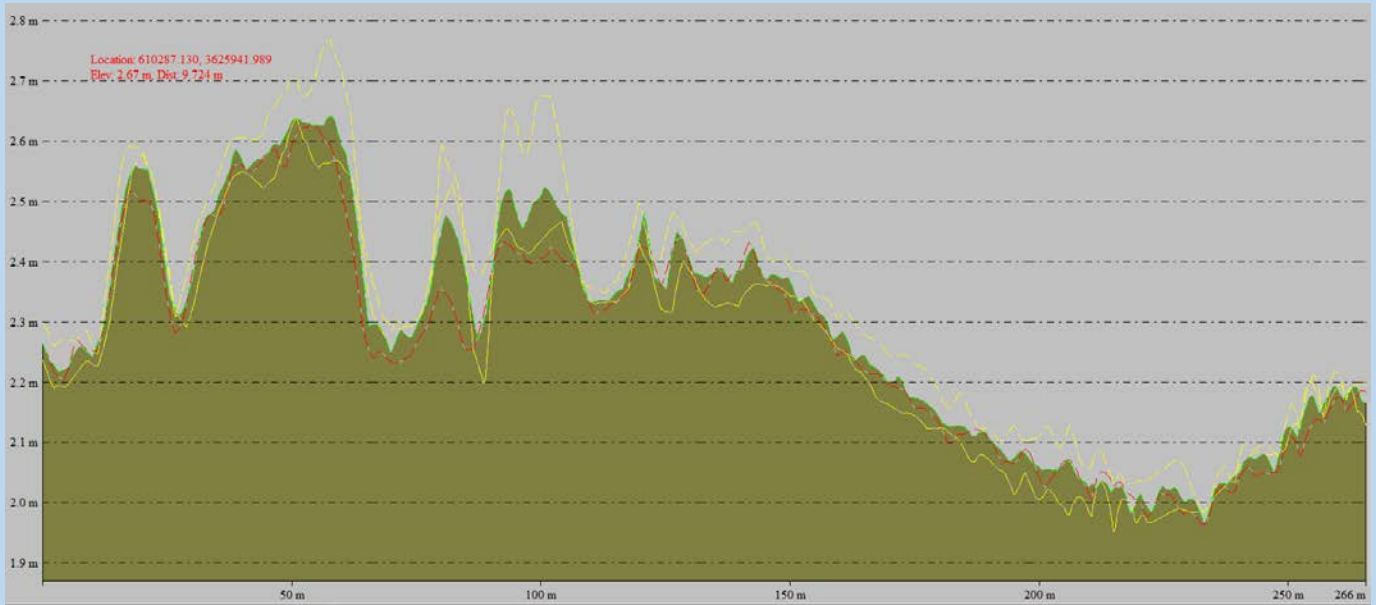
1. 20 Years of Lidar Data
2. Re-occurring Coverage
   - Looking for areas with 3 or more to invoke statistics.
3. Existing GCP's, Accuracy Assessments

Testing/Proof of Concept – NCEA

(nearly continuous error assessment)

- Assess a previously QA'd data set (2006-7) in an area with multiple data sets and GCP's
- Generate a 'truth surface' – i.e. a GCS – from existing data (2000-2010)
- Discriminate: not all areas are valid as the truth
  - None are absolute truth
  - Neither are GCP's

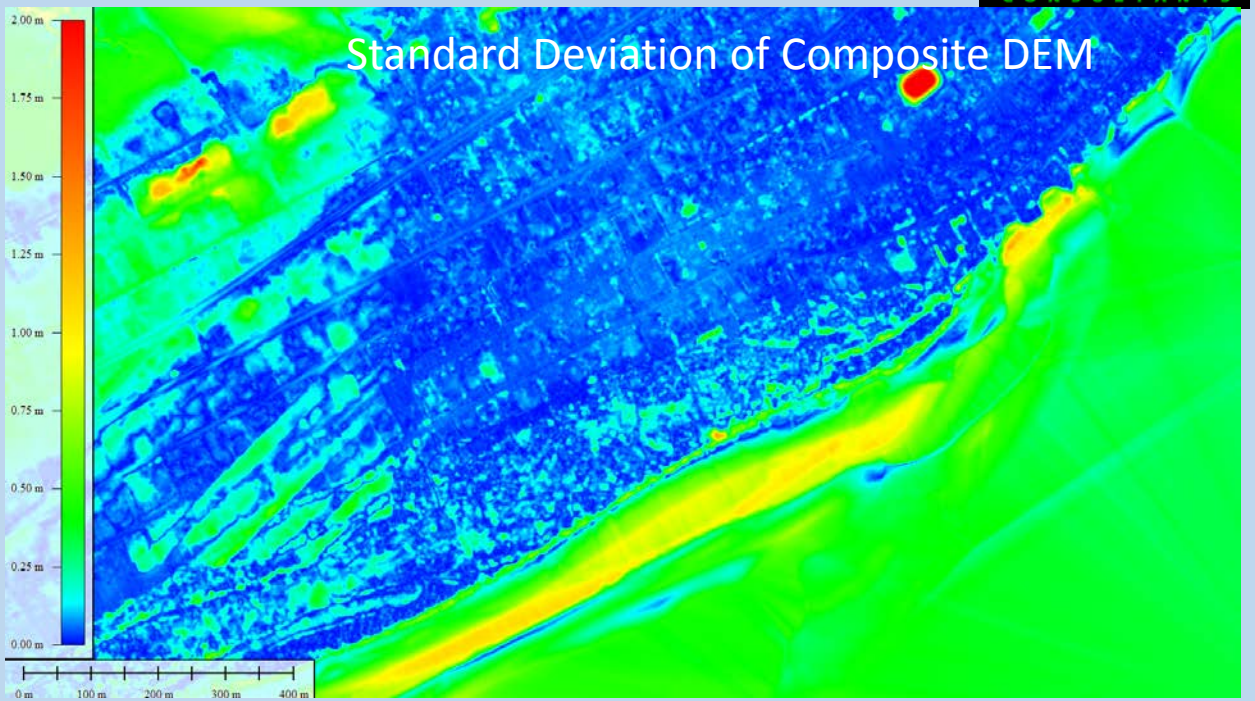




How to Define ‘Valid’ Locations?

- Define how much truth the GCS really holds
  - THIS IS THE ELEPHANT IN THE ROOM
  - Compute Standard Error of the Mean
  - Other ways to do it (variance)
- 6 cm SEM cut-off
- 5 degree slope cut-off
- BIG Advantage – sheer # of points

$$\mathrm{SE}_{\bar{x}} = \frac{s}{\sqrt{n}}$$

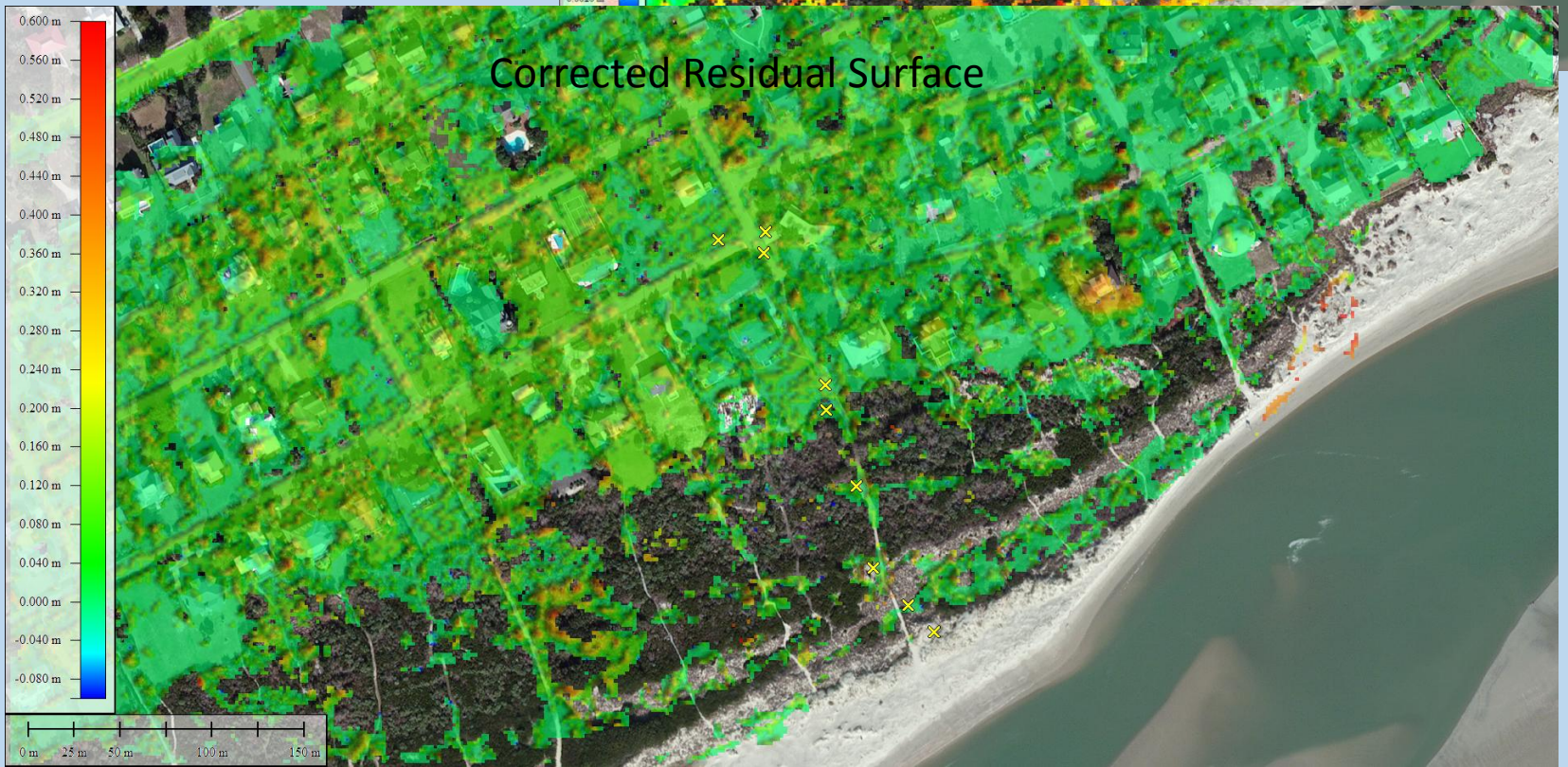


Testing - Continued

- Measure the difference between a 'truthified' GCS and the 2006-7 data set.
  - Using DEM surfaces in this example
- Corrected Residual = Residual - SEM
- Compare that to the traditional results

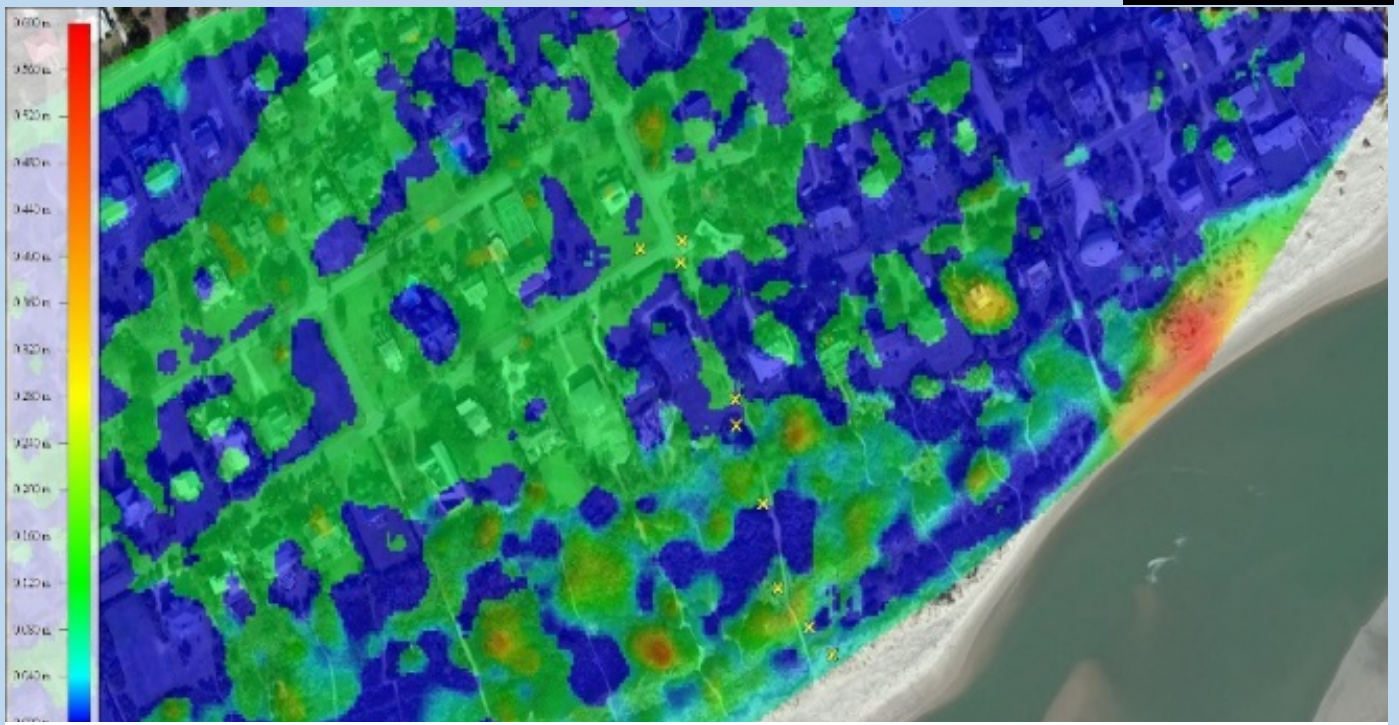
Valid SEM

50611	610700.4	3626124	-0.003	0.000009	0.003
50612	610700.4	3626122	-0.002	0.000004	0.002
50613	610700.4	3626118	-0.004	0.000016	0.004
50614	610700.4	3626116	0.055	0.003025	0.055
50615	610700.4	3626112	0.045	0.002025	0.045
50616	610700.4	3626110	0.033	0.001089	0.033
50617	610700.4	3626108	-0.013	0.000169	0.013
50618	610700.4	3626106	-0.012	0.000144	0.012
50619	610700.4	3626104	-0.004	0.000016	0.004
50620	610700.4	3626102	0.009	0.000081	0.009
50621	610700.4	3626100	-0.016	0.000256	0.016
50622	610700.4	3626098	-0.024	0.000576	0.024
50623	610700.4	3626096	-0.014	0.000196	0.014
50624	610700.4	3626094	-0.007	0.000049	0.007
50625	610700.4	3626092	0.006	0.000036	0.006
50626	610700.4	3626090	0.004	0.000016	0.004
50627	610700.4	3626088	0.019	0.000361	0.019
50628	610700.4	3626086	0.028	0.000784	0.028
50629					
50630			mean	0.008435	0.06675
50631			RMSE	0.091844	
50632			95%		0.176



Results: Comparison to Tested Values

- Resulting ‘valid’ cells = 590/acre
- Existing GCPs = 0.0007/acre
- 6 – 7 orders more GCP’s
- Local GCP’s (9) = 10.3 cm RMSE
- Overall agreement with traditional accuracy assessment
- Use of CCAP land cover product to produce per-class values



Interpolated error surface (a different vertical scale is used for the residual and interpolated surface)

Comparison of results for simple land cover categories

Land Cover	Traditional RMSE (cm)	NCEA RMSE (cm)
Total	9.4	9.2
Open	8.1	6.5
Vegetated	10.5	12.3

Traditional Accuracy Metrics

Land Cover Type	No. of Points	RMSE (cm)	$Accuracy_z$ or FVA (1.96 x RMSE) (cm)
Total Combined (all points)	166	0.094	0.19
Open Terrain	47	0.081	**0.16**
Weeds/Crops	36	0.098	0.19
Scrub/Shrub	24	0.100	0.20
Forest	35	0.116	0.23
Built-up/Urban	24	0.071	0.14

Application - Test

- Mapping 10% Risk based on single SLR value
  - 10% Risk for 40 acres using published RMSE
  - 10% Risk for 31 acres using NCEA surface
- About 20% difference/improvement
- Main Difference: Non-vegetated areas have lower risk then initially mapped
- Technique used in larger mapping effort in Mt Pleasant, SC

Inundation risk (10%) based on data set collection metrics specifications

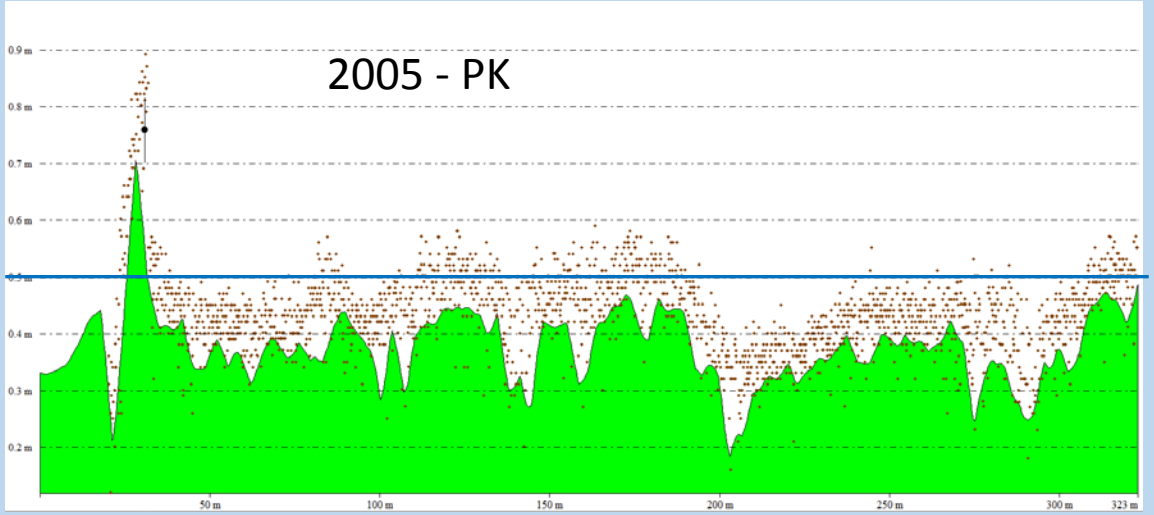
Inundation risk (10%) based on NCEA technique

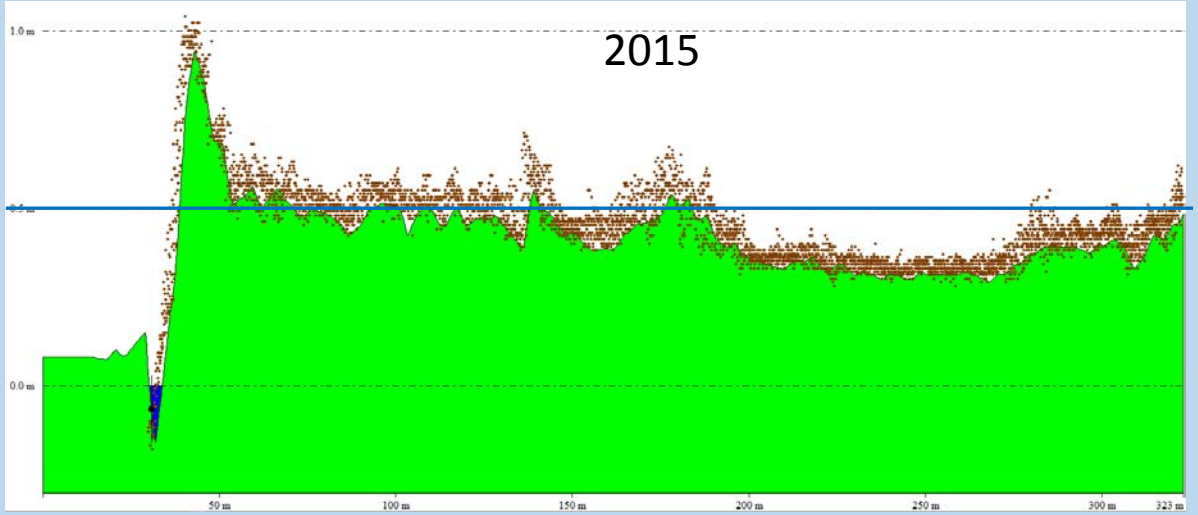
Time and Data

- Beach Volume Changes:
  - Common use – accuracy and change magnitudes well suited
  - However, difficult to model with the results; there is a lot going on between measurements.
  - Temporal change (high frequency change) requires dedicated flight planning (i.e., post Sandy, post Katrina) or lucky timing
- Marsh Volume Changes:
  - Temporal-spatial change well suited (one-way continuous process dominated)
  - Change magnitudes are small
  - But we are approaching 20 years in some locations now.
  - Vegetation and bias some of the difficult parts
  - Help to guide marsh renourishment (thin layer deposition)

Thin Layer Planning Example

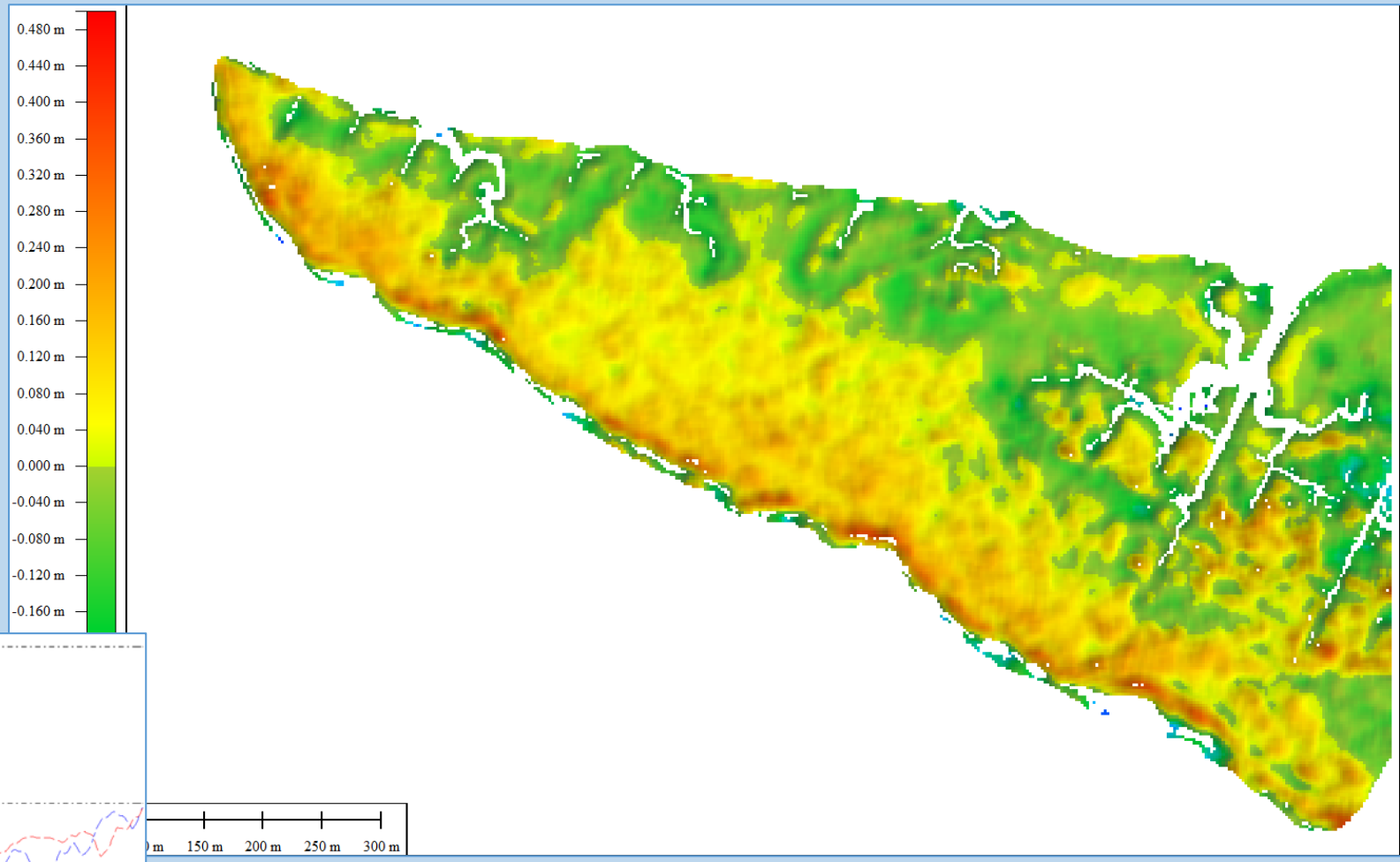
- Part of BU planning project
- 2005 Post Katrina and 2015 lidar compared – 10 years
- Bias checked off-site on flat-open areas
- Min-bin used to remove vegetation

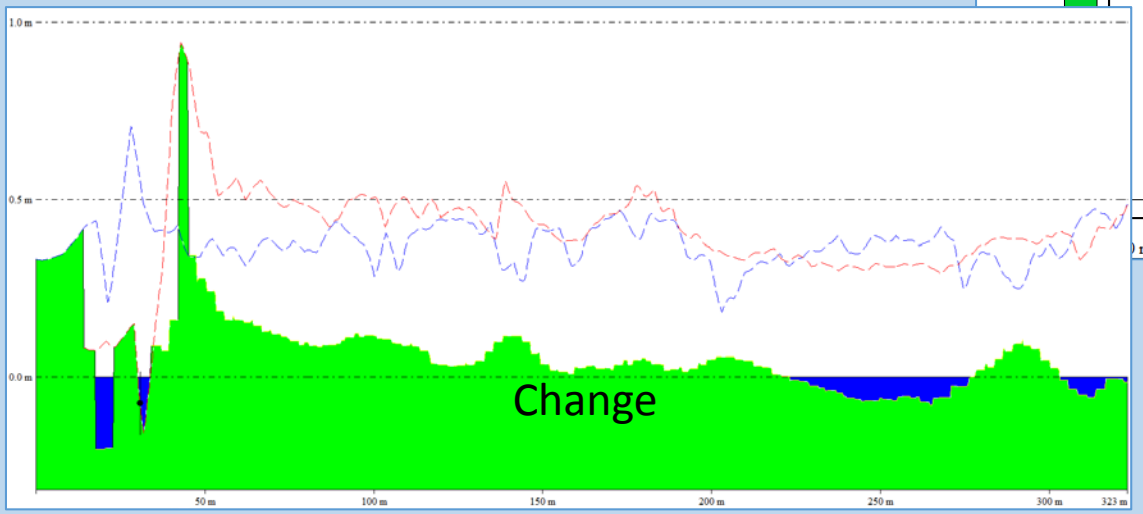




Marsh Renourishment Planning

- Very similar to beach change
- Highlights areas in need
- Calculate approximate volumes
- Time vs. deposition rates





Wrap-Up

- NCMP – Lots of data; Lots of time
- Previous QA's – lets use them and build on them
- Use of reoccurring coverage – Development of virtual GCP's
  - NCEA returns similar values to traditional techniques but error coverage is 10^6 times denser
  - No need to choose veg vs. non-veg RMSE in models
  - Can it be done with bathy data?
- Use of time
  - Slow, continual processes (more time the better)
  - Marsh change – becoming a viable option to SETs?
  - Morphology/Habitat changes – more difficult (changes in energy) but clearly on the horizon
  - Leverage SET data for surface generation and use in models.
- What is more valuable - Old Data or New Data?

Questions?

White Papers available if anyone is interested

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