

NOAA's

National Geodetic Survey/Remote Sensing Division

Utilization of the Applanix Digital Sensing System (DSS) Model 439 DualCam for Shoreline Mapping

Stephen White

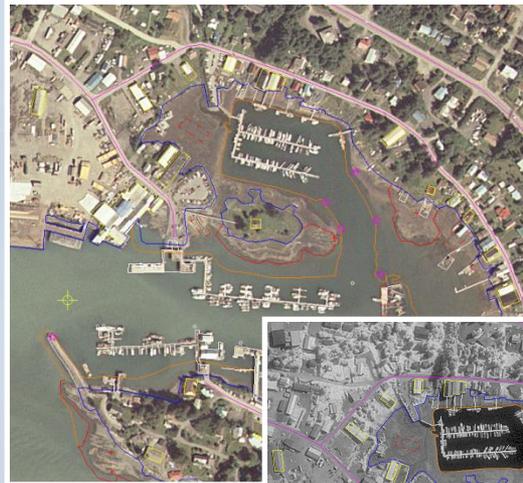
**Civil Commercial Imagery Evaluation
Workshop 2010**



National Oceanic and Atmospheric Administration

Shoreline Mapping: Coastal Mapping Program

- **NOAA**
 - National Ocean Service
 - National Geodetic Survey
 - Remote Sensing Division
- A congressional mandate to conduct remote sensing surveys of coastal regions of the United States and its possessions for demarcating the nation's legal coastline.
- **CMP Goal:** Provide the Nation with Accurate, Consistent, Up-to-Date National Shoreline
- **Sources:**
 - High Resolution Satellites
 - Digital Cameras
 - Film Photography
 - Lidar



National Shoreline

- Used in defining the United States' territorial limits
- Important applications:
 - NOAA nautical charting
 - Coastal resource management
 - Storm surge and coastal flooding modeling
 - GIS analysis
 - Coastal geomorphology studies
 - Many more...



Applanix DSS DualCam



Dual 39 MP nadir: 5412 x 7216 each image

Pixel Size: 0.0068 mm

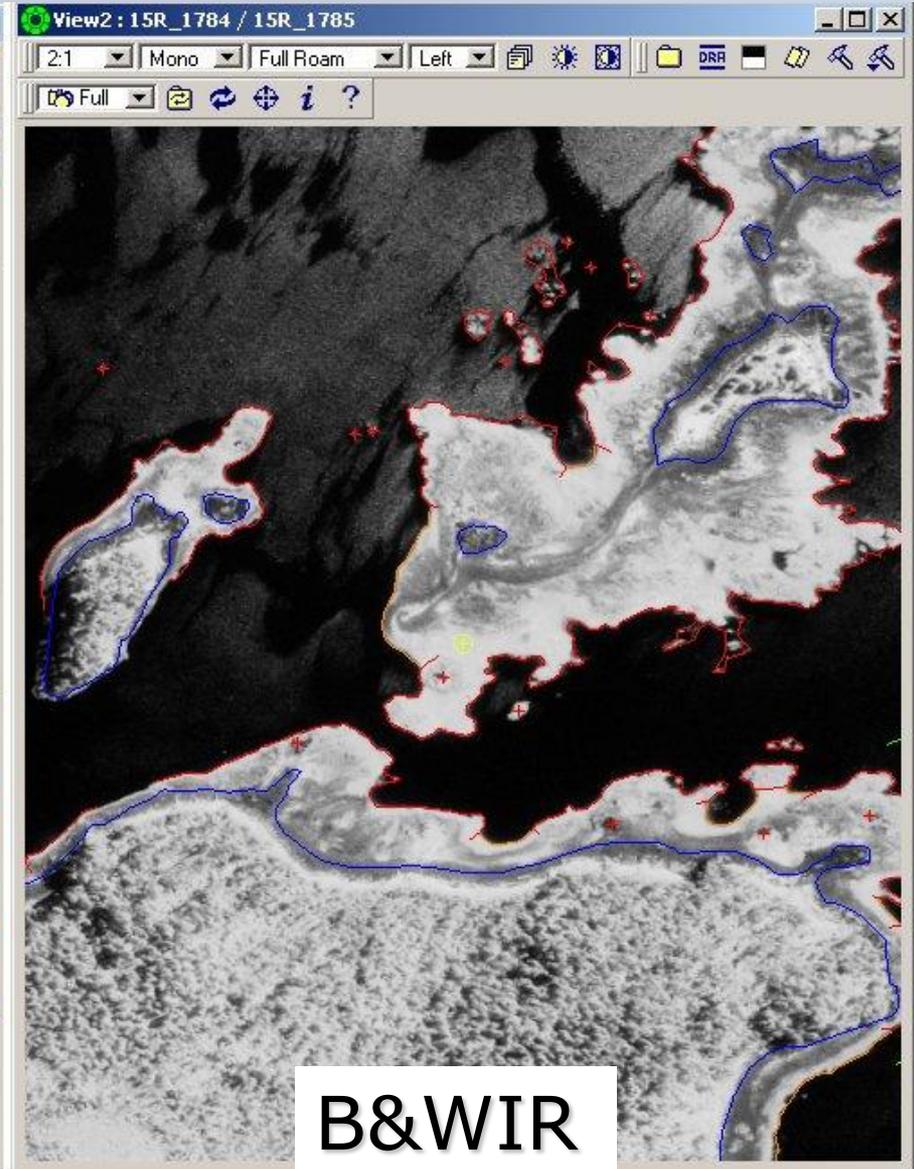
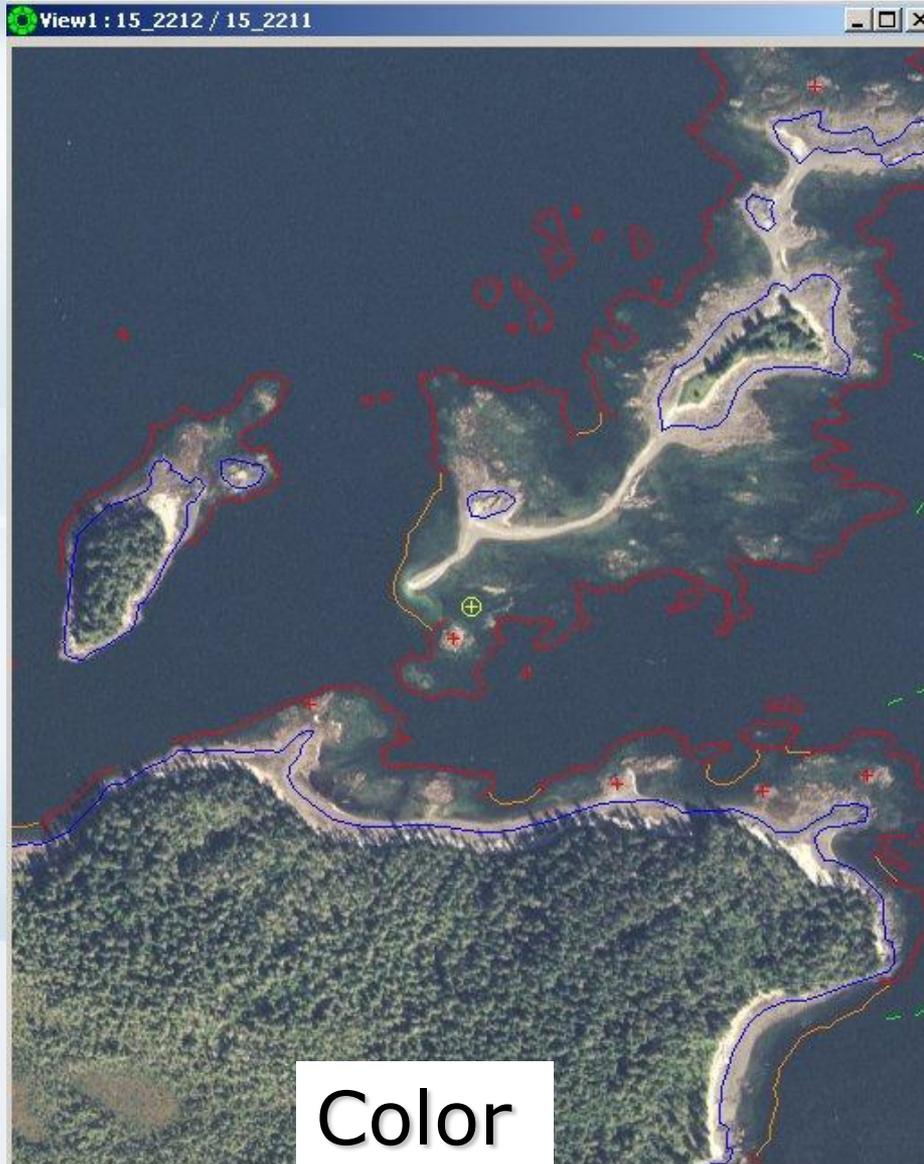
Filter Array: Bayer Array Color (VIS) and Monochromatic Near-Infrared (NIR)

Applanix AeroLens by Carl Zeiss:
60mm or 40mm

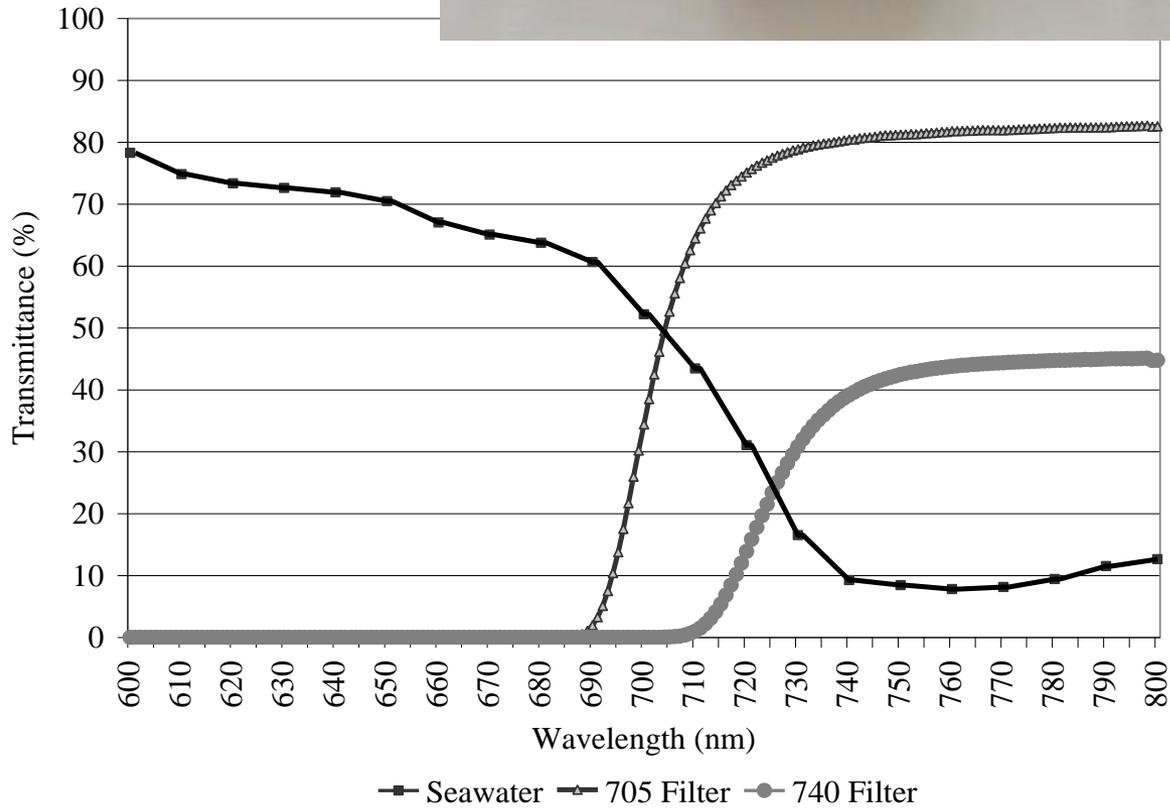


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Film Photography

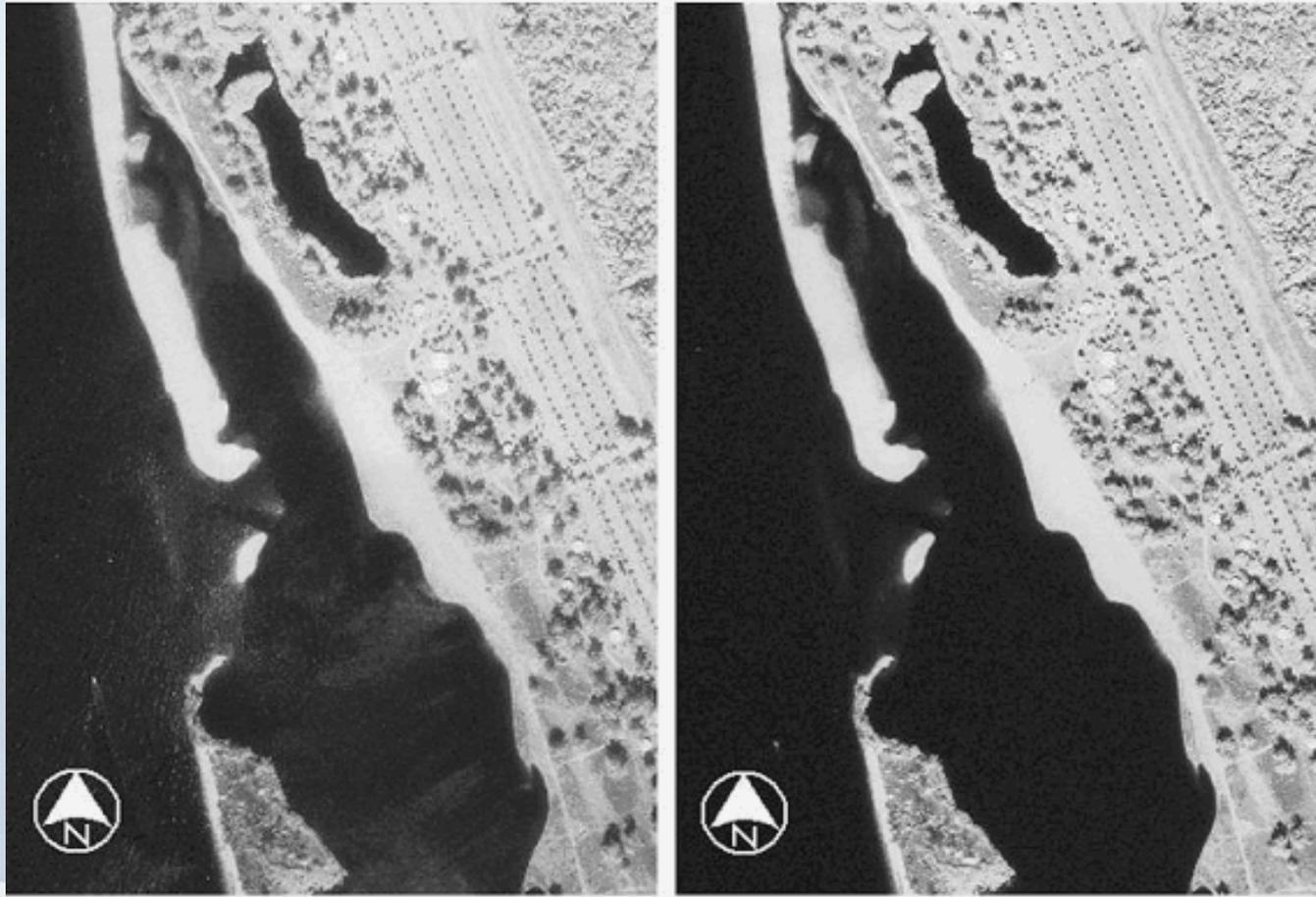


740 nm Optical Filter



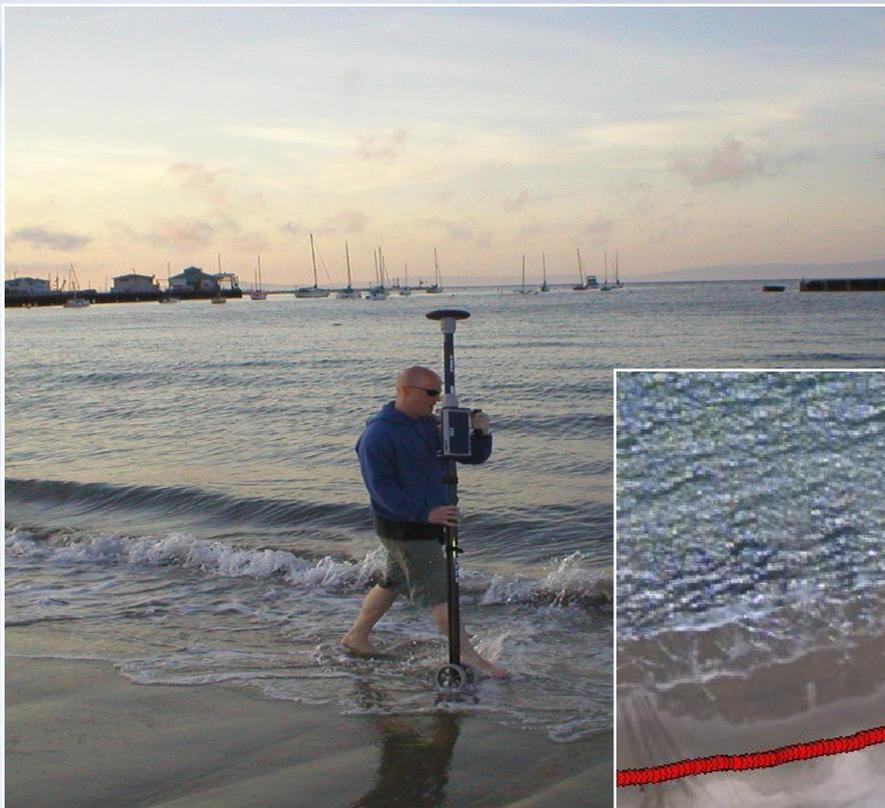
$$T = e^{-Kd}$$

Aerial film imagery acquired utilizing the 705 nm filter (left) compared against imagery acquired with the 740 nm filter (right).



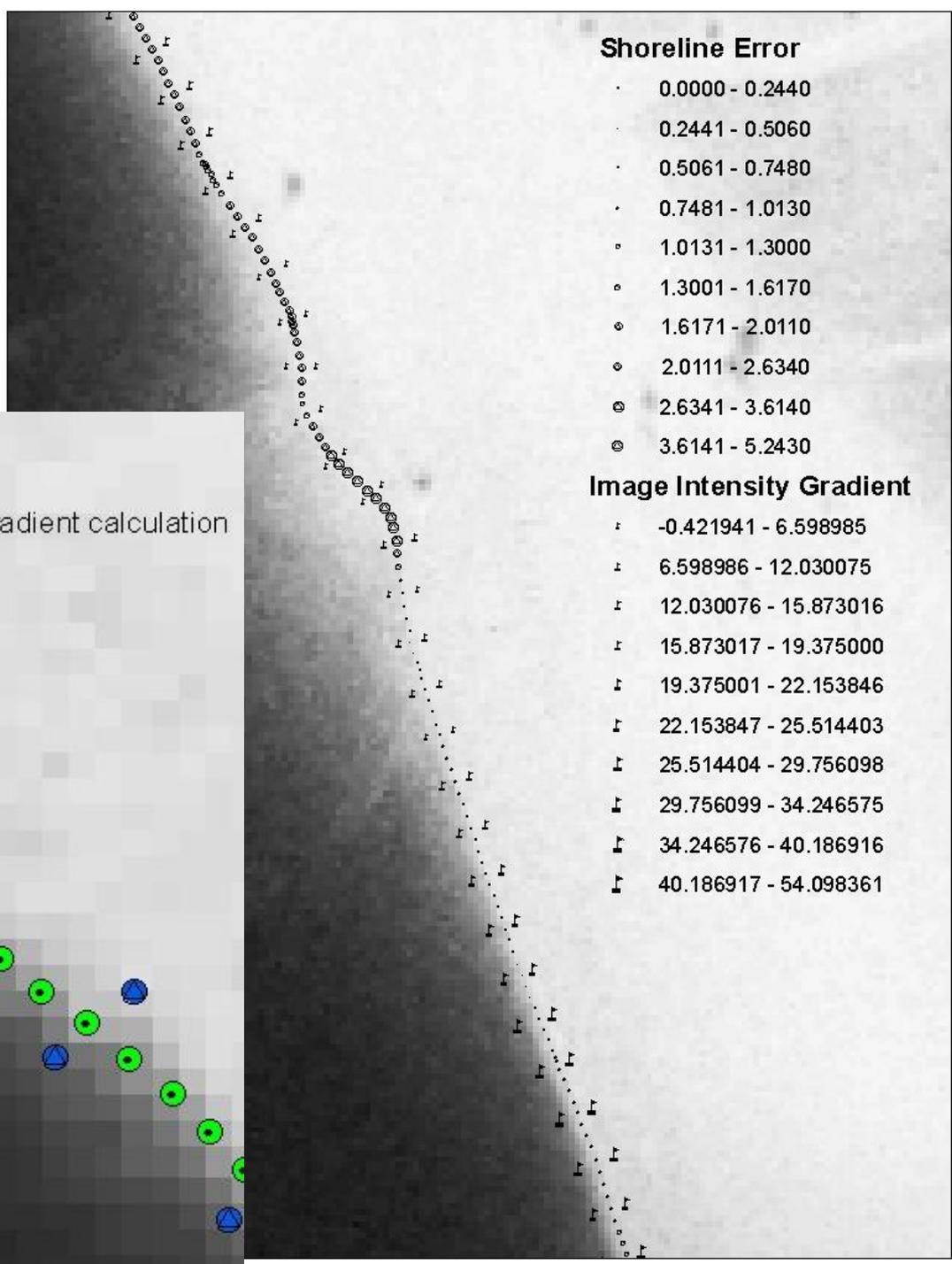
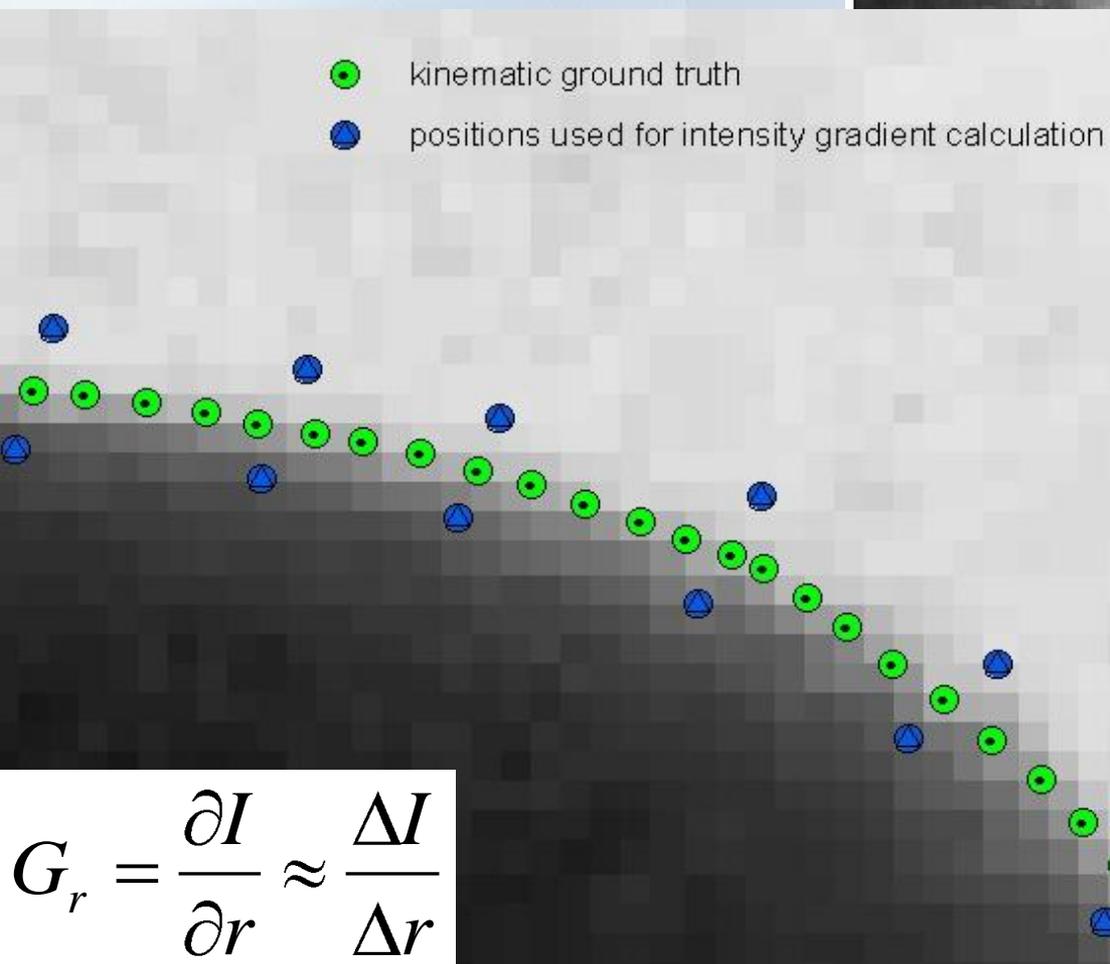
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Reference Shoreline



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Image Intensity Gradient Across Land/Water Interface



Digital NIR: Driving Issues

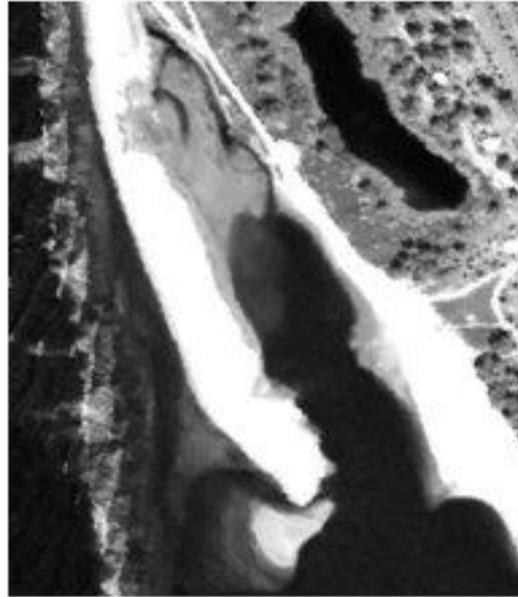
- Emulsion based photography is being phased out in all but the most commercially-viable sectors
 - Kodak informed NGS in May 2006 that it was immediately ceasing production of 2424 large format B&WIR film
 - Sales of digital aerial mapping cameras is increasing
- Workflow would benefit from digital image collection
 - Streamlined all-digital workflow
 - Better dynamic range
 - Can sense further into the NIR



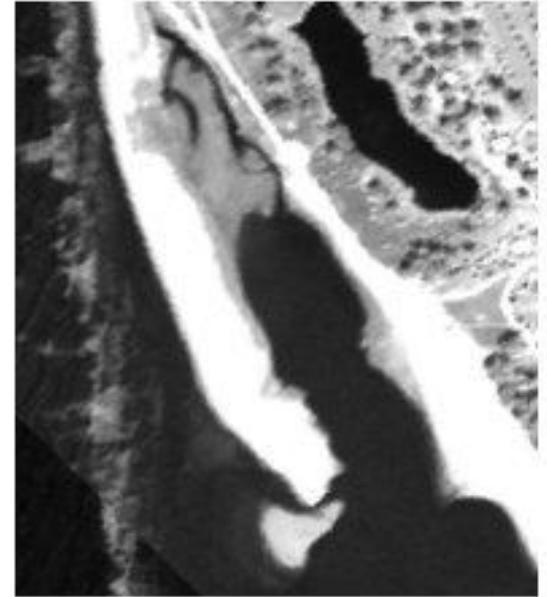
CASI Hyperspectral Data



700 nm



739 nm



900 nm



Investigation of Filters with the IR Camera

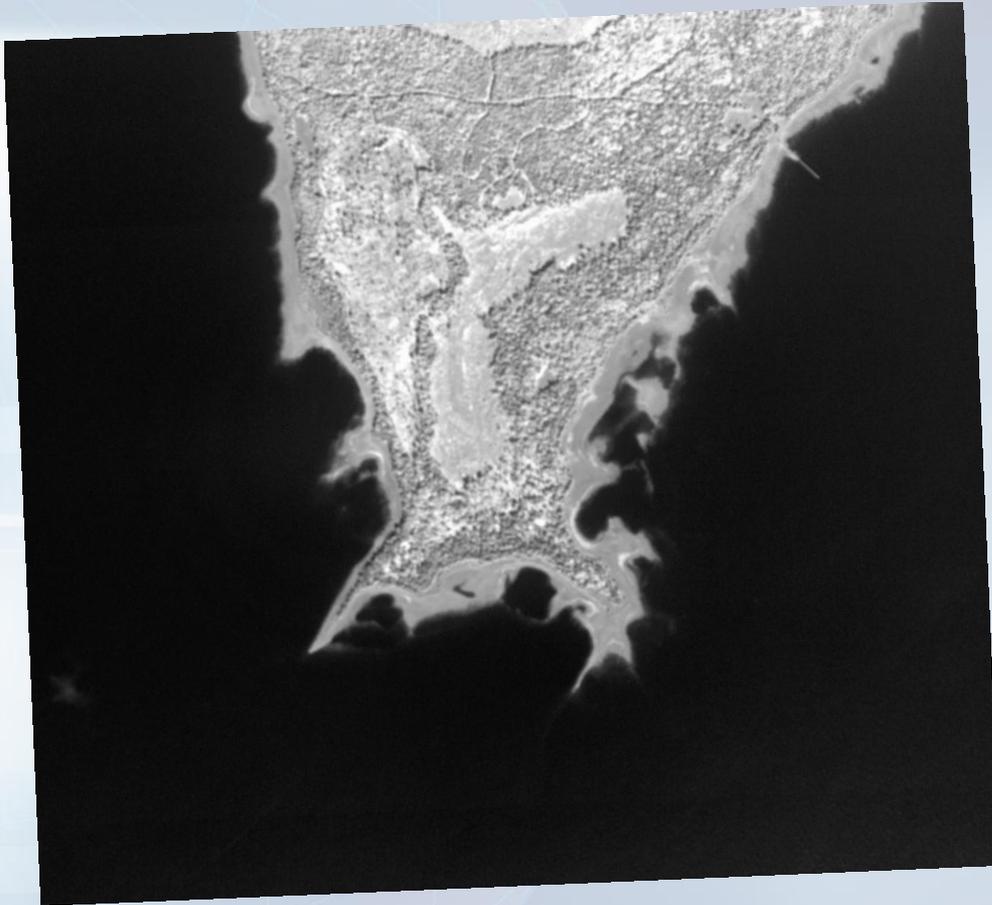
Phase I
Studied general NIR imagery capability

Phase II
Initial Ground Truthing

Phase III
Rigorous evaluation of post lens calibration
and examination of performance in clear
shallow water



Phase I-Thunder Bay NMS



850 nm

Experiment:

- Three Filters
 - 740 nm (current on film camera)
 - 780 nm (slightly higher)
 - 850 nm (will it even work?)
- Two ISO's
 - 300
 - 400
- Three Exposure speeds
 - 500
 - 1000
 - 2000

Conclusions:

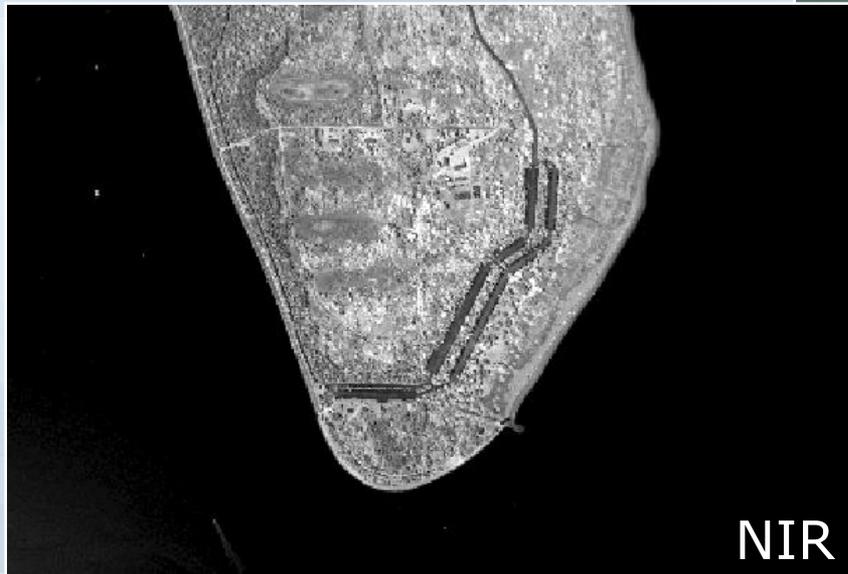
- All three filters worked
 - Even the 850!
 - ISO 300
 - Exposure Speed 1/1000 th
- Imagery a little on the soft side due to longer wavelengths
 - Focal length needs to be longer in the NIR
- Lens returned to Applanix for tuning



Phase II-Key Biscayne, FL

Experiment:

- Test Specially tuned 60 mm lens
- Ground Truth Shoreline during over flight



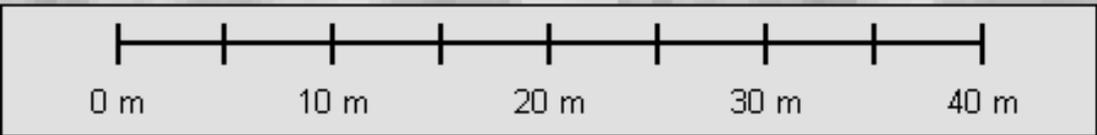
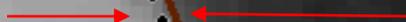
Conclusions:

- Focus issues resolved
- 850 nm worked well for compilation



Kinematic GPS collected during over flight

Compiled shoreline from imagery

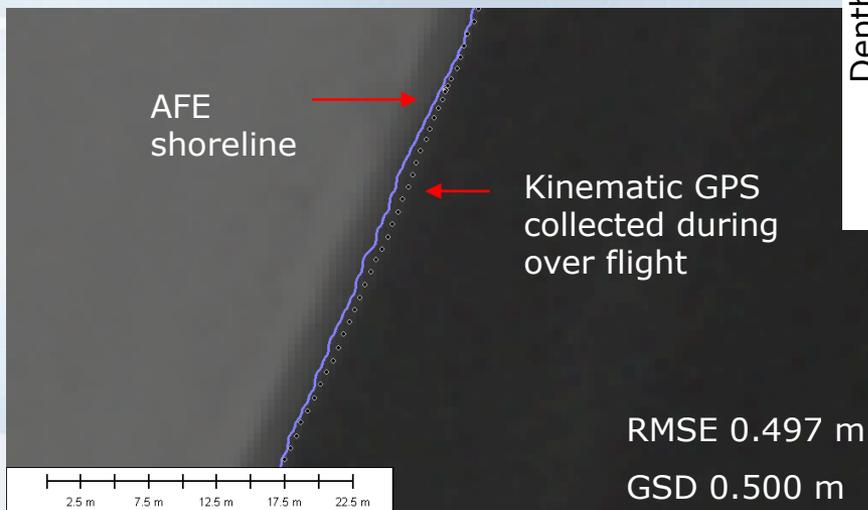
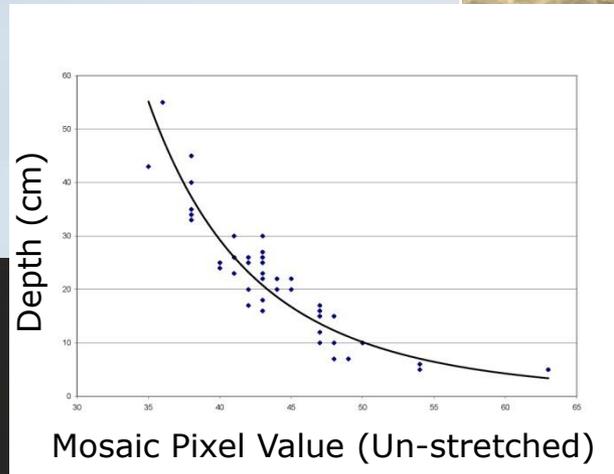


RMSE 0.92 m
GSD 0.50 m

Phase III-Sheboygan, WI

Experiment:

- Specially tuned 60 mm lens
 - 850 nm
 - 1000 nm
- Ground Truth Shoreline during over flight
- Examine performance in clear shallow water



The imagery acquired with the 1000 nm filter was very noisy



RGB/NIR Band Stacking

DSS Image Co-Registration

File Help

RGB Camera Inputs

E:\0532010_Austin\DSS\RGB\05374855\band-stk-rgb

E:\0532010_Austin\DSS\RGB\05374855\NavData\ImageEvents.csv

Mask Color Name Prefix Name Suffix

NIR Camera Inputs

E:\0532010_Austin\DSS\B\WIR\05370172\band-stk-nir

E:\0532010_Austin\DSS\B\WIR\05370172\NavData\ImageEvents.csv

Mask Color Name Prefix Name Suffix

Processing Parameters

Data Bit Depth

Transform Method

Event Time Offset

Clip to Overlapping Image Regions

Output Formats

4 Band Image (R/G/B/NIR)

False Color Infrared Image (NIR/R/G)

Channel Image (R)(G)(B)(NIR)

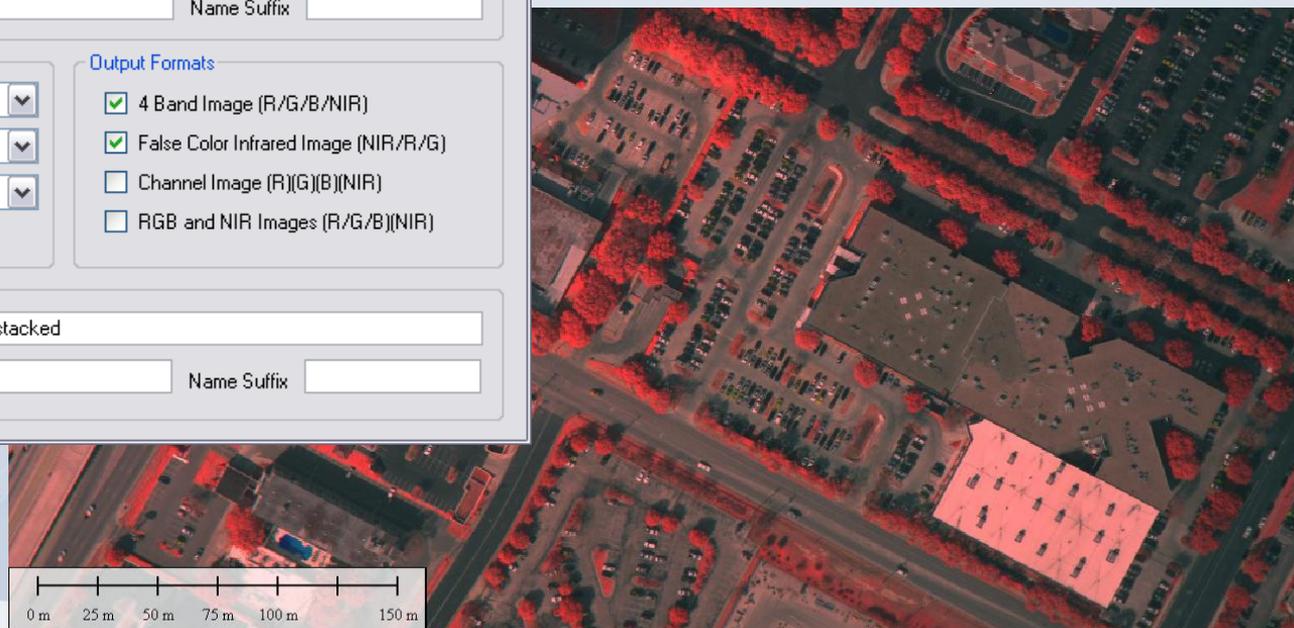
RGB and NIR Images (R/G/B)(NIR)

Output Paths

E:\0532010_Austin\DSS\band-stacked

Name Prefix Name Suffix

Austin, TX DSS CIR Image



Emergency Response



Remotely sensed data is acquired to support NOAA's homeland security and emergency response requirements.

NOAA maintains the capability to provide tools, technology, and expertise in a timely and efficient manner.

The remotely sensed data collected is disseminated to federal, state, and local government agencies as well as the general public to facilitate support efforts.



Rapid Ortho Accuracy Assessment

Purpose:

- Quantify the accuracy of images generated using the Rapid Ortho process
- Identify the impact of different workflow combinations on the overall quality of the product
- Perform analysis at the “product level”

Study Area: Virginia Beach, VA

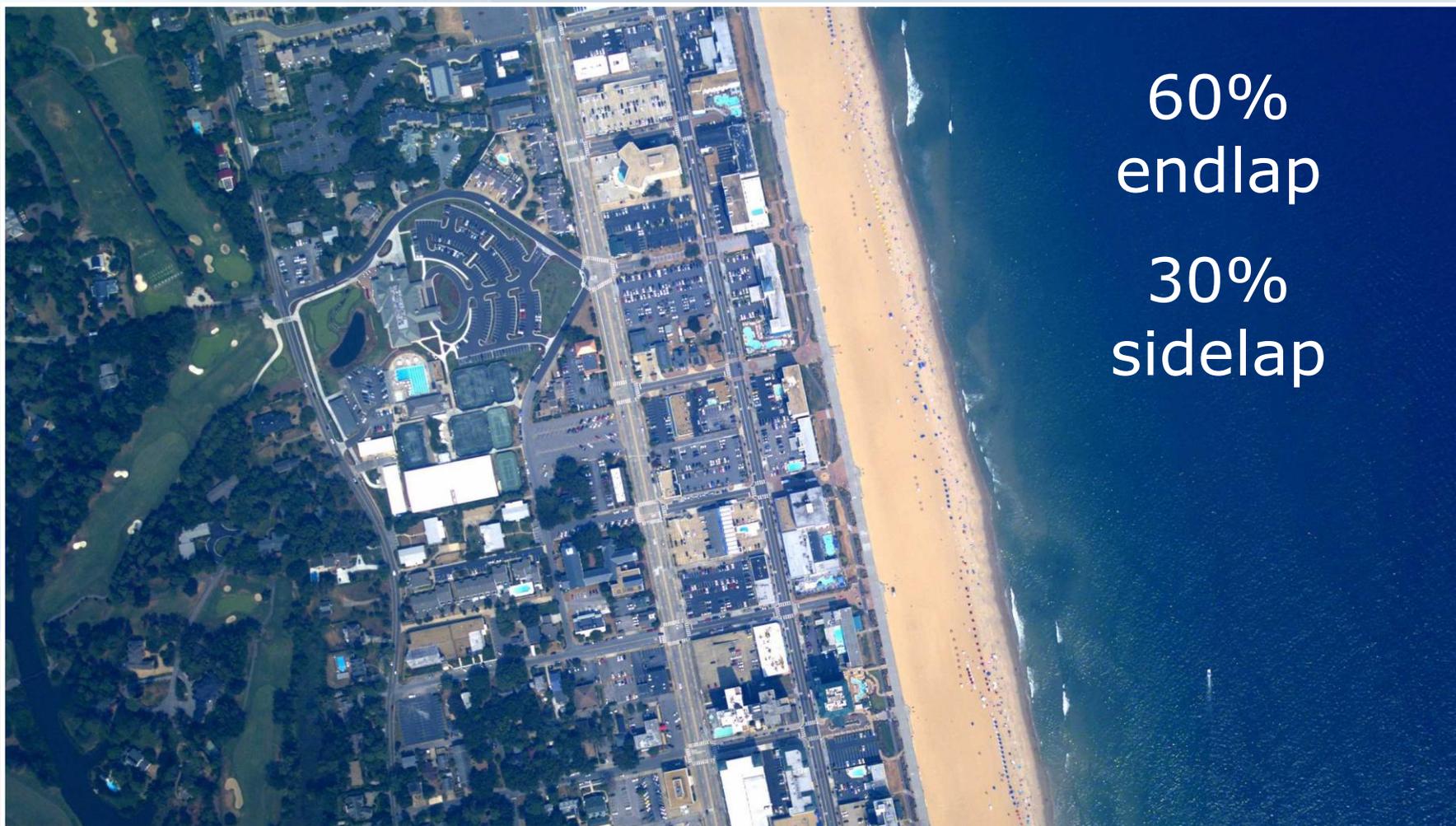
- DSS imagery acquisition
- Topographic lidar acquisition
- Static GPS ground control point acquisition



DSS Imagery

7500 ft AGL, 60 mm lens, 34 cm GSD

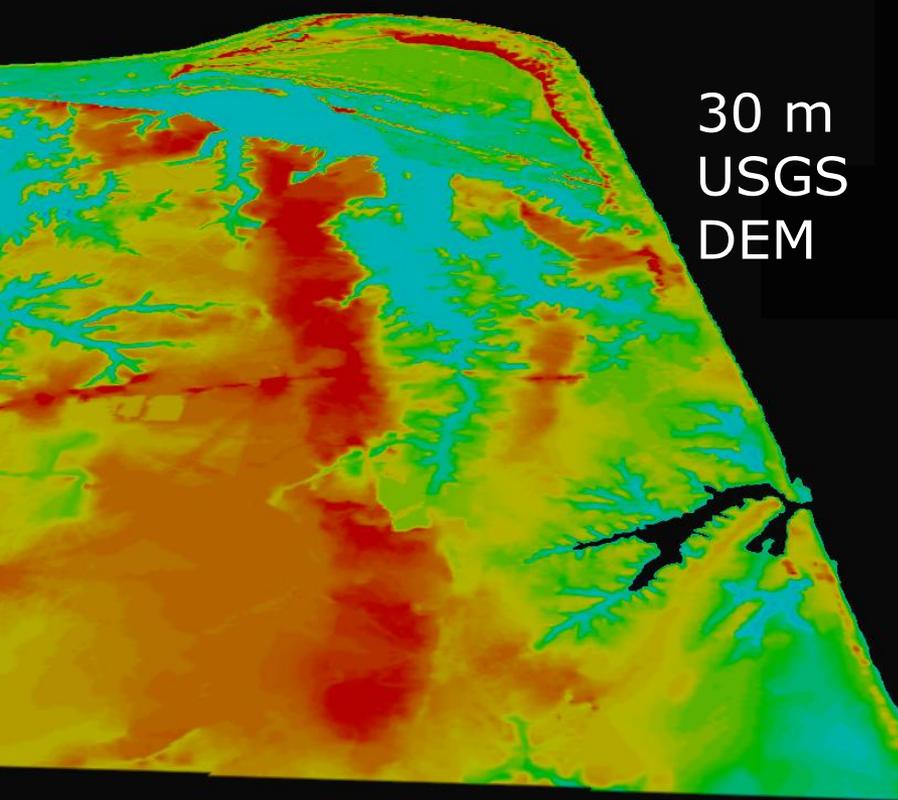
4500 ft AGL, 60 mm lens, 21 cm GSD



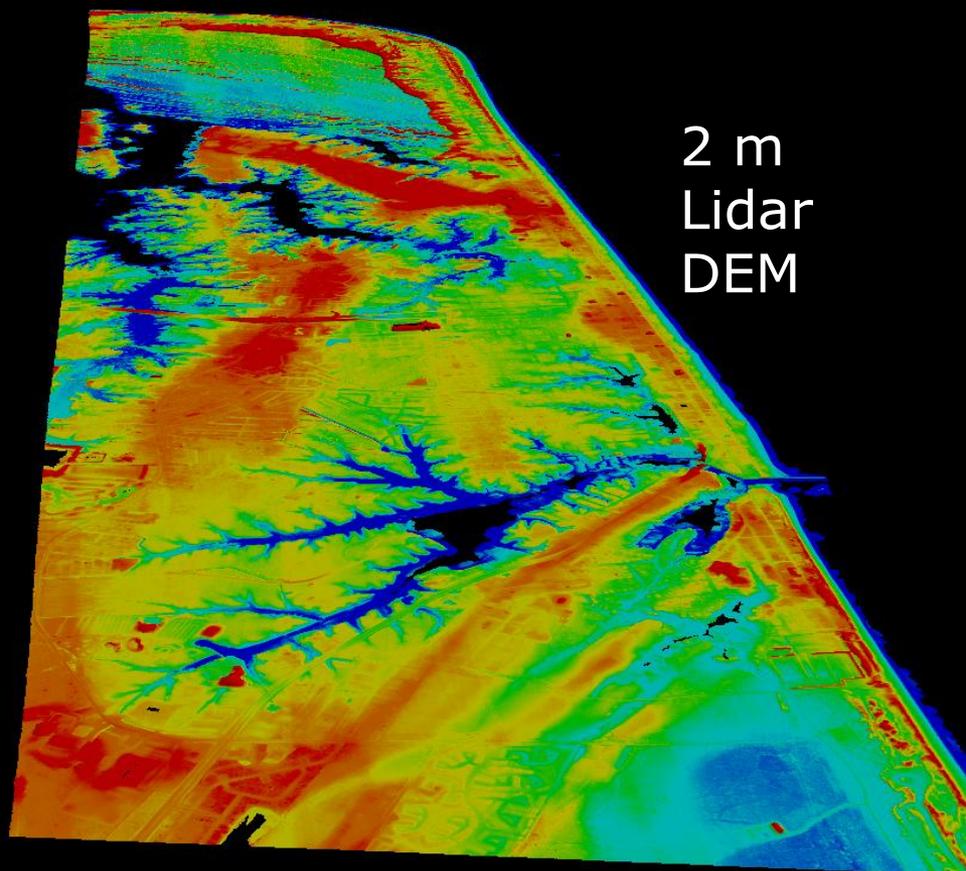
60%
endlap
30%
sidelap

Digital Elevation Models

USGS DEM downloaded from NationalMap.gov Topographic Lidar acquired at 1 m post spacing



30 m
USGS
DEM



2 m
Lidar
DEM

GPS Control Points

- 50 static post-processed GPS control points at photo identifiable locations



GCP VB07



GCP VB11



Nav Data Processing

- **NavCom Starfire**
 - Global satellite-based augmentation system providing precise real-time positioning
 - Network of approx. 60 reference stations worldwide compute satellite orbit and clock corrections
 - Corrections are broadcast via 3 geostationary satellites
- **PPK – Post Processed Kinematic GPS**
 - Dedicated GPS base station at airport
 - Applanix POSPAC workflow



7500 ft AGL dataset / 0.5 m orthos

4500 ft / 0.3 m orthos

NavCom
GPS

PPK GPS

PPK GPS

Rapid Ortho
Constant
Elevation

Rapid Ortho
USGS
30m DEM

Rapid Ortho
Constant
Elevation

Rapid Ortho
USGS
30m DEM

Rapid Ortho
USGS
30m DEM

Rapid Ortho
Bare Earth
Lidar 2m

OrthoVista
Mosaic

OrthoVista
Mosaic

OrthoVista
Mosaic

Measure
Points in
GIS

Measure
Points in
GIS

Measure
Points in
GIS

Least
effort
required

Most
effort
required

Workflow Combinations

Results

**NavCom (ITRF00)
50 cm GSD**

**PPK (NAD83)
50 cm GSD**

(m)	No Dem	USGS 30 m (corrected to ITRF)	No Dem	USGS 30 m
Ave X	0.51	0.47	0.11	0.15
RMSE X	0.63	0.63	0.33	0.34
Ave Y	-0.12	-0.10	0.02	0.08
RMSE Y	0.46	0.41	0.31	0.31



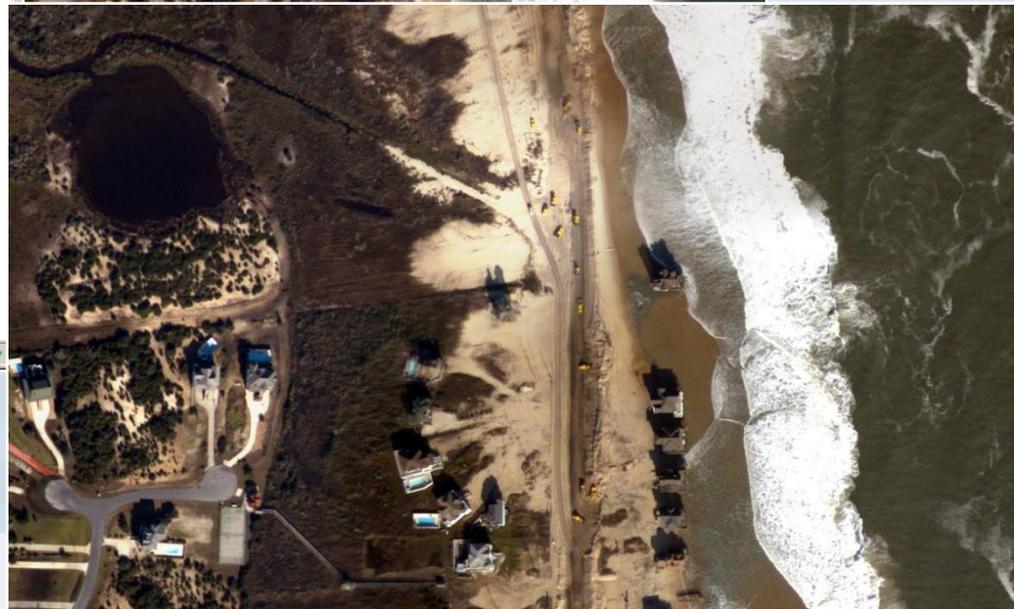
Results

PPK (NAD83) 30 cm GSD

(m)	Lidar Dem	USGS 30 m
Ave X	-0.05	-0.02
RMSE X	0.23	0.21
Ave Y	< 0.01	-0.06
RMSE Y	0.22	0.33



Nor'Easter November 2009



Hurricane Nov09_ne NOAA Images - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://ngs.woc.noaa.gov/nov09_ne/index.html

Most Visited Getting Started Latest Headlines

National Oceanic and Atmospheric Administration's National Geodetic Survey

Nor'easter November 2009

The imagery posted on this site is of the coast of Virginia, North Carolina, Maryland and Delaware after Hurricane Nov09_ne made landfall.

This imagery was acquired by the NOAA Remote Sensing Division to support NOAA national security and emergency response requirements. In addition, it will be used for ongoing research efforts for testing and developing standards for airborne digital imagery.

Individual images have been combined into a larger mosaic and tiled for distribution. The approximate ground sample distance (GSD) for each pixel is 50 cm (1.64 feet). Image file size is between 1 MB and 6 MB and covers 2.5 by 2.5 kilometers (1.55 miles.)

Index Maps:



Click on the image on the left to locate and view individual images.

Click here for [additional information](#), including metadata files, world files, image index shape files, batch downloads..

In an effort to acquire imagery in a timely manner, clouds may be present in the imagery.

[Click here for imagery.](#) [Click here for Frequently Asked Questions.](#)

[Google Earth Interface](#)

Other Emergency Response Imagery:

[Click here](#)

Contact:

Email: [Questions regarding content and technical issues](#)
[Comments and policy issues](#)



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Done



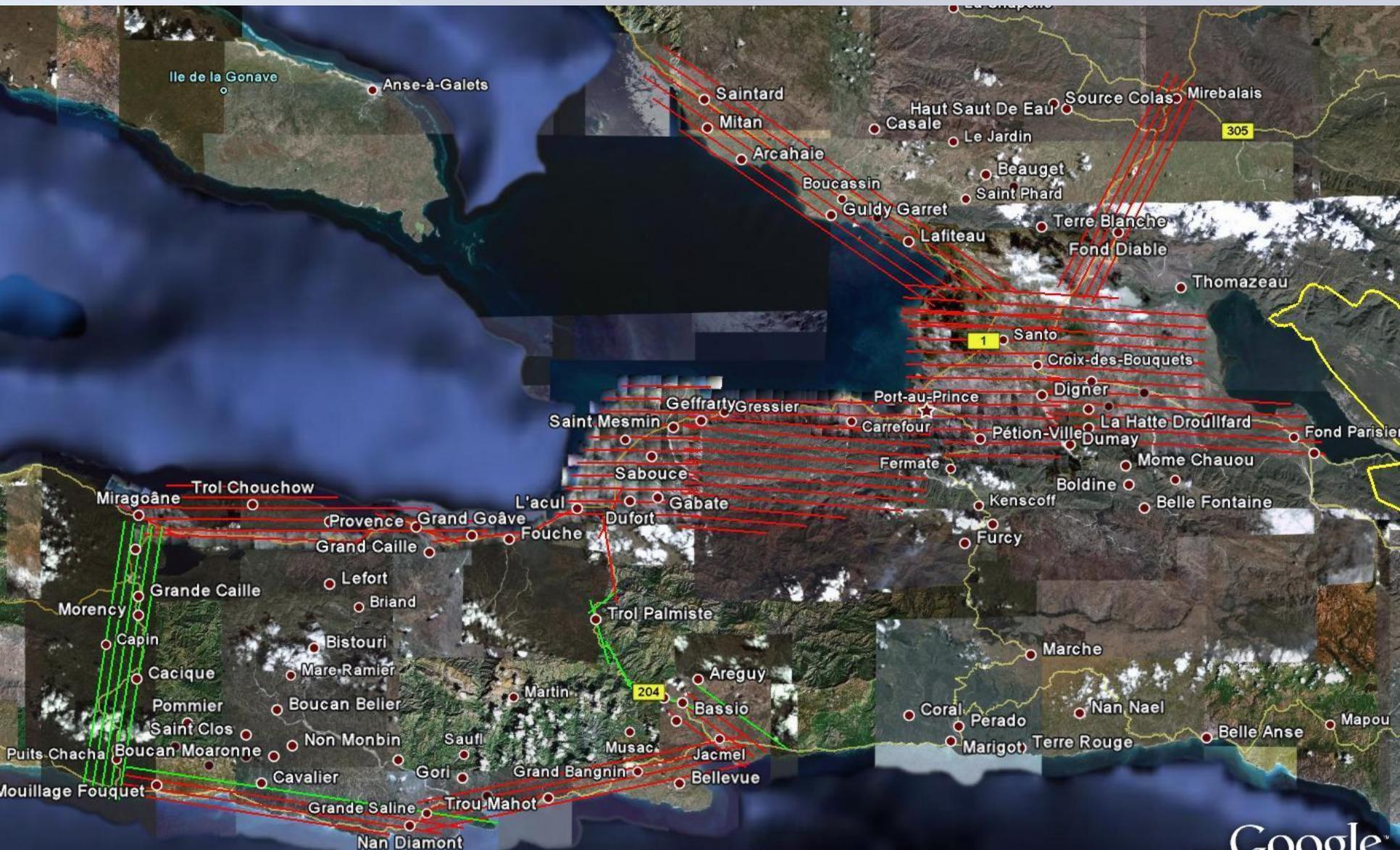
National Oceanic and Atmospheric Administration

Operations



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Operations





National Oceanic and Atmospheric Administration

Dissemination of Data:

ESRI WMS:

<http://www.arcgisonline.com/home/search.html?t=content&q=haiti>

ERDAS WMS:

<http://apollopro.erdas.com/apollo-client/index.jsp?fullscreen=true>

USGS EROS:

<http://hdds.usgs.gov/hdds/>

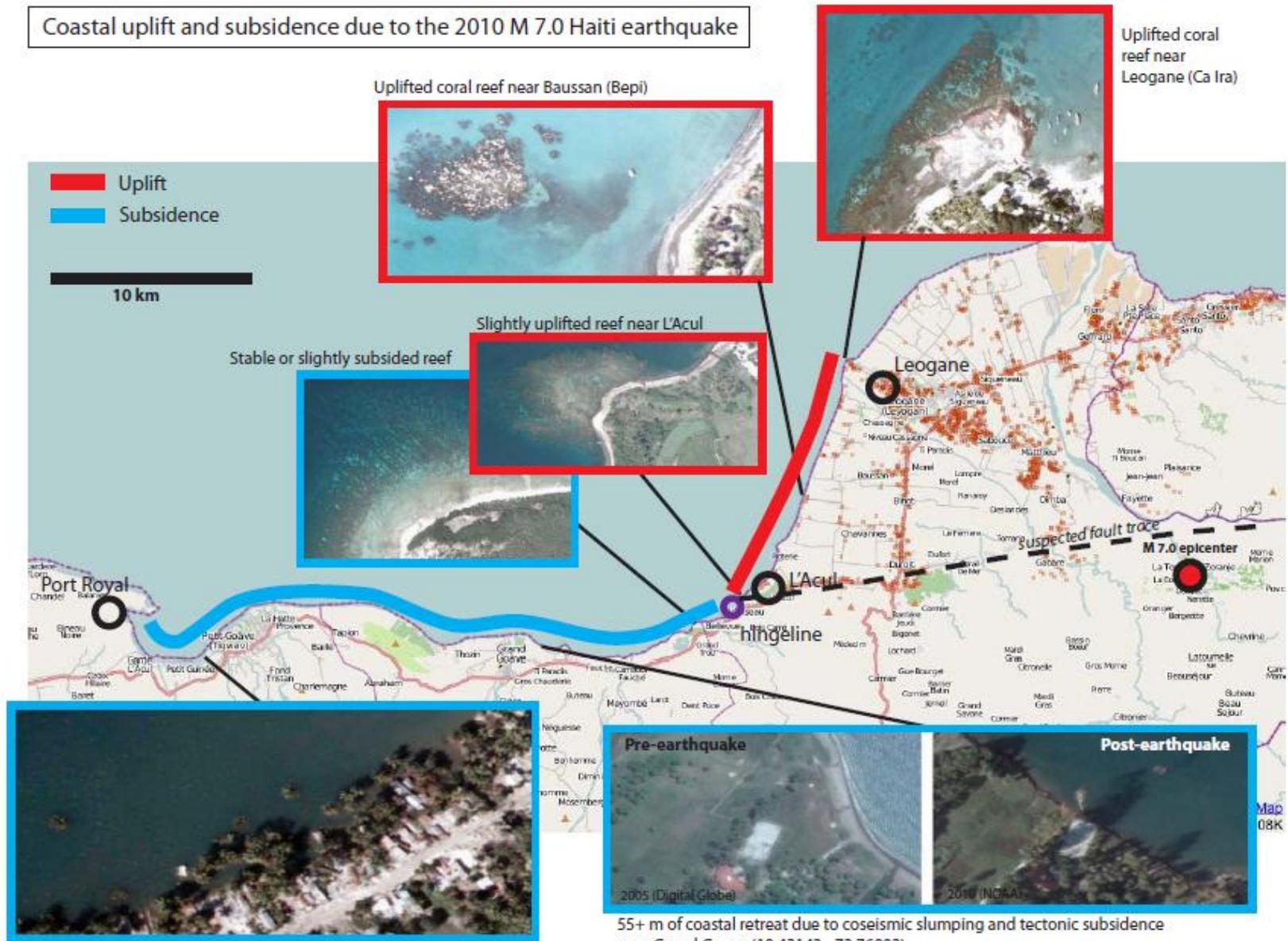
Google Earth Overlay:

http://mw1.google.com/mw-earth-vectordb/haiti_noaa_jan17thv4/haiti_noaa_jan17thv4.kml



Application of Data (USGS/NEIC): Potential Hazards related to Uplift and Subsidence

Coastal uplift and subsidence due to the 2010 M 7.0 Haiti earthquake

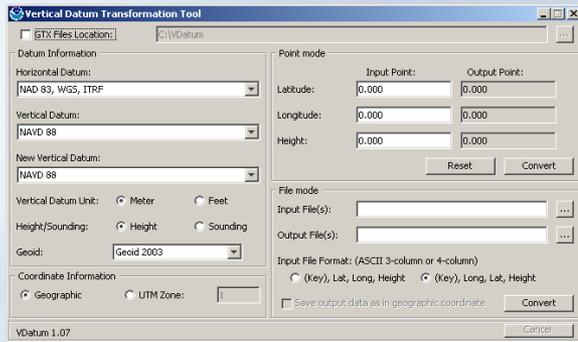
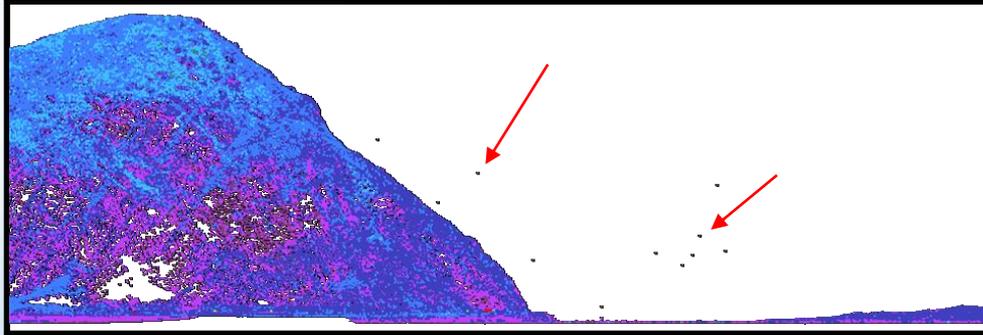


Vegetation and structures in surf, Petit Goave (18.42522, -72.87521)

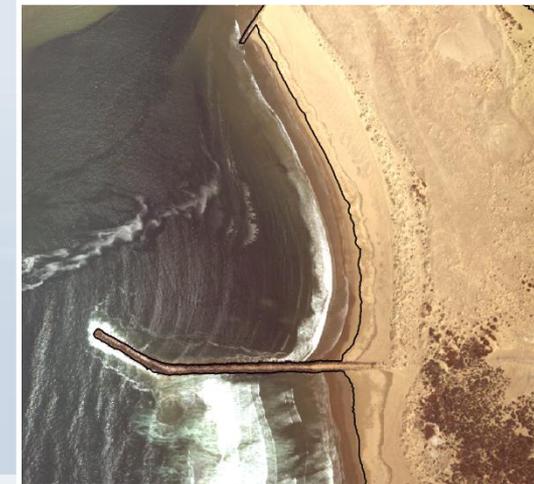
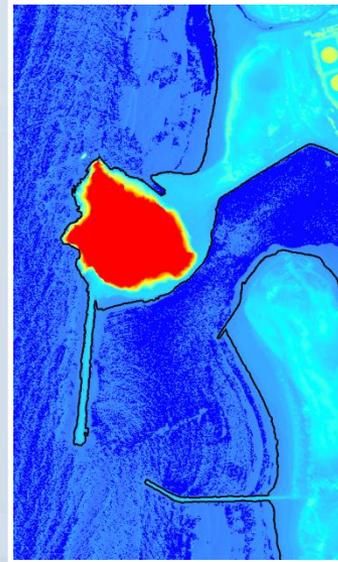
55+ m of coastal retreat due to coseismic slumping and tectonic subsidence near Grand Goave (18.43142, -72.76002)

Lidar Shoreline Extraction

Edit Lidar Point Cloud



VDatum



Contour Shoreline from DEM

Quality Control & Feature Attribution

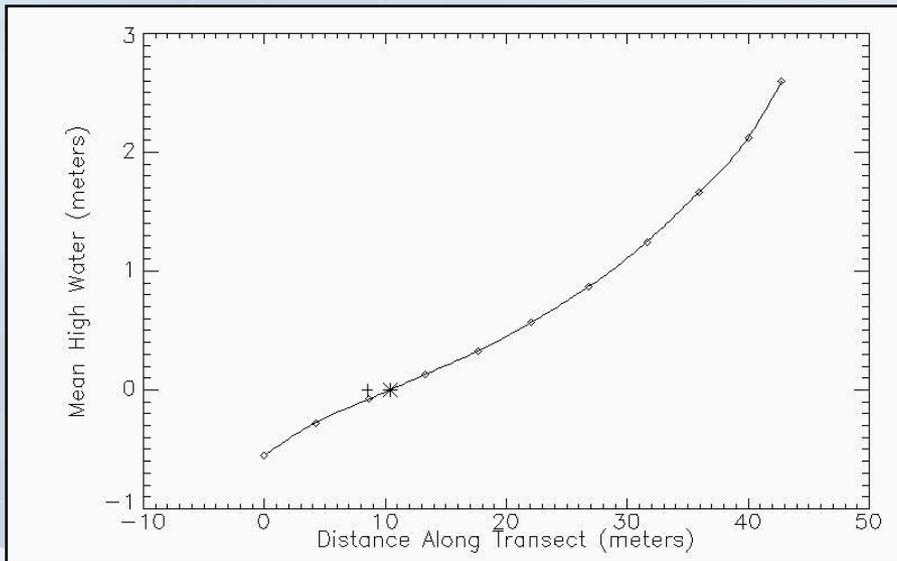


Lidar-derived Shorelines on Varying Coastline Features



National Oceanic and Atmospheric Administration

Empirical Uncertainty Analysis



	ALONG TRANSECT		NEAREST POSITION	
	cubic spline	linear	cubic spline	linear
$RMSE_{HOR}$	2.60	2.62	2.61	2.62
<i>Mean distance between lidar-derived MHW and Topcon-measured transects</i>	2.16	2.19	2.17	2.18
<i>Std. Deviation of distance between lidar-derived MHW and Topcon-measured transects</i>	1.46	1.46	1.46	1.46
<i>NSSDA Accuracy_r (95% Confidence Level)</i>	4.50	4.44	4.51	4.53

Combined horizontal positional lidar-derived shoreline accuracy statistics (meters) computed for all accuracy sites.

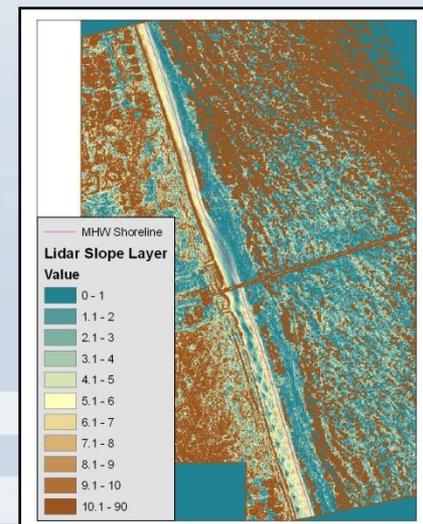
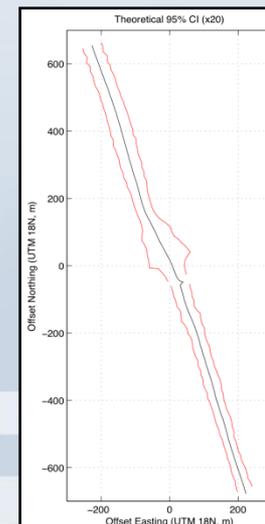
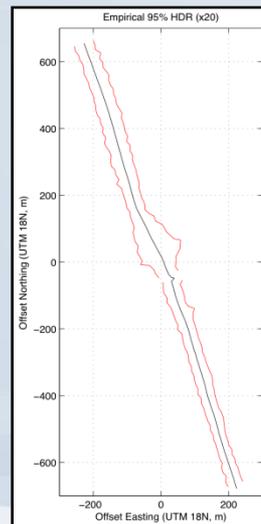
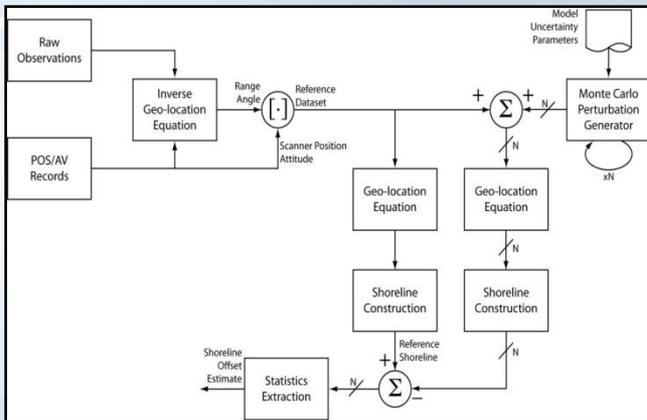
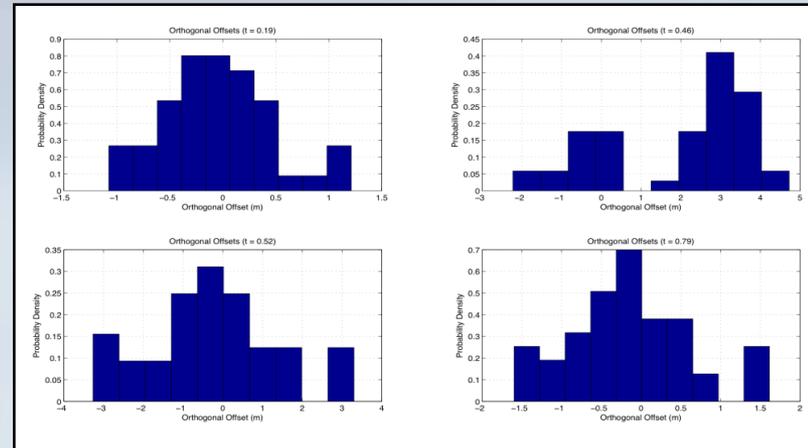
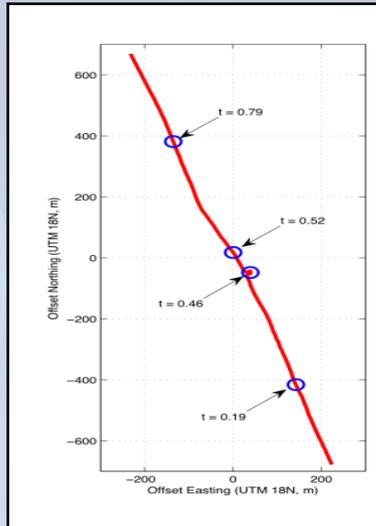
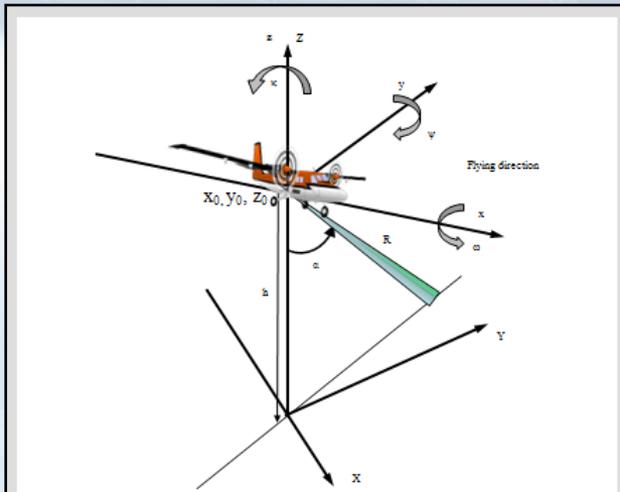


	Frisco		Coquina		Duck	
	cubic spline	linear	cubic spline	linear	cubic spline	linear
<i>RMSE_{HOR}</i>	0.36	0.36	0.43	0.47	0.54	0.55
<i>Mean distance between lidar-derived MHW and Topcon-measured transects</i>	0.32	0.32	0.39	0.43	0.44	0.48
<i>Std. Deviation of distance between lidar-derived MHW and Topcon-measured transects</i>	0.16	0.17	0.17	0.19	0.32	0.28
<i>NSSDA Accuracy (95% Circular Error)</i>	0.60	0.63	0.74	0.81	0.93	0.93

Horizontal positional shoreline accuracy statistics (meters) computed along the shoreline Topcon transects with systematic biases removed.



Stochastic Uncertainty Analysis



Thank You!

Contact Information:

Stephen White

Email: stephen.a.white@noaa.gov

Phone: (301) 713-1428 x167

www.noaa.gov

www.nos.noaa.gov

www.ngs.noaa.gov



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