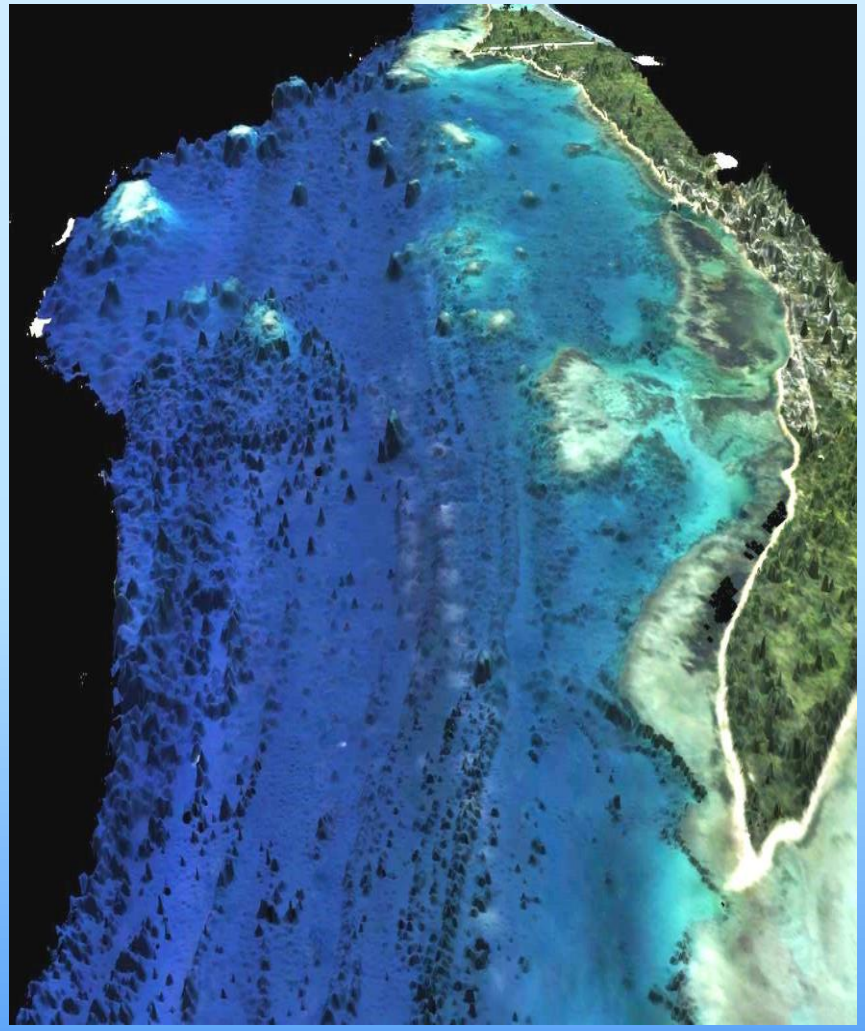

Combined Bathymetric/Topographic LiDAR in the Coastal Zone

Rupert Forester-Bennett

Hydrographic Surveyor IHO Cat A

Thursday Feb 5th 2015

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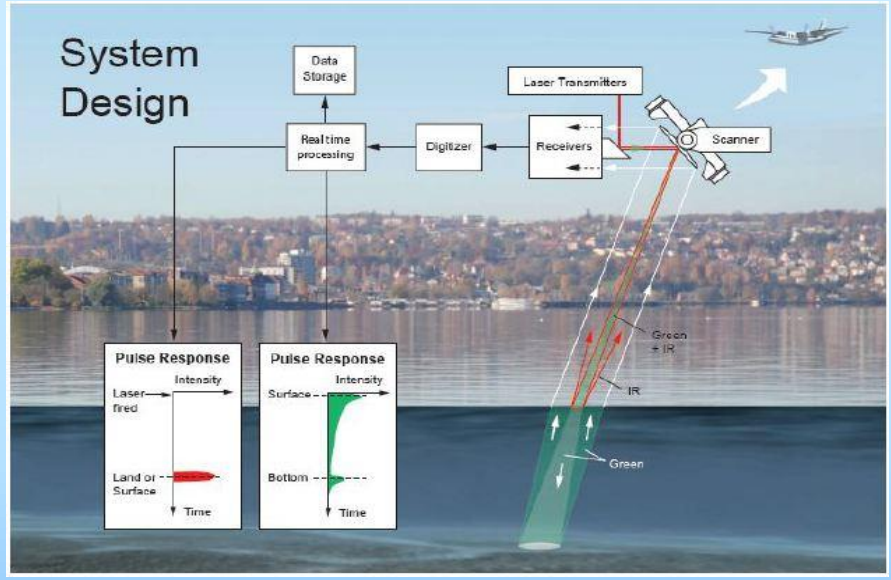
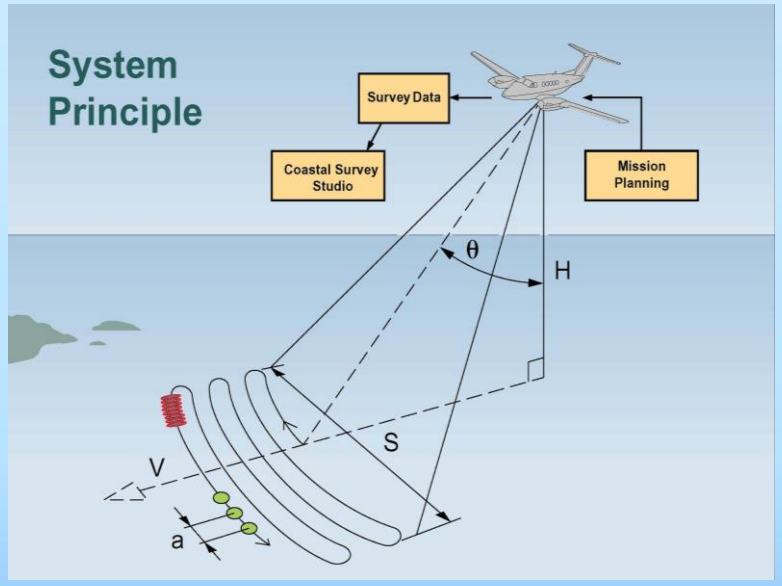
HORIZON GEOSCIENCES

FLORIDA SHORE & BEACH PRESERVATION ASSOCIATION

A League of Cities and Counties on Beach and Coastal Issues

Principle of Operation





- **Bathymetric LIDAR systems use laser pulses at two wavelengths:**
- **Green (532nm) penetrates the water and reflects off the sea bed,**
- **Infra-Red (IR) (1064nm) is reflected at the surface.**
- **Water depths, sea level surface and height of land are determined by measuring the time delay between the transmission of a pulse and its return signal detecting the seafloor.**

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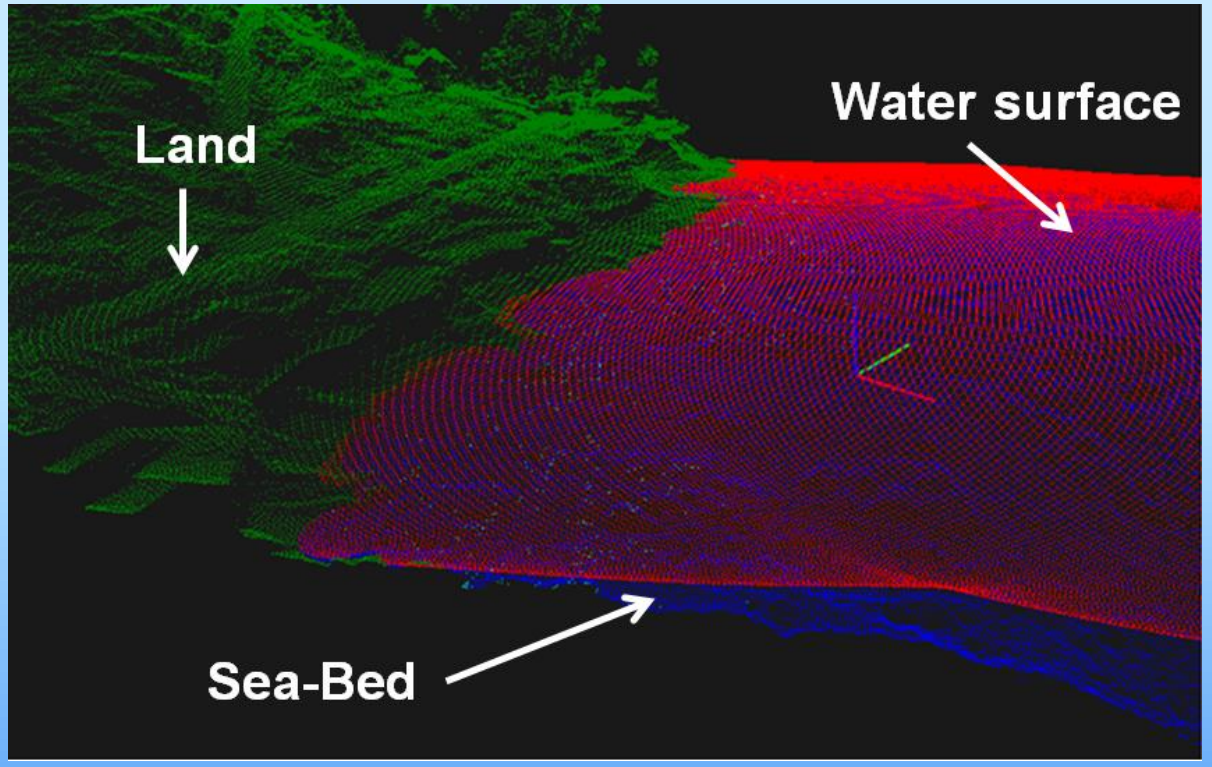
Capability of Bathymetric LiDAR

Bathymetric LiDAR (**Green**) allows the collection of depths from the seabed over a wide area from a low flying aircraft.

When used <u>simultaneously</u> with **Topographic LiDAR** (**Red**) - depths can be taken of the seabed seamlessly up on to the land



Note: <u>Water surface detection</u>

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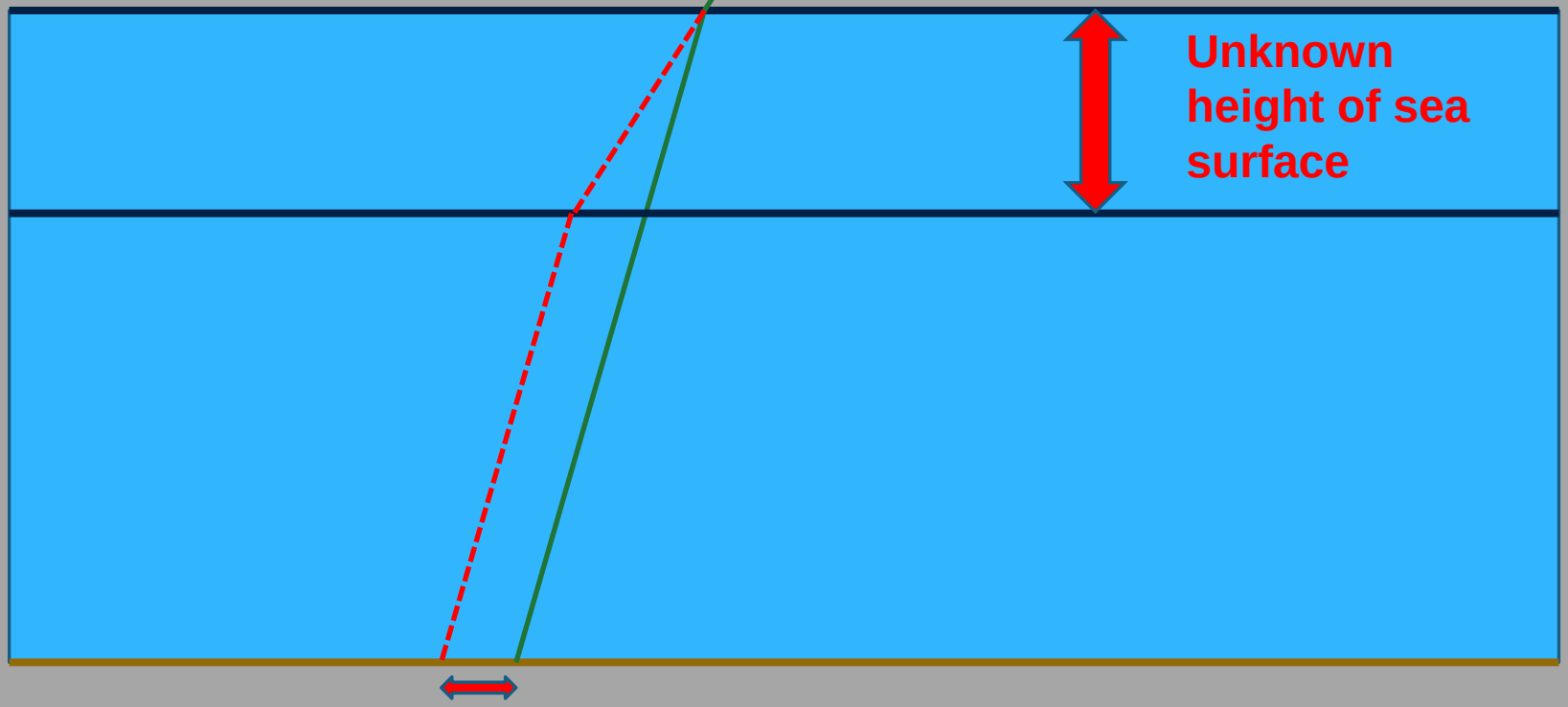
Errors caused by lack of knowledge of sea surface height



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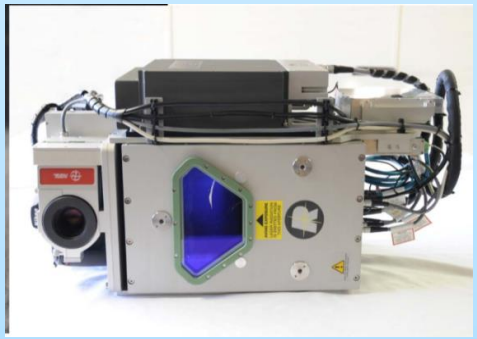
Current Generation Bathymetric LiDAR Systems

Riegl VQ 820-G

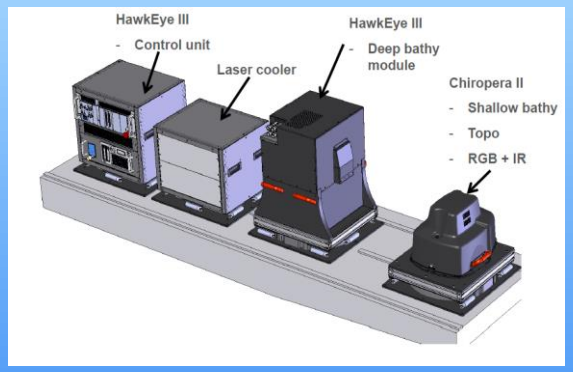


OPTECH CZMIL

LADS Mk 3

Chiroptera II

Hawkeye III



SHOALS

Hawkeye IIb

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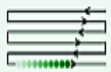
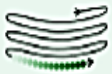
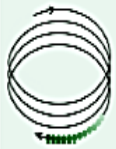
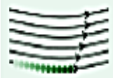
	Fugro LADS Mk3	Optech SHOALS 3000	Optech SHOALS 1000T	AHAB HawkEye IIB	AHAB HawkEye III	AHAB Chiroptera	Riegl VQ-820-G
Typical Sensor Environment	Bathy	Bathy	Bathy	Bathy	Bathy/Topo-Bathy	Topo-Bathy	Topo-Bathy
Origin	Australia	Canada	Canada	Sweden	Sweden	Sweden	Austria
Year Released	2011	2010	2005	2009	2013	2012	2011
Still in Production	Yes	No	No	No	Yes	Yes	Yes
Laser Wavelength/s	Green 532nm	Green 532nm Infra-Red 1064nm	Green 532nm Infra-Red 1064nm	Green 532nm Infra-Red 1064nm	Green 532nm x 2 (Deep and Shallow) Infra-Red 1064nm	Green 532nm Infra-Red 1064nm	Green 532nm
Scan Pattern Diagram (Not to Scale)							
Scan Shape	Rectilinear	Circular Arc	Circular Arc	Elliptic Arc	Elliptical	Elliptical	Elliptic Arc
Scan Direction and Angle From Nadir	Fwd up to 8°	Fwd 22°	Fwd 20°	Fwd 20°	Fwd and Aft 14° Sideways 20°	Fwd and Aft 14° Sideways 20°	Fwd or Aft 20°
Scan Method	Oscillating Mirror	Oscillating Mirror	Oscillating Mirror	Oscillating Mirror	Palmer Scanner	Palmer Scanner	Rotating Multi-Facet Mirror
Laser Energy Per Pulse (Green 532nm)	7mJ	4mJ	4mJ	3mJ	3mJ Deep (D) 0.1mJ Shallow (S)	0.1 mJ	0.02mJ
Pulse Duration	6.5ns	5ns	5ns	4ns	4ns (D) 2.5ns (S)	4ns	1.2ns
Peak Measurement Frequency	1.5kHz@532	3kHz@532	1kHz@532	4kHz@532 128kHz@1064	10kHz@532 (D) 35kHz@532 (S) 400kHz@1064	36kHz@532 400kHz@1064	Up to 512kHz@532
532nm Nominal Footprint Diameter @ Water Surface (1/e²)	3m	2m	2m	6m	3m (D) 1.5m (S)	1.5m	0.6m @ AGL Below
Nominal Flying Height	400–915m AGL	300–400m AGL	300–400m AGL	250–500m AGL	400–1000m AGL	250–600m AGL	Nominal 600m AGL
Swath Width (as a function of point spacing or altitude)	585m@8x5m 360m@5x5m 125m@2.5x2.5m	160m@2x2m 300m@3x3m	60m@2x2m 130m@3x3m	160m–260m @400m AGL 100m@250m AGL	290m@400m AGL 730m@1000m AGL	300m @400m AGL	400m
Typical Bathymetric Point Spacings	2x2m–8x5m	2x2m–5x5m	2x2m–5x5m	0.5x0.5m–3.5x3.5m	1.7x1.7–3.3x3.3m (D) 0.4x0.4–0.8x0.8m (S)	0.4x0.4m–1 x 1m	0.2x0.2m–0.8x0.8m
Maximum Depth	~80m 2.5–3 x Secchi depth	~50m 2–2.5 x Secchi depth	~50m 2–2.5 x Secchi depth	~50m 2–3 x Secchi depth	~50m 2–3 x Secchi depth	~20m 1 x Secchi depth	~10m 1 x Secchi depth
Minimum Depth	The minimum water depth of most sy						
Vertical Accuracy	All LiDAR systems have the capab						

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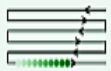
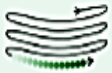
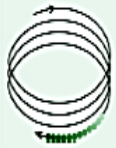
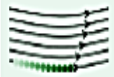
Year Released	2011	2010	2005	2009	2013	2012	2011
Still in Production	Yes	No	No	No	Yes	Yes	Yes
Laser Wavelength/s	Green 532nm	Green 532nm Infra-Red 1064nm	Green 532nm Infra-Red 1064nm	Green 532nm Infra-Red 1064nm	Green 532nm x 2 (Deep and Shallow) Infra-Red 1064nm	Green 532nm Infra-Red 1064nm	Green 532nm
Scan Pattern Diagram (Not to Scale)							
Scan Shape	Rectilinear	Circular Arc	Circular Arc	Elliptic Arc	Elliptical	Elliptical	Elliptic Arc
Scan Direction and Angle From Nadir	Fwd up to 8°	Fwd 22°	Fwd 20°	Fwd 20°	Fwd and Aft 14° Sideways 20°	Fwd and Aft 14° Sideways 20°	Fwd or Aft 20°
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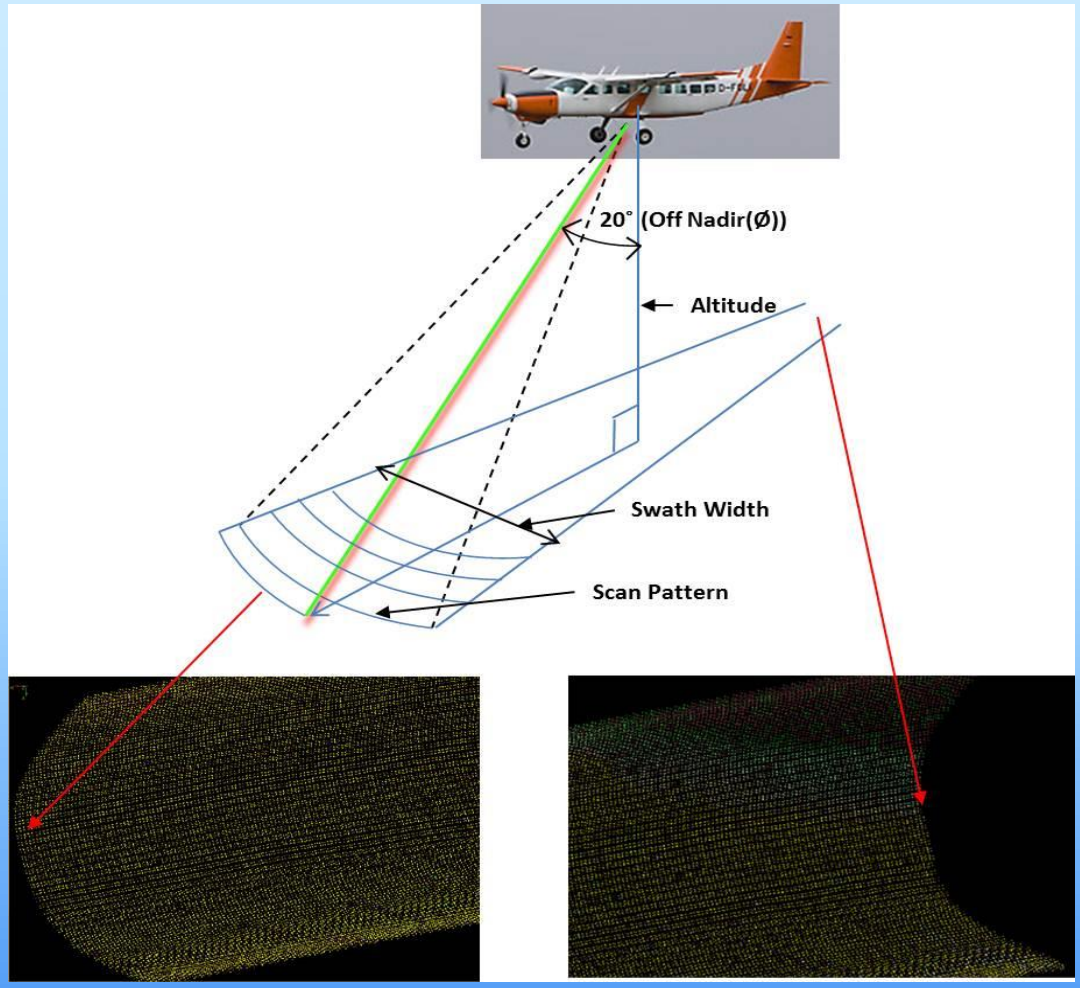
Typical Bathymetric Point Spacings	2x2m–8x5m	2x2m–5x5m	2x2m–5x5m	0.5x0.5m–3.5x3.5m	1.7x1.7–3.3x3.3m (D) 0.4x0.4–0.8x0.8m (S)	0.4x0.4m–1 x 1m	0.2x0.2m–0.8x0.8m
Maximum Depth	~80m 2.5–3 x Secchi depth	~50m 2–2.5 x Secchi depth	~50m 2–2.5 x Secchi depth	~50m 2–3 x Secchi depth	~50m 2–3 x Secchi depth	~20m 1 x Secchi depth	~10m 1 x Secchi depth
Minimum Depth	The minimum water depth of most sy						
Vertical Accuracy	All LiDAR systems have the capab						

Scan – forward arc

- The scanning mirror compensates for pitch and roll by adjusting the direction in which the laser beams are transmitted, ensuring that they are transmitted ahead of the aircraft at an off-nadir angle of 20˚ and scan left and right either side of the line of advance of the aircraft.

- The result is a generally evenly spaced pattern of transmissions and returns covering the seabed.



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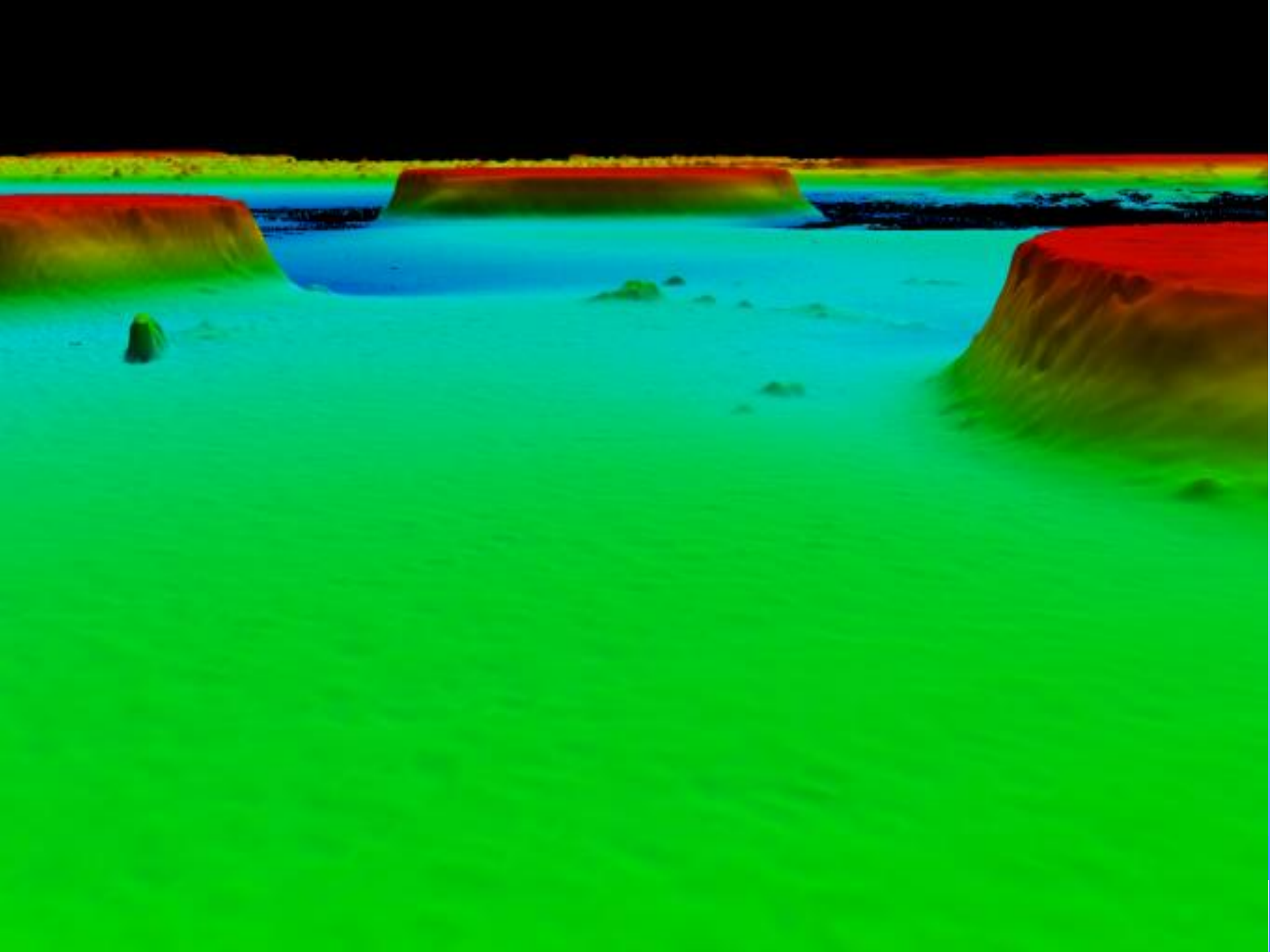
forward arc shadow

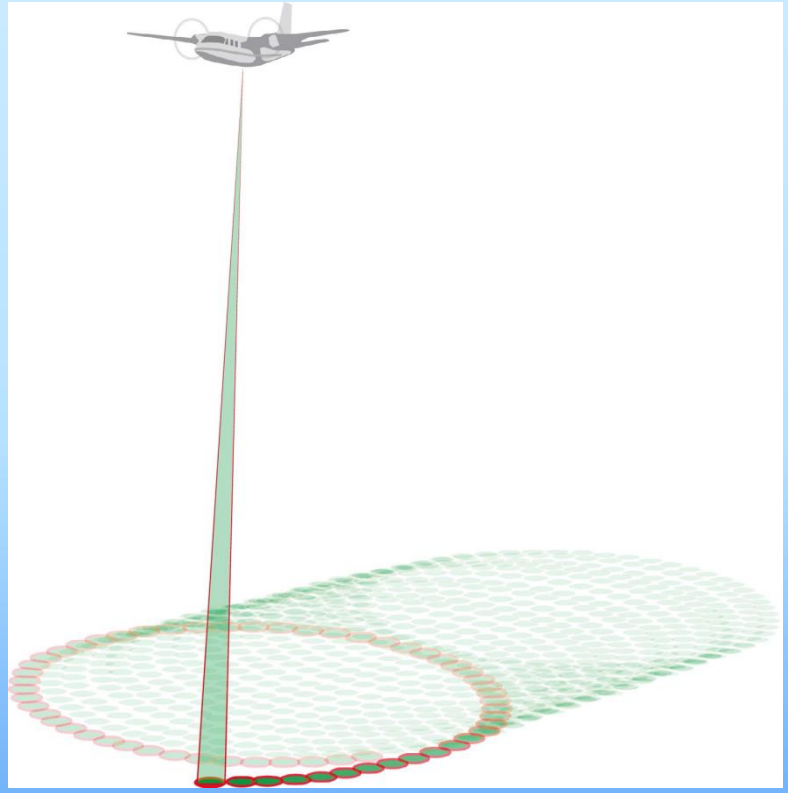


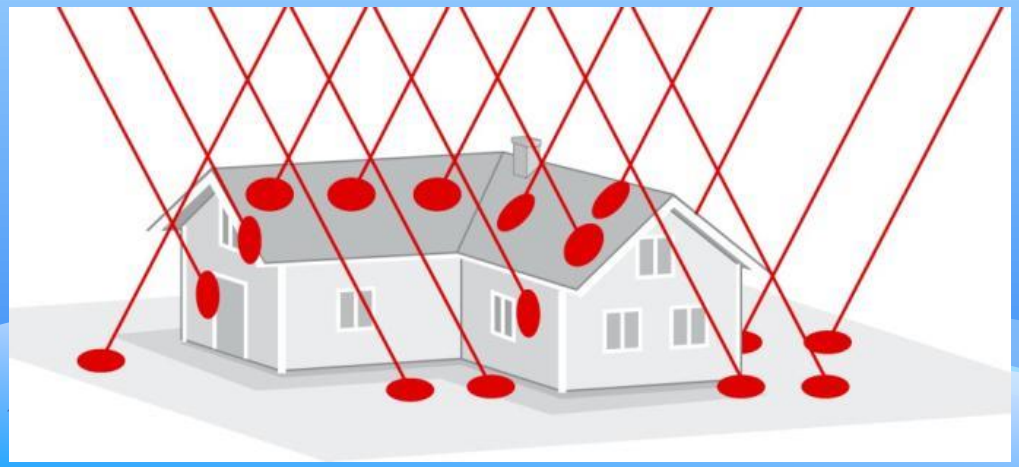
Scan Pattern – Circular/elliptical

Features

Oblique LIDAR offers LIDAR capture from more than one angle of incident, which provides a higher coverage and more rich LIDAR waveform information

- Full-waveform capture in both topo and bathy channels
- Tools for land and seabed characterization
- Automatic water refraction correction





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So…what products can Topo/Bathy LiDAR bring to the Coasts of the South and East?

Sand bars
Complex beach
Lagoon
Marshland
Waterway
Mixed Vegetation

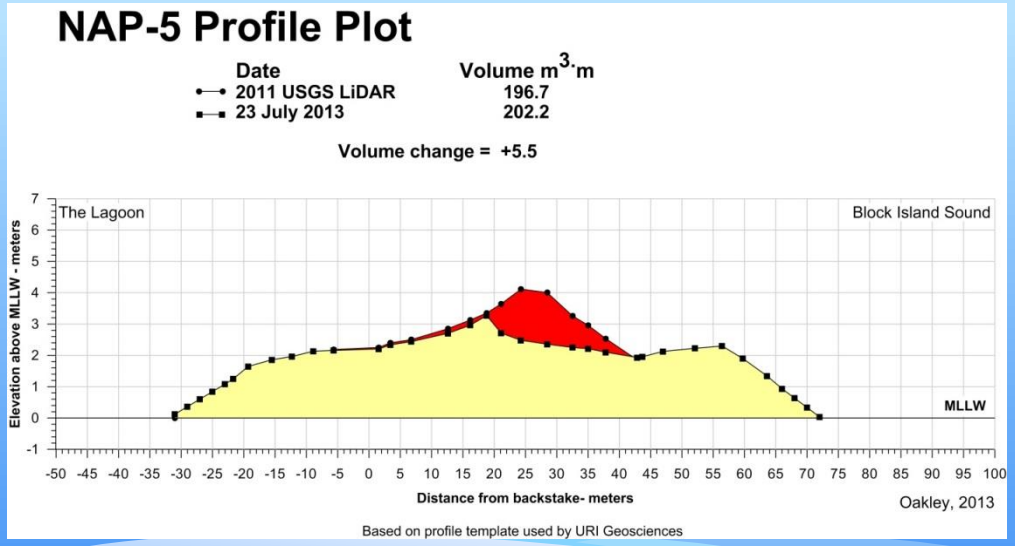
Pelydr

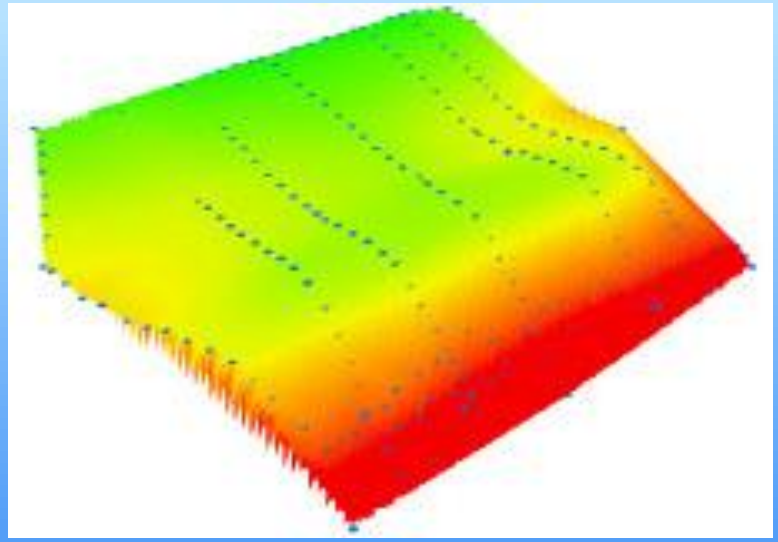

10 09 2009 16:34

Data density

Manpower intensive

Laborious data recording





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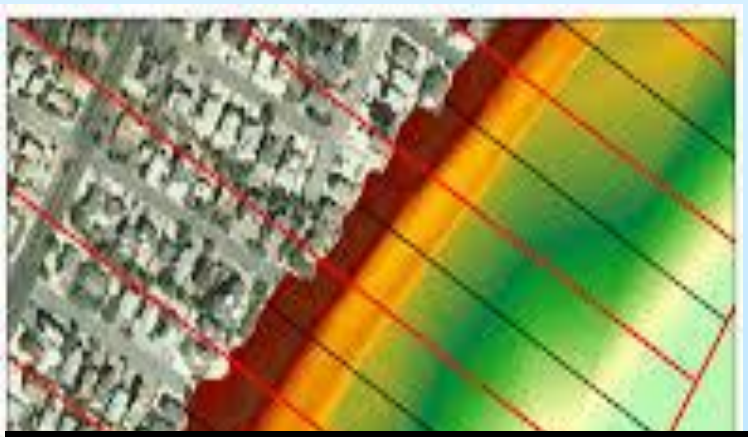

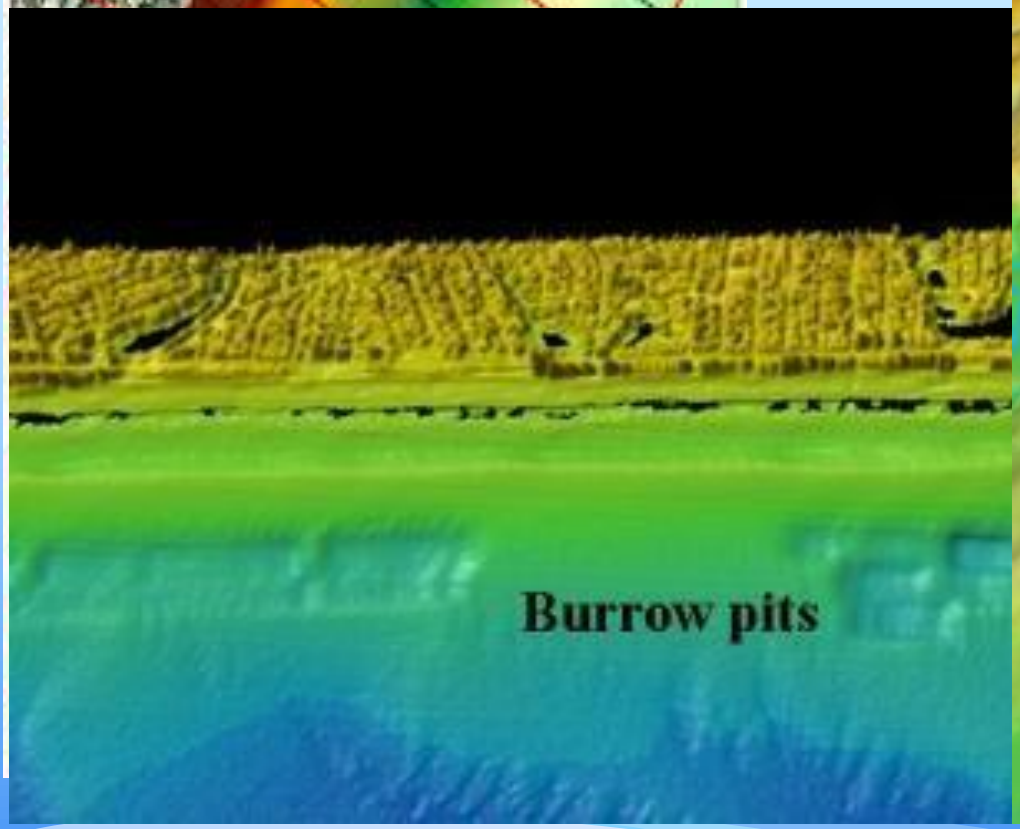

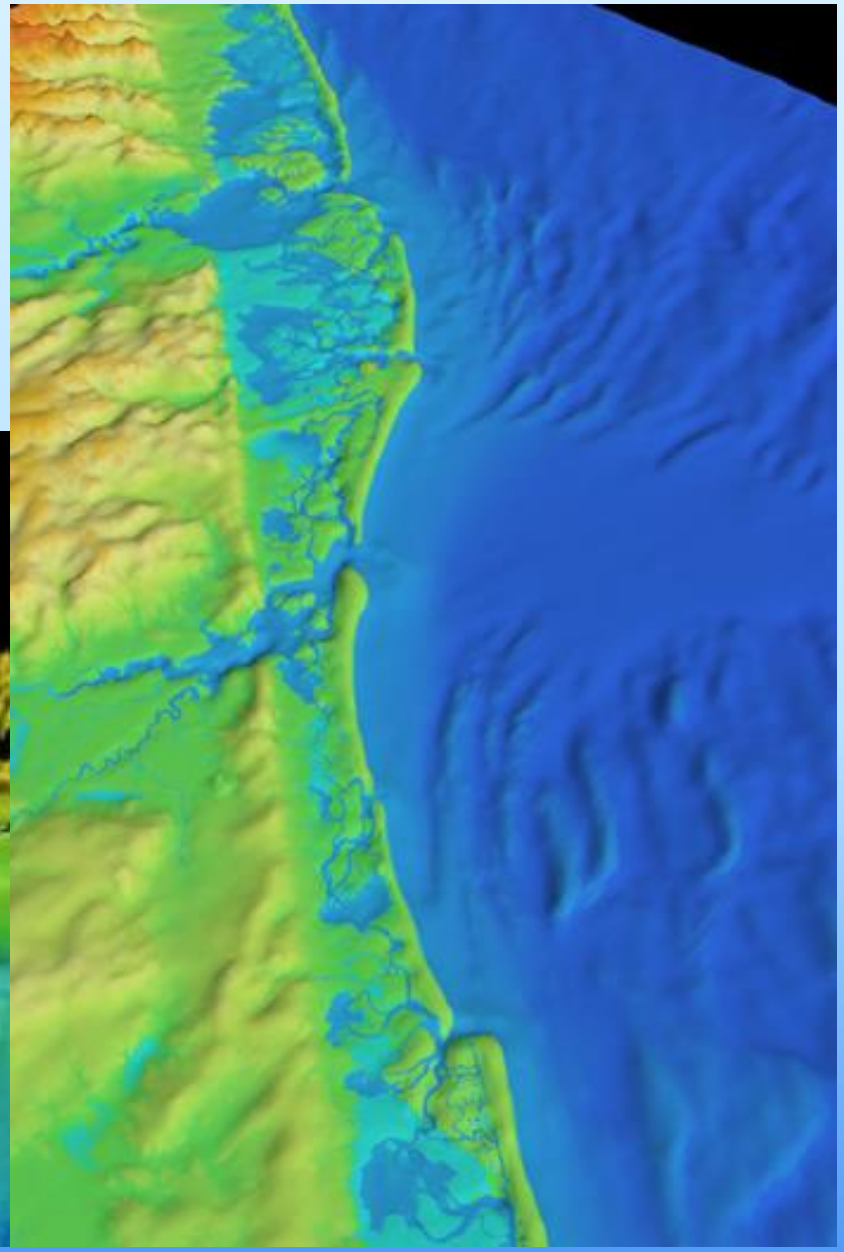

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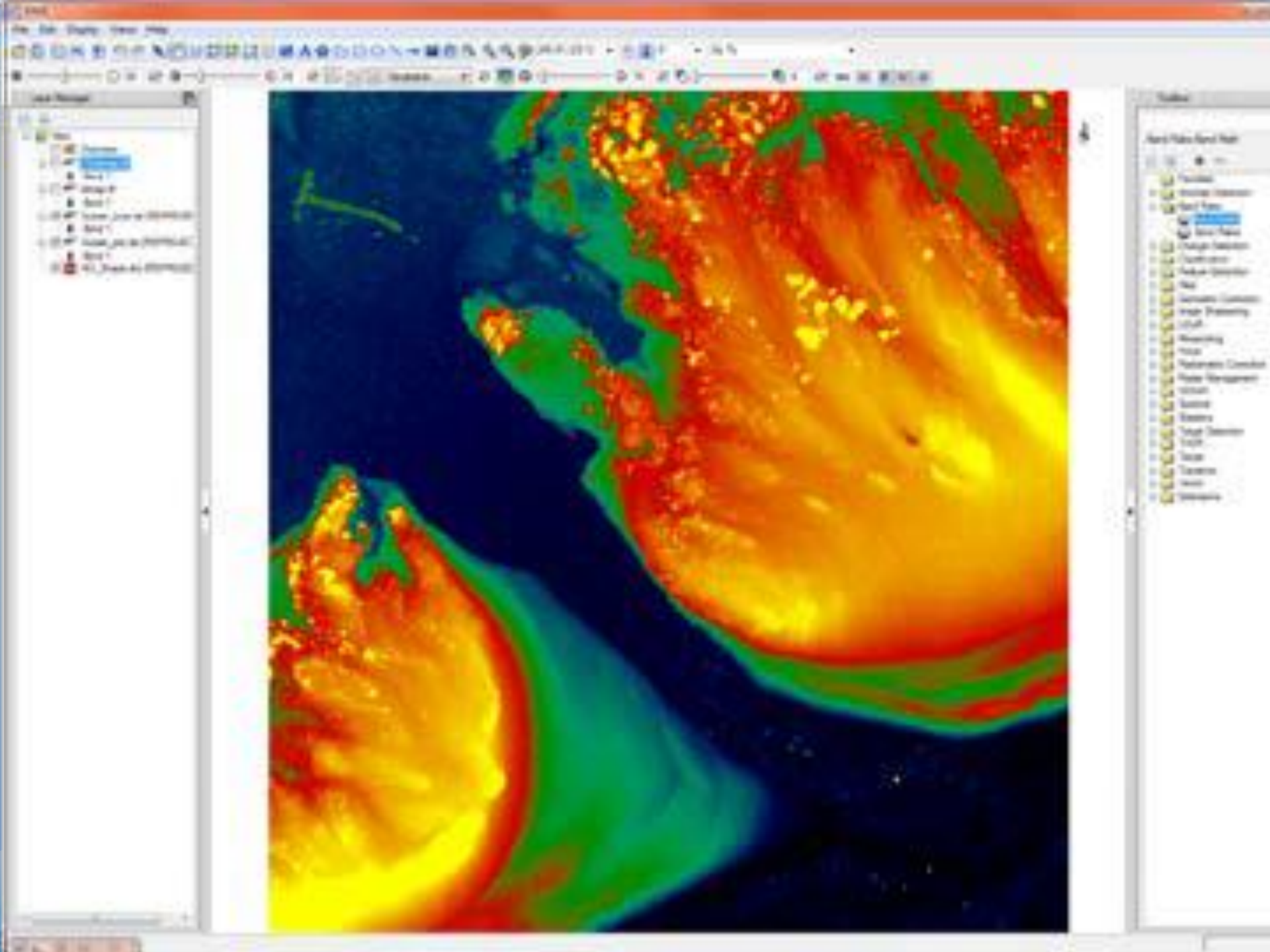
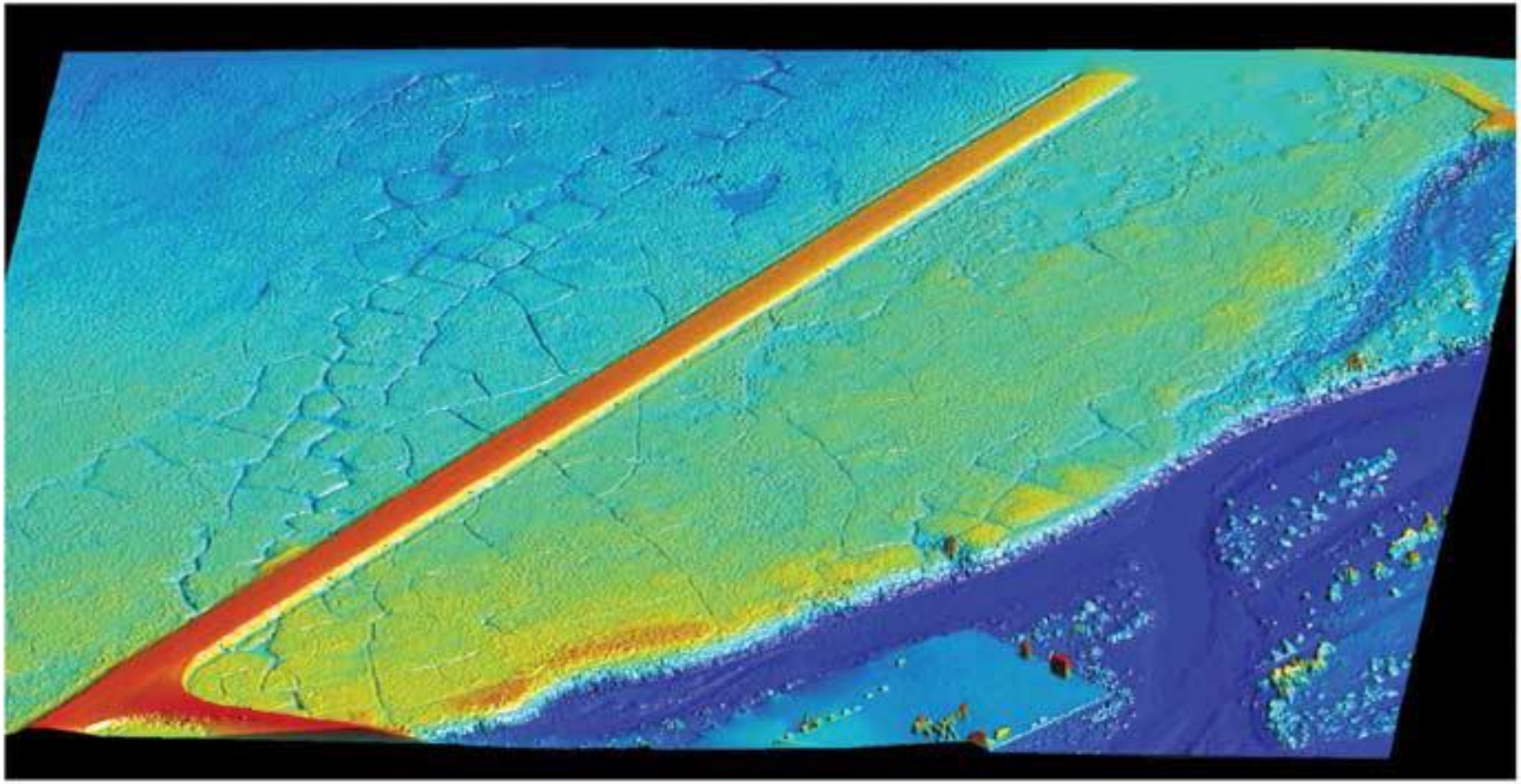


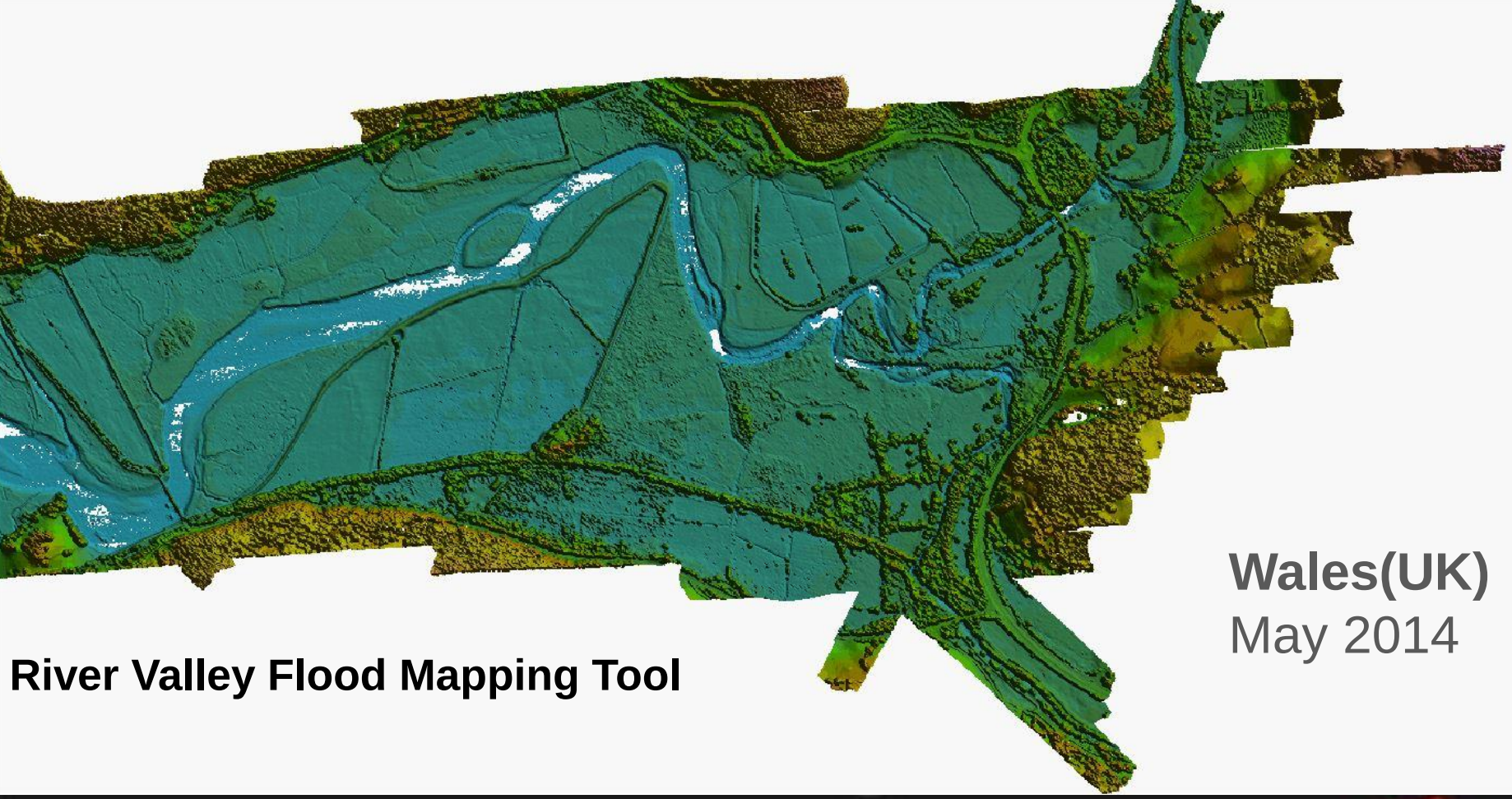
Data density - microtopography

DEM (25 cm cell) from 400 kHz data,



Perspective view to northwest

Seamless Data Sets

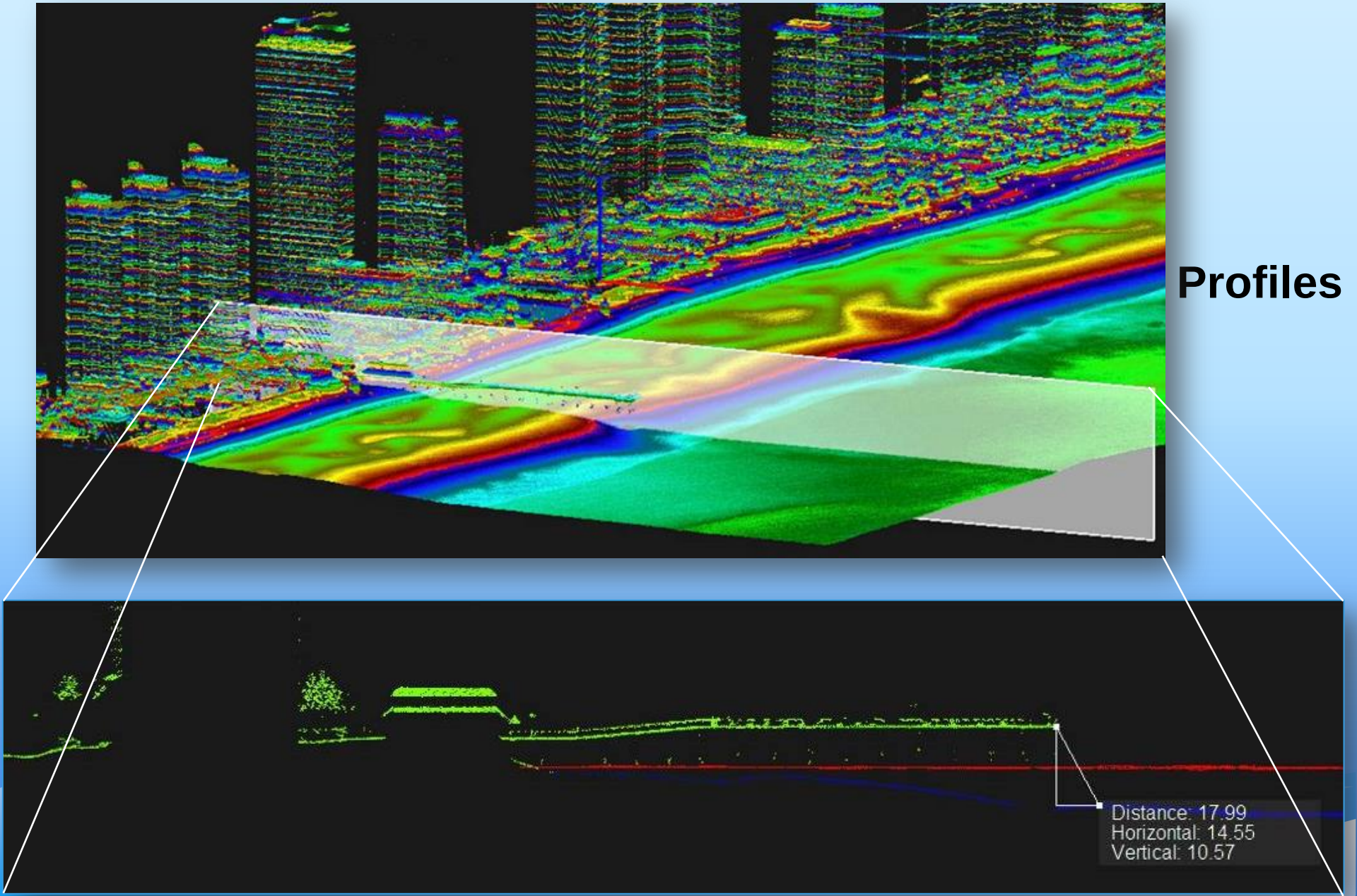


River Valley Flood Mapping Tool

Wales(UK)
May 2014

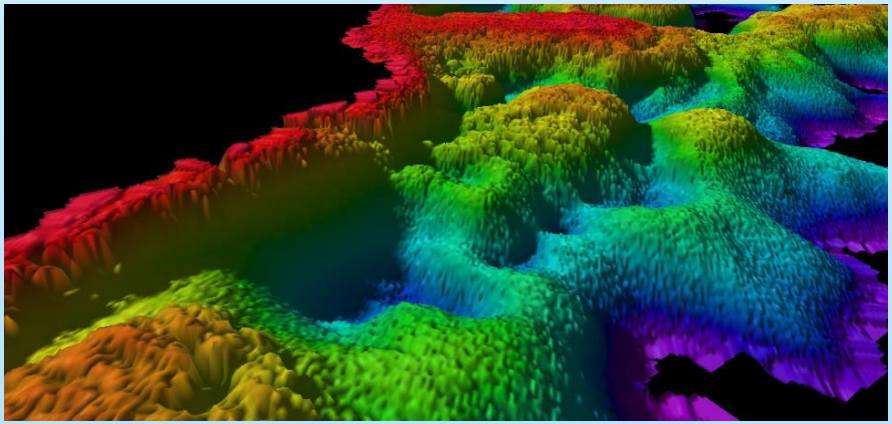
River Cross Section Profile

Profiles

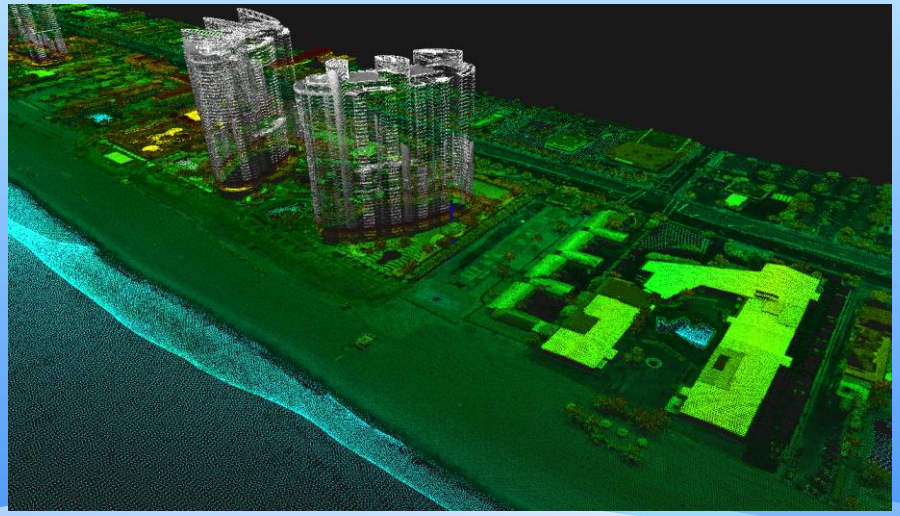


Products

One Flight Multiple Products



Bathymetric DEM



Topographic DEM

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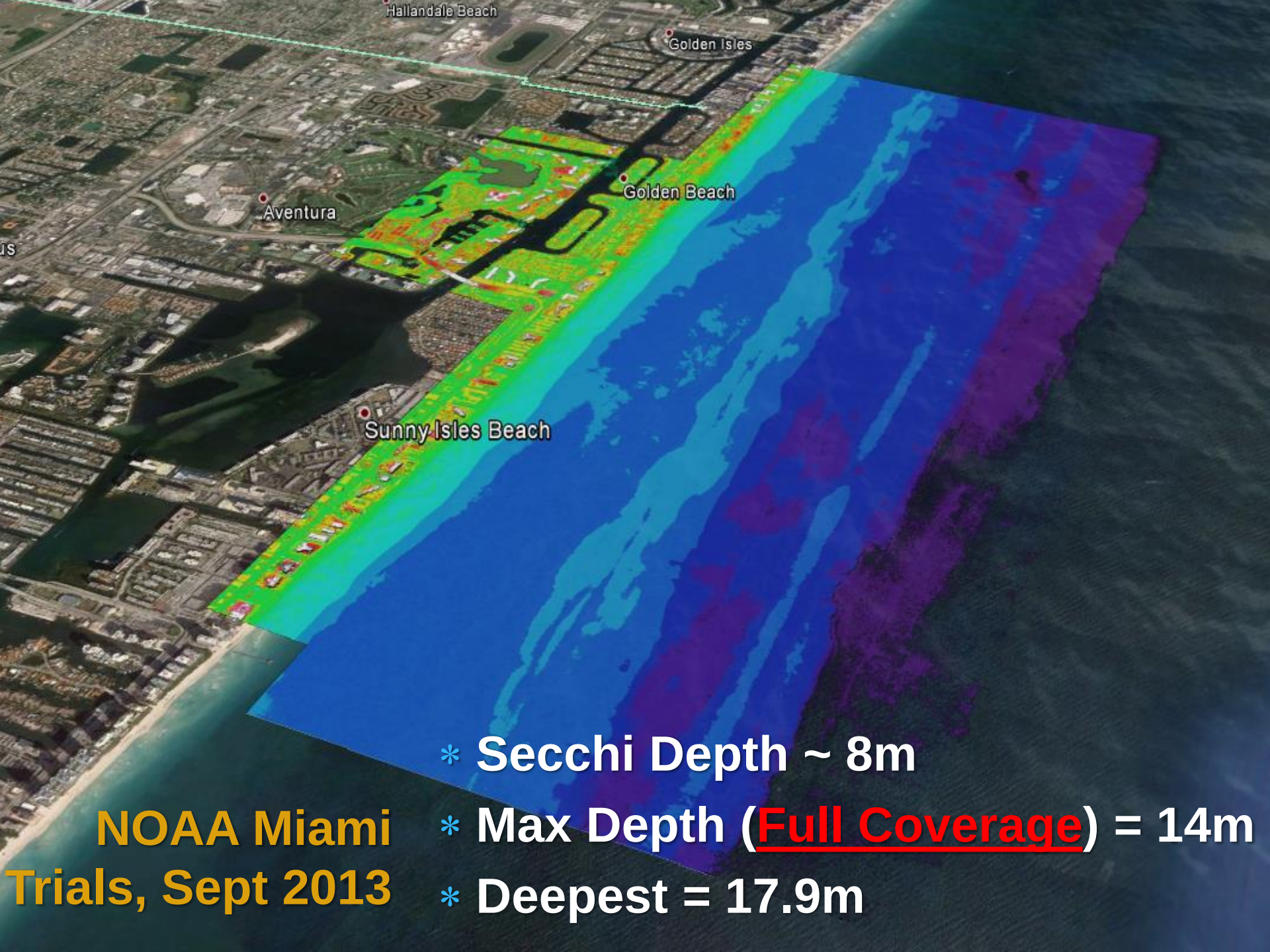


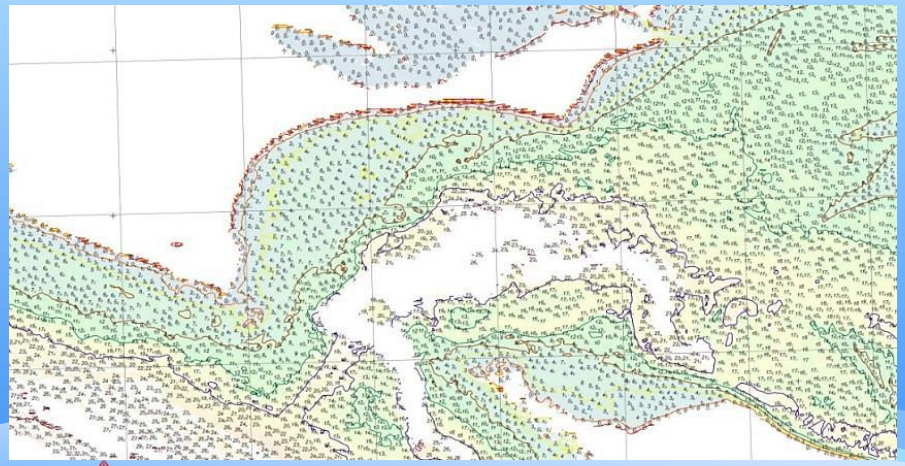
NOAA Miami Trials, Sept 2013

* Secchi Depth ~ 8m
* Max Depth (Full Coverage) = 14m
* Deepest = 17.9m

Products

One Flight Multiple Products

Contours



Sounding Collectors

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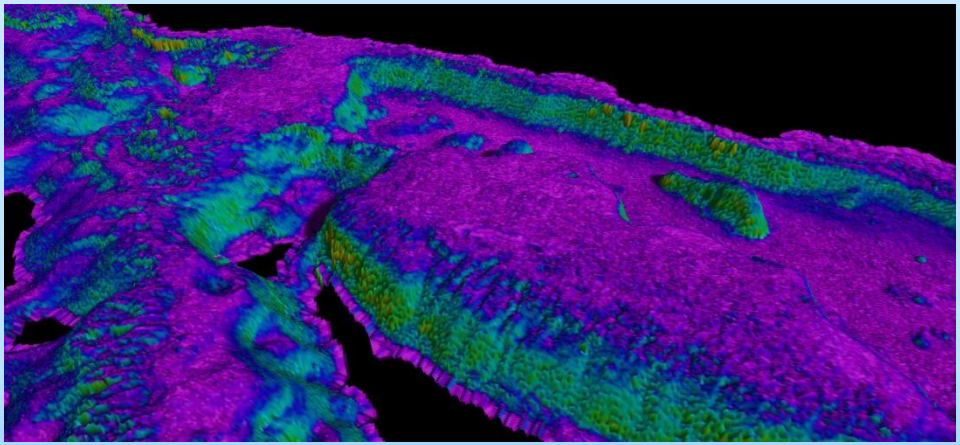
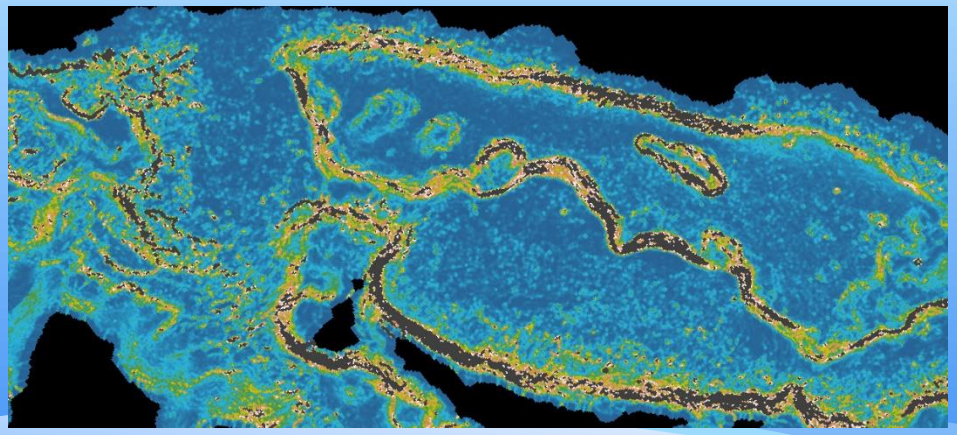
Products

One Flight Multiple Products



Slope Analysis

- Beach?
- Pipes?



Rugosity

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Products

One Flight Multiple Products

Photo Mosaic

Habitat mapping
Cadastral
Land use etc etc

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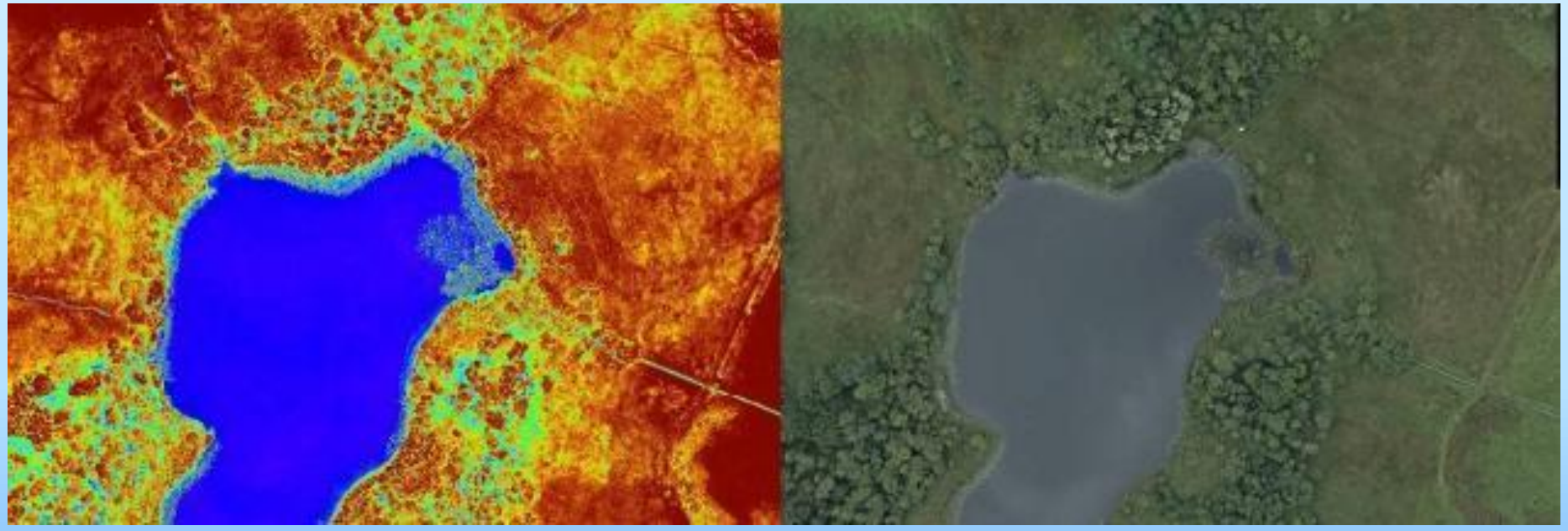
Products

Spectral data suitable for the assessment of vegetation health.



Advanced cameras also include near infrared as well as RGB

- foliage chlorophyll concentration,
- above-ground biomass and
- canopy water content.
- Plant stress

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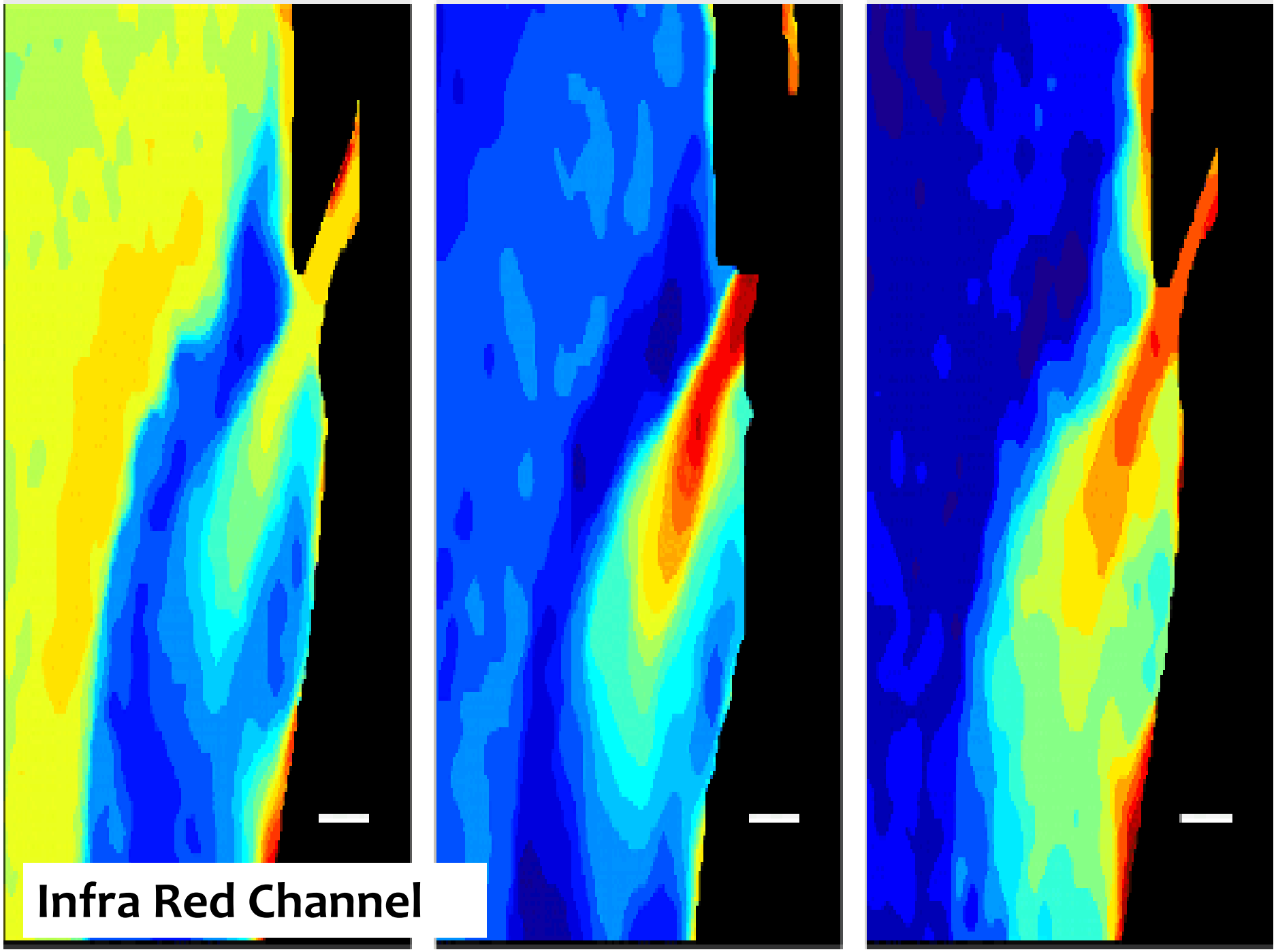
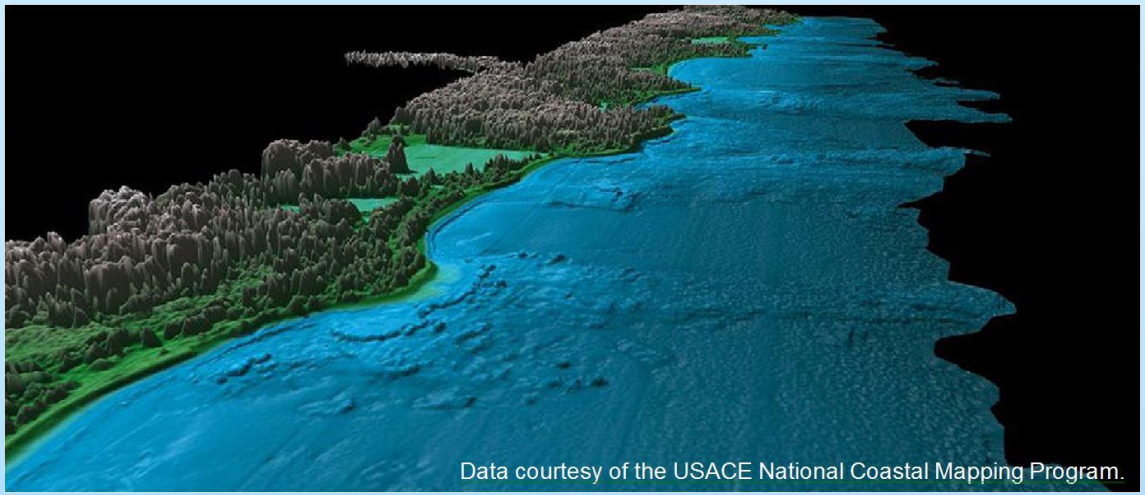
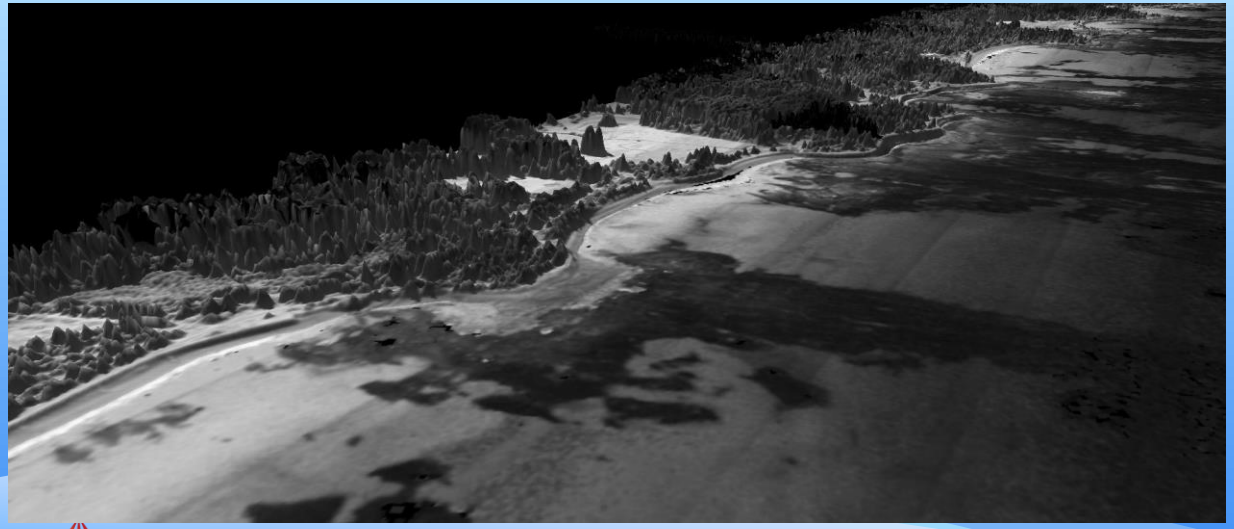

Infra Red Channel

Products

One Flight Multiple Products

Seabed Reflectance





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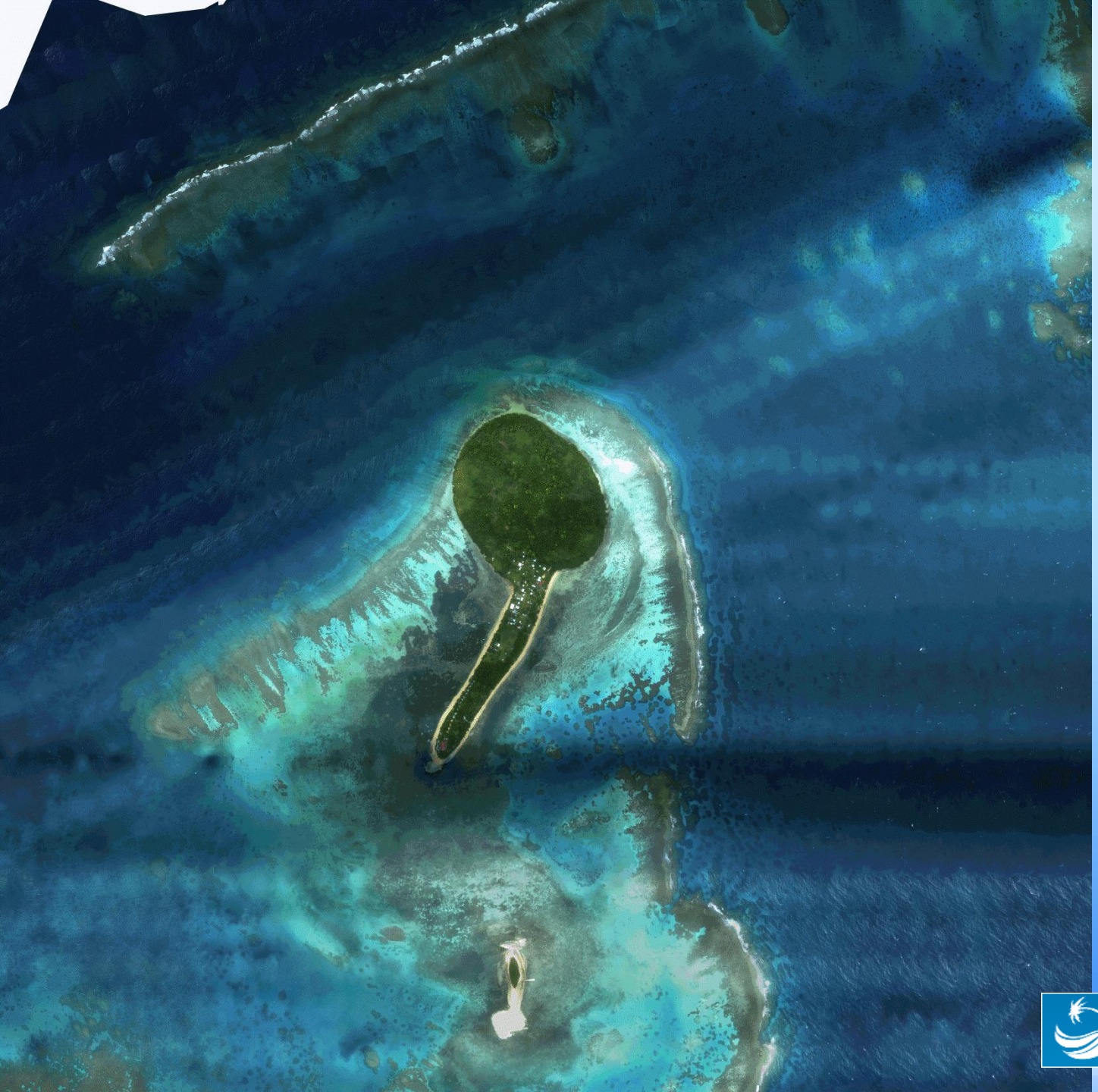
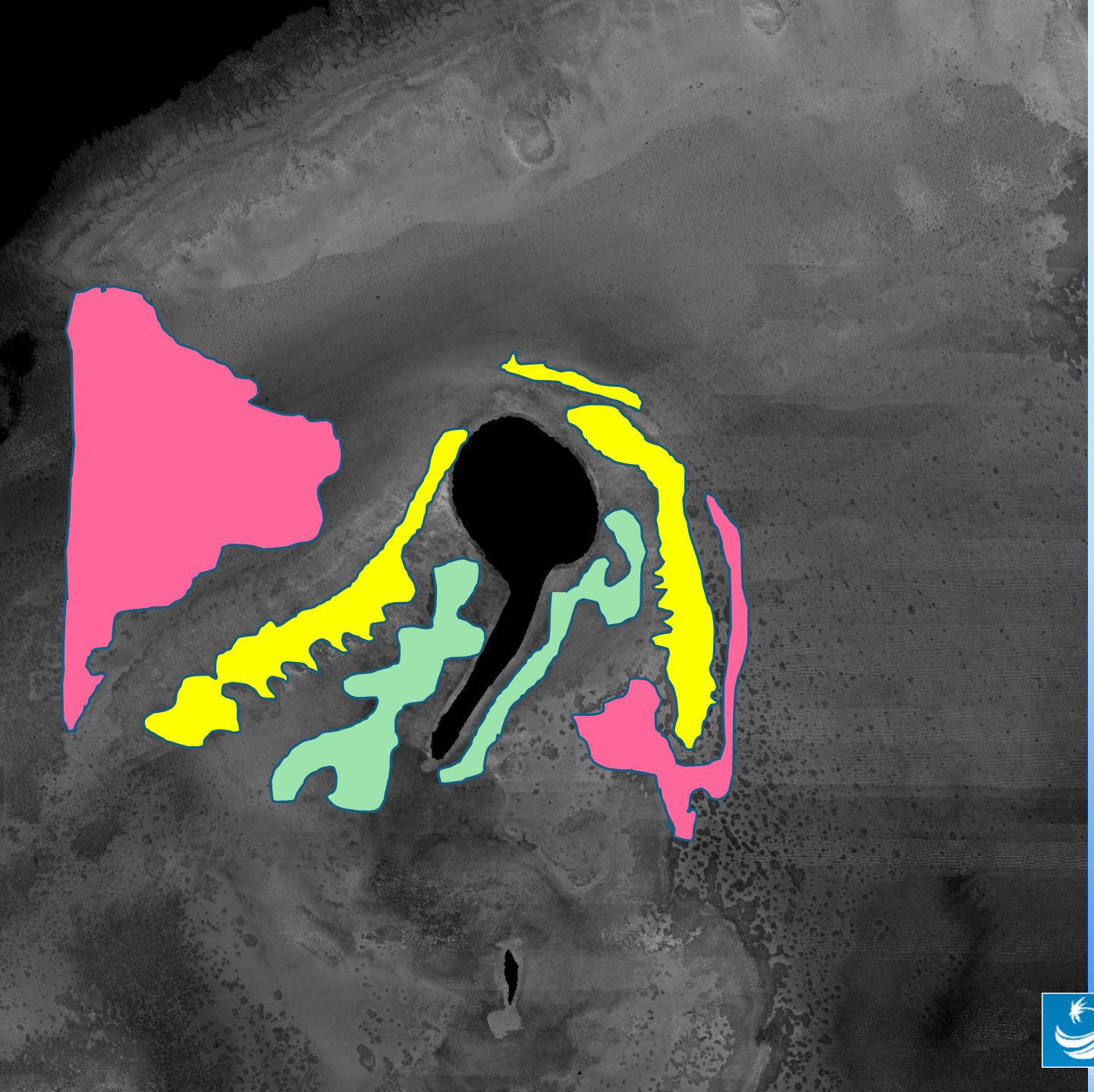


Island off Tonga ‘reflectance’



Isolated Coral heads

Shallow coral reef fringe

Seagrass Beds

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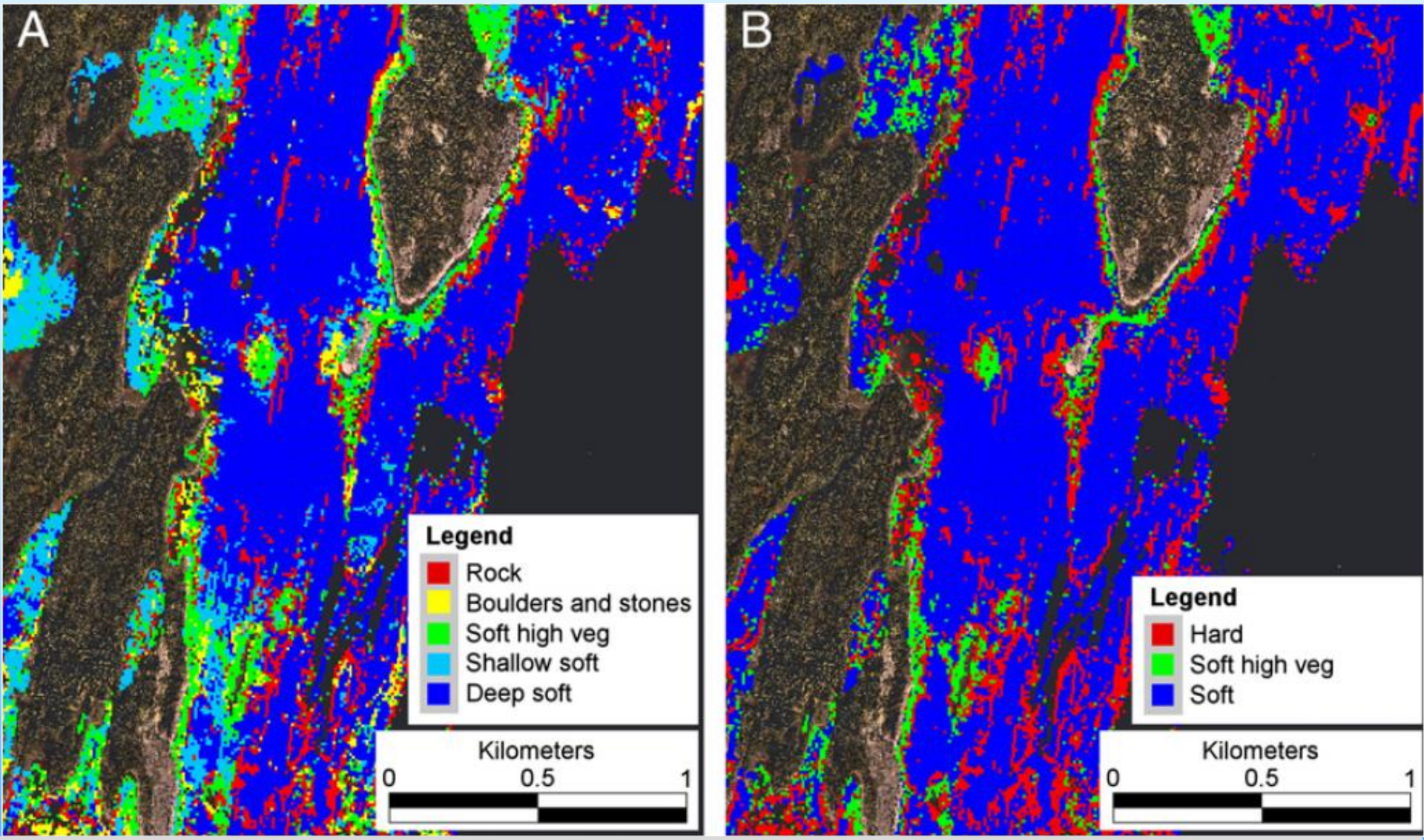

Automated Lidar classification results using four variables (slope, standard deviation, pulse width, pulse area):

A) classification into five classes

B) B) generalization into three classes.

Results were generated using a 10 m×10 m grid.

Bibliography

Thanks to

- Nathan Quadros & LiDAR News Magazine, Dec 2013
- AHAB/Leica
- University of Texas Bureau of Economic Geology
- Fugro Pelagos
- US ACE National Coastal Mapping Program

All illustrations have previously appeared on public media

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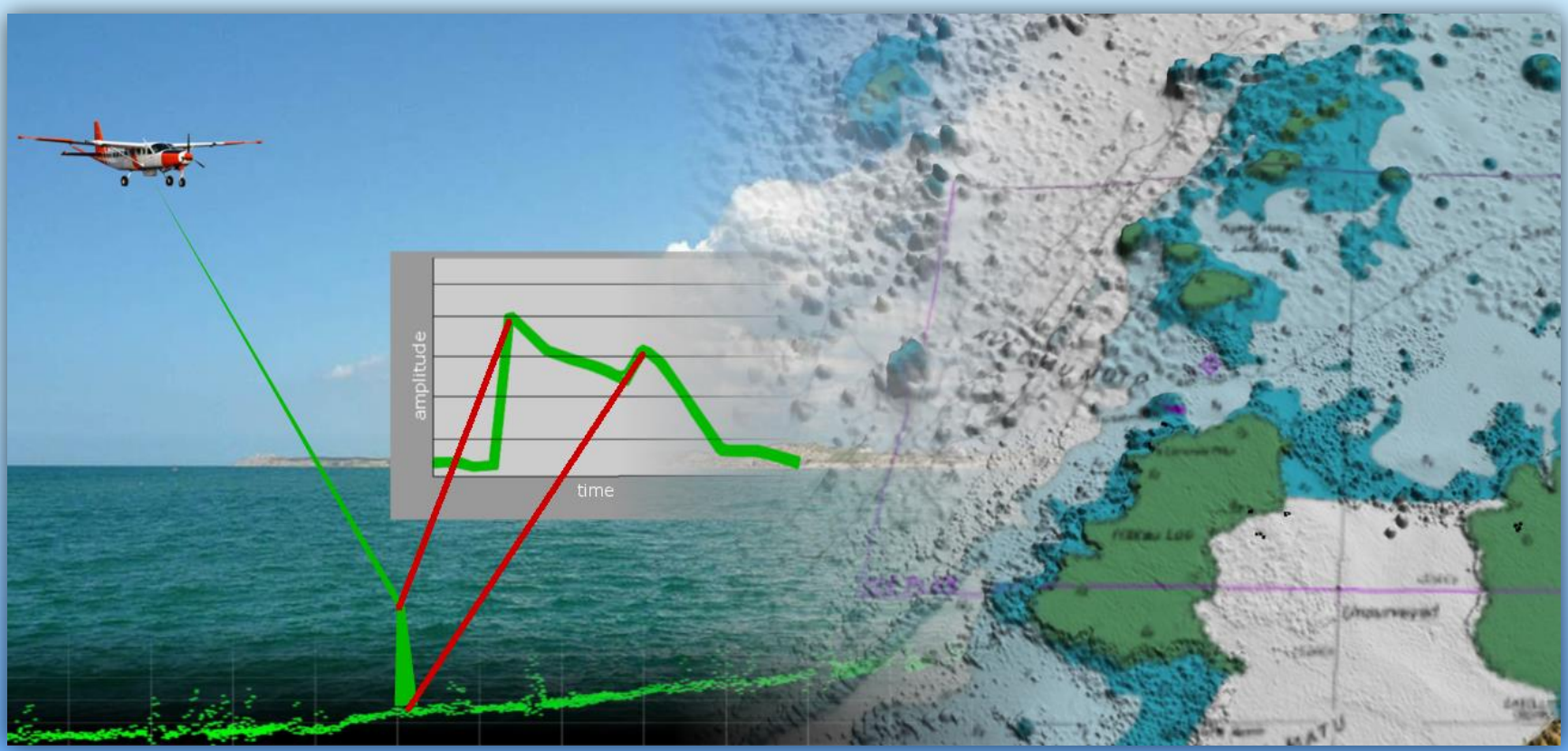
Thank You



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