Topographic LIDAR Surveys for GIS Analyses in Coastal Parks

Jeremy Bracone, John Brock, Amar Nayegandhi

2006 ESRI User Conference

August 10, 2006

USGS
science for a changing world

National Park Service

NASA

USGS
science for a changing world

Topics

- Previous studies relating to park management.

- Current study – Topographic Complexity
  - Description of Methods
  - Accuracy and Usefulness
  - Questions and Future Goals

Previous Park Management Studies

- Develop methods for extracting geomorphologic features from data
  - Detect and quantify dune formation and migration
  - Shoreline mapping and monitoring
  - Map shoreward edge of vegetation

Previous Park Management Studies

- Develop methods for extracting geomorphologic features from data
  - Detect and quantify dune formation and migration
  - Shoreline mapping and monitoring
  - Map shoreward edge of vegetation

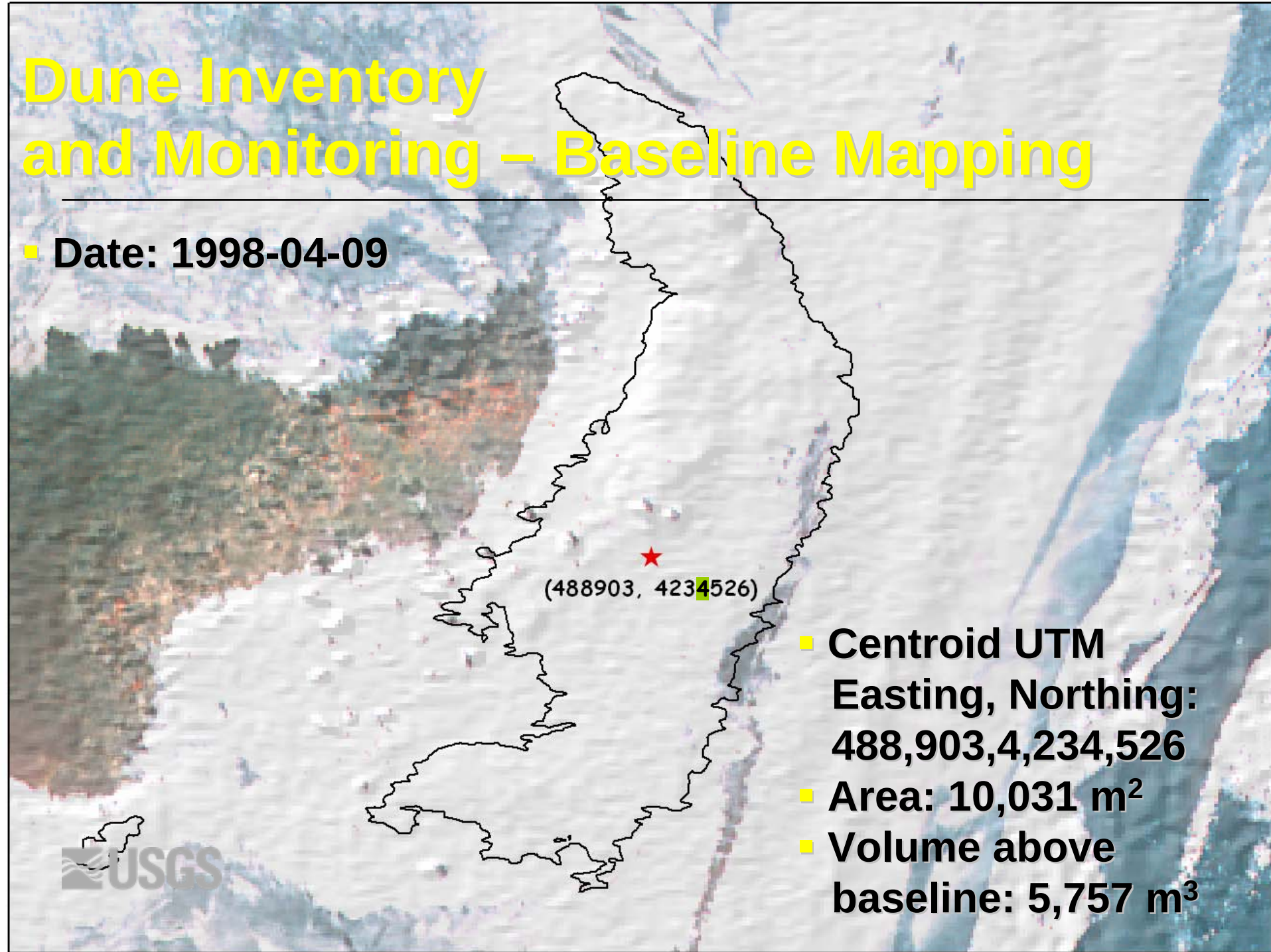
Dune Inventory and Monitoring

- Features and Attributes associated with each dune:
  - Date of 1st Recognition
  - Unique Dune ID
  - Dune-Only DEM
  - Base Elevation
  - Basal Polygon
  - Dune Area Centroid Location
  - Total Dune Area
  - Total Dune Volume

USGS

Dune Inventory and Monitoring – Baseline Mapping

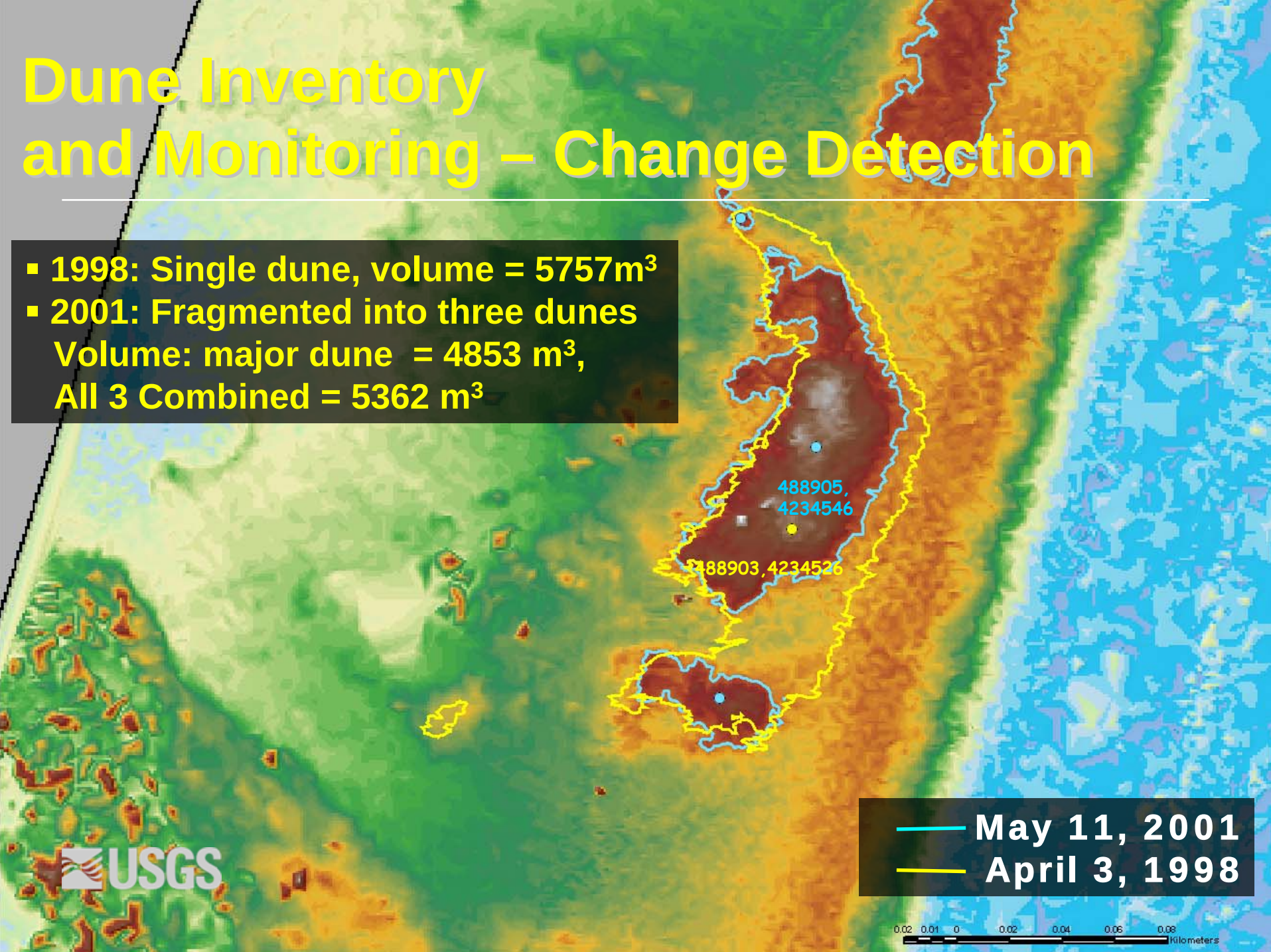
- Date: 1998-04-09



- Centroid UTM Easting, Northing: 488,903,4,234,526
- Area: 10,031 m^2
- Volume above baseline: 5,757 m^3

Dune Inventory and Monitoring – Change Detection

- 1998: Single dune, volume = 5757m^3
- 2001: Fragmented into three dunes
  Volume: major dune = 4853 m^3,
  All 3 Combined = 5362 m^3

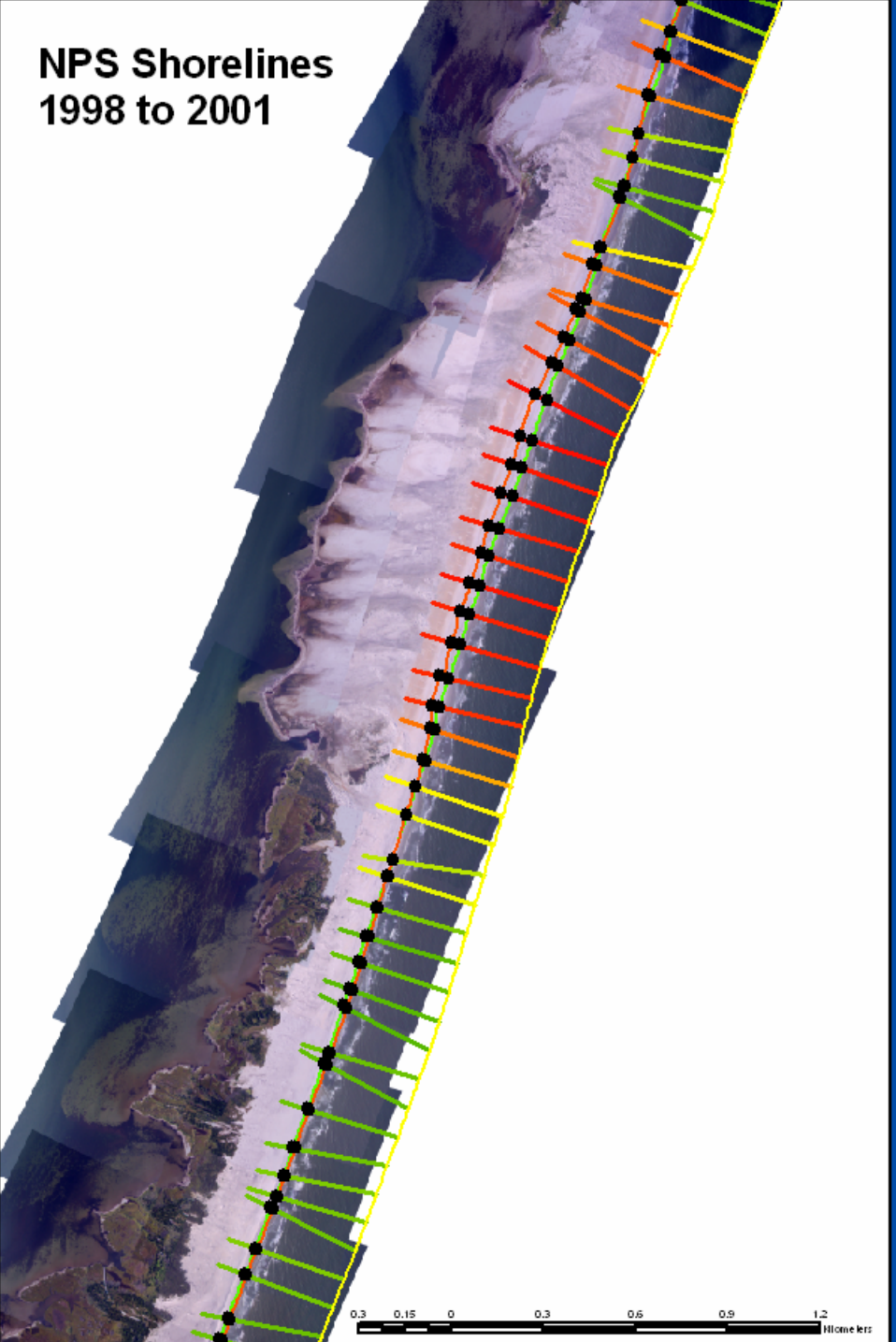


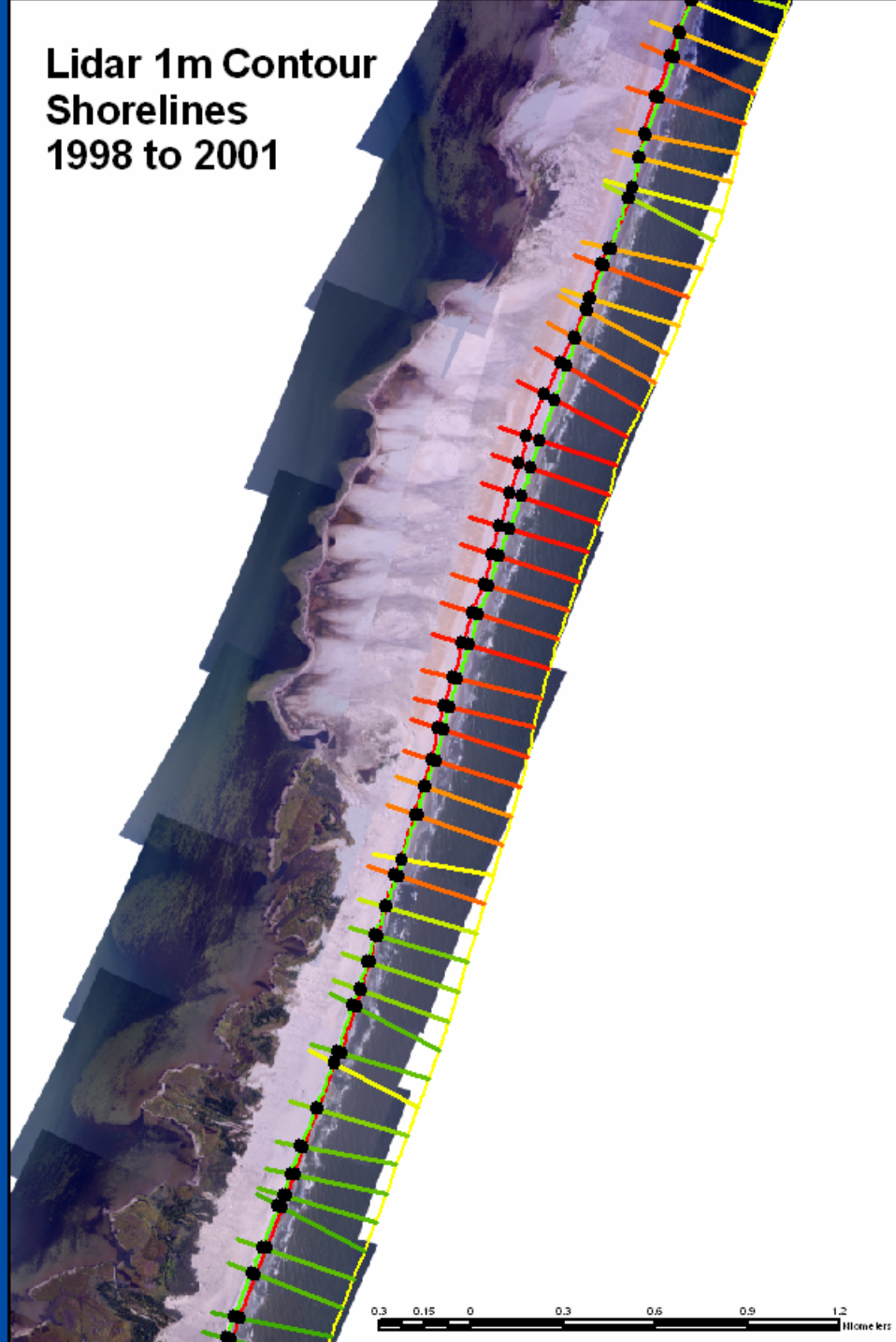
Previous Park Management Studies

- Develop methods for extracting geomorphologic features from data
  - Detect and quantify dune formation and migration
  - Shoreline mapping and monitoring
  - Map shoreward edge of vegetation

Previous Park Management Studies

- Develop methods for extracting geomorphologic features from data
  - Detect and quantify dune formation and migration
  - Shoreline mapping and monitoring
  - Map shoreward edge of vegetation


NPS Shorelines
1998 to 2001
0.3 0.15 0 0.3 0.6 0.9 1.2
Kilometers

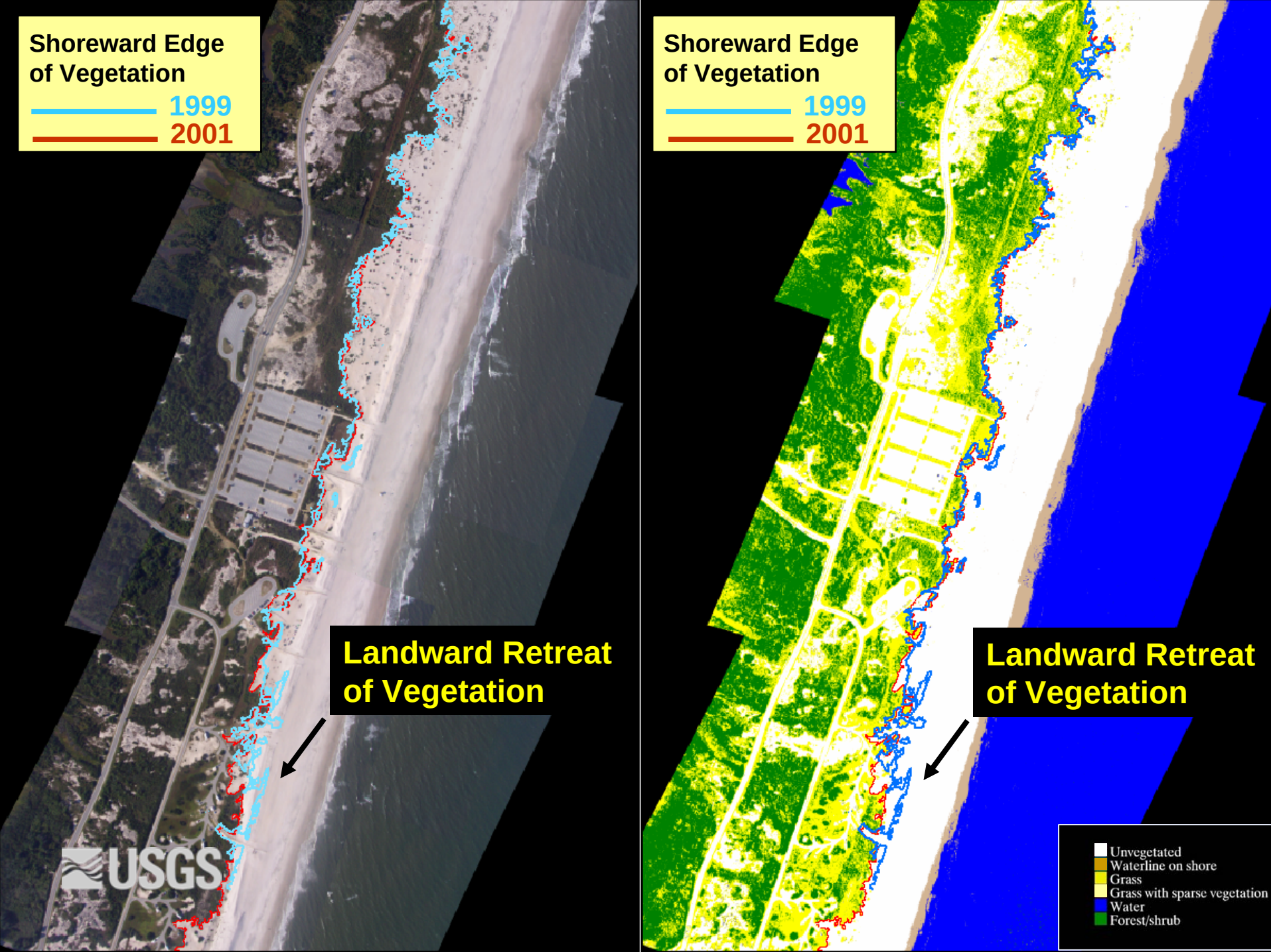

Lidar 1m Contour
Shorelines
1998 to 2001
0.3 0.15 0 0.3 0.6 0.9 1.2
Kilometers

Previous Park Management Studies

- Develop methods for extracting geomorphologic features from data
  - Detect and quantify dune formation and migration
  - Shoreline mapping and monitoring
  - Map shoreward edge of vegetation

Previous Park Management Studies

- Develop methods for extracting geomorphologic features from data
  - Detect and quantify dune formation and migration
  - Shoreline mapping and monitoring
  - Map shoreward edge of vegetation


Shoreward Edge of Vegetation
1999
2001
Landward Retreat of Vegetation
USGS
Shoreward Edge of Vegetation
1999
2001
Landward Retreat of Vegetation
Unvegetated
Waterline on shore
Grass
Grass with sparse vegetation
Water
Forest/shrub

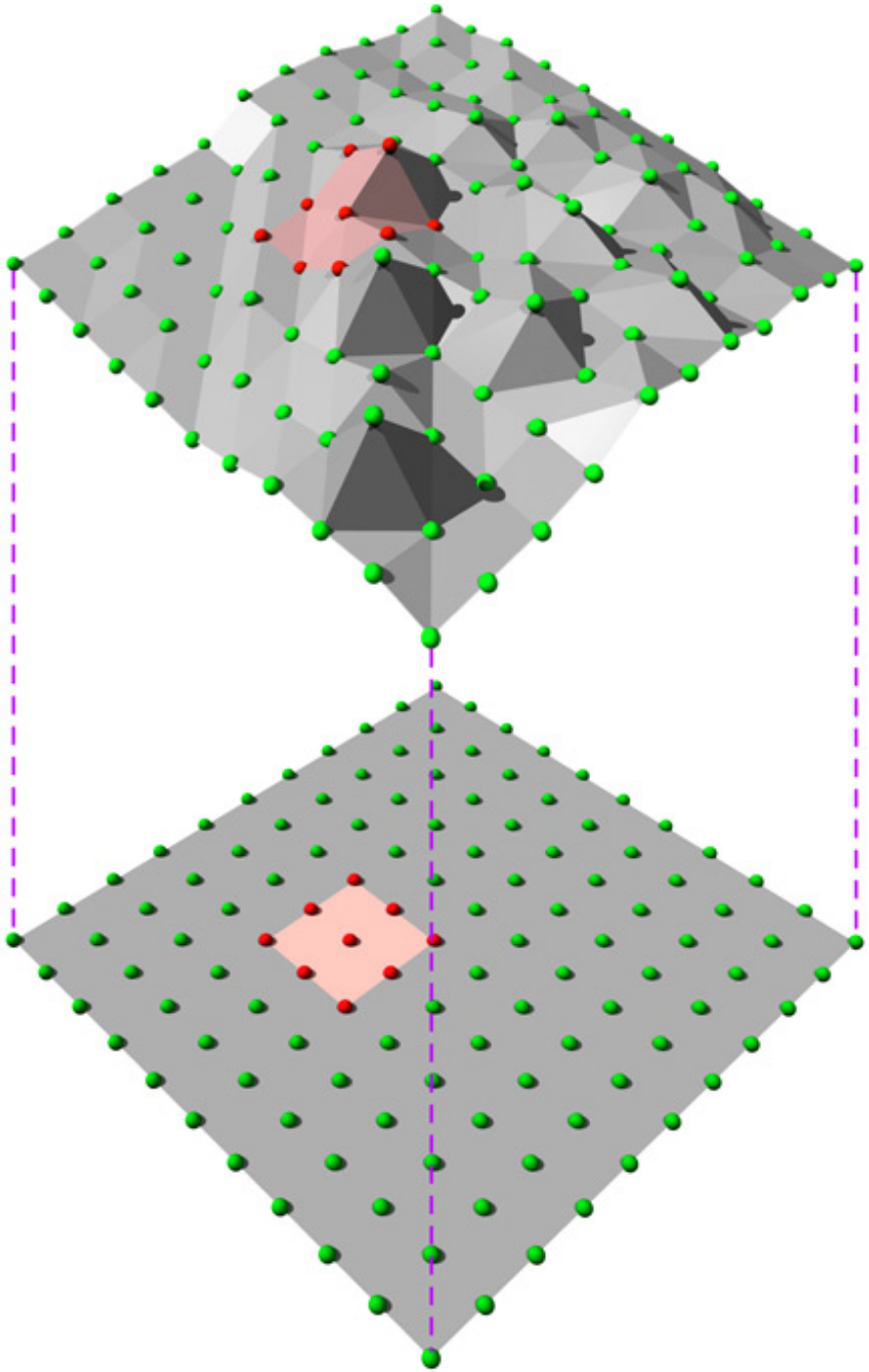
Determining Topographic Complexity

- Rugosity – Surface Roughness + Vertical Relief
- Important factor for assessing the complexity of coral reef habitats.
- Rugosity is significant factor in controlling species diversity and distribution

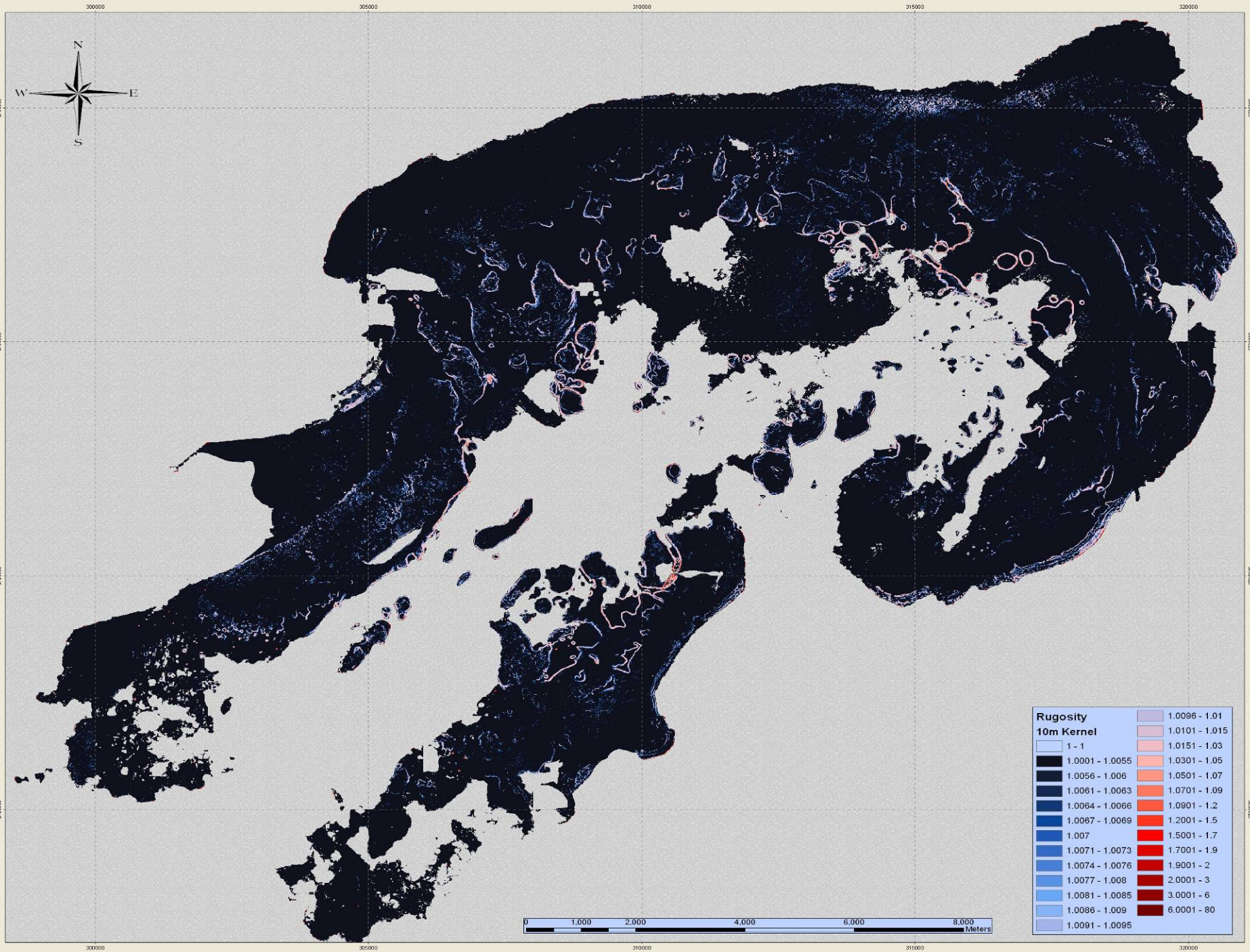
Determining Topographic Complexity

- Measured in field by divers draping a chain along a transect.
  - Length of Chain / Linear Distance = Rugosity

- Grayscale Satellite Imagery
  - Light intensity is analyzed to derive rugosity



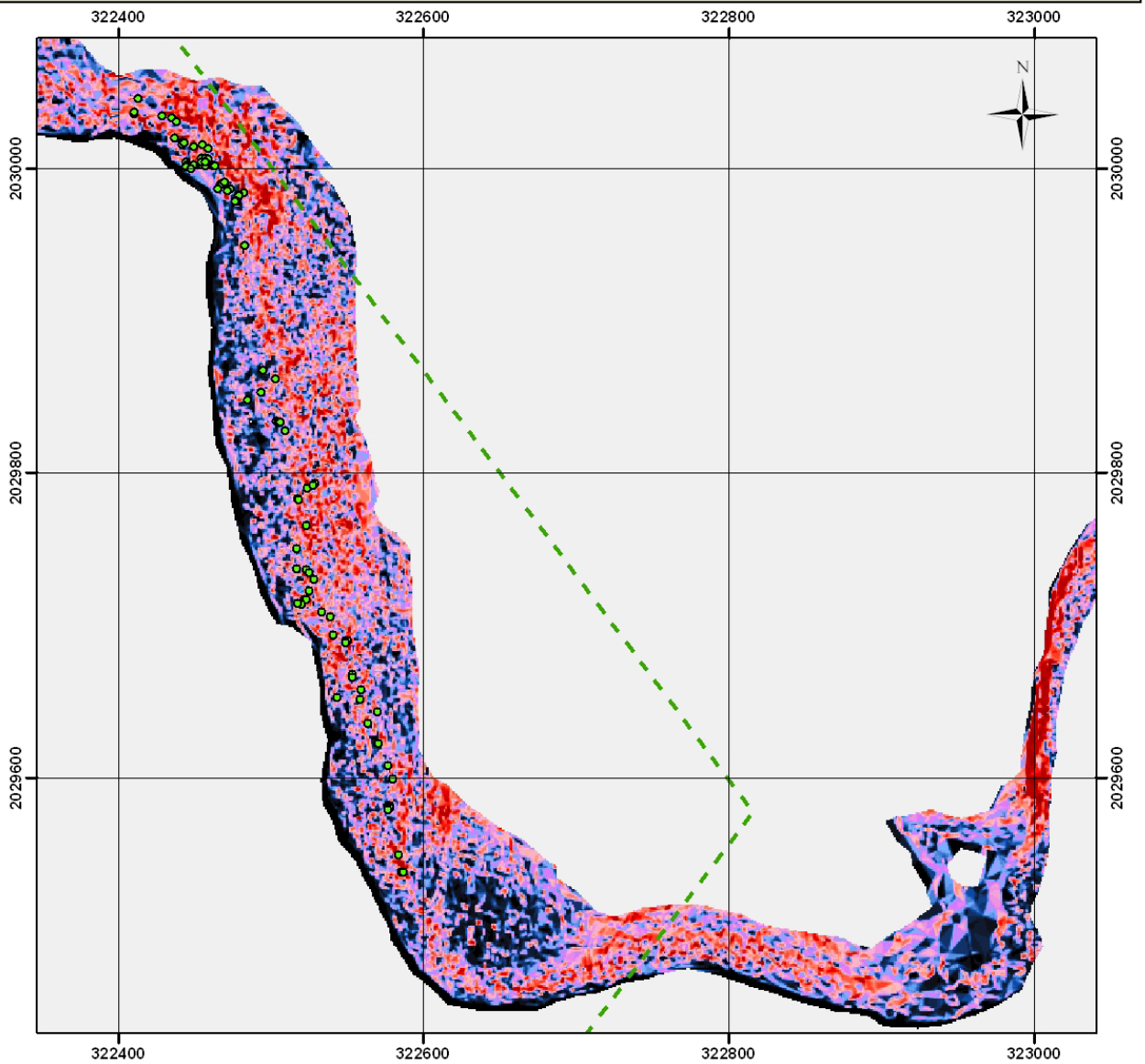
Creation of synoptic topographic complexity (rugosity) maps based on airborne lidar surveys


300000
305000
310000
315000
320000
N
W
E
S
2735000
2730000
2725000
2720000
Rugosity
10m Kernel
1 - 1
1.0001 - 1.0055
1.0056 - 1.006
1.0061 - 1.0063
1.0064 - 1.0066
1.0067 - 1.0069
1.007
1.0071 - 1.0073
1.0074 - 1.0076
1.0077 - 1.008
1.0081 - 1.0085
1.0086 - 1.009
1.0091 - 1.0095
1.0096 - 1.01
1.0101 - 1.015
1.0151 - 1.03
1.0301 - 1.05
1.0501 - 1.07
1.0701 - 1.09
1.0901 - 1.2
1.2001 - 1.5
1.5001 - 1.7
1.7001 - 1.9
1.9001 - 2
2.0001 - 3
3.0001 - 6
6.0001 - 80
0
1,000
2,000
4,000
6,000
8,000
Meters

Problems

- Current Rugosity algorithm heavily biased towards areas with high slope.
- Makes distinguishing between a rough slope and a smooth slope impossible
- Rugosity calculations for steep fringing reefs will primarily reflect slope.

USVI - St. John - Haulover Bay: Topographic Complexity



Elevation (meters)

-10.0 -3.0 4.0

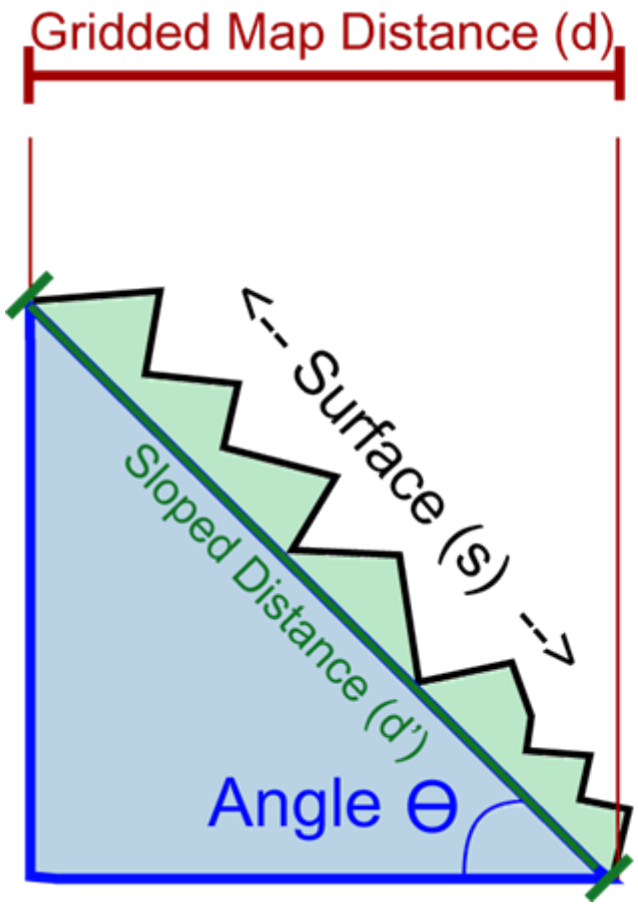
Slope (degrees)	
0.35 - 4.19	6.64 - 9.07
4.20 - 6.63	9.08 - 12.22
	12.23 - 24.78

Rugosity
2 Meter Kernel

1.0011	1.0065 - 1.0070	1.0138 - 1.0147	1.0408 - 1.05
1.0012 - 1.0027	1.0071 - 1.0075	1.0148 - 1.0158	1.0501 - 1.06
1.0028 - 1.0037	1.0076 - 1.0080	1.0159 - 1.0171	1.0601 - 1.07
1.0038 - 1.0043	1.0081 - 1.0086	1.0172 - 1.0187	1.0701 - 1.08
1.0044 - 1.0054	1.0087 - 1.0094	1.0188 - 1.0206	1.0801 - 1.09
1.0055 - 1.0059	1.0095 - 1.0102	1.0207 - 1.0228	1.0901 - 1.2
1.0060 - 1.0064	1.0103 - 1.0110	1.0229 - 1.0254	1.2001 - 1.6
	1.0111 - 1.0118	1.0255 - 1.0289	1.6001 - 2
	1.0119 - 1.0126	1.0290 - 1.0335	2.0001 - 3
	1.0127 - 1.0137	1.0336 - 1.0407	

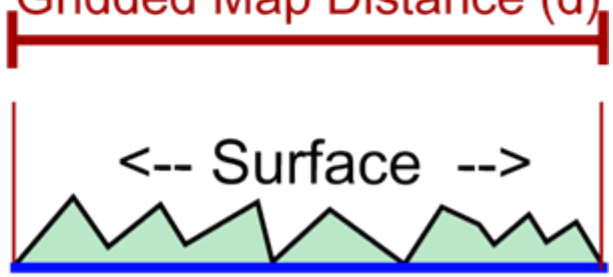
Surface Complexity

- Surface Complexity (or roughness) differs from Rugosity
- Examines the roughness of the surface after compensating for topographic relief
- Unit change to percent:
  - Percent more complex than a flat surface

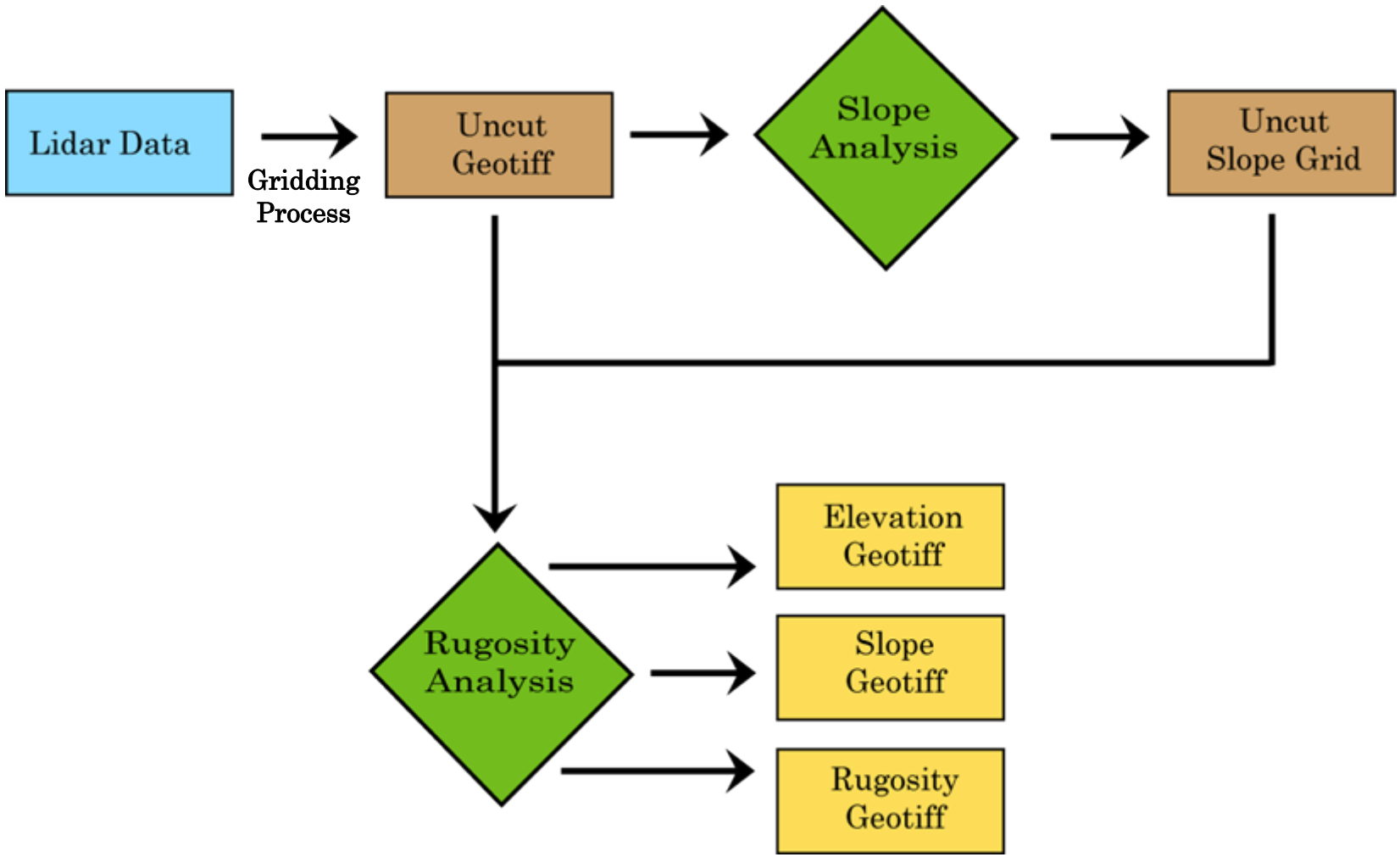


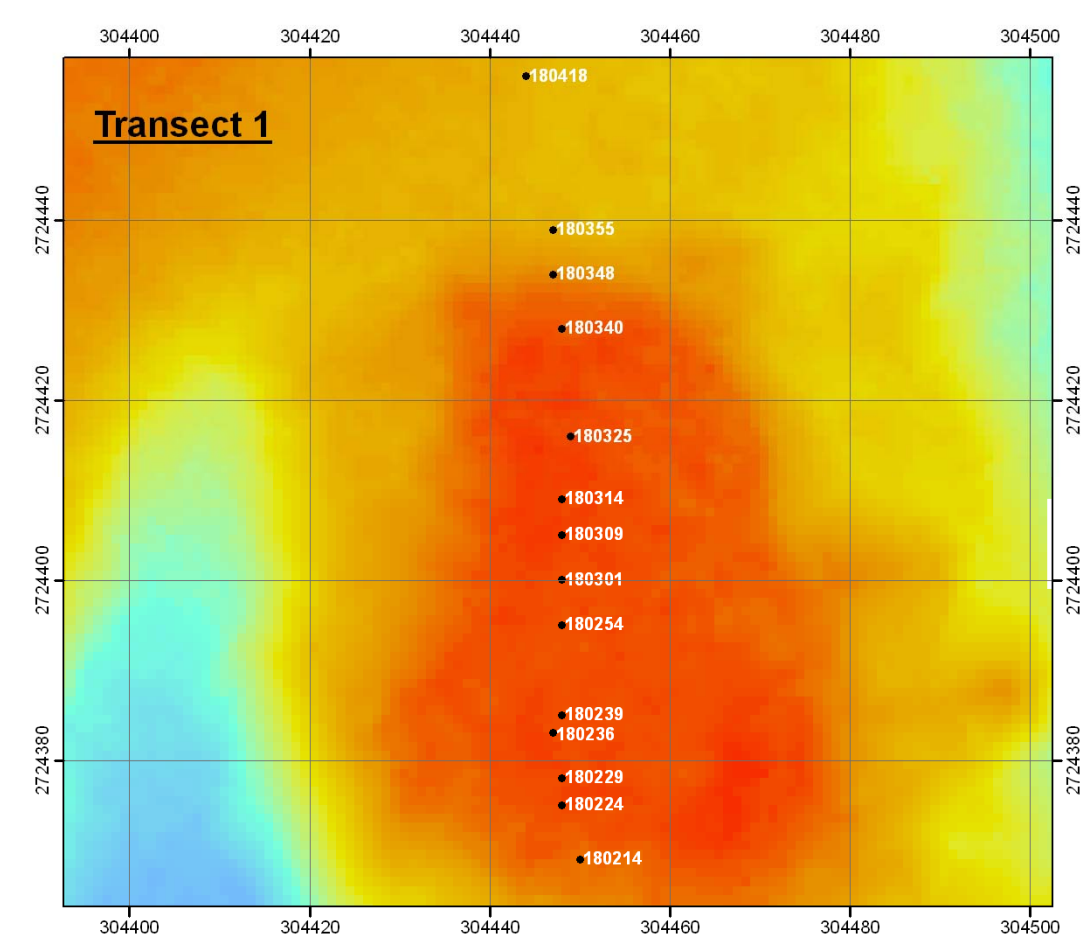
2D Rugosity Calculation = + = s/d

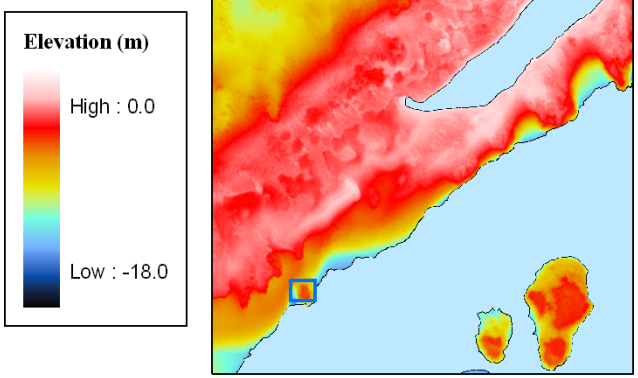
Slope Compensated Rugosity
(Surface Roughness/Complexity) = = s/d'

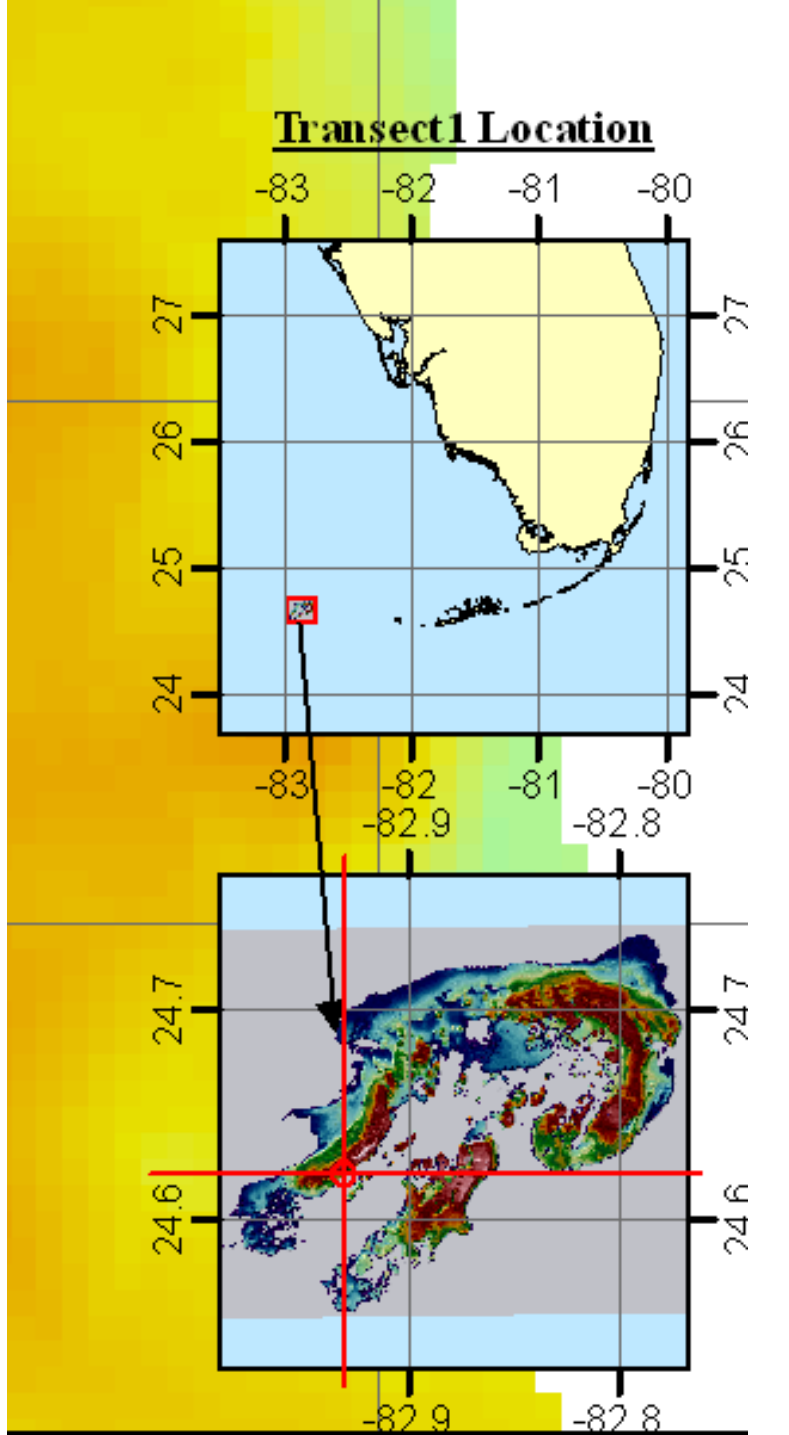


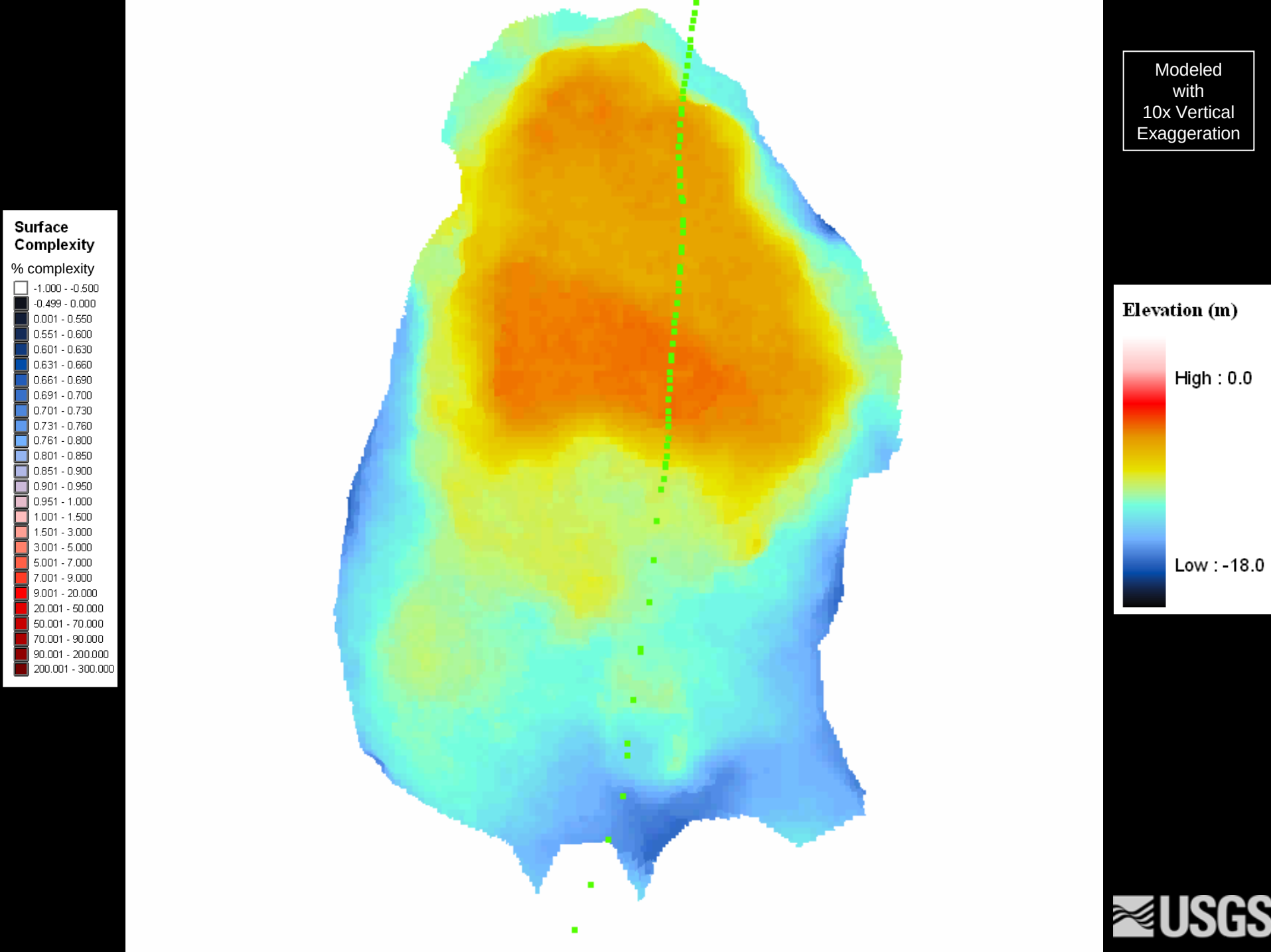
Methods

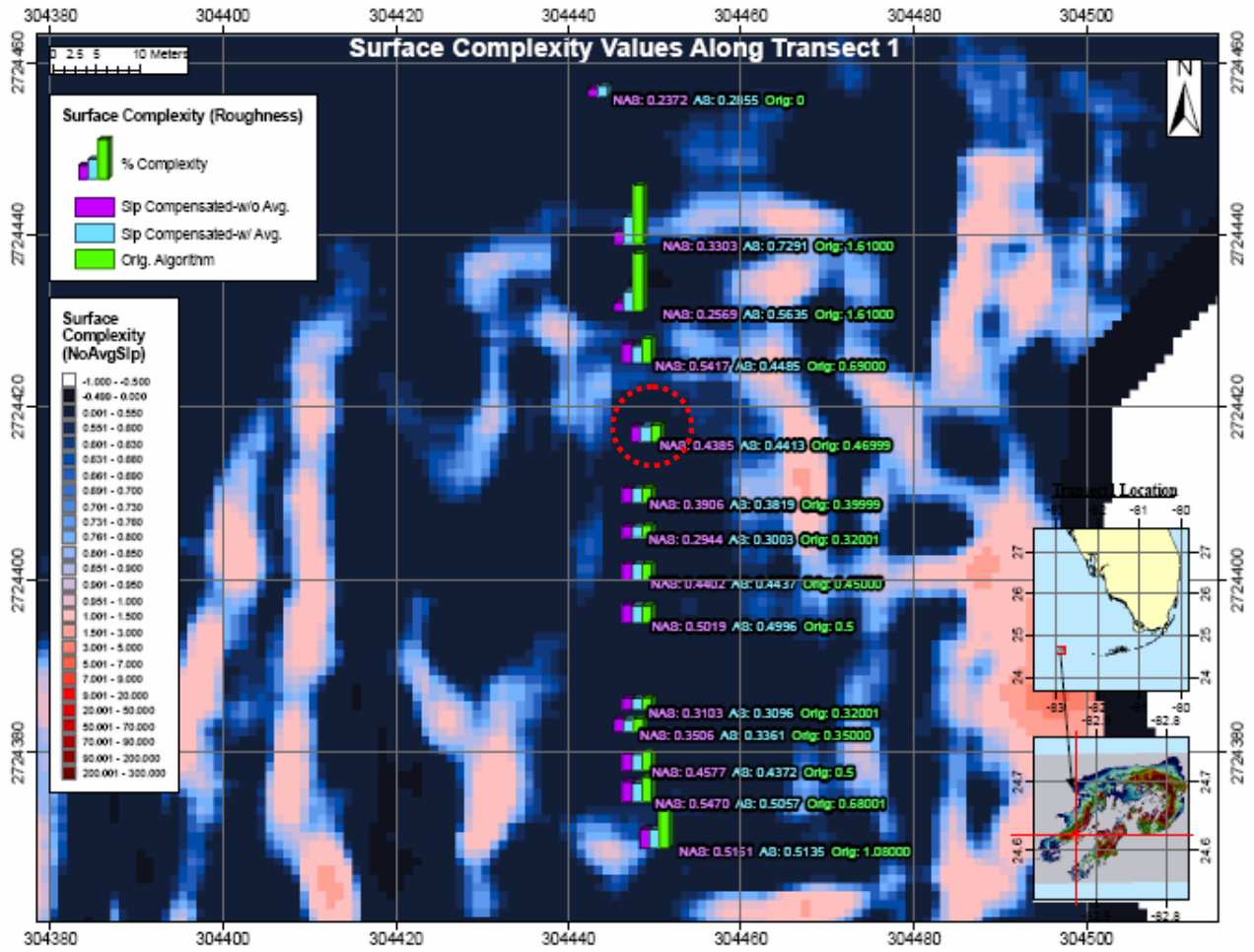

Lidar Data
Gridding Process
Uncut Geotiff
Slope Analysis
Uncut Slope Grid
Rugosity Analysis
Elevation Geotiff
Slope Geotiff
Rugosity Geotiff

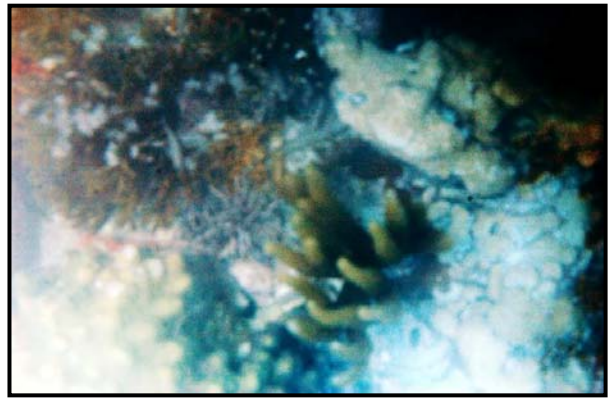

Transect 1
304400
304420
304440
304460
304480
304500
2724440
2724420
2724400
2724380
180418
180355
180348
180340
180325
180314
180309
180301
180254
180239
180236
180229
180224
180214

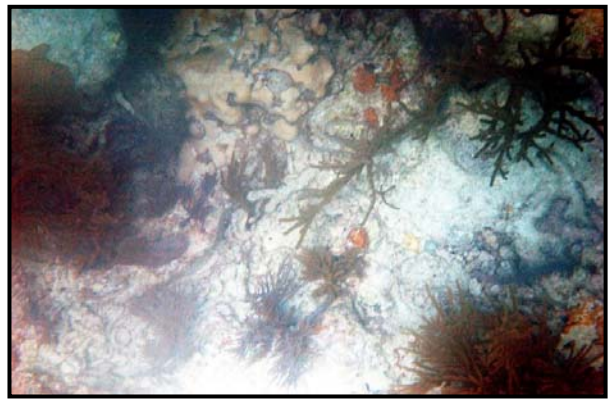

Elevation (m)
High : 0.0
Low : -18.0

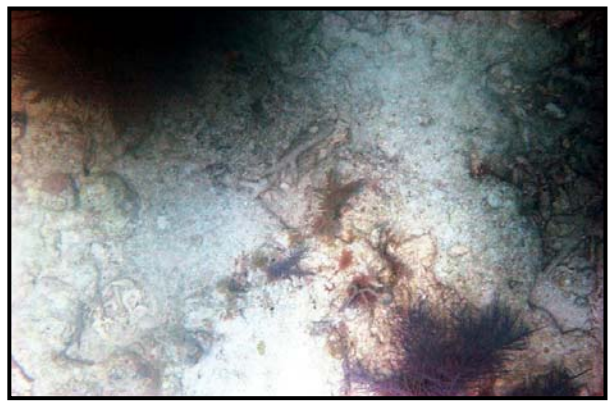

Transect1 Location
-83
-82
-81
-80
27
26
25
24
-82.9
-82.8
24.7
24.6

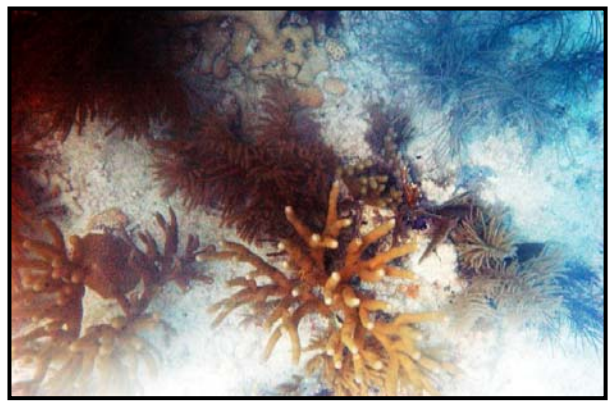

Surface Complexity
% complexity
-1.000 - -0.500
-0.499 - 0.000
0.001 - 0.550
0.551 - 0.600
0.601 - 0.630
0.631 - 0.660
0.661 - 0.690
0.691 - 0.700
0.701 - 0.730
0.731 - 0.760
0.761 - 0.800
0.801 - 0.850
0.851 - 0.900
0.901 - 0.950
0.951 - 1.000
1.001 - 1.500
1.501 - 3.000
3.001 - 5.000
5.001 - 7.000
7.001 - 9.000
9.001 - 20.000
20.001 - 50.000
50.001 - 70.000
70.001 - 90.000
90.001 - 200.000
200.001 - 300.000
Modeled with 10x Vertical Exaggeration
Elevation (m)
High : 0.0
Low : -18.0
USGS


Surface Complexity Values Along Transect 1
Surface Complexity (Roughness)
% Complexity
Sip Compensated-w/o Avg.
Sip Compensated-w/ Avg.
Orig. Algorithm
Surface Complexity (NoAvgSip)
Transect Location
304380
304400
304420
304440
304460
304480
304500
2724460
2724440
2724420
2724400
2724380









Current Studies Utilizing Rugosity

- Study of the development of the FL Keys.
  - Hypothesis:
    - Rugosity increases southeastward towards older reef structures due to reef decay
    - Can be used as an indicator for reef maturity
- Utilizing Rugosity as an indicator of species diversity.

Future Inquiries into New Algorithm

- How do different surface complexity values relate to habitat?
- Is there a relationship between surface complexity value and substrate?
- Is a smaller kernel size more useful for surface and substrate relationships?

USGS
science for a changing world

Acknowledgements

- NASA Wallops Flight Facility
  Wallops Island, VA
- U.S. Geological Survey
  Center for Coastal and Watershed Studies, FL
- National Park Service
  - Southeast / Caribbean Network
  - Northeast Network
  - Gulf Islands Network

USGS
science for a changing world

Integrated Remote Sensing and Modeling Group Website:

http://coastal.er.usgs.gov/remote-sensing/