Can Multiscale Roughness Help Computer-Assisted Identification of Coastal Habitats in Florida?

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Coastal habitats in Florida provide a wide range of critical ecosystem services (e.g., protection from erosion and storms, opportunities for tourism and outdoor activities, provide habitats for other species, fisheries)

Many of these habitats and the services they provide are facing extreme pressure (e.g., unsustainable tourism, inadequate protection and management, climate change, pollution)

(Edgar et al., 2008; Devillers et al., 2014; Broderick, 2015; Orlikowska et al., 2016)
Ongoing restoration and monitoring efforts do not have baseline data against which to quantify success

NEED FOR FREQUENT, EFFECTIVE, AND COMPREHENSIVE MAPPING AND MONITORING METHODS

(Edgar et al., 2008; Devillers et al., 2014; Broderick, 2015; Orlikowska et al., 2016)
Coastal Habitats in Florida

A multiscale framework for coastal habitat mapping and monitoring using remote sensing

Images courtesy of USGS, Andrew Ortega and Kwanmok Kim

Images:
- Broad-Scale: A map of Florida.
- Fine-Scale: An image of a coastal habitat.

The Marine Geomatics Lab
Bridging Ecological and Spatial Sciences
Dynamic environment means that we need to adopt an ecosystemic perspective.
remote sensing

Article

Quantifying Intertidal Habitat Relative Coverage in a Florida Estuary Using UAS Imagery and GEOBIA

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Coastal Habitat Mapping

Introduction

GEOBIA Analysis

Multiscale Mapping

Results

Conclusions

Images courtesy of Andrew Ortega and Michael Espriella

- Mudflats
- Salt Marshes
- Oyster Reefs
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Marsh
Coastal Habitat Mapping

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Marsh

Mud
Object-based image analysis (OBIA)
Water / tidal movement causes spectral changes and artifacts in mosaic.

Accuracy around 80%
Water / tidal movement causes spectral changes and artifacts in mosaic.
Coastal Habitat Mapping – Issues

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Spectrally similar habitats

Spectral Responses

Data from Michael Espriella
For monitoring, we need to do better: what can we do?

Coastal Habitat Mapping – Issues

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Accuracy around 80%

Class
- water (51%)
- marsh (13%)
- mud (17%)
- oyster (18%)
- unclassified (<1%)
First, use structure-from-motion photogrammetry to produce a DSM…

…and then derive terrain variables (e.g., slope, terrain complexity)
Different habitats are characterized by different features and patterns that relate to different ecological processes at different spatial scales.

It is well-known in ecology that single-scale studies may fail to capture the relevant patterns and processes.

Solution: Implement multiscale analyses.
Can we use multiscale terrain characteristics to extract a topographic signature for our different habitat types?
WhiteboxTools

WhiteboxTools is an advanced geospatial data analysis platform developed at the University of Guelph’s Geomorphometry and Hydrogeomatics Research Group (GHRG). The project began in January 2017 and quickly evolved in terms of its analytical capabilities.

- Contains more than 445 tools for processing various types of geospatial data.
- Many tools operate in parallel taking full advantage of your multi-core processor.
- Written in the safe and cross-platform systems programming language Rust and compiled to highly efficient native code.
- Small stand-alone application with no external dependencies, making installation as easy as downloading the 8Mb zip file and decompressing it.
- Simple yet powerful Python scripting interface that allows users to develop custom scripted workflows.
- Embed WhiteboxTools functions into heterogenous scripting environments along with ArcPy, GDAL, and other geoprocessing libraries.
- Serves as an analytical back-end for other GIS and remote sensing software (e.g. the QGIS Whitebox for Processing plugin).
- Permissive MIT open-source license allows for ready integration with other software.
- Transparent software philosophy allows for easy source code inspection and rapid innovation and development.

See Download to obtain a copy of the WhiteboxTools software for your system.
Hyper-scale analysis of surface roughness

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Multiscale Roughness

Analysis scales varying between 3 and 9750 (1.8 cm to 58.5 m)
Multiscale Roughness

Analysis scales varying between 3 and 9750 (1.8 cm to 58.5 m)
Multiscale Roughness

Magnitude of Roughness  Scale of Roughness

- Marsh:
  - Highest: Finest
  - Lowest: Broadest
  - Relatively High: Relatively Fine

- Mud:
  - Highest: Finest
  - Lowest: Broadest

- Oysters:
  - Relatively High: Relatively Fine
Multiscale Roughness

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Magnitude of Roughness | Scale of Roughness | Ecological Scale
--- | --- | ---
Marsh | Highest | Finest | 1.5 m
Mud | Lowest | Brodest | 12.9 m
Oysters | Relatively High | Relatively Fine | 5.3 m
Multiscale Roughness

**Introduction**

We can differentiate coastal habitats using their multiscale topographic characteristics.

**GEOBIA Analysis**

**Multiscale Mapping**

**Results**

**Conclusions**

<table>
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<tr>
<th>Magnitude of Roughness</th>
<th>Scale of Roughness</th>
<th>Ecological Scale</th>
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</thead>
<tbody>
<tr>
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</table>

We can develop topographic signatures.
Multiscale Roughness

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Marsh

Elevation (m)
-1.11
0.83

Scale
1
1795

Magnitude
11.50
65.13

Meters
Multiscale Roughness

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Good example of how geomorphometry can contribute to answering marine and coastal ecological questions.

Developing topographic signatures for different coastal habitats is promising to address some important surveying and sampling challenges associated with intertidal environments.
Conclusions

Next steps:

- Extending the analysis to other multiscale terrain variables
Conclusions

Next steps:

- Extending the analysis to other multiscale terrain attributes

- Comparing results from a DSM with results from a DTM and lidar data
Conclusions

Next steps:

- Extending the analysis to other multiscale terrain attributes
- Comparing results from a DSM with results from a DTM and lidar data
- Integrating these multiscale variables in the GEOBIA workflow
- Compare the topographic signature of intertidal oysters to that of subtidal oysters
Thank you!

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