Movement and grain size distribution of Bahamian sand shoals from remote sensing

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Motivation: Understand how sediment moves underwater

Transport

Grain size

Implications

- Evolution of shallow bathymetry
- Petroleum and natural gas reservoirs
- CO₂ reservoirs
How remote sensing data can help

• Obtain a 2-D snapshot of a modern day shallow carbonate environment

• Build up a time series of morphology and grain size

• Quantify the distribution and movement of sediment at a variety of temporal and spatial scales
  – Tides versus storms?

• Use the modern to better understand the 3-D patterns of porosity and permeability in the rock record
The Bahamas: A modern carbonate environment
Tongue of the Ocean

Crest spacing ~ 1-10 km

Google Earth
Crest spacing ~ 100 m

Crest spacing ~ 1 km
Sediment transport and bedform migration

Bedform spatial scales = 5-10 cm, 1 m, 10-100 m, 1-10 km

Temporal scales = Hours, days, years

Transport

\[ \Delta y \]

\[ \Delta x \]
Ideal Imaging Campaign

- High enough spatial resolution to see bedform crests on a number of scales
  - Sub-meter resolution
  - Auto-detection system
- High enough temporal resolution to distinguish between slow steady processes and storms
  - Image collection every 3 to 6 hours
- Spectral resolution depending on bedform scale of interest

Also useful:

- High resolution water topography (sub-meter resolution)
- Track currents, tides, and water velocity
Application of COSI-Corr

- Use the COSI-Corr software developed by Leprince et al. (2006) to see changes in shoal morphology
- Start with **Landsat** and **ASTER** data to provide longest time series at lowest cost
- Special order images that focus on active shoal areas
Scattering properties of carbonate sands

**Grain size:** 50-500 micrometers

**Grain shape:** Rounded carbonate grains, large fraction of ooids
Measuring grain-size distributions

- Variations in reflectance of ooid shoals from hyperspectral data
- Link reflectance, scattering properties, grain-size
- Test theoretical models of reflectance and transmittance through water

Ghrefat et al. 2007- White Sands, NM
Relevant data sets

• Hyperspectral Imaging
  – AVIRIS (18 m res)
  – Hyperion?
  – Worldview or GEOEYE 1

• Explore potential of lower resolution Landsat and ASTER data to extend migration of shoals back in time (decades)
Ground truthing in the field and lab

Field work in the Exumas, March 2010

Fish-tank experiments to calibrate reflectance, water depth and grain-size
Remote sensing in the Bahamas

- Potential problems with subaqueous studies:
  - Water contamination: sediment, biological, etc.
  - Depth
  - Compositional changes in the sediment

- Advantages of this study area:
  - Well-studied
  - Clear, shallow water (0-15 m)
  - Shoals consist of well-rounded carbonate grains
  - Accessible

Can we use visible imagery and VNIR spectral data to understand transport and grain size distribution?