# 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
- $CO_2$ 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


Google Earth

Tongue of the Ocean

20 km

Schooner Cays

20 km

Lily Bank

2 km

Exumas

2 km

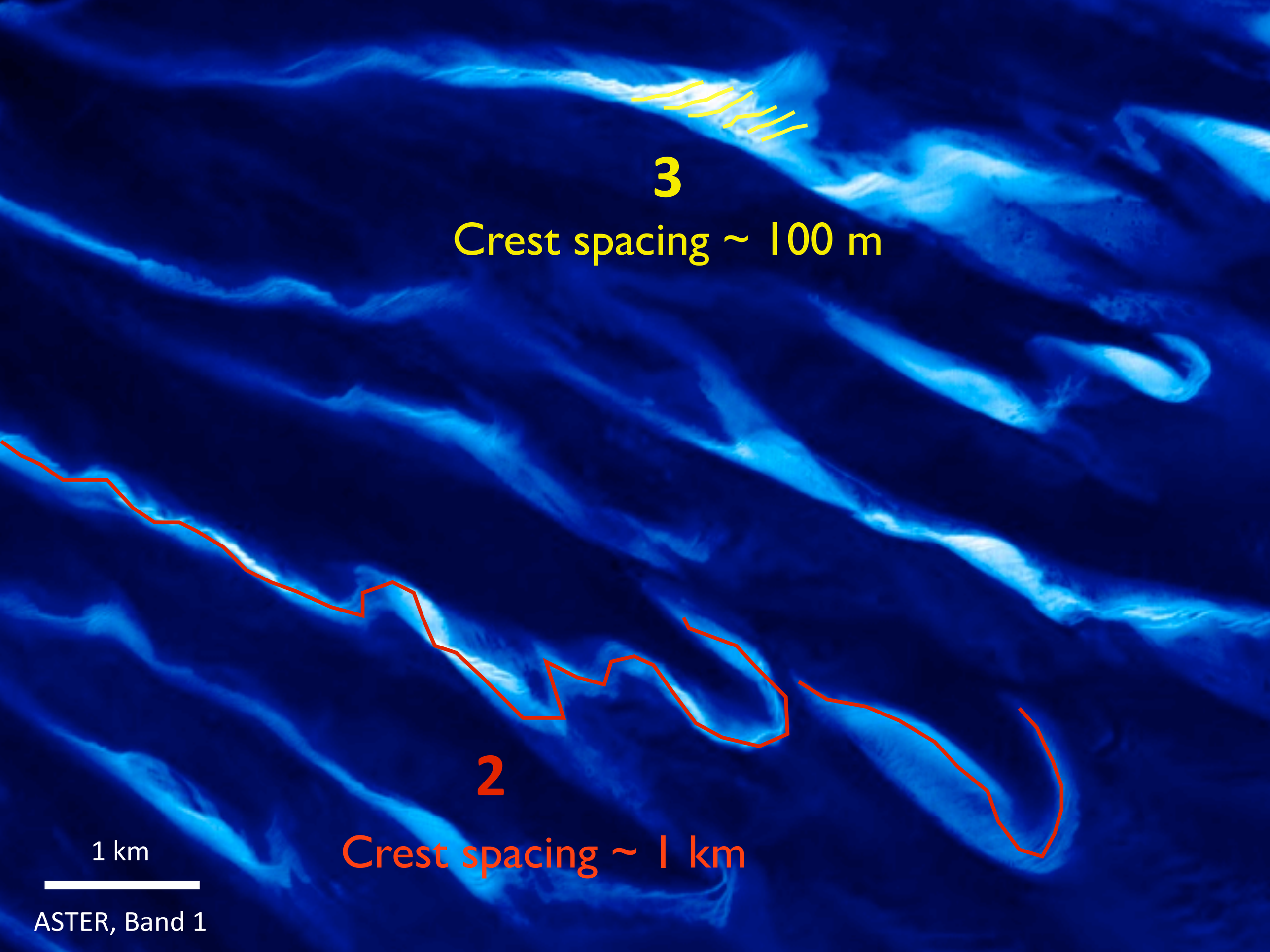
Tongue of the Ocean

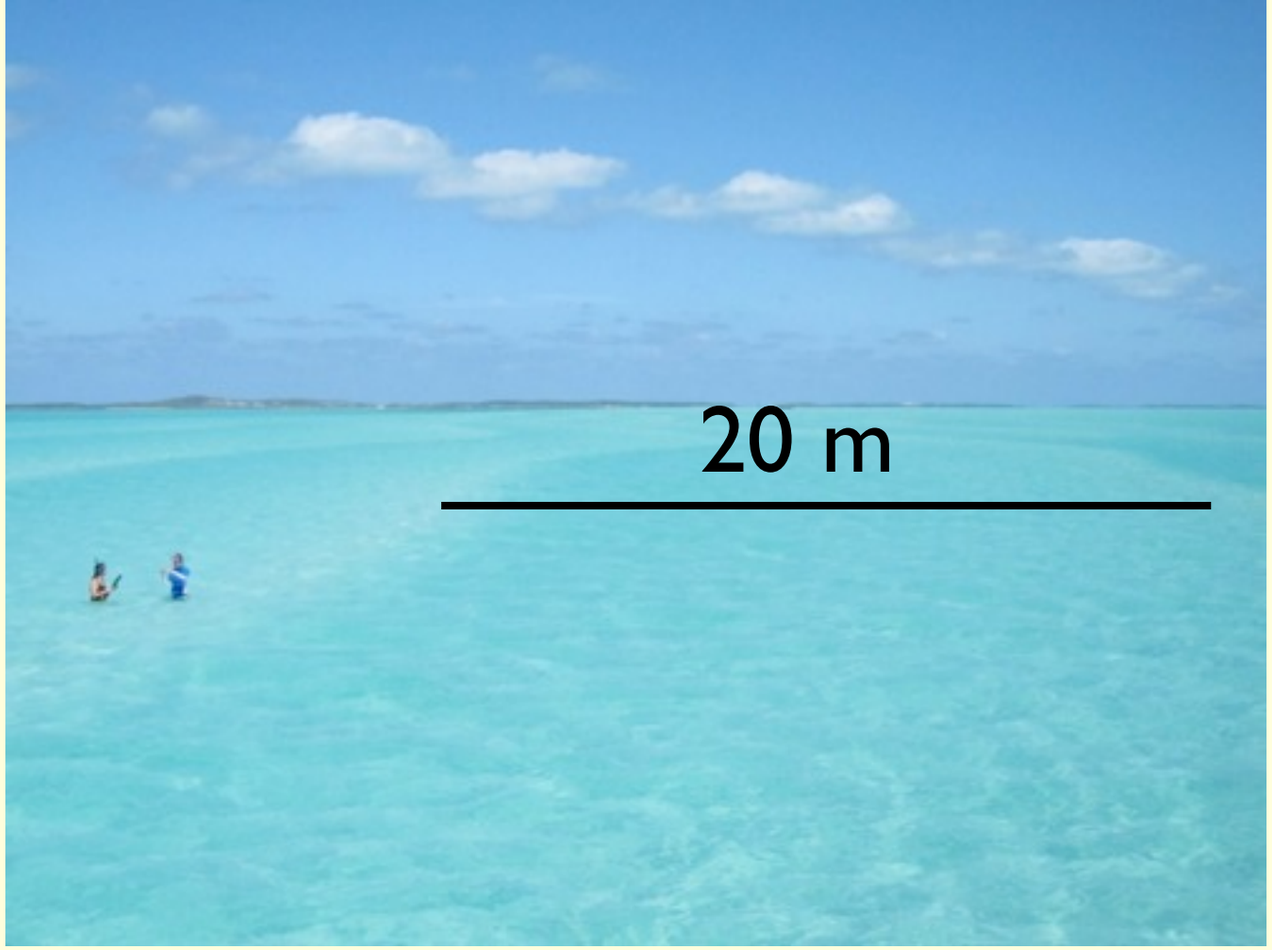
10 km

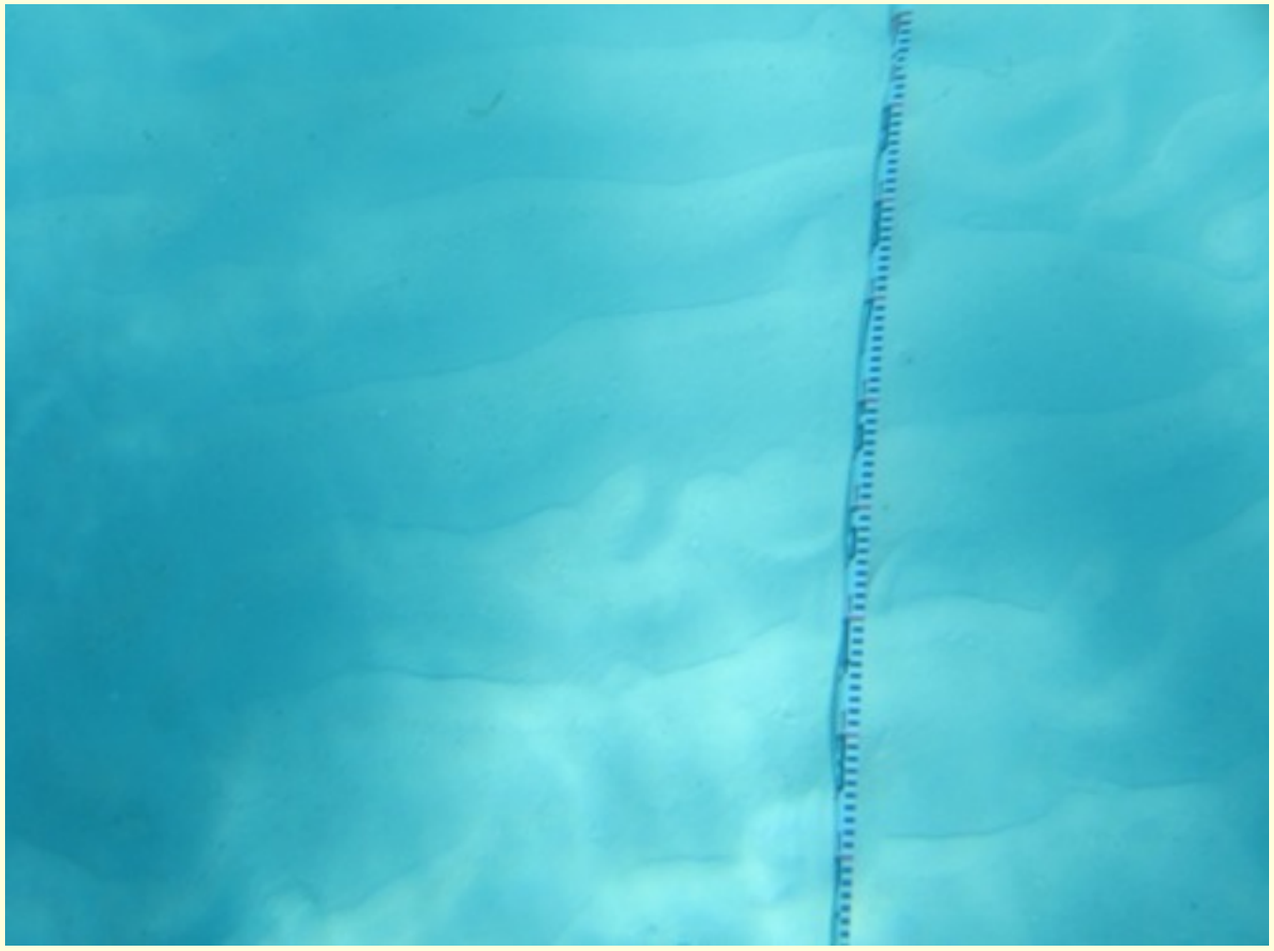
1

Crest spacing ~ 1-10 km

Google Earth


3
Crest spacing ~ 100 m
2
Crest spacing ~ 1 km
1 km
ASTER, Band 1

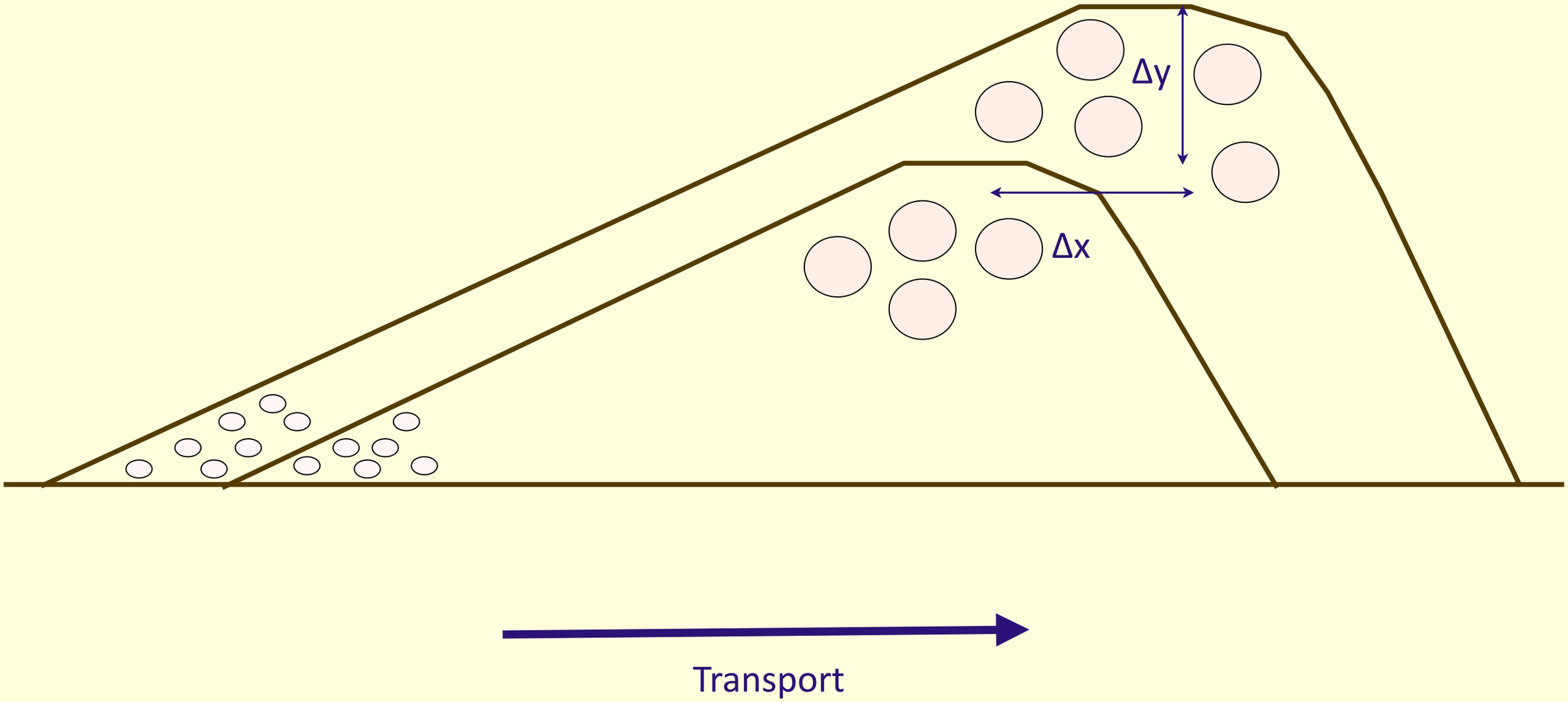

20 m



# Sediment transport and bedform migration

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

Temporal scales = Hours, days, years



# Ideal Imaging Campaign

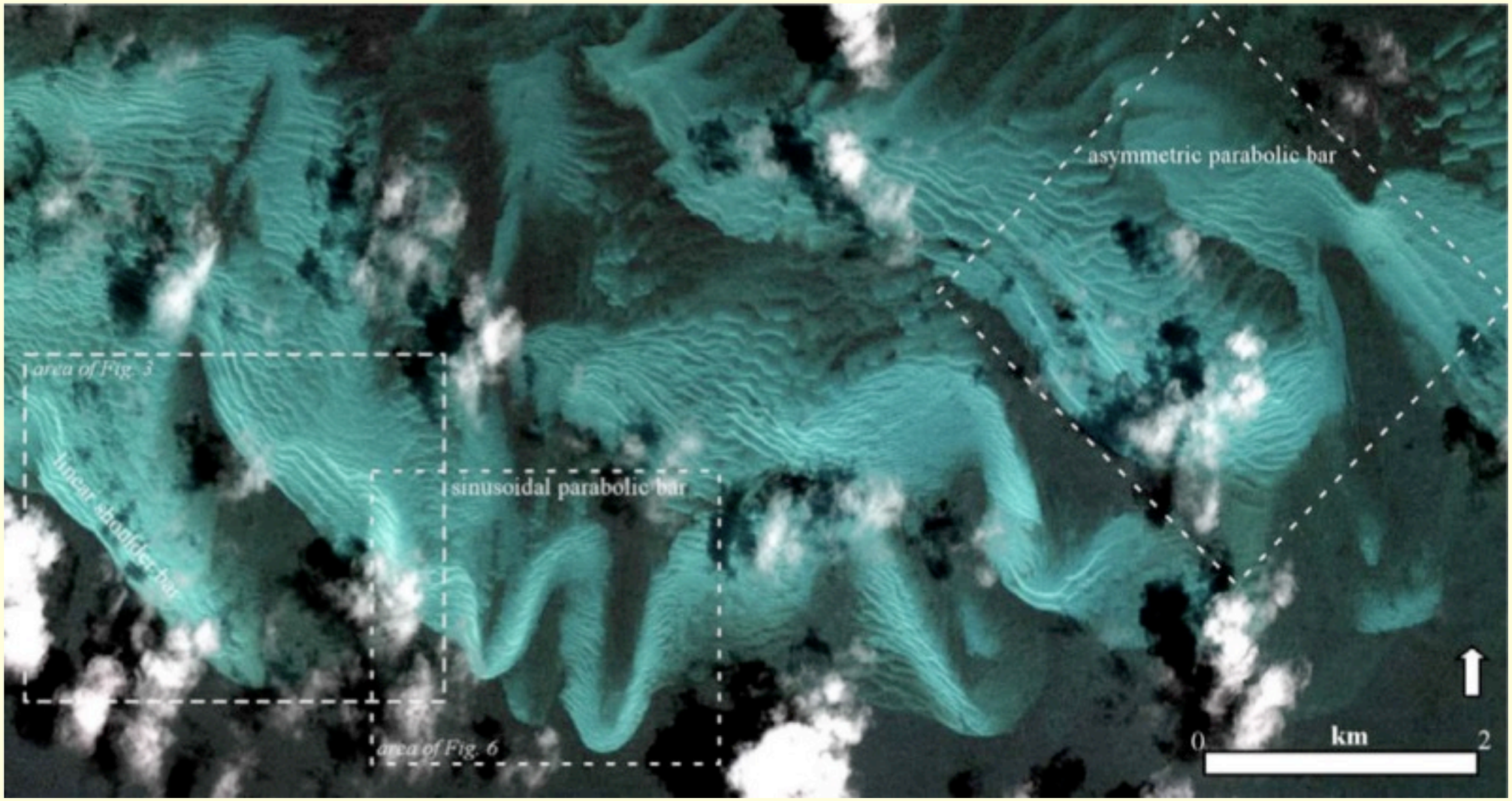
- High enough spatial resolution to see bedform crests on a number of scales
  - Sub-meter resolution
  - Auto-detection system
- High enough temporal resolution to distinguish between slow steady processes and storms
  - Image collection every 3 to 6 hours
- Spectral resolution depending on bedform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

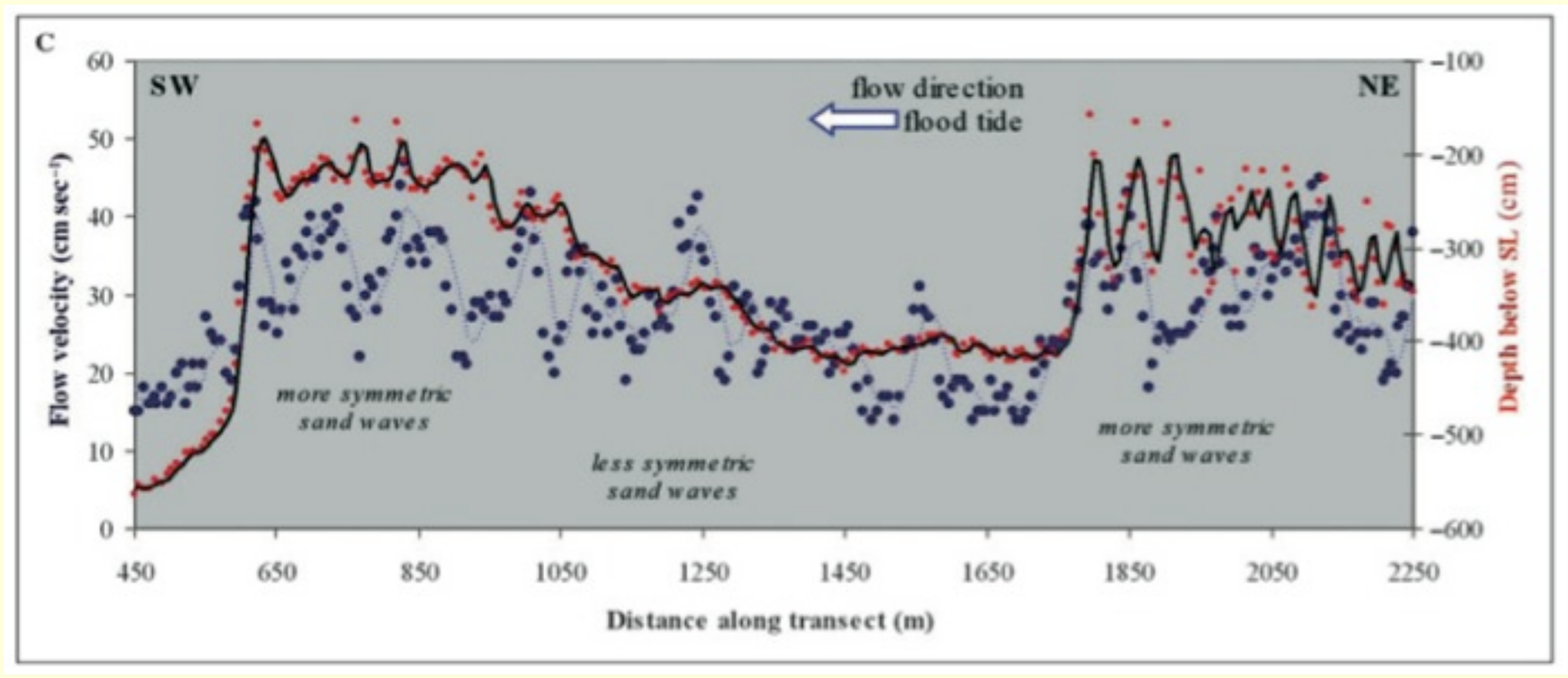
## Also useful:

- High resolution water topography (sub-meter resolution)
- Track currents, tides, and water velocity

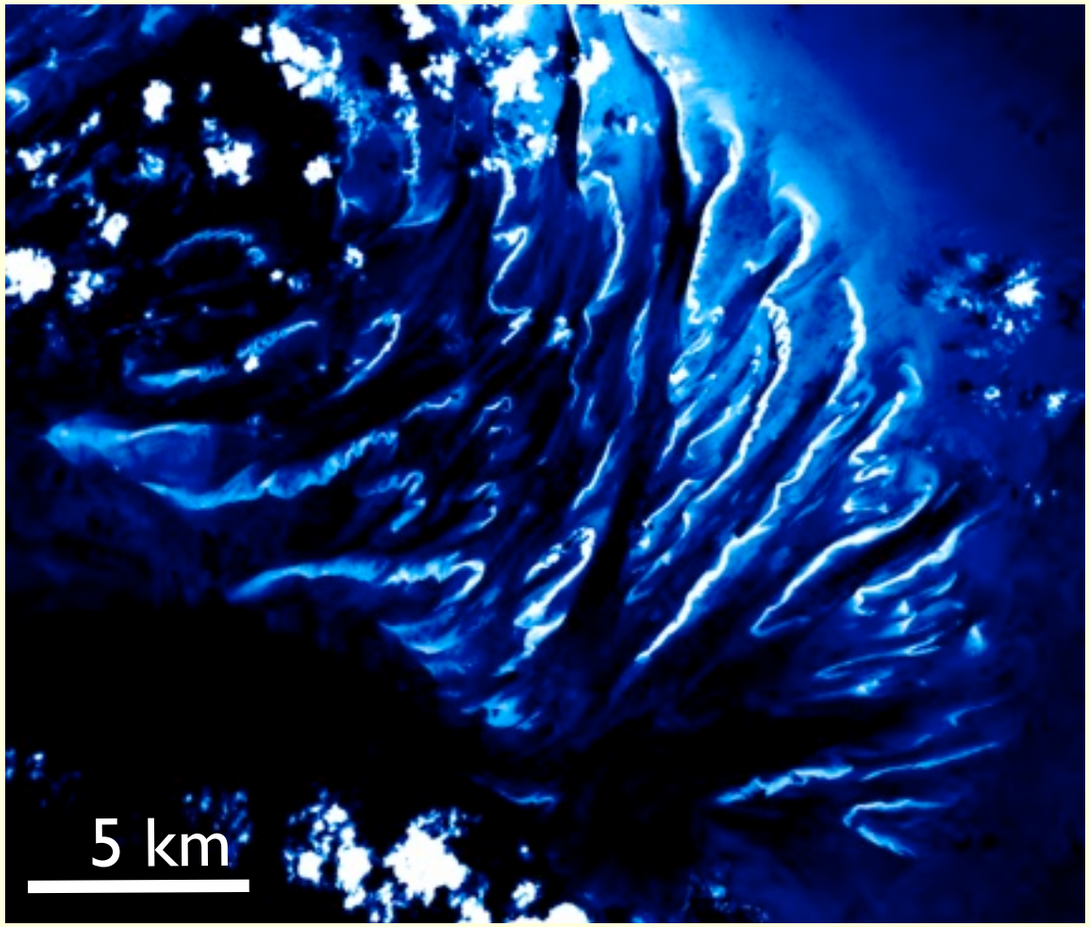
# Application of COSI-Corr

- 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

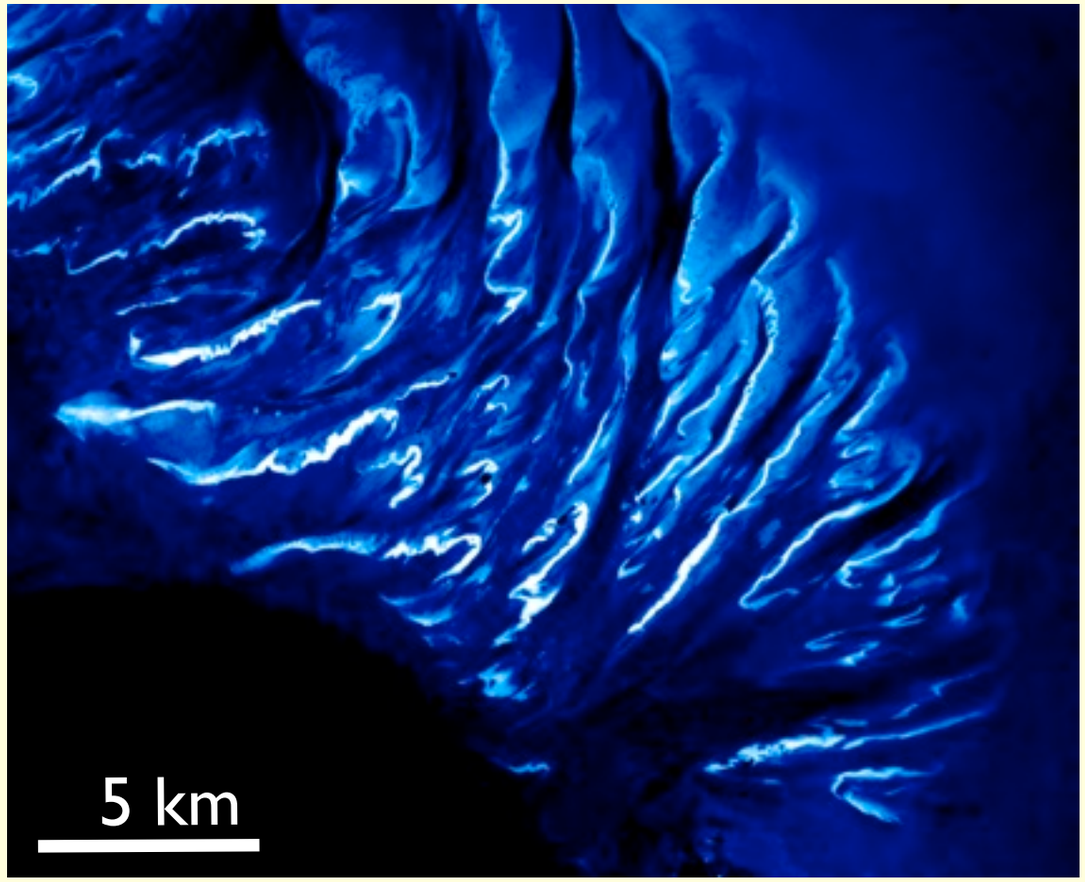


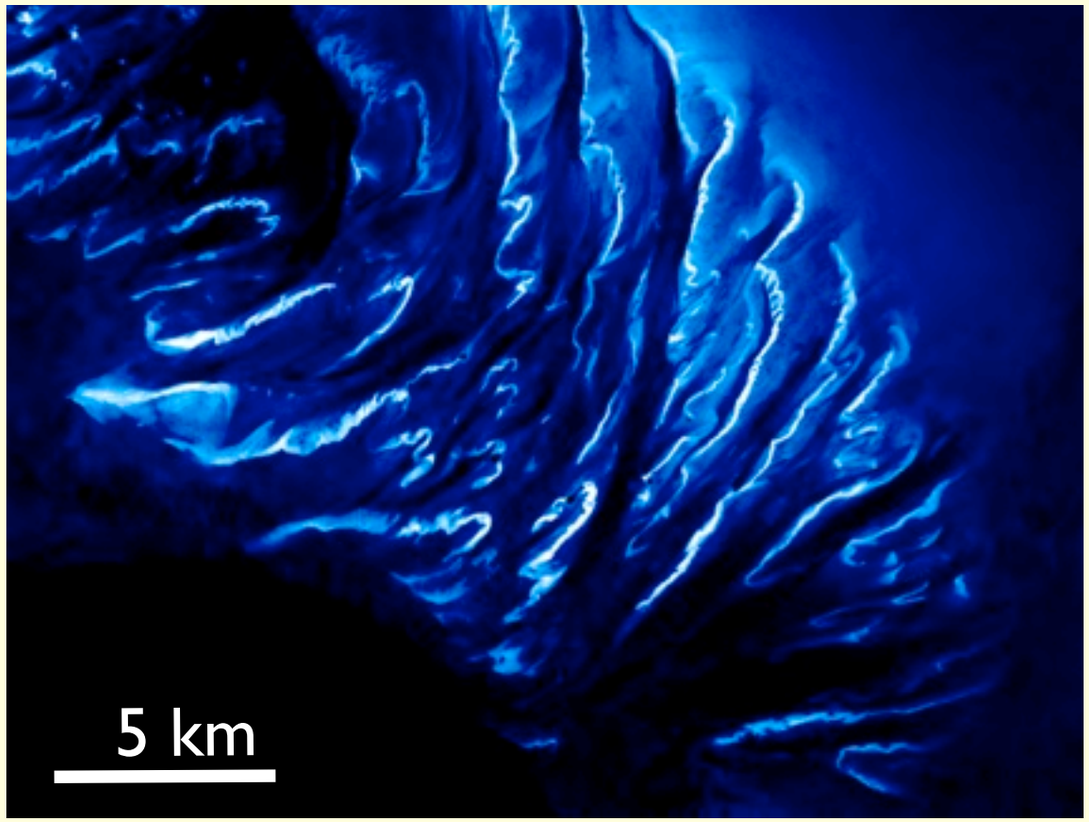

Rankey et al. (2006)- Lily Bank, Bahamas




1987




1994

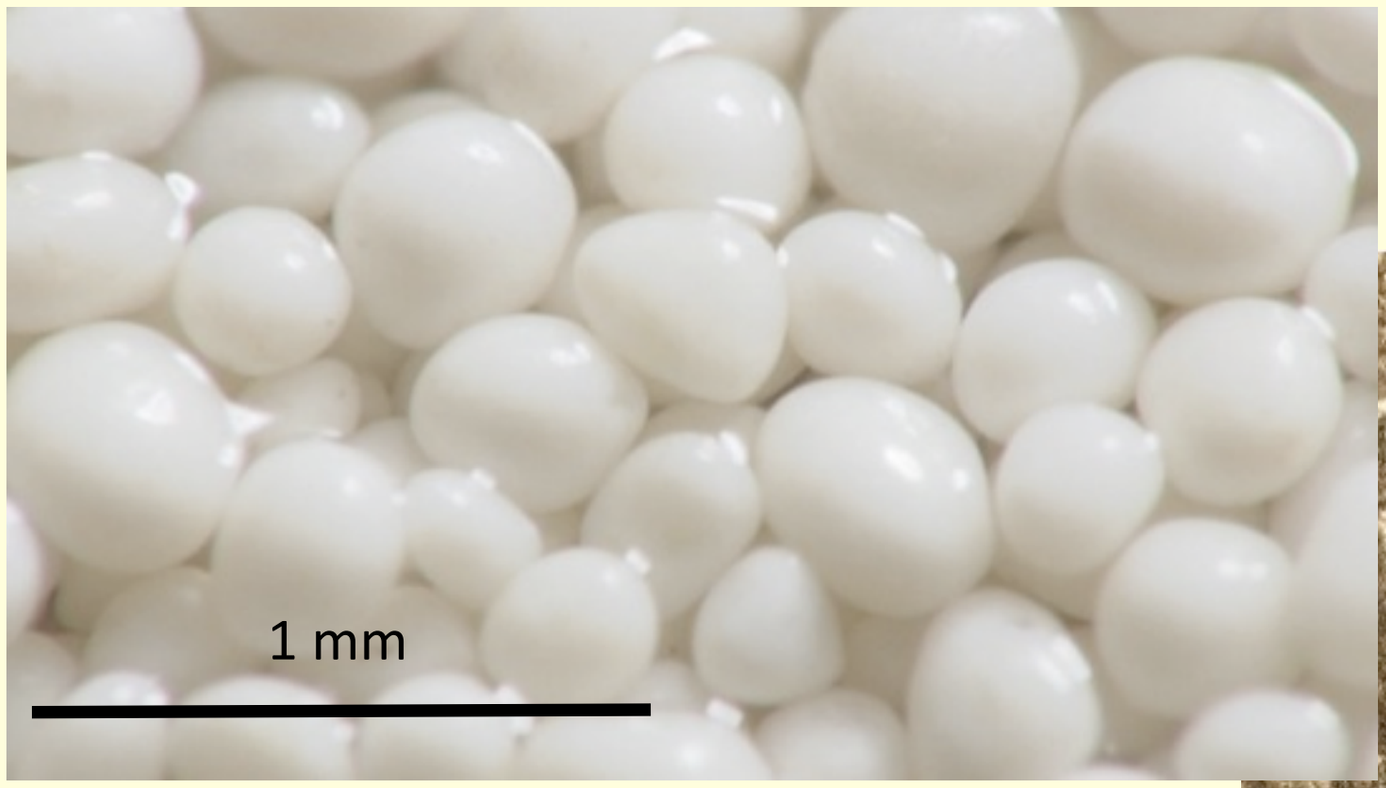


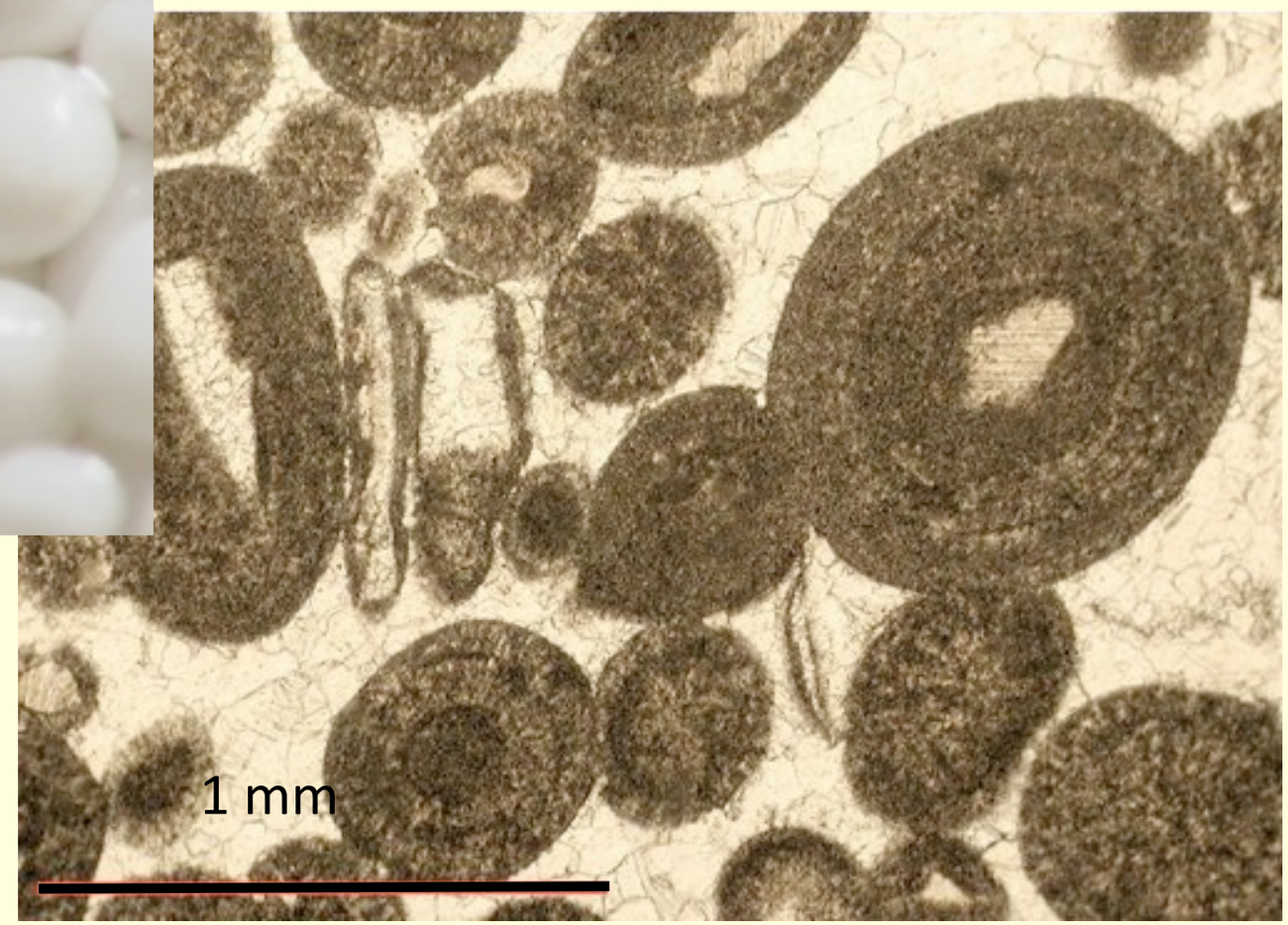

1999

Landsat, Band 1

# Scattering properties of carbonate sands

**Grain size:** 50-500 micrometers
**Grain shape:** Rounded carbonate grains, large fraction of ooids

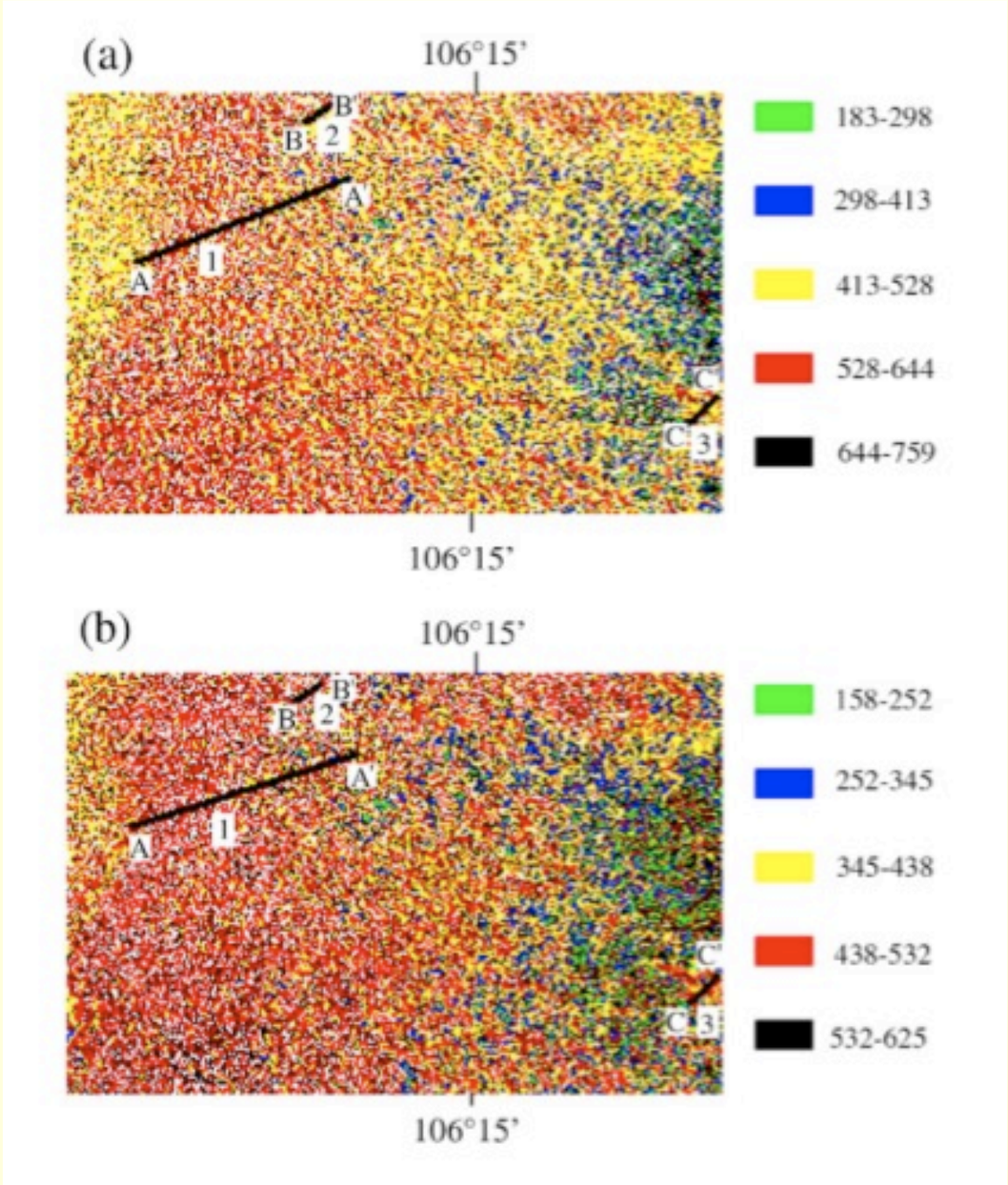



http://www.virtual-geology.info

# 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 **GEOEYE1**

- 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?