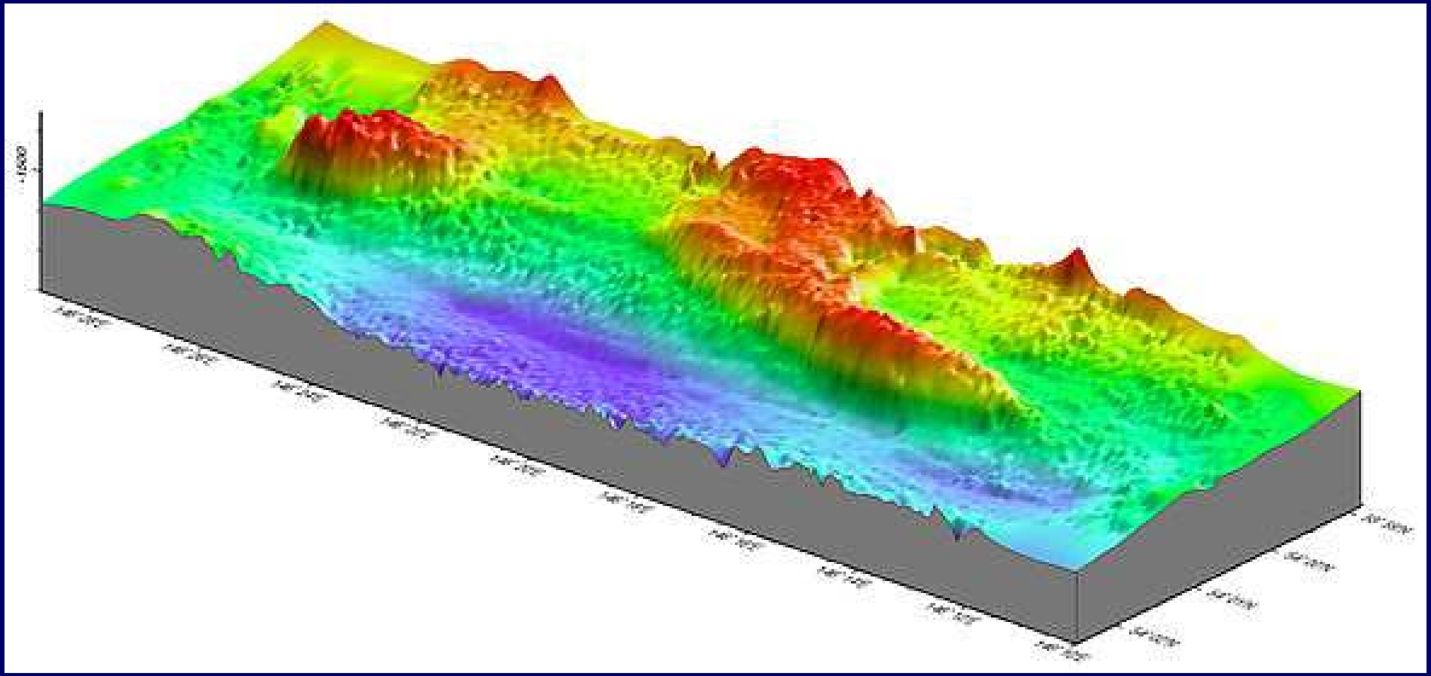
Introduction to ‘Acoustic Remote Sensing and Seafloor Mapping (AE4-E13)’



May 19, 2010

Delft Institute of Earth Observation and Space Systems

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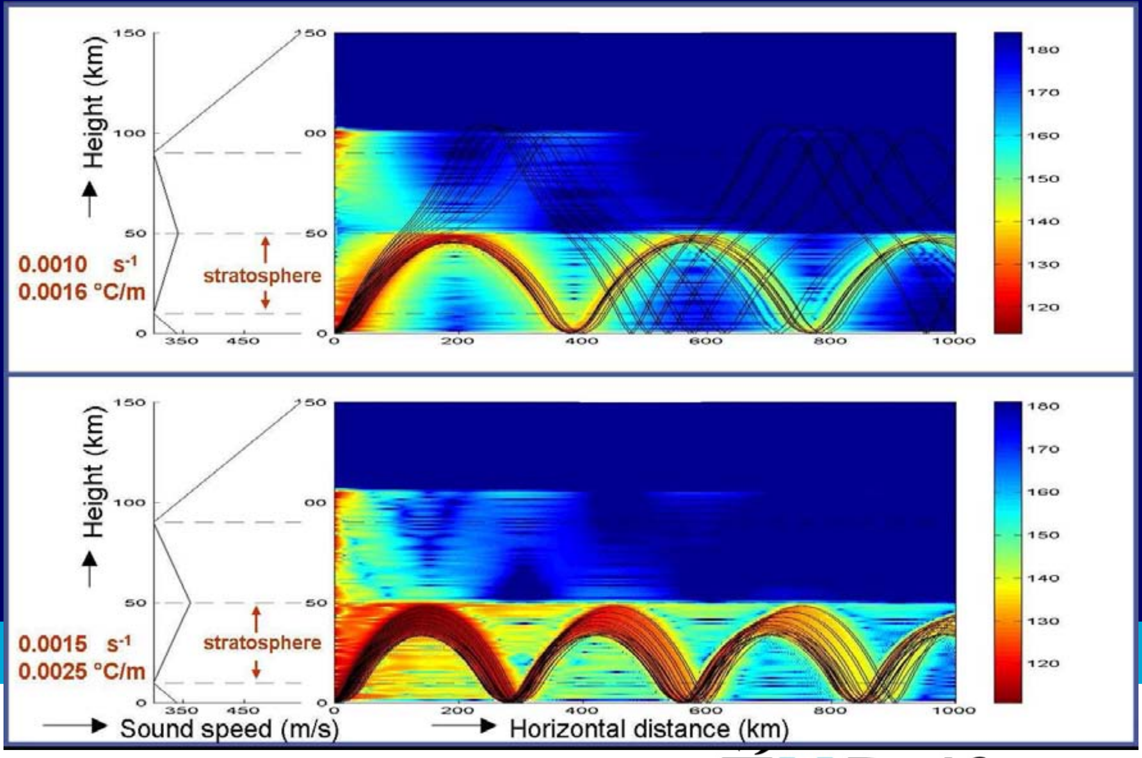
Why Acoustic Remote Sensing?

- Contrary to other wave types, sound can propagate large distances under water due to limited attenuation:
  Acoustic remote sensing is therefore the main technique for sensing the underwater environment

- Low-frequency sound can propagate over large distances through the atmosphere



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Mapping of the river and ocean-floors
What is it and why is it needed ?

What?

- We are interested in the geometrical description of:
  - The seafloor topography/morphology
  - Dynamic behaviour of seafloor topography (deformation)
  - The seafloor material properties (thematic information)

Example: for planning offshore wind mill parks, one needs to know:

- Water depths
- Seafloor dynamics
- Seafloor composition

Why?

- *Submarine earth observation* becomes more important because of the intensifying human exploitation of the oceanic space: increasing need for accurate maps of the seafloor.
  70 % of the Earth's surface is covered with water !

Applications of accurate maps of seafloor topography

Geology and geophysics

- Identifying areas of erosion/deposition on continental shelf
- Locating areas of geo-hazard like slumps and faults
- Neo-tectonic activity and submarine landslides
- Deformation and sediment transportation (pollutants)

Environmental contamination

- Study of the fate of offshore dredge disposal sites

Marine biology and fisheries

- Inter- relation seafloor morphology/composition & fish abundance

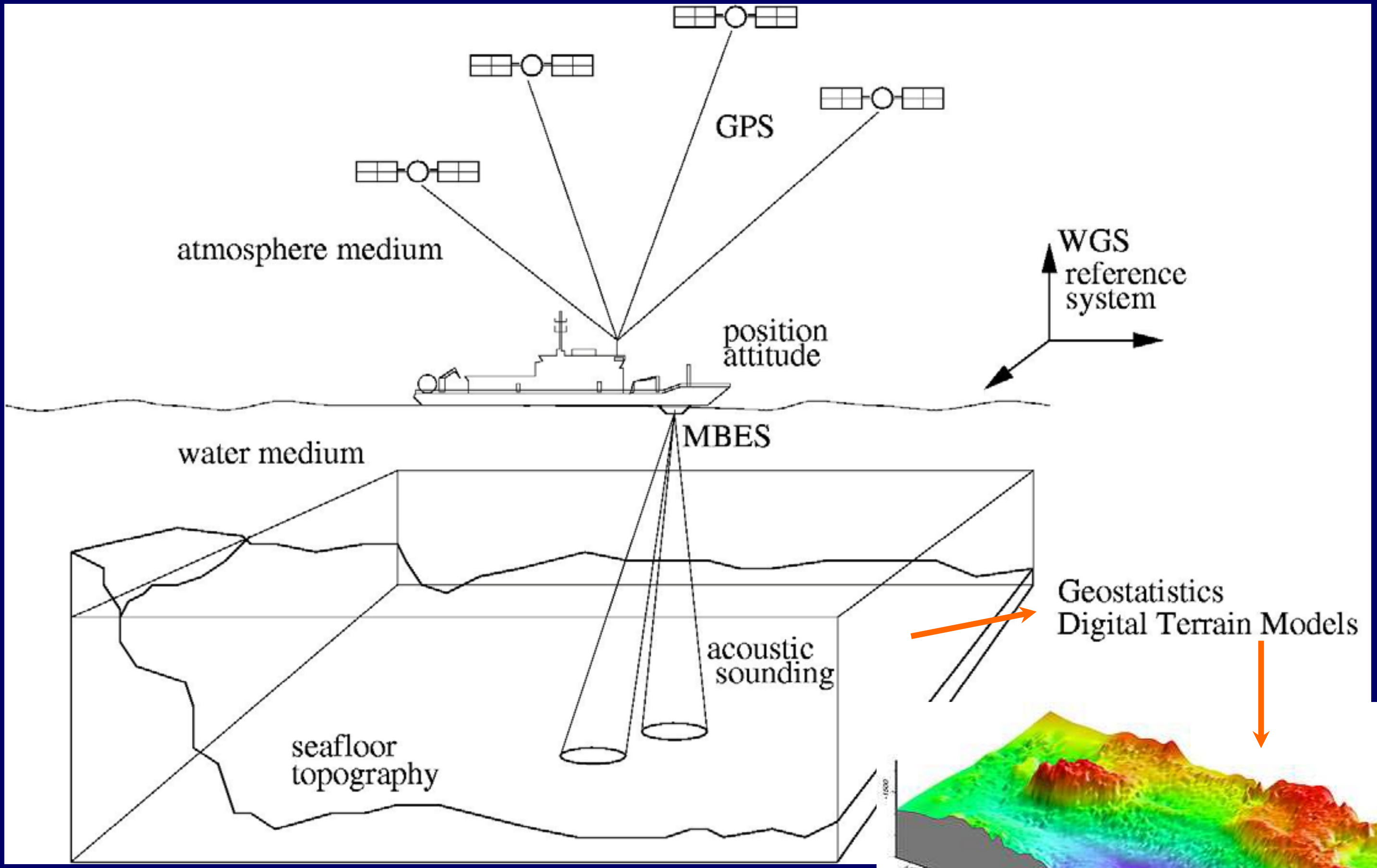
Hydrography and navigation

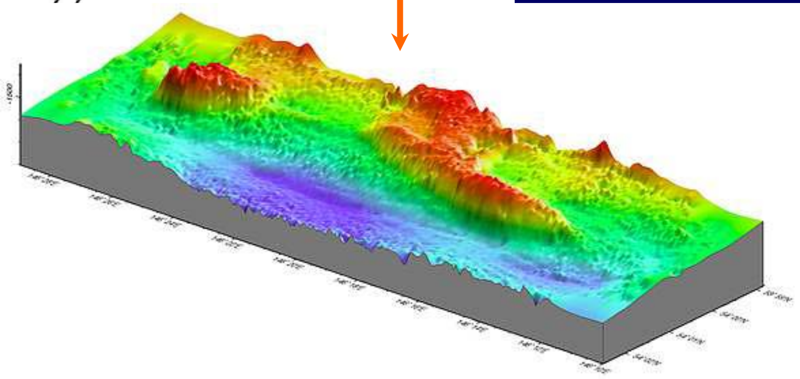
- Maintaining safe navigation in waterways (where do we need dredging?)
- Hydrographic surveying of new areas

Coastal engineering

- Cable and pipeline planning
- Coarse sand extraction for making concrete
- Preparing dredging operations
- Deployment of offshore structures, building wind farms

A mapping system overview





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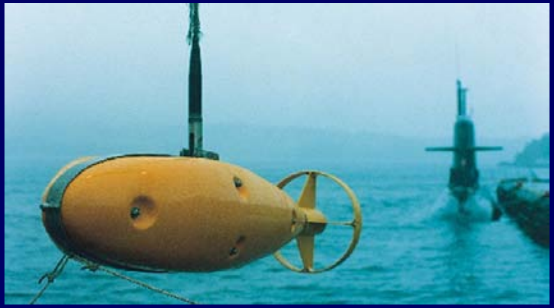
Acoustic seafloor mapping techniques

Technique	Basic principle	Lateral resolution shallow water (50 m)	Lateral resolution deep water (5 km)	Depth limit	Surveyed area/ per unit time	Platform
Single beam echo sounding	Acoustic ranging	10 m	1 km	none	low	ship (hull-mounted)
Side-scan sonar (forward looking)	Acoustic ranging	<0.1 m (across-track) 1 m (along-track)	in principle the same as for shallow water	none, in principle	low/medium	towed by ship
Multi beam echo sounding (MBES)	Acoustic ranging and beam-forming (imaging acoustic backscatter)	2 m	200 m	none	medium	ship (hull-mounted) or towed by ship
Synthetic aperture sonar	Imaging acoustic backscatter from the seafloor	0.1 m	Not applicable	< 1 km	Low/medium	Ship/ AUV
Seismic profiling	(low-frequency) acoustic ranging	10 m	10 m	none	medium	ship (hull-mounted) or towed by ship
Drifting sonobuoys	Inversion of LF long range propagation	Typically 100 m – 1 km	Typically 100 m – 1 km	none	medium /high	radio link to ship



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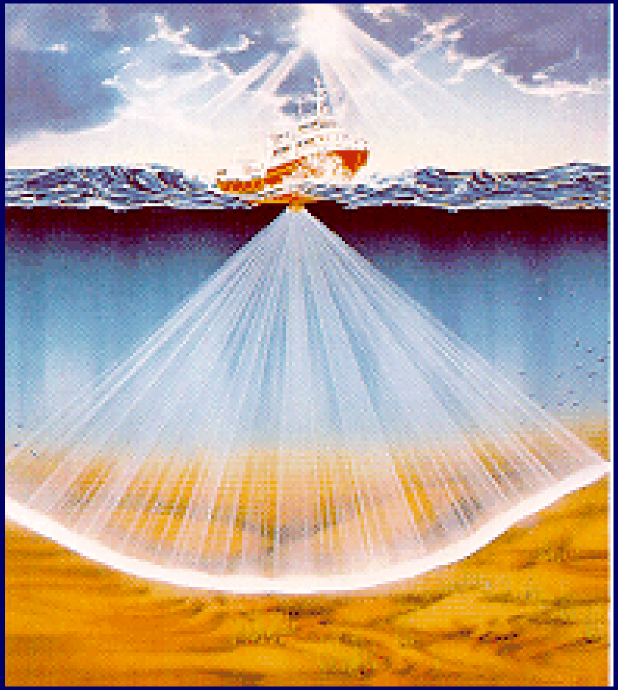
Non-acoustic seafloor mapping techniques

Technique	Basic principle	Lateral resolution shallow water (50 m)	Lateral resolution deep water (5 km)	Depth limit	Surveyed area/ per unit time	Platform
bottom coring and grabbing	mechanical	0.1 m	0.1 m	none	very low	ship
LIDAR	laser scanning and ranging	10 m	not applicable	< 30 m	medium /high	airborne
Synthetic Aperture Radar (SAR)	imaging of radar backscatter from sea surface (where bottom topography changes sea surface roughness)	3 m (10x10 km) 30 m (100x100 km)	not applicable	< 50 m	high	airborne satellite
Altimetry	accurate radar ranging of bumps and dips in ocean surface caused by topographic bottom features	not applicable	10 km	only deep water	high	satellite

Seafloor mapping with multi-beam echo sounders (MBES)

System:

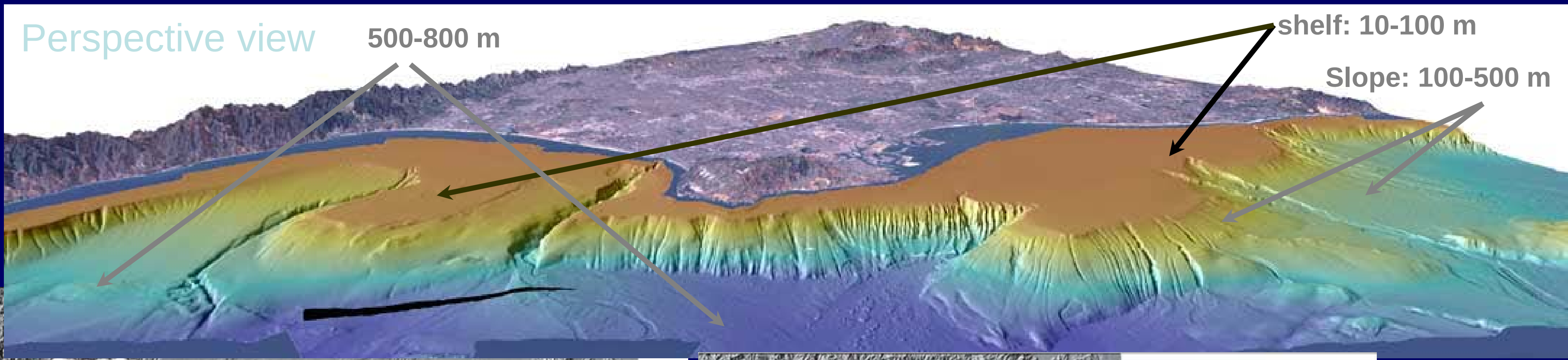


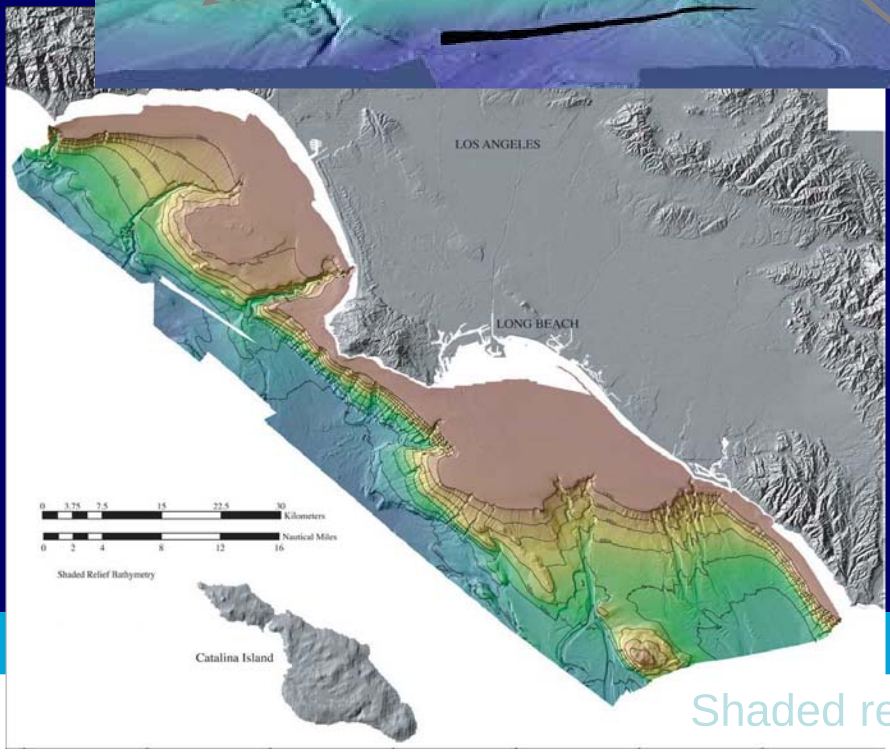
MBES characteristics

- operating frequency ~ 100 kHz
- more than 100 beams
- beam width ~1° or less
- angular sector covered ~120 ° or more

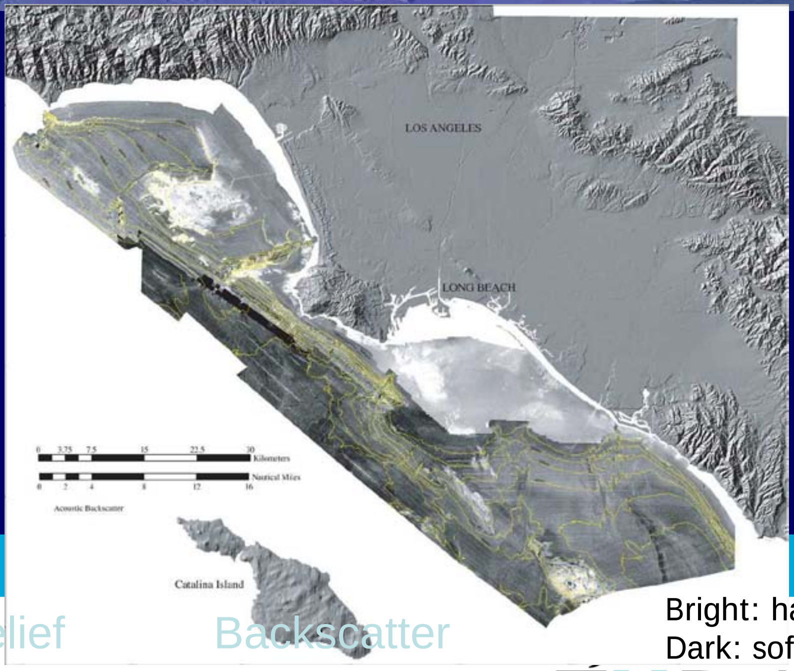
Seafloor mapping with MBES

Example of a topography and backscatter result: Los Angeles margin, California





Shaded relief



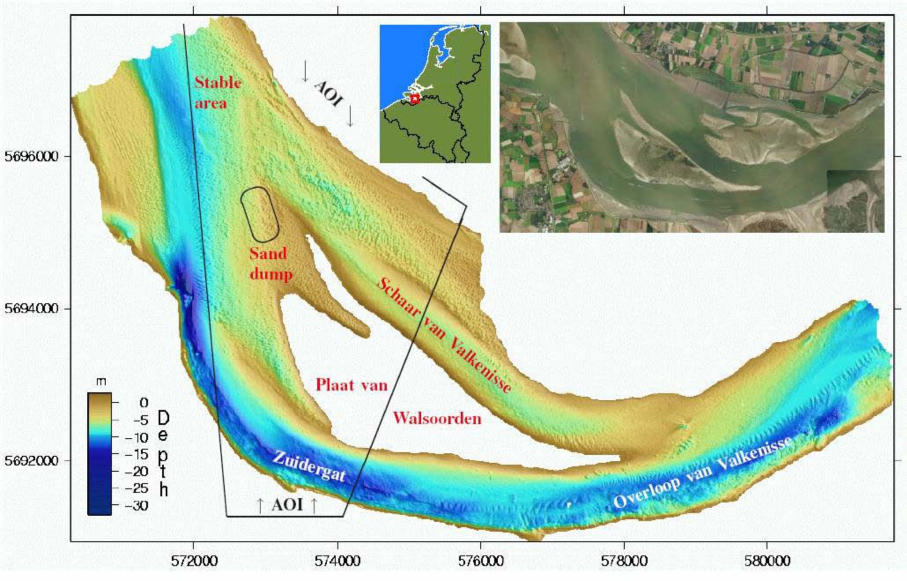
Backscatter

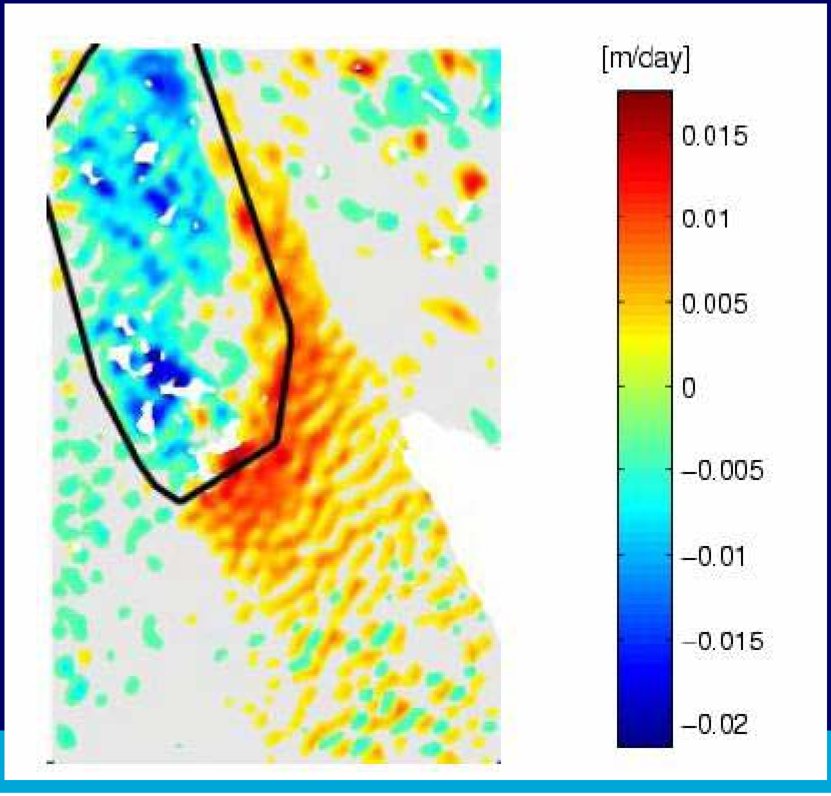
Bright: harder surfaces
Dark: softer surfaces

Seafloor mapping with MBES

Application: Selection of suitable dump sites

Analysis based on 16 MBES surveys





Western Scheldt estuary

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Seafloor mapping
Some current and near future developments

- Resolve small topographic features at large depth.
- Accurate topographic mapping in the near shore.
(by fusion of LIDAR/SAR and MBES data).
- Classification based on acoustic backscatter information.
- Convert backscatter maps into geological maps.
- Higher data rates, increasing amounts of data, better visualisation methods.
- Application and development of advanced mathematical and statistical methods
(e.g. data validation, feature extraction).
- Use of sound sources from natural origin