Satellite Derived Bathymetry: What can SDB Offer Coastal Mapping?

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Cross-NOS effort (NGS, OCS) and collaboration with Isabel Caballeros (Spain)
SDB

- Background
- What is SDB
  - Methods and effectiveness
  - Limitations and answers
- Uses

Capes St Blas, St George, Florida
Some Background: Why SDB?

(2001) Where are the NW Hawaiian Islands? Shift Astronomical to GPS datum

Papahānaumokuākea Marine National Monument

Maro Reef
Nautical Chart Update for Maro Reef, NW Hawaii
- using bathymetry derived by NOS from IKONOS data

Shift required to correct chart (> 2 km)

Nautical chart overlaid on satellite derived depth image

Nautical chart detail
Issues addressed by SDB

Reconnaissance

Mission planning

Monitoring of shoals

Storm response

Infilling of lidar/multi-beam

Courtesy: LCDR Anthony Klemm
Operational Planning

NOAA Ship *Thomas Jefferson*
SDB in Nantucket Sound

Courtesy: LCDR Anthony Klemm
Peshtigo Reef Lighthouse, Green Bay WI, evaluate shoaling
SDB: Areas of interest

- Coral reefs, infrequent turbidity
- Inlets, turbidity issues
- Capes, shoals, turbidity issues
SDB methods

• Passive optical (based on physics of light in water), most common

Other methods being examined and researched:
• Empirical (machine learning) methods, extensive calibration.
• Wave refraction (potential for turbid water), many images, coarser resolution.
• Photogrammetry (less water influence, also intertidal); limited acquisition, requires high resolution, not suitable for featureless bottom.
• IceSat (Lidar from space) fixed limited swath and frequency. May help cal/val in remote areas. Not ready for routine use.

Check out this story map on methods: “Satellite derived bathymetry 101”
https://storymaps.arcgis.com/stories/f8728c724d6d4c28ad48fe43aff2c48b
Commonest SDB

Passive optical based on physics of light in water (most common)

- Empirically tuned (based on how light changes with water depth)
  - NOAA method needs no more than 10-12 (existing) calibration depths
  - Calibration can work in more than one location (being evaluated)
  - Can readily support automation (semi-automation being tried now)

- Optimization tuned (sometimes called “physics-based”)
  - Coefficients have physical meaning (light attenuation, etc.)
    - Allows adaptability, customization
SDB acquisition

Sentinel-2 (open access)
- 10 m pixel,
- 5 day routine repeat.
- 300 km swath

Worldview-2/3 etc. (commercial)
- 2 m pixel
- 1-4 day possible revisit
- 16 km swath (repointable)

Other sensors with blue green red near-IR (quality depends on calibration and sensitivity)

20 m in clear water (e.g., Florida, Puerto Rico)
Turbidity (measured from satellite) decreases extinction depth

\[ \log(\text{SDBred}) = -0.54 \log(\text{Rrs709}) - 2.1 \]

Max depth decreases

Turbidity increases
Pick up fine-scale features.
Works on different bottom.
Multi-scene method improves results with turbidity.
Potential automation

27 Nov 2017 Clearest scene

Summer 2017 Multi-scene composite
Reduces turbidity, noise, etc.
North Carolina, evaluate change after hurricane. Fill in Lidar
Our goal, to mostly automate SDB at 10 m resolution, with national and global application

New capabilities coming onboard in NOAA

• Apply to Sentinel-2 (routine 10 m)
• Address mapping concerns (max depth, etc)
• More automation
• Improve calibration, reduce uncertainty, etc.

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