

Satellite-Derived Bathymetry:

Industry update for the Southwest Pacific Hydrographic Commission
(SWPHC21)

Dr. Magnus Wettle

EOMAP

Germany | Australia | United States | Abu Dhabi

www.eomap.com



EOMAP

Mapping and monitoring aquatic environments worldwide

Satellite remote sensing – Earth Observation

Two main product suites:
bathymetry and seafloor mapping
water quality monitoring

Innovative, proprietary algorithms

Operational processing systems

Software: enabling capabilities

First and leading commercial provider of SDB

Spin-off German Aerospace Center, 20+ years R&D



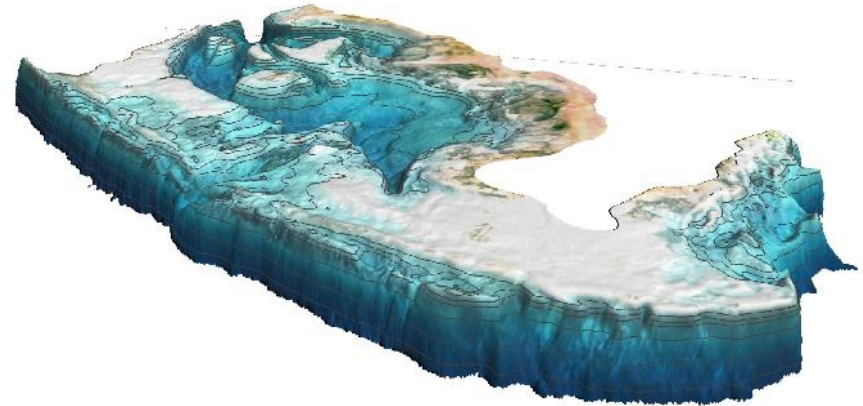
SDB Topics

Pacific Highlights

SDB Classroom

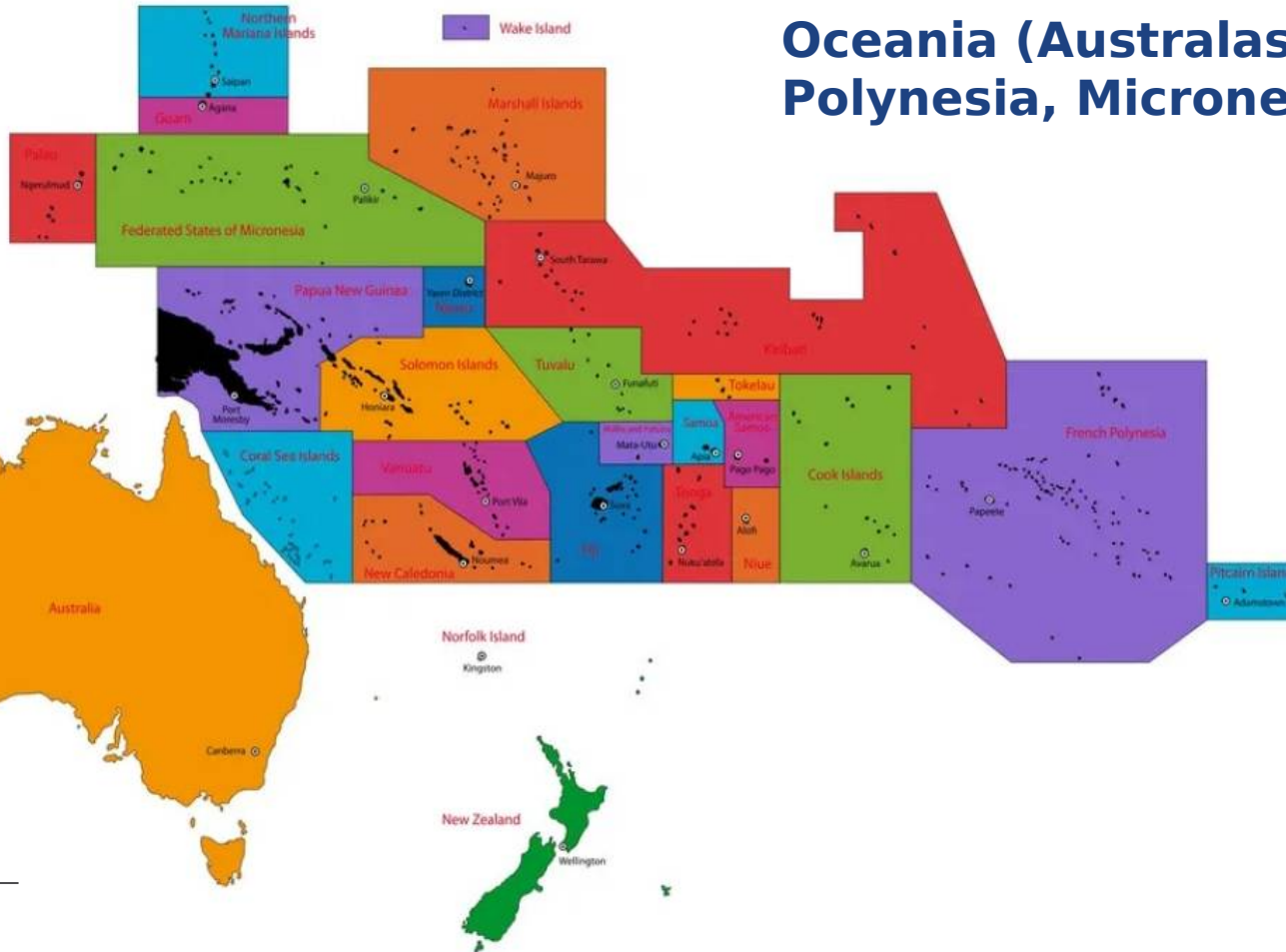
Technology developments

Capacity Building, Standards and Best Practice

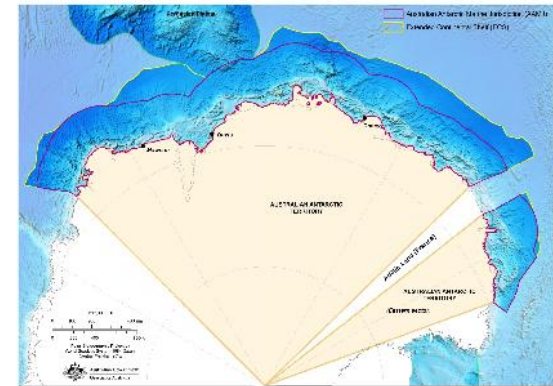


(EOMAP) SDB across the Pacific

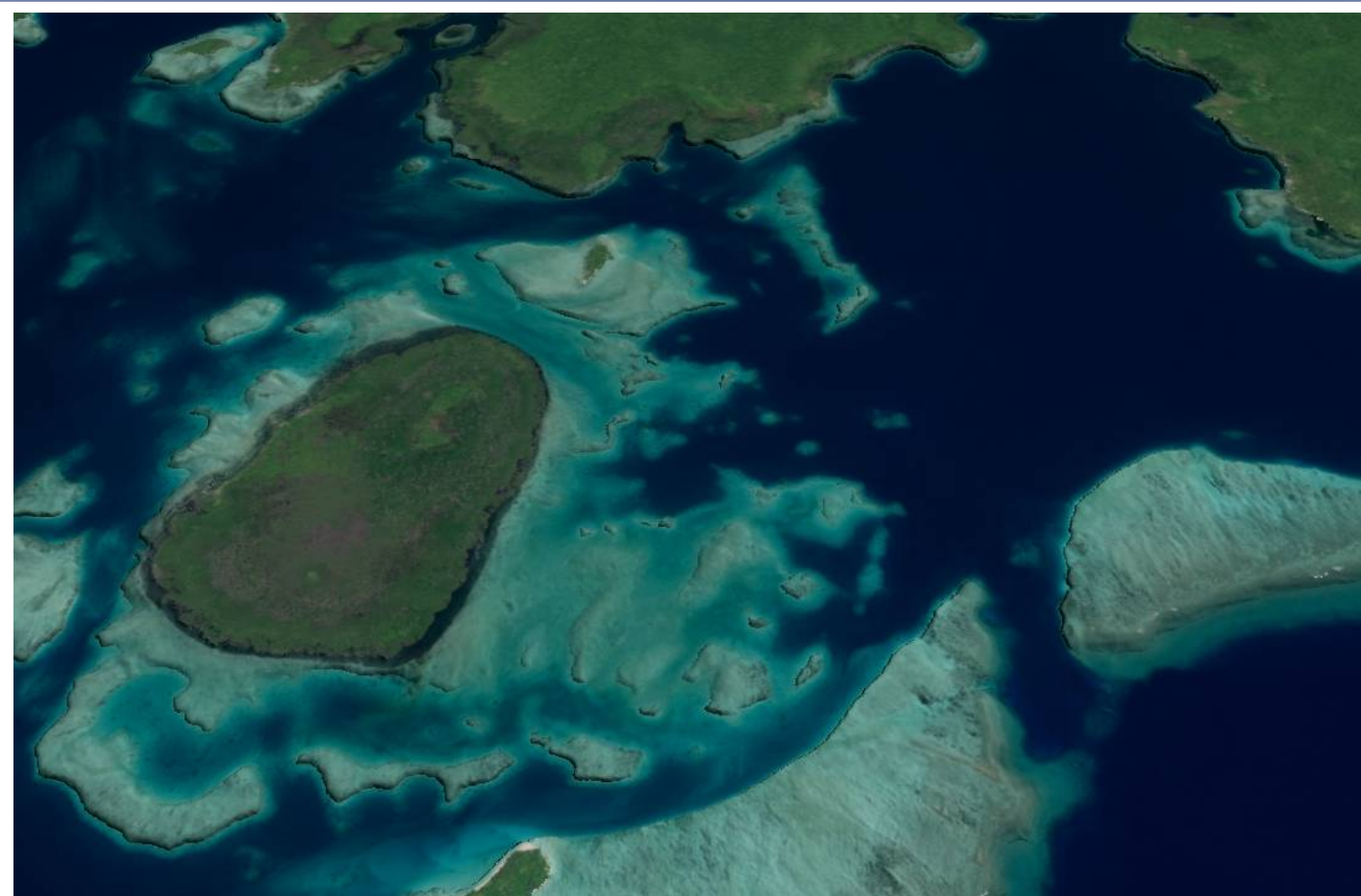
Oceania (Australasia, Melanesia, Polynesia, Micronesia)



Australia's Antarctic Marine Jurisdiction



Large SDB projects across the Pacific (2023)



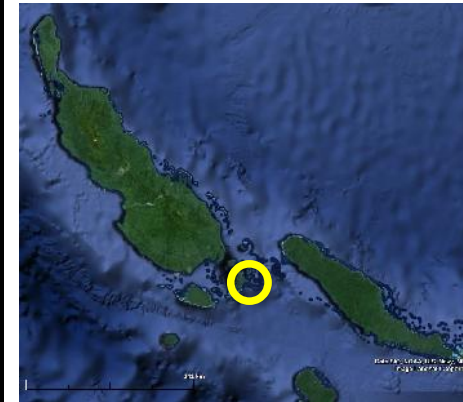
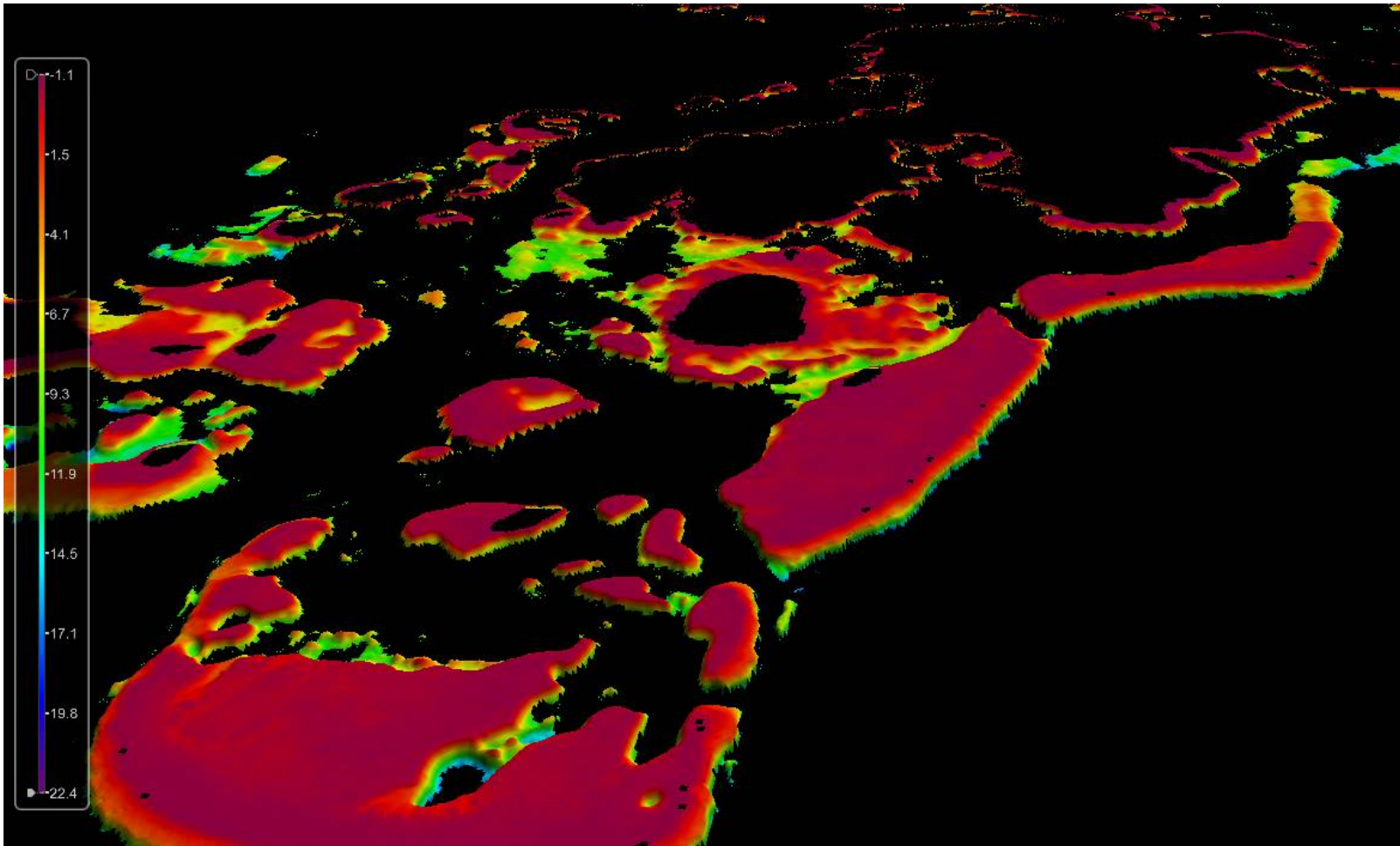
2m & 10m resolution
Pacific SDB for the AGO

Delivered SDB covering
~27,500 sq km of shallow
seafloor

(of which ~7,000 sq km at
2m resolution)

Including large areas in
Fiji, PNG and Torres
Strait

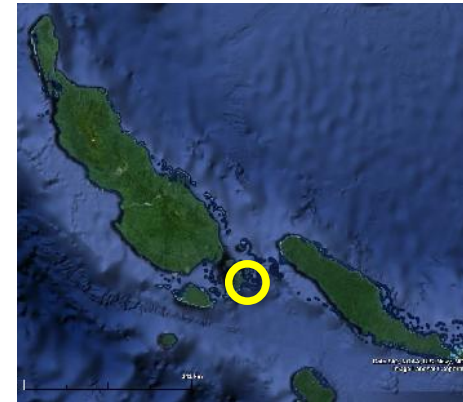
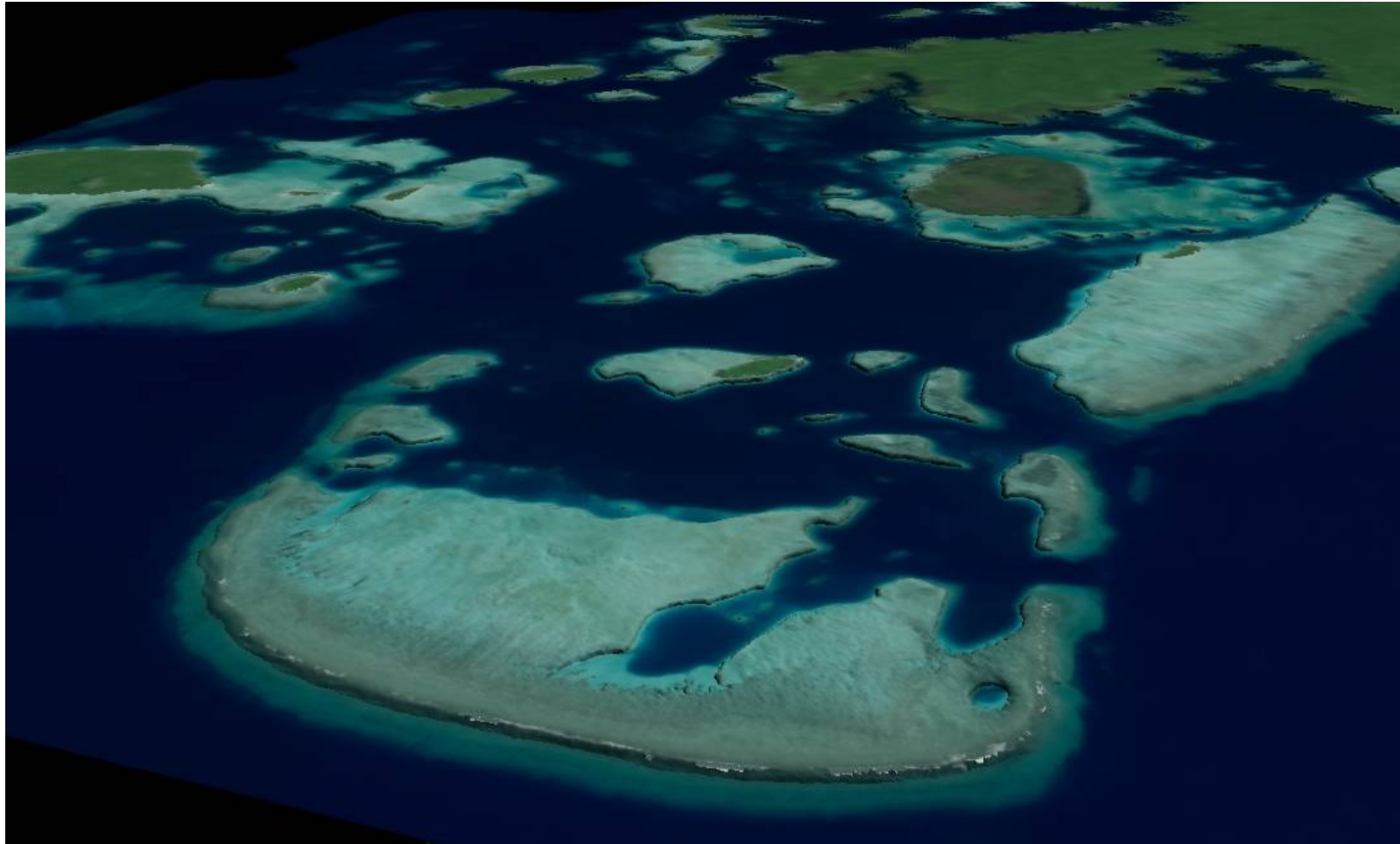
Large SDB projects across the Pacific (2023)



Fauro Island

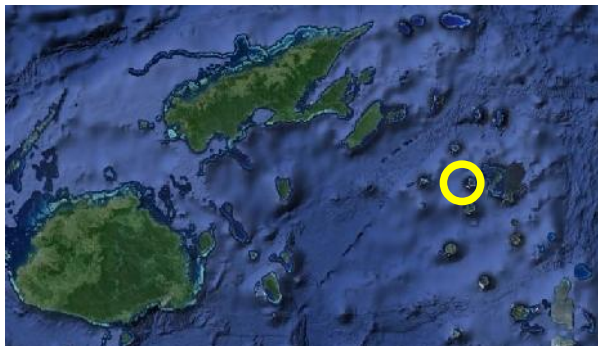
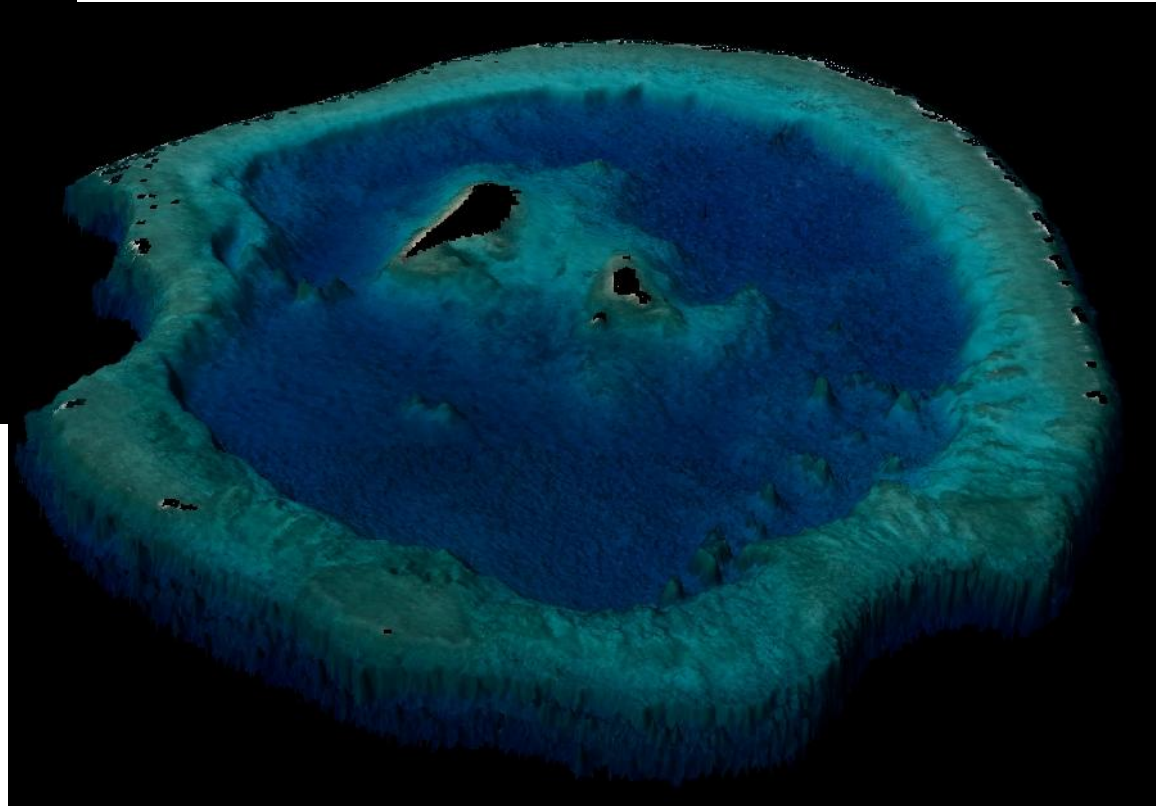
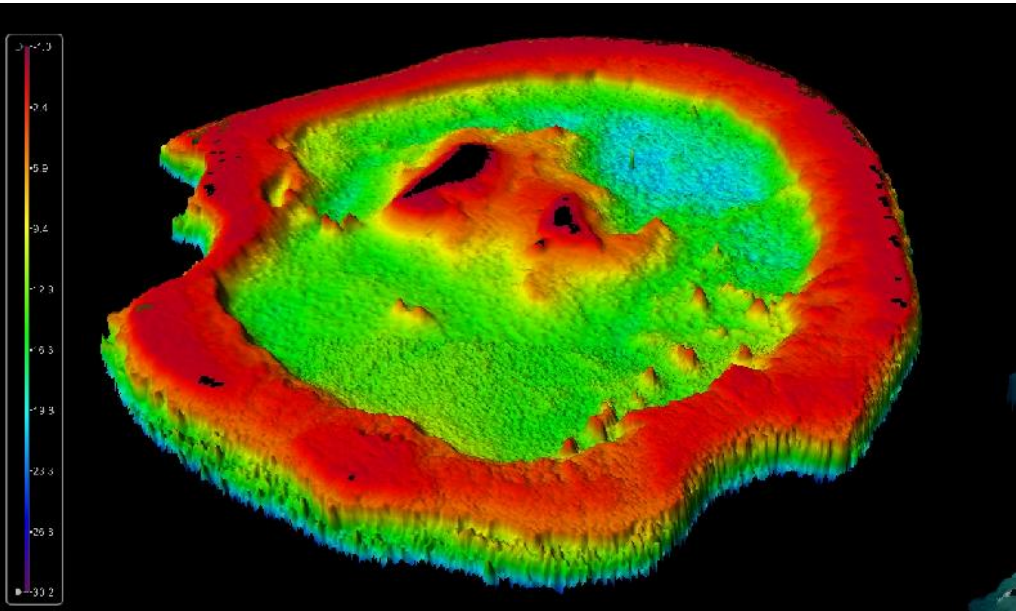


Large SDB projects across the Pacific (2023)

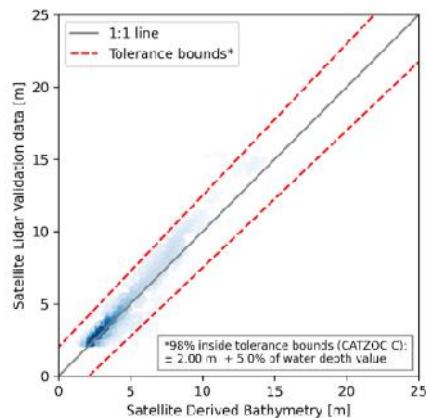


Fauro Island

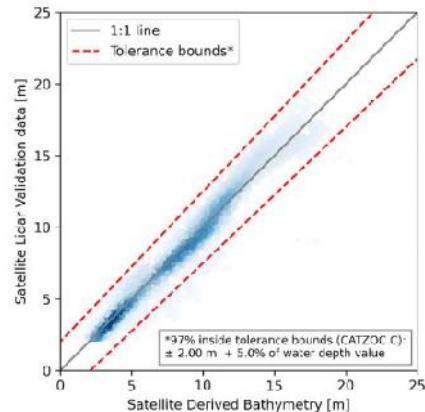
Large SDB projects across the Pacific (2023)



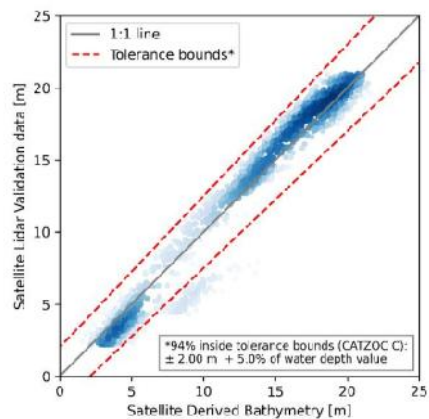
Independent physics-based retrievals vs ICESat



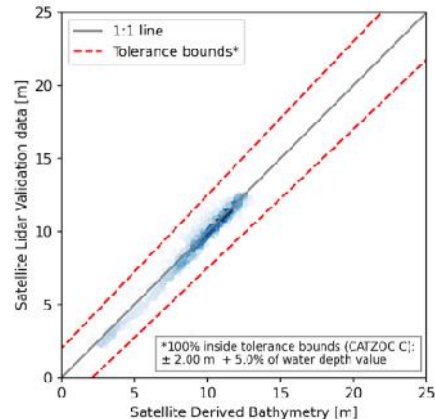
$R^2 = 0.92$
slope = 1.10
offset = 0.25
RMSE = 0.94
CATZOC A1: 55.19%
CATZOC A2 and B: 79.18%
CATZOC C: 97.55%
N = 1263



$R^2 = 0.94$
slope = 1.00
offset = -0.12
RMSE = 1.01
CATZOC A1: 60.58%
CATZOC A2 and B: 85.95%
CATZOC C: 97.42%
N = 5068

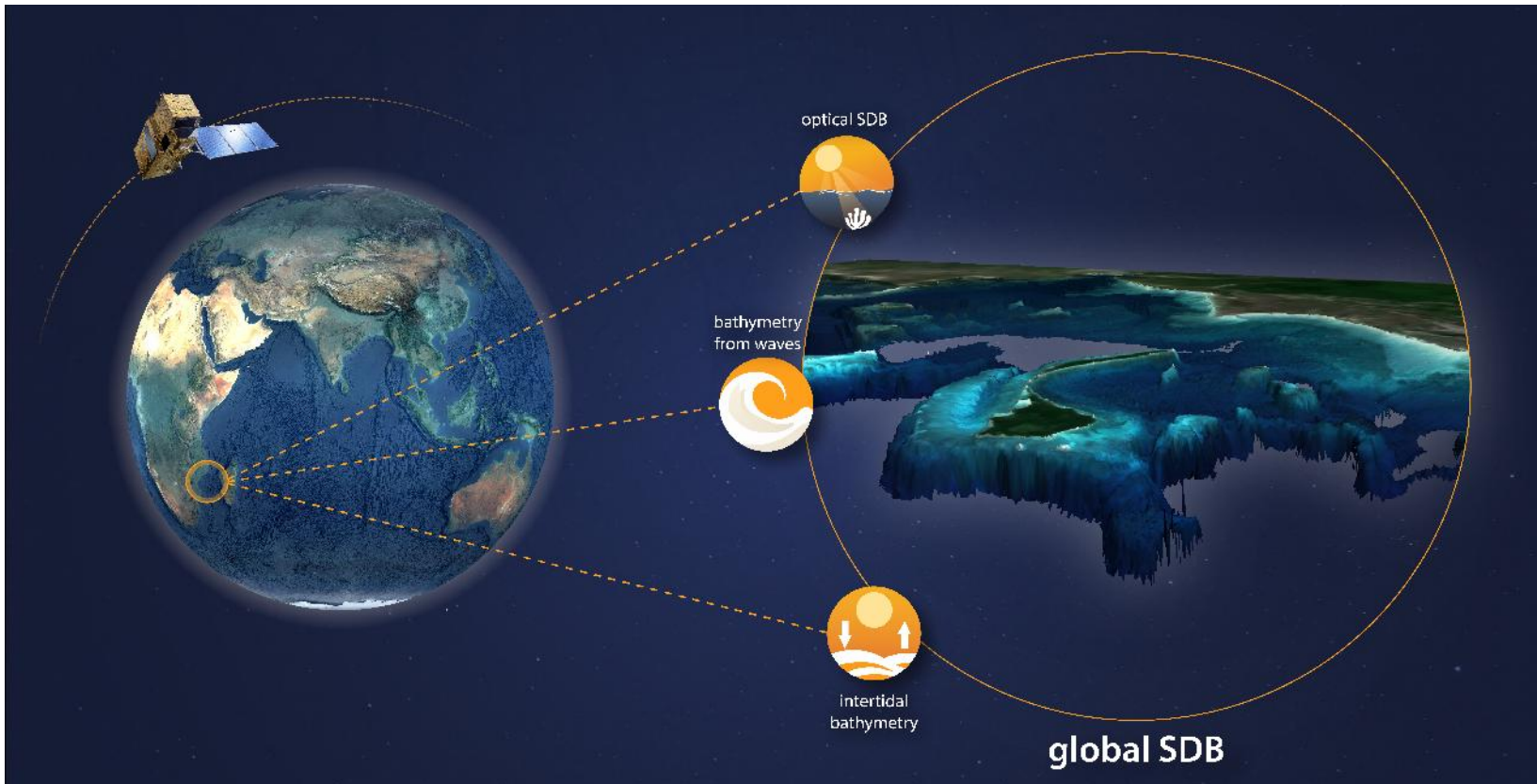


$R^2 = 0.95$
slope = 1.07
offset = -0.92
RMSE = 1.29
CATZOC A1: 41.79%
CATZOC A2 and B: 73.61%
CATZOC C: 94.20%
N = 2448



$R^2 = 0.96$
slope = 1.03
offset = -0.43
RMSE = 0.55
CATZOC A1: 78.26%
CATZOC A2 and B: 96.64%
CATZOC C: 99.79%
N = 952

100m resolution SDB of ... Everywhere



Global SDB product

Copernicus Program
(European Space Agency)

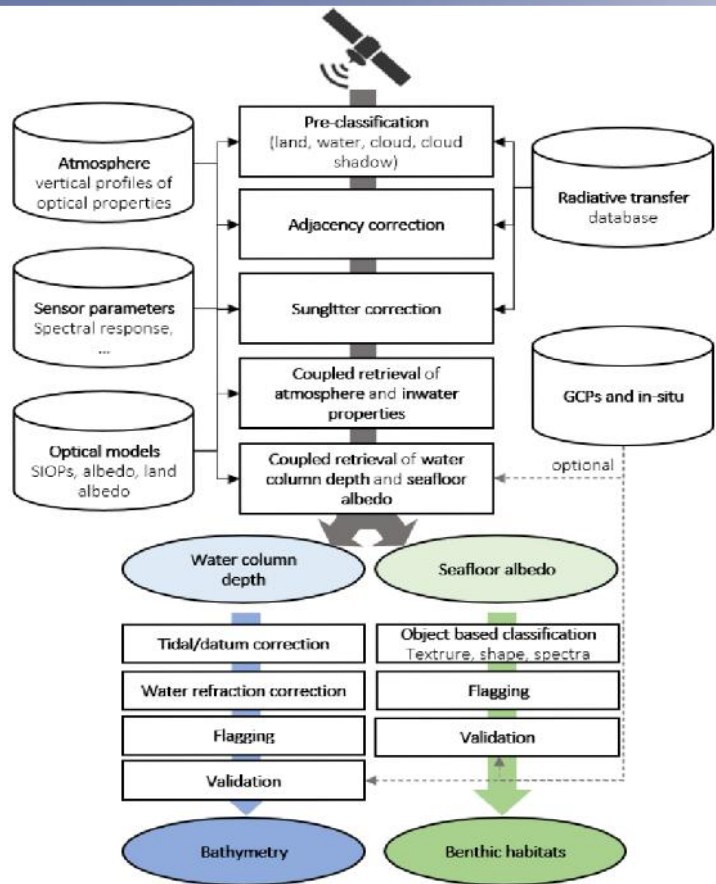
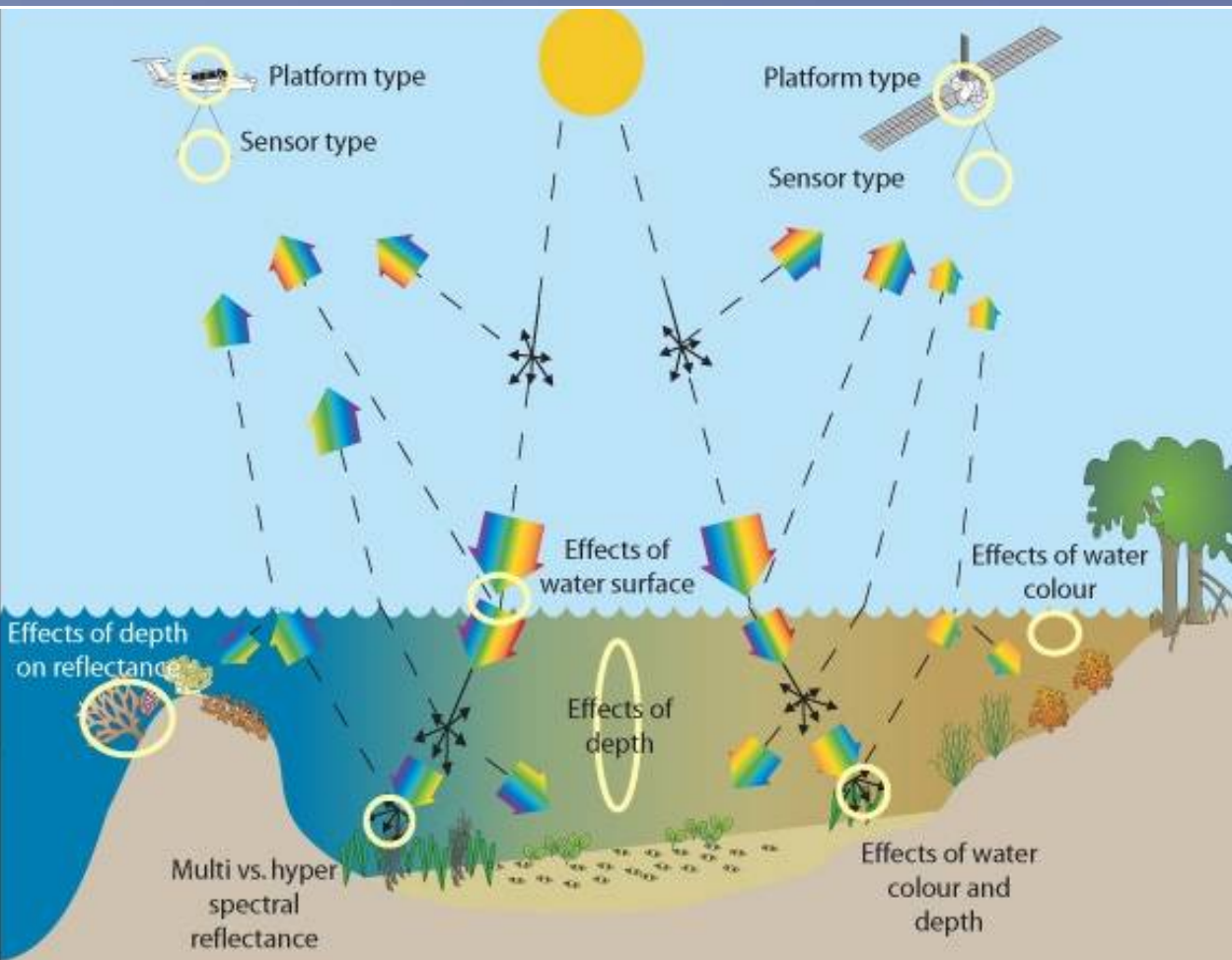
3 layers

Started Nov 2023

2 years

This work is being carried out as part of a Copernicus Marine Service contract. Copernicus Marine Service is implemented by Mercator Ocean in the framework of a contribution agreement with the European Union.

Mapping the seafloor with sunlight



Two main SDB approaches

Empirical: fitting satellite values to survey data

Pros: Rapid and easy

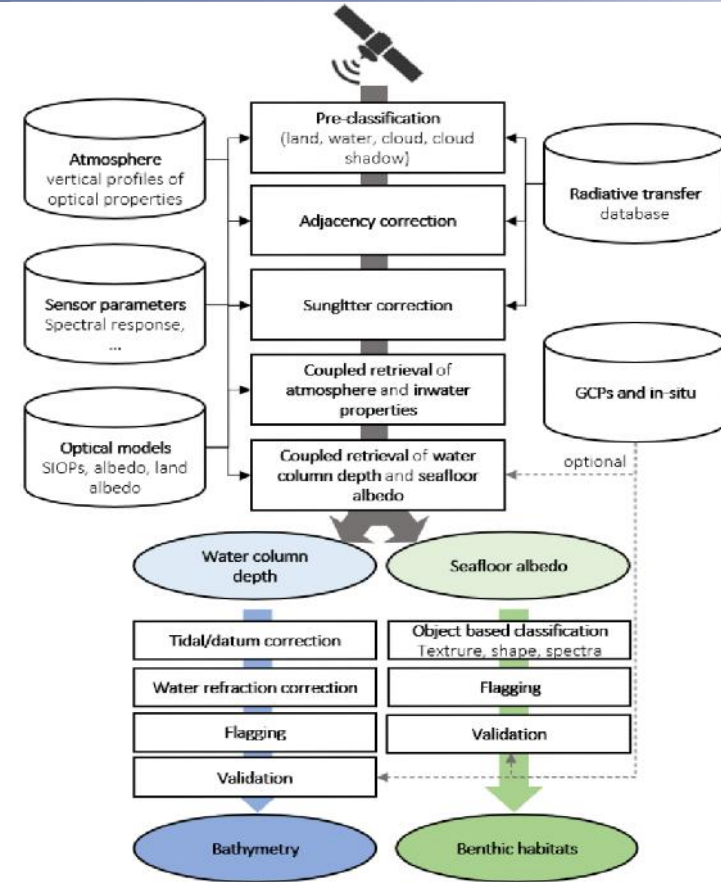
Cons: No control of uncertainties outside the training area; high quality training data required; issues with varying seafloor types; vertical accuracies

e.g. GEBCO Cookbook

Physics-based: fully modeling the light pathway

Pros: Quantification of uncertainties; quantitative measure without in situ data, vertical accuracy, sensor and location agnostic

Cons: Difficult



To need or not to need ... training data

Maching Learning (ML): includes 'straightforward' training algorithms e.g. random forest classifiers

ICESat: satellite-based LIDAR

ML + ICESat / chart data = increase in SDB providers and research papers (empirical nonetheless)

ICESat not same as airborne LIDAR:

- intimidating point cloud, errors, notably 0 - 3m
- transects can be several km's apart

1. Does the method require any form of training data?

2. Validating ICESat-based ML with ICESat is circular



Data derived using EOMAP's Satellite Lidar Bathymetry toolbox and based on IceSAT-2 ATLAS data.

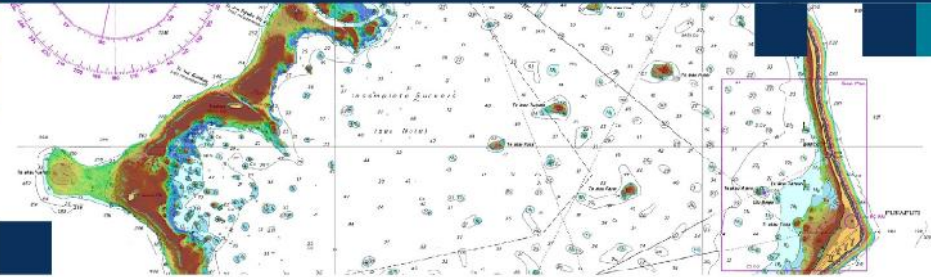
Requesting SDB made easy



UK Hydrographic
Office

Hydrographic Survey Specification (Satellite Derived Bathymetry)

December 2021



ADMIRALTY
Maritime Data Solutions



1. Area and extent, polygon
(e.g. shapefile / google earth / hand-drawn...)

2. Spatial resolution
(e.g. 2m, 3-5m, 10m..)

3. UKHO Hydrographic Survey Specification
(Satellite Derived Bathymetry)

(Extras: specific file formats, custom products,
Datum, QA/QC layers, validation, etc....)

WATCOR-X: sophisticated, stand-alone SDB software

Fully autonomous SDB capability from the comfort of your desk

The screenshot displays the WATCOR-X software interface with several overlapping windows:

- Main Window:** Shows required parameters (Sensor: Sentinel-2, Input data: IST071631_N0206_R006_T39RUK_201, Export directory: E:\WATCOR_X\Vs2\Arab\out), optional parameters (Tidal correction: 0.0000), and a validation file field. An 'Exit' button is visible at the bottom left.
- Workflow Control Panel:** A vertical sidebar on the right lists processing steps: 'Select shallow and deep water areas', 'Import satellite data', 'Masking' (highlighted with a yellow dot), 'Adjacency correction', 'Atmospheric and water parameter estimation', 'Bottom spectrum retrieval', 'Water depth retrieval' (highlighted with a blue bar), 'Postprocessing', and 'Export results'.
- Image Viewer (Top):** Displays 'Radiance' values for three bands: Band 1 (162.5107), Band 2 (177.0674), and Band 3 (156.3973). It includes a 'Land' flag value and a 'Land-Water mask' dropdown set to 'Singleband grey'.
- Image Viewer (Bottom):** Displays 'Subsurface Reflectances' for three bands: Band 1 (85 703.89 nm), Band 2 (83 560.01 nm), and Band 3 (82 706.51 nm). It includes a 'Subsurface refl.' table with values for 'BAND 1' (0.01119), 'BAND 2' (0.0865), and 'BAND 3' (0.0513), and an 'AOT' column with 'no data' for bands 2 and 3.
- Water Properties Dialog:** A modal window for 'Typical water species concentrations' with fields for 'Suspended matter' (0.51325440) and 'Yellow substance' (0.23508973). It also includes 'Suspended matter' (Min: 0.15397632, Max: 1.28313601) and 'Yellow substance' (Min: 0.07052692, Max: 0.30561665) sub-sections. 'Restore defaults', 'Save', and 'Cancel' buttons are at the bottom.
- Image Viewer (Bottom):** Shows a 2x2 grid of satellite images. The top-left is a false-color composite, the top-right is a grayscale mask, and the bottom two show a silhouette of a person on a boat against a sunset background.

The EOMAP logo is visible in the bottom right corner of the software interface.

SDB_Online

- **Powerful cloud backend**, fully **scalable**
- **Ultra easy to use**
- **Physics-based SDB** concept (radiative transfer inversion)
- **Coupled** with satellite archives (currently Sentinel-2)
- **Automatic** mode (image selection, full processing workflow)
- **Calibration/validation**: optional fine tuning with own survey data
- **Multi-image** mode (US patent)
- **Webapp** user interface, any browser
- **Pay-per-use**
- Machine-to-machine (**API**)

<https://www.sdb-online.eoapp.de/>



Process
&
Visualise



Define your site

Download



SDB_Online in the Pacific: enabling capacity

Done locally

No investment / no commitment

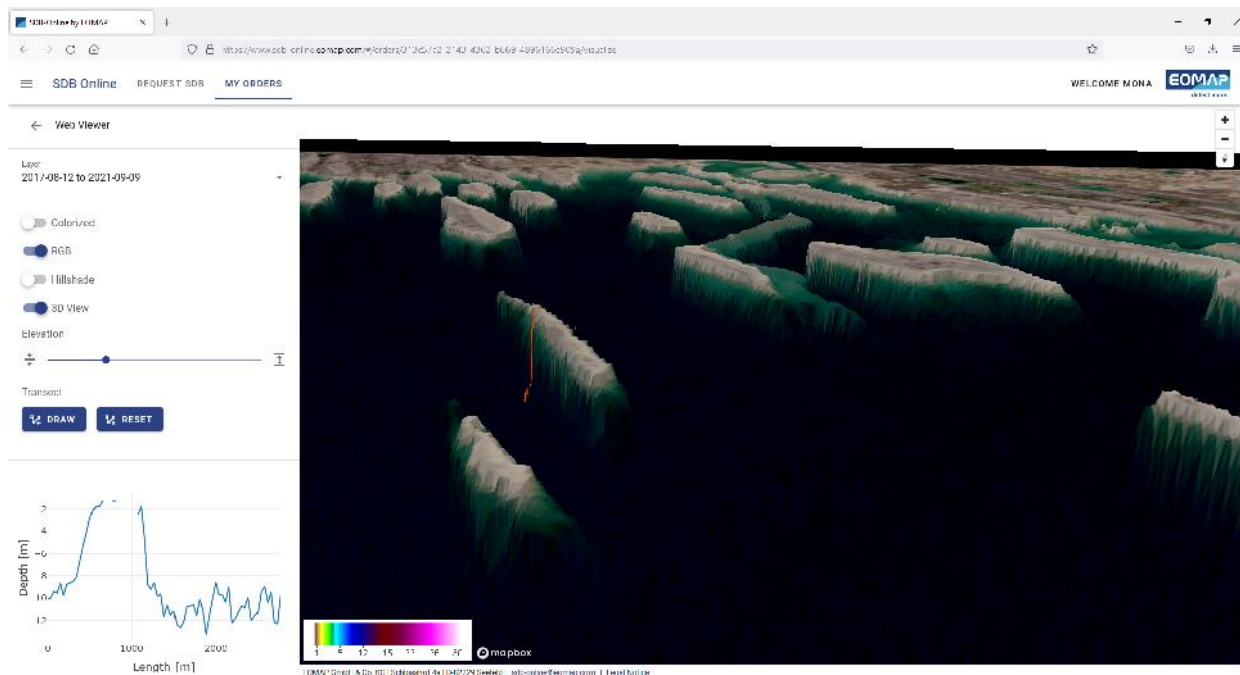
Leverages free satellite imagery

Minimal user training

No hardware requirement

Use Cases:

- Recon / planning: optimising precious boat time
- Monitoring critical areas of frequent change
- Otherwise un-mappable areas



SDB at the 22nd Pacific Maritime Boundaries Meeting

EOMAP workshop (with GA assist)

- Case studies
- How to use
- How to make (SDB_Online)

A key message:
autonomous SDB capacity
(fit-for-purpose, easy, low cost)

10+ agencies from 6 island
nations requested online demos



SDB Topics Summary

Pacific Highlights

SDB across the Pacific: Seabed 2030, AGO
Global 100m SDB layer

SDB Classroom

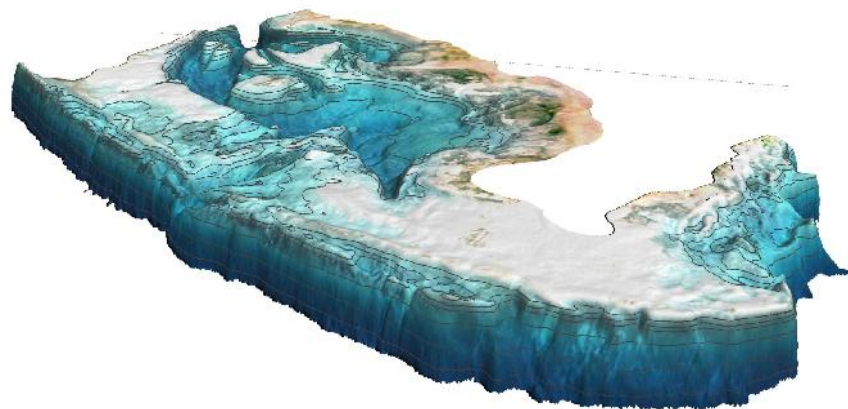
Approaches: with or without training/validation data
Implications of ICESat
Requesting SDB made easy

Technology developments

Easy, powerful, cloud software: SDB_Online

Capacity Building, Standards and Best Practice

SDB workshop: low threshold to SDB autonomy
IHO SDB Working Group and SDB document



The SDB journey so far

- ◆ 1980s-2000's: R&D
- ◆ 2005: First commercial SDB project: (environmental management)
- ◆ 2012-2014: NOAA, UKHO, AHO, SHELL, etc., evaluate SDB
- ◆ 2015: UK Hydrographic Office puts EOMAP SDB in chart
- ◆ 2019: NZ Hydrographic Authority puts EOMAP SDB in charts
- ◆ 2019: IHO S-44 updated for SDB
- ◆ 2020: 2 hydrographic agencies with commercial SDB software
- ◆ 2021: AHO signs extended contract for EOMAP software services
- ◆ 2021: IHO HSWG establishes SDBPT, chaired by EOMAP COO
- ◆ 2021: Seabed 2030 filling gaps with SDB
- ◆ 2022: UKHO selects EOMAP as primary SDB provider for next 3-5 years
- ◆ 2023: large scale Pacific SDB projects for the AGO
- ◆ 2023: ESA commissions EOMAP for global 100m SDB layer





Thank you

wettle@eomap.com

www.eomap.com