Developments in Satellite-Derived Bathymetry for hydrographic applications

SWPHC17, Wollongong, February 13, 2020

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EOMAP
Germany | Australia | United States
www.eomap.com

EOMAP and SDB

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

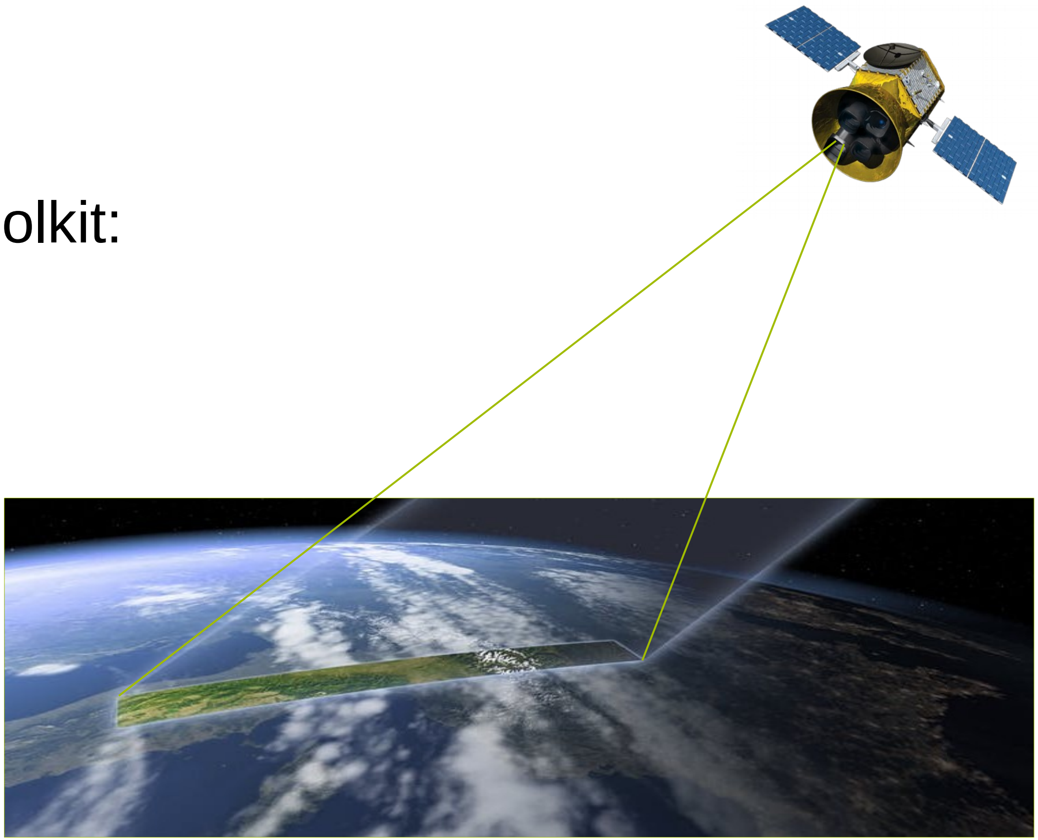
Robust and rapid processing systems

- First and leading commercial provider of SDB
- 20+ years R&D
- SDB uptake accelerating
- >75 projects in >25 countries in last 2 years
- 2015: UKHO puts EOMAP SDB in chart
- 2019: LINZ puts EOMAP SDB in charts
- 2019: S-44 updated for SDB

Remote Sensing – Earth Observation

Why it should be in your surveying toolkit:

- non-intrusive
- remote/inaccessible locations
- extensive coverage
- spatial and temporal continuity
- time travel
- complementary
- positioning
- low cost
- rapid



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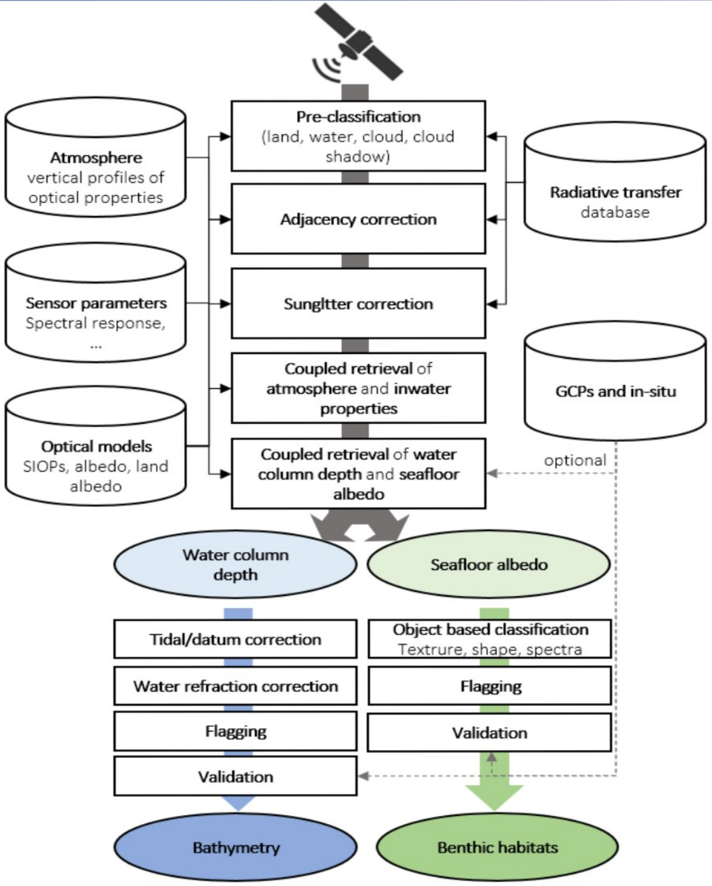
Two main SDB approaches

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

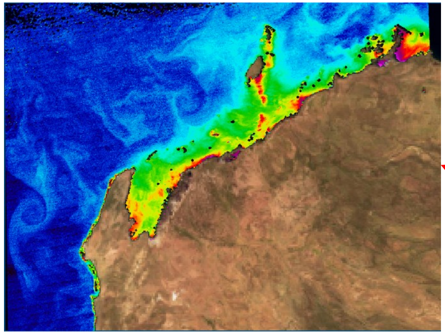
Physics-based: fully modeling the light pathway

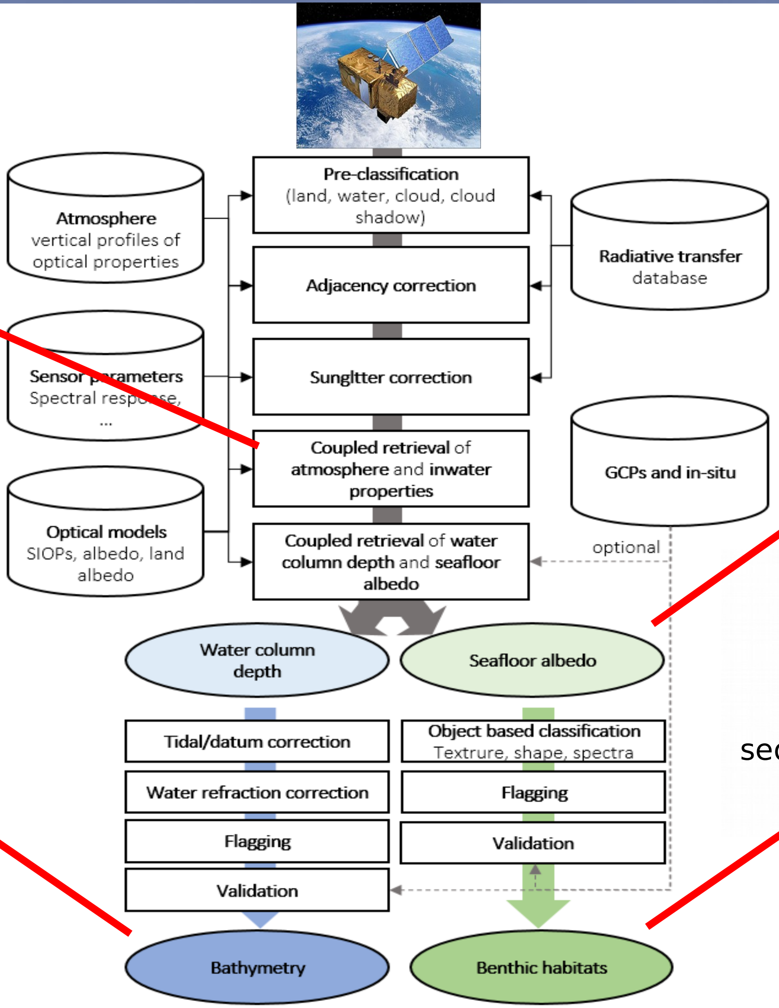
Pros: Quantification of uncertainties; quantitative measure without in situ data, vertical accuracy, sensor and location agnostic
Cons: Difficult



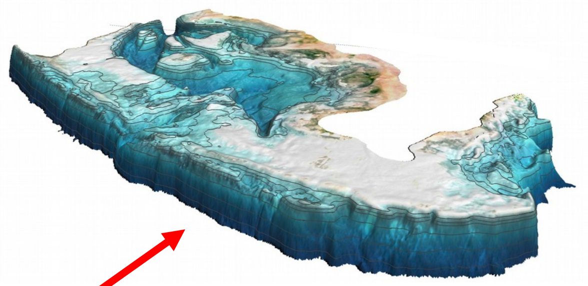
Physics-based Modular Inversion

Water quality

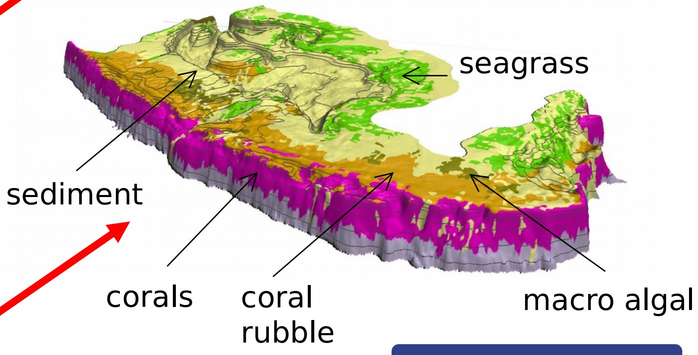


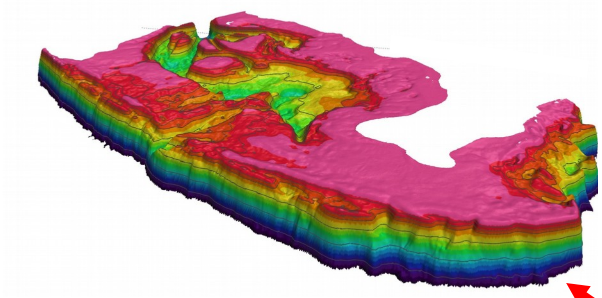


Seafloor reflectance (colour)



Benthic habitats





SDB (Satellite-derived bathymetry

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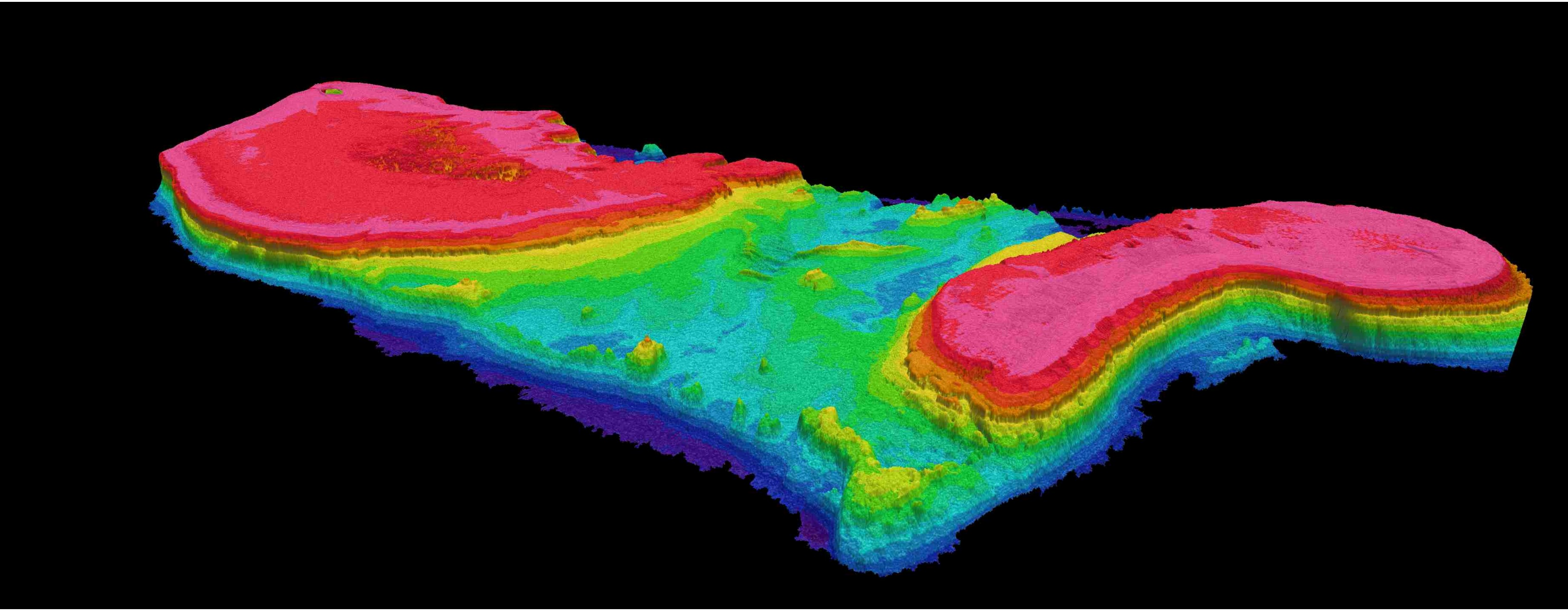
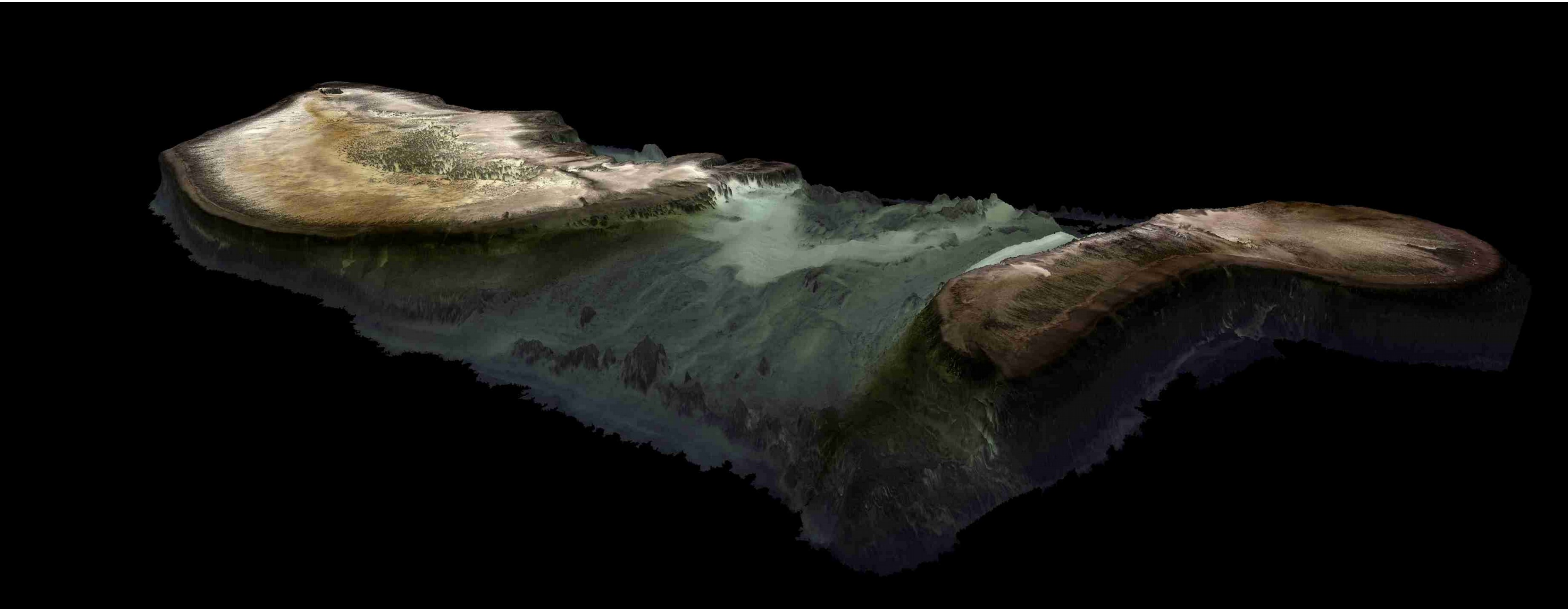
SDB @2m grid resolution



Heron and Sykes Reef, Great Barrier Reef

Seafloor reflectance draped over SDB



Heron and Sykes Reef, Great Barrier Reef

SDB in context

Planning, Mapping and Monitoring

Fit-for-purpose as stand alone: budget, speed, remoteness, extent

Optimising multi-disciplinary campaigns

Complementary

SDB less accurate than MBES and ALB (vertical)

Shallow zone is highly problematic for MBES

Mobilisation trivial vs. ALB and MBES

SDB and ALB don’t work in turbid waters

Otherwise in-accessible areas

Rapid, worldwide mapping from the comfort of your computer

Optimising a campaign with complementary technologies

Satellite-derived bathymetry of Pacific island states

Survey area: Kingdom of Tonga and several remote locations (up to 4,000+ km away)

Safety of navigation - economic development

LINZ PRNI Project

Land Information New Zealand
Toitū te whenua

iXblue

GEOMATICS DATA SOLUTIONS

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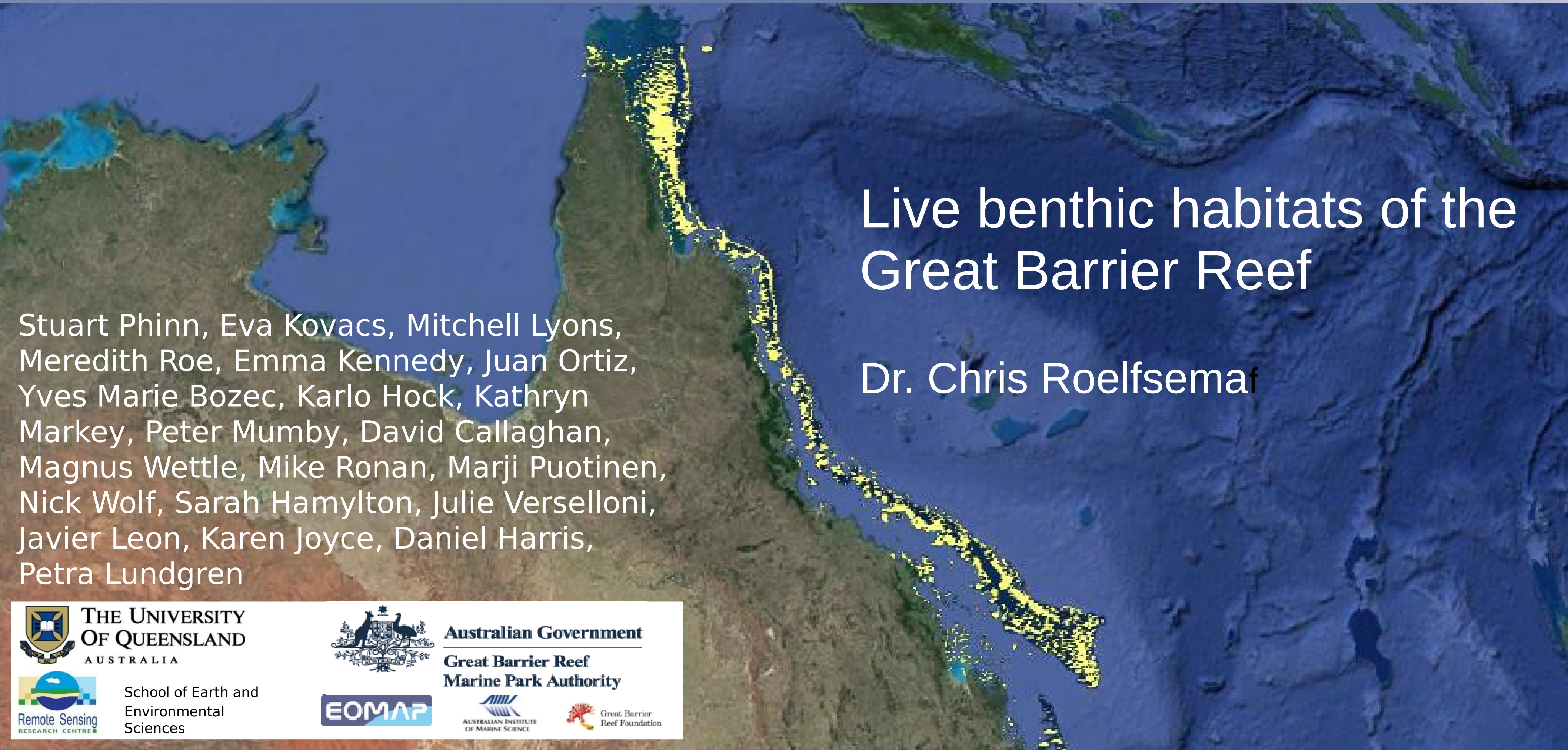
Entire Great Barrier Reef at 10m resolution



Live benthic habitats of the Great Barrier Reef

Dr. Chris Roelfsemaf

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The University of Queensland
Australia

Remote Sensing Research Centre

School of Earth and Environmental Sciences

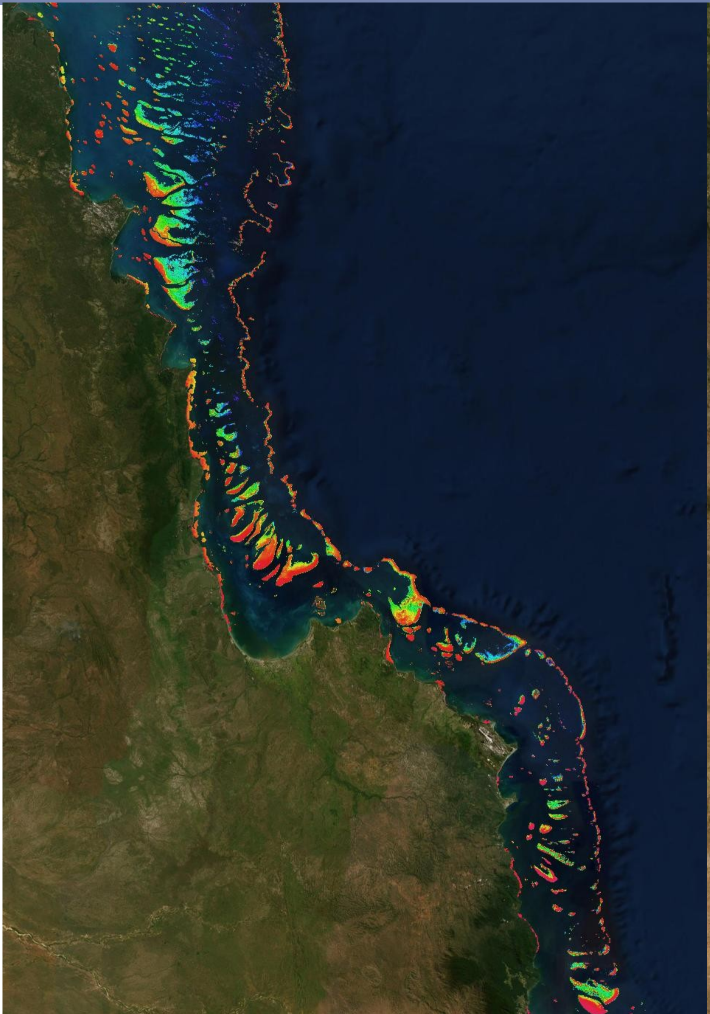
Australian Government
Great Barrier Reef Marine Park Authority

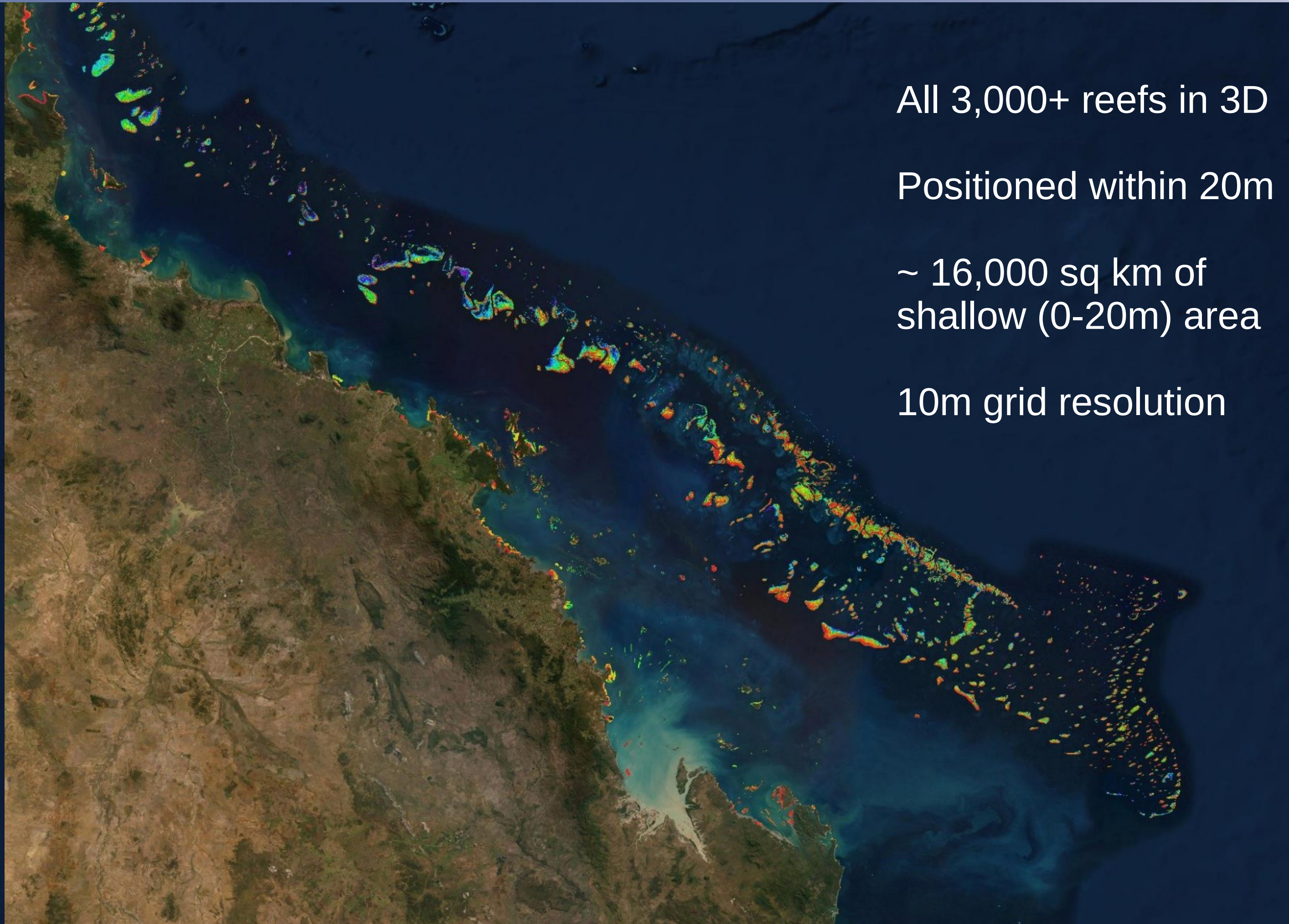
EOMAP

Australian Institute of Marine Science

Great Barrier Reef Foundation

Entire Great Barrier Reef at 10m resolution





All 3,000+ reefs in 3D

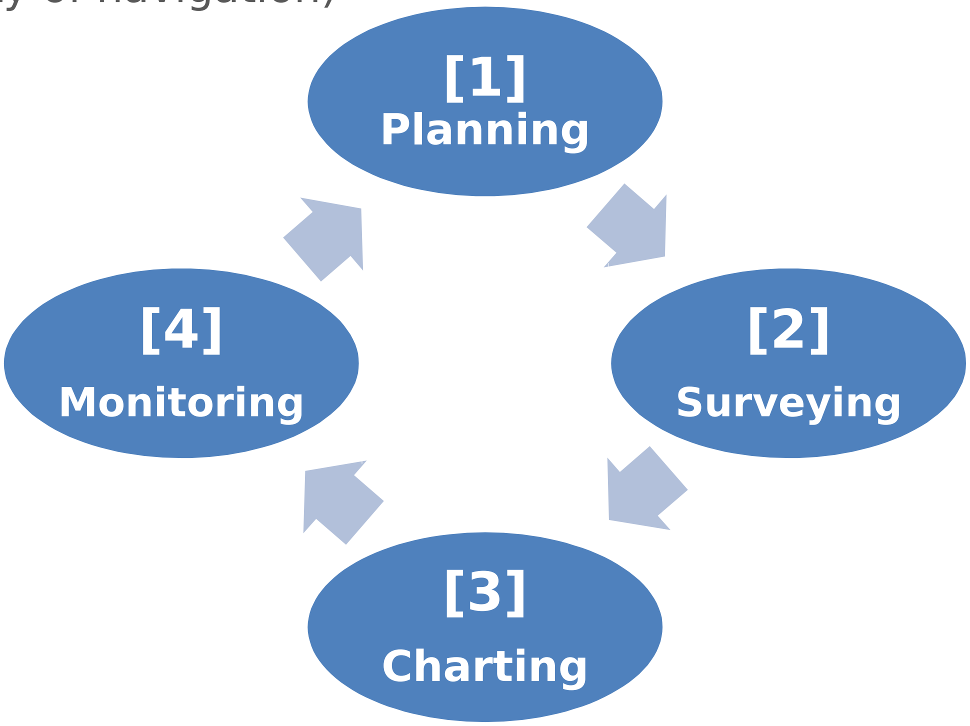
Positioned within 20m

~ 16,000 sq km of shallow (0-20m) area

10m grid resolution

SDB in hydrographic surveys

Prioritise locations, optimise deployment, (inform safety of navigation)



Optimise survey efficiency; reducing costs, time and risk

Access shallow, remote or otherwise in-accessible areas

Integrated survey approach: complementary technologies.

Integration of SDB in charts

Regular monitoring of seabed change

New Developments

Standards

Charting standards

ZOC [1]	Position Accuracy [2]	Depth Accuracy [3]		Seafloor Coverage	Typical Survey Characteristics [5]
A1	± 5 m + 5% depth	=0.50 + 1%d		Full area search undertaken. Significant seafloor features detected [4] and depths measured.	Controlled, systematic survey [6] high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 0.6 ± 0.8 ± 1.5 ± 10.5		
A2	± 20 m	= 1.00 + 2%d		Full area search undertaken. Significant seafloor features detected [4] and depths measured.	Controlled, systematic survey [6] achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder [7] and a sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 1.2 ± 1.6 ± 3.0 ± 21.0		
B	± 50 m	= 1.00 + 2%d		Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOC A2, using a modern survey echosounder [5], but no sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 1.2 ± 1.6 ± 3.0 ± 21.0		
C	± 500 m	= 2.00 + 5%d		Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 2.5 ± 3.5 ± 7.0 ± 52.0		
D	*Worse than ZOC C*	Worse than ZOC C		Full search not achieved, large depth anomalies expected.	Poor quality data or data that cannot be quality assessed due to lack of information.

Can be fullfilled with SDB

Survey standards

IHO S-44

HSPT4

IHO STANDARDS FOR HYDROGRAPHIC SURVEYS (S-44)
6th Edition draft 1.0 February 2019

Matrix
Specifications for the Collection of Hydrographic Data
(To be read in conjunction with the full text set out in this document.)

MATRIX Proposal 2, Standards Only		Ver . 5	CAN	Italy	does someone need / use this now			Section 6.5 uncertainties		Table2	USA	AUS	GBR	Fugro		
	Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
D	**Depth of water**															
a	**THU (Constant)**	---	>50m	50m	20m	10m	5m	2m	1m	0.5	0.1					
b	**THU (Variable, Depth Dependent)**	0	>20%	20%	10%	5%	2%	1%								
c	**TVU (Constant)**	---	>2m	2m	1m	0.5m	0.25	0.2m	0.15m	0.1	0.05					
d	**TVU (Variable, Depth Dependent)**	0	>20%	20%	10%	5%	2.30 %	2%	1.3%	1%	0.75 %	0				
e.1	**Bathymetry ~~Density~~Coverage**	---	1%	1.70 %	2.30%	3%	5%	100% (0% overlap)	120% (10% overlap)	150 % (25 % overlap)	200 % (50 % overlap)					
e.1	**Bottom Feature Search**	---	<10%	10%	20%	30%	50%	100% (0% overlap)	120% (10% overlap)	150 % (25 % overlap)	200 % (50 % overlap)					
e.1	**Seafloor Search (combined OPTION for coverage and line spacing)**	---	1%	1.70 %	2.30%	3%	5%	100% (0% overlap)	120% (10% overlap)	150 % (25 % overlap)	200 % (50 % overlap)					
e	**Seafloor Search**	---	>= 5 x average depth	4 x average depth	3 x average depth or 25m (whichever is greater); bathymetric lidar 5x5 spot spacing	100 % Search	120 % Search (10 % overlap)	150% Search (25% overlap)	200% Search (50% overlap)							
g	**Feature Size Detection (Constant)**	---	>5	5	2	1	0.5	0.25	0.1							
	Feature Detection (Variable, Depth Dependent)	0	>25% (or 20 - MAGNUS)	25% (or 20 - MAGN	10%	10% (beyond 50m										

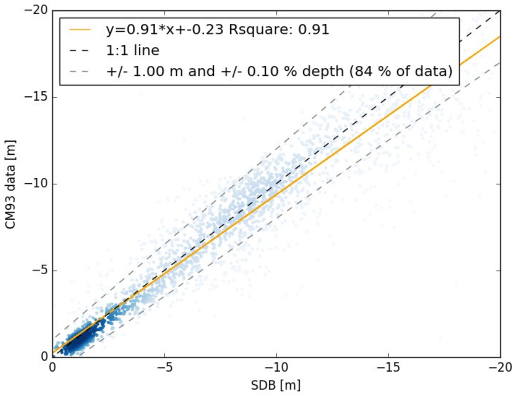
New Developments

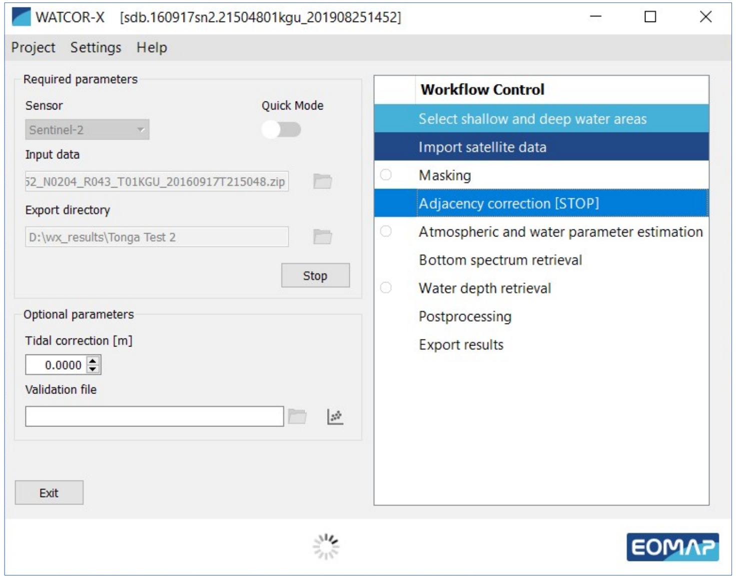
Software

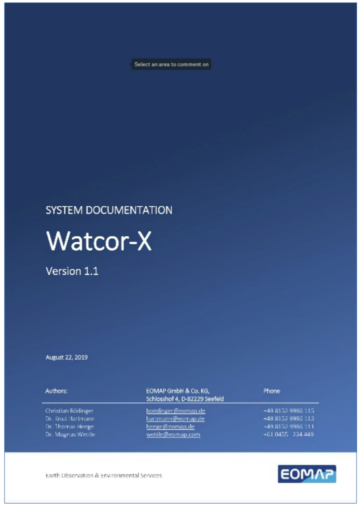
Enabling National Agencies

1. Watcor-X: autonomous, worldwide SDB capability

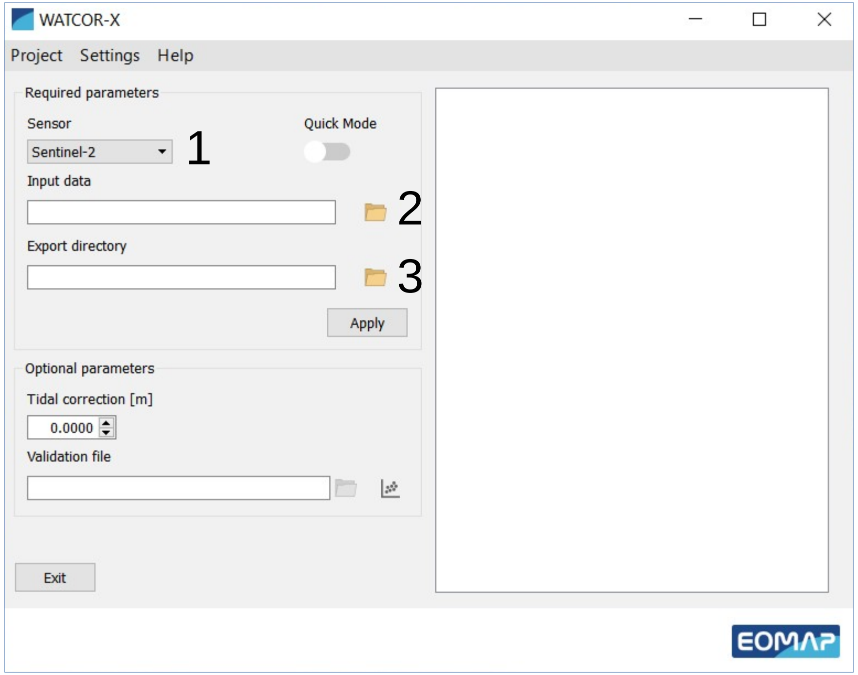
A physics-based SDB standalone solution.



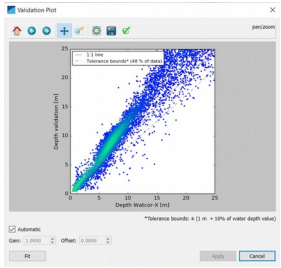


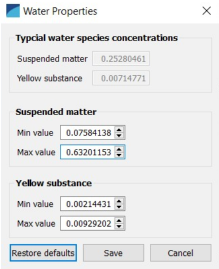


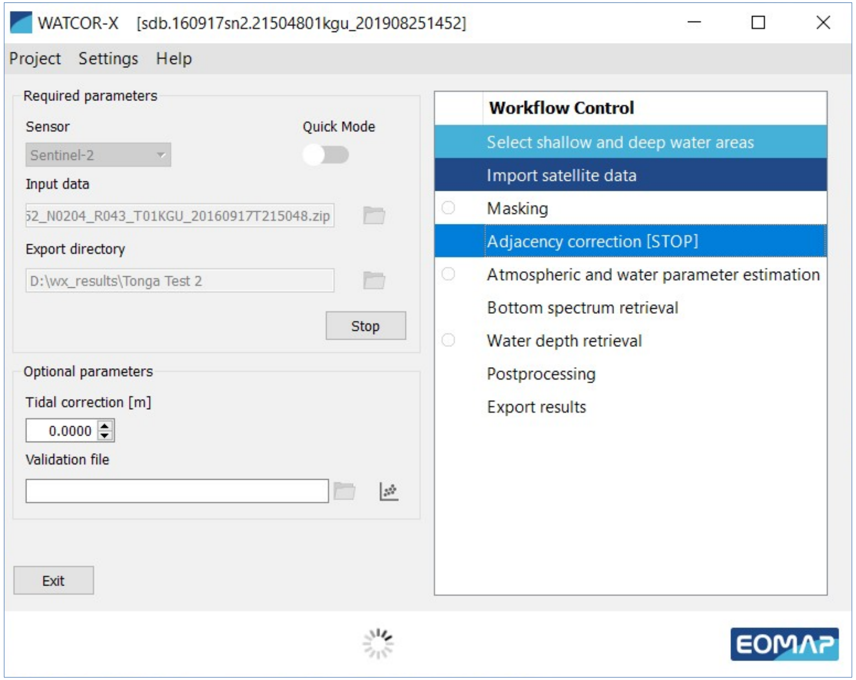
Watcor-X: simple

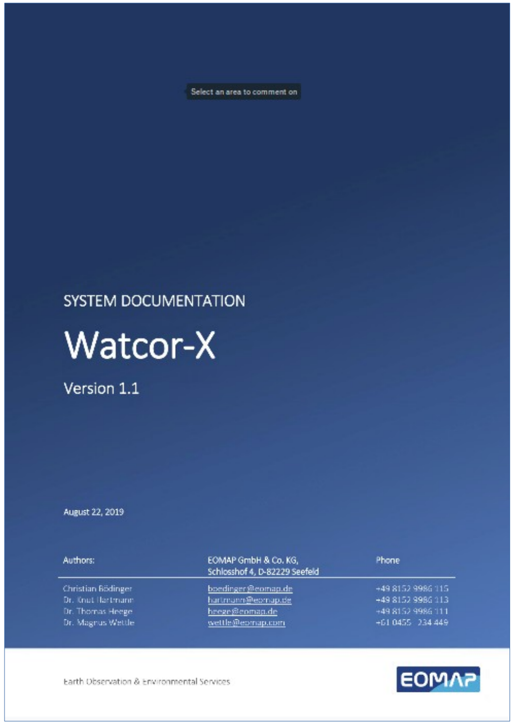


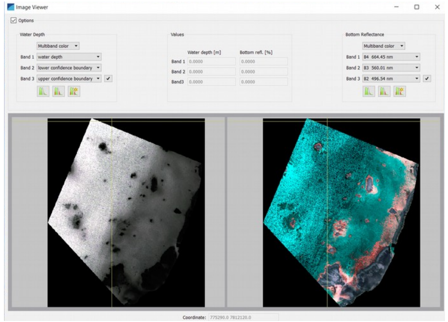
Watcor-X: sophisticated

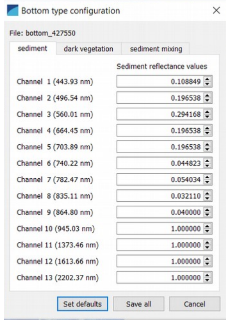


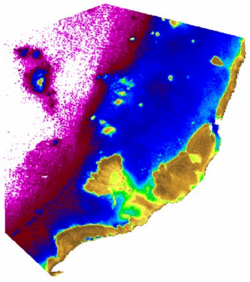


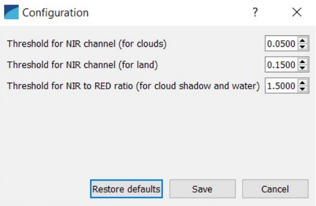


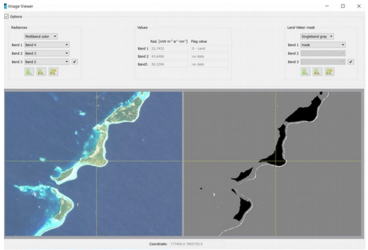












(The very low cost option)

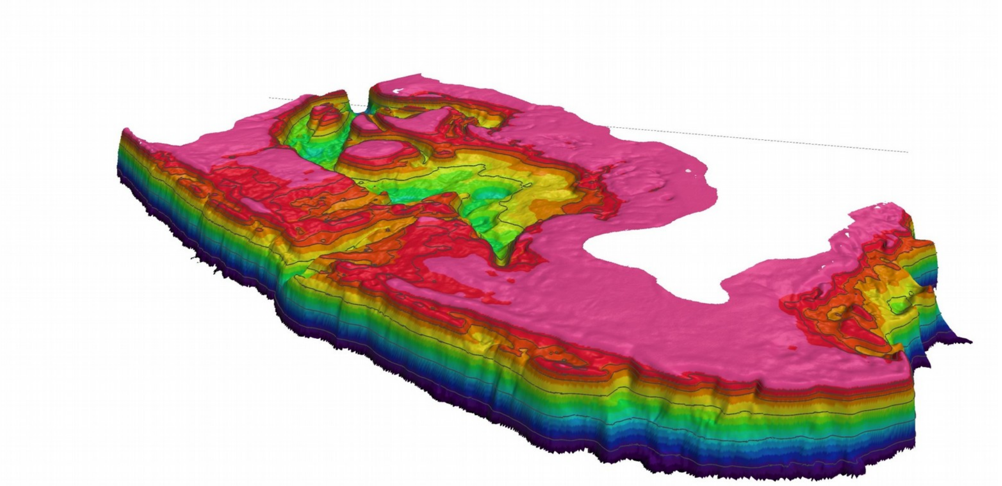
1. Implement band ratio algorithm
(e.g. GEBCO Cookbook)

2. Collect some in situ depth data
(range of depths and substrate types)

3. Use free (good quality) satellite image

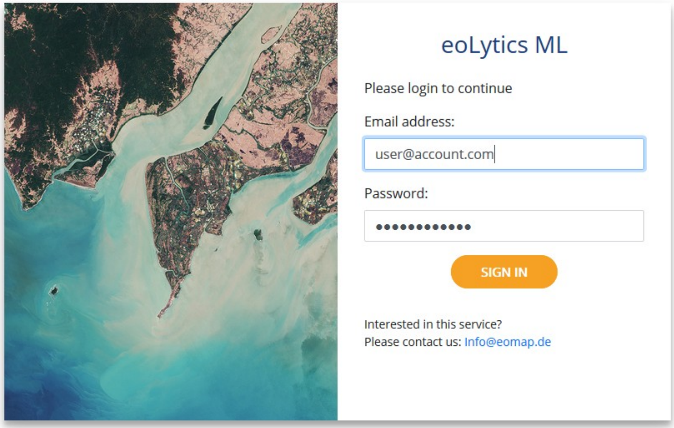
- Landsat 8: 30m resolution, online USGS portal

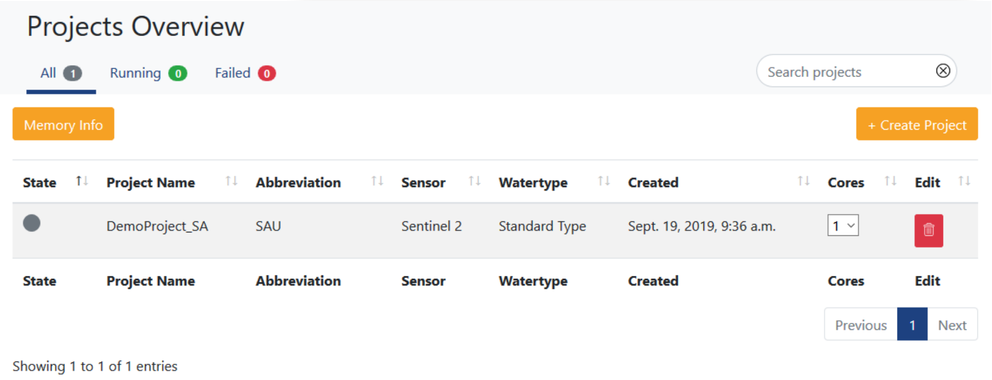
- Sentinel 2: 10m resolution, online ESA portal



2. eoLytics SDB

- Physics + Machine Learning (more rigour)
- Requires limited but good quality survey data
- Low cost
- Easy to use
- Example application:
  shallow areas to map/monitor,
  access w/ e.g. single beam
- Capability development

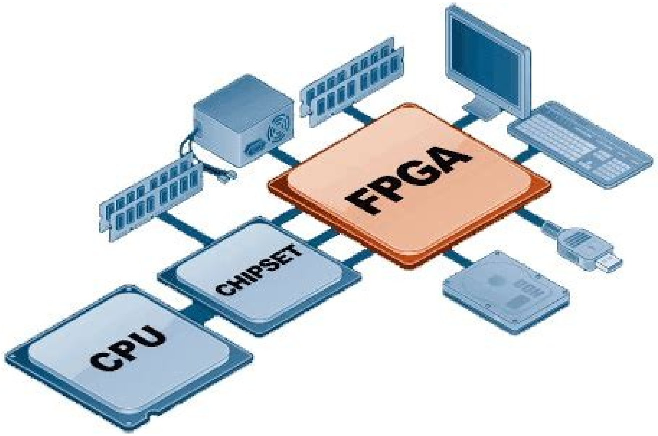




New Developments: Speed

Hardware acceleration (funding from European Space Agency)**:**

Field Programmable Gate Arrays and GPUs:
- expect to reduce processing time by 95% or more



Software acceleration:

Implications:
- Near real time SDB (in the field, defence, emergency response...)

- Improved accuracy: Multi-image processing (EOMAP patent)

- Very large areas…..

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Global SDB Layer: now technically possible

- Operational software
- Accelerated processing
- ICESat, onboard LIDAR: calibration and validation (limited coverage, narrow transects)
- Combining physics-based, AI and ML

Objective: all (optically) shallow waters globally

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Summary

Satellite-derived bathymetry

- Non-intrusive, remote/inaccessible locations, extensive coverage, low cost, rapid, trade offs, complementary or stand alone
- Planning, Mapping, Monitoring

New Developments:

- S-44 v6, matrix expanded to accommodate SDB specifications
- Software (and training): Enabling National Agencies and capacity building
- Hardware Acceleration: near-real time, improved accuracy
- Ready for global SDB layer

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Thank you