Current developments in Satellite-Derived Bathymetry

SWPHC18
February 17-19, 2021

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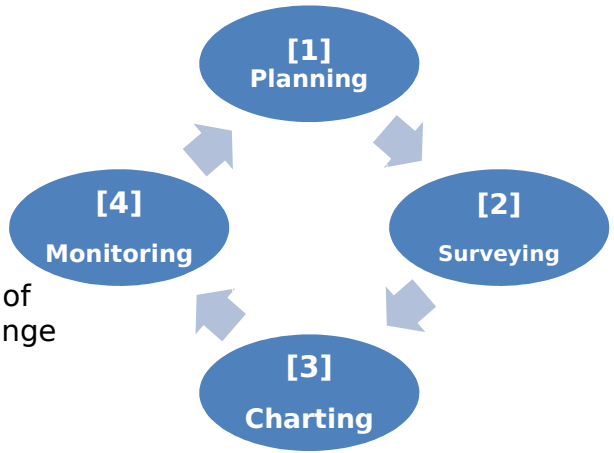
EOMAP
Germany | Australia | United States | Indonesia
www.eomap.com

Satellite-derived bathymetry in hydrographic surveys

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



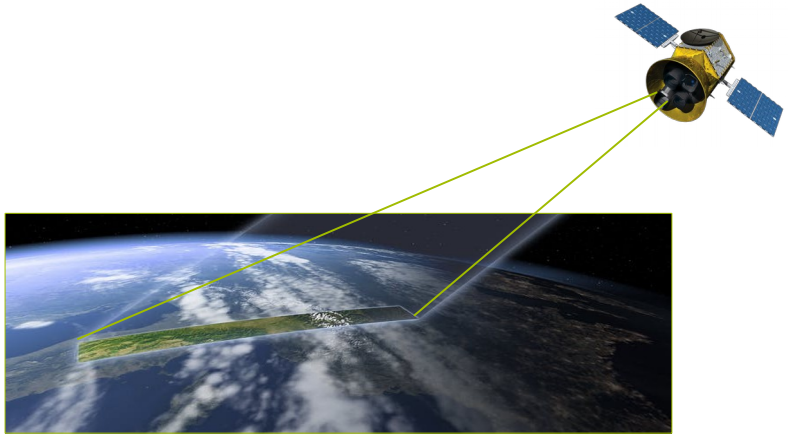
Regular monitoring of seabed change

Integration of SDB in charts

Optimise survey efficiency; reducing costs, time and risk

Access shallow, remote or otherwise in-accessible areas

Integrated survey approach: complementary technologies.



Why it should be in your surveying toolkit:

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

The SDB journey so far

- 1980s-2000's: R&D
- 2005: First commercial SDB project:
  (environmental management)
- 2012: NOAA and UKHO evaluate SDB
- 2013: Used by marine professionals (e.g. SHELL)
- 2015: UKHO puts EOMAP SDB in chart
- 2019: LINZ puts EOMAP SDB in charts
- 2019: IHO S-44 updated for SDB
- 2020: 2 hydrographic agencies with commercial SDB software
- SDB uptake accelerating
  (navigation, enviro. manag., offshore industry, defence, etc)
- >100 projects in >25 countries in last 2 years

Satellite-derived bathymetry standards and best practice

International SDB Day:
>50% respondents require standards for SDB adoption

(www.sdbday.org)

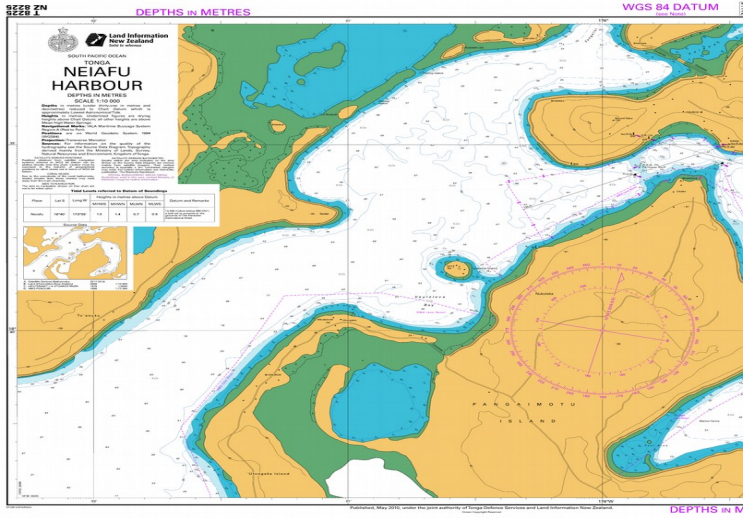
Topics: charting standards and best practice for using/including SDB data

Proposed: International SDB Working Group, kick-off end of April 2021, interact with IHO's HSWG

So far ~10 agencies

You are welcome to join.

	Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14
B	BATHYMETRY														
a	Depth THU [m]	500	200	100	50	20	15	10	5	2	1	0.5	0.35	0.1	0.05
b	Depth THU [% of depth]	20	10	5	2	1	0.5	0.25	0.1						
c	Depth TVU "a" [m]	100	50	25	10	5	2	1	0.5	0.3	0.25	0.2	0.15	0.1	0.05
d	Depth TVU "b" Note 1	0.20	0.10	0.05	0.023	0.02	0.013	0.01	0.0075	0.004	0.002				
e	Feature Detection [m]	50	20	10	5	2	1	0.75	0.7	0.5	0.3	0.25	0.2	0.1	0.05
f	Feature Detection [% of Depth]	25	20	10	5	3	2	1	0.5	0.25					
g	Feature Search [%]	1	3	5	10	20	30	50	75	100	120	150	200	300	



ZOC [1]	Position Accuracy [2]	Depth Accuracy [3]	Seafloor Coverage	Typical Survey Characteristics [5]
A1	± 5 m + 5% depth	=0.50 + 1%d Depth (m) / Accuracy (m) 10 / ± 0.6 30 / ± 0.8 100 / ± 1.5 1000 / ± 10.5	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.
A2	± 20 m	= 1.00 + 2%d Depth (m) / Accuracy (m) 10 / ± 1.2 30 / ± 1.6 100 / ± 3.0 1000 / ± 21.0	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.
B	± 50 m	= 1.00 + 2%d Depth (m) / Accuracy (m) 10 / ± 1.2 30 / ± 1.6 100 / ± 3.0 1000 / ± 21.0	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.
C	± 500 m	= 2.00 + 5%d Depth (m) / Accuracy (m) 10 / ± 2.5 30 / ± 3.5 100 / ± 7.0 1000 / ± 52.0	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.
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

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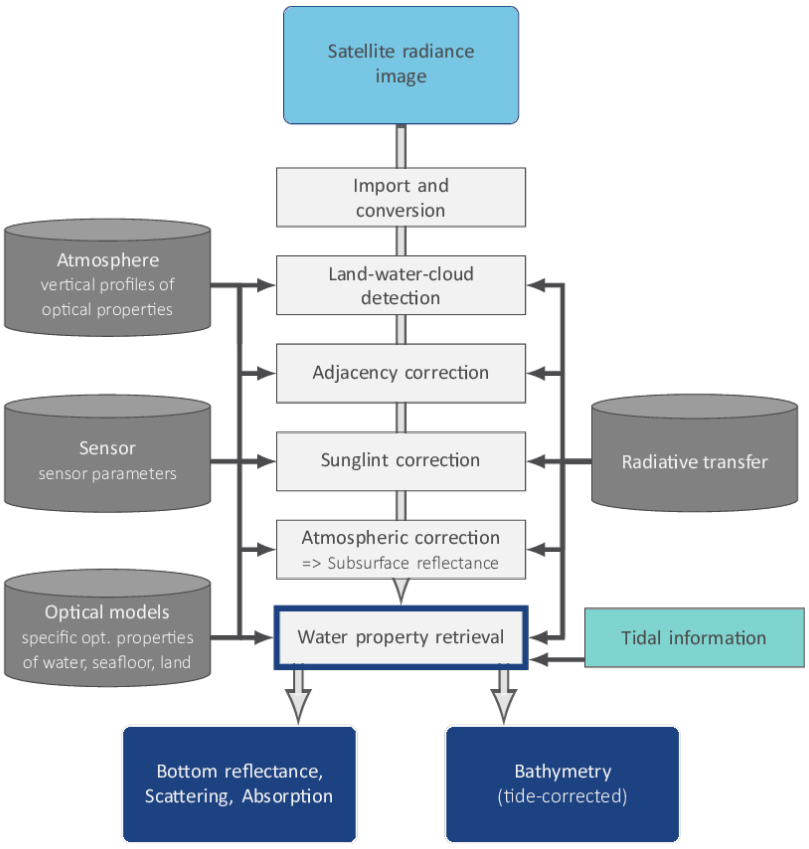
Vertical accuracy



Objective 1: maximise accuracy and autonomy

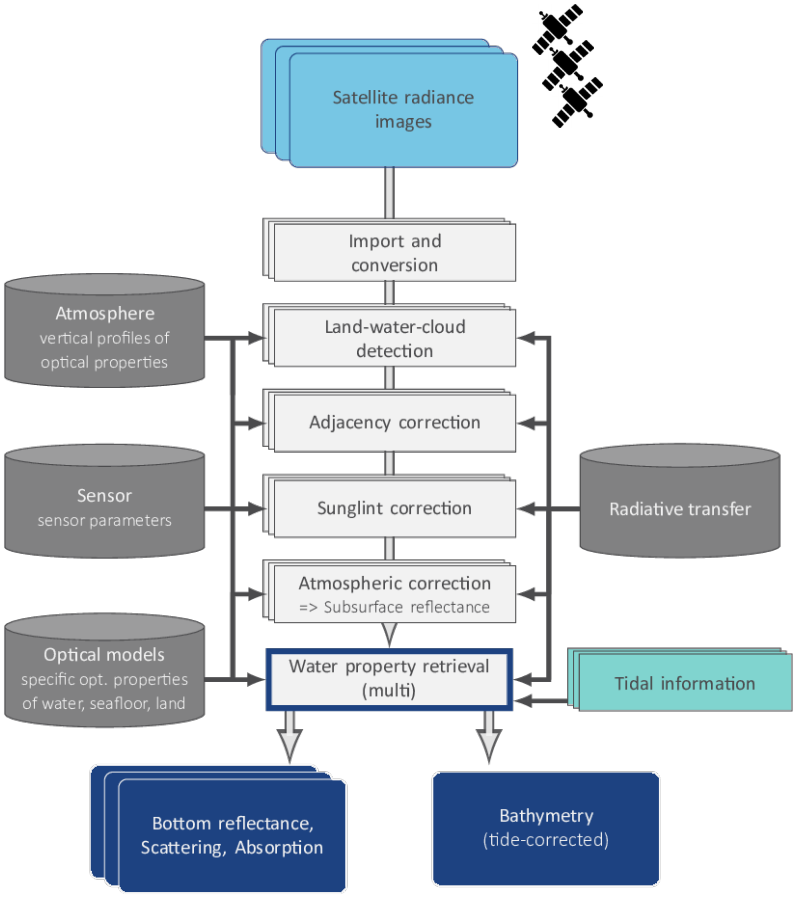
Objective 2: transparency and traceability

Fully physics-based vs. semi-physics-based vs. empirical

pixel = *f(aerosol properties, adjacency, sunglitter, water surface, absorbers and backscatterers of the water column, full bidirectionality from sun and sensor geometry)*

pixel = *f(**depth**, absorbers and backscatterers of the water column, seafloor reflectivity, full bidirectionality from sun and sensor geometry)*

Physics-based multi-scene processing: SDB 2.0



Fully physics-based

pixel = *f(aerosol properties, adjacency, sunglitter, water surface, absorbers and backscatterers of the water column, full bidirectionality from sun and sensor geometry)*

pixel = *f(**depth**, absorbers and backscatterers of the water column, seafloor reflectivity, full bidirectionality from sun and sensor geometry)*

condition: depth $z_i = z$

US Patent 2017, No 9613422
Realization fundet by BMVI

Bundesministerium für Verkehr und digitale Infrastruktur

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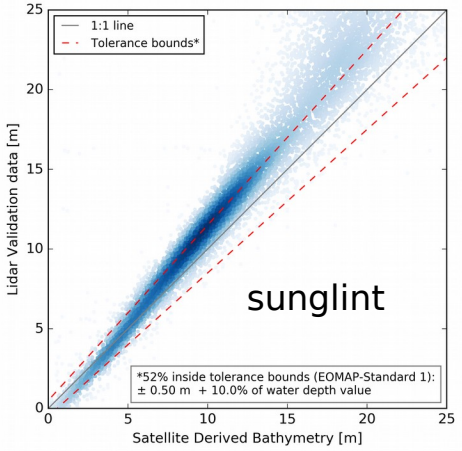
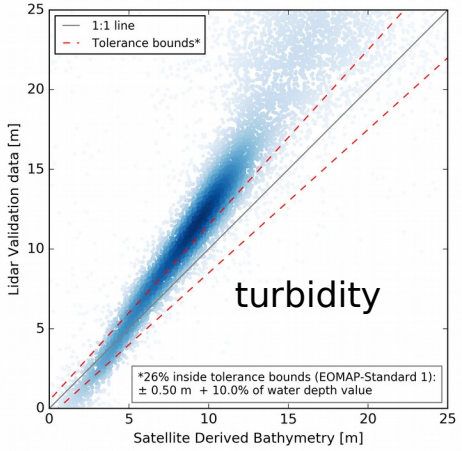
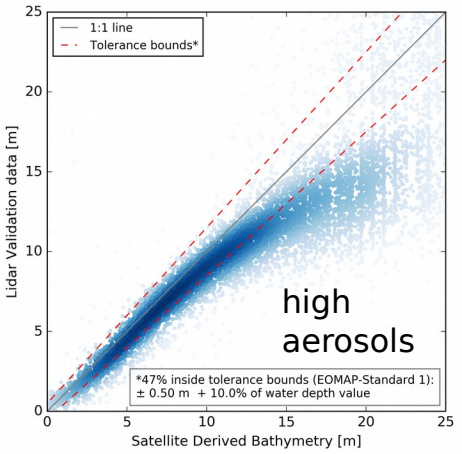
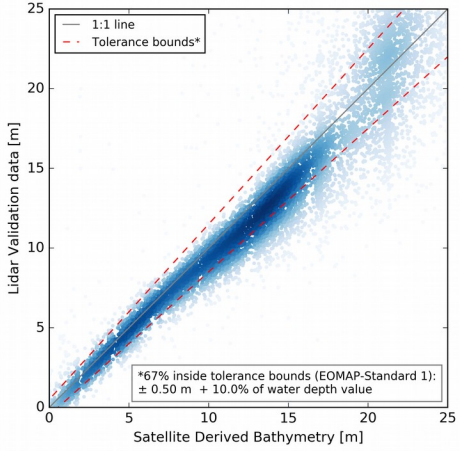
Physics-based multi-scene processing







- Absolute accuracy increases



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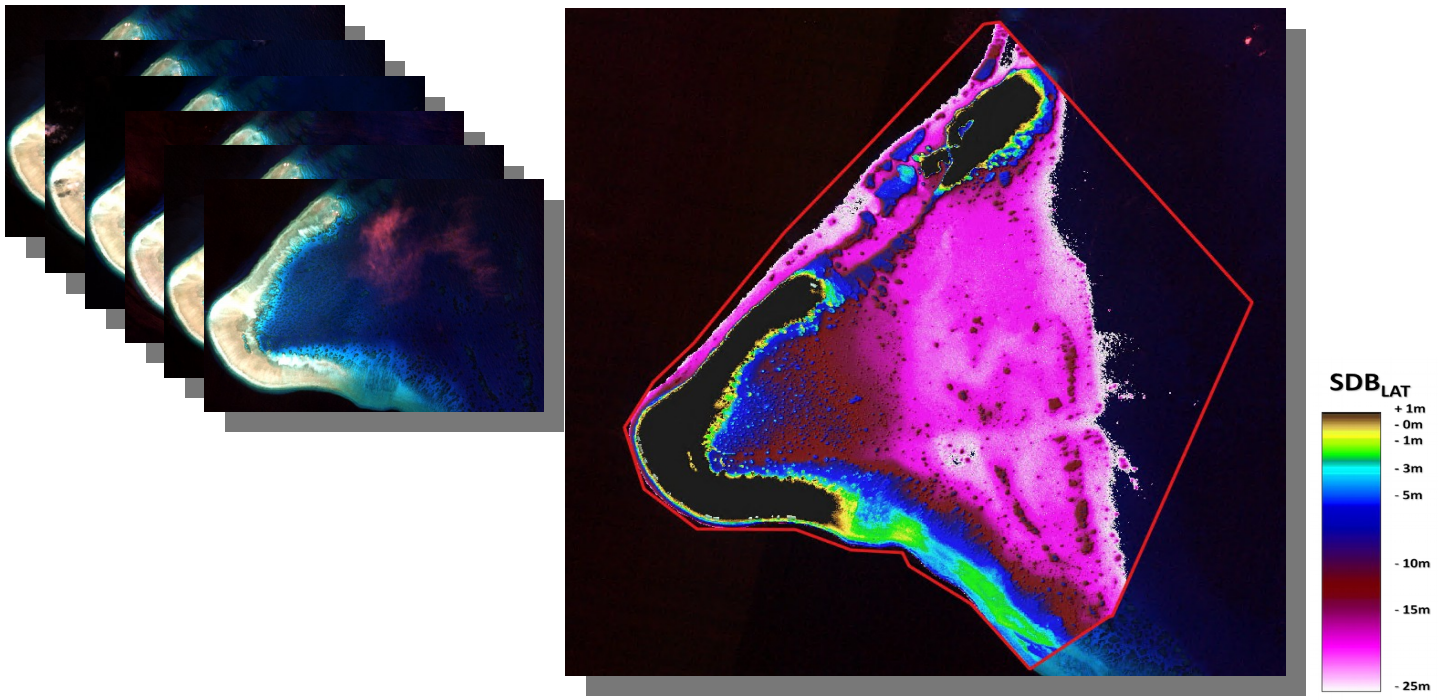
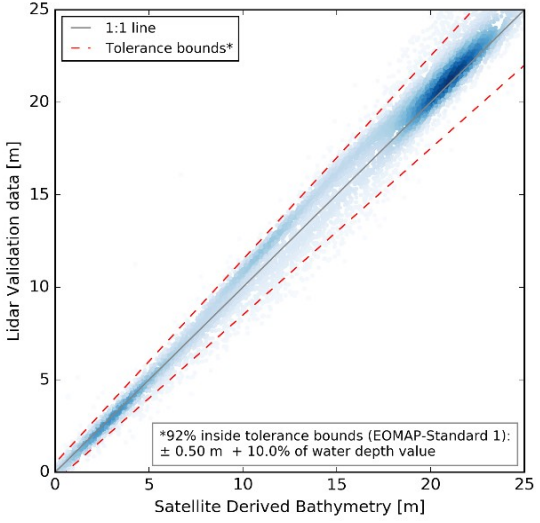
detect more.

Physics-based multi-scene processing

improves accuracy & autonomy

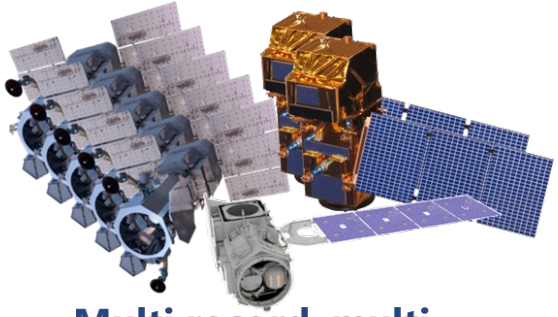


n=16 scenes, no manual cleaning

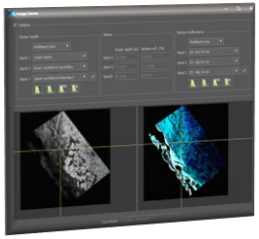


Ongoing journey of improvements

Single record analytics

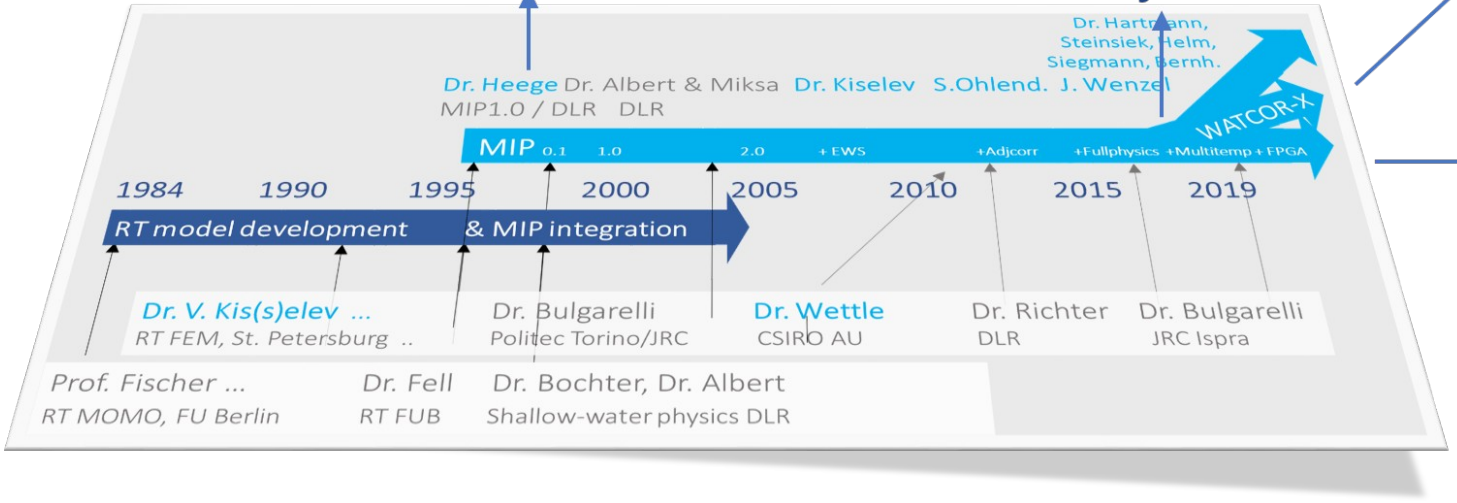


Multi record, multi sensor analytics



Desktop software

Online software



SDB software, fit-for-purpose

	software installation	calibration data	features
WATCOR-X	**local**	**independent**	transparent, accuracy assessment, sophisticated
LiteCOR-X	**local**	required	**fast, easy**
eoLytics-SDB	**online***	required	**fast, easy**
eoLytics-SDB$_{wc}$	**online****	**independent**	transparent, accuracy assessment, sophisticated
eoLytics-SWIFT, -WQ, -ICESAT …	**online***	-	Image finder, water quality analysis, ICESAT toolkit …

* online, connected to satellite archives

** from 2021

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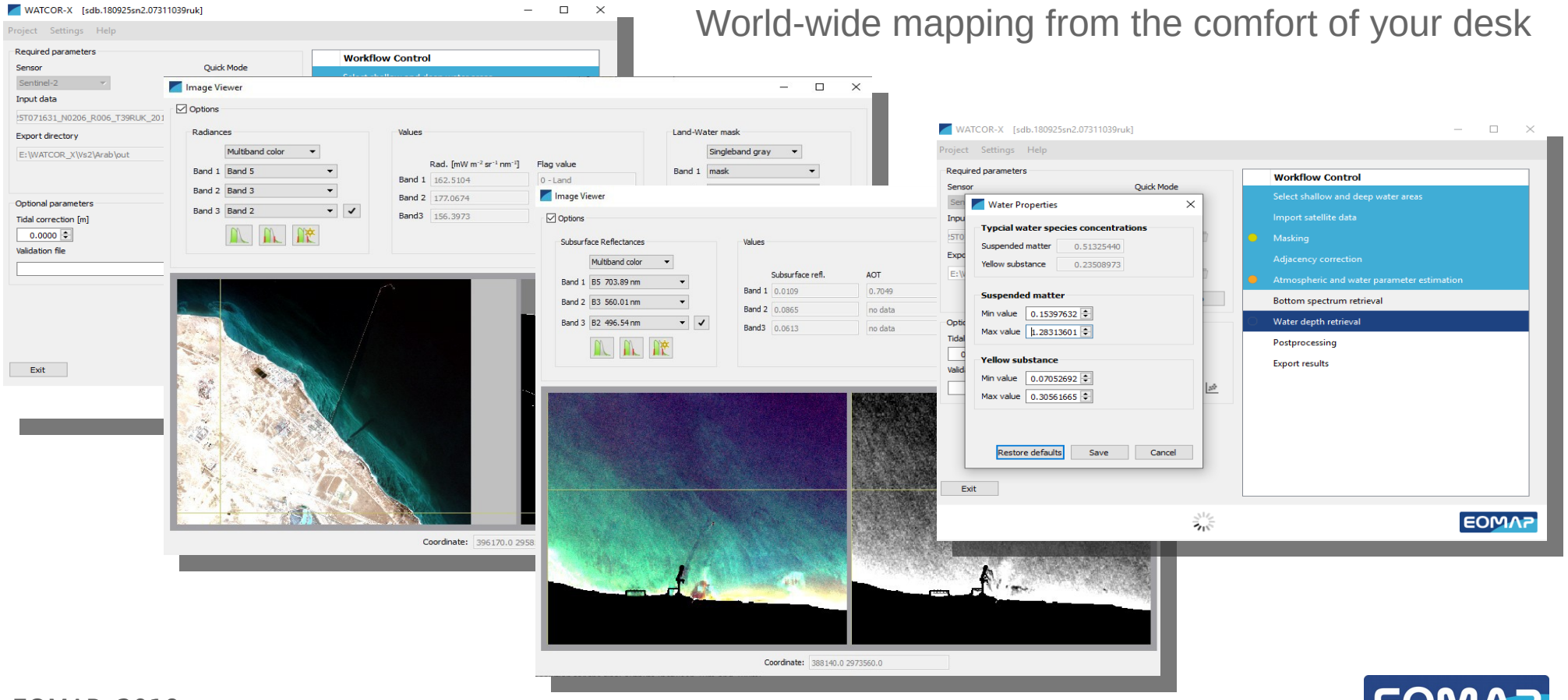
WATCOR-X: state-of-the-art desktop SDB software

World-wide mapping from the comfort of your desk



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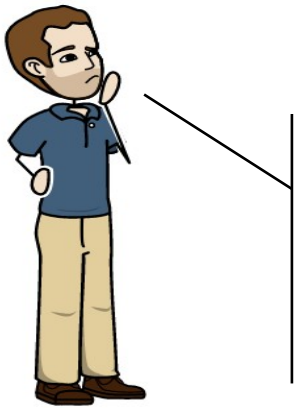
LiteCOR-X and eoLytics SDB

Physics + AI: fast and easy SDB

Fill gaps and expand surveys



How can I **fill survey data gaps** without introducing interpolation bias?

How can I expand the knowledge of my local bathymetry to adjacent areas **without sending a new survey team**?

… and **how can I do this in 1 hour**?

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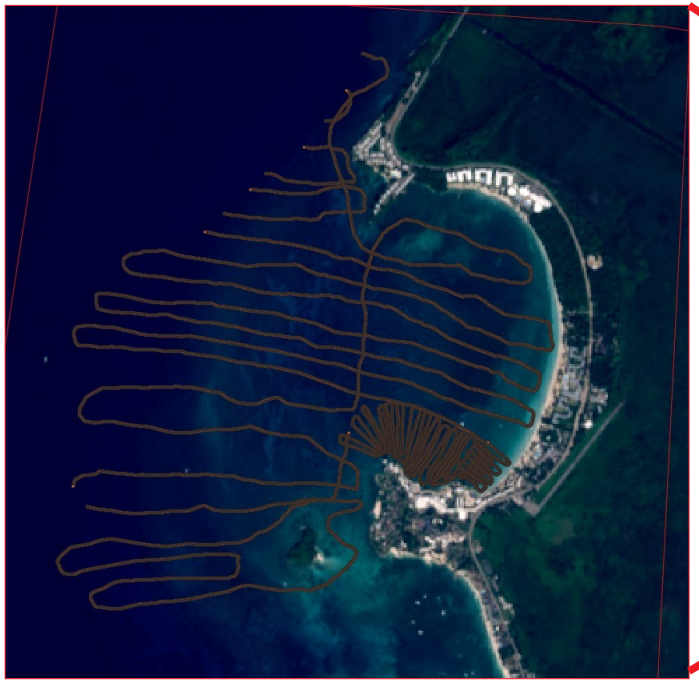
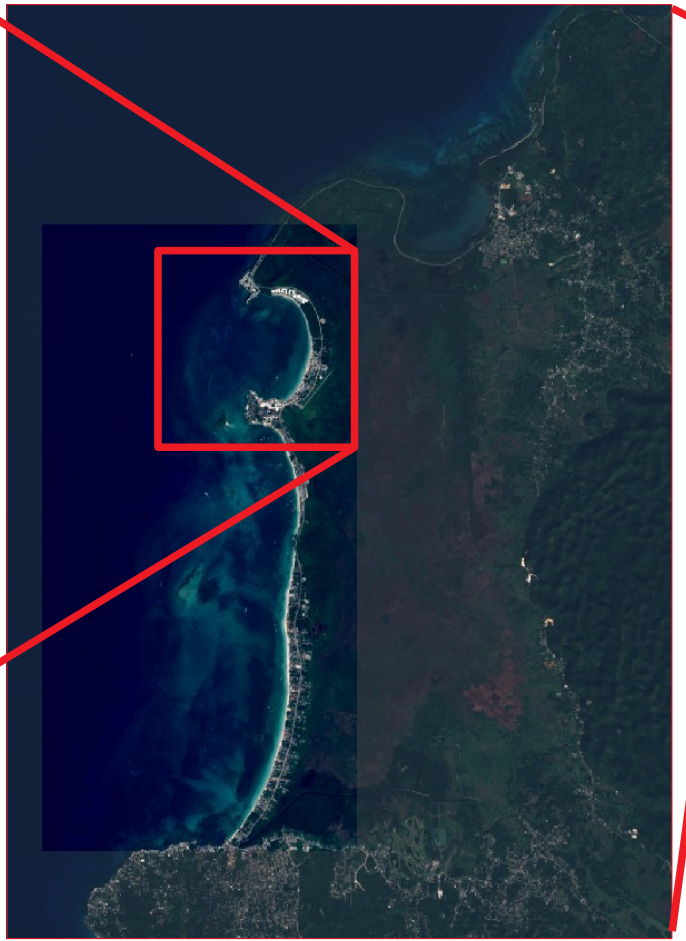
LiteCOR-X (stand alone): Jamaica





Satellite: Sentinel 2
(free, 10m grid resolution)

Calibration data:
Single beam from small boat

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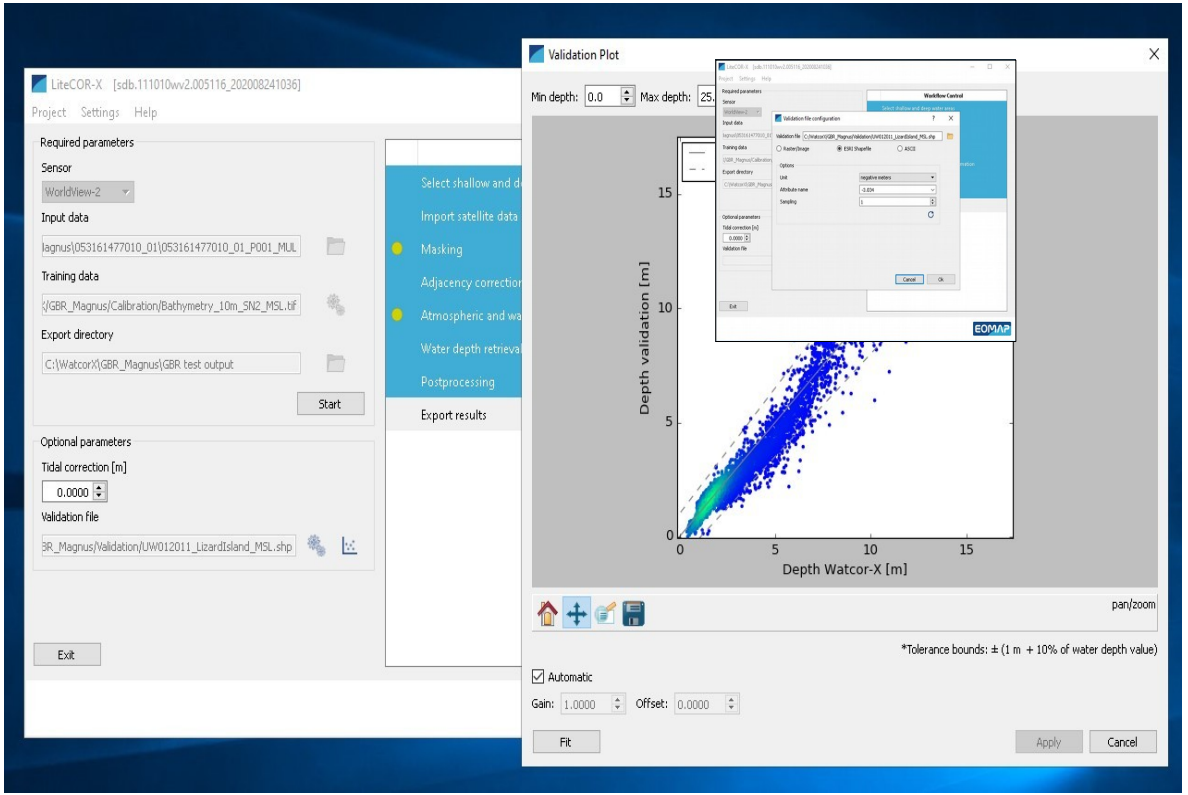
LiteCOR-X



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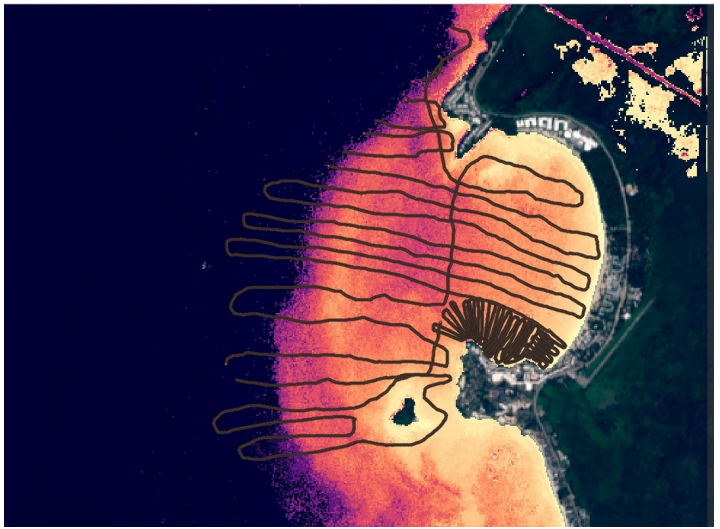
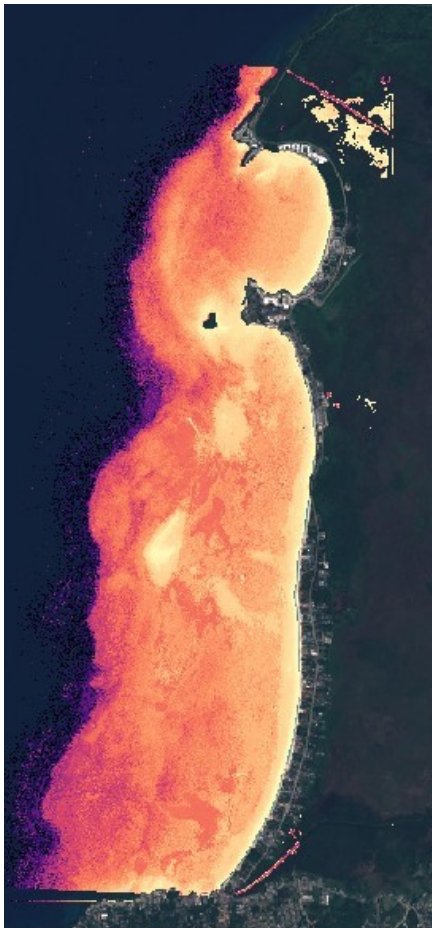
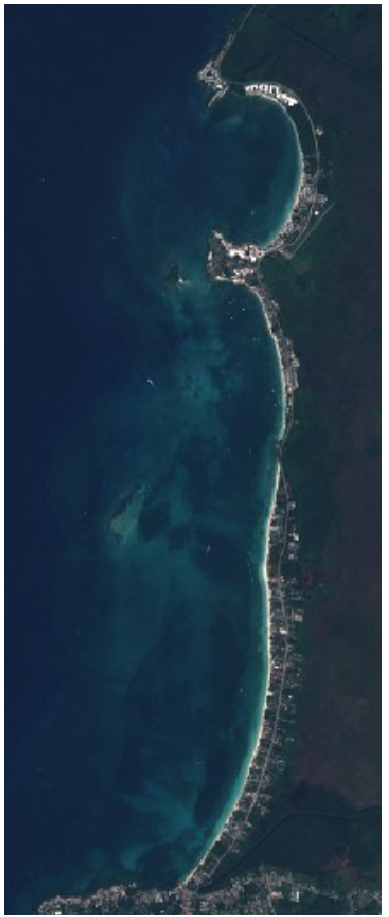
LiteCOR-X example: Jamaica







Cheap and cheerful single beam acquisition + Litecor-X (eolytics SDB)
=
high density bathymetry grid over a much larger area

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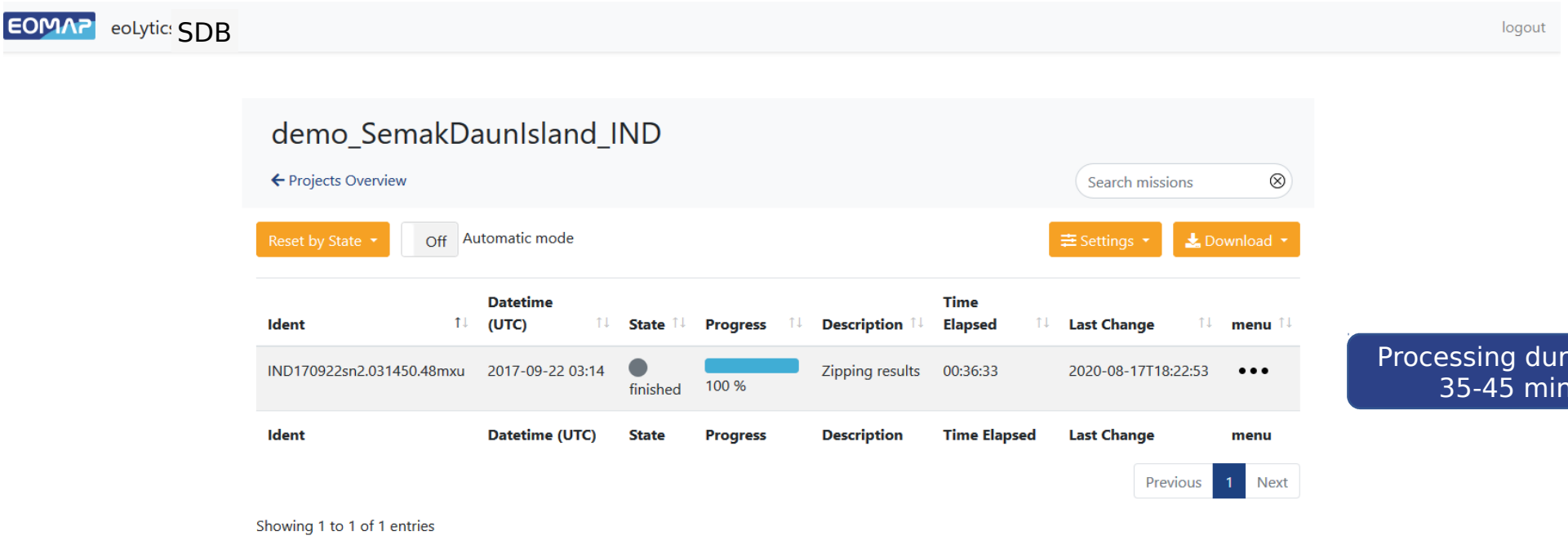
eoLytics SDB: generate SDB in your browser



Processing duration
35-45 min

Download SDB data only
(from 32bit rasters to vector files)

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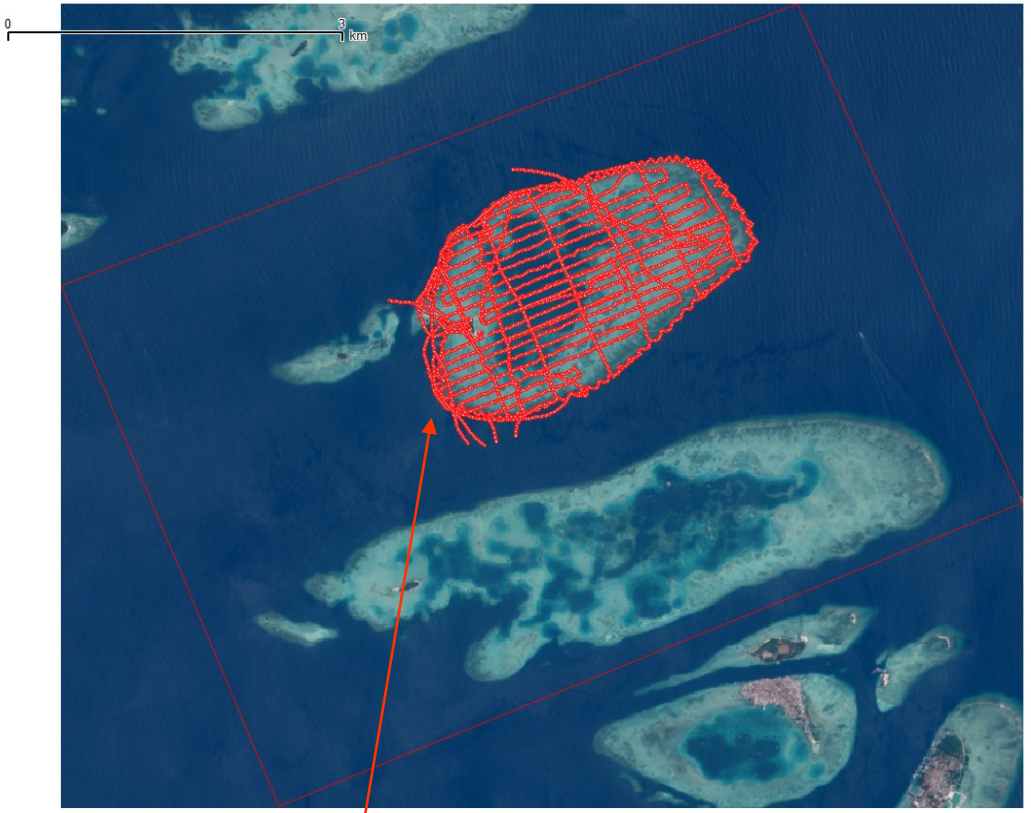
EoLytics SDB (online): Gosong Congkak



Survey data, single beam,
Gosong Congkak Source: Hydrography Laboratory ITB

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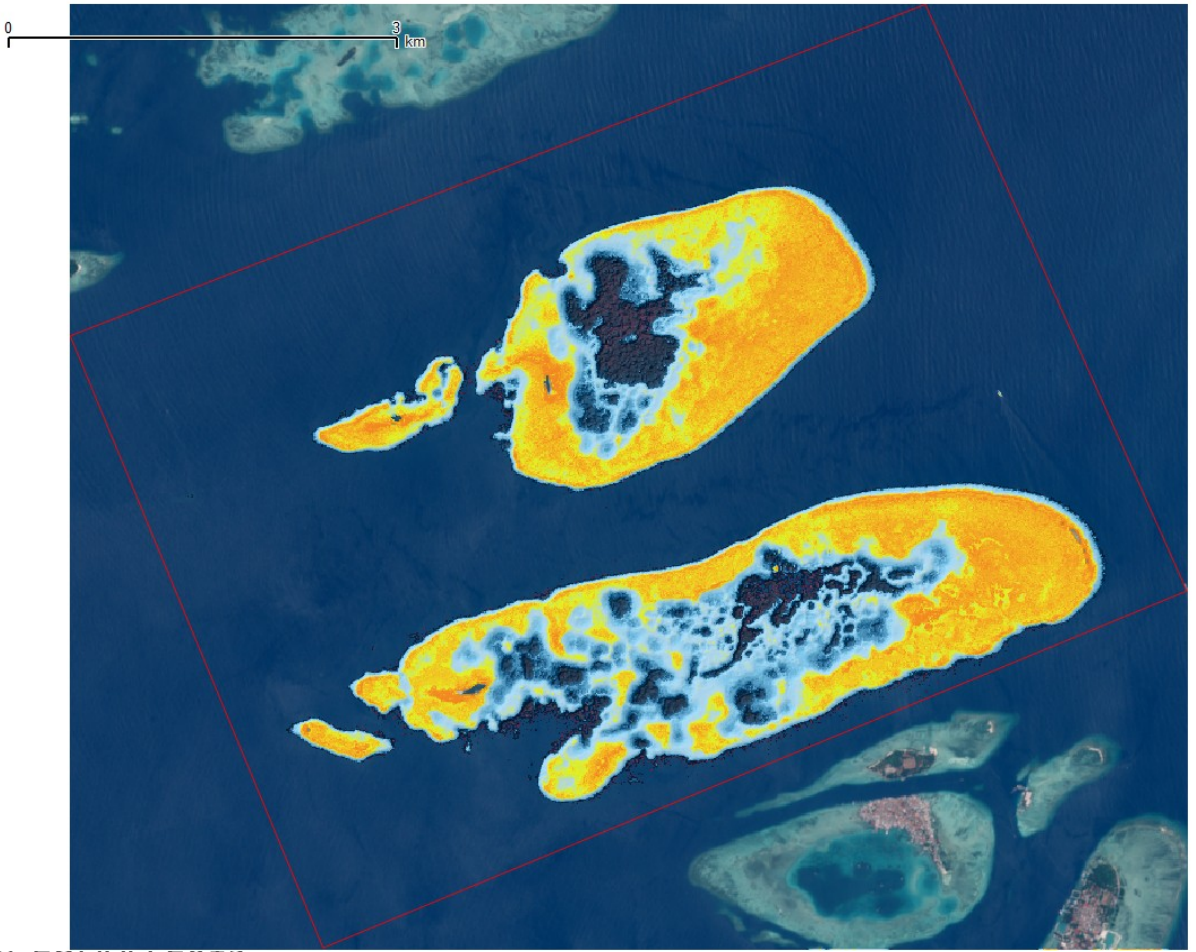
EoLytics SDB Example: Gosong Congkak



Gaps filled, area expanded, in 1 hour

Depth in m

-15
-10
-5
-2
0
0.2
0.5

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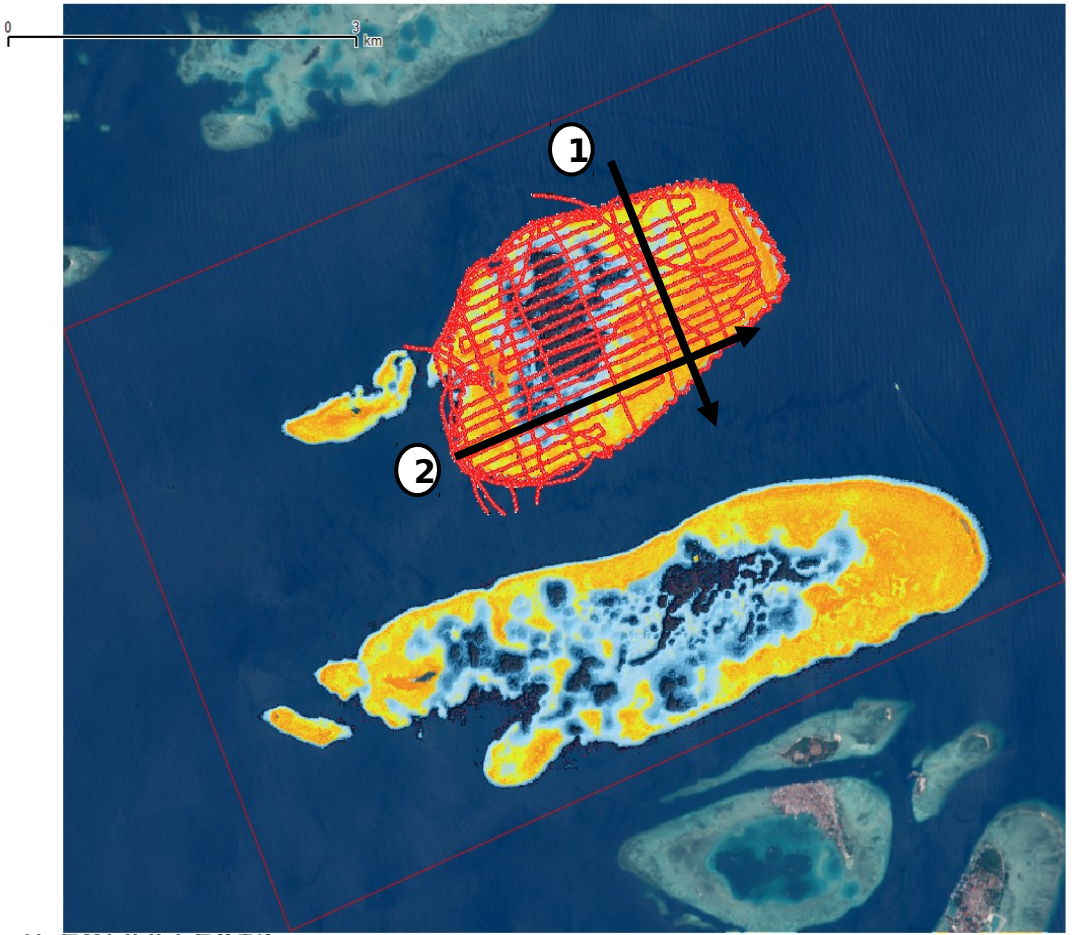
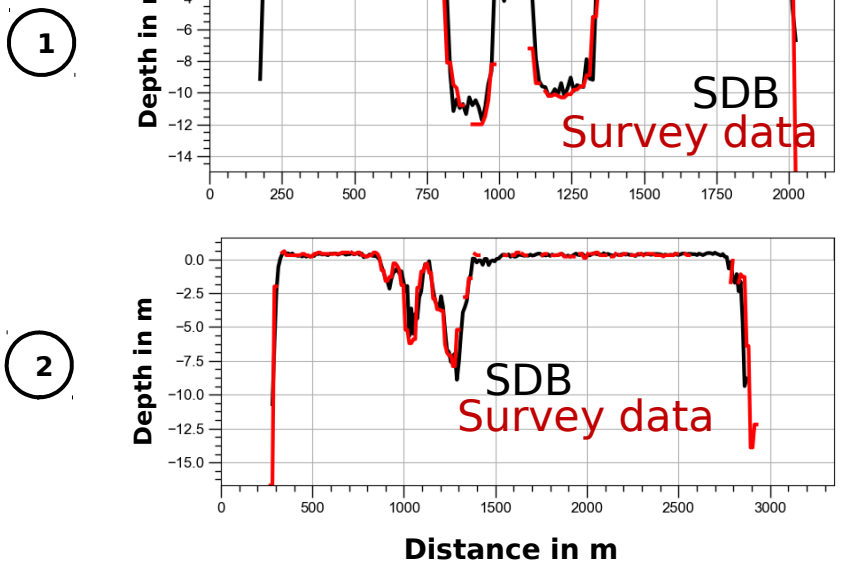
Example 1: eoLytics SDB, Gosong Congkak





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SDB software for different needs

	software installation	calibration data	features
WATCOR-X	**local**	**independent**	transparent, accuracy assessment, sophisticated
LiteCOR-X	**local**	required	**fast, easy**
eoLytics-SDB	**online***	required	**fast, easy**
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eoLytics-SWIFT, -WQ, -ICESAT …	**online***	-	Image finder, water quality analysis, ICESAT toolkit …

- Extend survey capabilities with modest resources

- Monitor change, cost effectively

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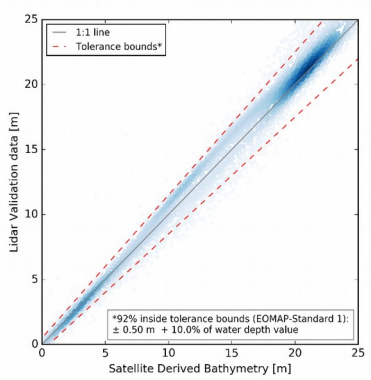
Summary

1. Improving vertical accuracy and validation:
multi-image processing, gpu acceleration

2. Software, tools and training:
enabling agency in-house SDB capabilities

3. Standards and best practice:
establishing SDB working group (April 2021)



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d	Depth TVU "b" Note 1	0.20	0.10	0.05	0.023	0.02	0.013	0.01	0.0075	0.004	0.002
e	Feature Detection [m]	50	20	10	5	2	1	0.75	0.7	0.5	0.3
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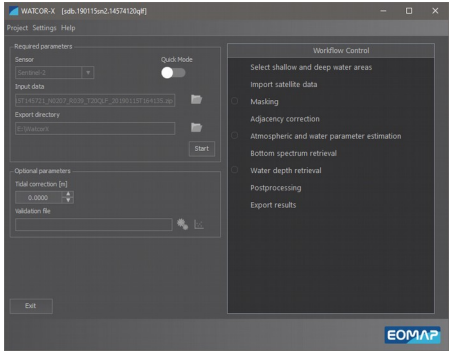
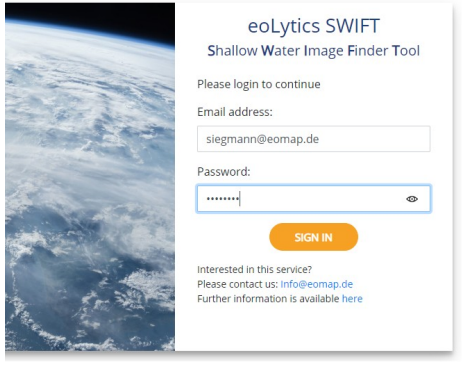
g	Feature Search [%]	1	3	5	10	20	30	50	75	100	120





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Thank you

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