

Satellite-Derived Bathymetry

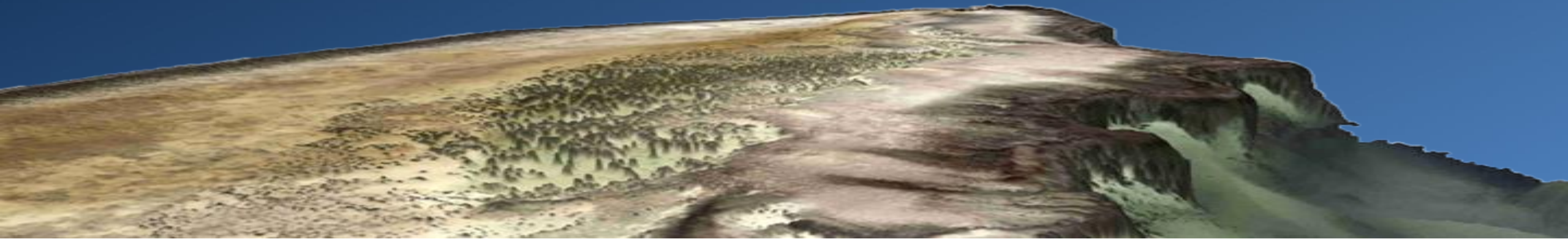
In a nutshell and quality assurance

2019-12-03

Dr. Knut Hartmann

EOMAP Germany | Australia

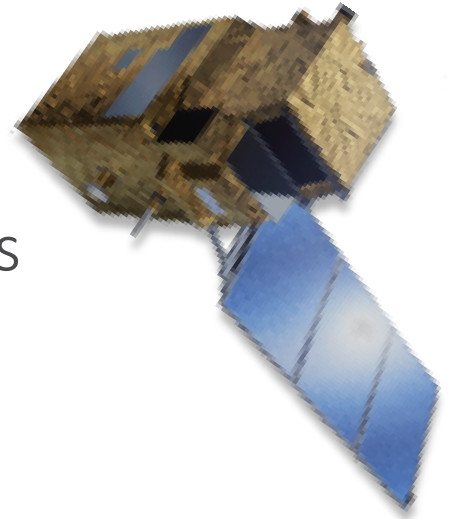
www.eomap.com



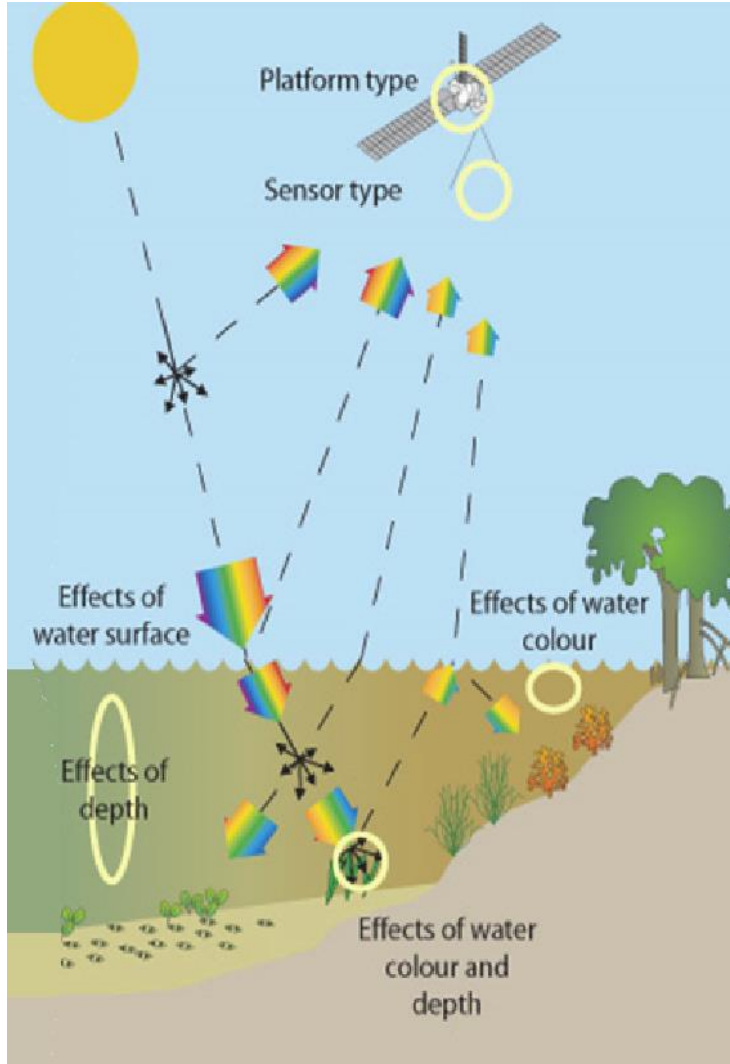
EOMAP

Solution provider for mapping and monitoring aquatic environments, with

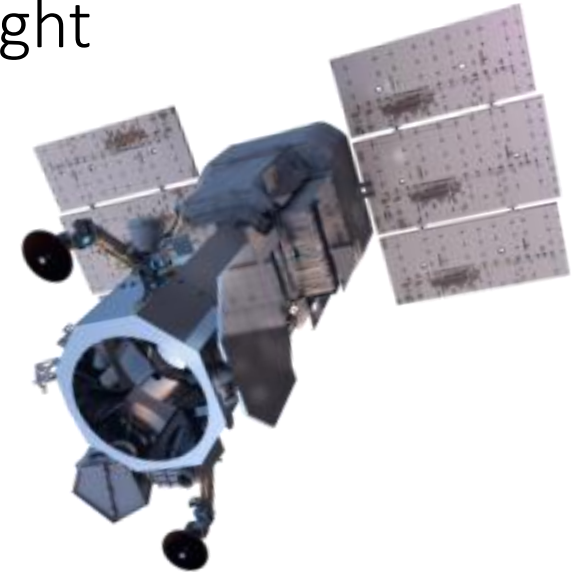
- >75 Satellite-Derived Bathymetry projects in 25 countries in just the last 2 years
- Seabed2030, EMODnet Bathymetry, GEBCO data contributor
- Trained staff for all aspects of satellite data analytics
- R&D on aquatic Earth Observation since 20 years with continuous integration of innovations into the market



Surveying shallow waters from space - Satellite-Derived Bathymetry



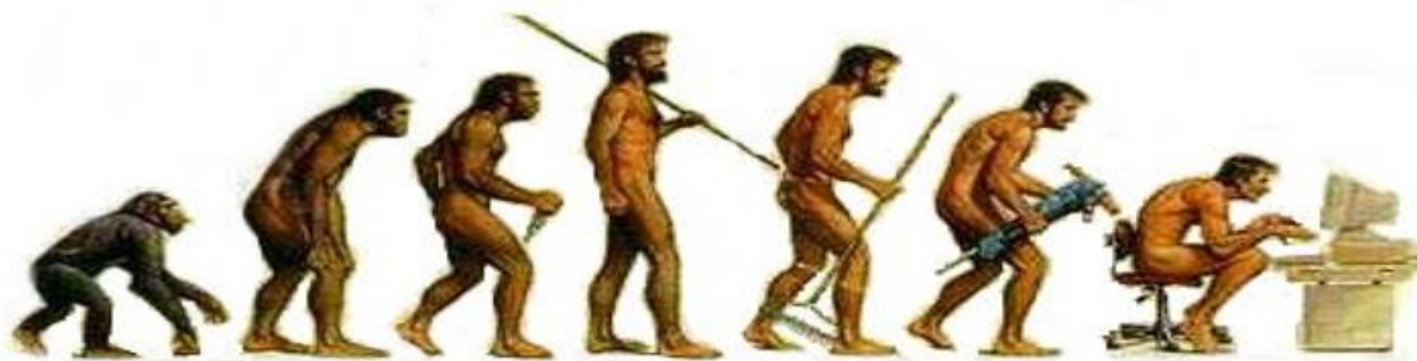
- Passive system: earth-orbiting optical sensors + sunlight
- Limited to water depth where sunlight is being reflected by the seafloor.
- Non-intrusive, rapid, low cost for shallow/remote/ in-accessible locations



Satellite-Derived Bathymetry =
Surveying shallow waters with optical (hyper-)multi-spectral cameras

History

Evolution of Satellite-Derived Bathymetry



Manual
interpretation

Empirical SDB
IHO cookbook

AI

semi physics
based SDB

Fully physics
based SDB

Bathymetry training
data required

Training data
not required

197x

197x

201x

2015

197x

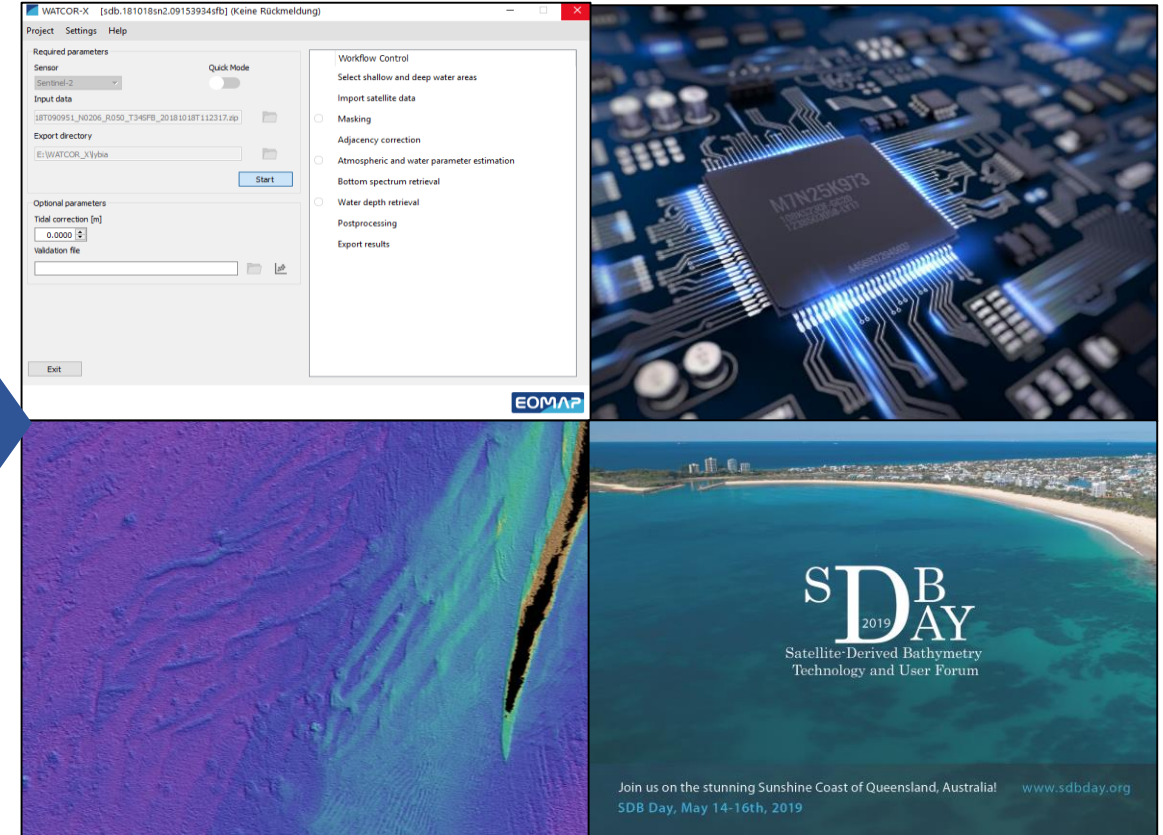
198x

Time travel of physics based Satellite-Derived Bathymetry



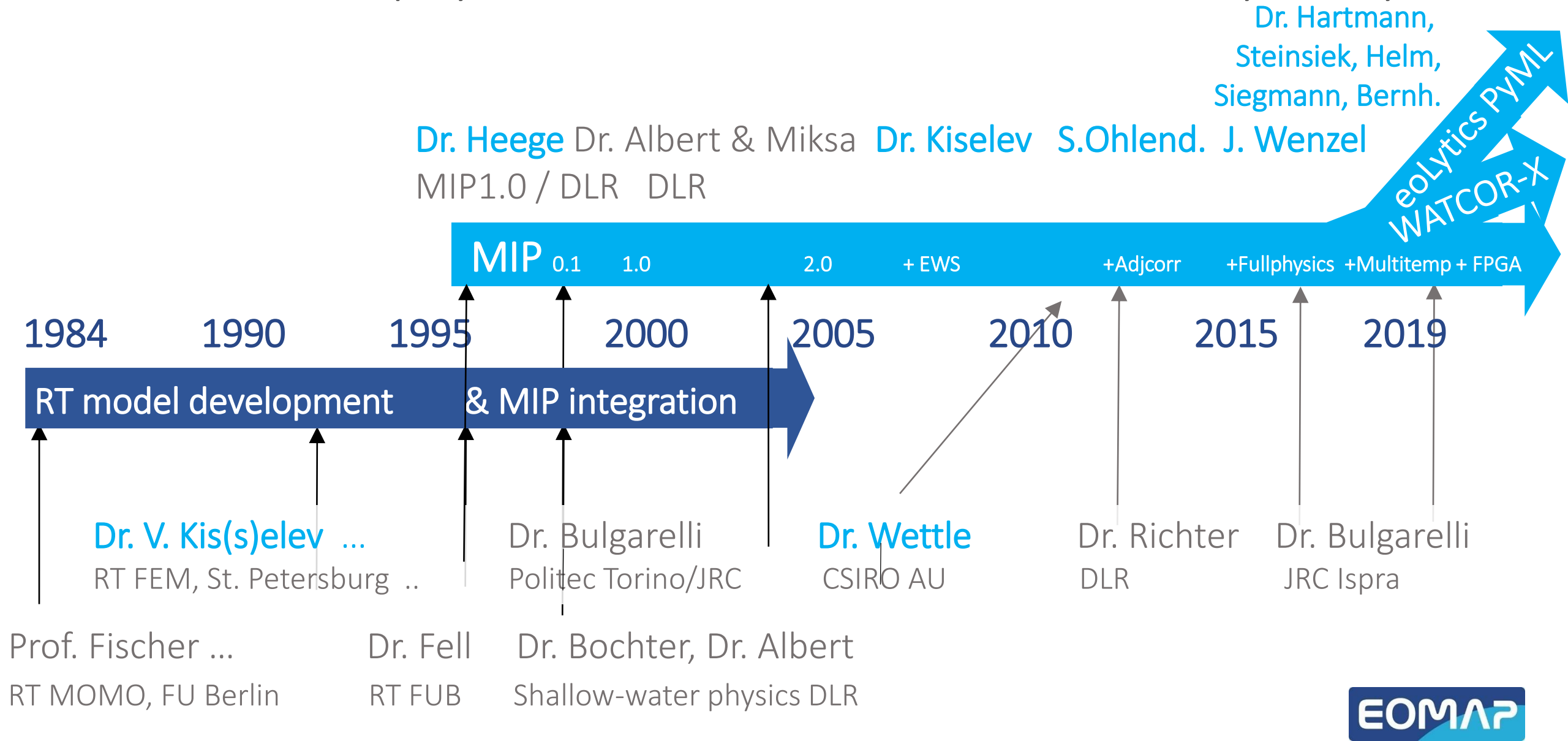
MicroBRIAN (CSIRO)

80ties



2019

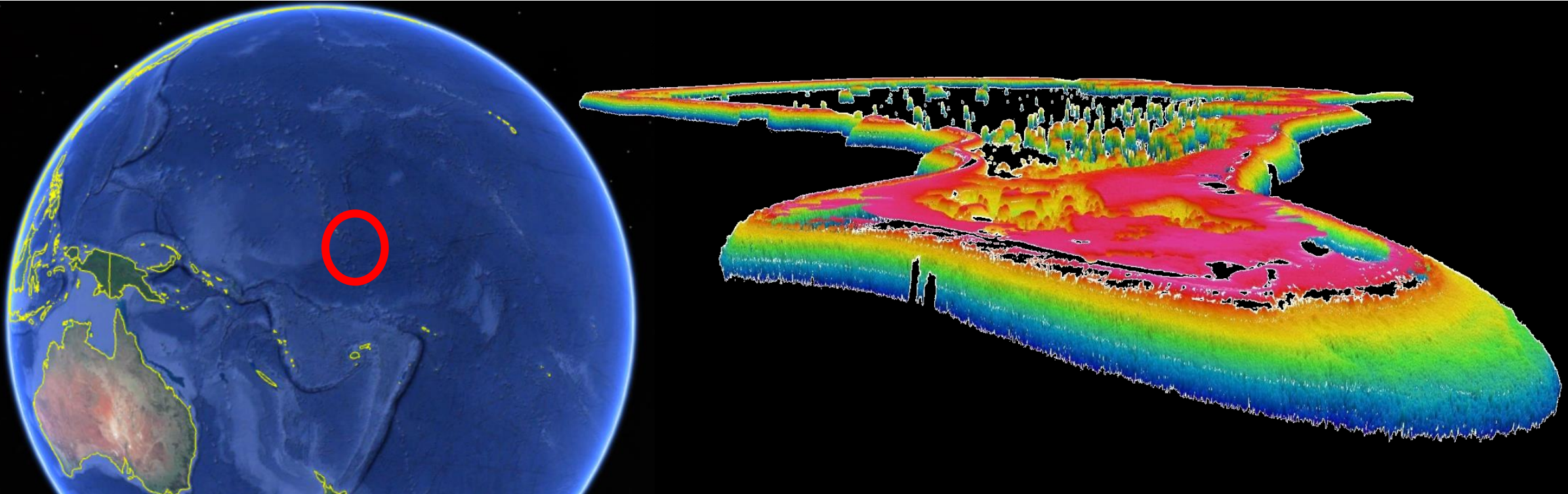
EOMAP's physics based Satellite-Derived Bathymetry



Satellite-Derived Bathymetry flagships

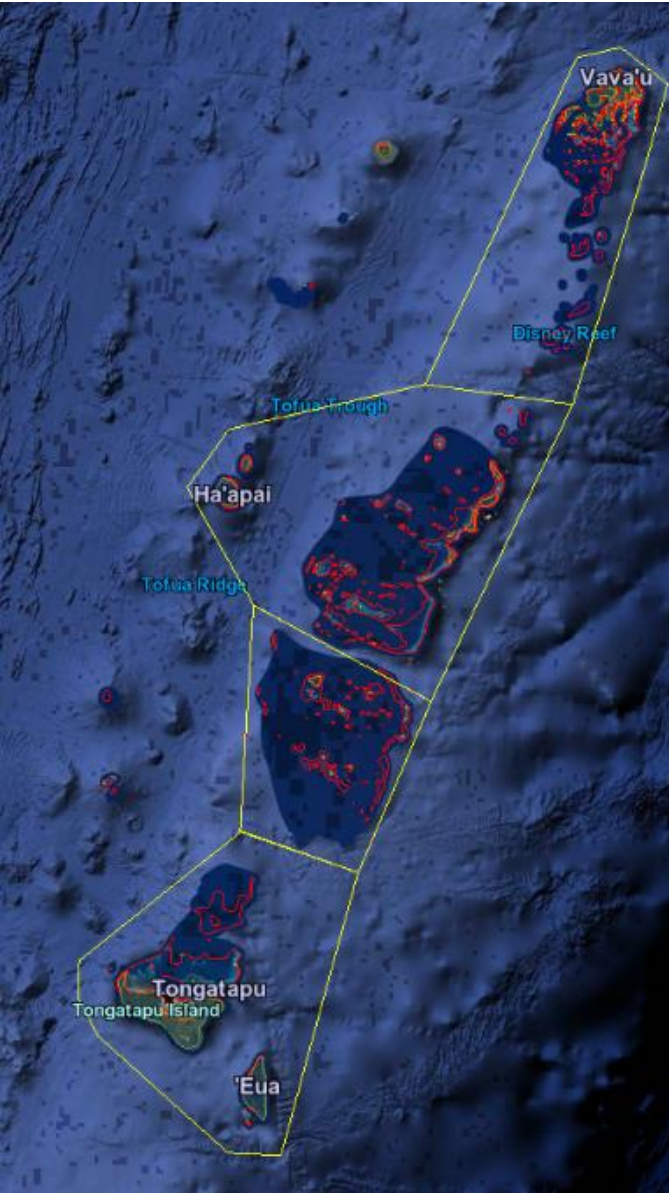
SDB to support charting: Tuvalu mapping for UKHO

- The project awarded through a competitive bid contract issued and overseen by the UKHO.
- 2m resolution SDB survey to support the update of BA charts for 7 atolls, Tuvalu



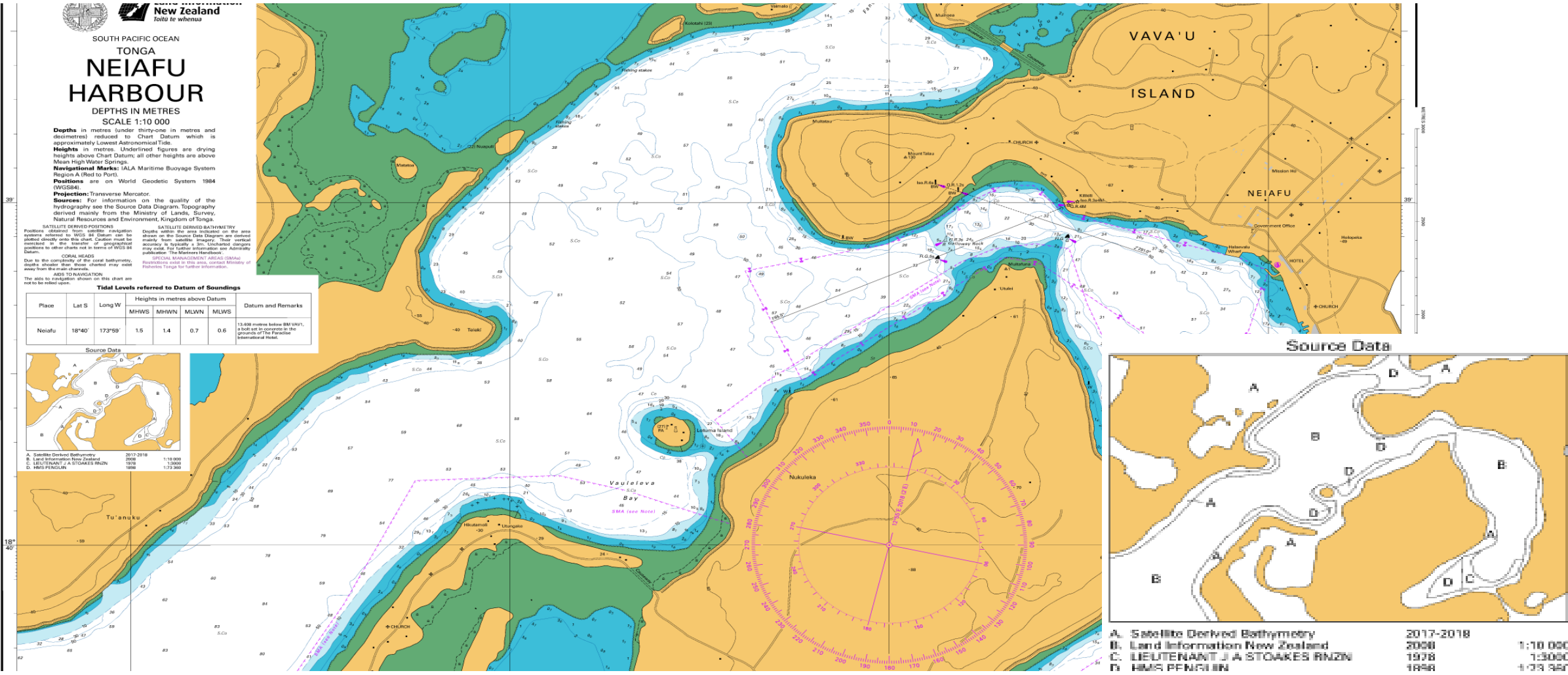
SDB to support charting: Tonga mapping for LINZ

- Area of 400,000 sq km, with 6,500 sq km shallow water mapped for LINZ in teaming with IXsurvey.
- Integrated SDB, MBES and ALB surveys
- 2m resolution SDB survey



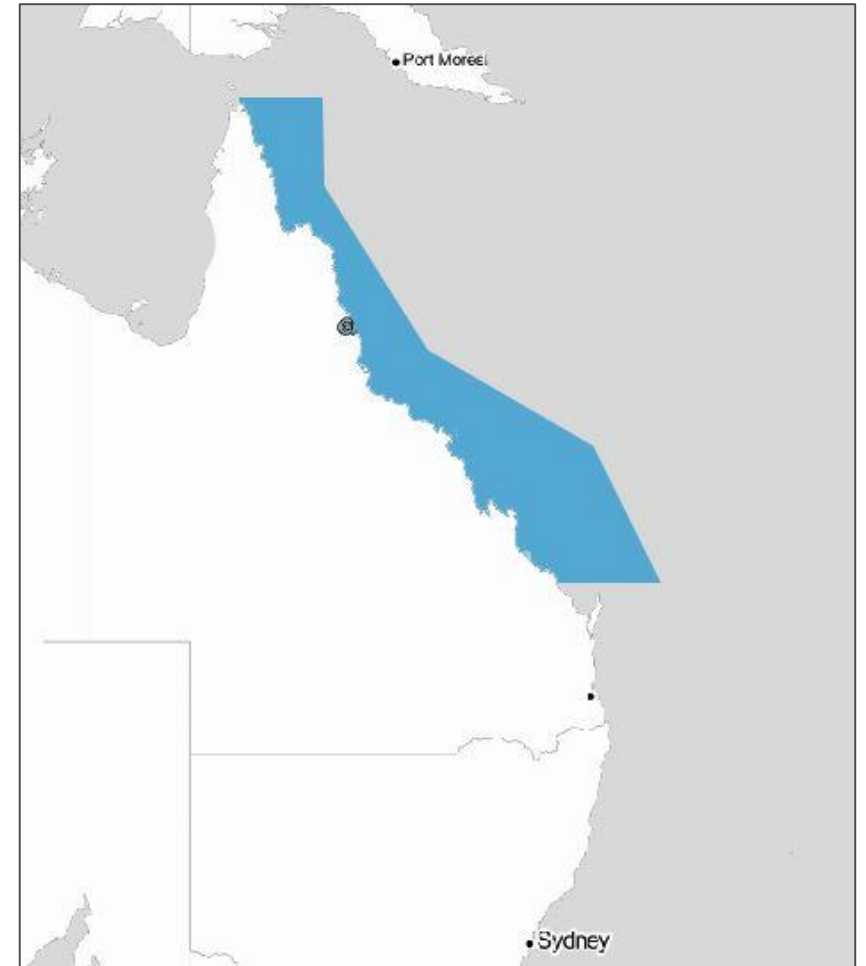
SDB to support charting: Tonga mapping for LINZ

EOMAP's SDB integrated into the most recent chart of Neiafu Harbour (LINZ).

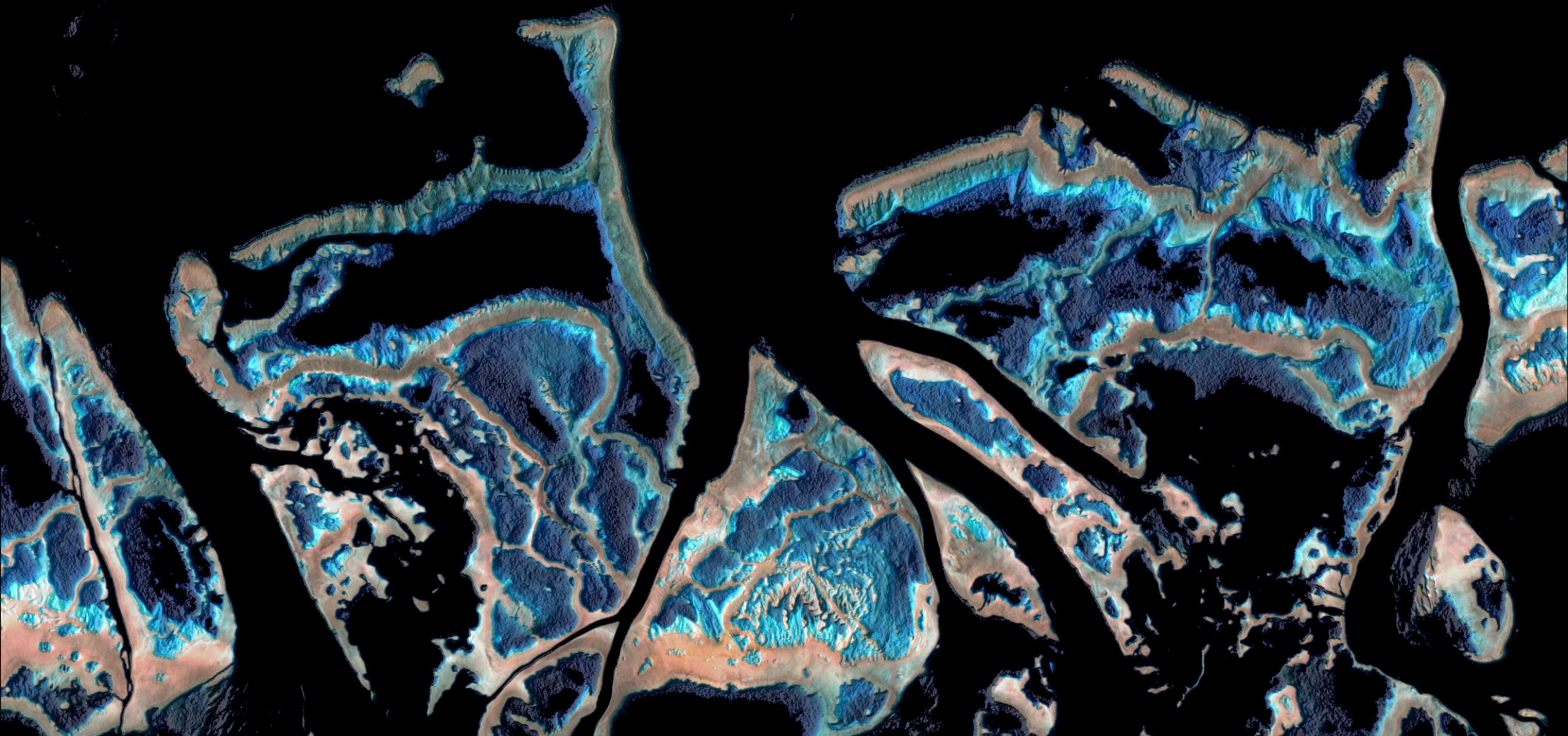


SDB for environmental mapping: Great Barrier Reef (2019)

- 3000+ reefs covering an area of approx. 10% of coral reefs globally
- 450 satellite recordings processed, corresponding to 3TB of raw data.
- Resulting in 16,000 sq km of shallow water bathymetry and reflectance data down to a depth of up to 20 metres
- Base layer for reef knowledge system, part of the Reef 2050 Integrated Monitoring and Reporting Program.



SDB for environmental mapping: Great Barrier Reef (2019)



Extreme High Resolution Satellite-Derived Bathymetry



9cm spatial resolution bathymetric grid:
Data fusion of airborne drone and satellite data

Standards

Standards on SDB

- The matrix approach Appendix A3 will be beneficial to SDB for hydrographic surveys.
- *Line spacing* is not of relevance to SDB
- *Full seafloor coverage* can be achieved for the optically shallow water zone only, and often requires multi-temporal satellite data analysis
- *Feature detection* capability is a function of sensor, depth and environmental conditions and does not fit the order 1a/b criteria

→ Underlying question: **How to assure that standards are being met?**

Quality assurance

(S44 and C-13 Manual on hydrography)

Quality Assurance ANNEX B: GUIDELINES FOR QUALITY MANAGEMENT

B.2 Equipment

*The equipment in use must be capable of producing data that meets the required uncertainties. This is [...] the **total of propagated uncertainties of all equipment and corrections** used to derive the reported surveyed value. [...]*

1 Modelling of uncertainties

Quality Assurance ANNEX B: GUIDELINES FOR QUALITY MANAGEMENT

B.3 Procedures

*Using standardised procedures for hydrographic data collection and processing can **reduce the risk of errors**. [...] Procedures may involve complete flow schedules that can be used for **external auditing** and **standardised data products**. [...]*

2 Standardisation and **traceability** of SDB processes and analytics

Quality Assurance ANNEX B: GUIDELINES FOR QUALITY MANAGEMENT

B.4 Personal

*All survey work must be performed by **qualified personnel**. The personnel must be trained and capable. Formal qualifications like CAT A and B are preferred but proven working experience may be sufficient.*

3 Trained personal („remote surveyors“)

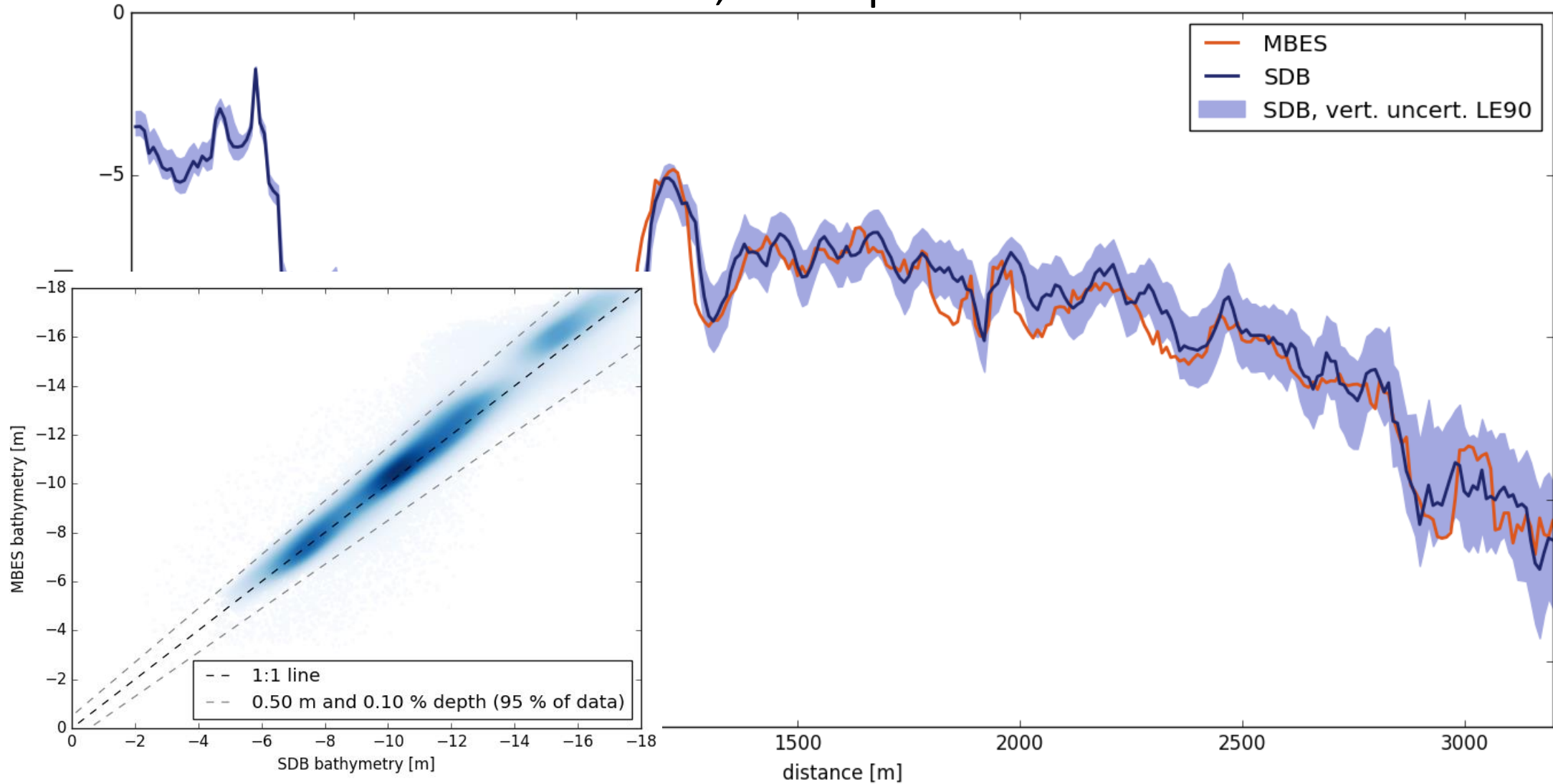
1 Modelling of uncertainties

Standardisation and Traceability

Requires...

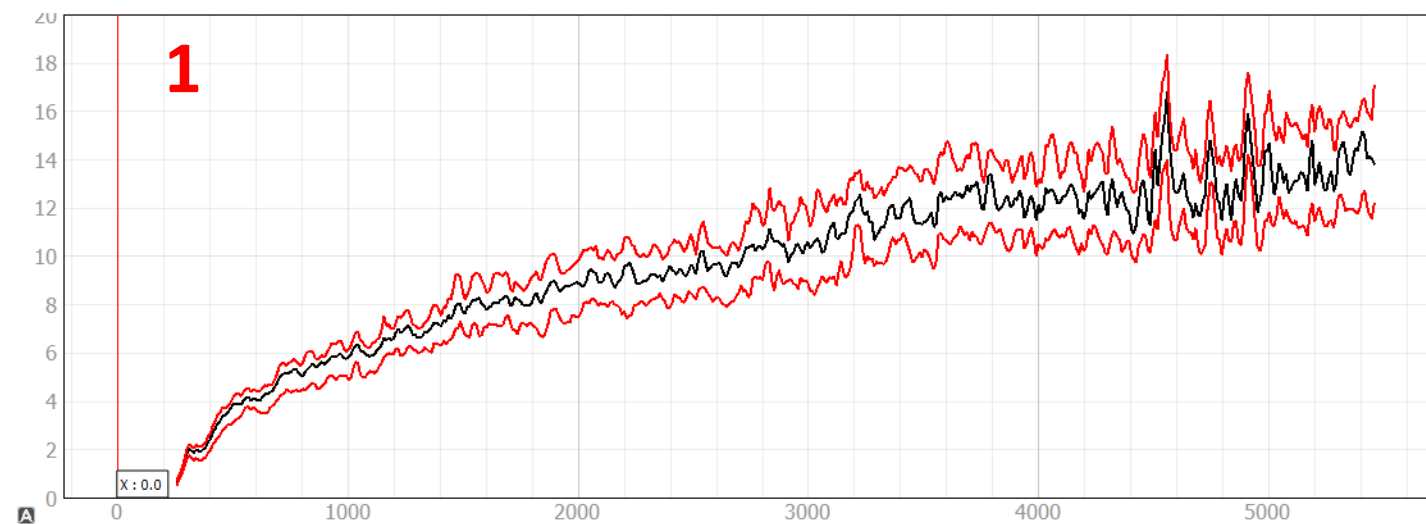
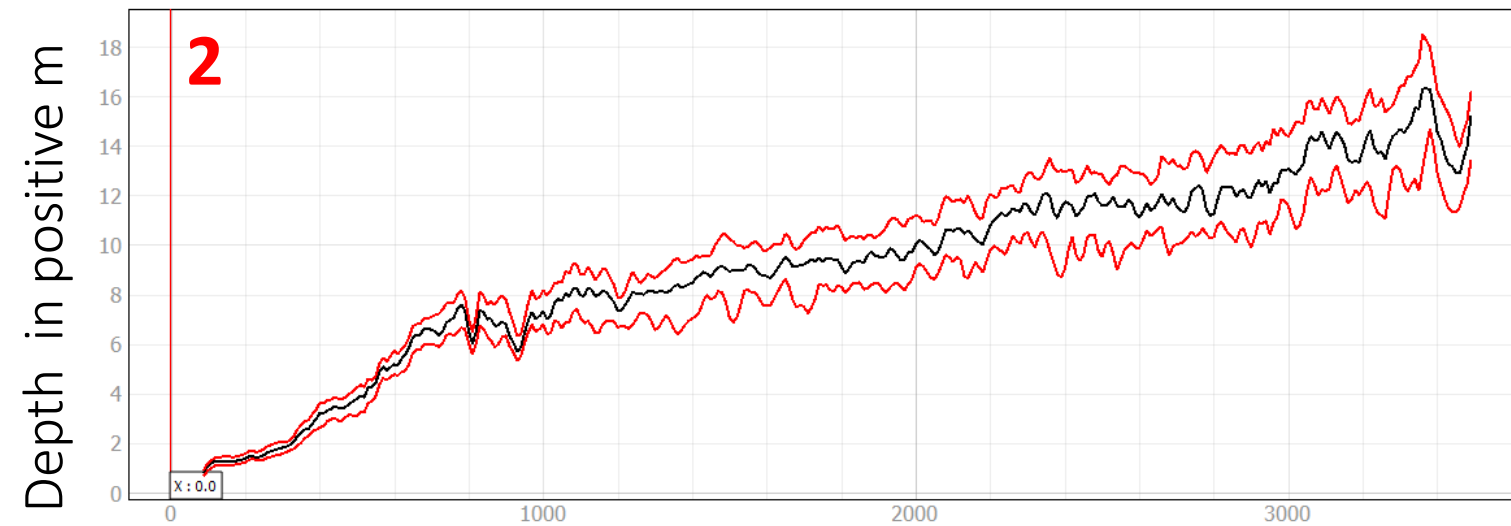
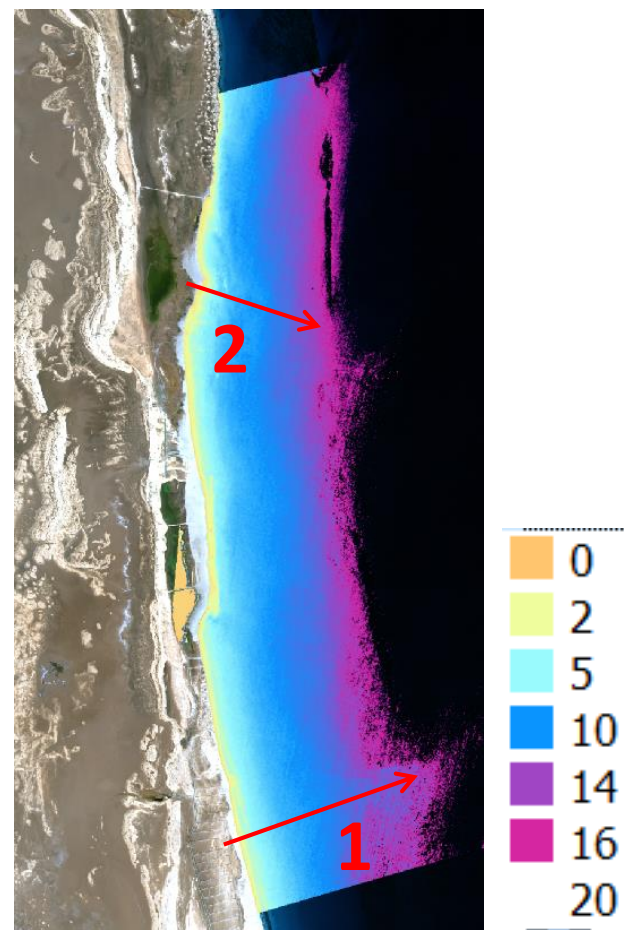
- the modelling of uncertainties of the satellite sensor and SDB model uncertainties for various environmental conditions (and tides)
 - Uncertainties required for each coordinate
 - Repeatability of procedures
- Physics based modelling of uncertainties together with the depth calculation

Vertical uncertainties, comparison SDB with MBES



Fully physics based processing, No training datasets, no parameter tuning

Vertical uncertainties, Watcor-X



Supporting navigation and engineering activities, Gulf region

SPE-188714-MS

Acquisition of Satellite Derived Bathymetry Data for Offshore Engineering Projects - Island Case Study

Jayaprakash Athmaram & Ashish GS Srinivasan, ZADCO

After detailed multi-level quality checks for various systematic and non-systematic errors, the most reliable bathymetry that was found to meet ZADCO selection criteria was noted to be between 0m and 3m water depths, with an error of $\pm 0.3\text{m}$. Water depths between 3m and 5m presented themselves with an error of $\pm 0.4\text{m}$, whereas for depths between 5m and 10m, the errors varied between 0.5m to 1.0m. It was found that in the extreme nearshore areas with depths between 0m and 3m water depths, SDB could

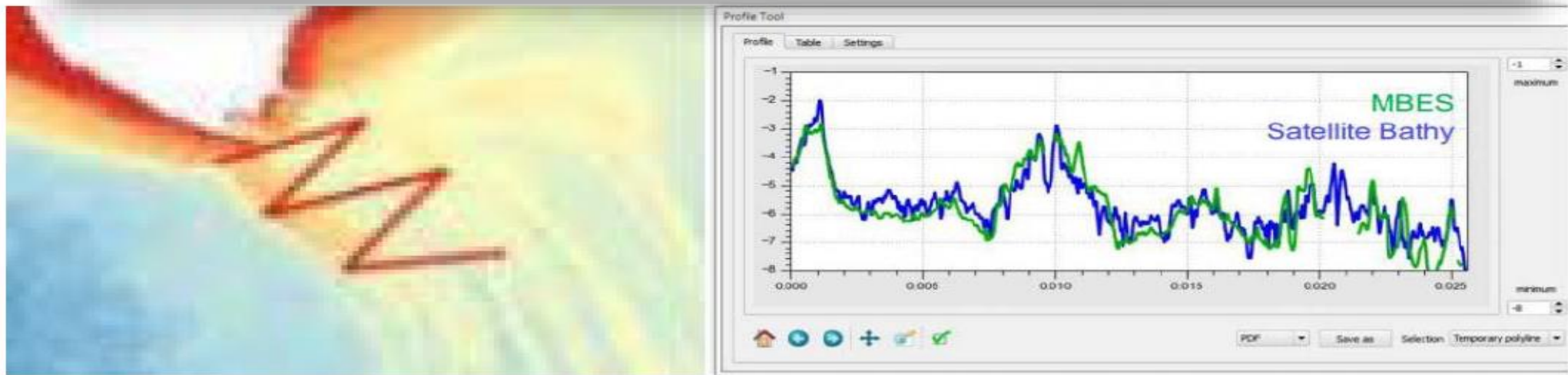


Figure 17: Correlation between Multibeam Survey Data and Satellite Derived Bathymetry

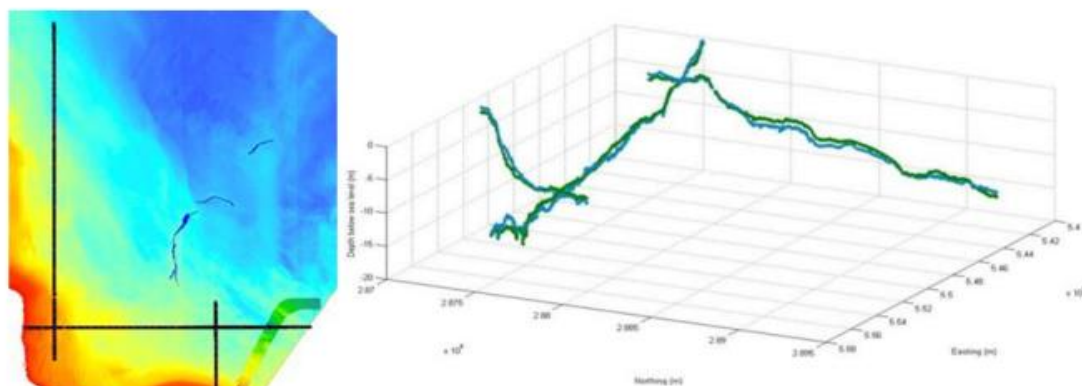
Supporting navigation and engineering activities, Gulf region

IPTC-17346

Satellite derived Bathymetry and Digital Elevation Models (DEM)

Joris Siermann, SPE, Qatar Shell GTL Limited; Craig Harvey, Qatar Shell Upstream International; Gareth Morgan, Shell Global Solutions International; Thomas Heege, EOMAP

VERIFICATION - BATHYMETRY

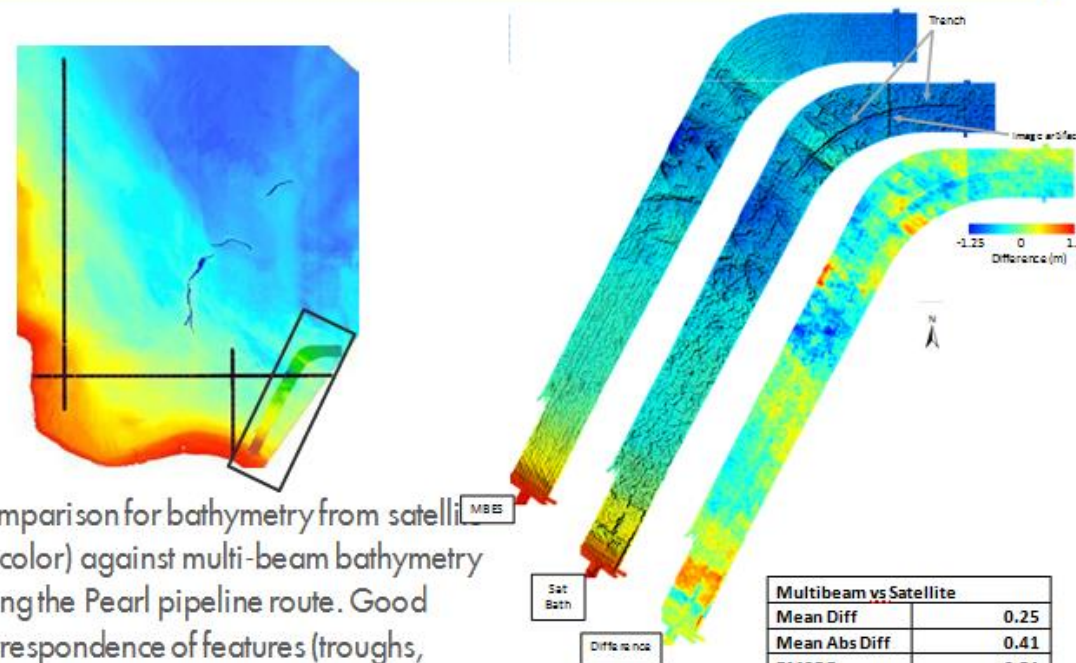


Comparison for bathymetry from satellite (in blue) against LIDAR bathymetry (in green) along 3 calibration lines

Average absolute error: 60cm

Sounding vs. Satellite (meter)	
Mean Diff	0.25
Mean Abs Diff	0.60
RMSQE	0.73

VERIFICATION - BATHYMETRY



Comparison for bathymetry from satellite (in color) against multi-beam bathymetry along the Pearl pipeline route. Good correspondence of features (troughs, highs). **Average absolute error: 41cm**

Multibeam vs Satellite	
Mean Diff	0.25
Mean Abs Diff	0.41
RMSQE	0.51

2 Standardisation and traceability of SDB processes and analytics

Standardisation and Traceability

Requires...

- a defined and operational process
- continuous documentation on parameters, variables and intermediate products.
- as little human interaction as possible
- Repeatability of procedures

→ Stand-alone software embedding fully physics based Satellite-Derived Bathymetry methods... WATCOR-X

Standardisation and Traceability



WATCOR-X [sdb.181018sn2.09153934sfb] (Keine Rückmeldung)

Project Settings Help

Required parameters

Sensor: Sentinel-2 Quick Mode: ☐

Input data: 18T090951_N0206_R050_T34SFB_20181018T112317.zip

Export directory: E:\WATCOR_X\ybia

Start

Optional parameters

Tidal correction [m]: 0.0000

Validation file:

Exit

Workflow Control

Select shallow and deep water areas

Import satellite data

☐ Masking

Adjacency correction

☐ Atmospheric and water parameter estimation

Bottom spectrum retrieval

☐ Water depth retrieval

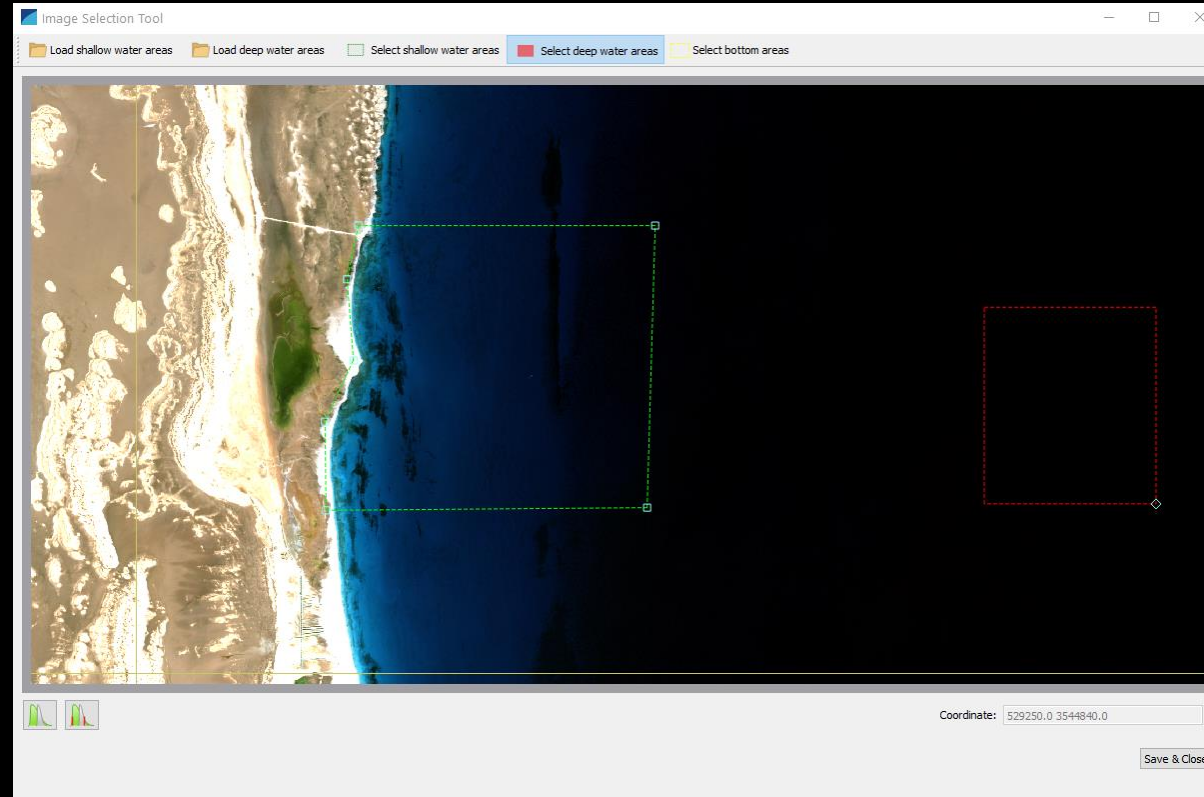
Postprocessing

Export results

EOMAP

WATCOR-X pyhsics based SDB software

Standardisation and Traceability



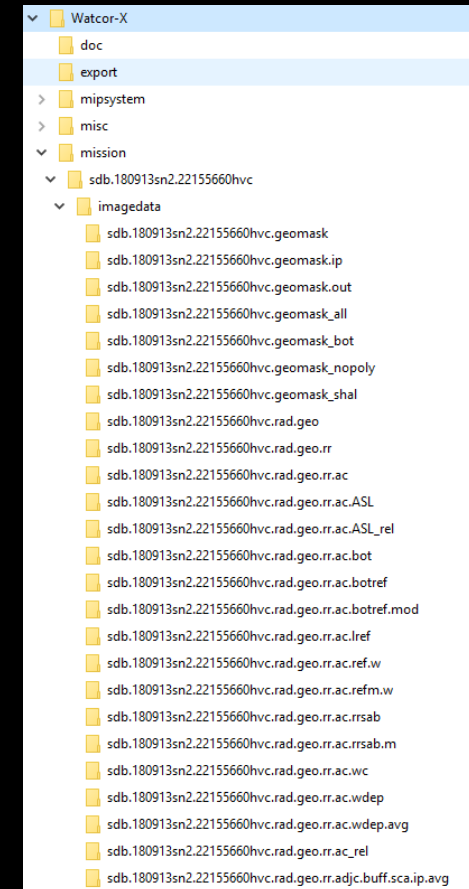
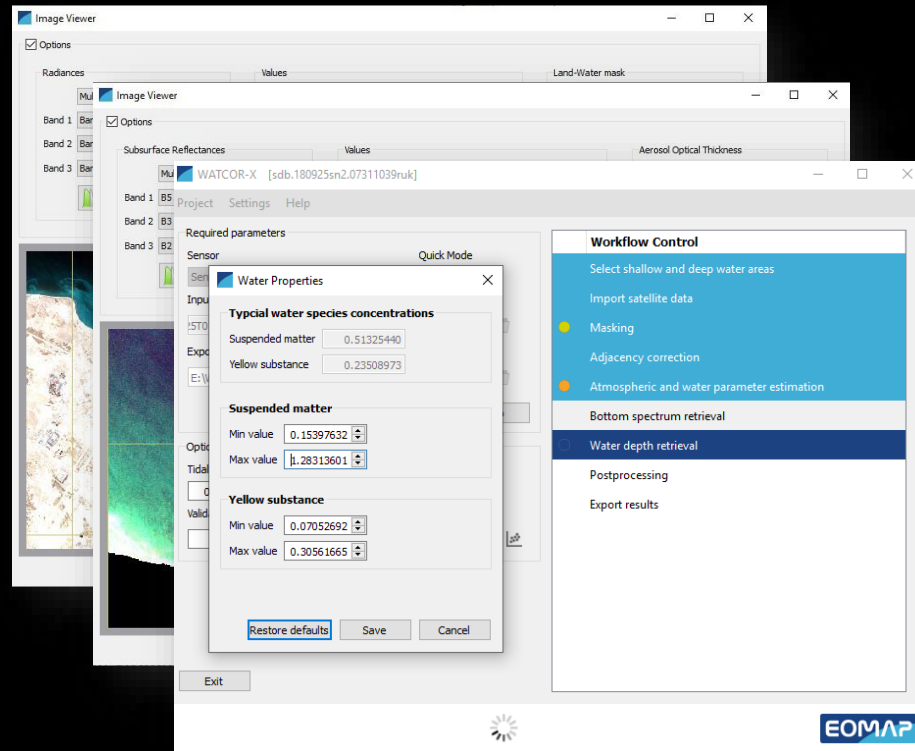
WATCOR-X pyhsics based SDB software

Standardisation and Traceability

Desktop
Software

Standardized, repeatable and
traceable processes

All data and side products
accessible and open



WATCOR-X physics based SDB software

3 Trained personal

Trained personal (*remote surveyors*)

Trained personal required for SDB procurement, quality assessment and control, satellite-derived bathymetry **analysis**.

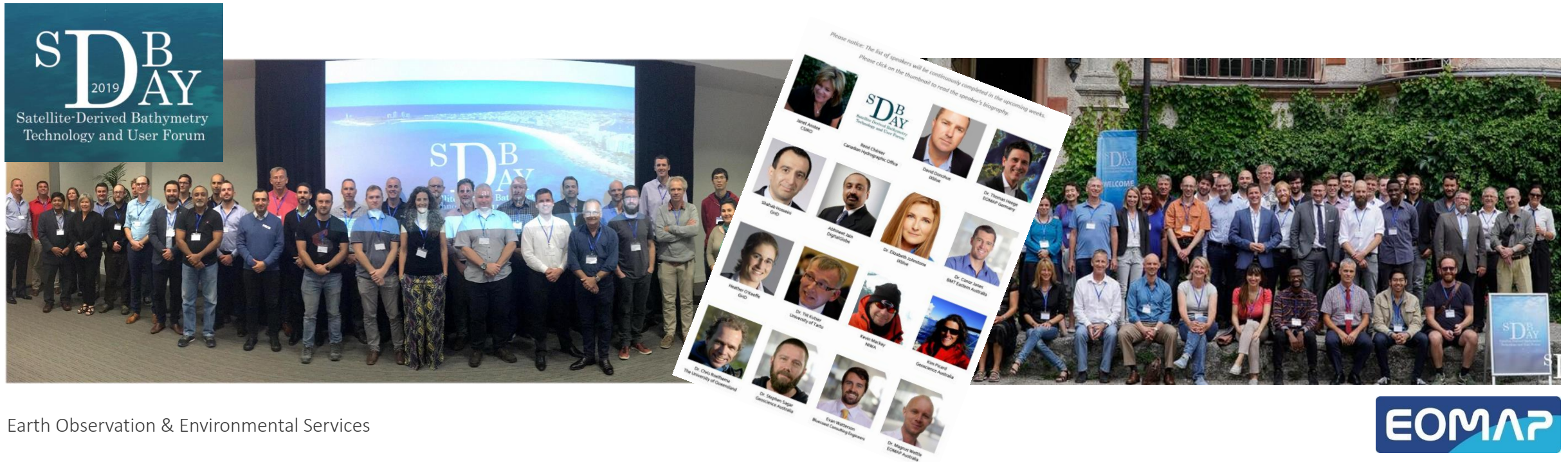
(Mandatory) skills require:

- Image interpretation and analysis
- Satellite image feasibility classification
- Satellite Derived Bathymetry analyses training
- Access to relevant SDB software
- QA/QC processes on SDB data



Capacity building and training

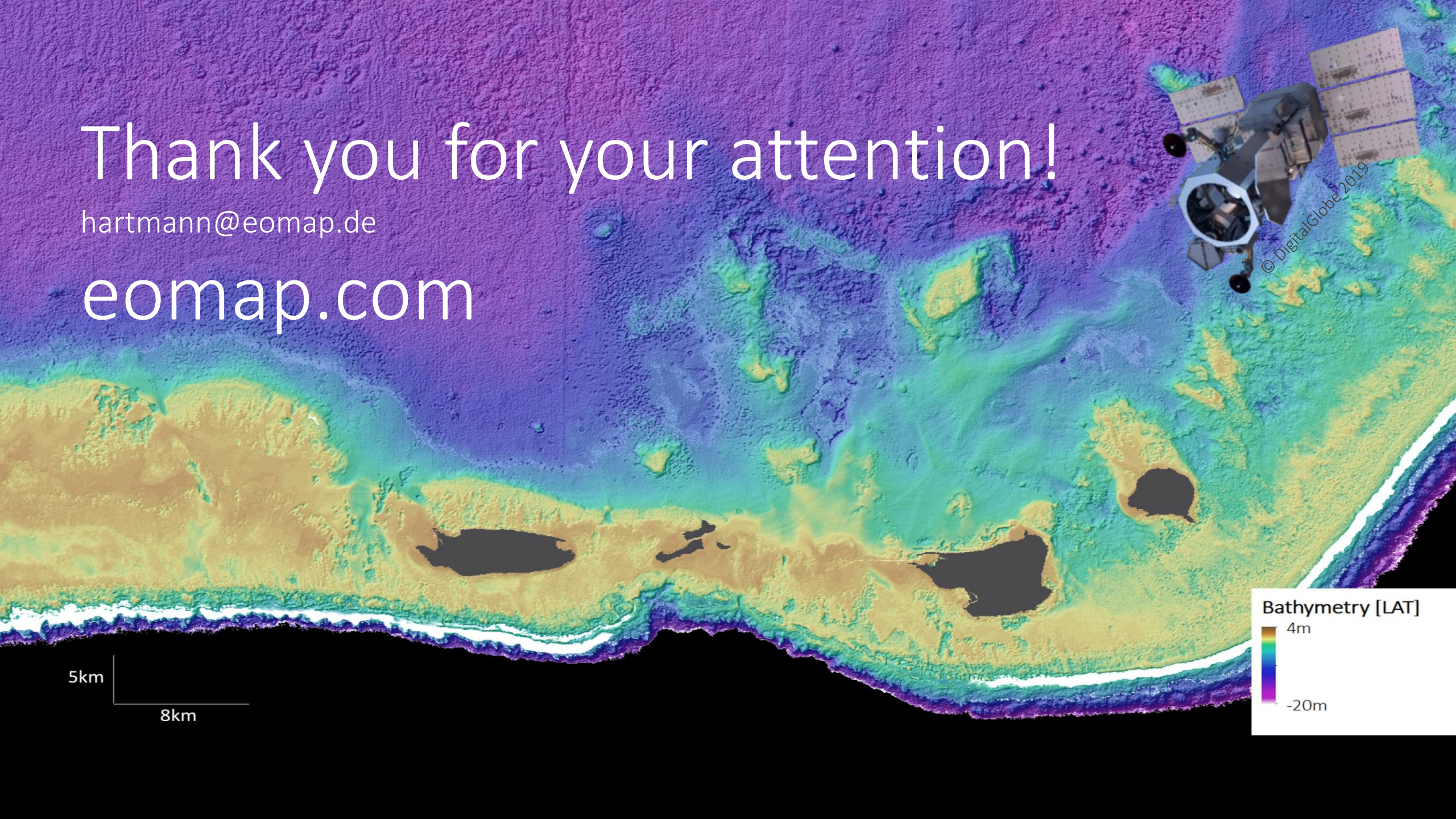
- Organising and main sponsor of the annual SDB Day Conference since 2018
- Frequent participation in regional IHO conferences and meetings
- Member of the national regional hydrographic society and maritime cluster
- Lead and member of international research and innovation activities



Thank you for your attention!

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eomap.com



5km

8km

Bathymetry [LAT]

4m

-20m