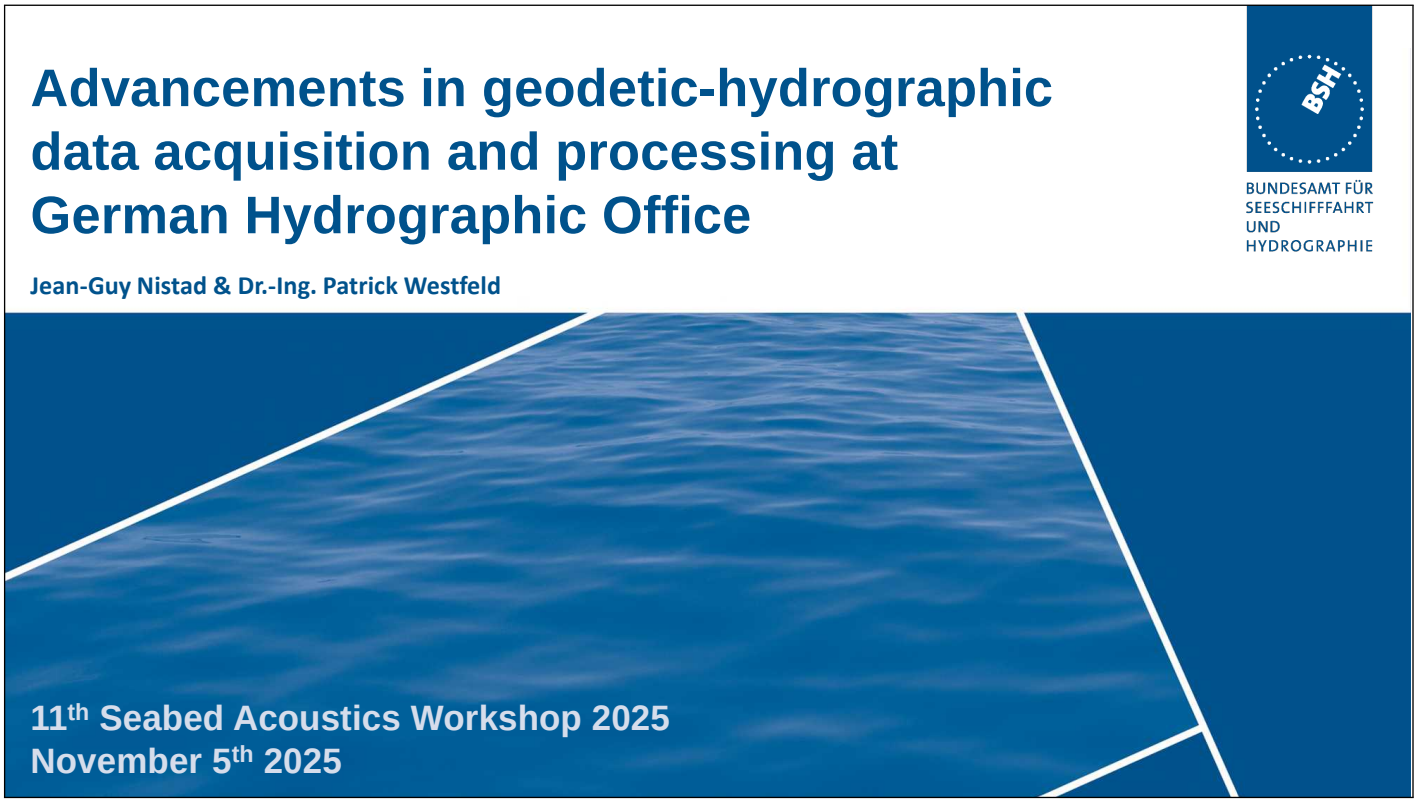
Proceedings of the 11 th Workshop "Seabed Acoustics", Presentation P01:

Advancements in geodetic-hydrographic data acquisition and processing at German Hydrographic Office

Jean-Guy Nistad
Federal Maritime and Hydrographic Agency (BSH), Germany

5 th November 2025



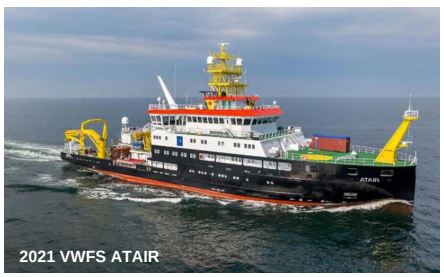
The BSH.

In the service of maritime navigation and the seas

- Centralized maritime agency
- Under jurisdiction of the Federal Ministry of Transport
- We promote sustainable use of the oceans, protect the marine environment, and thus the climate.

The BSH

- **Employees: ca. 1000**
- **Offices in Hamburg und Rostock**
- **Marine Chemistry Laboratory in Hamburg-Sülldorf**
- **5 ships for the North Sea and the Baltic Sea**
- **Biggest governmental marine research institution in Germany**
- **6 divisions:**
  - Marine Sciences
  - **Nautical Hydrography**
  - Management of the Sea
  - Maritime Shipping
  - Central Services
  - Maritime Data Center

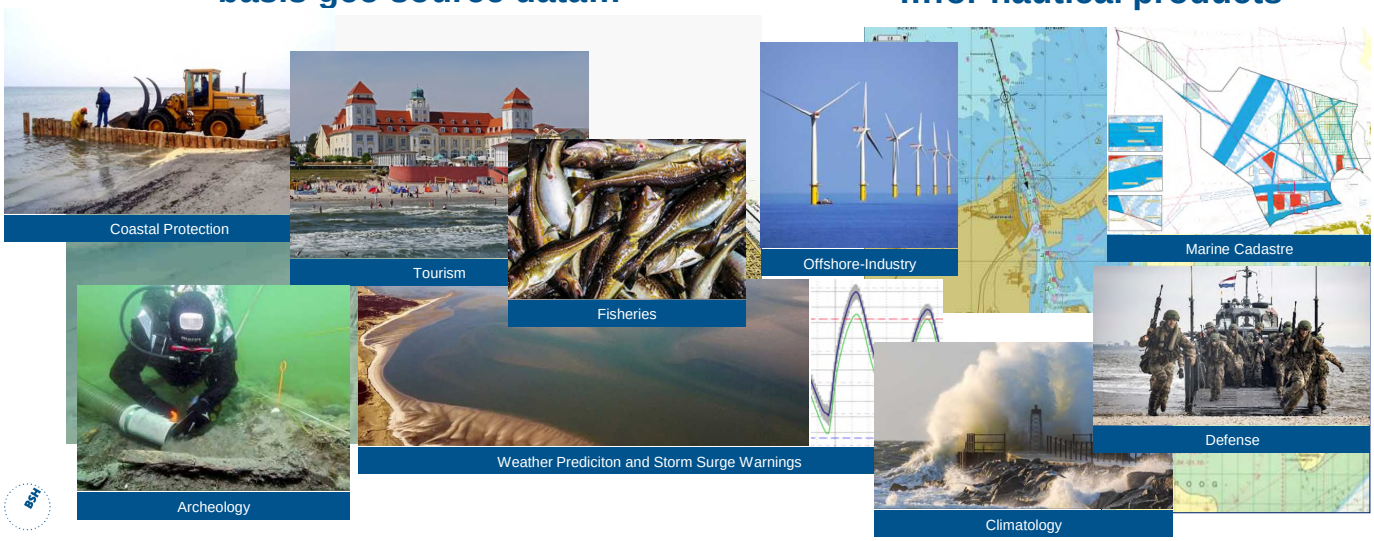


4

Nautical Hydrography

Traditionally,

basis geo source data… **…for nautical products**



Diverse Clients

with

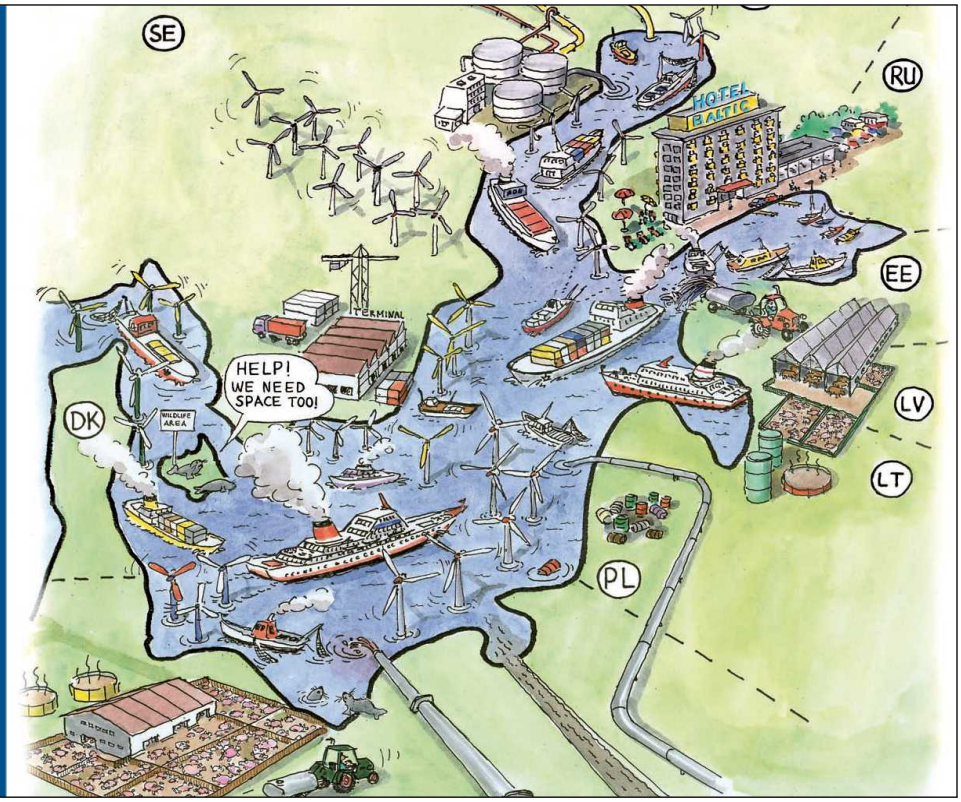
differing interests

and

high **demands in terms of** quality, up-to-dateness, usability

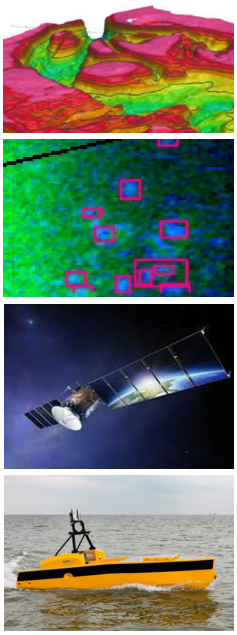
requires

continuously development.



Development Priorities

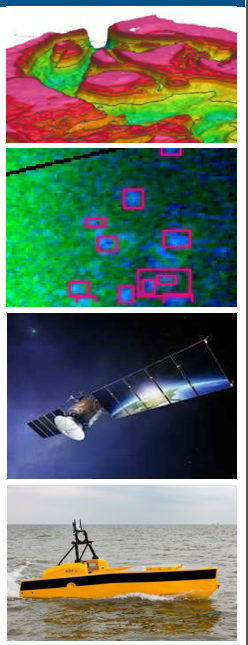
- **Increased use of automation**
- **Fully digital processes**
- **Increased transparency through Open Data**
- **Latest measurement techniques**
- **Alternative measurement platforms**



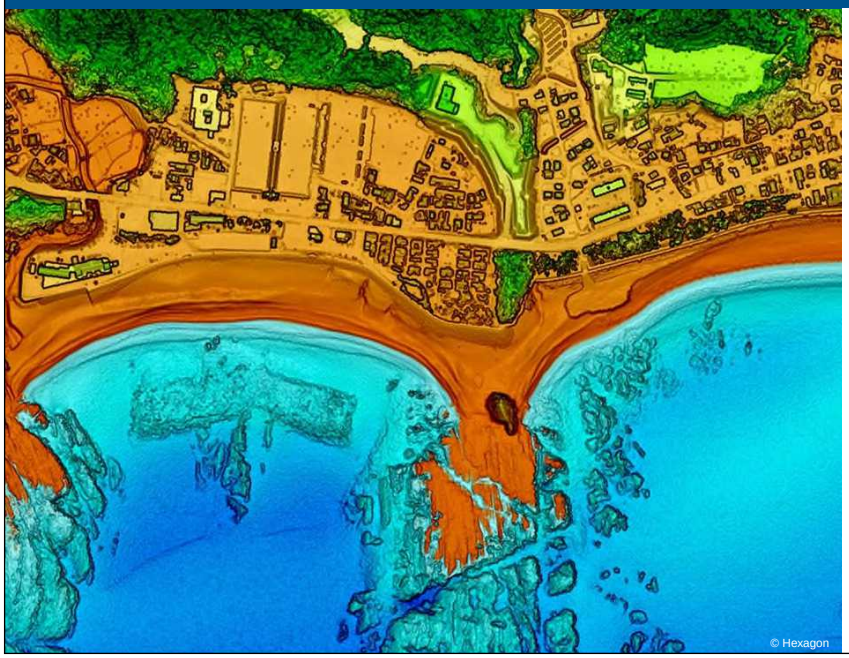
Examples of R&D hydrographic projects

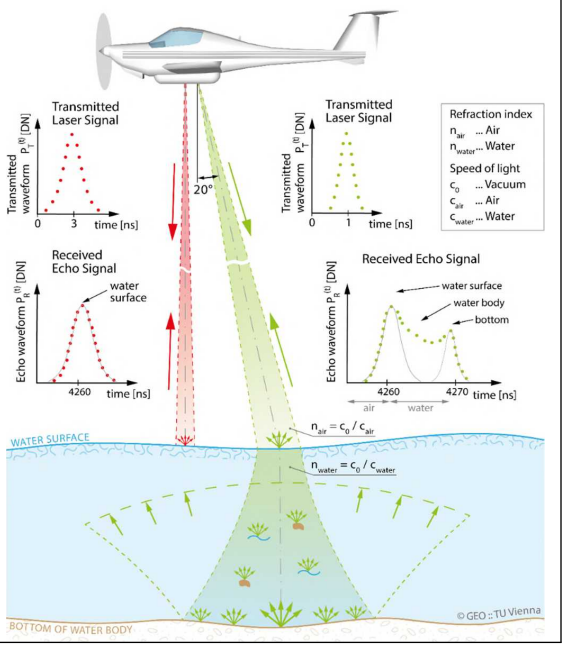
from applied research to operational use

1. **Airborne Laser Bathymetry (ALB)** for an efficient data collection of near-shore shallow areas.
2. **Satellite Derived Bathymetry (SDB)** for optimal survey planning.
3. **AI-Boulder Detection** for rapid, reliable and objective analysis of **Big Data**.



ALB
Measurement Principle



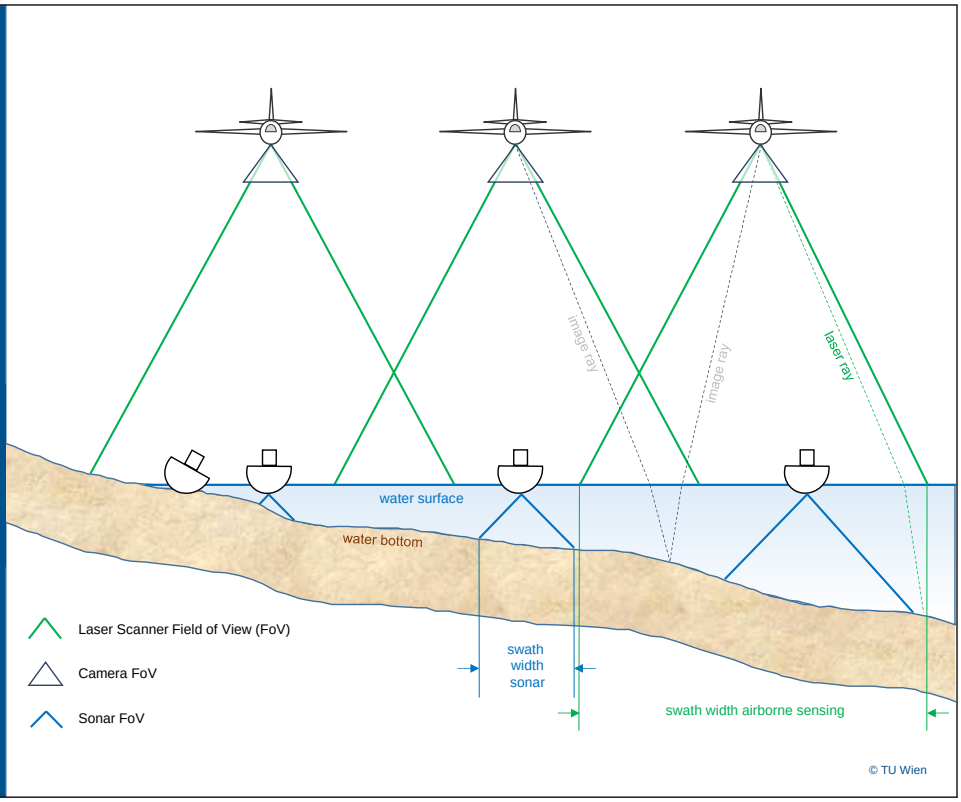


ALB

Efficient data collection in near-shore shallow depth areas

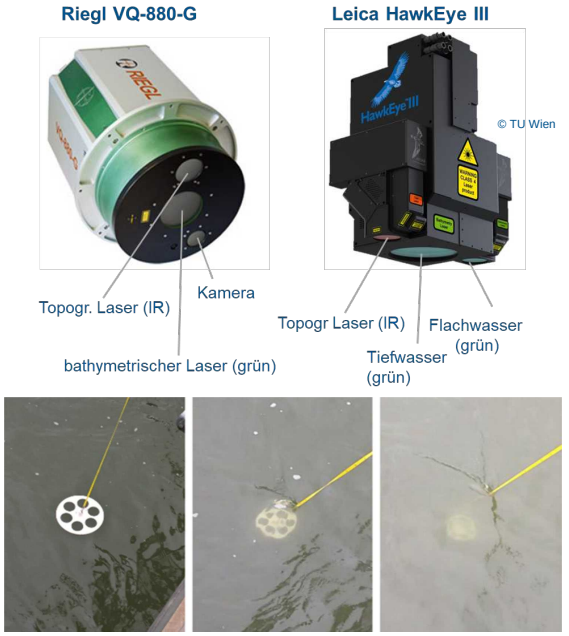
Surveying the near-shore shallow depth areas of the North Sea (< 10m) accounts for 80% of the survey effort (time)!

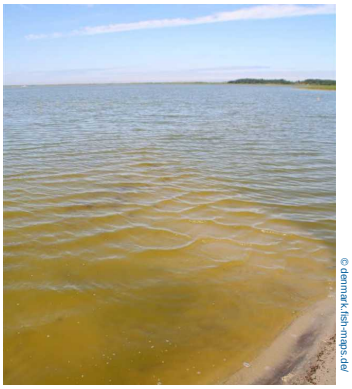
Yet these areas account for only 20 % of the total area to suvey.



ALB

A question of optical penetration

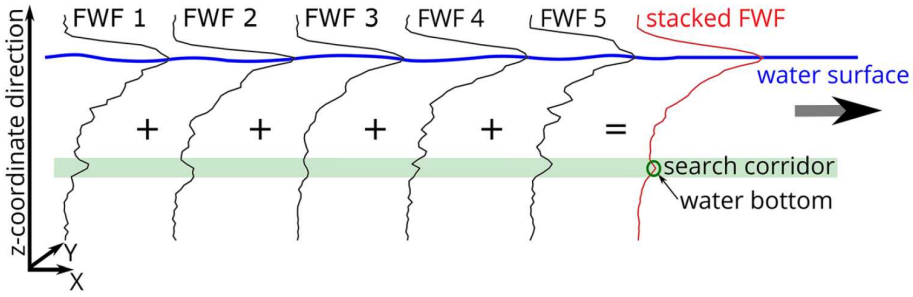




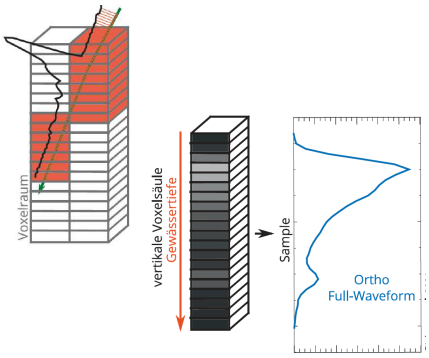
ALB in the near-shore areas of the North Sea

TECHNISCHE UNIVERSITÄT DRESDEN

- Novel Full Waveform Stacking Approach
- Improvement in bottom detection (penetration and coverage)



Signal (upper plot) or volumetric (right figure) Full Waveform Stacking



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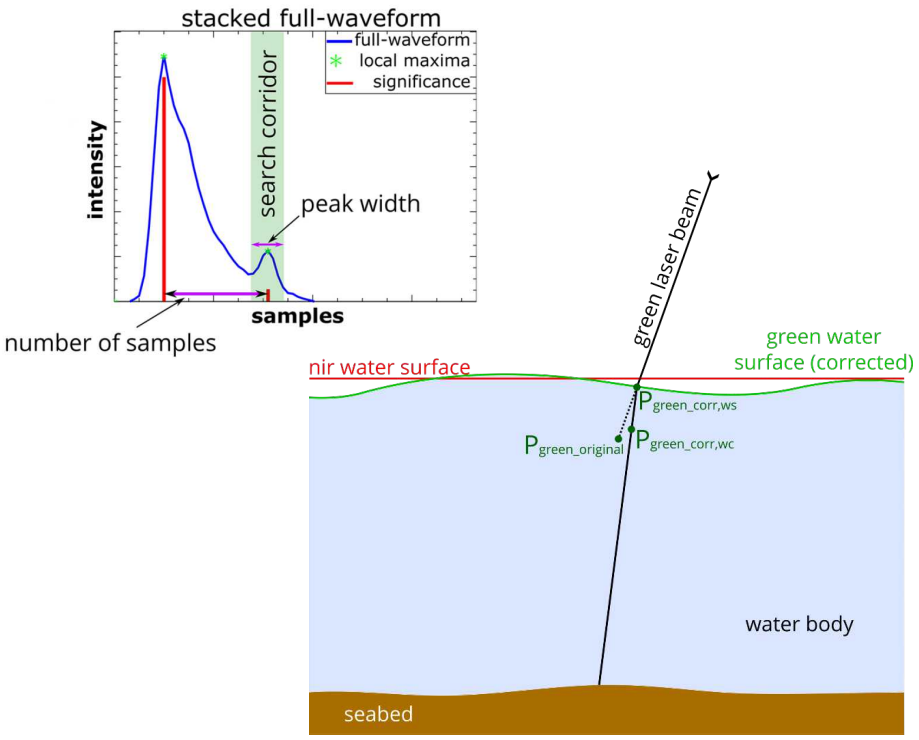

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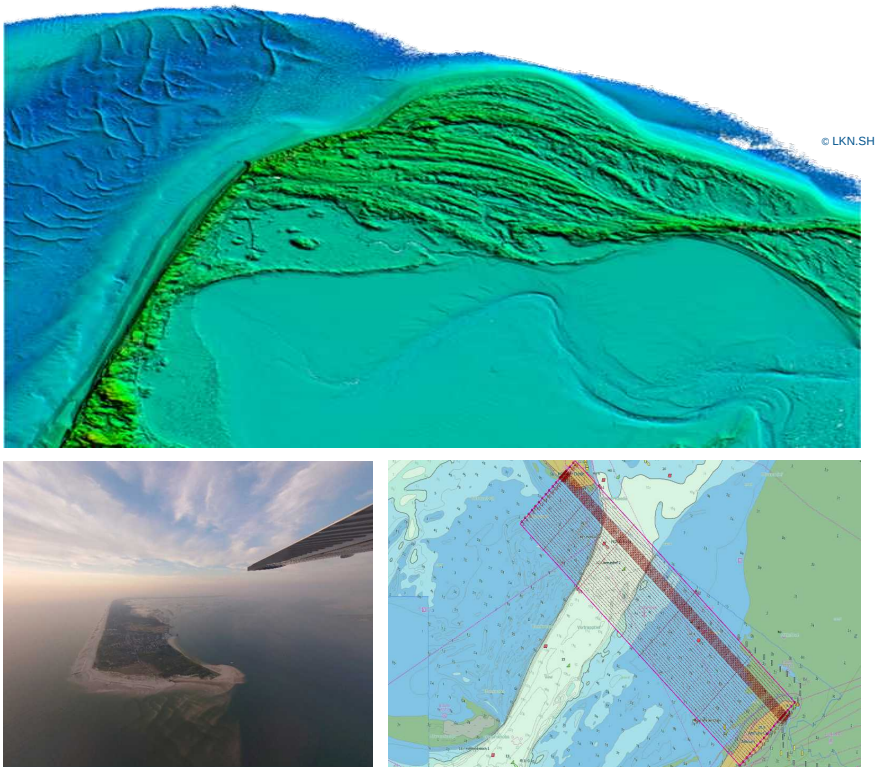

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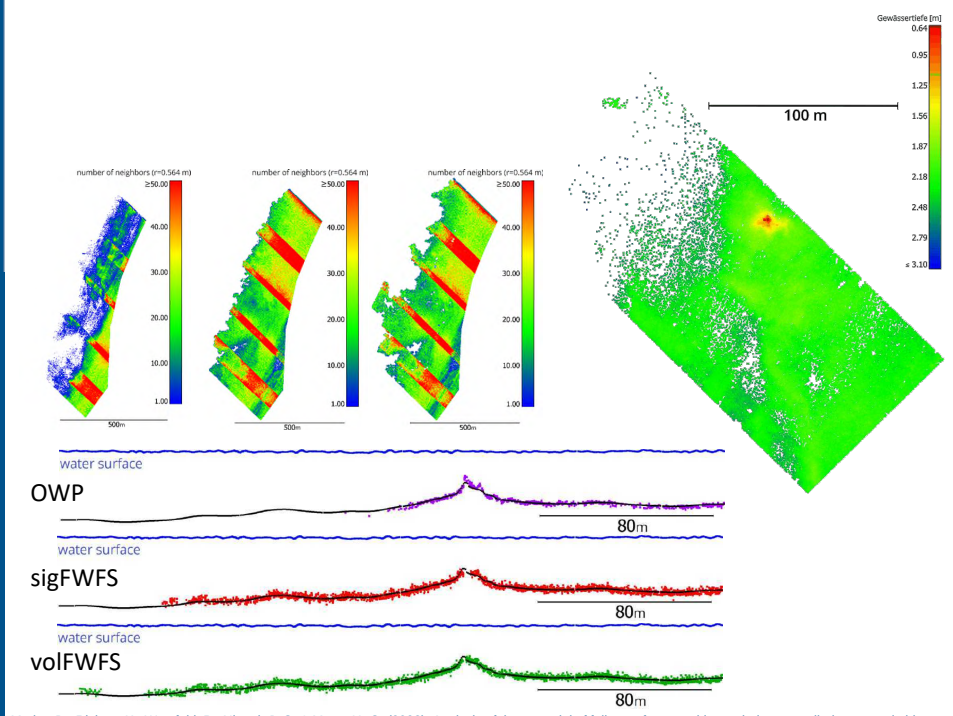

Mader, D., Richter, K., Westfeld, P., Nistad, J.-G. & Maas, H.-G. (2023). Analysis of the potential of full-waveform stacking techniques applied to coastal airborne LiDAR bathymetry data of the German Wadden Sea National Park. *The International Hydrographic Review*, *29*(2), https://doi.org/10.58440/ihr-29-2-a31

ALB in the near-shore areas of the North Sea

- Novel Full Waveform Stacking Approach
- Improvement in bottom detection (penetration and coverage)
- Development of quality control schemes

For more information:

Mader, D., Richter, K., Westfeld, P., Nistad, J.-G. and Maas, H.-G. (2023). **Analysis of the potential of full-waveform stacking techniques applied to coastal airborne LiDAR bathymetry data of the German Wadden Sea National Park**. *The International Hydrographic Review*, *29*(2), https://doi.org/10.58440/ihr-29-2-a31

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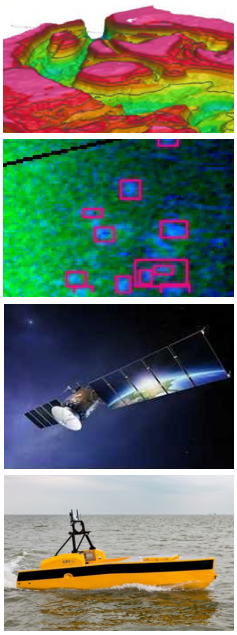
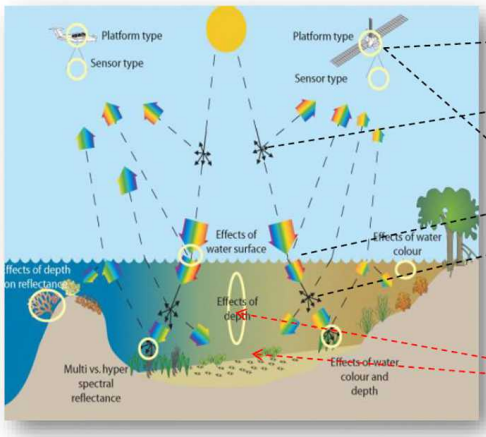
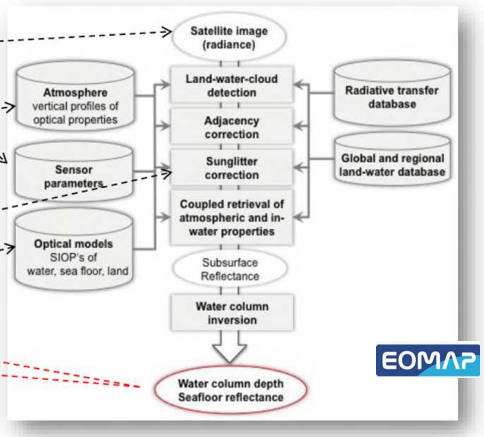


Depth determination from multispectral sensors

Schema of the light signal measured by optical satellites



EOMAP's mathematical translation of the system



pixel = *f(atm., adjacency, water surface, aborbers and backscatterers of the water column, seafloor, water depth, seastate, sun and sensor geometry, SNR ratio)*

Pe'eri, S. et al. (2014). Satellite Remote Sensing as Reconnaissance Tool for Assessing Nautical Chart Adequacy and Completeness, *Marine Geodesy*, 37(3), 293–314.
Stumpf, R., Holderied, K. & Sinclair, M. (2003). Determination of water depth with high-resolution satellite imagery over variable bottom types, Limnology and Oceanography, 48, 547–556.

Depth determination from multispectral sensors

Contrasting water clarity for the Seychelles (Indian Ocean, left) with the island of Sylt (German North Sea, bottom)

SDB for Monitoring

Satellite-based operational planning of hydrographic resources

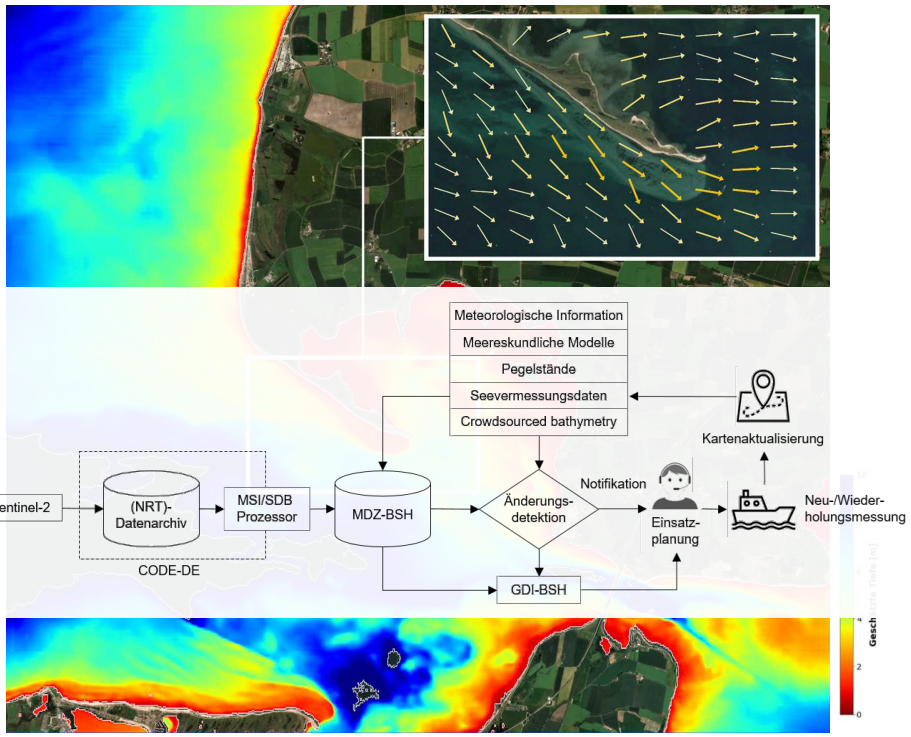
2022–2025

Bundesministerium für Digitales und Verkehr

DLR

Copernicus Europas Blick auf die Erde

- Development of a process to reliably detect changes in seabed topography
- Implementation of a prototype operational service



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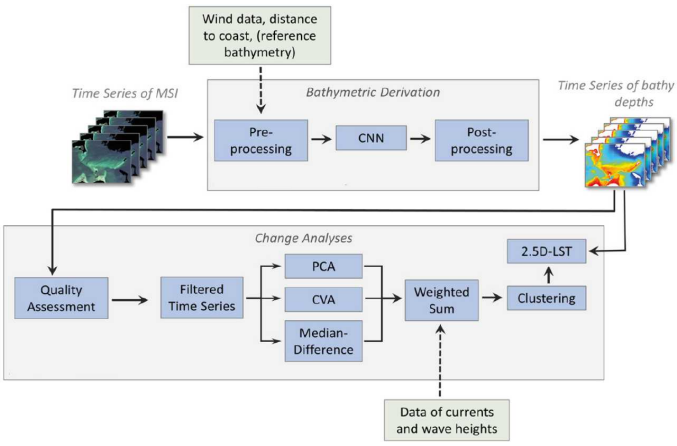

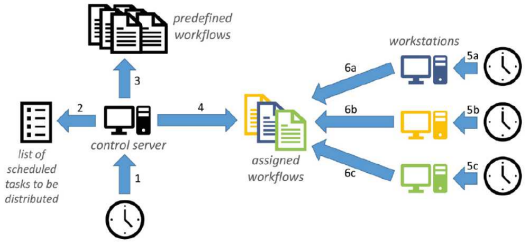

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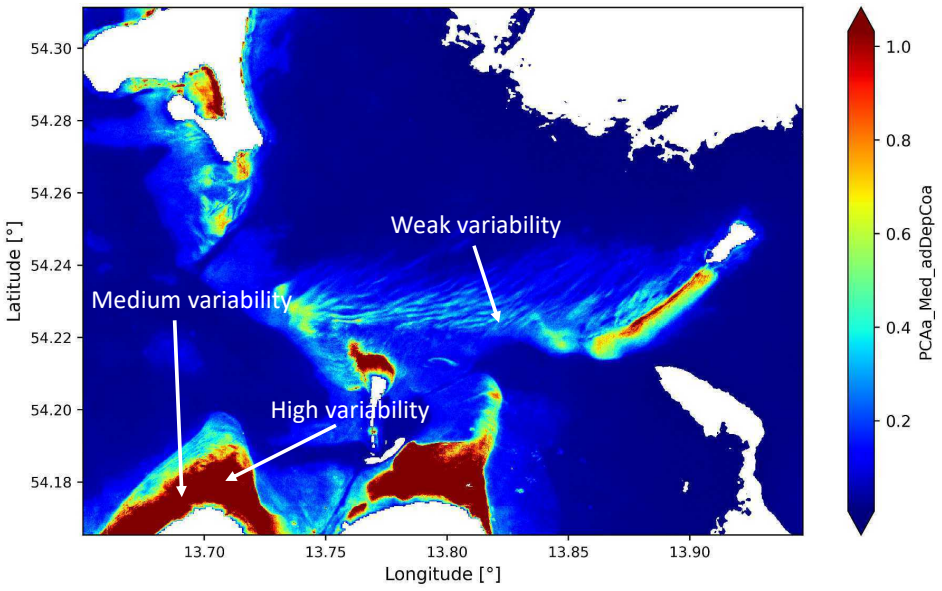
Use of spatiotemporal change detection methods on bathymetry, wave height and surface currents to identify areas of variability



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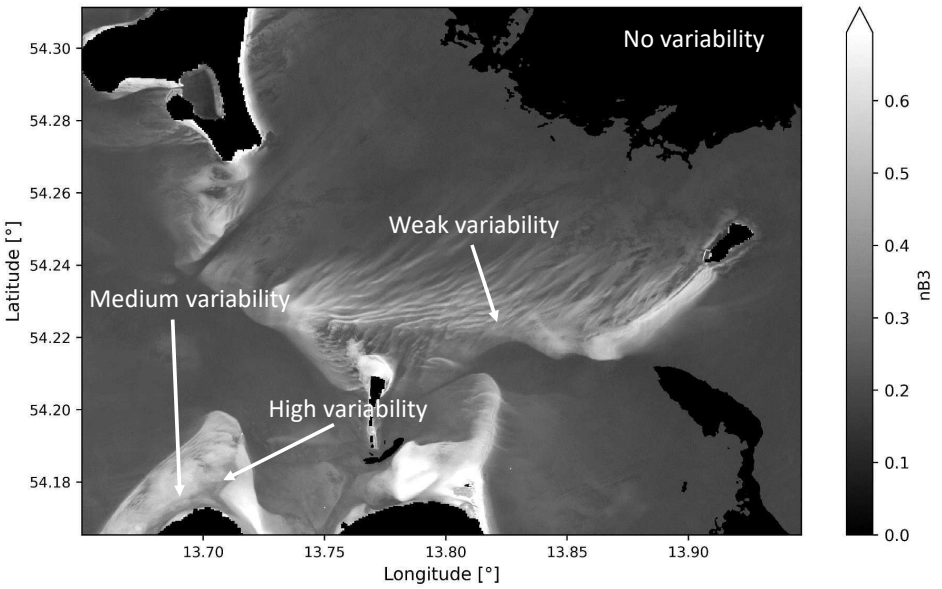
BSH

Multispectral bands from B1 (*coastal aerosol*) to B8 (*near infrared*) of a Sentinel-2 image sequence



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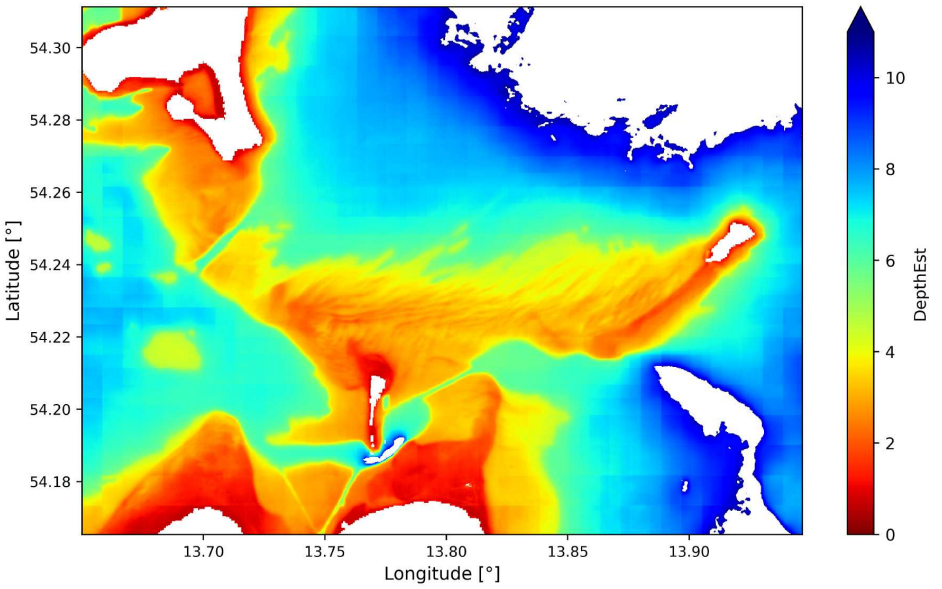
BSH

AI-based spectral depth determination to derive the seabed topography of shallow depth areas



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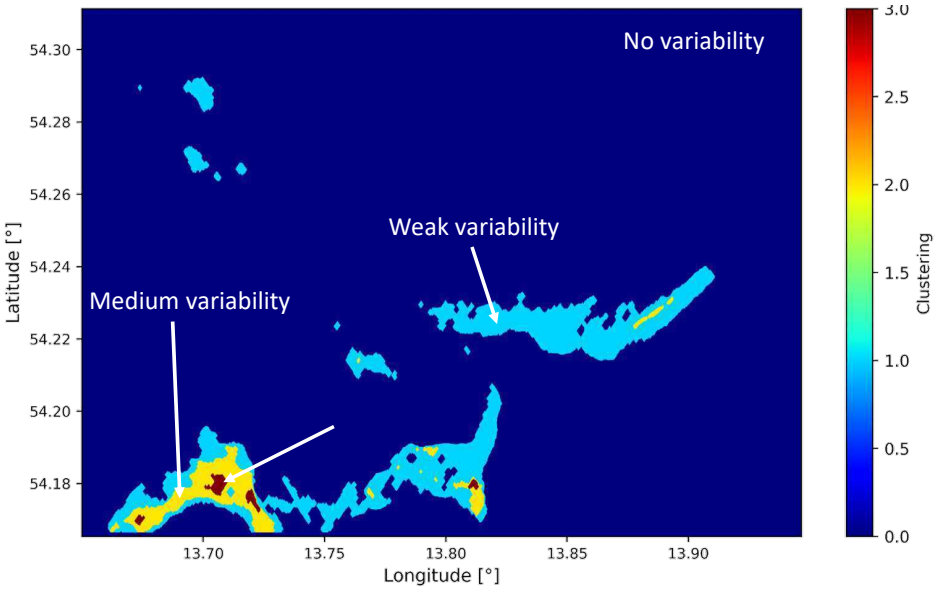
Clustering of areas with seabed variability



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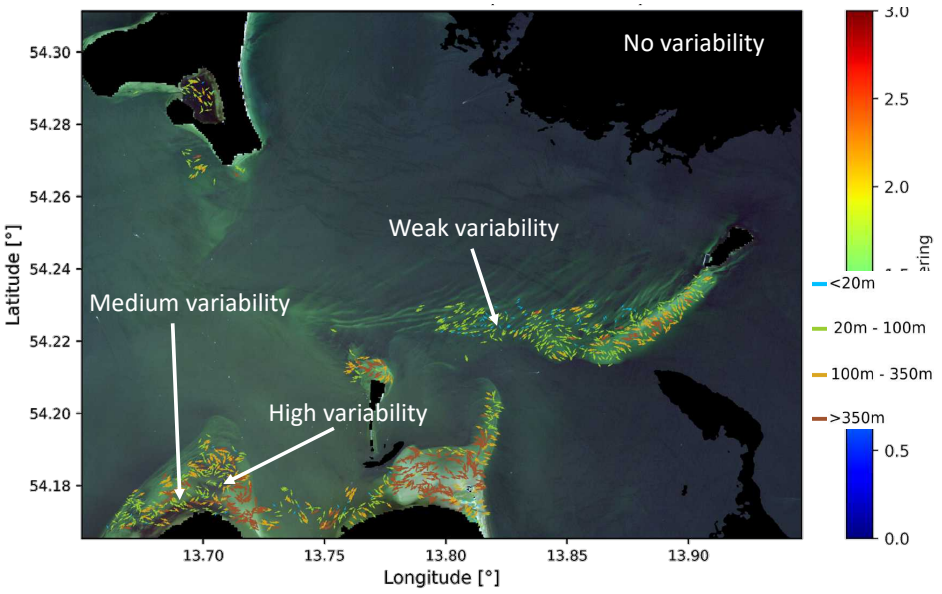
2.5D least-squares tracking to derive the vector field of seabed changes



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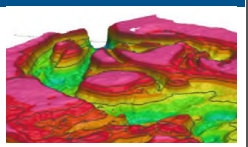
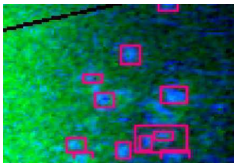

Data Analysis

AI-Based Boulder Detection in Sonar Data

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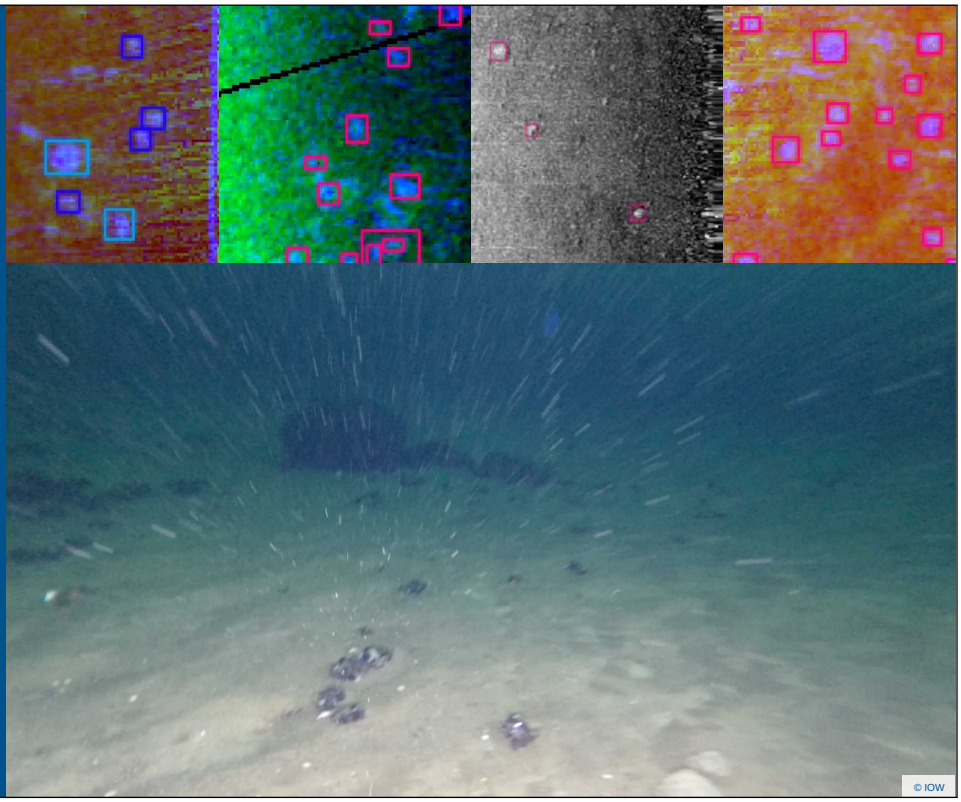
IOW

- Development of an AI-based procedure to locate and identify boulders in acoustic data.
- Development and Release of an operational software.



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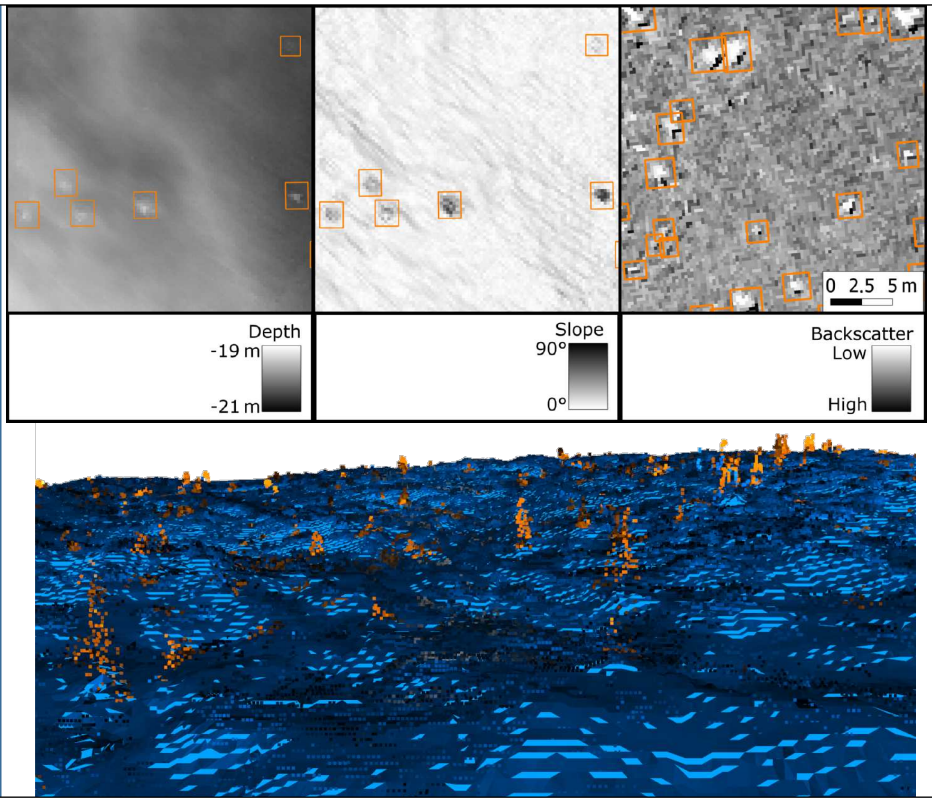
Data in Raster or 3D Point Cloud Form

- Sidescan data imagery
- Multibeam depth (and slope)
- Multibeam backscatter



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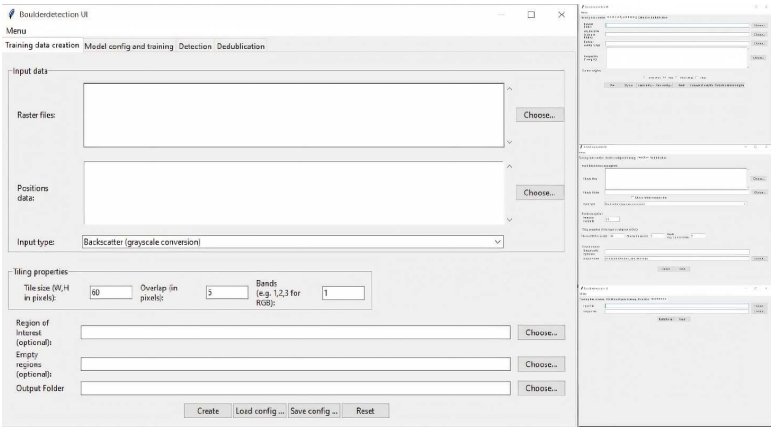
Operational Software

- For non-programmers
- Scalable
- Python based

T1: Boulder annotation
T2: Ground Truth creation
T3: Training and validation
T4: Testing
T5: Detection in a production environment
T6: Mitigation of shortcomings

Existing feature
Under development



Data Analysis

AI-Based Boulder Detection in Sonar Data

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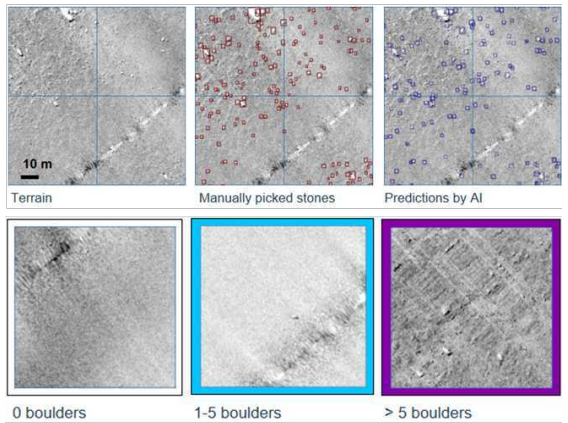
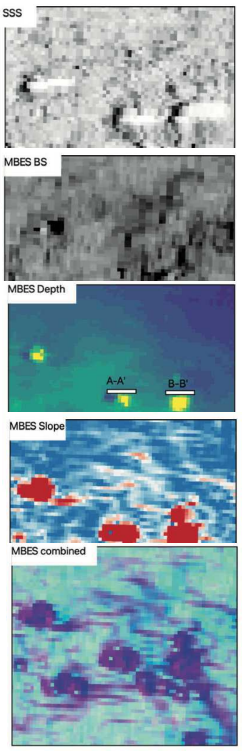
Results

- Rapid, reliable and objective analysis.
- Clustering in 50m x 50m regions for habitat mapping.
- Very good agreement with expert annotation.





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For more information:

Hinz, M., Westfeld, P., Feldens, P., Feldens, A., Themann, S., Papenmeier, S. (2024). **AI-based boulder detection in sonar data – Bridging the gap from experimentation to application.** *The International Hydrographic Review*, *30*(1), pp. 78-98. https://doi.org/10.58440/ihr-30-1-a08

Have a fruitful workshop!

Federal Maritime and Hydrographic Agency
R&D in Hydrography and Geodesy
patrick.westfeld@bsh.de
jean-guy.nistad@bsh.de

www.bsh.de