NANOKnavi

- Nautical Navigations Operational Knowledge

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DHI at a glance

1000+ employees, 80% with an MSc or PhD degree

A **global network** with over 25 offices worldwide and footprint in more than 150 countries

GTS accreditation
UNEP-DHI centre
Foundation owned

State-of-the-art physical and digital **test facilities**

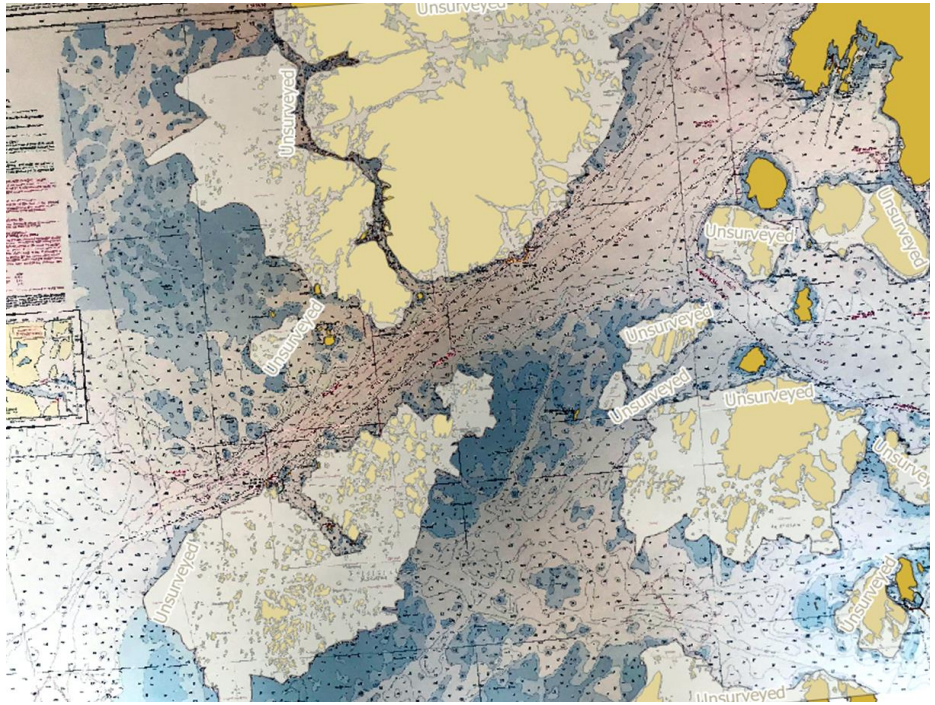
MIKE Powered by DHI

Advanced **technology and software**

Market-driven, co-creative **Innovation Centre**

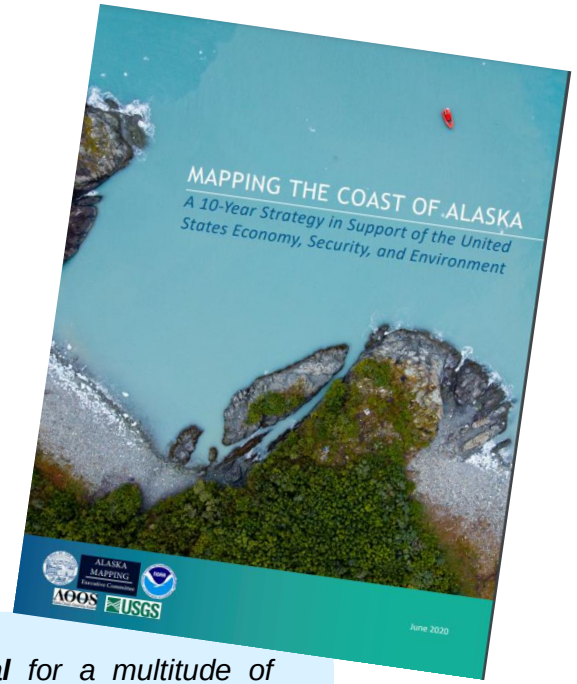
NANOKnavi – what's the problem?

Lack of near shore maritime information across Greenland (and larger parts of the Arctic), highly increases navigational risk and diminishes maritime operational capabilities across all maritime sectors.



"A major difficulty with the paper charts available for ***Greenland waters is the incorrect positioning of the coastline*** in the geographic net in the charts. In general, charts of the ***northern and eastern Greenland coastlines are misplaced by 0-5,000 meters***, and in some areas of the extreme northeast Greenland even more. Charts of the ***West Greenland coastlines are misplaced by 0-1,000 metres***."

DMA - IMO NAV 55/INF.6 21 May 2009



*"For Alaska, **coastal mapping data are critical** for a multitude of reasons, including informed management of coastal lands and Alaska Native trust resources; **safe navigation** in an ice-diminished Arctic…. **Community resilience** to coastal hazards such as flooding, erosion, and tsunami begins with mapping data to establish baseline conditions and model change."*

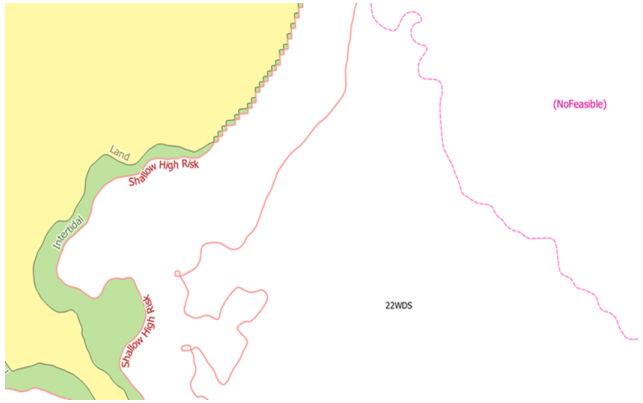
State of Alaska, Alaska Mapping Executive Committee, NOAA, USGS – Mapping the Coast of Alaska June 2020

NANOKnavi what it does

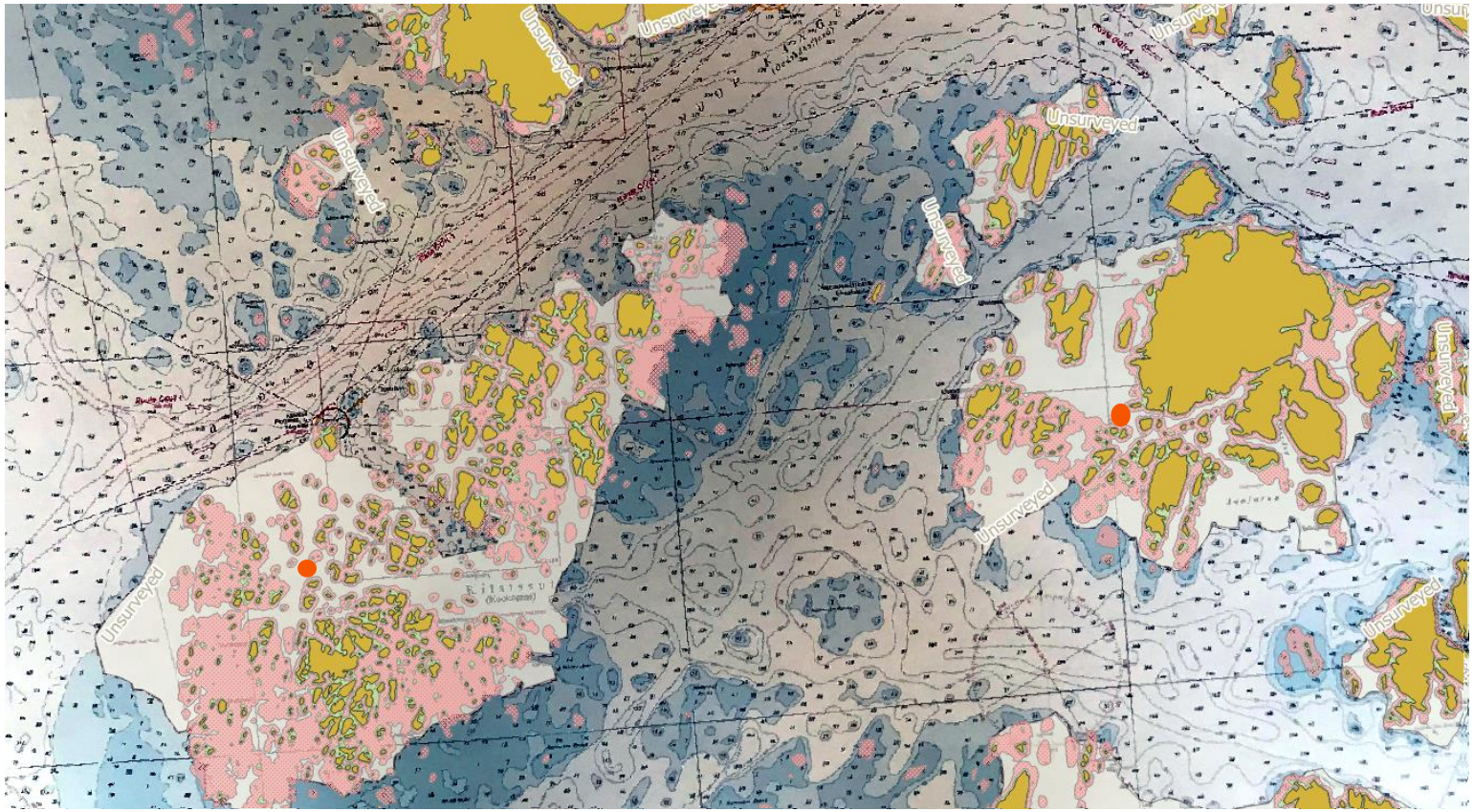
NANOKnavi provides satellite-based, on-board, screening regarding navigational high risk features in Arctic coastal regions. These features are: *submerged reefs* (0-9 meters depth), *intertidal zones* and *coastlines.* These are all features which needs certain attention, when navigating into unsurveyed or poorly surveyed coastal areas (eg. the red dots below). NANOKnavi thereby provides supplementary information to the existing official nautical charts.

Attributes mapped with NANOKnavi

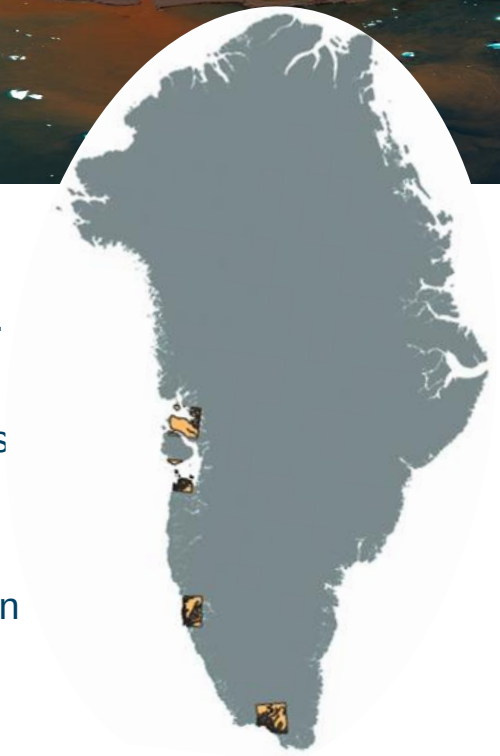
NANOKnavi is specifically tailored to onboard navigation systems for the Danish Navy (ECPINS using AMLs) and as second screen solution (GeoPDF or OpenCPN) for civil use.



AML visualisation for on-board use in existing naval navigation systems (ECPINS).

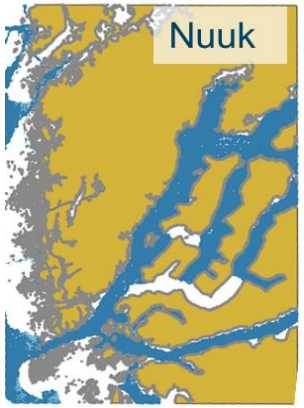


NANOKnavi what it is



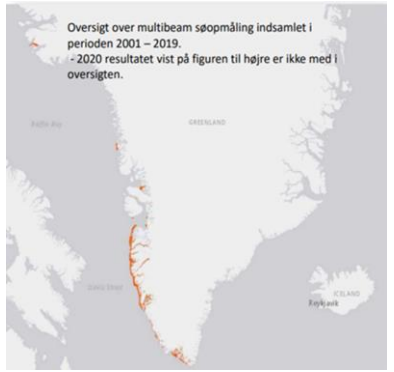
- The NANOKnavi mapping builds on DHI proprietary bathymetric retrieval model and machine learning applied on publicly available Sentinel-2 satellite data, i.e. spatial resolution of 10 m and horizontal accuracy of 12.5 m (CE95.5%).
- Multi-temporal methodology (every pixel is mapped based on multiple images) – enabling mapping of tidal zones, coas lines and removal of artifacts.
- Methodology is automated and scalable, i.e. well suited for large scale mapping – entire Greenland coastal zone can be mapped within one year.
- Validated against 19 years of bathymetric survey data in Greenland and ICESat-2 laser altimetry data.

NANOKnavi	Extent of current mapping
Total area	47.500km^2
Area reef zone	916km^2
Area Tidal zone	298km^2
Length coast line	13.218km



Validation of current mapping against existing survey data

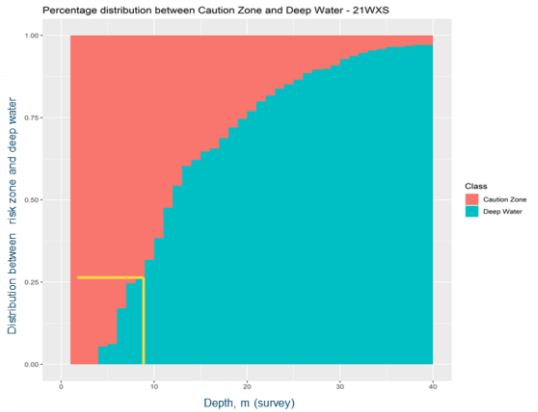
Hydrographic survey data, from Joint GeoMETOC Support Center at the Danish Defense Acquisition and Logistics Office.

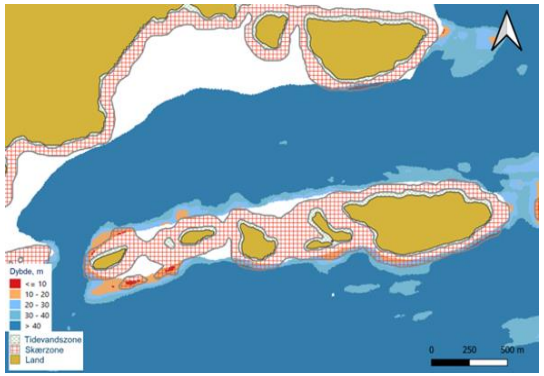


- Time period of data collection: 2001 - 2019
- Spatial resolution: 5m
- Total area covered 4479 km^2
- Data type: Multibeam, tidal corrected, data prepared for production of nautical charts.
- Survey data coverage is very scarce in shallow waters 4,9 km^2 (0-10m depth) and 37,9 km^2 (0-20m depth)

Validation against survey data

- Submerged hazard detection performance: 4m 100% detection rate 9 m 73% detection rate
- Mapping is conservative, i.e. high risk is enlarged due to optical spill over effects.



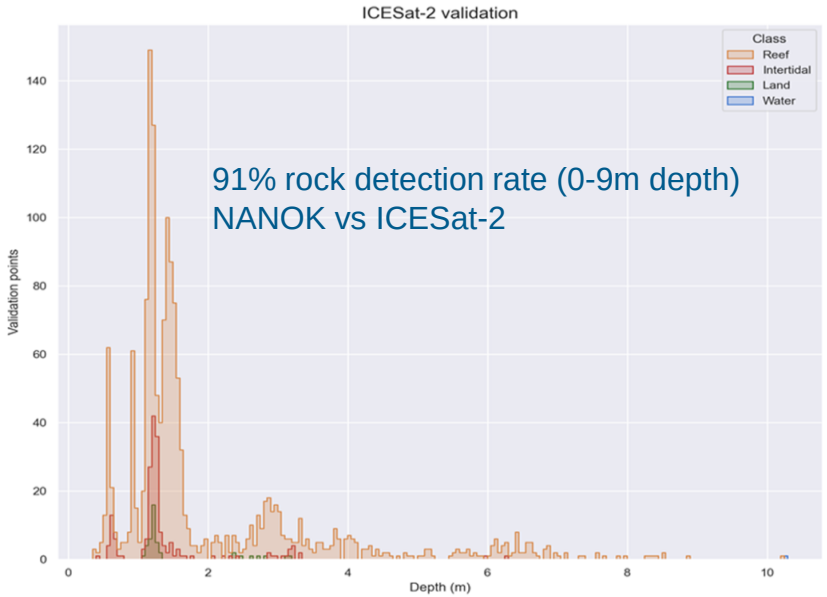


Validation against rock database

GeoMetoc submerged rock database	NANOKnavi detection rate
22WDS Nuuk	84%
21WXS Aasiaat	**91%**
23VMH Narsaq	77%
21WXU Uummannaq	80%
Over all	81%

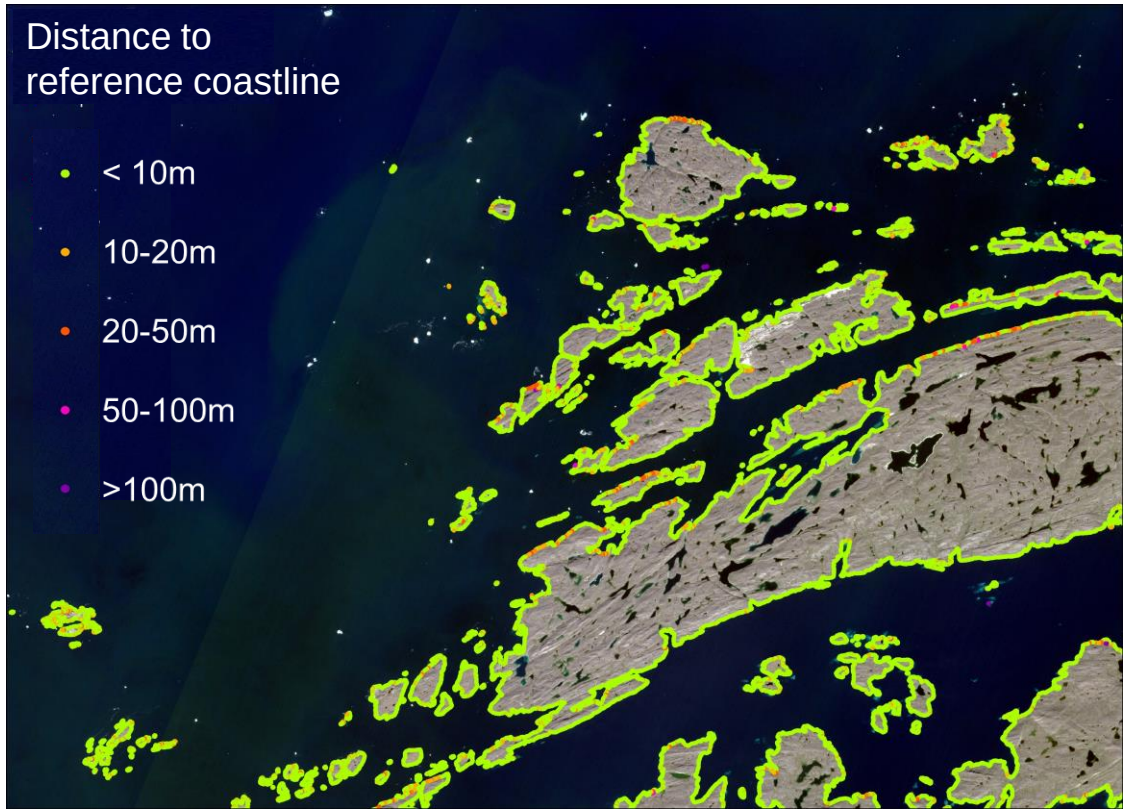
NANOK validation cont.

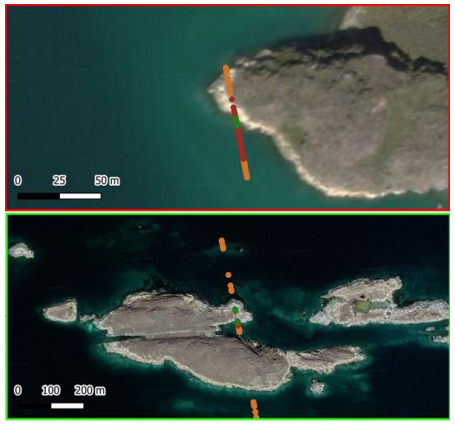
ICESat-2 validation



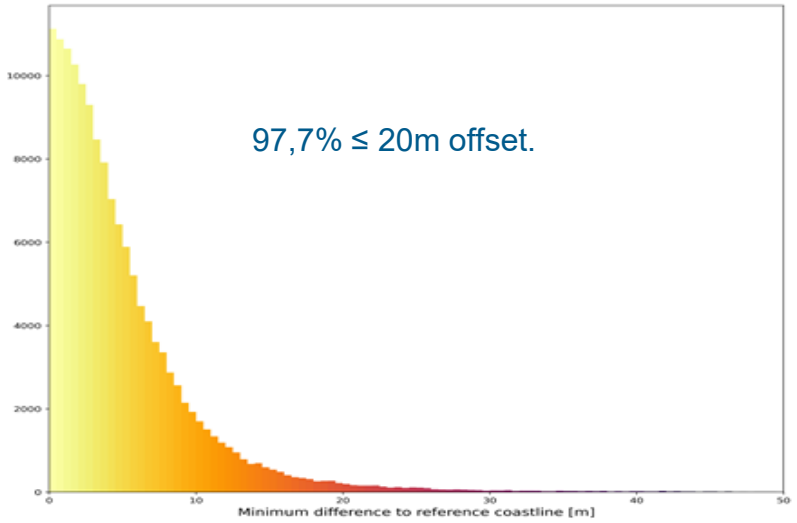
91% rock detection rate (0-9m depth)
NANOK vs ICESat-2

NANOK validated against ~ 150.000 ICESat-2 points (May 2018 – June 2019), of which 1773 reach the sea bed.



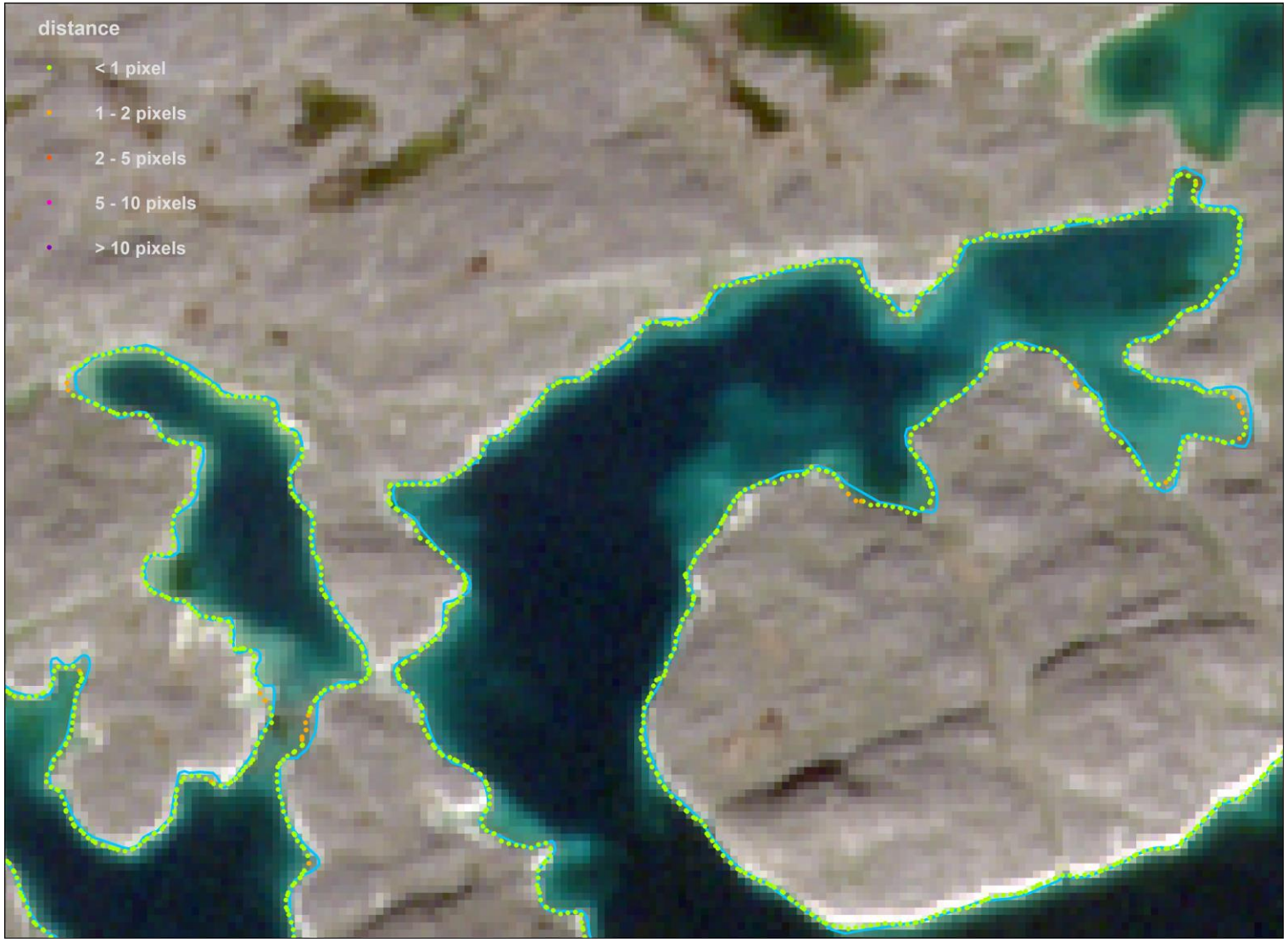


Coastline validation



NANOK validated against traditional manually drawn coastline (DK Hydrographic Office) based on VHR imagery

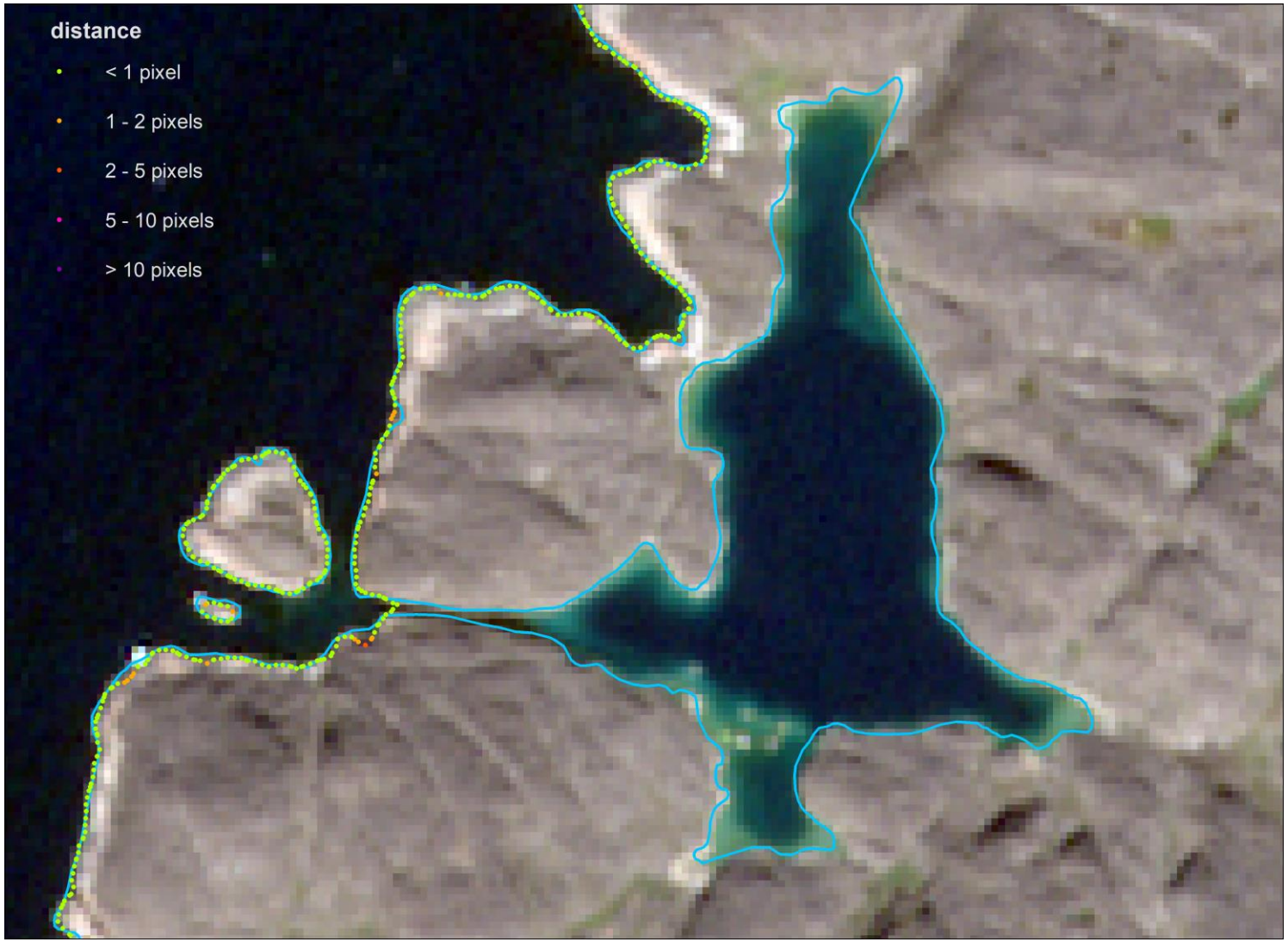
General good performance also in complex areas



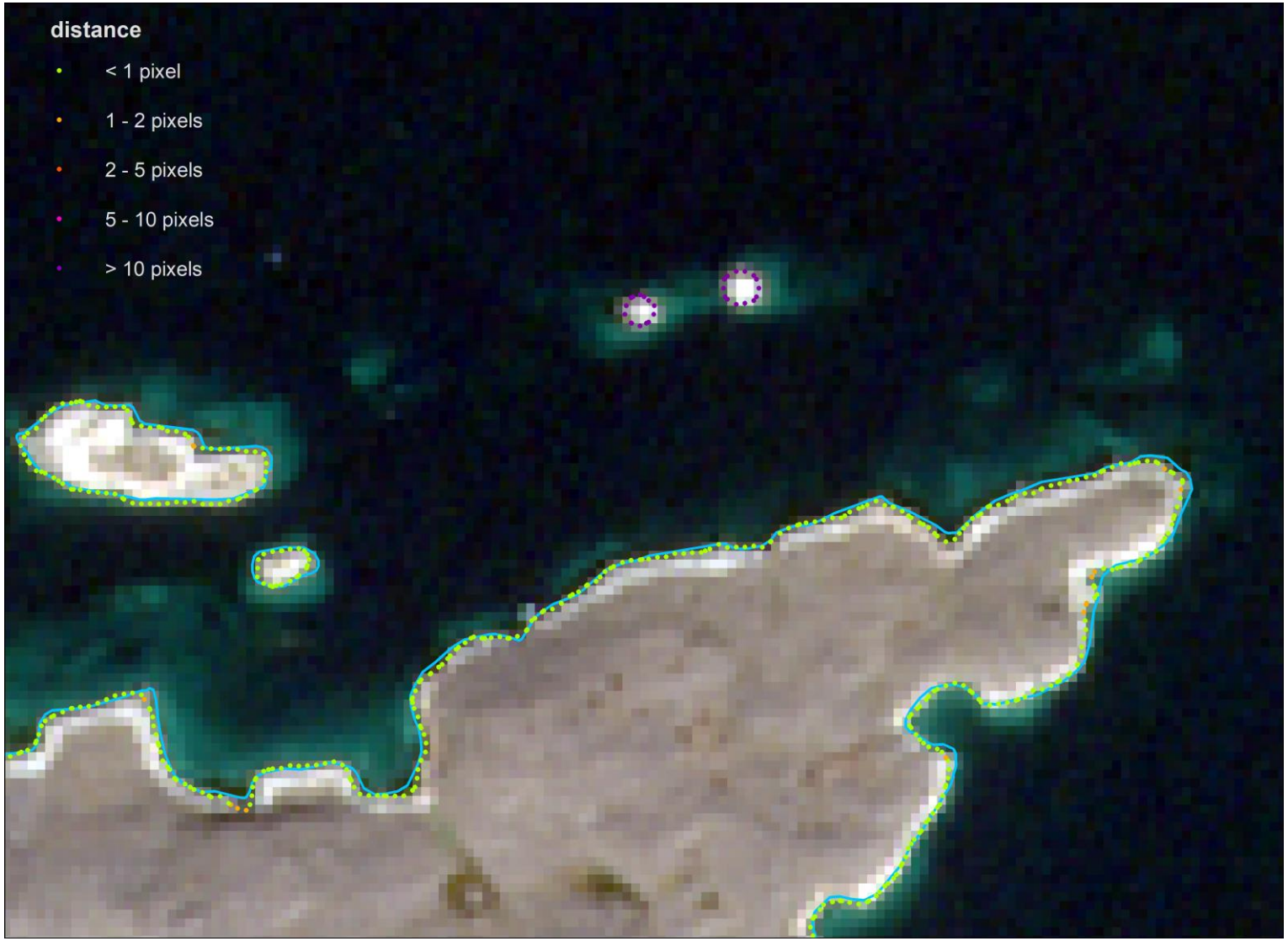
In 2,3% percent of the cases issues arise

Shadows on north facing slope can create issues – but the solution is ready for implementation…

Despite good performance – some narrow straits <10m will create issues



Manual digitizing holds inherent risk of missing features



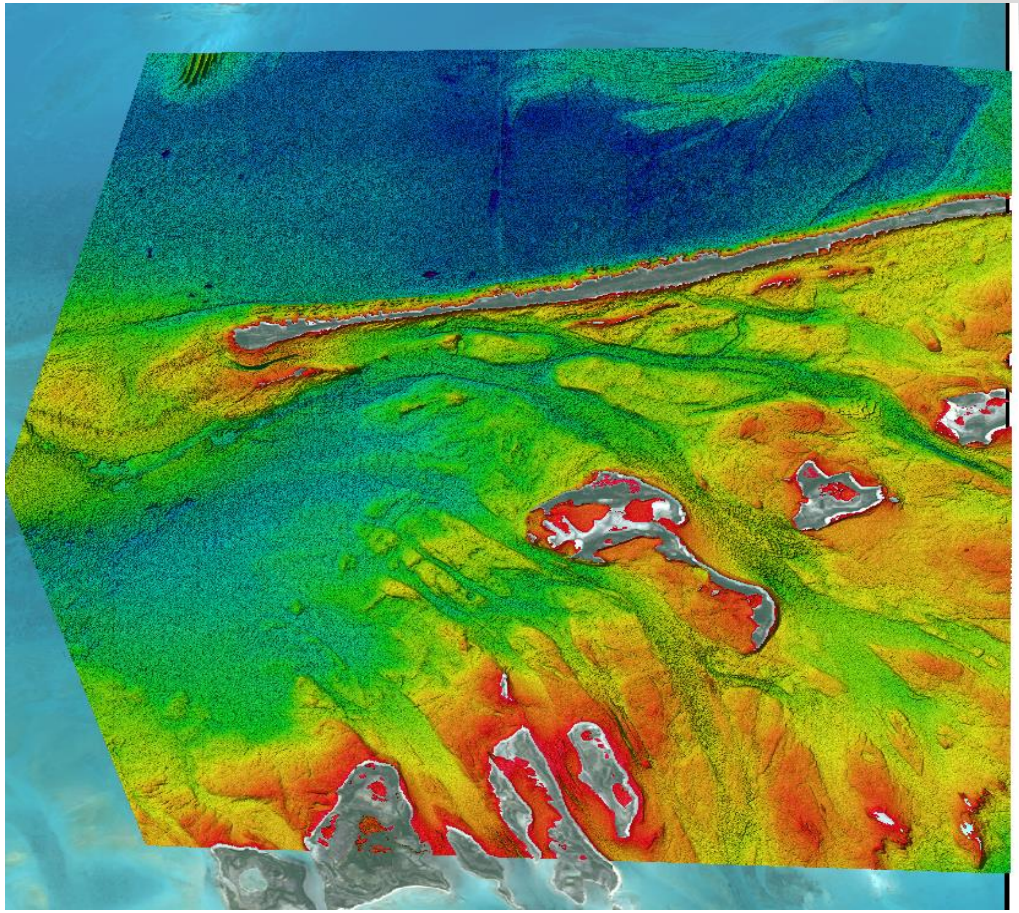
Satelitte Derived Bathymetry (SDB)

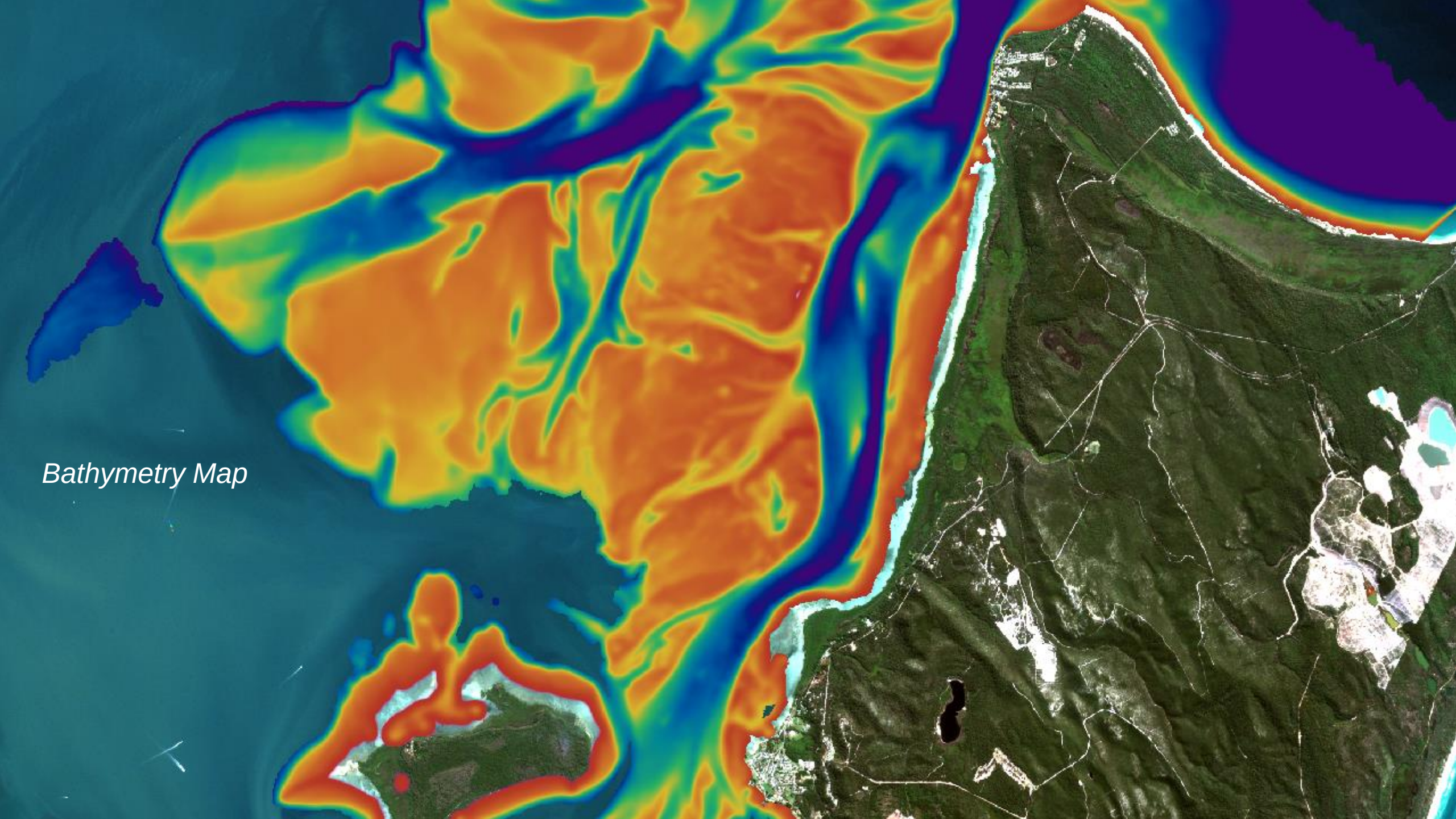
Bathymetry in shallow waters

- Key points:
  - Detailed bathymetry down to 25m depths under optimal conditions
  - Not feasible under turbid conditions
  - Cost efficient supplement to traditional methods (e.g. screening of shallow water before applying MBES)

- Client Value:
  - Very low cost compared to Lidar / sonar / field survey
  - Archive data means quick turnaround time
  - No permits required, easy mobilization, no personnel exposed

- Global References:
  - Denmark, Caribbean, Persian Gulf, Red Sea, Australia, Malaysia, Europe, Arctic

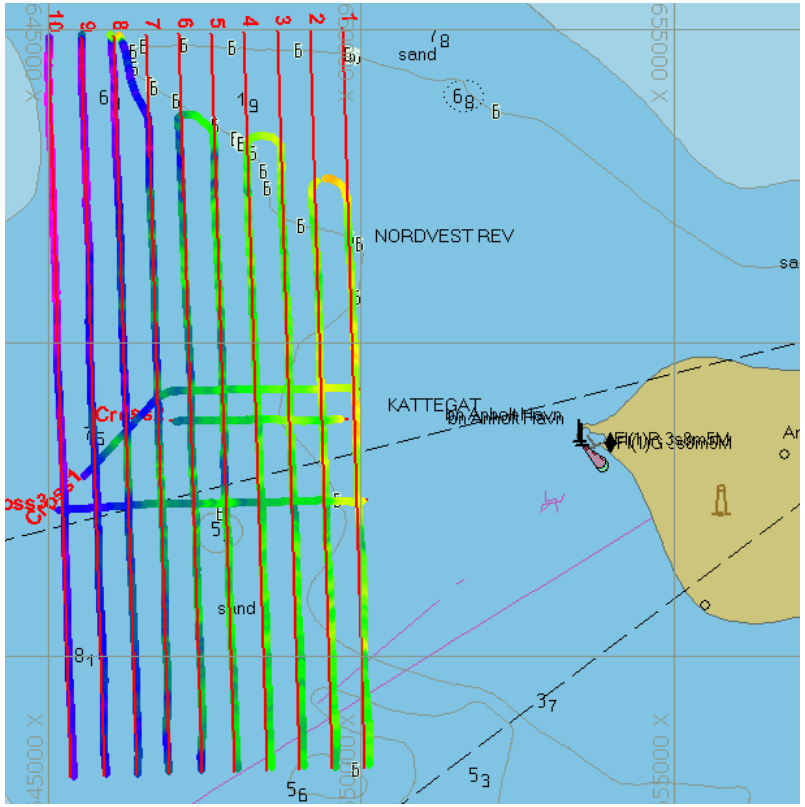



Bathymetry Map

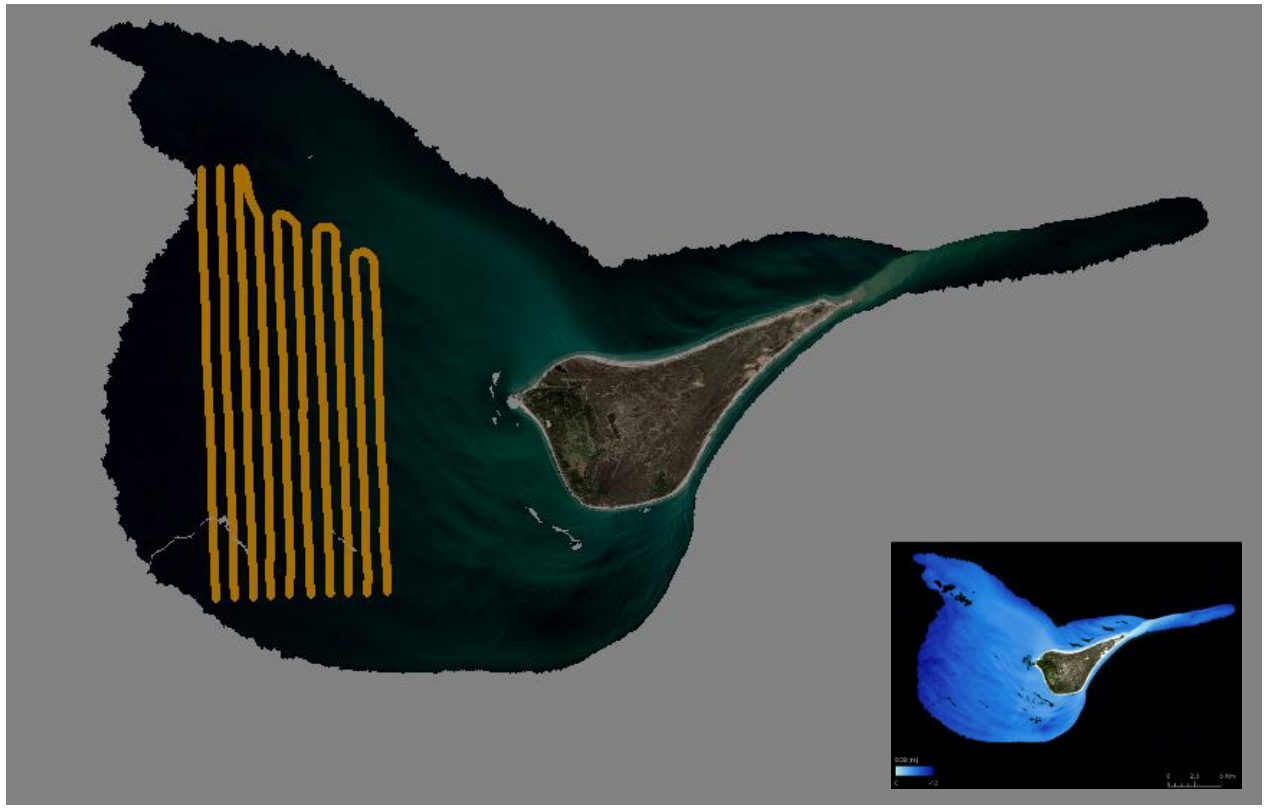
Example: multi-temporal bathymetry at Thyborøn

SDB is a cost-efficient alternative to traditional methods

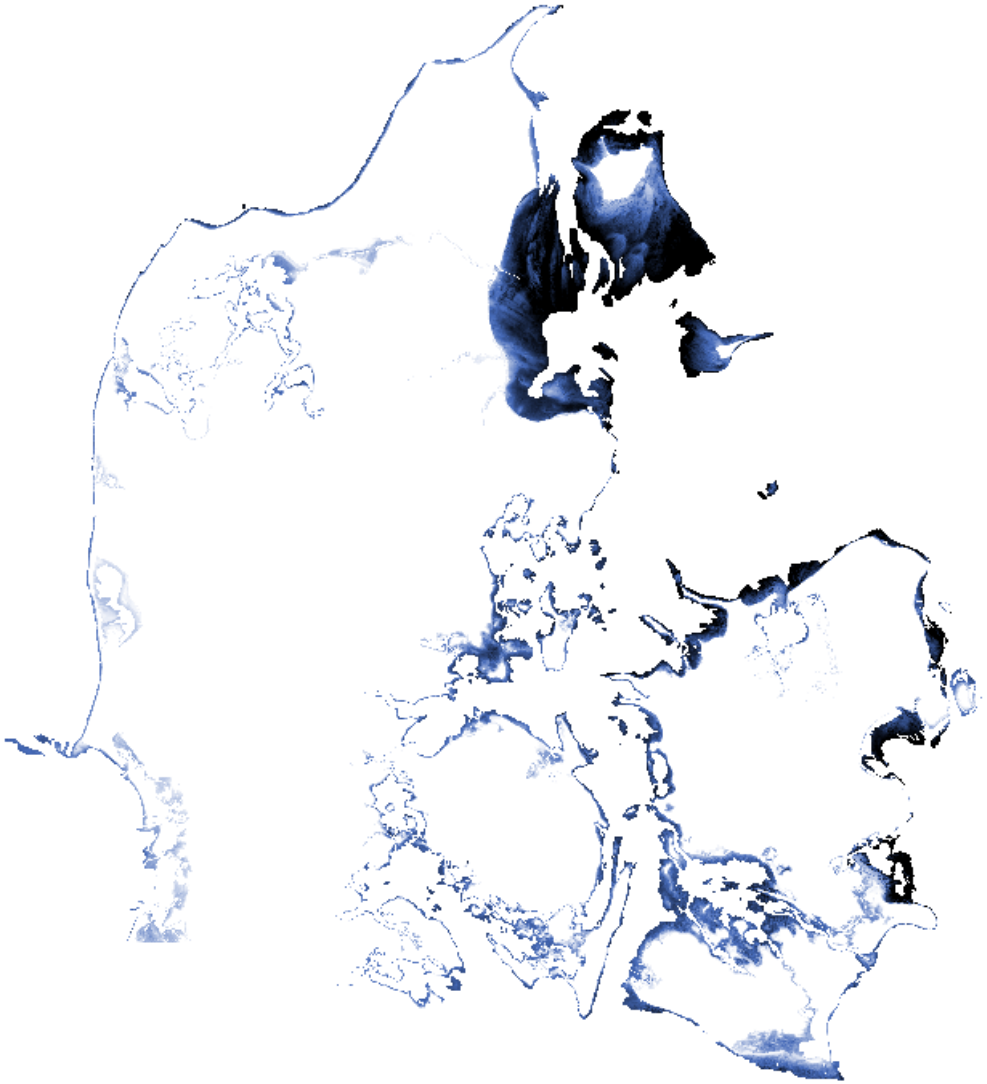
- Multibeam survey from ship:
  - No coverage in shallow water, incomplete spatial coverage, expensive/risky
  - Higher precision (and confidence)

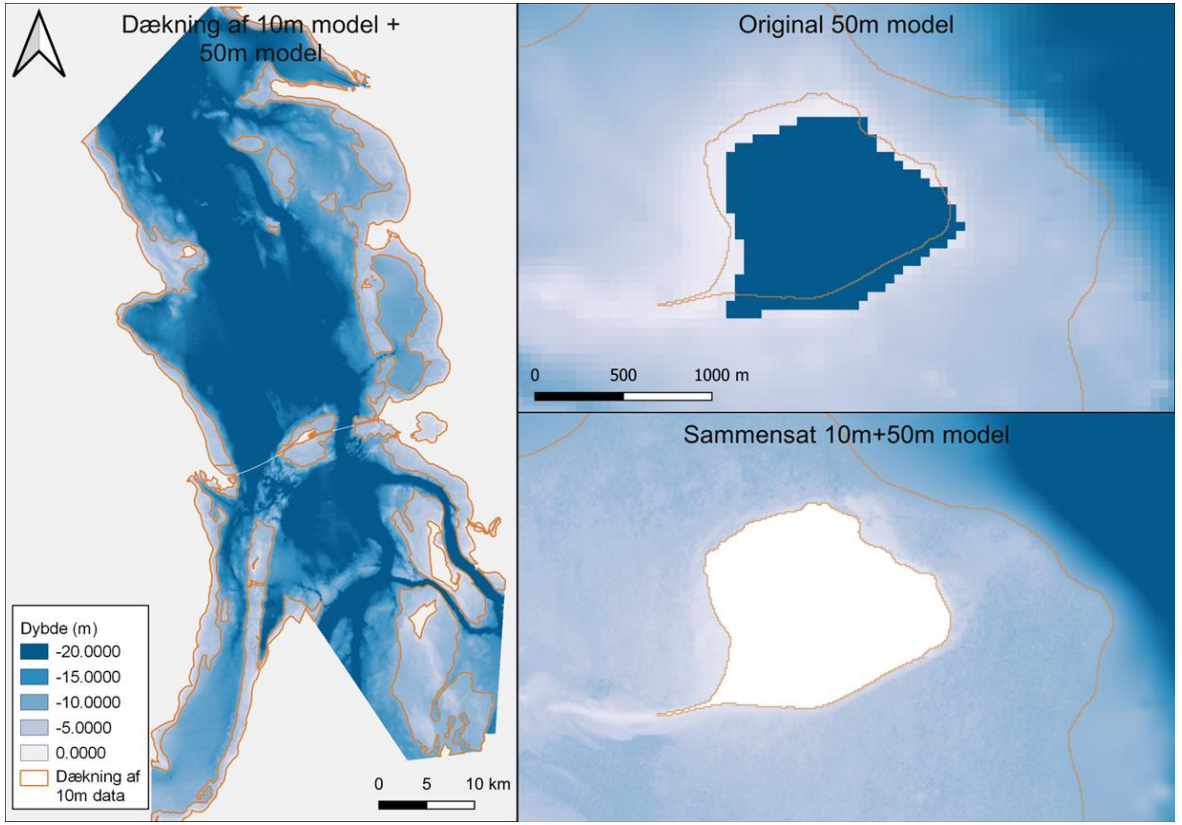


- SDB:
  - Shallow water coverage, full spatial coverage down to app. 10m, cost-efficent
  - Lower precision (and confidence))

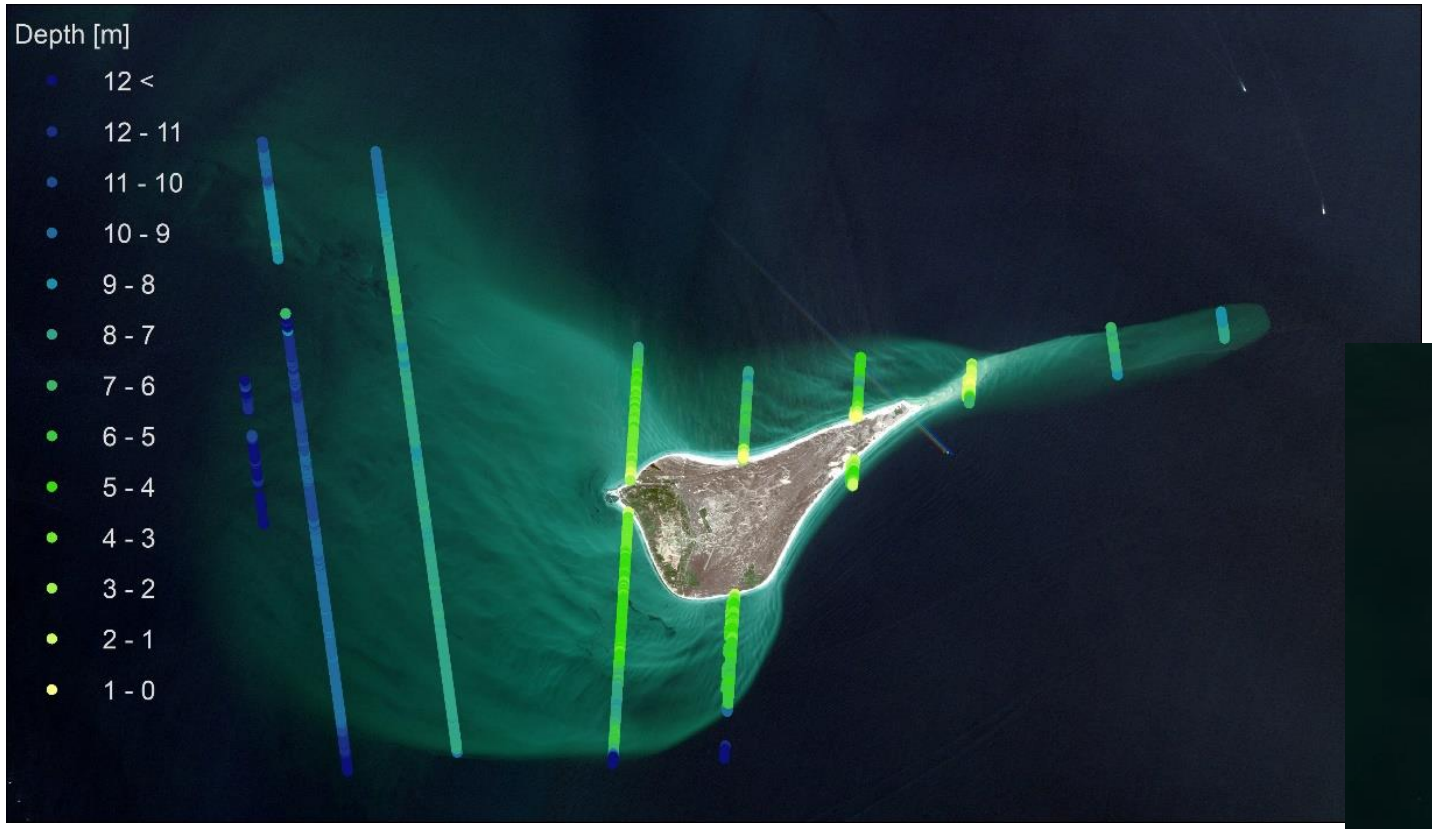


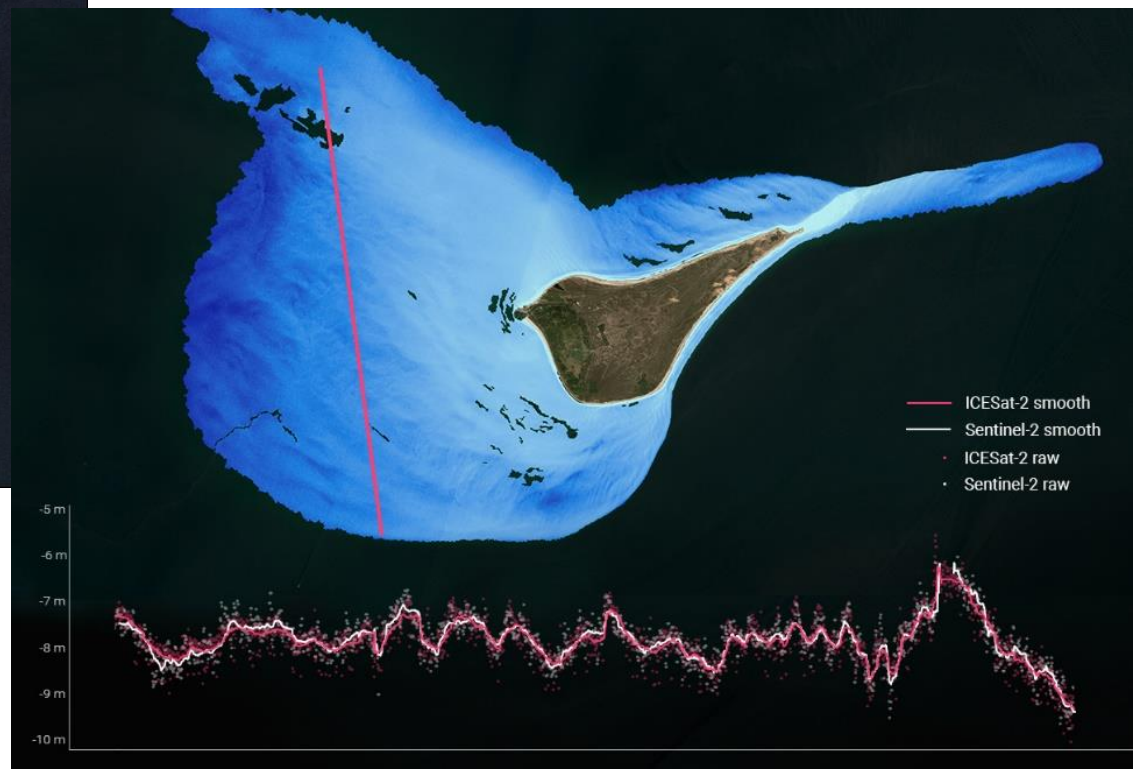
New national depth model for the Danish coastal zone



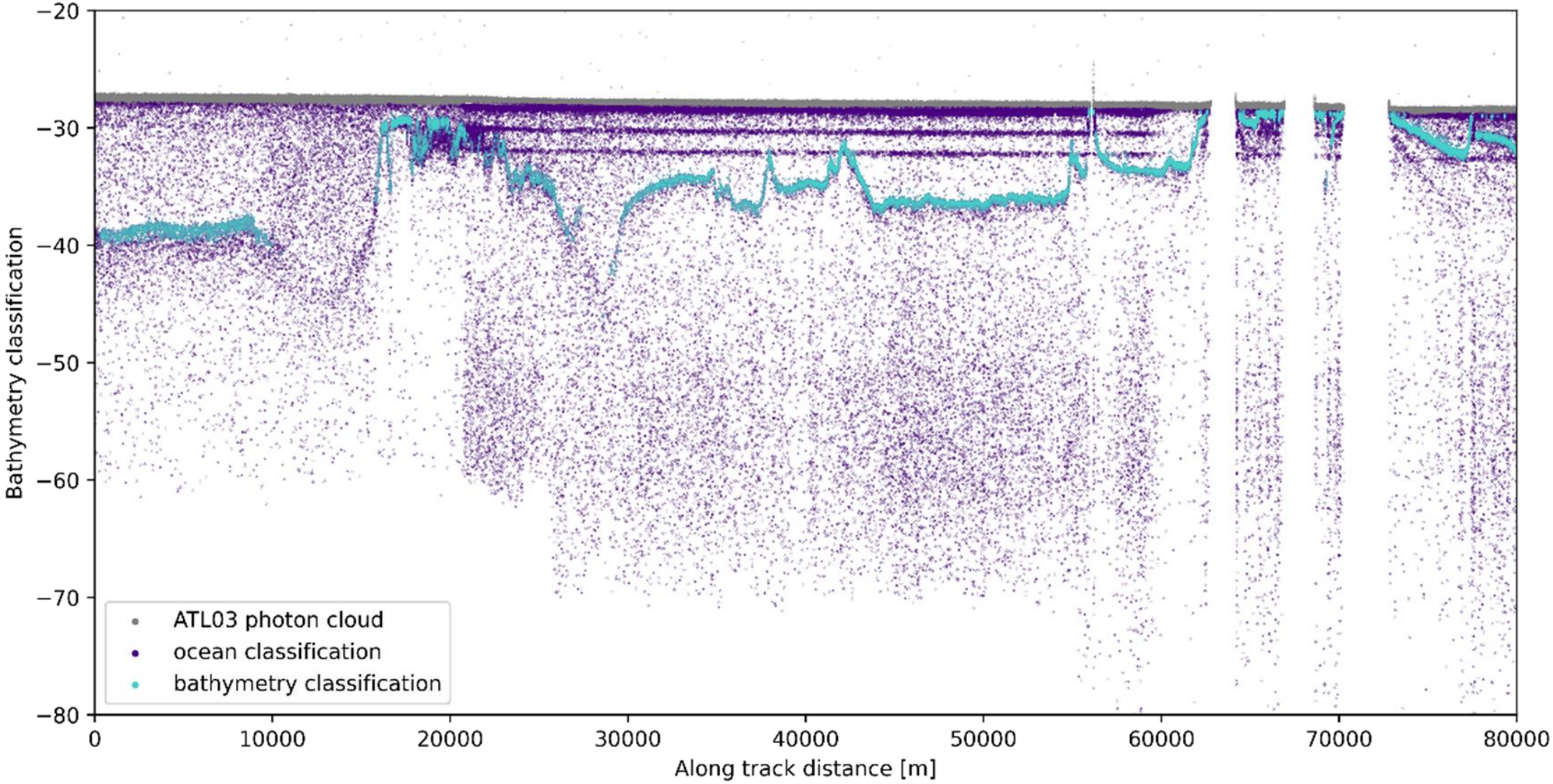


ICESat-2 for calibration & validation of bathymetry

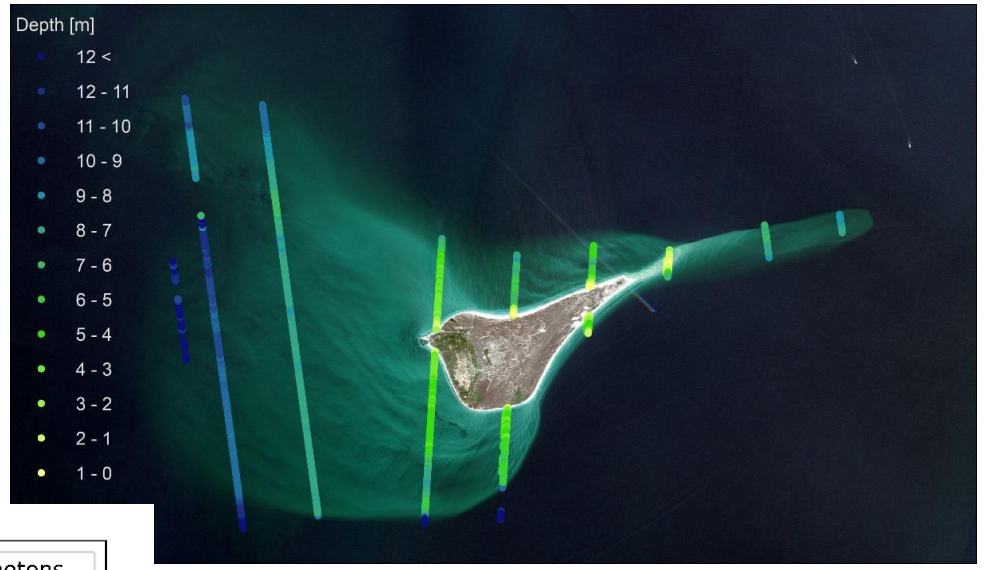


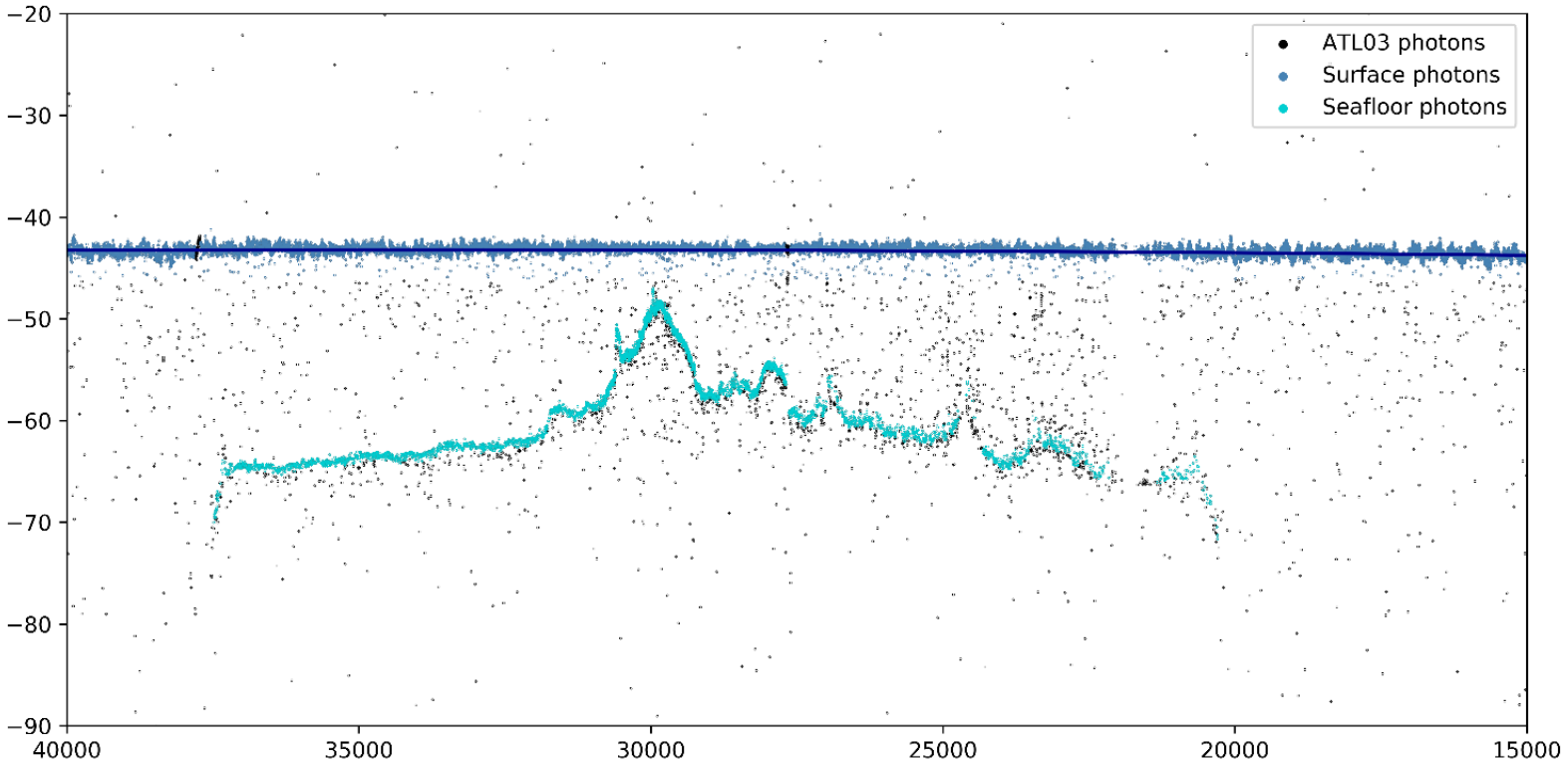


ICESat-2 – Laser Altimetry

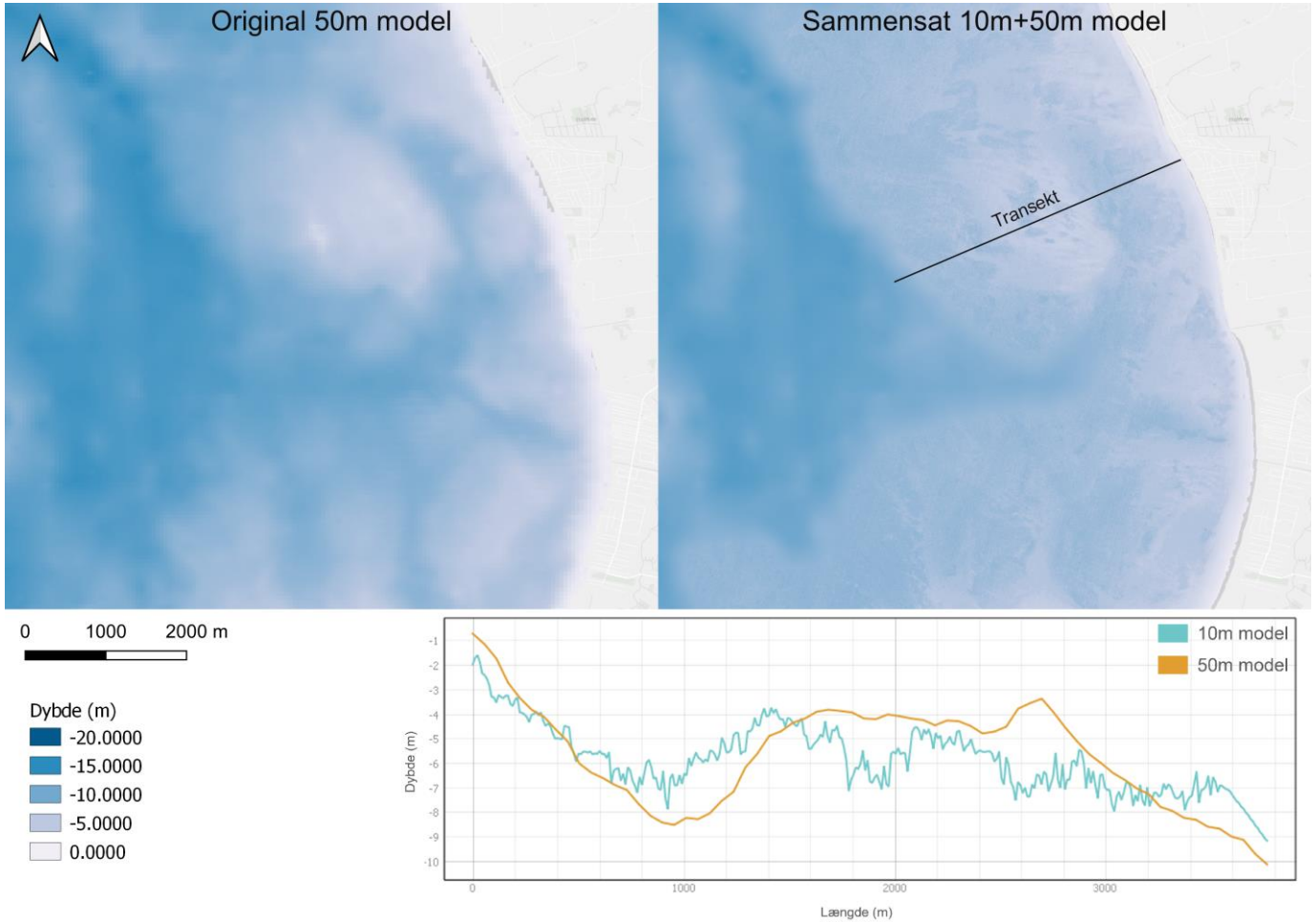


ICESat-2 – Laser Altimetry

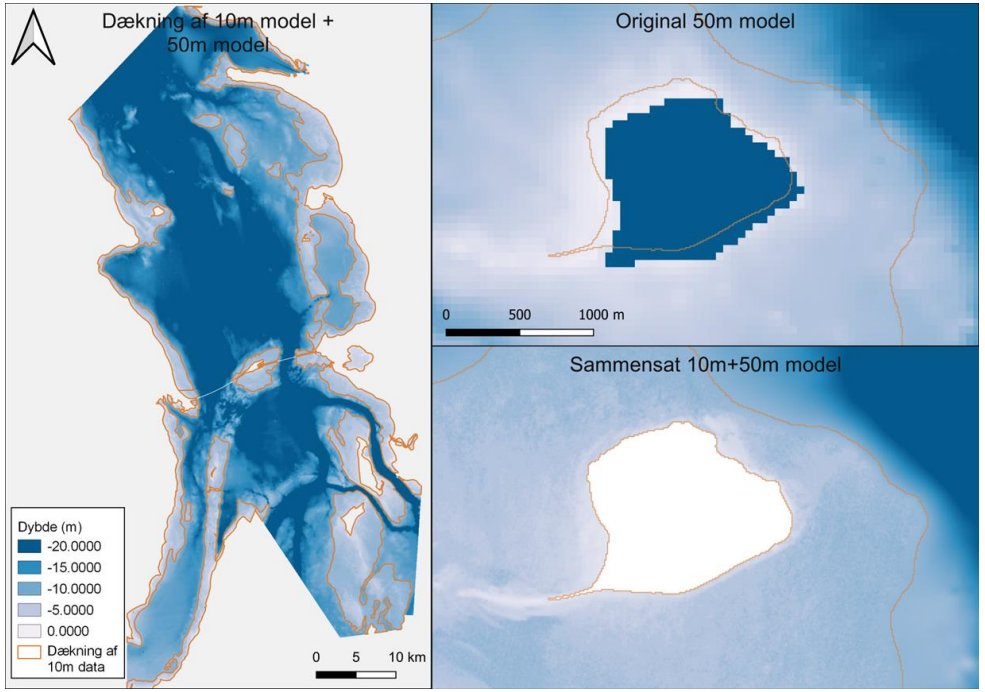




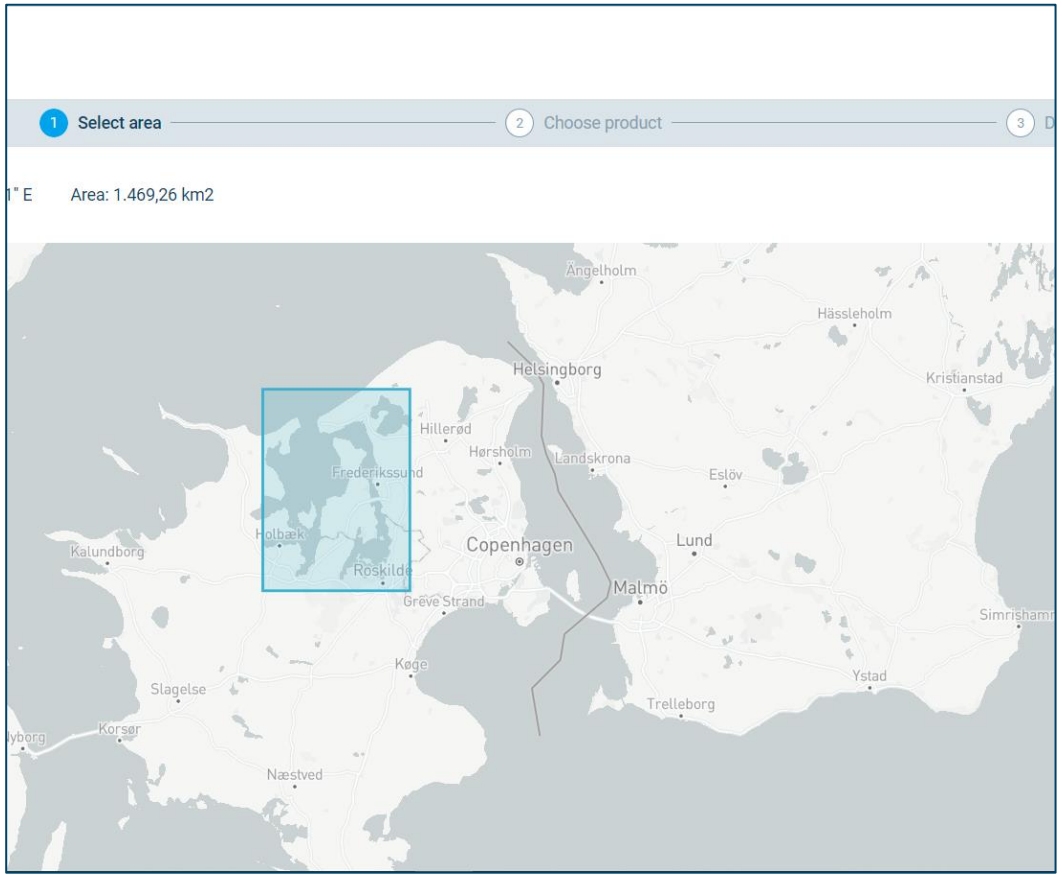
Merging of SDB with authoritative data



This merging procedure can be performed for any other data source, e.g. EMODnet bathymetry



How to access your bathymetry data



https://www.bathymetrics.shop/

Thank you!

Merci!

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