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Massively Scalable, Cloud-native Hydrographic Data Processing

From Sensor Data to High-Resolution Deliverables

HYDRO 2025

29th of October 2025

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01

Introduction

Information about the company and background

The Ocean Big Data Specialists

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Building Technology for managing, visualizing and processing ocean big data at scale

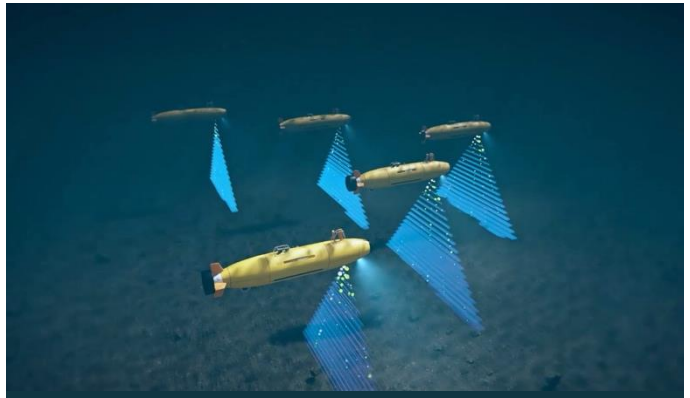
- Founded in 2011
- Cloud & Big Data
- 50+ employees
- Located in Kiel, Germany

GEO AWESOME

GLOBAL TOP 100 GEOSPATIAL COMPANIES IN 2025

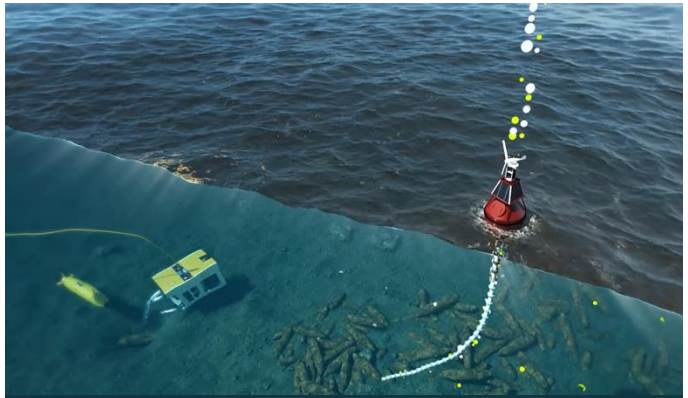
Megatrends in Ocean Data

Ocean data handling needs new paradigms



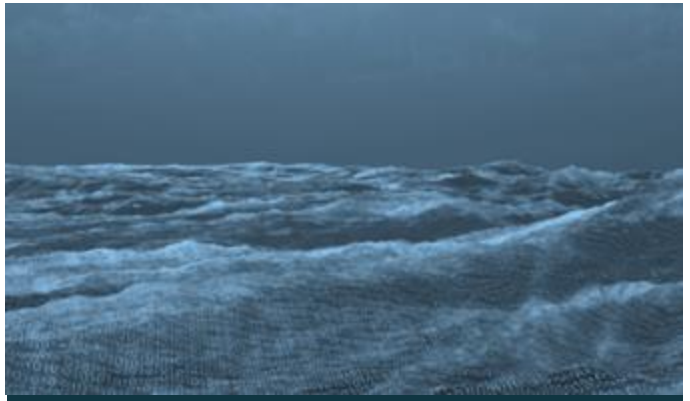
Autonomy

Autonomous systems and next-gen sensors are redefining data collection at sea



Connectivity

Connectivity and bandwidth is increasing, enabling smarter data workflows



Big Data & AI

Ocean data is growing fast in volume, variety, and velocity — unlocking potential for Artificial Intelligence

Our Technology

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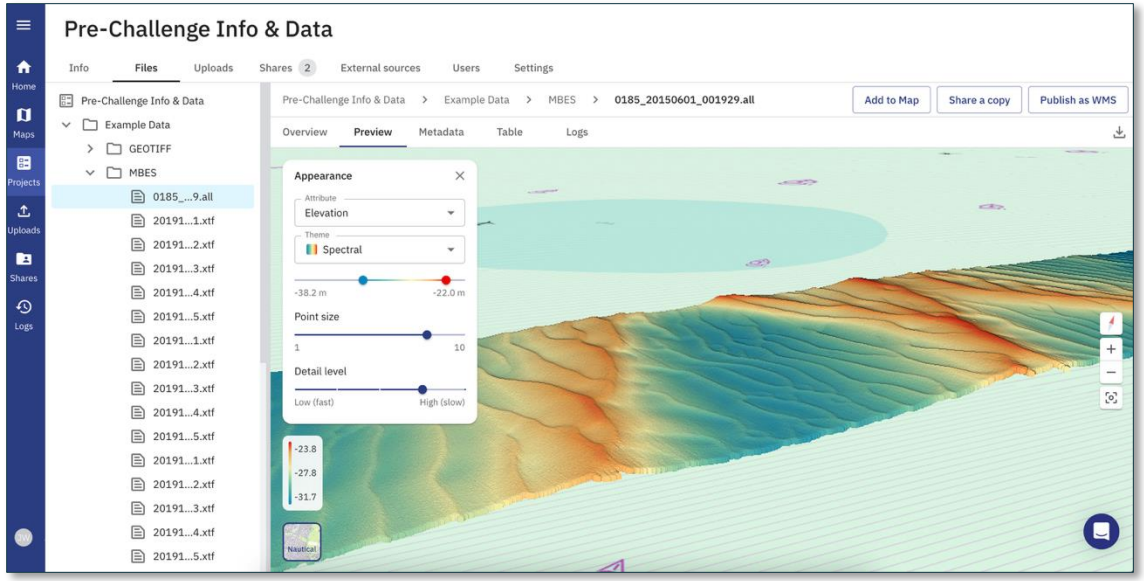

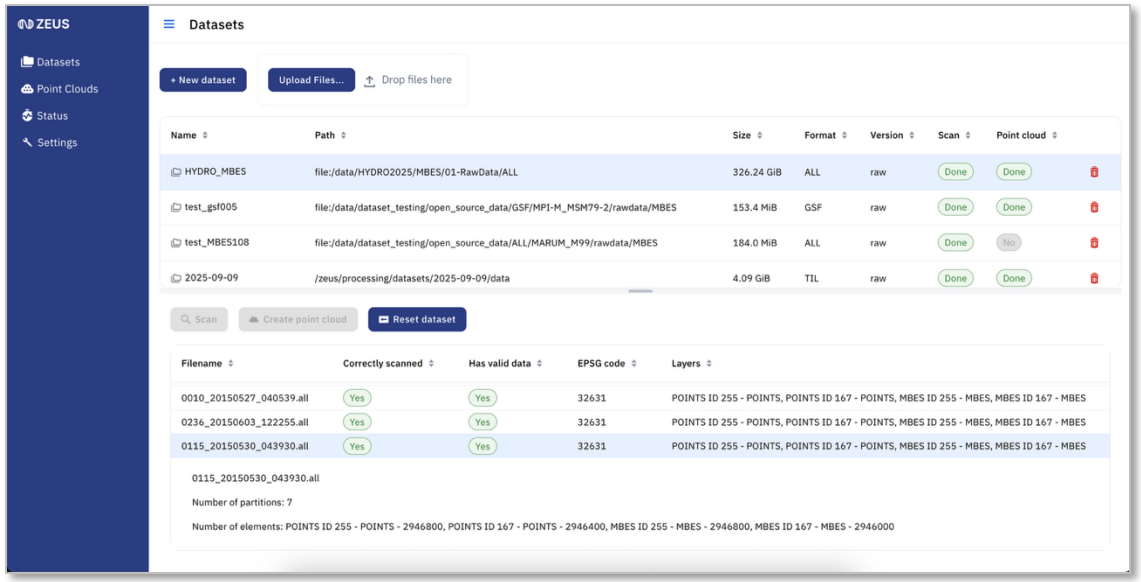

Ocean Data Platform

Managing, sharing and visualizing large volumes of hydrographic and geospatial data

Ocean Data Processing Engine

Processing very large volumes of hydrographic and geospatial data in distributed environments

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02

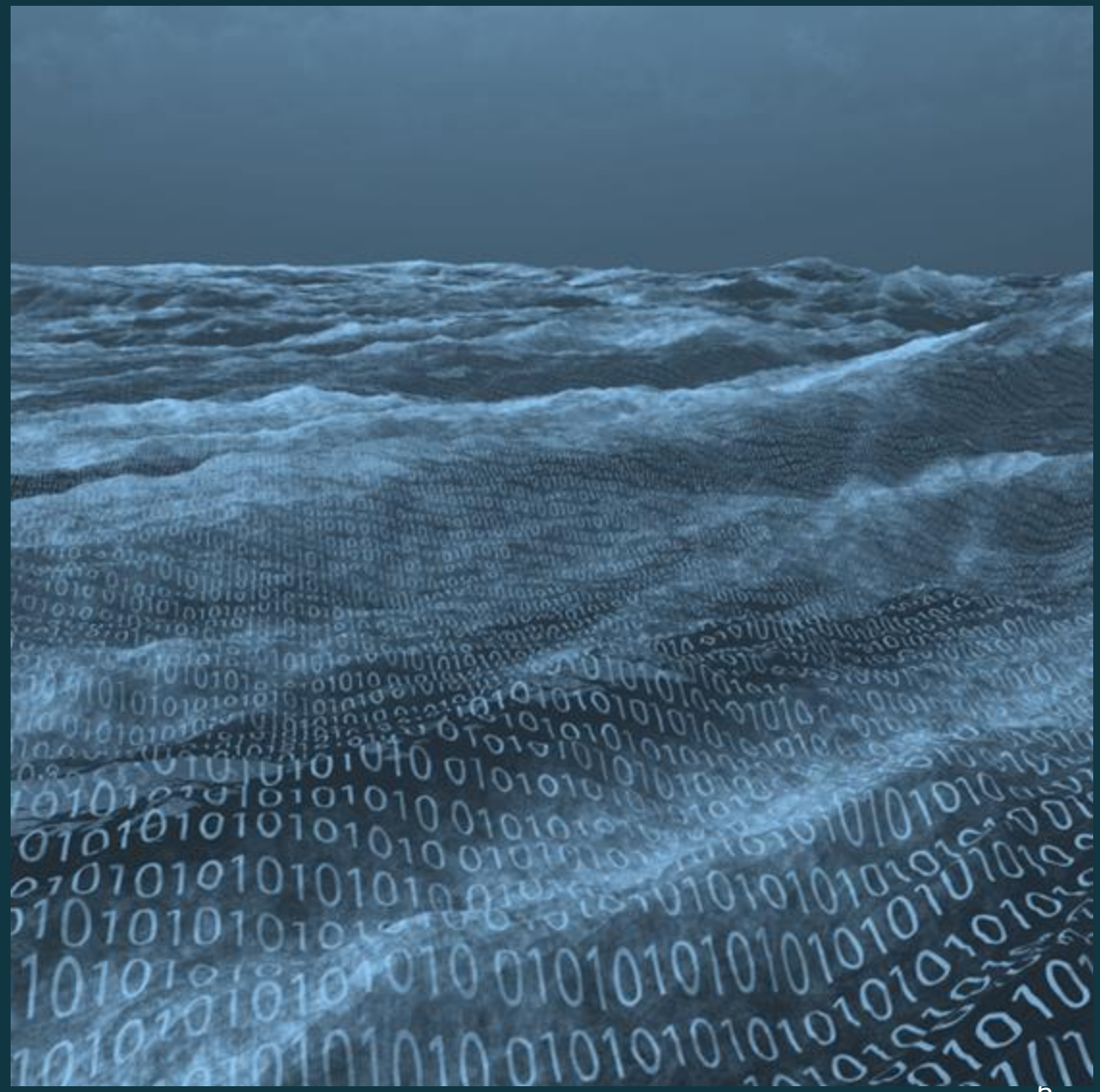
Why?

Do we need some new paradigms when dealing with ocean data?

Why

The need of something new?

- Being able to process increasing data sizes without limitations - Terabytes, Petabytes and even more
- Process and analyse data without loss of information
- Unify data from non-standardized, diverse binary data formats
- Open-source technology to allow compatibility with any other system
- Automate processing workflows to support people‘s work



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02

Technical Background

Which technologies are used and why did we specifically decide for these

Key Factors

Technological choices have been made based on the factors scalability, inde-pendence and holistic

Scalable

Independent

Holistic

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Scalability

We want to scale our computing and only be limited by the available hardware resources

Independence

We want to be able to run our technology everywhere at every time, and be interoperable with any other system

Holistic

Processing massive datasets as a whole is key for unlocking the full potential of advanced data analysis and AI approaches

Key Technologies

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kubernetes

Resource management system for maximum efficiency of hardware usage

APACHE Spark

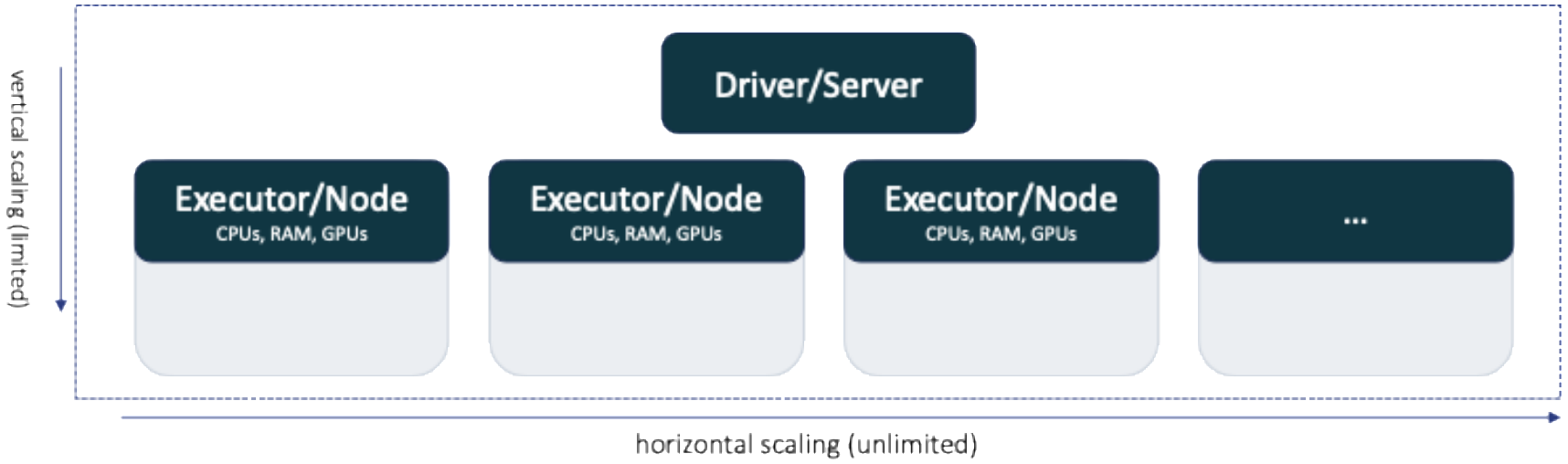
Distributed computing framework based on MapReduce paradigm

Parquet

Open source data format highly optimized for big data operations

Cluster

A cluster consists of an unlimited amount of individual executors nodes



Processing Flow

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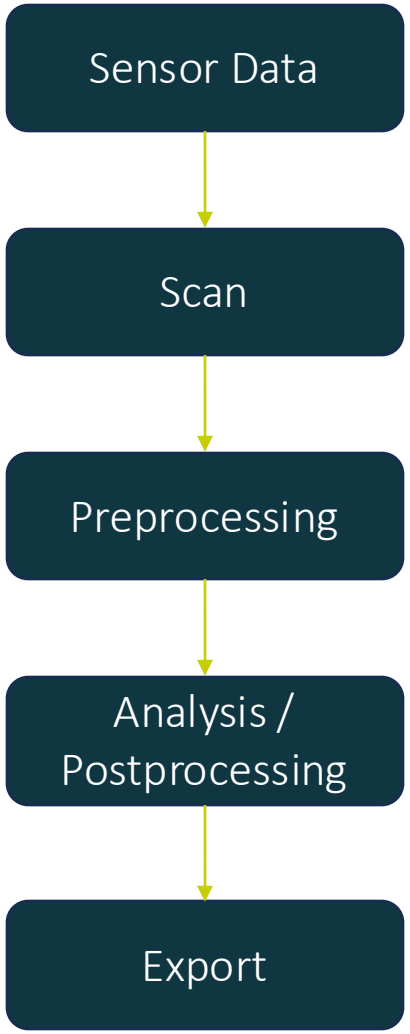


Supported data formats for reading

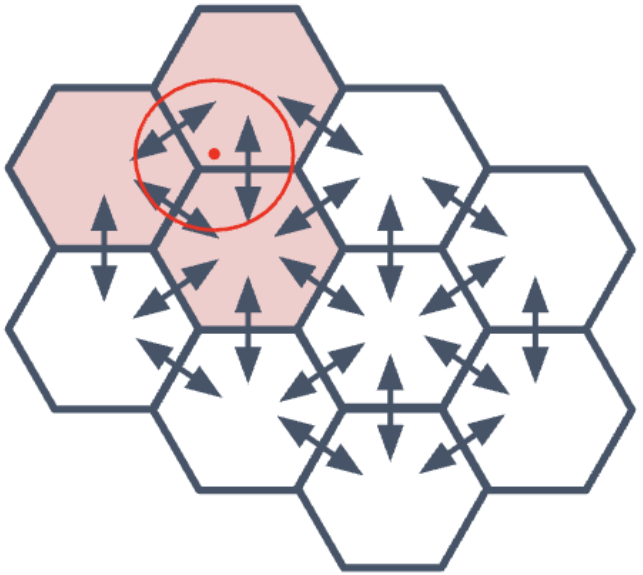
- MBES: *.all, *.kmall, *.s7k, *.gsf, *.xtf, *.til, *.las/laz, *.xyz ; SSS: *.xtf, *.jsf, *.sdf, *.sds, *.til
- Raster: geotiff/cog, asciigrid, csv, geoparquet; Pointcloud: las/laz, pts, xyz, csv, geoparquet

Unification of marine binary sensor data formats

- using Kaitai binary parser for reading binary files
- compatible with almost all programming languages

Partioning of data for parallel computing

- based on the MapReduce programming model
- sensor specific preprocessing steps



Pointcloud based computations

- keeping all information for processing
- sensor independent “calculation library”

Supported data formats for writing

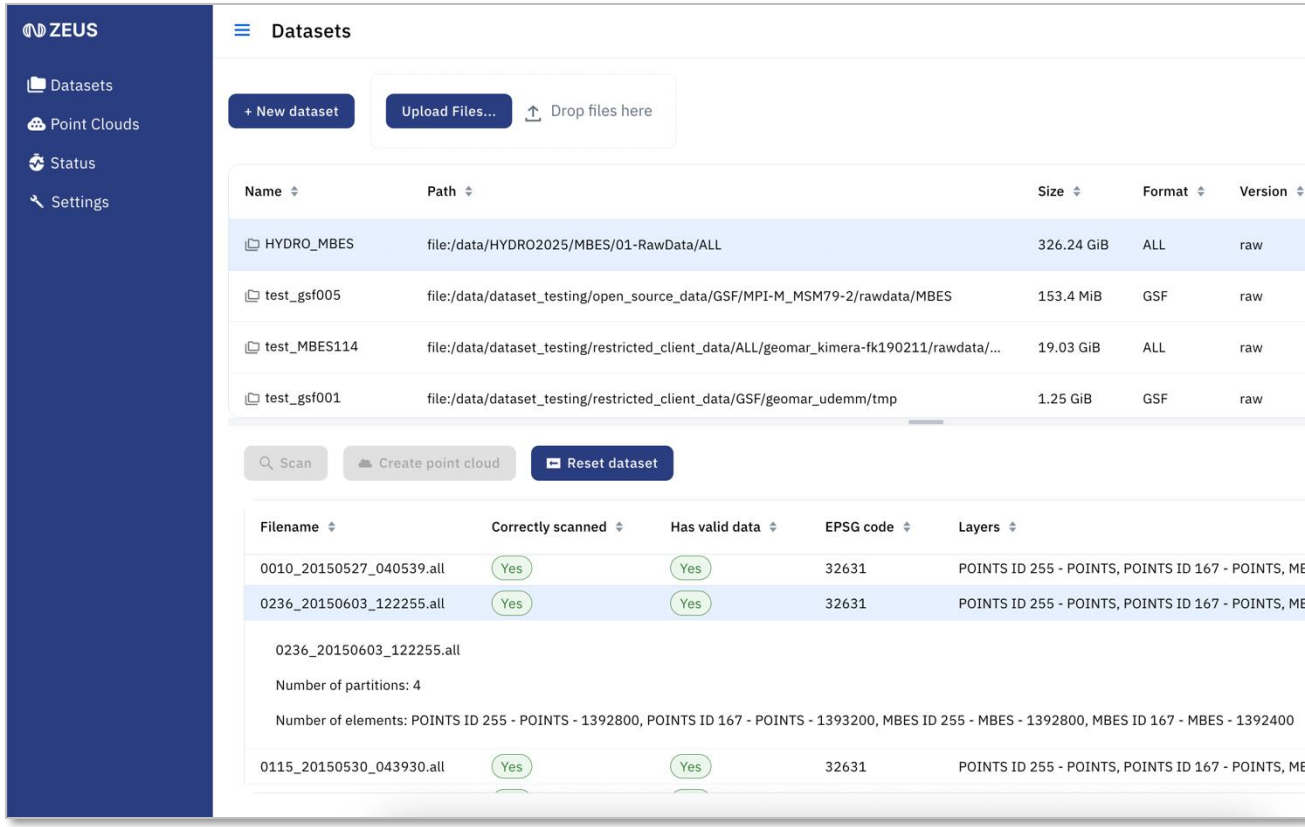
- Raster: geotiff/cog, asciigrid, csv, parquet/geoparquet, png, tms;
- Pointcloud: cesium, csv, parquet/geoparquet, las/laz

Scan

Conducting quality checks

- Is sensor data compliant with format specifications
  → Correctly scanned
- Are required datagrams for processing available
  → Has valid data
- Is CRS information available
  → EPSG Code
- Which data layers are contained (e.g., several frequencies in SSS data)
  → Layers

Data partitioning for parallel processing



Unified reader system for diverse set of marine sensor data

Preprocess

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Raster/Pointcloud

Data Type	Data Sources
Ping Data	*Datagram XYZ*
Coordinates	*Datagram Position*
Attitude	*Datagram Attitude*

Preprocessing Step
Conversion to unified parquet

SSS

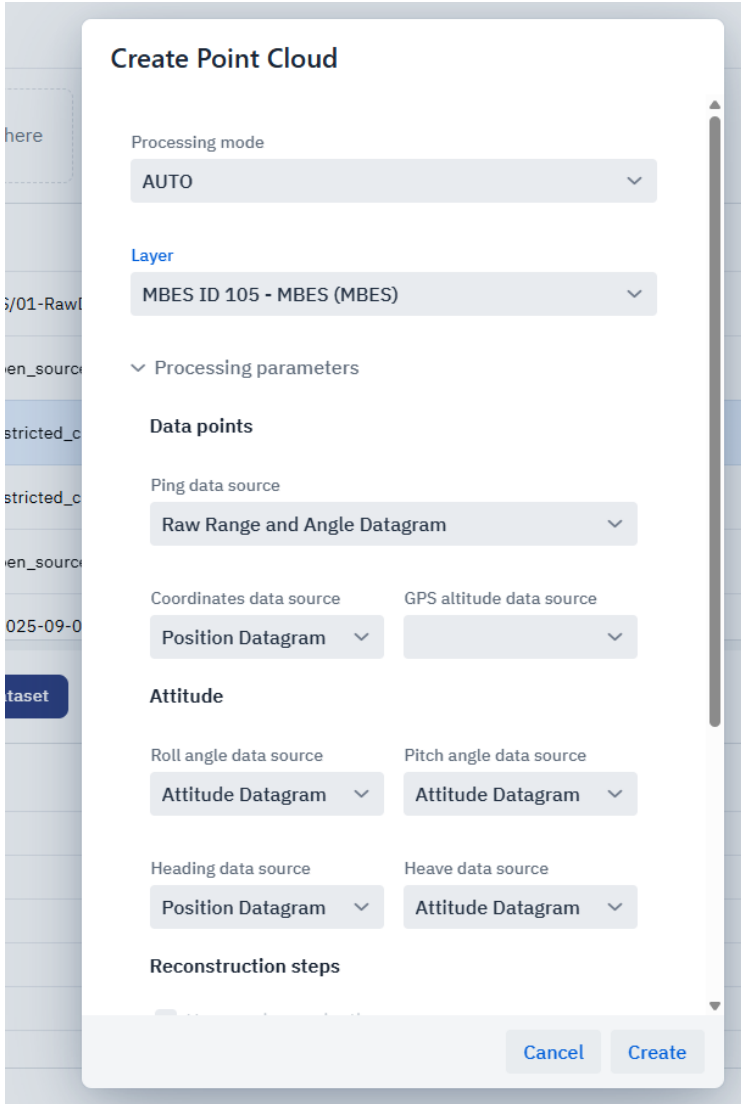
Data Type	Data Sources
Ping Data	*Datagram XYZ*
Coordinates	*Datagram Position*
Attitude	*Datagram Attitude*

Preprocessing Step
Bottom detection
Slant range correction
Ground range correction
Interpolate GPS & smooth heading
Georeferencing
Conversion to unified parquet

MBES

Data Type	Data Sources
Ping Data	*Datagram XYZ*
Coordinates	*Datagram Position*
Altitude	*Datagram Position*
Attitude	*Datagram Attitude*

Preprocessing Step
Interpolate GPS
Correct for SVPs
Correct sensor offsets
Correct rotation
Correct heave
Conversion to unified parquet



Two processing modes: „AUTO“ and „MANUAL“ with sensor specific processing steps

Analysis

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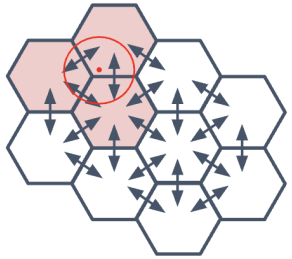
Flexible “calculation library” independent of input sensor due to unified data structure

Calculations

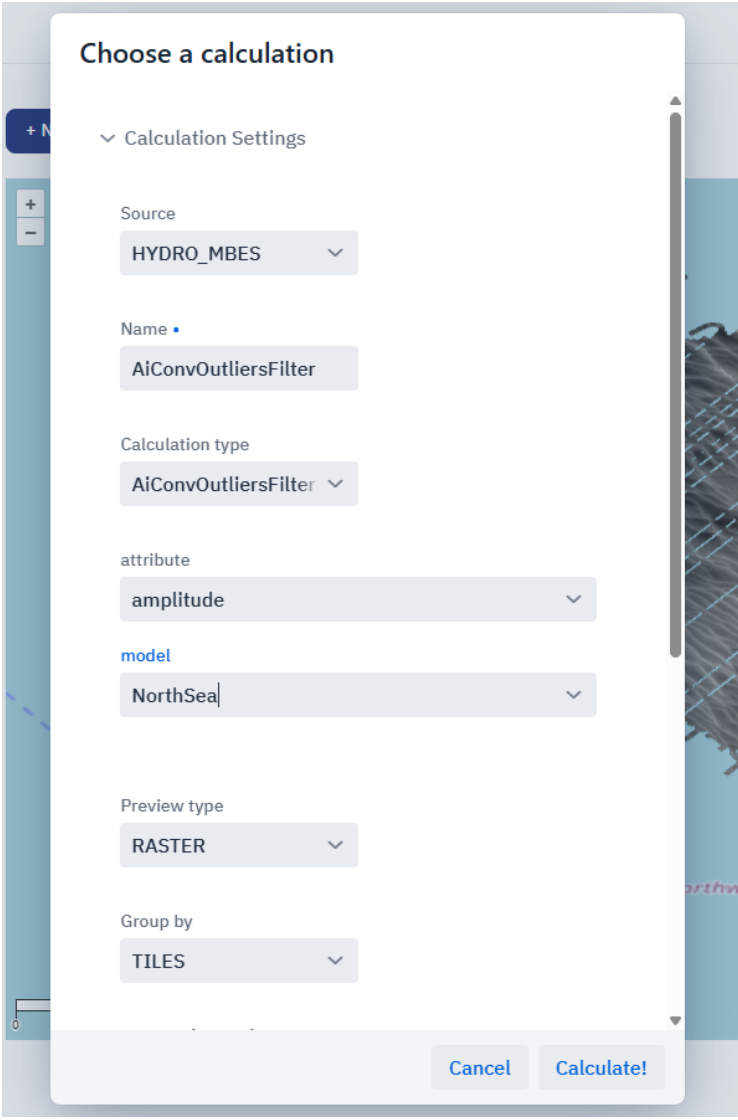
- data quality checks (point spacing, footprints, coverage, …)
- filtering (statistical, AI-based)
- neighbourhood analysis (gradient, tpi, curvature, …)
- anomaly detection (statistical, AI-based)



Interoperable with Python libraries for advanced analytics

Custom developed algorithm for nearest neighbour search

- up to 9× faster than existing methods (KNN in Spark MLlib, R^2 in Apache Sedona, FAISS, etc.)



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03

Benchmarking

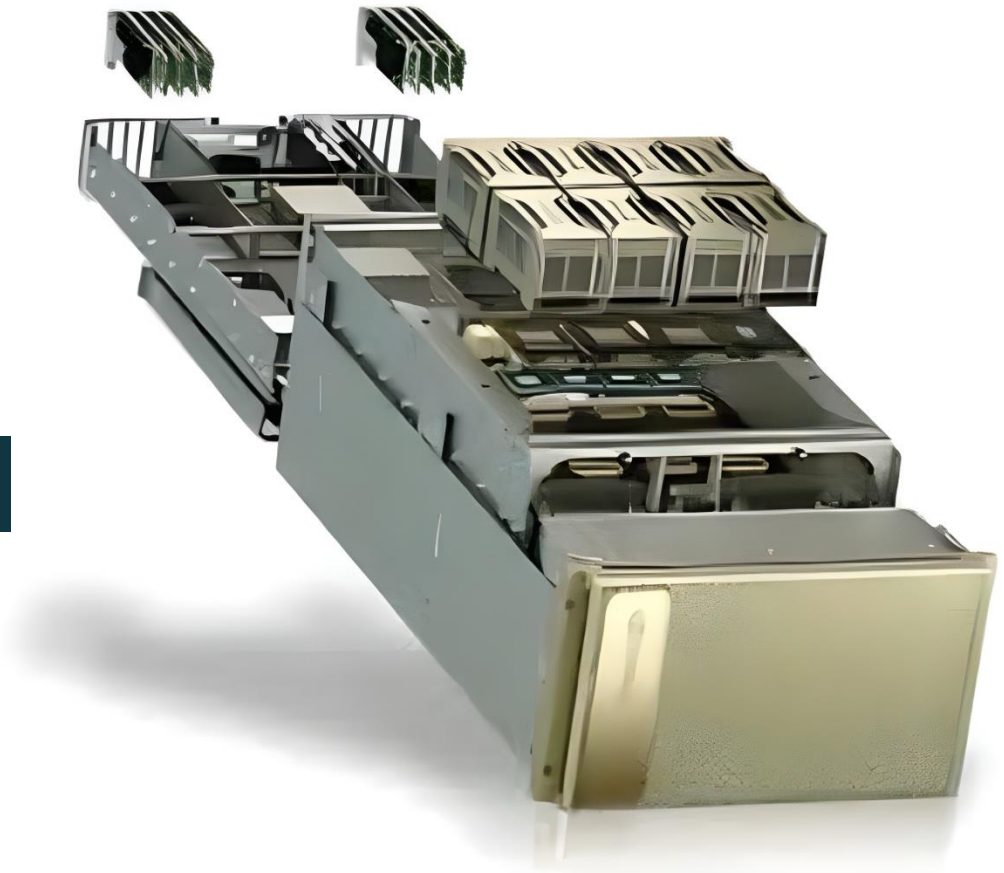
Ocean Data Processing Engine

Benchmarking

Physical hardware setup for benchmarking

Our chosen setup for the benchmark uses a general-purpose configuration (about 1 CPU / 4.7 GB RAM) suitable for most computational tasks and not optimized for any specific workload.

Fraction	Executor	Logical CPUs	Memory [GB]
Full (1×)	7	168	784
Half (½×)	4	96	448
Quarter (¼×)	2	48	224
Eighth (⅛×)	1	24	112



Nvidia DGX A100

Ocean Data Processing Engine

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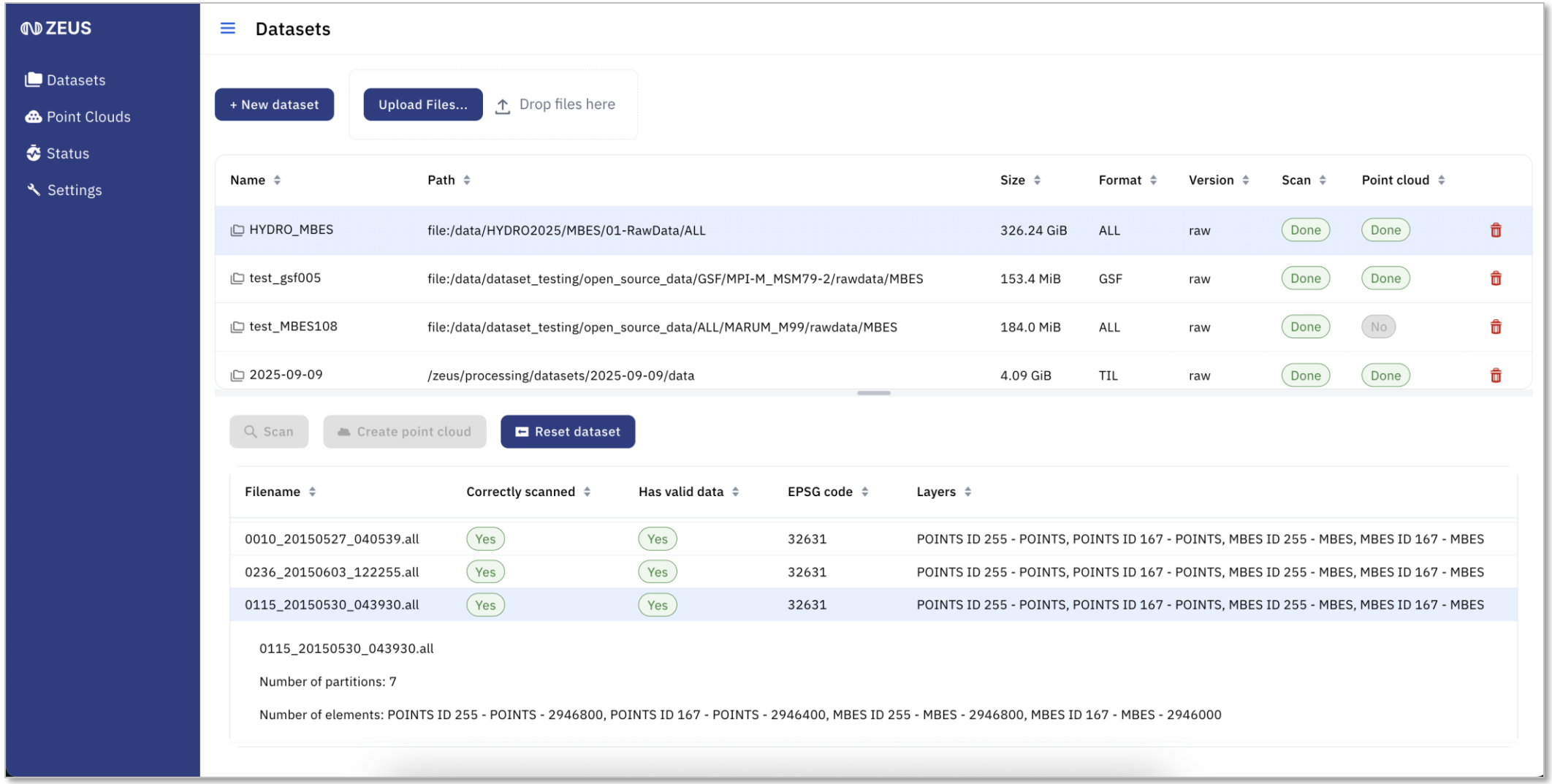


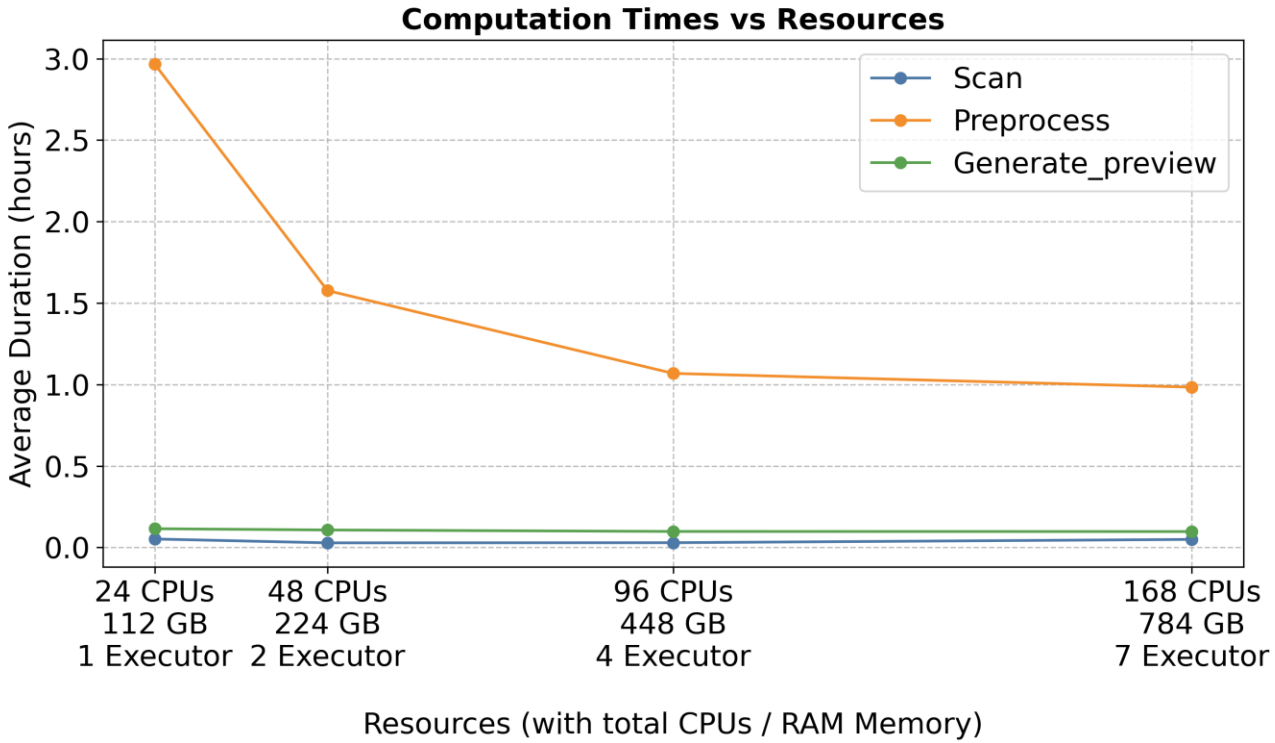
Benchmarking - MBES

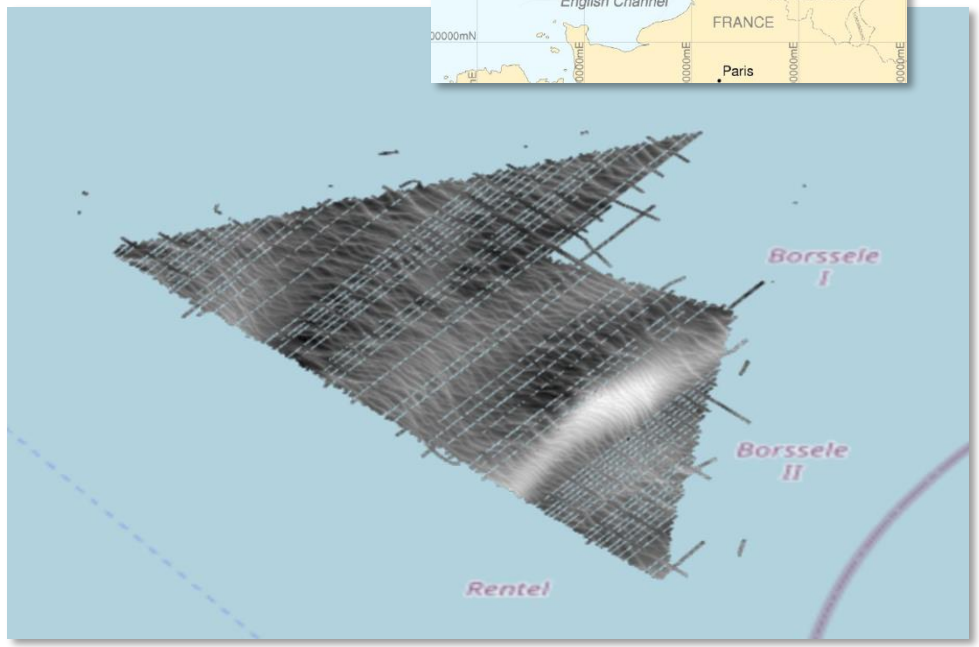
Data

- Kongsberg EM 2040 Dual Head
- 326 GB (raw data, *.all), 93 GB after preprocess
- Total number of data points **6,287,475,200**
- From initially 3 hours to 1 hour

Processing Steps

- Scan
- Preprocessing (Auto-Mode)
- Preview: 1.0 m grid





Benchmarking - SSS

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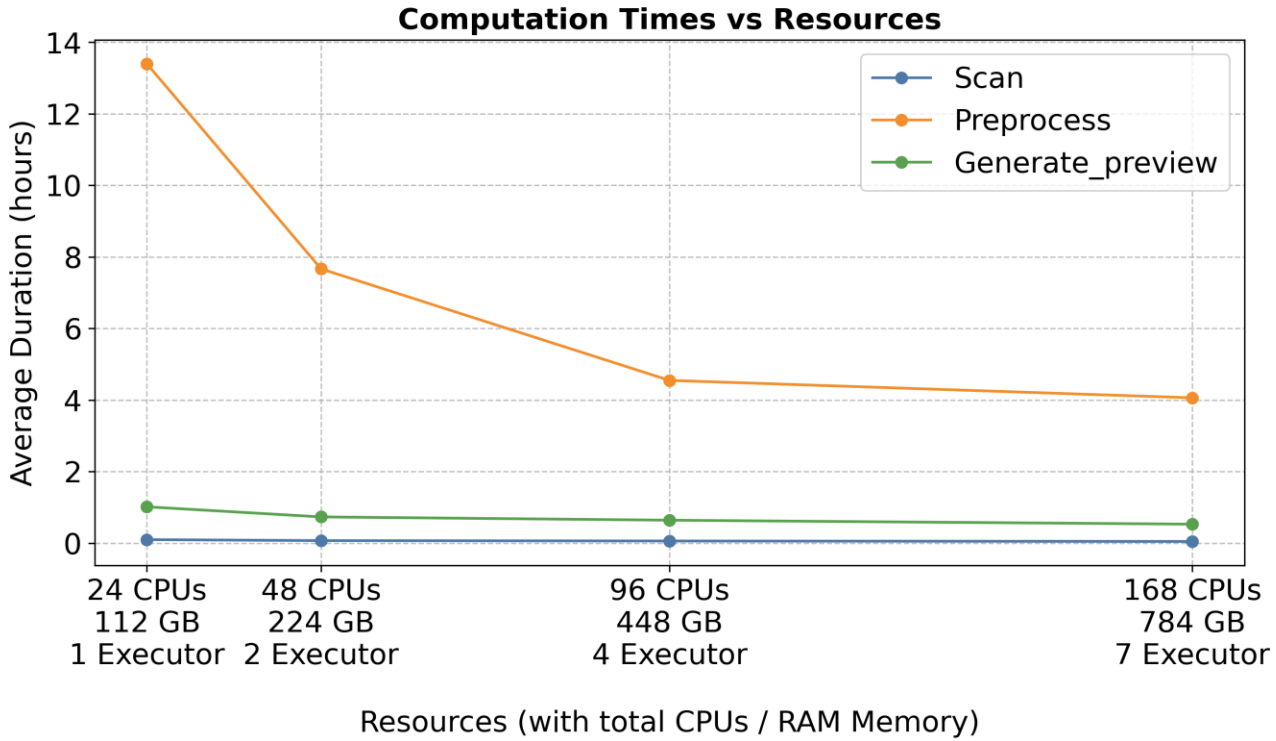
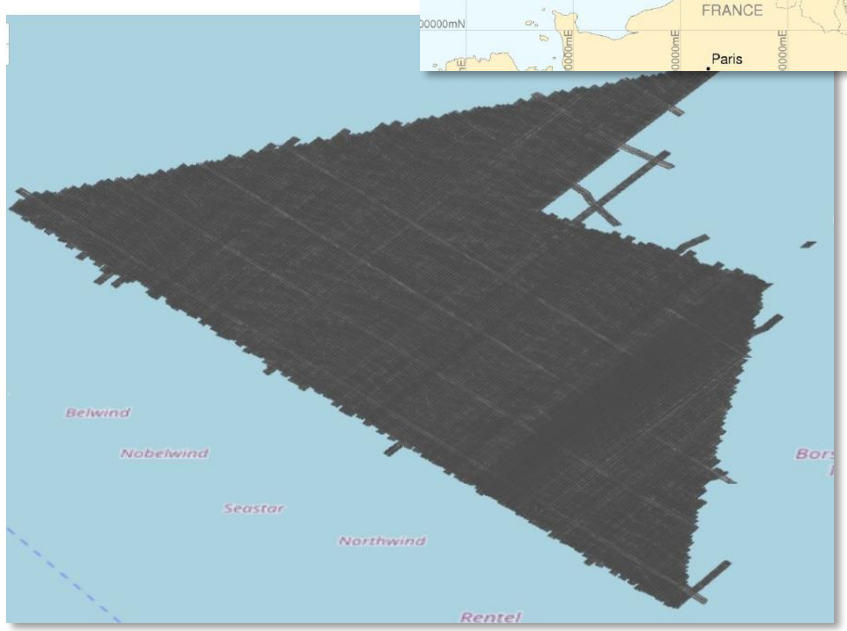
Data

- EdgeTech 4200-FS
- 303 GB (raw data, *.xtf), 3.3 TB after preprocess
- Total number of data points **160,048,458,164**
- From initially 14 hours to 4 hours

Processing Steps

- Scan
- Preprocessing (Auto-Mode)
- Preview: 0.5 m grid

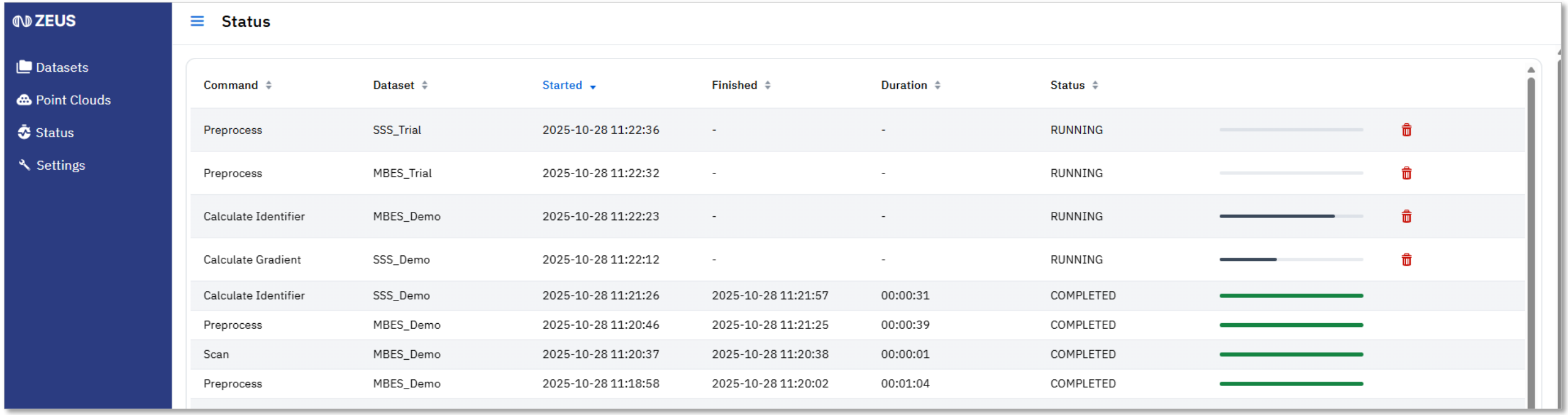




Parallelization

Parallelization is not only happening on the data level but also on the process level:

- **Capacity Scheduling** – based on pre-allocated resources
- **Fair Scheduling** – based on dynamic balancing and automated resource optimization



Command	Dataset	Started	Finished	Duration	Status
Preprocess	SSS_Trial	2025-10-28 11:22:36	-	-	RUNNING
Preprocess	MBES_Trial	2025-10-28 11:22:32	-	-	RUNNING
Calculate Identifier	MBES_Demo	2025-10-28 11:22:23	-	-	RUNNING
Calculate Gradient	SSS_Demo	2025-10-28 11:22:12	-	-	RUNNING
Calculate Identifier	SSS_Demo	2025-10-28 11:21:26	2025-10-28 11:21:57	00:00:31	COMPLETED
Preprocess	MBES_Demo	2025-10-28 11:20:46	2025-10-28 11:21:25	00:00:39	COMPLETED
Scan	MBES_Demo	2025-10-28 11:20:37	2025-10-28 11:20:38	00:00:01	COMPLETED
Preprocess	MBES_Demo	2025-10-28 11:18:58	2025-10-28 11:20:02	00:01:04	COMPLETED

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04

Use Cases

Test and technology verification with different industry groups

NATO Exercise - REPMUS

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Data Fusion Cell

- Managing and visualizing large SSS & SAS datasets
- Processing these datasets at scale as fast as possible
- Streaming the data directly via WMS into the Common Operational Picture (COP)
- Running a fully isolated system showing the capability for classified environments
- Total: 3 TB raw data

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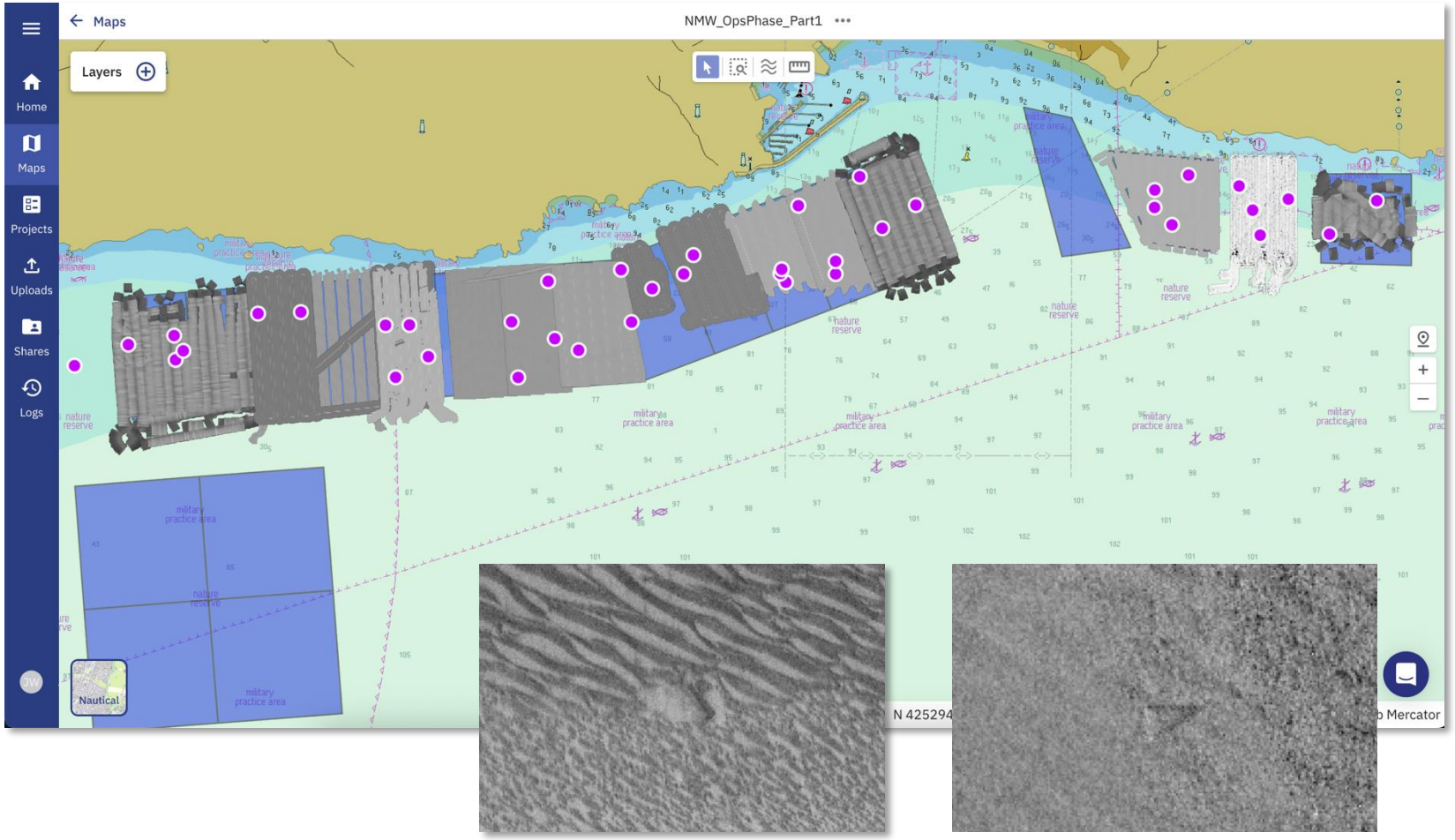

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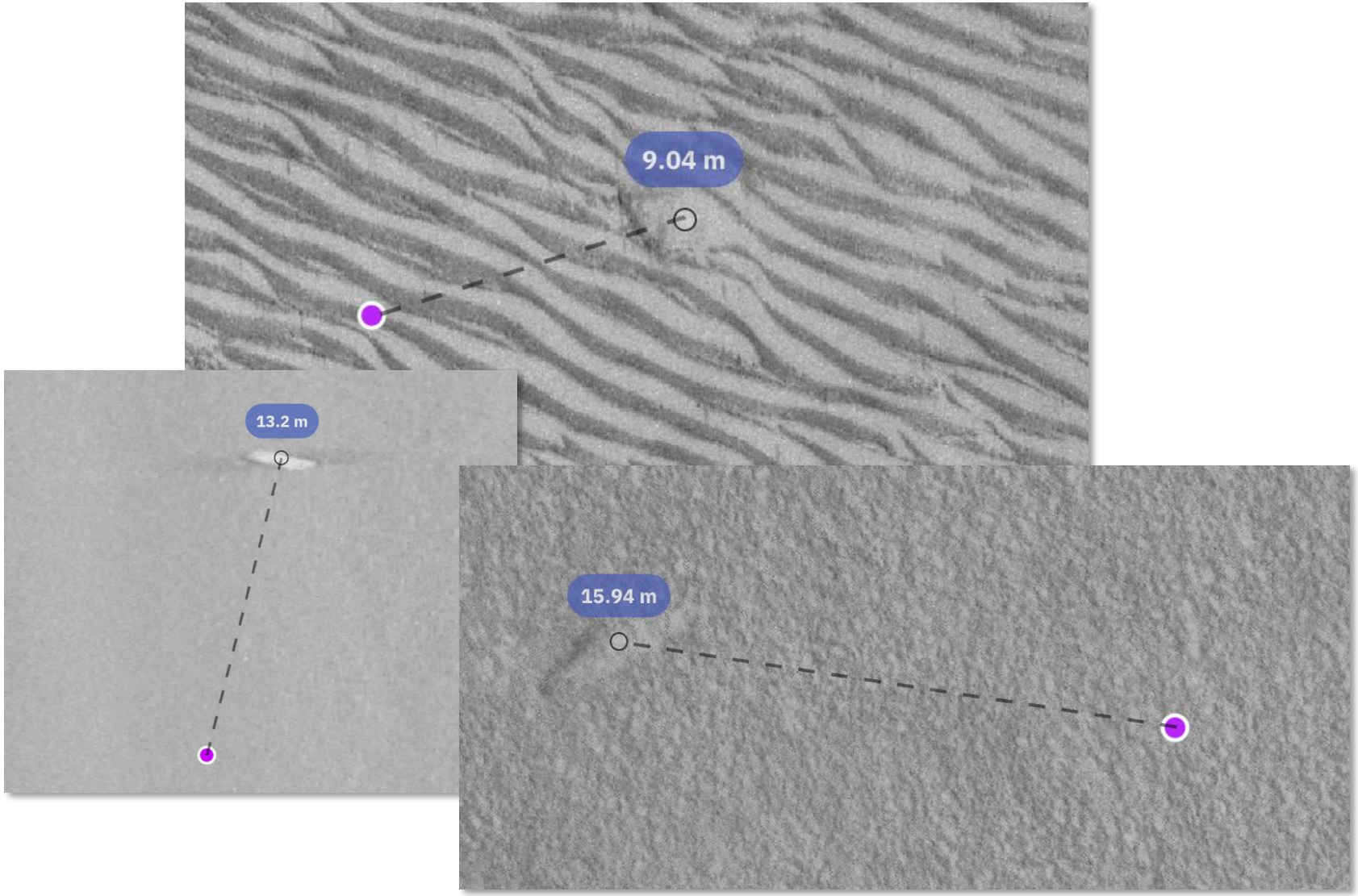

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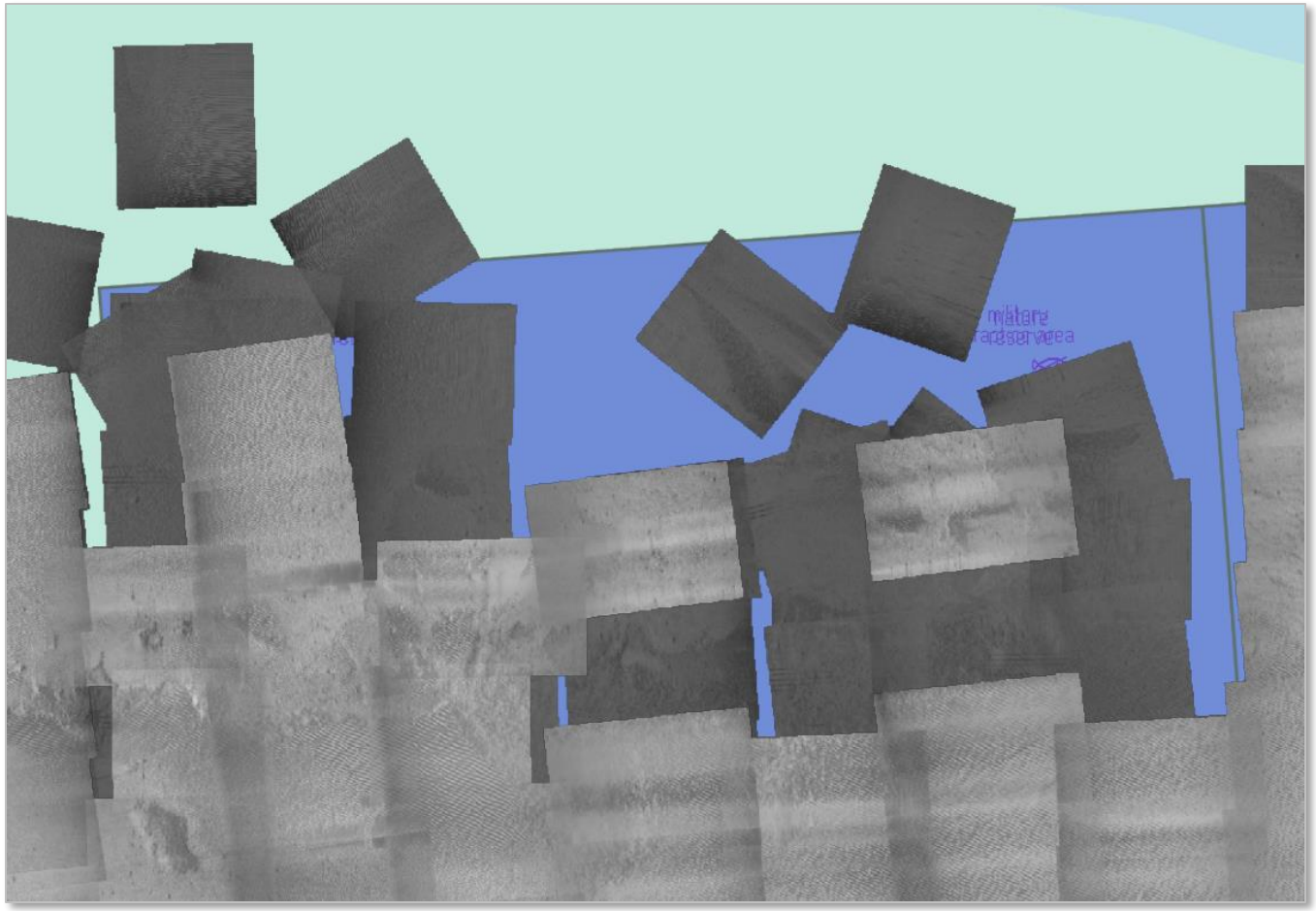

Benchmarking & Testing

- We are right now testing and verifying with different partners our data processing technology
- Integrating immediately feedback based on agile driven development
- Covering a broad variety of use cases, different domains and perspectives

We are continuously looking for interested parties testing and verifying with us

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XOCEAN

Ocean data, delivered.

GEOMAR

Marine

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05

What’s next?

The next steps in the technology development roadmap

What’s next?

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- Further enhancing and automatizing the multibeam processing
- Conducting further testing on larger cloud environments: preparing a test with more than 1,000 CPUs
- Full integration of the Ocean Data Processing Engine into the Ocean Data Platform
- Continuing the development of AI-based analysis (anomaly and object detection) on pointcloud level

Contact

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Thanks!