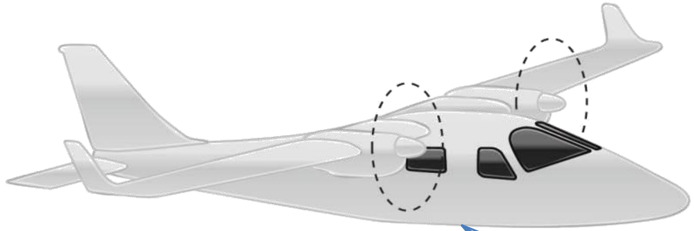


GREENSURVEY

AHM
AIRBORNE HYDRO MAPPING

AHM
AIRBORNE LAND MAPPING

AHM
AIRBORNE NATURE MAPPING

AHM
AIRBORNE ICE&SNOW MAPPING

1. Workshop zum Comet K – Projekt
„Alpine Airborne Hydromapping“

FFG

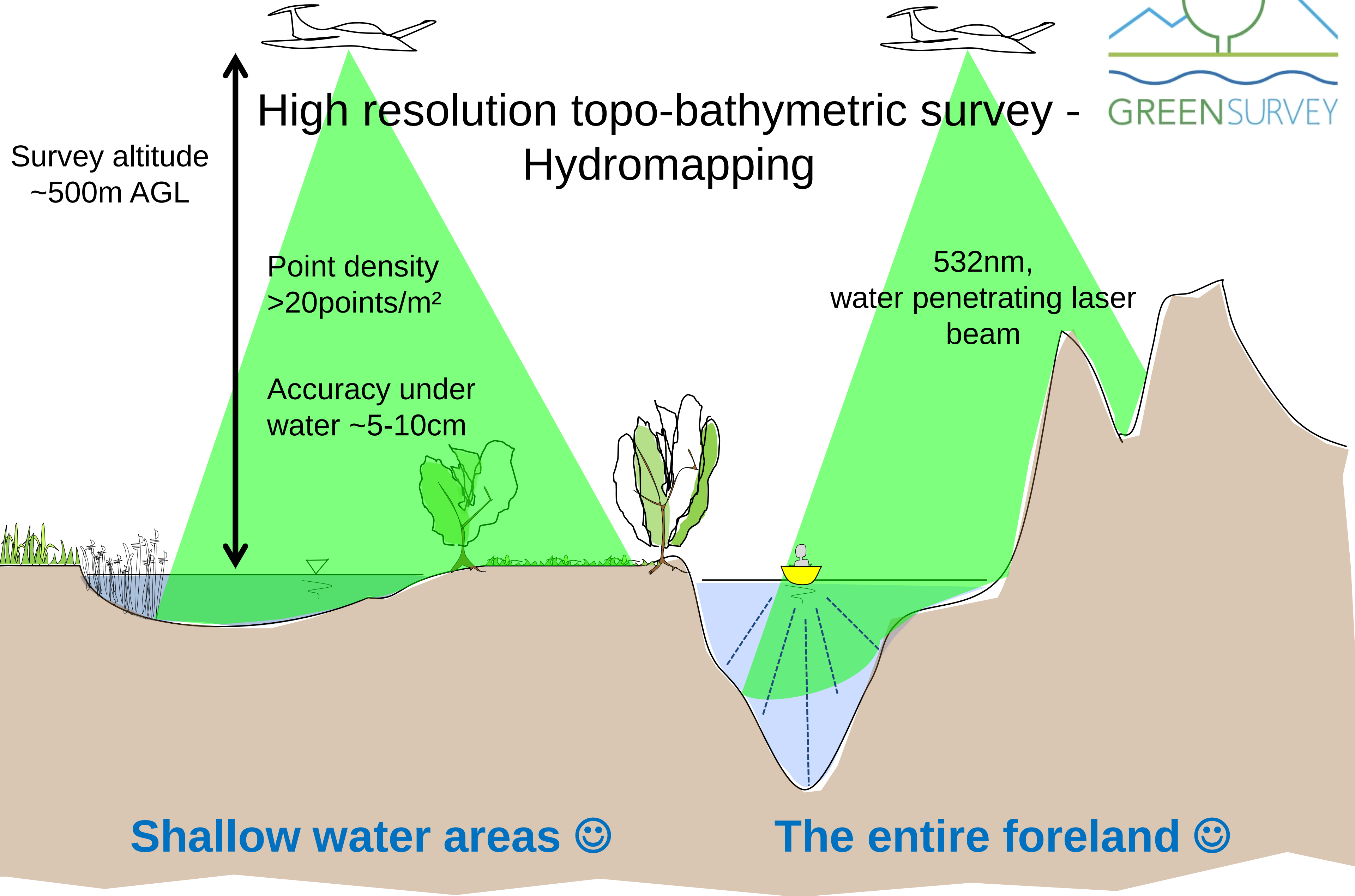
Gewässervermessung aus der Luft

Einsatzmöglichkeiten und Einschränkungen in der Praxis

Frank Steinbacher

High resolution topo-bathymetric survey - Hydromapping

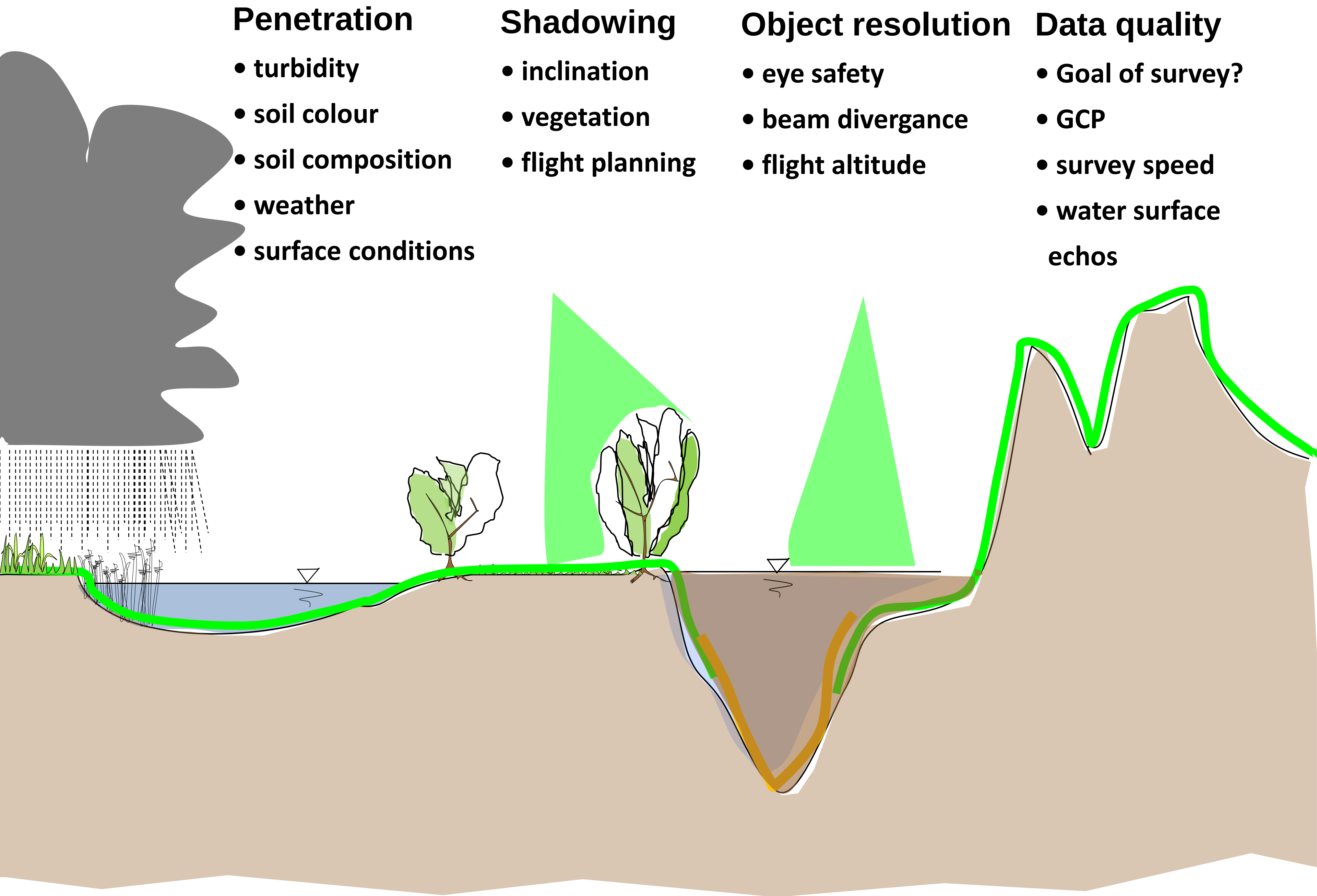
GREENSURVEY



Shallow water areas ☺

The entire foreland ☺

Only deeper areas need to be captured by echo sounders ☺


Penetration
• turbidity
• soil colour
• soil composition
• weather
• surface conditions
Shadowing
• inclination
• vegetation
• flight planning
Object resolution
• eye safety
• beam divergance
• flight altitude
Data quality
• Goal of survey?
• GCP
• survey speed
• water surface echos

Standard
Survey mission

- **Survey parameters**
- **Survey sensors**

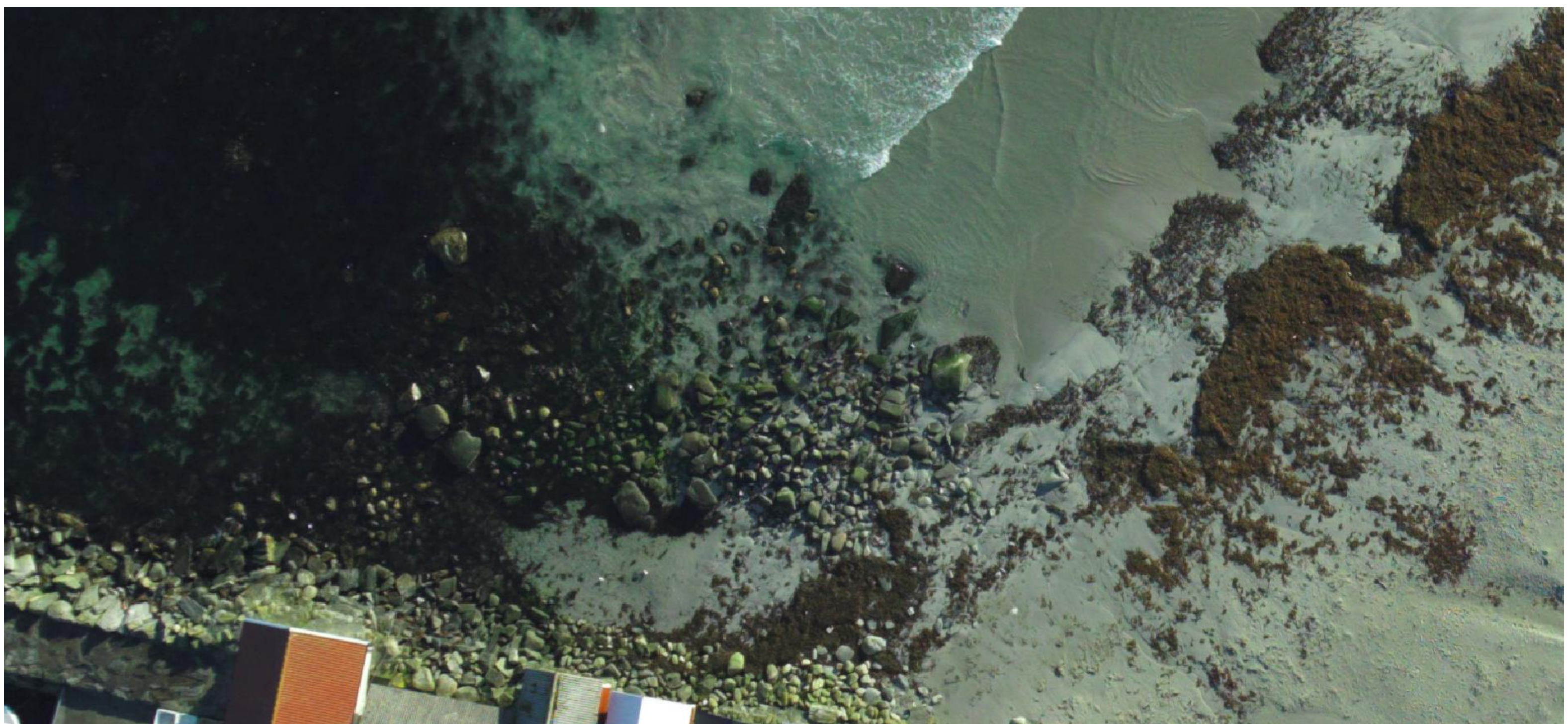
Flight speed: ~80kts
Noise: won’t hear during normal operation (take-off noise ~68dB(A))
Normal operation altitude: ~500m (eye-safety)
Footprint size: ~0.5m
Pulse Repetition Rate: 256 kHz
FOV: 69°-111°
Max. Scanline Resolution: ~200000lines/s -> no equal point spacing relat. to flight speed

-> Results in about 25-35 points/m²

Survey mission

- Survey parameters
- Survey sensors

Topo-Bathymetric Lidar Scanner: Riegl VQ-820G (Riegl VQ-880G within 2nd part of AAHM)
RGB-Camera: Hassleblad H39 (IGI) (GSD ~5cm)
4K-Videocamera: GoPro 3 (Black)
Thermal Camera: Infratec HD900 (GSD ~20cm)



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AIRBORNE HYDRO MAPPING

AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

Penetration

- turbidity
- soil colour
- soil composition
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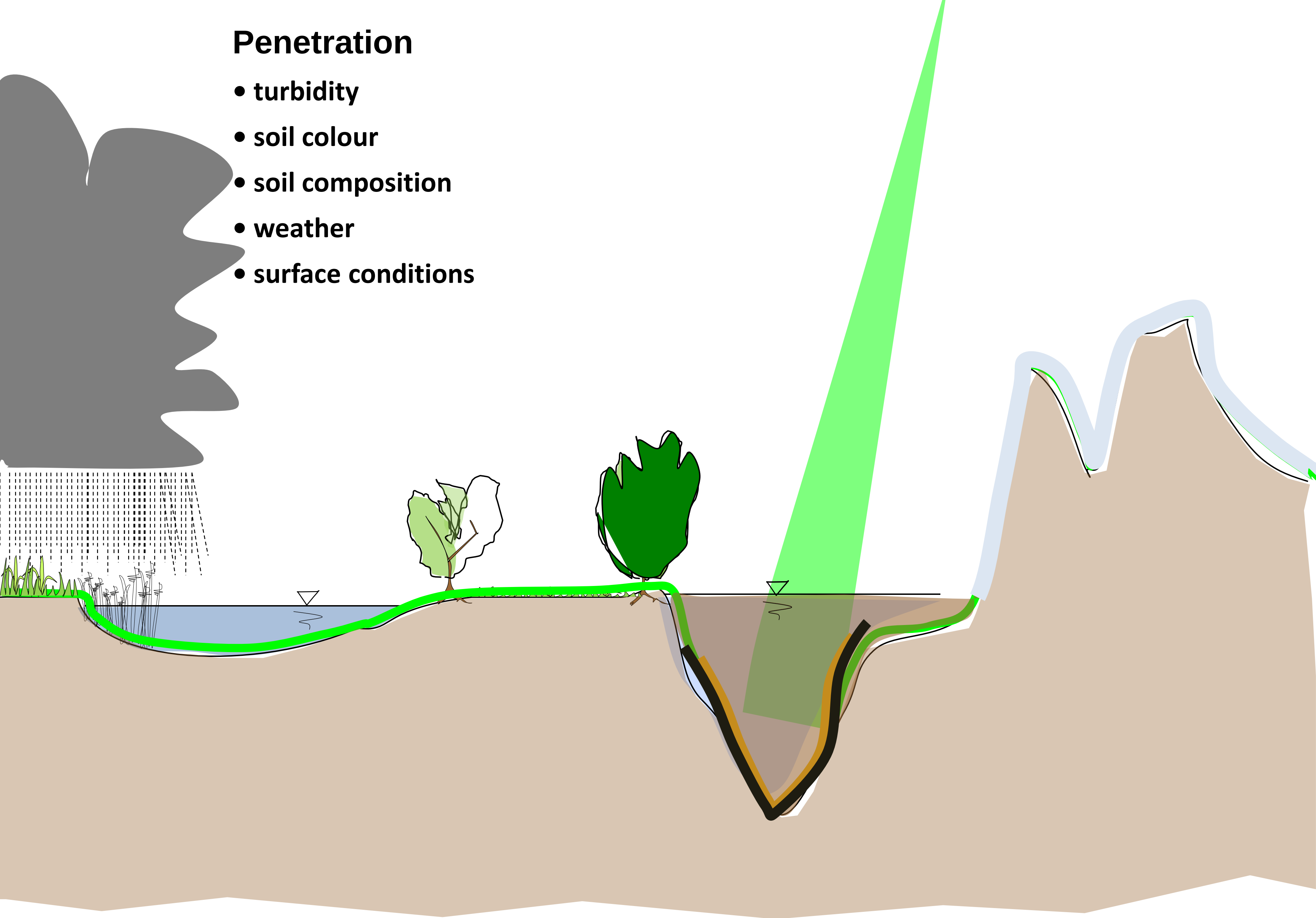


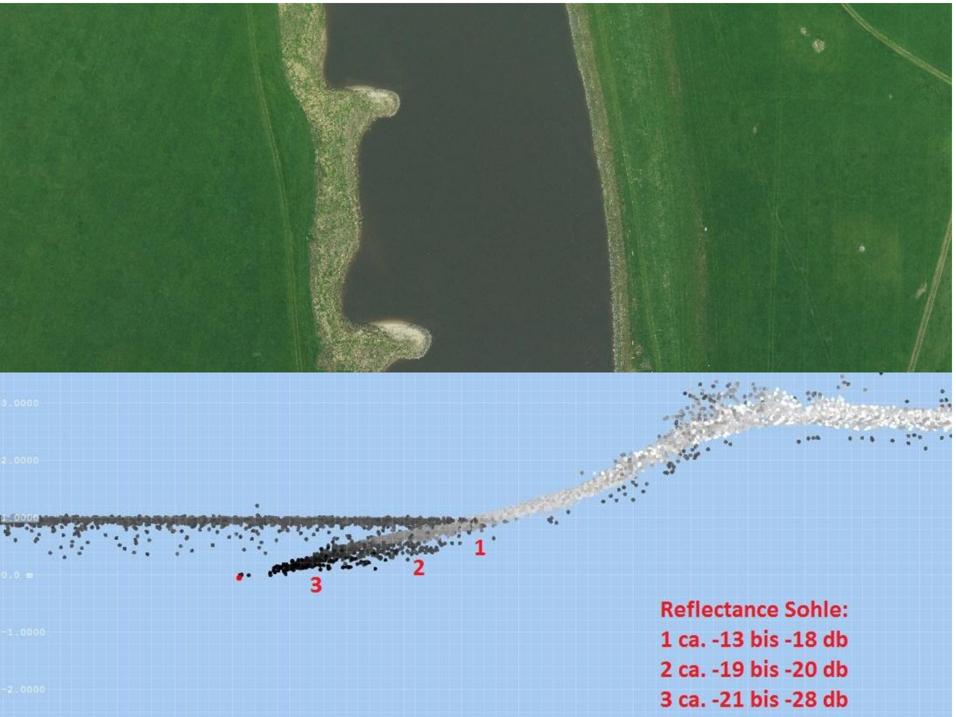
Penetration

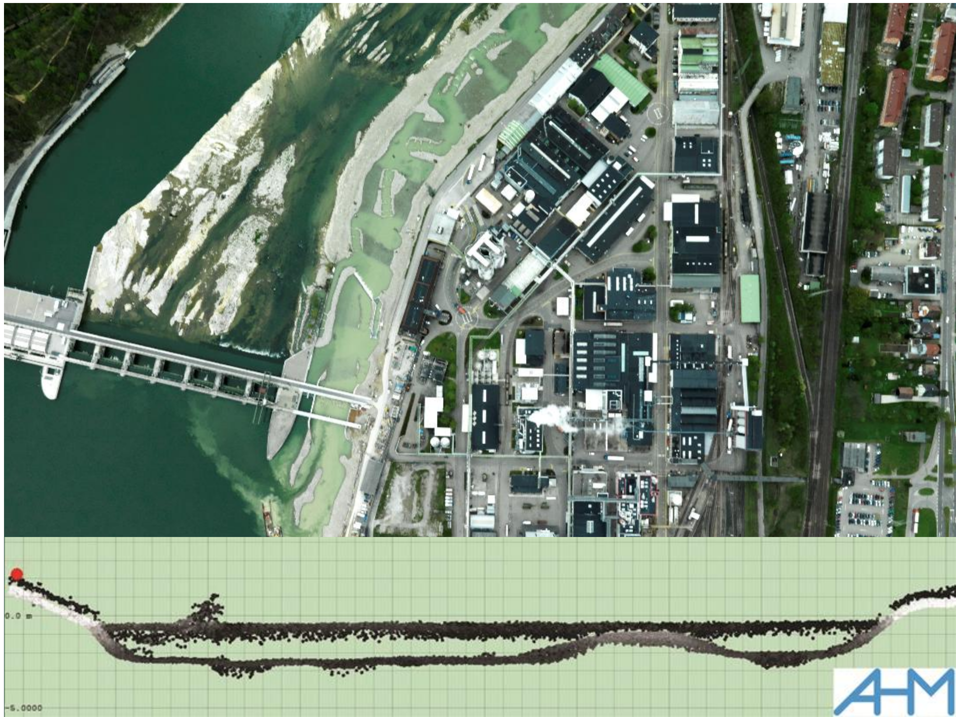
- **turbidity**

ELBE vs. Rhein

Secchi depth

1m vs. 0.7m





Penetration

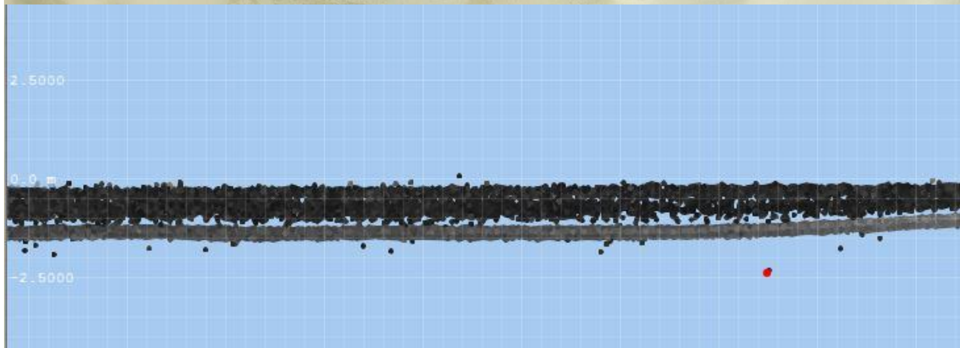
• soil colour

• soil composition

ELBE / Rhein vs. Wadden Sea

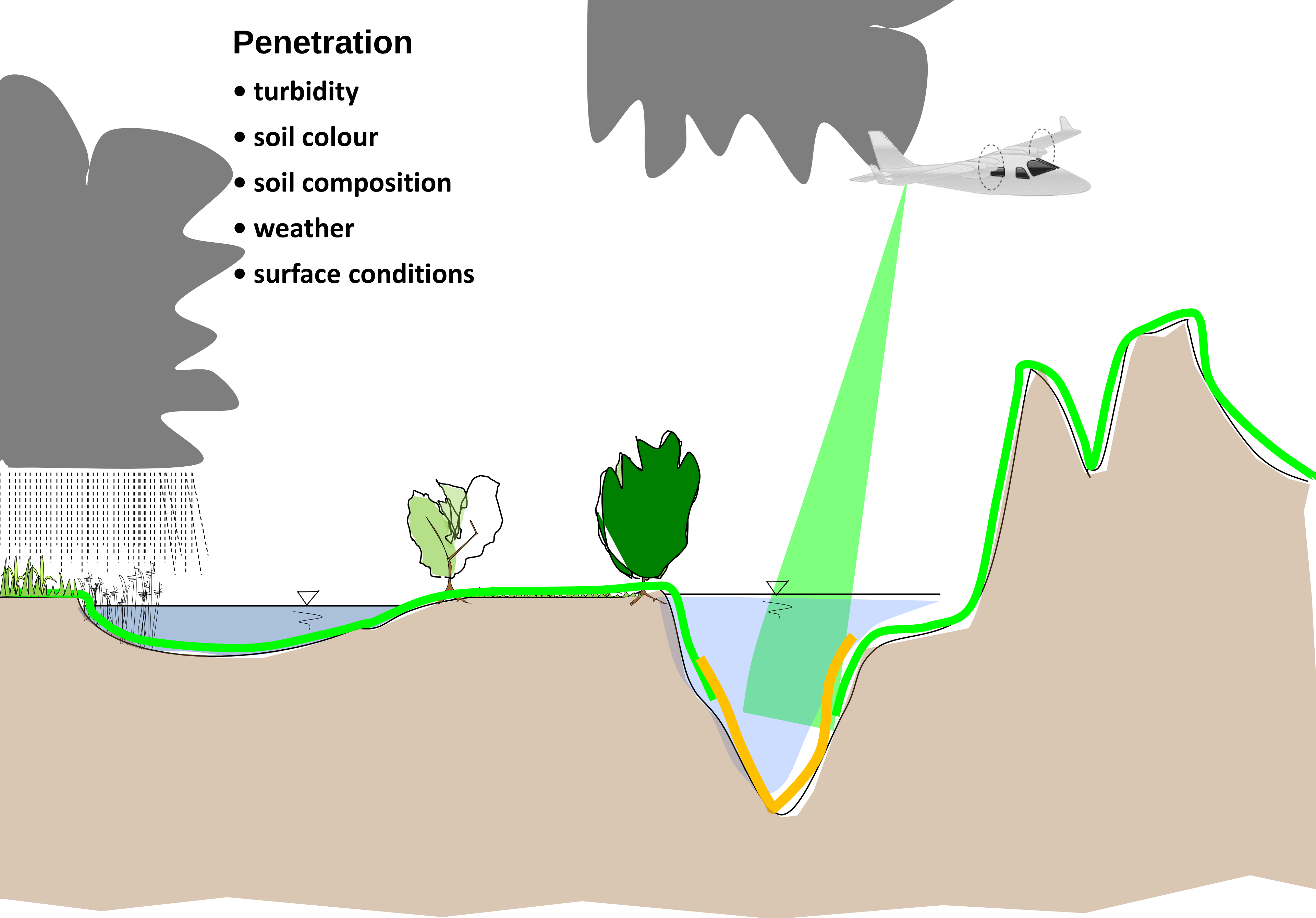
Secchi depth

1m vs. 0.2m



Penetration

- turbidity
- soil colour
- soil composition
- weather
- surface conditions

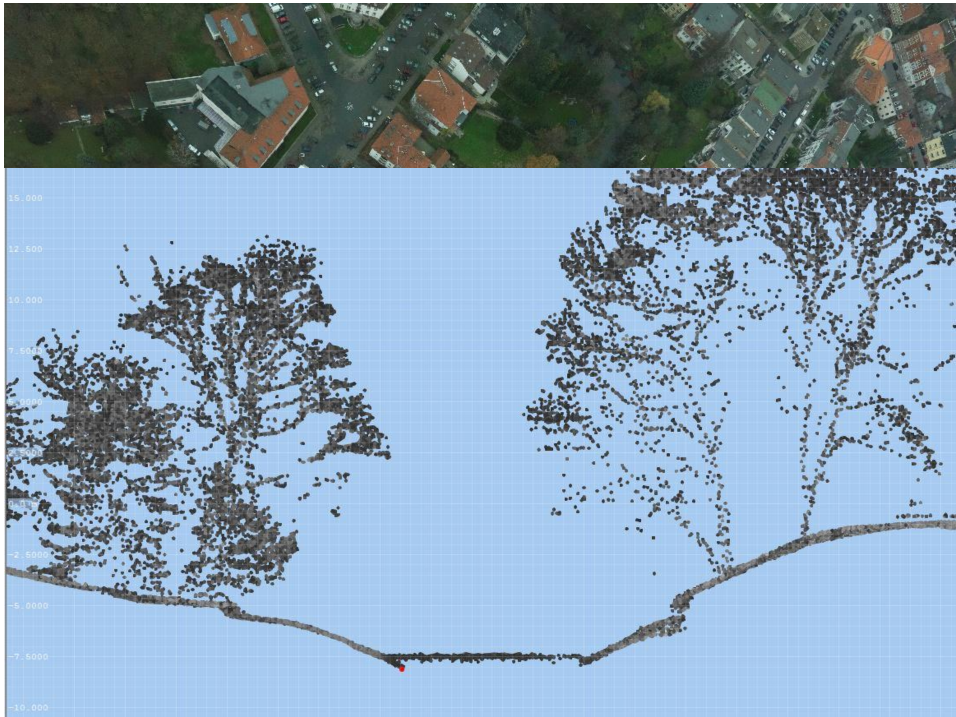


Penetration

- **weather**
- **surface conditions**

Wolterdingen vs. Oker

clear sky vs. high humidty

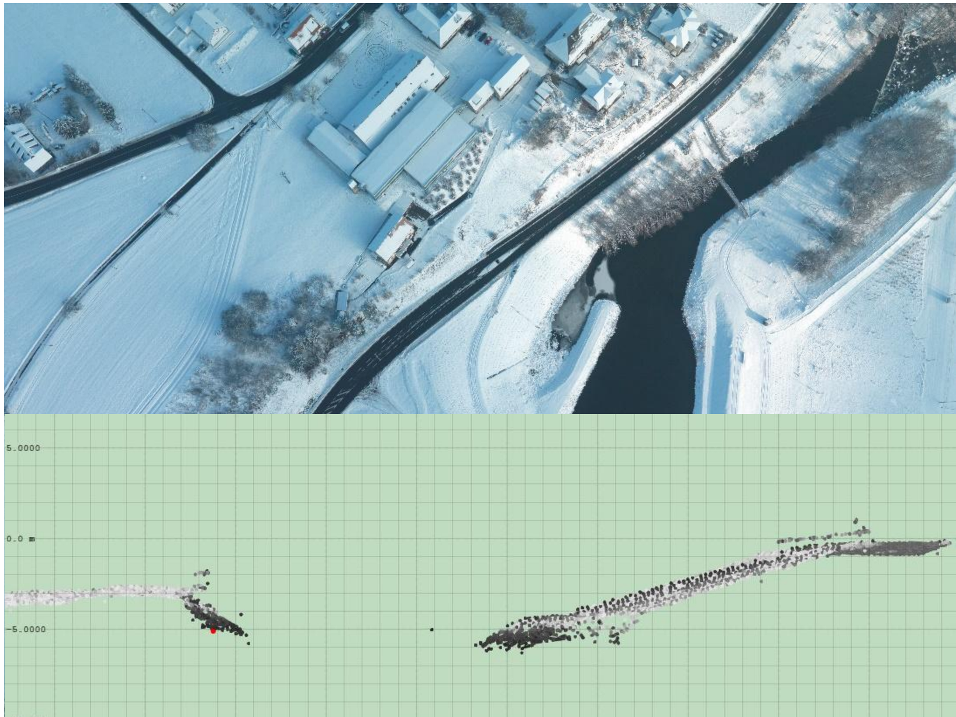


Penetration

- **weather**
- **surface conditions**

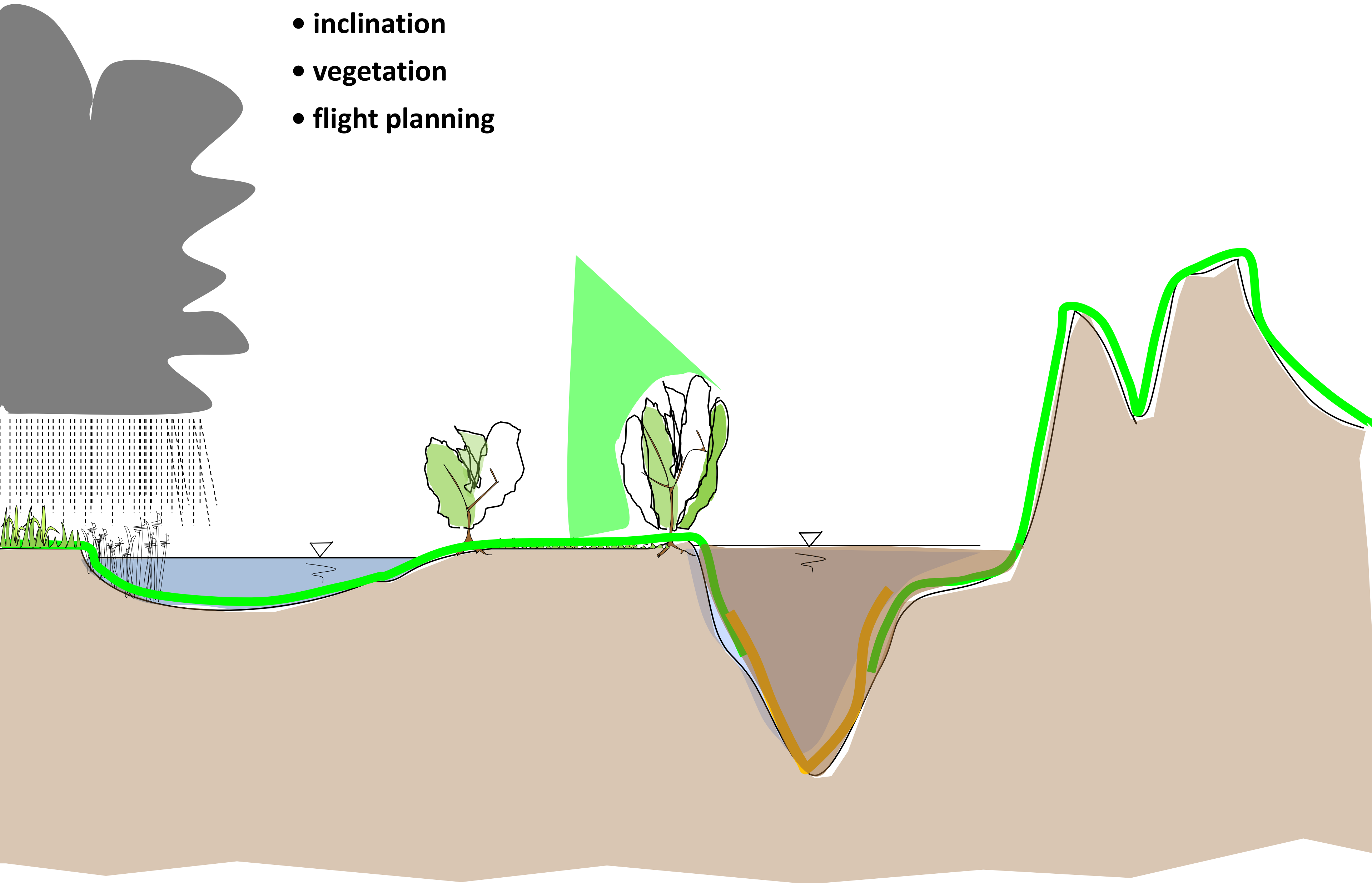
Wolterdingen vs. Wolterdingen

normal surface colour vs. bright surface colour



Shadowing

- inclination
- vegetation
- flight planning



Shadowing

- inclination
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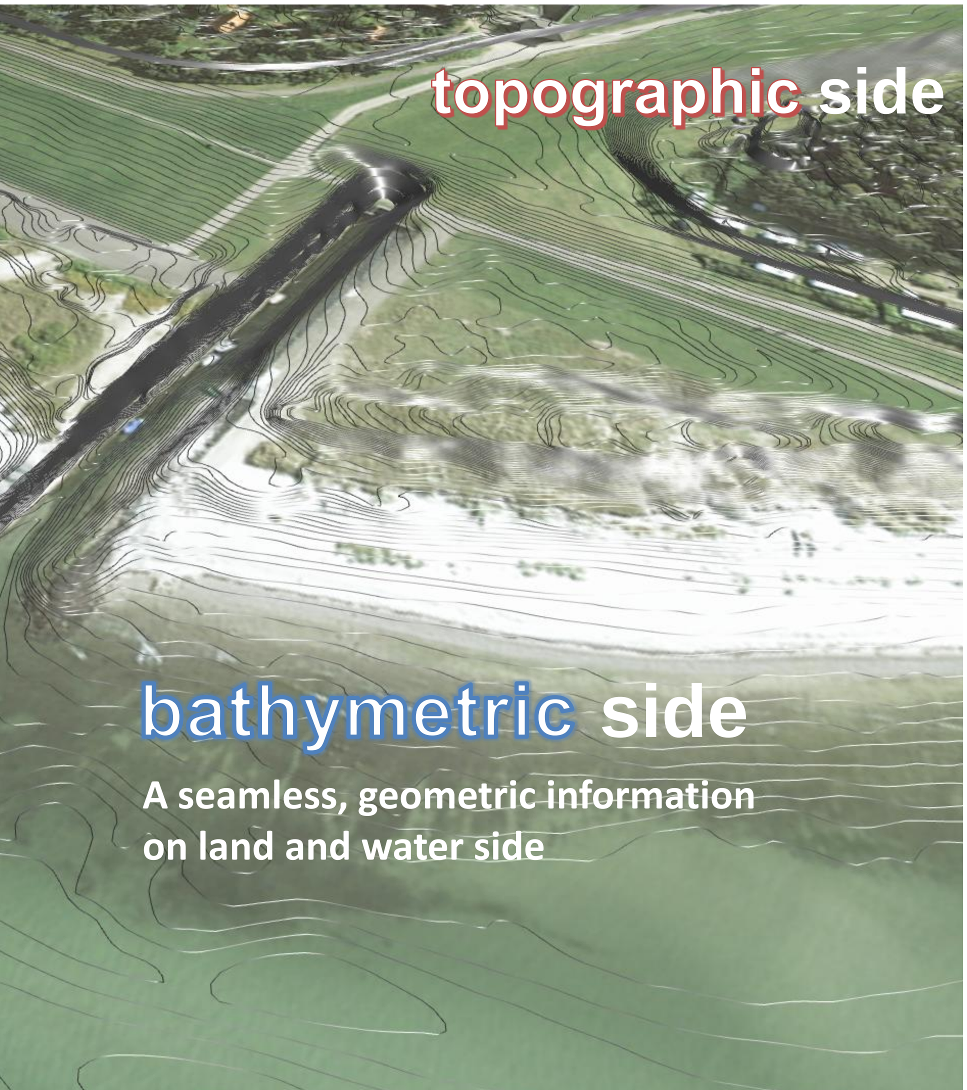
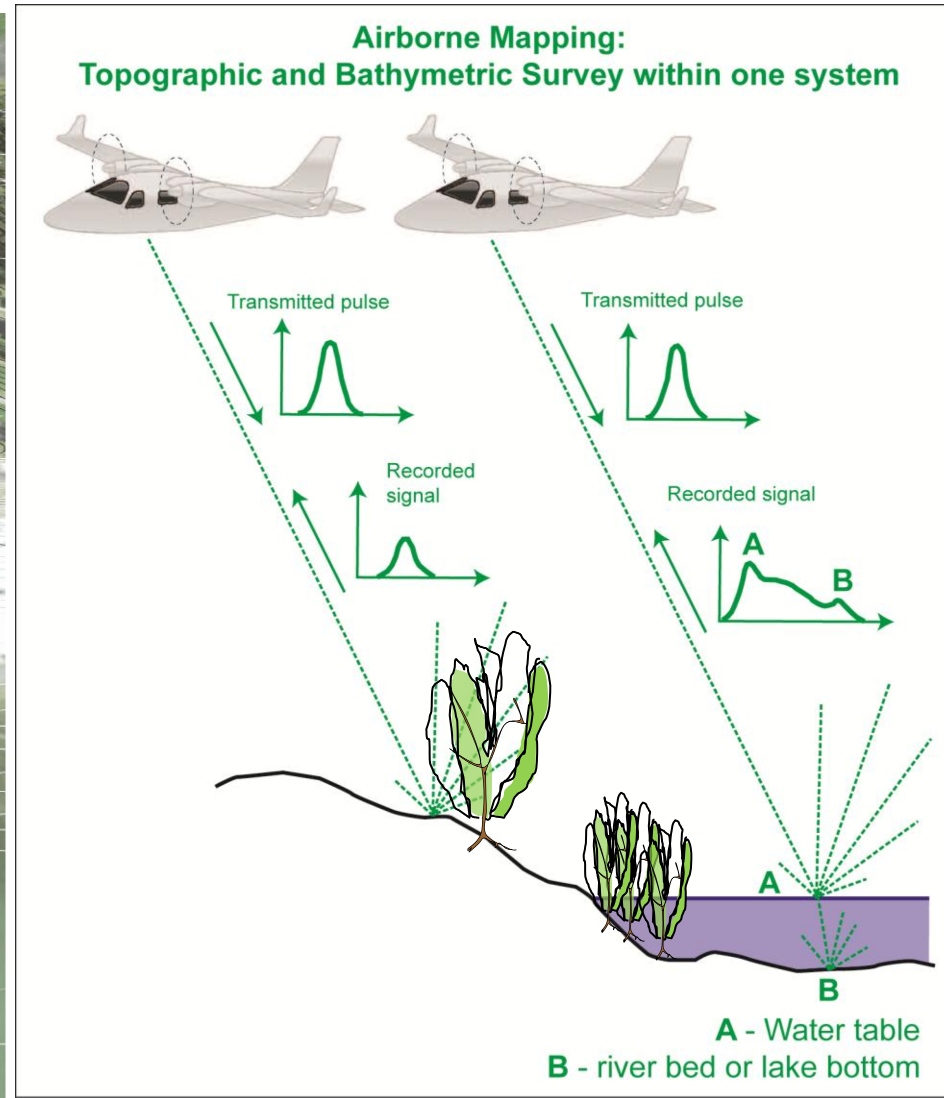
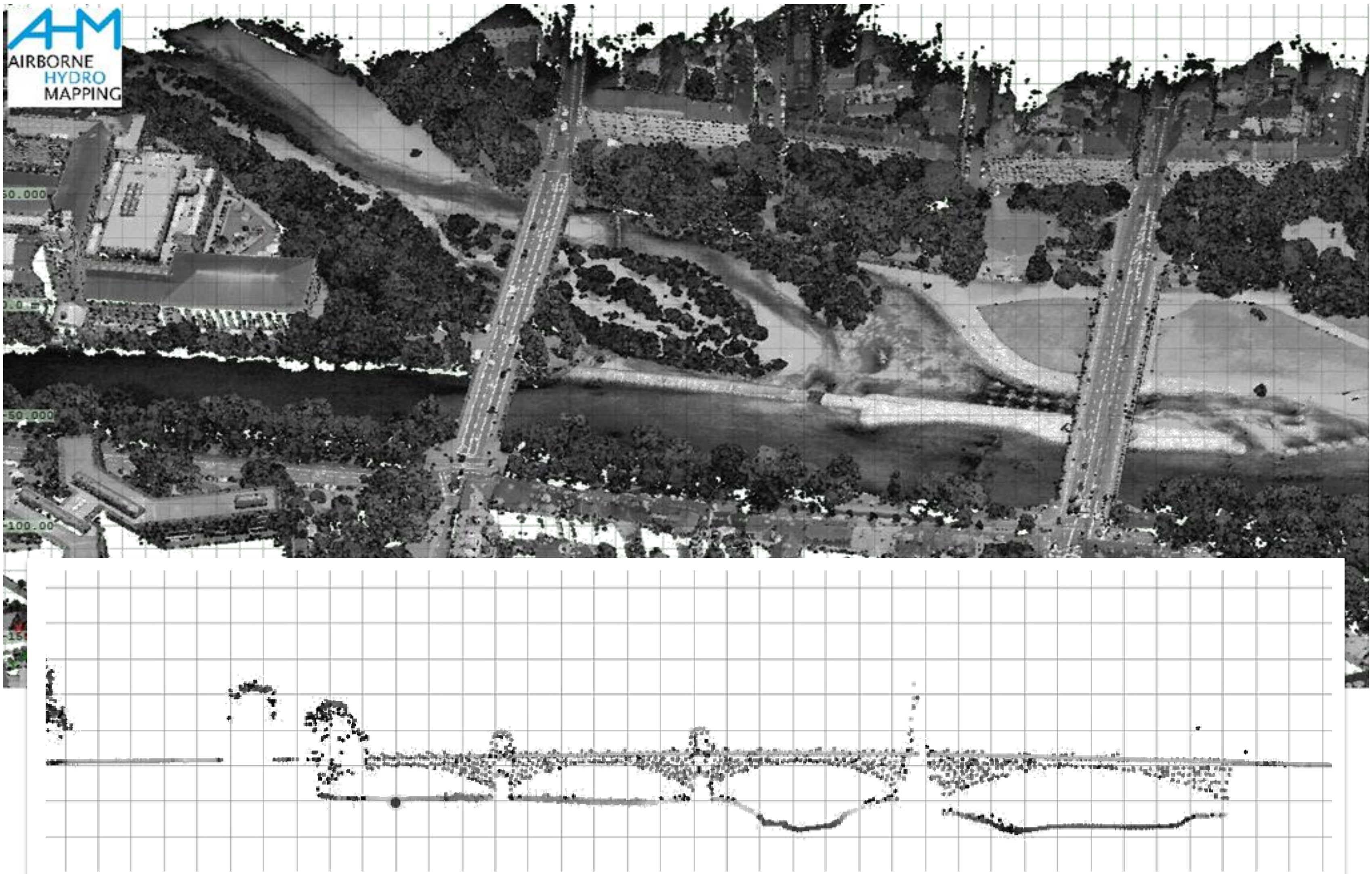




Shadowing

- inclination
- vegetation
- flight planning

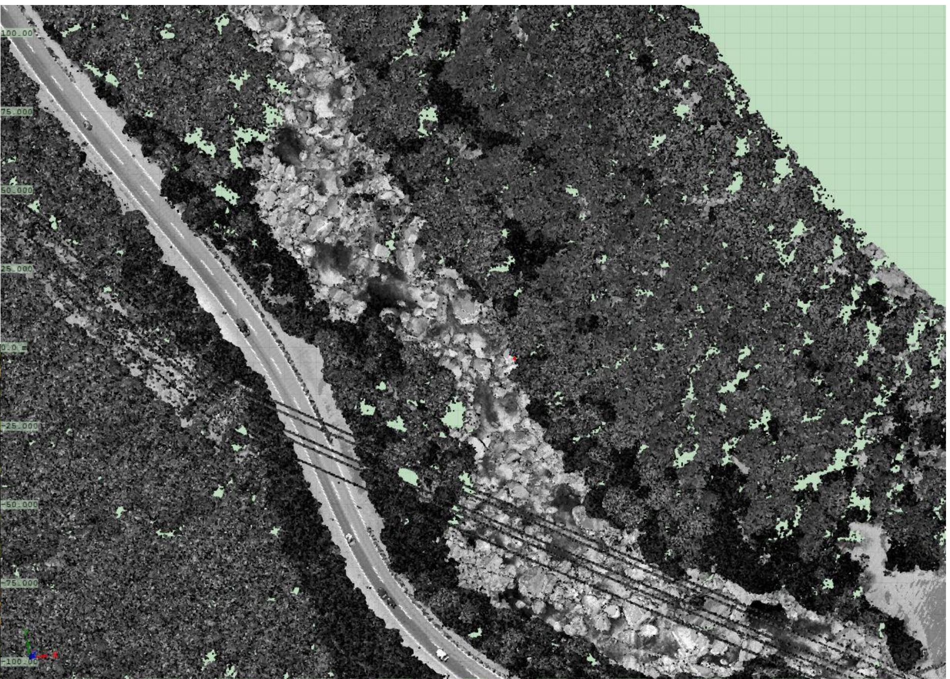
20° inclination

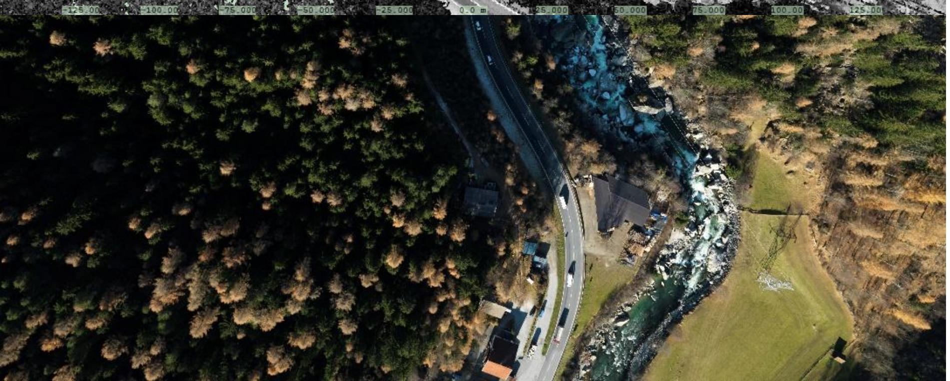


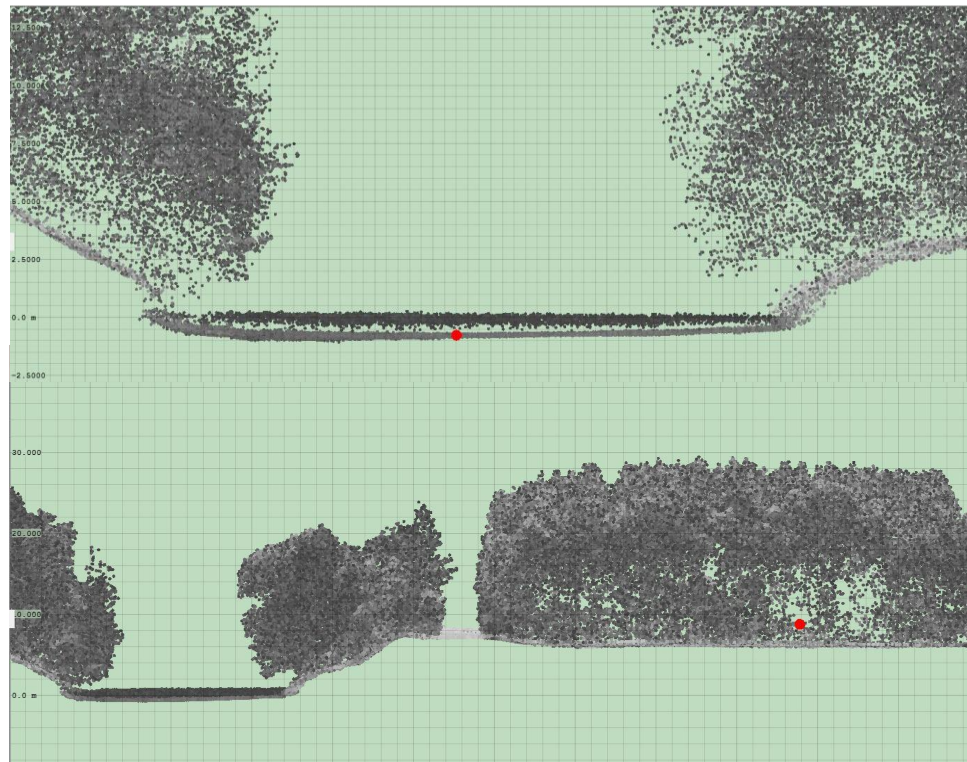
Shadowing

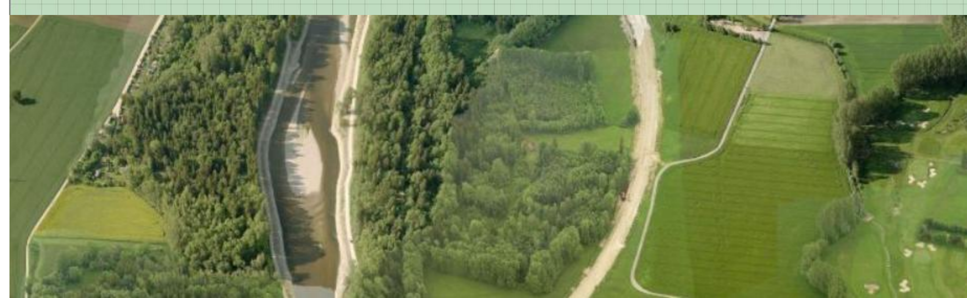
- inclination
- vegetation
- flight planning

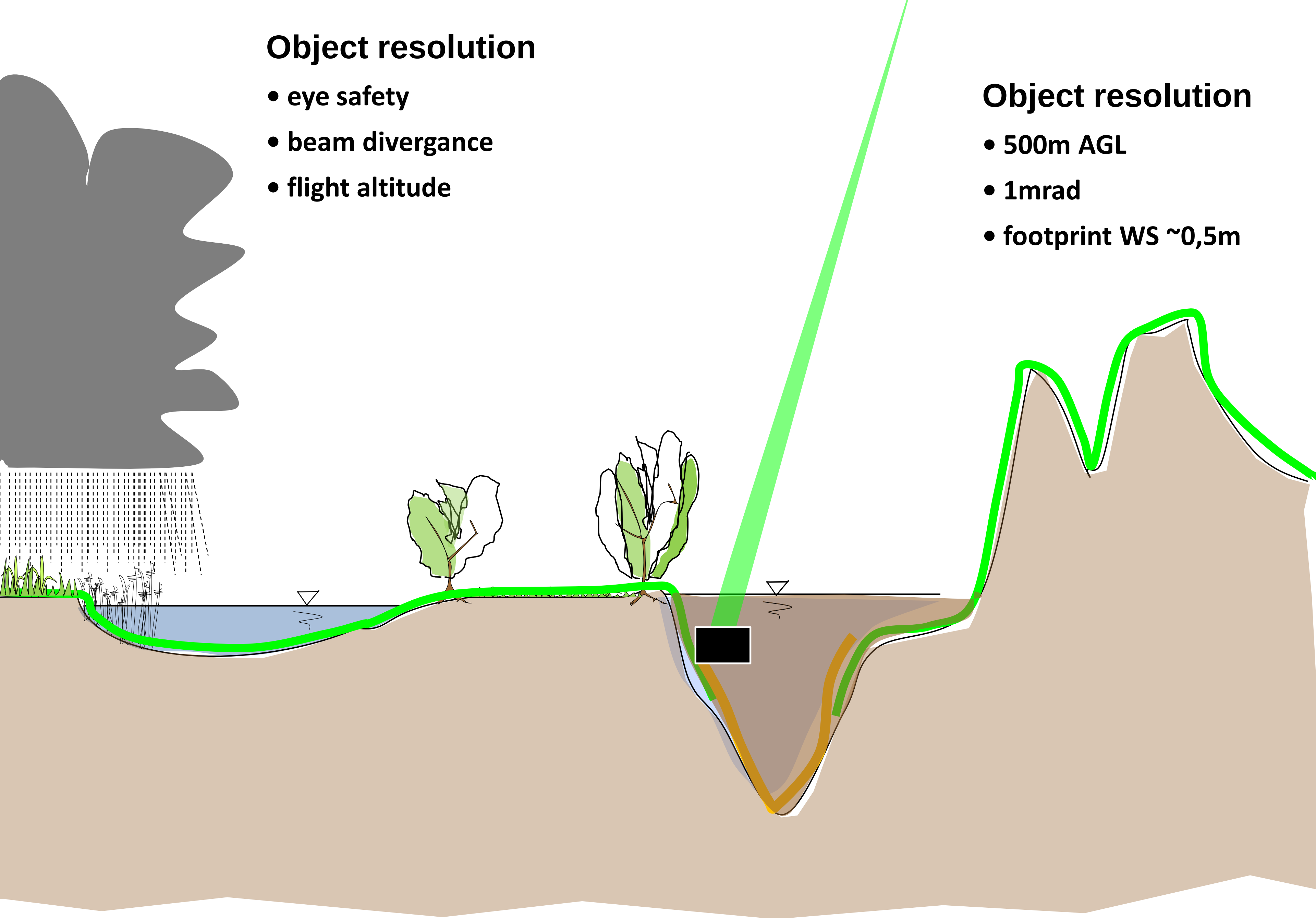
Ötztaler Ache vs. Wertach










Object resolution
• eye safety
• beam divergance
• flight altitude
Object resolution
• 500m AGL
• 1mrad
• footprint WS ~0,5m

Altitude and footprint–object resolution under water

GREENSURVEY

DEPARTMENT OF GEOSCIENCES AND NATURAL RESOURCE MANAGEMENT

FACULTY OF SCIENCE

UNIVERSITY OF COPENHAGEN

On the performance of topobathymetric LiDAR in shallow water environments

Aron Gergely[1], Mikkel S. Andersen[1], Mathias Teglbrænder-Bjergkvist[1], Zyad K. Al-Hamdani[2], Jørgen O. Leth[2], Frank Steinbacher[3], Laurids R. Larsen[4], Carlo Sørensen[5], Verner B. Ernstsen[1]*

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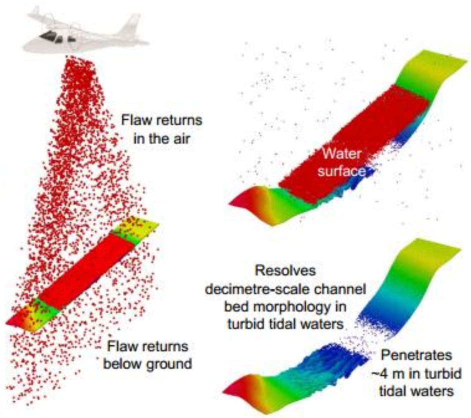
[2] GEUS, Copenhagen
[3] AHM – Airborne Hydro Mapping GmbH, Innsbruck, Austria
[4] NIRAS, Allerød
[5] Danish Coastal Authority, Lemvig / DTU Space, Lyngby



Mapping shallow water environments in the land-sea transition zone at high spatial resolution and at large spatial scales is challenging. Historically this has led to gaps between terrestrial and marine surveys. Airborne topobathymetric LiDAR can close this gap and bridge scales from landforms to landscapes; but what is the resolution, smoothing, precision and accuracy of this revolutionizing mapping technology?

Aim and objectives

The aim is to investigate the performance and the potential of topobathymetric LiDAR in shallow water environments with the specific objectives to:

- determine the resolution and smoothing as well as the vertical precision and accuracy of topobathymetric LiDAR based on object detection.
- assess the potential of topobathymetric LiDAR as a tool to bridge morphological scales and to combine and integrate terrestrial and marine mapping and investigations in the land-sea transition zone.

Airborne topobathymetric Light Detection And Ranging (LiDAR)

- Water-penetrating green wavelength.
- Seamless topography/bathymetry across the land-water interface.
- Small foot print size.
- High spatial resolution (~20 points/m^2).

Field experiment

- Topobathymetric LiDAR surveys in spring 2014.
- Ribe Vesterå river (~7 km reach).
- RIEGL® VQR-820-G airborne green laser scanner.

The resolution and smoothing, and the vertical precision and accuracy were determined from two geometrically defined objects:

- Cement block (250 x 125 x 80 cm) on land close to the Kammerslusen sluice gate.

Altitude and footprint–object resolution under water

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AIRBORNE HYDRO MAPPING

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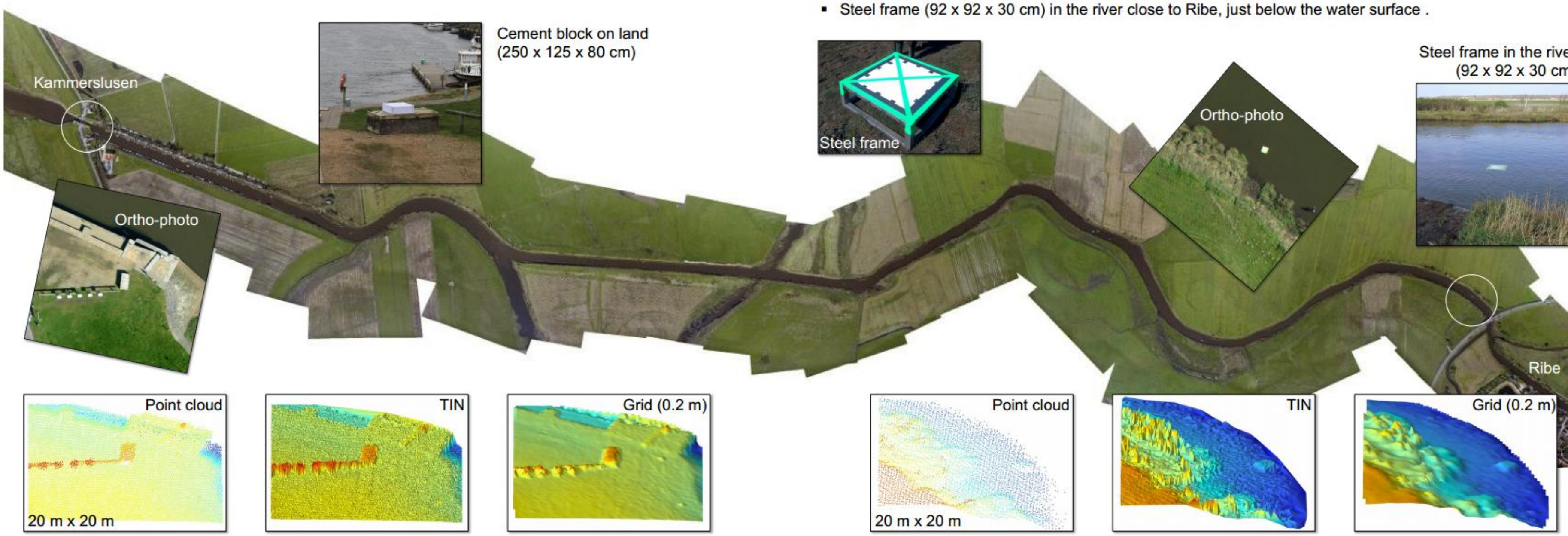
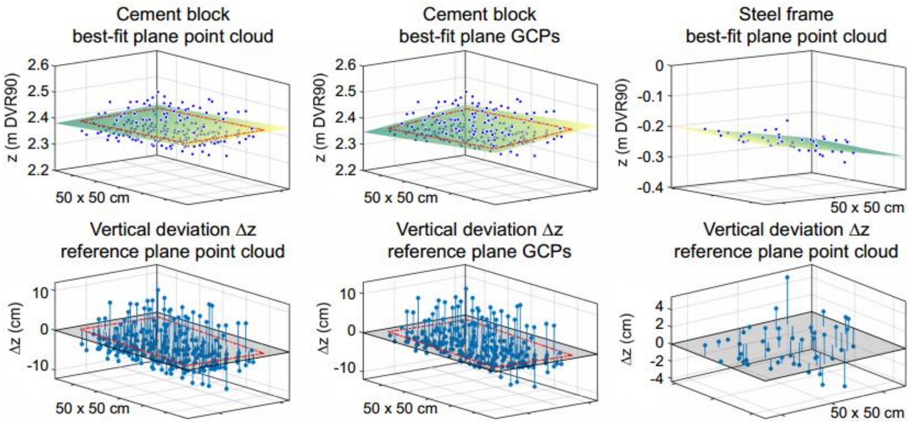
The resolution and smoothing, and the vertical precision and accuracy were determined from two geometrically defined objects:

- Cement block (250 x 125 x 80 cm) on land close to the Kammerslusen sluice gate.
- Steel frame (92 x 92 x 30 cm) in the river close to Ribe, just below the water surface .



Altitude and footprint–object resolution under water

Vertical precision and accuracy



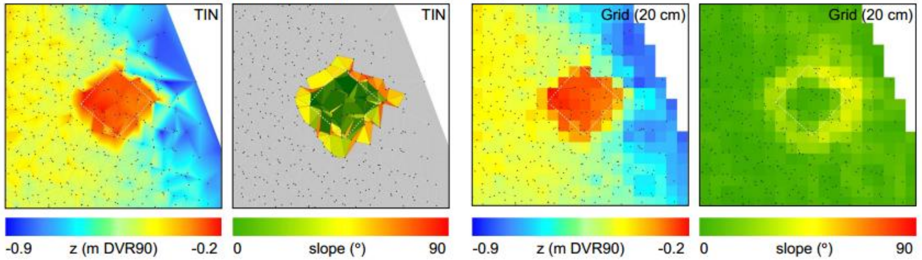
Object	Reference plane	# points n	Min error (cm)	Max error (cm)	Mean error (cm)	STD* (cm)	RMSE** (cm)	95%-confidence (cm)	Precision/ Accuracy
Steel frame	Point cloud	46	0.02	5.5	1.6	2.0	1.9	±3.8	Precision
Cement block	Point cloud	227	0.04	12.9	2.8	3.9	3.9	±7.6	Precision
Cement block	GCPs***	227	0.01	12.1	3.5	4.1	4.1	±8.1	Accuracy

*STD: standard deviation; **RMSE: root mean square error; ***GCP: ground control point.

Resolution and smoothing

- High spatial resolution (point densities > 20 points/m^2).
- Steel frame (decimetre-scale feature) is detected.
- Smoothing of the surface overestimates the surface area and volume of the steel frame.
- Smoothing of the surface underestimates the slope angles of the steel frame.
- Resolved slope angles of the steel frame > angle of repose.

Steel frame just below the water surface (zoom-in 4 m x 4 m)



	Spatial resolution (points/m²)	Surface area (m²)	Volume (m³)	Mean slope (°)	STD* (°)	RMSE** (°)
Reference	-	1.95	0.25	90	-	-
TIN	> 20	3.10 (1.6)	0.42 (1.6)	56 (0.6)	16	38
Grid (0.2 m)	> 20	2.85 (1.5)	0.43 (1.7)	30 (0.3)	7	60

*STD: standard deviation of the point cloud; **RMSE: root mean square error from a 90° angle.

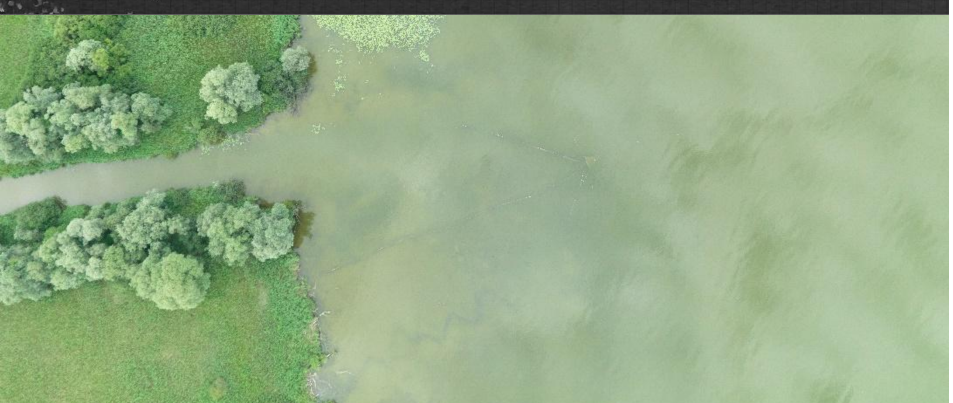
Concluding remarks and perspectives

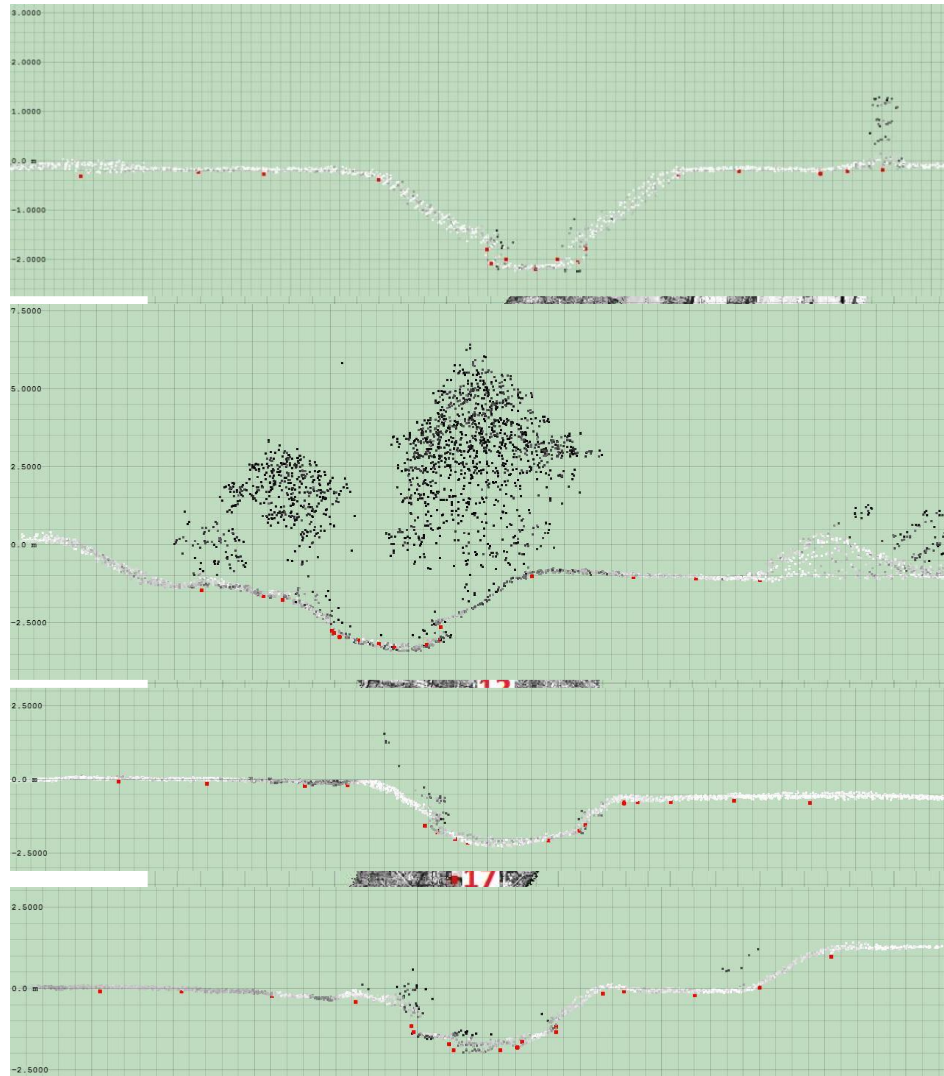
- Airborne topobathymetric LiDAR can detect decimetre-scale features in shallow water environments.
- Sharp-edged, sharp-cornored, steep-angled decimetre-scale features are smoothed:
  - Surface areas and volumes are overestimated.
  - Slope angles are underestimated, but slope angles larger than the angle of repose are resolved.
- Precision and accuracy is at centimetre-scale.
- Airborne topobathymetric LiDAR has the potential to bridge morphological scales and, therefore, to combine and integrate terrestrial and marine mapping and investigations in the land-sea transition zone; this enables a closing of the historical gap between terrestrial and marine surveys.

Object resolution

- eye safety
- beam divergance
- flight altitude

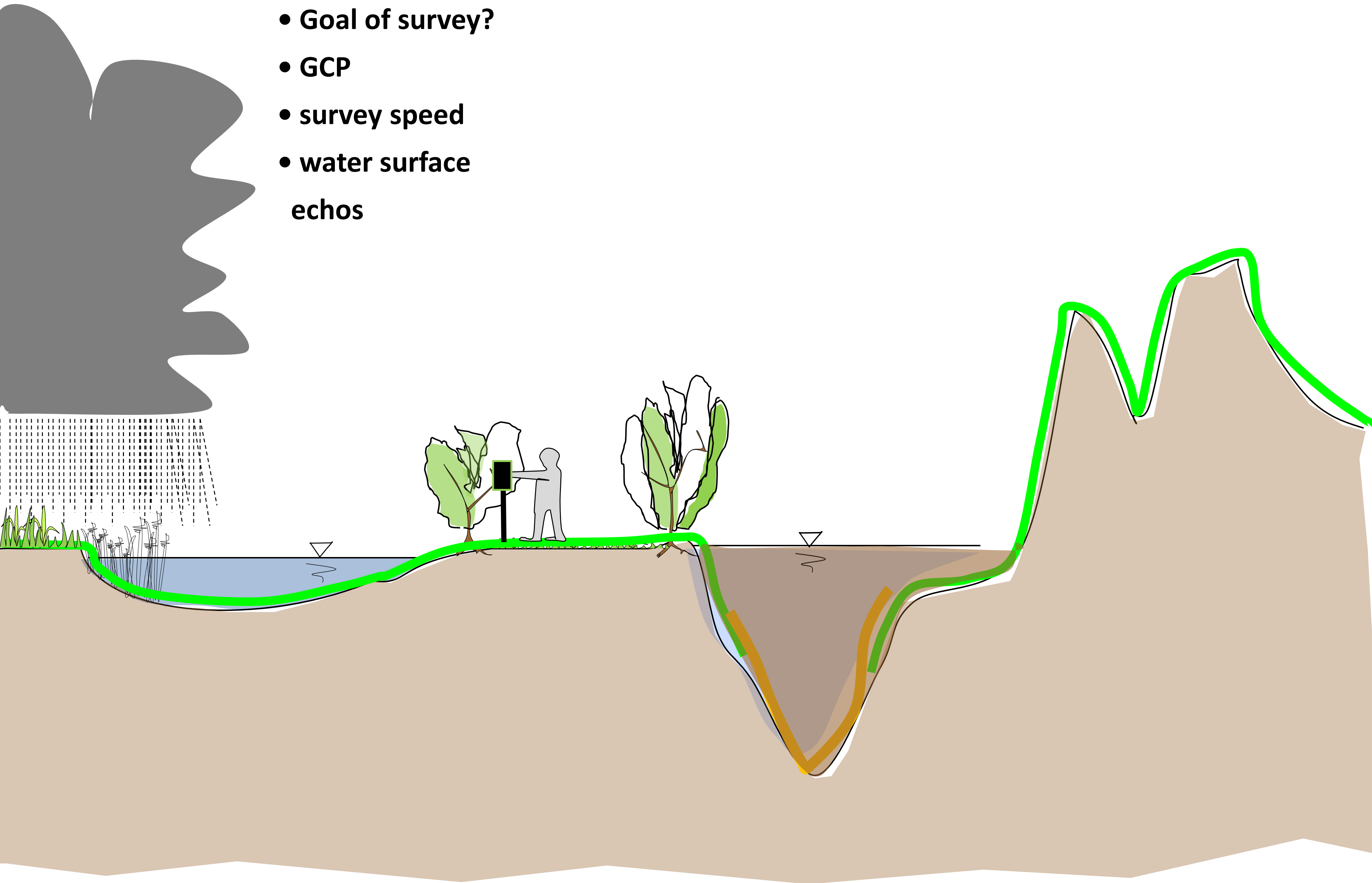
Ammersee vs. Hachinger Bach





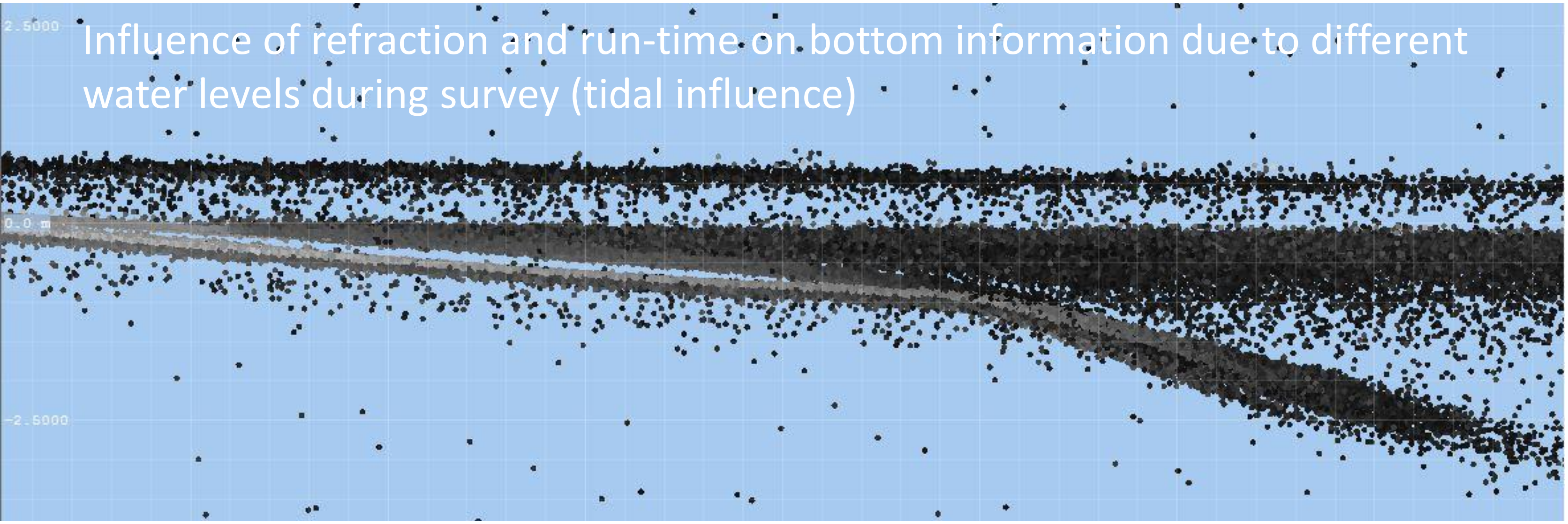
Data quality

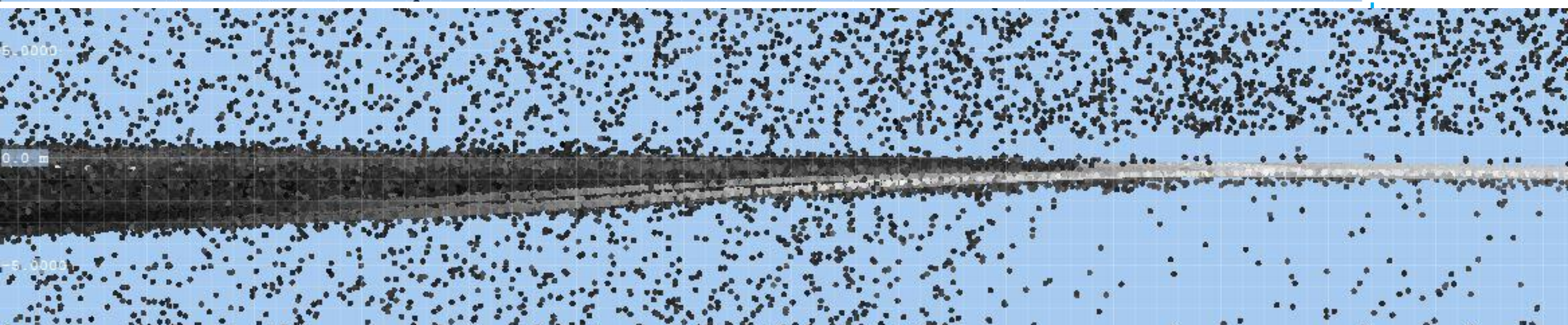
- Goal of survey?
- GCP
- survey speed
- water surface echos

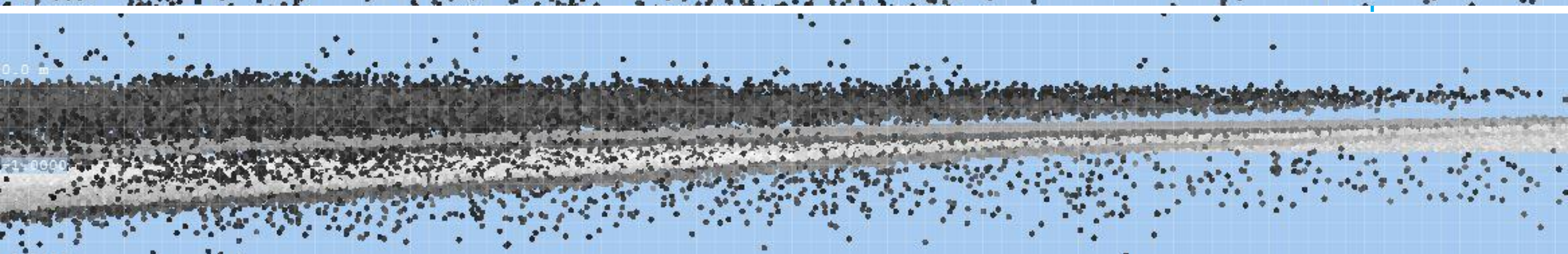


Changing water level

Influence of refraction and run-time on bottom information due to different water levels during survey (tidal influence)







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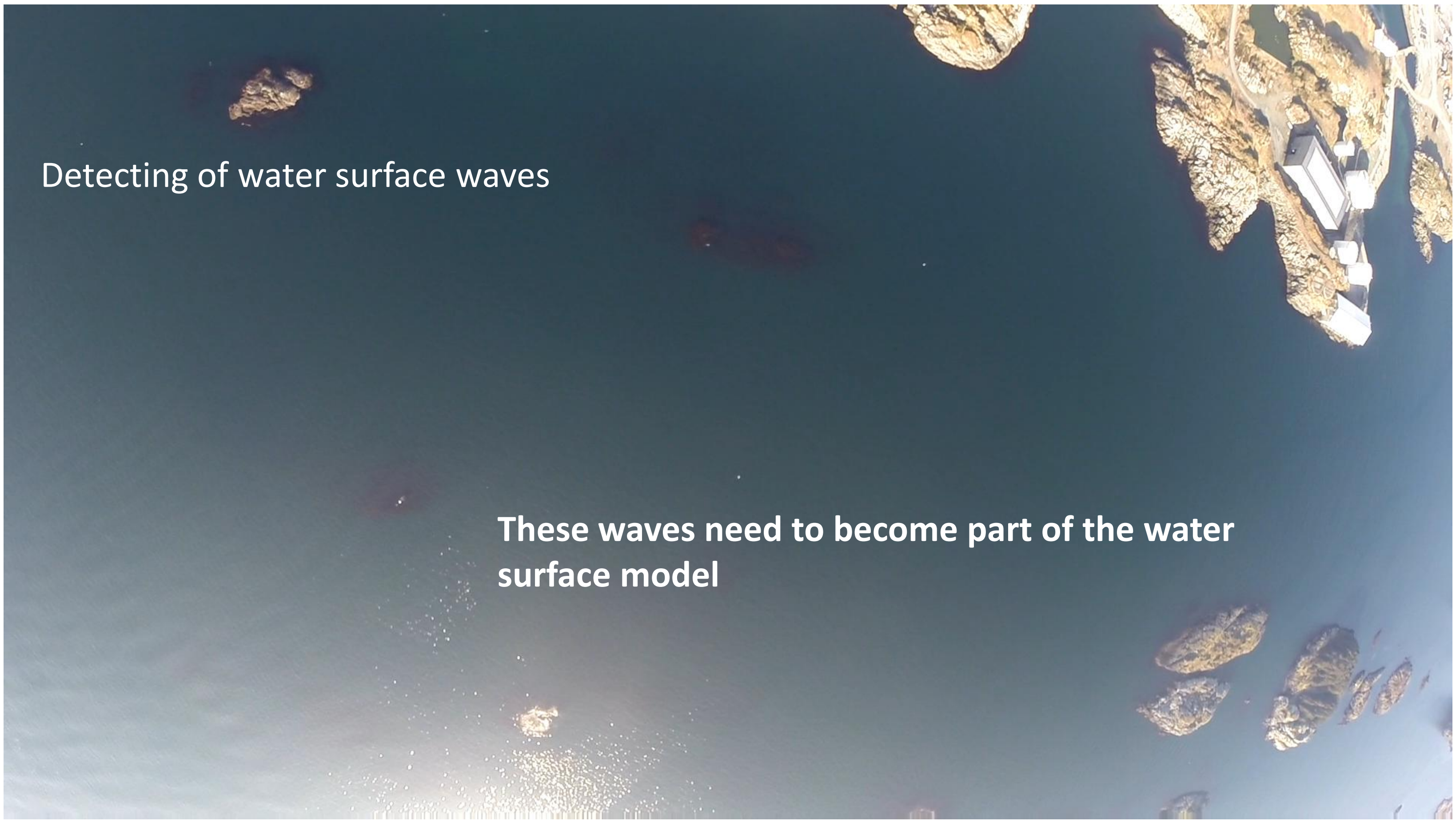
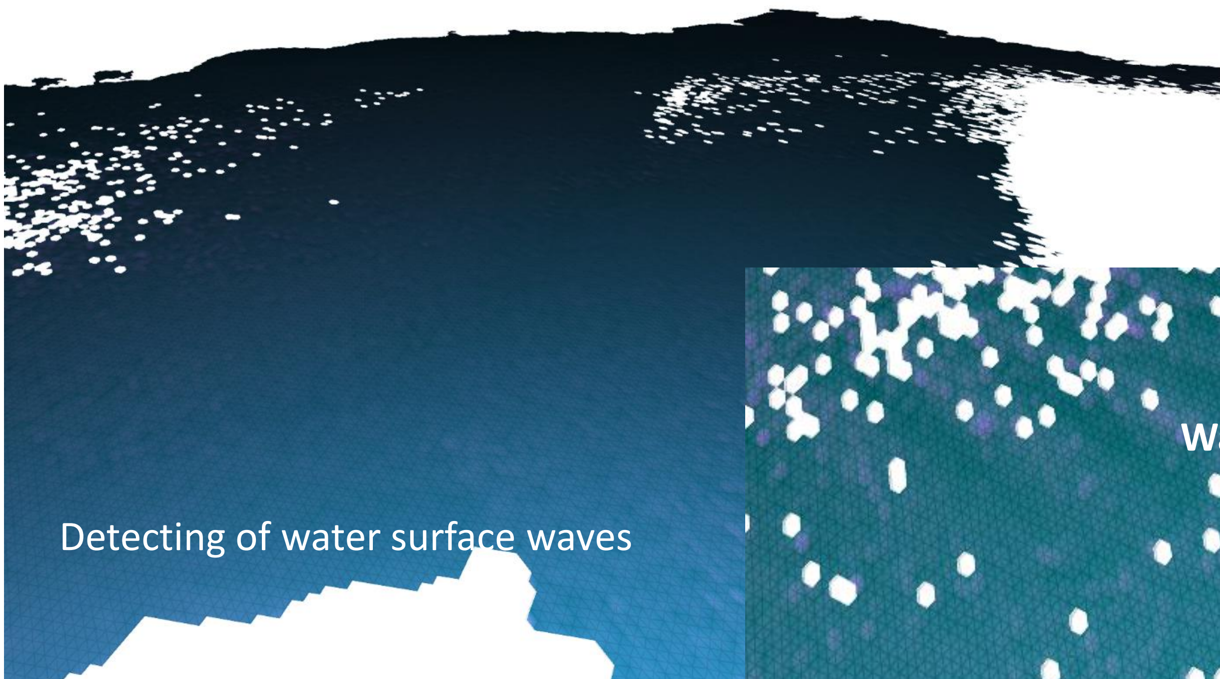
Changing water level

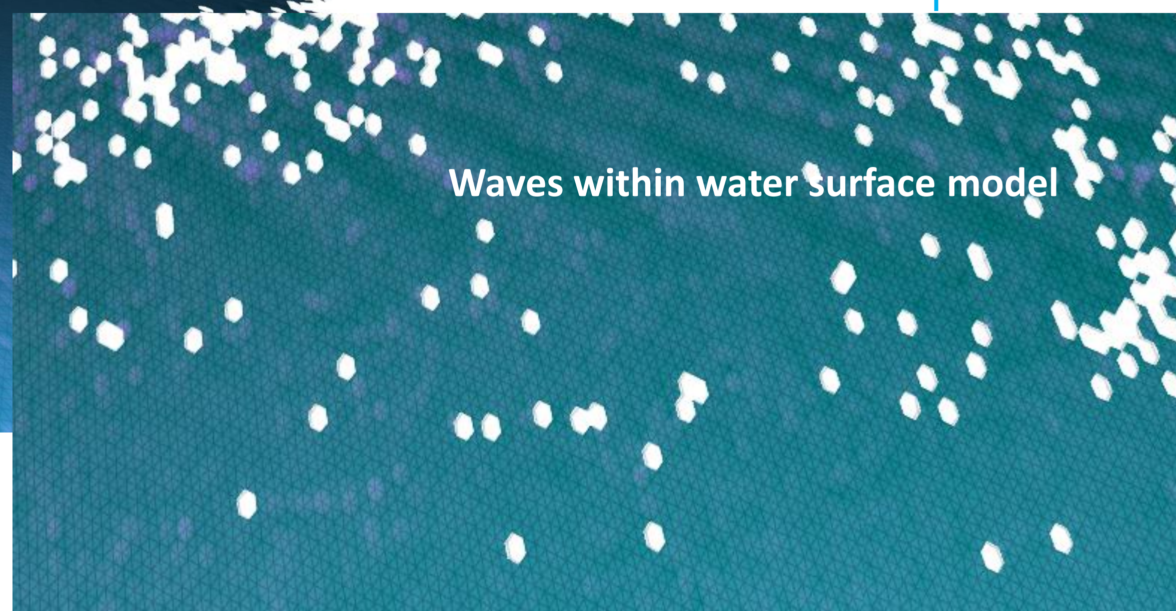
- Survey parameters
- Survey duration
- Survey conditions



Changing water level

- Noise and false point removal (QC on results)
- Water surface classification and water surface model (QC on results)
- Refraction (QC)
- Classification
- Rasterization
- DTM / Meshing / Data combination with MBES
- Visualization





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