Unmanned Airborne Vehicles (UAVs) for monitoring small streams and optimizing river maintenance

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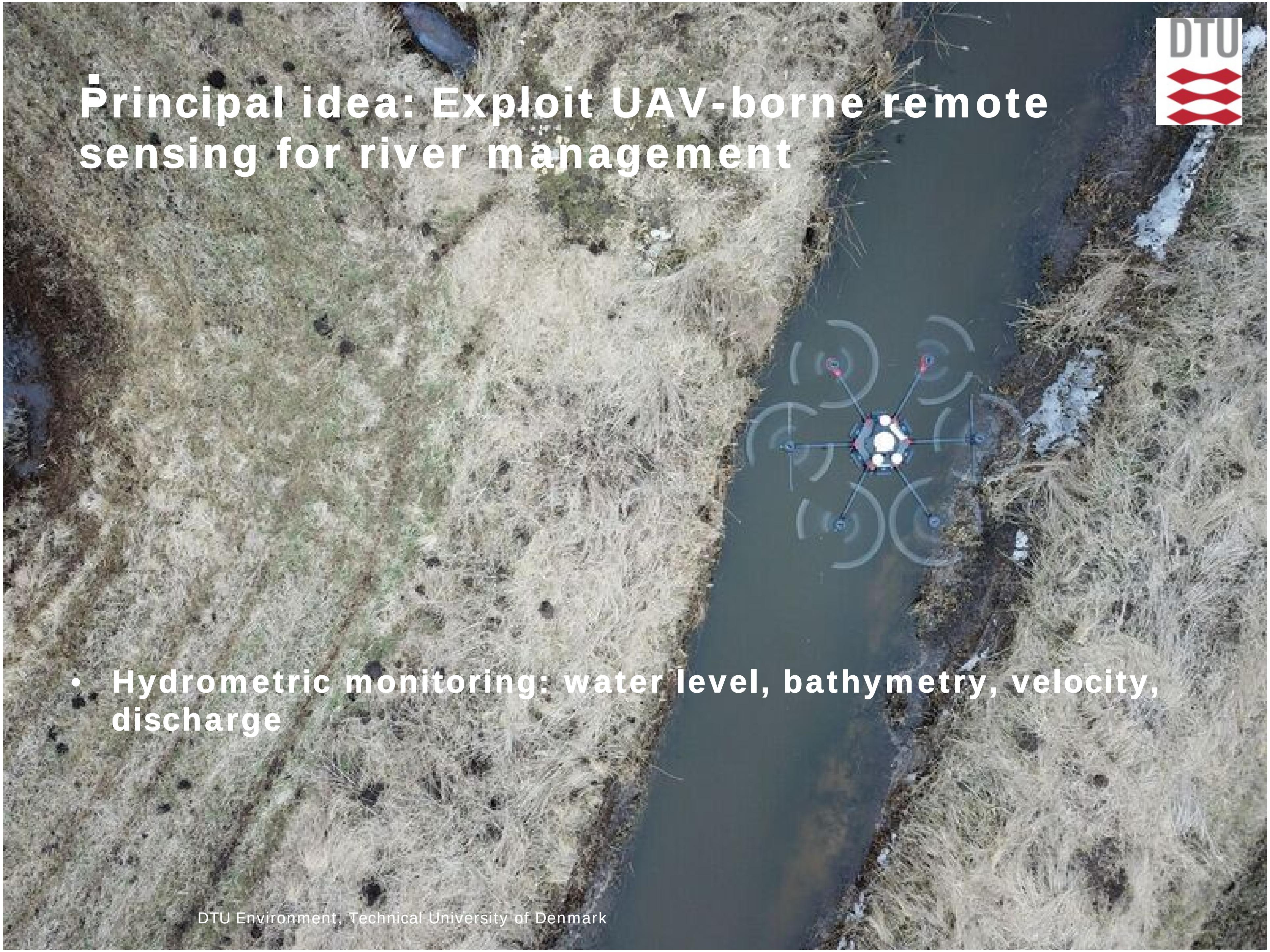
Principal idea: Exploit UAV-borne remote sensing for river management



- **Hydrometric monitoring: water level, bathymetry, velocity, discharge**

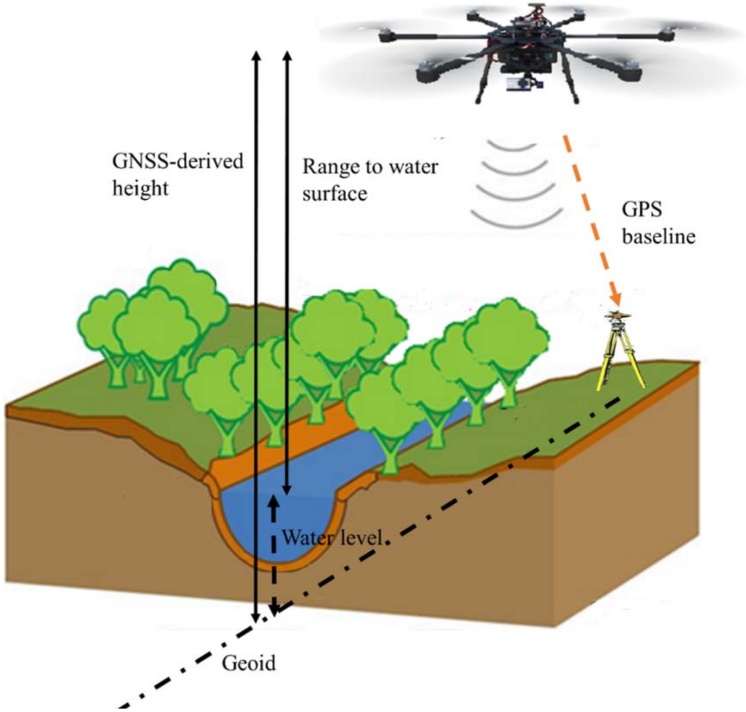
Application: Hydrometry

- **Conveyance and shape control** of Danish streams costs approx. **200 millions DKK** per year.
- The "Vandløbsregulativer" prescribe that **each municipality is obliged to ensure the river shape or conveyance** set by the current regulation.
- For this reason, **15-20 000 km public rivers in DK must be surveyed** with in-situ measurements of bathymetry, water level and discharge every 3-10 years.

Observations of water level, discharge, bathymetry with high spatial resolution to

- Estimate rating curves (for "*Water Bodies Regulations*")
- **Optimize river maintenance** (e.g. vegetation cutting)
- **Flood mapping** at higher spatial resolution than satellite observations and with excellent timing

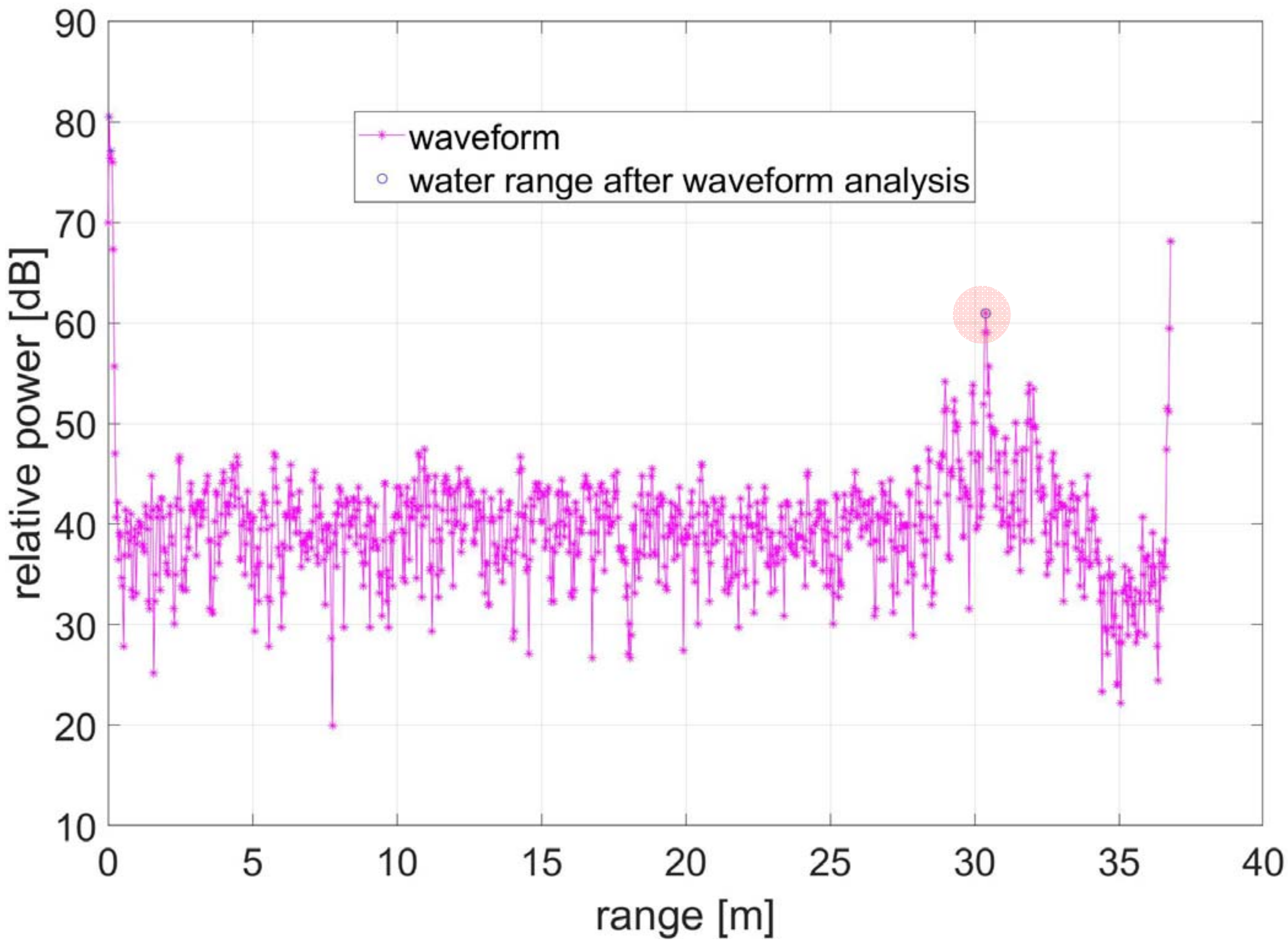
Measurements of water level



- The radar (77 GHz) measures range to water surface
- The GNSS measures the drone height above the reference ellipsoid (convertible into **altitude above geoid**)

- **Water level** is computed by subtracting the range measured by the radar from the GNSS-derived height.

Full waveform



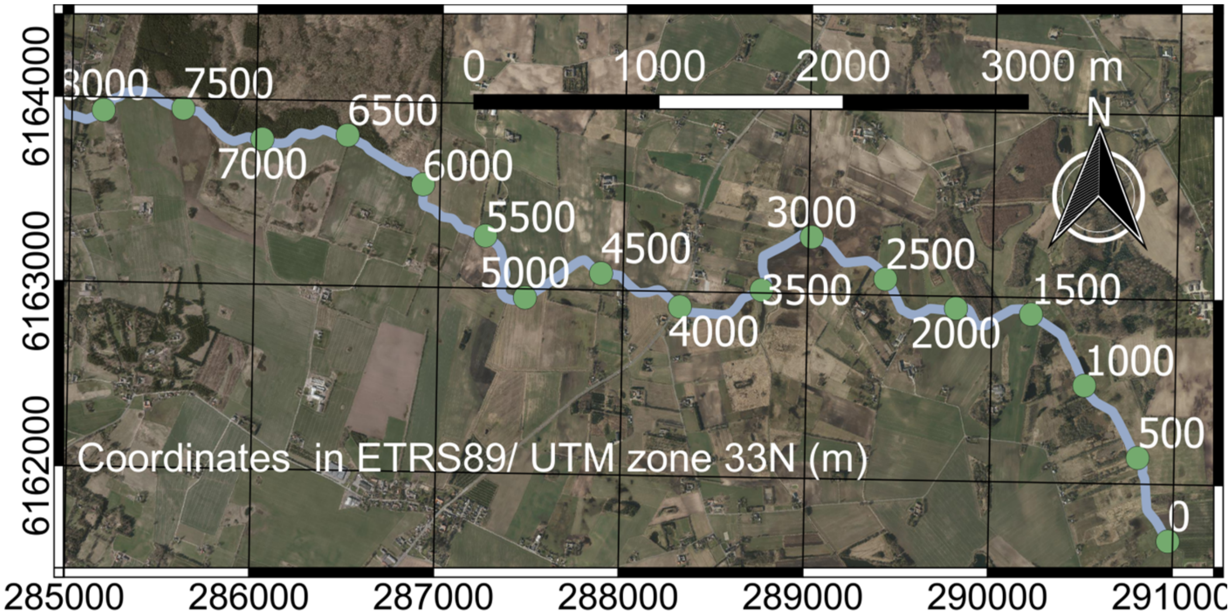
Our radar chip allows:

- Separation between land and water
- Accuracy (sub-cm) higher than resolution (3.75 cm)

Field site

Åmose Å (total length 40 km, drains an area of approx. 350 km²)

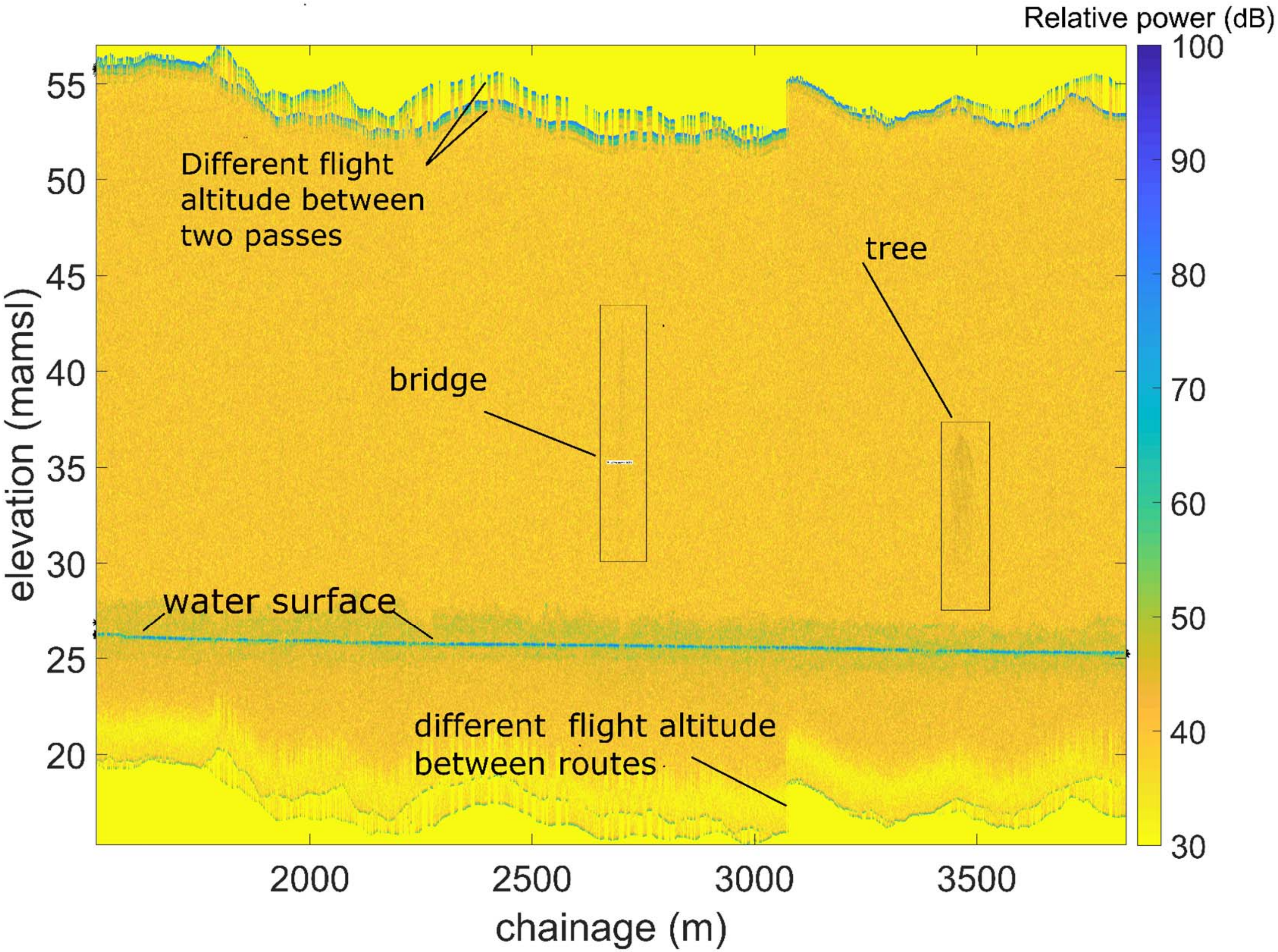
Chainage (meters) reference system from Orbicon:



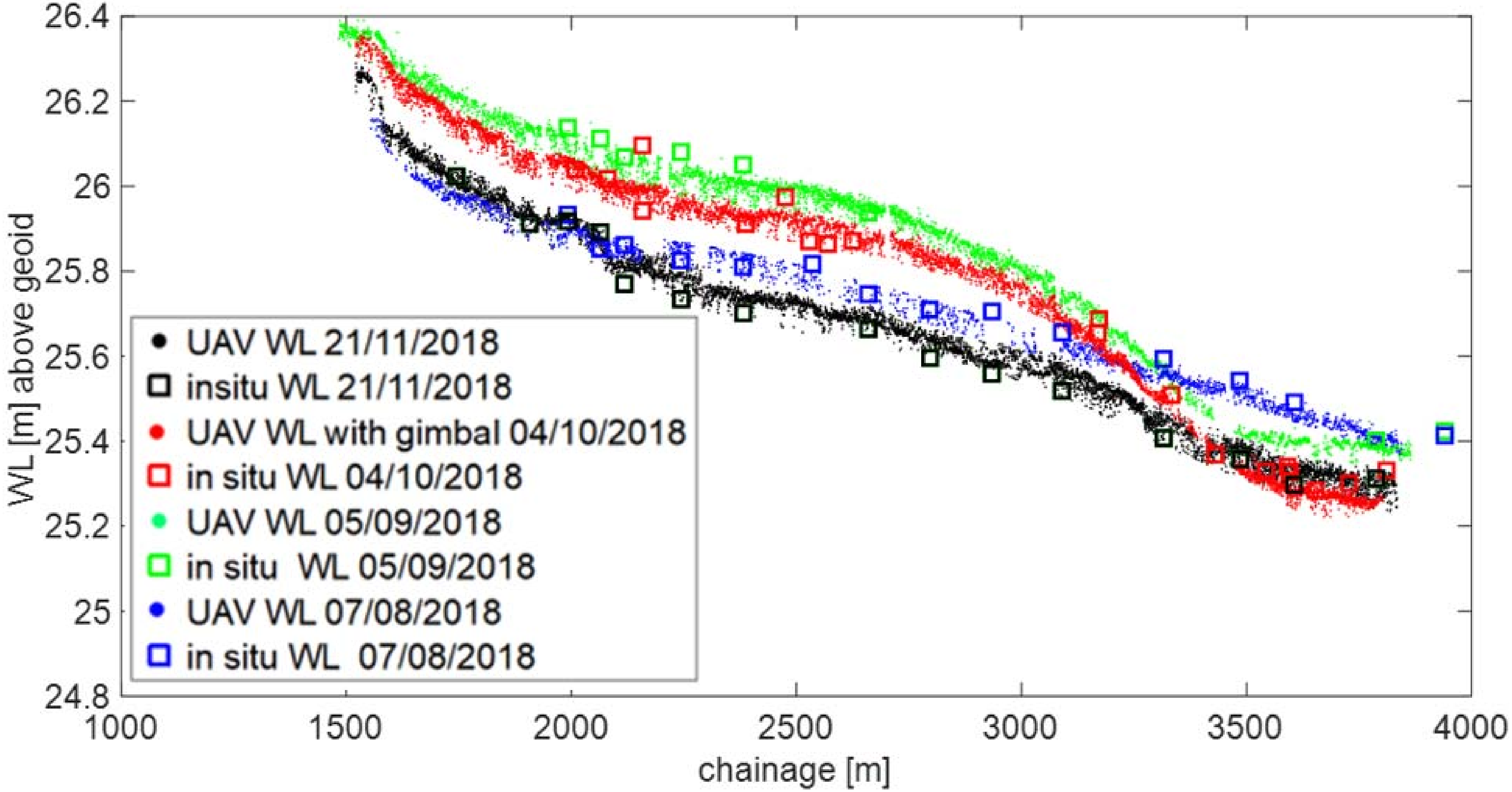
Our test area (stretch of Åmose Å):

- **Length ca. 3 km**
- Catchment area 112 km^2
- Yearly average width 4-5 m
- Yearly average depth 0.6 m
- Yearly average velocity 0.3 m/s

Full waveform plot

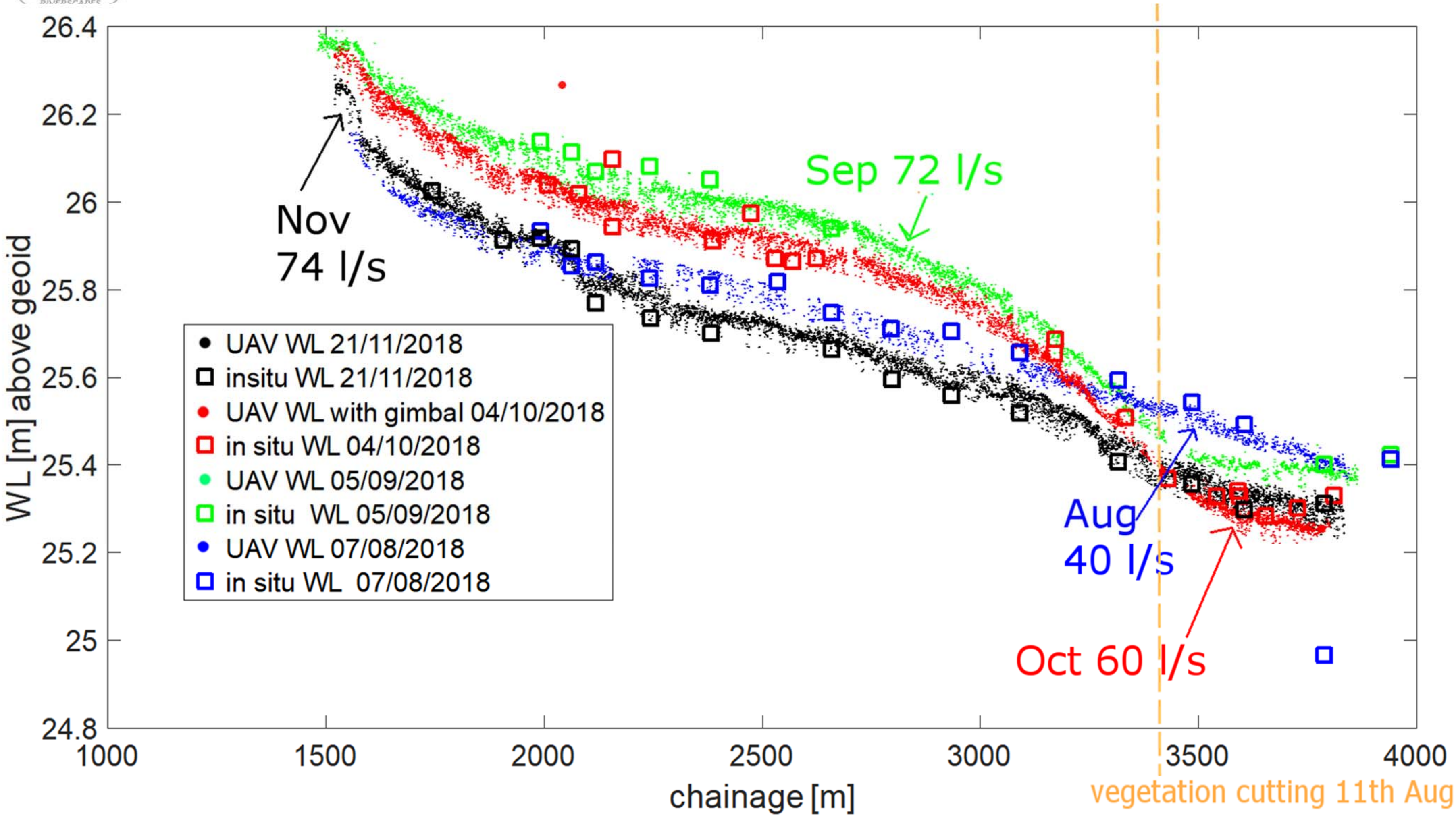


Water level Åmose Å-observations



Accuracy: ***RMSE 3 cm*** *without gimbal, 2.5 cm with gimbal, when compared to in-situ ground truth observations*

Water level Åmose Å-explanation

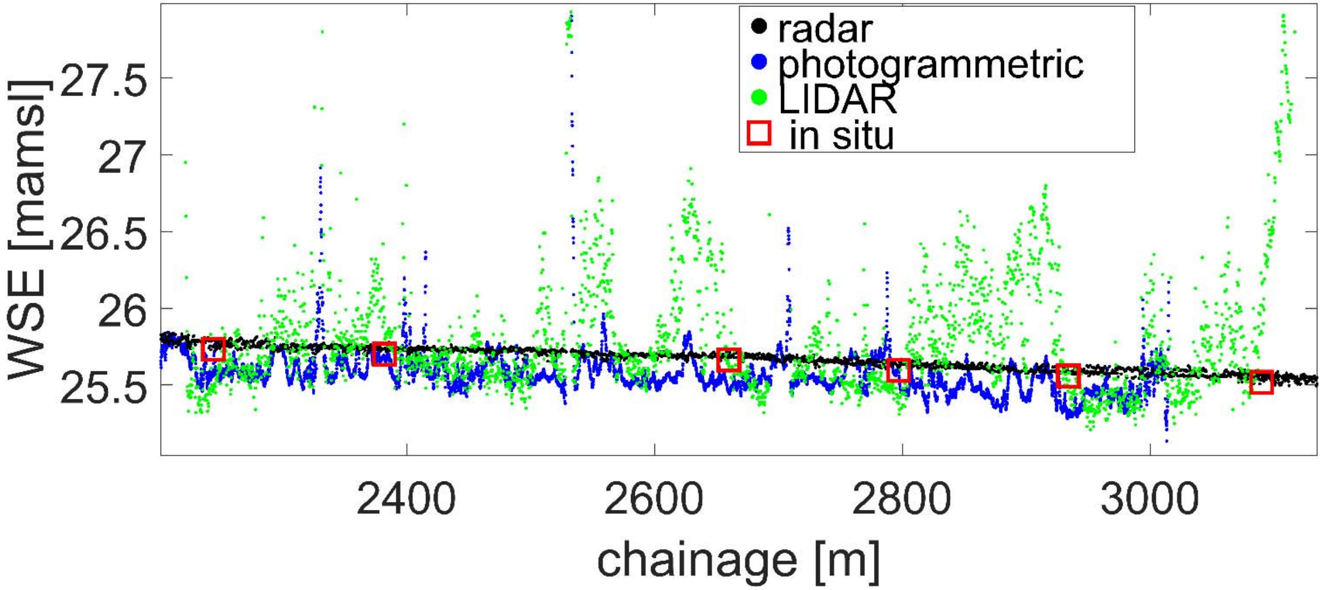


Vegetation cutting, 2 episodes:

- 11th August: downstream of chainage 3300.
- 21st October: all stretch

WL: Radar vs photogrammetry vs LIDAR

- Comparison of radar with photogrammetry estimates of water level during the ”November” flight



- Photogrammetry is very efficient for land elevation, but it cannot be directly used for water elevation
- UAV LIDARs **generally** do not get clear returns from water surface

Technique used for LIDAR and photogrammetry: “**water-edge**” or shoreline technique

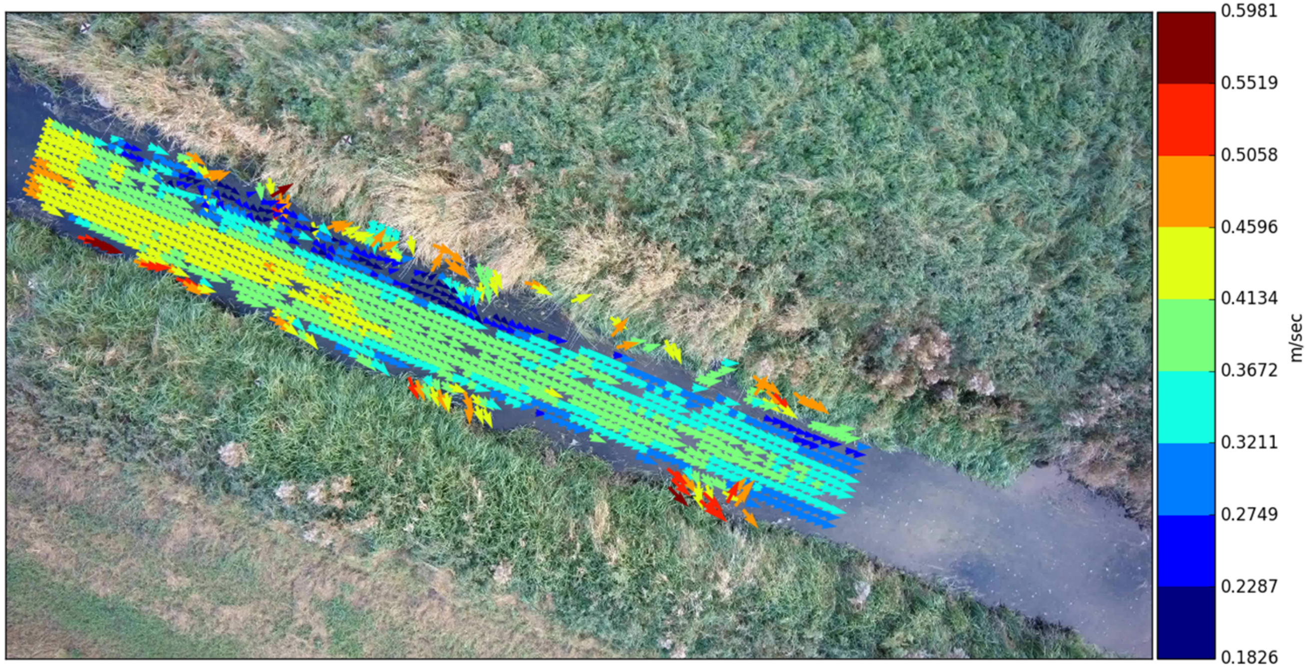
UAV-borne
Water Surface Velocity

- UAV-borne high-resolution video of the water surface

- Video stabilization

- **Photrack algorithms**

- Water surface 2D velocity field



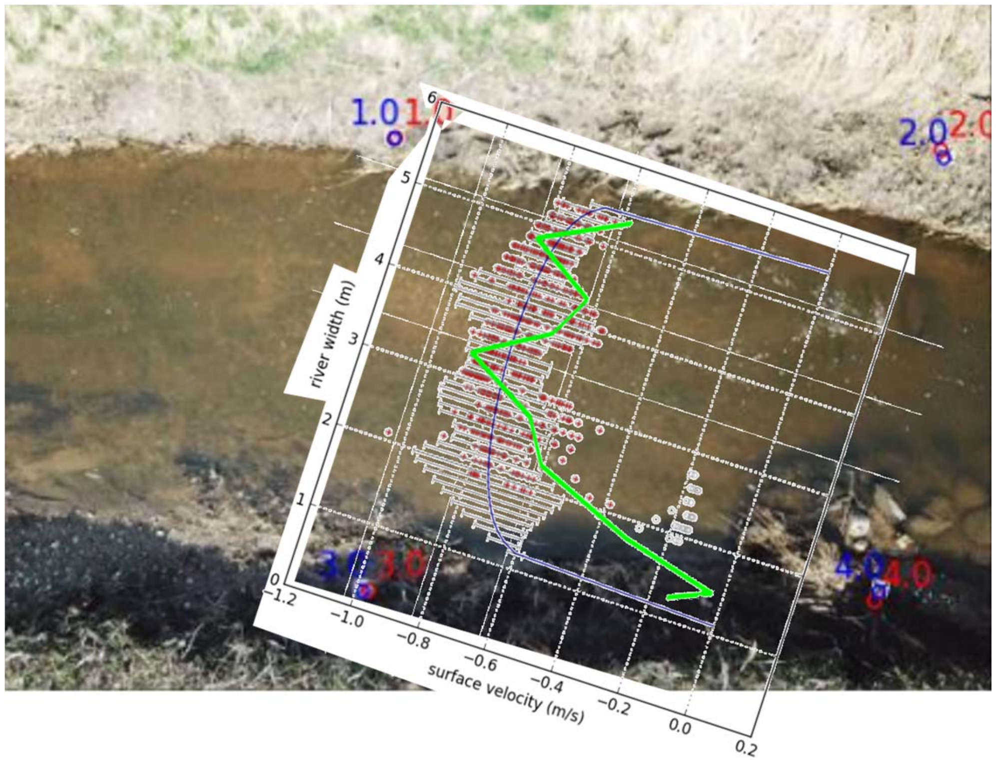
Værebro å, Snydebro (Veksø)

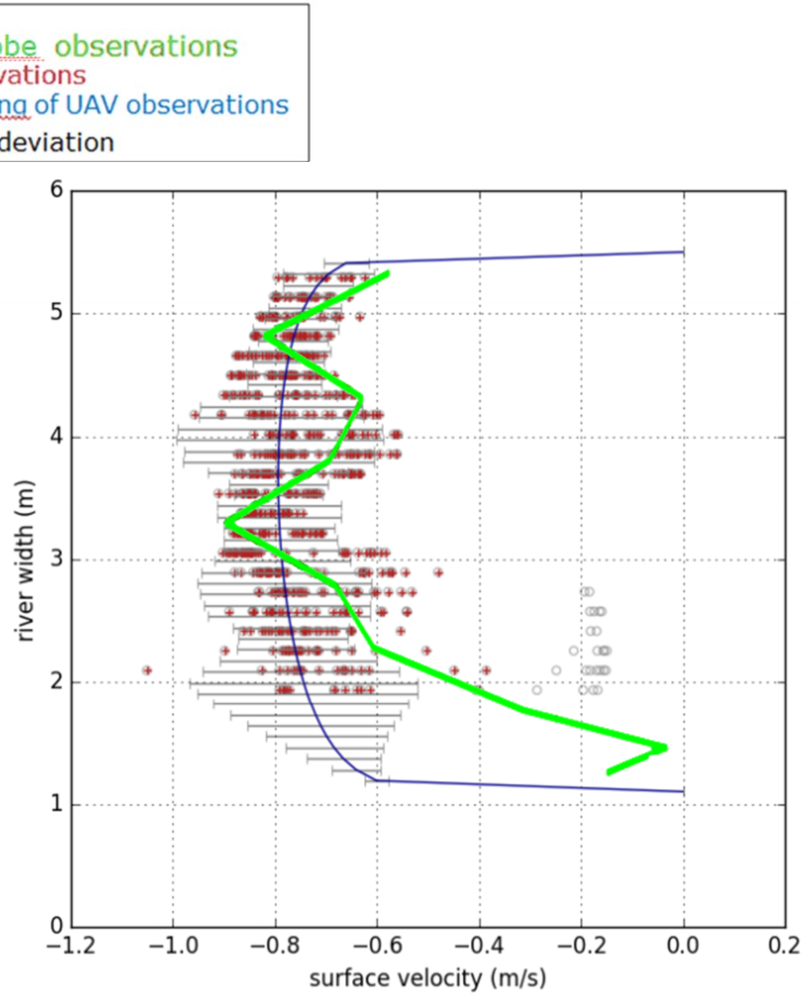
photrack ag
flow measurements

In-situ velocity probe vs UAV-estimates

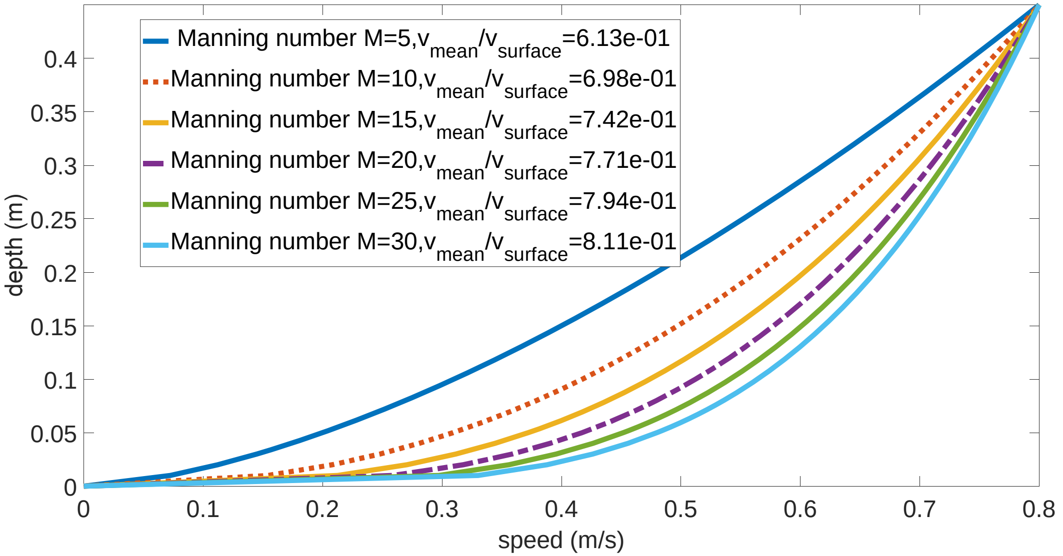
- Good agreement between velocity probe and UAV water velocity observations

photrack ag
flow measurements



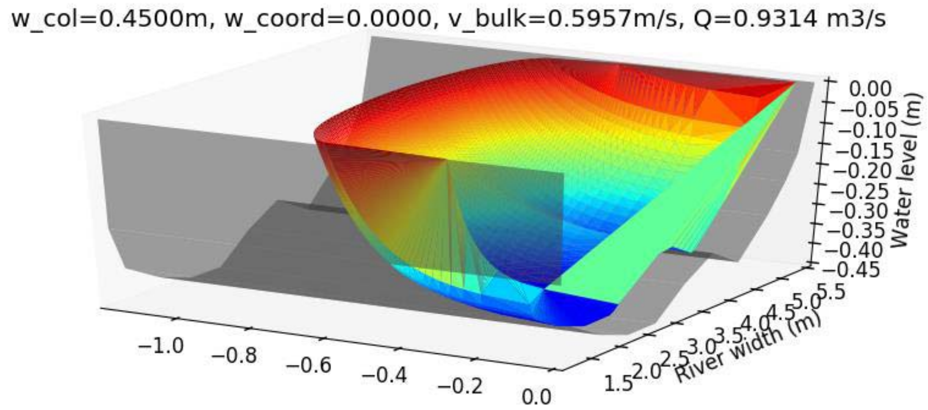


From surface velocity to discharge



Vertical velocity profile for different Manning numbers M [$m^{1/3}/s$]
Ref. EN ISO748:2007

Discharge estimation

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Thanks for your attention