## **Hydraulics & Drones**





#### Unmanned Aerial Vehicle observations of water surface elevation, depth and surface velocity

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#### **Hydraulic variables**



Hydraulic observations are used to inform open-channel hydrodynamic models

- Water surface elevation (WSE)[m]: water surface elevation above mean sea level (m.s.l.)
- Bathymetry [m] : riverbed elevation above m.s.l.
- Water depth [m]: water surface elevation above the riverbed
- Velocity [m/s] : speed varies along, across the river course and throughout water depth
- Discharge [m<sup>3</sup>/s]: it is generally derived from depth-integrated water speed profiles and water depth.



#### **Measurements of WSE**





- The radar measures range to water surface
- The GNSS (Global Navigation Satellite System) measures the drone height above the reference ellipsoid (convertible into altitude above geoid)
- **WSE** is computed by subtracting the range measured by the radar from the GNSS-derived height.

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### A flight to retrieve WSE of a river





- Flight route over Mølleåen (Sjælland, Denmark)
- Flight time: ≈400 seconds
- Flight height: 30 m above ground level with  $\sigma$ =5 m.

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#### WSE and its slope along the surveyed stretch





Accuracy:

• UAV-observations 5-10 cm

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#### Measurements of water depth and bathymetry





- Sonar: needs to be in contact with the water surface, thus tethering
- The more narrow beam is used to measure water depth and bottom structure
- Water depth can be obtained with an accuracy of 2.1% of the actual depth
- Water depth capability up to 80 m
- Bathymetry is computed by subtracting water depth from WSE



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# Bathymetry observations of a river cross-section



- UAV-borne bathymetry observations in Po river, Italy (2017)
- Ground truth retrieved with a single beam sonar on boat (2012)



Po River cross section at WGS84 coordinates LAT 45.073375  $^{\circ}$  , Long 10.934940  $^{\circ}$  (Italy)



#### Water surface velocity



- UAV-borne high-resolution video of water surface
- Application of Large Scale Particle Image Velocimetry (LSPIV)
- 4 Ground Control Points to convert pixel units into metric units
  - No artifical seeding. LSPIV on natural tracers



 $\approx\!15\%$  surface velocity accuracy when compared to in-situ velocity probe observations

Video processed with http://www.photrack.ch/



#### From surface velocity to discharge



Video processed with http://www.photrack.ch/

- Bulk average velocity can be computed from surface velocity
- A velocity vertical profile can also be estimated from surface velocity
- Velocity vertical profile and bathymetry allow for computation of discharge





# Thanks for your attention

#### **Reference list:**

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