Eawag
Swiss Federal Institute of Aquatic
Science and Technology

photrack ag
flow measurements

eawag
aquatic research

Measuring runoff using surveillance cameras

João P. Leitão, Department Urban Water Management, Eawag
Salvador Peña-Haro, Photrack AG

photrack ag
flow measurements

eawag
aquatic research

Every year floods cause disruption to cities and peoples' lives all over the world!

Mozambique, Jan 2013
184th in IMF GDP 2017 rank

Colombia, Dec 2011
85th in 2017 IMF GDP ranking

Switzerland (Lausanne), Jun 2018
2nd in 2017 IMF GDP ranking

Continued **urbanization** and **climate changes**
Floods are becoming more frequent and more intense

2017 IMF GDP ranking comprises 188 countries

photrack ag
flow measurements

eawag
aquatic research

What is special about urban pluvial floods?

photrack ag
flow measurements

eawag
aquatic research

Urban pluvial floods are caused by localised storms in urban areas

Difficult to predict *where* and *when* it will occur

“Rapid events” due to impervious urban surfaces

Short lead time to get prepared

https://www.globalweatherclimatecenter.com/south-america-weather-climate-topics/classic-rain-shaft-on-the-edge-of-a-severe-storm-in-parana-brazil-earlier-today-a-great-shot-of-this-storm-from-a-distance-credit-celso-diastempero-severo

https://www.reddit.com/r/mildlyinteresting/comments/9et1ak/a_rain_shaft_in_baton_rouge_la/

https://www.lancashiretelegraph.co.uk/news/16183208.4-9m-facelift-flood-defence-boost-padiham/

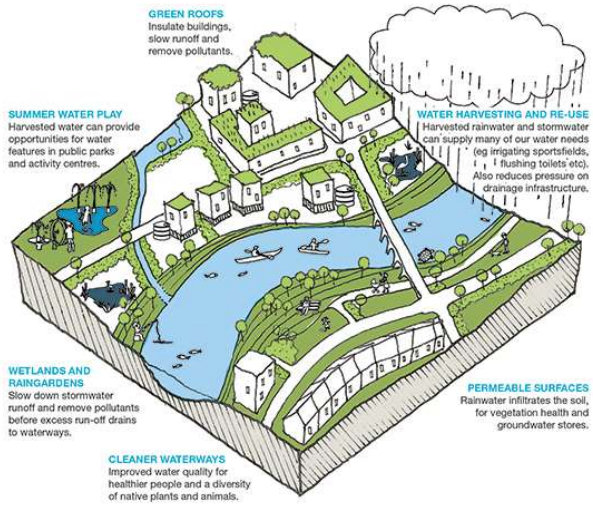
photrack ag
flow measurements

eawag
aquatic research

Flood management tools can be used to better prepare for urban flooding events

Models: *(re-)Design cities* to cope with additional (due to climate changes) water volume and dynamics (involve city planners, landscape architects, engineers, …)

Data: *React to floods* (civil protection agencies, rescue services, …) and *Calibrate* models



photrack ag
flow measurements

eawag
aquatic research

Water in pipes is "commonly" measured but water on the surface is hard to measure

"… new measuring techniques are urgently required…"

Hunter, N. M., Bates, P. D., Neelz, S., Pender, G., Villanueva, I., Wright, N. G., … Mason, D. C. (2008). Benchmarking 2D hydraulic models for urban flooding. In *Proceedings of the Institution of Civil Engineers - Water Management*, 161(1), 13–30

photrack ag
flow measurements

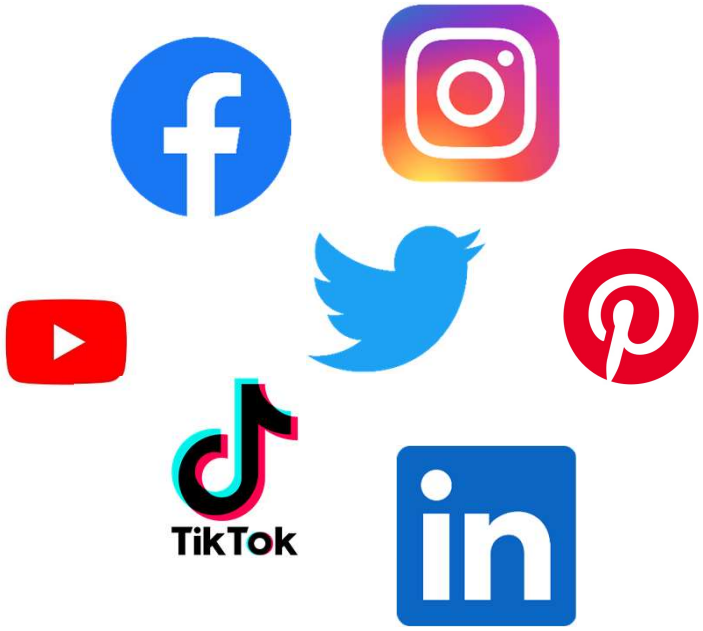
eawag
aquatic research

Are videos like this of any value?

photrack ag
flow measurements

eawag
aquatic research

… and social media?



photrack ag
flow measurements

eawag
aquatic research

Photrack AG

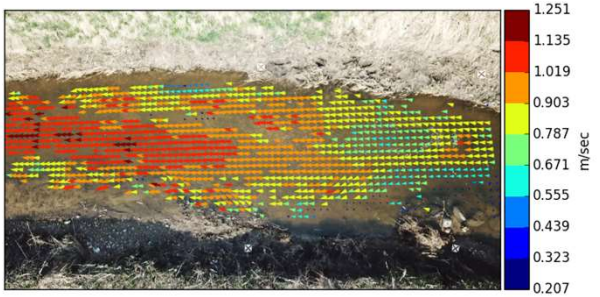
Image-based flow measurements

ETH spin-off

Image-based river flow measurements: fix cameras, smartphone application, software

Advantages: non-contact, reliable during floods, easy installation, few maintenance.

Main application: hydrology



Collaboration Eawag-Photrack -> urban drainage and urban wastewater applications

photrack ag
flow measurements

eawag
aquatic research

Image-based flow estimation methods

Particle Image Velocimetry (PIV),
Particle Tracking Velocimetry (PTV),
Space-Time Image Velocimetry (STIV)...

PIV

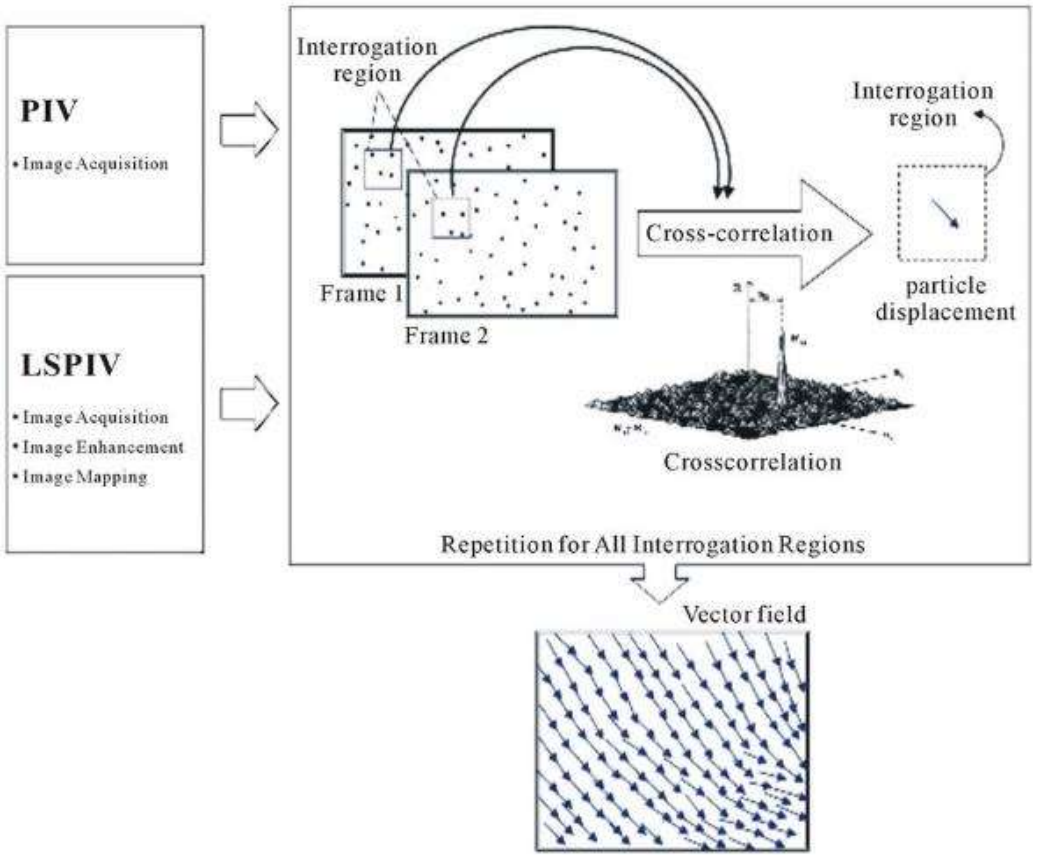
Need of tracers (artificial)

Light sheet in a lab channel

Large-scale PIV (LSPIV)

Flow surface images - orthorectification

Usually tracers (natural)



Jung et al. (2012)

photrack ag
flow measurements

eawag
aquatic research

Surface Structure Image Velocimetry (SSIV)

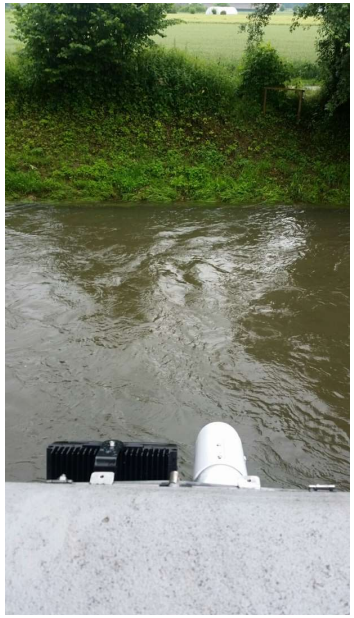
Inspired on Particle Image Velocimetry (PIV)

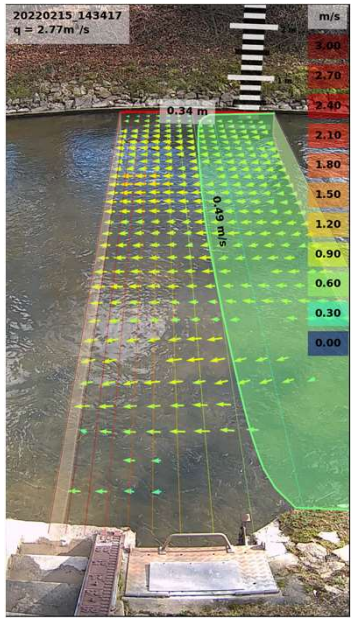
LSPIV is negatively influenced by

- Glare and shadows on the water surface, and
- Lack of traceable features

SSIV applies a filter prior applying the cross-correlation

SSIV designed for operational





photrack ag
flow measurements

eawag
aquatic research

Eawag-Photrack collaboration 1

Estimating overland flow velocity using surveillance cameras videos

Development and application of SSIV (Leitão et al. 2018)

- *No tracers needed?*
- *Overland (shallow) flow?*

What is the impact on the flow velocity estimates of

- Video quality (frame rate, resolution)
- Camera location
- Different light conditions (day, night!?)

Photo: António Araujo (LUSA)

Leitão, J.P., **Peña-Haro, S.**, Lüthi, B. Scheidegger, A., Moy de Vitry, M. (2018). Urban runoff velocity measurement with consumer-grade surveillance cameras and surface structure image velocimetry. *Journal of Hydrology, 565, 791-804.* doi: 10.1016/j.jhydrol.2018.09.001

photrack ag
flow measurements

eawag
aquatic research

Eawag-Photrack collaboration 1

Estimating overland flow velocity using surveillance cameras videos

floodX project

Installation of four cameras in a flood rescue training facility in CH

Installation of “conventional” sensors as benchmark

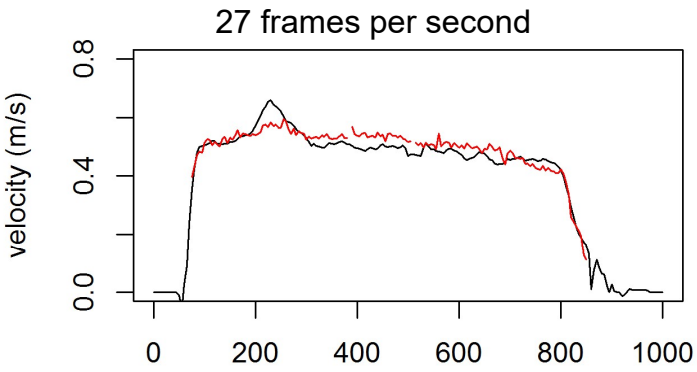
Simulation of multiple flood events

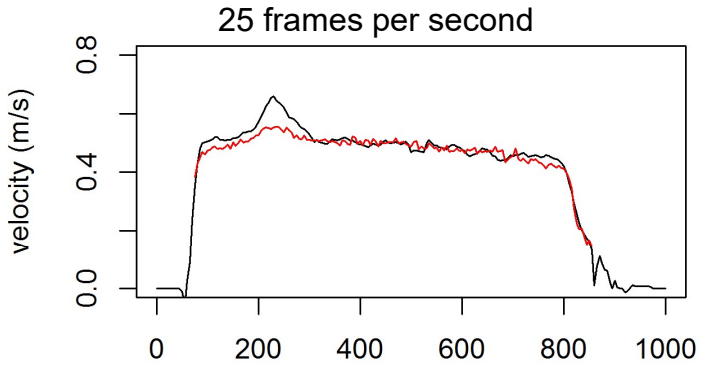
photrack ag
flow measurements

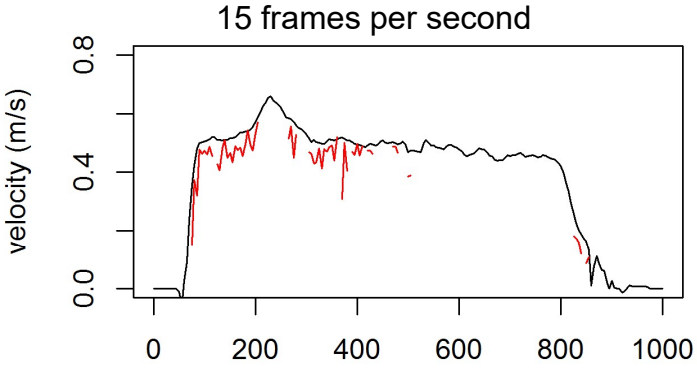
eawag
aquatic research

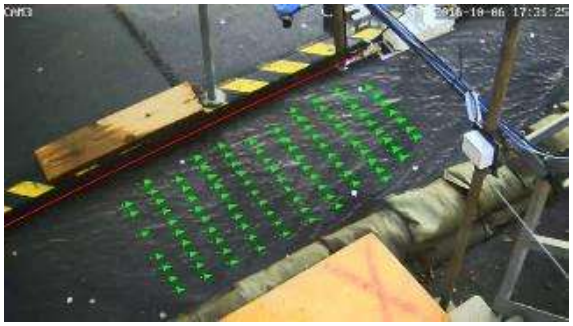
Eawag-Photrack collaboration 1

Video frame rate influence SSIV flow velocity estimation!







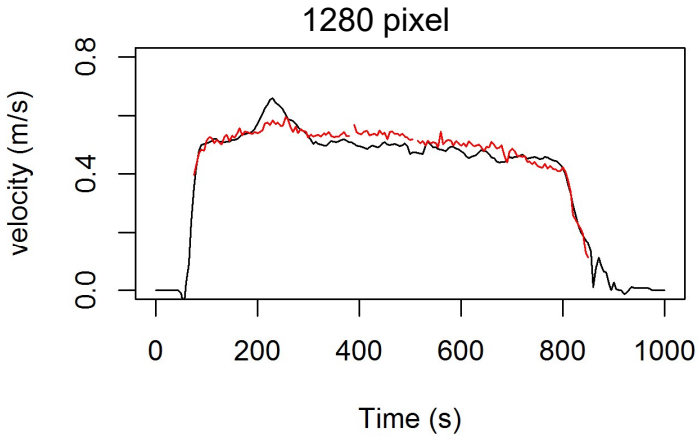


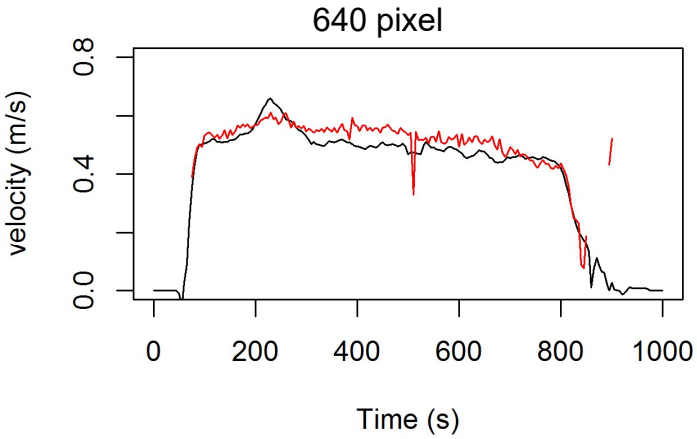
photrack ag
flow measurements

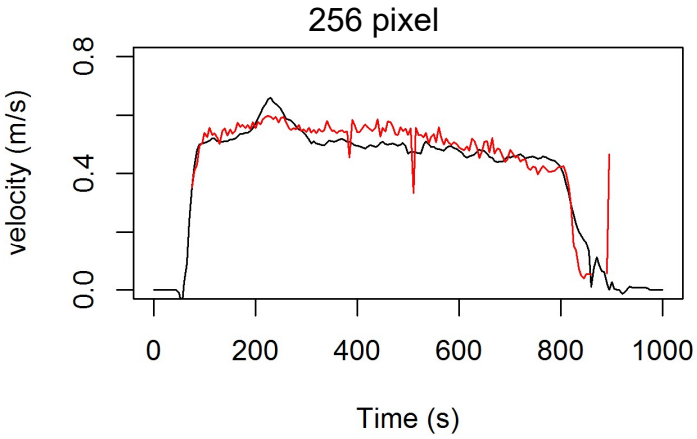
eawag
aquatic research

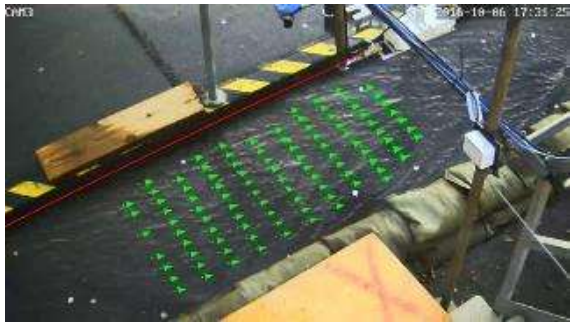
Eawag-Photrack collaboration 1

The impact of video resolution (i.e. camera distance) is small









photrack ag
flow measurements

eawag
aquatic research

Eawag-Photrack collaboration 2

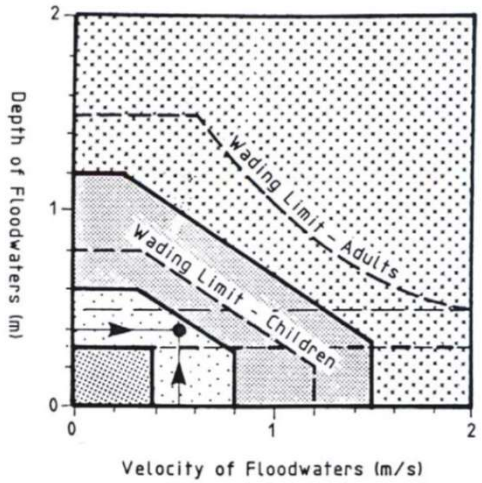
Assessing flood hazard using video data

Should I cross the street?

https://www.koamnewsnow.com/road-safety-concern-water-rescues-in-joplin

$$HR = d \times (v + 0.5) + DF$$

Are road conditions safe?



Wade, S., Ramsbottom, D., Floyd, P., Penning-Roswell, E., Surendran, S. (2005). Risks to people: developing new approaches for flood hazard and vulnerability mapping. In *Proceedings of the 40th Drfta Flood and Coastal Management Conference*

photrack ag
flow measurements

eawag
aquatic research

Eawag-Photrack collaboration 2

Assessing flood hazard using video data

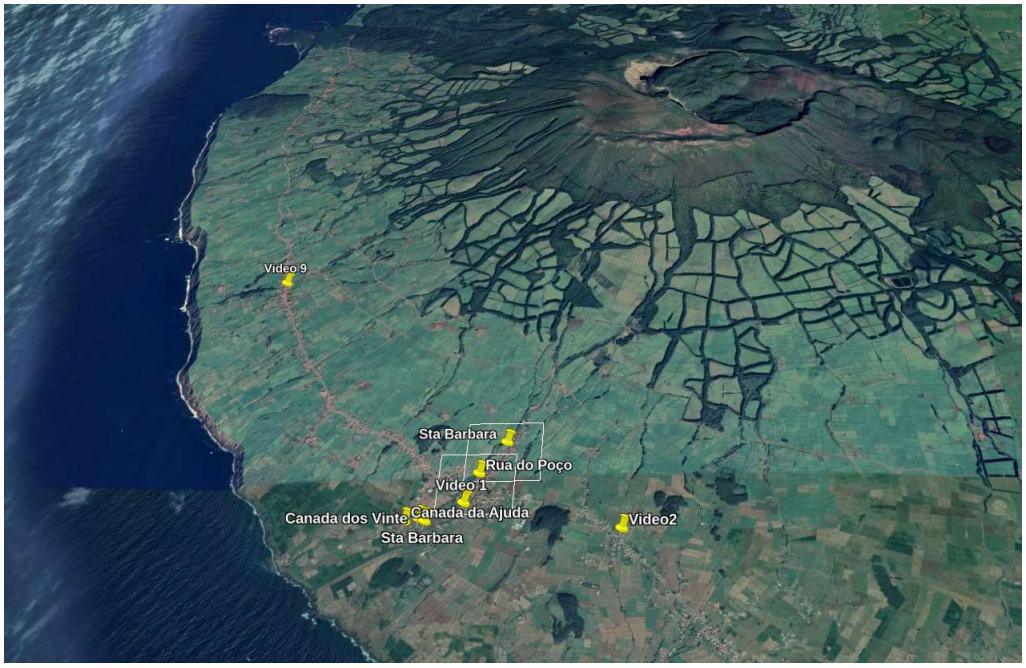
Terceira island (the Azores, Portugal)

Rainfall volume: 23 mm during two hours

(average rainfall volume for the entire month of June is 48.8 mm)

Mobile phone camera videos on Facebook

224x400 pixel resolution



Location of facebook videos reporting flooding
(Terceira island, the Azores, Portugal)

photrack ag
flow measurements

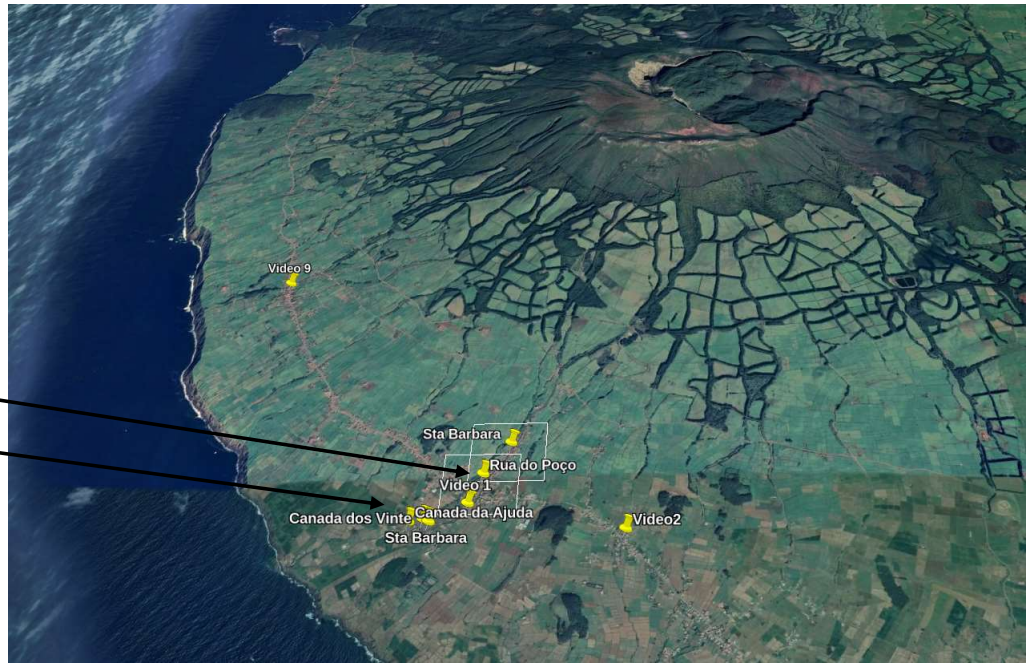
eawag
aquatic research

Eawag-Photrack collaboration 2

Assessing flood hazard using video data

Location A.
Canada dos Vinte

Location B.
Rua do Poço



Location of facebook videos reporting flooding
(Terceira island, the Azores, Portugal)

photrack ag
flow measurements

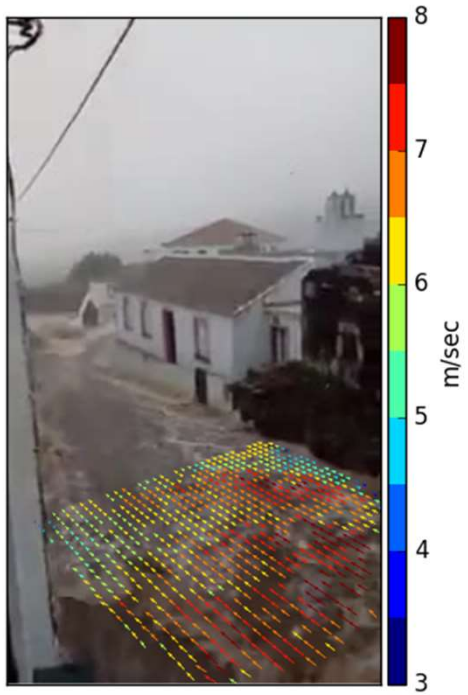
eawag
aquatic research

Eawag-Photrack collaboration 2

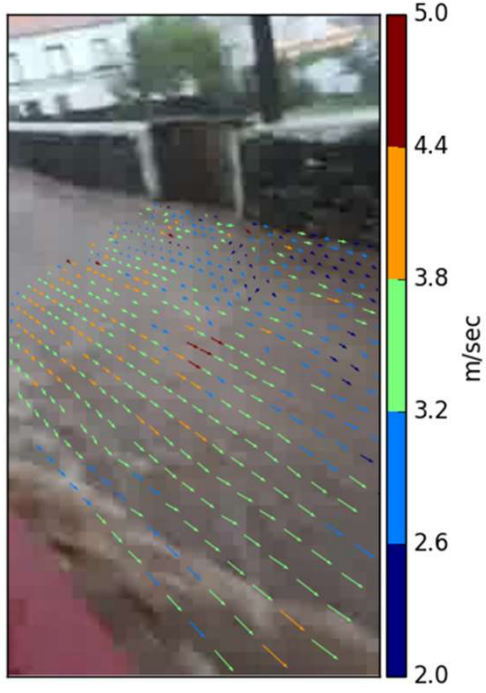
Limited camera shaking, stabilization not relevant

For slower flow velocities, camera movements may become more important

(as expected) Different locations show different velocities (at the same time)!



Location A.
Canada dos Vinte



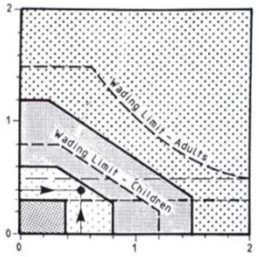
Location B.
Rua do Poço

photrack ag
flow measurements

eawag
aquatic research

Eawag-Photrack collaboration 2

Using this information to assess flood hazard



$$HR = d \times (v + 0.5) + DF$$

Depth [m]	Flood hazard for people safety [-]		Flood hazard for flood evacuation route planning	
	Location A	Location B	Location A	Location B
0.1	1.33 (moderate)	1.03 (moderate)	Extreme hazard	
0.2	2.16 (significant)	1.56 (moderate)		
0.3	2.99 (extreme)	2.09 (significant)		

Since exact water depth information was not available, we considered three water depth values in 0.1 m steps.

photrack ag
flow measurements

eawag
aquatic research

Eawag-Photrack collaboration 2

Informing citizens and rescue services!

Should I cross the street?

No, it is dangerous!

Are road conditions safe?

NO, extreme hazard! Find another route!

Location A.
Canada dos Vinte

Location B.
Rua do Poço

photrack ag
flow measurements

eawag
aquatic research

Take home messages

Videos are a relevant source of flood information!

SSIV produces meaningful flow velocity measurements

Data available everywhere (from social media to surveillance cameras)

Flood risk assessment/ mapping can be made available in *quasi-real time*. No need for modelling...

Collaboration Eawag-Photrack has been key to develop urban water management tools to protect citizens from flood events and monitor receiving water bodies pollution

The collaboration accelerates the transfer of knowledge and technology to the society

photrack ag
flow measurements

eawag
aquatic research

Further developments

Estimating flow characterisitics in urban drainage networks

Eawag-Photrack collaboration is still going on!

Water quality estimation from images (Innosuisse proposal in preparation)

Improvement of current methodologies to water quantity (depth) and quality estimation using Machine-Learning

In collaboration with CSEM