HARMONIOUS
uas for environmental monitoring

HARMONIOUS

UAS Techniques for Environmental Monitoring

Flavia Tauro – Valencia, February 15th 2018

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme
of the European Union

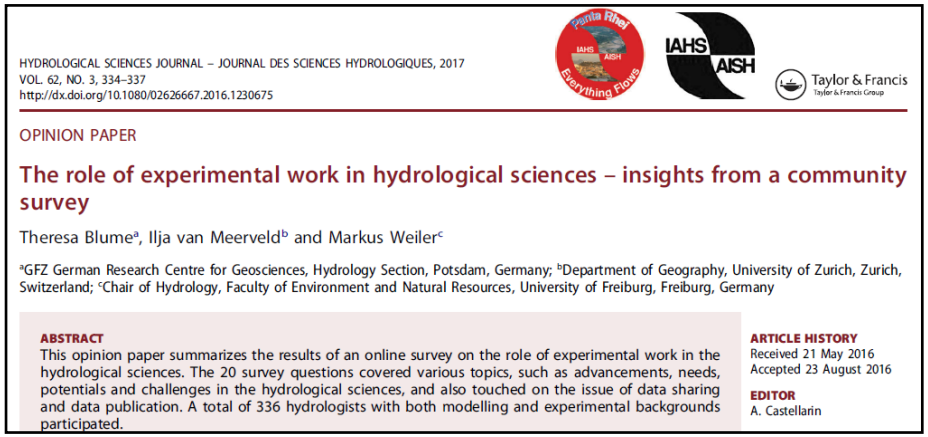
Streamflow observations from UASs: technical challenges and image processing

Agenda

- Objective: improving and increasing observations
- State of the art on streamflow observations
- Methodology: setup and algorithms
- Case study
- Conclusions

Improving and increasing observations

- Hydrological process understanding demands data
- What is needed:
  - New measurement techniques and equipment
  - More field measurements and monitoring
- Greatest challenge:
  - Maintenance of monitoring networks



HYDROLOGICAL SCIENCES JOURNAL – JOURNAL DES SCIENCES HYDROLOGIQUES, 2017
VOL. 62, NO. 3, 334–337
http://dx.doi.org/10.1080/02626667.2016.1230675

OPINION PAPER

The role of experimental work in hydrological sciences – insights from a community survey

Theresa Blume[a], Ilja van Meerveld[b] and Markus Weiler[c]

[a]GFZ German Research Centre for Geosciences, Hydrology Section, Potsdam, Germany; [b]Department of Geography, University of Zurich, Zurich, Switzerland; [c]Chair of Hydrology, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg, Germany

ABSTRACT
This opinion paper summarizes the results of an online survey on the role of experimental work in the hydrological sciences. The 20 survey questions covered various topics, such as advancements, needs, potentials and challenges in the hydrological sciences, and also touched on the issue of data sharing and data publication. A total of 336 hydrologists with both modelling and experimental backgrounds participated.

ARTICLE HISTORY
Received 21 May 2016
Accepted 23 August 2016

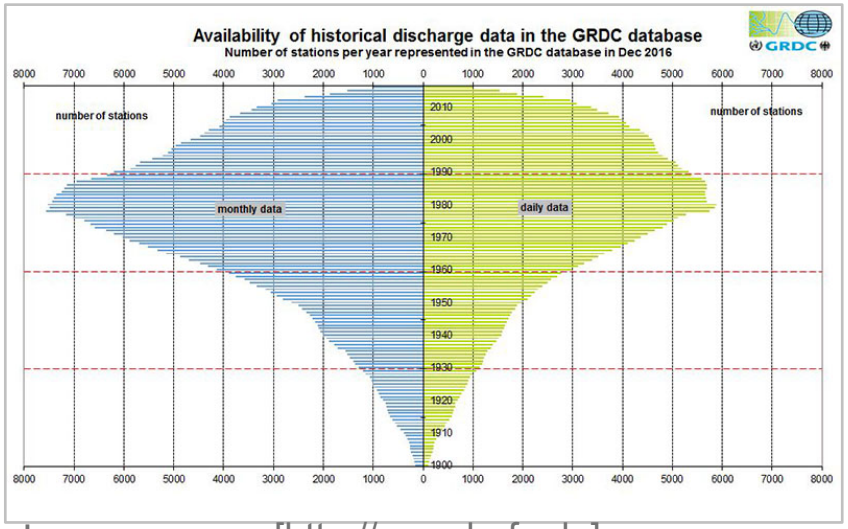
EDITOR
A. Castellarin

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

HARMONIOUS UAS for environmental monitoring

Improving and increasing observations

- Traditional monitoring systems

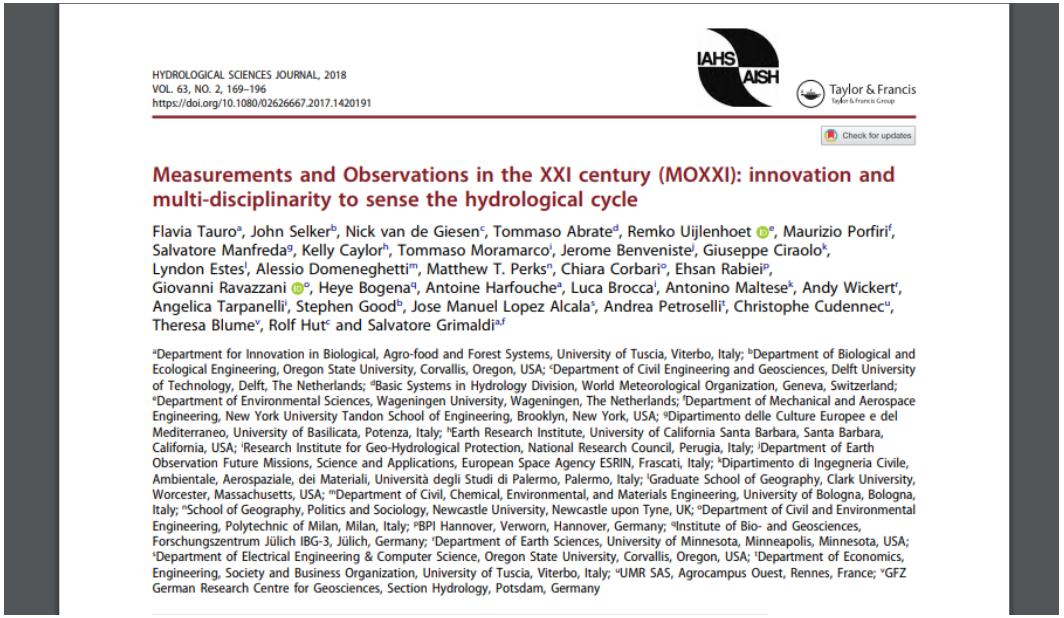


[http://www.bafg.de]

- Where we stand:
  - Limited spatial and time coverage
  - Expensive equipment
  - High maintenance costs

Improving and increasing observations

- Novel sensing systems
  - Multi-disciplinarity
  - Innovation (smart, opportunistic measurements)
  - Affordable solutions



HYDROLOGICAL SCIENCES JOURNAL, 2018
VOL. 63, NO. 2, 169–196
https://doi.org/10.1080/02626667.2017.1420191

IAHS AISH

Taylor & Francis

Check for updates

Measurements and Observations in the XXI century (MOXXI): innovation and multi-disciplinarity to sense the hydrological cycle

Flavia Tauro[a], John Selker[b], Nick van de Giesen[c], Tommaso Abrate[d], Remko Uijlenhoet[e], Maurizio Porfiri[f], Salvatore Manfreda[g], Kelly Caylor[h], Tommaso Moramarco[i], Jerome Benveniste[j], Giuseppe Ciraolo[k], Lyndon Estes[l], Alessio Domeneghetti[m], Matthew T. Perks[n], Chiara Corbari[o], Ehsan Rabiei[p], Giovanni Ravazzani[q], Heye Bogena[a], Antoine Harfouche[a], Luca Brocca[i], Antonino Maltese[k], Andy Wickert[r], Angelica Tarpanelli[i], Stephen Good[b], Jose Manuel Lopez Alcala[s], Andrea Petroselli[t], Christophe Cudennec[u], Theresa Blume[v], Rolf Hut[c] and Salvatore Grimaldi[a,f]

[a]Department for Innovation in Biological, Agro-food and Forest Systems, University of Tuscia, Viterbo, Italy; [b]Department of Biological and Ecological Engineering, Oregon State University, Corvallis, Oregon, USA; [c]Department of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands; [d]Basic Systems in Hydrology Division, World Meteorological Organization, Geneva, Switzerland; [e]Department of Environmental Sciences, Wageningen University, Wageningen, The Netherlands; [f]Department of Mechanical and Aerospace Engineering, New York University Tandon School of Engineering, Brooklyn, New York, USA; [g]Dipartimento delle Culture Europee e del Mediterraneo, University of Basilicata, Potenza, Italy; [h]Earth Research Institute, University of California Santa Barbara, Santa Barbara, California, USA; [i]Research Institute for Geo-Hydrological Protection, National Research Council, Perugia, Italy; [j]Department of Earth Observation Future Missions, Science and Applications, European Space Agency ESRIN, Frascati, Italy; [k]Dipartimento di Ingegneria Civile, Ambientale, Aerospaziale, dei Materiali, Università degli Studi di Palermo, Palermo, Italy; [l]Graduate School of Geography, Clark University, Worcester, Massachusetts, USA; [m]Department of Civil, Chemical, Environmental, and Materials Engineering, University of Bologna, Bologna, Italy; [n]School of Geography, Politics and Sociology, Newcastle University, Newcastle upon Tyne, UK; [o]Department of Civil and Environmental Engineering, Polytechnic of Milan, Milan, Italy; [p]BPI Hannover, Verworn, Hannover, Germany; [q]Institute of Bio- and Geosciences, Forschungszentrum Jülich IBG-3, Jülich, Germany; [r]Department of Earth Sciences, University of Minnesota, Minneapolis, Minnesota, USA; [s]Department of Electrical Engineering & Computer Science, Oregon State University, Corvallis, Oregon, USA; [t]Department of Economics, Engineering, Society and Business Organization, University of Tuscia, Viterbo, Italy; [u]UMR SAS, Agrocampus Ouest, Rennes, France; [v]GFZ German Research Centre for Geosciences, Section Hydrology, Potsdam, Germany

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

HARMONIOUS
UAS for environmental monitoring

State of the art: streamflow observations

- How is streamflow currently measured?

- Pointwise observations at selected cross-sections
- Often invasive measurements
- Expensive equipment
- Rare measurement campaigns

State of the art: streamflow observations

- Multiscale and heterogeneity

rivers:
- high flow regime
- vegetation
- large cross-section and depths

RILLS

STREAMS

RIVERS

hillslope rills:
- from a few to several cm
- turbidity
- vegetation

streams:
- sediments
- high regime
- shallow depths
- irregular beds
- reflections

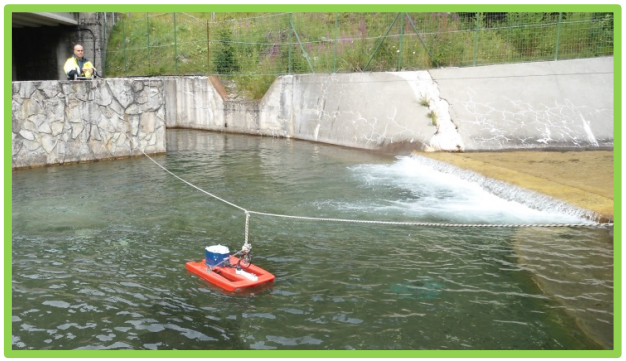
cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

HARMONIOUS
UAS for environmental monitoring

State of the art: streamflow observations

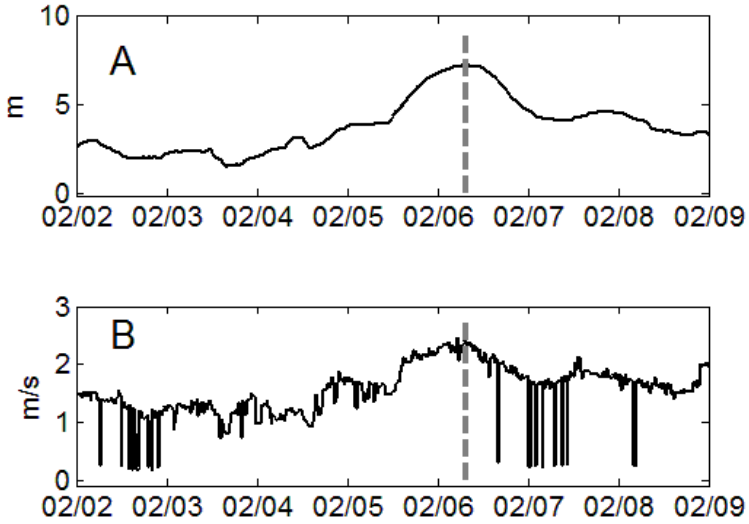
- Difficult-to-access environments
  - Sensor deployment
  - Operators' safety issues





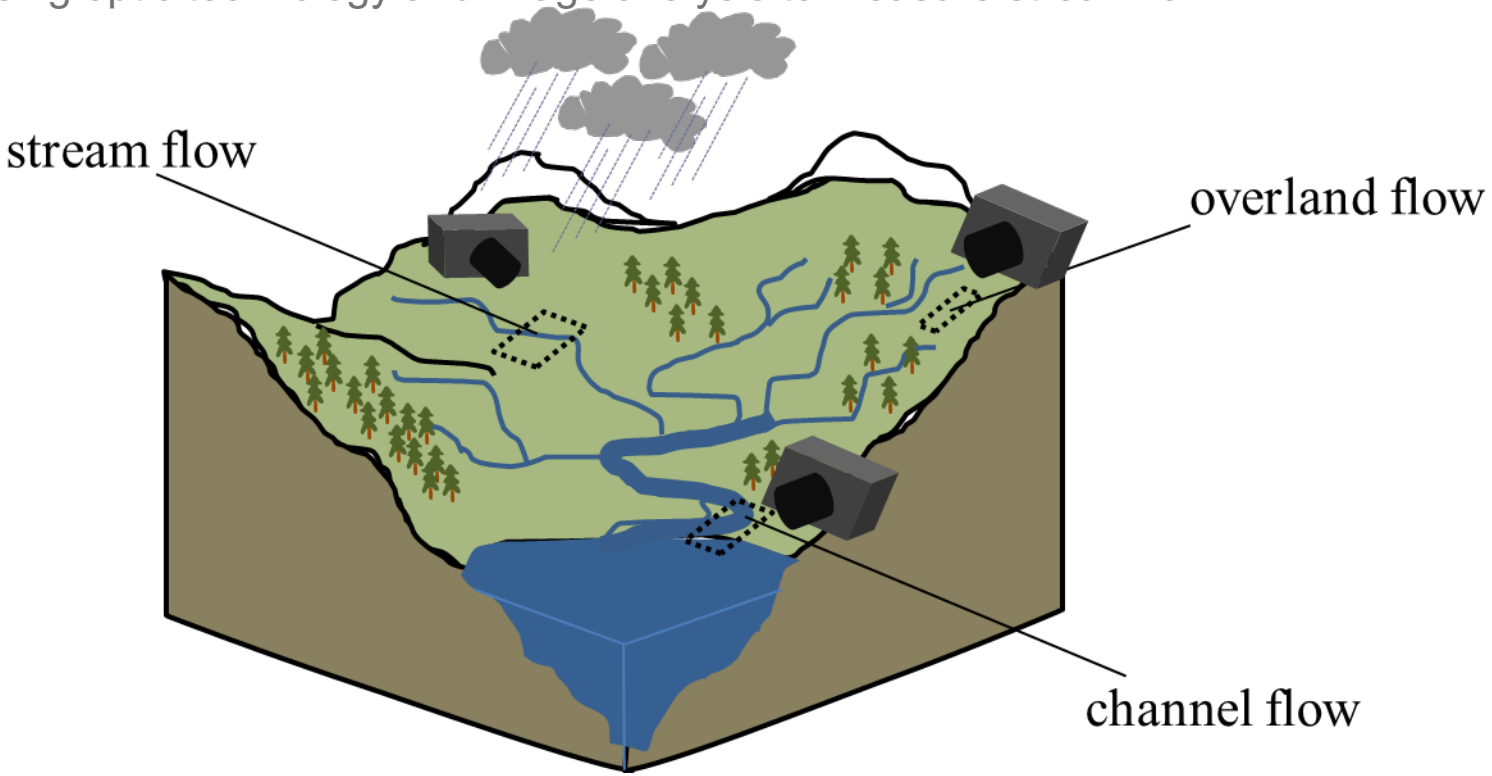

State of the art: streamflow observations

- Fastly evolving processes



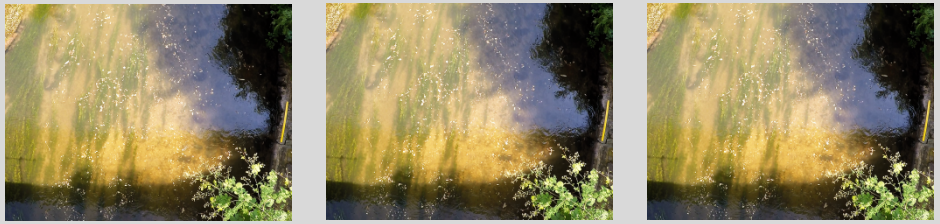
Proposed methodology

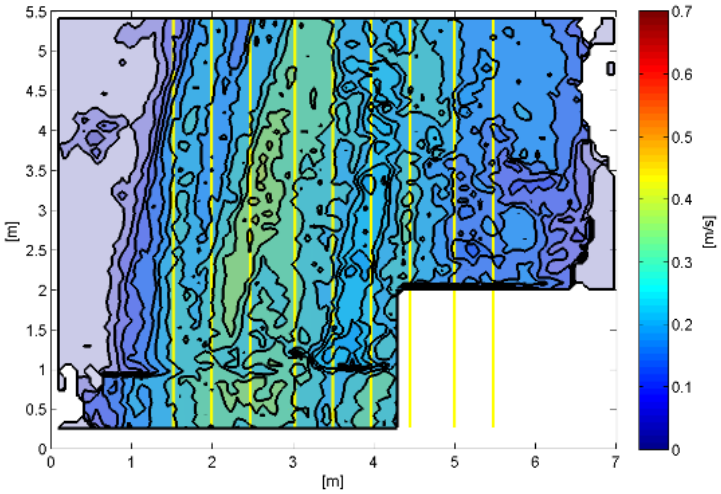
- Using optic technology and image analysis to measure streamflow



Methodology

- Images offer several advantages
  - Noninvasive observations
  - Spatially distributed measurements
  - Potentially high time resolution
  - Observations at multiple scales



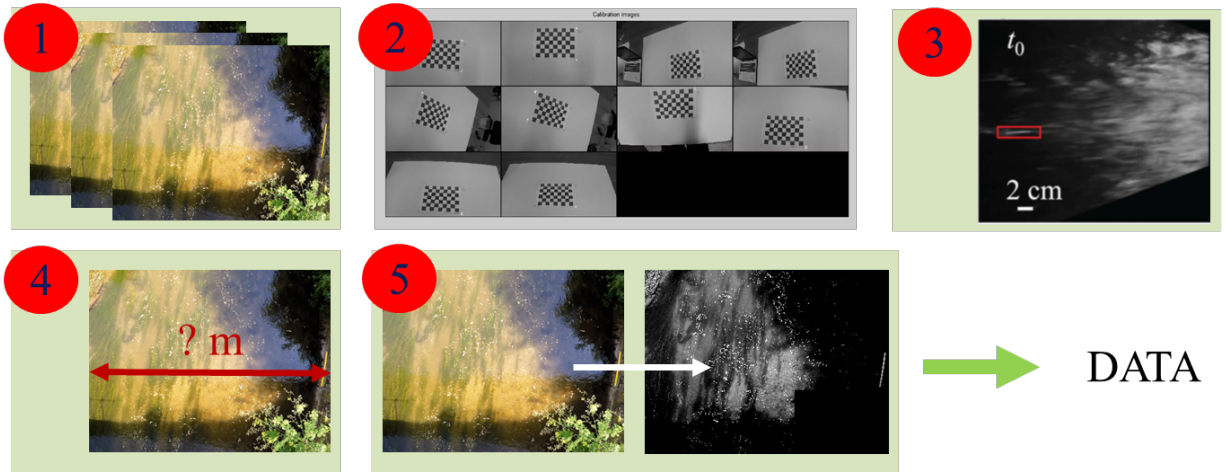


cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

HARMONIOUS
UAS for environmental monitoring

Methodology: algorithms

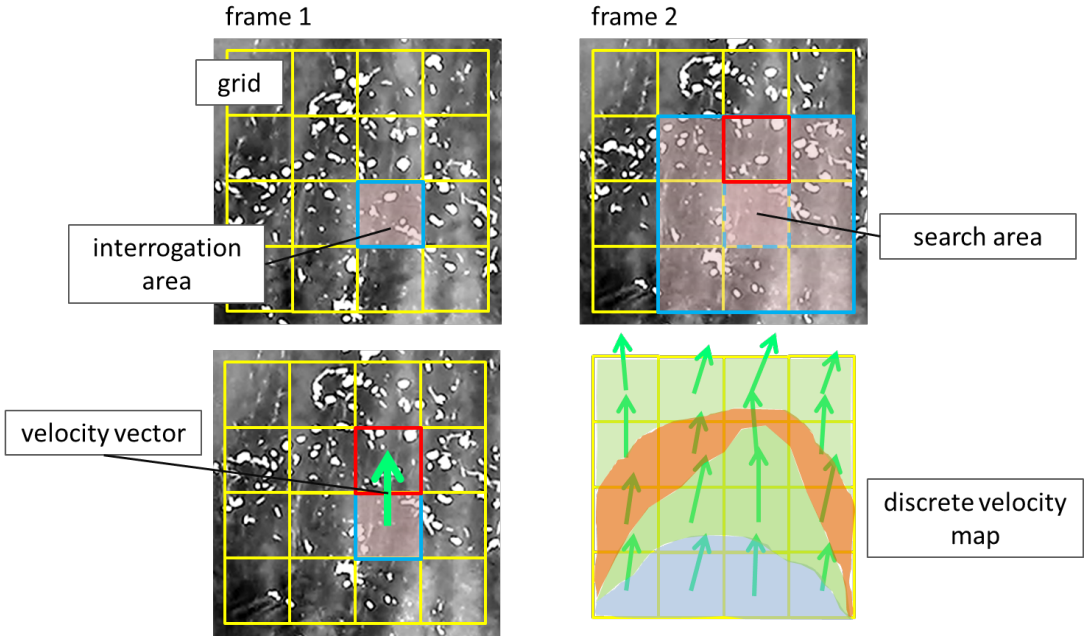
- From raw to usable data



1. Frame extraction
2. Camera calibration
3. Image orthorectification
4. Frame calibration
5. Frame enhancement

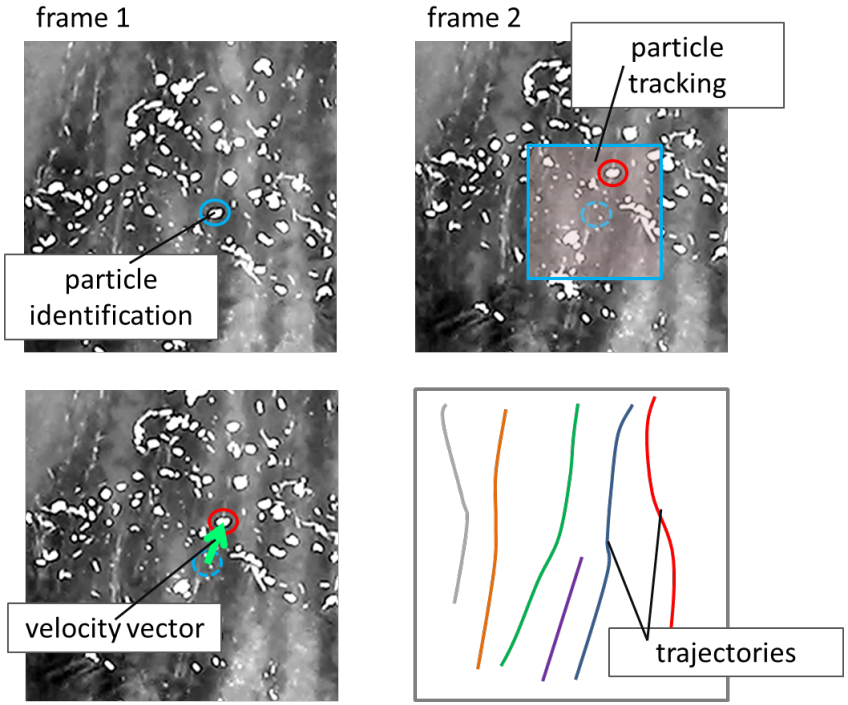
Methodology:algorithms

- Large Scale Particle Image velocimetry



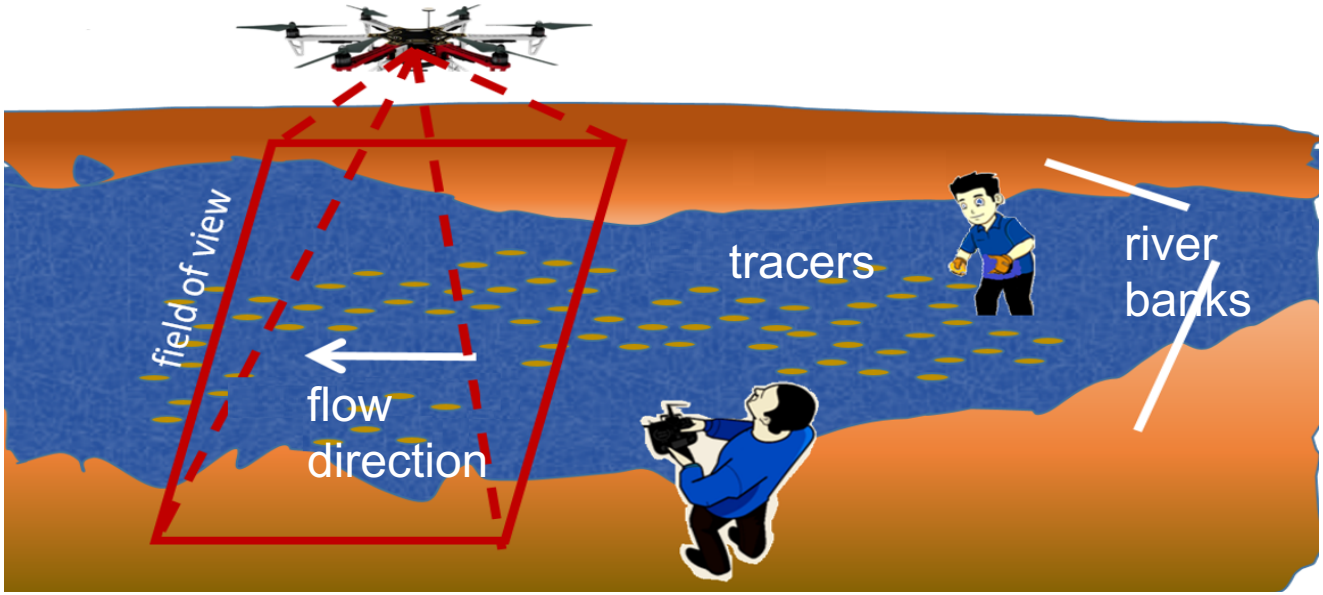
Methodology: algorithms

- Particle Tracking Velocimetry



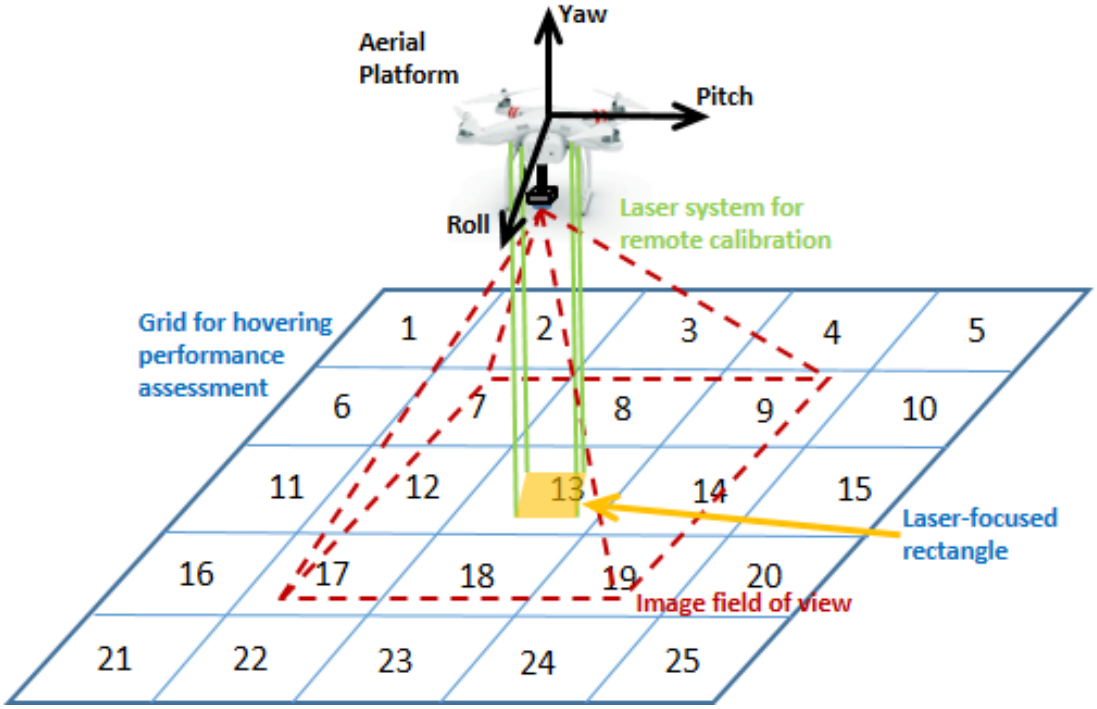
Methodology: setup

- Unmanned aerial systems for surface flow velocity field observations

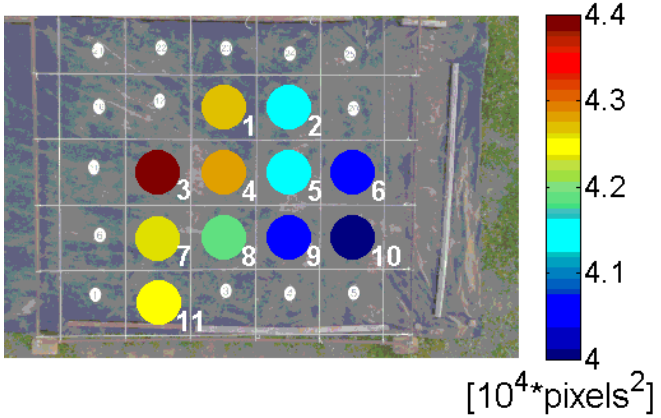


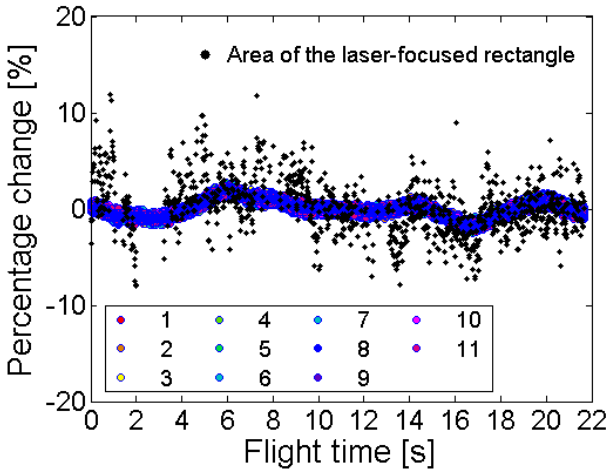
Case study

- Feasibility assessment



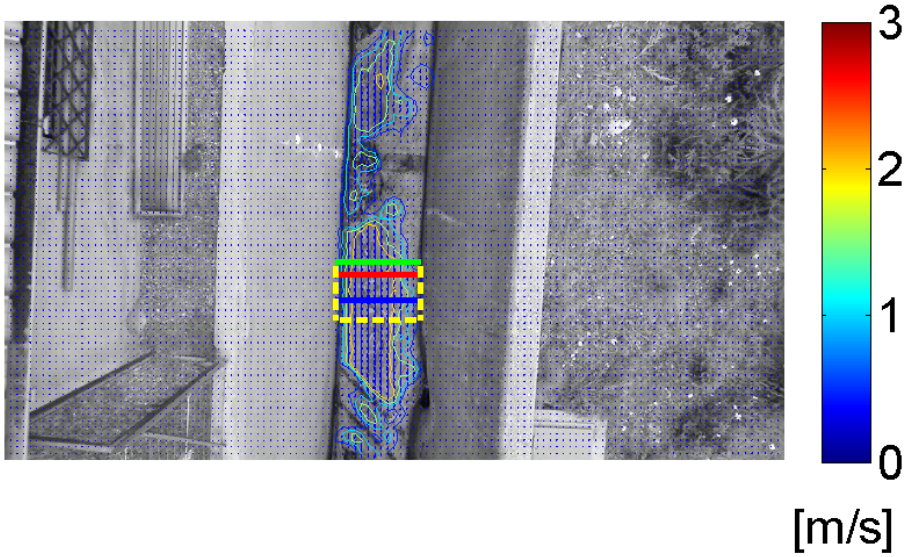
[Tauro et al., 2016, *J. Hydrol.*]

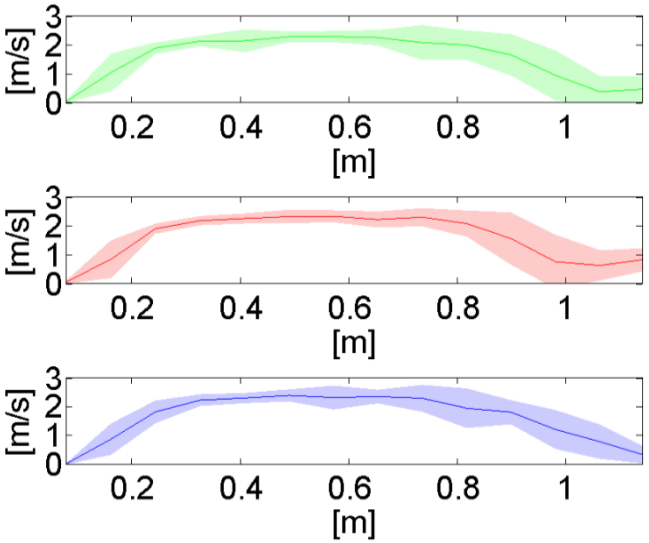




Case study

- Surface flow measurements





[Tauro et al., 2016, *J. Hydrol.*;Tauro et al., 2016, *Hydrol. Process.*]

Conclusions

- UASs offer several advantages with respect to traditional instrumentation for streamflow observations
- Low-cost platforms have led to reliable surface flow velocity maps
- Image processing with alternative algorithms may lead to quicker measurements

Future directions

- Fully remote discharge measurements
- Real-time streamflow measurements