MOXXI Measurements & Observations in the 21st Century
Working Group - International Association of Hydrological Sciences

→ MEASUREMENTS AND OBSERVATIONS IN THE 21st CENTURY CONFERENCE

Variability in flow state during a flash flood through process reconstruction using an Unmanned Aerial Vehicle (UAV)

Matthew Perks, Andy Russell, Andy Large
Matthew.perks@ncl.ac.uk

Newcastle University

21 November 2016 | ESA–ESRIN | Frascati (Rome) Italy

NERC SCIENCE OF THE ENVIRONMENT

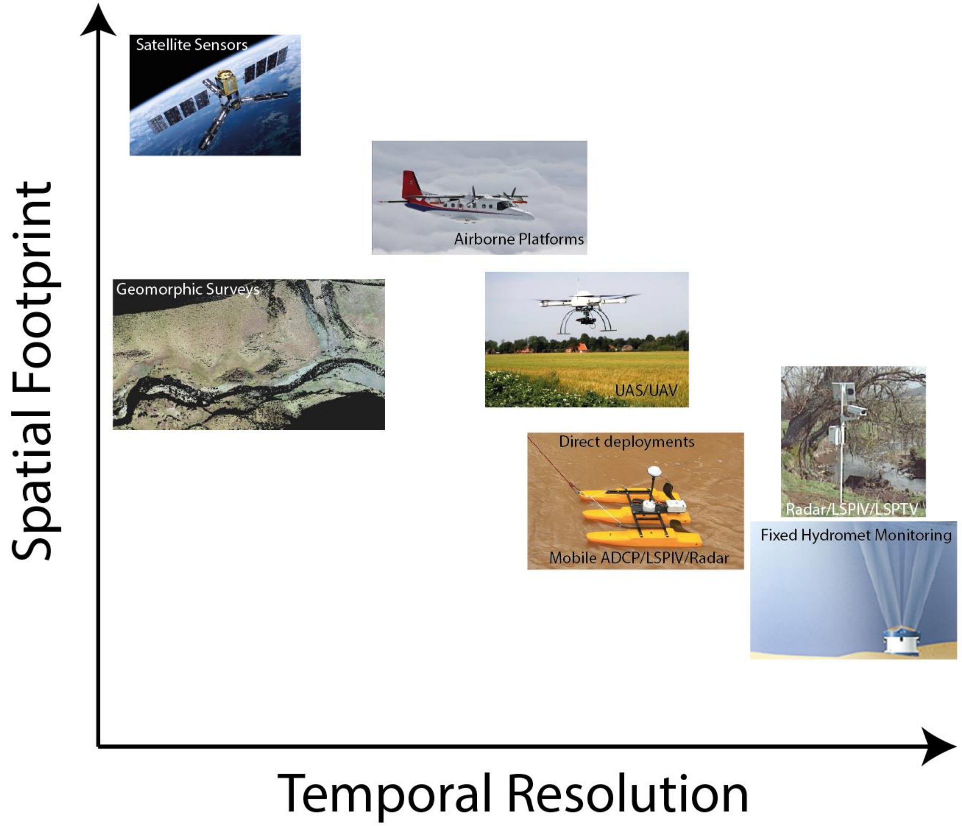
Aim

- Improve identification and characterisation of interacting **hydrological and hydro-morphological processes** that contribute to flooding associated with high-intensity rainfall events

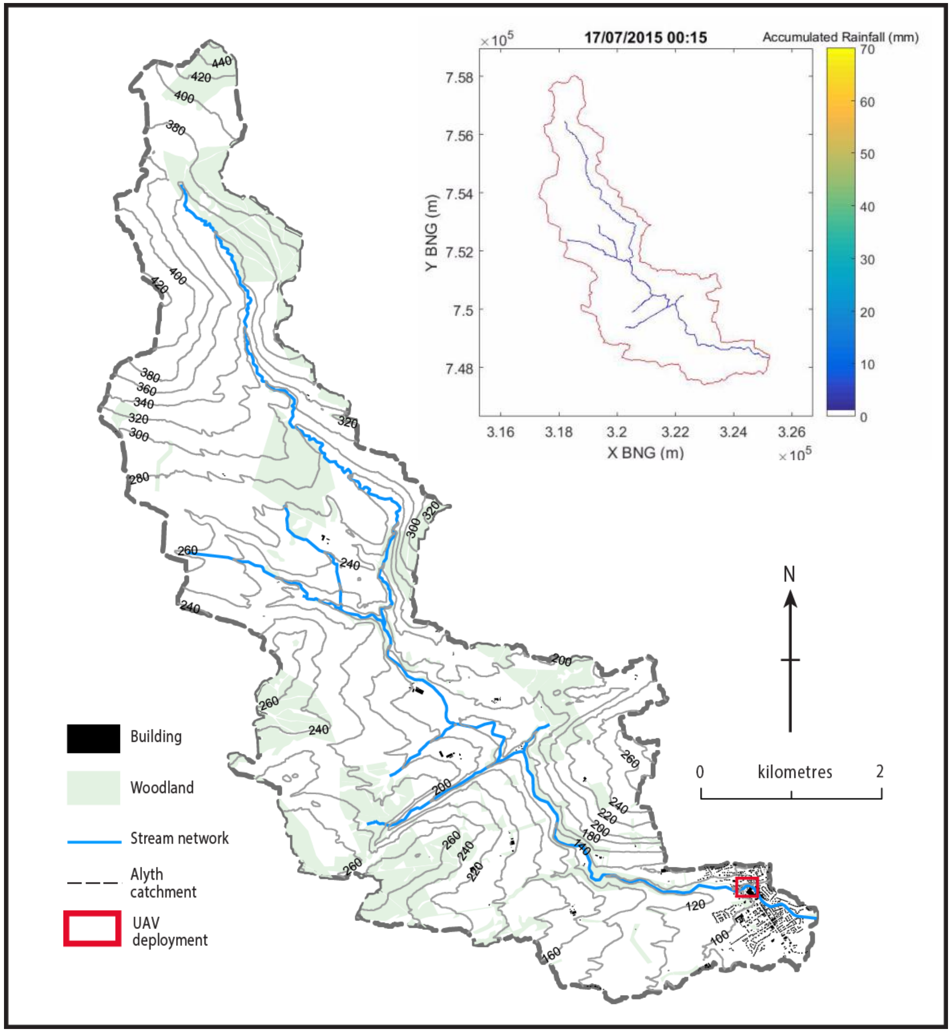
Research Questions

- How can we better measure the processes and interactions occurring during flash floods in typically small ungauged catchments?

- Can mobile platforms be used to acquire process information during a flash flood through non-contact approaches?

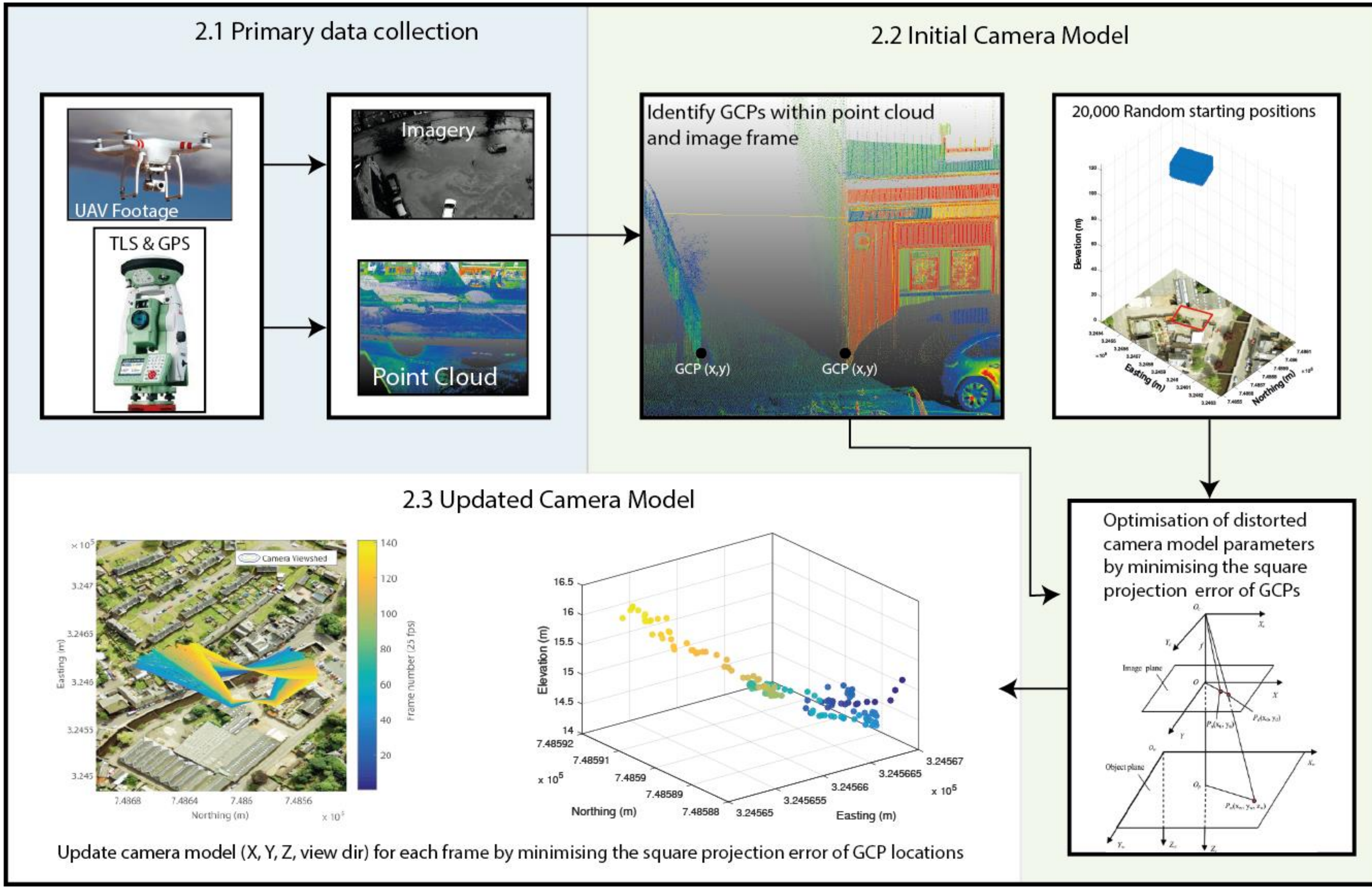


- >4000 deaths, losses of $1bn/yr
- FF account for 16% occurrence but 45% of fatalities
- Highly dynamic flood events
- Inundation extent, velocities and interactions
- Process understanding, warning systems, model validation and calibration
- Inadequate sampling using conventional monitoring – under-representation
- Responsive and hindered by practical difficulties

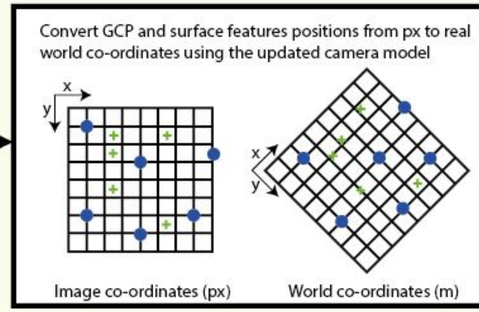

17/07/2015 00:15
Accumulated Rainfall (mm)
Y BNG (m)
X BNG (m)
N
0 kilometres 2
Building
Woodland
Stream network
Alyth catchment
UAV deployment

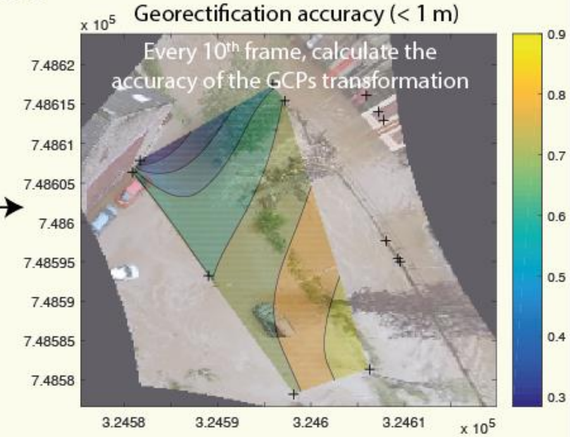

visiteastperthshire.co.uk

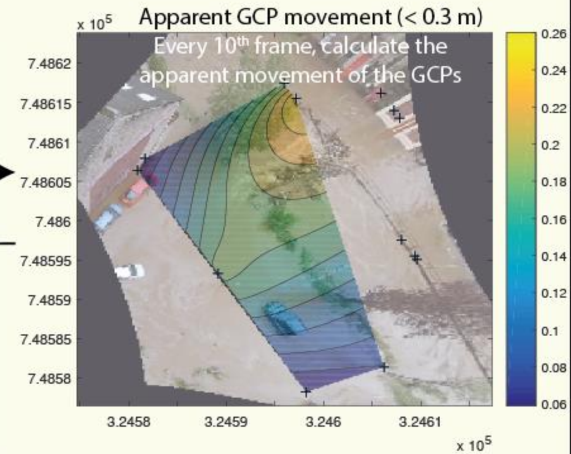

thecourier.co.uk


2.1 Primary data collection
UAV Footage
TLS & GPS
Imagery
Point Cloud
2.2 Initial Camera Model
Identify GCPs within point cloud and image frame
GCP (x,y)
GCP (x,y)
20,000 Random starting positions
Elevation (m)
Easting (m)
Northing (m)
Optimisation of distorted camera model parameters by minimising the square projection error of GCPs
Image plane
Object plane
2.3 Updated Camera Model
Camera Viewshed
Easting (m)
Northing (m)
Frame number (25 fps)
Elevation (m)
Northing (m)
Easting (m)
Update camera model (X, Y, Z, view dir) for each frame by minimising the square projection error of GCP locations

2.4 Transformation accuracy and apparent movement of GCPs

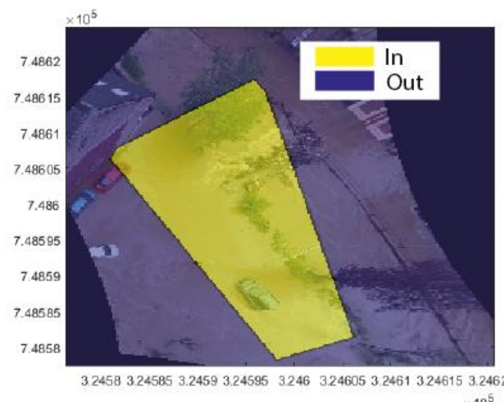




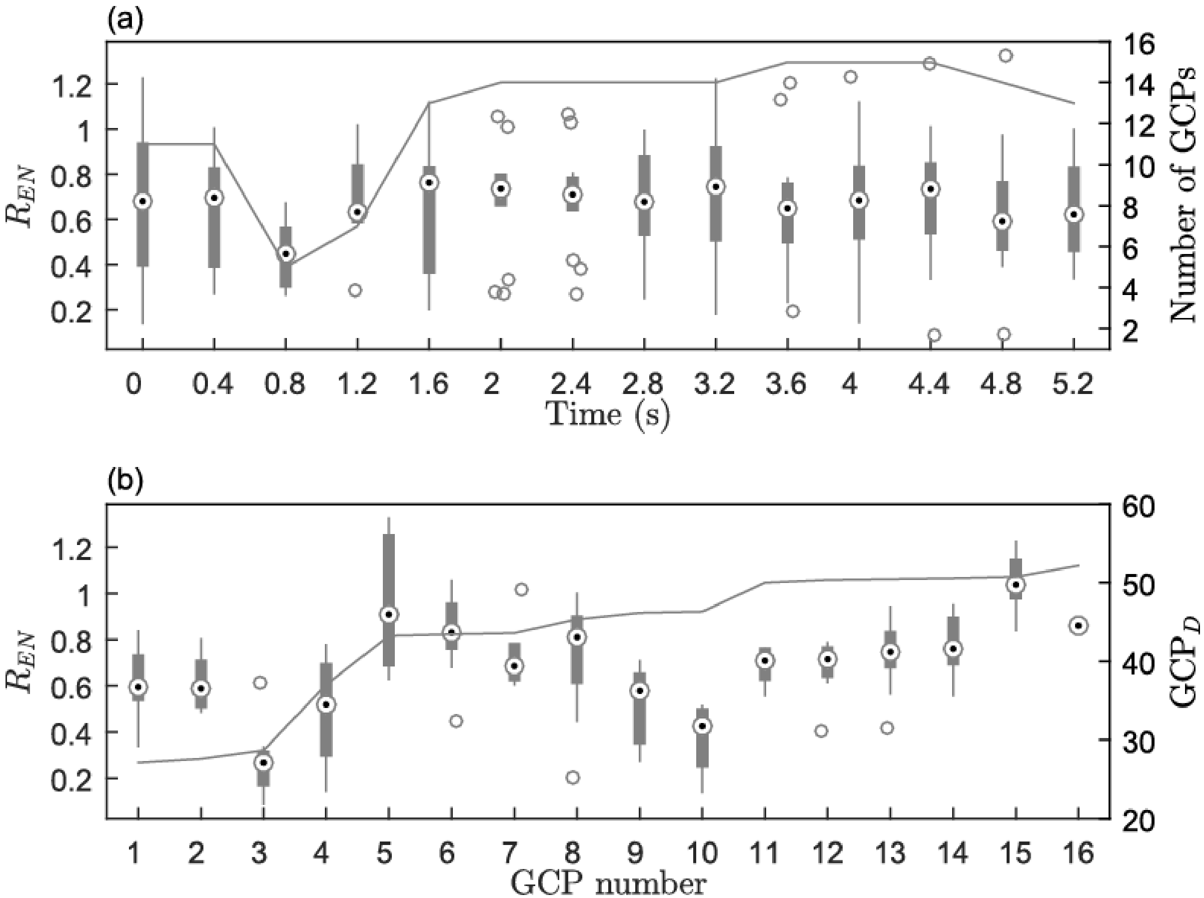


2.5 Surface Velocity Calculation

Calculate the velocity of the surface features

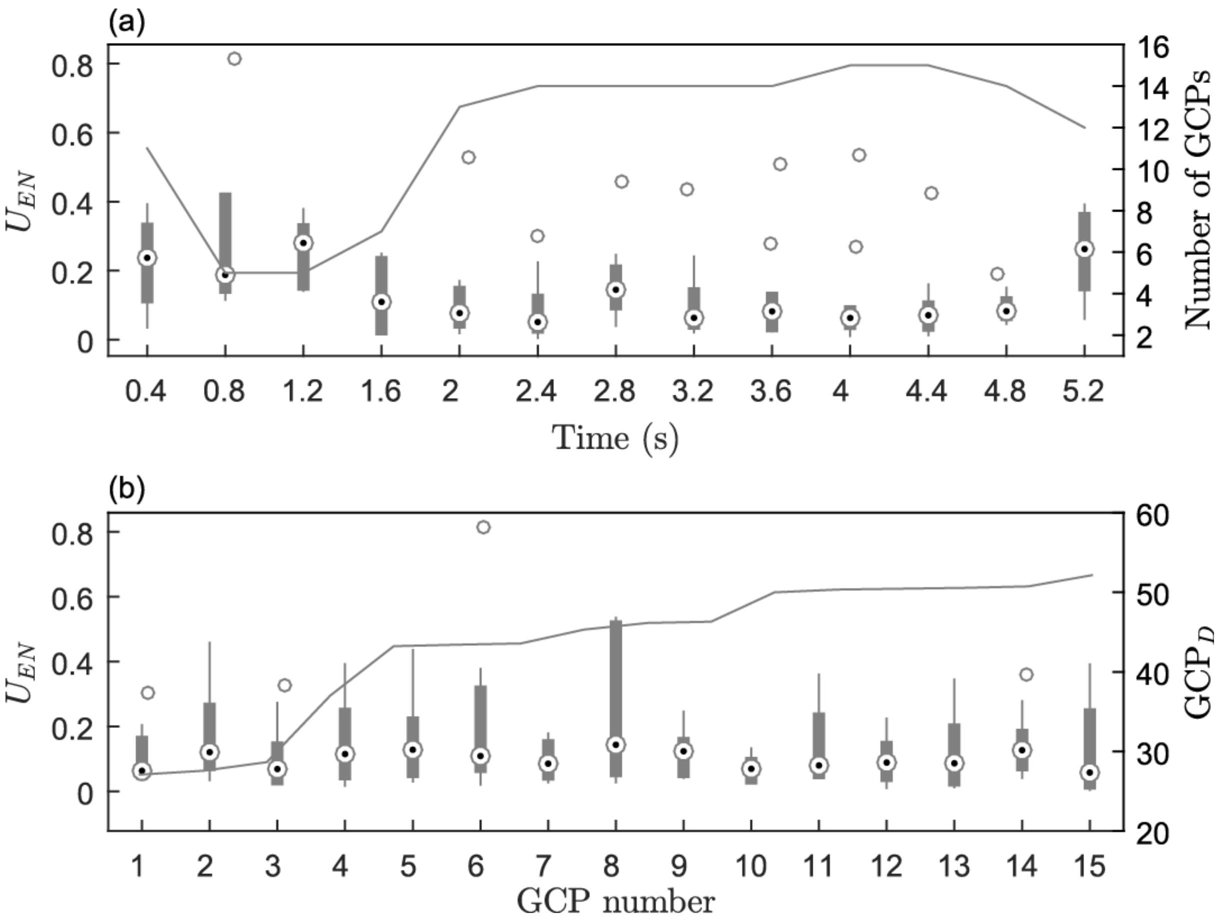


Mask out areas of poor transformation, and/or apparent GCP movement



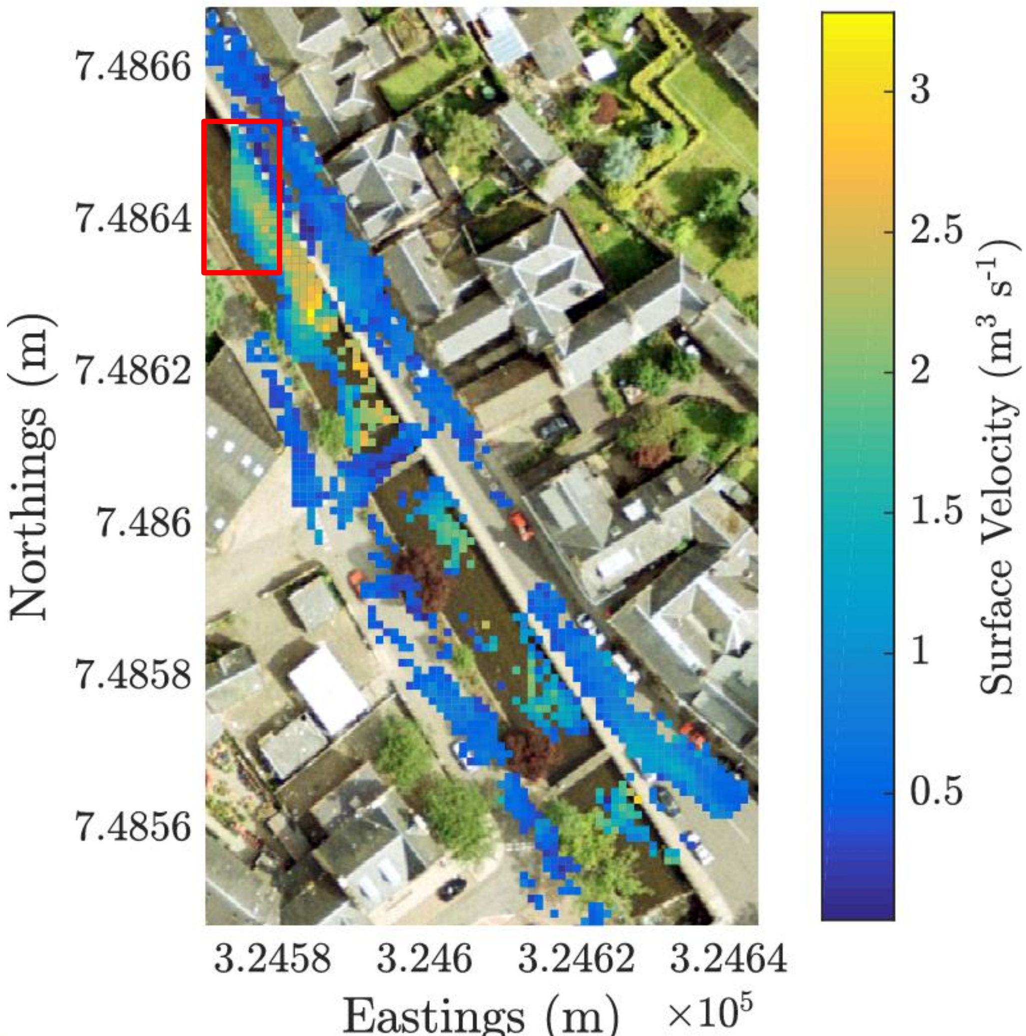
Perks *et al.* (2016) HESS, 20, 4005-4015.

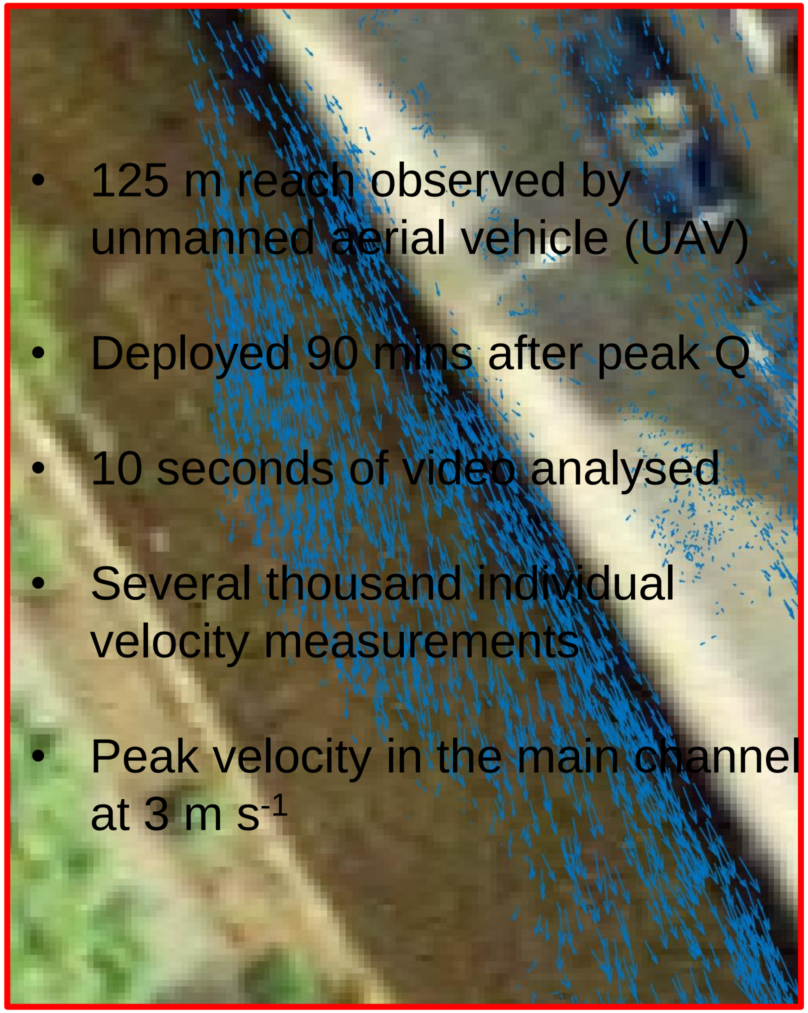
- R_{EN} = Absolute position of GCPs
- No. of GCP varies between 6 and 15 – highly dynamic scene
- Median R_{EN} stable at ~0.6 over time
- R_{EN} of individual GCPs varies from 0.2 – 1.0.
- Bi-linear interpolation across domain and velocity reading stored if < 0.7m.



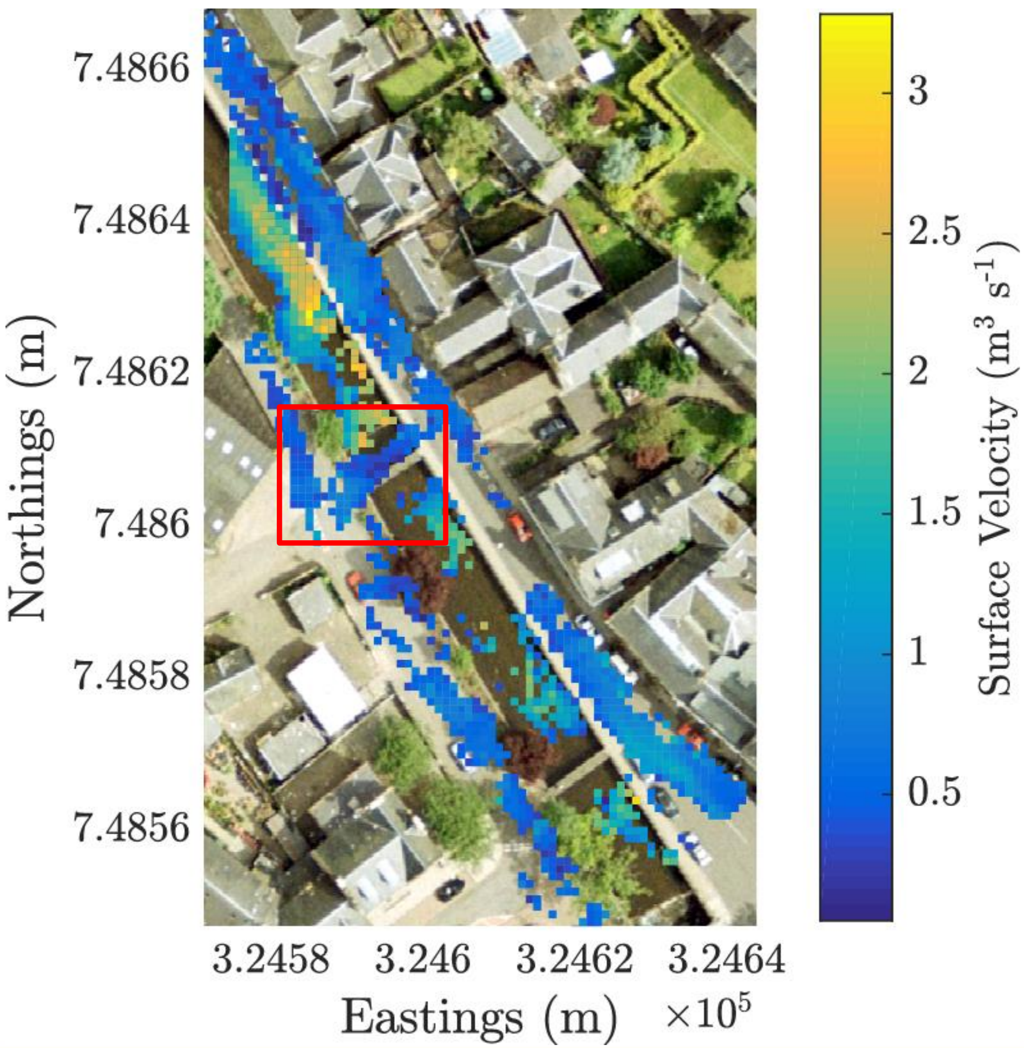
Perks *et al.* (2016) HESS, 20, 4005-4015.

- U_{EN} = Movement of GCPs between 10 frames
- Median U_{EN} varies over time from 0.05 – 0.3 m
- Median U_{EN} of individual GCPs varies from <0.1 – 0.2.
- Bi-linear interpolation across domain and velocity reading stored if < 0.3m.

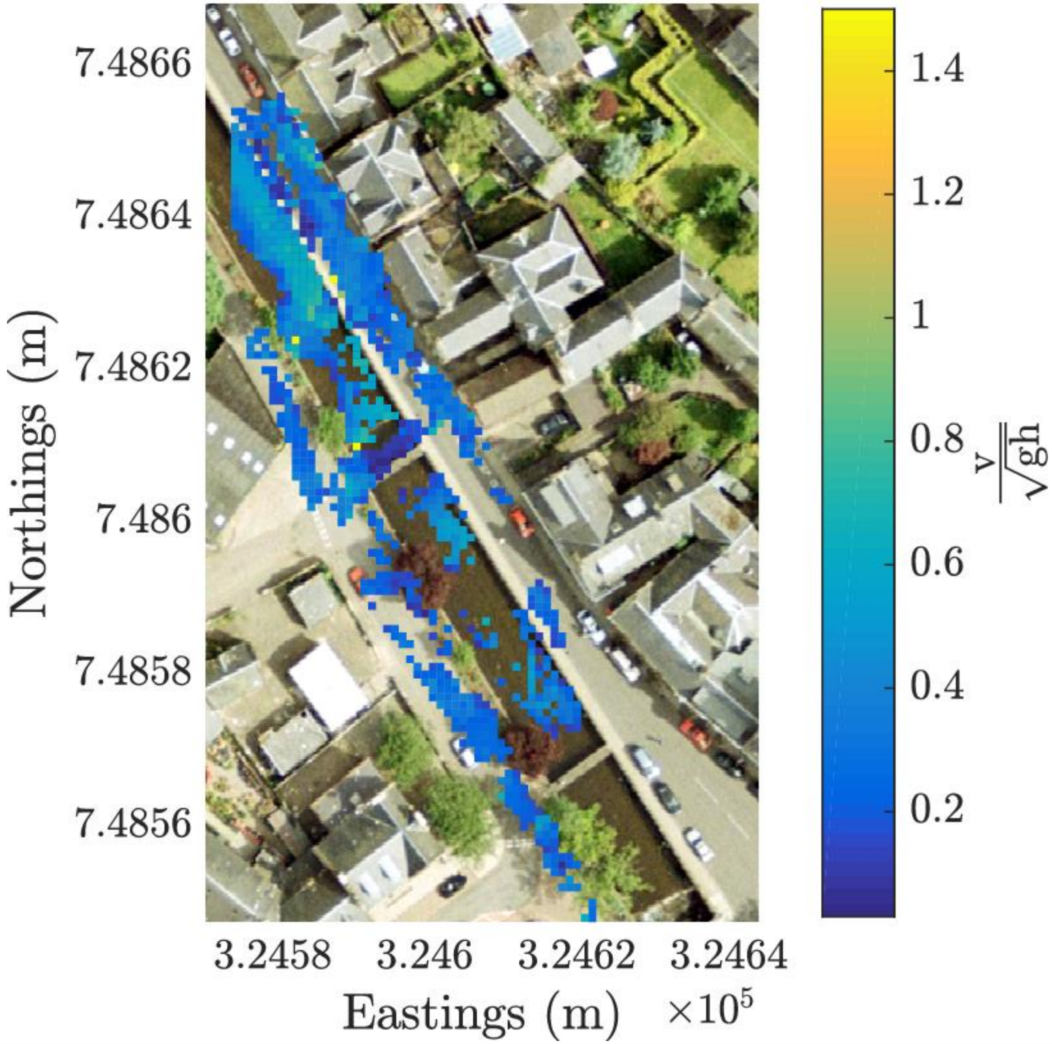


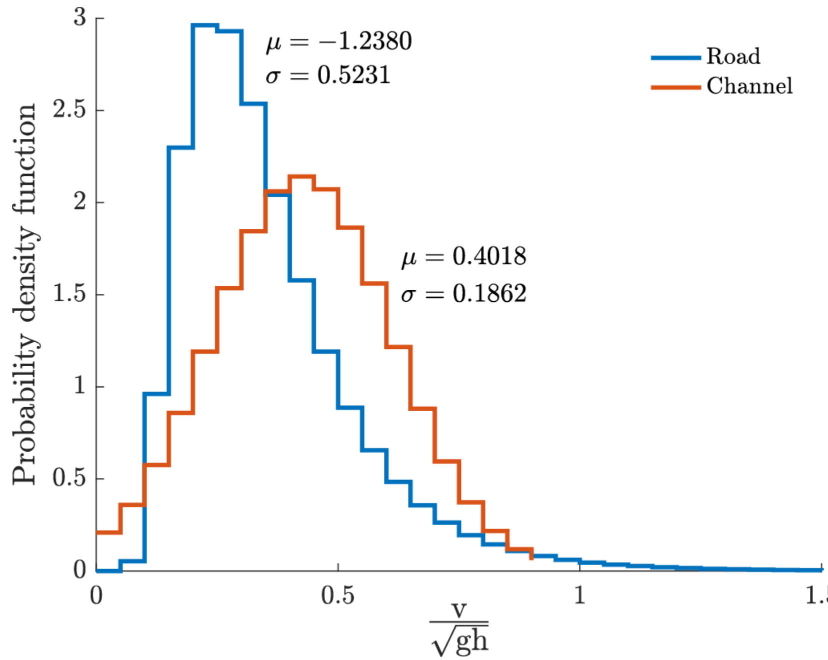


- 125 m reach observed by unmanned aerial vehicle (UAV)
- Deployed 90 mins after peak Q
- 10 seconds of video analysed
- Several thousand individual velocity measurements
- Peak velocity in the main channel at 3 m s^{-1}



- Interactions between infrastructure and flow dynamics
- Apparent reduction in main channel velocity immediately upstream of bridge
- Due to bridge blockage with flow being diverted along adjacent road





Application of spatially varied but temporally constant Fr number enables peak Q to be estimated as 43 m^3 s^{-1} **TBC with full analysis of uncertainty**

- UAVs have increased our ability to monitor and quantify higher magnitude, lower frequency environmental phenomena at previously unattainable spatial and temporal resolutions.

- Potential for adoption of low-cost, commercially available UAVs to extract key hydraulic data, such as surface velocities, during flash floods.

- Assessment of interactions between flow and physical structures.

- Main uncertainties are associated with camera calibration (distortion) and accounting for movement.

- Making observations of peak flood discharge in real-time remains a significant practical challenge.