On improving urban flood prediction through data assimilation using CCTV images

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DARE steps

in flood forecast improvement

To collect CCTV images of floods for a number of cities and towns in the UK.

To understand the data - quality control, information extraction, error information.

To improve the SAR delineation algorithm for urban areas. (David Mason)

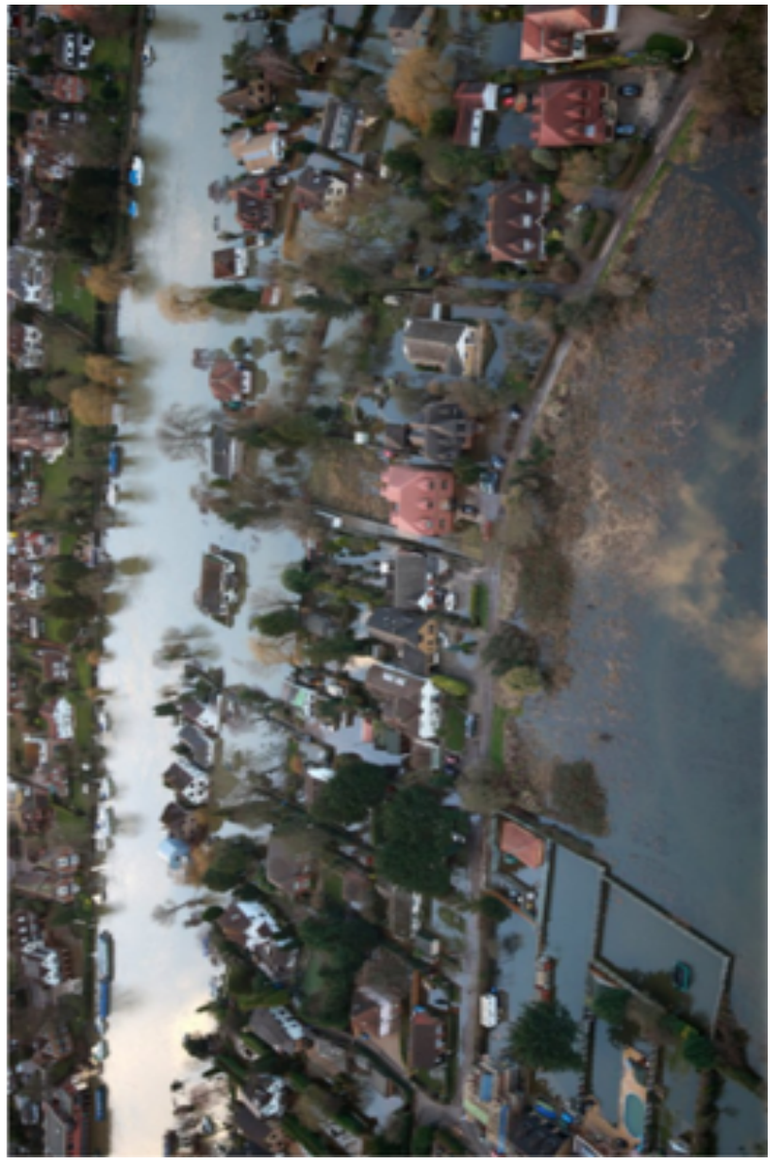
To assimilate data extracted from CCTV and SAR images into flood models.

Urban flood observations

+ **river gauges**
  (sparse in space, frequent in time);
+ **SAR satellite images**
  (cover large spatial domains);
+ **CCTV cameras**
  (varied spatial distribution, frequent in time);
+ **rivercams**
  (sparse in space, frequent in time);
+ **surface water road sensors**
  (where available);
+ **other crowdsourced data**
  (e.g. Twitter, smartphone images, areal images).

SAR observations

Synthetic-aperture radar (SAR)



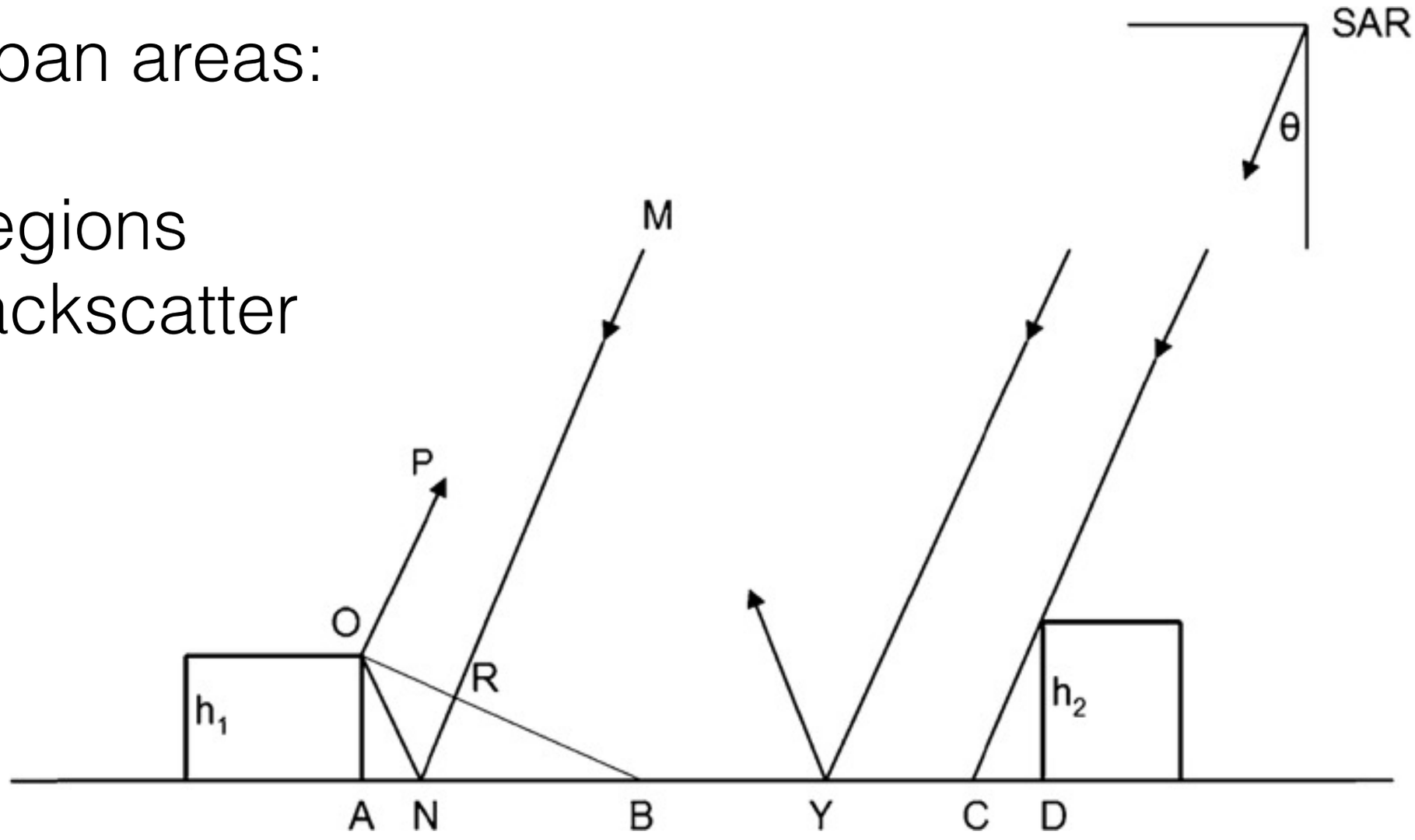
Aerial photo of flooding in Wraysbury, West London (about 300 x 300 m)

CSK sub-image (1 x1 km) of Thames flood in Wraysbury (dark areas are water). Red outline shows the area covered by the aerial photo.

SAR observations

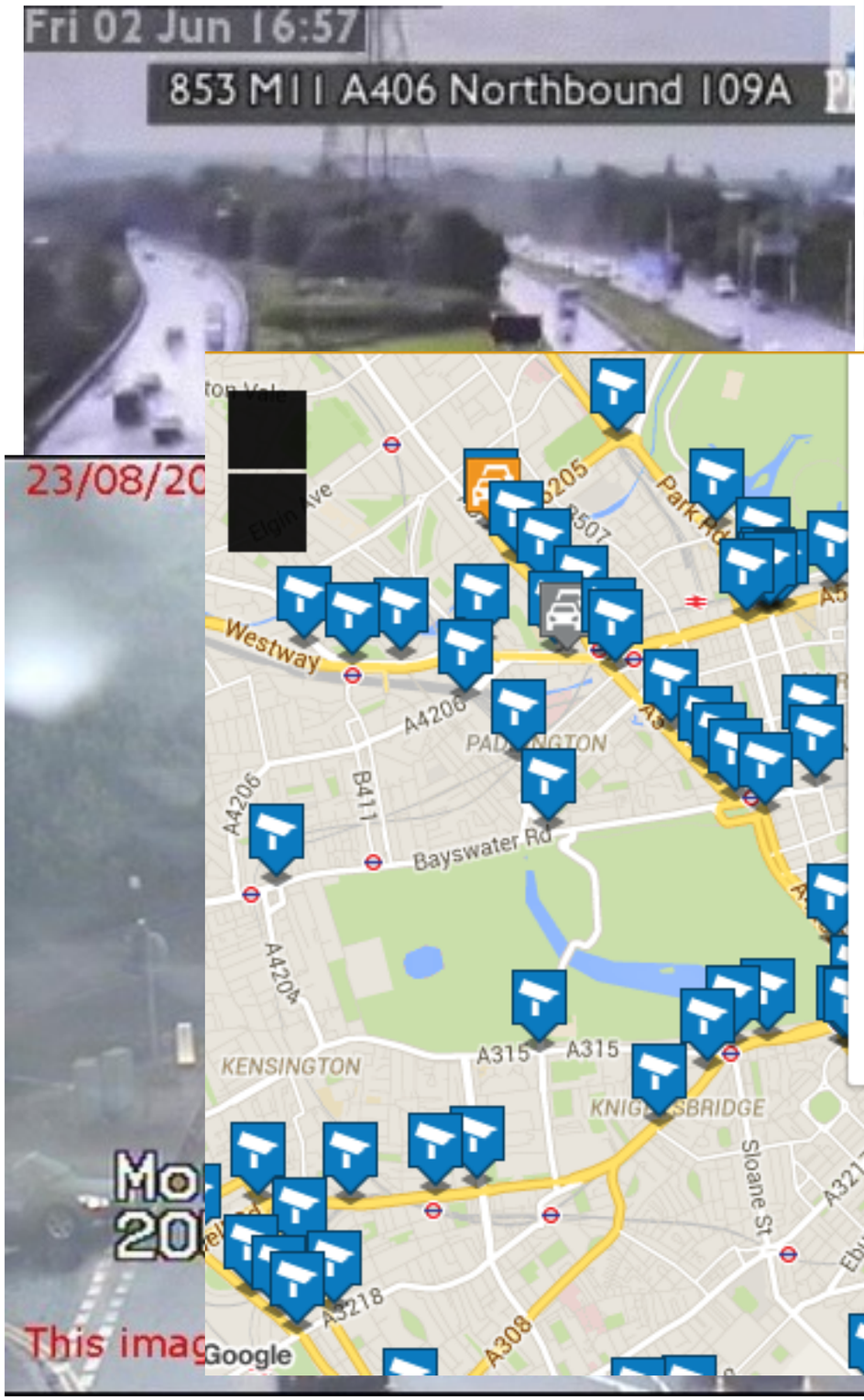
Issues in urban areas:

- resolution
- shadow regions
- double backscatter



Layover (AB) and shadow (CD) regions in a flooded street (AD) between adjacent buildings of height h1 and h2 (θ = incidence angle).

CCTV images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853 M11 A406 Northbound 109A
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20
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Westway
A4208
PADDINGTON
Bayswater Rd
A4206
B411
A4204
KENSINGTON
A315
A315
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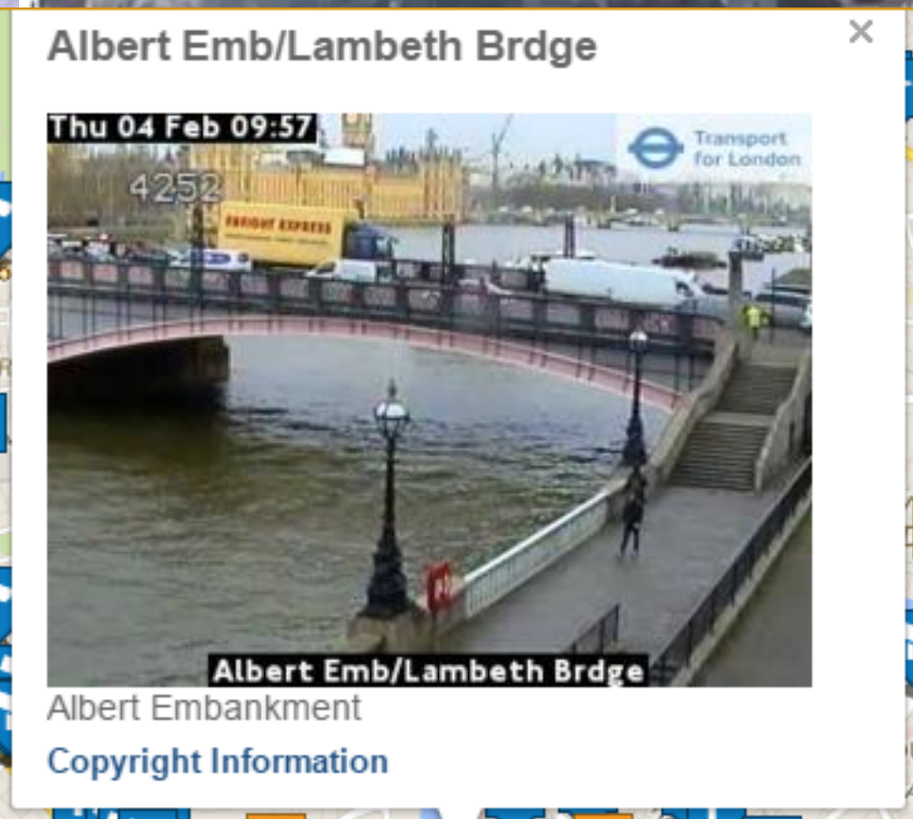
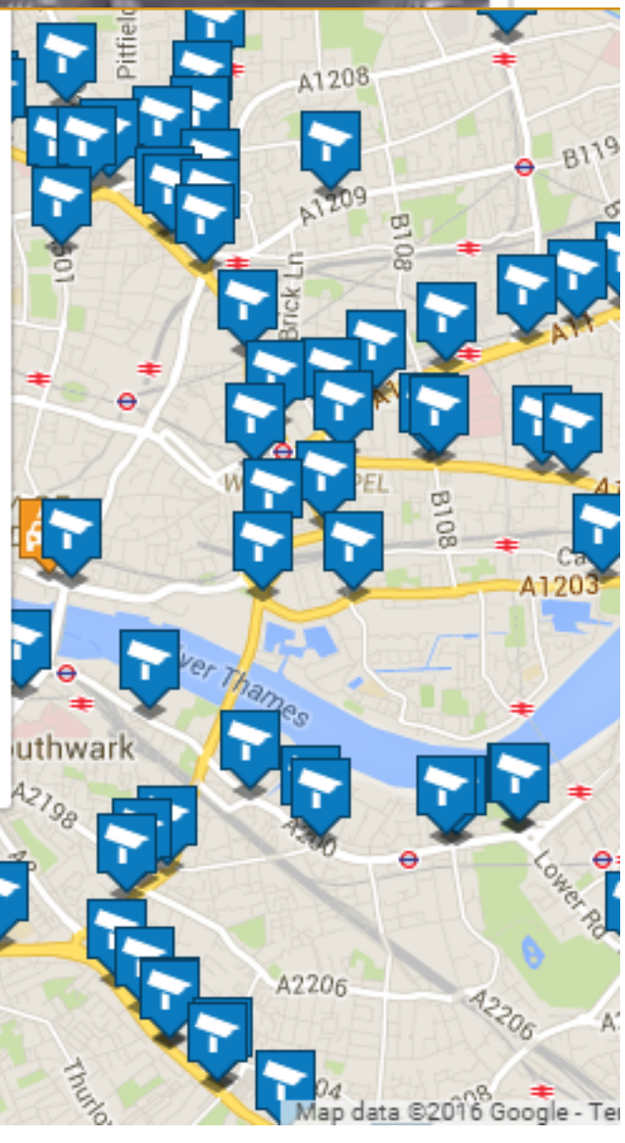
Sloane St
A3217
Ebury St
A3218
A308
Lupus St
PIMLICO
Victoria
Park Rd
Google


Albert Emb/Lambeth Brdge
Thu 04 Feb 09:57
4252
Transport for London
Albert Emb/Lambeth Brdge
Albert Embankment
Copyright Information


A1208
A1209
B108
B119
A1203
A2206
A2198
A200
Lower Rd
Walworth Rd
Map data ©2016 Google - Te

Quality control of CCTV

Lots of data thinning do since:

- some cameras move, zoom etc;
- obstructed view due to rain, vehicles, etc;
- faulty connections, low light;
- low resolution.

Powered by TfL Open Data

Rivercam test case:

Tewkesbury Nov/Dec 2012

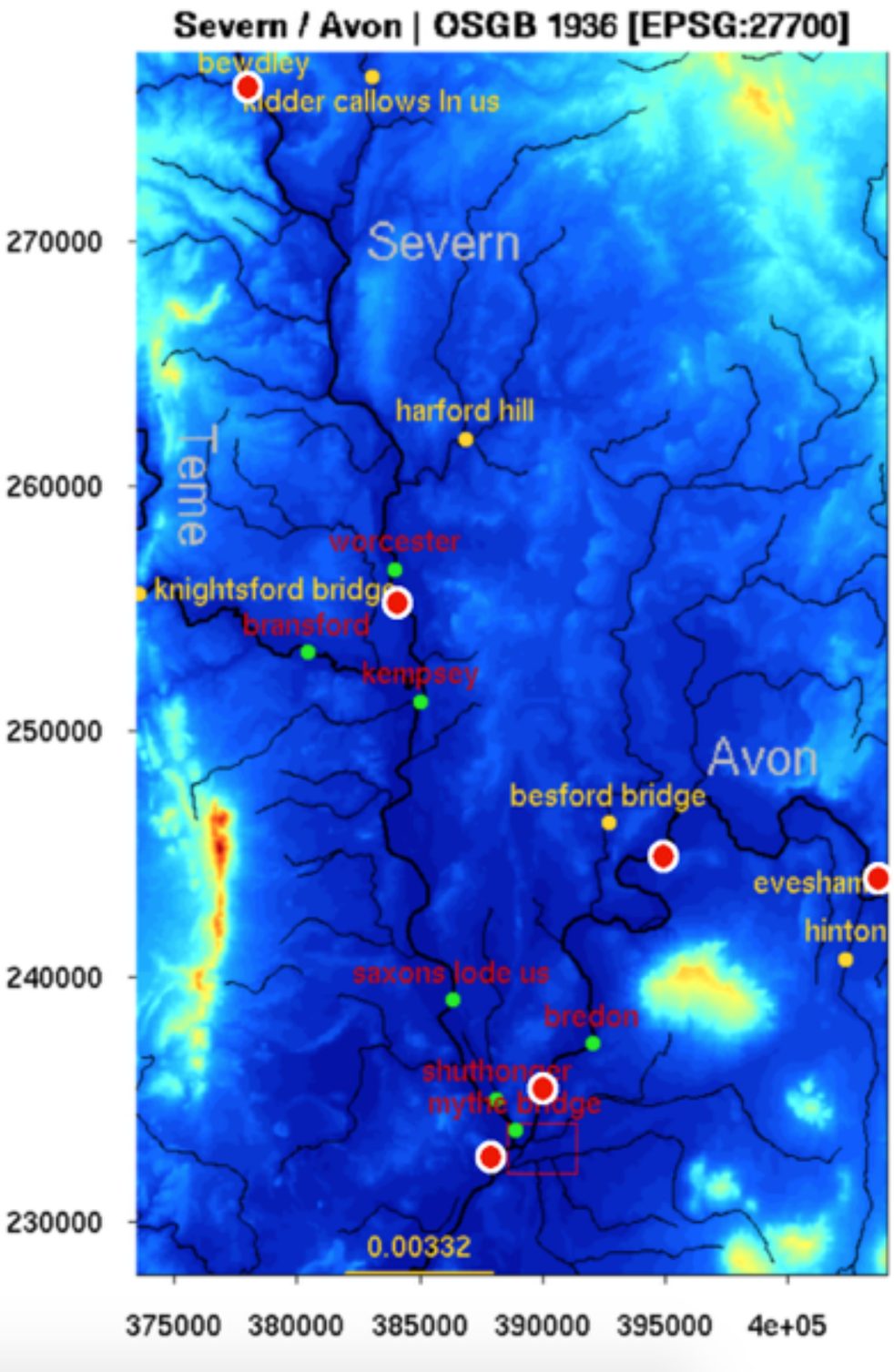
River cameras are used to monitor rivers for various purposes: water heights, fishing, bridge conditions, etc.

- HD cameras;
- Images available every 10s;

The densest network of river cameras in UK is provided by **Farson Digital Watercams** (https://www.farsondigitalwatercams.com/).

Rivercam test case:

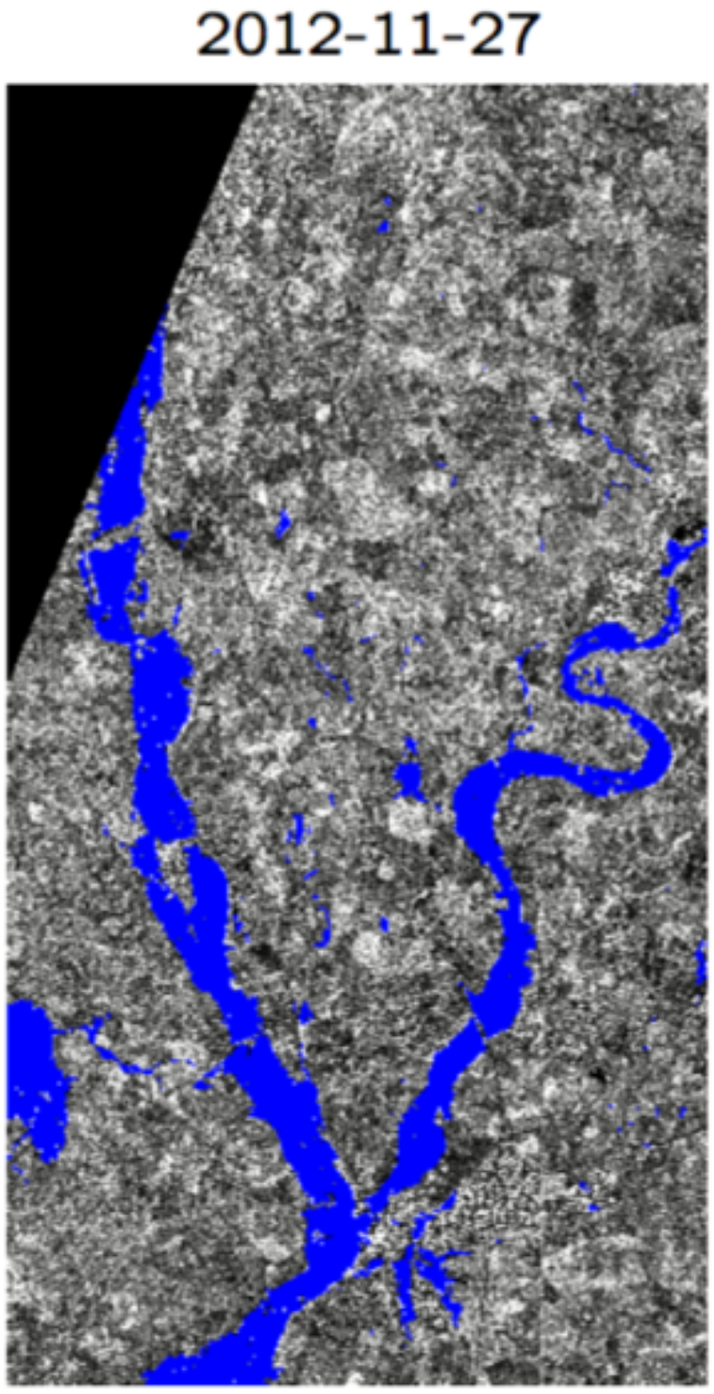
Tewkesbury Nov/Dec 2012

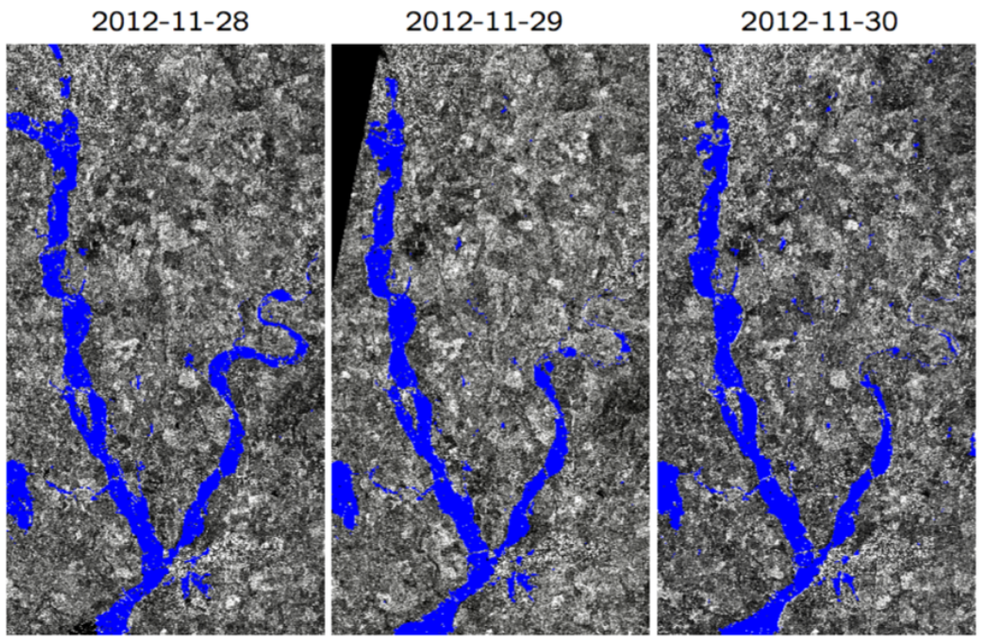


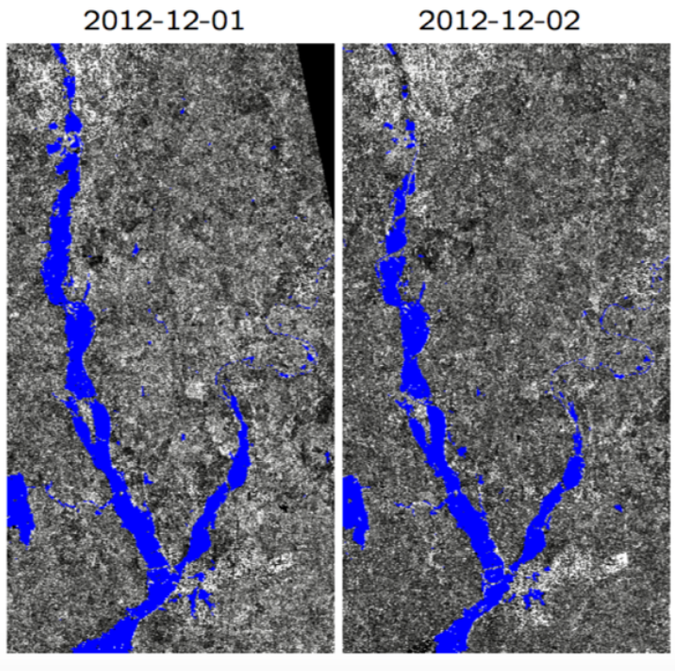
- 21/11/2012 - 05/12/2012
- LisFLOOD-fp model (García-Pintado et al. 2015)
- 7 SAR images available and assimilated
- EA gauge data used for verification
- 4 Farson Digital Ltd river cameras available in the domain with hourly data in the daylight

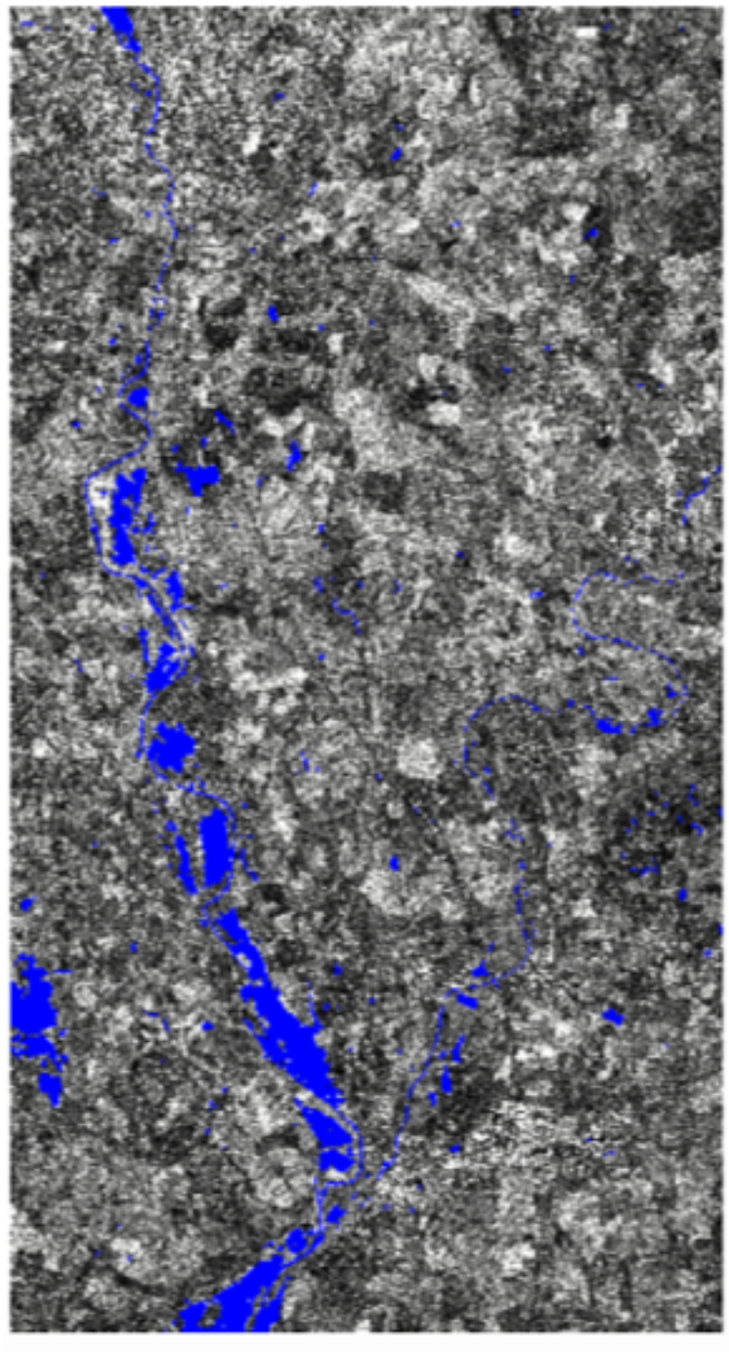
Rivercam test case:

Tewkesbury Nov/Dec 2012









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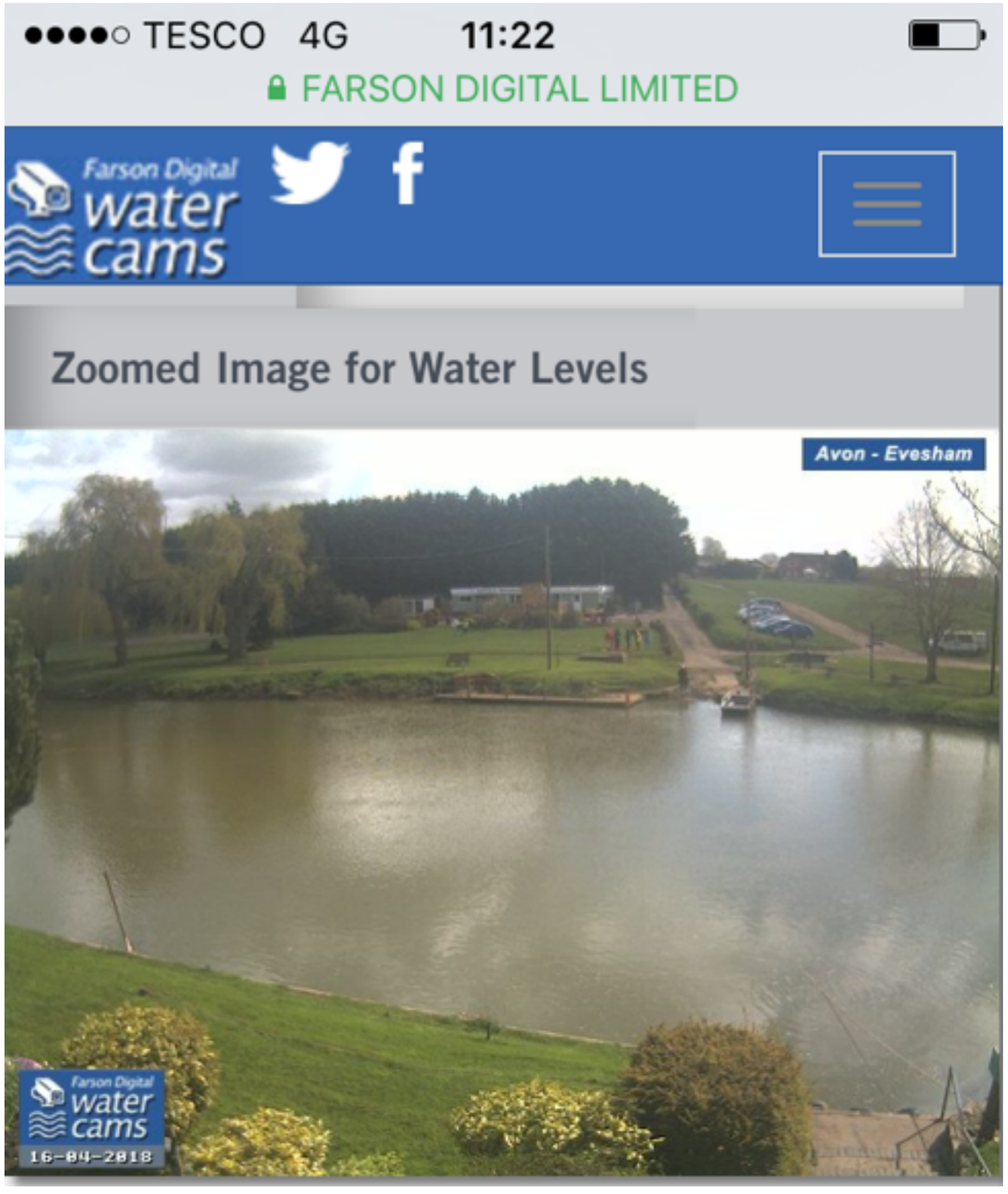
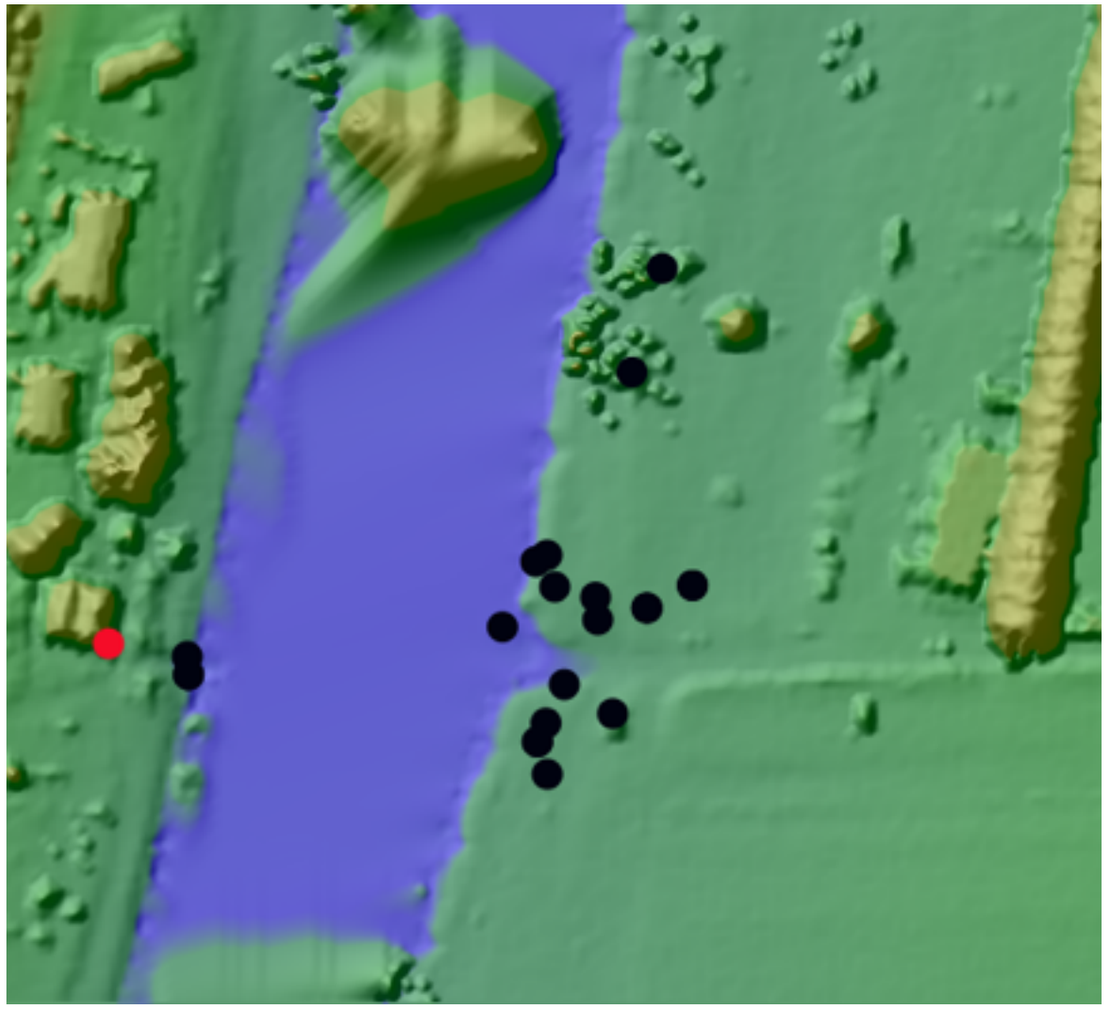
Tewkesbury Nov/Dec 2012



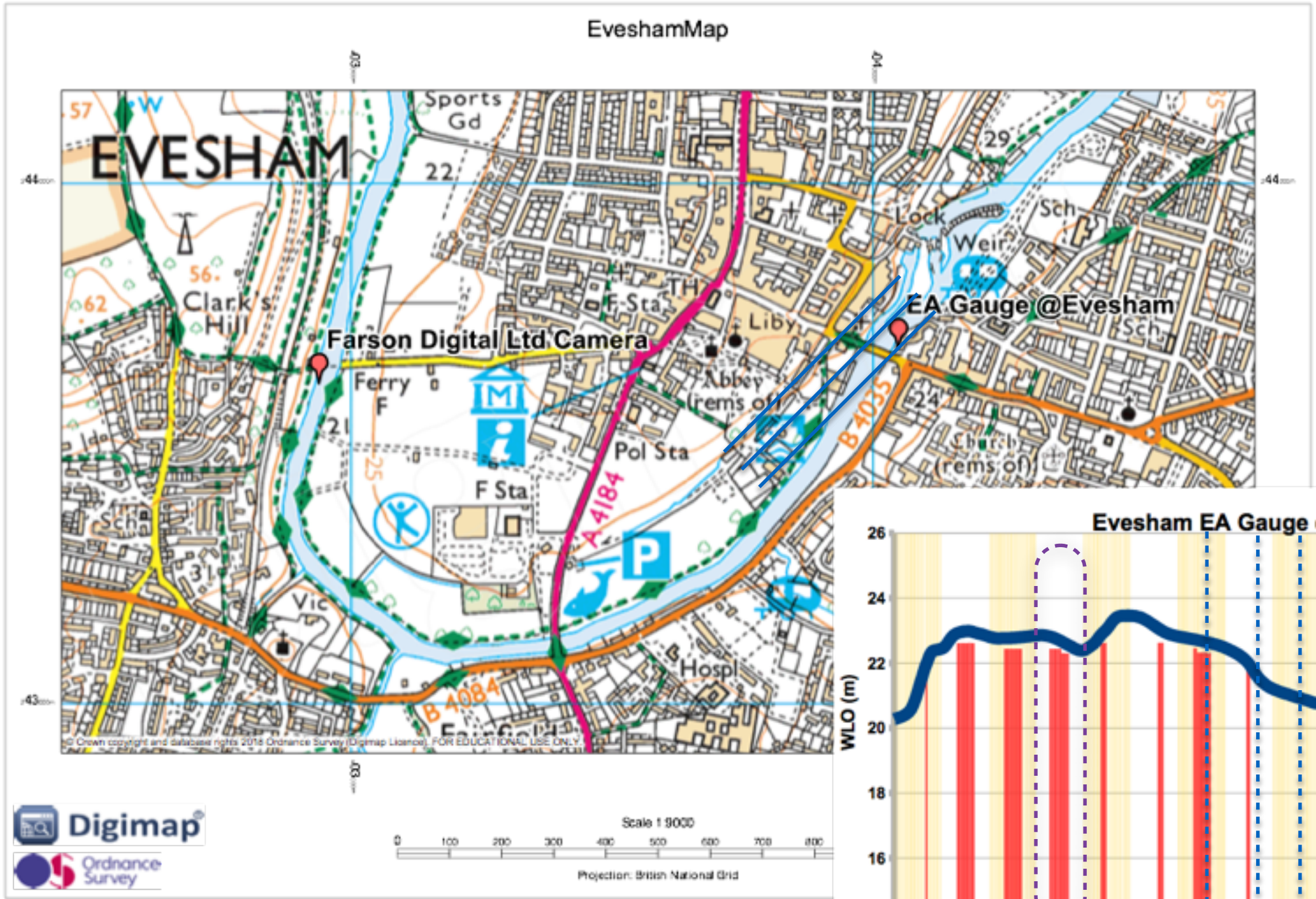


EA Lidar 1m DSM

Image used with permission of Farson Digital Ltd

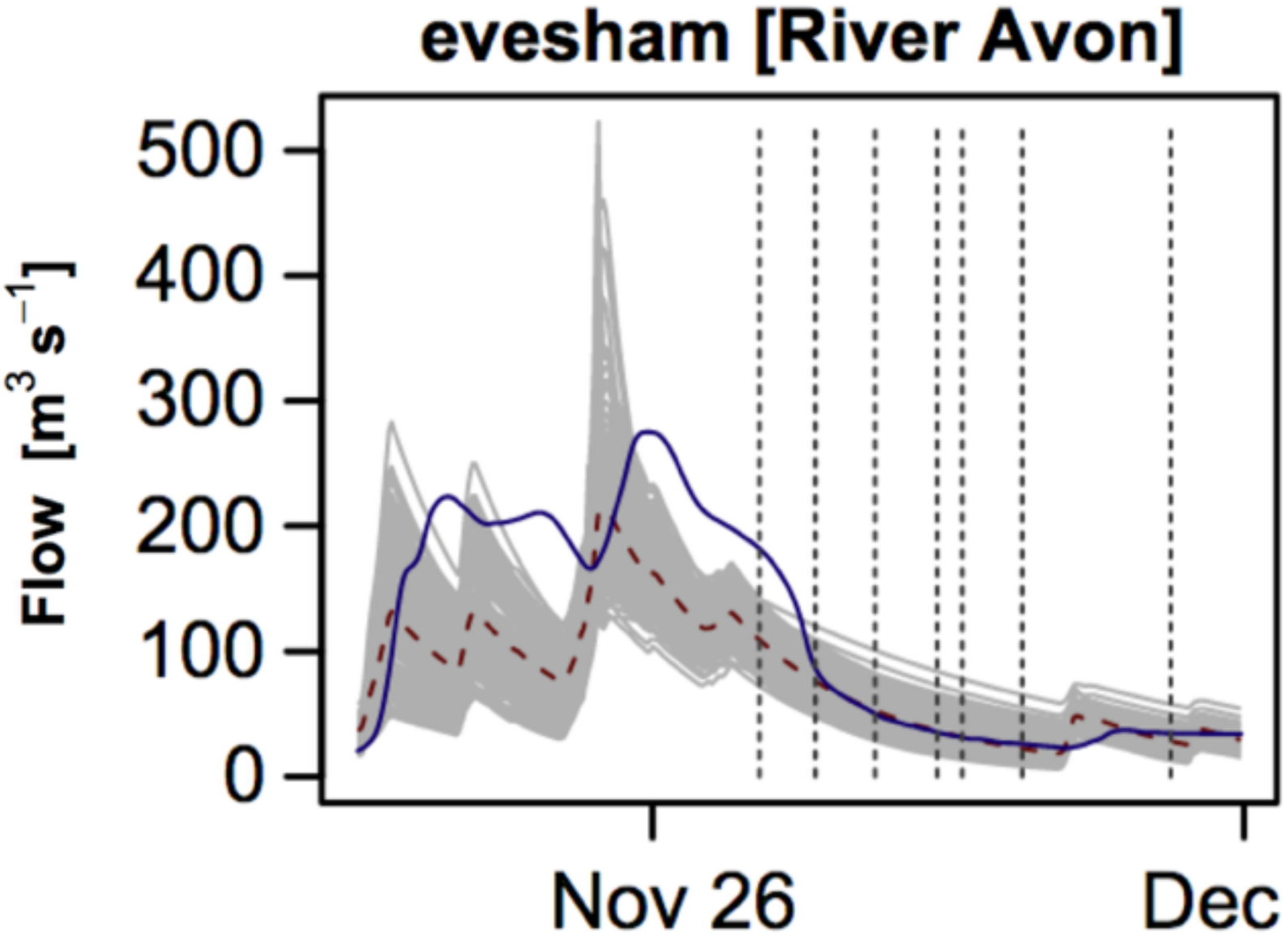
Rivercam test case:

Tewkesbury Nov/Dec 2012



Rivercam test case:

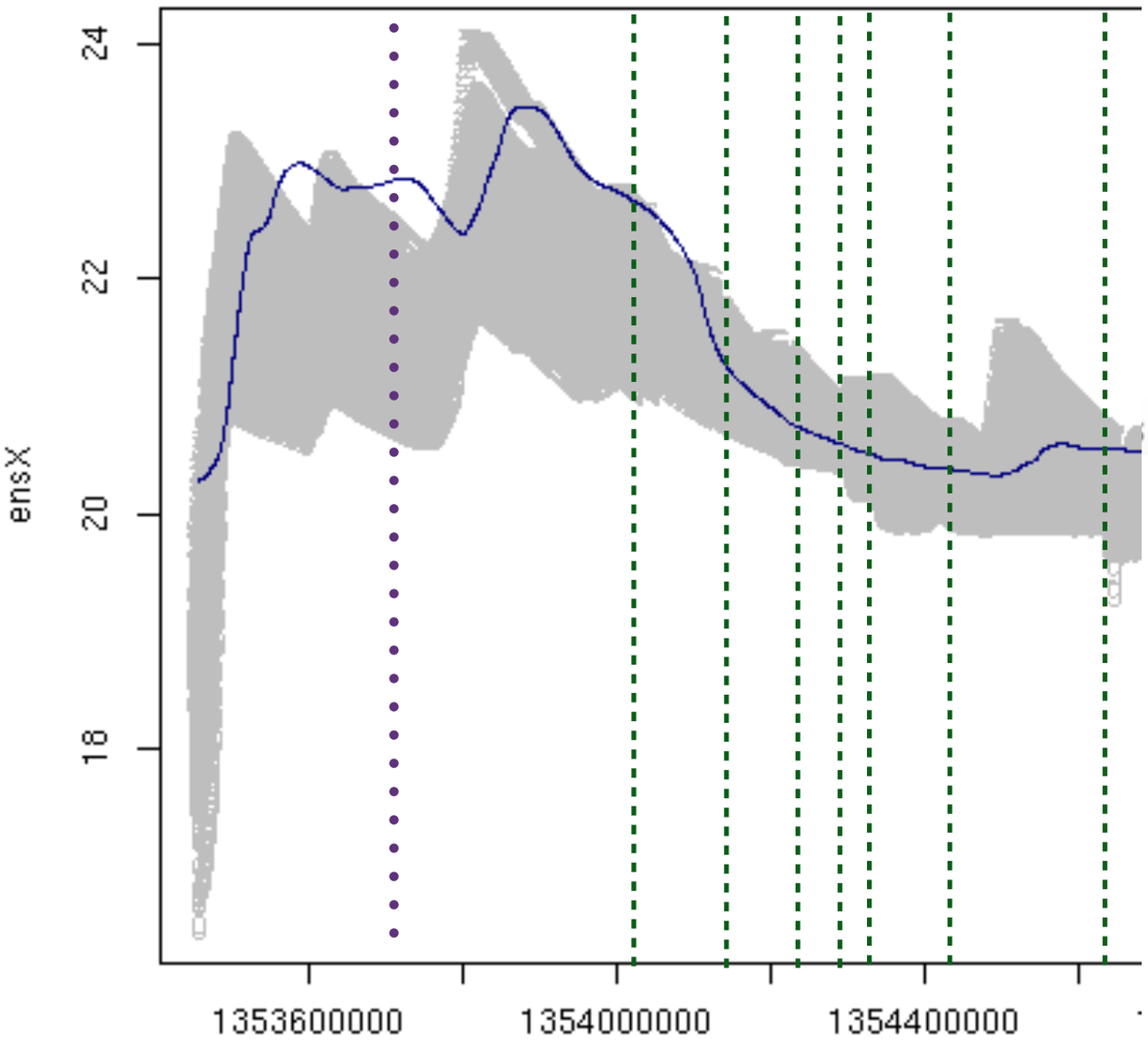
Tewkesbury Nov/Dec 2012

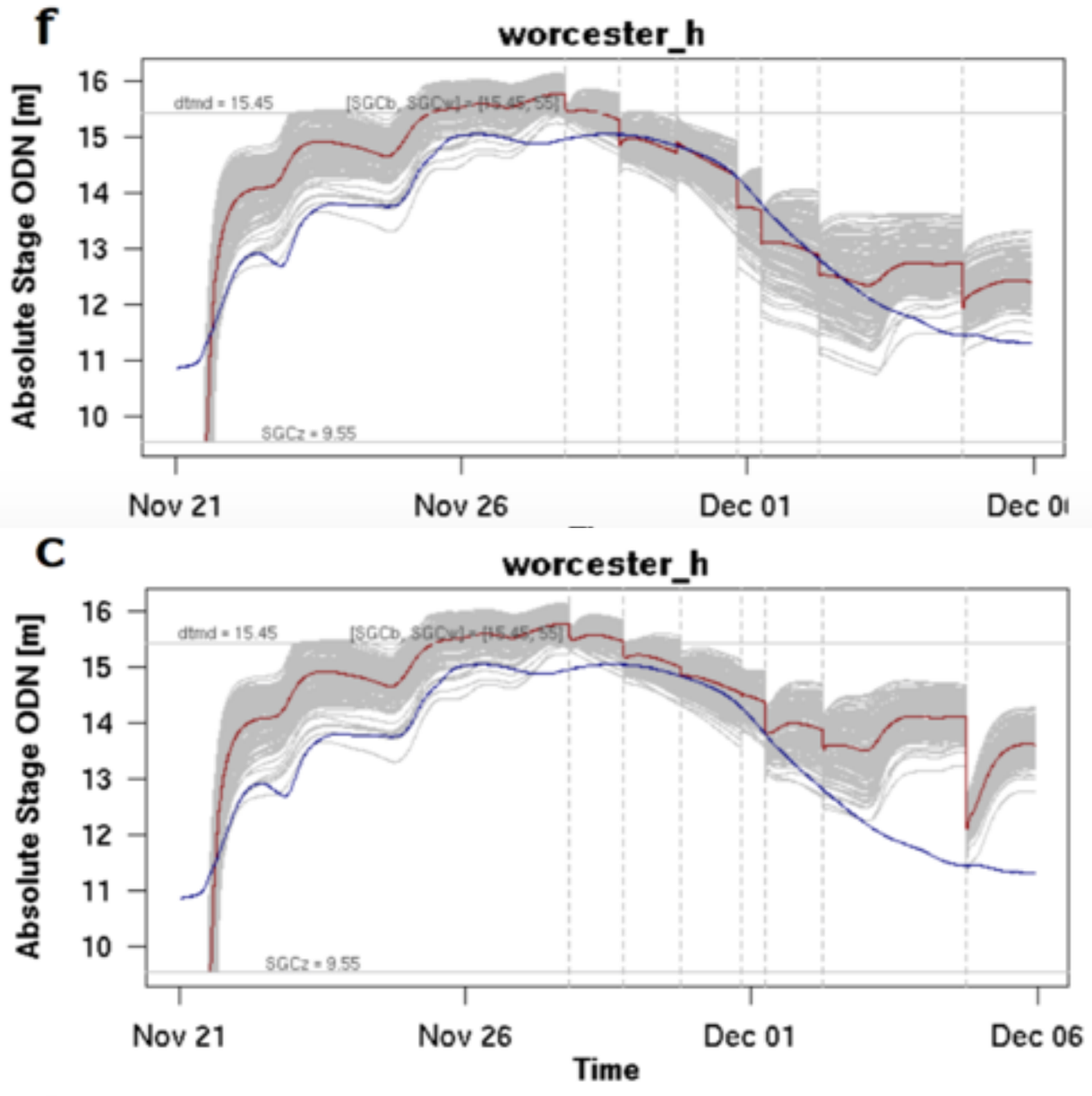


Inflow ensemble at Evesham station

García-Pintado et al. (2013)
García-Pintado et al. (2015)

Results with SAR data



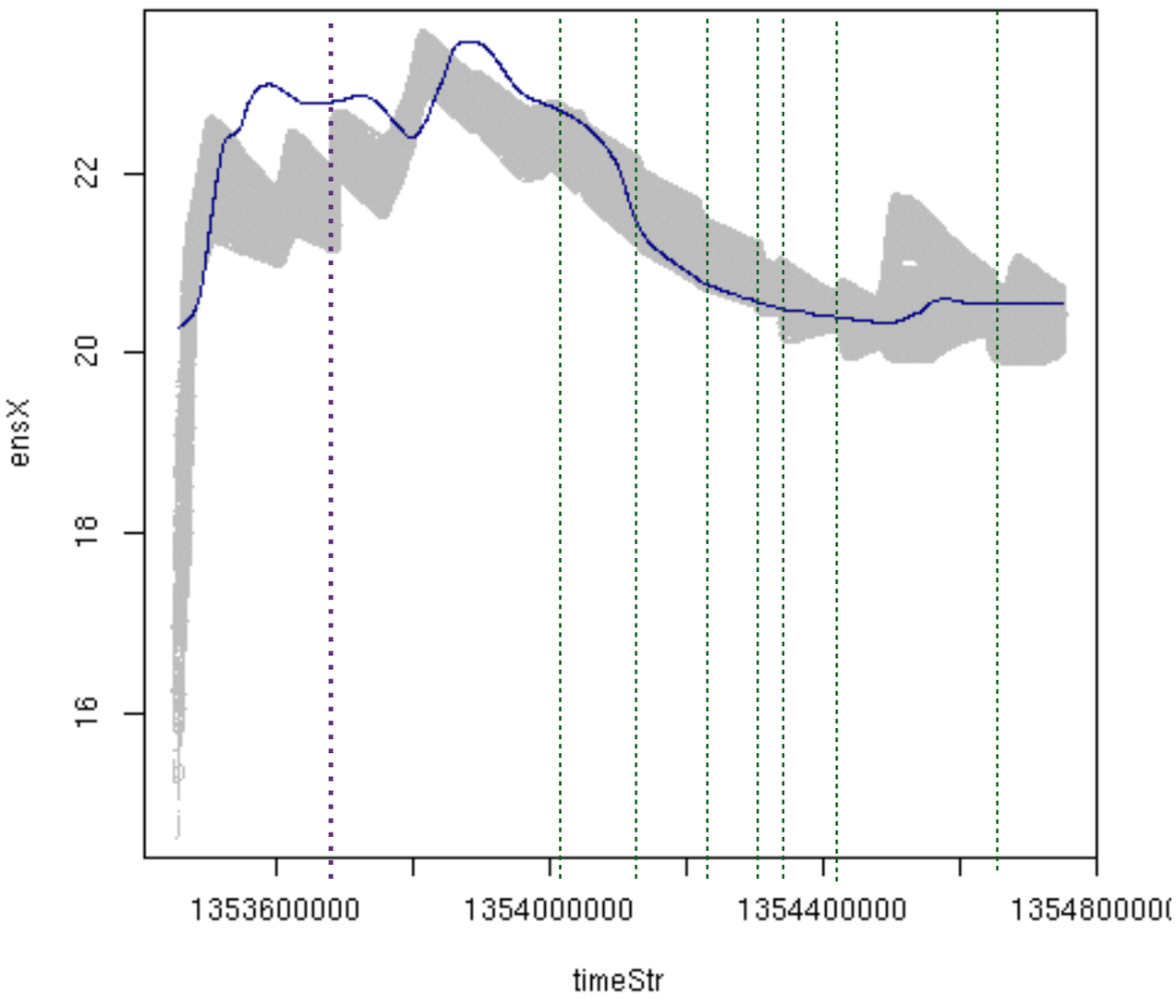


N = 100
Along network localisation

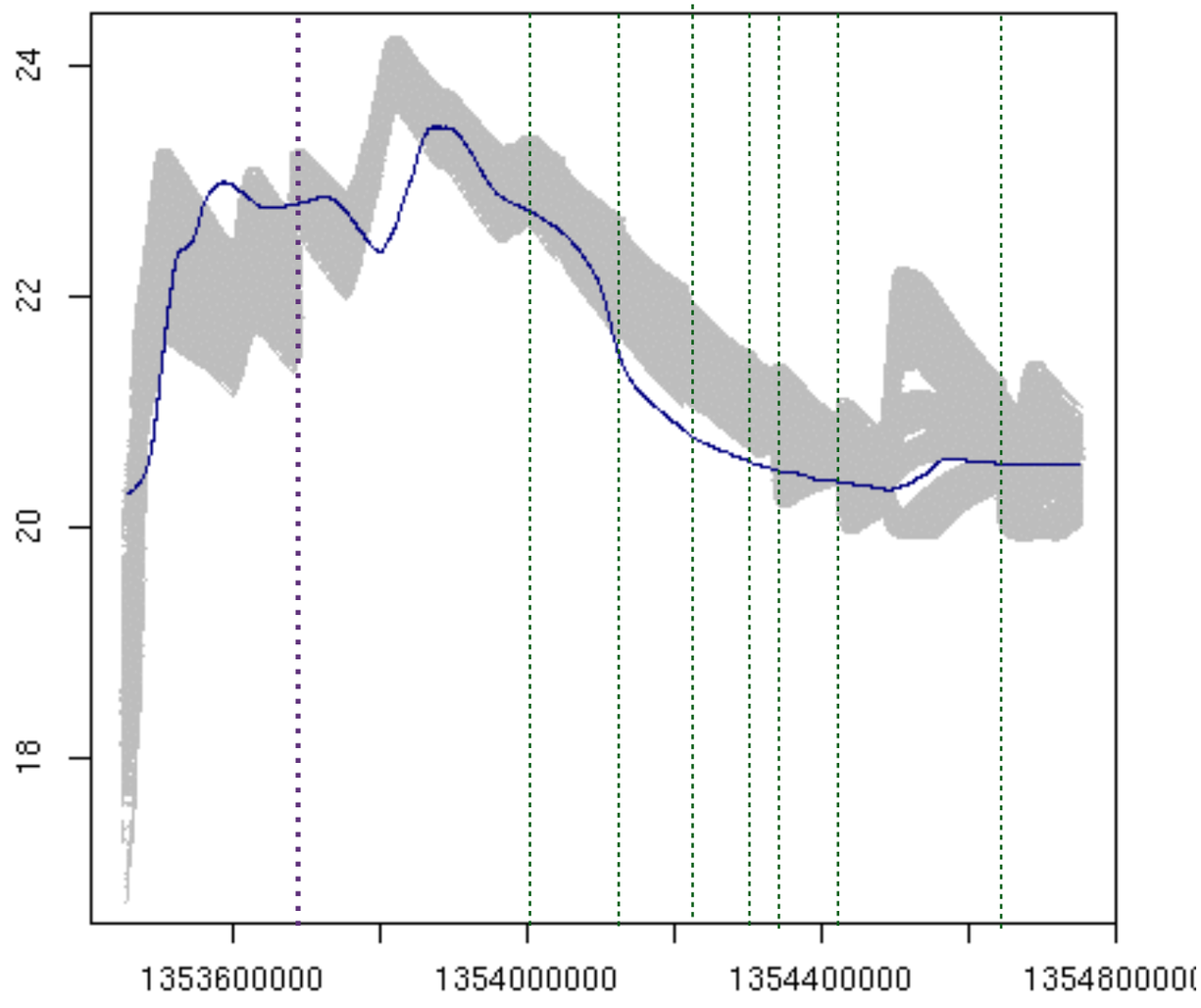
Assim.: SAR water levels
Aug.: inflows

Initial data test

Evesham_Camera



Evesham_h



N = 21

Along network localisation

Assim.: SAR + camera WL

Aug.: inflows

Summary

- We are working on improving urban flood predictions using data of opportunity - CCTV & river camera images, within our data assimilation system.
- Continuously collecting urban flooding data visible on CCTV from chosen cities in the UK.
- Advancing SAR delineation algorithms for use in urban areas;
- Investigating more advanced urban hydrological model and DA assimilation setup;
- Testing different DA methods to improve accuracy of inflow boundary conditions.

Bibliography

- E. S. Cooper, E. S., Dance, S. L., García-Pintado, J., Nichols, N. K. and Smith, P. J. (2018) **Observation impact, domain length and parameter estimation in data assimilation for flood forecasting.** Environmental Modelling and Software, 104. pp. 199-214.

- J. García-Pintado, Neal, J., Mason, D., Dance, S. and Bates, P. (2013) **Scheduling satellite-based SAR acquisition for sequential assimilation of water level observations into flood modelling.** Journal of Hydrology, 495. pp. 252-266.

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