3rd UK National Observers Group (NOG) Meeting

Friday, 21 March 2014

Presentation by

Susana Ochoa-Rodriguez,
Imperial College London

Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IVB

Tackling the Challenges

Rainfall Estimation / Forecasting

Flood Modelling / Forecasting

Management (urban planning, emergency)

RainGain

IMPLEMENTATION OF PILOT LOCATIONS

- Cranbrook catchment (London Borough of Redbridge)
- Purley Area (London Borough of Croydon)
- Torquay City Centre (Torbay, Devon)

ACTIVITIES TO DATE

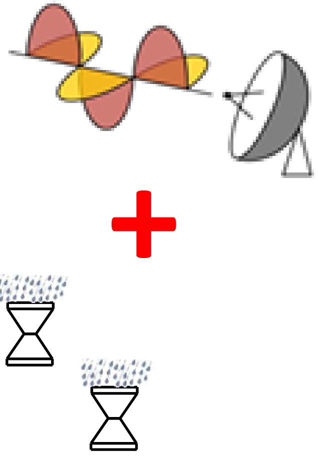
- Continuous data collection (especially rainfall data) & processing
- Implementation of monitoring systems
- Understanding of flooding mechanisms and flood risk management objectives
- Other activities which will be described next

Rainfall Estimation / Forecasting

Flood Modelling / Forecasting

Management (urban planning, emergency)

- Installation and testing of low cost X-band radar in London (APR – SEP 2013)



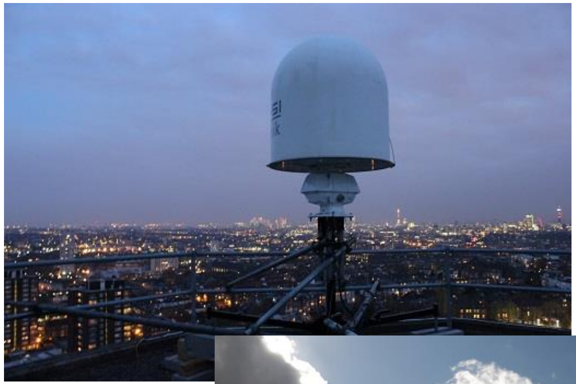
- Continuous development and testing of raingauge-radar merging techniques to improve accuracy of rainfall estimates

Rainfall Estimation / Forecasting

Flood Modelling / Forecasting

Management (urban planning, emergency)

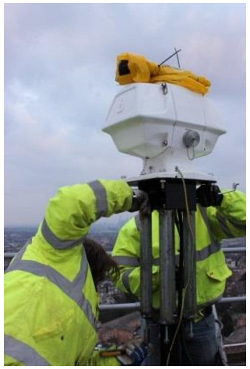
Installation and testing of low cost X-Band radar in London (Mar-Oct'13)



- This campaign aimed at exploring:
  - The **potential benefits** of a low-cost, portable X-band radar for urban hydrological applications
  - The **challenges** associated to its installation and operation
- Potential benefits include:
  - Smaller wavelength makes X band radar more sensitive and able of detecting smaller particles (e.g. drizzle, light snow, cloud formation).
  - Higher spatial and temporal-resolution rainfall estimates can be obtained, which match the small scale of urban areas.
  - Measurement of rainfall closer to the ground

London's low-cost X-band radar:
Selex RainScanner RS90

	Selex RainScanner RS90
Radar type	X-band
Polarisation	Single-polarisation
Doppler (yes/no)	No
Antenna	Parabolic, pencil beam antenna
Beamwidth	2°
Frequency range	8 to 12 GHz
Wave length	2.5 – 4 cm
Range resolution	30 m
Pulse length (m)	Approx. 100 m
Temporal resolution	1 min
Elevations (°)	2



Can detect:

- Light rain: within 35-40 km range
- Moderate rain: within 60-70 km range
- Heavy rain: within 70-100 km range

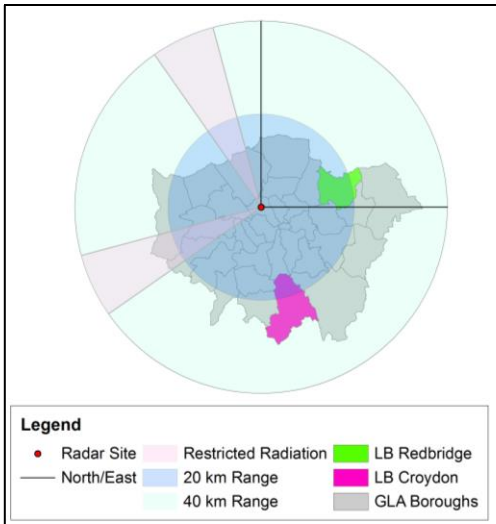
4 Stages of X-band radar monitoring campaign in Central London

1. Preparatory stage
2. Installation & testing stage
3. Monitoring stage
4. Decommissioning and ‘wrap-up’ stage

1. Preparatory stage

(June 2012 – February 2013)

a) Search of an appropriate location for the radar in terms of coverage, ‘visibility’ and permission!



b) Radar radiation permission, risk assessment and mitigation

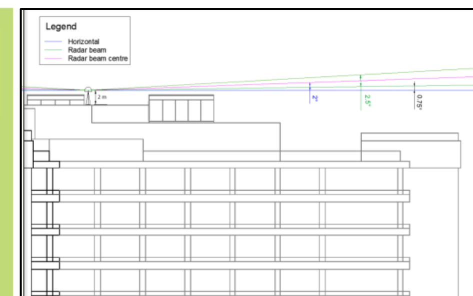


Table A.3: Risk grading matrix

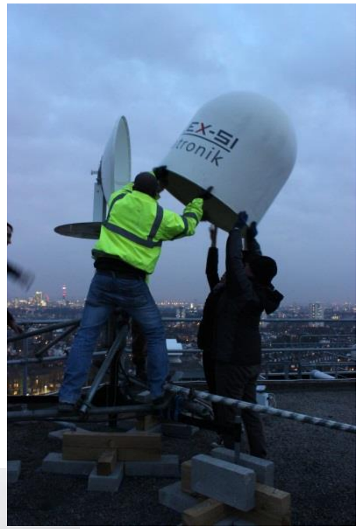
Likelihood	Consequence				
	None	Minor	Moderate	Major	Catastrophic
Rare	Very low	Very low	low	moderate	High
Unlikely	Very low	Very low	low	moderate	High
Possible	Very low	Low	Moderate	High	High
Likely	Low	Low	Moderate	High	High
Almost certain	Low	Low	Moderate	High	High

c) Training

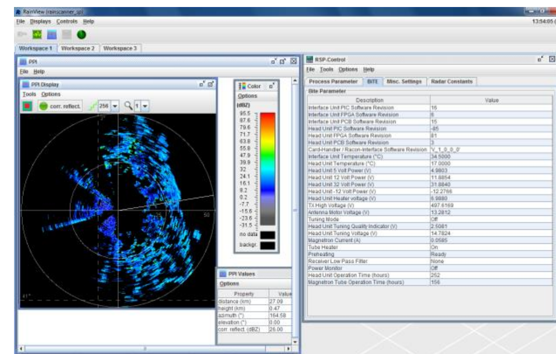
2. Installation & testing stage

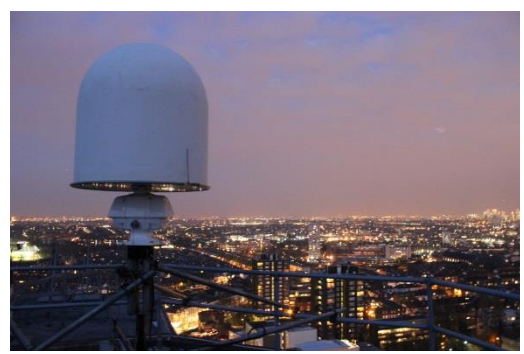
(March 2013 – May 2013)

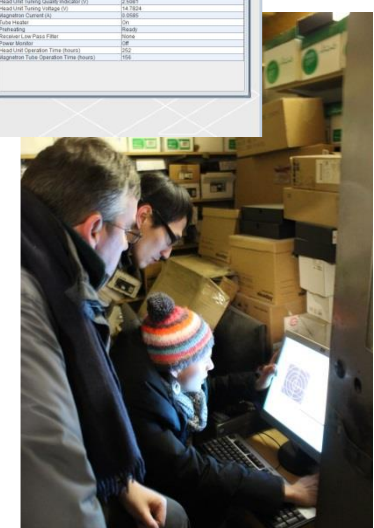
a) Radar installation



b) Software and hardware testing





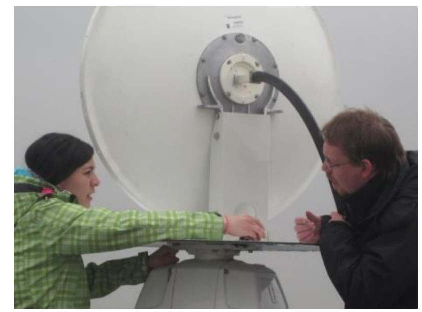


3. Operational stage

(June 2013 – October 2013)

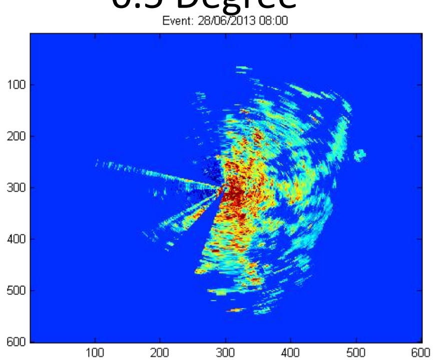
a) Raw data collection (8 'big' storm events recorded)

b) Hardware adjustment and maintenance

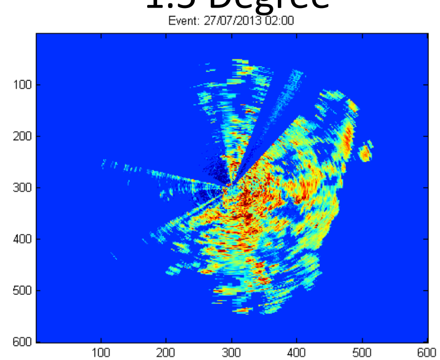


Physical increase of the elevation of the radar antenna was done twice after initial installation in order to reduce clutter interference

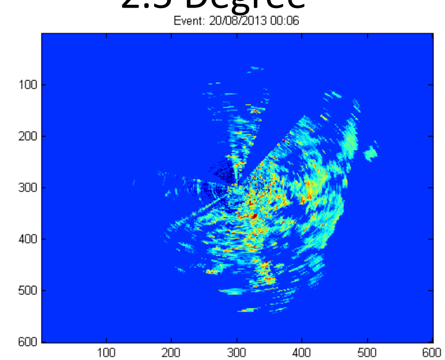
0.5 Degree



1.5 Degree



2.5 Degree



3. Operational stage

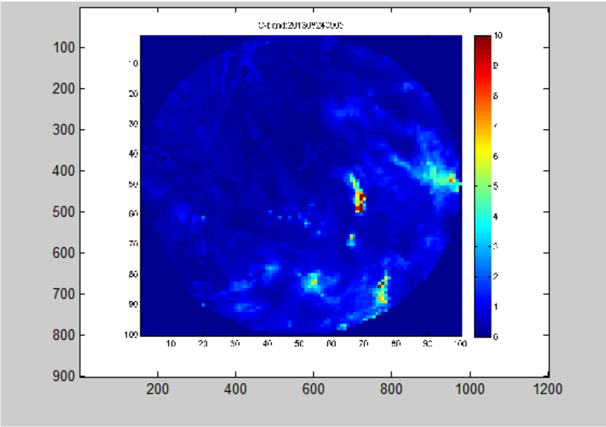
(June 2013 – October 2013)

c) Data processing

- Signal stability correction
- Clutter filtering
- (Range-dependent) Z-R conversion / calibration
- Attenuation correction
- Polar to Cartesian coordinate conversion
- Gauge-based adjustment

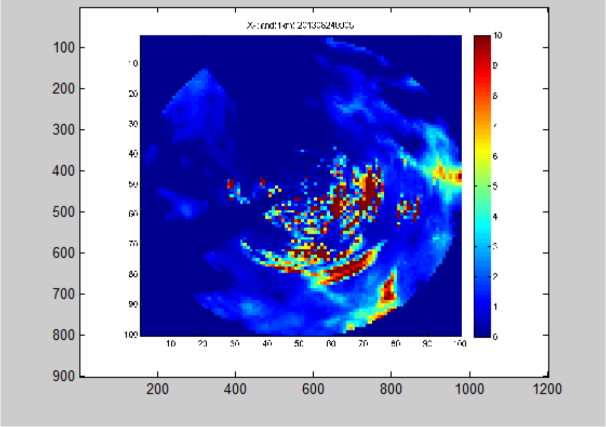
d) Data quality assessment (through comparison with C-band radar, raingauges and hydraulic outputs)

UKMO Nimrod Data
5 min / 1 km

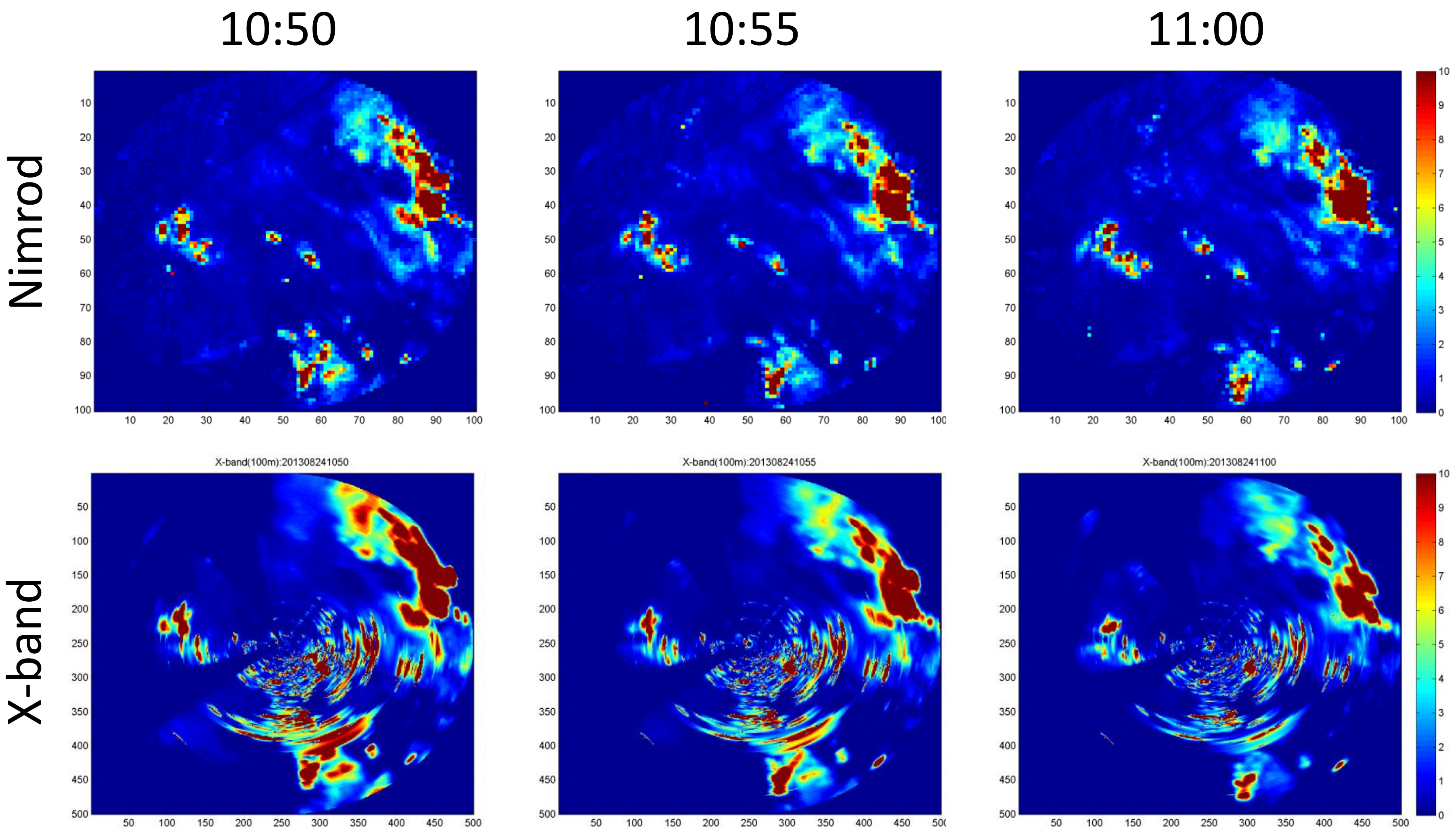


2013/08/24
09:00-11:00

X-band radar data
5 min / 100 m

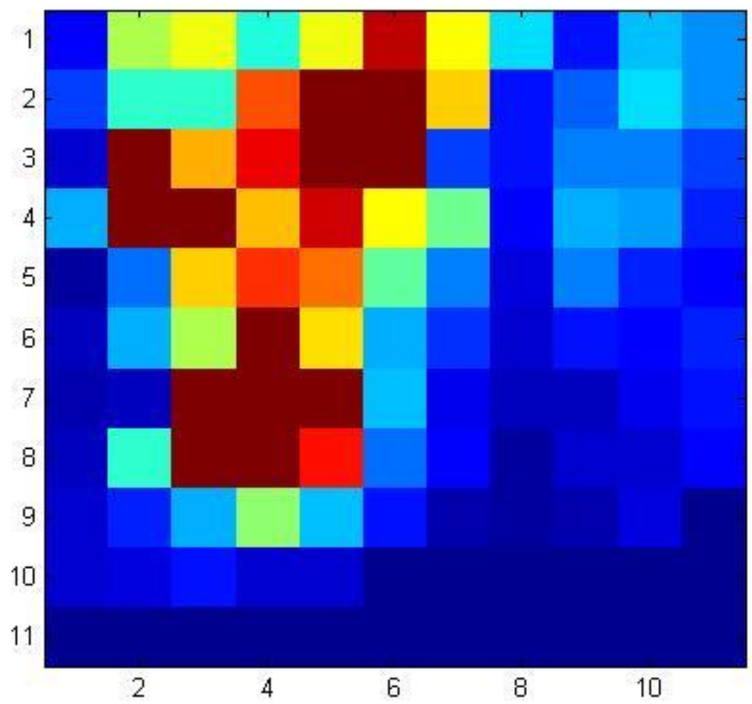


X-band radar can successfully capture storm cells (also captured by Nimrod) at higher resolution, but suffers from serious clutter in the area closest to the radar

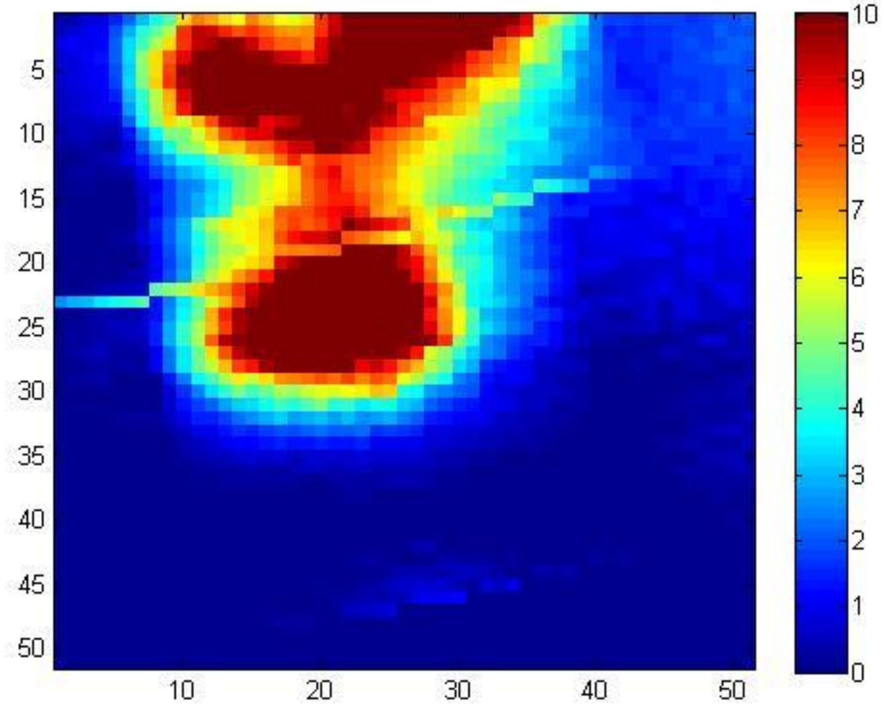


Low cost X-band radar data have the potential to provide more detailed information of rainfall spatial structure, but their accuracy is rather poor

UKMO Nimrod Data
5 min / 1 km



X-band radar data
5 min / 100 m



Accuracy is hard to improve, given the limited parameters available for the low-cost radar

4. Decommissioning and ‘wrap-up’ stage

(October 2013 - Present)

a) Continued data processing and analysis
b) Documentation
c) Dissemination

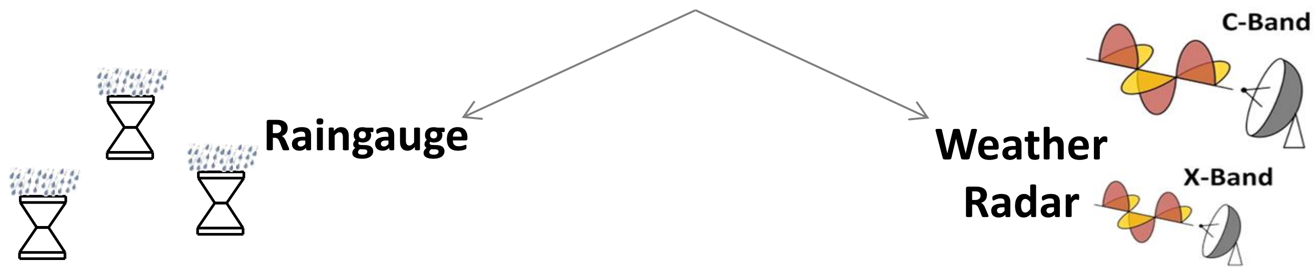
A website for displaying raw as well as processed X-band radar data for selected storm events is being implemented (for the use of the urban hydrology community)

X-band radar monitoring campaign in Central London: Conclusions & Lessons learnt

- It is not easy to install a radar in the heart of a dense urban area such as London.
- In general: low cost X-Band radar can effectively capture storm cells and storm movement at high resolution; however, the accuracy of the estimates is rather poor.
- The main reasons for poor accuracy are clutter and attenuation.
- Accuracy can be improved based on complementary data from other sensors (e.g. C-band radar, raingauges); however, the need for data from multiple sensors to produce reliable estimates makes the added value of the low-cost X-band radar questionable, especially in areas such as London where C-band radar coverage and quality is quite good.
- Low cost X-bands could be useful for tracking and forecasting storm movements in areas where no other data area available. For example: in coastal areas.

Rainfall Estimation / Forecasting → Flood Modelling / Forecasting → Management (urban planning, emergency)

Continuous development and testing of raingauge-radar merging techniques to improve accuracy of rainfall estimates

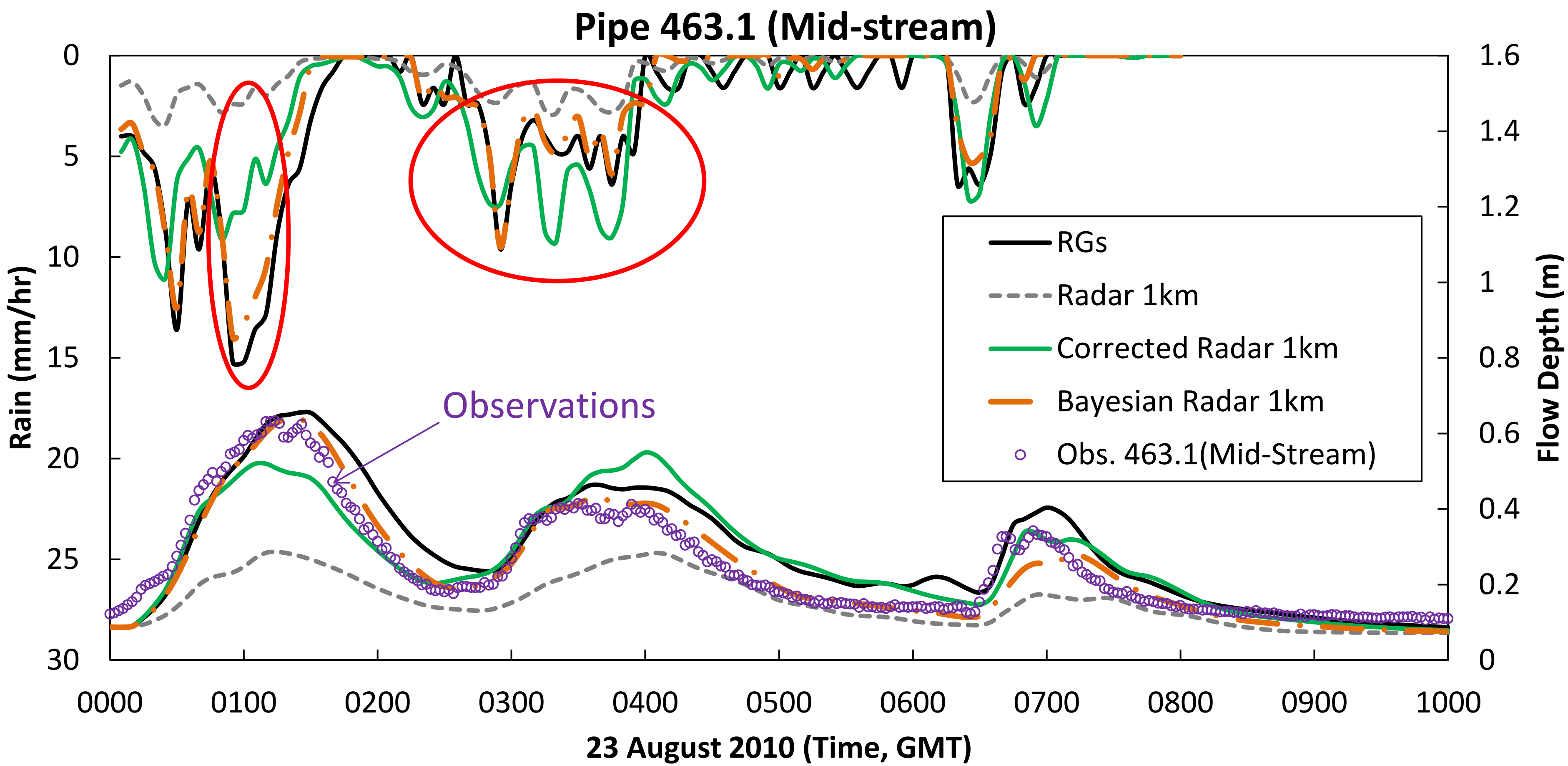


	RAINGAUGE	RADAR
Accuracy		
Coverage, spatial characterisation of rainfall field		

By adjusting radar estimates based on point raingauge measurements, it is possible to combine the advantages of both sensors and to have a better spatial description as well as local accuracy of urban rainfall

Previous work: initial testing of some merging techniques in the Cranbrook catchment pilot site

Initial results: Simulation of flow depths can be largely improved using radar rainfall estimates “locally” adjusted with the co-located raingauge measurements

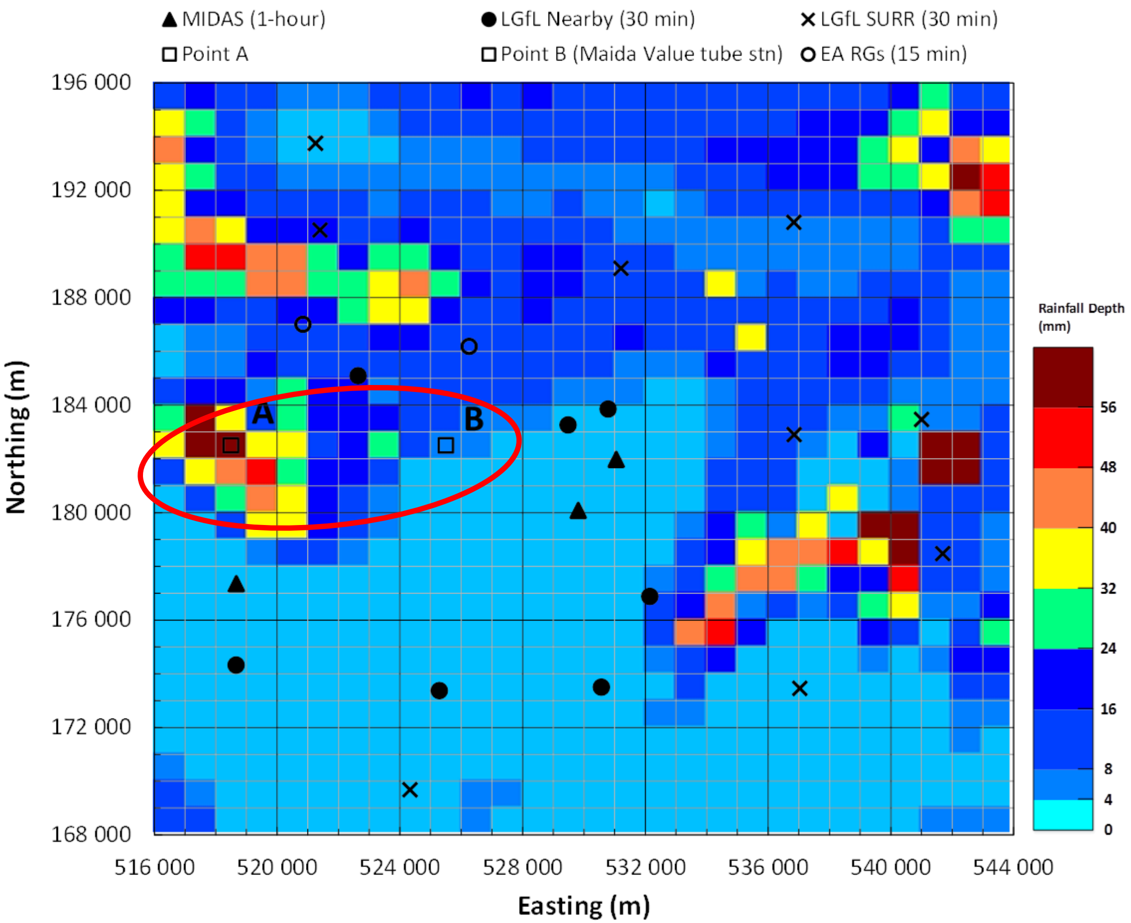


Problem posed by one of our observers following last year's NOG meeting:

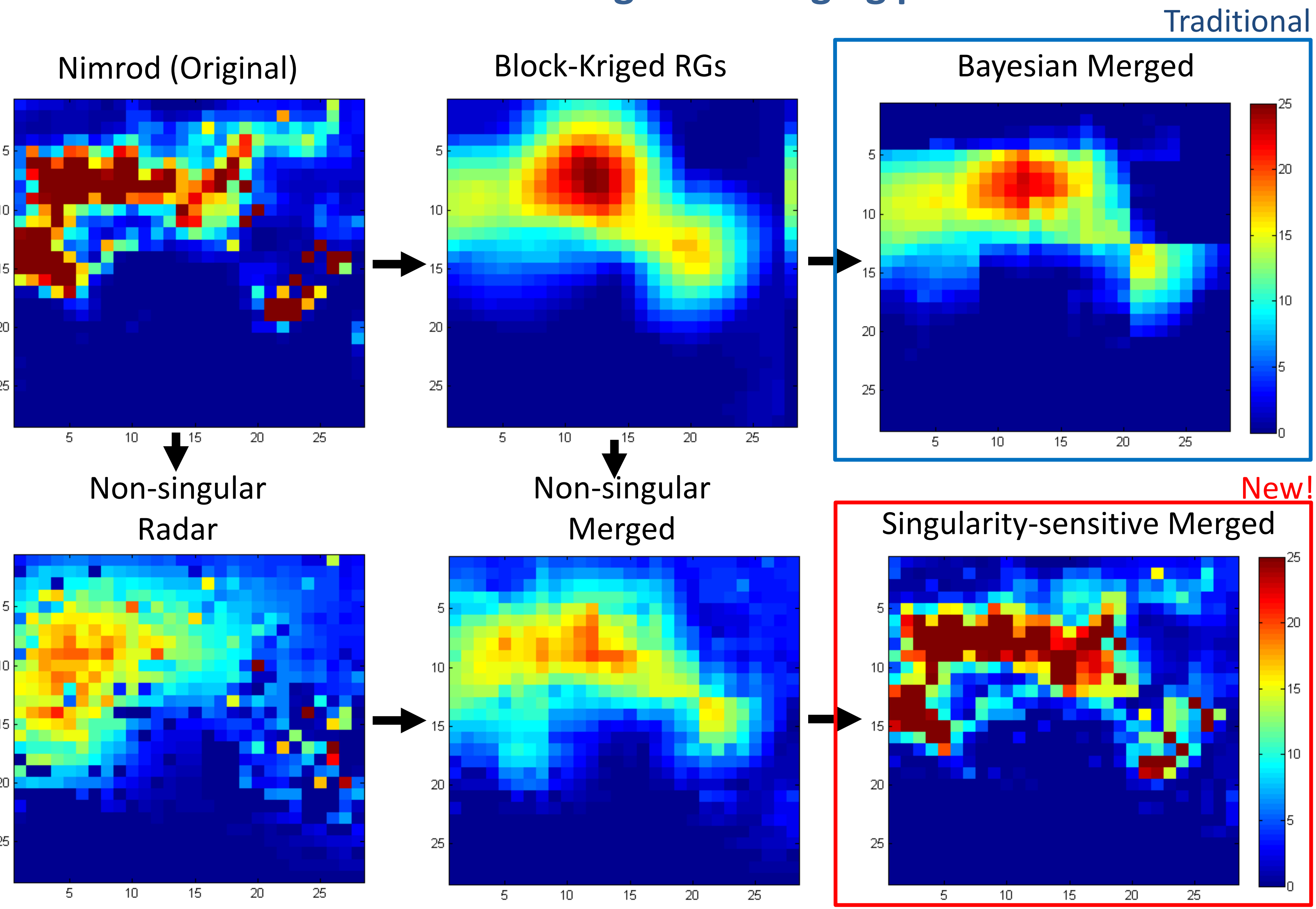
- Reconstruction of a historical (2009) storm event that caused flooding in a sector of London
- Radar estimates showed storm cell, but seemed to underestimate intensities
- No RG data available within the area of interest

What we did:

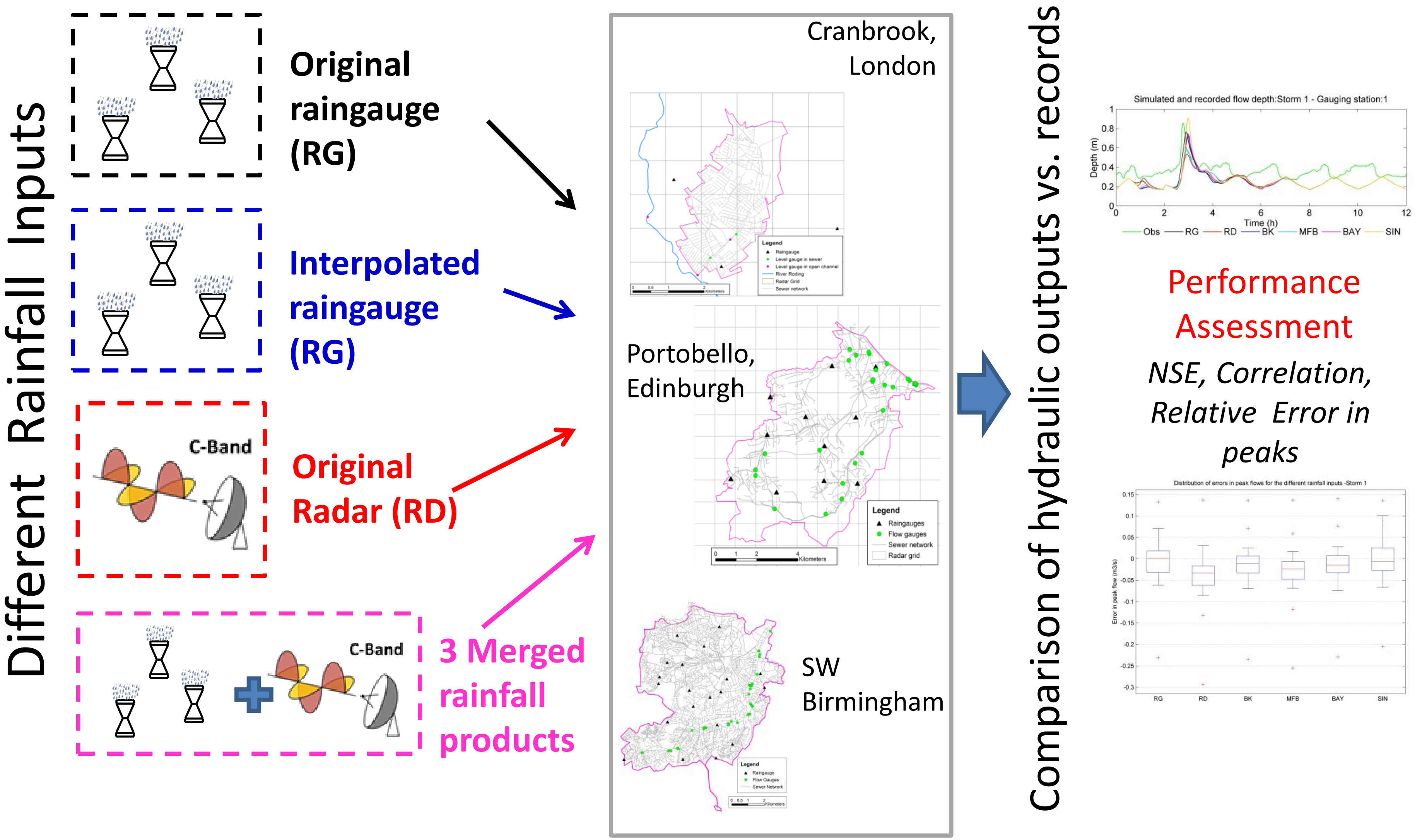
- Gathered RG data from multiple and often under-utilised sources
- Realised that the techniques we had tested tend to smooth-out rainfall extremes, especially when there are no RGs in the areas of extreme precipitation
- Developed a new technique which allows identifying and better preserving rainfall extreme patterns through the merging process



New technique: singularity analysis for better capturing and preserving storm extremes through the merging process



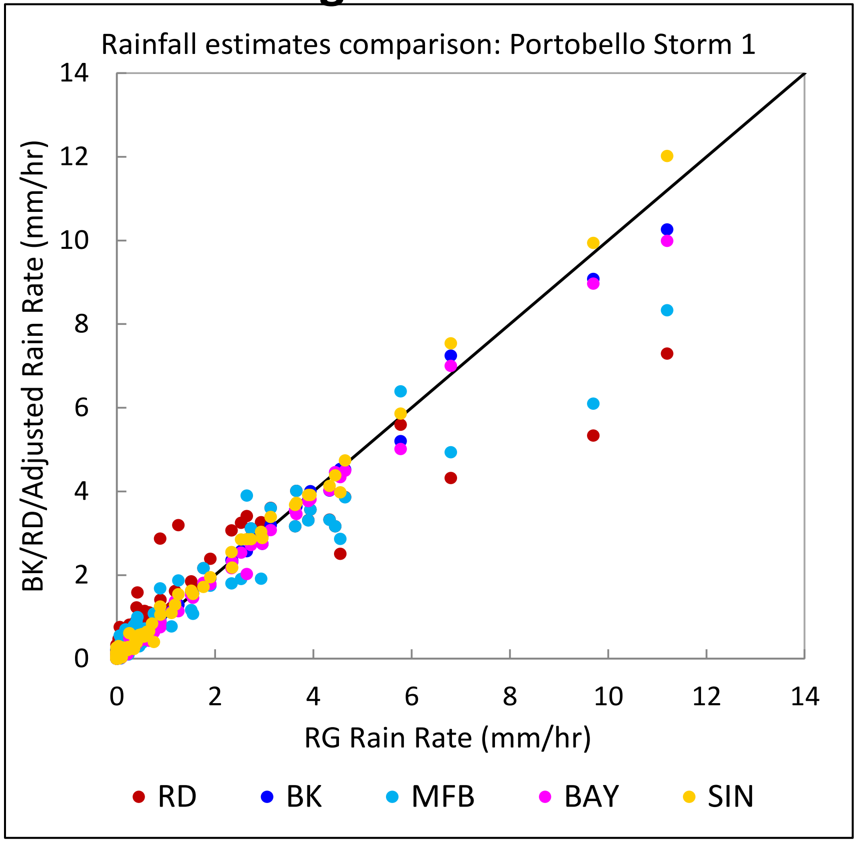
Using the **RainGain pilot locations**, as well as **new pilot locations and datasets from project observers**, we have tested the performance of the different merging techniques



Areal average total rainfall accumulations

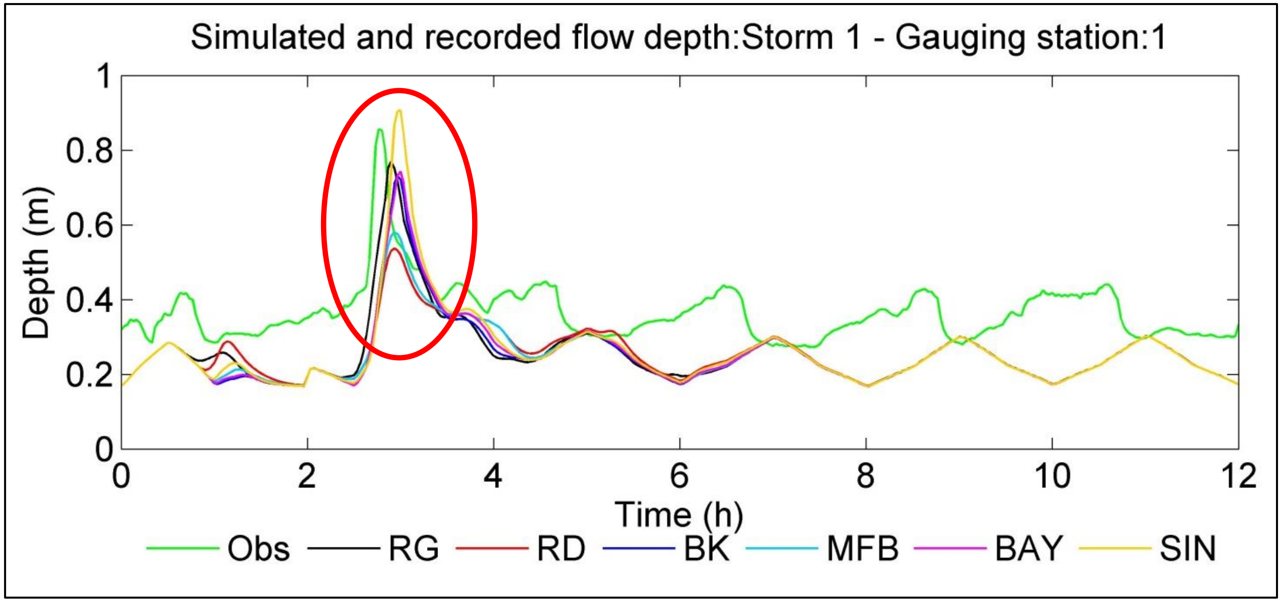
	PORTOBELLO CATCHMENT		
Rainfall Estimates	**Storm 1**	**Storm 2**	**Storm 3**
RG	9.25	7.70	32.96
RD	9.67	10.80	25.85
BK	9.02	7.50	30.69
MFB	8.47	7.13	31.94
BAY	8.80	7.51	26.94
SIN	9.66	7.56	33.73

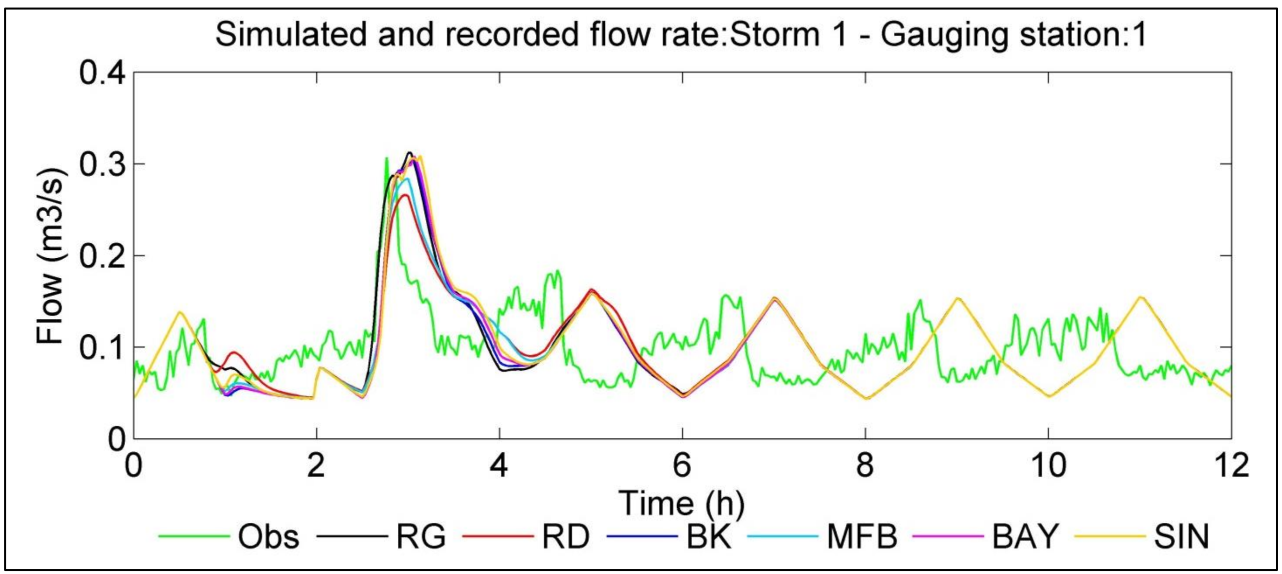
Areal average RG rain rates VS. areal average rain rates of radar and merged estimates

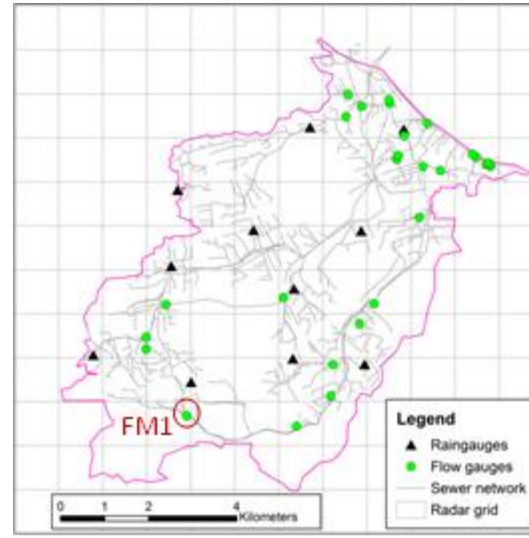


- All adjustment methods can, in general, reduce RG/RD cumulative bias, leading to areal total accumulations similar to those recorded by raingauges
- But: not all methods can effectively correct instantaneous rainfall rates (SIN performs particularly well at this)!

PORTOBELLO CATCHMENT : Observed vs. Simulated flow depth and rate at up-stream gauging station







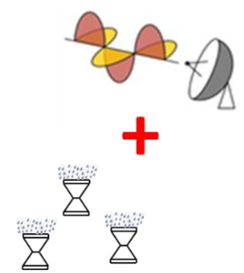
- In spite of small RG/RD bias, RD underestimates peaks
- MFB not enough
- BAY ok
- SIN better at capturing peak

Rainfall Estimation / Forecasting → **Flood Modelling / Forecasting** → Management (urban planning, emergency)

- Improved modelling and forecasting of urban pluvial flooding based upon improved rainfall estimates
- Assessment of benefits of higher resolution rainfall estimates and models
- Identification of resolution requirements
- Continuous work on implementation of a pilot urban pluvial flooding forecasting system

Rainfall Estimation / Forecasting → **Flood Modelling / Forecasting** → Management (urban planning, emergency)

- **Improved calibration** of urban drainage models based on monitoring data and **improved rainfall estimates**



- Development of methodologies for overall uncertainty analysis and risk-based model calibration

Rainfall Estimation / Forecasting → **Flood Modelling / Forecasting** → Management (urban planning, emergency)

- **Multi-catchment analysis of the impact of rainfall input resolution on the hydraulic output of semi-distributed urban drainage models**

Aim: answer questions such as:

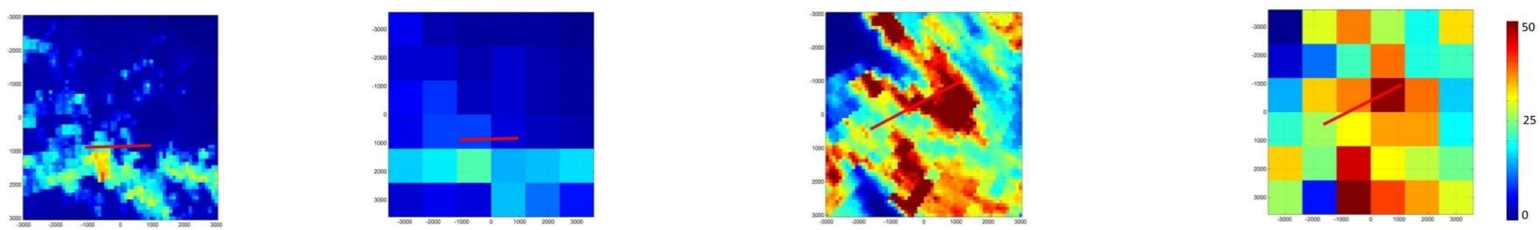
What are the actual rainfall input requirements for urban catchments with different characteristics?

Rainfall Estimation / Forecasting → **Flood Modelling / Forecasting** → Management (urban planning, emergency)

- **Multi-catchment analysis of the impact of rainfall input resolution on the hydraulic output of semi-distributed urban drainage models**

Rainfall data of 2 spatial resolutions: 100 m and 1000 m

(a) Convective – 28/06/2011		(a) Stratiform – 29/10/2012	
(100 m resolution)	(1000 m resolution)	(100 m resolution)	(1000 m resolution)



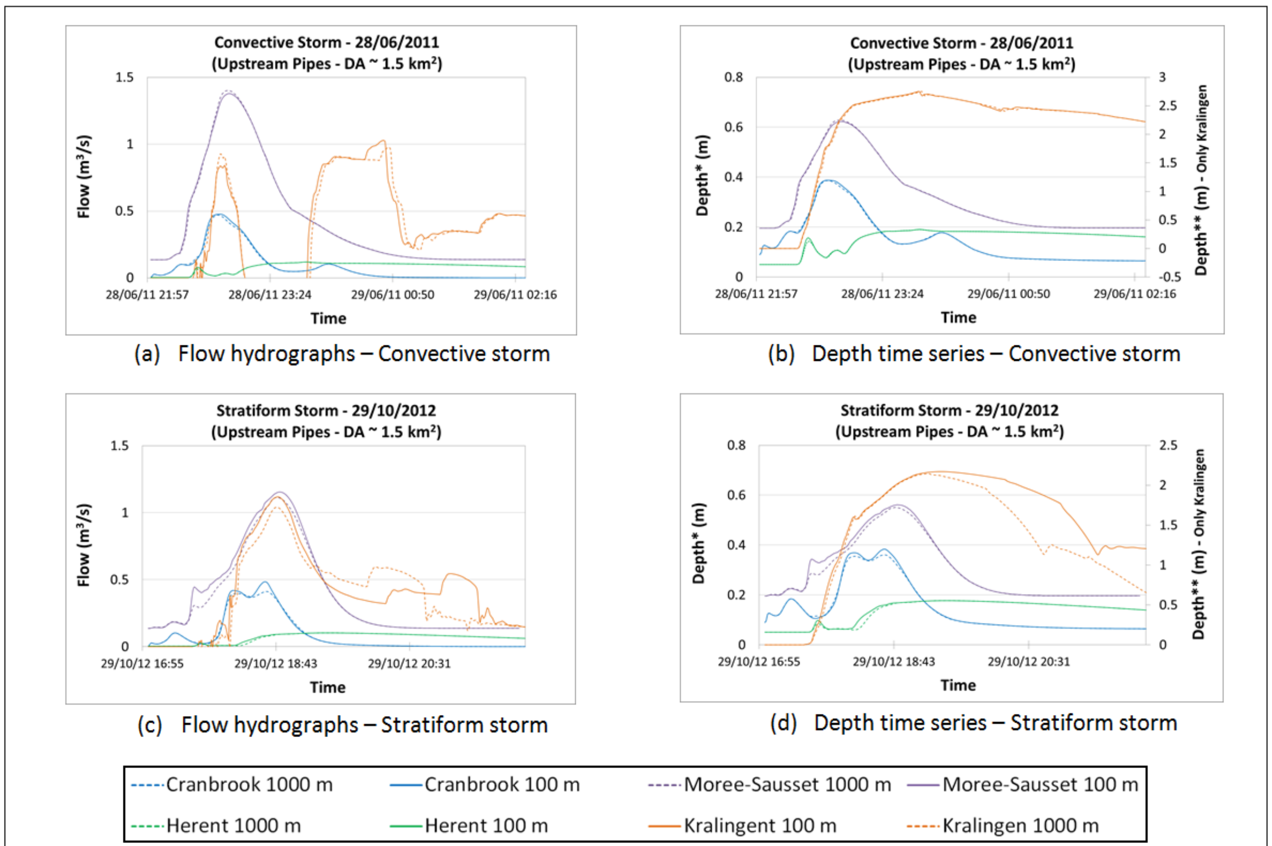
Semi-distributed urban drainage models of 4 RainGain pilot sites

Cranbrook (UK)	Morée-Sausset (FR)	Herent (BE)	Kralingen (NL)
Area: 8.65 km^2	Area: 5.60 km^2	Area: 4.75 km^2	Area: 6.70 km^2
Slope: 0.0093 m/m	Slope: 0.0029 m/m	Slope: 0.0220 m/m	Slope: 0.0003 m/m
SC Mean/STD: 0.49/0.71ha	SC Mean/STD: 11.92/10.34ha	SC Mean/STD: 0.71/1.27ha	SC Mean/STD: 1.20/1.33ha

Rainfall Estimation / Forecasting → **Flood Modelling / Forecasting** → Management (urban planning, emergency)

- **Multi-catchment testing of the impact of rainfall input resolution on the hydraulic output of semi-distributed urban drainage models**

Results



(a) Flow hydrographs – Convective storm

(b) Depth time series – Convective storm

(c) Flow hydrographs – Stratiform storm

(d) Depth time series – Stratiform storm

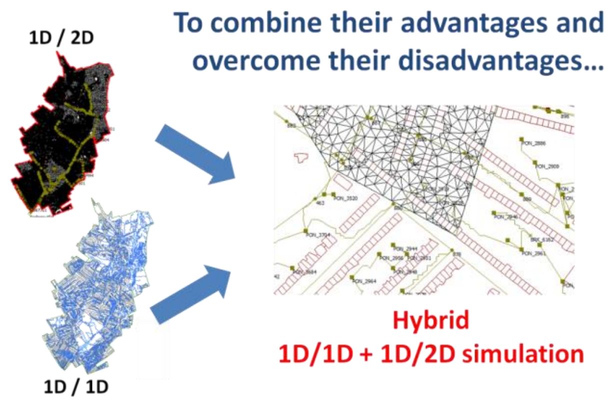
- Not significant impact of rainfall input resolution is observed for two storms under consideration
- More storms need to be tested
- Need to understand interactions between model resolution, rainfall input resolution, catchment and storm characteristic
- Work in progress!

Rainfall Estimation / Forecasting

Flood Modelling / Forecasting

Management (urban planning, emergency)

- **Models of different levels of complexity and resolution are being implemented, calibrated and benchmarked**



Aim: answer questions such as:

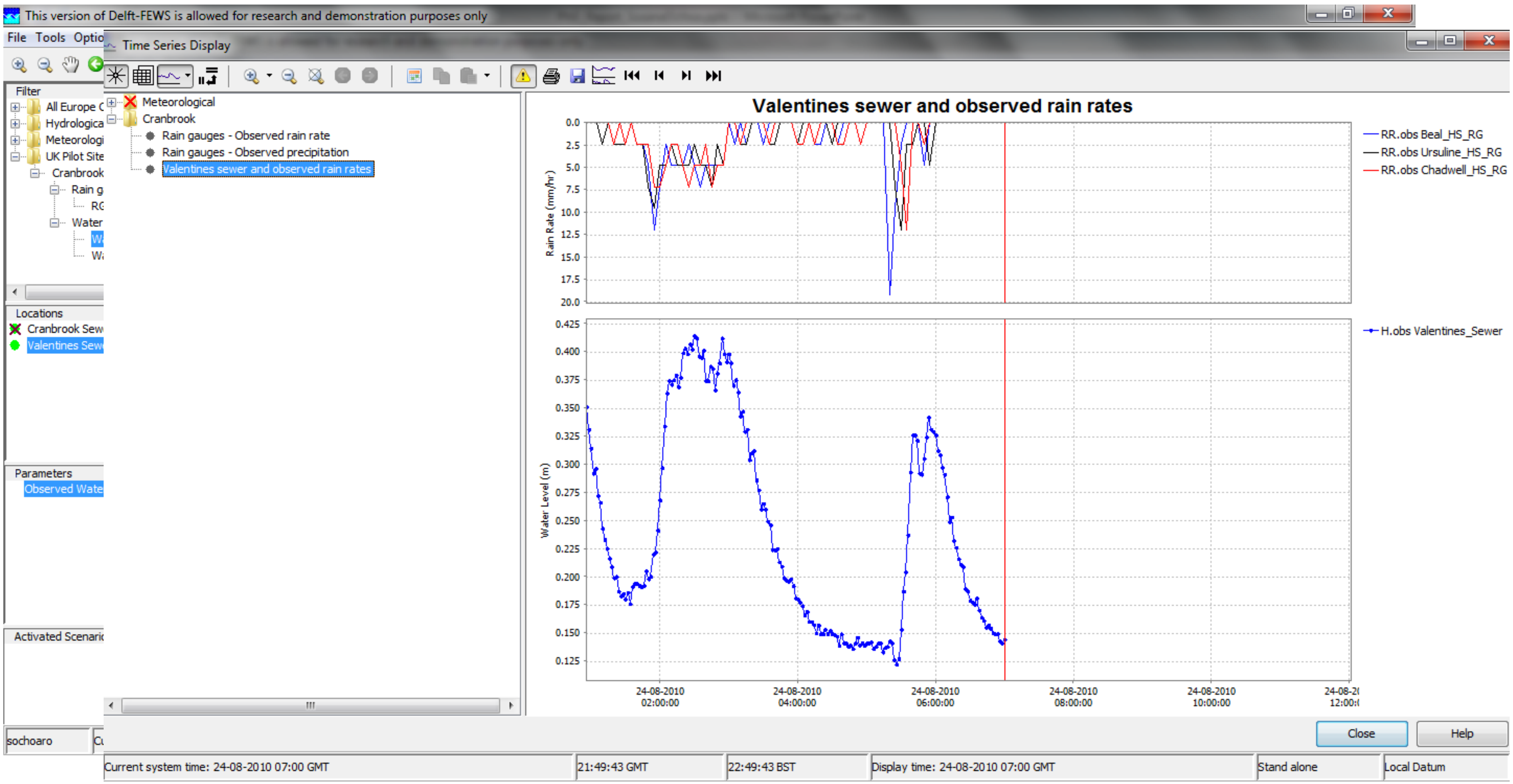
- *Are current hydrodynamic models able of taking full advantage of improved rainfall estimates?*
- *What is the added value of higher resolution models and rainfall inputs?*
- *What are practical minimum model resolution requirements?*

Rainfall Estimation / Forecasting

Flood Modelling / Forecasting

Management (urban planning, emergency)

Implementation of pilot platform for urban pluvial flood forecasting



Rainfall Estimation / Forecasting → Flood Modelling / Forecasting → **Management** (urban planning, emergency)

Continuous communication and discussion with end users to understand their needs and ensure optimum use of the tools developed throughout the project

Through National Observers Group Meetings

Rainfall Estimation / Forecasting → Flood Modelling / Forecasting → **Management** (urban planning, emergency)

Continuous communication and discussion with end users to understand their needs and ensure optimum use of the tools developed throughout the project

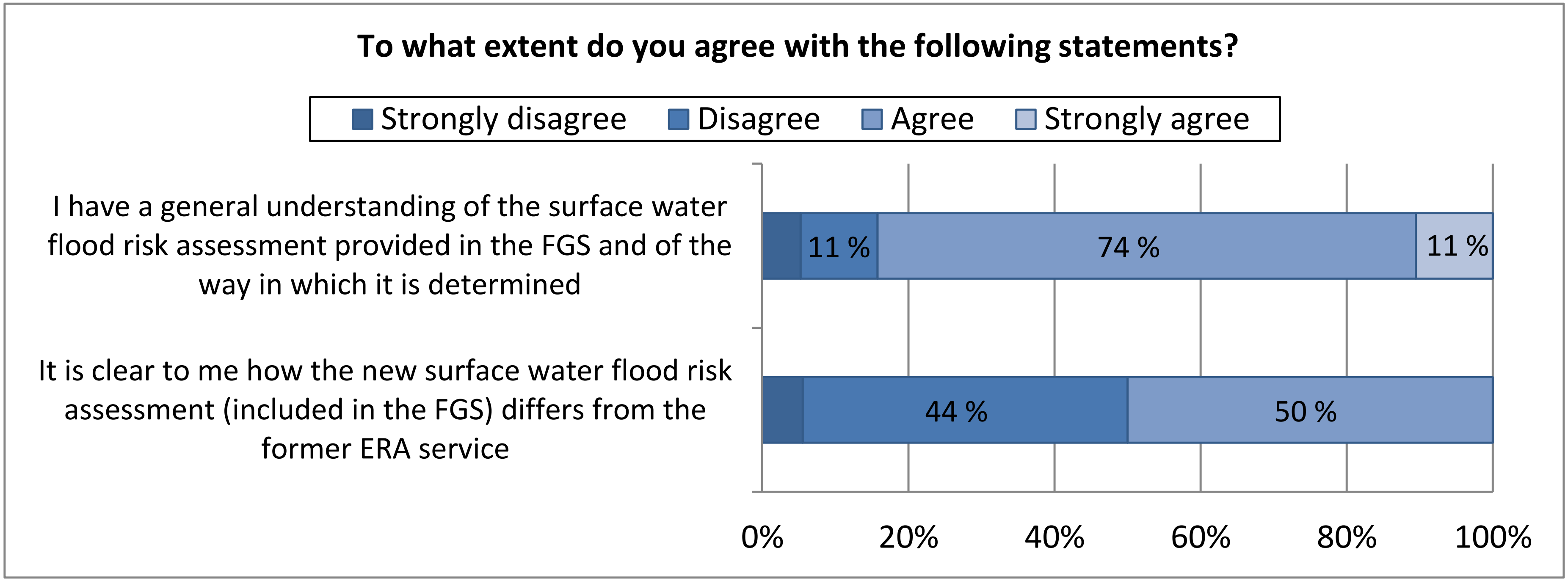
Through survey amongst local authorities:

(April – September 2013, 78 responses)

Purpose:

- Understanding, usefulness and drawbacks of current surface water flood warnings
- Exploring LA's tolerance and minimum requirements in terms of probability and lead time of warnings

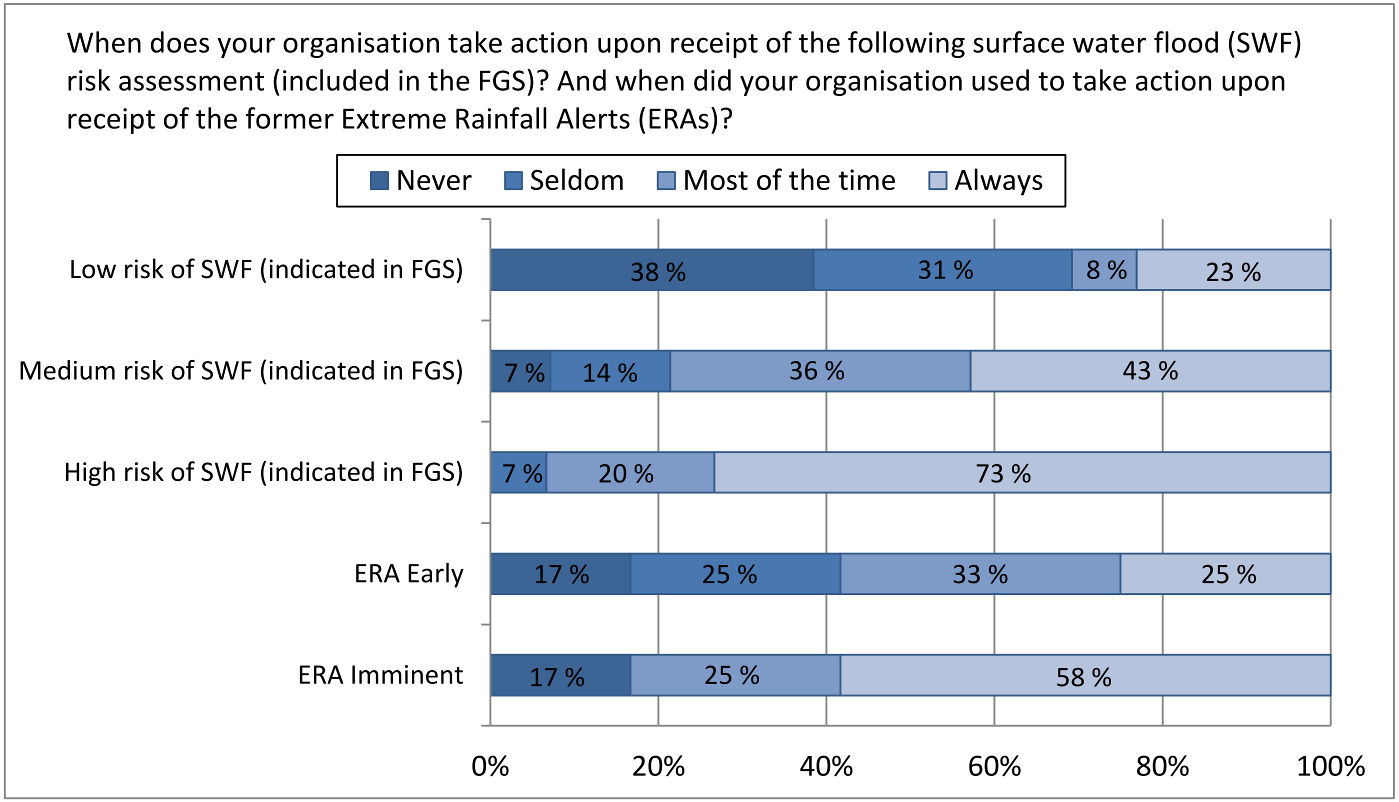
UNDERSTANDING OF CURRENT SWF WARNING SERVICES



"A key issue we have is that some parts of the organisation don't understand the difference between likelihood and potential impacts. I don't know if this could be incorporated into the five day maps at the top of the statements in a graphical way?"

Local Authorities have a basic understanding of the ERA and SWF risk assessment services, but do not understand the rationale behind them nor their differences in depth and would benefit from additional information

USEFULNESS OF SWF WARNING SERVICES



- In spite of limitations: the current service is considered useful by most local authorities (provides an overview).
- Most Local Authorities currently take some action upon receipt of SWF risk alerts, with the type of action depending on the risk level and lead time of the alert
- Local Authorities are more reactive to the new SWF risk assessment service than they were to the former ERAs. **This is a positive and encouraging development towards increased resilience to SWF!**

MAIN DRAWBACK OF CURRENT SYSTEM

According to LAs, the main drawback of the current SWF risk assessment service is its broad spatial resolution (i.e. county level) which is insufficient given the localised nature of SWF.

MINIMUM REQUIREMENTS FOR FUTURE 'LOCALISED' SURFACE WATER FLOOD FORECASTING SYSTEMS

PROBABILITY:

- 40%: minimum probability of occurrence at which LAs would be willing to implement substantive action
- 20%: warnings with as little as 20 % probability would still be useful for triggering low cost precautionary measures such as monitoring of critical areas.

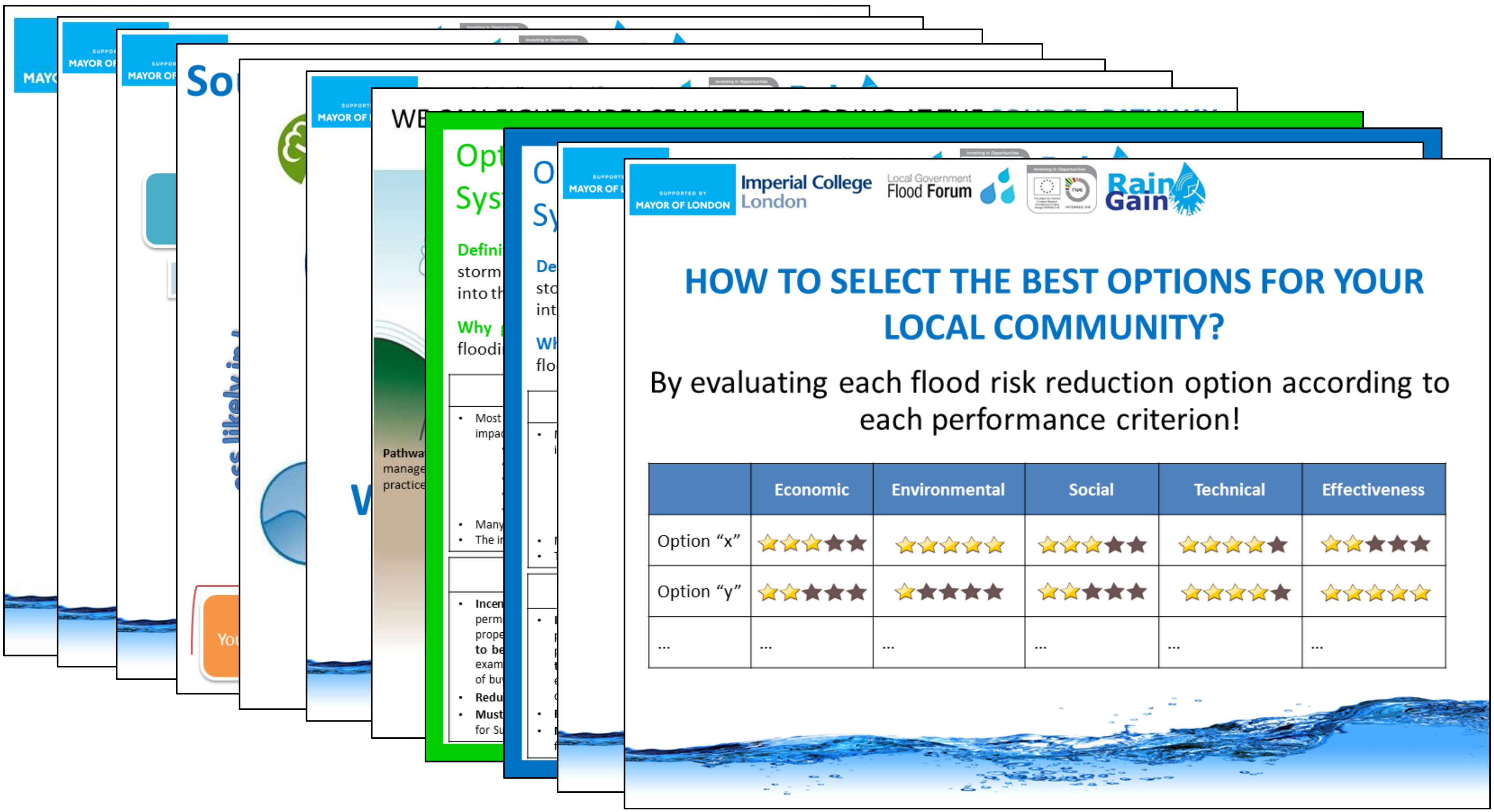
LEAD TIME:

- Desirable: 2 h
- Still useful: as short as 30 min

- This survey sheds light upon the future of surface water flood forecasting and warning systems in the UK

Rainfall Estimation / Forecasting → Flood Modelling / Forecasting → Management (urban planning, emergency)

Workshop pack for participatory management of local surface water flood risk



Thank you

s.ochoa-rodriguez@imperial.ac.uk