# Report – Work Package 3

By Susana Ochoa-Rodríguez

RainGain Project Consortium Meeting, Antwerp, 1st April 2014

# WP3: Urban pluvial flood modelling and prediction

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
INTERREG IVB

## General Objective of WP3:

To implement rainfall data (WP2) into improved urban storm water models to enhance short term pluvial flood modelling and prediction

# WP3 ACTIONS

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
INTERREG IVB

**Action WP3A10:** Adoption, customisation and automatic linkage of rainfall forecasts to pluvial flood models.

**Action WP3A11:** Improvement and customisation of models for urban pluvial flood forecasting at fine scales in each of the pilot locations

**Action WP3A12:** Full-scale testing of the models for pluvial flood prediction at each of the pilot locations.

**Action WP3A13:** Development of guidelines and training material for capacity building and training of future end-users.

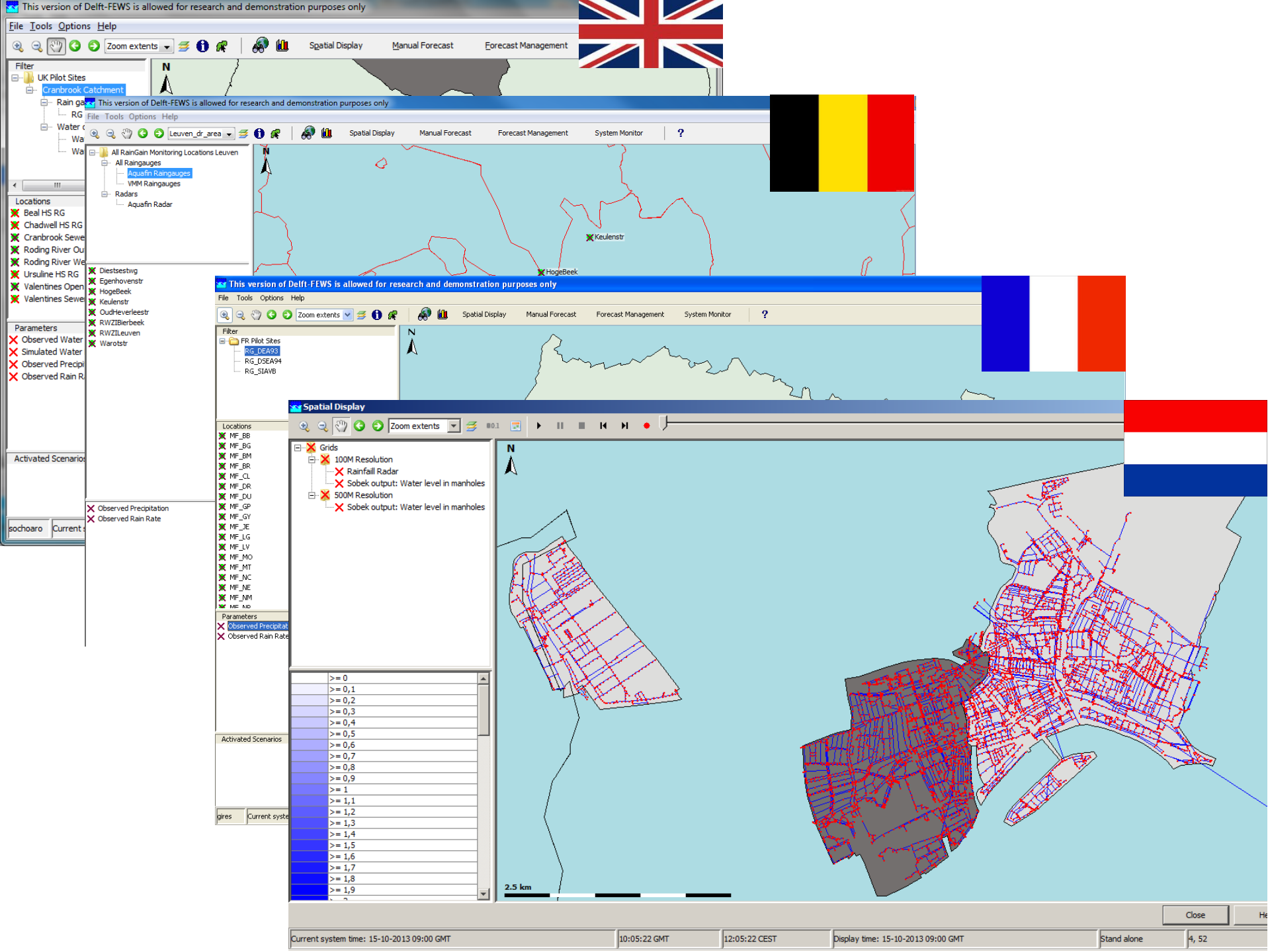
# REVIEW - WP3 A10

**A10:** Linkage of local rainfall data to flood models

**Output:** protocols and software for automatic linkage of rainfall to models

## PROGRESS TO DATE:

- Agreement on adoption of Delft-FEWS platform as common 'core' (Jun 2012) – Platform is seen by pilot leaders as a useful tool mainly for exchanging the data and rainfall processing algorithms generated throughout the project. However, it may not be used operationally in all pilot locations. This is specially the case of Belgium and France, where separate forecasting systems are being implemented.
- Pilot Delft-FEWS platform implemented for UK pilot location (Oct 2012)
- Training courses on use of the Delft-FEWS platform (Feb 2013, Aug 2013), including: customisation of displays and locations, import/export of sensor data, creation and linkage of external algorithms
- First version of Delft-FEWS platform implemented for BE, FR and NL pilot locations (Apr - Sep 2013)


This version of Delft-FEWS is allowed for research and demonstration purposes only
File Tools Options Help
Zoom extents
Spatial Display
Manual Forecast
Forecast Management
System Monitor
Filter
UK Pilot Sites
Cranbrook Catchment
Locations
Parameters
Activated Scenarios
Leuven_dr_area
All RainGain Monitoring Locations Leuven
All Raingauges
Aquafin Raingauges
VMM Raingauges
Radars
Aquafin Radar
Keulenstr
HogeBeek
FR Pilot Sites
RG_DEA93
RG_DSEA94
RG_SIAVB
Spatial Display
Grids
100M Resolution
Rainfaill Radar
Sobek output: Water level in manholes
500M Resolution
Sobek output: Water level in manholes
Observed Precipitation
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2.5 km
Close
Current system time: 15-10-2013 09:00 GMT
10:05:22 GMT
12:05:22 CEST
Display time: 15-10-2013 09:00 GMT
Stand alone

# REVIEW - WP3 A10

**A10:** Linkage of local rainfall data to flood models

**Output:** protocols and software for automatic linkage of rainfall to models

## PROGRESS TO DATE:

- Definition of standard formats for data exchange (csv files mainly, but tools for format conversion to/from Nimrod & ASCII will be available) (Oct 2013)
- Pre-definition of algorithms to be shared (Oct 2013):
  - Mainly RD-RG merging and downscaling algorithms (concrete algorithms could be defined during Researchers' Meeting on Wednesday)
  - Possibly X-band radar processing routines, but benefit of implementing these routines in the platform may be limited
- Progress has been made towards implementation of data format conversion routines and processing algorithms, but these are not yet operational (Apr 2014)

# REVIEW - WP3 A10

## PROPOSED NEXT STEPS:

- Identification of specific algorithms which we'd like to share through the Delft-FEWS platform (during researchers's meeting on Wednesday).

Quick Question: should X-band processing algorithms be incorporated in platform (considering delay in installation of radar and radar-specific characteristics)?

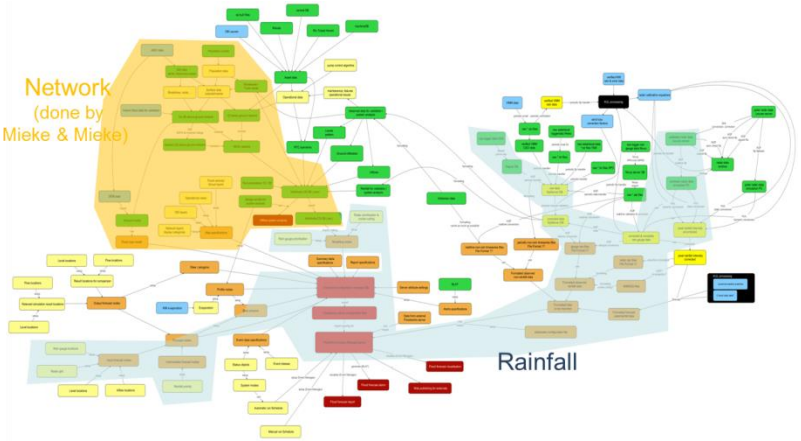
- Completion of data format exchange functionalities and incorporation of algorithms into Delft-FEWS platform

- Completion of Cranbrook pilot - demonstration of RT forecasting system.
  Question: is anyone else **(NL)** interested in using the platform for RT purposes?

- Documentation of **exchange** as well as **forecasting platform** (main output)

- Continuous work at Aquafin with InfoWorks ICM Live system (see next slides)

# REVIEW - WP3 A10




## AQUAFIN'S FORECASTING SYSTEM FRAMEWORK (switch from FloodWorks to InfoWorks ICM Live)

- First trials with ICM Live have started (still a lot of configuration issues to be sorted out)
- Radar data can be loaded into ICM Live and assigned to subcatchments
- 2D simulations in real-time not yet possible due to long initialisation
- Some questions from first trials
  - How to feed both raingauge and radar data in realtime
  - How to "hotstart" simulations
  - …

# REVIEW - WP3 A11

**A11:** Customisation of flood models

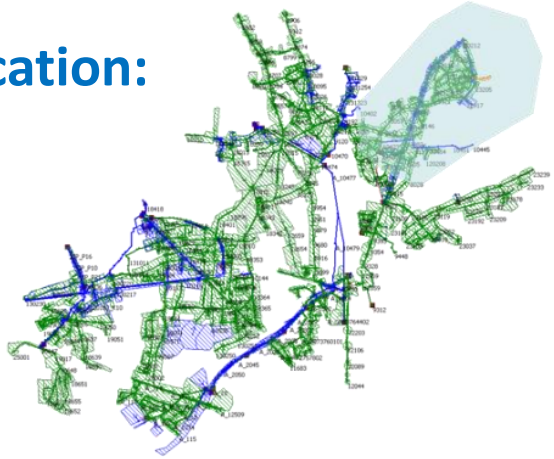
**Output:** Customised flood models for pilots

## PROGRESS TO DATE:

- It has been agreed that at each pilot location the software package commonly used/readily available would continue to be used for the implementation of urban pluvial flood models in the RainGain project (Jun 2012)
  - UK: Infoworks
  - Belgium: Infoworks
  - Netherlands: Sobek
  - France: Canoe and Multi-Hydro
- Initial models implemented for all pilot locations
- Rainfall and flow/depth data have been continuously collected at pilot locations and are being used for model calibration and validation
- Updated user guidelines and tutorial on AOFD

# REVIEW - WP3 A11

## Recent developments in Herent/Leuven (BE) pilot location:



- **1D/2D model trials are ongoing on the full (Northern) catchment (approx.  3000 ha)**

- InfoWorks CS is used for first assessments -> later switch to InfoWorks ICM

- Initially used default mesh (25-100 $m^2$) over full area, now being changed into 25-100 $m^2$ in critical areas and 125-500 $m^2$ outside those areas.

- Current underlying DTM is irregular TIN (on average 1 pt. per 4 $m^2$); new DTM is expected, this will contain on average 10-15 pts. per $m^2$ (problems to load in IW expected).

- Simulations are run using design storms, selected events with raingauges and occasional test with X-band radar data.

- Some good results, but refining still needed + troubleshooting

# REVIEW - WP3 A11

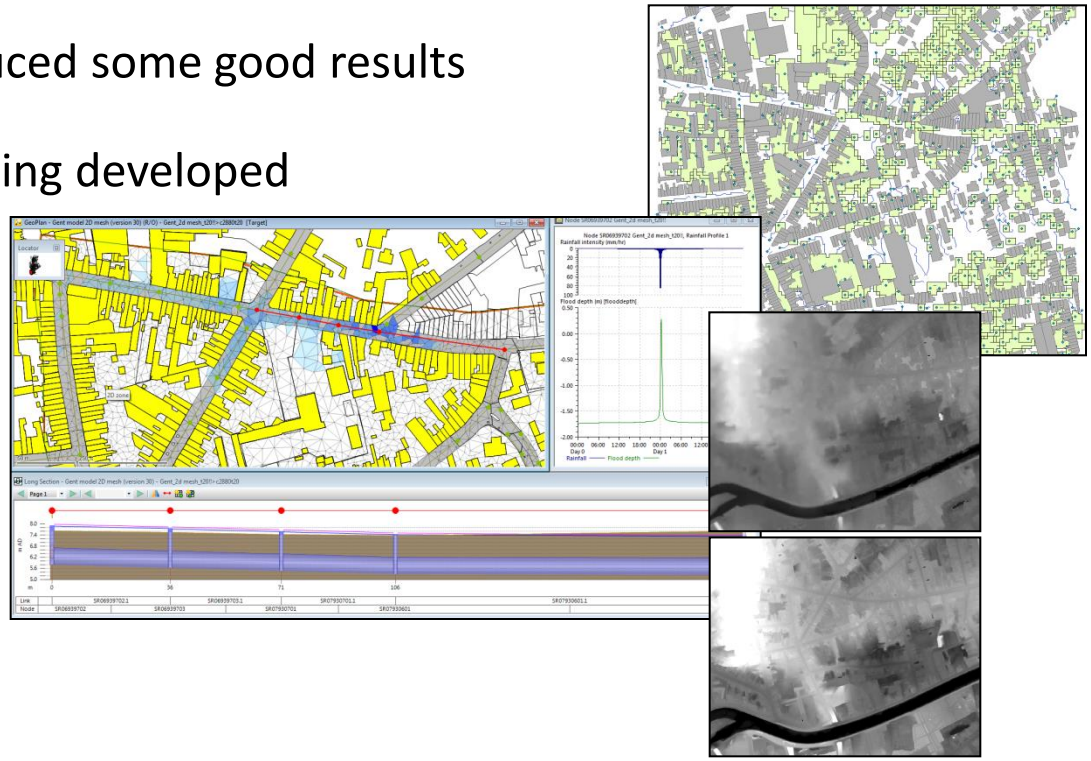
## Recent developments in Herent/Leuven (BE) pilot location:

- **Problems:**
  - High detail of building ‘maps’ lead to too many mesh elements.
  - Instabilities
  - Inconsistencies between 1D ground levels, open channels and mesh levels
  - Problems with outfalls in the 2D zone – also in UK!
  - Extremely long initialisation (to be checked with Innovyze)
- **Given the slow progress and the above described issues, modelling the full Leuven network in 2D will not be feasible anymore within the project duration**

# REVIEW - WP3 A11

## Recent developments in Ghent (BE) pilot location:

- Test area – approx. 20 ha
- 1D/1D-CS surface model produced some good results
- 1D/1D-AOFD surface model being developed
- First 1D/2D tests in IW ICM
  - Different mesh resolutions



- Low/High resolution DTM
- Composite storms
- Rain gauge data (5 RGs)
- Radar data (C-band estimates, KMI)
- Gauge-radar data merged tests

- **Inter-comparison between different approaches**
- **Model calibration and validation**

# REVIEW - WP3 A11

## Recent developments in Ghent (BE) pilot location:

- **Questions/Problems:**
  - Flood mapping (without 2D mesh) in ICM possible? 1D flood mapping in ICM?
  - Infiltration/Evaporation parameters during simulatons? – Some ponds remain flooded after rainfall.
  - Ground infiltration inputs?
  - .csv ICM rainfall input format files (seems to differ from the IW-CS format)

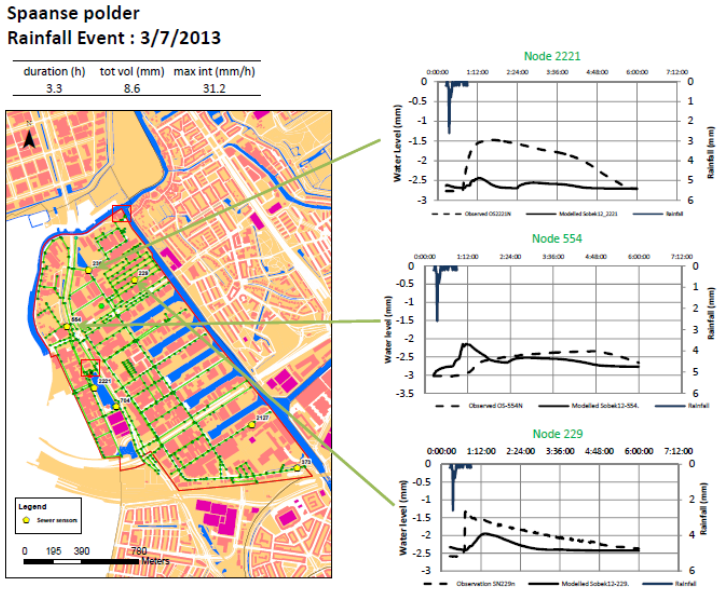
# REVIEW - WP3 A11

## Recent developments in NL pilot locations:

- Initial tests for implementing a Multi-Hydro model of two areas in Rotterdam: the Spaanse Polder and Centrum districts, in collaboration between TU Delft and ENPC. Problems encountered during the implementation are being solved by ENPC.

- Comparison between Multi-Hydro (fully distributed) and Sobek (semi-distributed) models envisaged

- **Spanse polder**: Reliability of both model and water level sensors have been tested, based on simulations fed with Spaanse polder raingauge. Poor agreement. Sensor maintenance and model calibration needed.



# REVIEW - WP3 A11

## Recent developments in NL pilot locations:

- **Questions/Problems:**
  - Implementing models with 2D overland flow module: suggestions about resolution adopted, problems with computational time, other issues related to 2D processes.
  - Complextity of the models: looped systems, no defined outlet: comparison with other pilot locations has been problematic- it is not possible to define sub-catchments and contributing area to given nodes. How could we solve the issue?

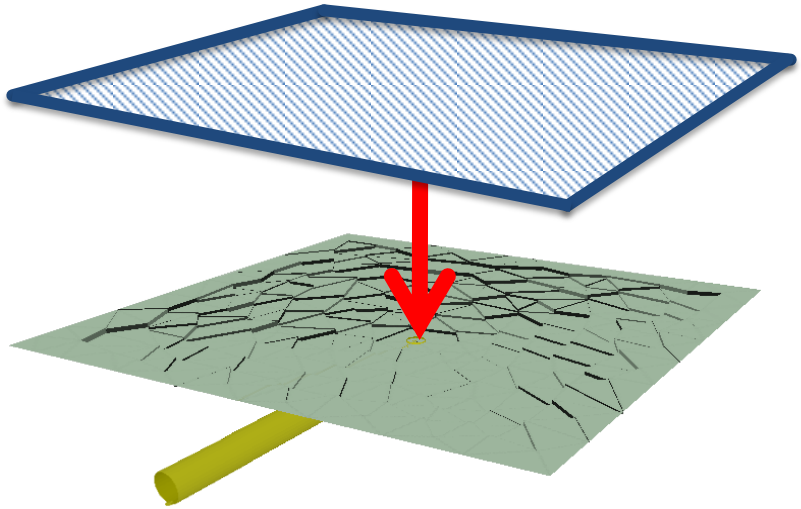
# REVIEW - WP3 A11

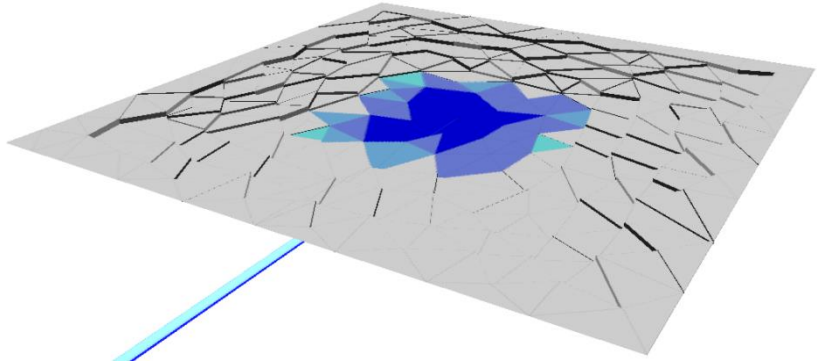
## Recent developments in UK pilot locations:

- Comparison of **semi-distributed vs. fully distributed models** (in InfoWorks ICM) – initially done for Portuguese catchment (Coimbra), soon for Cranbrook catchment

### Main differences:

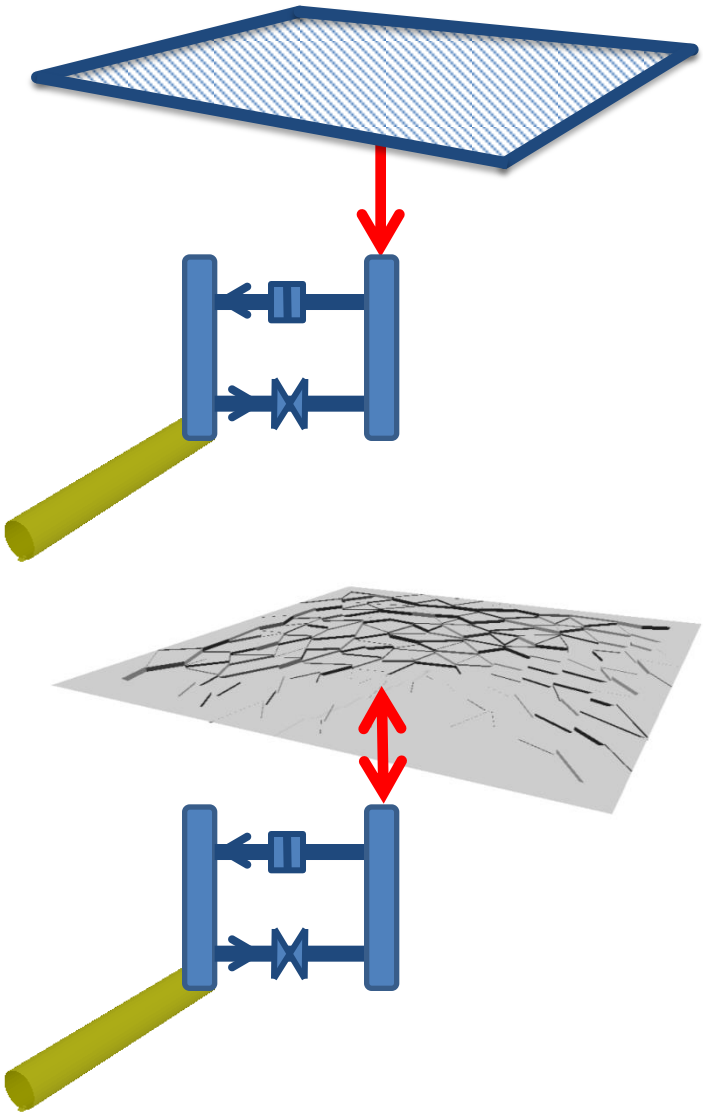
1. **Connection with sewer network**
2. **Hydrological characterization**

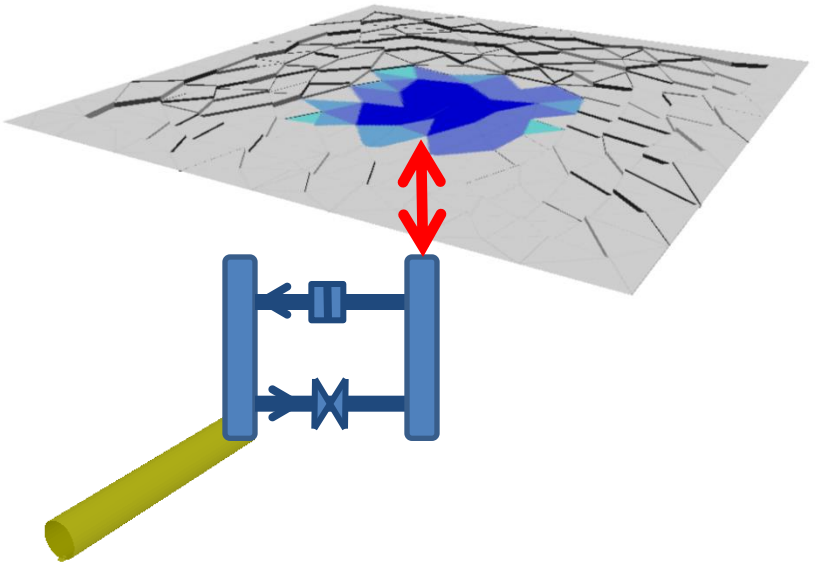




# Semi-distributed vs Fully distributed

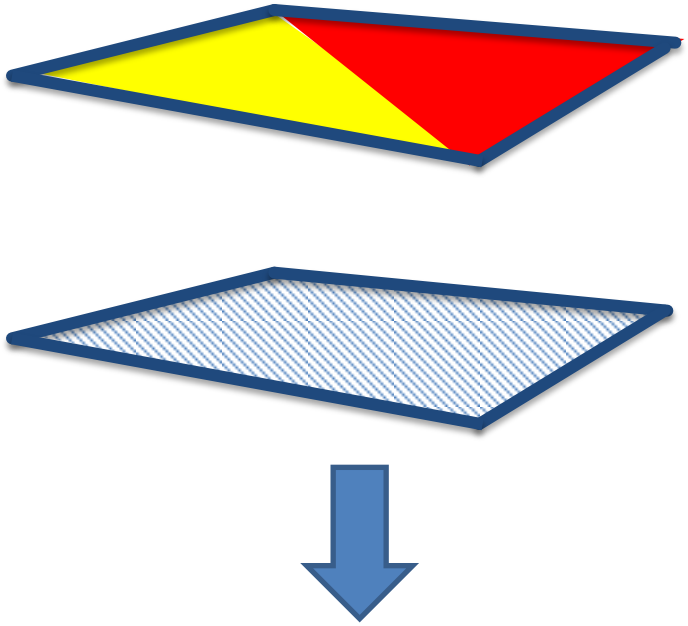
**1. Connection with the network**



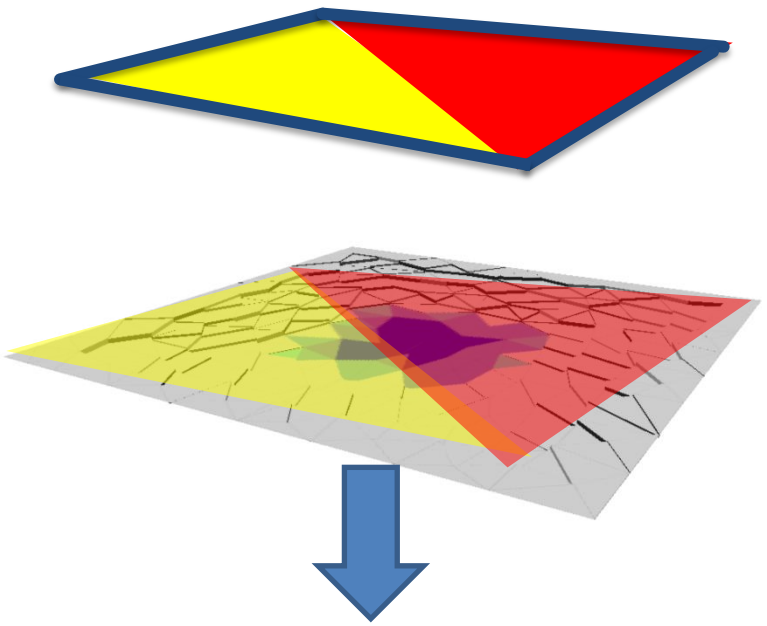


# Semi-distributed vs Fully distributed

## 2. Hydrological characterization

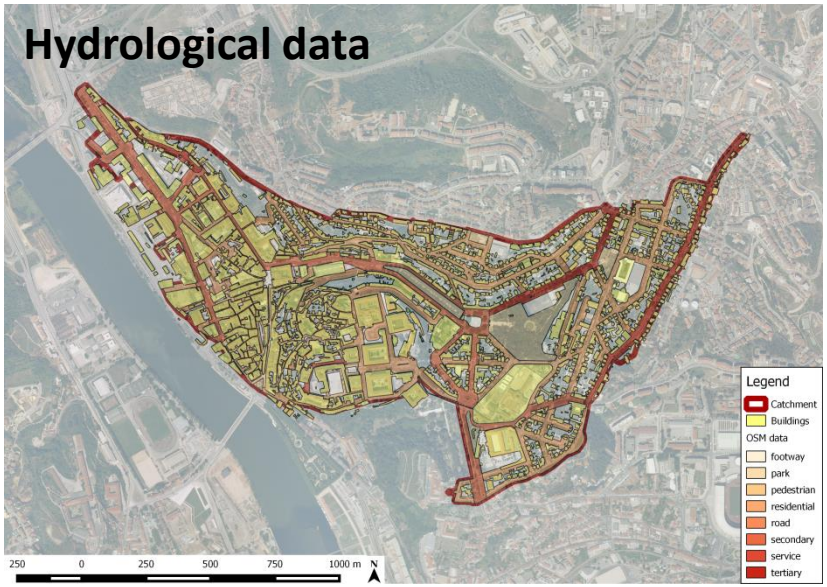


1. % Type yellow
2. % Type red

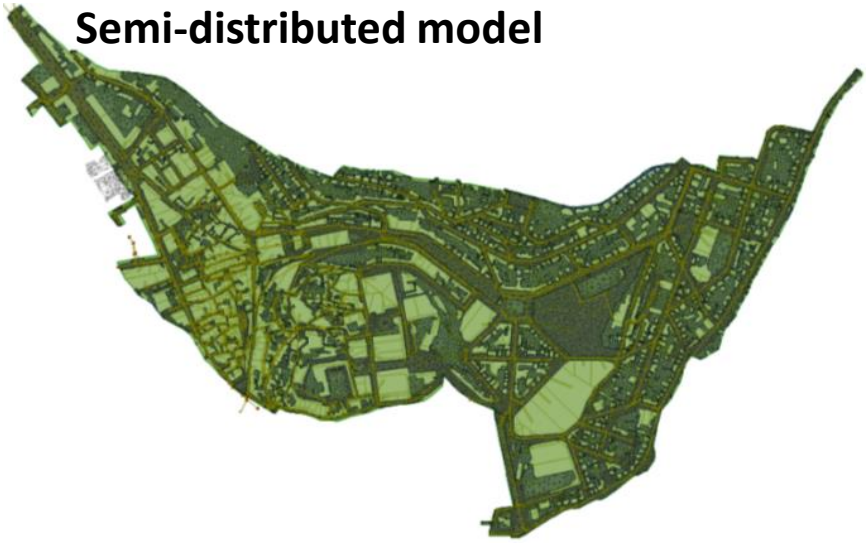


Each 2D mesh cells type yellow or red

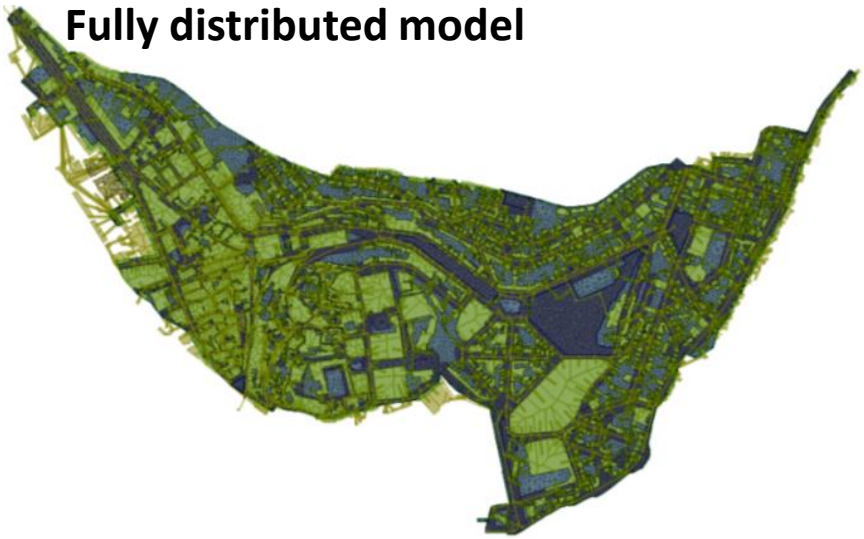
# Coimbra case study



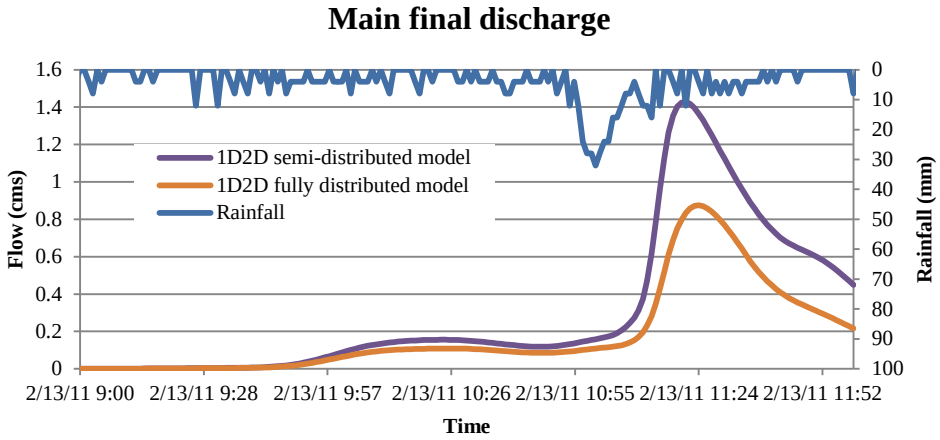

**Semi-distributed model**

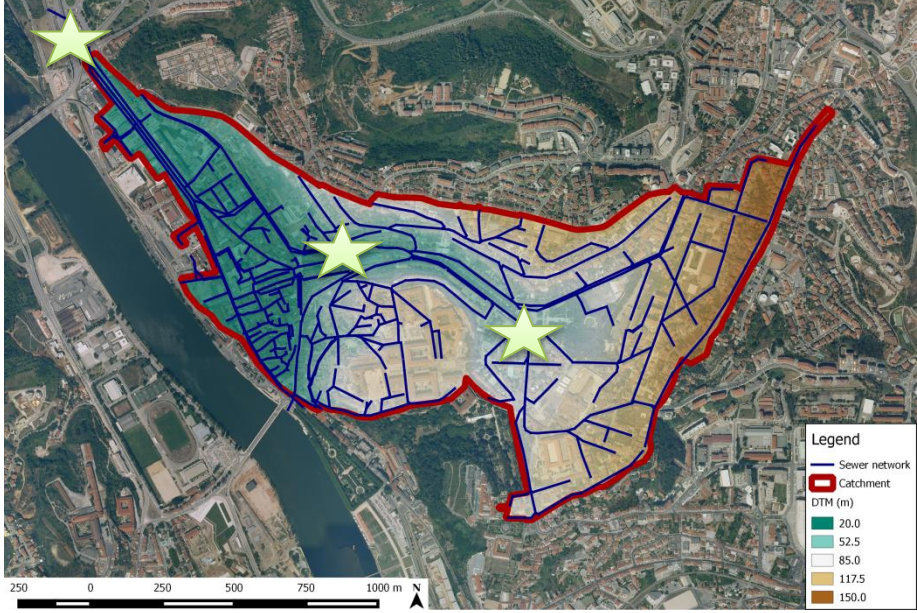


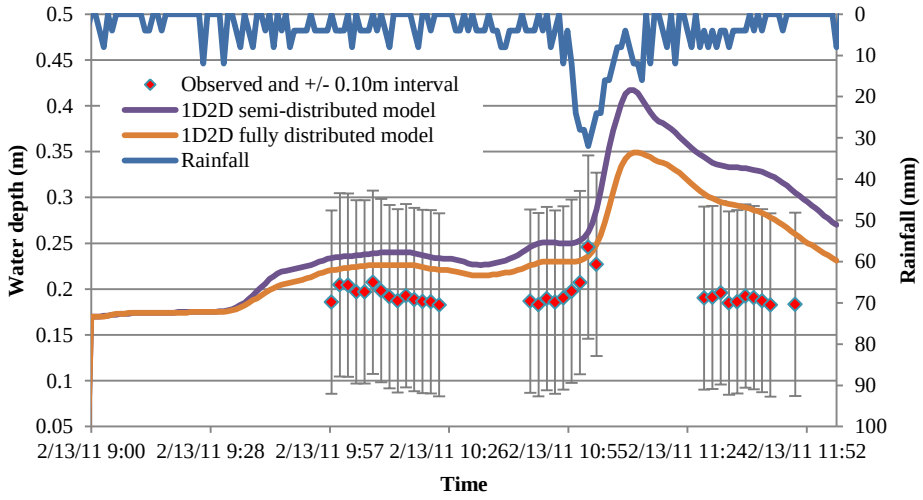
**Fully distributed model**

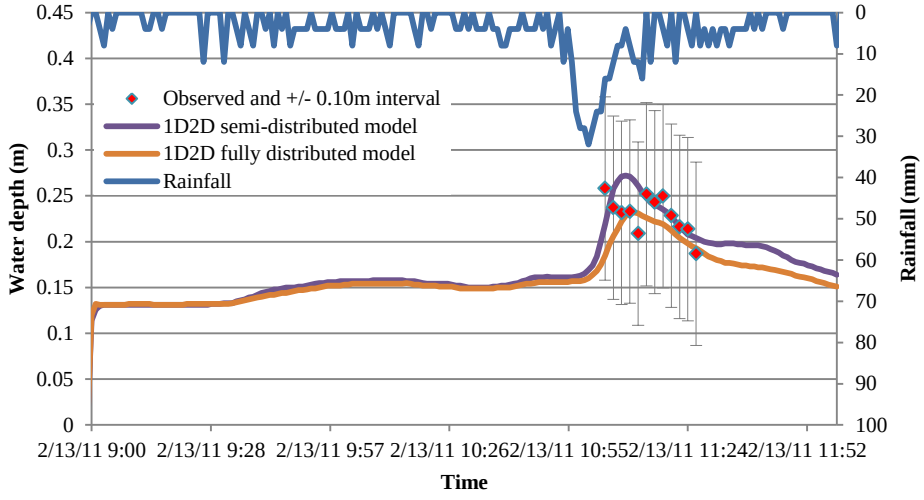


# Coimbra results



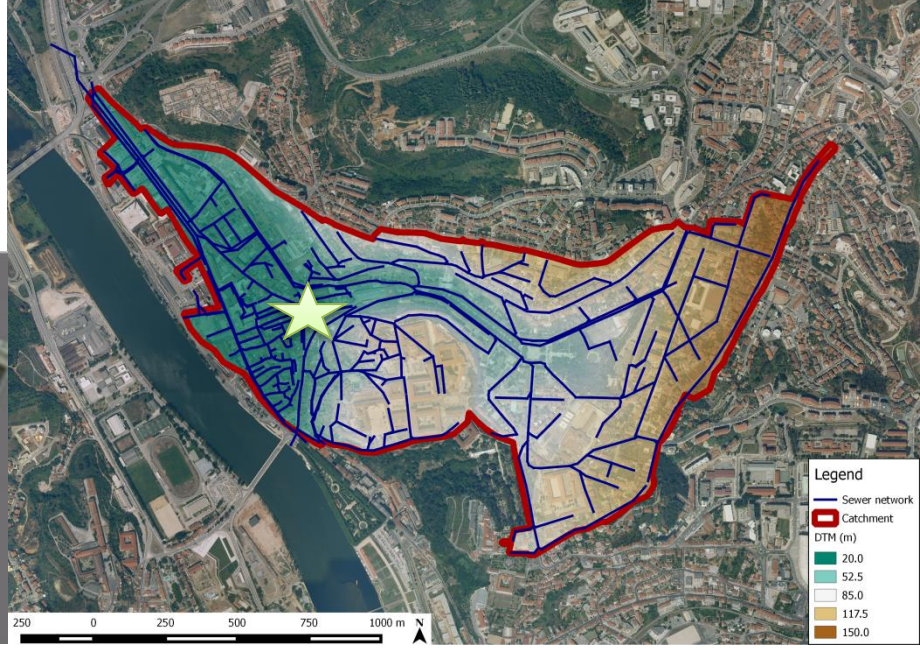



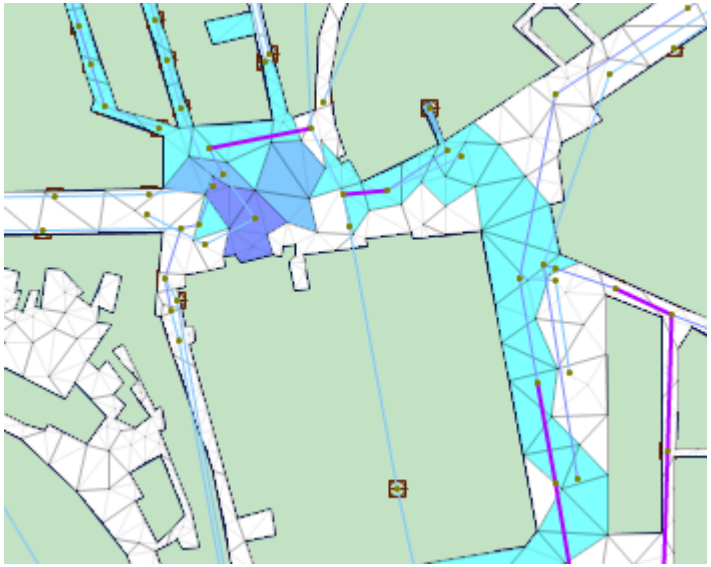

| Volume balance report (m3) | Total Rainfall | | | Volume lost | | | Total runoff | | | Flooded area (ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | Subcatchments | 2D zone | Total | Subcatchments | 2D zone | Total | Subcatchments | 2D zone | Total | End of the simulation | Maximum |
| Semi-distributed model | 19251.8 | 0.0 | 19251.8 | 6408.8 | 0.0 | 6408.8 | 12843.0 | 0.0 | 12843.0 | 26.4 | 55.4 |
| Fully distributed model | 8504.1 | 11564.5 | 20068.6 | 2538.0 | 5360.2 | 7898.2 | 5966.1 | 6204.3 | 12170.4 | 22.9 | 91.8 |

# Coimbra results

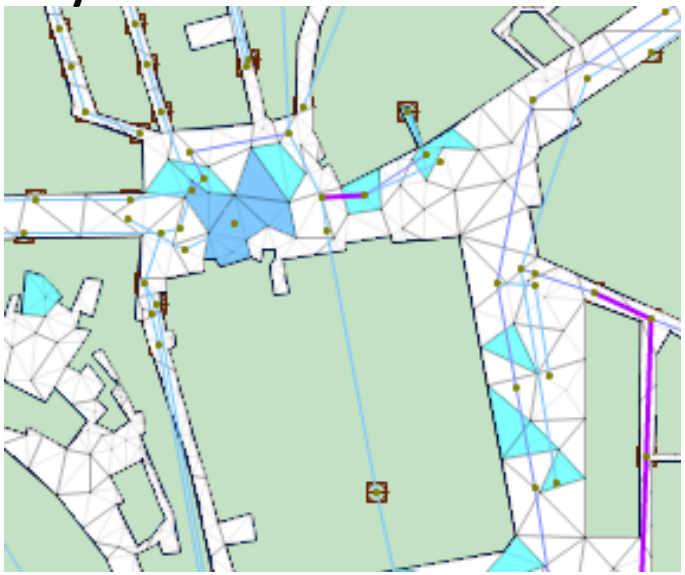
Flood registered on 9 June 2006




**Semi-distributed model**



**Fully distributed model**



# REVIEW - WP3 A11

## Recent developments in UK pilot locations:

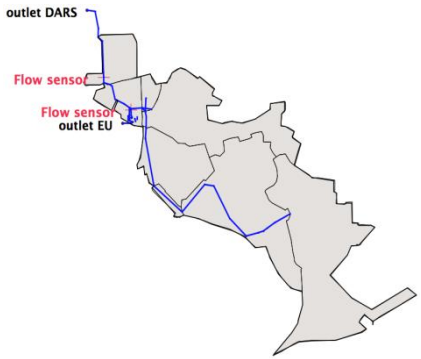
- **Questions/Topics for discussion:**

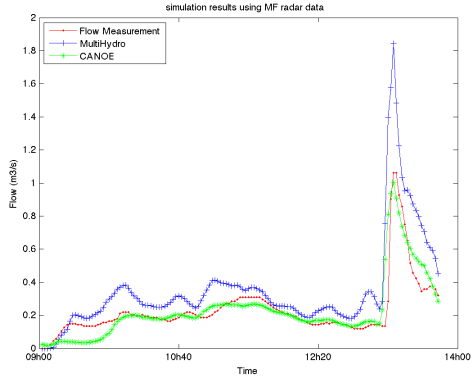
1. Connection with the network
2. Hydrological characterization
3. 2D mesh cells resolution


4. Model calibration in order to make different model structures comparable

# REVIEW - WP3 A11

**- Sucy-en-Brie catchment:** comparison fully distributed Multi-Hydro vs. semi-distributed Canoe




**- Jouy-en-Josas catchment:** Implementation and initial validation of Multi-Hydro in Jouy-en-Josas

**- Kodak catchment:** combined spatio-temporal multifractal analysis of radar rainfall and simulated surface runoff

**→ See presentation by French partners for more details**

# REVIEW - WP3 A11

**In all 4 partner countries: testing and comparison of different model structures!**

Room for inter-comparison, joint problem solving and analysis of results!

Afterwards, I will summarise findings and add to WP3 review document

# REVIEW - WP3 A12

**A12:** Full scale testing of pluvial flood models at pilot locations

**Output:** tested and implemented flood models for pilots + reports

## PROGRESS TO DATE:

- Data for testing of models are being collected
- The datasets to be used for testing of models have been agreed upon (Feb 2013) – these will come from WP2:
  - One common rainfall datasets for all pilots (for testing effects of resolution, etc.)
  - One specific data set of coincidental rainfall and hydro measurements for each pilot
- **In NL:** Analysis of the impact of spatial and temporal resolution of rainfall estimates on the outputs of the hydraulic model of Rotterdam Centrum District (using data from Cabauw X-band radar); not much impact was observed, results discussed with pilot leaders

# REVIEW - WP3 A12

## Recent developments in NL pilot locations:

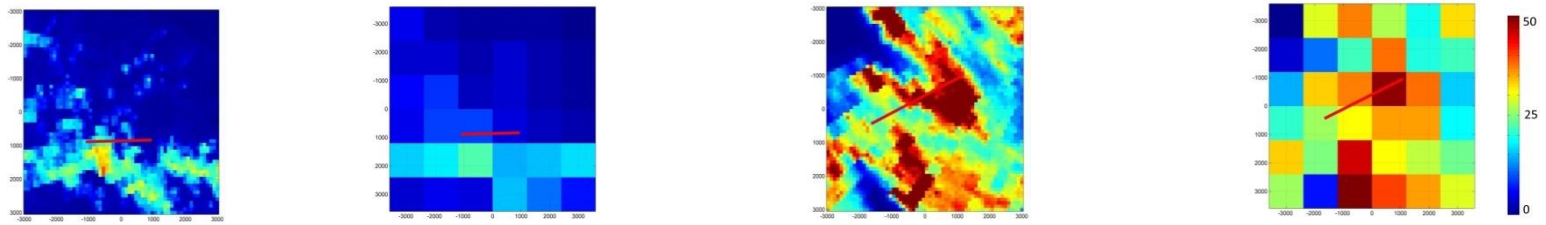
- **Centrum District**: extension of the analysis on rainfall spatial and temporal resolution effect on the catchment to 2 more rainfall events (4 in total): sensitivity is quantified using dimensionless parameters that describe the relationship between rainfall resolution and spatial characteristics of catchment, storm and model topology.
- **Problems / Questions:**
  - Temporal resolution effect on Centrum catchment - suggestion on what results should be analysed:
    - Delays on time to maximum water depth and time to runoff peak?
    - Or also magnitude of peaks?

# Weather Radar and Hydrology joint paper

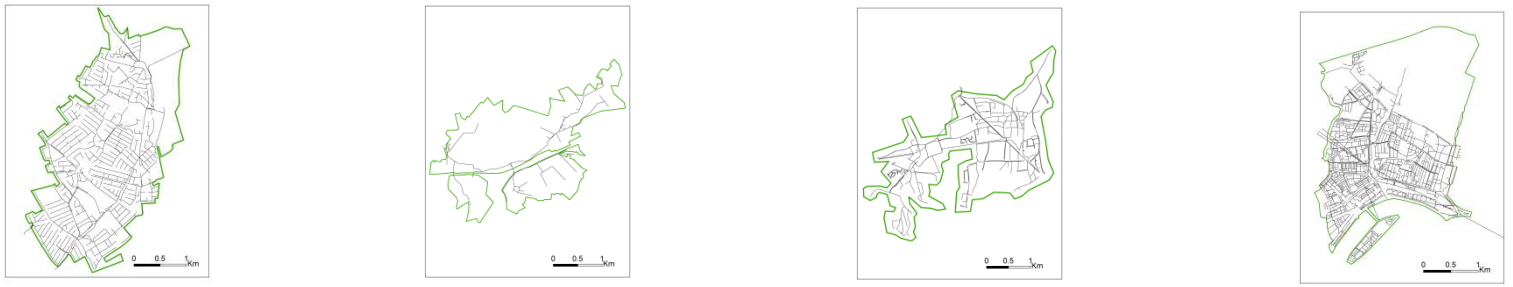
## Multi-catchment analysis of the impact of rainfall input resolution on the hydraulic output of semi-distributed urban drainage models

### 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) |



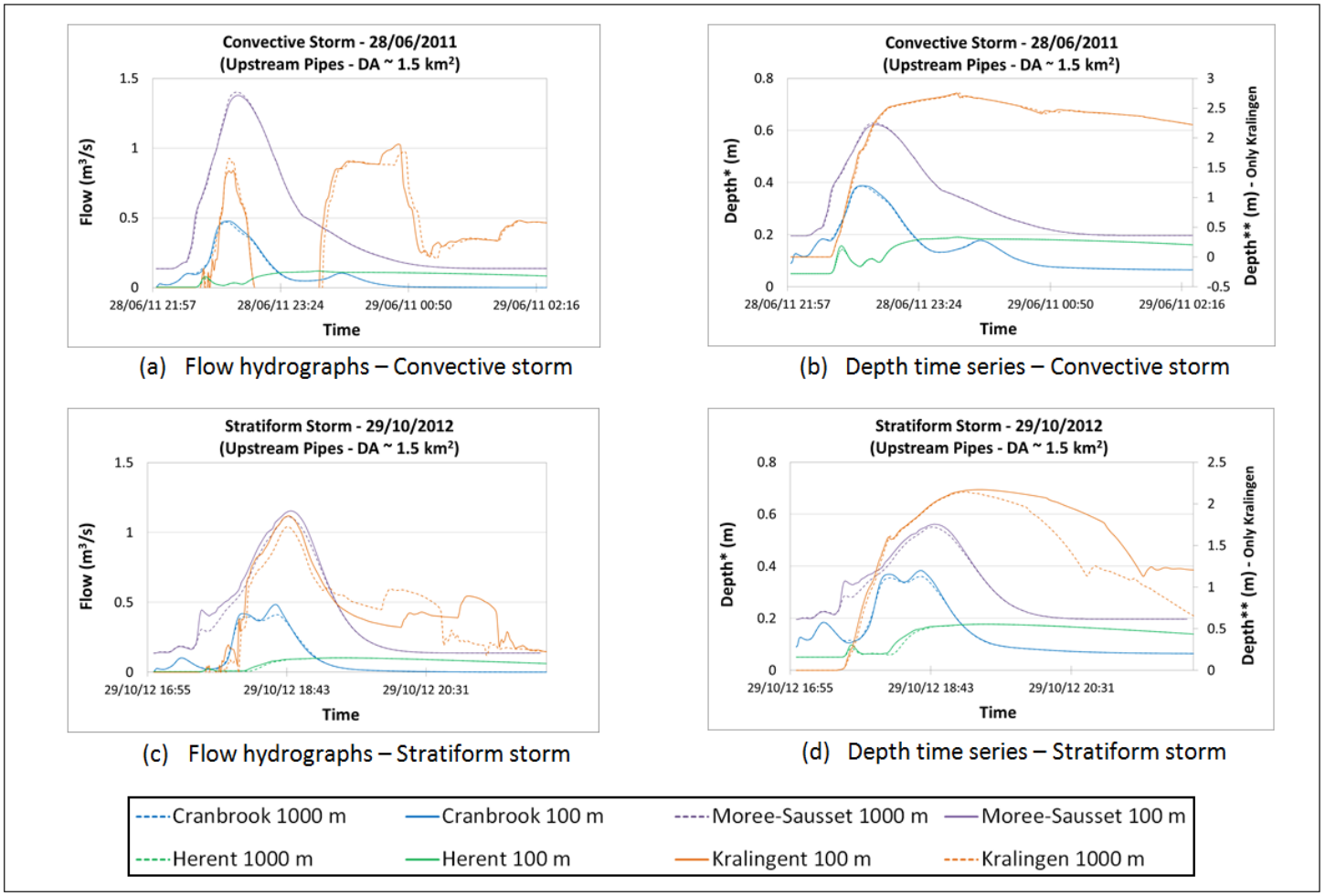

### Semi-distributed urban drainage models of 4 RainGain pilot sites



| 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 |

***Standardisation of results whenever possible:*** *relative storm alignment, catchment size, etc.*

# Results




- Analysis at 3 points in each catchment (upstream, mid-stream, downstream)
- Not significant impact of rainfall input resolution is observed for two storms under consideration
- Work in progress!

## Next steps (for journal paper)

- Many more storms need to be analysed (how many? 10? From Cabaw?)
- Analysis of impact of more drainage areas (instead of only 3)? – how many?
- Analyse more storm directions?
- Analysis of impact of rainfall input resolution vs. model resolution vs. data resolution vs. homogeneity/heterogeneity of catchment characteristics. Even if not detailed analysis, further discussion is required in paper
- Analysis of impact of Kralingen pumping schemes on changes in sensitivity to rainfall input resolution
- Should we also analyse impact of temporal resolution of rainfall inputs? On same paper or different one?
- Anything else?

# REVIEW - WP3 A12

- **NEXT STEPS:**
  - Data collection will continue at all pilot locations
  - Assessment of benefits of finer resolution rainfall estimates from new X-band radars and UKMO, based upon comparison against coincidental hydro measurements!

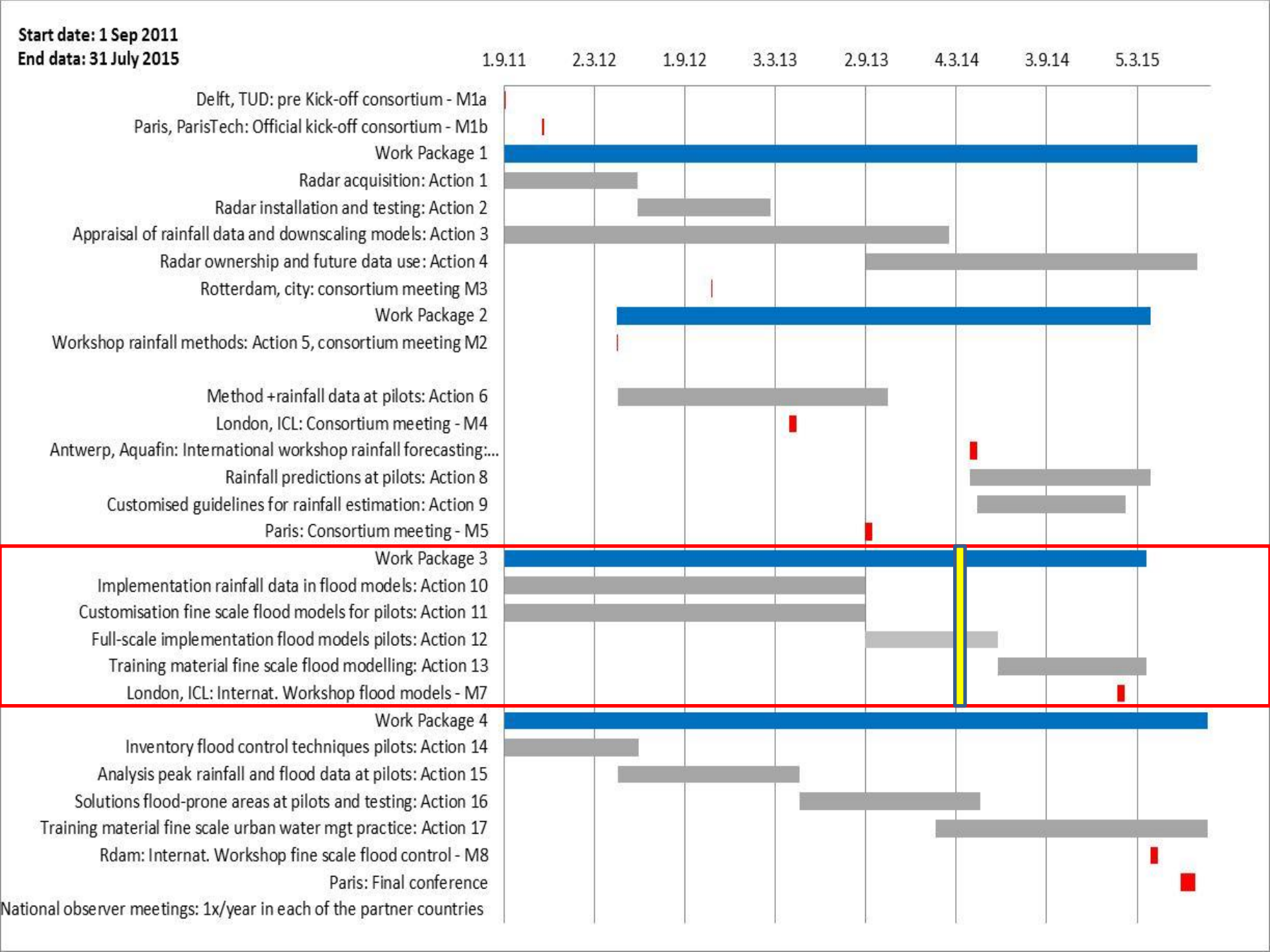
Looking forward to rainfall data from new radars and 100 m radar product over Greater London!

# REVIEW - WP3 A13

**A13:** Training material and guidelines

**Output:** Training material and guidelines for pilots

- **PROGRESS TO DATE:**
  - ICL developed a workshop pack for engagement of stakeholders in local flood risk management.
  - Initial version of review document on urban pluvial flood models produced by ICL (Feb 2013), further updated based upon detailed feedback from partners (Dec 2013).
- **NEXT STEPS:**
  - As more results become available from pilot locations, general conclusions will be drawn and will be included in the WP3 review document


Start date: 1 Sep 2011
End data: 31 July 2015
1.9.11
2.3.12
1.9.12
3.3.13
2.9.13
4.3.14
3.9.14
5.3.15
Delft, TUD: pre Kick-off consortium - M1a
Paris, ParisTech: Official kick-off consortium - M1b
Work Package 1
Radar acquisition: Action 1
Radar installation and testing: Action 2
Appraisal of rainfall data and downscaling models: Action 3
Radar ownership and future data use: Action 4
Rotterdam, city: consortium meeting M3
Work Package 2
Workshop rainfall methods: Action 5, consortium meeting M2
Method +rainfall data at pilots: Action 6
London, ICL: Consortium meeting - M4
Antwerp, Aquafin: International workshop rainfall forecasting:...
Rainfall predictions at pilots: Action 8
Customised guidelines for rainfall estimation: Action 9
Paris: Consortium meeting - M5
Work Package 3
Implementation rainfall data in flood models: Action 10
Customisation fine scale flood models for pilots: Action 11
Full-scale implementation flood models pilots: Action 12
Training material fine scale flood modelling: Action 13
London, ICL: Internat. Workshop flood models - M7
Work Package 4
Inventory flood control techniques pilots: Action 14
Analysis peak rainfall and flood data at pilots: Action 15
Solutions flood-prone areas at pilots and testing: Action 16
Training material fine scale urban water mgt practice: Action 17
Rdam: Internat. Workshop fine scale flood control - M8
Paris: Final conference
National observer meetings: 1x/year in each of the partner countries

# OVERALL PROGRESS

- In general, progress according to proposed timeline
- Permanent (and very useful) consultation and discussion with partners on forecasting platform, urban pluvial flood modelling approaches and modelling results