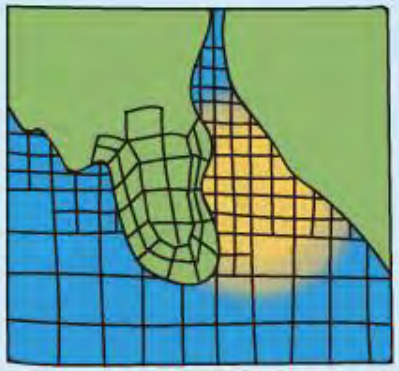

HAZRUNOFF

PROJECT

Modeling strategy and pilot cases

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TÉCNICO LISBOA

Lígia Pinto
Ana Oliveira

Bentley Advancing Infrastructure

Luís Fernandes
Rodrigo Fernandes

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HazRunoff ultimate goal

- To allow realtime and simulated information on rivers, estuaries and coastal areas as a continuum environmental compartment
- Supported with fusion of model and data-oriented holistic view
- Provide smart and actionable information for better decisions in preparedness & response duties.




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Modelling approach

An innovative and holistic model approach with integration of the different models to reproduce and forecast the processes associated with floods and the dispersion of pollutants

- Why integrated approach is important?
  - several processes and scales
  - many flood sources: pluvial flash flooding; fluvial flooding; dam break; sea-level rise due to storm surge; sea-level rise due to “sunny-day flooding”; combination of flood types
  - various pollution sources

System complexity can only be reproduced and understood following an holistic approach

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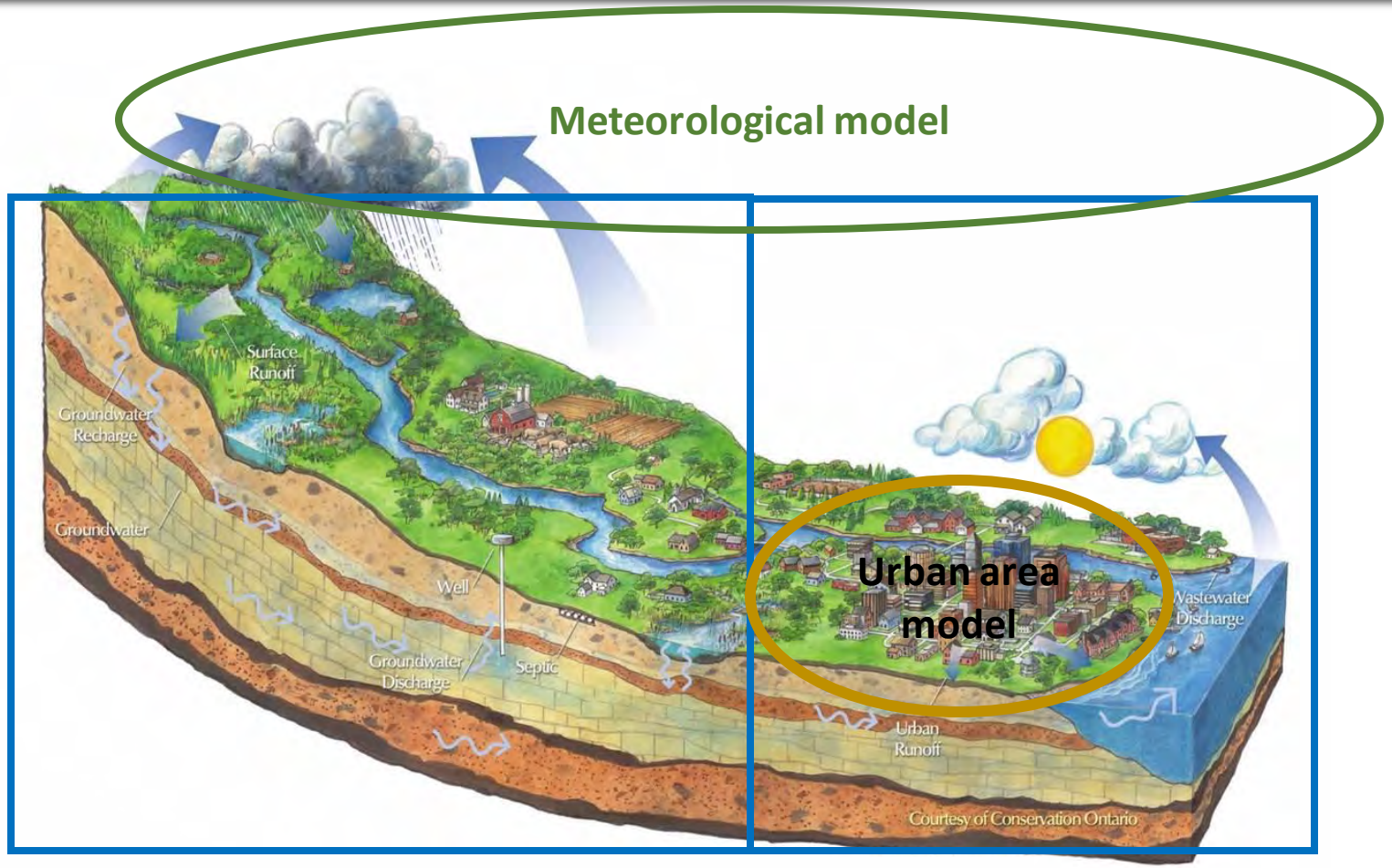
Watershed – Estuary – Urban - Coastal zone



Watershed model

Estuarine and coastal model

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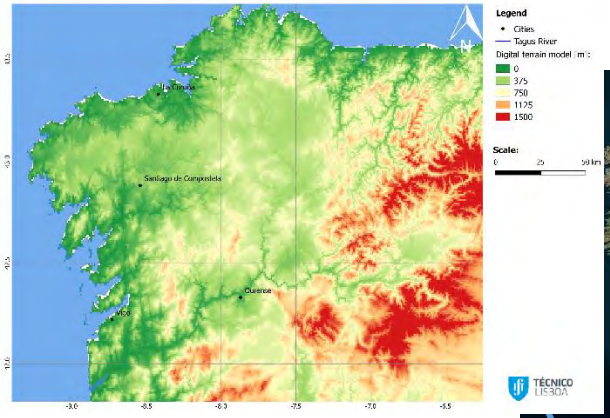
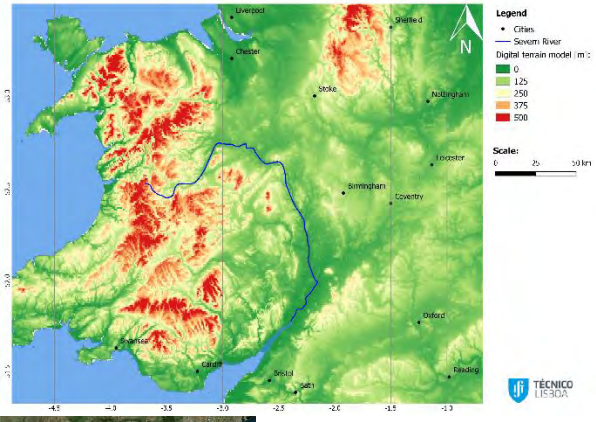
HazRunoff pilot cases

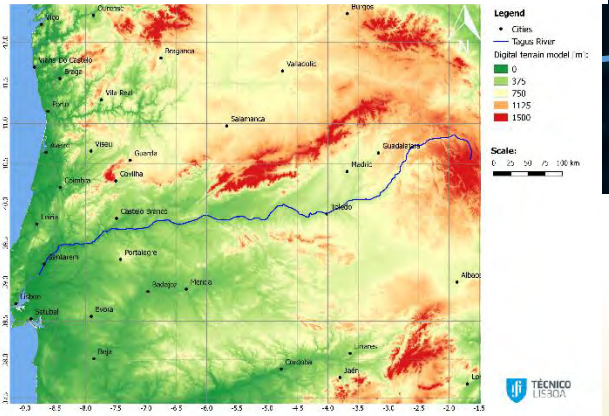
Spain: Ulla and Sar rivers\Ria Arosa



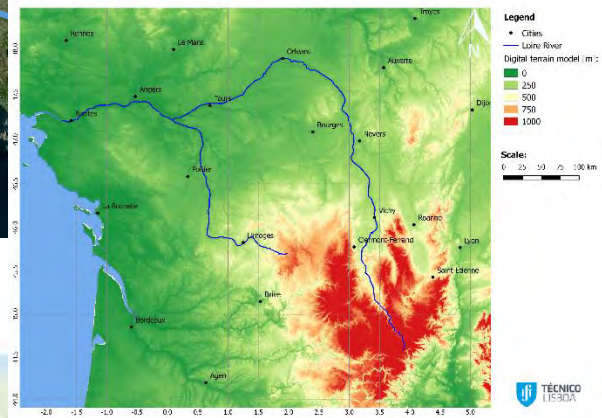
UK: Severn river\estuary



Portugal: Tagus river\estuary



France: Loire river\estuary



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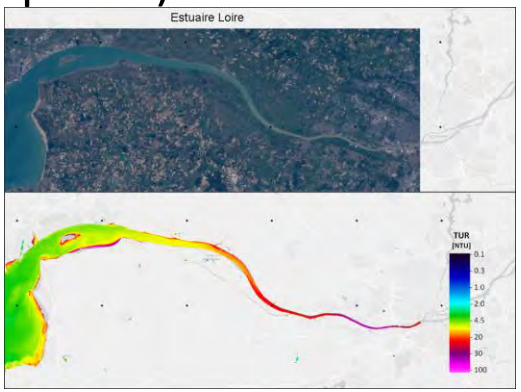
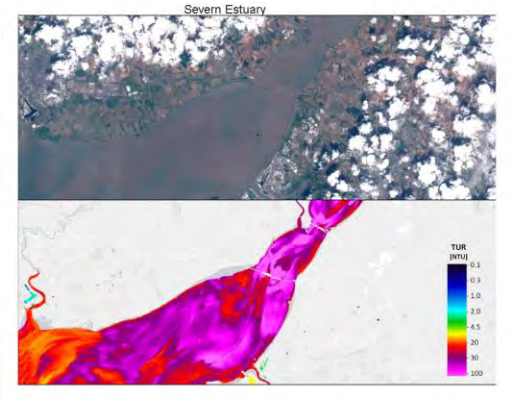
Pilot case areas

- Areas with strong socio-economic relevance, with several water-based activities (fishing, tourism, ports, industry)
- Directly associated with flood risks and potential hazmat incidents, due to the presence of industries (including nuclear power plants)



➢ Loire

- ↘ 'The last wild river in western Europe' due to the relative absence of large dams and the consequent semi-natural condition of the river
- ↘ Chinon nuclear power plant



➢ Severn

- ↘ hyper-tidal estuary (mean spring tide range >6 m) with funnel-shaped
- ↘ Storm surge events - flooding

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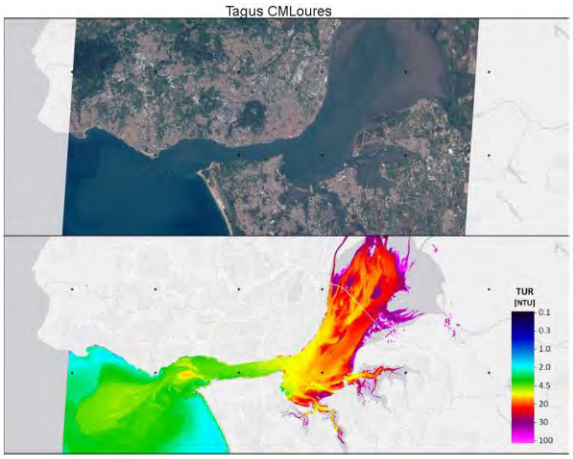
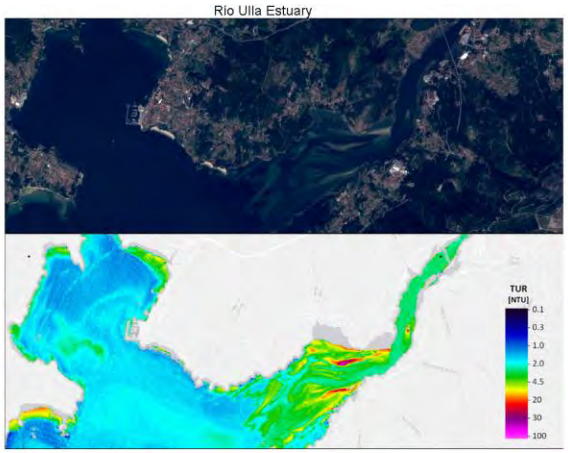
Pilot case areas

- **Tagus**
  - The longest river in the Iberian Peninsula
  - Several dams
  - Almaraz nuclear power plant
  - Sacavém urban area (flooding episodes)





- **Ria de Arousa Ulla\Sar rivers**
  - The largest of the Galicia estuaries
  - Shellfish aquaculture area
  - Padrón urban area (flooding episodes)

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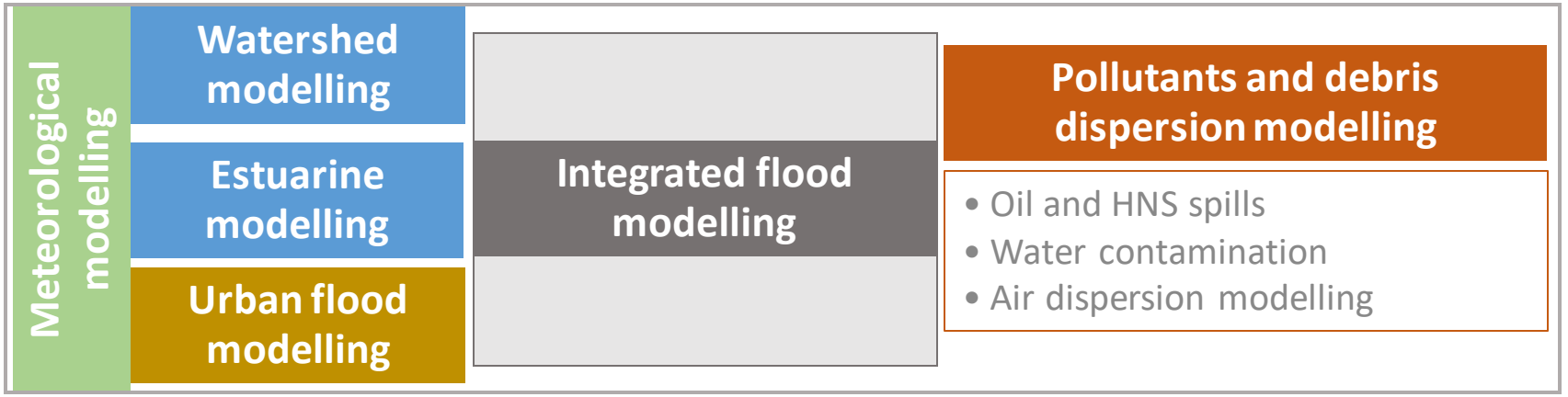
HazRunoff models

To simulate and **integrate the water continuum from the watershed up to the estuary** to reproduce and forecast the processes associated with floods and the dispersion of pollutants



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HazRunoff models

- Implemented, calibrated and validated in the 4 pilot areas

- Sacavém
- Padrón

Meteorological model	Watershed model	Estuarine model	Urban flood modelling
WRF model	**MOHID Land**	**MOHID Water**	**MOHID + SewerGEMS**
Horizontal resolution 9 km – 3 km – 1 km		Horizontal resolution 4 km – 2 km – 250 m	
Bentley Advancing Infrastructure	TÉCNICO LISBOA	TÉCNICO LISBOA	Bentley Advancing Infrastructure

Spain – Meteorological and ria Arousa models from MeteoGalicia

Spain – Augas de Galicia, MeteoGalicia
France – GIPLoire
UK - Maritime & Coastguard Agency
Portugal – Loures Municipality (partner)

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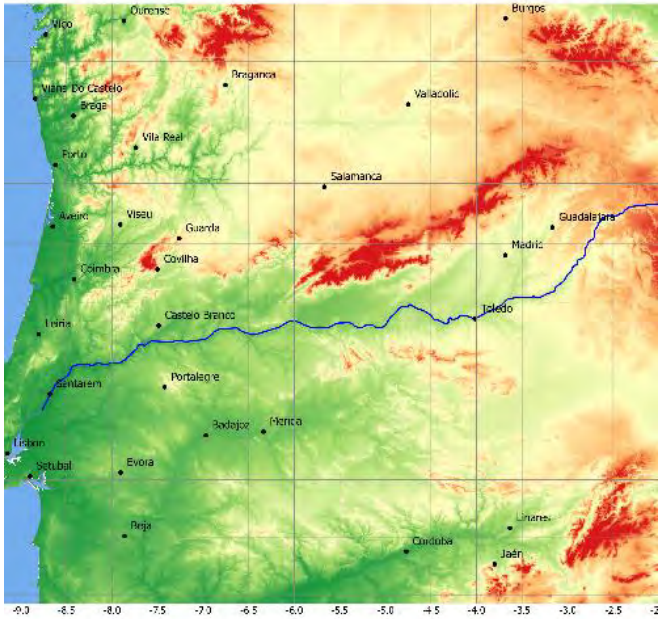
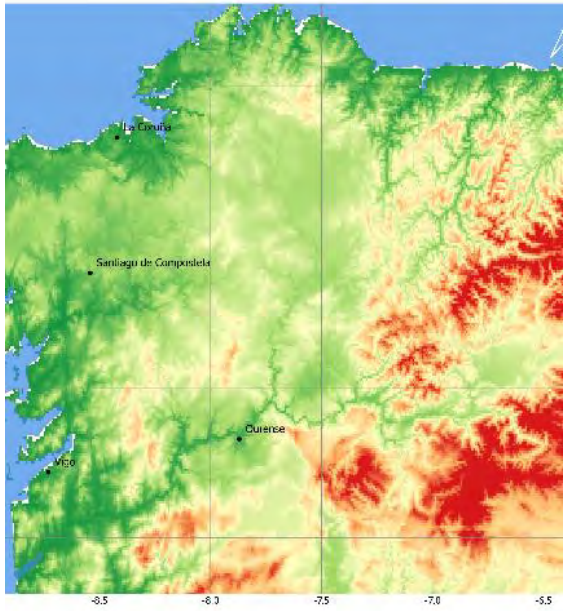
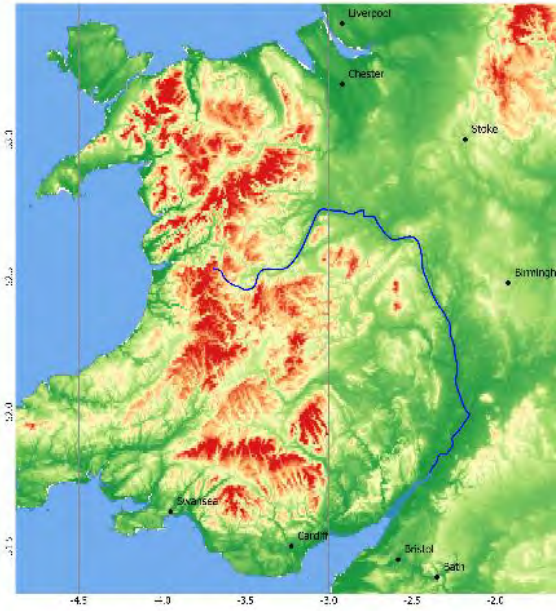
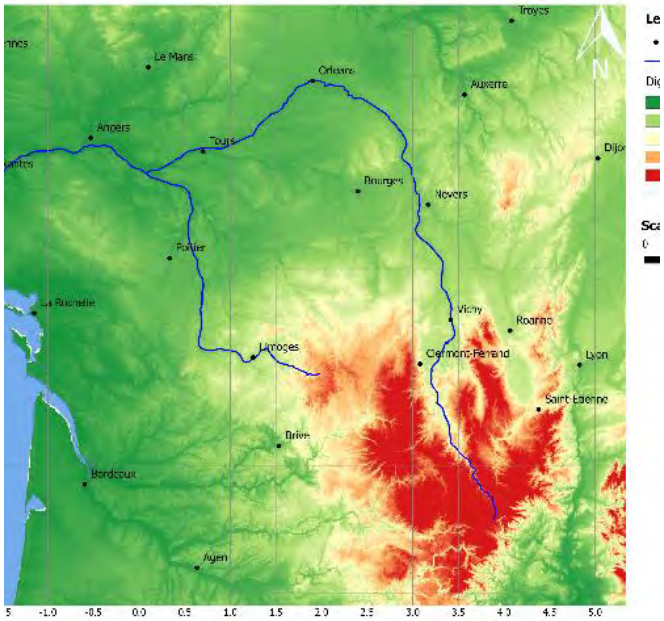


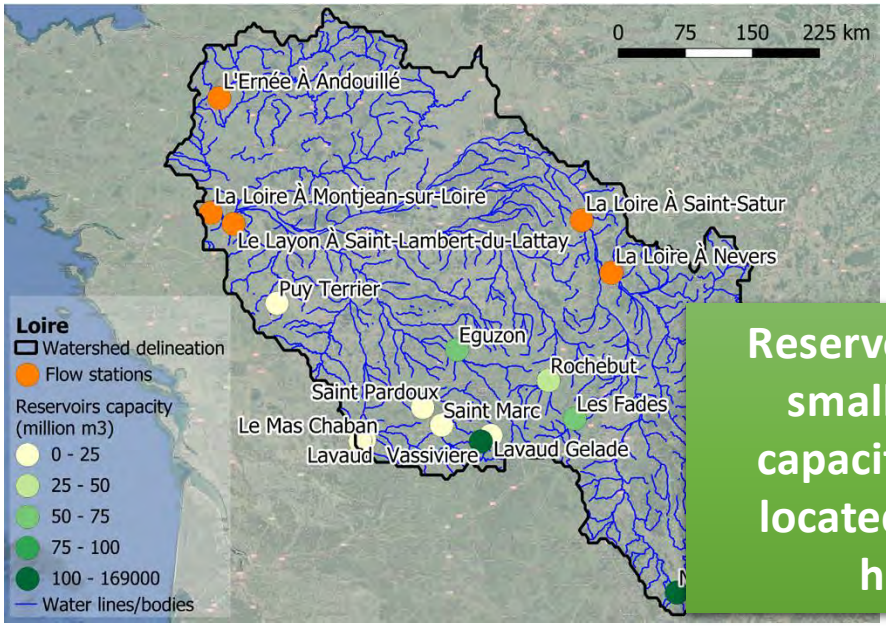


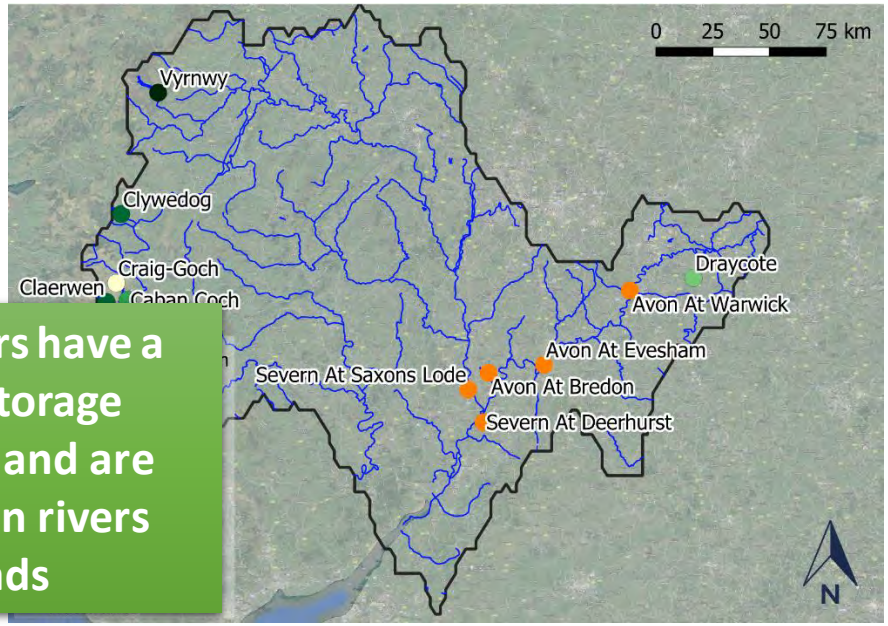




Watershed models

Watershed model – Loire and Severn





Reservoirs have a small storage capacity and are located in rivers heads

Reservoirs	
Name	*Capacity (millions m3)*
Lavalette	41
Rochebut	25.8
Lavaud Gelade	21.4
Saint Marc	20
Saint Pardoux	22
Lavaud	10.5
Le Mas Chaban	14.2
Puy Terrier	11.5

Influence on flow regime: despicable

Reservoirs	
Name	*Capacity (millions m3)*
Caban Coch	35.5
Craig-Goch	9.2
Claerwen	48.3
Clywedog	50
Draycote	22.7
Vyrnwy	59.7

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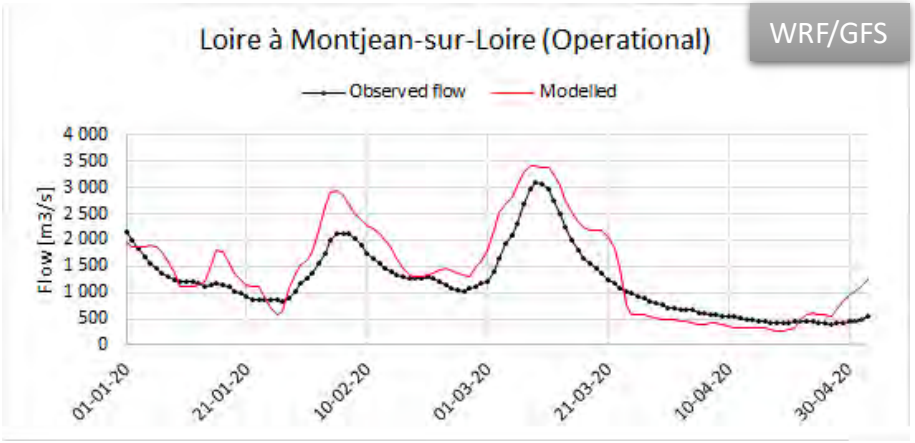
Watershed model – Loire and Severn



Loire

Statistical parameter	*Calibration*	*Validation*	*Operational*
NSE	0.37	0.70	0.59
PBIAS	-26	-18	-16
R2	0.82	0.85	0.89
RMSE	409	373	414

Severn

Statistical parameter	*Calibration*	*Validation*	*Operational*
NSE	0.53	0.65	0.83
PBIAS	-22	-15	4
R2	0.66	0.68	0.84
RMSE	72	72	45

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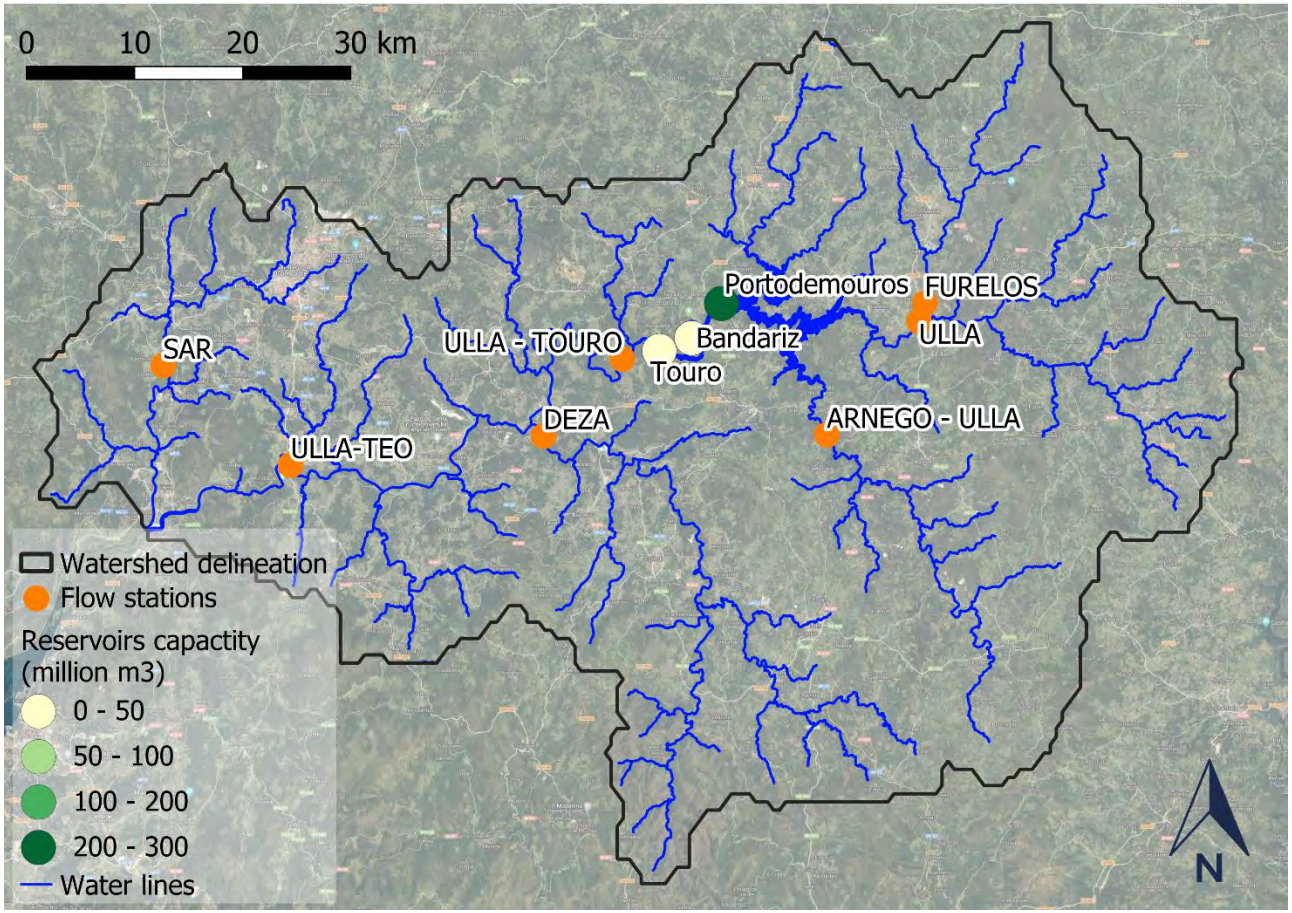
Watershed model - Galicia



One reservoir has a substantial impact on flow regime.

How to deal with the unknown about the outflow?

Artificial neural network (ANN) to estimate the outflow

Reservoirs	
Name	*Capacity (millions m3)*
Portodemouros	297
Brandariz	2.74
Touro	3.78

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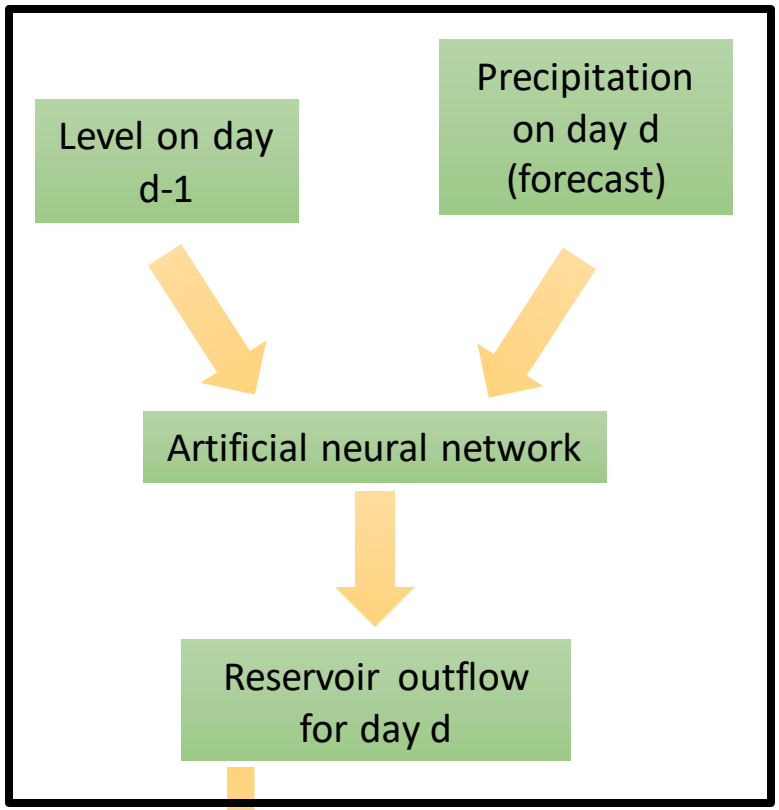
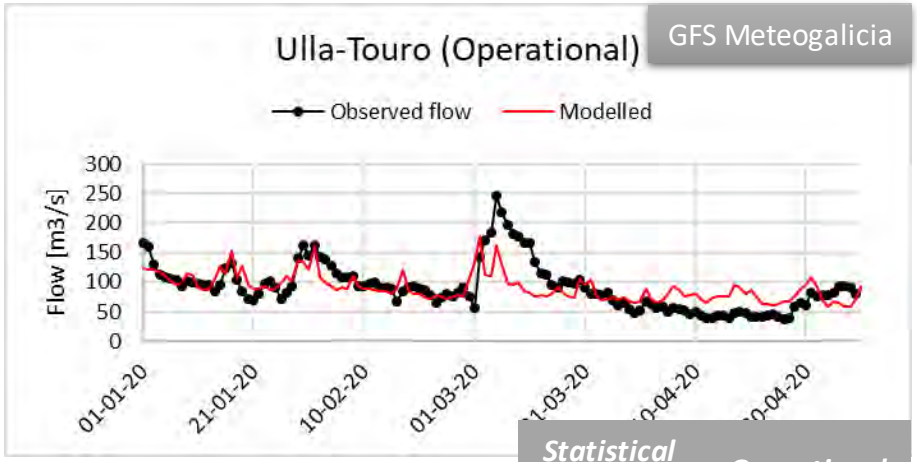
Artificial neural network assimilation



× number of reservoirs in the watershed



Statistical parameter	*Operational*
NSE	0.37
PBIAS	1
R2	0.38
RMSE	32

MOHID-Land implementation

Flow forecast for day d reservoir's downstream

Precipitation

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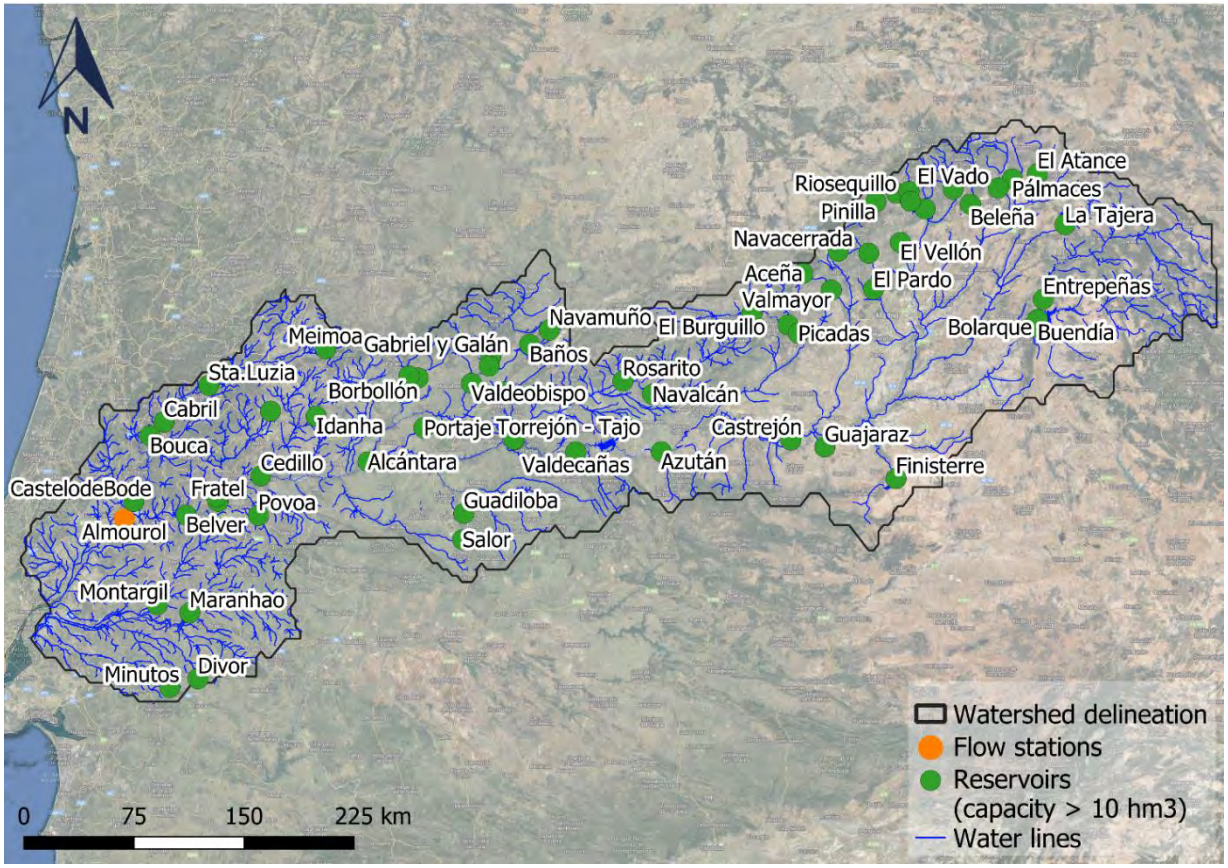
Watershed model - Tagus



60 reservoirs with a capacity higher than 10 hm³

Artificial neural network to estimate the outflows

How to deal with reservoirs without data to train the ANN?

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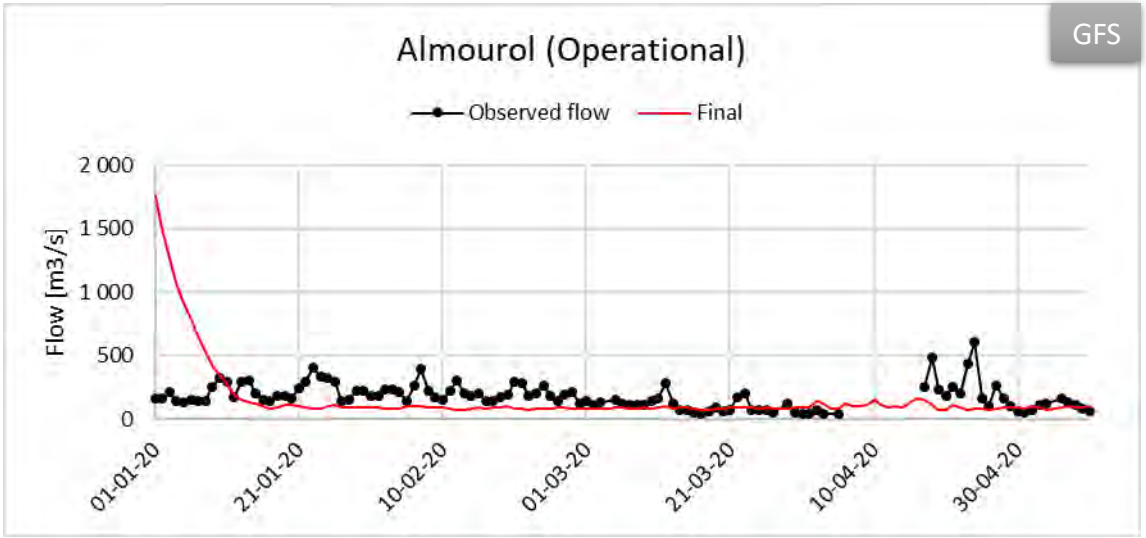
Watershed model - Tagus

- **Replication of the methodology developed for Galician case study**
  - ↘ Application of ANN to estimate reservoirs outflow, for reservoirs with enough data.
  - ↘ For reservoirs without data an operational curve was defined (estimates outflow as a function of stored water and inflow).



Statistical parameter	*Operational*
NSE	-5.78
PBIAS	7
R2	0.0
RMSE	286

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Watershed model - Tagus

➢ Main difficulties

↘ Tagus watershed has a lot of reservoirs distributed over its entire area only remaining very small sub-basins with natural flow regime.

↘ Without enough reservoirs data and due to limited time, it was impossible to study an independent ANN for each reservoir. The one developed to Galician case study was applied.

↘ The Tagus-Segura water transfer system (with significative impact on Tagus river flow) was not considered.

↘ Due to the high level of complexity of the system, the time consumption of the models (ANN and MOHID Land) is extremely significative, making the calibration and validation processes impossible to perform.

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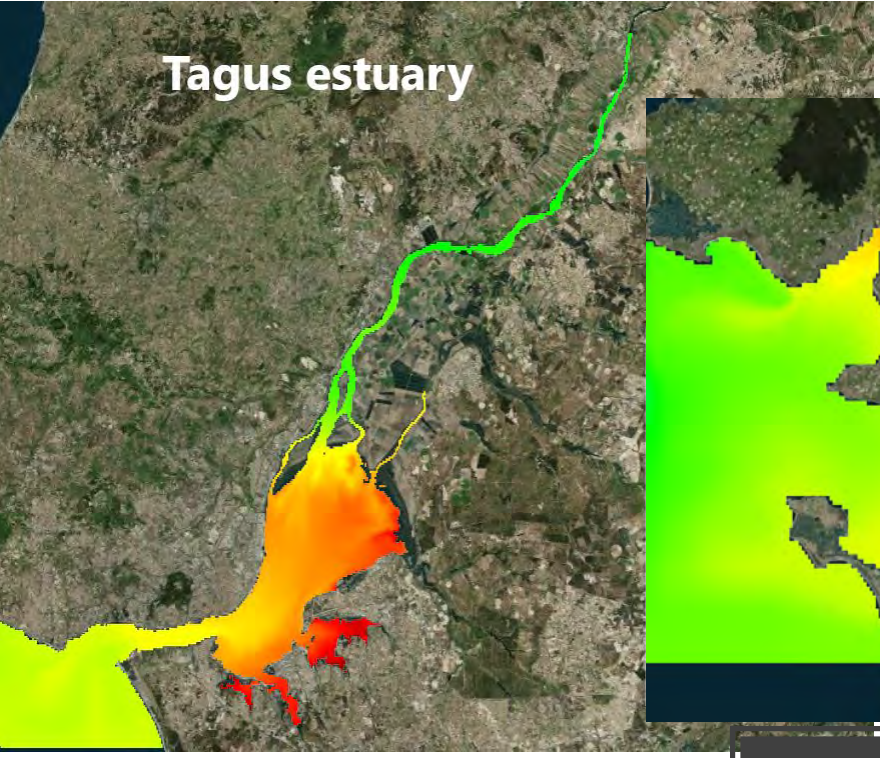
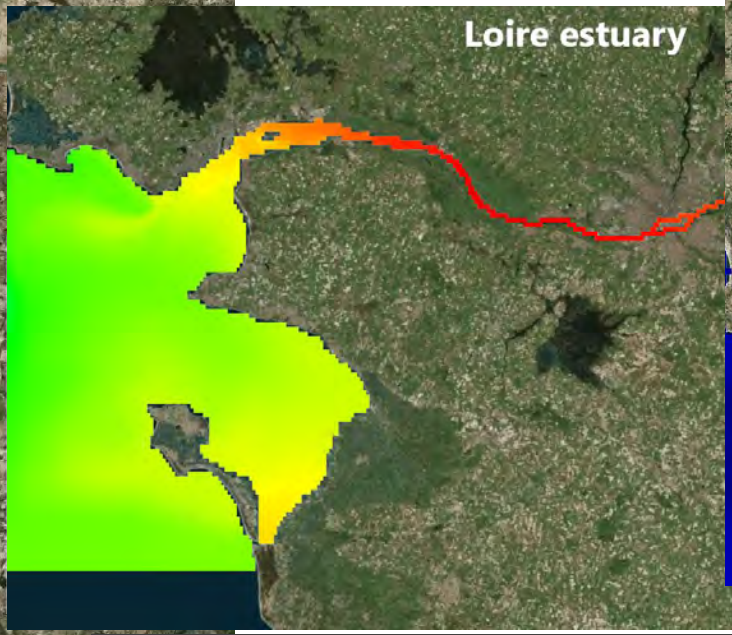
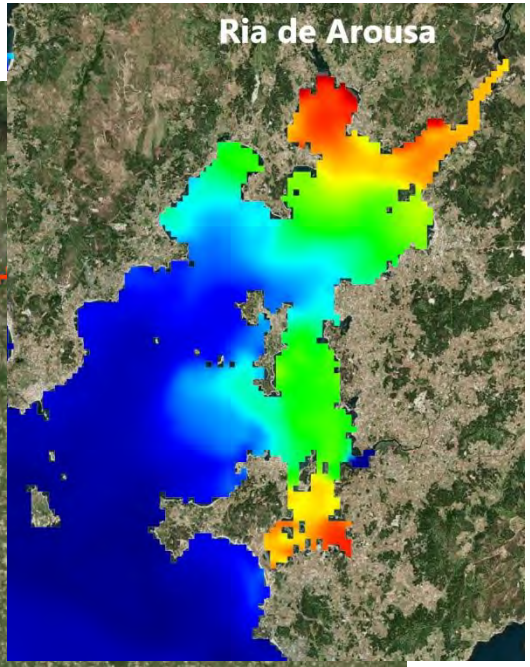
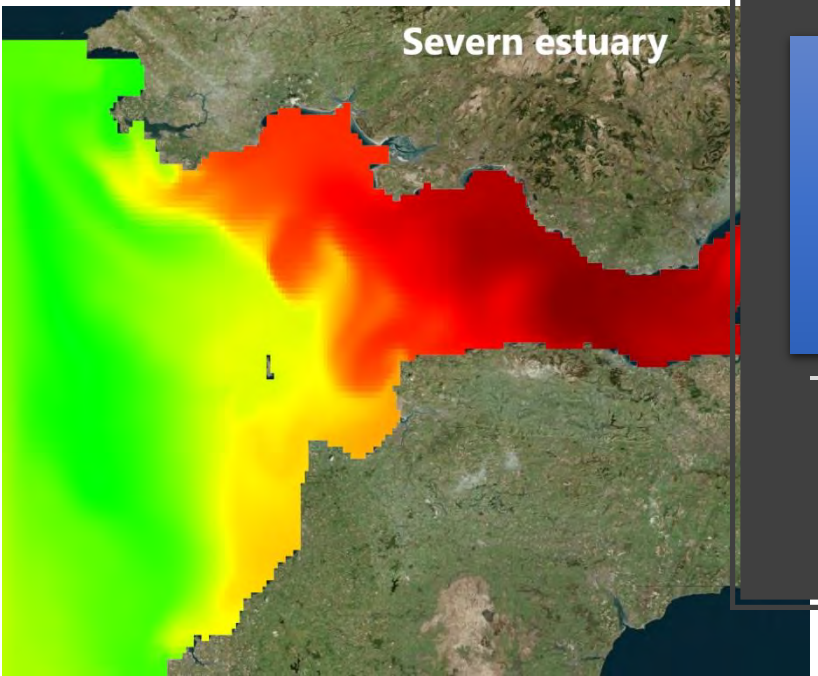




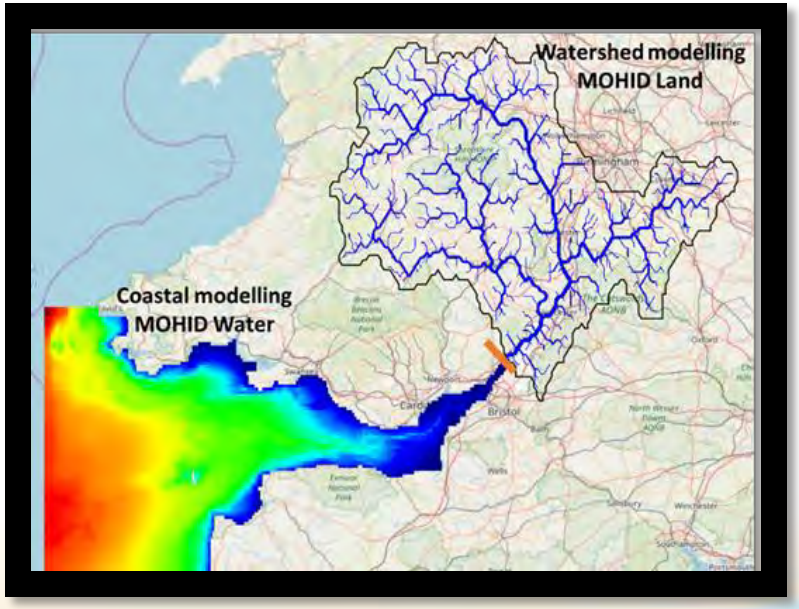


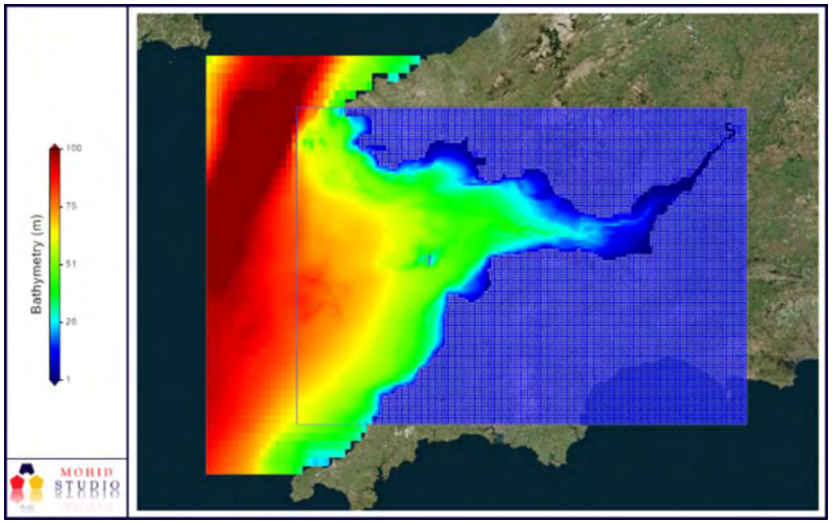


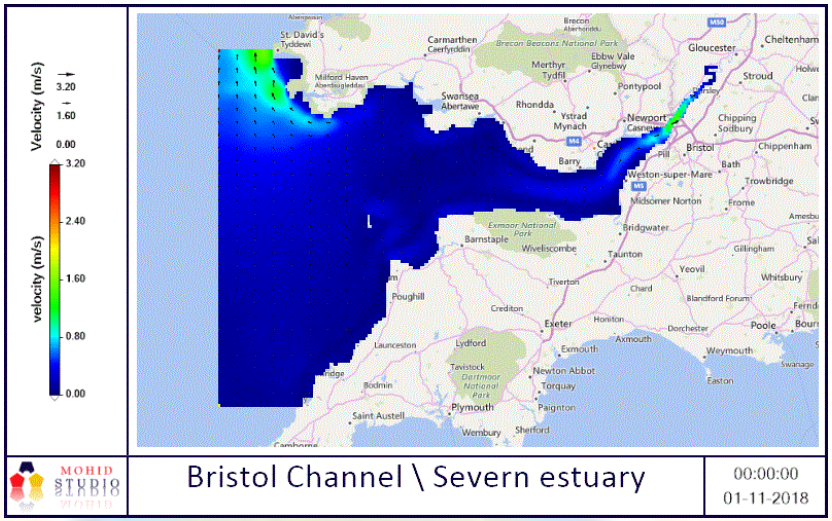
Estuarine models

Estuarine model – Severn

- 2 nested domain: 4km and 1km horizontal resolution
  - Swansea area 250 m model resolution
- 3D baroclinic model: 23 vertical levels







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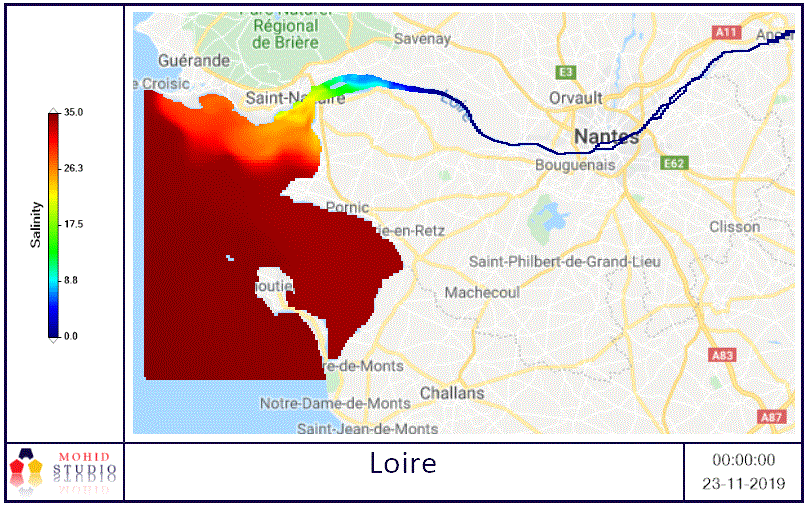
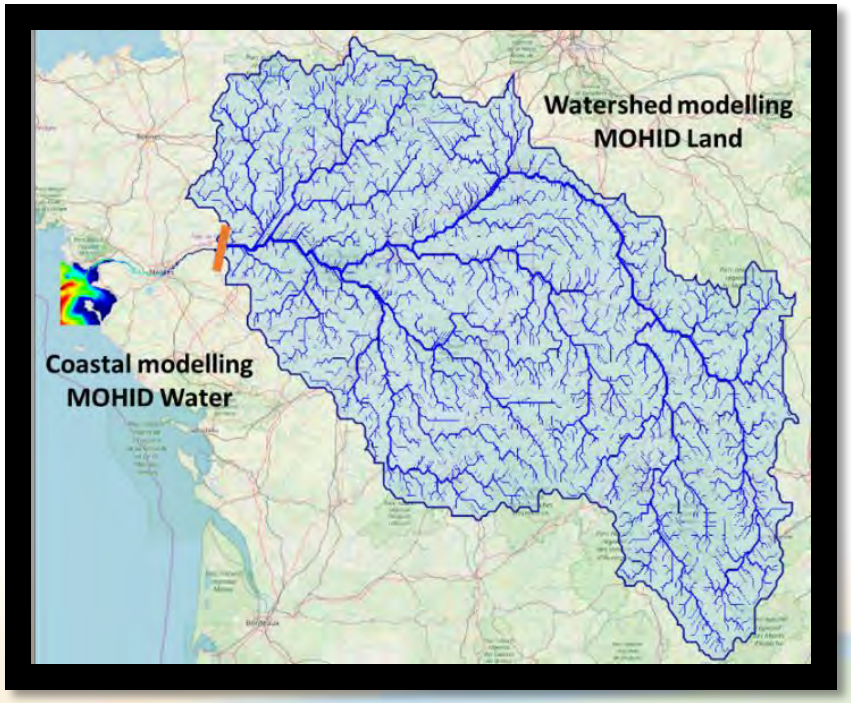
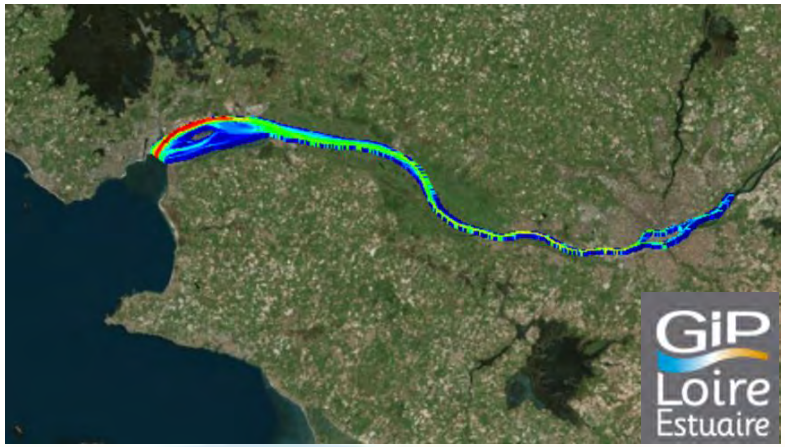
Estuarine model – Loire

- 3 nested domain: 4km, 1km, 400-200m horizontal resolution
- 3D baroclinic model: 26, 26, 19 vertical levels







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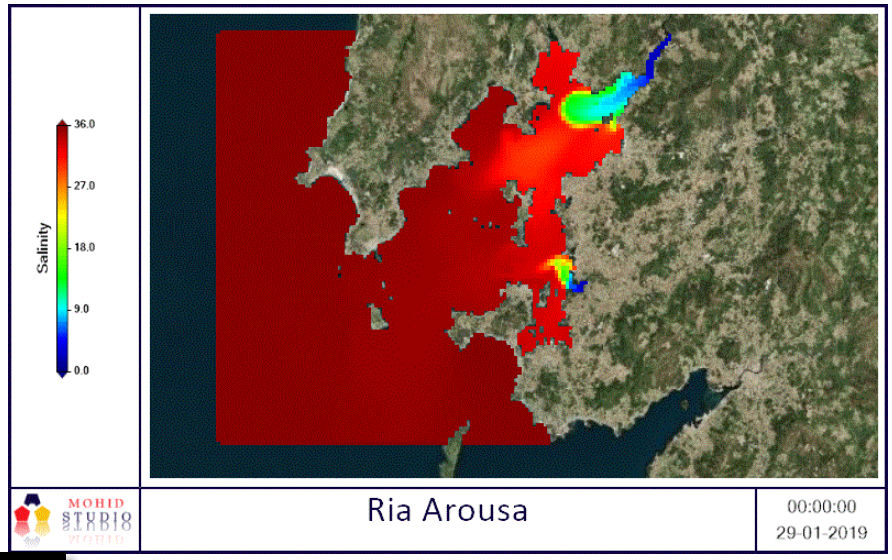
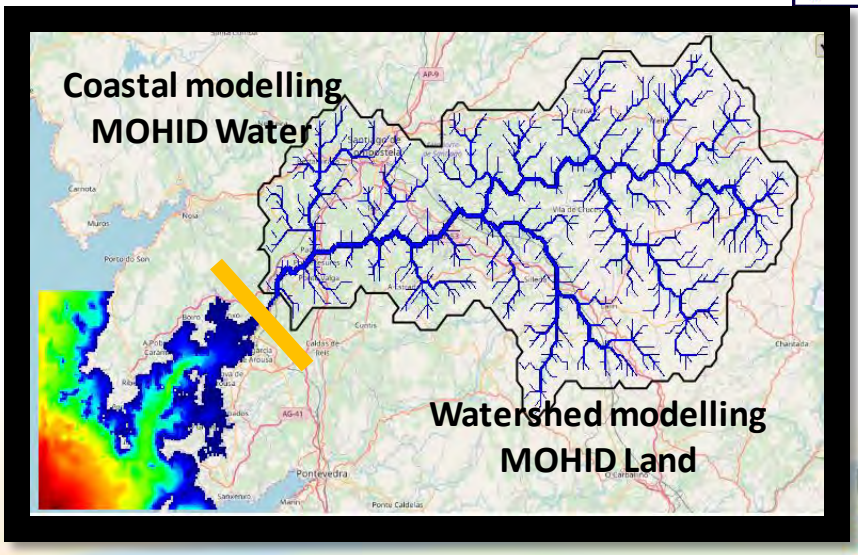
Estuarine model – Ria de Arousa

meteogalicia

3D baroclinic model
- 34 vertical levels

Main Parameters
- Water level
- Velocity
- Temperature
- Salinity





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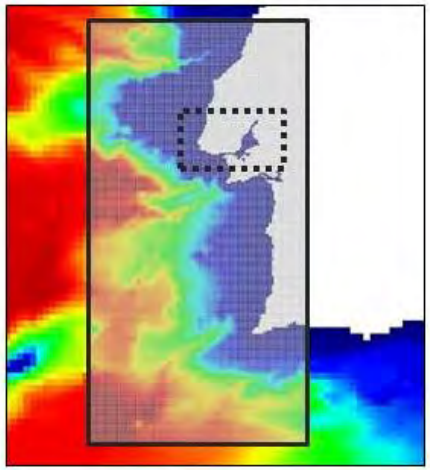
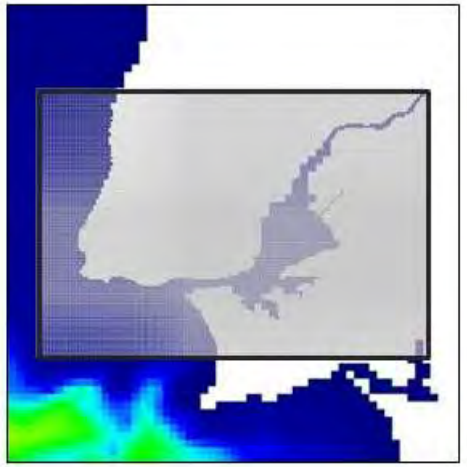
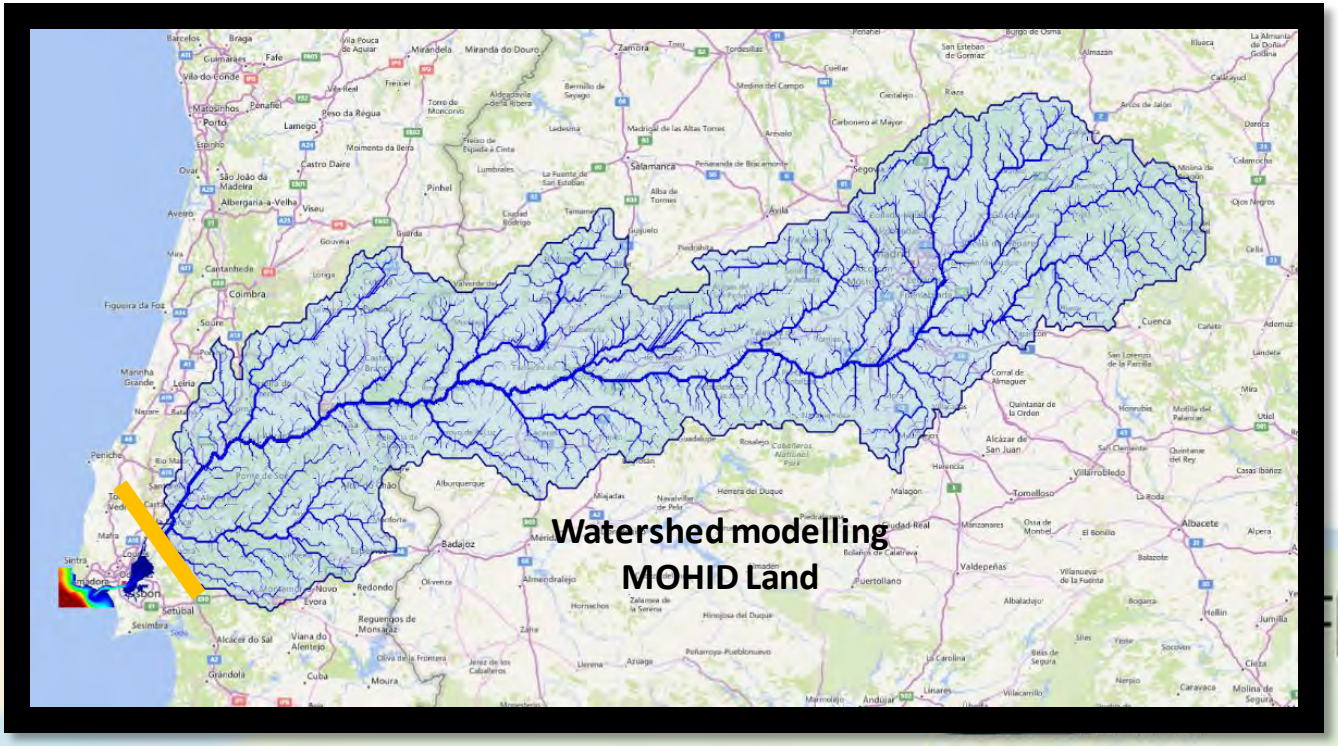
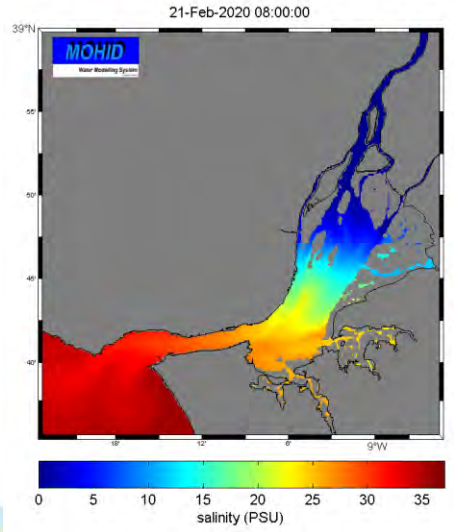
Estuarine model – Tagus

- 2 nested domain: 5km, 2km-200m horizontal resolution
- 3D baroclinic model: 50 vertical levels
- Water quality: Dissolved oxygen, Nitrate, Chlorophyll.









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HazRunoff platform

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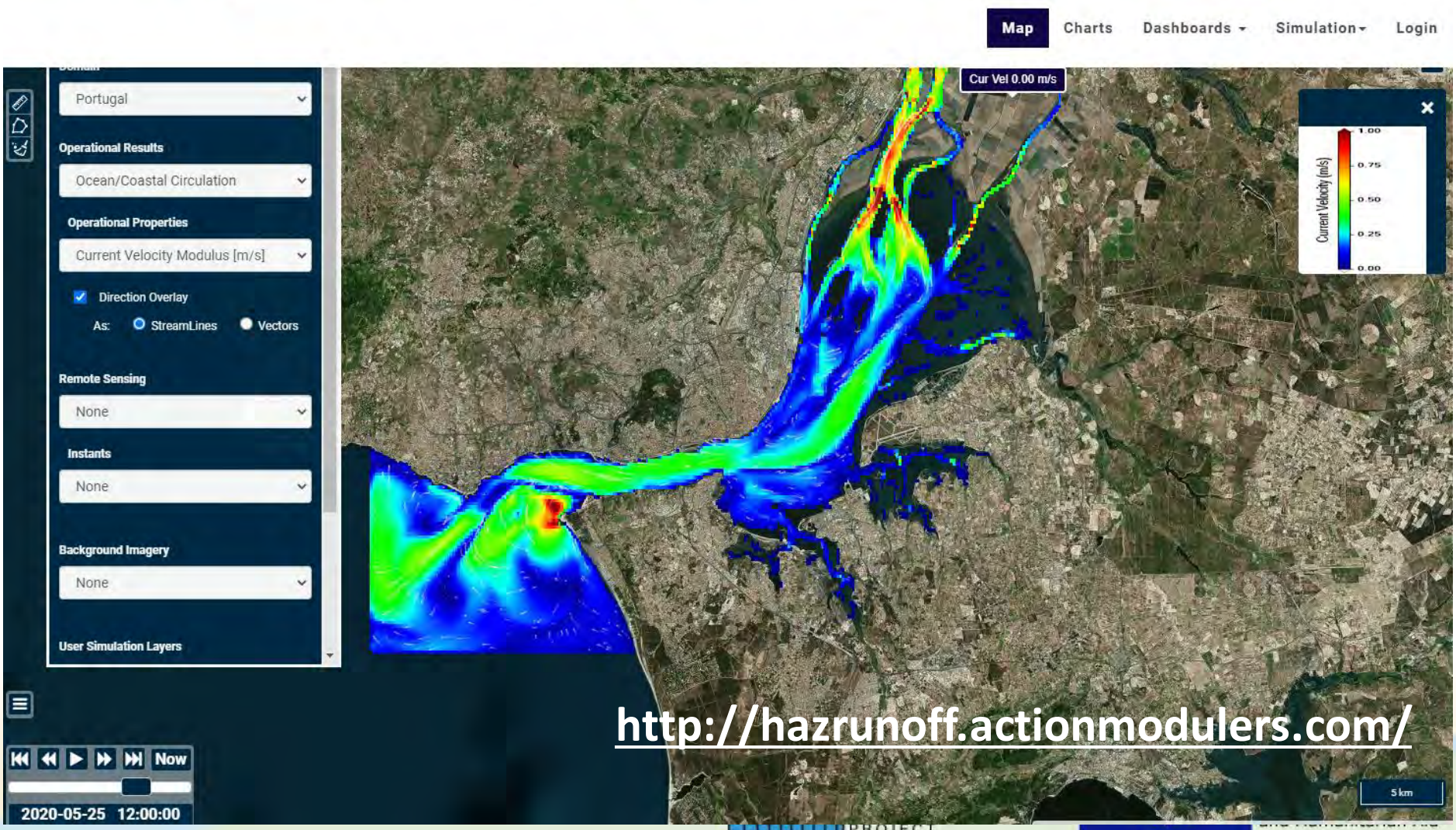
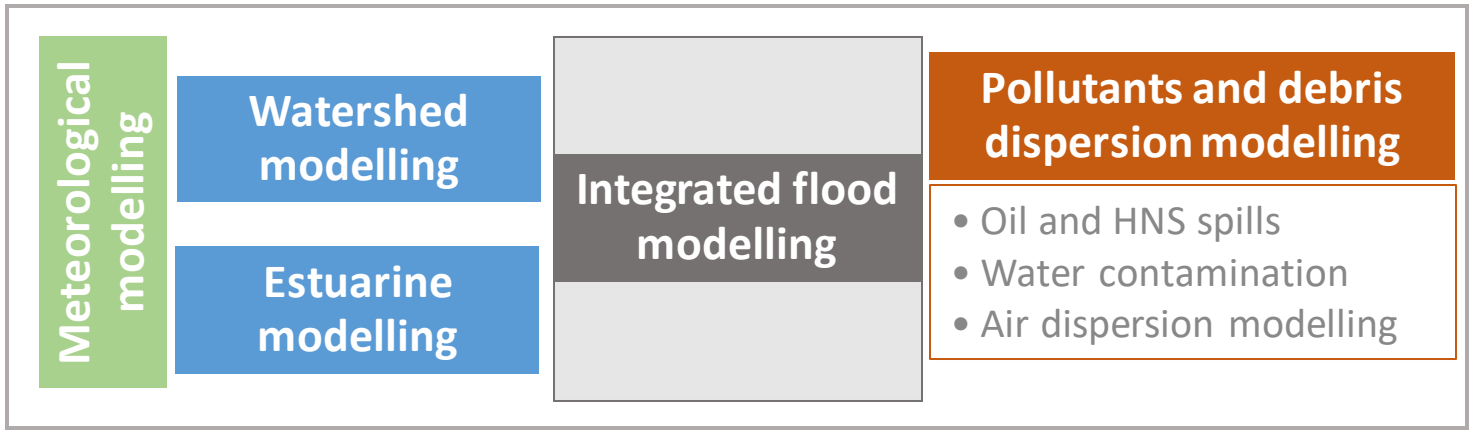


Integrated flood model



- An example of application is the environmental risk analysis of radioactive contamination from nuclear powerplants:
  - Study of potential impacts from a hypothetical water leakage in a nuclear powerplant in Spain (Almaraz), and the potential impact in Portugal, between the Tagus River and the coastal area around Lisbon metropolitan area.

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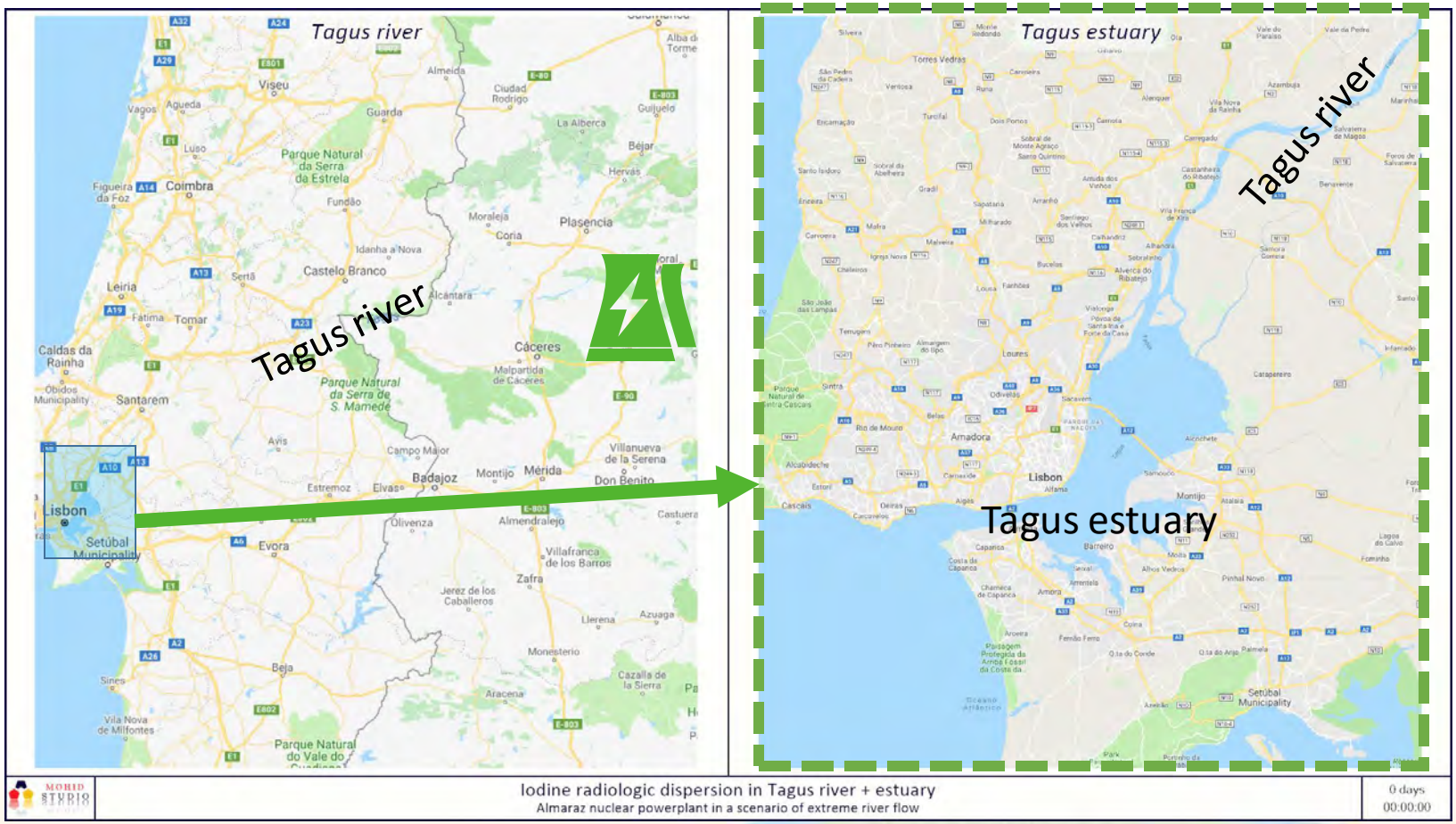
Floods & water pollution

- Virtual scenario: a nuclear power plant has a leakage of radioactive material due to flood



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Urban flood models

Flooding - Padrón, Galicia, Spain (14 January 2016)

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Primer Plano Opinión Galicia Santiago Área Tendencias Deportes Última Hora Más

14 ENE 2016 / 10:42

intensas lluvias

El temporal inunda casas, carreteras y provoca desprendimientos en la provincia de A Coruña

Se vieron afectadas localidades como Negreira, Outes, Curtis o Carballo, entre otras

(ECG)

Las fuertes lluvias caídas durante la pasada noche han causado numerosas inundaciones de viviendas, garajes y carreteras, así como desprendimientos de tierra. La zona más afectada, según los datos del Centro de Atención a Emergencias 112-Galicia, ha sido la provincia

LO MÁS VISTO

Fase 2 / Así quedan las normas de la fase 2 de la desescalada
24 may 2020 / 14:29

Galicia se reivindica para salir del estado de alarma "en los próximos días"
24 may 2020 / 19:04

Albergues privados piden exclusividad
24 may 2020 / 01:10

Playas / Desencuentro por el aforo de playas y la pleamar: el Atlántico no es el Mediterráneo

La Voz de Galicia

SANTIAGO

«Os veciños facemos garda para ver como está o río pero esta nova inundación colleunos durmindo»

Alicia Cardama, vecina del lugar de Lamas, en Padrón, reclama soluciones después de ver cómo su casa se ha vuelto a anegar. La segunda inundación en menos de una semana

O.S.
15/01/2016 09:08 H

Está acostumbrada a ver el río Sar desbordarse y a que el agua le llegue al felpudo, pero sufrir dos inundaciones en menos de una semana ha agotado su paciencia. Alicia Cardama, la vecina del lugar de Lamas, en Padrón, que el viernes pasado contemplaba

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Flooding - Padrón, Galicia, Spain (14 January 2016)

La Voz de Galicia

ÁLBUMES 13 DE 13

Terrenos de la parte posterior del polígono de Pazos (Padrón) tras las nuevas inundaciones. MERCE ARES

La aldea de Lamas, nuevamente inundada

Algunos domicilios acumulan hasta metro y medio de agua en su interior

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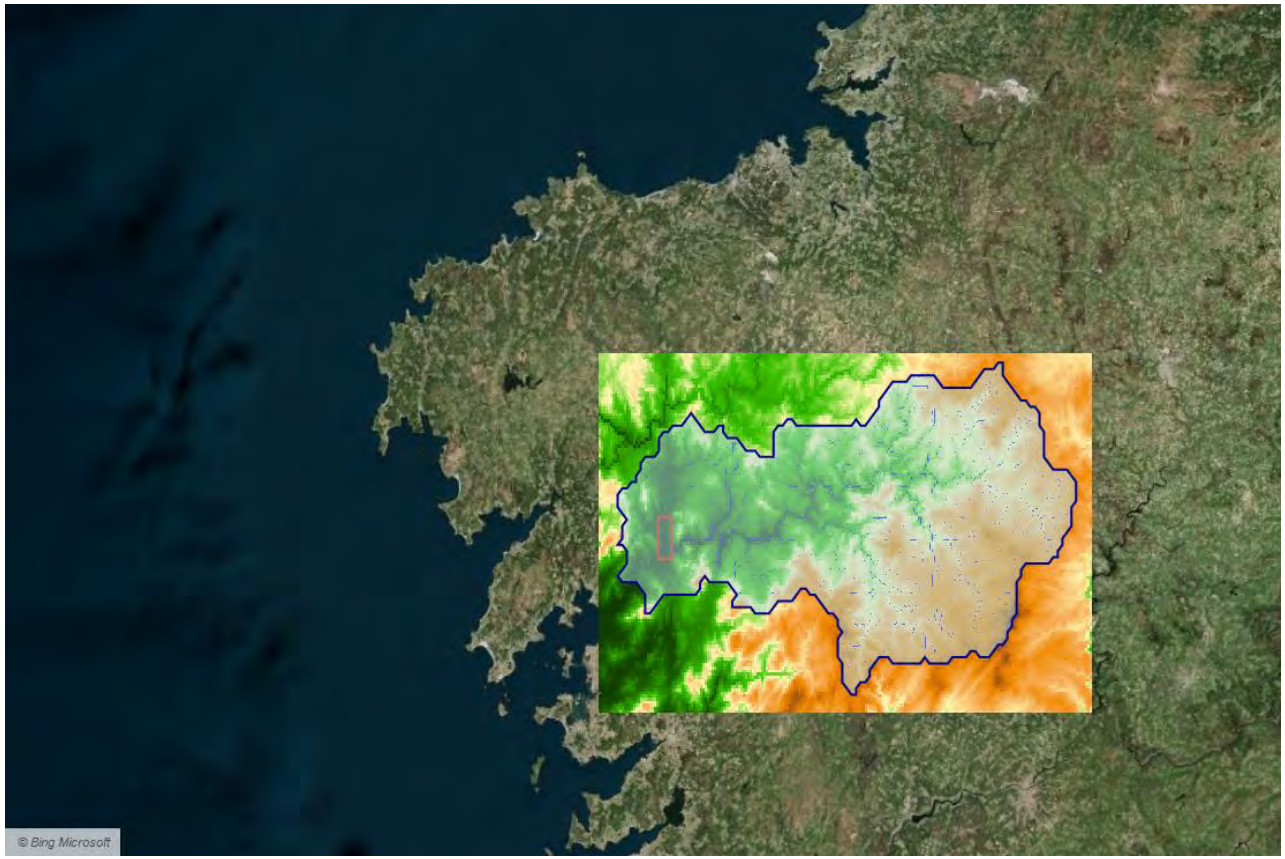
Floods near Padrón, Galicia, Spain



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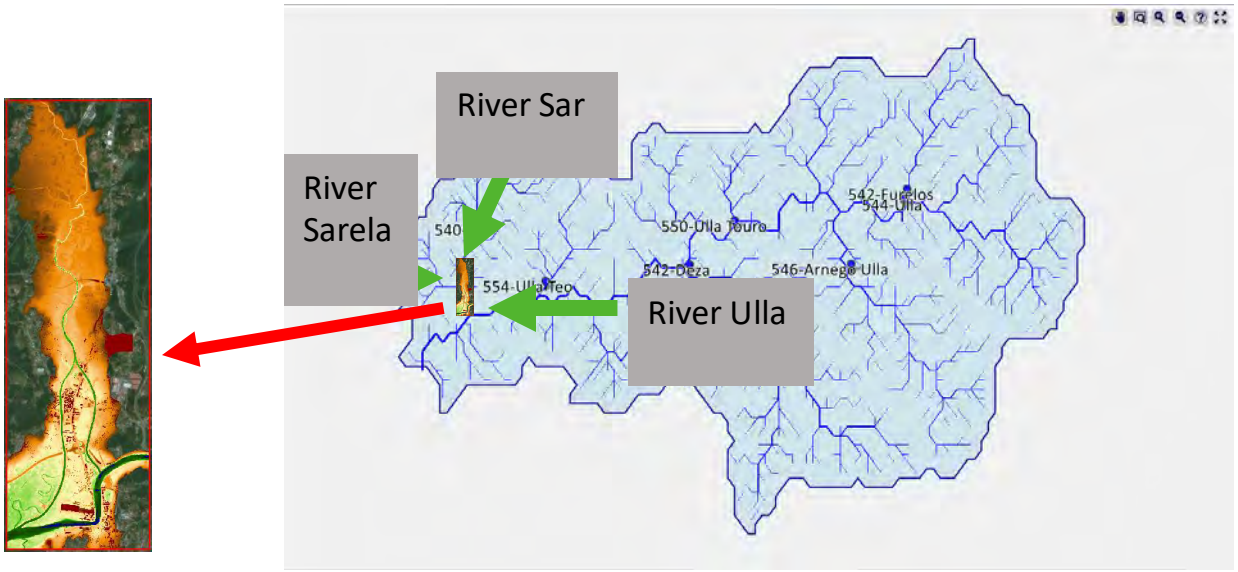
Flood modelling – Padrón (Galicia)

- Integration with Mohid Land (500m resolution) watershed model for boundary conditions



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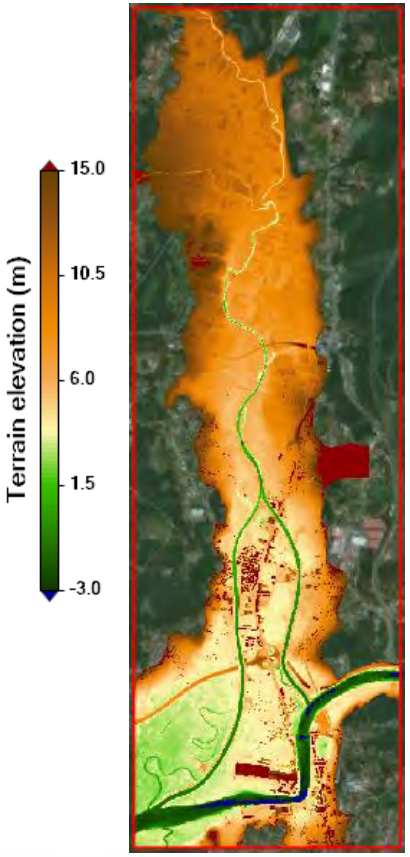
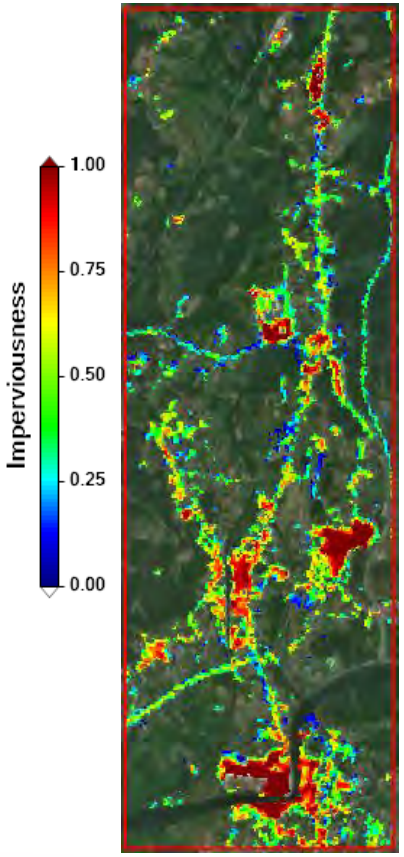
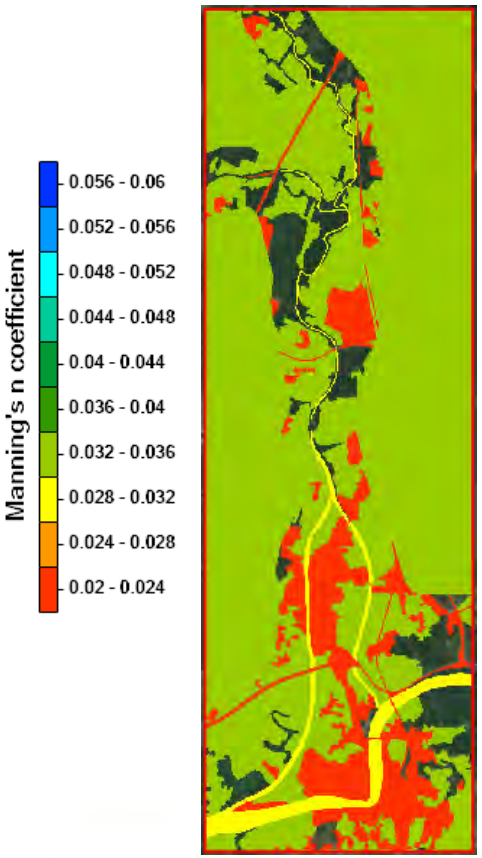
Model setup



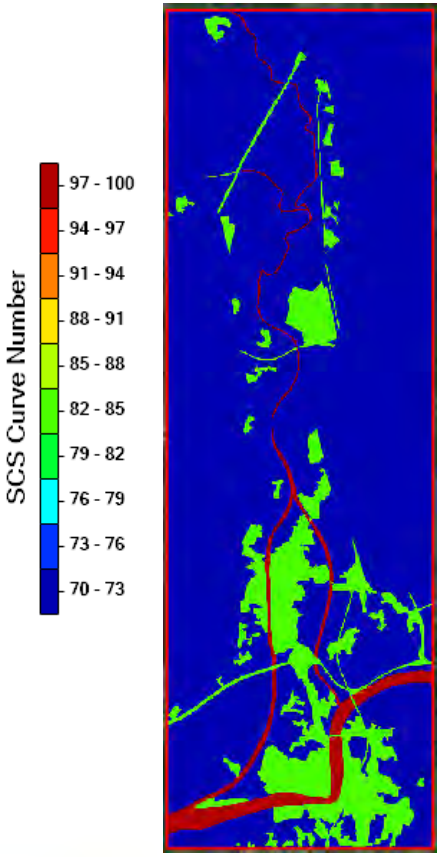
Digital terrain model



Impermeability



Manning's coef.



Curve Number.

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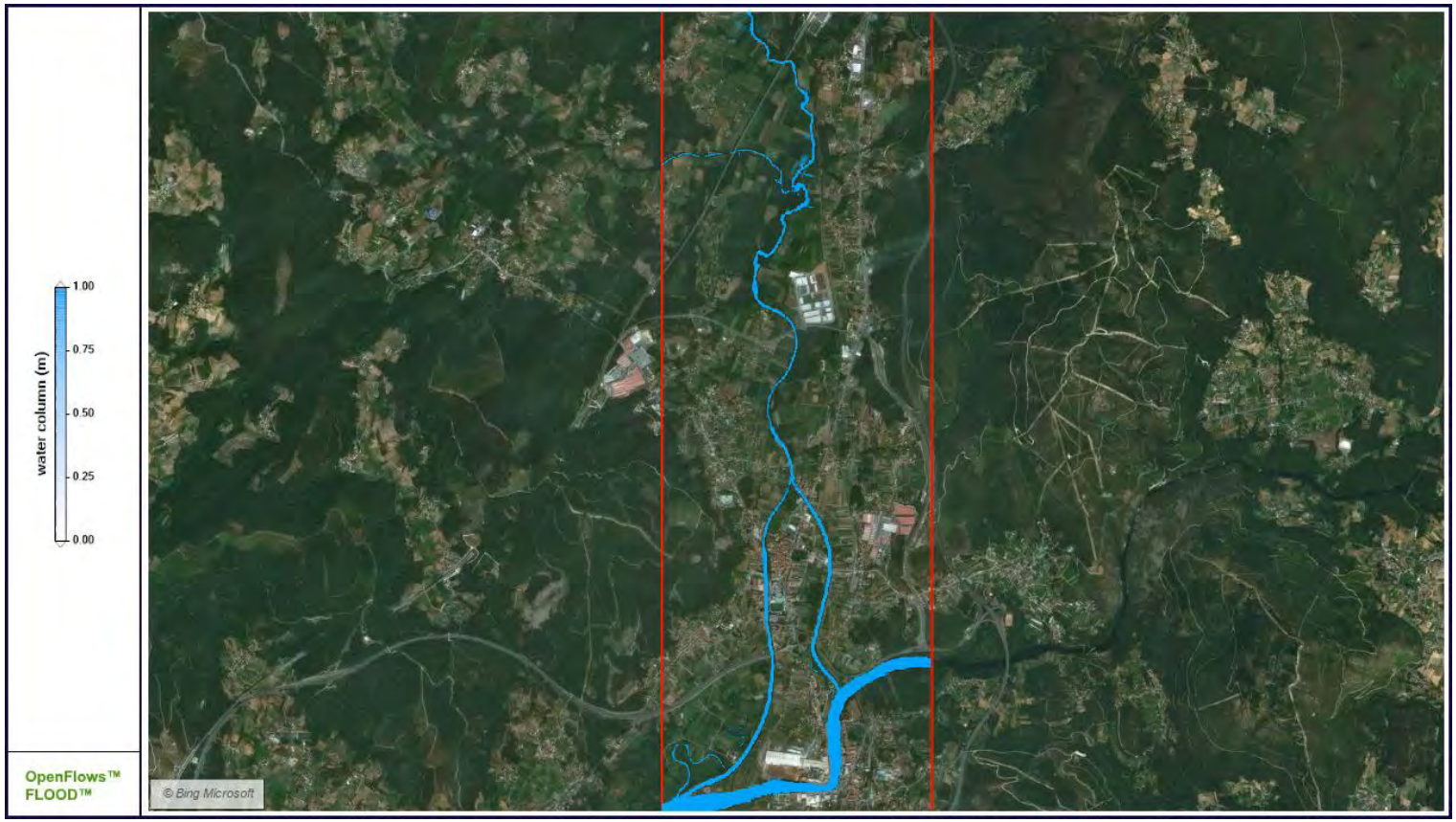

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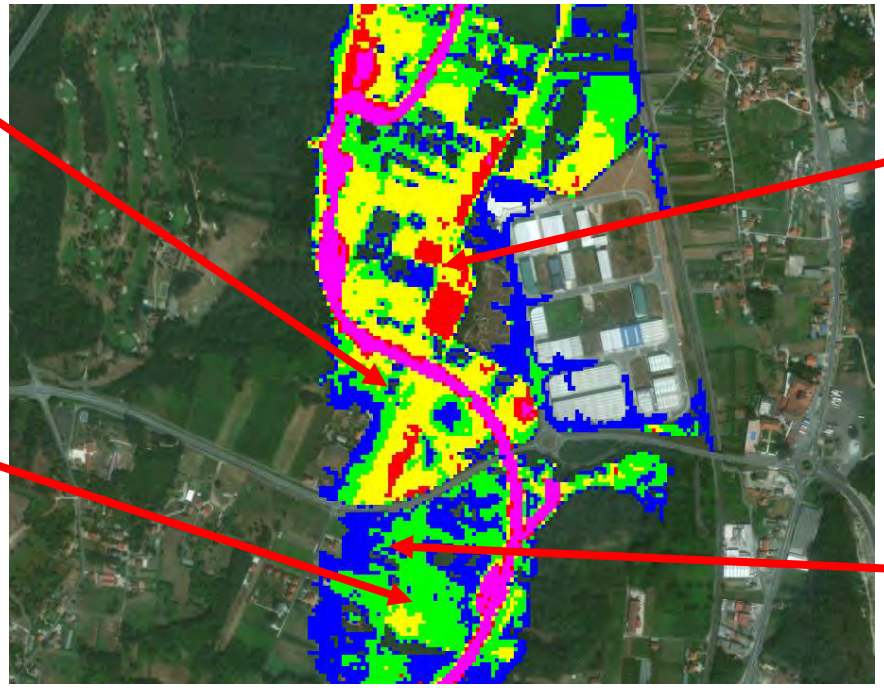
Flooding - Padrón, Galicia, Spain (14 January 2016)



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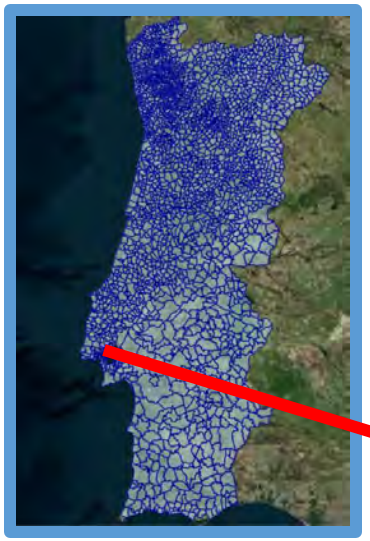
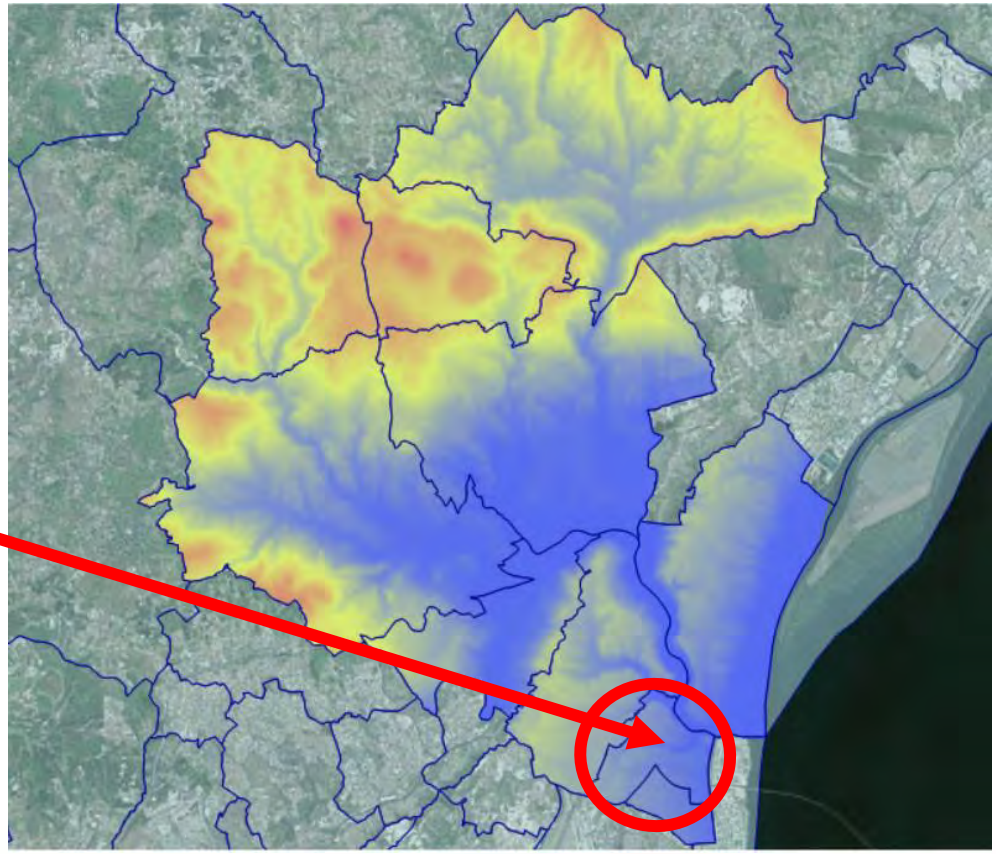
Urban flood modelling – Loures municipality (Sacavém)





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Urban flood modelling –Sacavém, 2008

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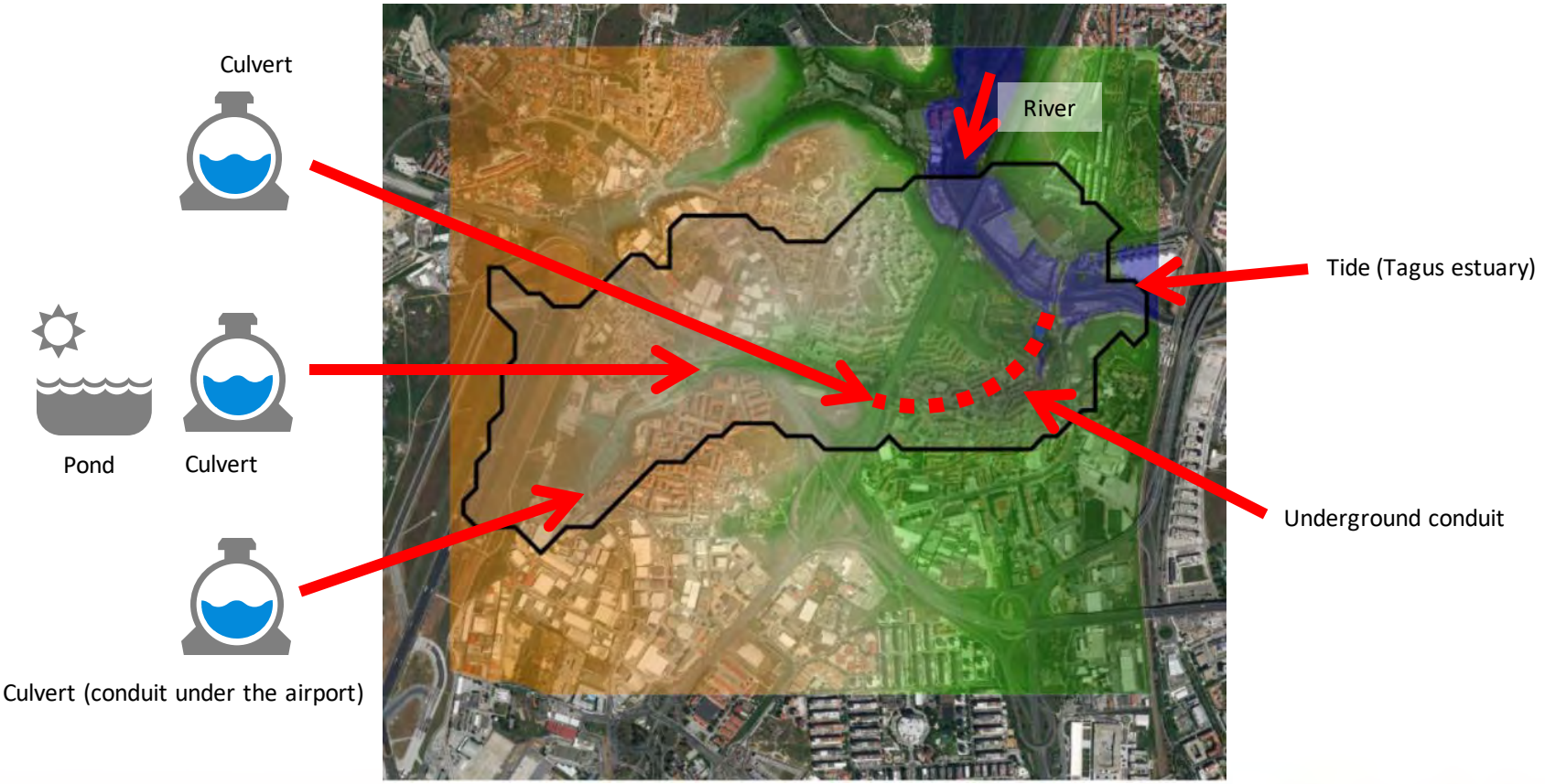
Watershed delineation, DTM and main features



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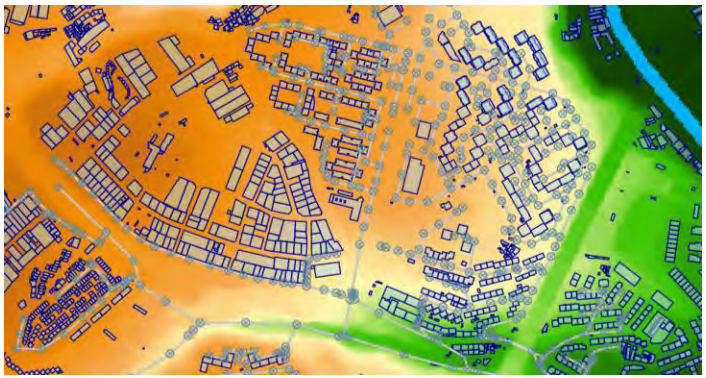
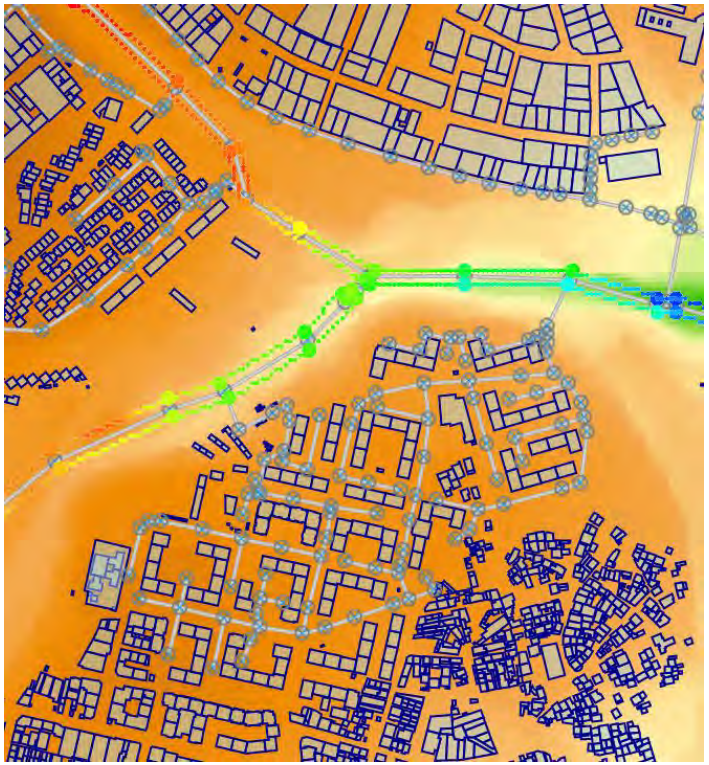
Stormwater system





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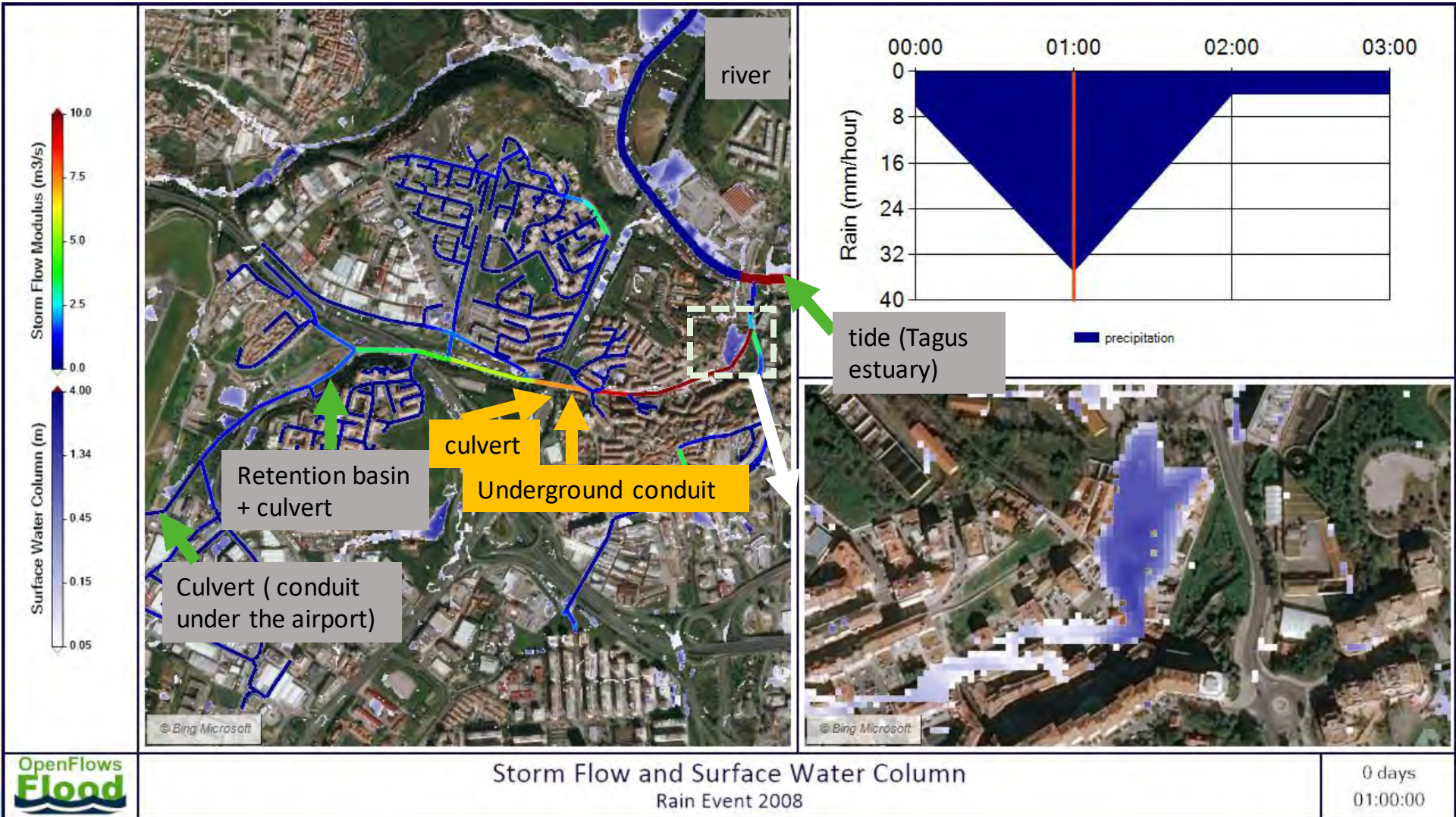
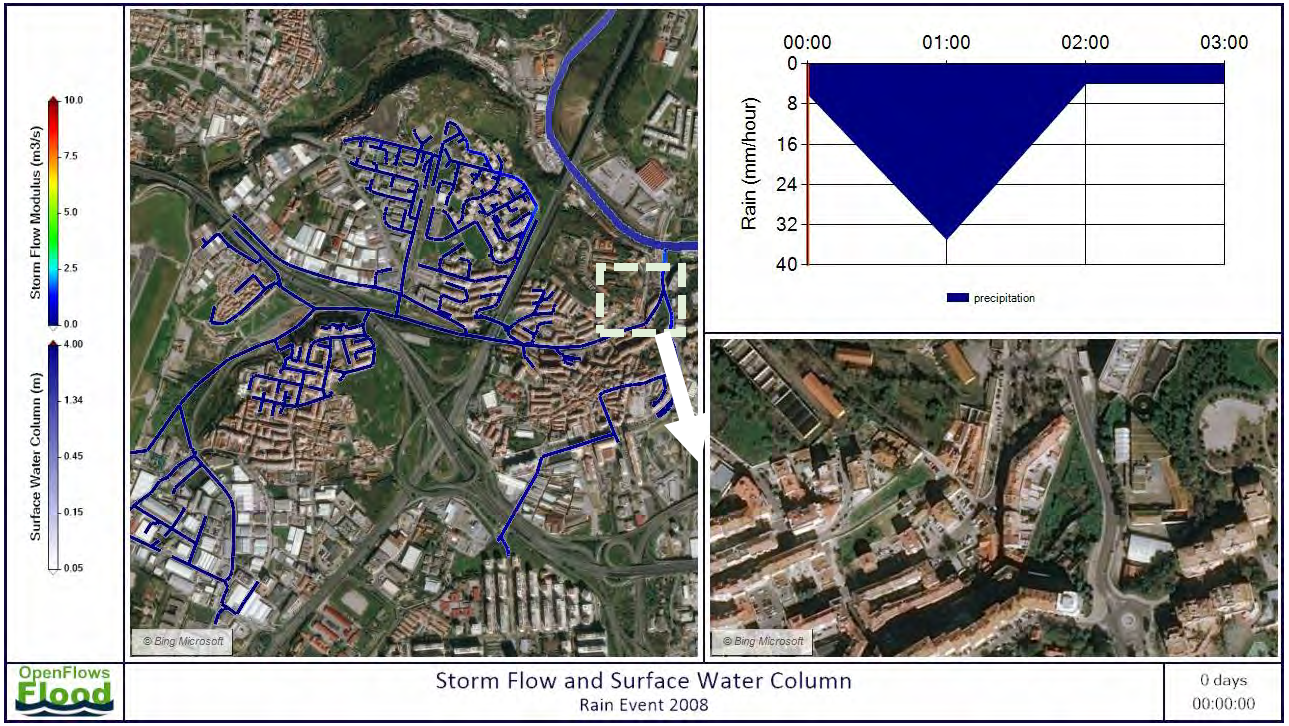
Integrated urban flooding

- dynamic exchange between open channels, underground conduits, and surface runoff



Integrated urban flooding

- dynamic exchange between open channels, underground conduits, and surface runoff



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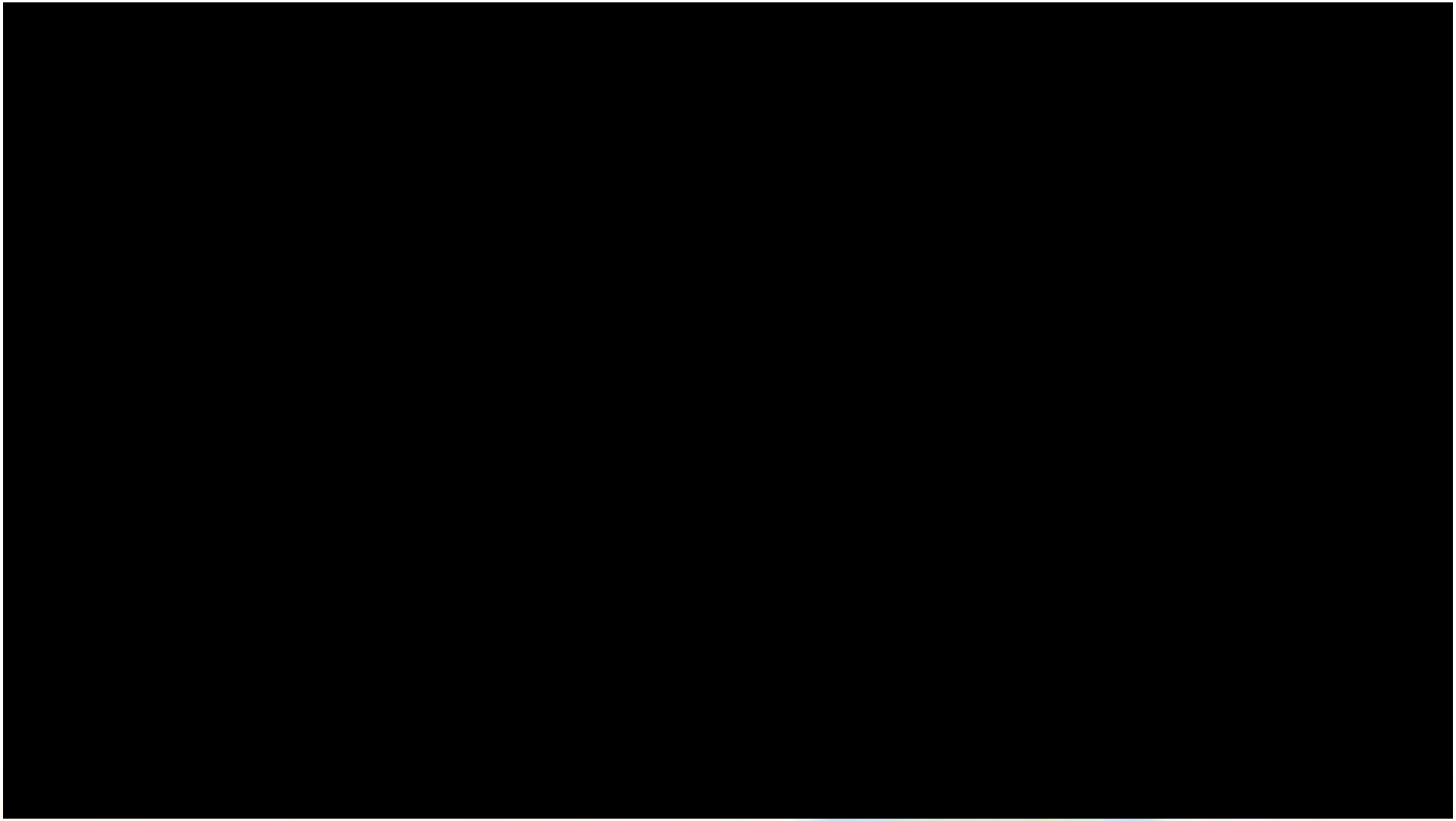
Sacavém 3D reality model



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Sacavém – Flood reality modelling

Obrigada

Thank you

TÉCNICO LISBOA

Bentley Advancing Infrastructure

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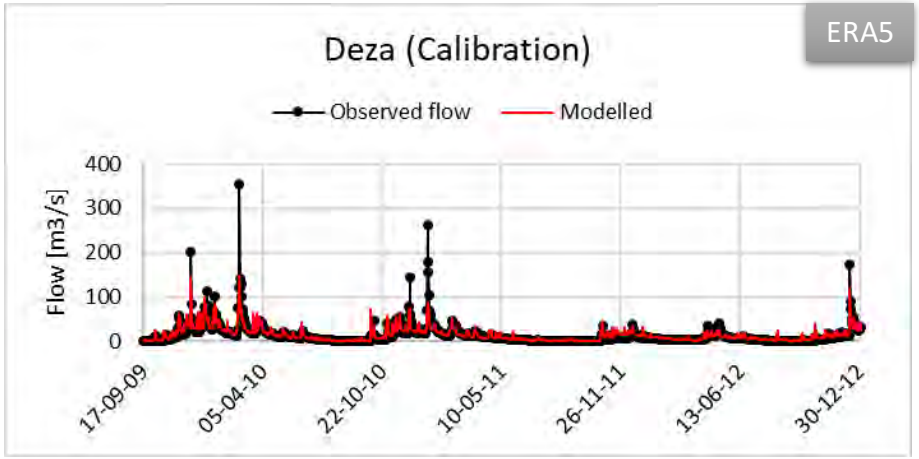
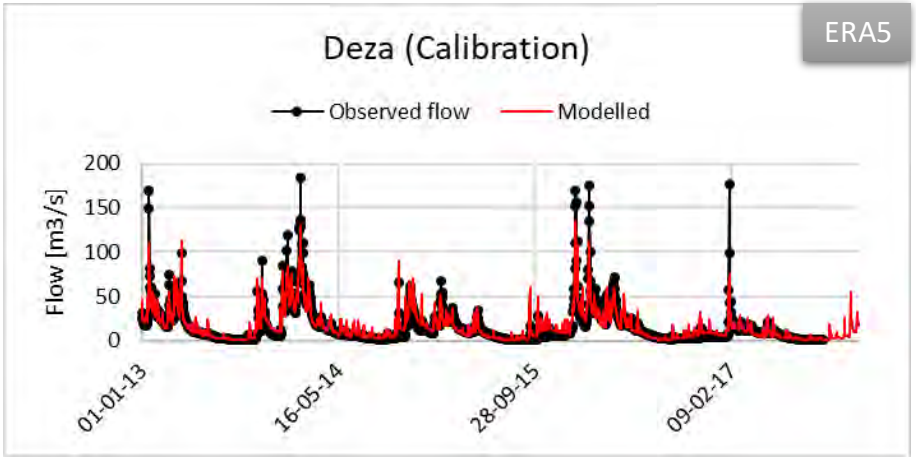
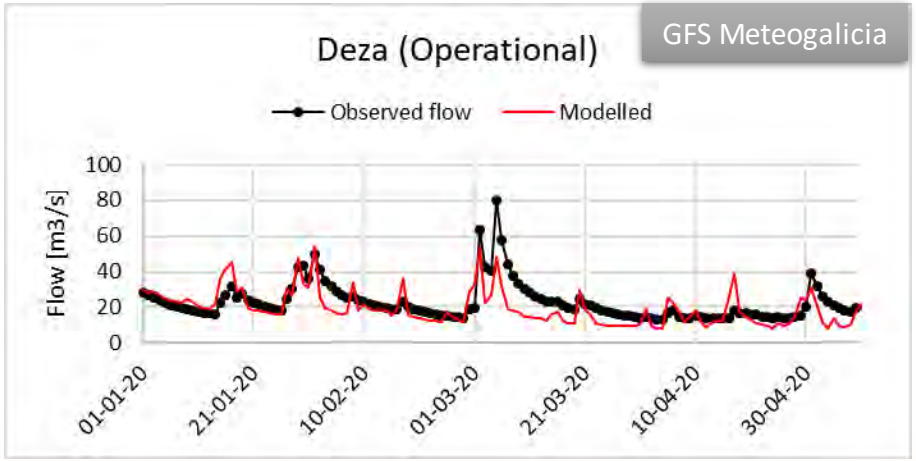
Natural flow regime







Statistical parameter	*Calibration*	*Validation*	*Operational*
NSE	0.72	0.84	0.28
PBIAS	-9	-4	17
R2	0.74	0.85	0.45
RMSE	11	8	9

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