Hindcasting Storm Surge and Overland Flooding at High Resolution using Delftd-3D Flexible Mesh: Case study - Xynthia Storm, France

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TU Delft Delft University of Technology
UNESCO United Nations Educational, Scientific and Cultural Organization
IHE DELFT Institute for Water Education under the auspices of UNESCO
AXA
AXA Research Fund
Deltares Enabling Delta Life

Motivation

- dynamically coupled Delft3D-FM and SWAN to **obtain storms surge** (SS) driven **flood depths (tide + surge + wave setup)** and **flow velocities** at high resolution (~10m).
- assess **economic loss** due to SS events by developing site specific **fragility functions**.
- quantitative **cost-benefit analyses** of proposed SS defense measures (i.e., levees, elevated landfill, seawalls, pumps) along coasts with high loss potential.

Case study: Xynthia storm, 27th-28th Feb 2010, in France

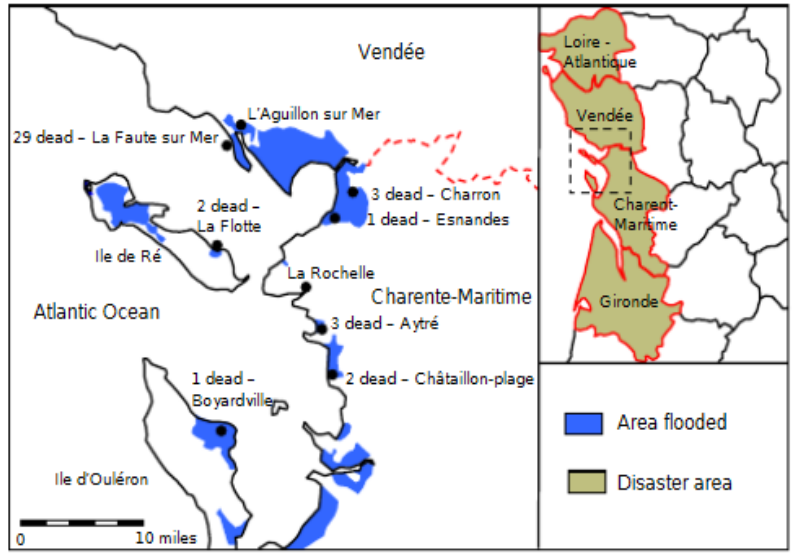
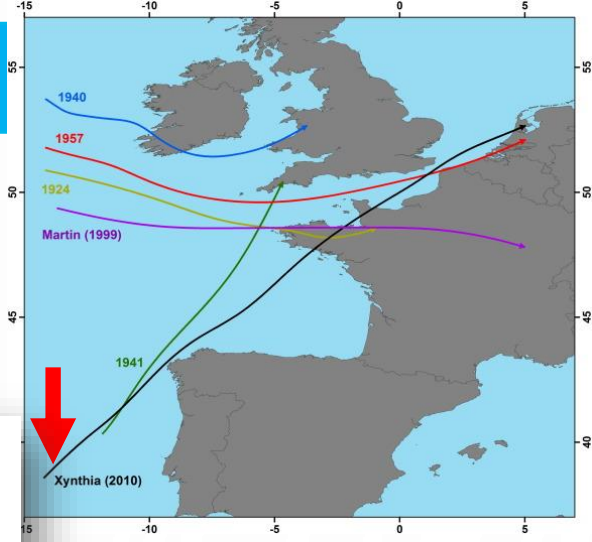


Fig. 3. Area flooded and the loss of life as the result of Xynthia in 2010.

D. M. Lumbroso and F. Vinet, 2011. Nat. Hazards Earth Syst. Sci., 11, 2321–2333

Xynthia storm track (27th – 28th Feb 2010)



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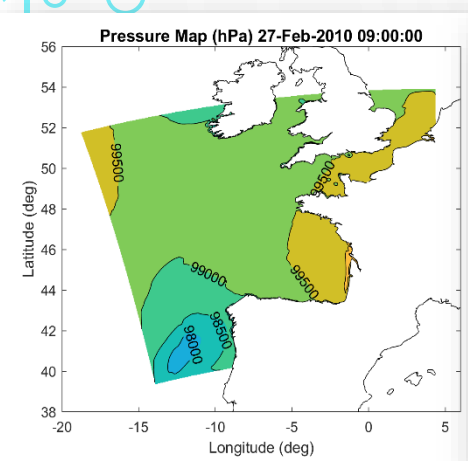

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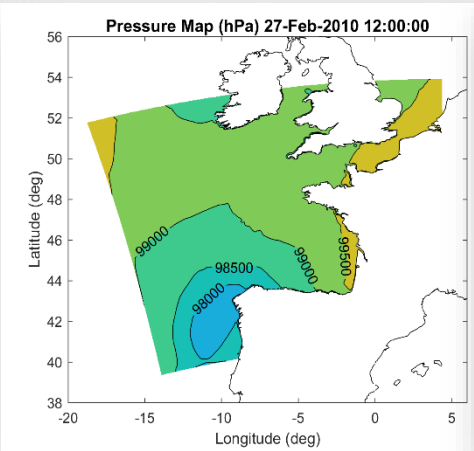

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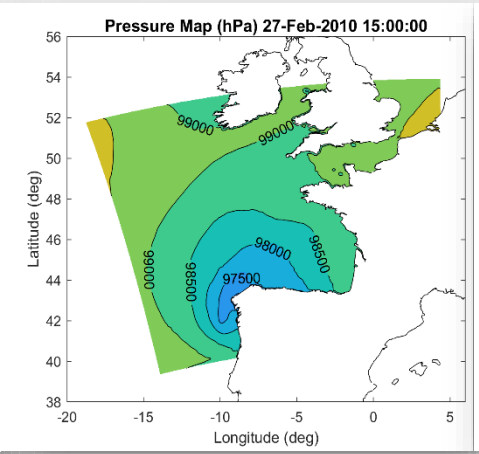

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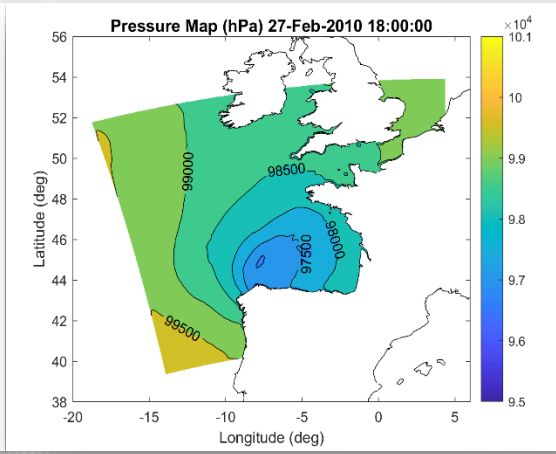

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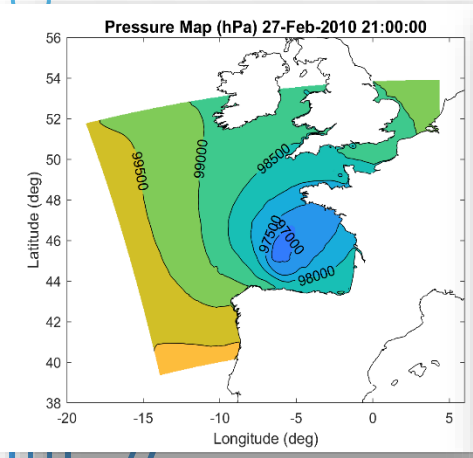

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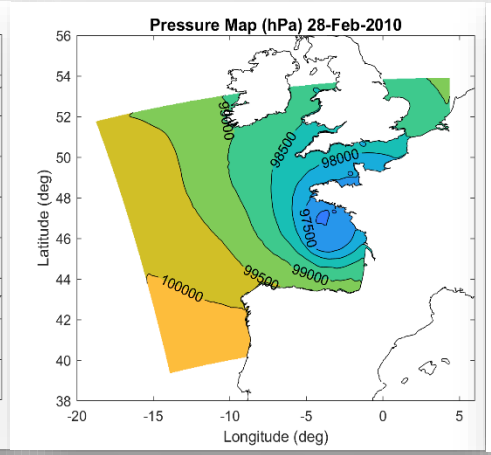

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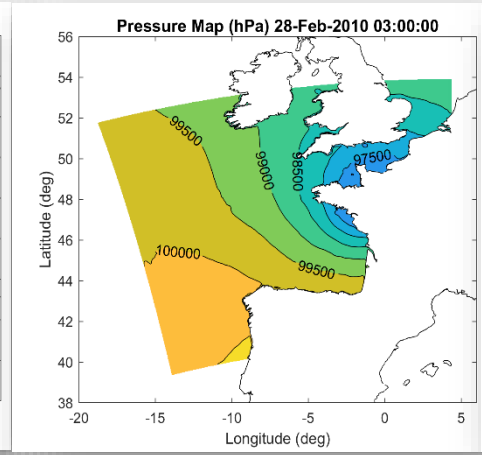

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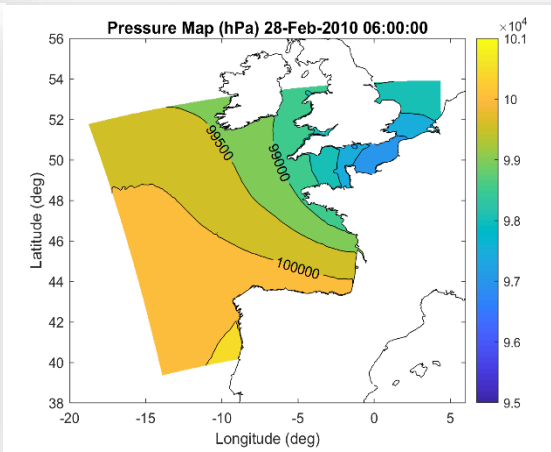

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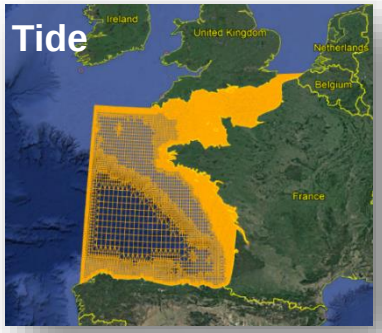
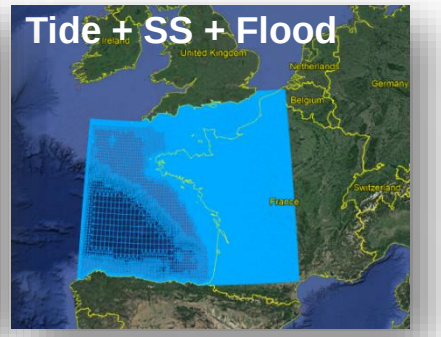
Modelling framework

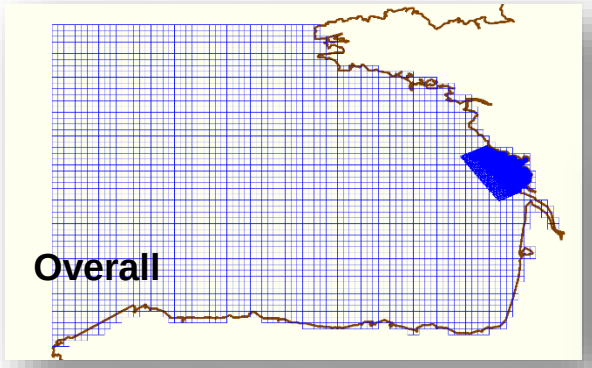
- **Large scale coarse** Delft3D-FM Tide, surge and flooding model (finest ~300m resolution), for **Bay of Biscay**.

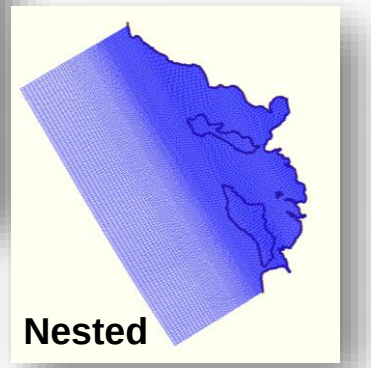




Tide/ Wind/ Pressure

- **SWAN** model (overall + nested)

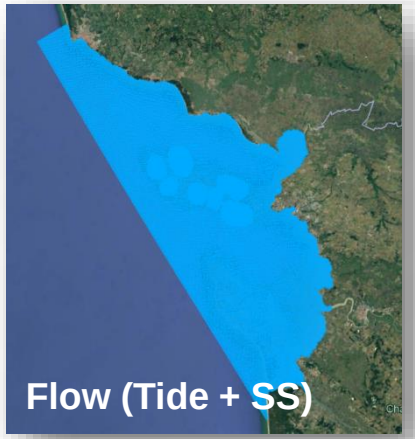


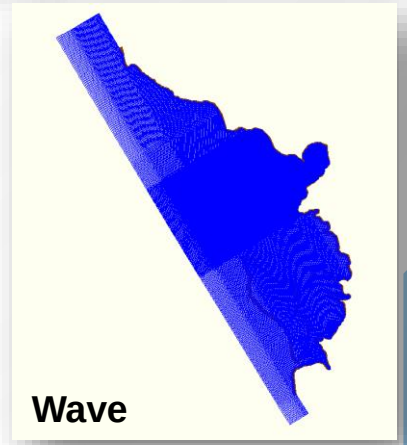


Wind/ ERA5 waves

- **Fine** Delft3D-FM model: **dynamically coupled** (tide, surge and wave) total WL and flooding with (~10m resolution), for **Ile de Re', France**

TWL = Tide + Surge + Wave set-up





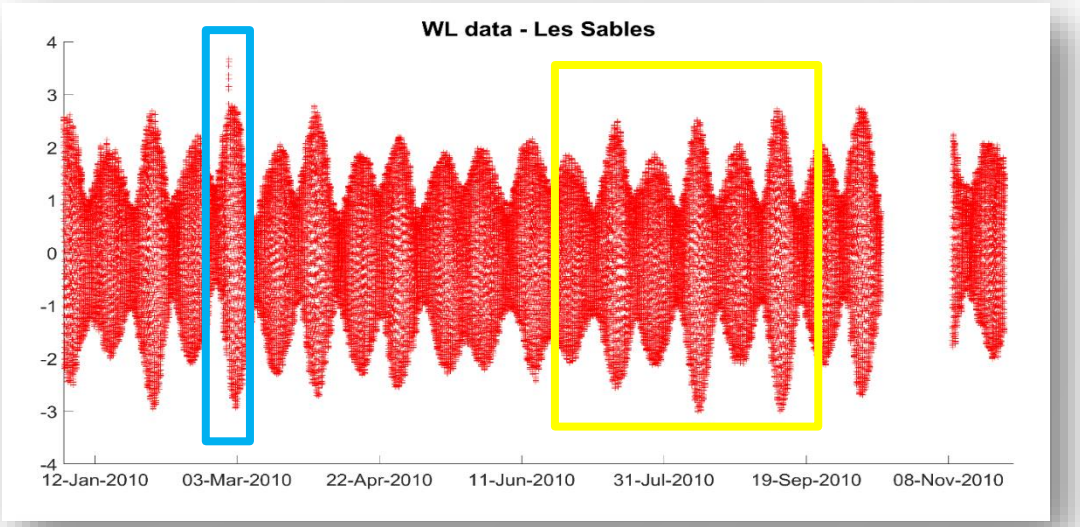
Model Simulation Time

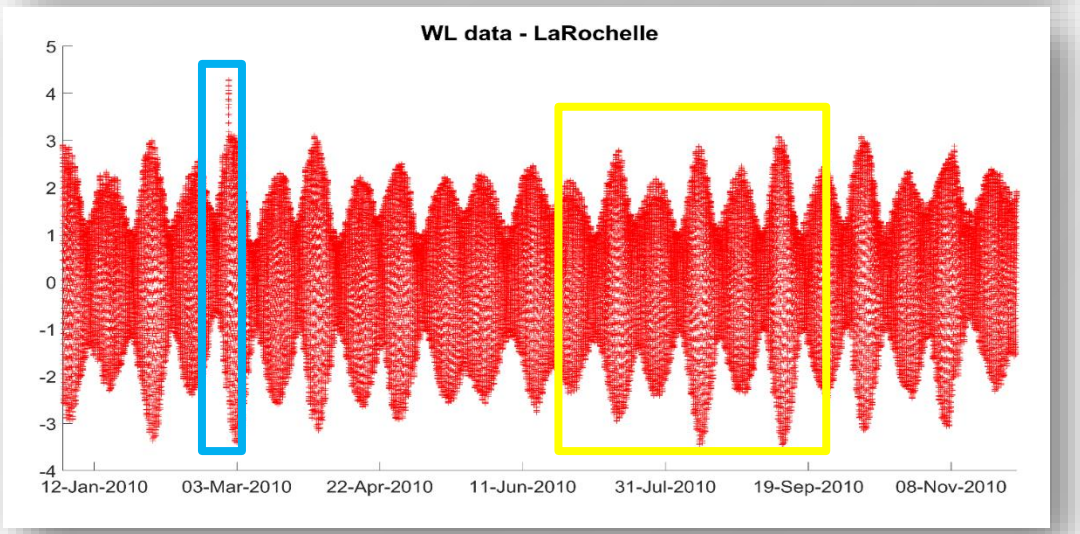
Large Scale Model	Simulation time	Forcing	Output	Bathymetry
Tide	25/06/2010-01/09/2010	- GTSM Tidal forcing	- His: 10mins	- Bathymetry: GTSM
Tide+SS+Flood	22/02/2010 - 05/03/2010	- GTSM Tidal forcing - Spatial downscaled wind and pressure fields	- His:10mins - Map:6hrs	- Bathymetry: GTSM - Topography: IGN DEM data (75m resolution)

Water Level data availability

- 2 stations with available WL data (Source: SHOM) in **year 2010**:

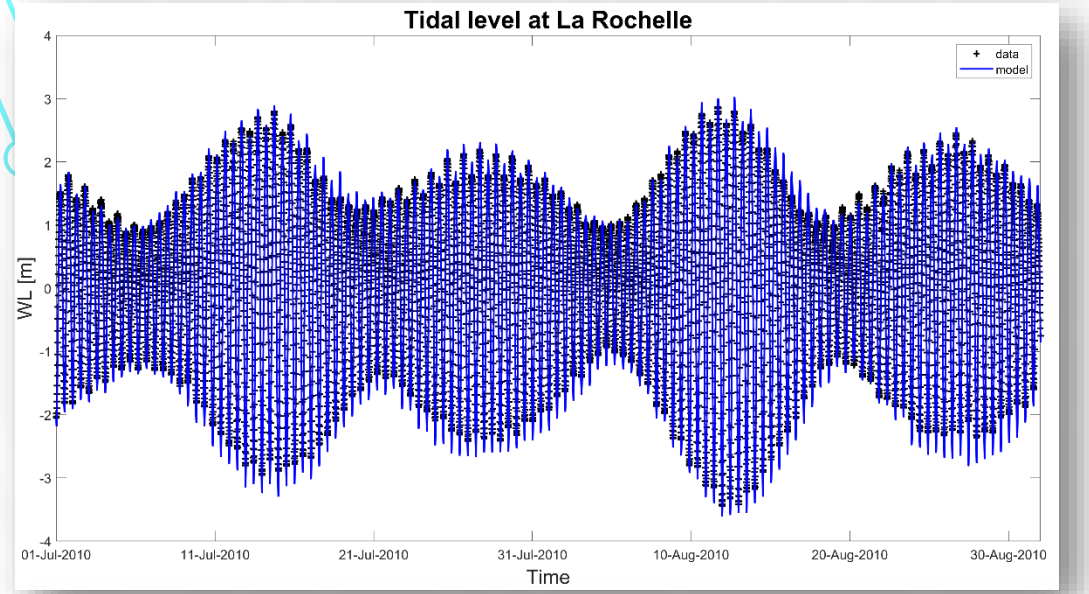
La Rochelle, Les Sables *(during: summer (yellow box) and Xynthia storm (blue box)).*

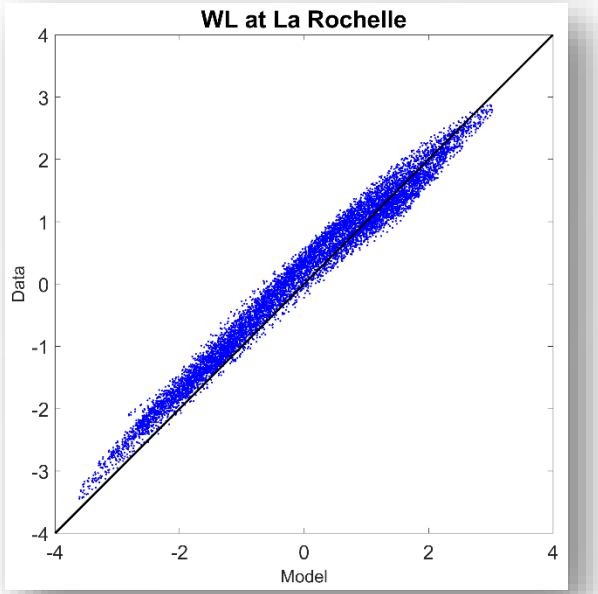




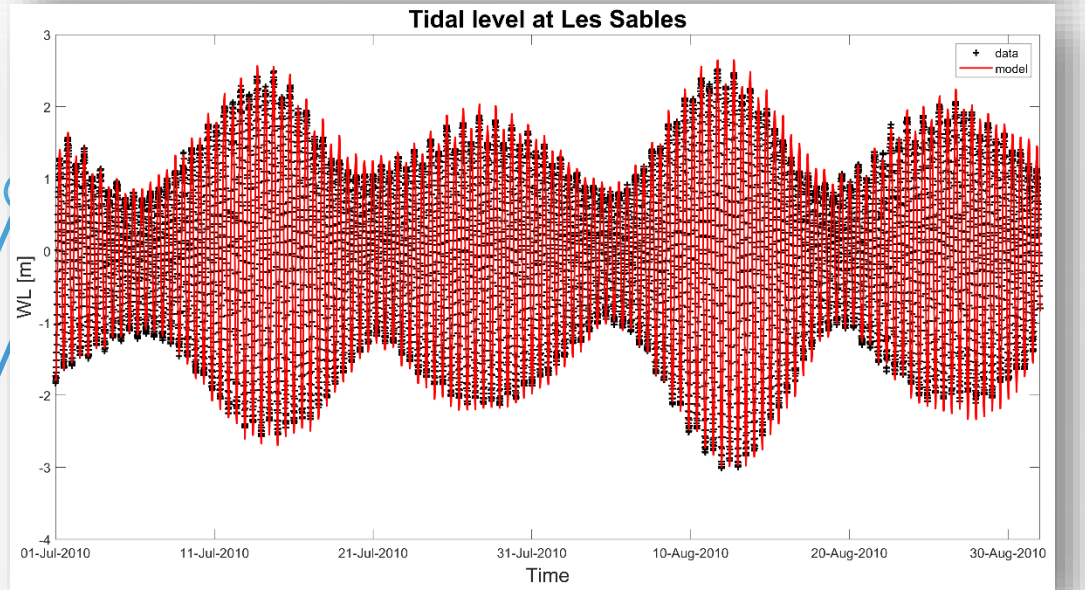
1. Large Scale Delft3D-FM Tide Model

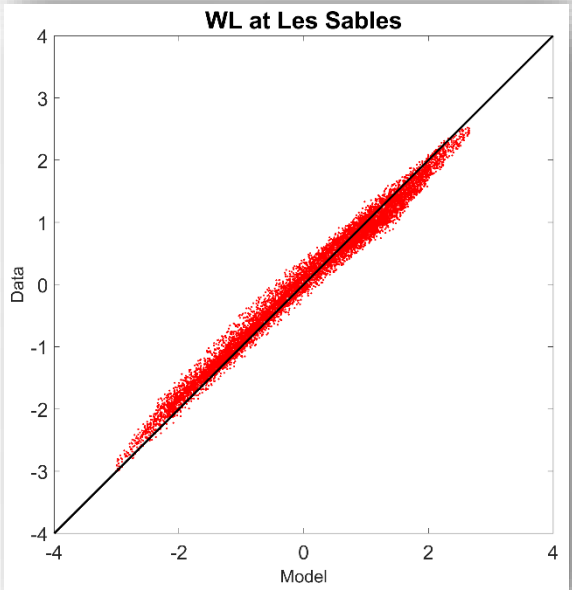
- Model Validation





Bias	RMSE
-0.15m	0.27m

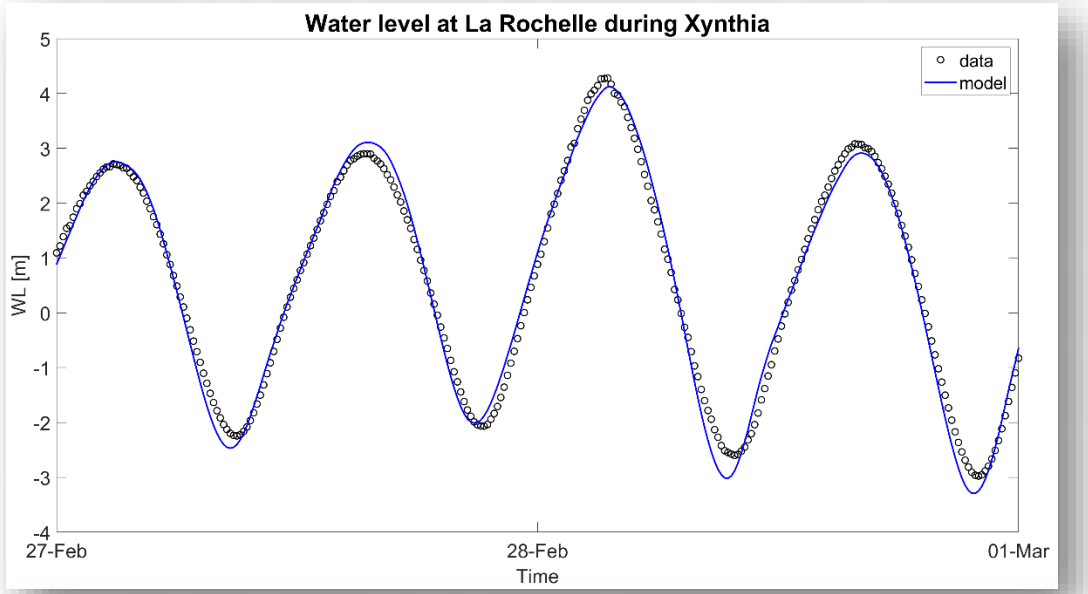


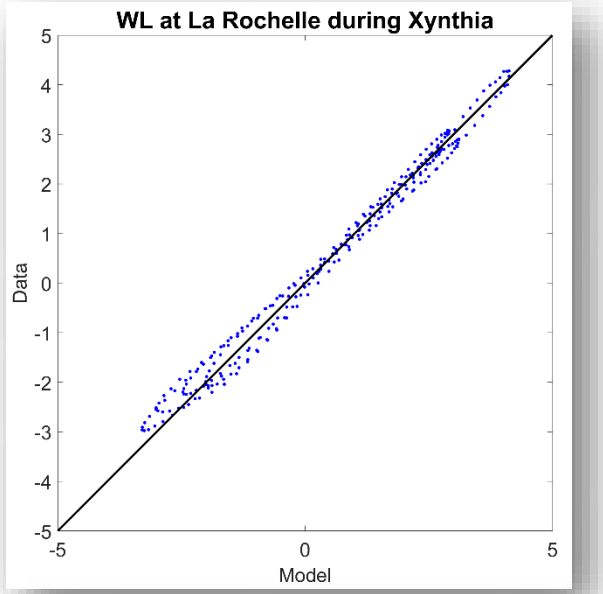


Bias	RMSE
-0.02m	0.16m

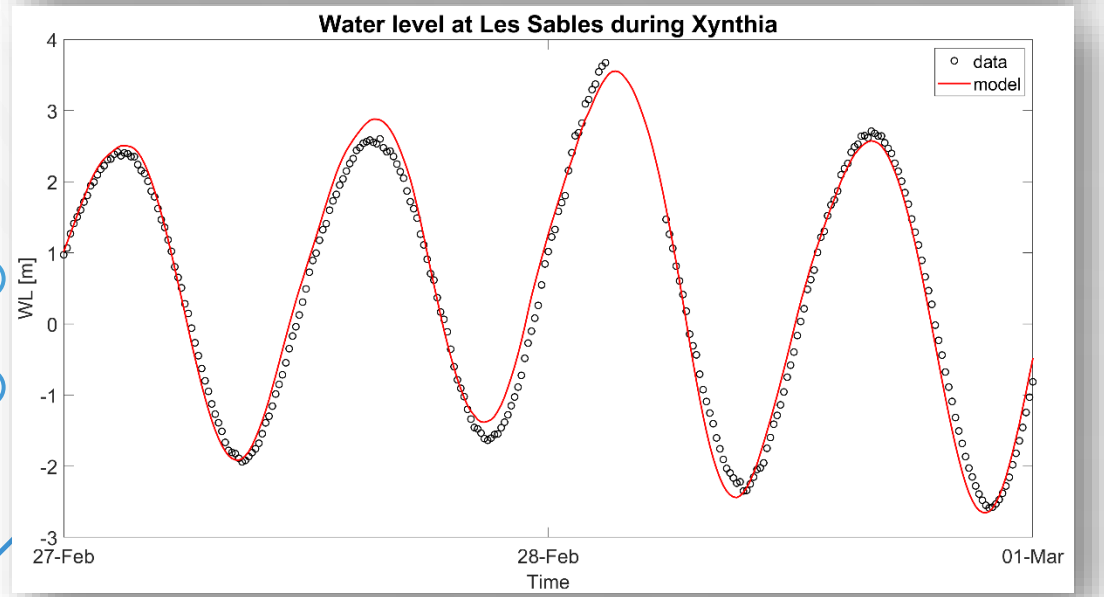
2. Large Scale Delft3D-FM Tide + SS + Flooding model

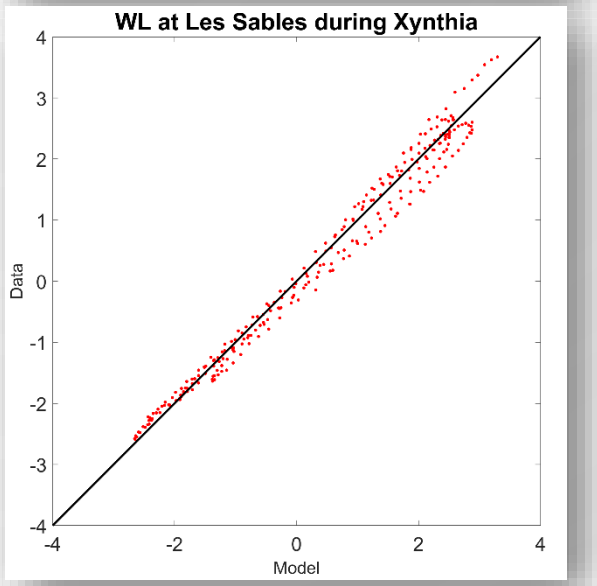
- Model Validation





Bias	RMSE
-0.02m	0.23m

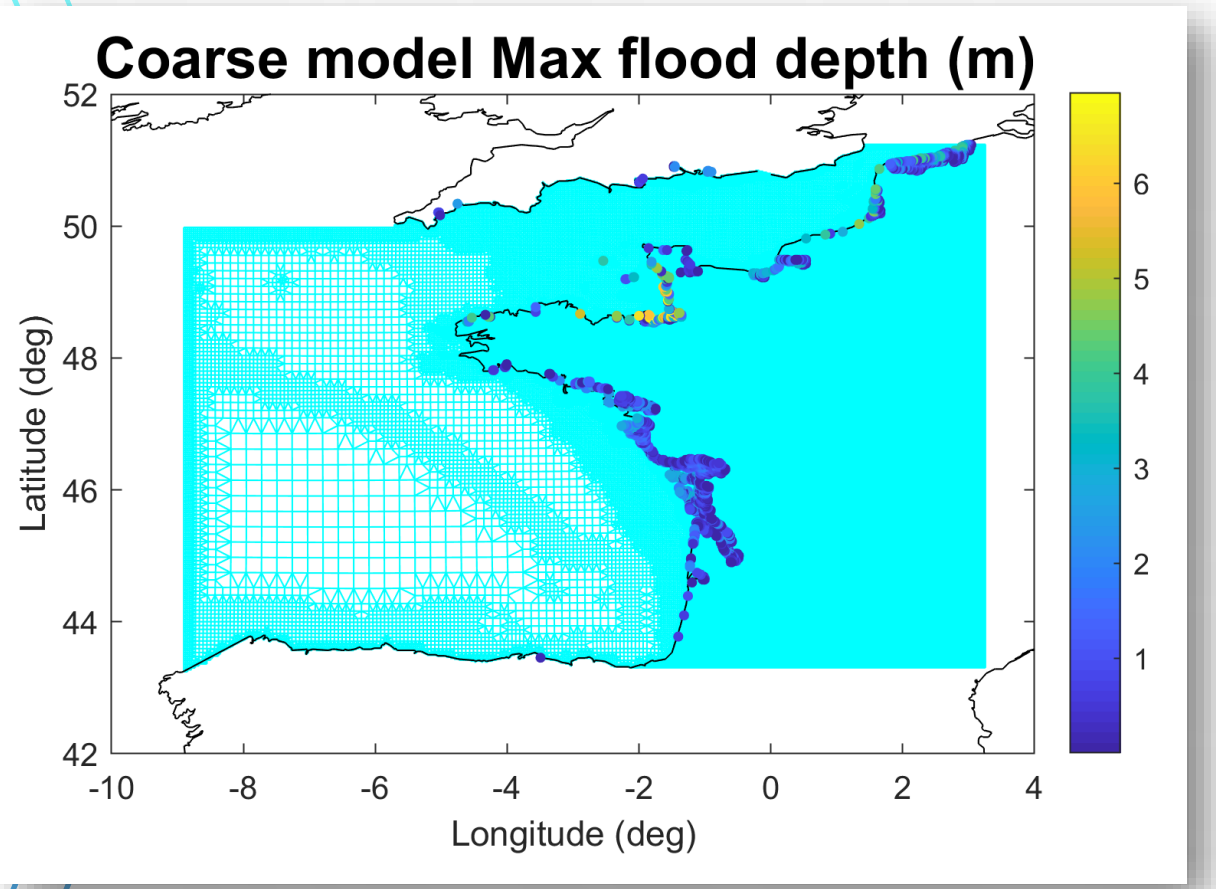


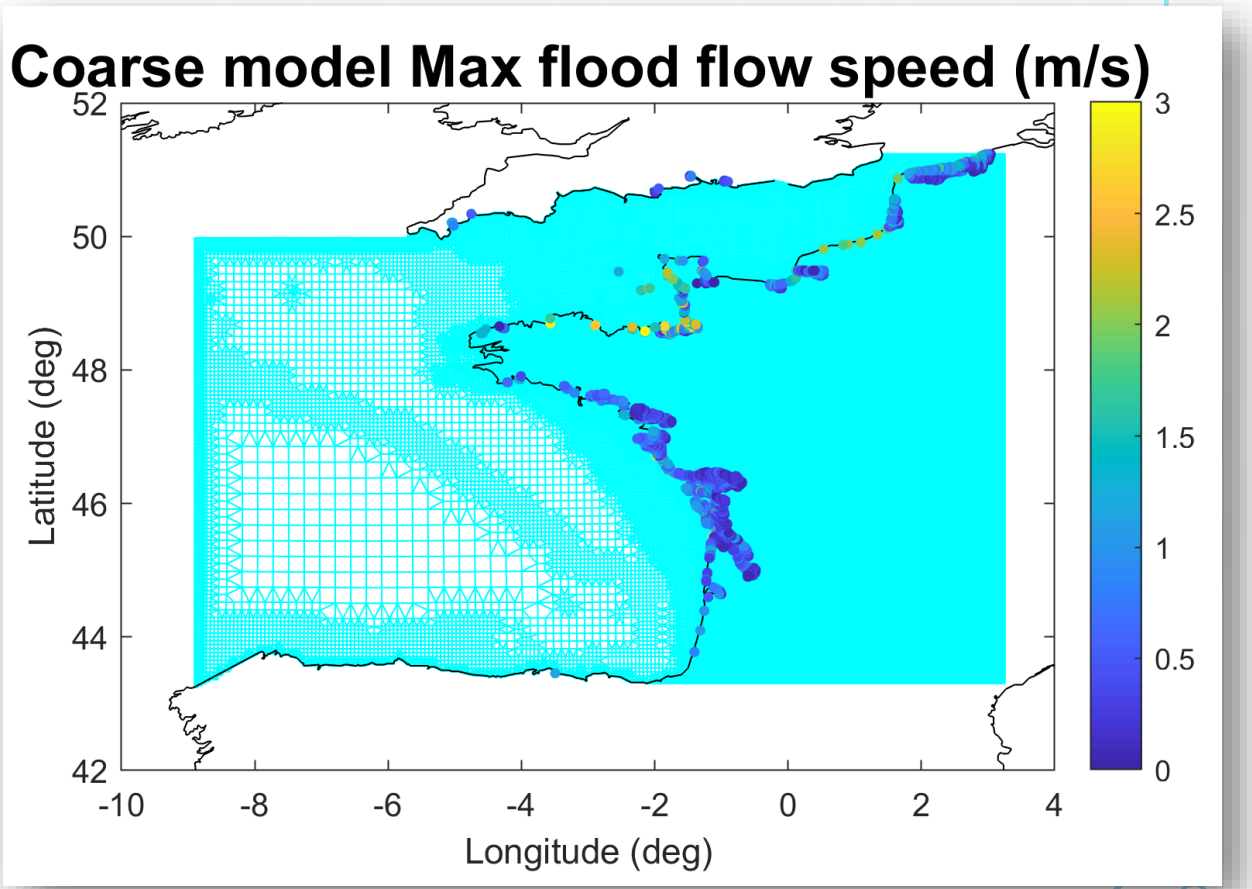


Bias	RMSE
0.04m	0.24m

2. Large Scale Delft3D-FM Tide + SS + Flooding model

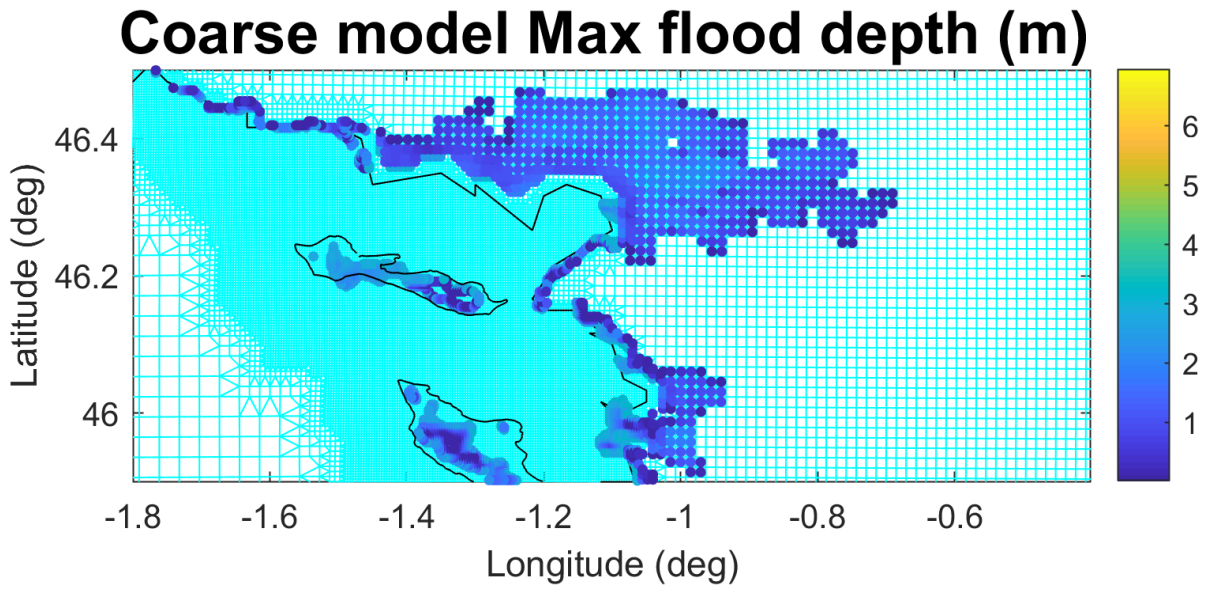
- **Max flood depth and Max flood flow speed**

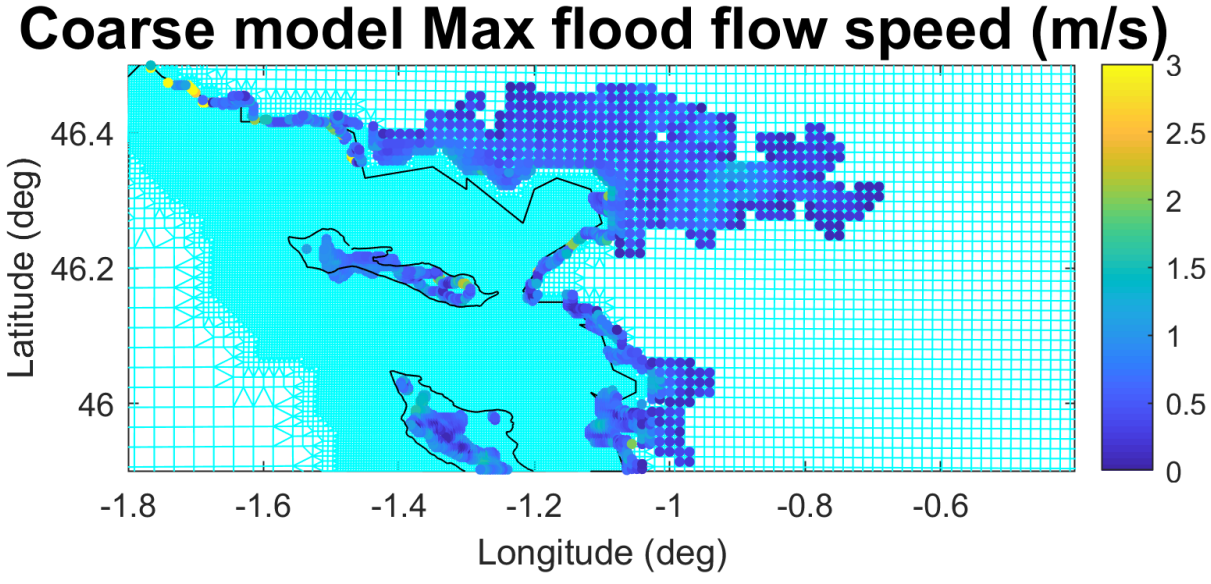




2. Large Scale Delft3D-FM Tide + SS + Flooding model

- **Max flood depth and Max flood flow speed (zoom in)**





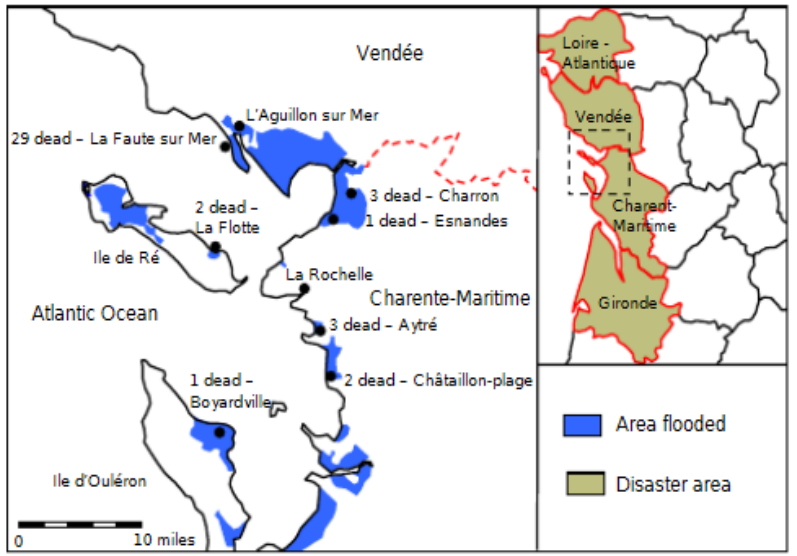
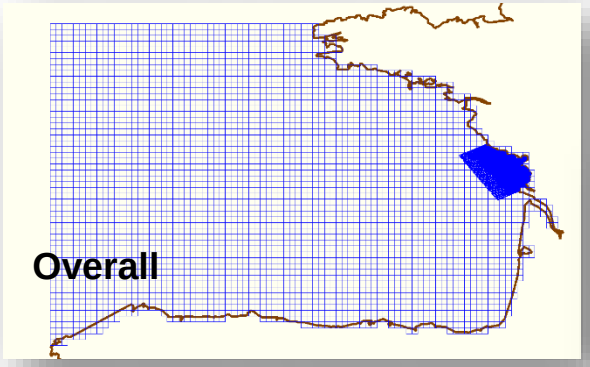
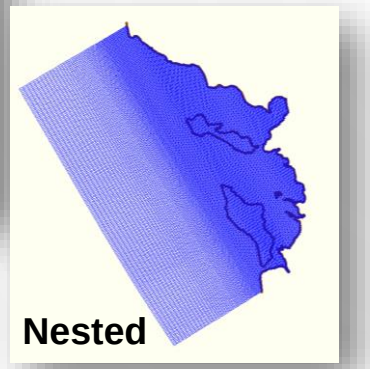


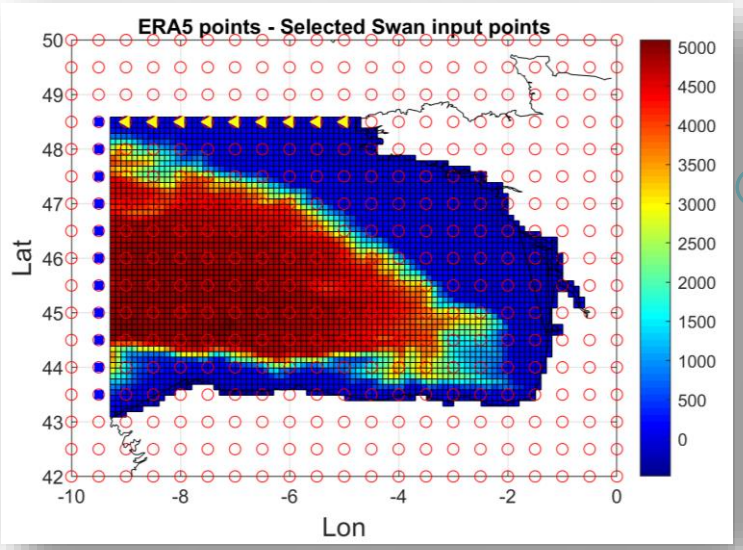
Fig. 3. Area flooded and the loss of life as the result of Xynthia in 2010.

3. Wave modelling

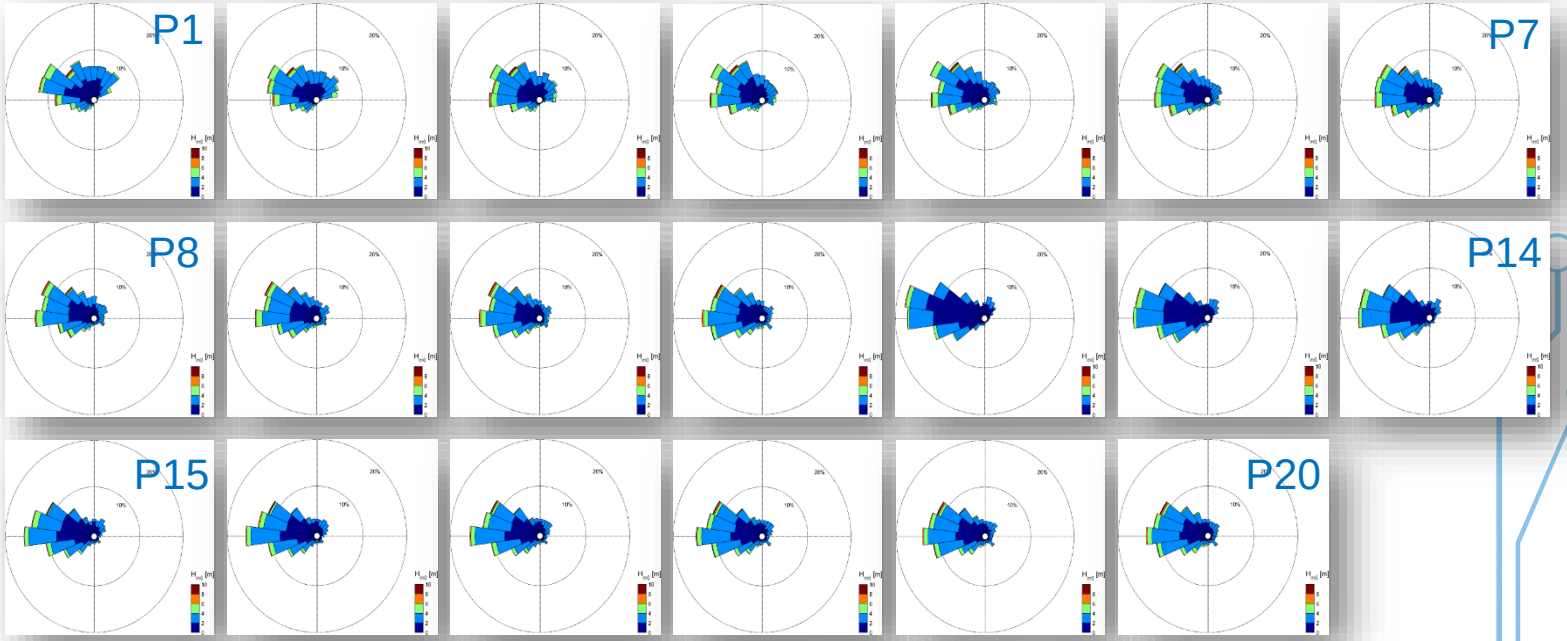




Spatial Wind +
Offshore ERA5 waves

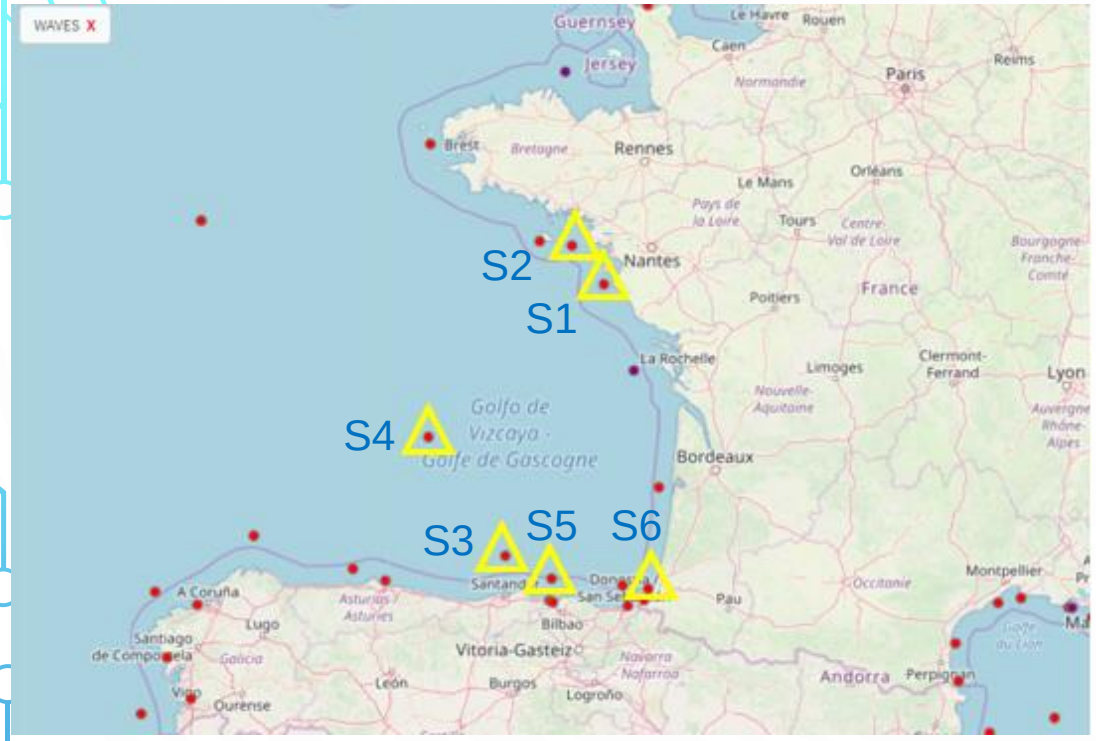


Simulation time: same time as large scale SS model for Xynthia



3. Wave data availability

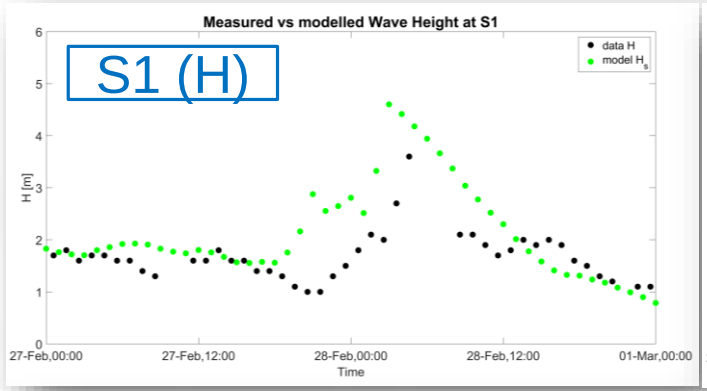
- 6 wave buoys with available wave data (Source: EMODnet) during Xynthia in year 2010: (in yellow)



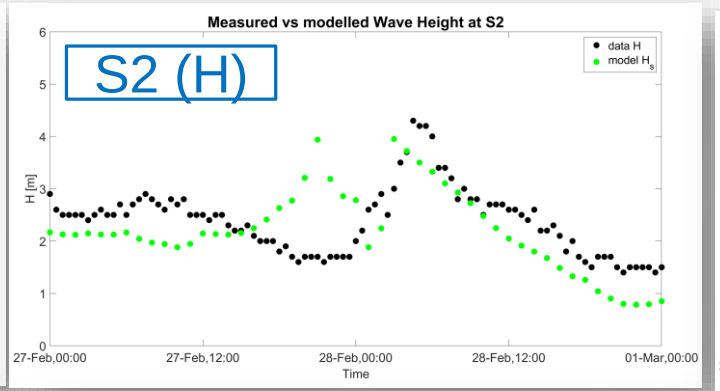
Station	Name	Coordinate	Available data
S1	**Ile d'Yeu Nord**	Lon=-2.295 Lat=46.833	H (Swell height) T (Swell period)
S2	**Plateau Du Four**	Lon=-2.787 Lat=47.239	H (Wave height) T (Wave period) D (Wave direction)
S3	**Missing (named: S3)**	Lon=43.8916 Lat=-3.8159	H (Wave height) T (Wave period) D (Wave direction)
S4	**Gascogne**	Lon=-5 Lat=45.2	H (Swell height) T (Swell period)
S5	**Missing (named: S5)**	Lon=43.6382 Lat=-3.1012	H (Wave height) T (Wave period) D (Wave direction)
S6	**Anglet**	Lon=-1.614 Lat=43.53	H (Wave height) T (Wave period) D (Wave direction)

3. Wave model validation

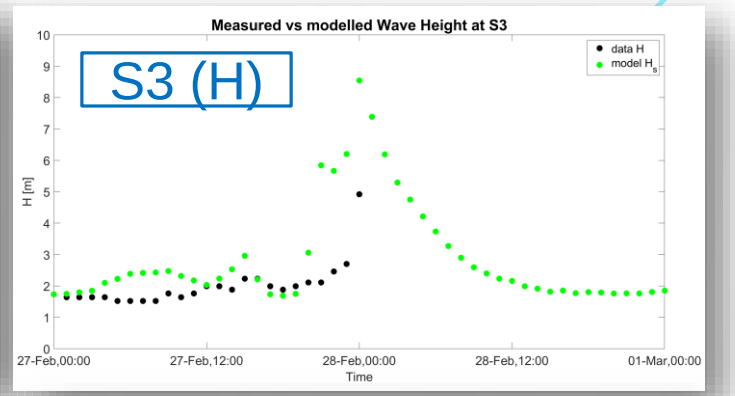
- Wave validations (time series, scatter plots, Bias/RMSE)



S1 (H)



S2 (H)



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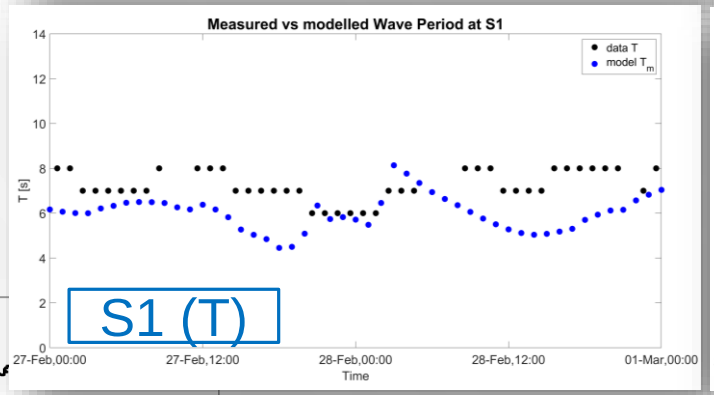
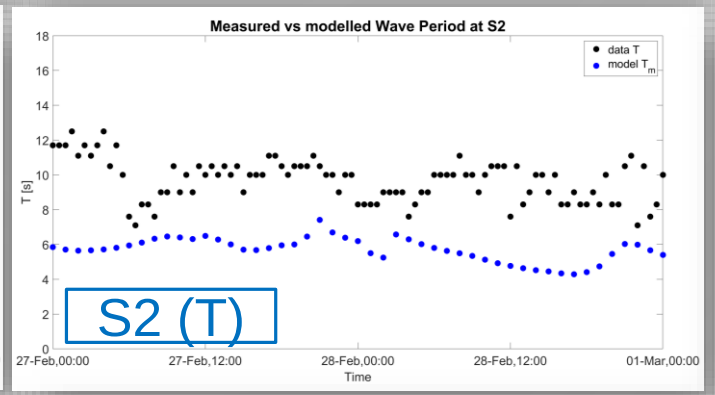
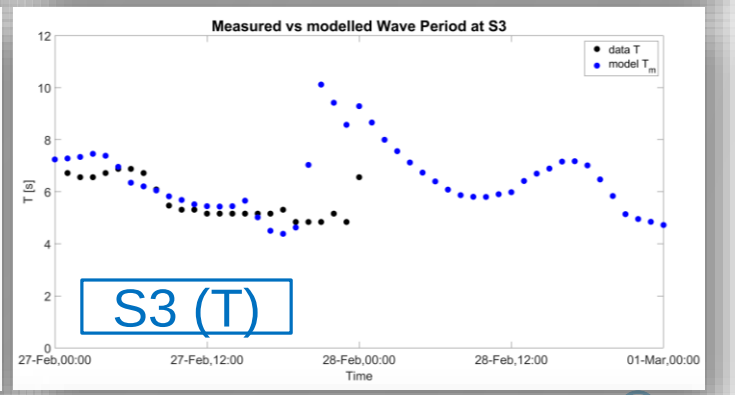


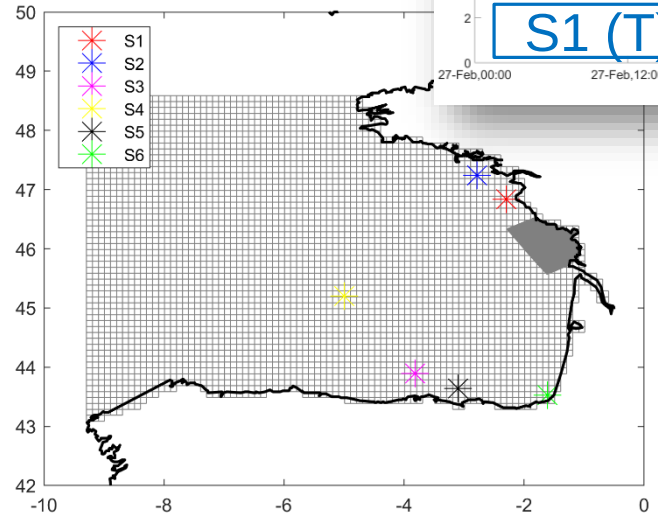
S1 (T)

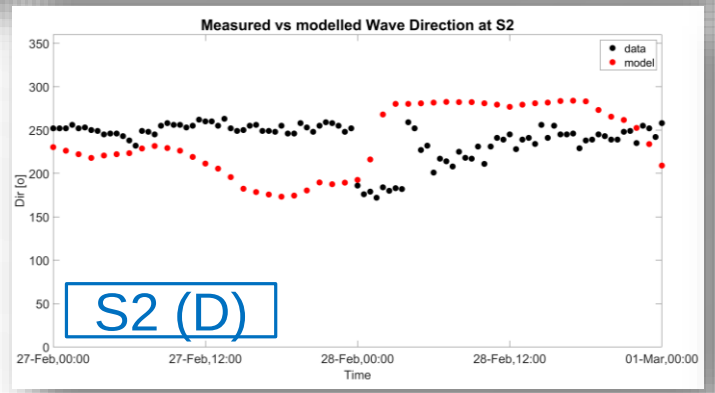


S2 (T)

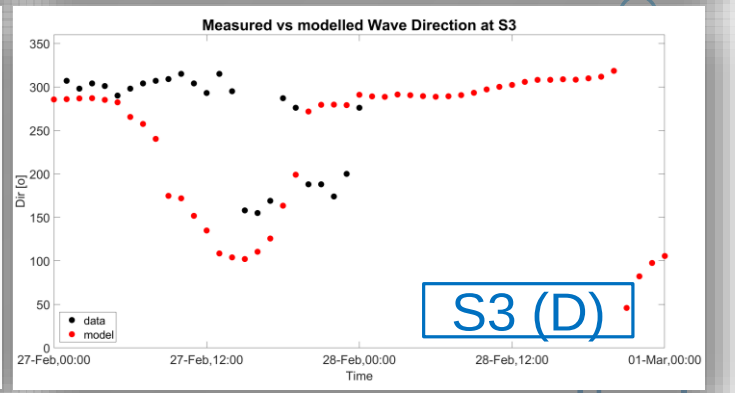


S3 (T)





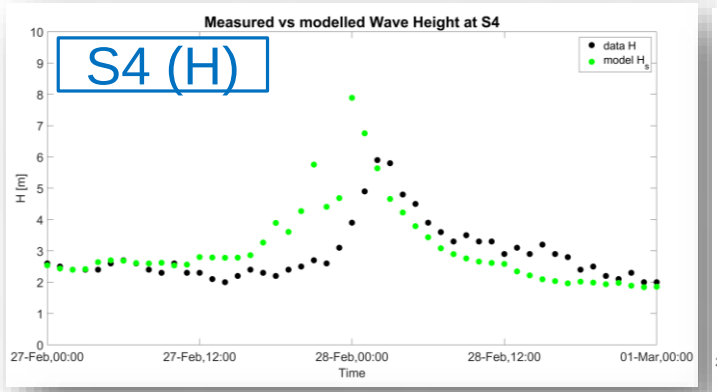
S2 (D)

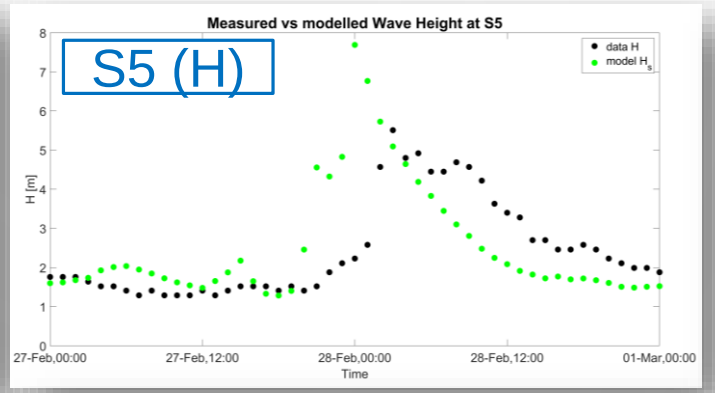


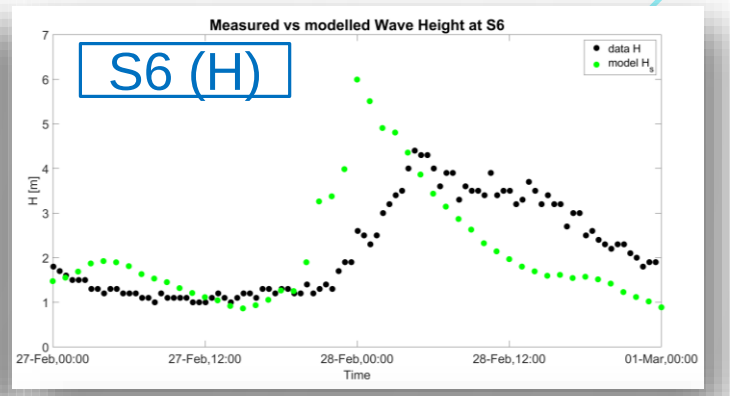
S3 (D)

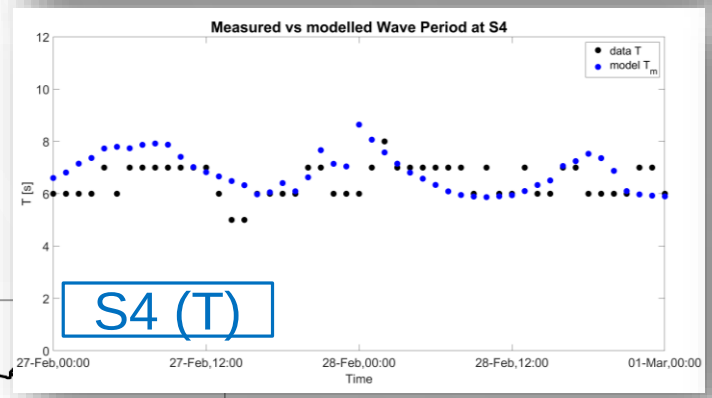
3. Wave model validation

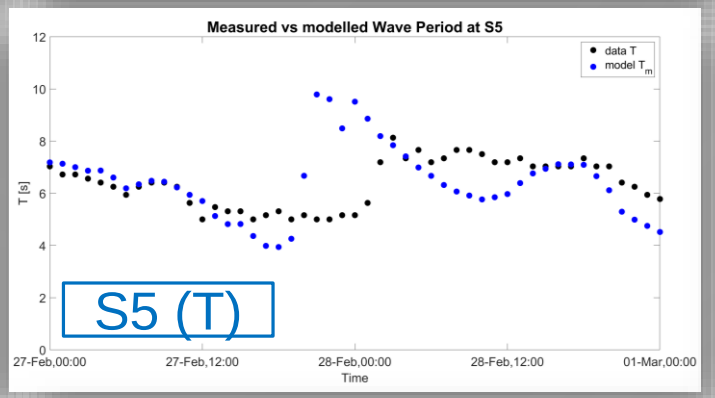
- Wave validations (time series, scatter plots, Bias/RMSE)

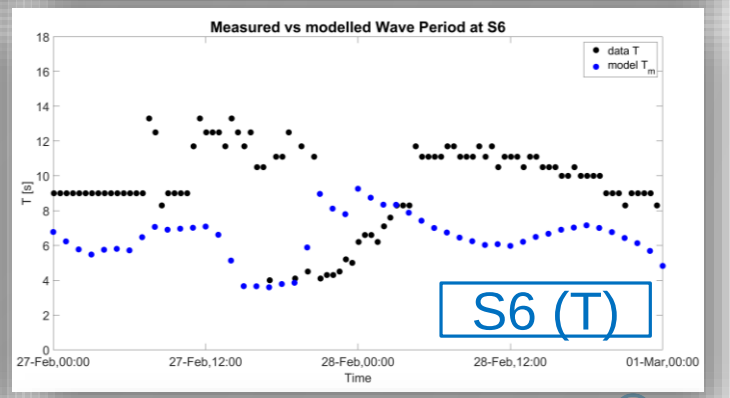


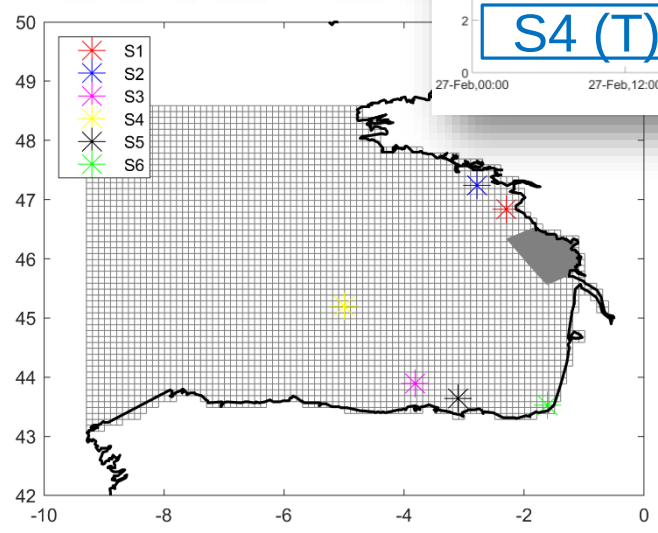


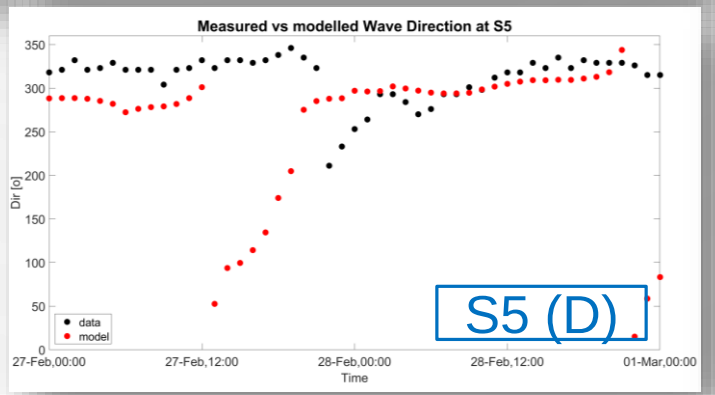


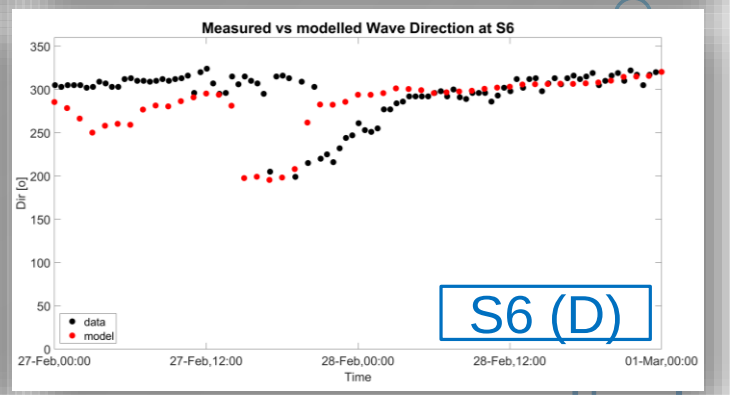












4. Fine Tide, SS, Flooding Model (Flow+Wave)

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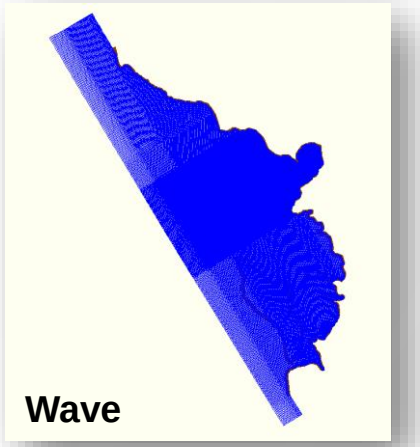
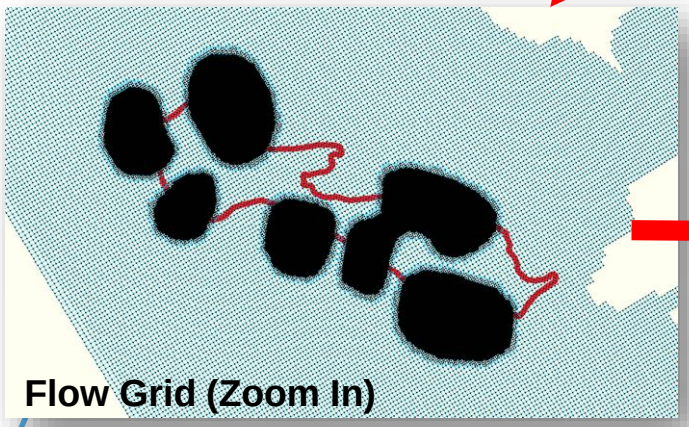
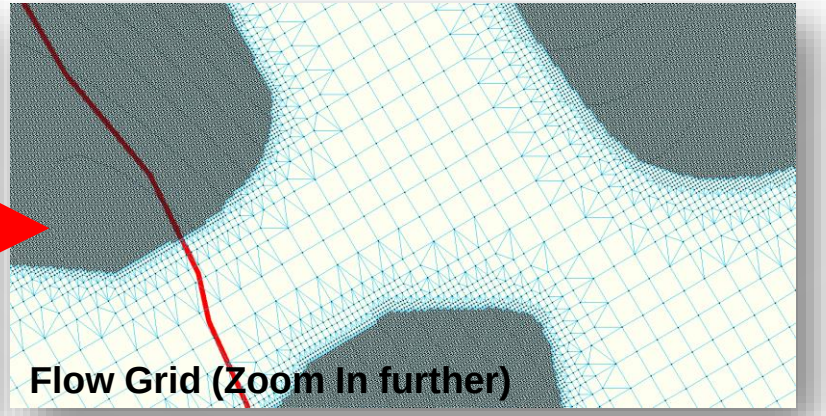






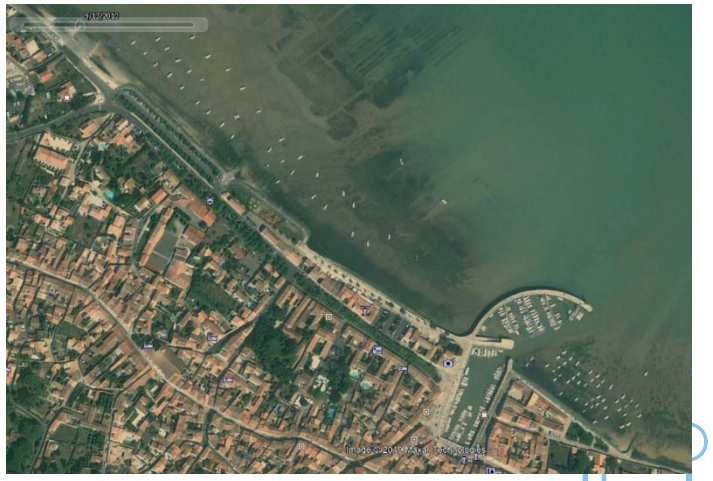
Insurance claims data:

1. SAINT-CLÉMENT-DES-BALEINES
2. LA FLOTTE
3. LES PORTES-EN-RÉ
4. LA COUARDE-SUR-MER
5. ARS-EN-RÉ
6. SAINT-MARTIN-DE-RÉ
7. SAINTE-MARIE-DE-RÉ
8. LE BOIS-PLAGE-EN-RÉ

Fine Model	Simulation time	Forcing	Output	Bathymetry + Topography
Flow (Tide+SS) + Wave	22/02/2010 - 05/03/2010	- Tide from large scale (Tide+SS) model - Spatial downscaled wind and pressure fields - Wave from local nested SWAN model	- His:10mins - Map:6hrs	- Bathymetry: GTSM - Topography: IGN DEM data (5m resolution)

4. Fine Tide, SS, Flooding Model (Flow+Wave)

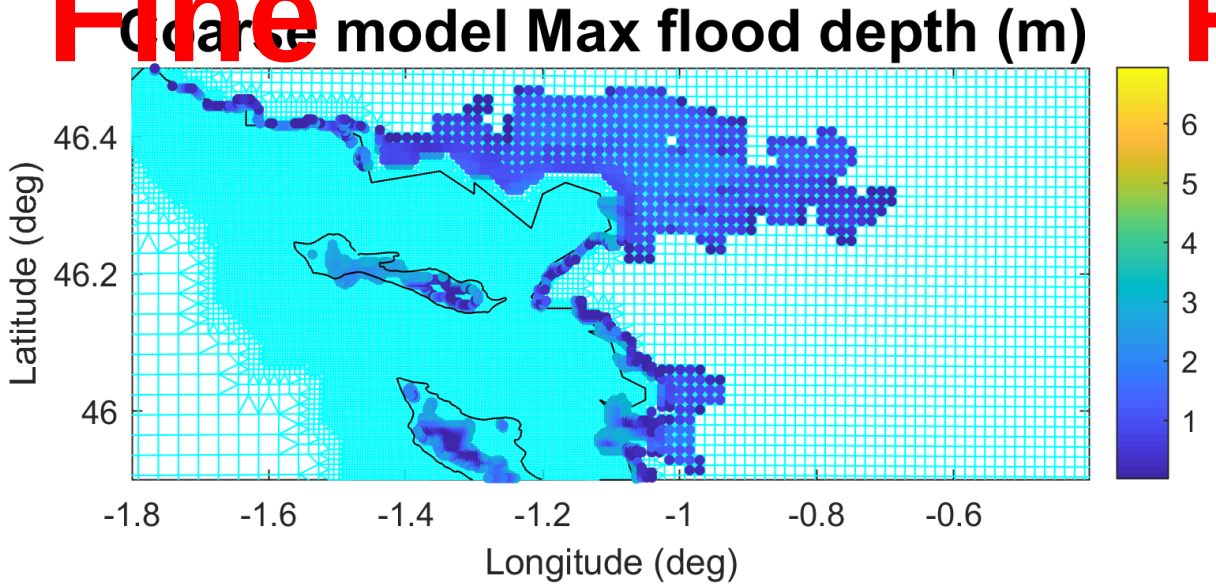
- Manually checking and including all structures (sea walls, dunes, groynes, breakwaters, harbours/ports, etc…) in the model, all along the claimed areas of the whole island.



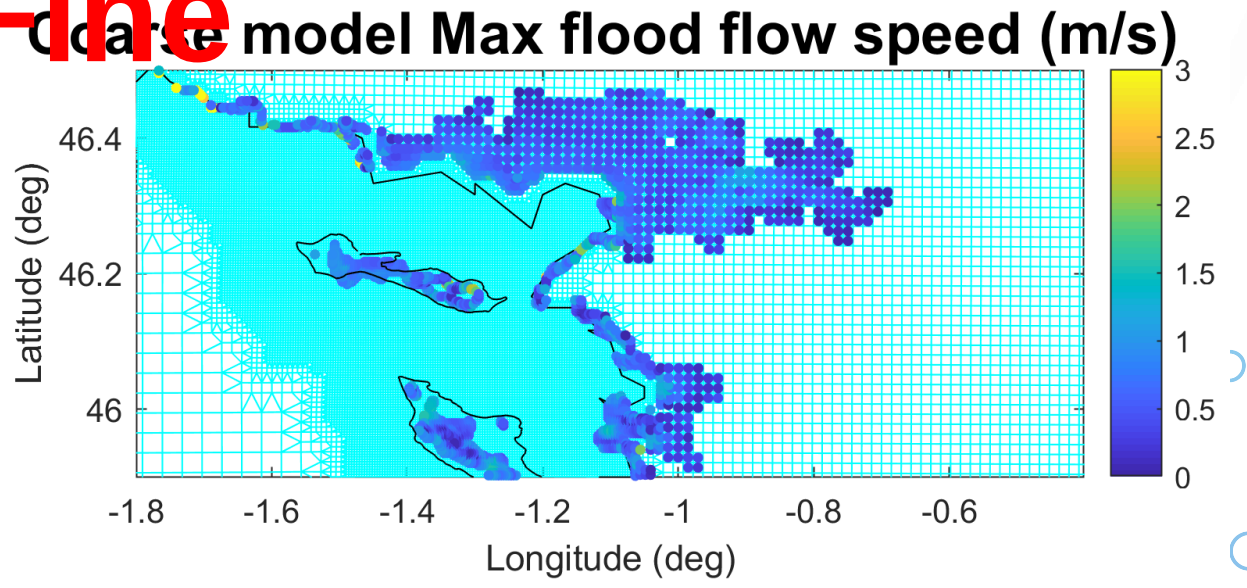
4. Fine Model - Expected outcomes

- ✓ max flood depth and flow velocities at high resolution (individual building scale)
- ✓ To build fragility functions at high spatial resolution which may be used for future decision making regarding coastal flood risk management.

Fine



Fine



THANK YOU!

United Nations Educational, Scientific and Cultural Organization

IHE DELFT Institute for Water Education under the auspices of UNESCO