Evolution of surge levels inside harbour basins: the case of le Havre harbour

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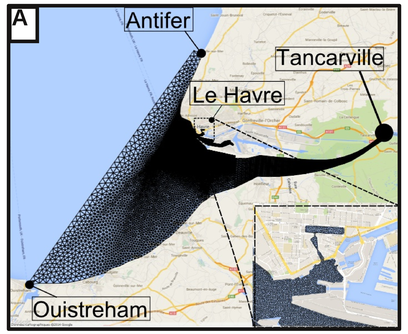
Background and objectives

Within the Technical Commission for the Study and the Evaluation of Maritime Submersions in the Seine Estuary, a hydrodynamic model of surge levels and associated submersions in the Seine bay (see Figure A) has been used to :



• improve the knowledge about the **interactions between waves, currents, tide and surge levels inside the Seine Estuary** and in harbour basins;

• bring a better knowledge about the **phenomenon of submersion waves in harbours** and, in particular, about h**arbour seiches and amplification of the surge level signal** from the sea to the harbour basins.

Methodology

Data sources

For events **JOHANNA** (March 2008), **XYNTHIA** (February 2010) and 2004 storm event, the model was fed by several data sources :

• **wind fields** interpolated from CFSR data provided by the NOAA

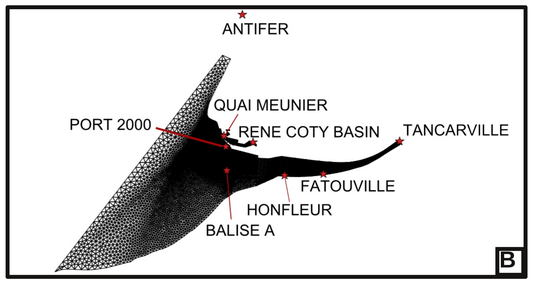
• at the maritime boundary (located on a line linking Ouistreham and Antifer) (Figure A), a **global signal (tide level + surge level)** provided by a numerical model for surge levels on the Atlantic coast developed in Saint-Venant hydraulics laboratory [4].

• at the Eastern part of the model (Figure A), **at Tancarville bridge, water levels** of the Seine river given by the port of Rouen for 2004, 2008 and 2010.

Validation of the numerical model of the Seine Bay for JOHANNA and XYNTHIA

• **adjustment of numerical parameters** (friction coefficient and the influence coefficient of the wind)

• to minimize **some statistical indicators** evaluating the difference between water levels observed and predicted by the numerical model at several locations in the Seine Bay (Figure B)



Results

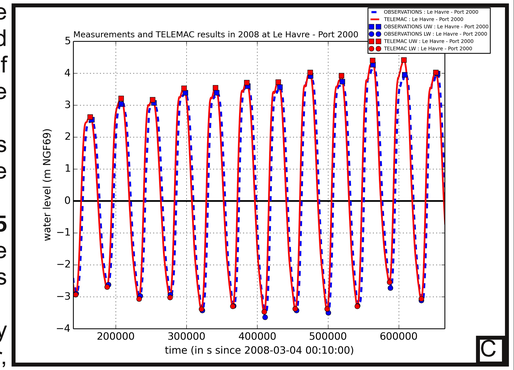
Calibration on Johanna storm (March 9th and 10th 2008)

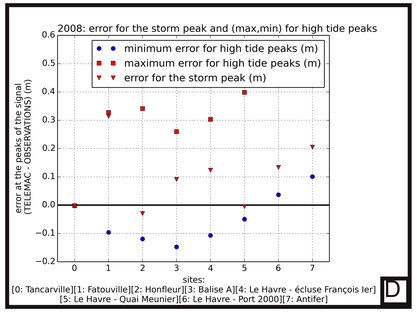
• Calculations realised on the time slice between the 4th and the 13th March 2008 (duration of simulations about 10 days, i.e 776700 s)

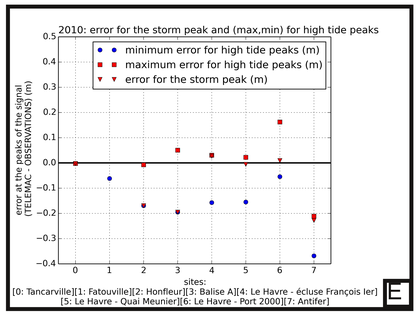
• storm peak at about 560000 s after the beginning of the simulation.

► **average error less than 5 cm**, except for Antifer, Fatouville and Port 2000, where it reaches 15 cm (Figure B and Figure C)

► water levels are particularly well represented at Honfleur, Balise A and Quai Meunier (see Figures C and D).







Calibration on Xynthia storm (February 27th and 28th 2010)

• realised on the time slice between the 24th of February and the 2nd of March 2010 (duration of simulations about 7 days, i.e 518400 s)

• storm peak at about 377400 s after the beginning of the simulation.

► numerical model is well adjusted at high tides, particularly at Le Havre Quai Meunier at the storm peak (see Figure E).

► **average error is less than 10 cm at each validation point**, except at Antifer.

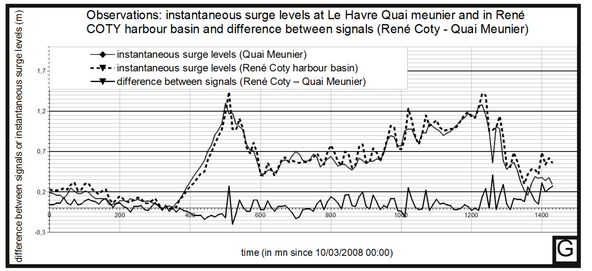
Conclusions about calibration

► **average error smaller than 5 cm at Quai Meunier and in René Coty basin**.

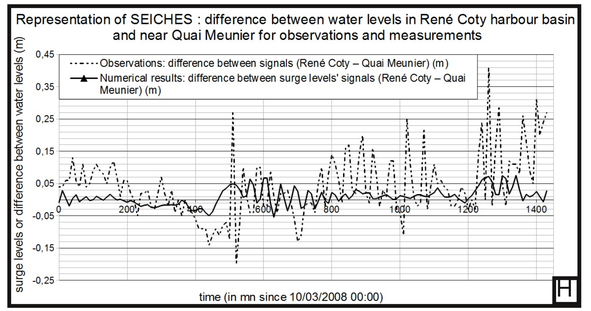
► **absolute error at the storm peak less than 1 cm at Quai Meunier** for both events and around 10 cm inside of René Coty basin for Johanna.

Identification and simulation of seiches inside of "René Coty" harbour basin

► **seiche effects** (longitudinal and transverse oscillations determined by the basin dimensions) **with amplitudes of 0,41 m for 2008 observed in Le Havre Harbour**, maybe attributable to effects induced by the storm surge (Figure G).



► peak water level in René Coty harbour basin **0.14 m higher** than the peak near Le Havre Quai Meunier (Figure G).



► **wide under-estimation of the amplitude of oscillations calculated by the numerical model (Figure H)** that may be linked to the smoothing the numerical model realises on surge levels' oscillations, whereas the frequency of harbour oscillations is quite similar.

► maxima of seiches obtained with the numerical model and surge levels' maxima occur at the same time, as observed (see Figures G and H).

Conlusions and perspectives

• apparition of **an oscillating signal added to the signal at the entry of the Harbour, but smoothed and under-estimated** by the model.

• further numerical investigations must be realised to reproduce the magnitude of these harbour oscillations.

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Acknowledgments

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