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Tide in the Gironde estuary

An equation between absolute measurement and the need for modeling

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Introduction: The framework of the study consists in studying the dynamics of the tide in the Gironde estuary with the aim of representing and understanding the deformation of the tidal wave that occurs in an estuary as well as establishing choices of parameters likely to control its propagation: slope of the river bed, friction on the bottom, river flow. The objective is to progress in our still incomplete knowledge of the tide in estuaries and to develop a method to improve its prediction even if a certain number of locks remain to be undone.

In dynamic regions such as those of the Atlantic continental shelf, the sources of major errors in a model of ocean dynamics from bathymetry, boundary conditions and bottom friction highlight the importance of representing the physical processes related to the dynamics of water masses near the bottom.

Methods: Starting from the statement that the strong non-linearity of estuaries makes the harmonic tidal analysis method, classically applied in the ocean, fail, a barotropic tidal model has been developed (T-Ugom, Legos). It has been identified as a preliminary step necessary to progressively advance in the parameterization of tidal dynamics in this highly constrained environment. The dynamic forcing of the model is presented as well as the result of the optimization of the bottom friction. The challenge here is to separate the part of the physics solved explicitly by the model from what cannot be solved and must consequently be parameterized in the case of resolutions ranging from 10 m to 1 km. However, in a barotrope model, the background friction coefficient (Cd) synthesizes the vertical diffusive effects (turbulence) and the friction effects on the bottom. The transposition of a 2-dimensional Cd to realistic dynamics remains a complex question. In order to provide an answer to the question of the representativeness of the adjusted Cd in a barotrope model, a test of the setting of this friction coefficient was carried out from spectral simulations. The sequential simulations then brought a first refinement expected for this study. The evaluation of the models was done by comparison with in situ measurements.

The tide in an environment of high spatial variability also raises the question of the representativeness of point measurements used to constrain a dynamic model or to validate it. An analysis of the quality of the dataset and a reflection on their uses were therefore carried out with one objective in mind. The realistic tidal modelling is based on a measurement campaign carried out in 2018 especially for this study (MarEst*) and within the framework of the SWOT space mission project** (Cnes, Nasa) (N. Ayoub et al. 2018).

Three types of data were used to evaluate the configurations: radar tide gauges, GNSS data including a floating slick and a fixed buoy. It is important, for validation, to take data at the same period as for modelling. Data from tide gauges provided by the Grand Port Maritime de Bordeaux, by Shom (Refmar), data from Shom specifically deployed for this study, and from the DREAL Aquitaine, constitute the set of in situ observations. The data carried out for the project (2018 campaign) were used for validation in this study as they were concomitant with the numerical simulation period.

In addition, the sensitivity of the tidal wave propagation to the disturbance due to the river flow, as well as to the slope of its free surface, allowed to progress on the question. Like the calibration curves, the elevation curves show a relationship between elevation and flow, different between a rising and a falling tide. Thus, the problem lies partly in the reconstruction of time series in the case of forcing freshwater flows by a real data set.

Results and conclusion: In the simulation, bathymetry strongly conditions the amplitude and phase of a tidal wave, the dissipation and the generation of harmonics. The effect of the new parameterization of the bottom friction coefficient on the bathymetry (Cd) on the global performance of the model results in a water height score compared to the observation which sees this difference significantly decreased. Even if the dynamics are integrated over the entire length of an estuary, the impact of the bathymetry errors is of the first order and remains difficult to distinguish from that of other parameters such as bottom friction (Cd). This has made it possible to calibrate several terms responsible for the damping of waves and the generation of higher harmonics

For example, the automation of the Cd calibration method with the analysis of the 2018 data allowed obtaining results on the error in tidal amplitude from 197 mm to 31 mm. The results in tidal and weak tidal conditions are presented with a first report on the validation of the numerical simulation, in particular for Bordeaux and Laména where the phasing of the tidal is improved.

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