

General Comments

This manuscript, entitled “*Dual evolution of tides in a turbid macrotidal estuary at decadal timescales*,” investigates the long-term evolution of tidal dynamics along the Gironde Estuary and the Garonne tidal river using historical tide-gauge observations, bathymetric data, and river discharge records. The authors examine the spatial and temporal variations in tidal range, tidal amplification, and tidal asymmetry, and discuss the potential influences of oceanic tidal forcing, morphological changes, river discharge, and bottom friction.

The results suggest that tidal variability in the lower estuary is primarily controlled by the 18.6-year lunar nodal cycle, whereas the increasing tidal range in the upper estuary and tidal river is associated with morphological changes and variations in river discharge and bed roughness. The study benefits from valuable long-term observational datasets and addresses an important topic in estuarine hydrodynamics.

However, several important issues need to be addressed before the manuscript can be considered for publication. In particular, the analysis of tidal wave propagation is incomplete, as it mainly focuses on tidal amplitude variations without adequately examining changes in tidal phase or wave celerity. Moreover, although several potential driving factors are discussed, their individual contributions to the observed tidal changes remain insufficiently quantified. Further analyses are therefore needed to strengthen the physical interpretation and scientific contribution of this study.

My specific comments are provided below.

Major Comments

1. Tidal wave propagation is characterized not only by the spatial evolution of tidal amplitude and its amplification or damping rate, but also by changes in tidal phase and propagation wave speed. The present study mainly examines tidal range, amplification factors, and tidal asymmetry, while the spatial and temporal variations in tidal wave celerity have not been adequately investigated.

Since harmonic analysis has already been performed using water-level observations from multiple stations, I suggest that the authors further examine the longitudinal variations in the phase of the principal tidal constituent (e.g., M_2) and estimate the corresponding tidal wave propagation speed. It would be particularly valuable to investigate how these characteristics have changed over the past decades and whether their variations are consistent with the observed changes in tidal amplitude and estuarine morphology. Such an analysis would provide a more comprehensive

understanding of long-term tidal wave propagation in the Gironde Estuary.

2. Tidal wave propagation in the Gironde Estuary is jointly influenced by oceanic tidal forcing at the seaward boundary, estuarine geometry and bathymetry, bottom friction, and upstream river discharge. Although the authors discuss the potential effects of these factors in Section 5, their relative contributions to the observed changes in tidal propagation remain unclear.

I acknowledge that these factors are strongly coupled and that a complete separation of their effects may be challenging using observations alone. Nevertheless, I encourage the authors to consider applying a simplified analytical tidal wave propagation model to better identify and quantify the contributions of individual factors. For example, an analytical framework based on the one-dimensional tidal wave equations could be used to evaluate the sensitivity of tidal amplitude and phase to changes in channel geometry, water depth, friction, and river discharge.

Such an analysis would help distinguish the direct influence of river discharge from its indirect effects through morphological evolution and changes in bottom friction. It would also provide stronger physical support for the proposed feedback mechanisms and substantially improve the depth of the manuscript.

3. According to Fig. 6, the relationship between river discharge and tidal amplification appears relatively weak, particularly when river discharge is below 500 m³/s. Within this discharge range, the amplification factor does not exhibit a clear or consistent dependence on river discharge, whereas noticeable differences in tidal amplification exist between 1982 and 2017.

This observation raises questions about the relative importance of river discharge as a direct controlling factor compared with morphological changes and bottom friction. The authors should therefore provide a more careful assessment of the role of river discharge and avoid attributing the observed long-term tidal amplification primarily to discharge variations without sufficient quantitative evidence.

In addition, I suggest examining the relationship between tidal wave propagation speed (or phase lag) and river discharge using the available observations. Tidal phase or wave celerity may provide complementary information on the influence of river discharge that is not evident from tidal amplification alone. This additional analysis would help clarify the physical mechanisms governing tidal wave propagation under different discharge conditions.

Minor Comments

1. Several references and citations are missing or incorrectly displayed in the manuscript, including those around Lines 57, 348, and 402, as well as other locations where question marks appear instead of proper citations. The authors should carefully check the entire manuscript and reference list to ensure that all citations are correctly formatted and that the corresponding references are provided.

2. Around Line 407, the expression of Green's law should be checked carefully. The conventional expression for tidal amplitude scaling is proportional to $b^{-1/2}h^{-1/4}$, where b is the channel width and h is the water depth. The authors should verify the expression presented in the manuscript and clearly distinguish the classical Green's law from the modified formulation adopted from Jay (1991), if applicable.

3. The code and data availability statements near Line 480 still contain the placeholder “TEXT”, and three overlapping headings (“Code availability”, “Data availability”, and “Code and data availability”) are included. These sections should be completed and consolidated according to the journal's requirements.

4. The captions of Figs. 5b and 8 appear to contain an error in the definition of the lower whisker, which is expressed as $Q1 + 1.5 \times (Q3 - Q1)$ rather than $Q1 - 1.5 \times (Q3 - Q1)$. The authors should correct this expression and verify that the whiskers are consistently defined and calculated throughout the manuscript.

5. In Section 3.1.1 (around Lines 128–130), the years selected for water-level analysis are listed as 1963, 1971, 1982, 1994, 2000, and 2007. However, Table 2 and the subsequent analyses also include 1953 and 2017.

6. Several figure references and year labels should be carefully checked. For example, around Line 356, the discussion of tidal asymmetry refers to Fig. 2b, whereas the relevant results are presented in Fig. 2c. Around Line 379, the discussion of Fort-Médoc mentions 2005, although this year does not appear among the water-level analysis years presented in Fig. 7. Additionally, the reference to Fig. 3 around Line 411 contains an incomplete parenthesis. The authors should verify all figure and table references, as well as the consistency between the text, figures, and captions.

7. The manuscript contains several typographical and grammatical errors, inconsistent reference formatting, and unclear expressions. Examples include “usptream” and “Restults” in Section 5.2.2, inconsistent citation formatting, and incomplete punctuation in several sentences. The authors should carefully proofread the entire manuscript and ensure consistency in scientific notation, units, abbreviations, figure captions, and reference formatting before resubmission.

Overall Recommendation

The manuscript presents valuable observational evidence of long-term tidal evolution in the Gironde Estuary. However, the current analysis does not yet provide a sufficiently comprehensive description of tidal wave propagation or a convincing quantitative attribution of the different controlling factors. I therefore recommend major revision, with particular emphasis on the analysis of tidal phase and propagation speed, and a more quantitative assessment of the physical mechanisms responsible for the observed tidal changes.