

The manuscript presents a clear, well-structured and compelling analysis of the impact of Storm Louis on two Spanish harbours using a comprehensive multi-sensor observational approach. The writing is strong, the methodology is robust, and the results are clearly articulated and well contextualised within the broader synoptic dynamics of the event. In my view, the manuscript is suitable for publication in its current form. Below, I provide a series of comments and questions that could further strengthen clarity and interpretation for the reader.

We sincerely thank the anonymous Reviewer 1 for the detailed review and the thoughtful questions aimed at fostering discussion. Below, we provide a thorough point-by-point response, with the aim of improving the manuscript and ensuring its suitability for final publication.

The authors refer to synoptic-scale conditions “at the maximum on the 23rd”. It is unclear whether the maps represent: a daily mean, a specific time step (e.g., 00 / 06 / 12 / 18 UTC), or a daily maximum field. Clarifying this would help readers better connect the synoptic configuration with the timing of the metocean forcing.

We fully agree that additional clarification is required, notwithstanding the fact that the caption of Figure 1 already indicates that the maps represent daily mean values. To avoid any potential ambiguity, this point has now been explicitly clarified in the revised manuscript. The first sentence in 3.1 section (“Methodology: characterization of Storm Louis”) has been revised to read:

“To elucidate the driving mechanisms underlying the development of Storm Louis, the prevailing atmospheric conditions were briefly examined at the synoptic scale, with particular emphasis on daily mean fields of SLP and W10”.

Similarly, the first sentence in section 4.1. (“Results: Analysis of Storm Louis”) has also been modified as follows: *“The large-scale synoptic conditions associated with Storm Louis were characterized using daily-averaged ERA5 reanalysis data for SLP, W10 and SWH (Fig. 1a-c).”*

Storm Louis primarily affected the northeastern Atlantic, and its impacts in the Mediterranean were, operationally speaking, relatively limited. To my knowledge, Louis did not generate significant swell or storm surge in the western Mediterranean; observed wave heights were below historical maxima, and its most notable impacts in the region were related to wind and precipitation (e.g., northern Italy), rather than oceanographic extremes. Given this context, I was surprised by the relatively strong harbour agitation reported at Tarragona.

A) Were any operational issues or disruptions actually observed in Tarragona during the event?

Several month ago, we contacted the Port of Tarragona operators for clarification and event validation. They indicated, on an informal basis, that although sea-state conditions at the harbour entrance -where the tide gauge is located- were relatively rough during the event, oceanographic conditions inside the harbour basins (i.e., along the piers, where mooring and cargo operations occur) remained sufficiently calm to allow normal operations. Consequently, no operational disruptions were officially reported.

Notwithstanding, it should be noted that port operators are generally cautious about publicly acknowledging operational issues, owing to potential implications for the harbour’s reputation.

Accordingly, we have revised this paragraph in the Introduction as follows: “*Additionally, harsh metocean conditions were also observed in NE Iberia: strong southeasterly winds (above 12 m·s⁻¹, Fig. 1b) induced high waves that easily penetrated into Tarragona harbour due to its mouth orientation (Fig. 1e and Fig. A1b). While these conditions may have challenged port operations at the entrance, no operational disruptions were officially reported along the piers.*”

B) How do the recorded agitation values compare with typical operational thresholds or known port sensitivities?

In the absence of official reports of operational disruptions due to extreme agitation, the recorded agitation at the port entrance should be considered within the tolerance ranges for routine activities within the port basin, consistent with the port’s historical operational experience under similar wind and wave conditions. It should also be noted that harbour-specific thresholds are highly berth-dependent and often account for factors such as vessel size, mooring arrangements, operational schedules and type of activity performed.

To our knowledge, the operational thresholds typically used by Port of Tarragona’s decision makers are primarily related to wind and overtopping, particularly when exceptionally strong winds and waves originate from the climatologically predominant NE sector, as observed during the record-breaking Storm Gloria (January 2020).

C) To what extent is the unexpectedly strong response primarily attributable to the harbour’s directional sensitivity, as highlighted in the manuscript?

Although it is neither easy nor straightforward to quantitatively determine which portion of the strong port response can be attributed uniquely to directional sensitivity, Figure 3e provides valuable qualitative insight by clearly linking the incoming wave direction with the observed port agitation, with SWH and MWP playing an important but secondary role. Notably, peaks in SWH and MWP do not coincide with peaks in port agitation; instead, the highest agitation levels are unequivocally associated with waves approaching from the SW–S sector.

The following paragraph has been added to Section 5: “*In addition to directional sensitivity -largely controlled by the configuration of the breakwaters and the harbour entrance- other structural features not analysed in this study, such as the basin layout (including basin shape, dimensions, and depth), have also been shown to influence how incoming waves from different directions are transmitted and amplified within the port (Casas-Prat et al., 2012).*”

Accordingly, the following reference has also been added to the list:

Casas-Prat, M. and Sierra, J. P.: Trend analysis of wave direction and associated impacts on the Catalan coast, *Climatic Change*, 115, 667–691, <https://doi.org/10.1007/s10584-012-0466-9>, 2012.

The paper defines extreme agitation levels using high climatological percentiles (>99%). However, the absolute thresholds differ markedly between Langosteira (~0.5 m) and Tarragona (~1.2 m). Could the authors clarify: whether these percentile-based thresholds correspond to real operational limits used by port authorities, or are purely statistical indicators; and what drives the strong difference—e.g., harbour geometry, resonance

characteristics, exposure, or differences in instrumentation or reference periods? This would help readers understand whether the identified extreme conditions have direct operational implications.

Following Reviewer 2's suggestion, we acknowledge that the 2014–2024 period does not constitute a full climatological baseline, as the World Meteorological Organization guidelines require time series of at least 30 years. Accordingly, the term “*climatological percentiles*” has been replaced throughout the manuscript with the more accurate expression “*historical percentiles based on the available 11-year observational record*”.

In light of the above, the extreme agitation thresholds defined using high historical percentiles are intended as statistical indicators of anomalous harbour response, rather than direct representations of formal operational limits, which are berth- and activity-specific and not publicly available. This percentile-based approach provides a consistent framework to identify rare agitation conditions across ports without assuming uniform operational criteria.

To clarify this point, a brief paragraph has been adequately added to Section 3 (Methodology): “*In the specific case of port agitation, historical percentiles were intended as purely statistical indicators of anomalous harbour response, rather than direct representations of formal operational limits applied by port authorities.*”

With regards to the substantial difference in absolute threshold values between Langosteira and Tarragona, it mainly reflects site-specific characteristics, as indicated in Section 5:

“This heterogeneity in storm response between both harbours may be attributable to i) differences in mouth orientation relative to the predominant incident wave direction; and ii) the contrasting exposure levels of the tide-gauge locations. Specifically, the Tarragona tide gauge is situated in an exposed position at the harbour entrance, at the seaward terminus of the main breakwater (Fig. A1b), which makes it more susceptible to incoming wave energy. By contrast, the Langosteira tide gauge is located in a more protected position, behind a secondary breakwater (Fig. A1a), resulting in significantly lower agitation levels during the same storm event. This outcome highlights the critical functional role of secondary defensive structures—such as inner or secondary breakwaters—in mitigating wave-induced agitation”

The manuscript provides an excellent explanation of the synoptic drivers of Louis. Given that the synoptic peak occurred on 23 February, whereas the harbour agitation maxima occurred later (24th for NWI, 26th for NEI), it would be valuable to expand briefly on the mechanisms underlying these temporal shifts. I.e, propagation time of wave energy from the North Atlantic to the regional offshore areas, directional effects and wave transformation processes, intrinsic response times or resonant behaviour within the harbours. A short discussion would enhance the physical interpretation of the multi-scale connections that the paper aims to highlight.

We thank the reviewer for this insightful and constructive comment. The role of multi-scale processes in explaining the delayed and site-dependent agitation peaks has now been explicitly addressed in Section 4.2 of the revised manuscript, thereby strengthening the physical interpretation of the observed responses. In particular, we have added the following text:

“These contrasting behaviours can be interpreted within a multi-scale framework linking large-scale wave generation to local harbour response. Wave energy generated in the North Atlantic required finite time to propagate toward the regional offshore domains and underwent directional evolution before interacting with each harbour. At the local scale, harbour agitation did not respond instantaneously to offshore wave forcing; rather, it was strongly modulated by site-specific factors, including directional sensitivity, wave transformation processes at the harbour entrance, and intrinsic response times associated with wave–structure interactions. Processes such as diffraction and reflection within the harbour basins played a key role in shaping both the magnitude and temporal persistence of the observed agitation, thereby explaining the pronounced differences between the two sites despite their exposure to the same synoptic-scale storm event.”

Overall, this is a strong and insightful manuscript with clear scientific and operational relevance. My comments are intended purely to clarify some aspects and enhance interpretability, not to challenge the quality of the work. I recommend publication after minor revisions.

We thank the reviewer once again for the constructive and insightful comments, which have clearly contributed to improving the quality of the paper.