Dear Reviewer,

We would like to sincerely thank you for your thoughtful and constructive review of our manuscript. We greatly appreciate your positive assessment of our work and your recognition of its relevance to understanding dune effects in coastal inundation modeling. Your detailed line-by-line suggestions have been extremely valuable in improving the clarity, accuracy, and overall readability of the manuscript.

Your comments have been carefully addressed in the revised version. Specifically, we have:

Reviewer:

Line 32. Hereinafter, you have to report “Sea-Level Rise”.

Authors:

Corrected Sea Level to Sea-Level

Reviewer:

Line 33. Add also the reference for IPCC 2021.

Authors:

Added the reference for IPCC 2021.

Reviewer:

Line 60. Change form in landform.

Authors:

Changed form in landform

Reviewer:

Line 61. Change beach interface in backshore.

Authors:

Changed to beach interface in backshore.

Reviewer:

Lines 61-62. Here, you refer to storm surge and wave overwash as causes of dune erosion. However, you also reported dune breaching in the abstract, which is one of the most evident effects of dune erosion during a storm. Please revise the list of storm-related effects to include dune breaching.

Authors:

Thank you for this valuable comment. We acknowledge that dune breaching is indeed one of the most evident and severe outcomes of dune erosion during storm events. The storm surge and wave overwash will act as primary drivers of both dune erosion and dune breaching. In response to your suggestion, we have revised the introduction to include a more detailed explanation of the dune erosion process, highlighting how these mechanisms can lead to breaching under extreme conditions (lines 64-72).

"Coastal dune erosion refers to the landward retreat of sandy beaches and dune systems as a result of storm-induced wave action and elevated water levels. The extent of this erosion can be described using an erosion hazard scale (Leaman et al., 2021) based on the degree of horizontal recession experienced during a storm. At the lowest level, *minor beach narrowing* ***occurs when the beach width is reduced but the dune system remains unaffected. As erosion intensifies,*** *substantial beach narrowing* ***takes place, where the dune system is still intact but becomes more vulnerable to damage from subsequent storms. More severe conditions lead to*** *dune face erosion*, ***in which erosion progresses landward from the dune toe but does not yet reach the crest. Under the most extreme circumstances,*** *dune retreat* ***occurs, where significant erosion impacts and undermines the landward side of the dune crest, leading to a loss of dune volume and a reduction in the coastal buffer that protects inland areas from storm surges and flooding."***

Reviewer:

Line 67. Substitute "are erected" with "have been built".

Authors:

Substituted "are erected" with "have been built".

Reviewer:

Lines 97-98. Revise the definition of wave runup, which is not a contribution to the TWL. The wave runup is defined as the maximum vertical extent to which a high-energy wave reaches the coastal landforms above the instantaneous water level (e.g. Villarroel-Lamb and Williams, 2022).

Authors:

We thank the reviewer for this valuable observation and for providing the reference. We acknowledge that, strictly speaking, wave runup represents the maximum vertical extent of wave uprush above the instantaneous water level. However, in coastal engineering, TWL usually defines the sum of tide, surge, and wave runup (Carneiro-Barros et al.,2025; Hsu et al.,2023; Stockdon et al.,2023). In our study, the

concept of wave runup is useful to evaluate the interaction between waves and coastal dunes. Nevertheless, when estimating the water volume available for inundation, we recognize that the full extent of the swash should not be included. For this reason, we introduced the concept of a **supply total water level** ***(STWL), which accounts for the water level contribution relevant to inundation processes without incorporating the entire runup excursion.***

Carneiro-Barros, Jose Eduardo, Ajab Gul Majidi, Theocharis Plomaritis, Tiago Fazeres-Ferradosa, Paulo Rosa-Santos, and Francisco Taveira-Pinto. 2025. "Coastal Flooding Hazards in Northern Portugal: A Practical Large-Scale Evaluation of Total Water Levels and Swash Regimes" **Water** ***17, no. 10: 1478.*** ***https://doi.org/10.3390/w17101478***

Hsu, C.-E., Serafin, K. A., Yu, X., Hegermiller, C. A., Warner, J. C., and Olabarrieta, M.: Total water levels along the South Atlantic Bight during three along-shelf propagating tropical cyclones: relative contributions of storm surge and wave runup, Nat. Hazards Earth Syst. Sci., 23, 3895–3912, https://doi.org/10.5194/nhess-23-3895-2023, 2023.

Stockdon, H.F., Long, J.W., Palmsten, M.L. et al. Operational forecasts of wave-driven water levels and coastal hazards for US Gulf and Atlantic coasts. Commun Earth Environ 4, 169 (2023). https://doi.org/10.1038/s43247-023-00817-2

Reviewer:

Line 135. Change in "The approach proposed in this study is based on the work of ….."

Authors:

Changed in "The approach proposed in this study is based on the work of ….." to "The approach proposed in this study draws inspiration from Shustikova et al. (2020), who developed a methodology for the representation of levees and their breaching processes."

Reviewer:

Line 160. Insert some toponyms in Figure 3 and a scale bar.

Authors:

We thank the reviewer for this helpful suggestion. We have added relevant toponyms and a scale bar to Figure 3. This improvement has indeed enhanced the clarity and interpretability of the figure.

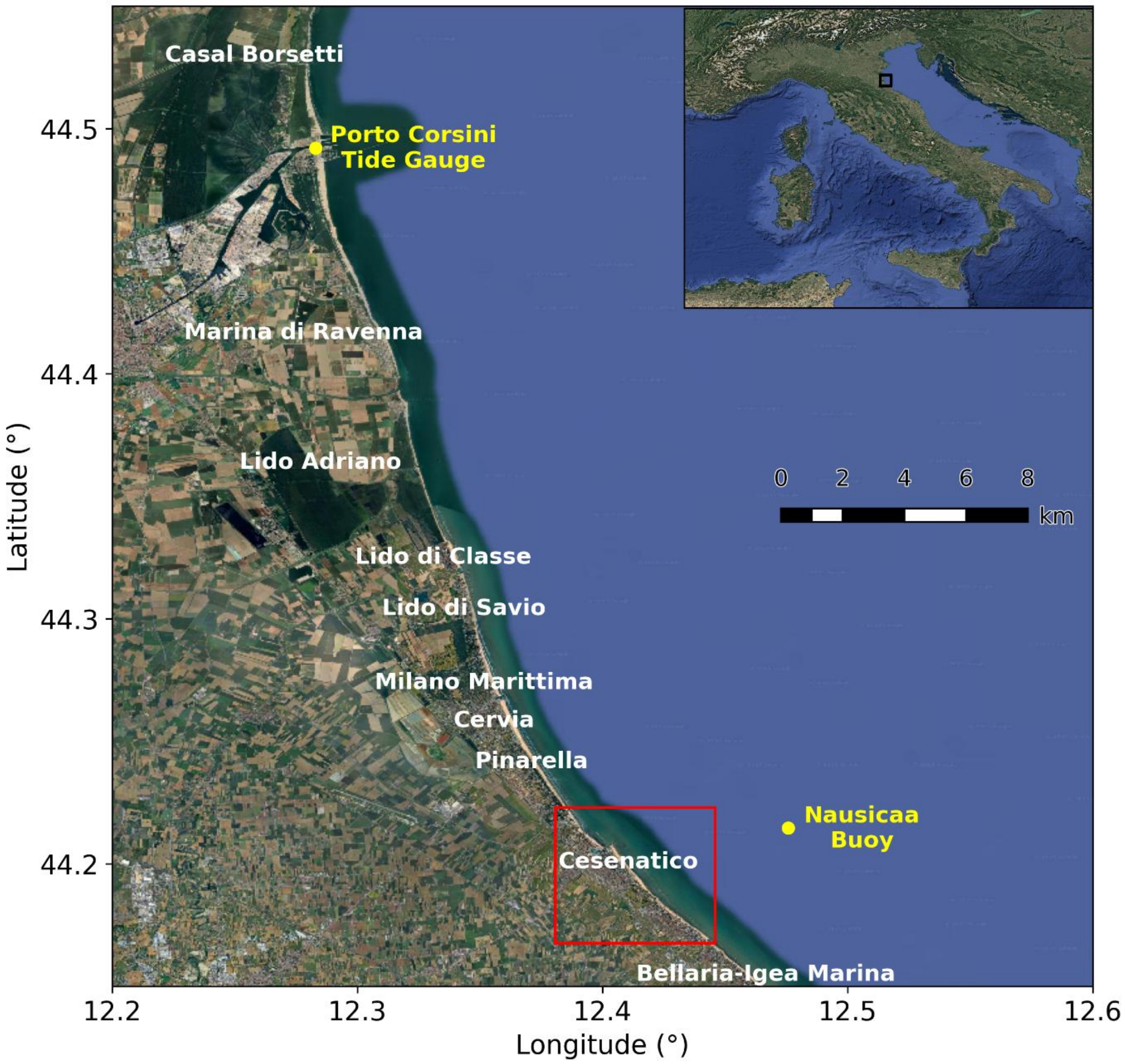

Figure 1: Emilia-Romagna's coast in the northeast of Italy. Yellow dots represent Porto Corsini's tide gauge (north) and Nausicaa's wave buoy (south). Red rectangle represents the modeled area in the town of Cesenatico. © Google Maps

Reviewer:

Line 180. When you describe the DTM features, provide also some info about the Reference System, in particular about the orthometric elevations (which is the datum?). This is very important if you are applying a simulation based on tide gauge and buoy data.

Authors:

We appreciate the reviewer's observation and agree that including information about the reference system is essential. We have therefore added details about the reference system used for the DTM, including the orthometric elevation datum, to ensure clarity and consistency in the description of our data sources and their

application within the modeling framework. The following was added in lines 189-190:

"The DTM was provided by the Geological, Seismic and Soil Service of the ER region with a spatial resolution of 5 m, referenced to the WGS84/UTM Zone 32N coordinate system (EPSG:32632) and an acquisition date of 2009."

Reviewer:

Line 205. Maybe Figure 6 and Figure 7 can be merged into a unique figure, because boundary conditions for the two storm events are reported in a similar way.

Authors:

We appreciate the reviewer's suggestion. However, after several attempts to merge the figures, we found that each contains a substantial amount of information and combining them would negatively affect the overall layout and readability of the manuscript and make the boundary condition patterns more difficult to interpret. Therefore, we have chosen to keep Figures 6 and 7 separate to preserve clarity and facilitate comparison between the two storm events.

Reviewer:

Lines 289-291. There are some unreadable sentences.

Authors:

The presence of placeholder text in Section 3.2 was an oversight on our part. This has now been corrected in the revised manuscript.

Reviewer:

Line 365. Several important factors influencing dune erosion are not addressed in the Discussion section, namely sediment mineralogy, grai n size, and biological factors. In particular, it is necessary to cite references stating that dune nourishment requires compatible sediments. If the nourishment sediments are incompatible with the native material in terms of mineralogy, grain size, and biological components, the dune will fail to act as an effective barrier against storm impacts and will be more susceptible to erosion.

Authors:

We sincerely thank the reviewer for this insightful comment. We fully agree that sediment mineralogy, grain size, and biological factors play a crucial role in dune erosion and nourishment performance. Following the reviewer's suggestion, we have expanded the discussion section to address these aspects in more detail and have included relevant references highlighting the importance of sediment

compatibility in effective dune nourishment. This addition has strengthened the discussion and improved the overall completeness of the manuscript. The following paragraph was added to the discussion (line 391-414):

"Dune failure, like any coastal protection failure, is inherently stochastic, governed by the interaction between structural characteristics and hydrodynamic forcing such as water levels and wave action. The evolution of dune erosion occurs across both time and space through processes including scarp formation, slumping, and sediment redistribution. These processes are strongly influenced by sedimentological properties—such as mineralogy, grain-size distribution, sorting, compaction, and biological content—which play a crucial role in determining dune resistance to storm impacts (Bertoni et al., 2014; De Falco et al., 2022; Xie et al., 2020).

An important limitation of the present modeling approach lies in its binary representation of dune failure, in which a dune cell is instantaneously and completely removed once the total water level (TWL) exceeds the dune's Failure Water Depth (FWD). This simplification neglects the spatial and temporal complexity of dune erosion, meaning that a uniform FWD parameter may either overestimate or underestimate dune stability depending on local sedimentary and biological conditions. Nevertheless, this assumption represents a pragmatic compromise that enables coupling with a non-morphodynamic model such as LISFLOOD-FP.

Despite its simplicity, the binary failure scheme provides a computationally efficient, first-order approximation that captures the hydrodynamic consequences of dune erosion and breaching. More sophisticated morphodynamical approaches, while physically more realistic, generally require extensive parameterisation and data inputs that are rarely available to coastal managers. The proposed binary framework thus provides a practical and parsimonious means of approximating floodplain dynamics with limited input requirements. Future developments of this approach will involve close collaboration with stakeholders to assess parameter availability and to explore the inclusion of partial or time-dependent erosion formulations, thereby enabling a more gradual and physically realistic representation of dune degradation while maintaining computational efficiency.

Finally, the implemented modeling framework is designed to allow flexibility in dune representation: dunes can be repositioned within the simulation domain and assigned varying FWD values. This capability enables the exploration of alternative dune configurations and failure scenarios, thereby improving the understanding of how dune position, continuity, and resistance influence coastal flooding dynamics, even under conditions of limited data availability."