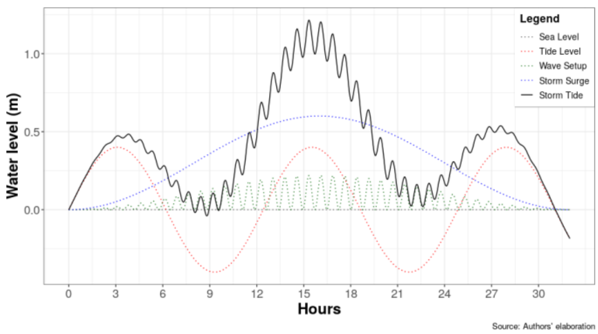
Dear Editor,

Thanks for your insightful review. Please find below our answer to each point raised.

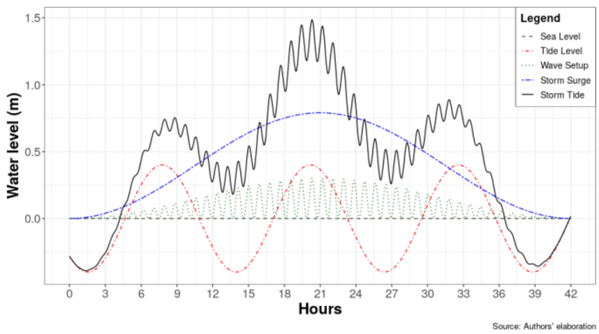
1. It is not clear how the information of figure 4 is used by the ANUGA model. Is it a boundary condition? The ANUGA model should compute the water level and not to adopt it from an external source. Please clarify.

➢ Thank you for your valuable comment. The information shown in Figure 4 aims to show how the boundary conditions in ANUGA are set-up during a theoretical storm tide event, in the case of Figure 4 for an example case of a once in 10 years return period. Each of the components shown in Figure 4 are considered independently, according to the intensity (i.e. water level) and duration of the respective storm tide event, and added to generate the black continuous line representing the storm tide level (or total water level, TWL) as a boundary condition in ANUGA. The detailed numeric information of the components considered is shown in Table 1. The flood model then takes into account the boundary conditions specified in Table 1 and dynamically shown in Figure 4 to simulate the dynamics within the domain, such as water flow through the canals and the flooding of land areas. For each return period scenario, a different idealised storm tide event is designed in order to match the maxima level of tide and surge (following the worst-case scenario assumption, as mentioned in line 60 and 239). We attach here these figures (also added as document annex1) representing each one of the dynamic scenarios considered for the different RPs.
Paragraph has been amended to clarify our approach.

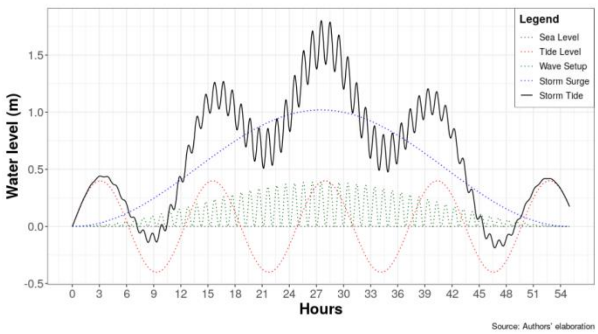
RP 1



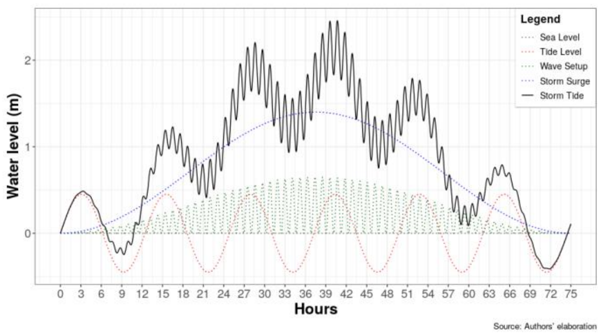
RP 10



RP 100



RP 250



2. The methodology of your simulations is not clear. It seems to me that you have simulated a set of idealized events, corresponding to different RPs under different VLM and local mean sea level hypothesis. Please clarify.

➢ Thank you for your comment. Yes, we simulated the coastal flood dynamics from a set of idealised storm tide events corresponding to the worst-case scenario, when extreme water level is the result of the combination of tides and storm surge. Such events do occur (e.g. Storm Xynthia in Western Europe), also along the coastline of the study area (e.g. extreme sea level event between the 15th and the 16th of November 2011 along the Emilia-Romagna coast). In this paper, we are not interested in forecasting water levels nor storm surge events, thus we do not provide information about the likelihood of such events happening along the coastline of the case study cities. Instead, we design scenarios that take into account the worst-case situation of coinciding storm tide events and evaluate the cost-benefits of flood defence measures against those worst-case scenario events. This is a traditional approach when designing engineering projects to safeguard public's safety, health and welfare.

3. The basis for the time evolution of the different components shown in figure 4 is not clear. They are strongly idealized (see previous comments). Please justify that they are representative of real events. Particularly the oscillations of the wave setup deserve an explanation. What is their cause? What is the corresponding evolution of the wave height?

➢ Thank you Thank you for your valuable comment. As discussed in the last comment, in the work developed in this paper, we are not interested in forecasting storm surge and spring tides along the coastline of the case study cities. As such, we assume a general functional form describing the oscillation of water level due to the different components defining extreme sea level, following trigonometric functional forms for each component. Each function, then, has a different period and magnitude, to reflect the contribution of each component. For instance, for simulating tides, we consider a function of period of 12 hours and 25 minutes and magnitude according to the scenario that we are considering. Trigonometric functions have been used with different degrees of complexity to approximate tidal levels and storm surge residuals (Boon 2004; Fuhrmann et al. 2019; Familkhalili et al. 2020).

  Regarding the wave component, since ANUGA is a 2D model that cannot simulate wave breaking and the swash component of wave runup, we simulate just the wave setup component using data obtained from the literature. The wave setup is a relevant component of the total water level, and we incorporate it as a function of the intensity of the storm surge level, as shown in Figure 4. As such, wave setup is simulated as composite function, where the maximum wave setup level is designed to coincide with the maximum storm tide level, and the directions of the waves are set to coincide with the direction of the storm surge event, in our case, perpendicular to the coastline. This is done first to follow the assumption of worst-case scenario, and second to incorporate the flood dynamics resulting from the momentum of waves directed inlands.

  A new paragraph has been included to 3.6, after table 1, to better explain our simulation approach. Figure 4 describing the simulation domain has been added.

4. For storm surges (height and duration), wave set up and tides, you use the results of Armaroli et al. 2012, Armaroli and Duo 2018. Please add a few sentences to describe the observational basis for these estimates (instrumentation used, its location and duration of the time series)

- Sentence amended: *Both variables are obtained from analysis of observations recorded during historical ESL events on the coast of Emilia-Romagna from 1946 to 2010 (Perini et al. 2011), matched with the probabilistic distribution of RP scenarios (Armaroli et al. 2012; Armaroli and Duo 2018).*

5. Table 1: The values of the column historical and TWL (2100) do not correspond to the sum of the components. Please use consistently the number of significant digits in the different columns. Abbreviations are explained in the text, but please add them to the caption to help the readers.

- Thanks, columns digits were made consistent.

Other points to be changed, integrated or clarified

i. Page 2 lines 65-66 and elsewhere in the text. Local RSL changes cannot be separated in a global eustatic component and the vertical land movement. Eustatic sea level changes are global sea level changes related to changes in the volume of water in the world ocean. The local sea level is affected by regional density and circulation changes, and mass addition (which is not spatially uniform). Please provide a clear conceptual framework for the components that you use for computing the local RSL rise.

   - Sentence corrected. The manuscript has been revised to correct the terminology.

ii. Section 3.3 Observed and future sea level rise in the Adriatic is discussed in Lionello and Scarascia which estimated that the average sea level rise of the North Adriatic in the 20th century has been 1.3mm/year https://doi.org/10.1016/j.gloplacha.2013.03.004

   - Sentence and references amended.

iii. Your answer to the reviewer comment asking for clarifying the reason for the difference between Tmax RP250 and shorter RPs is not clear to me. Is this difference based on previous studies or is it a subjective estimate? please clarify and justify the specific RP250 value.

   - The value of Tmax in relation to RP250 is inferred from the data adopted by ARPA to define risk zones: in particular, in the referenced study from Perini et al 2016 (www.nat-hazards-earth-syst-sci.net/16/181/2016/) the spring tide is set as 0.45 m for worst case scenario (Table 1) and is unspecified for RP>100 years in Table 2, though it can only be 0.45 in order to consistently sum up to 2.50 m. Section 3.6 has been amended to clarify:

   The high tide contribution grows from 0.40 m to 0.45 m, while wave setup near the shore ranges from 0.22 m to 0.65 m. We select the scenario RP 250 years as the upper boundary of hazard intensity, considering all components of TWL to reach their most extreme values and summing up to +2.5 meters over MSL.

iv. Line 186 "change in trend" would mean acceleration or deceleration of an existing trend. Further it is not clear to which variable you are referring. I think you mean "… no strong evidence supporting a significant positive trend of marine storminess for the next future". In such a case a suitable citation would be https://doi.org/10.1016/j.gloplacha.2016.06.012

   - Sentence amended, reference added.

v. Line 217 Section 3.6 please clarify briefly the difference between hydraulic, hydrodynamic and hydrostatic models or erase the sentence

- Sentence is removed.

vi. Figure 5 : the meaning of the label “Factor” of the y-axis is not explained in the text. Further, it is not clear the relation between this figure and eq.(1)

- Figure is amended; caption is extended: *Schematic representation of the numerical integration of the damage function D(p) with respect to the exponential probability of the hazard events. Damage (Y axis) represents the ratio of damage to the total exposed value estimated up to the most extreme scenario (RP 250 years). Events with a probability of occurrence higher than once in a year are expected to not cause damage (grey area).*

Other changes

Corresponding author was added.

Annex 1 was added with figures of TWL boundary conditions for the model.