

# “The role of tidal modulation in coastal flooding on a micro-tidal coast during Central American Cold Surge events”

by Wilmer Rey et al.

## ANSWER TO COMMENTS OF REVIEWER #1

### Major points

1) The English of the paper needs to be thoroughly revised. Many typos, awkward and incorrect sentences can be found in the text and should be fixed. The help of a native speaker could be beneficial.

**Authors response:** You are right. The new version of draft paper was reviewed by a professional native English speaker.

2) The paper actually deals with coastal flooding in a specific location. It does not assess, in general terms, the role tidal modulation in coastal flooding. Please consider to revise the title, as tidal modulation is only one aspect of the overall process analyzed in the paper. I'm thinking of something as “Assessment of coastal flooding in the Yucatan coast during Central American Cold Surge Events”.

**Authors response:** We propose “Assessment of coastal flooding and associated hydrodynamic processes on the Yucatan coast during Central American Cold Surge Events”.

3) The presentation of the paper is very confused. Different type of data, validation of model results and of input data (i.e., water residuals and wind data), characterization of CACS events and analyses of the entire 30-years time series, etc. are mixed together. The Authors should re-order, and possibly shorten, the paper, which needs to be less dispersive to the reader attention. Rather than being a vast report of all the analyses carried out by the Authors, a scientific paper should lead the reader to clear

**Authors response:** You are right. We shortened significantly the draft paper. Figures 2 and 3 were joined, lower panel of Figure 5, figure 8 and figure 9 and their respective paragraphs of explanation were removed. Figures 10 and 11 were joint in two panels of a single figure. Based on this, we tried to focus only on the assessment of the inundation threat from CACS. In addition, the pertinent references you suggested were included in the manuscript, except #5 of your list (see list at the end of this document).

4) The Introduction is too long; many specific information should be moved from Introduction to Section 2.

**Authors response:** We moved information from Introduction to section 2 and indeed improved clarity and readability.

5) Although an interest topic per se, I do not understand the role of hydrogeology in coastal flooding. How can an aquifer discharge affect the sea level? This question needs to be clearly assessed (if aquifer discharge actually plays some roles), or otherwise, being not even mentioned in the paper.

**Authors response:** We acknowledge your comment. We assessed the contribution of the Yucatan aquifer to the sea level during CACS passes over the Yucatan Peninsula through a constant discharge along the coast. The model results indeed suggest that this contribution is not relevant (although the total discharge of the aquifer is estimated to be  $4900822 \text{ m}^3 \cdot \text{d}^{-1}$  along 208 km of coast line (Weidie, 1985)) and then, as you suggest, was removed from the manuscript. Maybe in future studies, this can be analyzed in more detail.

6) The “References” section contains many typos and missing/wrong information (the formatting of conference proceedings and book chapter has problems with the conference/book title and with the number of pages). Please check carefully all the details of each bibliographic item.

**Authors response:** Thank you. This was done. However, there are some conference proceeding that do not have book title, such as:

Rey, W., Salles, P., Mendoza, E. T., Trejo-Rangel, M. A., Zhang, K., Rhome, J. and Fritz, C.: Hurricane Storm Surge Risk Assessment for the Yucatan State Coastal Area, in Proc. 32st Conference on Hurricanes and Tropical Meteorology, p. 1, American Meteorology Organization, San Juan, Puerto Rico., 2016.

Torres-Freyermuth, A., Puleo, J. A., Ruiz de Alegría-Arzaburu, A., Figlus, J., Mendoza, T., Pintado-Patino, J. C., Pieterse, A., Chardon-Maldonado, P., DiCosmo, N. R., Wellman, N., Garcia-Nava, H., Palemón-Arcos, L., Roberts, T., López-González, J., Bravo, M., Ojeda, E., Medellín, G., Appendini, C. M., Figueroa, B., González-Leija, M., Enriquez, C., Pedrozo-Acuña, A. and Salles, P.: Nearshore Coastal Dynamics on a Sea-Breeze Dominated Micro-Tidal Beach (NCSAL), in Proc. American Geophysical Union, AGU Fall Meeting Abstracts, San Francisco, USA., 2014.

They are found on the following websites:

- <http://adsabs.harvard.edu/abs/2014AGUFMOS11A1266T>
- <https://ams.confex.com/ams/32Hurr/webprogram/Paper293952.html>

We used the Copernicus style with default values for the references.

### **Minor points**

-Check for the presence of double consecutive spaces into text.

**Authors response:** Ok. Done.

-The use of acronyms and abbreviations should be limited, as it makes difficult to follow the text for those readers that are not already familiar with them. Finally, make sure that all the abbreviations are properly introduced when they first appear.

**Authors response:** Ok. Done.

-Abstract: the reason why hindcast sea level time series was used (i.e., the lack of Interactive measurements) has to be stated. Rather than reporting specific numerical data, please specify the locations object of the study (Progreso and Chelem lagoon) and clearly outline the analyses carried out and the main results.

**Authors response:** You are right. We made the corresponding changes on it.

-page 1, line 11: an "...occurrence probability" cannot be performed.

**Authors response:** That sentence was change to: "To diagnose the mechanisms controlling the water levels, the two worst storms in terms of maximum residual tide (Event A), and maximum water level (Event B) were identified".

-p. 1, l. 16: "inlet" of what?

**Authors response:** We refer to "lagoon inlet". The study area included a coastal lagoon, this is mention on the new version of abstract.

-p. 1, l. 17: "despite micro-tidal conditions" what does this means? What is the difference between the tide (mentioned just before) and these "micro-tidal conditions"?

**Authors response:** the term "microtidal" refers to tidal ranges less than 2 m (see, e.g., Pugh, 1987). If needed, it can be removed. In that same sentence, the difference between tide (noun) and micro-tidal (adjective) is obvious for us.

-p. 1, l. 34: "passing over the GoM"

**Authors response:** That paragraph was deleted based on your major point # 3.

-p. 2, l. 4: "methodology" pertains to the "study of methods", use "method" instead.

(see also p.6, l. 14).

**Authors response:** That paragraph was deleted based on your major point # 3.

-p. 2, l. 14: replace “induced by..... on the sea surface and” with “enhanced by”

**Authors response:** Ok. Done.

-p. 2, l. 15: Shorten the sentence as “Consider that the effect of pressure field is relatively small during high-pressure atmospheric systems as CACS (Flather, 2001).”

**Authors response:** That sentence was change as “Considering that the effect of atmospheric pressure is relatively small (Massey et al., 2007) especially during CACS events, the storm surge is mainly due to the shear stress of the wind, principally in shallow waters in the coastal zone (Flather, 2001)”.

-p. 2, l. 19: which currents?

**Authors response:** littoral currents.

-p. 2, l. 22: “:flood hazard is defined...”

**Authors response:** Ok, Done.

-p. 2, l. 23: “...and period; it depends on...”

**Authors response:** “it” was added to the sentence

-p. 2, l. 24: delete “However”

**Authors response:** Ok. Done.

-p. 2, l. 25: The year is missing in the reference to Dorrestein

**Authors response:** Sorry, it is Dorrestein, 1961

-p. 3, l. 13: delete “However”

**Authors response:** Ok, Done.

-p. 3, l. 28: “back-barrier lagoon of Chelem, behind Progreso”

**Authors response:** Ok. Done.

-p. 3, l. 32: Start a new paragraph with “In terms of hydrogeology...” (see also major point n. 5)

**Authors response:** You are right, all of this paragraph was removed based on your major point # 5.

-p. 3, l. 34: delete “in”

**Authors response:** that sentence was removed based on your major point # 5.

-p. 4, l. 17: units: remove periods from within units' expressions (e.g., m<sup>3</sup>s instead of m<sup>3</sup>.s). Please check throughout the text.

**Authors response:** Ok, period was removed.

-p. 4, l. 17: put a reference to Fig. 2 after “Holbox”.

**Authors response:** Ok. Done

-p. 4, l. 22: please define “HD”

**Authors response:** Ok. Done.

-p. 4, l. 23: “shallow water equations”, not “shallow waters equations”

-p. 4, l. 23) Authors response: Ok. Done.

-p. 4, l. 25-26: awkward sentence

**Authors response:** That sentence was change to: “By means of the integration of the horizontal momentum equations and the continuity (1) equation over  $h = \eta + d$ , the following two-dimensional shallow water equations are obtained.”

-Eq. (1), (2), and (3): What kind of discharge is S, whose units are 1/s? How are the components of the “lateral stress” evaluated? Are these Reynold/dispersion stresses?

**Authors response:** S is a discharge in m<sup>3</sup> s<sup>-1</sup>, but first vertically integrated, and then per unit area.

“The lateral stress terms include viscous friction, turbulent friction and differential advection. These are estimated using an eddy viscosity formulation based on the depth-averaged velocity gradients.”

-p. 5, l. 4: delete “studying”. This sentence seems incomplete.

**Authors response:** That sentence was change to: “The wave model used to compute the wave conditions and associated radiation stresses was the MIKE 21 third generation spectral wave (SW) model. This model has been used for several spectral wind-wave modeling applications (Strauss et al., 2007; Appendini et al., 2013, 2015).”

-p. 5, l. 10: After “wave action equation” please put a reference (bibliographic or to an equation reported in the paper).

**Authors response:** The DHI (2014b) reference was added to that sentence.

-eq. (4) is correctly written?

**Authors response:** Yes, it was literally copied from the Spectral Wave manual.

-p. 5, l. 15: the sentence “: the directionally ...formulation” is duplicated

**Authors response:** Ok. Done.

-p. 5, l. 18: “as described in”

**Authors response:** Ok. Done.

-p. 5, l. 21: what’s the meaning of “(10-10 km)”?

**Authors response:** Sorry, it is 10-100 km.

-p. 5, l. 22: “and both swell and combined...are not important”

**Authors response:** Ok, it was corrected.

-p. 5, l. 27: I don’t see S in the equation

**Authors response:** The energy source term,  $S$ , represents the superposition of source functions describing several physical phenomena. “ $S = S_{in} + S_{nl} + S_{ds} + S_{bot} + S_{surf}$ ” was added to that sentence.

-p. 6, l. 9: “as reported”

**Authors response:** Ok. Done.

-p. 6, l. 14: Does the last sentence refer to the previously described treatment of the boundary condition? In this case, this sentence should be moved before the description of the boundary condition.

**Authors response:** Ok, this sentence was moved before the description of the boundary condition.

-p. 6, l. 19: “according to Arcement and Schneider (1989)”, “of the Yucatan sand”

**Authors response:** Ok. Done

-p. 6, l. 22: what is the result of the further calibration of Cd?

**Authors response:** The “further calibration” consisted on: (a) varying (up and down) the Lin and Chavas (2012) values and selecting the best combination that resulted in the smallest WSL error. As in that paper, the Cd used varies linearly with the wind speed, as in other studies (e.g., Bryant, K. and Akbar, M.: An Exploration of Wind Stress Calculation Techniques in

Hurricane Storm Surge Modeling, J. Mar. Sci. Eng., 4(3), 58, doi:10.3390/jmse4030058, 2016). If needed, we can include details in the manuscript.

**The following minor points (p. 6, l. 37 to p. 7, l. 16) correspond to a section of the manuscript that was removed, addressing your suggestion of shortening the paper (see “Major Point #3”).**

-p. 6, l. 37-ff: This paragraph should be reorganized. The risk of coastal flooding is only associated with the total sea level, not directly with the sea residual. Clearly, the analysis of the sea residual is crucial, e.g. in order to improve sea level forecasts, since the sea residual is affected by major uncertainties than the astronomical tide (e.g., Met et al., 2014).

**Authors response:** That paragraph was removed (see above)

-p. 7, l. 5-10: D1 and D2 are datasets, i.e. sets of data, but they are described as actions/procedures (“consisted in identifying”, “consisted in adding”). In D1 the astronomical tide is removed, in D2 is added again...Please make the description of the two datasets clearer.

**Authors response:** That paragraph was removed (see above).

-p. 6, l. 13 (in deep is p. 7, l. 13) : datasets have to be denoted with D1 and D2, not with (a) and (b).

**Authors response:** That sentence was removed (see above).

-p. 6, l. 16 (in deep is p. 7, l. 16): “selected and then analyzed”

**Authors response:** That sentence was removed (see above).

-p. 6, l. 26 (in deep is p. 7, l. 26): “At the peak”. Remove the comma after “were”

**Authors response:** Ok, corrected.

-p. 6, l. 31 (in deep is p. 7, l. 31): “while” is a temporal expression, use “whereas for Event B..” instead. In addition, “closer to the normal to the coast”.

**Authors response:** Ok, corrected.

-p. 8, l. 15-16: It is not clear to me how this goal was pursued. By shifting the astronomical tide for the entire 30-years’ time series?

**Authors response:** No, only for Event A.

-p. 8, l. 27-ff: As for what I understand, a hypothetical scenario (TSSE) is compared with a measured (reanalyzed) wind field. Does this make sense?

**Authors response:** We were trying to compare/correlated the increase of the sea level with the increase of the offshore wind speed. However, that paragraph was removed from the draft based on the major point # 3.

-p. 9, l. 27 Figure 10, not Figure 9.

**Authors response:** That sentence and figure were removed from the draft addressing your suggestion of shortening the paper (see “Major Point # 3.”)

-sect. 4 and sect. 5 are quite long. I suggest a sensibly shortening of these sections.

**Authors response:** These sections were shortened significantly as you suggested.

-p. 14, l. 11: “consist in using the... assuming that...and performing...”

**Authors response:** Ok. Done.

-p. 14, l. 16: “events”

**Authors response:** Ok. Done.

-p. 14, l. 23: A study cannot perform anything...

**Authors response:** Right, it was change to: “This study has developed a thirty-year sea-level hindcast.”

-p. 14, l. 24: “to identify extreme water levels and characterize their probability of occurrence using....”

**Authors response:** Corrected.

-p. 14, l. 27: “different”. “conditions”, not “configurations”.

**Authors response:** Corrected.

-p. 14, l. 31: The fact that an area is more populated cannot be a cause of more Flooding.....Rather, it can cause greater damages...

**Authors response:** Right, it change by “Since the wind stress over the lagoon was stronger for Event A, this event caused larger flooding than Event B over the back barrier lagoon of Progreso.”

-p. 14, l. 33: “producing large set-up”; and waves? See, .e.g., Carniello et al. (2005).

**Authors response:** No, inside this small lagoon, the waves are not large (for the Event A, the biggest waves did not reached highs of 1 m. inside the lagoon).

-p. 14, l. 33: "Chelem lagoon". "were" in place of "occurred".

**Authors response:** Ok. Done

-p. 14, l. 34-35: "The passage of CACS, besides affecting water exchange with the sea and renewal dynamics inside the Chelem Lagoon (Viero & Defina, 2016a,b), is show to produce significant wind and wave set-up, characterized by nonlinear interactions between meteorological forcings and the astronomic tide.

**Authors response:** We totally agree about this. Your references were included.

-p. 15, l. 1: "Based on modeling results from..."

**Authors response:** "modelling" was added.

- p. 15, l. 2: "total flooded area"

**Authors response:** flooded was added.

-p. 15, l. 5: delete "is"

**Authors response:** "is" was added.

-p. 15, l. 6: awkward (and quite obvious) sentence.

**Authors response:** The sentence was change to: "However, the maximum flooding occurs when the CACS peak coincides with rising tide near zero level or high tide (TS4 and TS1 scenarios)". We do not consider that this is obvious, in particular during rising tide (near MWL).

-p. 15, l. 14: "storm surge, and set-up due to both wind and wave".

**Authors response:** Corrected

-Figure 3: I suggest putting the text in magenta on a white box to improve readability.

**Authors response:** Figure 2 and Figure 3 were joined.

-Figure 9, top panel: change the labels "Progreso" and "Progreso" with "Wind speed" and "Residual tide".

**Authors response:** this figure was removed based on your "major point #3".

-Figure 9, bottom panel: as for the top panel, labels should indicate the kind of data, not the location. "Reading (1992) method" is redundant here.

**Authors response:** this figure was removed based on your “major point #3”.

-Additional References Interactive.

**Authors response:** Thanks for these suggestions.

1. Carniello L., Defina A., Fagherazzi S., D’Alpaos L., 2005. A combined wind wave-tidal model for the Venice lagoon, Italy. *Journal of Geophysical Research – Earth Surface*, 110, F04007, doi:10.1029/2004JF000232.
2. Mel R., Viero D.P., Carniello L., Defina A., D’Alpaos L., 2014. Simplified methods for real-time prediction of storm surge uncertainty: The city of Venice case study, *Advances in Water Resources* 71, 177-185, doi:10.1007/s00193-013-0452-9.
3. Vousdoukas M. I., Voukouvalas E., Mentaschi L., Dottori F., Giardino A., Bouziotas
4. D., Bianchi A., Salamon P., Feyen L., 2016. Developments in large-scale coastal flood hazard mapping, *Natural Hazards and Earth System Sciences* 16(8), 1841-1853, doi:10.5194/nhess-16-1841-2016.
5. Viero D.P., Defina A., 2016. Water age, exposure time, and local flushing time in semienclosed, tidal basins with negligible freshwater inflow, *Journal of Marine Systems* 156, 16-29, doi:10.1016/j.jmarsys.2015.11.006. Viero D.P., Defina A., 2016. Renewal time scales in tidal basins: climbing the Tower of Babel. In “Sustainable Hydraulics in the Era of Global Change”, *Proceedings of the 4th IAHR Europe Congress, 27-29 July 2016*, Eds: Erpicum et al., 338-345, Liege, Belgium.
6. Woodruff J. D., Irish J.L., and Camargo S.J., 2013. Coastal flooding by tropical cyclones and sea-level rise, *Nature* 504, 44-52, doi:10.1038/nature12855.