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Reply to Alberto A. Boretti's "Discussion of Natalya N. Warner, Philippe E. Tissot., 2012. Storm flooding sensitivity to sea level rise for Galveston Bay, Texas. Ocean Engineering 44, 23–32"

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The authors thank the discussers for their feedback on the paper and their review of recent works and discussions of rates of sea level rise based on historical tide gauge and satellite altimetry records. The authors are generally in agreement with the discussers that based on the past century of water level records there is no strong evidence of a substantial deviation from a linear rate of sea level rise for Texas or globally. In one of the discussers' referenced contributions [Houston and Dean \(2011c\)](#) even compute a small decrease in rates of sea level rise for several long term tide gauge data sets. Further discussions of Houston and Dean's paper by [Rahmstorf and Vermeer \(2011\)](#) and [Donoghue and Parkinson \(2011\)](#) as well as [Houston and Dean's \(2011a, 2011b\)](#) replies constitute a most interesting overview of the topic with salient arguments focusing on geographic distribution and length of the selected data sets. Other considerations include the respective importance of land based contributions to sea level changes; a topic discussed in the last paragraph of the discussers' contribution. [Rahmstorf and Vermeer \(2011\)](#) also discuss the best approach to place recent sea level changes in the context of the last century's temperature fluctuations. While these discussions are of the highest importance for the modeling of past sea level rise and calibration of predictive models the authors of the discussed paper agree with the discussers that presently a substantial deviation from last century's global linear sea level rise has yet to be observed.

Where the authors and discussers disagree is on the likely rates of future sea level rise. The discussers' quoted references and their contributed sea level charts and table focus on past sea level rise. As discussed by [Donoghue and Parkinson \(2011\)](#) "... a study of processes of the recent past, such as long-term tide-gauge records, is not necessarily a good indicator of future circumstances. This is especially true in a future where models predict conditions that have not been experienced for many millennia." They further argue that "... analyses of small subsets of the historic tide-station database are of little prognostic value." While a substantial increase in the rate of sea level rise has yet to

be observed, this is not incompatible with the onset of a quadratic like rate of sea level rise nor with the vast majority of scenarios predicting various increases in the rates of sea level rise compatible with our warming climate [see discussed paper ([Warner and Tissot, 2012](#)) and references within]. Given the large uncertainty in future rates of sea level rise, several scenarios should be considered by coastal planners. While both discussers and authors agree on the selection of a continuing linear rate of sea level rise, the authors reiterate that they believe this is a low-end scenario. They further reiterate that the business-as-usual scenario of the last IPCC Fourth Assessment Report (AR4) ([Meehl et al., 2007](#)) is a more likely or at least a better alternate scenario compatible with our warming climate and the majority of the published literature. The resulting estimates for 21st century sea level rises in Galveston, TX of 1.08 m and 0.65 m correspond to eustatic sea level rises of respectively 0.60 m and 0.17 m after removing the likely local subsidence component (estimated based on 20th century records). A 0.60 m 21st century eustatic sea level rise is by no means a high-end estimate when compared to a number of models predicting up to 2 m of global sea level rise ([Nicholls et al., 2011](#)). The discussers' suggestion that a window including a continuing linear increase in sea level rise should be the high-end scenario and a decreasing rate of sea level rise should be the other case is surprising, at odds with most studies and, in the opinion of the authors, imprudent to adopt for coastal planners. The authors further believe that not including a sea level rise scenario in line with the IPCC business-as-usual (which does not include likely additional future contributions from Greenland and Antarctica) or similar scenario for the 21st century would be imprudent when planning coastal adaptations.

Evidence for one of the scenarios discussed or possibly even higher rates of sea level rise will unfold as the century progresses. The authors and discussers will likely agree for the continued need to monitor carefully sea level rise through collocated tide gauges and high precision GPS and satellite altimetry. The data gathered is of the highest importance to guide decisions both directly and through the verification and calibration of predictive models which provide essential guidance in a changing climate. The authors urge coastal planners to follow such discussions and consider large ranges of sea level rise as they continue to develop

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adaptation plans. The upcoming IPCC AR5 documents will hopefully narrow the range of likely future sea level rise.

References

- Donoghue, J.F., Parkinson, R.W., 2011. Discussion of: Houston, J.R. and Dean, R.G., 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *J. Coastal Res.* 27 (3), 409–417. (*Journal of Coastal Research*, 994–996).
- Houston, J.R., Dean, R.G., 2011a. Reply to: Donoghue, J.F. and Parkinson, R.W., 2011. Discussion of: Houston, J.R. and Dean, R.G., 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *J. Coastal Res.* 27 (3), 409–417. (*Journal of Coastal Research*, 997–998).
- Houston, J.R., Dean, R.G., 2011b. Reply to: Rahmstorf, S. and Vermeer, M., 2011. Discussion of: Houston, J.R. and Dean, R.G., 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *J. Coastal Res.* 27 (3), 409–417. (*Journal of Coastal Research*, 788–790).
- Houston, J.R., Dean, R.G., 2011c. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *J. Coastal Res.*, 409–417.
- Meehl, G.A., Stocker, T.F., Collins, W.D., Friedlingstein, P., Gaye, A.T., Gregory, J.M., Kitoh, A., Knutti, R., Murphy, J.M., Noda, A., Raper, S.C.B., Watterson, I.G., Weaver, A.J., Zhao, Z.-C., 2007. Global climate projections. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Nicholls, R.J., Marinova, N., Lowe, J.A., Brown, S., Vellinga, P., de Gusmão, D., Hinkel, J., Tol, R.S.J., 2011. Sea-level rise and its possible impacts given a 'beyond 4 °C world' in the twenty-first century. *Philos. Trans. R. Soc. A* 369 (1934), 161–181.
- Rahmstorf, S., Vermeer, M., 2011. Discussion of: Houston, J.R. and Dean, R.G., 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *J. Coastal Res.* 27 (3), 409–417. (*Journal of Coastal Research*, 784–787).
- Warner, N.N., Tissot, P.E., 2012. Storm flooding sensitivity to sea level rise for Galveston Bay, Texas. *Ocean Eng.* 44 (0), 23–32.