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Discussions

Interactive comment on "Multivariate statistical modelling of the drivers of compound flood events in South Florida" *by* Robert Jane et al.

Anonymous Referee #1

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Authors have proposed a framework for assessing the compounding effects of flooding drivers in coastal areas of South Florida (e.g. rainfall, coastal water level (WL) and groundwater level). They first assess the significance of dependence between these variables, and then propose bivariate and trivariate approaches to generate compound design scenarios. They finally compare the generated design scenarios with the current design approaches (with the assumption of full dependence between variables). The idea is very interesting and manuscript is very well written. This work would be a significant and novel contribution to the community and deserves publishing in NHESS, however after a major revision. My main concerns are: i) continuity of probability density function along the hazard isolines must be checked, ii) generated bivariate and trivariate hazard scenarios are significantly inconsistent at the margin (rainfall-WL

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plane) which needs a careful consideration. Details are provided below:

Major comments: - When the quantile-isoline is created by overlapping two separate isolines, could you please explain how you ensure that the joint PDF estimates are consistent along the envelope? I mean, theoretically taking derivative of CDF function, we are not necessarily dealing with a continuous function, and there is a chance that derivatives (that give us relative likelihood estimates and shading along the curve in Figure 5) diverge around the break point, right? Please, elaborate here. I see that you explained the process as "In this work, the relative probabilities are estimated non-parametrically via a Kernel Density Estimate (KDE), using the ks R package (Duong, 2007). Initially KDE was applied to the observations, however, particularly for larger return periods the design event proved highly sensitive to a small number of observations. Hence, design events were determined by applying KDE to a large sample ðİŚĄ = 10,000 from the two fitted copulas, with sample proportions consistent with the empirical distributions, and transformed back to original scales." But not yet clear to me how you check the continuity of PDF along the quantile-isoline. This probably helps better understand why "For small return periods ($\leq$20 years), design event rainfall remained <1mm, thus they may be considered "surge only" events." Looking at Figure 5a, we see some orange spectrum around the break point, while most likely scenario falls on the margin! You have also come up with the conclusion that "At sites S20 and S28, although the bivariate design events for return periods 1- and 100-years were "surge events", non-negligible probability density was located along part of the isoline comprising compound events" To me it raises a reddish flag that continuity is omitted.

- In page 18, where you analyze the timing before the O-sWL in the bivariate design event derived from the two-sided sampling approach reaches the corresponding value obtained from SFWMD scenarios (Figure 7), there is a significant underlying assumption that needs an explicit explanation, which is non-stationarity of the correlation structure. Indeed, the Copula parameters are assumed to remain unchanged over time.

- There is significant difference between compound scenarios using bivariate and

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trivariate approaches. In Figures 5a and 5b, the design scenario is picked so close to the margin (with rainfall $\sim$ 0) and a conclusion is made "In the bivariate analysis, at site S22, low return period (< 20 year) design events constituted "surge only" events". While in Figure 8 upper right panel, RP= 10 yr comes with $\sim$200 mm of rainfall. Also, in Figure 5c the pair associated with RP=50 yr is (Rainfall = 185, WL = 1.11), while in Figure 8 (upper right panel) the pair associated with RP = 50 yr is (Rainfall = 340, WL = 1.778) that is significantly larger than the one proposed under bivariate analysis. I understand that sampling approach is different between cases, but distribution functions must be compatible at the margins (i.e. at Rainfall-WL plane) otherwise yields in a great confusion. Especially when you state "The output of the bivariate and particularly trivariate applications can also act as boundary conditions for coupled hydrologic/hydraulic models for assessing flood risk and designing flood defence structures". Also, bivariate approach is based on extreme two-sided sampling, which is a more realistic approach compared with the one under trivariate analysis. So, does this significant different between outcomes suggest inappropriateness of employed trivariate scheme with the aim of "accounting for actual dependencies"?

Minor comments: L180-185: Sampling specifications not provided. L223: Define the variables used in this equation. L496: have not defined "mNGVD"

Nice work and good luck!

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