Joint probability analysis of storm surge and wave caused by tropical cyclone for the estimation of protection standard: a case study on the eastern coast of the Leizhou Peninsula and Hainan Island of China

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REFEREE REPORT

General comments

I regret to say that, in my opinion, the quality of this paper is not suitable for publication. Language is poor and technical terms are associated rather randomly resulting in nonsense sentences (e.g. L69, 74, 135, 143, 154, 197, just to mention a few).

Leaving aside the general confusion of the text (denoting lack of familiarity with theoretical concepts), the data analysis is the usual superficial application of bivariate copulas already reported in hundred of papers, iterating widespread mistakes and lacking whatever uncertainty assessment (I cannot understand why uncertainty assessment is fundamental to provide a decent univariate frequency analysis, but it suddenly disappears and is neglected when moving to multivariate frequency analysis, which is affected by the additional uncertainty related to the unknown dependence structure).

Some results that are interpreted as empirical findings are just theoretical constraints that do not provide any insight.

Justifying a paper with sentences like "*Presently, a few scholars have conducted studies on the interaction and joint distribution of storm surges and waves*" makes no sense: the use of joint distributions and copulas have been used in coastal/ocean engineering for at least 15 years worlwide to model not only surge and significant wave height but also other met-ocean variables; these methods have also been incorporated in national guidelines (e.g. UK and Netherlands, to mention a few) for several years, and are subject to ongoing improvement and update. So, please perform a decent preliminary literature review before running out-of-the-shelf computer packages.

Specific comments

L17: "*the surge height shows an increasing trend closer to the coastline*" ?? -> the surge height shows higher values closer to the coastline.

L18: "*when one variable is constant, the simultaneous, joint, and conditional risk probability tends to decrease as the other variable increases*"
Marginal and joint distributions are monotonic functions! This behaviour is related to their mathematical properties and has nothing to do with the analysed variables.

L58: "*the study of the joint probability distribution of tropical cyclone storm surges and waves is conducive to improving the accuracy and precision of joint hazard assessment*"
Yes, this is true if we neglect the fact that joint distributions are affected by the same uncertainty of their marginals and the additional uncertainty of the dependence structure.

L69: "*However, the constructed joint distribution is still a probabilistic result, and further search for constraint relations is needed to provide a basis and guidance for disaster prevention and mitigation. Therefore, this paper quantitatively analyzes the occurrence probability of storm surge and wave combinations based on the fitting results of the copula function*"
Words have a meaning and should be used accordingly! First, you say that "constraint relations" are needed because joint distributions are still a probabilistic (which seems to be a minus, whatever that sentence means), and then joint distributions are used neglecting constraints. Those sentences contradict each other.

L74: "*In the design process of sea dikes, breakwaters, and harbors, the surge height and significant wave height in different return periods is separately considered… disregarding the correlation between storm surge and so that the calculated water level may be underestimated or overestimated*."
This is incorrect, underestimation/overestimation means that an estimate is smaller/larger than a true value. In real-world applications, (i) the true value is unknown, so you never know if an estimator overestimates/underestimates, and (ii) univariate probabilities cannot be compared with joint probabilities as they refer to different processes! The choice of the required probabilistic model depends on the specific problem/failure mechanism. Univariate analysis is perfectly fine if there is a unique target design variable, and it correctly estimates the required probability (these concepts are explained here https://link.springer.com/article/10.1007/s00477-014-0916-1)

L80: "*optimize*" -> fit
As the confusion due to meaningless terminology already affects a significant part of the literature, please, use consistent technical terms without inventing a new vocabulary!

L81: "*function by the passing rate of the K-S test*"
When performing tests, the only meaningful "rate" is the rejection rate! (see here https://www.sciencedirect.com/science/article/pii/S0309170817305845 for an explanation)

L135: If the result of rewording concepts is this one, then it is preferable copying and pasting from some good paper/handbook. These sentences are just a set of randomly chosen words that make no sense whatsoever.

L151: Archimedean, elliptical and quadratic are not families but classes of copulas, and they are not the only existing classes. Archimedean copulas can be multiparametric as well! Please, do not use models without knowing the underlying theory, as the result is just a collection of misconceptions, meaningless statements, and misinterpreted figures and tables.

L154: "*analyze the joint probabilities of the marginal distributions of two variables*" -> "the joint probabilities of two variables" Joint probabilities of the marginal distributions do not exist!

L175: The conditional probabilities and the corresponding conditional distributions and return periods are not joint (multidimensional) but univariate (unidimensional).

L197: "*The marginal and joint probabilities of storm surge and wave scenarios cannot be directly employed as reference values for engineering protection standards*"
Return periods are just indicators derived from probabilities: if the former can be used, the latter can be used as well.

Sect. 3.4.2: this awkward method is quite useless because AND and OR return level curves are complementary, and their surfaces are monotonic and diagonally symmetric for the considered Archimedean copulas. This means that the point estimate (x,y) resulting from the (unnecessary) nonlinear optimization is just the intersection of the main diagonal of the copula and the OR level curve with RP = k. No optimization is required, just some familiarity with the theoretical properties of the models one intends to use.

L214: "determine whether it passes the 95% significance level."
"Passing the 95% significance level" makes not sense. A test can only reject or not reject the reference/null hypothesis at a given significance level. The significance level is not 95% but 5%.

Table 3 and corresponding discussion: Using the rate of no rejection to select the best model makes no sense for several reasons:

1) "No rejection" does not mean acceptance, and if two or more models are not rejected for a given data set, the only possible conclusion is that the information/ data is not enough to discriminate among the models.
2) The comparison includes distributions with different number of parameters (1-parameter Exponential, 2-parameter Gamma, Gumbel and Weibull (assuming that the Weibull does not include a location parameter), and the 3-parameter GEV). So, GEV has the obvious advantage of being more flexible due to higher parameterization.

3) Performing a test on 1665 nodes (i.e., 1665 times) is a multiple testing exercise. Under independence (which is not valid in this case), if the null hypothesis is valid, the number of no rejections has an expected value equal to 1582 (95%), and a binomial distribution, thus meaning that the 95% confidence interval of the number of no rejections is (1564, 1599). Therefore, Exponential and Gumbel cannot be discarded for the variable SH.
   However, met-ocean variables come from a model and refer to grid points of a connected area, they are surely strongly correlated in space. This means that the binomial distribution strongly underestimates the actual variability of the number of no rejections because of information redundancy. Therefore, other distributions for both SH and SWH might not be discarded. This is not surprising as these distributions are fitted to just 60/65 annual maxima, i.e. a very small sample size.
4) "No rejection" rate for Weibull and SWH is reasonably wrong because (i) WH/SWH (in deep water) has been historically modelled by Rayleigh distribution, which a particular case of Weibull, (ii) Weibull was shown to be a very good model in shallow water for WH (see https://doi.org/10.1016/j.coastaleng.2022.104130), and (iii) Weibull and 3-paremeter Weibull are closely related to GEV, and Weibull is also a pre-asymptotic distribution in EVT.

In summary the selection strategy seems to work just because it neglects the foregoing theoretical aspects.

Figure3: What about complementing these figures with confidence/prediction intervals?

L249: "*In general, the SWH increases with an increasing return period*"
In general? Distributions are monotonic functions: higher quantiles always correspond to higher return period for whatever (continuous) random variable… always, not "in general"!

Fig. 6: This figure (along with Fig. 7) is uninformative. The shape of the surfaces of generic joint PDFs and CDFs is well known. What matters is some diagnostic plot showing the goodness of fit (with uncertainty!)

L270: "*When the intensity values of the two disaster-causing factors are equivalent, $R_{\cap}$ is greater than $R_{\cup}$, which indicates that $P_{\cap}$ is smaller than $P_{\cup}$.*"
This is not a result but the effect of theoretical constraints (see here https://link.springer.com/article/10.1007/s00477-014-0916-1)

Figs 8-10: These figures just report what is expected according to the monotonic nature of bivariate distributions.

L315: "$P_{\&}$" was not defined in the text. I guess it refers to the discretised classes in Sect. 3.3.3 and Fig. 11.

L409-410: These statements are not related to the preceding text; they are just generic sentences.

Sincerely,

Francesco Serinaldi