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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "The susceptibility assessment of multi-hazard in the Pearl River Delta Economic Zone, China" *by* Chuanming Ma et al.

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Comments of referee 2: The manuscript describes an attempt to perform a multi-hazard susceptibility map of Pearl Delta Economic Zone in China. The issue of multi-hazard assessment is very interesting and it has still many open questions. The term "multi-hazard" is frequently used in the literature as an adjective to indicate multiple sources of hazard that are analysed in parallel and finally integrated into a multi-risk analysis. According to Corominas et al. (2013) multi-hazard assessment should refer to the joint probability of independent events occurring in the same area in a given time span. Multi-hazard assessment becomes relevant when hazard sources can in-

teract, giving rise to a domino effect that occurs when a hazard event triggers a secondary event. In this paper six different hazards are considered. For each of them a susceptibility map is performed and then all the six maps are simply overlaid in GIS environment, providing a final multi-hazard map, thus not considering any potential interactions among the hazards and the possible domino effects. Comments of referee 2: For example landslides ad soil erosion are strictly connected and this aspect should be considered in the analysis. Author's response: We selected influencing factors affecting occurrence mechanism and formation conditions of individual geo-hazaras as susceptibility indexes. Multi-hazard susceptibility assessment is carried out by using the Difference Method to provide decision-makers with visual information on the spacial distribution of various geological disasters susceptibility for geo-hazards management and land use planning, which reduce confusion of decision-makers on high number of individual geo-hazard maps. Collapse and landslide have theÂăinherentÂărelationship in occurrence mechanism and formation condition, so we carry out collapse and landslide susceptibility assessment. And, there are weak correlation between other geo-hazards in occurrence mechanism and formation condition. Thus, the relation between geo-hazards is considered in geo-hazards susceptibility assessment. Comments of referee 2: Furthermore the susceptibility assessment of each specific hazard is carried out with a simple method, completely neglecting the extensive literature on the geohazards susceptibility assessment, with special reference to the methodology and the selection and preparation of predisposing factors. In particular the selection of predisposing factors is arguable and an incomplete set of factors is considered. Some important factors, infact (such for example vegetation) are not considered. Author's response: The Analytic Hierarchy Process verified by lots of researches is widely used to evaluate geo-hazards susceptibility. Geo-hazards susceptibility assessment is carried out by using AHP and GIS, which reduce obvious subjectivity and provide visual information. And, we have performed validation of susceptibility results through sensitivity analysis. The sensitivity analysis result indicates the accuracy and rationality of the assessment method and shows it suits the particularity of the study area. We selected

influencing factors as individual geo-hazard susceptibility indexes based on consideration for occurrence mechanism and formation conditions of individual geo-hazard, human triggering factors were not considered. Comments of referee 2: Another relavant limitation of the analysis is that no information are provided about the model input data (resolution, date, source). In particular the resolution of the input data affects the resolutions of the final susceptibility maps that are not provided in the work. Eventually, what about the geological hazards database (landslide inventory map, collapse map and so on..) used to assess susceptibility? Some detailed information should be provided. Author's response: We took into account this comment. Author's changes in manuscript: We have added a new chapter (section 3.1) to provided some information about data. High number of data have been used in geo-hazard susceptibility assessment, along of them, natural geographical conditions, geological condition, the spacial distributed of major geological hazards, vegetation cover and land use type have been provided in section 2, soil type, the distribution and thickness of mollisol, and groundwater information is provided in supplement data. Comments of referee 2: The introduction is too long and not well focused. Some parts are useless (lines 37-50) and some other parts are not clear (lines 85-88). It is quite curious that in the Introduction you don't mention which type of hazards you consider in your analysis. In line 94 you state "...aforementioned geohazards" but I cannot find where you have mentioned them! Author's response: We took into account this comment. Author's changes in manuscript: For content in lines 37-50, we only have removed lines 43-50, because the research background was introduced in line 37-43. To clarify the statements, we have rewritten the paragraph line 85-88 (new line 79-83) in the following way: "Thus, multi-hazard susceptibility assessment is completed by synthesizing all individual geological hazards susceptibility result with the Difference Method. The major principle of the Difference Method is that the multi-hazard susceptibility in this a unit is considered high, as long as there is a kind of geological hazard under high susceptibility in specific evaluation unit. And, we have clarified type of hazards occurred in the study area in line 48-52: According to geological survey result, geo-hazards occurred

in the Pearl River Delta Economic Zone mainly include collapse, landslide, debris flow, ground subsidence, karst collapse, water and soil erosion and seawater intrusion, the scale of debris flow is small, so it is not considered as object of study." Comments of referee 2: Some sections inside the study area are very short (2.2, 2.3 and 2.4). I think they can be merged. Author's response: According to your kind suggestion, section 2.2, 2.3 and 2.4 have been merged in section 2.2. Original section 2.2, 2.3 and 2.4 are now section 2.2.1, .2.2.2 and 2.2.3, respectively. Comments of referee 2: What is the definition of collapse in your work and which is the difference between collapse and karst collapse? Author's response: Collapse refers that rock-soil block is divorced from the slope body under the influence of external factors. Collapse belongs to the problem of slope rock mass instability. When natural caves is affected by sudden changes of stability conditions due to karst dissolution, karst collapse trends to occur. The formation conditions of karst collapse mainly includes karst with certain development, overlying rock and soil, and the karst groundwater system. Comments of referee 2: Furthemore why landslide and collapse have the same casual factors? In my point of view they are quite different phenomena. This point shoud be clarified better. Author's response: Collapse and landslide belong to the problem of slope rock mass instability, they often associated with each other in the cause of formation. There are also internal relations and transformation relations between them, which make them have strong consistency in temporal and spatial distribution. Landslides are closely related with collapses, and they usually occur accompanied. Collapse and landslide occur under the same geological tectonic setting and the same stratigraphic lithology conditions, with the same triggering factors. So they have the same casual factors. Author's changes in manuscript: We also clarified reason why landslide and collapse have the same causal factors in line 234-242. Comments of referee 2: No quantitative validation of susceptibility maps is performed. This is not correct since every model has to be validated in order to evaluate its performance. Author's response: We have carried out quantitative validation of susceptibility maps by sensitivity analysis (analysis of effective weight). The sensitivity analysis result validates the accuracy and rationality of

the assessment method and shows it suits the particularity of the study area. Author's changes in manuscript: Validation ofÂătheÂăresults is added in section 6. The text as been added as followed: "Sensitivity analysis is used to assess effects of the input criteria on the model output performance and also to validate the effect of changing variable conditions or parameter values on the system (Gomez and Jones 2010). Sensitivity analysis is to determine the effective weight of each parameter and compared it with the theoretical weight for verifying the information on the effect of scaled values and weights assigned to each parameter. The effective weight, called coefficient of variation, is computed using the following Eq.Âă(4) (Napolitano and Fabbri 1996).

where W is the effective weight of the parameter P, Pr and Pw are the weight and the scaled value of the parameter, respectively, and V is the susceptibility index of geo-hazard. The result of individual geo-hazard susceptibility assessment (e.g. collapse and landslide, Karst collapse, ground subsidence, water and soil erosion and seawater intrusion) is verified by sensitivity analysis. The sensitivity analysis result is shown in Table 4. Table 4 represents the effective weights with the theoretical weight for individual geo-hazard susceptibility criterion. The effective weights of each parameters are slightly different from the theoretical weight assigned to individual geo-hazard susceptibility, which validates the accuracy and rationality of the assessment method." Comments of referee 2: There is only one general sentence in the Con-clusion (lines 566-568), which is absolutly not enough. Author's response: We do not understand this comment well, so we hope you can give more comments. Comments of referee 2: Figures are too small, words inside are not redable. Author's response: The size of figures and the formatting of words inside, such as font, font size, and spacing have been adjusted for redable. The resolution of figures has been raised to be visible clearly. Comments of referee 2: In general English is not good. Even tough I am not an English mother tongue, I have identified several errors and mistakes and the authors have to carefully check the language. Author's response: we carefully have checked all language of this paper and corrected errors and mistakes.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-104/nhess-2018-104-AC3-supplement.zip

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