

***Interactive comment on* “Linking drought indices to impacts to support drought risk assessment in Liaoning province, China” by Yaxu Wang et al.**

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Manuscript nhess-2019-310 “Linking drought indices to impacts to support drought risk assessment in Liaoning province, China” – Point by point response to referee 1 comments We thanks referee #1 for the feedback to our manuscript. We appreciate all the comments and suggestions and it is very useful to improve its quality and readability. We would like to address the referee’s major concern. We have added a comparison with the paper of Hao et al. (2011), including methods, data and results. The vulnerability assessment method is a little confusing in the former manuscript, and we have added some explanations on how we did the quantitative vulnerability assessment. At the same time, some sentences are reorganized, which makes the manuscript more readable. In the discussion, we have added some comparison with other drought stud-

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ies, including research data, methods and results. More detailed changes and replies are in bold below.

Line 43, That strongly differs to me 2016, Naumann 2018, Voigt 2019 and Hagenlocher et al 2019; Especially check for the latter→drought risk and vulnerability review.

We thank the reviewer for this comment. Lots of drought risk assessment methods have been used in different study area. In Julia Urquijo & Veit Blauhut 2016, some reviewed paper defined risk as follows.

$$R = H \times V$$

Where risk (R) is considered to be a function of hazard (H) and vulnerability (V).

It is similar to the one of the class in this manuscript which drought risk evaluate by drought hazard (drought frequency, severity etc.), vulnerability (including the drought resistance ability) and exposure of affected bodies (density of house, property and so on). Lots of indices were selected to measure the hazard, vulnerability and exposure. Drought risk is calculated by the weighted indices.

$$R = H \times V \times E$$

Where risk (R) is considered to be a function of hazard (H), vulnerability (V) and Exposure.

Another drought risk assessment method was grouped in this manuscript as follows.

Where risk (R) used to be considered to be a function of probability of drought (P) and potential consequences & impacts (C).

In Blauhut et al. (2016), past drought impacts, drought indices and vulnerability factors were applied to assess drought risk. Blauhut et al. (2015) combine past drought impacts with hazard measurement in order to assess drought risk in pan-European. Probability of drought impact occurrence at five different drought hazard levels was used to measure drought risk. The higher of the probability of drought impact occur-

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rence (potential consequences & impacts) at same drought hazard levels (probability of drought), the higher of the drought risk. In Carrao et al. (2018) (Carrao, Naumann 2018), definitions of risk are commonly probabilistic in nature, referring to the potential impacts from a particular hazard in a future time period.

Essentially, these research assess drought risk from the drought severity and the potential drought impacts. These are similar with another class in this manuscript. We will clarify this in the revised manuscript..

Line 47: Indeed, quite some studies use 'risk' to characterize the hazard of drought (severity, frequency etc.). But the terminology of risk is by definition the likelihood of impacts! I recommend you to highlight this "missuse" a little more.

We agree with the reviewer and highlight this "missues" as suggested. Then we revised the manuscript.

Line 52: Reference?

Thanks for your suggestion and we added a reference here(Erhardt and Czado, 2017).

Line53: Vegetation drought?

We thank the referee for the comments and revised the manuscript to make it clear.

Line 66ijŽI believe Hao et al. 2011 published on this.

We thank the reviewer for this important comment. Hao's et al. (2011) is an important related study in this field to compare with. As mentioned above, we have added a reference to Hao et al in the revised manuscript. .

In Hao's study, drought impact only measured by affected crop area in a 10-day time step at county level, in our research, it is measured by eight types of annual drought impacts, which including the affected crop area at city level. Their result shows that West Liaohe Plain has a high risk. Most parts of Chaoyang and Fuxin are identified the highest vulnerability in our research which are located in West Liaohe Plain.

Line 78 ? Line 87 Line 94

We modified the reference as suggest.

Line 114: Does this mean from rainfall, recharge or water available for public water supply?

Here, it means the all the freshwater, we have clarified this in the revised paper.

Line 149: Please indicate why you selected these vulnerability factors: prestudies, expert knowledge, data availability, statistical tests?

We thank the reviewer for this comment and we fully agree with him on this point. Then, we added the reason why we selected these vulnerability factors. As mentioned in the response to reviewer 2, we selected these vulnerability factors, as the majority of impacts in Liaoning affected the agricultural sector. We have added some more description of this (and add some relevant previous studies that informed the selection) to the revised manuscript (Junling et al., 2015;Kang et al., 2014).

Line 170 SPI and SPEI are well know these days. Did you then interpolated between the stations, or did you keep stations values? If so why? Did you generalized to administrative border? If so how?

One station in each city was selected and calculated the SPI/SPEI for that one station and used it to represent the city (this meant the drought indices and drought impact data were at the same spatial scale – we will ensure this is clear in the revised paper.

Line 192 I just stumbled over this term again. You might explain what a city includes for your case. E.g. if you tale about cities in Europe it's only about the highly populated city centers, were actually no agriculture exists.

For this study, the city is divided by the city unit which include urban, town and village in its jurisdiction. We have added this definition to the data section.

Line 224 Where?

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We changed the sentence and made clearer.

Line 227 How has this been done? Furthermore is this for a single city? Of are this averaged values? Please be more precise.

We thank the reviewer for this comment. We added a sentence to explain it clear on how we calculated the sum of SDI. "Sum of SDI is the sum of all types of Standardized Drought Impacts in 14 cities for each year." The standardization of the drought impacts is described in Section 2.2.4 of the methods.

Line 229 visually detected or proven by stats?

It is visually detected and we corrected and made clearer.

Figure 3 Please improve the resolution and use the full terms. How are the class defined.

We thank the reviewer for this comment and we fully agree with him on this point. We used the full terms and a higher resolution in the figure. The threshold is identified by the Natural Breaks (Jenks) method in the Arcmap.

Figure 4 Again, lots of space. present the full term please.

We agree with the reviewer and we present the full term as suggest.

Figure 6 Please increase resolution.

Yes we increased resolution as suggest.

Line 301 Please be more precise here vulnerability analysis is most often a big issue and quantitative approaches are lacking. Hence, readership might be highly interested here (at least I am).

We thank the reviewer for this important comment. We added some explanation on how do we quantitatively assess vulnerability.

Because for a specific severity of drought, basically, the more serious the impact

caused, the more vulnerable the region is. Thus, the regressed Standardized Drought Impacts at a moderate drought severity with SPEI6 equals -1.5 were applied to measure the drought vulnerability.

For example when SPEI6 is equal to -1.5, the regression result shows that yield loss due to drought is 5 thousand ton in Chaoyang whilst it is 1 thousand ton in Huludao. It means that in the term of the yield loss due to drought, Chaoyang is more vulnerable than Huludao.

Line 316 Please note that Blauhut et al. 2016 did similar, but on the basis of multivariable regression—checking for suitable hazard indices (SPI, SPEI, Soil moisture, VHI, CDI) and also checking through a long list of vulnerability indices. Furthermore, the results of Hao et al. might be important for comparison.

The reviewer is right. We revised in the manuscript. Also we agree with the reviewer that we need make a comparison with Hao et al. 2011.

‘The above results are also in general agreement with Hao et al. (2011), their study used 10-day affected crop area data as the drought impacts to assess drought risk in China at county unit. Their result shows that West Liaohe Plain has a high risk. Chaoyang and Fuxin are identified the highest vulnerability and most part of these two cities are located in West Liaohe Plain.’

Line 335 Here I strongly recommend a comparison to other studies which combined NDVI to impacts! Normally NDVI (or other vegetation health indices) suite very good.

We thank the reviewer for this important comment. We added some comparison with other studies which combined NDVI to impacts.

In other studies NDVI is mainly used to identify vegetation (agriculture) impacts. In this manuscript, affected human and livestock are also collected to measure drought impacts.

Line 339 How did other studies perform with respect to drought risk? In Liaoning

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province? China? Globally? How good could the linkage be detected by others? For agriculture?

We thank the referee for the suggestion that we included the comparison in the new version of the manuscript. We added some comparison with other studies which used different method of drought risk assessment.

Line 353: I suggest to prove this statically. Naumann et al. did an easy/brief stats on linking impacts and vulnerability in Africa. Or..you might consider to integrate vulnerability information in your risk model?

We thank the reviewer for this important comment. In Naumann et al. (2014), the tetrachoric correlation was computed between the drought vulnerability indicator and the numbers of persons reported affected to assess how the vulnerability indicators are correlated with drought disasters.

In our manuscript, stepwise regression model was built to compute between each type of Standardised Drought Impact and vulnerability factors to explore the contribution of the vulnerability factors to drought impacts. We will clarify it in the revised paper.

Line 354 This sentence feels a little loose here. What so you mean with this?

Yes, we delete this sentence.

Line 356 ?

Corrected.

Line 360 This is very detailed

We rephrased the sentence and revised the sentence to make it more readable.

Line 363 This is most often not a good idea! Besides that, the selected vulnerability factors limit management possibilities a lot. You might state that, the detection of drivers can support this

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The reviewer is right. We changed the expression as suggested.

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