Response Letter to Reviewers Comments on NHESS-2019-166#R3

Dear Prof. Merz

Many thanks for the constructive comments and suggestions from you and the reviewers. We carefully considered all issues mentioned in the reviewer's comments, and we outlined every change point by point, as highlighted in the reversion. We believe that the reviewer's comments and suggestions have helped us to improve the quality and readability of the paper. The point-by-point responses are provided below.

(The highlighted parts are added to the revised paper)

Reviewer #2

I'm sorry to send this back one more time, but the statistical analysis is still not valid. It becomes very clear when we look at Fig. 3. The current approach in the paper is the following:

1. Take all rainfall values with SOI below -1
2. Compute % change in annual rainfall for each of these years compared to mean annual rainfall for the entire series
3. Fit a distribution to these values and use the 60 and 90% quantiles for evaluating the impact of El Nino.

Step 3 implies that the authors find the "60 and 90% biggest rainfalls" during El Nino years and evaluate how much bigger these are than the average annual rainfall. However, these quantiles are simply an expression for random variation in the data (we can see similar levels of variation in non-El-Nino years. In fact, the 3 years with highest annual precipitation are outside the El Nino season).

The correct question to ask would be:

How much bigger is the mean annual precipitation in El-Nino years compared to the mean annual precipitation in non-El-Nino years?

If have done a quick bootstrap and permutation test on the Mehrabad dataset (R script inserted below). The answer is that when we consider a SOI threshold of -0.8, there is no difference between the mean annual precipitation in El-Nino and non-El-Nino years. Considering a threshold of -1, there is a mean difference in the order of 11% (which is in line with the median difference mentioned in the paper). The statistical evidence for the difference in mean annual precipitation is weak - in the permutation test it is significant at a confidence level of 63%.

I suggest the following:

-Remove any mentioning of confidence levels in the paper (abstract, page 7, discussion, conclusions)

-Consider the 12% median change in annual precipitation as an expression for the change inflicted by El Nino and consider only these results.

In addition to the above, please mention clearly in the abstract and the outlook that

-Annual change factors cannot necessarily be transfered to extreme values.

-In fact, your own data suggest that when considering monthly rainfall the effect of El Nino might negative when considering periods where extreme rainfall occurs. These are badly understood effects that require more research.

Reply: Thank you for your precision and your help to improve the paper. All of your suggestion has been considered in the revised paper. Many parts of the paper have been changed and the added parts have been highlighted by blue color. In the revised paper the following practices have been done according to your suggestion:

1- **The confidence levels including Figure 4 (CDF curve) and distributions were removed and any explanation in this regard was omitted.**

2- **The topic of the paper was revised according to the revision as**

“Annual flood damage influenced by El-Niño in Kan River Basin, Iran”

3- **The median change in annual precipitation as an expression for the change inflicted by El Nino was calculated equals to 12.2% and the paper based upon this percentile was revised. Abstract, Methodology, Results and Conclusion parts were revised totally considering only this median value.**

3-1- Abstract (P1L16-24)

“To determine the flood damage costs, the median of annual precipitation changes during El-Niño condition was firstly estimated, although the annual precipitation change factor cannot necessarily be transferred to extreme values. Then, the flooded area was then determined under increased rainfall due to El-Niño for 5-, 10- and 50-year return period. The results showed that El-Niño increases the precipitation amount by 12.2% in average. Flood damage assessment using damage-elevation curves showed that the expected increase percentile in flood damage for smaller return periods, which is more frequent, is much more than that for larger return periods. In general, 12.2% increase in the precipitation would result in 1671% and 176% damage increase respectively for the return periods of 5- and 10- year. However, for the 50-year rainfall this increase amount will be about 52%.

3-2- Methodology

P5L30-P6L4

La-Niña and El-Niño are characterized respectively by SOI>+1 and SOI<-1 (WRCC, 2010). Then, precipitation change (*PC*) in the El-Niño condition is calculated as follow:

$$PC_t = (P_{El\,t} - P_N)/P_N \quad \forall t = 1.T \tag{4}$$

where $P_{El\,t}$ is annual rainfall in every El-Niño episode; P_N average annual rainfall in the normal episodes; and T is number of El-Niño events in the time period (here T=6). Then, median of *PC* values (ΔP) will be used to construct synthesized rainfall storms.

P6L12-16

Therefore, the intensity of design rainfall (i_d) can be deduced for different return periods (here, three return periods of 5-yr, 10-yr and 50-yr are considered). These return periods are selected in accordance with the paper's objective to show the importance of small floods in flood management plans compared to the high return period floods. Then, the rainfall intensity in the El-Niño condition (i_E) can be calculated by multiplying i_d and ΔP.

3-3- Results and Discussion

P8L4-10

Evaluation of the monthly SOI over the period from 1951 to 2017 shows that 161 months with El-Niño and 128 months with La-Niña have been occurred. The average monthly rainfall at Mehrabad station in the months of El-Niño is 21.4 mm and in the months of La-Niña 16.2mm, while in the normal months, the average rainfall is 19 mm. In Figure 3, the annual rainfall of stations is plotted against the SOI index. It is obvious that with decreasing SOI index, annual rainfall increases in the study area and vice versa. In the period of 1951 to 2017, a total of 6 El-Niño (SOI<-1) and 5 La-Niña (SOI>+1) events have been occurred. Out of 6 El-Niño years, 5 periods have experienced increase in the precipitation (2%-45%) and 1 period with decrease in the precipitation (-34%).

P8L15-22

There are 6 years with El-Niño and 55 normal years among the total of 66 years (1951-2017). Using Eq. (4), for 6 years with El-Niño condition, *PC* value ranges from -34% to 45% while the latter is related to the year 1983 in which 334 mm rainfall was recorded. Then, the median can be calculated as ΔP=12.2%. It should be noted that, the threshold of SOI=-1 is an assumption that affects the results significantly.

The Kan River basin has 135.19 min time of concentration. Therefore, considering the duration of the design rainfall as D=150 min, i_d can be estimated from IDF curves. For return periods of 5, 10, and 50-yr, i_d values are 7.8, 9.5, and 13 mm/hr, respectively. Thus, i_E values can be calculated as 8.76, 10.66, and 14.59 mm/hr respectively for return periods of 5, 10, and 50-yr.

P10L6-13

Table 3 provides details of the physical damage costs to the present land uses for different return periods. Similarly, the increased rainfall due to El-Niño is simulated and the damages are estimated in the same procedure (Table 4). Results revealed that, firstly, the expected flood damages cost during El-Niño event increases much more than that of rainfall increase, and secondly, in the smaller return periods, the increases of flood damages is much more than that in the bigger return periods. In the return period of 5-year, in average El-Niño increases the damages to 1671%. The main reason for this high amount is that the average depth of 5-yr flood is very small (<0.04m) and with an increase of 12.2% in the rainfall intensity, the flood depth increases considerably (about 0.5m). During the 10-yr and 50-yr floods, due to El-Niño, damages increases by average of 176% and 52%, respectively.

Table 3. Physical damages to the sub basins properties for different return periods

50-yr flood					
Sub-basin	Average inundation depth (m)	Damage to residential building (10^3US $)	Damage to content (10^3US $)	Damage to restaurant (10^3US $)	Damage to agriculture (US$)
Imamzadeh Davood	0.61	201	37	42	519
Rendan	0.6	68	12	20	723
Sangan	0.5	393	68	19	1,259
Keshar	0.66	343	62	67	550
Sulaghan	0.25	81	11	55	843
Sum (10^3US$)		**1,086**	**190**	**203**	**3,893**
Total damage cost (10^3US$)					**5,372**
10-yr flood					
Imamzadeh Davood	0.15	29	3.2	6.1	107
Rendan	0.2	17	2.2	5.1	249
Sangan	0.09	21	6.2	1	210
Keshar	0.41	202	46	39.6	283
Sulaghan	0.05	11	2.3	7.3	145
Sum (10^3US$)		**280**	**60**	**59.1**	**994**
Total damage cost (10^3US$)					**1,394**
5-yr flood					
Imamzadeh Davood	0.03	4.9	0.98	1.02	36
Rendan	0.01	1.4	0.11	0.41	6.2
Sangan	0.009	4.1	0.61	0.2	0
Keshar	0.04	9.3	2.1	1.83	16
Sulaghan	0.01	5.4	0.45	3.66	26
Sum (10^3US$)		**25.1**	**4.2**	**7.12**	**84.2**
Total damage cost (10^3US$)					**121**

Table 4. Flood damages cost and expected increases during El-Niño event

T (yr)	Damage cost (US$)		Damage increase (%)
	No El-Niño effect	12.2% increase under El-Niño effect	
5	120,529	2,135,486	1,671
10	1,393,753	3,852,095	176
50	5,372,472	8,158,454	52

3-4- Conclusion (P10L22-P11L2)

In the present paper, the effect of El-Niño on the flood damages was investigated. The methodology was based on the calculation of increasing rainfall amount during El-Niño event compared to the normal conditions. Considering SOI=-1.0 as the threshold of El-Niño, the annual %-increased rainfall is 12.2%. Noticed, the annual change factor cannot necessarily be transferred to extreme values. While, considering monthly rainfalls the effect of El Niño might be negative in some periods when extreme rainfall occurs. The annual change factor was then applied for generating design storms of different return periods of 5, 10 and 50 years. Using HEC-HMS and HEC-RAS models flood zoning was performed for both episodes of neutral and El-Niño. Therefore, a total of 6 models were developed and flood zoning results turned into physical damage. To estimate the flood damage cost the damage-elevation curve method was used. The results showed that the occurrence of El-Niño in less return periods, which is more frequent, increases the relative damages very much and for the higher return periods the increase percentile are not considerable. More specifically in a flood with a return period of 5 years, an increase of 1671% in damages may be occurred. The average increase in the expected damages cost is 1176% for 10-yr return period, while it is 52% for 50-yr return period. It implies that flood managers should pay more attentions to small floods during El-Niño years.

4- In the abstract and Conclusion the limitation of our study as you mentioned were clearly mentioned:

P1L16-18

To determine the flood damage costs, the median of annual precipitation changes during El-Niño condition was firstly estimated, although the annual precipitation change factor cannot necessarily be transferred to extreme values.

P10L24-26

Noticed, the annual change factor cannot necessarily be transferred to extreme values. While, considering monthly rainfalls the effect of El Niño might be negative in some periods when extreme rainfall occurs.