Interactive comment on "Patterns and comparisons of human-induced changes on river flood impacts in cities" by Stephanie Clark et al.

Thank you very much for your time in reviewing this paper, Dr Larsson. We appreciate all comments and will address each one as thoroughly as possible to produce an improved paper. It appears your main concern rests with the data source used in the paper. We understand that more information is needed in the referencing of this data set, and hope that the information provided below will allay these concerns.

General comments:

The topic of this paper is clearly both interesting and of great importance. The paper is well written and has a clear structure.

However, it seems to me that the paper does not really fulfil the promises implicit in the title. Which are the patterns in flood impacts on cities that are revealed in the paper?

The 'patterns' are the key characteristics extracted for each cluster of cities sharing similar baseline and projected flood conditions. Each city in each cluster is matched to the 'pattern' represented by the cluster centroid. As described on p6 lines 1-3, the values of the prototype vectors (map nodes) come to represent the prevalent patterns in the data after they have self-organized amongst the data items. For example, cities in cluster 10 in the upper right of Fig.3 share the 'pattern' of low baseline flooding impacts, with small increases in population impacts projected primarily due to climate change, and increases in material damages projected due to both climate change and development. For Fig3, the text on p13 and 15, and Fig 4 on p14 interpret these patterns in detail. The Method section (p6) may benefit from expansion, as it appears more detail is needed on the process of pattern extraction by the SOM.

There are some problems with the method used, and there is a problem with the general approach. The latter problem is related to the presumption that it is possible to draw conclusions about individual cities based on a global model. It is also doubtful whether any meaningful patterns can emerge from such a rather superficial study. The method issues are covered below.

It is not within the scope of our study to assess whether the model used to produce the data is comprehensive, but rather to provide a visualisation of the available data. The data set as published is immense and difficult to comprehend without a reduction and visualisation, which we are providing. Any conclusions about individual cities are based solely on the data items presented, and comparisons are based on similarities between data items, be them cities or merely numeric vectors.

Specific comments:

(p.3, lines41-44) The objective is given only in rather general terms. It would have helped the reader to get some more precise information about which types of "global patterns and relationships" that is meant to emerge from the study.

This sentence had previously been more long-winded, but was reduced to this phrase for brevity with the knowledge that the 'patterns and relationships' would be explained in detail throughout the paper. This sentence can certainly be expanded to detail the expected patterns and relationships.

(p.4, lines 11-20) The main problem with the method is the data source used in the paper. This source consists of output from a global tool produced by the World Resources Institute. In the paper this model is described as made up of “global hydrologic and hydraulic models” and more. It raises some concern about the accuracy of such models when they are “global”. Unfortunately, the only reference in the paper leads to a web site, which in turn refers to the name of a model but with no proper literature reference. So, it is quite difficult for the reader to judge for herself how useful the data used in the paper is. Considering the spatial resolution given in the said website the usefulness is doubtful. As an example of interest for the reviewer: the country of Sweden is presented as one “basin” !

Thank you for raising this issue. Perhaps the simple website address is not sufficient as a reference for this data, and that will be amended. Specific information on the creation of the database can be accessed through hitting on the ‘i’ in the upper right corner of the cited website, which leads to this page describing the models:

http://floods.wri.org/#/

This page cites the sources as:

> Winsemius, H. C., et al. "A framework for global river flood risk assessments." Hydrology and Earth System Sciences 17.5 (2013): 1871-1892.

and

> Ward, P. J., Jongman, B., Weiland, F. S., Bouwman, A., van Beek, R., Bierkens, M. F., ... & Winsemius, H. C. (2013). Assessing flood risk at the global scale: model setup, results, and sensitivity. Environmental research letters, 8(4), 044019.

As the first of these papers is in fact published by HESS, we have deemed this data to be trustworthy.

Further papers published with this data include:

> Winsemius, Hessel C., et al. "Global drivers of future river flood risk." Nature Climate Change 6.4 (2016): 381-385.
>
> Jongman, B., Winsemius, H. C., Aerts, J. C., de Perez, E. C., van Aalst, M. K., Kron, W., & Ward, P. J. (2015). Declining vulnerability to river floods and the global benefits of adaptation. Proceedings of the National Academy of Sciences, 112(18), E2271-E2280.
>
> Muis, S., Güneralp, B., Jongman, B., Aerts, J. C., & Ward, P. J. (2015). Flood risk and adaptation strategies under climate change and urban expansion: A probabilistic analysis using global data. Science of the Total Environment, 538, 445-457.

Yes, it is a concern that Sweden is represented as a single basin in this database! We have chosen to work with the city information instead of basins, so fortunately this is basin does not appear in our analysis.

(p.4, lines 29-34) Another weakness in the method is that the actual, real flood protection level is not included. Instead flood protection level is based on the assumption of proportionality with national income level.

This is a shortcoming of the method, as the real flood protection levels for each city are not known (by us) for each city. However, the assumptions made to overcome this are in line with current practice, as outlined in lines 33-37 of p4 with references to contemporary literature:

'…we assign an assumed flood protection level to each city based on the country's World Bank income level (as in the World Resource Institute's Aqueduct Global Flood Risk Country Rankings, website 6) due to a lack of information on each city's actual protection level. This method follows recommendations based on the rational that higher standards of protection against flooding may be expected in higher income countries (Jongman et al., 2012; Nicholls et al., 2008), and findings by Doocy et al. (2013) that flood impacts are significantly associated with classification of income level by the World Bank. '

This method is necessary as standardised, current information on the nearly 100 cities in the data set is not readily available. This shortcoming is acknowledged in the literature, as Winsemius et al. (2016) state that 'currently installed flood protection is an important missing link in the assessment of global flood risk'. If there is a better practise that we have missed, we would be very happy to learn of it.

(p.4, line 18-22, 38) On the one hand: changes due to socioeconomic development are driven by population and economy. On the other hand: protection level, which is assumed proportional to national income level is kept constant over time. This is inconsistent.

True, this is inconsistent. However, as discussed above the current flood protection levels are estimates, and therefore it seemed reasonable to retain them since the changes in flood protection in the 20 years of the study would also be estimates, however these would be based on estimated income levels, increasing the uncertainty.

(p. 6, lines 16-19) The present situation is in the paper characterized based on conditions 2010 while effects of climate change is based on projections for 2030. This time interval, 20 years, is a bit short for meaningful comparisons.

Whilst this is a short timeline, it is restricted by the data that is available. Studies at a global scale have been traditionally limited due to lack of cohesive data sets, and therefore this data set is valuable for the fact that it spans a global set of cities and provides an opportunity for comparison. As the data is only provided for 2010 and 2030, there was no choice for us to use different dates. Whilst it may not provide a long-term outlook, at the very least an insight into the current and near-future conditions can be gained.

(p.8, 3 lines 5-15; Fig. 1a) While the colouring of the maps allows for different absolute impact on people and material damage for an individual city, the location of all cities are exactly the same on both people and damage maps. This latter fact seems to indicate that the relative difference in impact between cities remains almost identically the same for both people and damage.

The relative placement of the cities on the map is the main map characteristic providing insight into the features of the data. The map is created based on both population and material damage data, organizing the cities with respect to each other based on both of these factors. The same map is repeated in Fig. 1a, with the background colouring indicating levels of population damage (on top left) and material damage (on top right). Therefore, the relative distance between cities on the map indicates the differences in a *combination* of population and material damages (which can be discerned from the colouring). For example, Cincinnati (top right) incurs high material damages costs, and medium population affected, whereas Ulan Bator (mid left) has similar population affected to Cincinnati, but much lower material damages costs. This interpretation is explained on p8 in lines 5-23.

(p.17, lines (23-38) The actual, on the ground flood management measures and other socioeconomic development are presented for Marrakech. However, in the model producing the source data for this paper only some of these factors were incorporated. See previous comment re page 4.

The analysis in this paper is based solely on the data provided. We are not aware of the extent to which the on-the-ground flood management measures are incorporated into the socioeconomic models which produced this data. The discussion on p17 is included as a point of interest to help characterise a couple of individual cities, providing possible reasons why they may fit into the map where they do, for the readers' interest.

Technical corrections:

(p.1) The title is".....changes on river..."should be".....changes in river..."

(p.7: 25) "....Whist..." should be ".....Whilst ..."

(Fig. 1) Fig. 1a) is difficult to read because of the many cities and the small font; however still ok.

Fig. 1b) is too blurry due to combination of background colours and text. More or less impossible printed; still difficult on the screen.

(Fig.2) Similar problems as with Fig. 1

(Fig.3) Similar problems as with Fig. 1 &2. Difficulties reading this figure exacerbated by all the information crammed into one page. The gradients indicated along the axes are impossible to interpret.

(p.13:1) ".....reduction on..." should be ".....reduction of ..."

P.16:16) ".....loses..." should be ".....losses ..."

Thank you for pointing out these technical corrections, they will be addressed in future submissions.