

Interactive comment on “Multi-hazards risks in New York City” by Yaella Depietri et al.

Anonymous Referee #2

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General Comments:

The authors present a risk / hazard assessment of New York City from the perspective of multiple hazard sources. The authors utilized an interesting methodology to quantify hazards via historical records and New York Times articles. While the article presents a new viewpoint on the subject matter I found several primary areas in which the work could be improved. 1) The literature review is missing much of the seminal work on vulnerability based hazard and risk assessments, as well as several studies that were conducted specifically in this same study region, covering much of the same material as this work, and in some cases much more thoroughly. It is a bit problematic that the authors repeatedly state that studies considering multiple hazards are largely absent, when in fact there is a fairly large body of work on exactly this subject. I would rework the language a bit from the perspective of the papers I mention below. 2) I believe the risk modeling based on expert opinion could be strengthened. The authors take a de-

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terministic approach by averaging the vulnerability and exposure estimates by a group of experts. While interesting and important to include local opinion, this neglects the variance within the population interviewed. I believe a more probabilistic assessment would lend more information. 3) The level of abstraction posed on the hazards seems a bit arbitrary, which could potentially be problematic. For example, the authors cluster all rainfall as one hazard, but include storm surge as another and note that these hazards could overlap. It would potentially be more meaningful then to disaggregate rainfall by mechanism as well to pull out the effect of tropical moisture sourced rainfall from local convective rainfall. 4) Finally, the writing could be improved. From the introduction it's not entirely clear what the purpose of the paper is (a new methodology, a case study of new york, a review of existing decision analysis approaches). The methodology is lacking important details. The discussion is a bit brief and doesn't really circle back to address issues raised in the introduction.

Specific Comments: Introduction - line 80: Why are you discussing CSOs? This is not a hazard that you revisit in the paper, so I would recommend shortening this section up by removing this.

Line 84: Point to an example of a hazard that overlaps spatially and temporally. You could even shorten the intro further by connection these linesto the above discussion of Hurricane Sandy (rainfall & surge).

Line 89: You don't deal with policy-related risk in this paper, so you should avoid discussing it here. Focus the discussion on the aspects of risk analysis that you are covering with your research.

Line 98: I disagree a bit with this paragraph. You perform a case study of New York City. How does this help us know more about risk analysis in other megacities? I would use more specific language, and again, just discuss what you are doing with this research. You could probably shorten this paragraph to just the first and last sentences.

Line 153: This sentence is awkwardly worded. Consider revising.

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Intro general: I think the authors are missing some of the seminal work on decision analysis here. I would research decision scaling, multi-objective decision making, and robust decision making. These frameworks are being applied to very similar risk analysis problems as this one, and circumvent some of the issues the authors are discussing. As a starting point, see these papers:

Brown, C., Ghile, Y., Laverty, M., & Li, K. (2012). Decision scaling: Linking bottom-up vulnerability analysis with climate projections in the water sector. *Water Resources Research*, 48(9).

Regan, H. M., Ben-Haim, Y., Langford, B., Wilson, W. G., Lundberg, P., Andelman, S. J., & Burgman, M. A. (2005). Robust decision-making under severe uncertainty for conservation management. *Ecological applications*, 15(4), 1471-1477.

Chankong, V., & Haimes, Y. Y. (2008). *Multiobjective decision making: theory and methodology*. Courier Dover Publications.

Section 1.2: In general I think the authors are missing much important research on hazards in this region. These papers have done much to examine regional risk within the context of multi-hazards. Again, these papers are meant as a starting point for the authors to perform a more thorough literature review.

Papers discussing storm surge: Lin, N., Emanuel, K. A., Smith, J. A., & Vanmarcke, E. (2010). Risk assessment of hurricane storm surge for New York City. *Journal of Geophysical Research: Atmospheres*, 115(D18).

Lin, N., Emanuel, K., Oppenheimer, M., & Vanmarcke, E. (2012). Physically based assessment of hurricane surge threat under climate change. *Nature Climate Change*, 2(6), 462.

Aerts, J. C., Lin, N., Botzen, W., Emanuel, K., & de Moel, H. (2013). Low-probability flood risk modeling for New York City. *Risk Analysis*, 33(5), 772-788.

Orton, P., Georgas, N., Blumberg, A., & Pullen, J. (2012). Detailed modeling of recent

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severe storm tides in estuaries of the New York City region. *Journal of Geophysical Research: Oceans*, 117(C9).

Papers discussing multiple extreme rainfall mechanisms in New York State: Knighton, J., Steinschneider, S., & Walter, M. T. (2017). A Vulnerability-Based, Bottom-Up Assessment of Future Riverine Flood Risk Using a Modified Peak-Over-Threshold Approach and a Physically Based Hydrologic Model. *Water Resources Research*, 53(12), 10043-10064.

Smith, J. A., Villarini, G., & Baeck, M. L. (2011). Mixture distributions and the hydroclimatology of extreme rainfall and flooding in the eastern United States. *Journal of Hydrometeorology*, 12(2), 294-309.

Towey, K. L., Booth, J. F., Frei, A., & Sinclair, M. R. (2018). Track and Circulation Analysis of Tropical and Extratropical Cyclones that Cause Strong Precipitation and Streamflow Events in the New York City Watershed. *Journal of Hydrometeorology*, (2018).

Agel, L., Barlow, M., Qian, J. H., Colby, F., Douglas, E., & Eichler, T. (2015). Climatology of daily precipitation and extreme precipitation events in the northeast United States. *Journal of Hydrometeorology*, 16(6), 2537-2557.

Talke, S. A., Orton, P., & Jay, D. A. (2014). Increasing storm tides in new york harbor, 1844–2013. *Geophysical Research Letters*, 41(9), 3149-3155.

Section 1.2.2: Throughout this section you refer to extreme precipitation as if it occurs by one single mechanism, when in fact extreme rainfall in this location occurs via by multiple distinct mechanisms. In a classic engineering analysis this isn't particularly problematic; however, you are claiming that this research presents a multi-hazard approach which successfully relates hazards in time and space. Wind driven surge does often correlate with rainfall, but probably only tropical moisture export sourced rainfall. At this point I'm a little lost as to how you will successfully overlay these two hazards

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without decomposing rainfall into at least tropical / non-tropical events.

Line 266: Again, here you're discussing CSOs when your paper does not cover CSOs. I would shorten this up.

Line 274: Are you suggesting that all precipitation events and mechanisms will increase uniformly based on trends observed at an annual time scale? I'm not sure that I agree. For example please see Knighton et al (2017).

Knighton, J., Steinschneider, S., & Walter, M. T. (2017). A Vulnerability-Based, Bottom-Up Assessment of Future Riverine Flood Risk Using a Modified Peak-Over-Threshold Approach and a Physically Based Hydrologic Model. *Water Resources Research*, 53(12), 10043-10064.

Line 292: This sentence is confusing "most in the month of September, but generally lead to large damages." What is it about September that makes you think damage would be less?

Line 319: What data? NOAA has many rainfall products. Be more specific.

Line 322: What do you mean by cross-referenced. Be more specific here. Did you keyword search archived records? If so, what keywords? Did you filter out specific dates? Did you do this manually, or with a scripting language?

Line 339: I am not sure I agree that a deterministic averaging makes the most sense here. I would be interested to know the distribution of weights from all survey responses. This approach hides issues that can be embedded in decision making groups, such as disagreement on vulnerabilities.

Line 361: I'm confused as to what these subjective definitions do to assist in decision making.

Eq1 and 2: What are the units of all variables?

Line 382: This is an interesting approach, but floodplain maps exist for the region. Why

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not use them? For example, see the Hudson River floodplain mapper produced by Columbia (<http://www.ciesin.columbia.edu/hudson-river-flood-map/>)

Line 389: I would check this against a NOAA tide gage at the Battery in NYC. The NCEI Storm event catalog is definitely missing some records over the period you are interested in. The continuously recorded water surface elevation on the Hudson could be a more reliable source of hazard information for surge.

All remaining equations: Again, what are the units of all variables? This is all presented in a confusing way. This paper could use a text description of these equations, and an annotation section to better explain how you are mixing units like this.

Equation 6: Why equal weighting? Was this a subjective choice by the authors?

Line 501: Instead of providing several anecdotal accounts, I would be interested in knowing how many events occurred over the n-years reviewed. What were the coincident mechanisms and frequencies? Are the pdfs of hazard the same for co-occurrences of two hazards?

Line 515: Hurricane Sandy hit in October, not the winter. The snowfall occurred in the midwest when the tropical moisture encountered another atmospheric event. You make it sound like this impacted NYC.

Tables 3 and 4: What are the columns? I'm lost as to what this table is showing.

Line 612: I'm not sure that I'm convinced that you've really shown this in an objective way. You presented several anecdotes about multiple events occurring at once, but I'm left without a good understanding of which mechanisms co-occur for the region, and at what frequency and intensity.

Line 641 "higher impacts": Here I disagree. Your survey asked people about vulnerability. As you say throughout your paper, the risk is exposure * vulnerability * hazard. Just because the surveyed population reports higher potential for vulnerability does not imply that there are larger impacts.

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