Wobus et al., "Modeled changes in 100 year Flood Risk and Asset Damages within Mapped Floodplains of the Contiguous United States"

Supplemental Information File #1: Uncertainty Analysis for Baseline 1% AEP Estimates

We used a bootstrapping method to estimate the uncertainty on the baseline 1% AEP event, based on a random sample of 1,000 nodes in the modeling domain. Our approach was as follows:

1) At each randomly selected node, we first extracted the complete set of 580 annual maximum flow values from the baseline period (20 years x 29 models = 580 annual values). We calculated the 1% AEP event from this full set of annual maxima by fitting a GEV distribution to the events, using the maximum likelihood method for finding the GEV parameters. We then extracted the 1% AEP event by extracting the 99th percentile value from the GEV fit. This was the 1% AEP value utilized in the remainder of the analyses described in the manuscript.

2) From these 580 annual maximum values, we then selected 500 random samples of 300 values each. For each of these 500 random samples, we repeated the process of fitting the GEV and extracting the 99th percentile value. The result of this exercise is a set of 500 estimates of the 1% AEP event for that node (see Figure 1.1).

3) From this distribution of 500 estimates for the 1% AEP event at each node, we calculated the 5th and 95th percentile values, and saved these values along with the value calculated from the full suite of 580 annual maxima.

4) We used the 5th and 95th percentile values to estimate the uncertainty in the 1% AEP event, as a percent of the estimate from the full set of 580 values. The result is a distribution of uncertainties in the 1% AEP event, expressed as a percent (Figure 1.2).

Figure Captions

Figure 1.1. Example of uncertainty analysis on 1% AEP event for a single node, based on bootstrapping method described above.

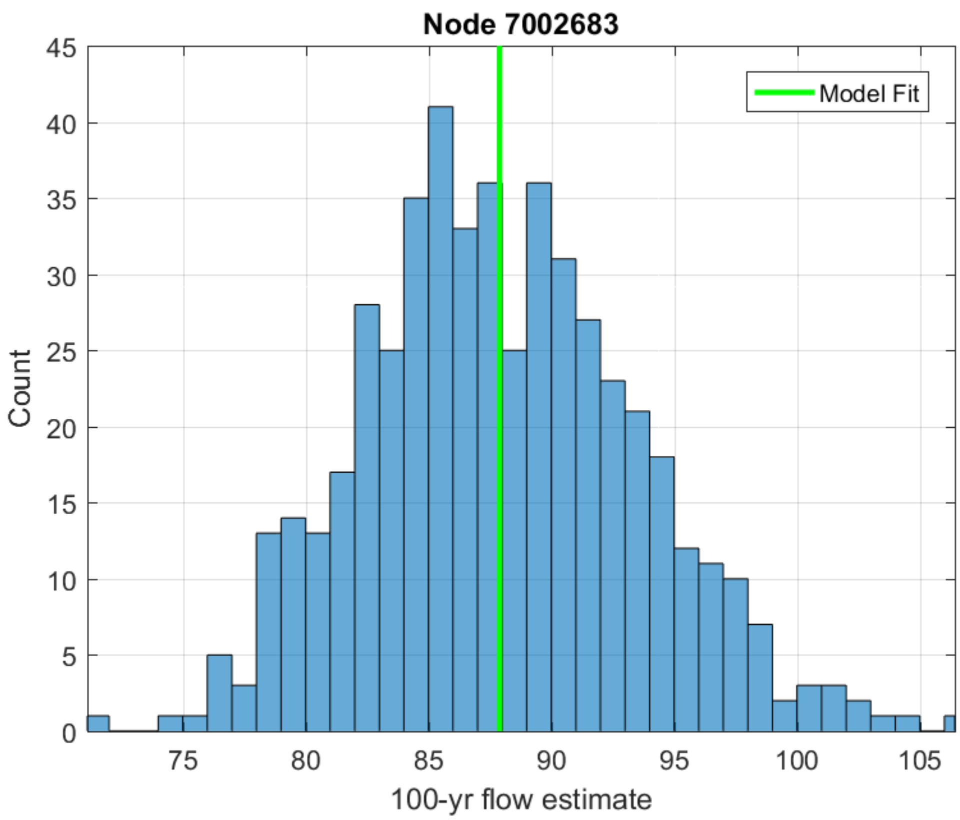
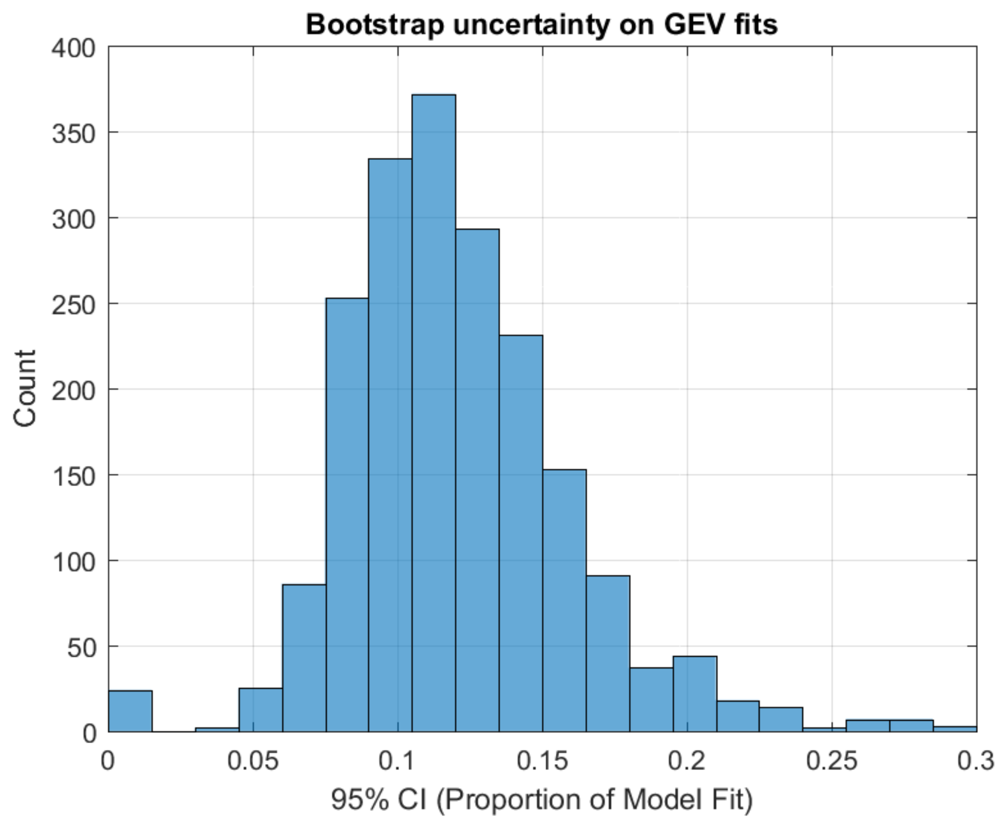


Figure 1.2. Distribution of uncertainty on 1% AEP event based on 1,000 randomly selected nodes in the model domain.



Supplemental Information File #2: Estimating flood depth and Asset Damages from 1% annual exceedance probability events

For each of the mapped floodplains in CONUS, we estimated flood damages using an experimental tool developed for the U.S. Army Corps of Engineers, referred to as the National Flood Risk Characterization Tool (NFRCT)[1]. The NFRCT includes asset exposure and damage estimates for the 1% ("100-year") and 0.2 % ("500-year") annual exceedance probability flood events, as determined by FEMA and compiled in the National Flood Hazard Layer (NFHL) [2]. Because the 100-year floodplain maps are substantially more comprehensive than the 500-year floodplain maps across the United States, we focused our analysis of damages on the assets within the 1% annual chance floodplains.

All of the steps we took to calculate asset damages were conducted in a spatially explicit framework, utilizing publicly available data on topography, floodplain extent, and assets. Damages from a 1% AEP flood were calculated for each of the mapped 1% annual probability floodplains in the NFHL as follows:

1. Intersect NFHL polygons and Census blocks[3] to create a new set of flood zone polygons subdivided by census block boundaries.
2. Query the National Elevation Dataset (NED) [4] along the perimeter of each flood polygon to determine the elevation of the 1% annual probability flood level along that perimeter.

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1 Developed by Abt Associates, Inc. for the Institute for Water Resources of the U.S. Army Corps of Engineers.

2 FEMA (2015). National Flood Hazard Layer (NFHL). Federal Emergency Management Agency. Washington, D.C. Available at: https://www.fema.gov/national-flood-hazard-layer-nfhl

3 Census Bureau (2010). 2010 Topologically Integrated Geographic Encoding and Referencing (TIGER)/Line Shapefiles. Released beginning November 30, 2010. Last update March 26, 2012. U.S. Census Bureau. Suitland, MD. ftp://ftp2.census.gov/geo/tiger/TIGER2010/

4 USGS: National Elevation Dataset (NED), U.S. Department of the Interior, U.S. Geological Survey, Available: https://lta.cr.usgs.gov/NED, 2016.

3. Randomly sample points within the interior of each of flood zone polygon to estimate the distribution of flood water depths within each polygon (sample consists of hundreds to thousands of points, depending on the size of the intersection area in (1)).
    a. First, at each randomly selected point, query the NED to find the ground level elevation at that location.
    b. Second, calculate the elevation of the flood surface using a nearest neighbor sampling method. The interior flood water elevation is calculated as a weighted average of sampled perimeter points around each randomly selected point.
    c. Compute the difference between the elevation of the estimated water surface and the ground level elevation. This value approximates the depth of a 1% annual exceedance probability flood event at this point.
4. For the sampled interior points, use the National Land Cover Dataset[5] to determine whether each point is categorized as "Developed" or not; track depth estimates separately for developed and undeveloped points within each polygon.
5. From the randomly sampled points within the interior of each flood zone polygon, calculate odd depth percentiles (1^{st}, 3^{rd}, 5^{th},…,99^{th}) for each flood zone.

The result of this process is a distribution (described by percentiles) of flood depths for each NFHL-Census Block intersection. For each intersection, three distributions are generated: 1) depths throughout the polygon, 2) depths within areas designated as Developed, and 3) depths within areas designated as Undeveloped. From these results, the following steps are used to calculate monetary damages:

1. For the "Developed" portions of the NFHL-Census block intersection, data on built assets are tabulated from FEMA's HAZUS-MH[6] General Building Stock inventory. The General Building Stock inventory provides estimates of the number and aggregate dollar value of multiple types of residential, commercial, and industrial buildings for each Census block.
2. The number and value of buildings and contents that are exposed to flood inundation is equal to the percentage of the Developed portion of a Census block that is intersected by a NFHL flood zone multiplied by the corresponding total number of residential assets and their values within the block. Buildings and aggregate building value are assumed to be evenly distributed across the Developed portions of each Census Block. For example, if

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[5] Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing*, v. 81, no. 5, p. 345-354

[6] FEMA (2015). HAZUS-MH 2.2, FEMA's Software Program for Multi-Hazard Loss Estimation for Potential Losses from Disaster. Federal Emergency Management Agency. Washington, D.C.

50% of the developed portion of a block is intersected by a floodzone, it is assumed that 50% of that Block's buildings and aggregate building value are exposed to flooding.

3. The same assumption is applied to estimate exposure to different depths – if the 10th percentile of depth for given polygon is 2.5 feet, it is assumed that 10% of the developed portion of that block, as well as 10% of its buildings and building value, is exposed to 2.5 feet of inundation.
4. Damage estimates are created using depth-damage functions from USACE and FEMA[7]. A separate depth-damage function is used for each of 28 different categories of buildings (e.g., residential one-story homes without a basement). Each depth damage function describes the percent loss as a function of depth.
5. The depth damage functions are applied to the aggregate value for each category of building within each NFHL-Census block intersection, using depth exposure results described above. In other words, if it was estimated that 10% of buildings are exposed to 2.5 feet of inundation, then the depth-damage estimate for 2.5 feet of inundation is applied to 10% of the aggregate building value.

[7] USACE (2000). Economic Guidance Memorandum (EGM 01-03): Generic Depth-Damage Relationships. http://planning.usace.army.mil/toolbox/library/EGMs/egm01-03.pdf

USACE (2003). Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements. http://planning.usace.army.mil/toolbox/library/EGMs/egm04-01.pdf

FEMA (2009a). HAZUS-MH, FEMA's Software Program for Estimating Potential Losses from Disaster. Federal Emergency Management Agency. Washington, D.C.