Detection and attribution of flood change across the United States

Stacey Archfield, U.S. Geological Survey, USA

ASCE Workshop
Engineering Methods for Precipitation under a Changing Climate
May 30, 2017

U.S. Department of the Interior
U.S. Geological Survey
Detecting changes in floods across the United States

Analyses of changes in floods across the United States has generally focused on trends in the annual, instantaneous maximum flood.

This implies that there is only one “flood” per year.

In drought years, the annual flood may not actually have been considered a flood.

Hirsch, R.M. and Ryberg, K.R., 2012, Has the magnitude of floods across the USA changed with global CO2 levels?, Hydrological Sciences Journal

“…development of improved empirical characterizations [will] help model future conditions, describe trends that may have occurred and better relate flood behaviour to atmospheric and land-surface changes.”

NATURE CLIMATE CHANGE | VOL 5 | MARCH 2015 | www.nature.com/natureclimatechange
A peaks-over-threshold approach to quantify changes in floods across the United States

- An alternative to the annual flood series is to create a series of independent flood events that exceed a certain threshold.
Application of the peaks-over-threshold approach

01073000 Oyster River near Durham, New Hampshire, USA
Application of the peaks-over-threshold approach to the United States
Regional changes in floods

Are the number of regions with significant increasing trends greater than the number of regions with significant increasing trends than what would have been expected by chance?
Regional changes in floods

Clustering flood change across the United States

Perspectives on flood change and attribution

**IPCC AR5**

<table>
<thead>
<tr>
<th>Impacts and impact events</th>
<th>Climate/weather drivers</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed trend</td>
<td>Observed trend</td>
<td>Section 3.2.7; Tables 18-5 and 18-6; WGI AR5 Section 4.5; Seneviratne et al. (2012)</td>
</tr>
<tr>
<td>Earlier timing and decreasing magnitude of snowmelt floods</td>
<td>Role of climate change</td>
<td>High</td>
</tr>
<tr>
<td>Confidence in detection</td>
<td>Confident in existence of trend</td>
<td>Medium</td>
</tr>
<tr>
<td>Reference behavior</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Confident in attribution</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Changes in flood frequency and magnitude in non-snowmelt-fed rivers</td>
<td>Confident in existence of trend</td>
<td>High</td>
</tr>
<tr>
<td>Confident in detection</td>
<td>Confident in existence of trend</td>
<td>Medium</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Changes due to land use</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Increased coastal erosion in lowland</td>
<td>Confident in existence of trend</td>
<td>High</td>
</tr>
<tr>
<td>Very low</td>
<td></td>
<td>Very low</td>
</tr>
<tr>
<td>Erosion due to shoreline modification and natural</td>
<td></td>
<td>Very low</td>
</tr>
</tbody>
</table>


**NCA3**

“Floods that are closely tied to heavy precipitation events...are expected to increase. **Other types of floods result from a more complex set of causes**...river floods are basin specific and dependent not only on precipitation...[but on] important human-caused changes to watersheds...across the United States.”


**National Academies of Sciences, Engineering, and Medicine**

“...science is currently unable to provide reliable forecasts of the types and direction of change that may occur on any river or in any given community.”

“...In those situations where there is sufficient scientific evidence to facilitate quantification of the impact of climate variability or change in flood risk, this knowledge should be incorporated in flood frequency analysis...All such methods employed need to be thoroughly documented and justified.”

Where is change happening?
How are floods changing?
What is causing the change?

How are flood frequencies adjusted for change?

USGS efforts towards synthesis and research on flood detection, attribution, and adjustment for change

Research Team

Stacey Archfield  Julie Kiang  Robert Hirsch
Karen Ryberg  Katherine Skalak  Robert Dudley  Glenn Hodgkins
Kelsey Kolars  Annalise Blum  Adam Benthem  Jesse Dickinson
Thoughts on detection, attribution, and adjustment for change

“The only way to figure out what is happening to our planet is to measure it, and this means tracking changes decade after decade and poring over the records.”

Keeling, 2008, Recording Earth’s vital signs, Science, p1771-1772

“In discussions about stationarity or nonstationarity, we should bear in mind that this is a research question [that] has practical consequences…in the design of structures and management policies.”


…doing the right things should not depend on waiting for the answers to the greenhouse forcing–flood issue. The continuation of empirical and model-based science and a “no regrets” strategy for limiting flood losses should be encouraged.
