Detection and attribution of flood change across the United States

Stacey Archfield, U.S. Geological Survey, USA

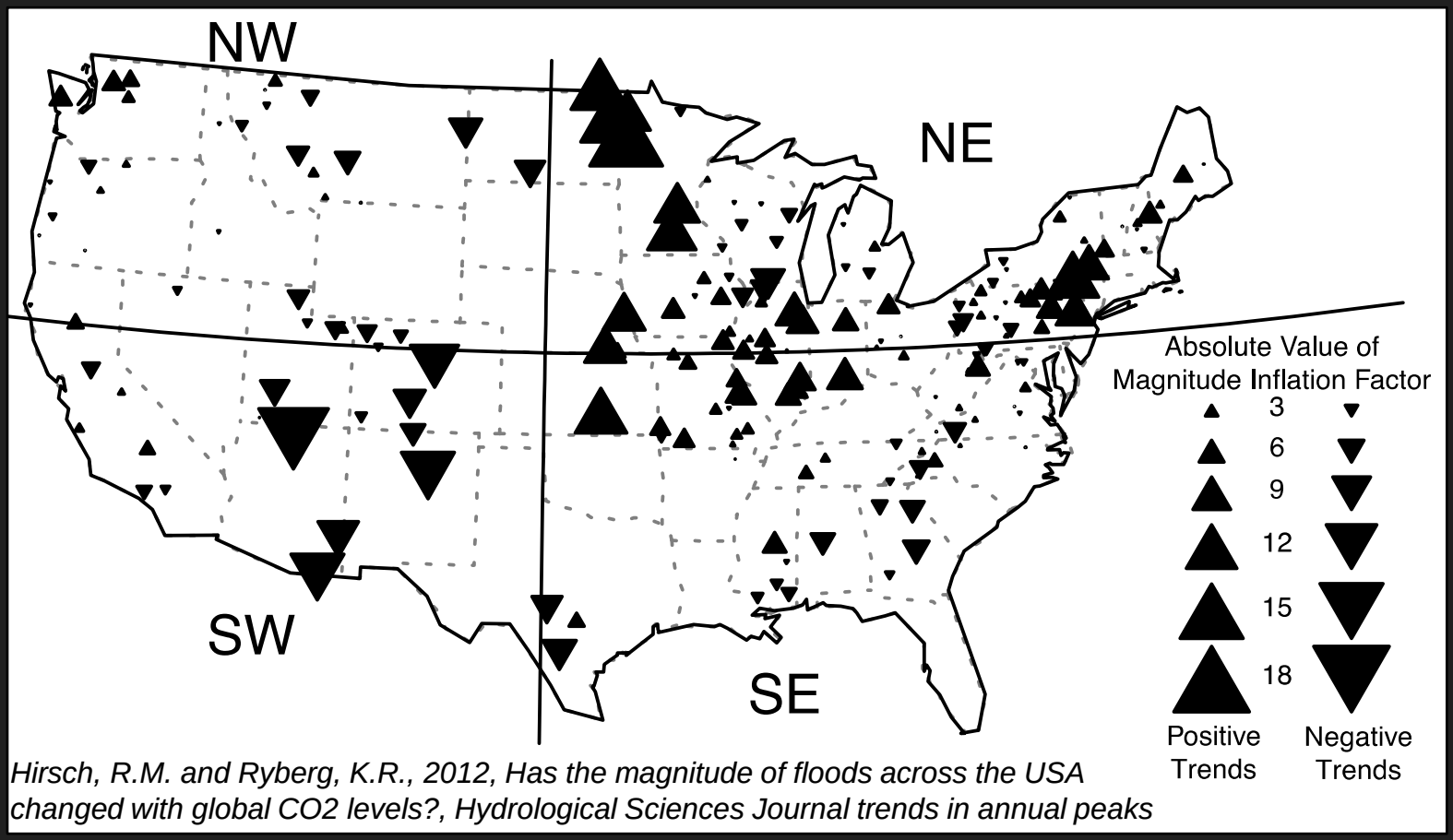
USGS responds to recent flooding near Houston, Texas on April 20, 2016.
Credit: Tom Pistillo, U.S. Geological Survey
Available at https://www.usgs.gov/media/images/flooding-near-houston-texas-april-20-2016

ACWI Subcommittee on Hydrology
April 20, 2017

U.S. Department of the Interior
U.S. Geological Survey

Railroad tracks in Minot, North Dakota surrounded by floodwaters of the Souris River on June 27, 2011.
Credit: Brent R. Hanson, U.S. Geological Survey
Available at https://www.usgs.gov/media/images/railroad-tracks-surrounded-floodwater

Changes in annual peak floods across the United States

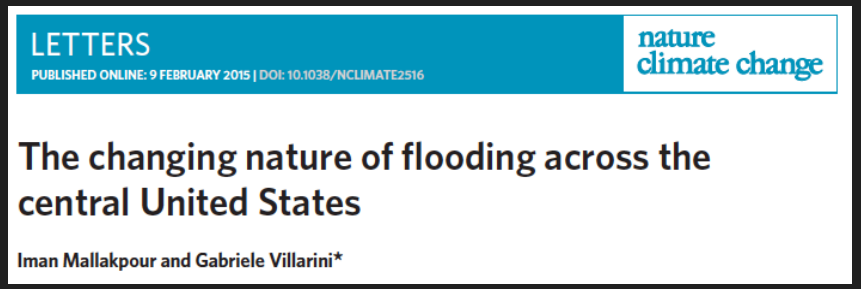


Hirsch, R.M. and Ryberg, K.R., 2012, Has the magnitude of floods across the USA changed with global CO2 levels?, Hydrological Sciences Journal trends in annual peaks

"It is crucial that analysis of the empirical data be conducted repeatedly [and] that a wide range of empirical approaches to this issue need to be undertaken [that] may reveal patterns that this analysis was unable to discern."

Detecting changes in floods across the United States

- Analyses of changes in floods across the United States had 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; it was merely the highest observed streamflow in that year
  - These studies ignore the possibly that the frequency of within-year floods may have increased.


LETTERS

PUBLISHED ONLINE: 9 FEBRUARY 2015 | DOI: 10.1038/NCLIMATE2516

nature climate change

The changing nature of flooding across the central United States

Iman Mallakpour and Gabriele Villarini*


news & views

FLOOD TRENDS

Not higher but more often

Heavy precipitation has increased worldwide, but the effect of this on flood magnitude has been difficult to pinpoint. An alternative approach to analysing records shows that, in the central United States, floods have become more frequent but not larger.

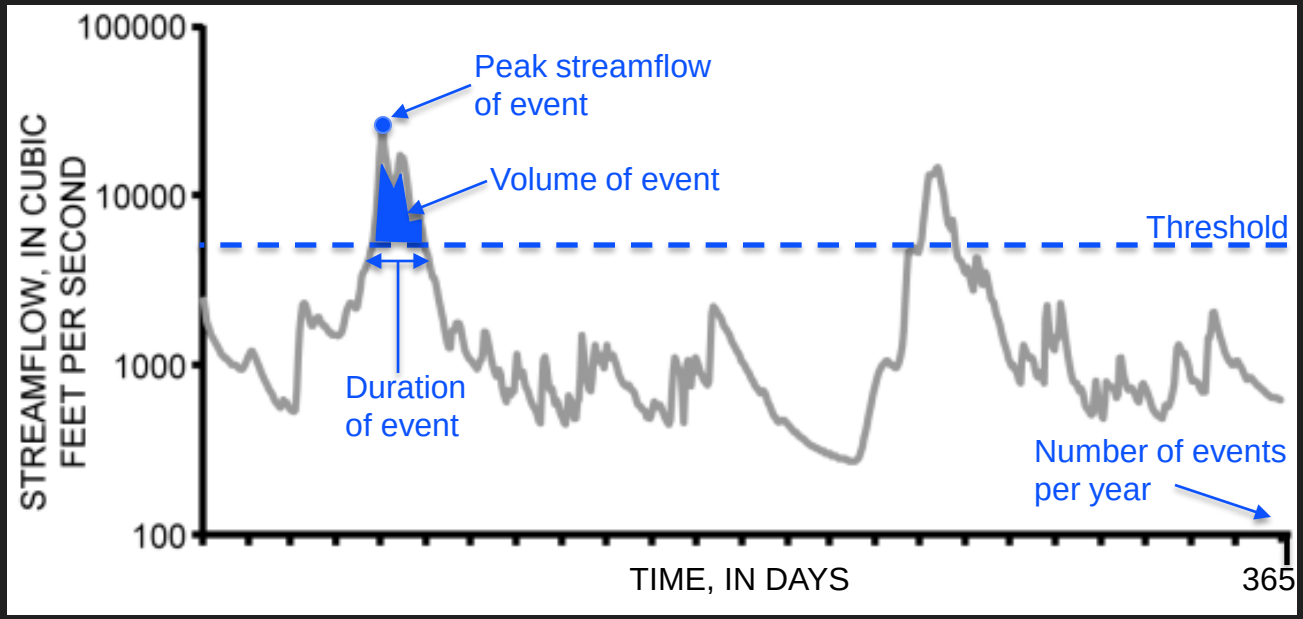
Robert M. Hirsch and Stacey A. Archfield

NATURE CLIMATE CHANGE | VOL 5 | MARCH 2015 | www.nature.com/natureclimatechange

USGS

A peaks-over-threshold approach to quantify changes in floods across the United States

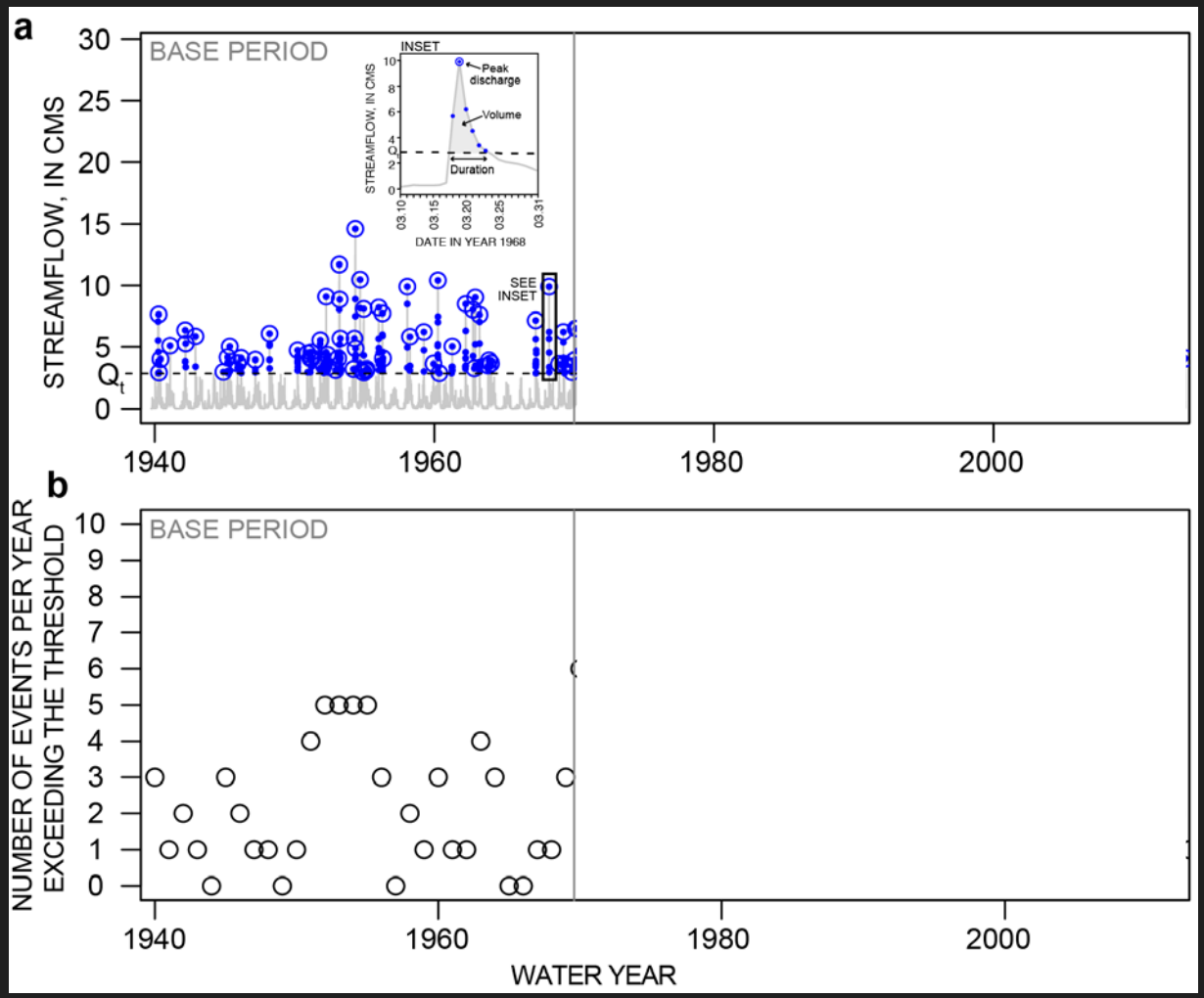
- An alternative to the annual flood series is to create a series of independent flood events that exceed a certain threshold



USGS

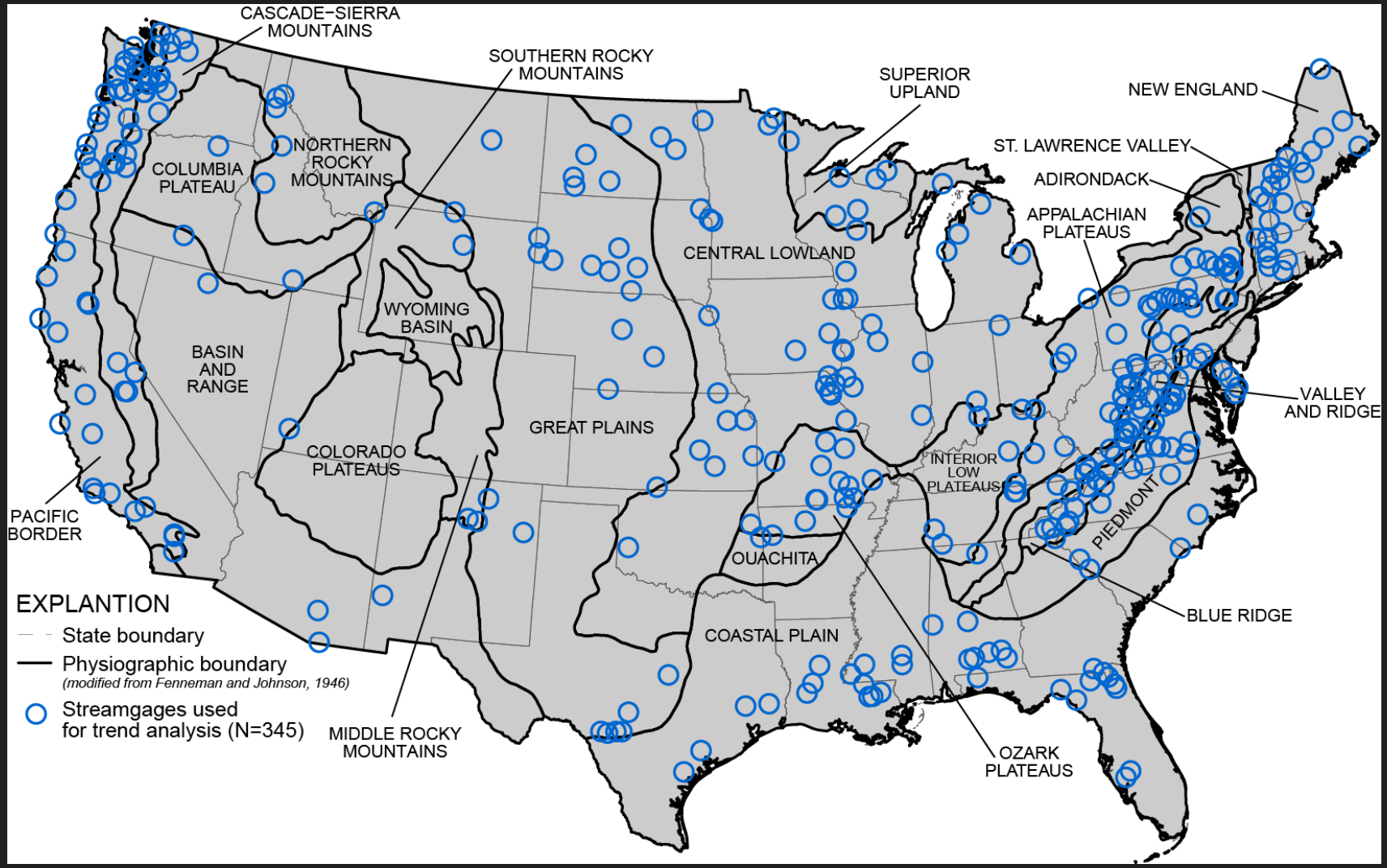
Application of the peaks-over-threshold approach

01073000 Oyster River near Durham, New Hampshire, USA



USGS

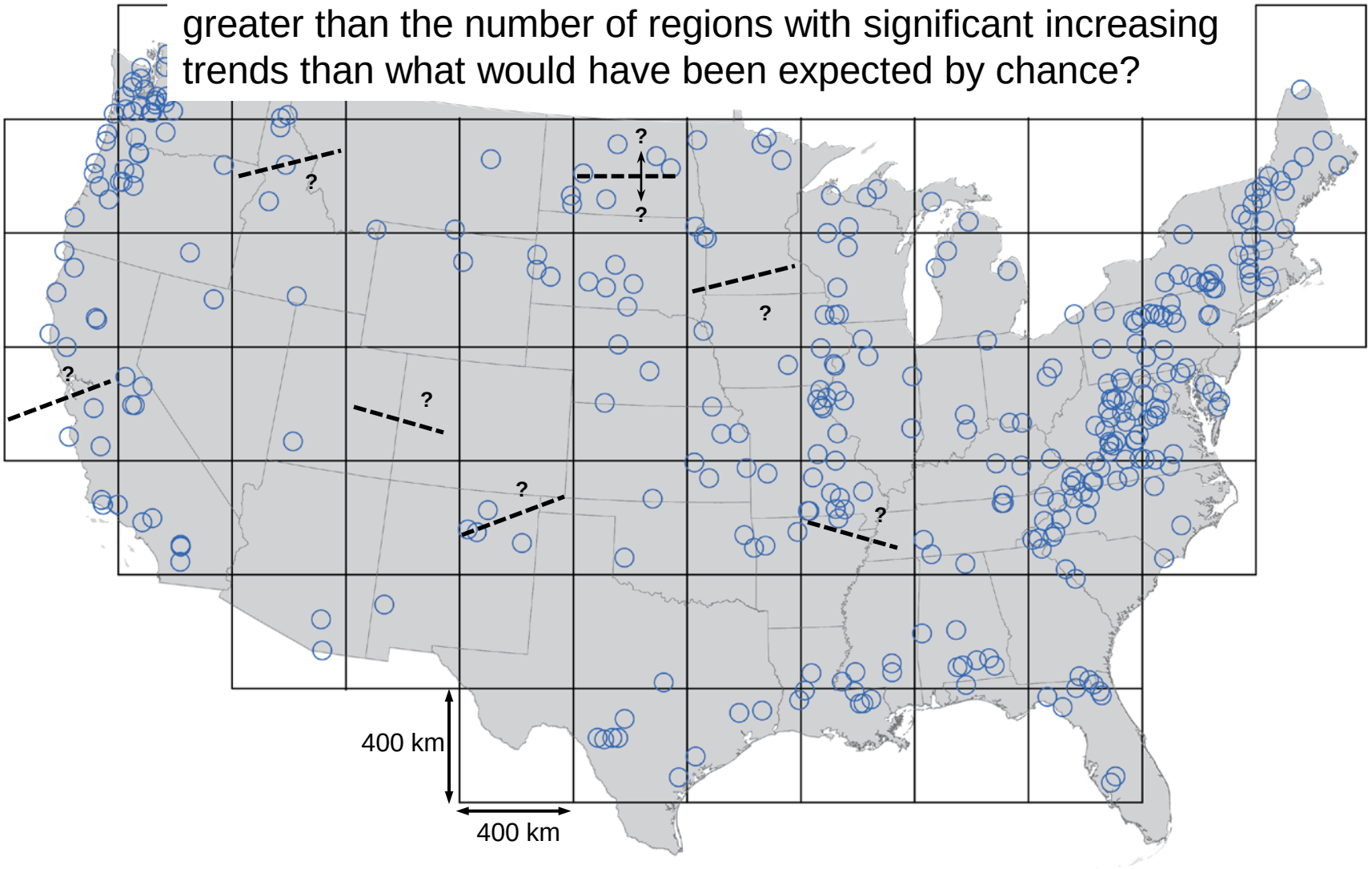
Application of the peaks-over-threshold approach to the United States



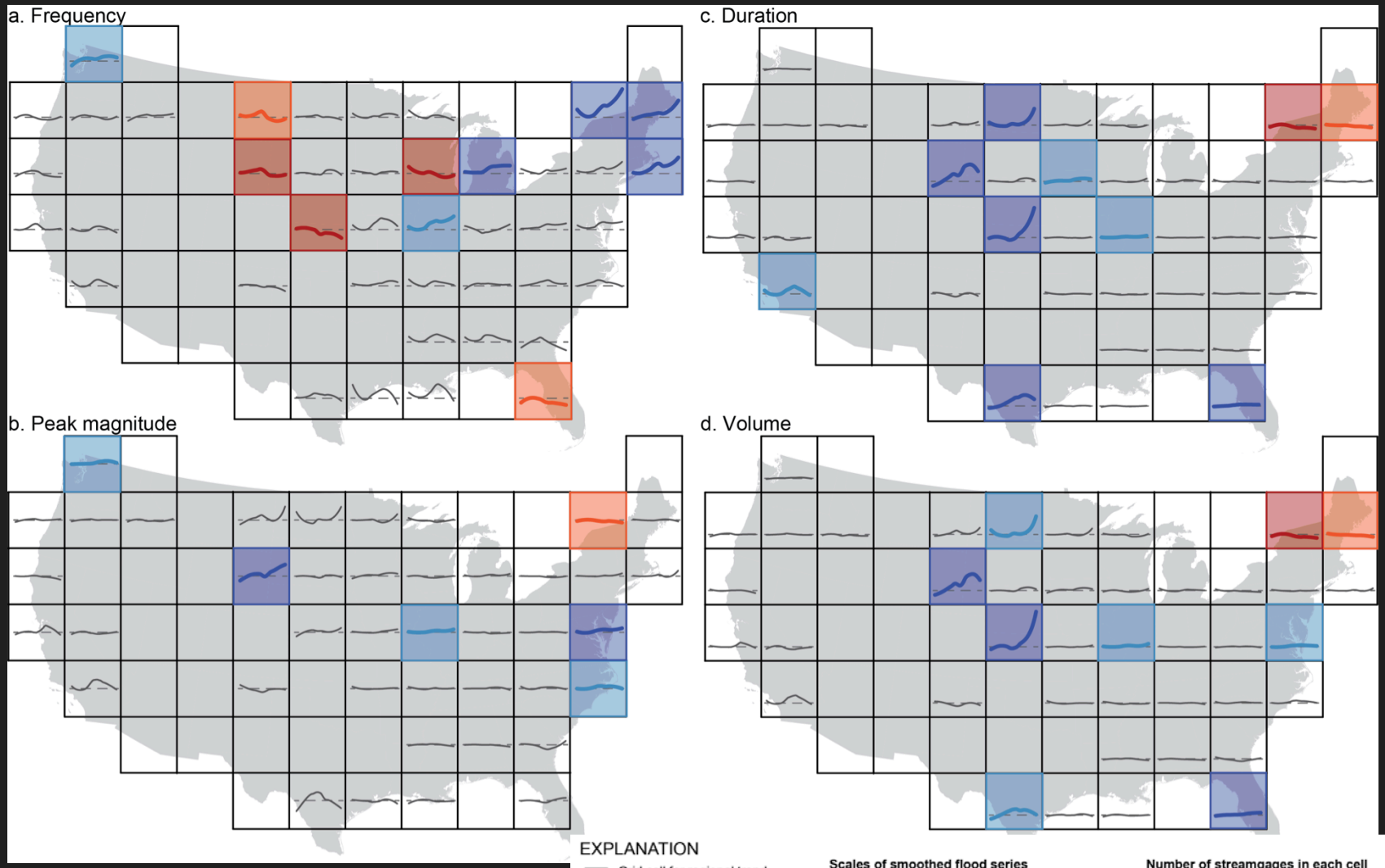
USGS

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?

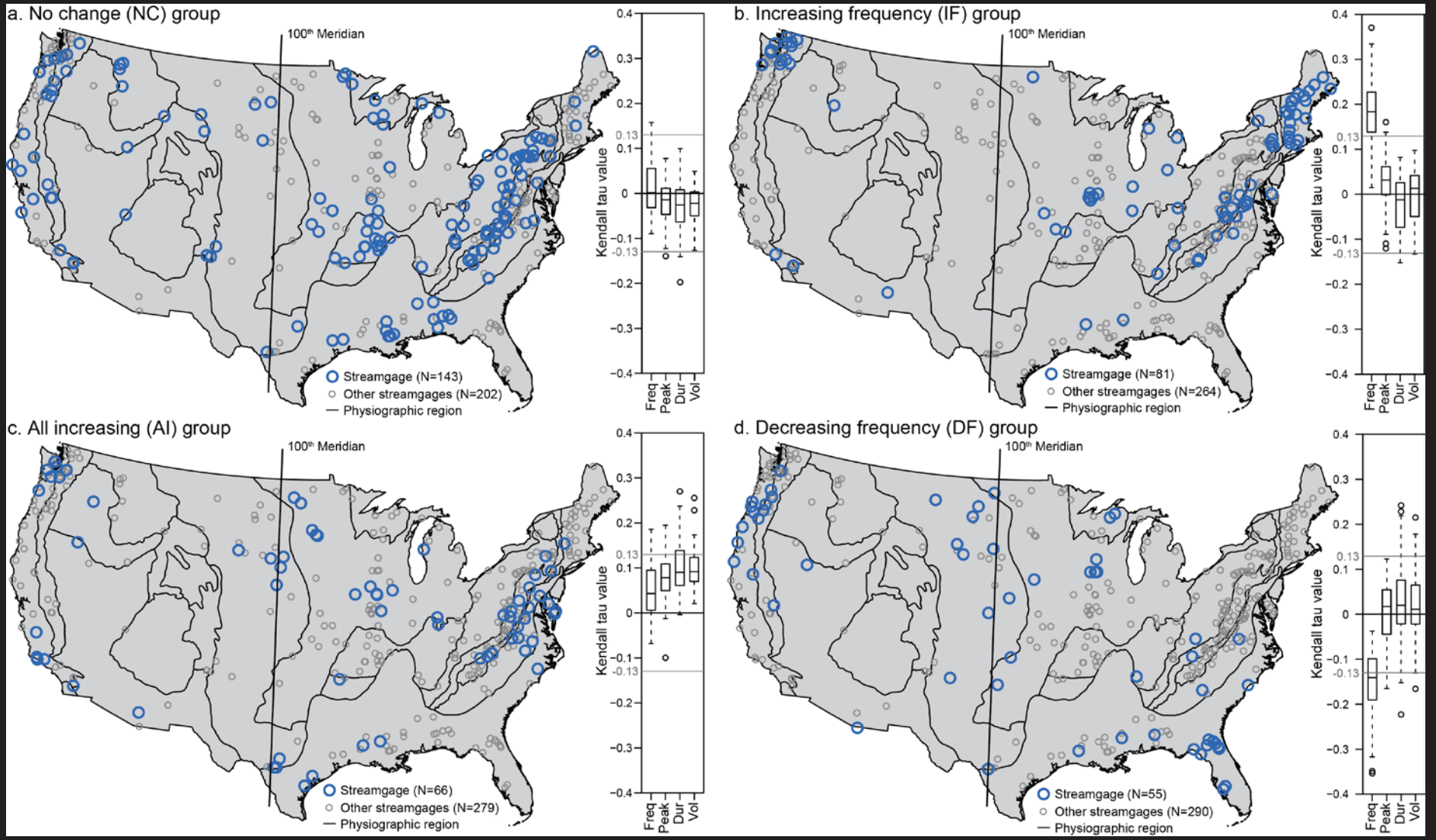


Regional changes in floods



Archfield, S.A., R.M. Hirsch, A. Viglione, and G. Blöschl, 2016, Fragmented patterns of flood change across the United States, Geophysical Research Letters, 43, doi:10.1002/2016GL070590.

Clustering flood change across the United States



USGS

Archfield, S.A., R.M. Hirsch, A. Viglione, and G. Blöschl, 2016, Fragmented patterns of flood change across the United States, Geophysical Research Letters, 43, doi:10.1002/2016GL070590.

Perspectives on flood change and attribution

IPCC AR5

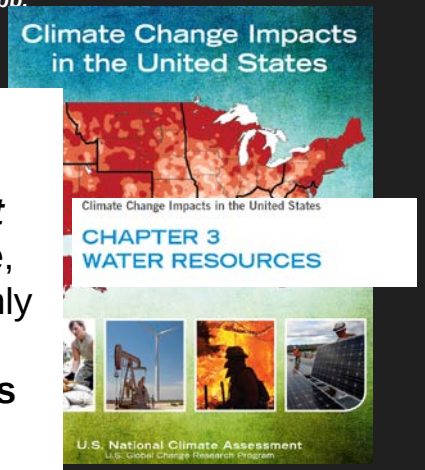
Table 18-10 | Confidence in detection and attribution of observed trends in impacts related to extreme weather. The assessment, for the impacts on various systems, is of attribution of those trends to climate change and of the confidence in existence of observed trends in that extreme weather. The assessment of confidence in detection is against the specified reference behavior, while the assessment of attribution is for the indicated minor or major role of observed climate trends. The confidence statements refer to a globally balanced assessment.

Impacts and impact events					Climate/weather drivers		
Observed trend	Confidence in detection	Reference behavior	Confidence in attribution	Role of climate change	Observed trend	Confidence in existence of trend	Reference
Earlier timing and decreasing magnitude of snowmelt floods	*Medium*	No change	*Medium*	Major	Decreasing snow pack	*High*	Section 3.2.7; Tables 18-5 and 18-6; WGI AR5 Section 4.5; Seneviratne et al. (2012)
					Increasing heavy precipitation amounts	*Medium*	
Changes in flood frequency and magnitude in non-snowmelt–fed rivers	*Low*	Changes due to land use	*Low*	Minor	Trends in extreme rainfall amounts	*Medium*	Min et al. (2011); WGI AR5 Sections 2.5.2 and 2.6.2
					Increased evapotranspiration and decreased soil moisture	*Medium*	
Increased coastal erosion in low and	*Very low*	Erosion due to shoreline modification and natural	*Very low*	Minor	Increasingly frequent high storm waves and surges	*High*	Sections 5.4.2 and 18.3.3.1; WGI AR5 Section 3.7.5

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

NCA3

"Floods that are closely tied to heavy precipitation events, such as flash floods and urban floods…are expected to increase. ***Other types of floods result from a more complex set of causes.*** For example, river floods are basin specific and dependent not only on precipitation…**important human-caused changes to watersheds and river courses across the United States.**"



Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, Terese (T.C.) Richmond, K. Reckhow, K. White, and D. Yates, 2014: Ch. 3: Water Resources. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 69-112. doi:10.7930/ J0G44N6T.

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."

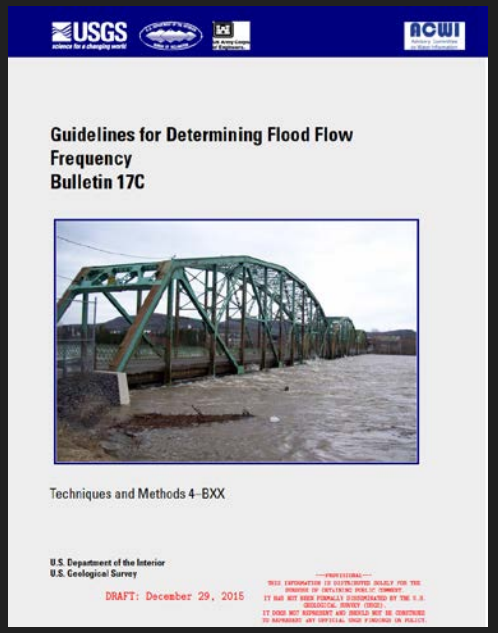
National Academies of Sciences, Engineering, and Medicine. 2015. A Community-Based Flood Insurance Option. Washington, DC: The National Academy Press, 89 p.

Bulletin 17C (DRAFT) -- Statement on climate variability and change

"There is much concern about changes in flood risk associated with climate variability and long-term climate change.. 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?

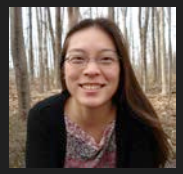
How are flood frequencies adjusted for change?



A call to action -- USGS efforts towards synthesis and research on flood detection, attribution, and adjustment for change

Research Team

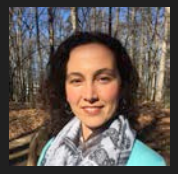

Stacey Archfield

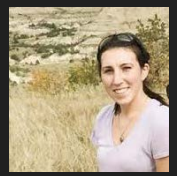

Julie Kiang


Robert Hirsch


Glenn Hodgkins

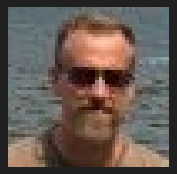

Karen Ryberg


Katherine Skalak


Kelsey Kolars


Annalise Blum


Adam Benthem


Robert Dudley


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, which has practical consequences with respect to the use of available information in the design of structures and management policies."

Montanari, A., and D. Koutsoyiannis (2014), Modeling and mitigating natural hazards: Stationarity is immortal!, Water Resour. Res., 50, 9748–9756, doi 10.1002/2014WR016092.

The scientific community needs to emphasize that the problem of flood losses is mostly about what we do on or to the landscape and that will be the case for decades to come [but] 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.

Kundzewicz, Z.W., et al., 2013. Flood risk and climate change: global and regional perspectives. Hydrological Sciences Journal, 59 (1), 1–28.

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Photo credit: Thomas Archfield