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Probabilistic Flood Hazard Assessment Workshop

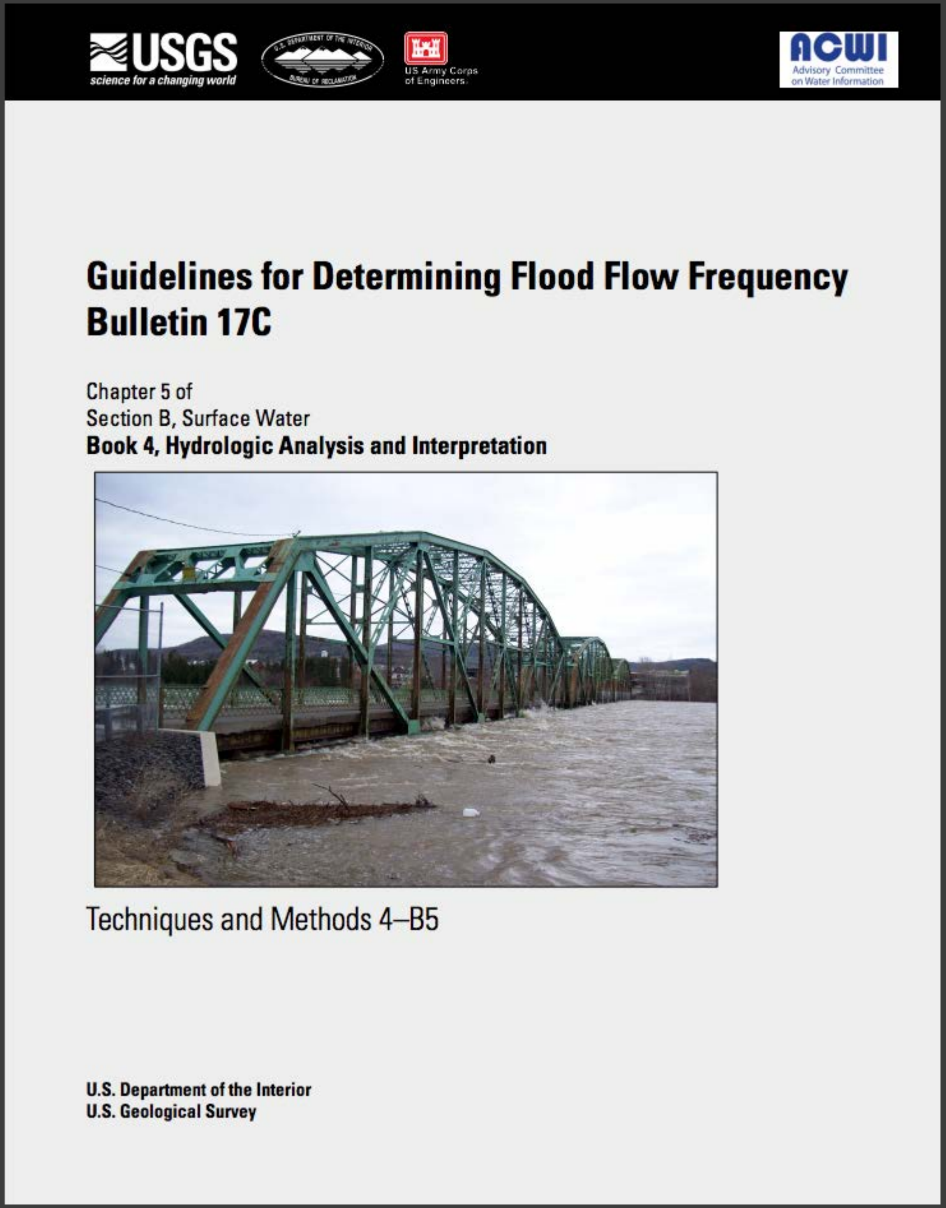
February 19–21, 2020

Attribution of Flood Nonstationarity across the United States—Climate-Related Analyses

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

Bulletin 17C

- England, J.F., Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas, W.O., Jr., Veilleux, A.G., Kiang, J.E., and Mason, R.R., Jr., 2018, Guidelines for determining flood flow frequency—Bulletin 17C: U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., https://doi.org/10.3133/tm4B5.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ACWI Advisory Committee on Water Information

Guidelines for Determining Flood Flow Frequency Bulletin 17C

Chapter 5 of
Section B, Surface Water
Book 4, Hydrologic Analysis and Interpretation

Techniques and Methods 4–B5

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Solutions Still Needed for Nonstationarity

Stationarity: a process that can be defined with a probability distribution with unchanging parameters, such as a peak-flow series used in flood-frequency analysis that has a defined, constant mean, variance, and skew.

Nonstationarity: a process that may exhibit gradual trends, sudden shifts (change points), or changes in variability. Regulation of a stream and natural or anthropogenic climate shifts can create one or more nonstationarities in a peak-flow series.

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Research Questions and Approach

Where is change happening?

How are floods changing?

What is causing the change?

How to adjust flood frequencies for change?

Detection

Monotonic trends

Step trends

Peaks-over-threshold

- 2 events per year
- 1 event per 5 years

Attribution

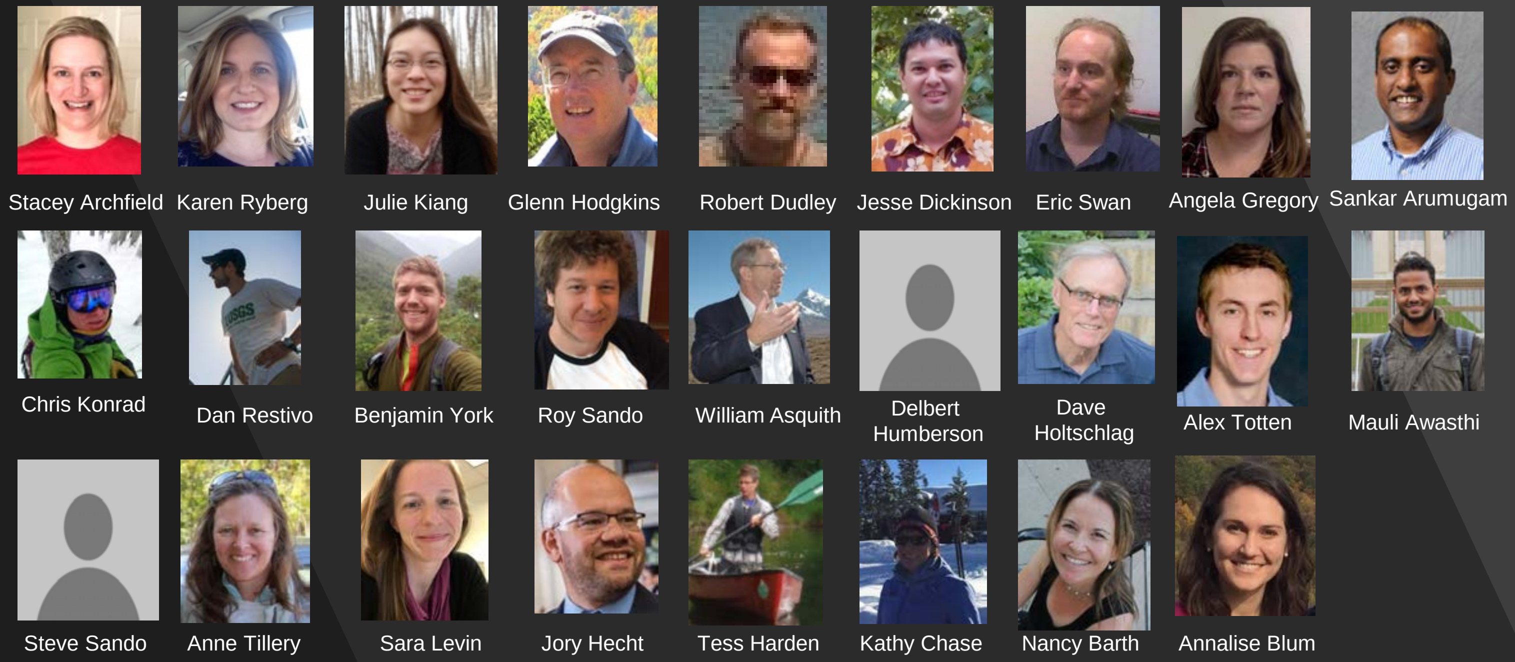
Use national datasets of dams, land cover change, and precipitation to develop and test hypotheses for causal attribution of observed changes

Adjustment

Develop an assessment framework to evaluate different approaches to trend adjustment where the “true” trend is known.

Research Team

Research team and collaborators (N = 26)



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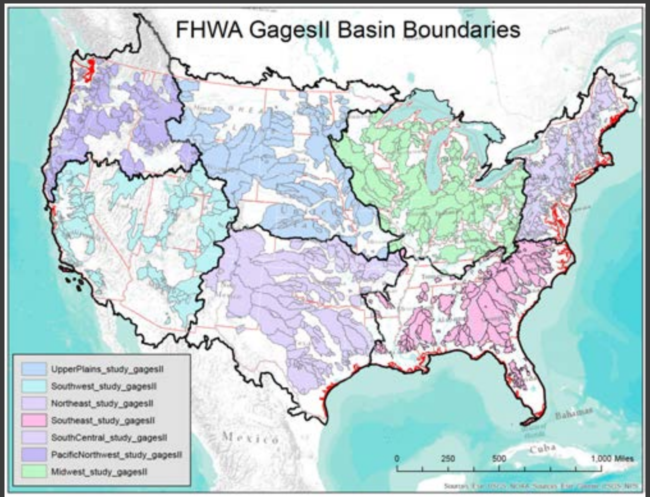
Attribution of Change – A Regional, Expert-Driven Approach using a Multiple Working Hypotheses Framework

75 years: 1941-2015 (n = 1464)



- Artificial Discharge
- Atmospheric Rivers
- Climate Variability
- Crop Type
- Data Quality
- Deforestation
- Developed Land
- Diversions
- Drainage
- Drought
- Fire
- Geomorphological Changes
- Grazing
- Groundwater Withdrawals
- Hurricanes and Tropical Storms
- Invasive Woody Species
- Percent Agricultural Land
- Population
- Precipitation
- Regulation
- Sea-level Rise
- Seismic Activity
- Temperature
- Seasonal Patterns of Change
- Volcanic Activity

The study is limited to national level analyses using attribution characteristics available at this scale. Further research is needed at the local and regional levels to understand drivers of flood change. The national results can be used as a starting place for detailed regional analyses that can leverage local expertise and regional model results.

Final List of Attributions Possibilities

- Short-term precipitation
- Long-term precipitation
- Snowpack
- Temperature
- Large artificial impoundment
- Small impoundments
- Surface-water withdrawals
- Groundwater withdrawals
- Artificial wastewater and water-supply discharges
- Agricultural drainage activities
- Inter-basin water transfers
- Agricultural crops
- Grazing activity
- Invasive woody species (riparian)
- Forest cover/composition including wildland fires
- Urban effects
- Glaciers
- Geomorphological changes
- Volcanic activity
- Sea-level rise
- Inconsistent quality in streamflow records
- Inconsistent quality in ancillary datasets
- Unknown

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Vocabulary for Confidence in Attributional Statements

Vocabulary	Further description
Robust evidence	One or more of the following: • strong and consistent results, • multiple sources (datasets, studies, analyses), • well documented data, • and attribution is consistent with causal mechanisms.
Medium evidence	Moderate consistency, emerging results, or weight of evidence points in the direction of attribution but there may be some divergent findings.
Limited evidence	Limited sources or inconsistent findings.
Additional information required	Insufficient evidence to make an attribution.

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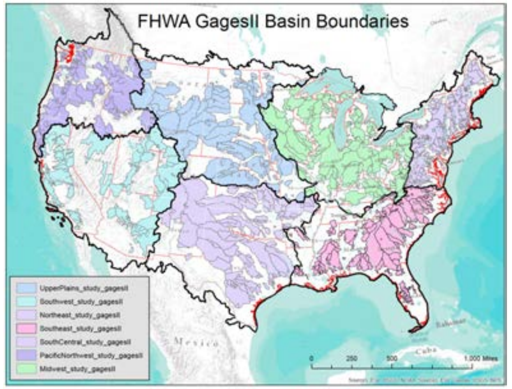

Gage #	Direction of trend	Primary attribution	Secondary attribution	Standard Confidence Statement	Attribution notes
ND05059500	Increase	Long-term precipitation		Regulation as cause of change refuted, Climate variability probable cause, Robust evidence	A dramatic increase in precipitation in this region has caused much larger flows (citations), despite regulation that would have made a decrease more likely - Since March 1993, flood flows that are diverted from the Sheyenne River just downstream from gaging station Sheyenne River above Sheyenne River Diversion near Horace (station 05059300) bypass this station (cite NWISWeb https://waterdata.usgs.gov/nwis/wys_rpt/?site_no=05059500).

Attribution of Change—Goals and an Example

Each statistically significant result will have a primary attribution assigned to it with a statement of confidence and possibly a secondary attribution.

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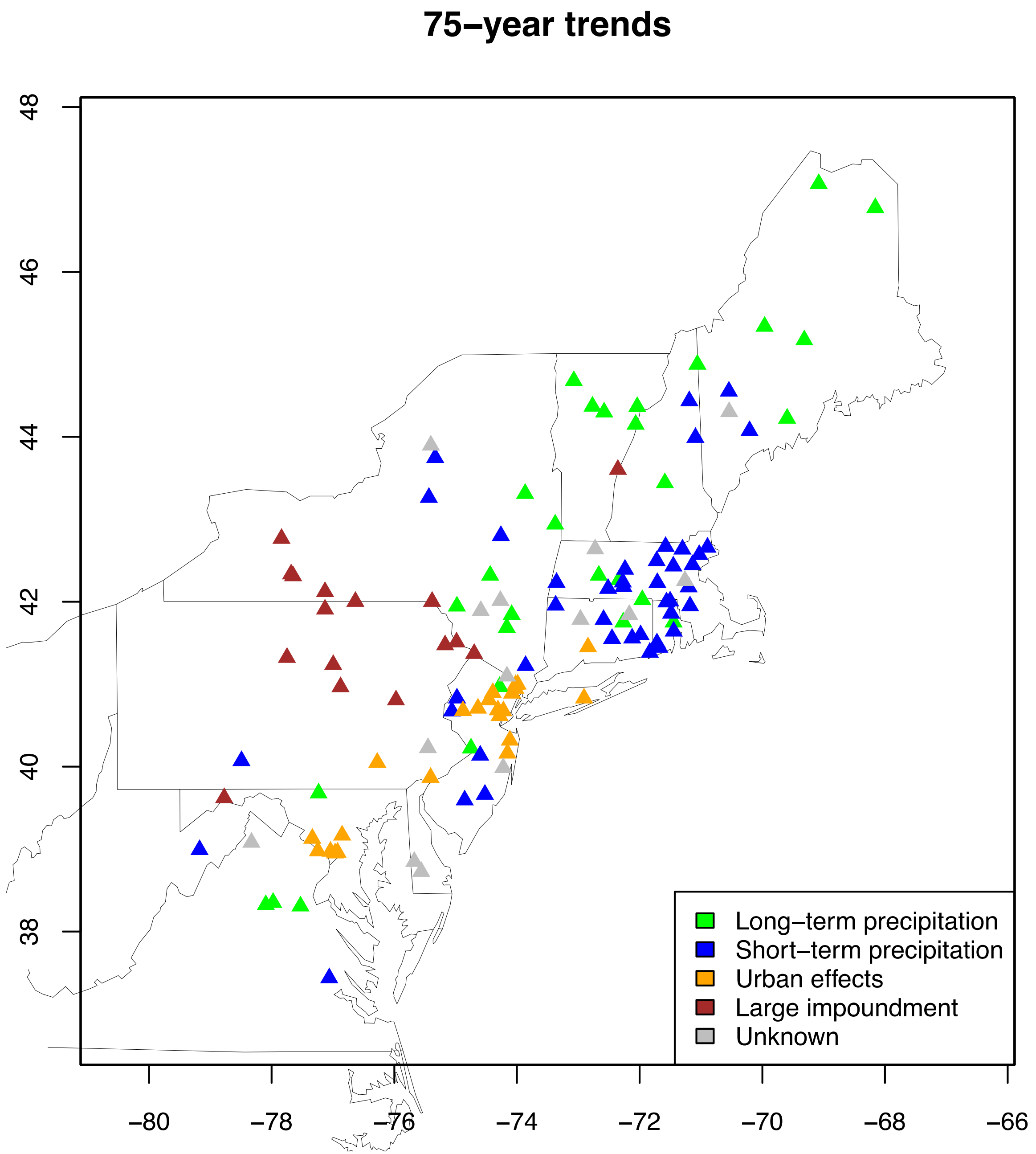
Examples

Climate-Related Attributions

Northeast Region Monotonic Trends



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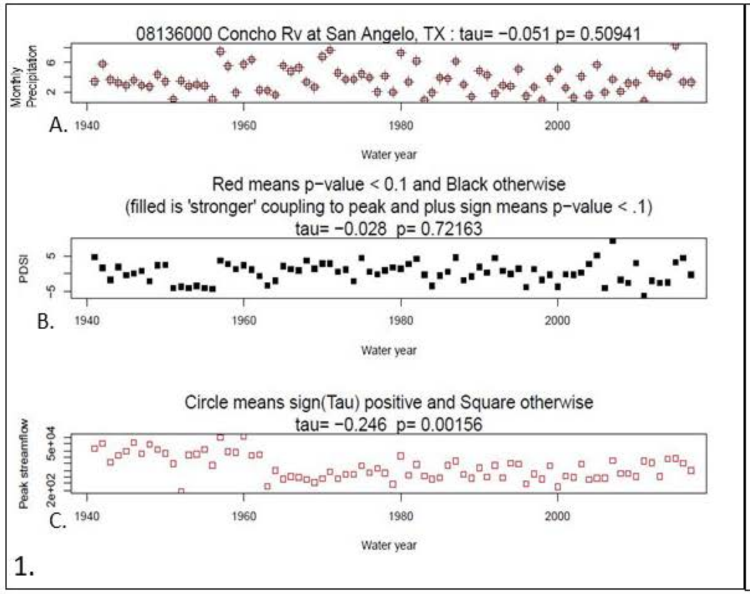
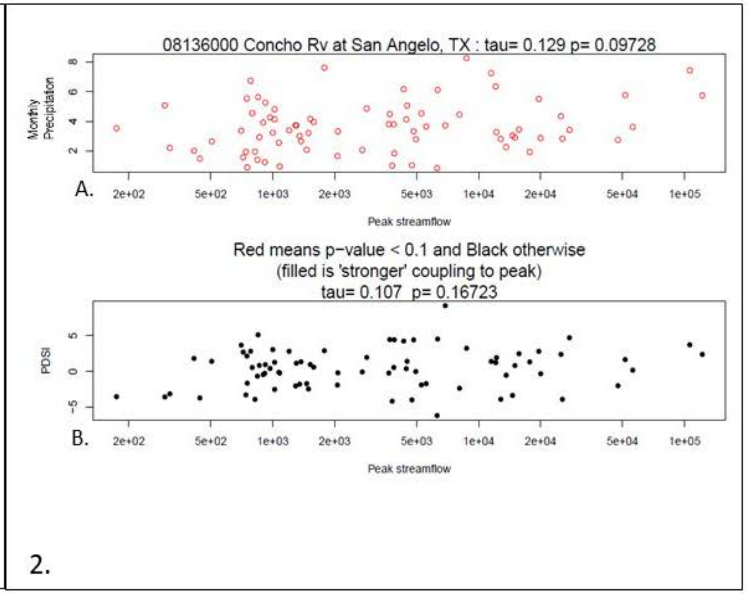
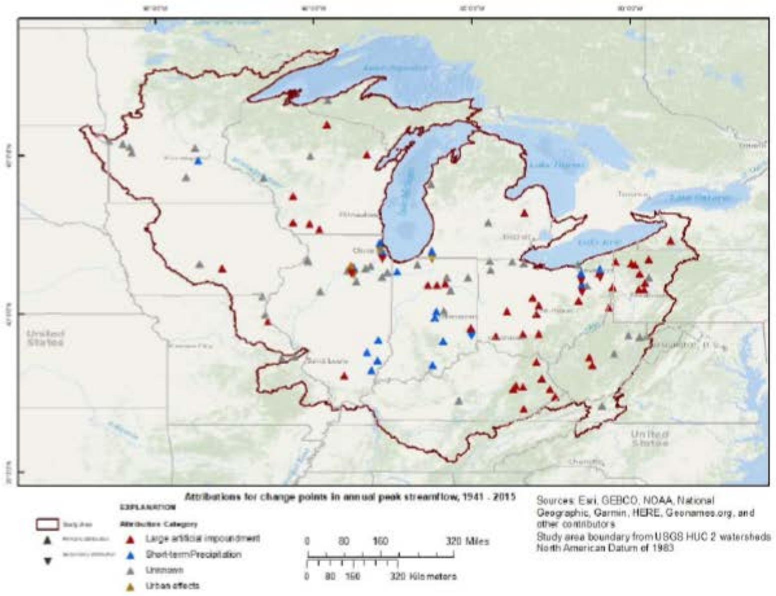
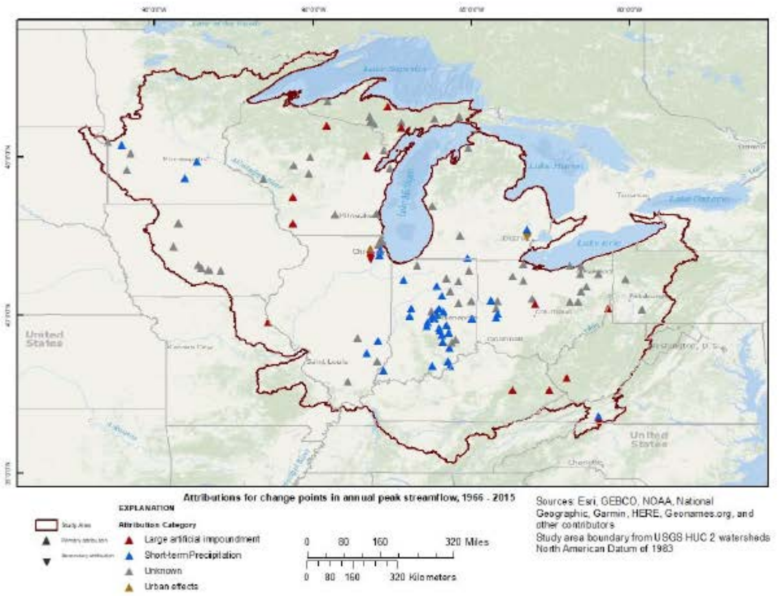
South Central Region





Midwest Region





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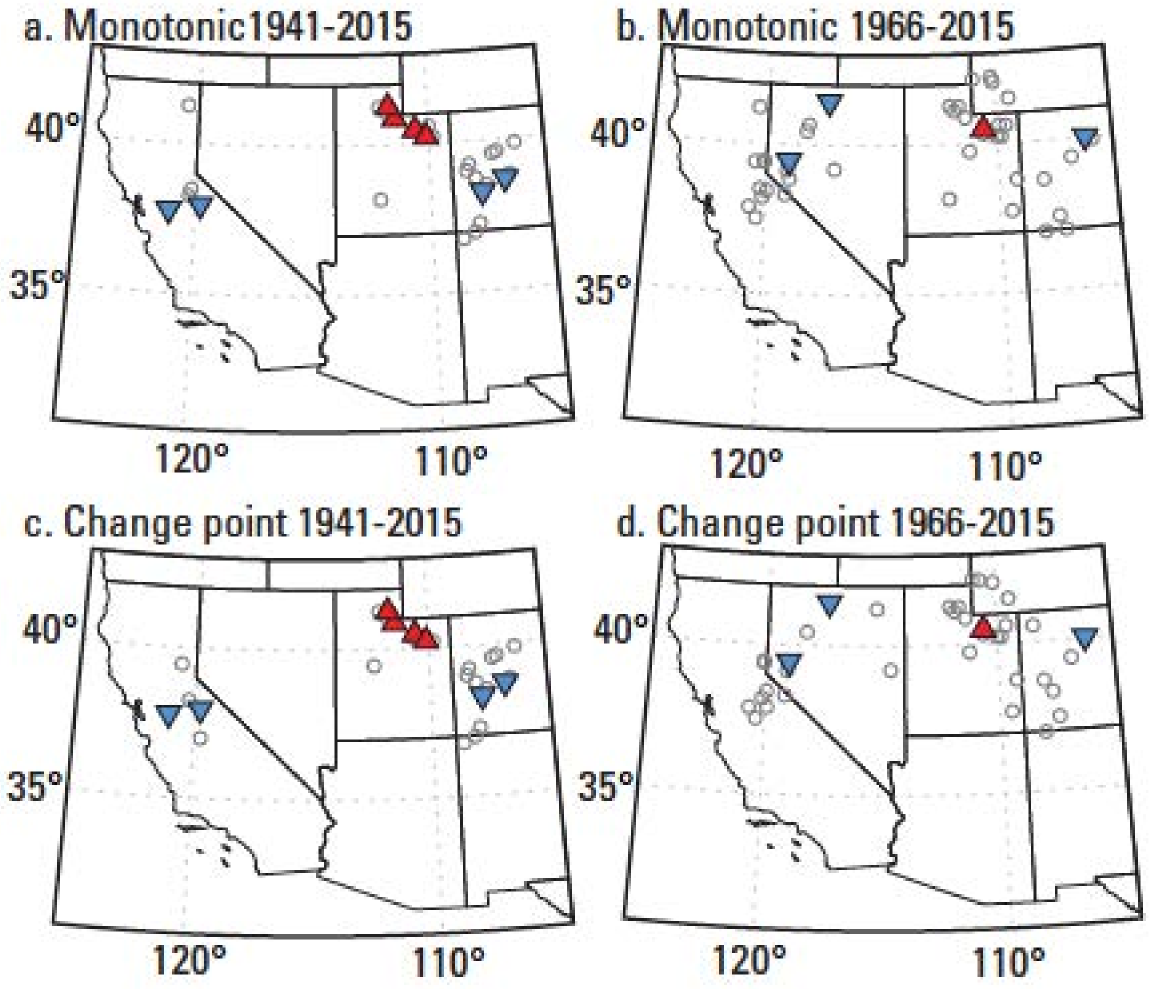
Southwest Region



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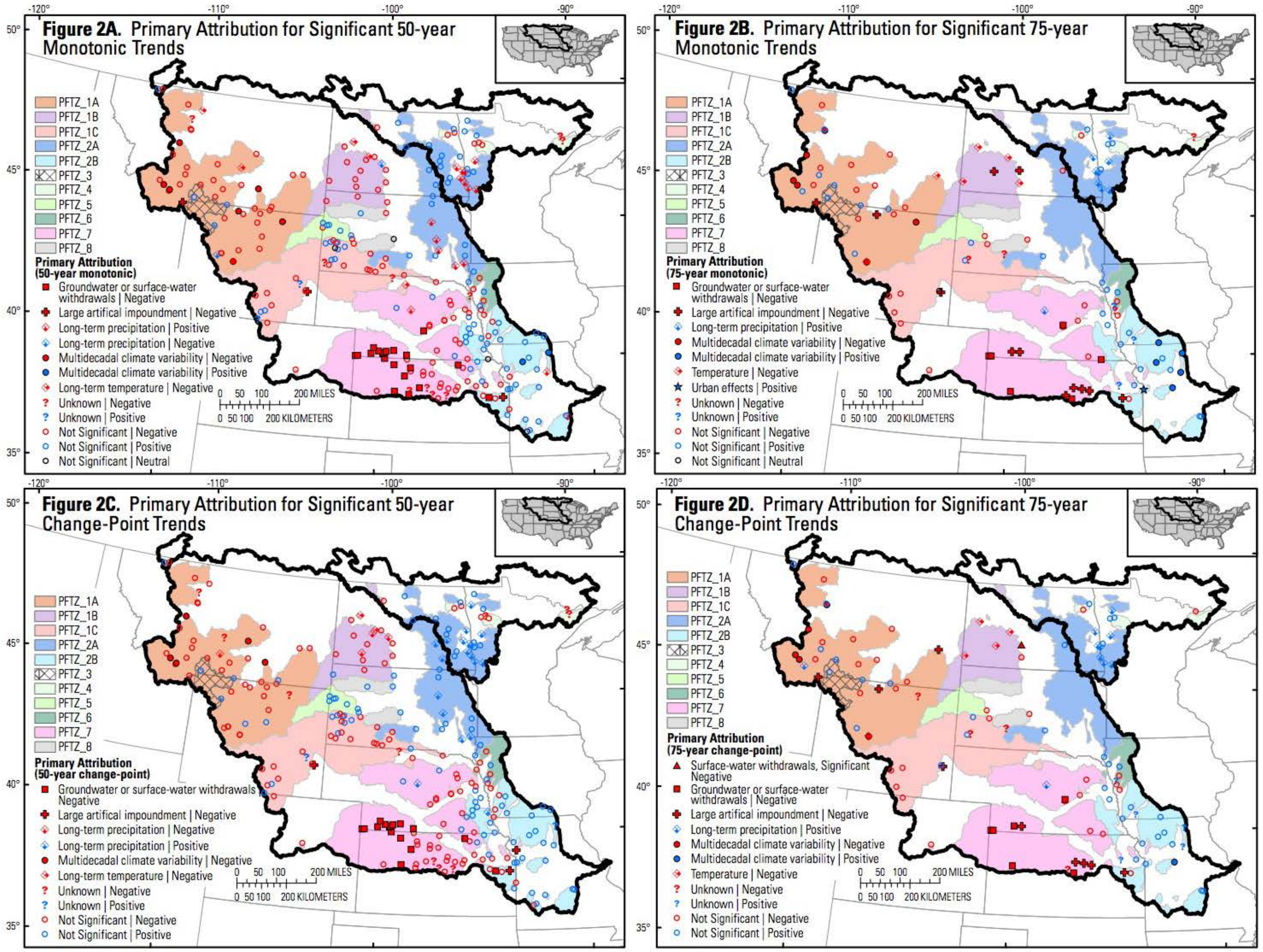
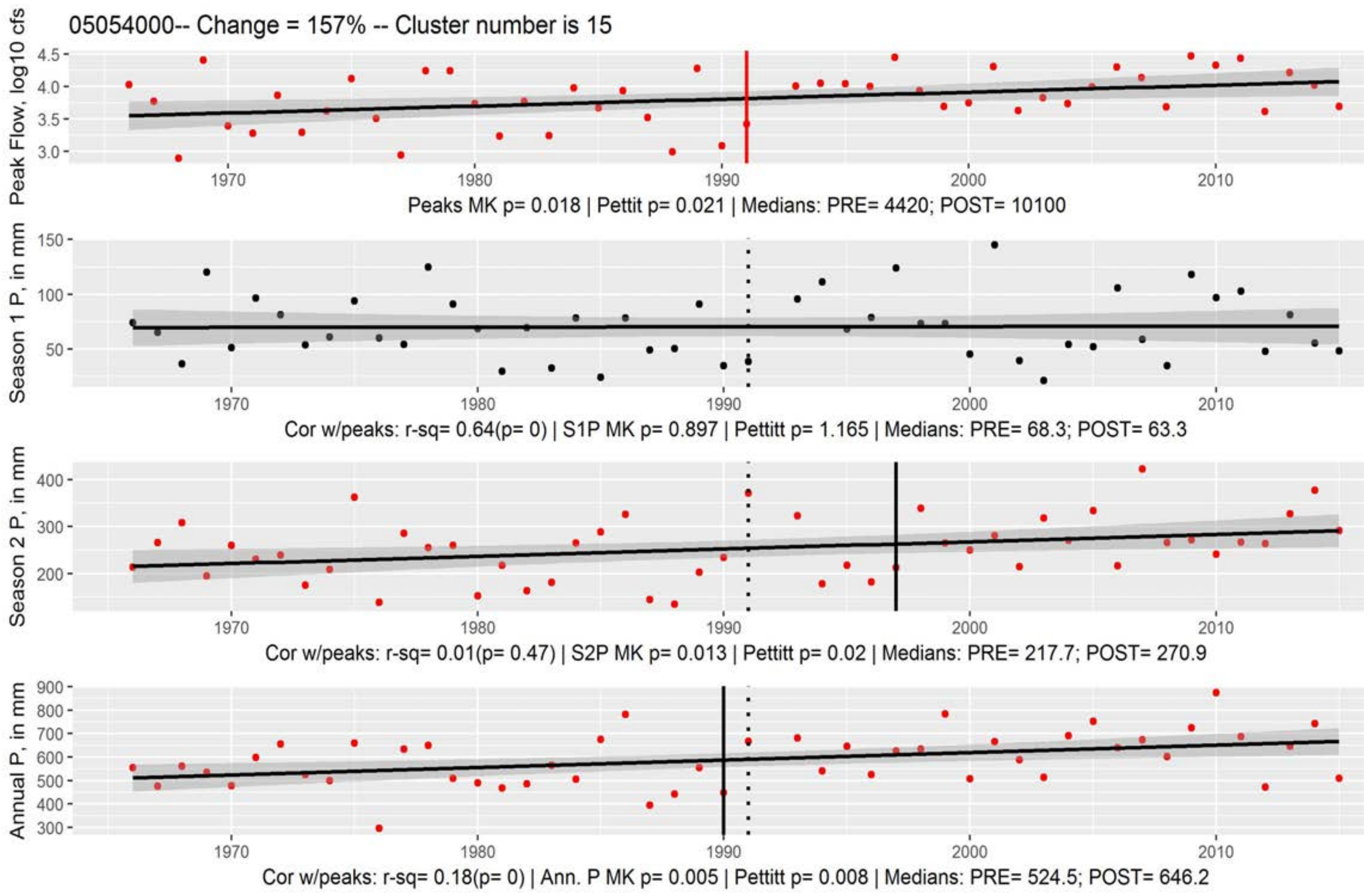
Upper Plains Region



Preliminary Information-Subject to Revision. Not for Citation or Distribution.



Upper Plains—Red River of the North at Fargo, North Dakota

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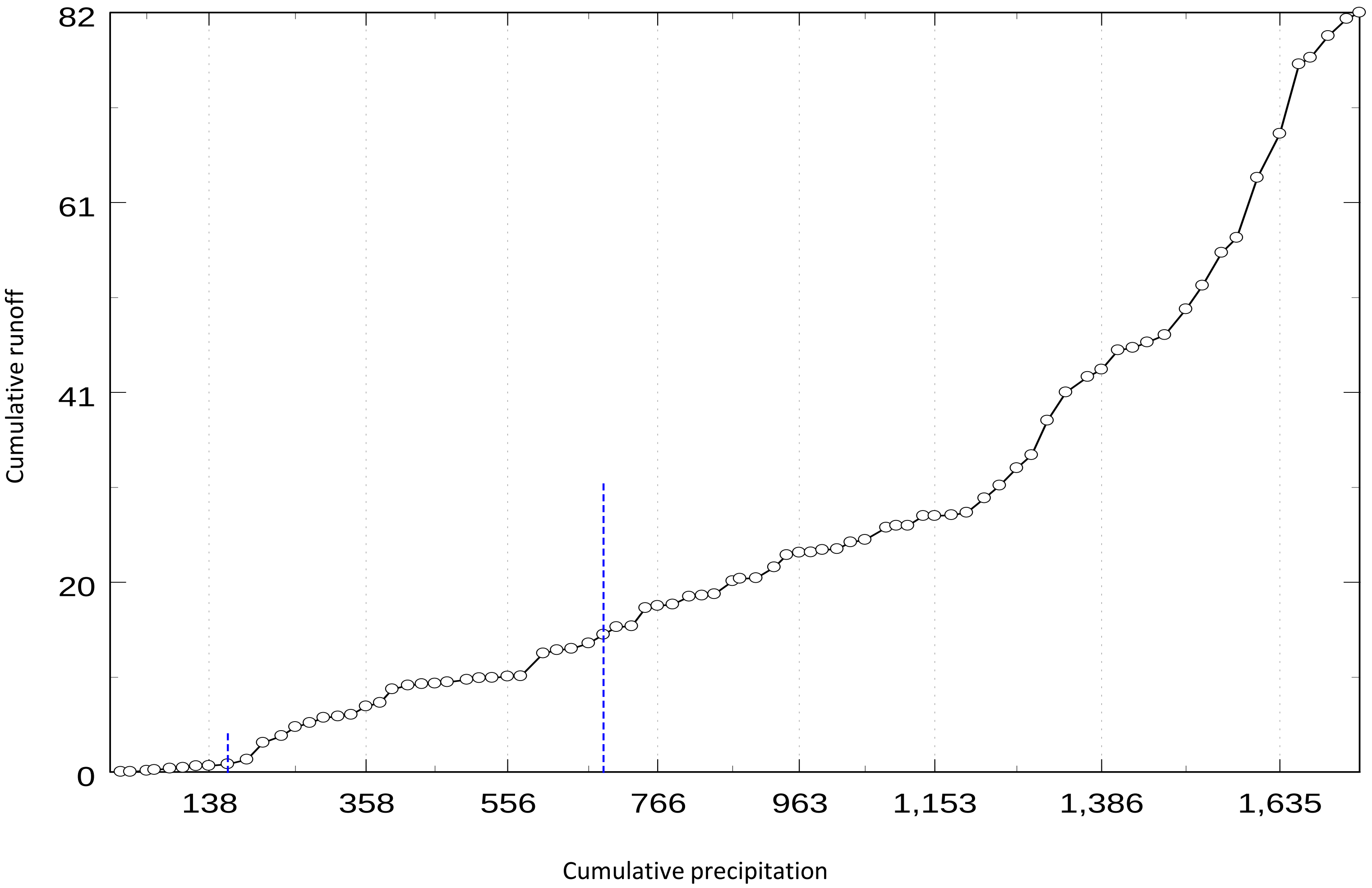
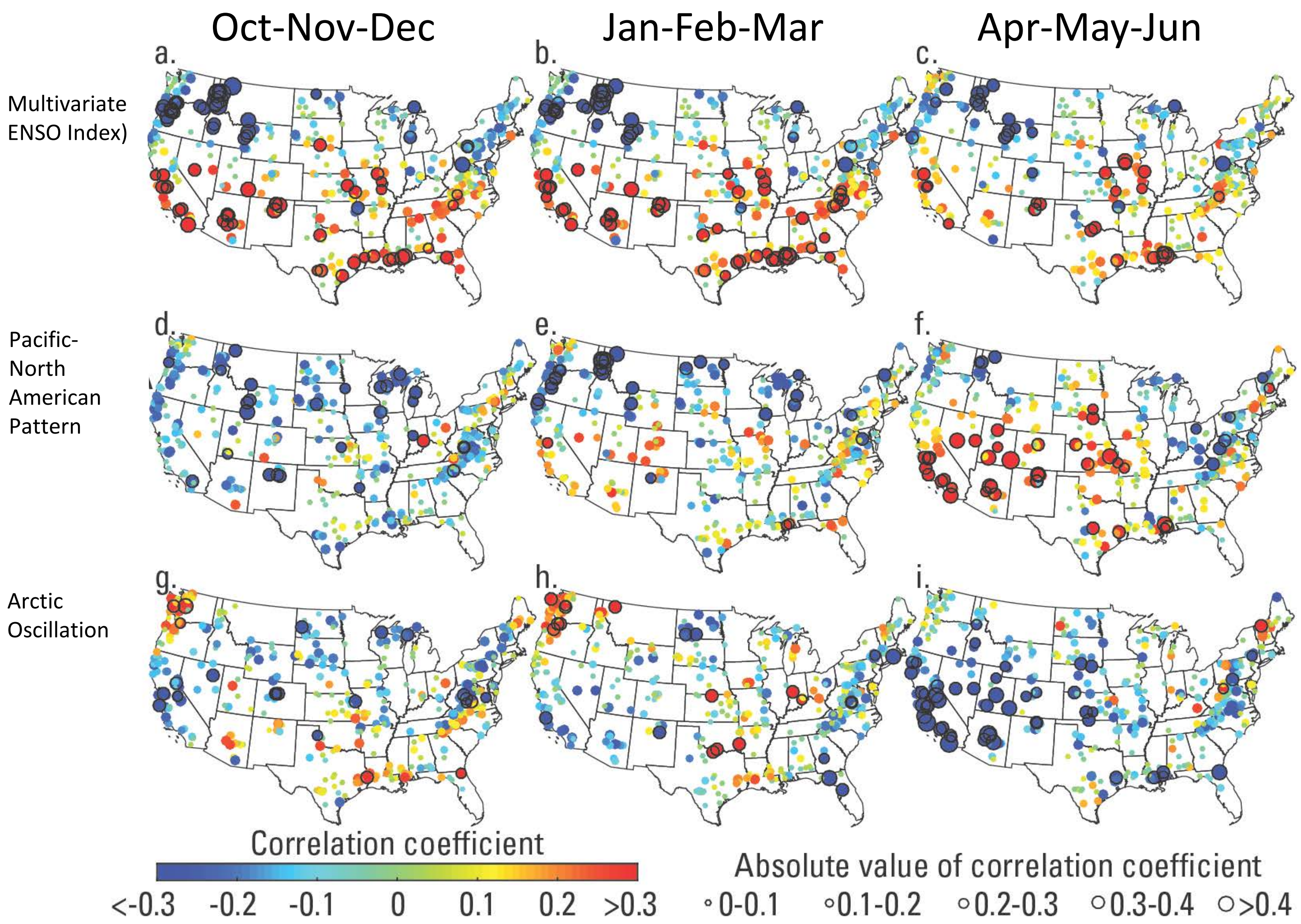
Upper Plains—Double-Mass Curve

The theory of the double-mass curve is based on the fact that a graph of the cumulation of one quantity against the cumulation of an other quantity during the same period will plot as a straight line so long as the data are proportional; the slope of the line will represent the constant of proportionality between the quantities. A break in the slope of the double-mass curve means that a change in the constant of proportionality between the two variables has occurred or perhaps that the proportionality is not a constant at all rates of cumulation.

USGS Water Supply Paper 1541-B, 1960



National Seasonal Patterns with Oceanic and Atmospheric Indices



Dickinson, J.E., Harden, T.M., and McCabe, G.J., 2019, **Seasonality of climatic drivers of flood variability in the conterminous United States**: Scientific Reports, v. 9, no. 1, 10 p., https://doi.org/10.1038/s41598-019-51722-8.

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Phase II publications

8-chapter USGS Professional Paper providing trend and change point attribution for seven regions in the conterminous United States (chapters in review or editorial)

A data release with the attributions and some supporting data (pending approval)

Collaboration with Johns Hopkins University: Blum, Ferraro, Archfield, and Ryberg, *Causal effect of impervious cover on annual flood magnitude for the United States*, under revision

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