

# Improvements Being Made to Mixed Population Flood Frequency Data, Tools, and Techniques by Multiple Federal Agencies



US Army Corps of Engineers®

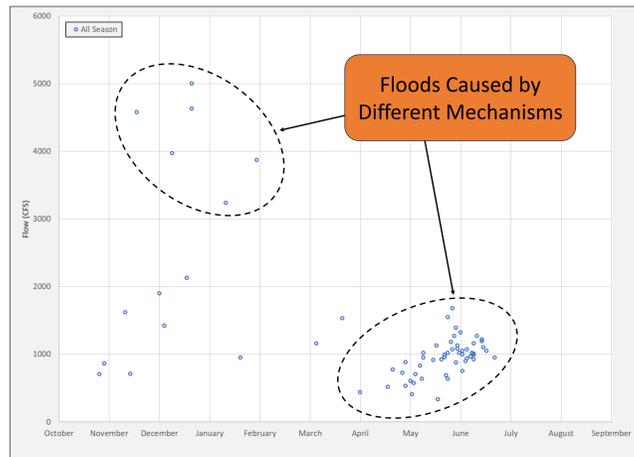
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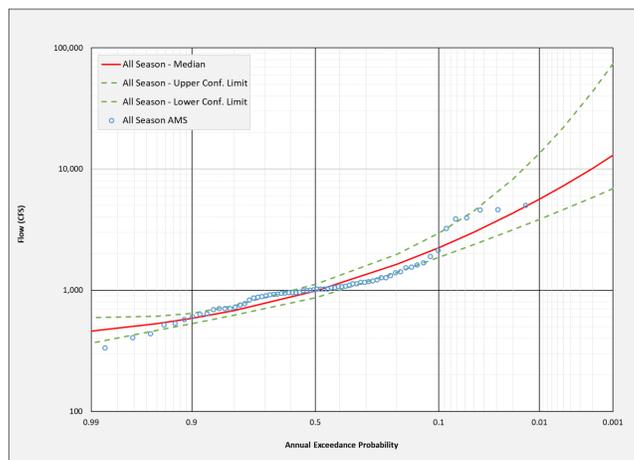
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## Overview

- Inland flooding caused an annual average of \$6.9 billion per year in damages from 1976-2006, more than any other type of natural disaster during this period, according to the U.S. Climate Resilience toolkit (2021)
- An improved understanding of the frequency of floods is critical for effective risk communication, planning, and mitigation
- Flood frequency analysis requires input observations to be Independent and Identically-Distributed
- Analysts commonly violate the “Identically-Distributed” requirement/assumption when performing flood frequency analyses at locations where floods are caused by multiple mechanisms
- This has negative consequences when predicting flood quantiles for rare annual exceedance probabilities, performing trend analyses, and regionalizing information, amongst others



Seasonality Plot of Observed Annual Maximum Series Demonstrating the Presence of Multiple Flood Mechanisms

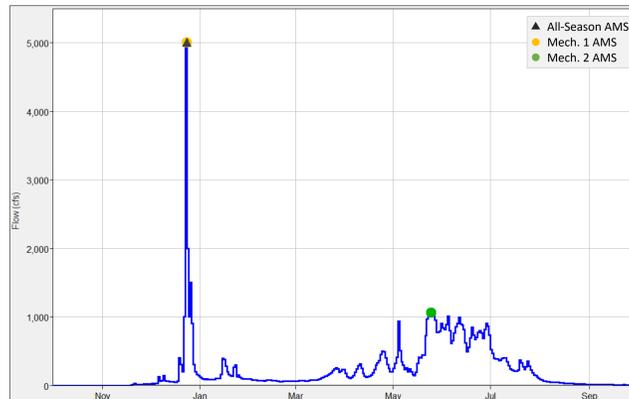


Flood Frequency Analysis Results Demonstrating Poor Fit when Multiple Flood Mechanisms Are Present

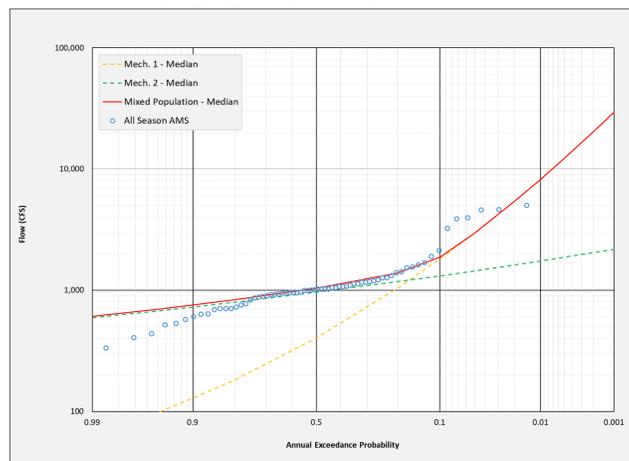
Separating floods by causal mechanism allows us to largely avoid these issues and **produce improved flood frequency estimates!**

## What's Taken So Long to Solve This Problem?

- We generally know what caused the top five to ten flood events at a site but classifying smaller flood events, particularly older ones, is difficult
- Gaged streamflow records are typically much shorter than the corresponding return period for design events (e.g., 1/1000 AEP)
- A lack of quantitative guidance describing how to analyze locations that experience floods caused by more than one mechanism means there isn't uniformity in the approaches taken by analysts



Example of Separating Floods by Causal Mechanism



Example of Improved Flood Frequency Results Using Mixed Population Analysis Techniques

FEMA has partnered with USACE and USGS to enhance state-of-the-practice data, tools and techniques to quantify flood risks at locations that are subjected to floods from multiple mechanisms

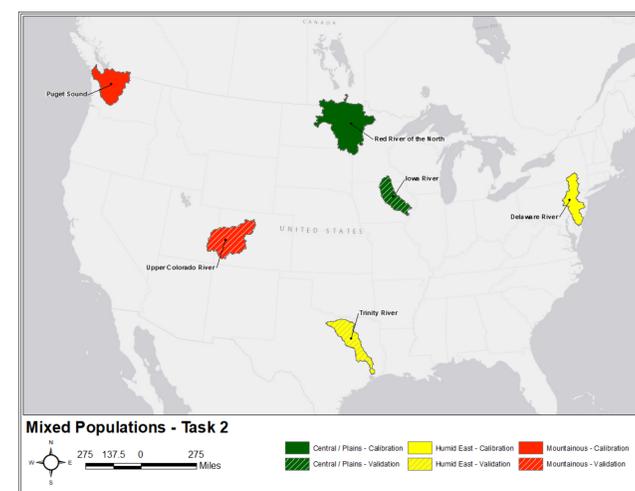
## Interagency Work Unit Goals

- Improve mixed-population flood-frequency analysis methods available for use at locations with long-term stream gages in the U.S. based on physical causal mechanisms
- Develop and test semi-automated methods for determining flood type classifications at stream gages across the U.S.
- Develop a storage system for flood type classification information in a centralized public database for each annual peak flow and each peak flow event above a critical threshold
- Project future floods of different recurrence intervals considering potential changes in proportions of floods originating from different combinations of meteorological drivers and antecedent watershed conditions
- Prescribe a plan for national implementation, including training of federal employees

## Pilot Region Selection

- Multiple criteria were used to evaluate several proposed regions for use in pilot studies
- A semi-quantitative elicitation approach using multiple criteria was utilized to rank the proposed regions

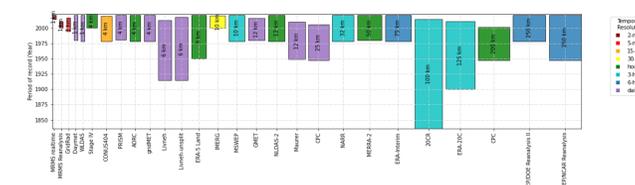
The Delaware River, Red River of the North, and Puget Sound were selected as calibration regions. The Trinity River, Iowa River, and Upper Colorado River were selected as validation regions.



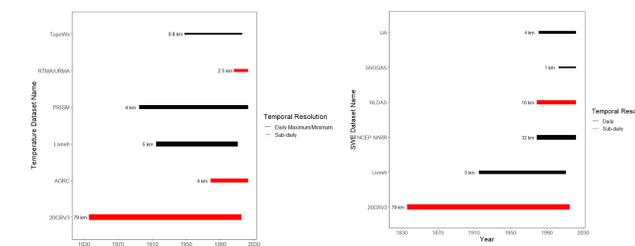
Map Showing Selected Calibration and Validation Regions

## Data Sources

- Numerous hydrologic, meteorological, and land surface data sources were evaluated for use in flood type classification for both historical and future time periods including streamflow, precipitation, temperature, snow water equivalent, integrated vapor transport, geopotential heights, storm tracks, ice jams, and wildfires, amongst others
- Gridded meteorological and land surface data was preferred over point data (i.e., gage) due to a desire to avoid conversion from points to spatial coverages
- To create flood typing processes that are as generic as possible, datasets that are available for CONUS were desired over region-specific data



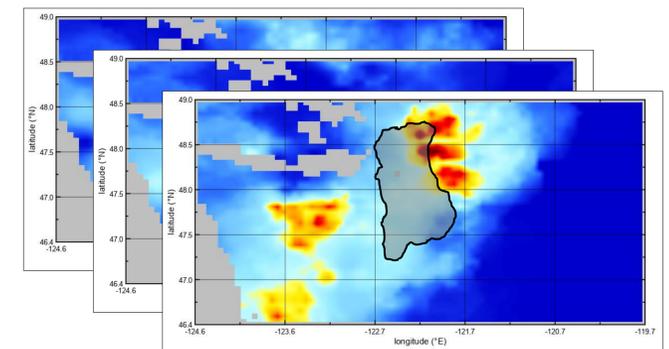
Example of Gridded Precipitation Data Source Availability and Resolution



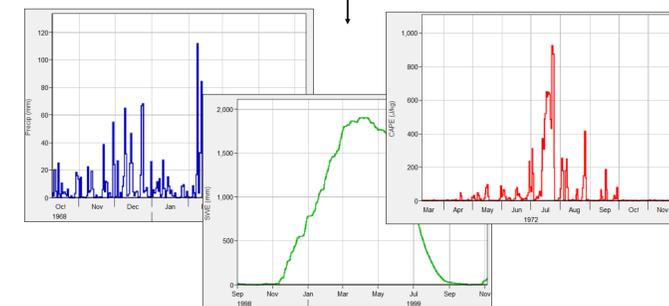
Example of Gridded Temperature and Snow Data Source Availability and Resolution

## Data Processing

- Time series were extracted from the gridded data sources for the contributing drainage areas of 40+ gages within each pilot region
- These time series were then used within subsequent manual and semi-automated flood typing and mixed population flood frequency analysis efforts



Vortex



Example Data Processing Steps Used to Classify Flood Mechanisms at a Location of Interest

## Ongoing and Future Efforts

- Evaluate the accuracy of multiple mixed population flood frequency analysis techniques
- Extract IID samples for all locations within each pilot region using semi-automated storm/flood typing algorithms
- Estimate current conditions flood frequency for all locations within each pilot region using mixed population techniques
- Analyze changes in flood mechanisms over historical and future periods
- Establish a national scope-of-work to upscale mixed population analyses
- Develop examples, training materials, and guidance documents
- Disseminate results to interested partners

## Acknowledgments

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