

ESTIMATING FLOOD RELEVANT STATISTICS FOR THE U.S. FROM 40 YEARS OF NATIONAL WATER MODEL STREAMFLOW

H451-1500

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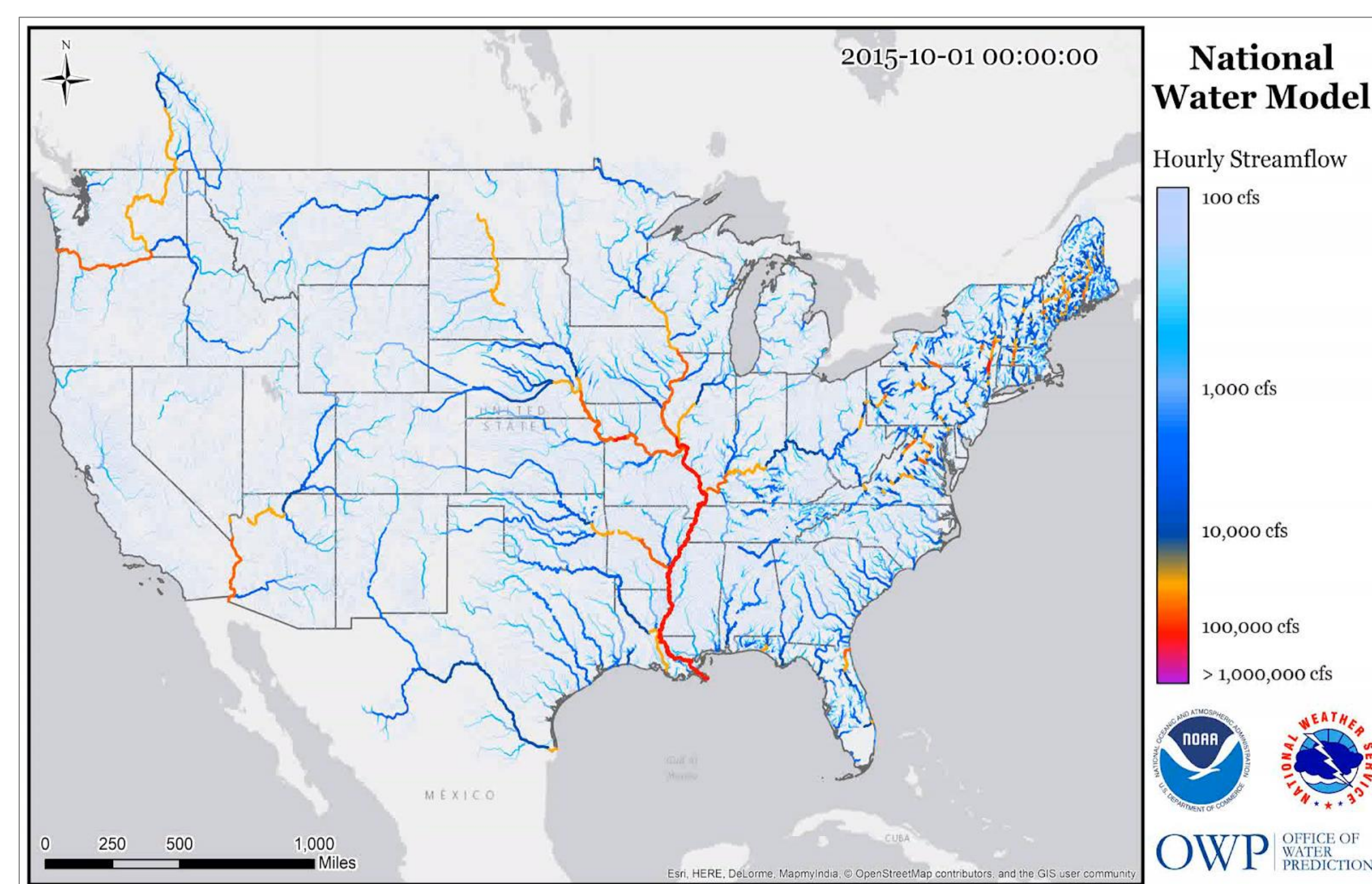
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Filling in the Gap in Observations

Understanding streamflow regimes is critical for flood planning. Calculating the probability of flooding requires years of discharge and/or stage observations, yet locations with this type of information represent a small percentage of total stream miles in the U.S., leaving many areas without guidance. The National Water Model (NWM) retrospective simulation provides 40 years (1979 – 2019) of streamflow along 3.4 million river miles, filling in the gap in observations in the U.S. with simulated flows.



Estimating Higher Streamflow AEPs

Streamflow Annual Exceedance Probabilities (AEP) relate discharge or stage to a probability, i.e. the flow associated with a 50% AEP has a 50% chance of occurring in any given year. To estimate streamflow AEPs at a more complete spatial scale than is possible with observations, we used the NWM 40 year retrospective to conduct flood frequency analysis for > 2.7 million reaches.

AEPs were first estimated using a simple, rank order method:

$$P = 100 \times \frac{m}{n+1}$$

Where:

P = the percent (%) probability that a given flow will be equaled or exceeded

m = the rank of the inflow value, 1 being the largest possible value

n = the total number of events or data points on record

Reliable estimates using the simple method are limited by the number of annual peak flows, therefore the National Water Center (NWC) uses this method to only estimate higher streamflow AEPs (10% and greater)

ACKNOWLEDGEMENTS:

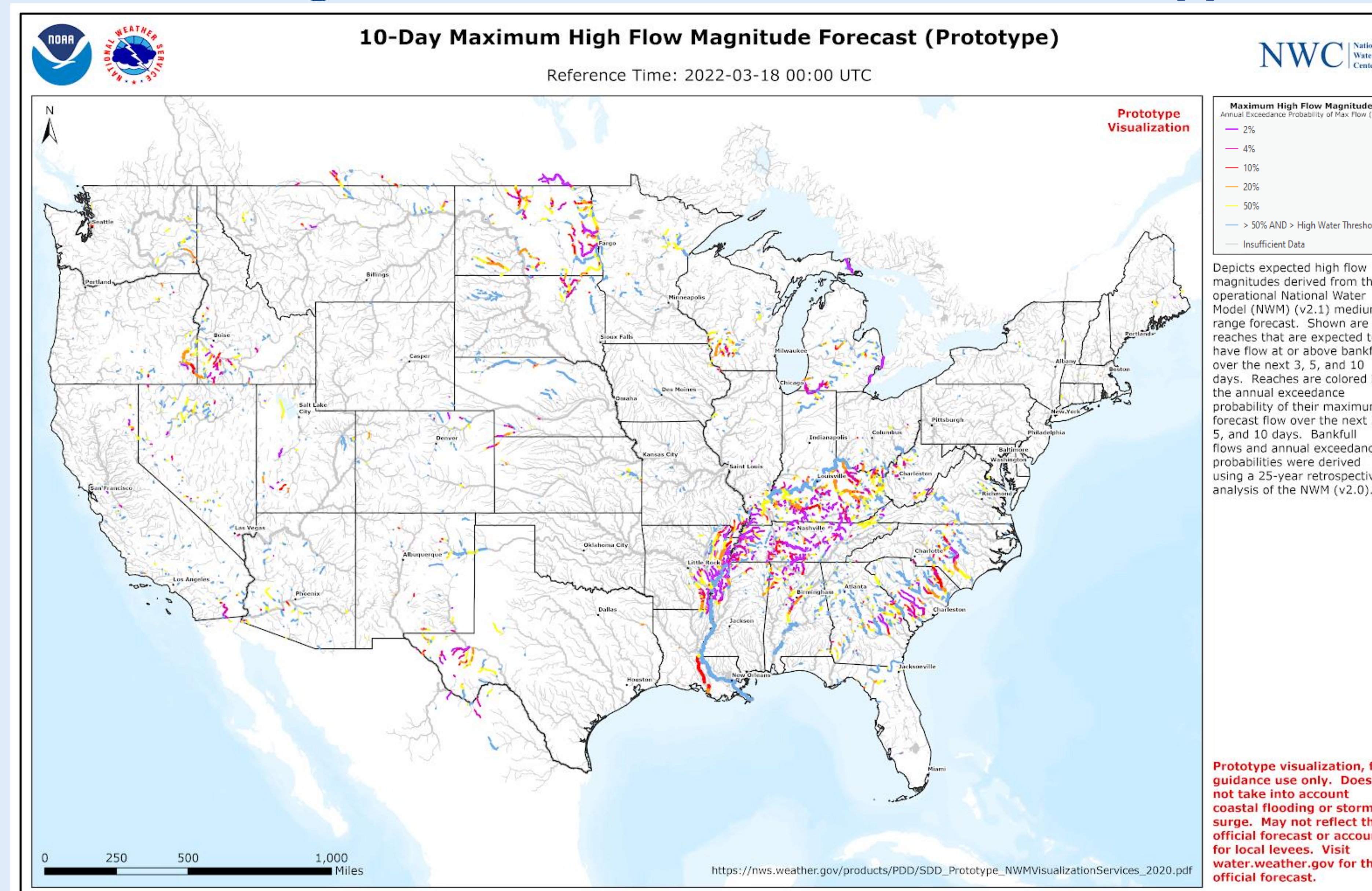
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Leveraging NWM Retrospective Flows Provides Flood Guidance in Places Without Observations



Flash Flooding in Southeastern Kentucky (near Quicksand, KY) in July 2022
(image credit: (Ryan C. Hermens/Lexington Herald-Leader, via Associated Press))

Using NWM Flood Statistics in Decision Support Services

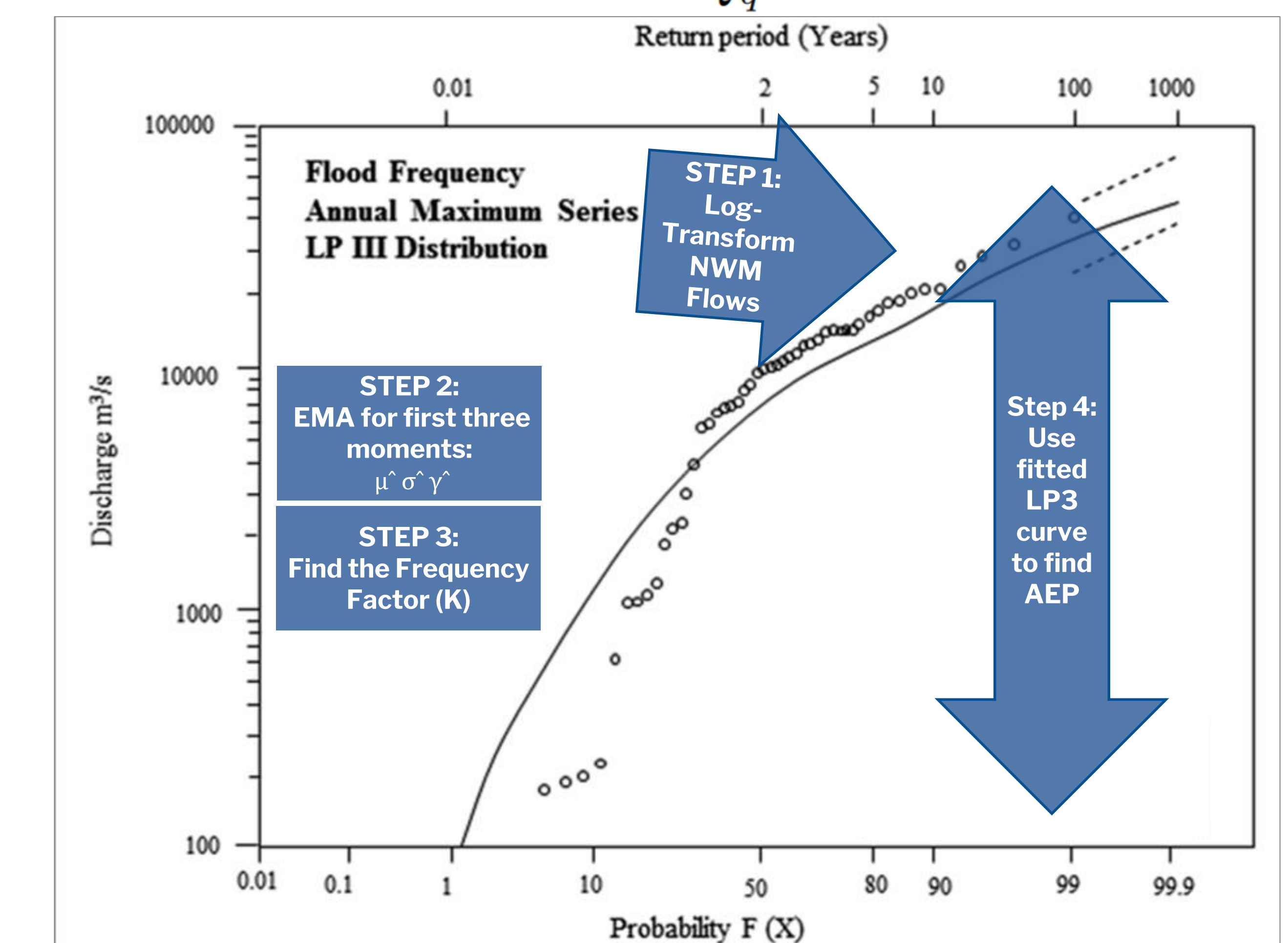


The National Water Center (NWC) Decision Support Services leverage streamflow AEPs derived from NWM retrospectives to provide flood guidance across the U.S. In the map on the left, forecasted streamflow lines are colored by associated AEPs – with High Water Thresholds using a high AEP based on the simple method, and lower AEPs using guidance from the USGS bulletin 17C. For details, see side panels.

Lower AEPs from USGS Bulletin 17C

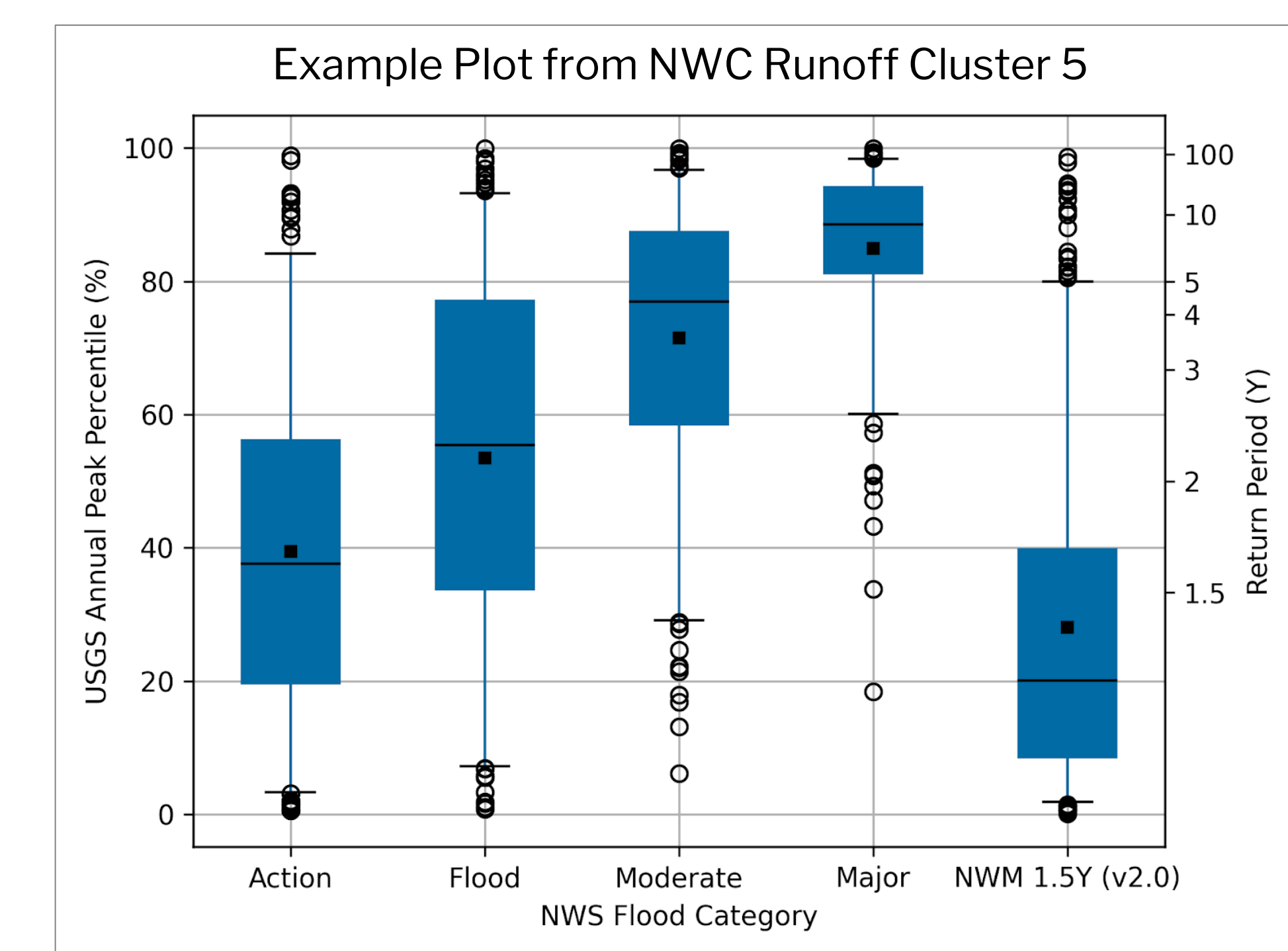
To estimate lower AEPs than possible with the simple method (i.e. 2%, 4%), we conducted a flood frequency analysis with guidance from USGS Bulletin 17C, which uses the log-Pearson Type III (LP3) distribution (England et al., 2019):

- 1 - NWM simulated annual peak flows log-transformed
- 2 - Expected Moments Algorithm (EMA) to estimate the first three moments (mean $\hat{\mu}$, standard dev. $\hat{\sigma}$, and skewness $\hat{\gamma}$)
- 3 - Frequency factor (K): $\hat{X}_p = \hat{\mu} + \hat{\sigma} K_{\hat{\gamma},p}$
- 4 - Solve for final flood quantiles $\hat{Q}_q = 10^{\hat{X}_p}$



Evaluating NWM Flood Statistics

To evaluate AEPs against categorical NWS flood stages (Action, Flood, Moderate, Major), NWS sites were first mapped to USGS sites with stage-discharge to convert NWS values to discharge. Then frequency distributions were calculated for discharges related to NWS categories and corresponding NWM streamflow AEPs.



Evaluation and plot courtesy Jason Regina

Box-and-whisker plot of discharge for NWS flood categories and NWM 66.67% streamflow AEPs (1.5 year return interval) ranked by annual peak flow percentile.



REFERENCES:

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., 2019, Guidelines for determining flood flow frequency — Bulletin 17C (ver. 1.1, May 2019); U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., <https://doi.org/10.3133/tm4B5>.

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