APPENDIX G: Equations for calculating climate threat risk factor values

For each hydrographic area, we applied the following equations using the seven different LOCA models:

\[
FC(j) = (1 - NORM_j) \times \frac{AV Ej \left( \sum_{0<k<n} f(SPEI(i,k)) \right)}{(m \times \text{max}_{spei})}
\]

Eq. G-1

\[NORM_j = \text{normalized variance (VAR) of sums (Sum) for a hydrographic area j based on the observed maximum variance (MAX) =}\]

\[
\frac{VAR(\text{sum}_{1,j}, \text{sum}_{2,j}, ..., \text{sum}_{m,j})}{\text{MAX(VAR}_{j=1}, \text{VAR}_{j=2}, ..., \text{VAR}_{j=y})}
\]

Eq. G-2

\[f(SPEI(i,k)) = \text{abs}(SPEI(i,k)) \text{ for year i and LOCA k if SPEI is } \leq -1; \text{ otherwise it is 0}\]

Eq. G-3

Where:

- \(FC(j)\) = climate threat risk factor value in hydrographic area \(j\) that varies from 0 to 1
- \(\text{max}_{spei}\) = maximum absolute value of the observed SPEI
- \(\text{sum}_{k,j}\) = temporal sum of SPEIs \(\leq -1\) from years 2022 to 2060 in hydrographic area \(j\) of LOCA \(k\)
- \(y\) = number of hydrographic areas = 256
- \(m\) = number of years = 38
- \(n\) = number of models = 7

In Equation G-1, the first portion to the left of the multiplication sign accounts for the variability in SPEI between the different LOCA models. We used a normalized variance approach, described mathematically in Equation G-2. The second portion of Equation G-1 estimates the amount of drought conditions in the future and is normalized by dividing the raw estimate for each basin by the maximum observed SPEI. Equation G-3 specifies that SPEI values less than or equal to -1 (i.e., droughty conditions) are included in the calculation. Anything less droughty than -1 standard deviation have a value of 0 for that year and LOCA model in Equation G-3.

After the \(FC(j)\) values had been calculated for all hydrographic areas, they were normalized again by dividing by the largest \(FC(j)\) value. This resulted in the hydrographic area with the largest \(FC(j)\) value (i.e., the hydrographic area with the highest risk) having a value of 1.0, the hydrographic area with the highest variance having a value of 0.0, and all other hydrographic areas having values in between these for the climate threat risk factor.

Example: \(y = 2\) hydrographic areas, \(n = 2\) LOCA models, \(m = 3\) years of SPEI values

For hydrographic area A and two LOCA models 1 and 2 for 3 years of SPEI values

- **LOCA model 1:**
  - SPEI for year 1 = -3, SPEI for year 2 = -1, SPEI for year 3 = -0.5 \(\rightarrow sum_{1,A} = 3 + 1 + 0 = 4\)
- **LOCA model 2:**
  - SPEI for year 1 = -2, SPEI for year 2 = -1.5, SPEI for year 3 = 2 \(\rightarrow sum_{2,A} = 2 + 1.5 + 0 = 3.5\)
  - Average = \((4 + 3.5) / 2 = 3.75\)
  - Variance = VAR(4, 3.5) = 1.125
For hydrographic area B and two LOCA models 1 and 2 for 3 years of SPEI values
- **LOCA model 1:**
  - SPEI for year 1 = 1, SPEI for year 2 = -1, SPEI for year 3 = -0.5 → \( \text{sum}_{1,B} = 0+1+0 = 1 \)
- **LOCA model 2:**
  - SPEI for year 1 = -3, SPEI for year 2 = 2, SPEI for year 3 = 2 → \( \text{sum}_{2,B} = 3+0+0 = 3 \)
- Average = \((1+3)/2 = 2\)
- Variance = \(\text{VAR}(1,3) = 2\)

Climate effect for hydrographic area A =

\[
\text{FC}(A) = \left(1 - \frac{1.125}{\text{MAX}(1.125,2)}\right) \times \frac{3.75}{(3 \times 3)} = 0.18
\]

Climate effect for hydrographic area B =

\[
\text{FC}(B) = \left(1 - \frac{2}{\text{MAX}(1.125,2)}\right) \times \frac{2}{(3 \times 3)} = 0.00
\]

If there were only these two hydrographic areas in Nevada, then the final normalizing process would make \(\text{FC}(A)_{\text{final}} = 1.0\) and \(\text{FC}(B)_{\text{final}} = 0.0\) after dividing both of the above values by 0.18, the largest \(\text{FC}(j)\) value.