Assessing the influence of the Pacific Decadal Oscillation and the Atlantic Multidecadal Oscillation on discharge variability in western North America

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ABSTRACT.

Flood frequency analysis assumes that annual peak flood events occur independently of each other, regardless of previous flood events (the independent and identically distributed (*i.i.d.*) assumption); however, annual peak flood records do not necessarily appear to conform to these assumptions. We tested the *i.i.d* assumption by analyzing the effects of the Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO) on 250 naturally flowing annual peak flood records across the entire western North American margin. Using permutation tests on quantile-quantile (Q-Q) plots, we found that the PDO has a greater impact on the magnitude of annual peak floods than the AMO. Twenty-six percent of the gauges have higher magnitude annual floods depending on the PDO phase ($p < 0.1$). Next, we examined the interacting effects of the PDO and AMO on the frequencies of lower and upper quartile annual peak floods, and found reinforcing, cancelling, and dominating effects. Lastly, we used permutation *t*-tests on the Julian dates of seasonal maximum and minimum streamflows to assess the impact of the PDO and AMO. We found that the PDO and AMO have substantial effects on the dates of winter maximum and summer minimum streamflow dates across the coastal margin. Since these two climate oscillations have significant effects on the magnitudes of annual peak floods, the *i.i.d.* assumption does not hold. Hence, we advocate for the need to re-assess baseline flood analysis in western North America to improve flood management strategies.

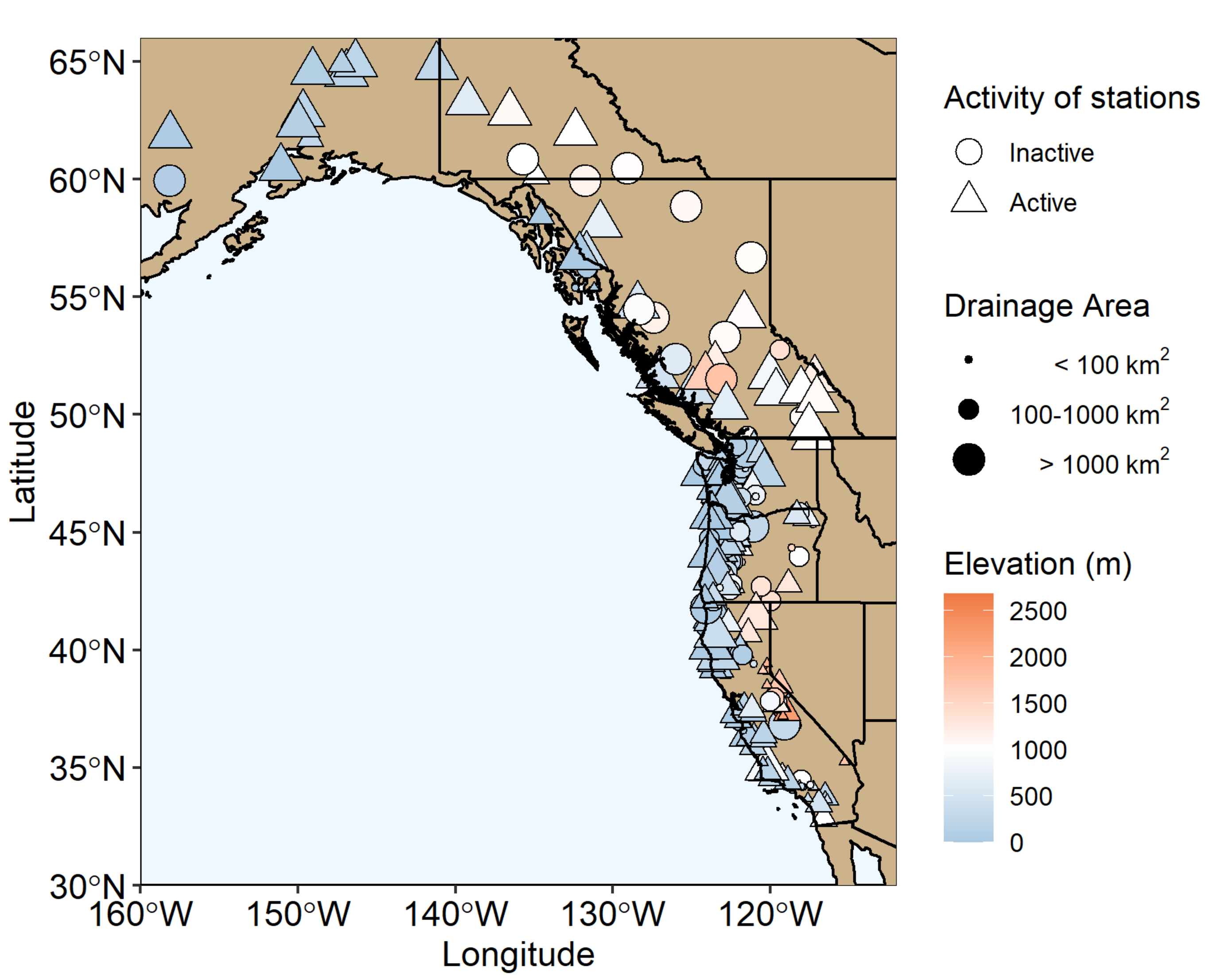

Figure 1. Locations of the 250 naturally flowing streamflow records across the western North American margin.

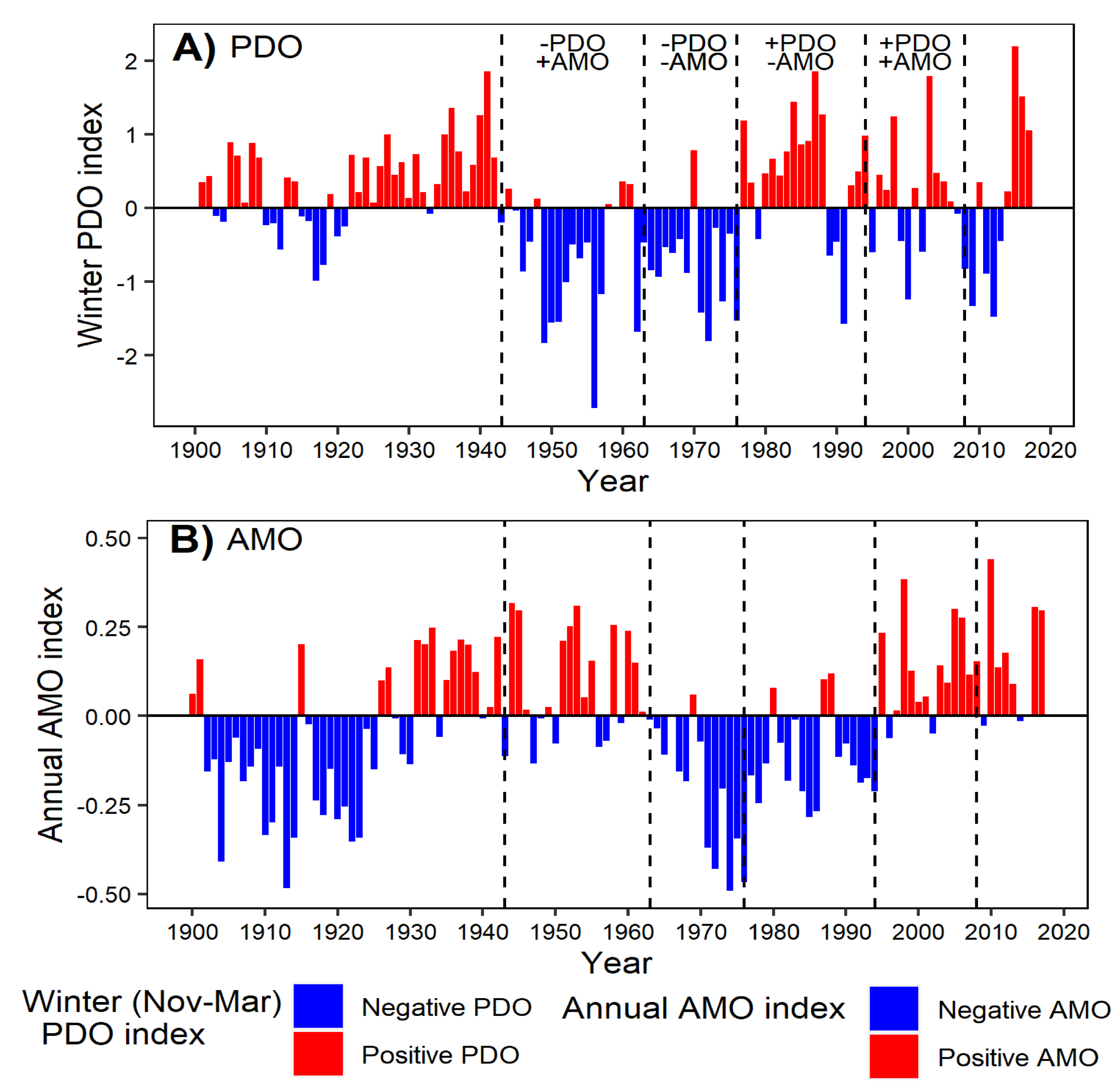

Figure 2. (A) Winter (November-March) averaged PDO and (B) annually (January-December) averaged AMO indices (1900-2017).

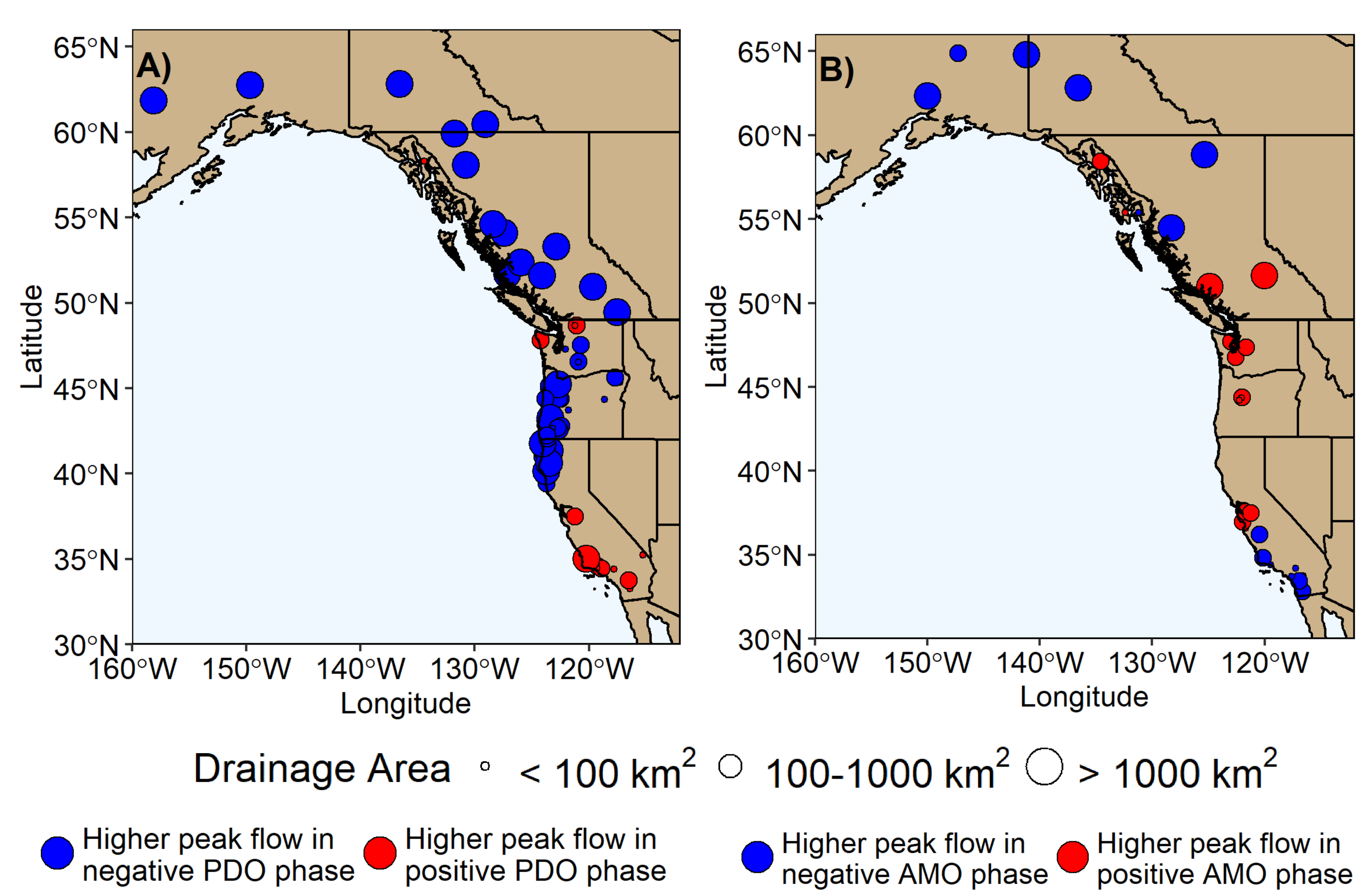

Figure 3. Significant permutation tests on quantile-quantile (Q-Q) plots of the annual peak flood records along the western North American margin stratified according to the A) winter (November-March) averaged PDO phase and B) annually-averaged AMO phase ($p \leq 0.1$).

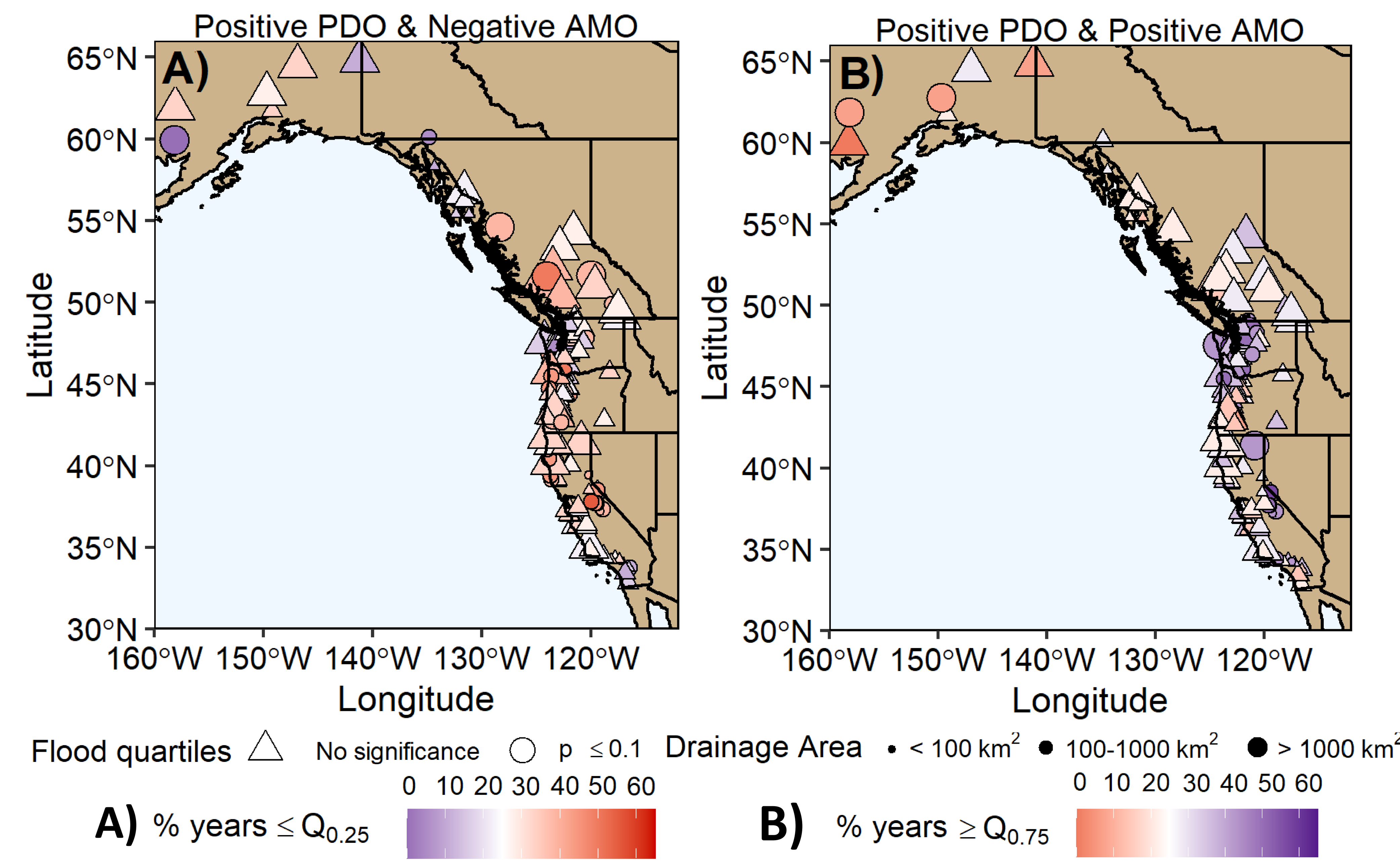

Figure 4. Percentages of lower and upper quartile floods for the PDO and AMO combinations for the western North American margin: A) lower quartile floods in the positive PDO and negative AMO, 1977-1994; and B) upper quartile floods in the positive PDO and positive AMO, 1995-2008.

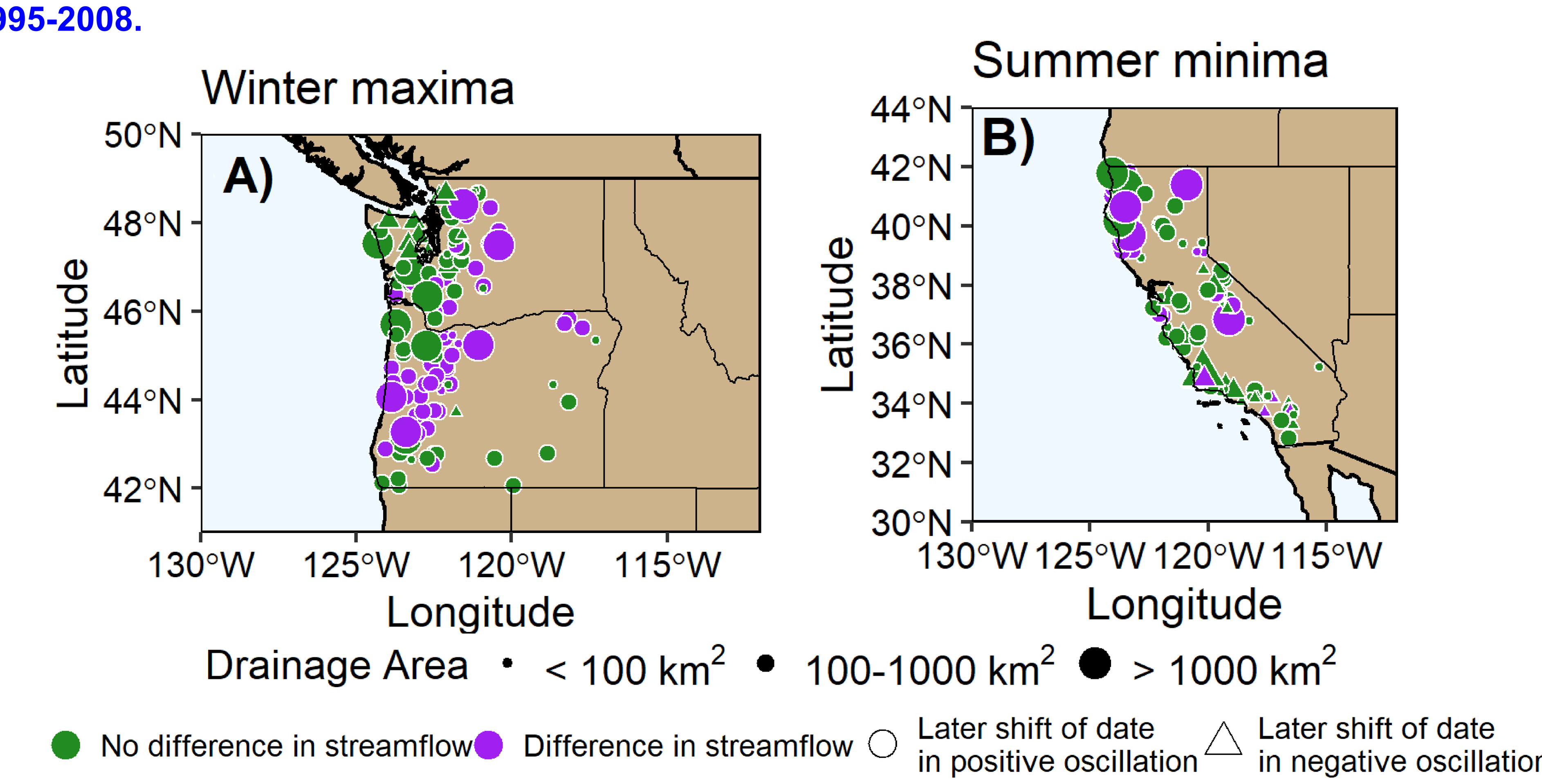

Figure 5. Differences in the Julian dates of the seasonal streamflow extremes according to the A) PDO and B) AMO phases along the western North American margin for: A) winter maxima, and B) summer minima ($p \leq 0.1$).

CONCLUSIONS.

- **PDO** and **AMO** influence **flood patterns** along the western North American margin.
- **Higher drought risk** during the **combined positive PDO** and **negative AMO** phases in **California**.
- **Higher flood risk** during the **combined positive PDO** and **positive AMO** phases in the **Pacific Northwest**.

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