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Improved early season seasonal streamflow volume prediction models considering equatorial sea surface temperature gradients: Trans-Niño Index

A.M. Kennedy (1), D.C. Garen (2), R.W. Koch (1)

(1) Environmental Sciences and Resources Program, Portland State University, Portland, Oregon, USA (kenna@pdx.edu, kochr@pdx.edu), (2) USDA Natural Resources Conservation Service, Portland, Oregon, USA (david.garen@por.usda.gov)

This research investigates large-scale climate signals affecting inter-annual hydrologic variability of streams flowing into Upper Klamath Lake, Oregon, USA. Upper Klamath Lake is an arid, mountainous basin located in the rain shadow east of the crest of the Cascade Mountains in the northwestern United States. It is an important reservoir serving the 971 km^2 Klamath Irrigation Project, established in 1906 by the US Bureau of Reclamation. Upper Klamath Lake has two major tributaries that merge shortly before their entry into the Lake, the Williamson River and the Sprague River. These have no dams or other major hydrologic alterations and serve as the major input into Upper Klamath Lake.

Developing accurate early season streamflow prediction models for these tributaries is difficult because the basin has a high degree of topographic, geologic, and climatologic variability. In an effort to reduce early season streamflow forecast uncertainty, six large-scale climate indices - the Pacific North American Pattern, Southern Oscillation Index, Pacific Decadal Oscillation (PDO), Multivariate El Niño Southern Oscillation Index, Niño 3.4, and a revised Trans-Niño Index (TNI) - were evaluated independently for their ability to explain inter-annual variation of the main hydrologic inputs into Upper Klamath Lake.

The TNI, which characterizes the equatorial sea surface temperature gradient between region Niño 1+2 and region Niño 4, was the only index to show significant correlations during the current warm phase of the PDO. During the warm PDO phase (1978-present), the averaged October through December TNI was strongly correlated (α =

0.05) with the subsequent April through September Williamson River discharge (r = 0.73), Sprague River discharge (r = 0.65), net inflow to Upper Klamath Lake (r = 0.68), and moderately correlated with observed Crater Lake 1 Aprilsnow water equivalent (SWE). Incorporating the TNI variable into optimized statistical streamflow prediction models reduces the uncertainty (as measured by the standard error) of forecasts issued on the first of January and February by 19% and 17%, respectively, for the Williamson River and by 24% and 15%, respectively, for the Sprague River.

These results suggest that warm PDO phase equatorial sea surface temperature gradients, as opposed to mean sea surface temperature or sea-level pressure patterns, explain a significant portion of hydrologic variability observed in the streams flowing into Upper Klamath Lake and are useful in real-time hydrologic applications. Furthermore, additional analysis indicates regional-scale correlations that may extend the usefulness of the TNI outside of the Upper Klamath basin. Thus, the TNI may prove useful for long-lead streamflow forecast operations, ecosystem scale modeling, and a variety of other environmental science applications.