

Effects of climate change on evapotranspiration and ephemeral channel networks in California

James W. Kirchner, Department of Earth and Planetary Science, UC Berkeley

Evapotranspiration exerts dominant control on low-flow hydrology in California's Mediterranean climate regime. Accurately predicting the future effects of climate change requires an understanding of how evapotranspiration rates will respond to changes in atmospheric forcing and to longer-term shifts in vegetation patterns. Uncertainty over future evapotranspiration rates is arguably one of the biggest obstacles to accurately projecting California's water supply situation in 2030 and beyond.

The lack of direct measurements at appropriate scales has impeded efforts to understand evapotranspiration (ET) processes. Rates of potential ET can be estimated from conventional weather data using a variety of methods, such as the Penman-Monteith equation, but these estimates are usually only applicable to uniform fields of well-watered crops. Rates of actual ET can be measured for individual trees using sapflow sensors, or for small patches of homogeneous vegetation using eddy-flux methods, but it is difficult to extrapolate these small-scale measurements to the whole landscape.

This CAL2030 pilot project is based on a recent proof-of-concept study showing that landscape-scale evapotranspiration rates may be measurable from detailed analyses of streamflow dynamics, by directly exploiting streams as indicators of whole-landscape processes. This work has grown out of a longstanding collaboration with the U.K.'s Centre for Ecology and Hydrology and their Plynlimon experimental watersheds in Wales, and has shown that fluctuations in streamflow can be used to quantitatively infer patterns of evapotranspiration rates through time.

If this same approach can be demonstrated to work in the Mediterranean climate of California, it would provide an important new tool for assessing how evapotranspiration (ET) rates respond to variations in weather patterns and landscape characteristics. Reliable streamflow data are much more widely available than reliable evapotranspiration estimates, so this approach has the potential to significantly expand the scope of locations where evapotranspiration patterns can be studied.

Our project will test the approach developed in Wales, using data from four California research watersheds (two in the California Coast Range, and two more in the Sierra Nevada). Because evapotranspiration is a larger fraction of the water balance at these sites than it is in the Welsh watersheds analyzed so far, the California sites represent a critical test of the method and its applicability to Mediterranean systems.

Expected outcomes:

The expected product of this work will be a scientific paper examining temporal dynamics in evapotranspiration from a whole-watershed perspective. More broadly, it is hoped that this project will lead to further proposals and projects that assess how differences in climatic conditions and vegetation patterns affect evapotranspiration rates and the low-flow hydrology of California streams. These studies will provide important information for developing better models of California's watersheds and for predicting their likely responses to climate change. In this way they will contribute to the objectives of the BWC's CAL2030 research thrust area.