Poster #21-39

Phenological Responses to Earlier Snowmelt and Potential Impacts on Evapotranspiration in a Colorado River Headwater Basin

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BER Program: SBR
Project: Berkeley Lab Watershed Function SFA
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Plant emergence, growth, and flowering phenology in mountain meadows are driven by either snowmelt timing (i.e. sites reach 0% snow water equivalents, SWE), temperature, photoperiod, or combinations of these. In mountain watersheds, meadows cover vast areas, especially at higher elevations. The East River, a headwater basin of the Colorado River, is experiencing increased spring air temperatures (mean daily +1.4°C/decade at SNOTEL #380, 1987-2018) and a greater frequency of dust deposition on the snowpack. Snowpack is also decreasing across Colorado and many mountain regions of the Western US. As a result, snowmelt is earlier with consequences for plant phenology that may alter water fluxes and element retention. We expect that early snowmelt in combination with warmer spring temperatures will lead to earlier greening at all elevations with a greater shift for higher than lower elevation regions of the mountain watershed. We have developed an approach to relate phenology to soil water content to determine potential impacts of early plant growth on evapotranspiration.

Climate years 2017 and 2018 were warm years in the mountains of Colorado. Air temperatures were greater than historical mean temperature and on some days exceeded historical maximum temperatures. Snowmelt was earlier in 2018 compared to 2017 due to substantially less snow. Across an elevation gradient (2774-3597 m) within the watershed, we observed snowfree conditions 21-49 days earlier due to this interannual variation, and in 2018 further advanced snowmelt by 10 days experimentally. In warm years, earlier snowmelt leads to earlier greening and increasing synchronization of plant growth and flowering across elevation from montane to alpine life zones. The advance in greening was far greater for the upper elevation sites 3475 m and higher, resulting in greater synchronization than expected based on years of working in mountain systems. When the window of time over which elevations reach 0% SWE shrinks, water inputs to soil, plants and rivers do not extend over time. Asynchronous snowmelt is critical to sustain water inputs prior to when seasonal rains begin (typically mid-July). Among the more than 40 species monitored, we observed earlier plant senescence and plants that remained green but for which production was low. A cold year or a cold spring would greatly benefit our understanding of plant phenology and its effect on water supply, yet, the likelihood of this is extremely low.