California-Nevada Climate Applications Program

A NOAA RISA team

EVAPORATIVE DEMAND

FEBRUARY 2022

What is Evaporative Demand?

The water cycle has two main parts. Precipitation adds water to the surface while evapotranspiration (water loss from plants, bare soil, and bodies of water) removes water. Evaporative demand quantifies the potential loss of water from the surface as driven by atmospheric factors including temperature, wind speed, humidity and cloud cover. Periods of high evaporative demand are connected to droughts and increased fire danger [Figure 1].

Connecting Evaporative Demand to Drought and Wildfire Danger

Tracking extended periods with above normal evaporative demand can be a useful way to detect drought onset, drought intensification, and elevated fire danger. Above normal temperatures, clear skies, and wind speed, and below normal humidity all drive evaporative demand up and lead to quicker drying at the surface. Soil moisture is reduced which leads to less water available for plants and vegetation becomes stressed and more flammable. When extended periods of below normal precipitation overlap with extended periods of above normal evaporative demand fuels become critically dry favoring rapidly spreading wildfires [Figure 2].

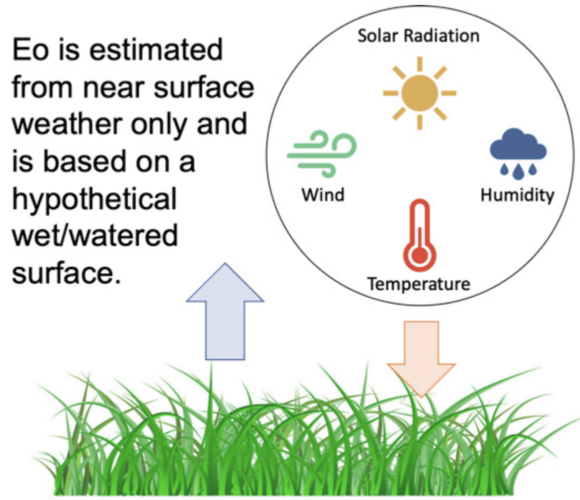

Figure 1. Schematic illustrating the atmospheric drivers of evaporative demand (labeled Eo in the figure) from a well-watered reference surface. Credit: Christine Albano/DRI.

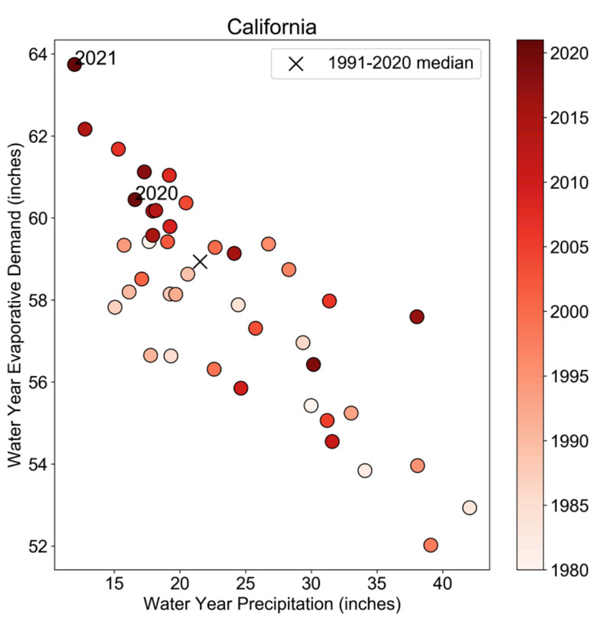

Figure 2. A comparison of water year evaporative demand against water year precipitation for California. 2021 stands out as the year with the highest evaporative demand and lowest precipitation since 1980 with 2020 not far behind on both metrics. These extremes combined over two years have led to critically dry forests in the region. Six out of seven of California's largest wildfires on record occurred in 2020 and 2021. Data: gridMET/ Climate Engine.

TOTAL CHANGE IN WATER YEAR EVAPORATIVE DEMAND 1980–2020

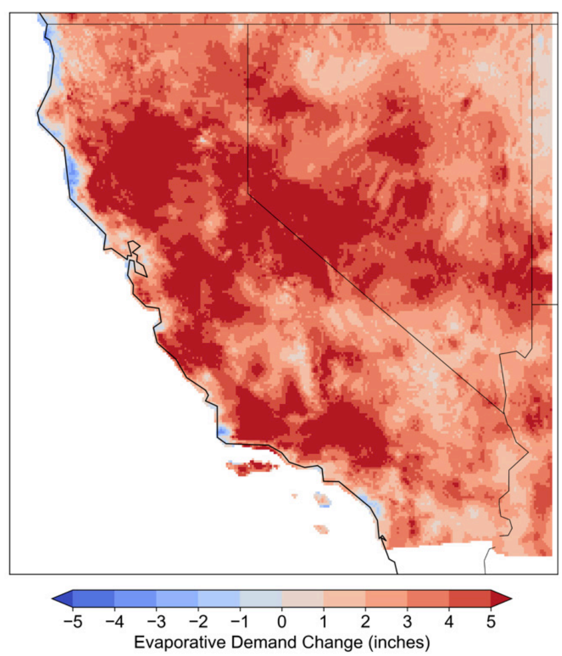

Figure 3. Trend in water year evaporative demand expressed as the total change over the period 1980–2020. Nearly the entire map is red indicating increased evaporative demand over time with large areas in the darkest shading of red where increases have exceeded five inches. Parts of coastal California are shaded blue indicating decreased evaporative demand over time. Data: gridMET/Climate Engine.

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How Has Evaporative Demand Changed Over Time?

A steady overall increase has been observed in water year evaporative demand over nearly the entire region in the past four decades. Increasing temperature is one of the major contributors to the increased evaporative demand but decreasing humidity has also played a role [Figures 3].

Projected Trends in Evaporative Demand

It is well understood that temperatures are expected to continue to rise with climate change in the coming decades and the same is true for evaporative demand. Future changes in evaporative demand are being largely driven by temperature and the magnitude of additional change in the next two decades is similar to what has been observed in the past 40 years [Figure 4].

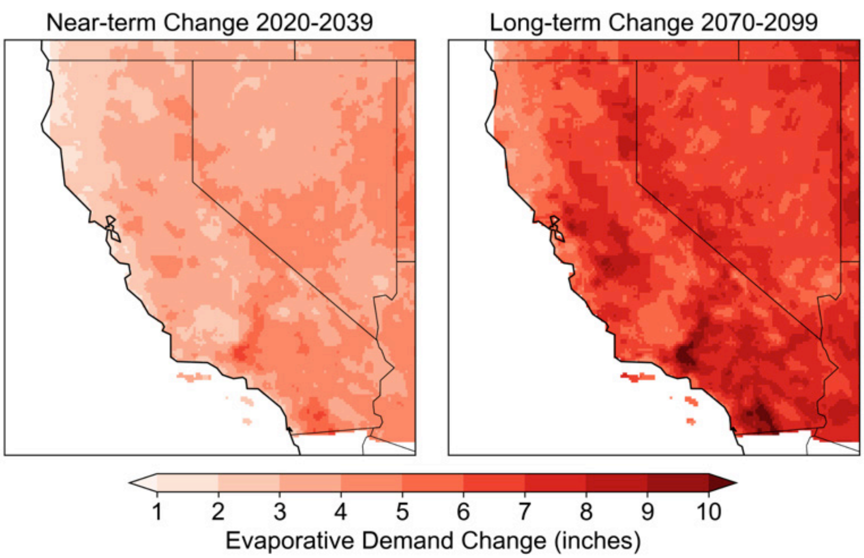

Figure 4. Climate model simulations showing the difference in average annual evaporative demand from the baseline period (1950-2019) average. Increases in evaporative demand are projected across the entire region. Results are based on the lower emissions scenario RCP 4.5. Data from LOCA; analysis from McEvoy et al. (2020).

REGION	HISTORICAL 1950-2019	ENSEMBLE MEDIAN	ENSEMBLE MAXIMUM	ENSEMBLE MINIMUM
NORTHERN SIERRA NEVADA, CA	5	18	26	11
MID-COAST TO MENDOCINO, CA	5	10	20	5
SOUTH COAST, CA	5	19	26	10
HUMBOLDT BASIN, NV	5	18	30	8

Table 1. Average number of days each summer (June-August) with extreme fire danger 2020-2039 in several fire prone regions from an ensemble of seven downscaled global climate models. Extreme fire danger is based on the 2-week Evaporative Demand Drought Index. Data from LOCA; analysis from McEvoy et al. (2020).

More Extreme Fire Danger Days in the Future with a Thirstier Atmosphere

One application of evaporative demand is using a standardized index approach to monitor fire danger. During the past several years a number of large and destructive wildfires have occurred in the region under extreme Evaporative Demand Drought Index (EDDI) conditions. Excessive accumulations of evaporative demand lead to high EDDI values and reflect elevated fire weather. The California fires of 2021 are no exception. The Dixie fire and the Caldor fire, both located in the northern Sierra Nevada, ignited under extreme EDDI conditions that persisted during rapid spread and growth of the fires. Future projections indicate the average number of summer extreme fire danger days are expected to more than double over the next twenty years [Figure 5/Table 1].

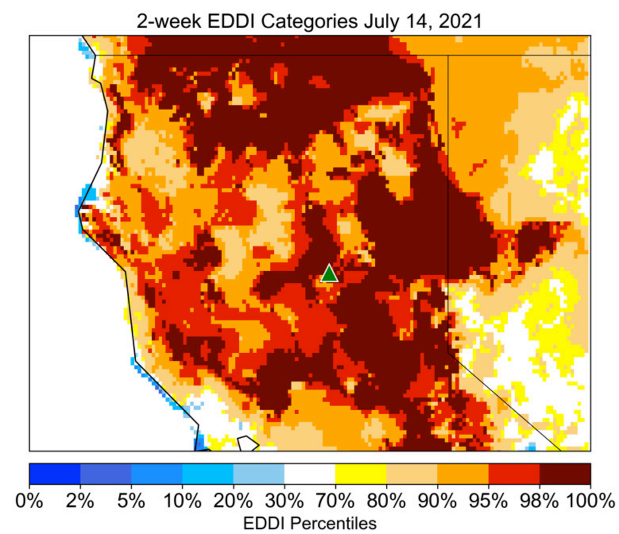

Figure 5. Map of the 2-week Evaporative Demand Drought Index on July 14, 2021. This accounts for the total evaporative demand during the first two weeks of July. Values of 95th percentile or greater (all areas shaded in reds) are considered extreme. The Dixie fire (ignition point indicated by green triangle), California's second largest wildfire ever, began in mid-July in an area with extreme 2-week EDDI values. Data: gridMET/Climate Engine.

LINKS TO REFERENCES/RESOURCES

- **Drought and Water Crisis Chapter on Evapotranspiration, Evaporative Demand, and Drought**
- **Evaporative Demand Drought Index website**
- **McEvoy et al. 2020: Projected Changes in Reference Evapotranspiration in California and Nevada: Implications for Drought and Wildland Fire Danger**
- **LOCA homepage**
- **Tools to access and visualize evaporative demand and EDDI data: Climate Engine and Climate Toolbox**