FOCUS AREA

EVALUATING DROUGHT IMPACTS AND HOW THEY ARE CHANGING

Dry periods develop into drought because the lack of precipitation has negative impacts on hydrology, ecosystems, and agriculture, which cascade through water dependent socio-economic systems (e.g., Wilhite & Glantz, 1985). The primary purpose of monitoring and assessing drought and its impacts is to reduce damage and identify and improve proactive drought resilience measures. This cannot be done without documenting how drought impacts social-ecological systems. Therefore, even without the considerations of non-stationarity, connecting drought indicators with drought impacts drives drought response. In a non-stationary climate, the characteristics of past droughts may not replicate or be good reference for future drought impacts, or the cumulative or composite outcome and cascading effects (e.g., drought and wildfire). Past drought response strategies and frameworks may be ill suited to address future droughts. Thus, non-stationarity creates increasing urgency to capture changing drought impacts across all types of droughts, sectors and communities. Understanding impacts includes the need to understand how human behavior can mitigate or exacerbate how impacts are felt as well.

At present, drought impacts on the agricultural sector are better quantified than for other economic sectors. Two areas where drought impacts are poorly documented are in socio-economic systems and ecosystems. Understanding and quantifying the full extent of drought impacts consistently is even more complex when considering cascading impacts (e.g., drought, wildfire, human health) and trying to tie an economic loss to a hazard like drought.

Improved understanding of drought impacts can come both from improved observations and documentation of impacts and from improved modeling of impacts within weather and climate models. Crop production and loss models and economic impact models can provide some indication of drought impacts. Accurate representation of the variation in vegetative responses within global climate models can also provide insights to how drought impacts might change in a non-stationary climate.

Priority Actions:

1. Investigate how well drought metrics relate to drought impacts for precipitation and temperature extremes and anomalies.
2. Further investigate the impacts of increased development (urban and rural) on water availability and drought indicators. For example, investigating the impacts of social-ecological systems (agriculture and community growth) on drought indicators.
3. Synthesize research on seasonality and changes around seasonality of drought and drought impacts on sectors beyond agriculture (e.g., tourism and recreation, public health). Identify and communicate which sectors (if any) might benefit from drought and which face additional challenges and any knowledge gaps that need to be addressed.
4. Collect systematic sectoral drought impacts for robust analysis, with use of emerging technologies such as artificial intelligence and upgrading existing condition monitoring systems.
5. Conduct research using compound event methods to examine amplified impacts of drought (e.g., drought and land subsidence due to groundwater depletion, river system declines and water quality issues, infrastructure failure due to low flows/low reservoir levels).
6. Investigate the cascading socio-economic impacts of drought and aridification across economic sectors and communities to address water access, equity and environmental justice issues, posed by drought and water scarcity.
7. Evaluate and explore other indicators (e.g., snowpack, groundwater, soil moisture, evapotranspiration, wind, vegetation) as they relate to national and regional-scale drought impacts. This could include the integration of various indicators to look at the intersection of drought and wildfire (e.g., fuel load, fuel moisture) and wildlife species data to improve our understanding of ecological drought impacts and their timescales.
8. Continue to develop and strengthen regional partnerships to improve drought impact information exchange between scientists, practitioners, and stakeholders.

9. Improve representation of vegetation response and feedback (e.g., transpiration) in weather and climate models at a finer scale. This can be done using machine learning techniques and by improving model physics, parameterizations, spatial resolution, and computing resources to better represent vegetative processes.

Research Questions:

1. What is the relationship between assessed drought conditions, antecedent conditions, and drought impacts? Can these criteria be adjusted to account for a changing climate given impacts are not stationary either due to changes in land management, resilience to extremes, technological changes, or changes in the relationship of climatic factors (e.g., relationship between temperature and rainfall impact).
2. How does the choice of reference period change the relationship between drought index and impact?
3. How does changing precipitation seasonality relate to seasonally-varying sectoral impacts? Can current decision calendars work with different sectors and communities to help define when precipitation is needed or expected and if and how the calendar is shifting?
4. What are the cascading impacts of drought across different sectors, and how are these changing over time? How could this information be incorporated into assessments to make them more actionable?
5. What insights are drawn from comparative analysis of impacts of historic, present-day, and future drought? How can those insights improve drought resilience and adaptation strategies?
6. Why do climate models predict dramatically different future trends in drought indicators (e.g., PDSI, SPEI) compared to drought impacts (e.g., soil moisture, runoff, vegetation) (Scheff et al., 2021 and 2022)?
7. How can land surface models be improved, with a focus on vegetation type, vegetation-land-atmospheric feedbacks, and soil layers, to better represent appropriate processes involved with non-stationarity?
8. How can models better represent vegetative processes to reflect vegetation contributions (e.g., transpiration, stomatal control, root depths, spatial and species heterogeneity, composition) to the hydrologic cycle during drought, including in future climate scenarios?
9. How can dynamic vegetation models be improved to include surface conditions (e.g., historical heavy livestock grazing pressures, post-fire effects, urban heat islands), which are valuable to capture post-disturbance behaviors, which change groundwater infiltration and precipitation recycling?
