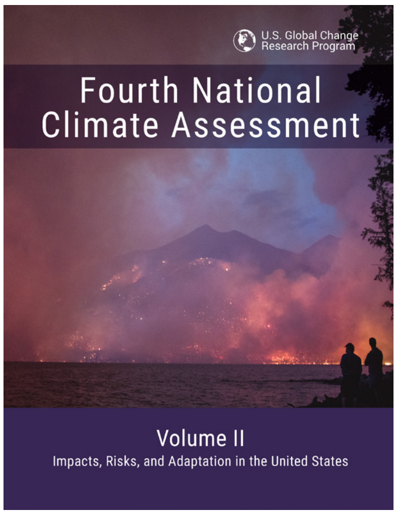
BENCHMARKING OUR UNDERSTANDING AND ASSESSMENT OF DROUGHT IN A CHANGING CLIMATE



Cover of Fourth National Climate Assessment. Source: U.S. Global Change Research Program

Broadly, there is a need to benchmark our current understanding of drought in a changing climate. This would allow for more targeted research to build on the current state of science. It would include defining the drought-to-aridification continuum to help differentiate between drought, multi-decadal drought, and aridification. There are also efforts needed to improve drought assessment at a national level based on current best practices internationally to account for non-stationarity and increase national level coordination. The impacts of non-stationarity are a concern that is much broader than drought, and knowledge exchange across hazards and sectors could accelerate learning within and outside the drought community. To this end, improvements in drought assessment will have co-benefits in situations where drought is linked to other threats and hazards and where there are cascading impacts to communities (e.g., wildfire, debris flows, heatwaves/heat health, water quality). Interdisciplinary collaborations that approach the issue of drought assessment holistically, breaking down silos, will be key.

Priority Actions:

1. A National Academies (or similar) study is needed to benchmark our current understanding of drought in a changing climate. This study could approach the broader topic of drought and climate change. Key components of that study could focus on defining the drought-to-aridification continuum with the goal of developing a conceptual framework that can clearly differentiate between drought, multi-decadal drought, and aridification.
2. Convene an international learning exchange to share drought assessment methodologies that account for non-stationarity and best practices in drought assessment.
3. The National Climate Assessment (NCA) summarizes the impacts of climate change on the United States, now and in the future. Additional review and effort could help ensure that the non-stationary context of drought is treated consistently in the NCA, either with the addition of a chapter or through the regional chapters.
4. Drought is a hazard with economic impacts that match or exceed most other natural hazards. Consider investments that offer comprehensive coordination across federal

agencies to help communities reduce the impacts of drought. This is akin to a National Interagency Fire Center, the coordinating structure of Federal Emergency Management Agency's (FEMA) National Disaster Recovery Framework, or NOAA National Hurricane Center, or amplified messaging akin to National Hurricane Preparedness Month.

Research Questions:

1. What current methodologies used to assess drought at national or continental scales account for non-stationarity and how well do they work? What best practices can be shared to improve assessment globally?
2. How are other hazards addressing non-stationarity in assessments and monitoring impacts? Are there best practices that can be applied to drought assessment?
3. How can collection and understanding of impact data be used to improve drought assessment especially in terms of understanding the contribution of drought to cascading hazards?

HIGHLIGHT: OBSERVATION AND MONITORING

The words observation and monitoring are sometimes used synonymously when applied to drought assessment and diagnosis. However, these two terms have subtle, but meaningful, differences. The word observation often describes the action or process of measuring or recording something to collect data about it, such as a rainfall observation. The word monitoring often describes observing the progress or impacts of the drought over time. These uses are in line with the Merriam-Webster definition for observation: “an act of recognizing and noting a fact or occurrence often involving measurement with instruments”, and for monitor: “to watch, keep track of, or check usually for a special purpose”. For drought, we observe and monitor the environment and the impacts of drought.

Environmental observations can be derived from many sources. *In situ* measurements are gleaned from observation networks such as:

- State mesonets
- U.S. Geological Survey (USGS) Groundwater and Streamflow Information Program (GWSIP)
- Natural Resources Conservation Service (NRCS) Snow Survey (SNOTEL)
- Remote Automatic Weather Station (RAWS) networks
- Climate Reference Network (USCRN)

Observations are also collected through citizen science efforts, like:

- NOAA’s Cooperative Observer Program (COOP)
- Community Collaborative Rain, Hail and Snow Network (CoCoRHaS)
- Local Environmental Observer Network (LEO)

Remotely sensed data are taken from radar and satellite products. A few of these include:

- Moderate Resolution Imaging Spectroradiometer (MODIS), Gravity Recovery and Climate Experiment (GRACE), Integrated Multi-satellitE Retrievals for GPM (IMERG), and Soil Moisture Active Passive (SMAP) from NASA
- Normalized Difference Vegetation Index (NDVI) and the Evaporative Stress Index (ESI) from the Geostationary Operational Environmental Satellite (GOES) ET and Drought (GET-D) product system from the NOAA National Environmental Satellite Data and Information Service (NESDIS) Center for Satellite Applications and Research (STAR)
- Crop Condition and Soil Moisture Analytics Tool (Crop-CASMA) from USDA
- Products from various other data providers.

Satellite and radar observations are also used to support modeled analyses, such as from NASA Short-term Prediction and Transition Center – Land Information System (SPoRT-LIS), which assimilates these remotely sensed data to produce soil moisture analysis.

In addition to measuring environmental changes, these data (*in situ* and remote-sensed) can support the inference of drought impacts. Satellite products can remotely observe vegetation

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health, which can indicate drought stress. Hydrologic measurements can indicate available soil moisture and reservoir storage which can also imply drought stress when these are low. Some of these inferences can be verified using volunteer impact reports such as from the Condition Monitoring Observer Reports (CMOR) system, as well as some of the previously mentioned citizen science programs. These conditions reports provide valuable intelligence on drought impacts and local conditions as a drought develops, worsens, or improves.

Despite the wealth of observation and monitoring, wide gaps remain. Spatial and temporal gaps exist in all surface observation networks. Satellite-derived data can have coarse spatial resolution, data latency, or verification/ground truthing challenges. Impact reports rely on willing volunteers to submit their reports, and many socioeconomic impacts are not reported.

CoCoRaHS rain gauge before a storm. Photo by Henry Reges/CoCoRaHS HQ

A mesonet station from the Montana Mesonet on the Confederated Salish and Kootenai Tribes Bison Range. Photo by Britt Parker