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Editorial: Advances in drought analytical tools for better understanding of current and future climate change

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Editorial on the Research Topic
Advances in drought analytical tools for better understanding of current and future climate change

When considering the effects on the economy, society, and environment, drought ranks near the top of the hydroclimatic hazards. Many social, economic, and ecological systems are negatively impacted by droughts, including water quality and supply, crop yield, biodiversity, aquatic, and riparian habitat quality, urban and industrial water supply, and hydropower generation. Accelerating urbanization and a warming planet only compound these impacts. As such, there is a growing need to enhance current knowledge of drought and develop more precise and timely forecasts of this phenomenon. Recently, more precise drought monitoring and analysis at various spatial and temporal scales have been made possible by high-resolution meteorological and satellite data and high-performance computing resources.

This Research Topic focuses on recent developments in understanding drought processes from local to global scales, and how these advances can improve current plans and strategies for reducing drought risks. Recent examples observed in different environments are introduced in this Research Topic, particularly in North America, Asia, and Africa, demonstrating the need for societal-level resilience initiatives to enhance drought preparedness and to accommodate the negative impacts of drought on natural systems and socioeconomic sectors. It is emphasized that strengthening resilience to drought risks is not an easy task; it calls for the confluence of many different drivers and processes. Also, different types of drought (e.g., meteorological, agricultural, hydrological, and socioeconomic), varying metrics, different assumptions, and interactions between natural and anthropogenic factors add to the complexity of drought resilience. It is noted that while drought is a global phenomenon, exacerbated by human-caused climate change due to increases in evapotranspiration and temperature, it is crucial to quantify drought risks on detailed spatial scales.

In ten articles with contributions from 45 authors, this Research Topic features novel and cutting-edge methods for describing, attributing, and forecasting drought events in the context of both current and future climate conditions, together with related challenges and opportunities. In their global assessment of drought variability, Fuentes et al. employed a variety of drought, vegetation, and runoff indices to quantify the duration, severity, and intensity of drought across a wide range of Köppen climate types. They found that drought has a more immediate effect on water runoff and streamflow than on plant life. However, the duration and intensity of this response vary across large regions and over time. Their research reveals that droughts are getting worse and expanding across southern South America, Australia, and south-western Africa, having remarkable negative effects on vegetation and hydrology. The article by Yu et al. analyzed data from 47 weather stations on the Yunnan-Guizhou Plateau (YGP), China, to determine the spatio-temporal distribution and zonal patterns of drought across the region using the Standardized Precipitation Evapotranspiration Index (SPEI), the Mann-Kendall test, and principal component analysis (PCA). Drought characteristics (e.g., duration, severity, intensity, and frequency) exhibited strong zonal patterns, as indicated by a positive multivariate linear correlation with longitude, latitude, and elevation. Jansen et al. examined the effects of climate change on streamflow and urban water demand in North America and developed an empirical model to estimate municipal water shortage risks and quantify supply and demand forecast risks. Five global climate models were used to simulate 2080–2099 streamflow under two climate scenarios (RCP4. 5 and RCP8.5). The models were validated by comparing their simulations with municipal water consumption data from 47 North American cities. Finally, they identified water-scarce areas. In another paper, Huang et al. developed a Standardized Groundwater Index (SGI) to assess groundwater drought in Xuchang (China) from 1980 to 2018. In this study, Morlet's continuous complex wavelet transform was used to analyze groundwater drought cycles over multiple timescales and across different geographic areas. In the paper of Zheng et al., the role of climatic variables (e.g., precipitation, air temperature, and evaporative demand) in drought occurrence in the Luanhe River Basin (LRB), China, was quantified using deep learning techniques. The interplay between evaporative demand, solar radiation, and wind velocity was largely responsible for drought evolution. Moving to Iran, Band et al. assessed the severity and duration of the drought and investigated changes in the drought into the future in Semnan city. They examined the impact of differentiation operations on improving the static and modeling accuracy of the Standardized Precipitation Index (SPI) time series. The findings point to hybrid differentiation as providing the most reliable indication of stability. Also, Li et al. used the SPI, trend tests, Run Theory, Moran's I, and General G to evaluate meteorological drought in arid and semiarid regions of Northwest China from 1960 to 2018. Global Moran's I (GMI) suggests that drought is more dispersed in winter and more damaging in summer and autumn. Afroz et al. conducted a systematic review to determine the relative importance of compound or concurrent extremes (CEs) hotspots, events, parameters (frequency and severity), large-scale drivers, and impacts (e.g., on yield loss and fire risk). This study summarized three CE analysis frameworks for drought- and heatwave-associated CEs: CE parameters (event-event), driver association (event-driver), and impacts (event-impact). They demonstrate that southern Africa, Australia, South America, and Southeast Asia are the most frequently reported hotspots of these CEs in global studies. Using the global outputs from the Lagrangian FLEXPART model, Stojanovic et al. conducted a case study over Ethiopia, pinpointing the primary sources of annual climatological moisture for 12 river basins. They identified major oceanic moisture sources (e.g., the Mediterranean Sea, Red Sea, and Indian Ocean), in addition to major terrestrial moisture sources (such as the Arabian Peninsula). The northeastern, southwestern, and western basins get the majority of their moisture from the African continent, while the southeastern basins get their water primarily from the Indian Ocean.

Overall, this Research Topic highlights advanced techniques used or developed to improve drought quantification under current and future climate conditions, outlining the main challenges and opportunities through case studies from different regions worldwide. Finally, we thank all authors and reviewers for their contributions to this Research Topic.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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