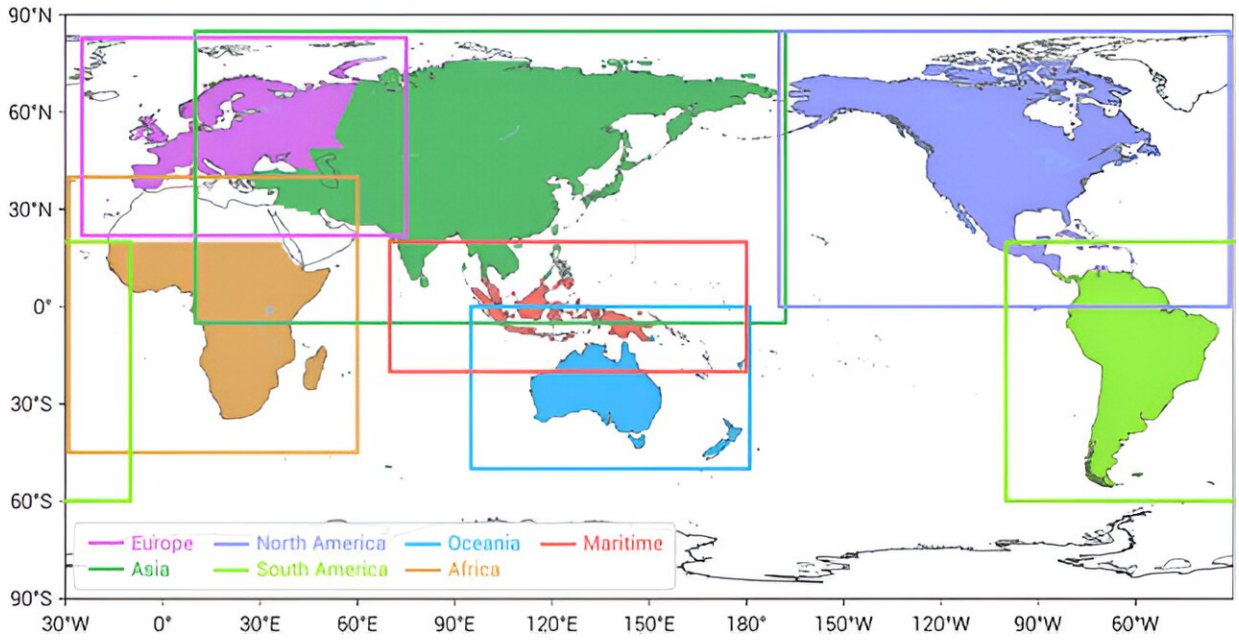
Global droughts found to differ by coastal or inland location, with only 40% accompanied by heat waves

September 12 2023



Regional grouping for event-based drought detection. The colored frames indicate areas where the 3D DBSCAN algorithm is performed, while the colored continental regions are prepared for computing the occupation ratios of continental coverage in subsequent steps (e.g., the Severe event selection using continental coverage–based conditions section). In particular, the Sahara Desert and Arabian Peninsula are not considered when computing the continental coverages under droughts, mainly due to the semiarid climate over subtropical deserts. Credit: *Ocean-Land-Atmosphere Research* (2023). DOI: 10.34133/olar.0016

Can a coastal area have a drought? Yes, but it'll look different than an inland drought, according to new research from team based at Fudan University in China. More surprising than the geographically influenced characteristics of droughts, the researchers said, was the revelation that only 40% of droughts are accompanied by a heat wave.

They published their findings in a two-part paper in *Ocean-Land-Atmosphere Research*.

"Drought is indeed an economically and ecologically disastrous natural hazard, and associated accurate identification methods and associated comprehensive spatiotemporal analysis are necessary for drought monitoring and prediction," said co-author Zhenchen Liu, postdoctoral researcher in Fudan University's Department of Atmospheric and Oceanic Sciences and Institute of Atmospheric Sciences.

"We set out to develop comprehensive knowledge of spatiotemporal characteristics of global-scale meteorological drought events, taking the difference between inland and coastal groups. We also aimed to investigate whether droughts are always concurrent with heat waves, as compound drought and heat wave extremes have recently drawn much attention."

Drought events can spread over space and evolve over time, Liu said, so the researchers developed a workflow based on an algorithm dubbed 3D Density-Based Spatial Clustering of Applications with Noise, or 3D DBSCAN. It's a clustering algorithm, meaning it can identify and group collections of data over a given space in three dimensions—longitude, latitude and time in this case.

The researchers then analyzed global-scale droughts, focusing on the proportion of continental coverage and associated duration to determine whether a drought was an inland or coastal type. They also examined the

symmetry of the drought events. About 92% of inland types and about 70% of coastal types had symmetric development, which the researchers said may help inform understanding of how droughts evolve and abate.

"To our knowledge, the most important novelty of the first part was to group droughts into inland and coastal types," said co-author Wen Zhou, professor of atmospheric sciences at Fudan University. Zhou is also affiliated with the university's Institute of Atmospheric Sciences. "Inspired by the terms 'landfall droughts' and 'Pacific coastal droughts' proposed by previous studies, we realize that some early signals of meteorological droughts—such as long-term precipitation deficits—can appear over adjacent oceans and extend to coastal regions."

"A typical case is the 2014 coastal drought over southeastern Brazil, which was physically influenced by adjacent marine heat waves. Considering the potentially different physical mechanisms associated with droughts over inland and coastal areas, the study groups meteorological drought events into inland and coastal types for further analysis."

In the second paper, the researchers developed a drought classification method based on temperature abnormalities, considering asynchronous and complicated variations in both coverage and intensity. They found that 40% of global-scale meteorological droughts occurred concurrently with hot temperatures, 10% with cold, 30% with normal and 20% with hybrid.

"Although compound drought and heat wave extremes have recently drawn much attention, whether droughts are always concurrent with heat waves remains unknown," Liu said. "Therefore, we systematically proposed and quantified the diversity of temperature anomalies synchronous with droughts. And, in this regard, only 40% of meteorological droughts globally accompany warmer-than-normal

situations."

According to the researchers, how droughts and associated temperature abnormalities start, evolve and terminate need in-depth investigation.

"We introduced methods for identifying critical process evolution-based parameters to help explore the evolution of temperature abnormalities during drought development," Zhou said. "For example, regarding about 80% of those 'hot' droughts, the anomalously increased temperatures followed the drought peak time. The statistical analysis concerning process evolution is a new starting point from which the physical mechanisms behind the temporal lead–lag relationship between drought extremes and temperature extremes can be further investigated."

Next, the researchers said they plan to further investigate the physical mechanisms underlying drought extremes accompanied with different temperature anomalies for both inland and coastal types. They also plan to assess agricultural economic losses caused by drought and compounded by extreme temperatures.

More information: Zhenchen Liu et al, Global Seasonal-Scale Meteorological Droughts. Part I: Detection, Metrics, and Inland/Coastal Types, *Ocean-Land-Atmosphere Research* (2023). DOI: 10.34133/olar.0016

Zhenchen Liu et al, Global Seasonal-Scale Meteorological Droughts. Part II: Temperature Anomaly-Based Classifications, *Ocean-Land-Atmosphere Research* (2023). DOI: 10.34133/olar.0017

Provided by Ocean-Land-Atmosphere Research (OLAR)