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Hate heatwaves? Droughts? How about both at the same time?

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With climate change comes more climatic extremes, and a higher chance of them happening simultaneously. But they are currently being studied in isolation. Together, drought and heatwaves prompted an exceptionally dangerous wildfire season in the Western U.S. in 2020 and 2021. We show that dry-AND-hot extreme events are increasing in intensity, frequency and spatial extent in the U.S.

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Have you noticed a surge in heatwaves in the last decade? Heatwaves are becoming more common and so are their negative effects. So how do we alleviate these negative impacts? Most answers to this question involve using water directly or indirectly. European cities, for example, adopt a variety of water-dependent strategies such as greening streets and roofs to adapt to a warming climate. But what if there is not enough water to support those strategies? What if droughts and heatwaves happen at the same time?

Traditionally, climate extremes like heatwaves and droughts are analyzed in isolation, and adaptation measures are adopted to address each phenomenon separately. However, when multiple extremes happen simultaneously or successively, they can cause larger ecological and societal damages than the sum of damages that each individual extreme would induce. Many extreme events have a complex chain of interdependencies that make their co-occurrence and succession more likely. It is, therefore, imperative to analyze codependent climate extremes together to avoid underestimating their risks.

We analyzed the frequency of dry, hot, and dry-AND-hot extremes across the contiguous U.S. between 1896 and 2017. We used a myriad of statistical tests to determine changes in the precipitation and temperature trends, and how they change together. Further, we used a spatial correlation analysis

method to determine if single climatic extremes are enlarging.

Our results show that while the frequency of dry years have not changed during the 122 years of this study over the contiguous U.S., the frequency of hot years has increased. More importantly, we show that Western U.S. has observed a larger frequency of dry-AND-hot years in the recent decades. For example, 25-year dry-AND-hot extremes – which are expected to happen only once every 25 years – have occurred eight to ten times in the past quarter-century in some regions. Even more worrisome, more intense extremes that are expected only once every 75 years occurred four or five times in the past 25 years. Not only such compound events occurred more frequently, but also dry-AND-hot extremes have notably intensified in the recent decades.

Intensification of dry-AND-hot extremes is partly due to land-atmosphere feedbacks. Dry soils partition a large portion of the incoming solar radiation to sensible heat (what we sense as hot air), and a small portion as latent heat (evaporation). This causes the local air temperature to increase, which in turn enhances local evaporation, causing more drying. This cycle, known as self-intensification, continues until a large-scale weather patterns breaks it.

We also show that the initiating mechanism of this cycle in the US has changed from the lack of precipitation in the 1930s to excess heat in recent decades. This is important because now if we have a year with even slightly below normal precipitation, we might experience a moderate to severe drought due to the increasing evaporation in a warming climate.

Further, we showed that dry-AND-hot extremes impact an increasingly larger spatial area across the contiguous U.S. Spatial correlation analysis shows that dry-AND-hot extremes have expanded in a homogenous, connected pattern, providing evidence for a process known as self-propagation – i.e. dry-AND-hot air move from one region to neighboring downwind areas causing self-intensification of dryness and heat in the new location.

Dry-AND-hot events are the recipe for large wildfires, add wind and a source of ignition, and they secure megafires. The 2020 fires across the western U.S. are examples of how dry-AND-hot extremes can cause major societal and ecological disasters. Drought alongside the hot summer of 2020 and several record-breaking heatwaves collectively dried out the forests in the region. Several storms brought thousands of lightning strikes and wind to fuel many megafires in California, Oregon and Colorado. Other western states were lucky to dodge the bullet this year!

All in all, frequency, intensity and impact area of concurrent dry-AND-hot events increased in the contiguous U.S. and across the world in the past century. A warming climate promotes concurrence of multiple extremes, which turn natural hazards into disasters and squander emergency management and relief resources. The future will bring us more of these disasters, if the current warming trends continue; are we ready? Are we adapting to a warming climate fast enough? Are we taking action to slow climate change?