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Impacts of a severe drought on vegetation and hydrological systems in the Yangtze River Basin, China

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Abstract: Studying the impact of megadroughts is a hot topic across various scientific disciplines, including meteorology, hydrology, ecology, and social sciences (Anderegg et al., 2018; Canarini et al., 2021; Yuan et al., 2023). While many studies have investigated the individual consequences of droughts, most of them have focused on hydrological or ecological aspects without considering human activities that affect the resilience of the system.

In 2022, we received financial support from the Ministry of Science and Technology of China for a key national project on megadroughts. The goal of the project is to develop an early warning system that can improve drought prediction and enhance human resilience to droughts across different regions and basins. The first step is to reconstruct various drought processes, including atmospheric, hydrological, ecological, and agricultural droughts on a large basin scale.

To achieve this goal, we used high-resolution remote sensing and observed soil water, streamflow, and water storage change data, along with hydrological modeling and machine learning, to investigate a severe drought that occurred in the Yangtze River Basin from May to November 2022. We employed two approaches: (1) statistical analysis based on the Run theory for drought propagation from meteorological drought to other droughts that occurred in the ground surface (agricultural and ecological droughts) and subsurface (hydrological drought), and (2) hydrological modeling that considers large-dam regulations to reconstruct drought evolution processes. Our preliminary results show that the propagation time from meteorological to hydrological drought varies from two to seven months, and the propagation pattern shows a clear regional trend from upper reach catchments to lower reach catchments. By using distributed hydrological modeling, we successfully reconstructed drought evolution processes in more than 100 catchments within the Yangtze River Basin, considering both natural conditions and human regulations.

In addition, we employed state-of-the-art machine learning techniques to predict drought (mainly indicated by air temperature and precipitation) in the Yangtze River Basin at seasonal and sub-seasonal scales. Combining all of these approaches, we are making good progress in building an early warning system for severe droughts. More research is necessary to consider various scenarios for smarter decision-making.

REFERENCES

Anderegg, W.R.L., Konings, A.G., Trugman, A.T., Yu, K.L., Bowling, D.R., Gabbitas, R., Karp, D.S., Pacala, S., Sperry, J.S., Sulman, B.N., Zenes, N., 2018. Hydraulic diversity of forests regulates ecosystem resilience during drought. Nature, 561(7724): 538-541.

Canarini, A., Schmidt, H., Fuchslueger, L., Martin, V., Herbold, C.W., Zezula, D., Gundler, P., Hasibeder, R., Jecmenica, M., Bahn, M., Richter, A., 2021. Ecological memory of recurrent drought modifies soil processes via changes in soil microbial community. Nature Communications, 12(1). doi:10.1038/s41467-021-25675-4.

Yuan, X., Wang, Y., Ji, P., Wu, P., Sheffield, J., Otkin, J.A., 2023. A global transition to flash droughts under climate change. Science, 380(6641): 187-191. doi:10.1126/science.abn630.

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