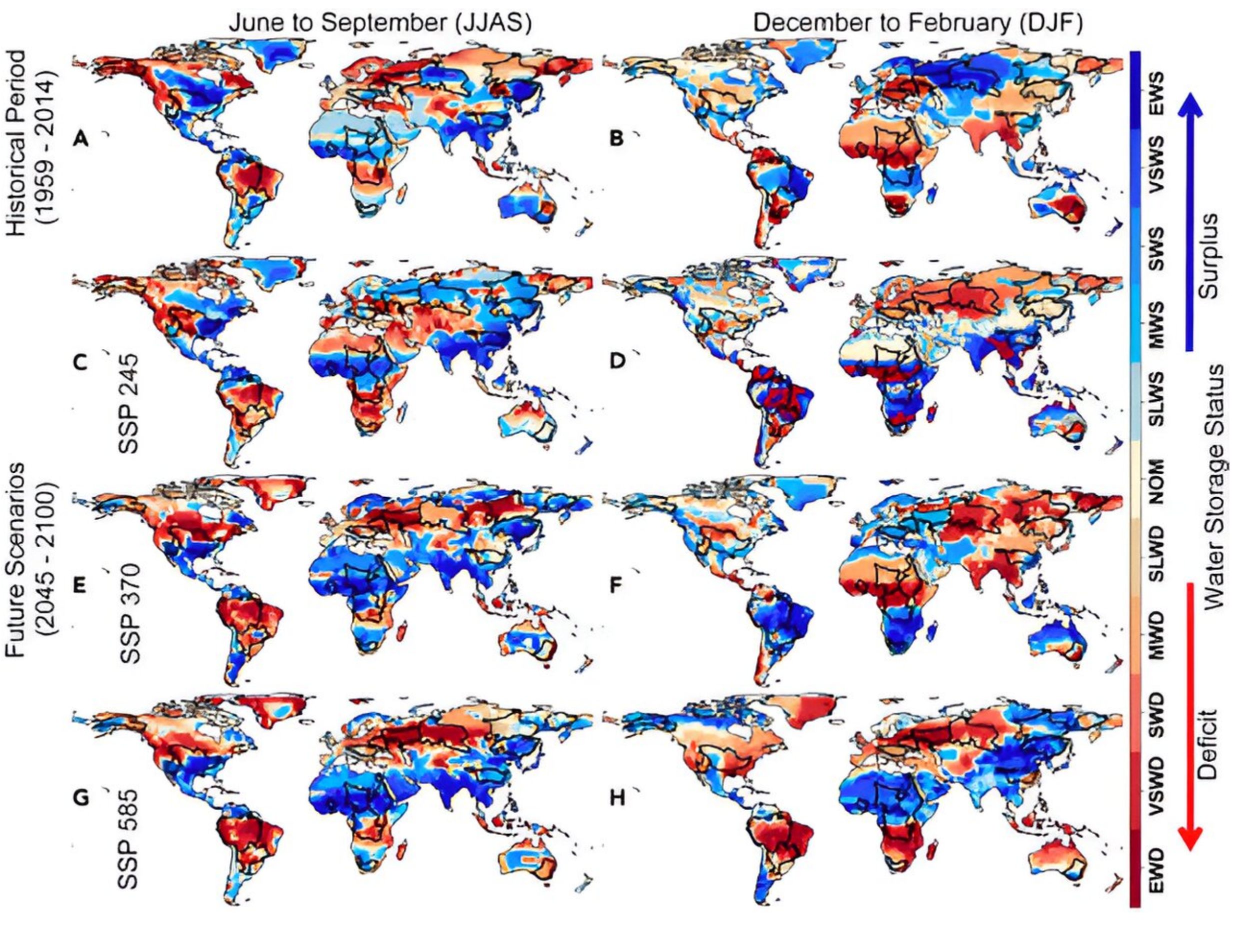
Projections reveal the vulnerability of freshwater to climate change

January 9 2024, by Colin Hutchins



Seasonal WS classifications are based on the self-organizing maps and GMM for (A) the JJAS historical period, (B) the DJF historical period, (C) JJAS future projection under SSP 245, (D) DJF future projection under SSP 245, (E) JJAS future projection under SSP 370, (F) DJF future projection under SSP 370, (G) JJAS future projection under SSP 585, and (H) DJF future projection under SSP585. The black polygons represent the river basins. Credit: *One Earth* (2024).

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Climate and land use changes are causing significant alterations in global terrestrial water storage, impacting extreme weather events such as floods and droughts, a Griffith University-led study has found.

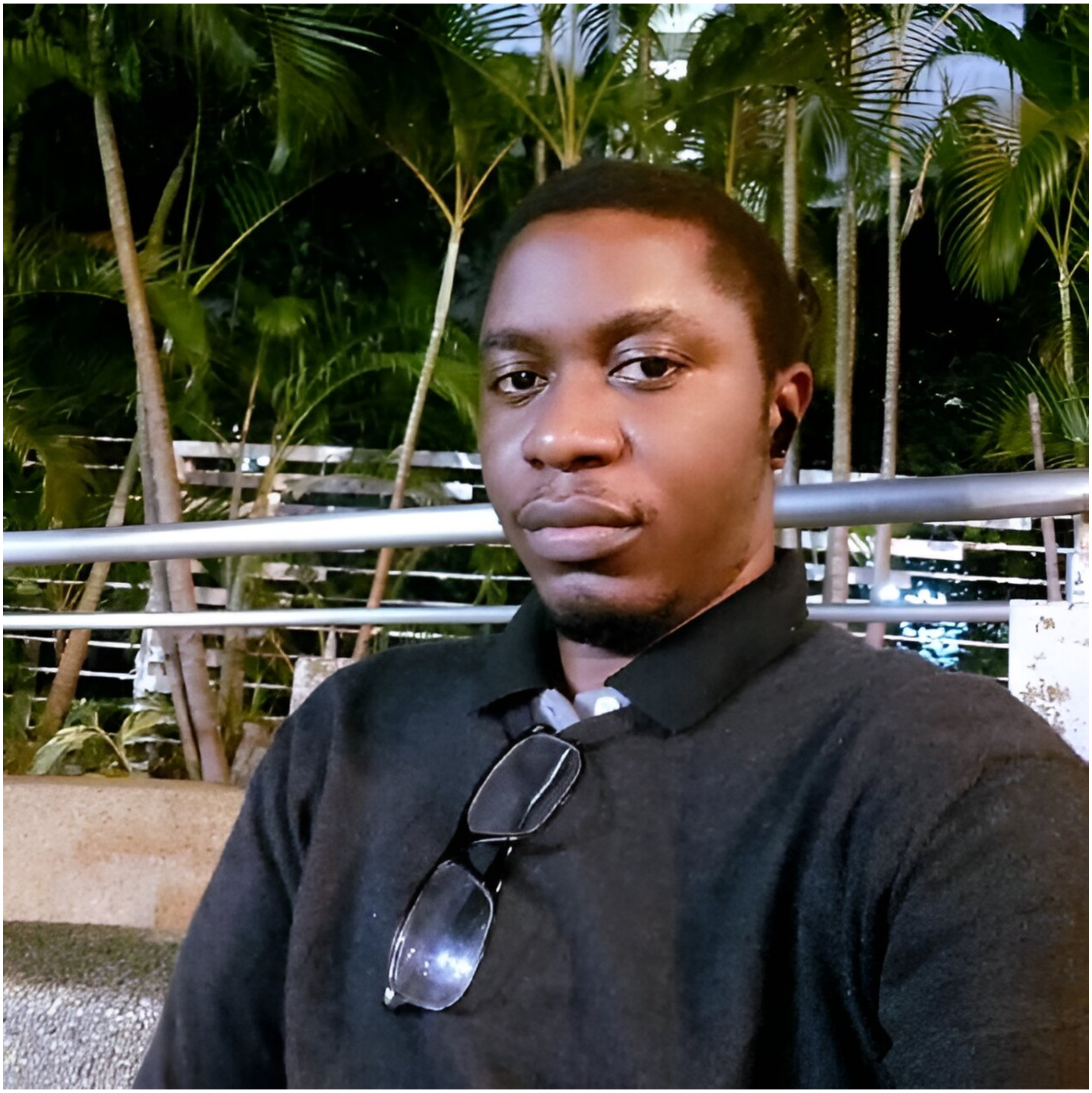
Published in *One Earth*, the study investigated terrestrial water storage and projected future changes under three different future climate change and socio-economic scenarios:

1. a middle-of-the-road scenario with balance economic growth, moderate population and cautious energy use
2. a regional-rivalry scenario with competitive, region-focused societies, high energy use and moderate environmental concerns
3. a fossil-fueled-development scenario with rapid economic growth, a rising global population and a heavy reliance on fossil fuels

"Water from groundwater, rivers and rainfall is undergoing disruption in its natural cycle due to climate and land use changes, which disrupt patterns and amounts of rainfall and affect how water moves across the landscape," said Dr. Adeyeri Oluwafemi, lead author from the Australian Rivers Institute.

"Terrestrial water storage plays a critical role in human well-being affecting water supply sustainability and public welfare.

"Its deficit could lead to severe water shortages, food insecurity, habitat degradation, species extinction, and public tension."



Dr. Adeyeri Oluwafemi, lead author from the Australian Rivers Institute. Credit: Griffith University

However, accessing long-term datasets needed to correctly understand water storage patterns is a challenge due to limited availability, monitoring infrastructure, and financial constraints.

"While direct observations provide a substantial amount of valuable information, the availability of such data is often restricted," Dr. Adeyeri Oluwafemi said.

Climate models have emerged as valuable tools for understanding long-term global-scale water budget in the form of precipitation, evapotranspiration, runoff, and storage changes.

However, Dr. Christopher Ndehedehe, a co-author and an ARC Fellow at the Australian Rivers Institute said, "The limitations in climate models for capturing fine-scale details and microphysical processes due to oversimplification of real-world features magnify their biases and make them unsuitable for the study of impact assessment.

"Correcting these biases and investigating how well they mimic the signs of climate change is crucial.

"There is a critical need to understand projected changes in water storage characteristics by using climate model outputs and remote sensing observations to improve the accuracy of future projections of the amount of available freshwater."

The findings from the study revealed how seasonal changes in climate factors affect water storage.

For example, shifting winds can impact moisture transport, leading to more frequent droughts or heavy rainfall, posing challenges for communities and ecosystems.

Correcting the biases in climate models reduced uncertainties, improving historical and future projections of water storage changes across all seasons.

As climate change modifies the global hydrological cycle, the distribution, amount, seasonal changes, and timing of water storage components such as runoff, precipitation, and evapotranspiration will likely change significantly.

Seasonal changes in winds that move across the earth affect how much moisture is carried from one place to another.

This can lead to areas experiencing more frequent droughts or heavy rainfall, causing problems for both people and the environment.

"In the December–February season, the easterly winds cross northern Australia causing rapid moisture inflow from the western Pacific Ocean," said Dr. Adeyeri Oluwafemi.

"During this time, the atmospheric pressure systems push moisture towards northern Australia, making the Northern Territory wet.

"More importantly, enhanced moisture accelerates the warming of the near-surface waters increasing evaporation which could lead to more water storage surplus.

"This can depend on where the moisture comes from and where it lands.

"For example, under the fossil-fueled-development scenario June–September season, most tropical basins show a northward shift of the water storage surplus.

"Notably, most basins in the Southern Hemisphere will get drier while basins just above the equator will get wetter, confirming the 'dry gets drier and wet gets wetter' paradigm."

These findings offer insight into how ecological and human systems dependent on water storage could be affected.

Water storage changes greatly influence ecological and social structures, including wetland maintenance, groundwater replenishment, lake health, irrigation scheduling, and improved water management in agriculture.

"The projected shortages or surpluses in water storage due to climate and land use change will impact water supply and may enhance or decrease the efficiency of hydrological and agricultural systems," said Dr. Adeyeri Oluwafemi.

"Policymakers need to consider the effects of water storage changes when formulating climate change adaptation or mitigation strategies for different subsystems as well as the potential implementation of sustainable land management approaches that promote ecosystem services and safeguard biodiversity."

More information: Oluwafemi E. Adeyeri et al, Minimizing uncertainties in climate projections and water budget reveals the vulnerability of freshwater to climate change, *One Earth* (2024). DOI: 10.1016/j.oneear.2023.12.013

Provided by Griffith University

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