Global drivers of lake water storage variability during the past 25 years

Fangfang Yao [1], Ben Livneh [1], Balaji Rajagopalan [1]

[1] Cooperative institute for research in environmental sciences, University of Colorado Boulder

Contact: fangfang.yao@colorado.edu

Introduction

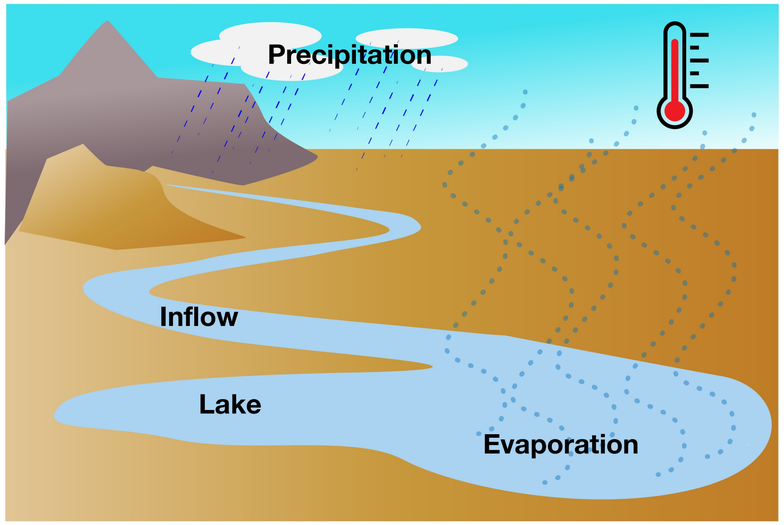
Lakes store the largest amount of Earth's surface freshwater and their water storage is sensitive to both climate and human activity. Yet, the underlying mechanism driving lake water storage variability is poorly understood at the global scale due to the lack of high-quality global databases on lake volume dynamics and natural and anthropogenic forcings. Here, we integrate a newly compiled global lake volume dataset from multi-source satellite observations and recent advancements in global climate and human water use data into a statistical modeling framework to examine the drivers of lake volume variability globally. Using statistical models that incorporate observed changes in lake water storage, simulated/observed climate variables (e.g., precipitation, potential evapotranspiration, runoff, near-surface soil moisture), and simulated human water withdrawal, we attribute the recent lake water storage changes to natural and anthropogenic causes. We also analyze the amount of population affected by lake water loss. These results will advance the understanding of surface water storage dynamics and provide the imperative implications for water resources management.

Data & Method

The key datasets include:

- Lake volume dataset which was constructed using a novel water mapping method (Yao et al. 2019) and radar altimetry
- Hydroclimate datasets from ERA5, MERRA, CRU and others
- Reconstructed human water use data (Huang et al. 2019)
- Hydro Basins (Lehner et al. 2013)

Method

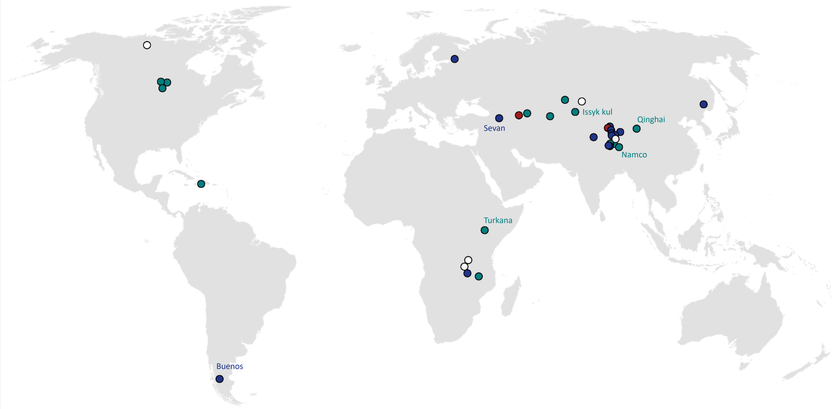


We attributed lake volume variability (V_L) to hydroclimate variables and human water use using a statistical model similar to Zou et al. (2018):

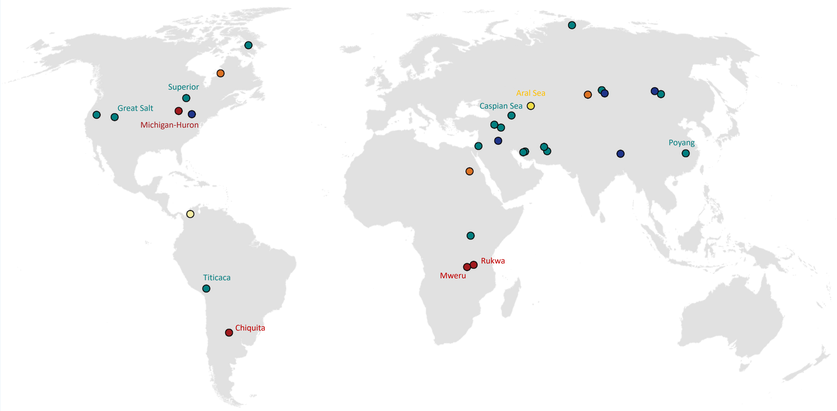
$$\mathrm{VL} = f(Prep, Runoff, Evaporation, Soil\ Moisture)$$

Results

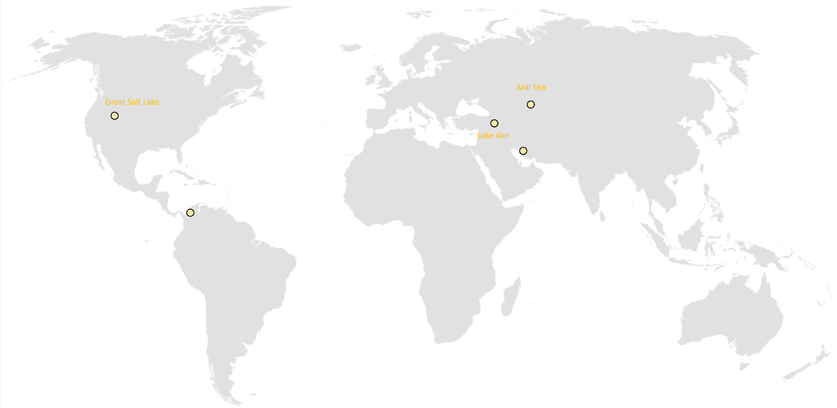
Dominant drivers of lakes with increasing water storage



Dominant drivers of lakes with decreasing water storage

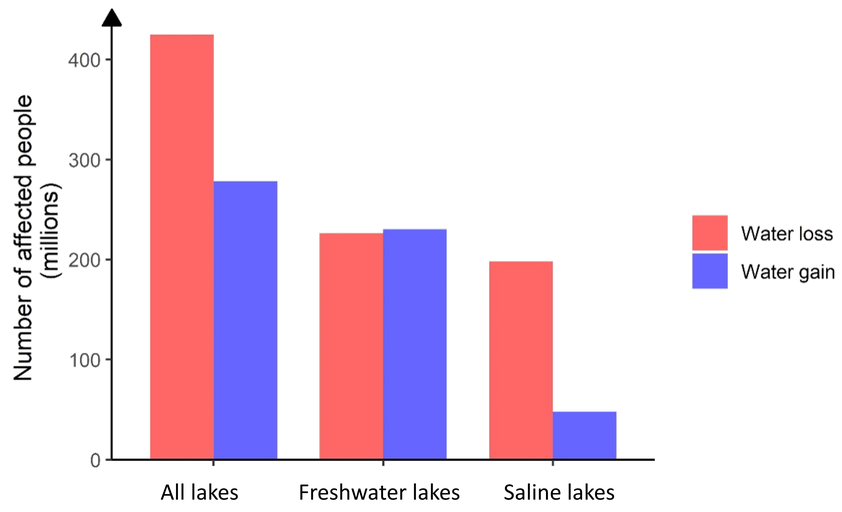


Possible human footprints on lake volume (significant driver)



Note: only lakes with volume changes larger than 0.1 Gt per year are shown for clarity

Results



The drying lakes can potentially affect human beings in a variety of ways including reducing water supply, receding shorelines, deteriorating water quality, degrading aquatic ecosystems, and human health.

A total of 420 millions of people can be potentially affected by lake water loss

Conclusions

- Volume variability in most of natural lakes were primarily attributed to climate (natural) variability. Aral Sea is the only notable exception, which desiccation is mainly due to human water use.
- River discharge seems to have a more predominant role than other hydroclimate variables on regulating lake water storage.
- Human water use compounded a drying climate and accelerated water loss in several large lakes, such as Aral Sea, Great Salt Lake.

References

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