Recent lake water storage changes in global endorheic basins revealed by multiple satellite missions

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Introduction

Endorheic (landlocked) basins are usually located in Earth’s arid/semi-arid regions, where river flow is too limited to erode through topographic barriers. Due to limited precipitation but high potential evapotranspiration, endorheic basins are inherently water-scarce and cover roughly half of the global land areas that are under water stress, erode through topographic barriers. The current water-scarcity situation is likely to be aggravated by both climate change and growing populations. Regional evidence has revealed desiccations of some largest water bodies (e.g., Aral Sea, Lake Urmia, and Great Salt Lake), suggesting a possible net decline in lake water storage in the global endorheic system. Yet, global assessments of recent lake water storage changes across the endorheic regions are rare.

Here, we provide an comprehensive assessment of recent lake water storage changes in global endorheic basins using multiple satellite missions. Climate impacts on endorheic basin lake water storage are also discussed.

Methods

This method leverages a novel water mapping algorithm and satellite-based altimetry to construct monthly storage records for 161 sizable lakes and reservoirs (i.e., larger than 50-100 km²) from 1992 to 2018 across the global endorheic basins.

1. Constructing monthly water area time series by leveraging the entire Landsat archives (including both cloud-free and cloudy images (Yao et al. 2019)

2. Combining the monthly water areas with altimetry-derived water levels to deduce storage changes

- Water levels from three major altimetry Archives
  - Hydroweb (Crétaux et al., 2011)
  - Global Reservoir and Lake Monitor database (G-REALM; Birkett et al., 2011)
  - The Database for Hydrological Time Series of Inland Waters (DAHITI; Schwatke et al., 2015)

- Monthly storage anomalies were calculated as the integrals of the hypsometric curve through monthly water areas

Results

Conclusions

- Lake water storage in global endorheic basins experienced a net decline at a rate of -20.61 ± 2.68 Gt yr⁻¹ during the past three decades.
- The net decline in endorheic basin lake water storage is dominated by water loss in salty lakes. Declined saline lake storage is widespread and found in all major endorheic zones. In contrast, freshwater lakes show a slight increase in volume for most of the major endorheic regions.
- Saline lake storage anomalies is insensitive to inter-annual climate variability, but decidual to multi-decadal climate variability seems to have a stronger impact on saline lake volume. The recovery of desiccated saline lakes is expected to be long given high potential evapotranspiration rates under a warming climate.

Reference


