World's landlocked basins drying

Most of the net water transferred over the past 15 years from non-glaciated land to the oceans has originated from landlocked basins, according to satellite data. This source of sea-level rise is often overlooked.

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Global sea-level rise over the past two decades has been mainly sourced from melting ice sheets and thermal expansion of the ocean. The transfer of water between liquid water storage on the continents and the oceans is a third important source that represents perhaps 10 to 15% of the total contribution to sea-level rise[1]. Until recently, this source has been poorly quantified using hydrologic models or limited ground-based analyses. Nonetheless, remote sensing measurements have facilitated meaningful observations of total water storage trends on continents, and led to better constraints on the global sea-level budget[2]. Writing in *Nature Geoscience*, Wang and colleagues[3] use a combination of remote sensing and hydrologic models to show that approximately two-thirds of the water transferred from land to oceans since 2002 originated from landlocked basins, although they comprise only 20% of Earth's land surface.

Land-locked (endorheic) basins are usually found in Earth's drier regions, where rivers lack sufficient flow to erode through topographic barriers. The largest grouping is in central Asia, although portions of Africa, the Arabian Peninsula, Australia, North America and South America are also endorheic. Because land-locked basins do not drain to the ocean, they tend to be ignored in discussions of sea-level rise. However, through fluctuations in the balance of precipitation and evaporation, significant changes in net water storage are possible. Because the water storage capacity of the atmosphere is negligible in comparison, any water that is removed from endorheic basins is transported either directly into the oceans or into basins that drain into the oceans.

Some endorheic basins have long been known to be drying, perhaps most famously the Aral Sea (Fig. 1), whereas others, such as lakes and aquifers on the Tibetan Plateau, are storing more water[4]. Meanwhile, depletion of groundwater in arid regions has become a concern[5].

Wang and colleagues[3] provide a comprehensive account of total water storage variations, since 2002. They use remotely sensed data to detect variations in glacier and lake water storage in endorheic basins and a suite of hydrologic models for other water cycle components. They find that approximately 75% of endorheic basins show a decline in storage, with the remainder increasing. Most of the total water loss is in Central Asia, especially the Caspian Sea Basin, but in basins in the Sahara, Arabia, the Andes, Western Australia and Western North America, water storage is also in decline. The most prominent increases in total water storage are in Tibet, sub-Saharan Africa and Eastern Australia.

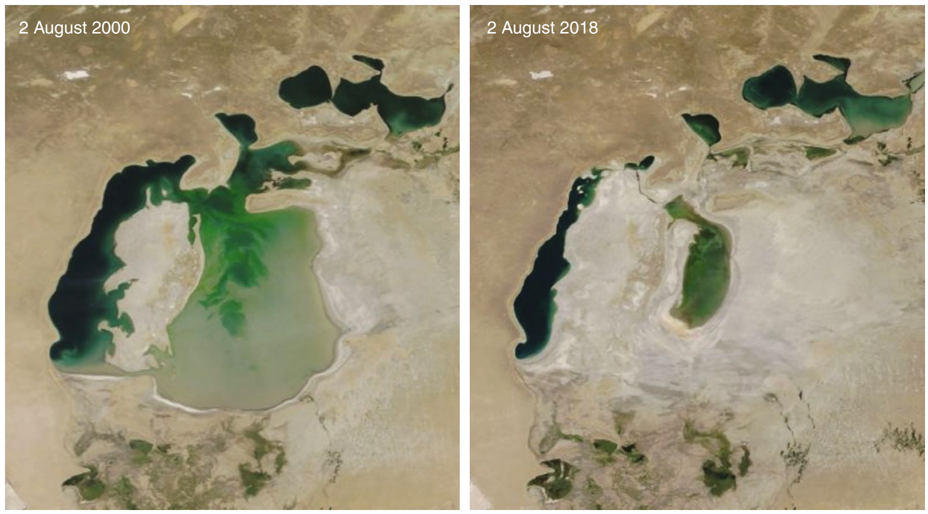

Fig. 1 | Extent of the Aral Sea in 2000 and 2018. Over the first 18 years of the twenty-first century, the Aral Sea has shrunk substantially. These changes are caused by a combination of human water diversion and climate change. Wang et al.[3] use long-term satellite datasets and hydrologic models to show that most landlocked basins, such as the Aral Sea, are losing water, which contributes to sea-level rise. Credit: NASA MODIS; downloaded from https://lpdaac.usgs.gov/

The origin of these changes is probably a combination of human water management and climate variability. Total water storage variations in basins that drain into the ocean closely track the El Niño–Southern Oscillation cycle, and it is likely that some endorheic basins are affected in the same way. Warmer temperatures associated with anthropogenic climate change, combined with increased groundwater pumping and river diversion for irrigation, result in elevated evapotranspiration. Without a corresponding increase in precipitation, this leads to a net transfer of water out of endorheic basins. Wang and colleagues show that net declines in total water storage are likely attributable to drying soil, groundwater abstraction and shrinking lakes.

Endorheic total water storage has declined by over 100 Gt per year since 2002, fairly consistently. Translated into sea-level rise equivalent, the net endorheic water loss has contributed about 0.3 mm yr^{-1}, or about 8% of total global sea-level rise: a remarkable contribution from already-dry regions that compose only a small fraction of Earth's surface.

Perhaps the most apparent implication of this finding is that understanding drivers of global sea-level rise requires additional attention to the spatial distribution of changes in terrestrial total water storage. Wang and colleagues show a large change in endorheic total water storage since 2002, but it remains unclear whether this trend will continue in the future. Continued impact of climate change and human water abstraction suggest that it might, but because both socioeconomic decision-making and the impacts of climate change on the water cycle are uncertain, endorheic basins could either act to exacerbate or ameliorate future sea-level trends.

There are also important implications for the endorheic basins themselves. Already, there are significant concerns regarding the sustainability of water use in some of these basins, both from groundwater and surface water. The detected decline in water storage suggests that changing water management practices may be necessary in some of these basins in response to both an inherently limited supply and to altered inputs associated with climate change.

The integral use of remote sensing in this study highlights the importance of supporting long-term, free and open satellite datasets. These datasets have existed for decades in oceanography[6] and terrestrial ecology[7] but are relatively new to hydrology. Nonetheless, long-term commitment to monitoring the water cycle from space is tenuous. Our ability to understand complex spatial patterns of hydrologic change, such as those revealed here, depends on this commitment, and maintaining it should be a high priority for scientists and policymakers.

Wang and colleagues[3] show that the world's endorheic basins have been significant net exporters of water in the past 15 years, and thus are significant contributors to sea-level rise, despite their relatively small area. With the addition of longer satellite time series and additional datasets focused on snow, smaller surface water bodies and soil moisture, we will learn if this trend is transitory or lasting. ❐

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