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Editorial: Climate change, land surface, and critical zone processes in endorheic basins

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Editorial on the Research Topic
Climate change, land surface, and critical zone processes in endorheic basins

Endorheic (terminal) basins are land-locked drainage systems where water does not drain into rivers that eventually reach the ocean. Most of these basins are typically found in drylands where water loss occurs mainly through evaporation and groundwater recharge. Endorheic basins and their sinks, such as lakes, are extremely sensitive to changes in climate and anthropogenic activities, including the overexploitation of water and land resources. Nevertheless, our understanding of the processes and fluxes on land surface and in critical zone (subsurface and vegetation) in these basins is still very limited. Thus, this topical issue was proposed to narrow the knowledge gap on environmental change(s) in endorheic basins under rapidly changing climatic conditions.

In the topical issue "Climate Change, Land Surface, and Critical Zone Processes in Endorheic Basins," two papers offer insights into the hydrological impacts of climate change. The first paper by Wang et al., investigates the changes in precipitation types and related climate indices in the upper Heihe River Basin (UHRB) on the Tibetan Plateau, from 1960 to 2021. The study compared three methods for improving precipitation type estimation using daily records from 24 discontinuous years. It examined the spatial and temporal changes in the total precipitation, rainfall, snowfall and air temperature at six stations and across the UHRB over 62 years. Using the RClimDex model and statistical analysis, the study evaluated the quantity, duration magnitude, and frequency of extreme climate indices. Their results reveal that the UHRB's warming rate, influenced by ENSO and the East Asian monsoon, is three times the global average. Extreme precipitation and rainfall events significantly increased in magnitude and frequency, alleviating annual droughts and extending the growing season. The study concludes by emphasizing the

need for water-and-soil conservation measures in the region to mitigate the impacts of intensified extreme precipitation, such as floods, soil erosion, and landslides.

The second study by Petch et al., explores the correlation between precipitation and water storage variability over large endorheic basins using GRACE satellite data. Their findings indicate a strong linkage between precipitation patterns and water storage, highlighting precipitation's crucial role in determining water storage dynamics in these basins. Both studies collectively illustrate how climate-induced Research Topic in precipitation control the hydrology and water resource management of endorheic basins, emphasizing the need for robust strategies to address these climatic challenges. These insights are crucial for developing effective mitigation and adaptation measures to sustain the ecological and hydrological balance in these sensitive regions.

Aeolian and fluvial transport are important land surface processes in endorheic basins. Two papers in the Research Topic looked into the movement of sediments and related hydrological effects. Field observations of various types of deposition around Qixing Lake in the Kubuqi Desert, Xi et al. revealed a bimodal distribution of these surface sediments is related to saltation and suspension. Based on the dominant suspended components in lakeshore terraces and wetlands, the authors suggests that dunes are not the main source for the suspended materials in the Qixing Lake area. Mishra et al. investigated the hydrology of Lake Balkhash by deploying time-series Landsat imagery to analyze spatial and temporal variability of turbidity using the normalized difference turbidity index (NDTI). Using multiple variables including precipitation, near-surface temperature, wind speed and direction, water level, and land use/land cover (LULC) in the catchment, they revealed an overall decrease in turbidity over interannual and seasonal timescales. The authors stressed that turbidity dynamics have an impact on the circulation, oxidation and overall health of Lake Balkhash's water and the warming climate and alterations of the lake hydrology significantly influence on water quality.

Endorheic basins often serve as reservoirs for mineralized groundwater and subsurface brines with unique hydrochemistry. For example, the Qaidam Basin of the Qinghai-Tibet Plateau hosts a Ca-Cl type brine essential for the formation of $MgSO_4$-deficient potash deposits. Genesis of this brine is poorly understood, however, Li et al. use lithium and boron isotope composition with geochemical models to show that calcium enrichment likely originates from water-rock interaction and that intrusion of hydrothermal fluids is key to the formation of this economically important Ca-Cl brine. They hypothesize that rainfall infiltration in margin fractures leads to the enrichment of B, Li, Sr, Ca, and other elements. Hydrochemistry suggests that migration of this fluid may have dissolved Tertiary evaporites leading to the current binary composition with Ca-Cl brines formed in the west of the Qaidam Basin (Li et al.). The arid Heihe River Basin in northwestern China also provides clues to genesis of the unique hydrochemistry found in terminal basins.

A study of the Gobi Region groundwater by (Zhang et al.) documents compositional changes along the Heihe River basin, attributed to water-rock interactions coupled with evaporation-crystallization processes. Inverse modelling identified primary water-rock interactions involved calcite dissolution in the upper-middle region with precipitation of dolomite, gypsum, halite, and sylvite, while the middle-lower basin exhibits a contrasting pattern of water-rock interactions leading to a binary composition of the basin's groundwater. In both basins, water-rock interactions during groundwater flow leads to geochemical sorting and enrichment. Present-day irrigation in the Heihe River basin has likely disrupted the hydrogeochemical equilibrium as compared to less agriculturally developed regions Zhang et al.

Drought is one of the key characteristics of endorheic basins, though the vegetation and its response to drought conditions and precipitation is underexplored. Yegizbayeva et al. investigated drought in the Lake Balkhash basin in Central Asia over 2 decades (2000–2020), emphasizing its impact on agriculture and water resources. The research uses MODIS satellite imagery and the Vegetation Health Index (VHI) to assess drought conditions from 2000 to 2020, including probabilistic mapping, trend analysis, and correlations with river discharge and lake area. Results reveal that 44% of the basin experienced drought, with severe episodes in specific years. Drought trends varied across the region, with some areas increasing, others decreasing, and some remaining stable. Correlations between drought and hydrological parameters differed among stations, highlighting the complex relationship between drought and water resources in the basin. The study concludes by emphasizing the need for precise water resource management and climate adaptation strategies in the region, including proactive monitoring and tailored interventions to mitigate drought's adverse effects. The work by Xu et al. explores the trends and drivers of vegetation changes in the Hehuang valley on the Tibetan Plateau (TP) over the past few decades (2000–2020) by analyzing the spatial and temporal changes of normalized difference vegetation index (NDVI). The TP has experienced widespread vegetation greening over the past few decades. This greening trend is driven by a combination of climate change (warming and wetting) and human activities (e.g., ecological restoration programs). Warming and increased precipitation have generally had a positive effect on vegetation productivity, with the Asian summer monsoon playing a significant role in the region's environment changes. However, time-lag and cumulative impacts of climate change have also been observed. Anthropogenic activities, such as grazing, land-use changes, and ecological engineering projects, have had both positive and negative impacts on vegetation dynamics. In areas with high human activity, the effects of human interventions can dominate over climate change effects. The TP exhibits significant spatial heterogeneity in vegetation responses, with some areas experiencing greening while others show browning or no significant changes. The authors conclude that the contribution of anthropogenic activities is the three times higher than the impacts of climate change.

These studies collectively highlight the importance of understanding and managing the environmental changes in endorheic basins to sustain their ecological and hydrological balance. We hope that this topical issue will serve as an avenue for further detailed investigation of hydrological and environmental processes in these sensitive systems.

Author contributions

VY: Conceptualization, Supervision, Writing–original draft, Writing–review and editing. SAK: Conceptualization, Writing–original draft, Writing–review and editing. DS: Writing–original draft, Writing–review and editing. KS: Writing–original draft, Writing–review and editing. XM:

Writing–original draft, Writing–review and editing. JL: Writing–original draft, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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