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**2.8**LAKE WATER STORAGE AND LEVEL  **-** M. E. Harlan, M. F. Meyer, E. S. Levenson, S. Cooley, and B. M. Kraemer

In 2024, water storage and levels across 4,486 lakes exhibited substantial variability. This variation depended on lake location, size, and human influence based on two global datasets. Lake water storage (LWS) from the GloLakes dataset (Hou et al. 2024; 4,190 lakes, median lake area 5.52 km2) saw a median increase in LWS of 1.61% in 2024 (representing a net cumulative increase of 10,566 million cubic meters (MCM)), compared to a baseline averaged period between 1993 and 2020 (Figure 1). Average 2024 lake water level (LWL) from the Global Reservoirs and Lake Monitor (GREALM) dataset (Birkett et al. 2011; 296 lakes, median lake area 449.6 km2) was relatively stable (0.065% median increase in LWL relative to 1993-2020 baseline, and a net cumulative increase of 125.6 m). However, small global average changes are obscuring more substantial regional changes. Lake water availability increased in 57.8% of lakes and decreased in 42.2% in at least one of the data sources, with a subset of these changes showing more statistical robustness (25.6% increased and 16.5% decreased with p < 0.05).

Countries with the largest mean increases in LWL and LWS (23.7% to 57.2%) include Ivory Coast, Senegal, Belize, Syria, Angola, Bangladesh, Mauritania, and Sudan, representing a higher proportion of wet regions. Countries with the largest mean decreases (-20% to -74.8%) include Niger, Mongolia, Chad, Algeria, Namibia, Argentina, Botswana, and Bosnia and Herzegovina, representing more arid climates. Beyond these regional trends, we also note a correlation between lake size, human management, and the degree of variability in lake storage and level, with smaller, managed lakes showing higher anomaly variability (Figure 2). These findings highlight the spatiotemporally complex interactions between climate variability, hydrological processes, and human activities in shaping global lake dynamics. The diverging LWL and LWS trends presented here generally align with previous studies (Kraemer et al. 2020, Feng et al. 2022). However, discrepancies exist in global LWS trends compared to more recent work (Yao et al. 2023) likely due to dataset differences. Continuing to monitor lake anomalies at both a global and regional scale is critical for better understanding where excessive LWS fluctuations are occurring to better predict changing dynamics in water availability, ecosystem resilience, and flood and drought risk (e.g. Weyhenmeyer et al. 2024; Han et al. 2024).

For our analysis, we used the “GloLakes” lake and reservoir storage dataset (Hou et al. 2024) to calculate lake storage anomalies. GloLakes combines laser altimetry data from ICESat2 (Jasinski et al. 2023), radar altimetry data from GREALM, and optical satellite data products from Landsat and Sentinel-2 to estimate lake water storage. We refined the GloLakes dataset by selecting lakes with at least 20 years of coverage between 1993 and 2024, no data gaps longer than three-years, and at least three observations in 2024. These 4,190 GloLakes lakes represent a small portion of global lake volume (1.1% of HydroLAKES; Messager et al. 2016); thus we also incorporate GREALM lake level data (Birkett et al. 2011), adding an additional 296 lakes representing 88.7% of total lake volume in HydroLAKES. We present anomalies based on *both* lake storage and lake level, and rely on a baseline period starting in 1993-2020 to account for GREALM data availability. We caution that our combined dataset is limited in spatiotemporal coverage globally, particularly in its disproportionately large coverage in North America (Plate 2.8), and lack of monitoring in small (< 1 km2) lakes (Figure 2), which dominate global lake variability (Pi et al. 2022; Xu et al. 2024). Further, datasets may contain errors. Among the 85 lakes shared between GloLakes and GREALM, the correlation (r2) between LWS and LWL anomalies in 2024 is only 11.7%. However there is general agreement in the direction of increase with 81.1% of lakes agreeing on anomaly direction. For these overlapping lakes, we only provide statistics for GREALM, given the denser interannual record. Future integration of data from the recently launched Surface Water and Ocean Topography (SWOT) satellite mission or data from longer missions such as MODIS may help alleviate spatial biases.

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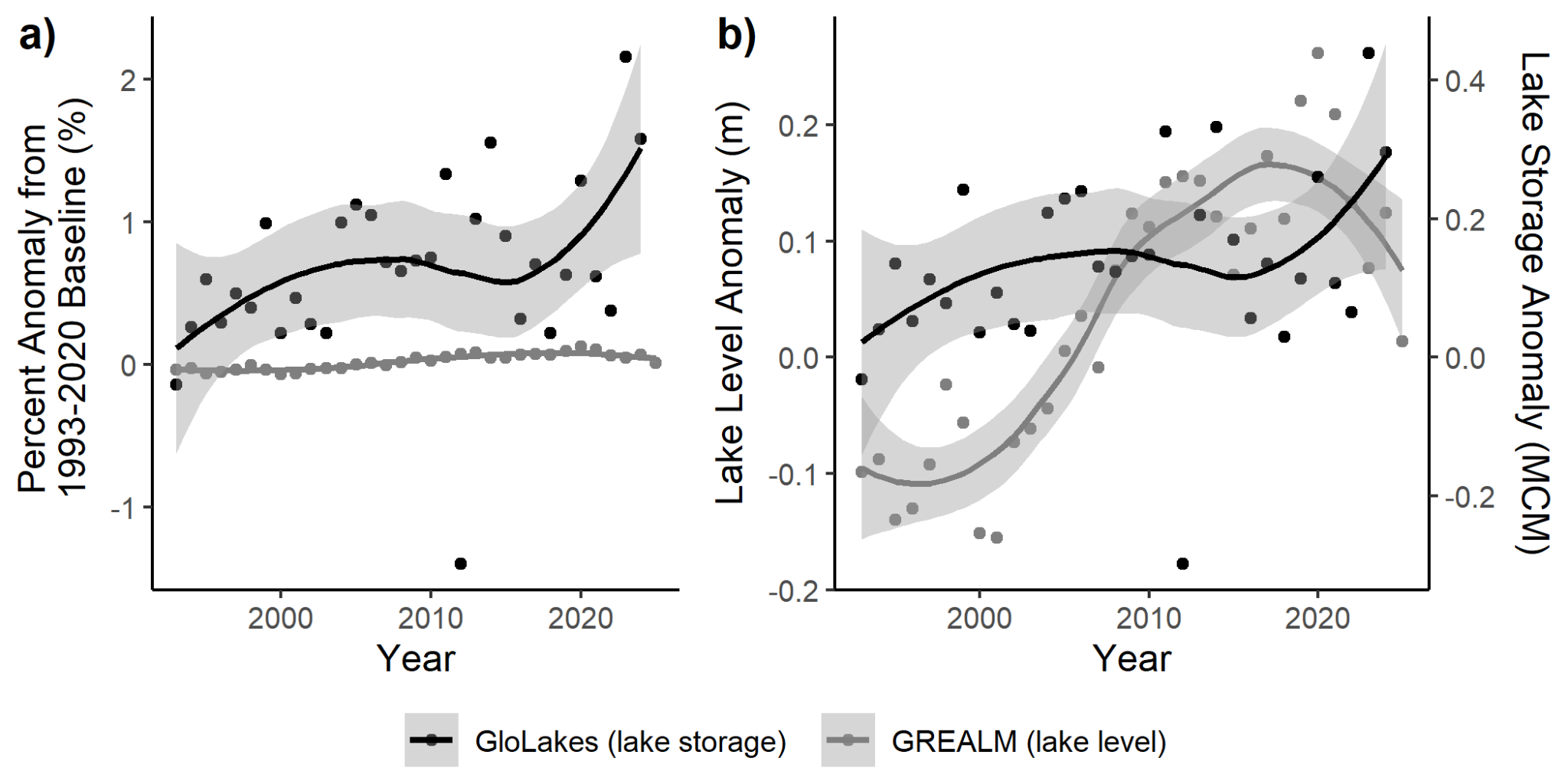
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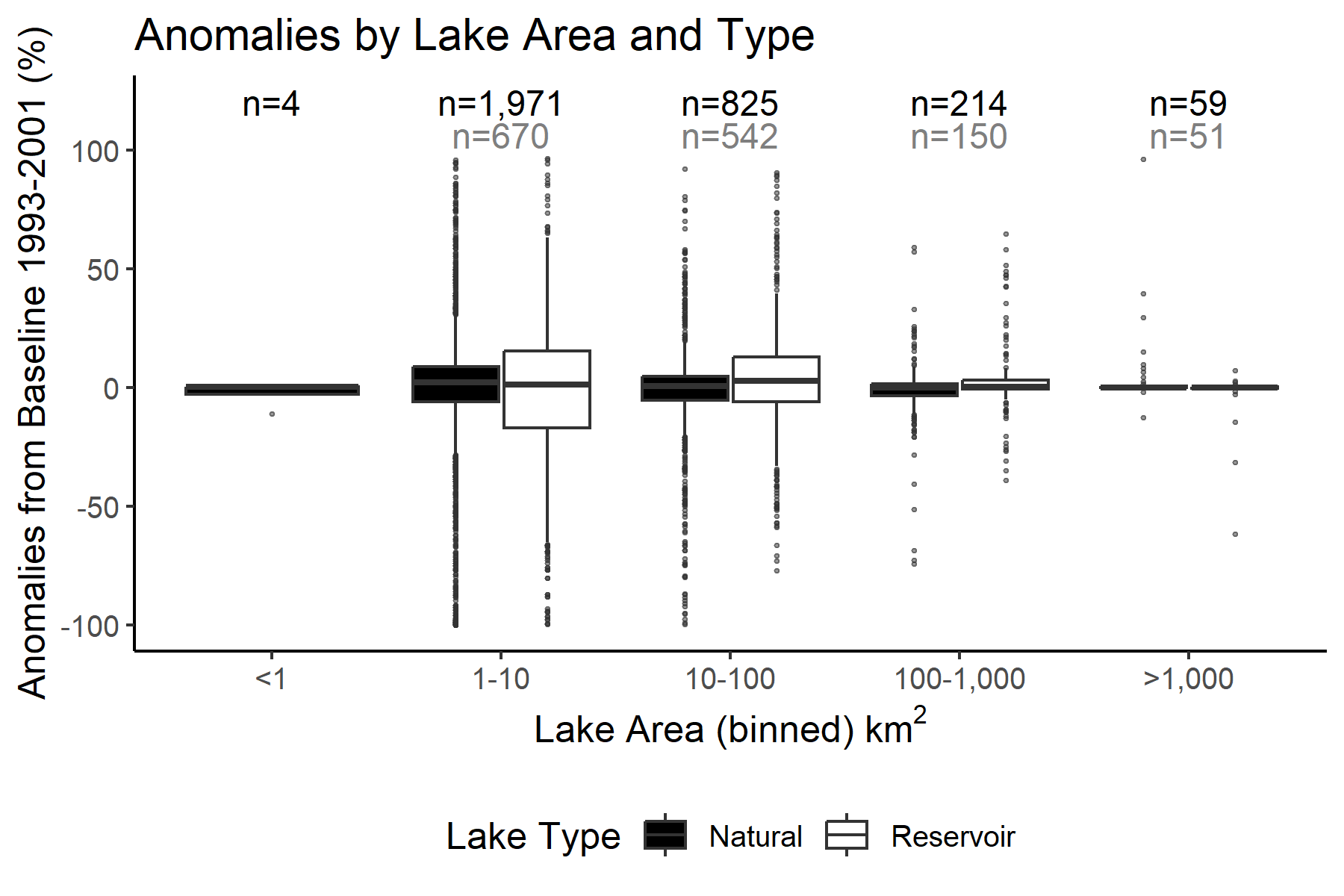
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**Figures**

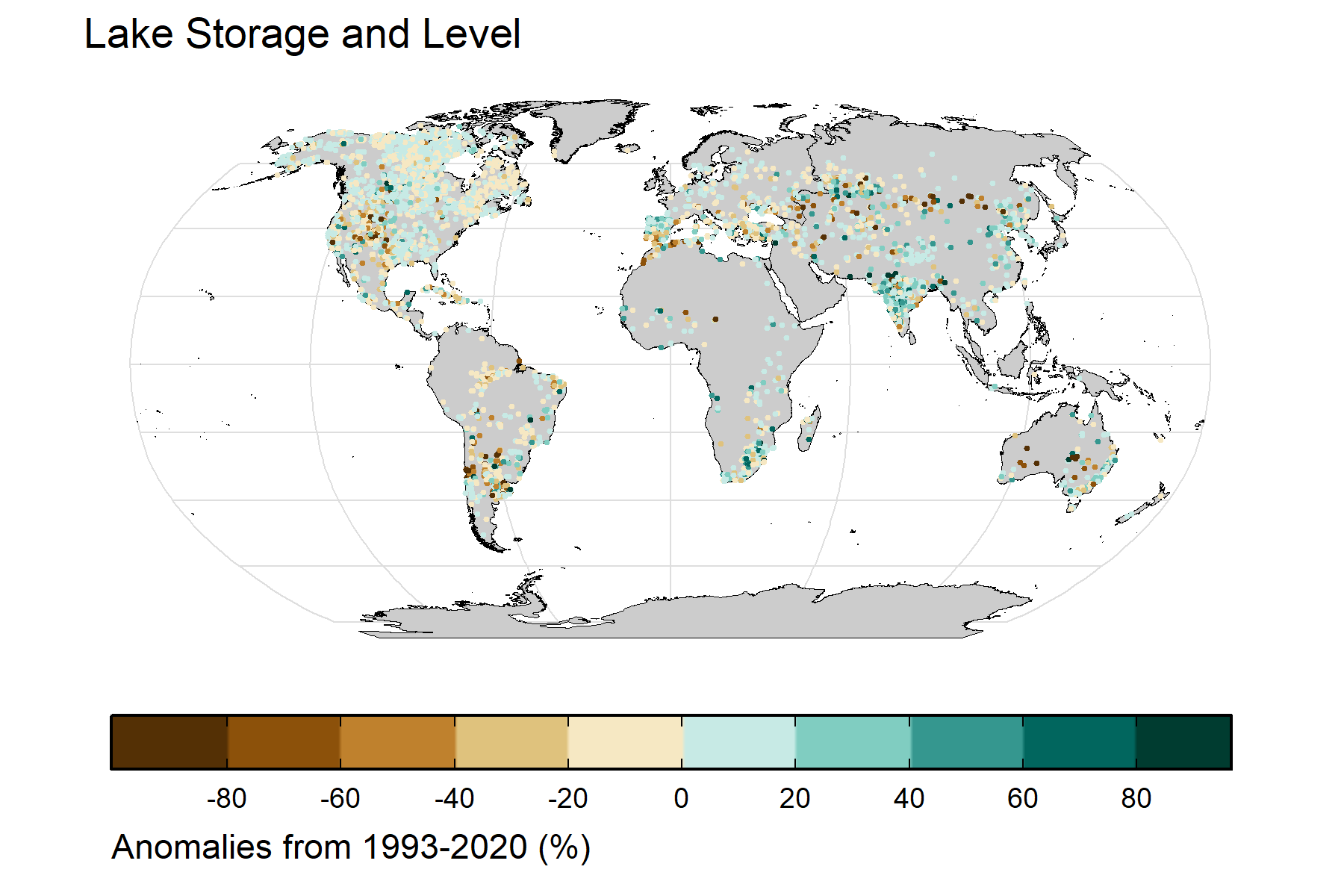
*Fig 1: Percent (a) and quantitative (b) water level and storage anomalies relative to 1993-2020, from 1993-2024. Percent anomalies are median-averaged globally; water level and storage anomalies in b) are shown on dual y axes, expressed in meters (m) and million cubic meters (MCM).*

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*Fig 2: 2024 lake storage and lake level anomalies (%) relative to 1993-2020 binned by lake size, and categorized as ‘natural’ or ‘reservoir’ based on inclusion in the Global Reservoir and Dam Database (Lehner et al. 2011). Lake bin counts (n) are displayed on top; reservoir and dam counts are shown in grey.*

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*Plate 2.8 Lake storage (GloLakes) and lake level (GREALM) anomalies (%)*

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**Datasets used and their URLs**

* ‘GloLakes’ lake and reservoir storage: <https://doi.org/10.5194/essd-16-201-2024>
* Global Lakes and Reservoir Monitor (GREALM) lake level: <https://ipad.fas.usda.gov/cropexplorer/global_reservoir/>

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**Summary bullet points**

* 2024 lake storage across 4,190 lakes on average increased by 1.61% compared to a baseline averaged period from 1993-2020.
* Although global average LWS and LWL changes appear small, 42.1% of lakes showed increases or decreases in 2024 (p < 0.05), highlighting strong regional variability.
* 2024 lake storage and level anomaly variability is correlated with lake size and whether the lake is categorized as a reservoir or dam.