Addendum: Human alteration of global surface water storage variability

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Our analysis of lake level and storage variability observed by ICESat-2 uses a modified version of the Global Surface Water Occurrence (GSWO) product to identify lakes (Pekel et al., https://doi.org/10.1038/nature20584 (2016)). When we originally calculated the area of lakes derived from this product, we assumed a grid cell resolution of 30 m, the native resolution of the Landsat imagery used to develop the GSWO product. However, the GSWO product is actually post-processed to a grid cell resolution of 0.00025° × 0.00025°. Since the Earth is an oblate spheroid, the length (in meters) of both a degree of latitude and a degree of longitude vary with latitude. The height (*y*-axis) of each 0.00025° grid cell is approximately 28 m and increases very slightly with latitude (+0.3 m between 0° N and 75° N). The width (*x*-axis) of a 0.00025° grid cell is more strongly latitude-dependent and decreases towards the poles. For example, the width of a GSWO grid cell is approximately 28 m at the equator, 20 m at 45° N and 10 m at 70° N. As a result, we inadvertently overestimated lake area especially at high latitudes.We therefore recomputed lake areas based on this 0.00025° × 0.00025° resolution and adjusted the results in the article accordingly. We thank Nan Xu (Hohai University), Hui Lu (Tsinghua University), Wenyu Li (University of Toronto) and Peng Gong (University of Hong Kong) for alerting us to this error.

Given that the article focuses on the observed water level variability (which is unaffected by the area calculations) and the proportion of storage variability that occurs in reservoirs (which tend to be located at lower latitudes), this modification has little effect on our overall findings and no effect on our key conclusions. In fact, we find that using the new area calculation, 61% (compared to 57%) of the global seasonal variability in water storage occurs in human-managed reservoirs.

The updates to the article are as follows:

Proportion of storage variability occurring in reservoirs. Values of the percent variability occurring in reservoirs are modified slightly due to the corrected lake areas. However, given that most of the error associated with area calculation occurs at high latitudes, where lakes are not as variable and where there are comparatively few reservoirs, the effect of this error on the percent storage variability occurring in reservoirs is minimal, especially at the basin-scale. In total, of the forty largest river basins for which we report percent storage change in reservoirs in Figure 4 and Extended Data Table 1, the mean difference between the original and updated values resulting from our new area calculation is ± 0.5%.

Uncertainty bounds. While neither our water level retrievals from ICESat-2 nor our uncertainty analysis in comparison with USGS gauge data were affected by this correction, the corrected area calculations did affect our uncertainty estimates. This is because the uncertainty bounds reported in the original article were binned by lake area and then propagated throughout the results to produce overall uncertainty estimates. We have recalculated the uncertainty bounds binned by our corrected lake areas, leading to slight changes in uncertainty bounds that average 0.02 to 0.04 m (i.e., from 0.13–0.33 to 0.11–0.35) across all water bodies.

Proportion of lakes observed by area. In the original article, we report the proportion of lakes that ICESat-2 observes by lake area. After performing this calculation accounting for our new area values, our results demonstrate that ICESat-2 actually observes a greater percentage of large lakes than we originally reported, increasing from 52% to 72% for lakes larger than 1 km^2.

Comparison with California Department of Water Resources (CDWR). Due to the area corrections, the area of California reservoirs shrank by 33% on average (owing to their location between 33° N and 40° N). As a result, we now find that our analysis using ICESat-2 slightly underestimates storage change relative to CDWR storage values (mean absolute error = 0.027 km^3 and mean absolute bias = −0.026 km^3, vs. 0.019 km^3 and −0.01 km^3 in the original article; see Extended Data Figure 6). Despite these updates, this corrected comparison to CDWR does not impact any of our key findings or conclusions. We have always known that our analysis underestimates lake storage variability due to ICESat-2's incomplete sampling as well as our use of a static, conservative water mask (see Methods section "Uncertainty in seasonal variability and bias analysis" for discussion of this sampling underestimation). Importantly, as this is a consistent underestimation, it does not influence our overall conclusions about the proportion of storage variability occurring in reservoirs since the underestimation due to both the temporal sampling and the use of a conservative lake mask is consistent across both artificial reservoirs and natural water bodies.

The recalculation affects data reported in the Abstract, Results, Discussion, Methods, and Figures 3, 4, Extended Data Figures 1, 6 and Extended Data Tables 1–4, which are all now updated in the HTML and PDF versions of the article. The original, uncorrected article is available as Supplementary information alongside this notice to allow comparison.

Supplementary information is available in the online version of this notice.