

### **Response to Comments by Anonymous Referee #1:**

The authors validated MODIS-based RIC estimates using medium-resolution (30 m) Landsat 7/8/9 and high-resolution (10 m) Sentinel-2 imagery. However, it remains unclear whether the fixed 500m buffer mask used for MODIS was also applied to these higher-resolution datasets. It is recommended that the authors compute RIC from Landsat and/or Sentinel-2 imagery using two distinct masking approaches for various river segments: (1) the fixed 500m mask, and (2) a more accurate mask delineating the actual ice-season river channel extent. This comparison would clarify the potential impact of inadvertently including snow-covered floodplain and non-channel areas on RIC estimates.

### **Response:**

Thank you for this constructive recommendation. We agree that the masking strategy applied to the higher-resolution reference imagery should be stated explicitly, and that a two-mask comparison is an appropriate way to assess any potential influence from inadvertently including snow-covered floodplain/bank areas in RIC estimates.

### **Mask used in the original validation:**

In the original validation, we applied the same referenced river mask used for MODIS to Landsat 7/8/9 and Sentinel-2. Specifically, we used a buffered river-corridor mask (250 m on both sides) to accommodate realistic seasonal expansion/contraction of the active channel. RIC was computed using the same 3-km grid partition for MODIS and the higher-resolution imagery to ensure strict spatial alignment during the accuracy assessment. We acknowledge that, for some reaches, this buffered corridor may include some non-channel areas (e.g., snow-covered floodplain/banks), which could bias RIC if such surfaces are misclassified as ice.

### **Additional validation result:**

In direct response, we repeated the Landsat/Sentinel-2 RIC computation using a channel-accurate mask that strictly follows the “actual watercourse” (i.e., the shapefile converted from the GRWL Mask raster, without buffered expansion), and we re-evaluated agreement against MODIS on the same 3-km grid. Because Landsat/Sentinel-2 observations are not daily and do not provide wall-to-wall coverage of the full river network, the available cloud-filtered scenes sample only parts of each basin and the sampled reaches (wide or narrow) vary spatially with

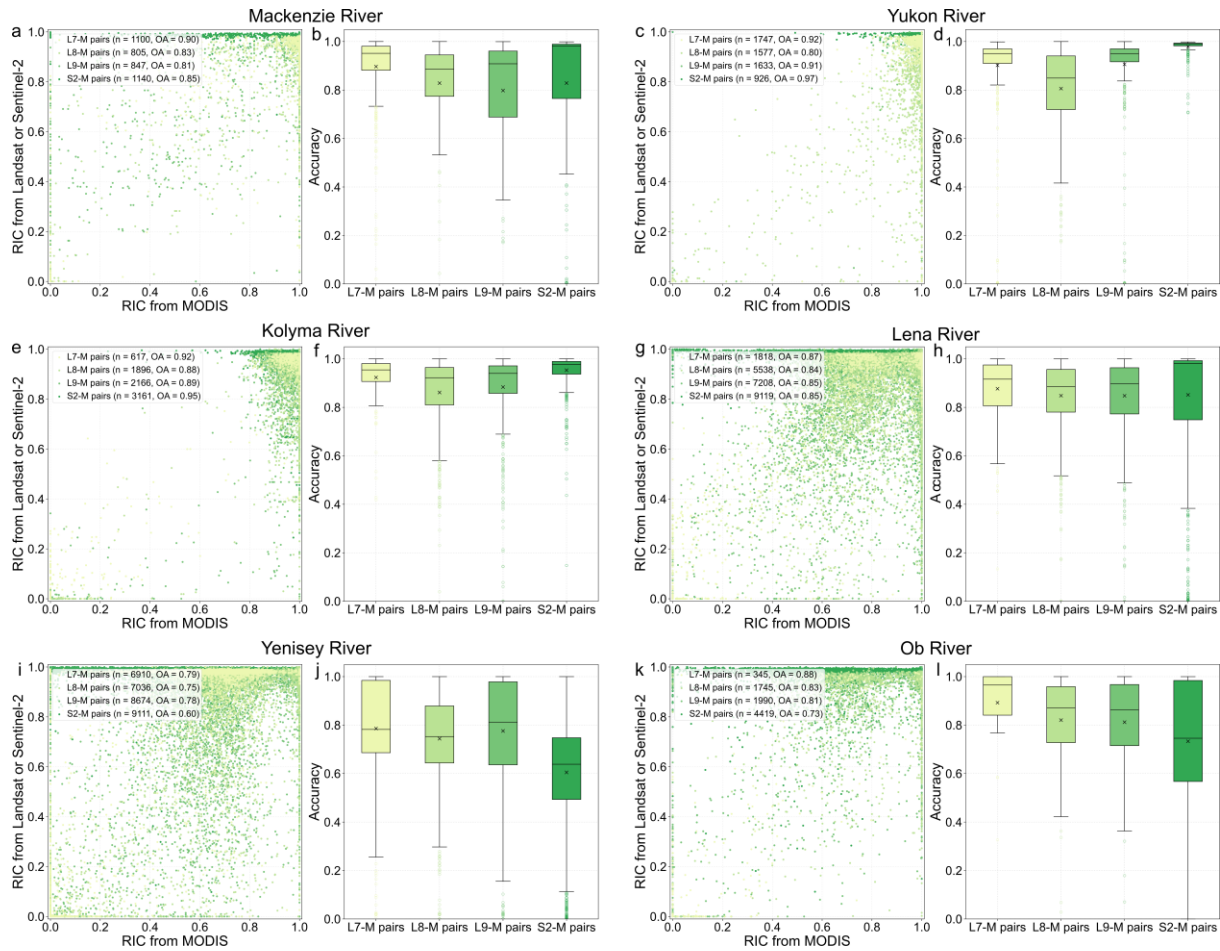
swath footprints. Consequently, adopting the strict watercourse mask substantially contracted the effective ROI and reduced the number of valid matched data pairs by ~90%.

Across all six rivers, switching from the buffered corridor mask to the strict watercourse mask resulted in only modest changes in agreement (see Figs. III and 3). The mean OA (overall accuracy) remained comparable and showed a slight increase (from ~0.83 to ~0.84), and most sensor–river comparisons changed within a small range (18 out of 24 comparisons changed by  $\leq 0.05$ ). On average, improvements were more evident for Sentinel-2, whereas Landsat-based agreements changed only marginally.

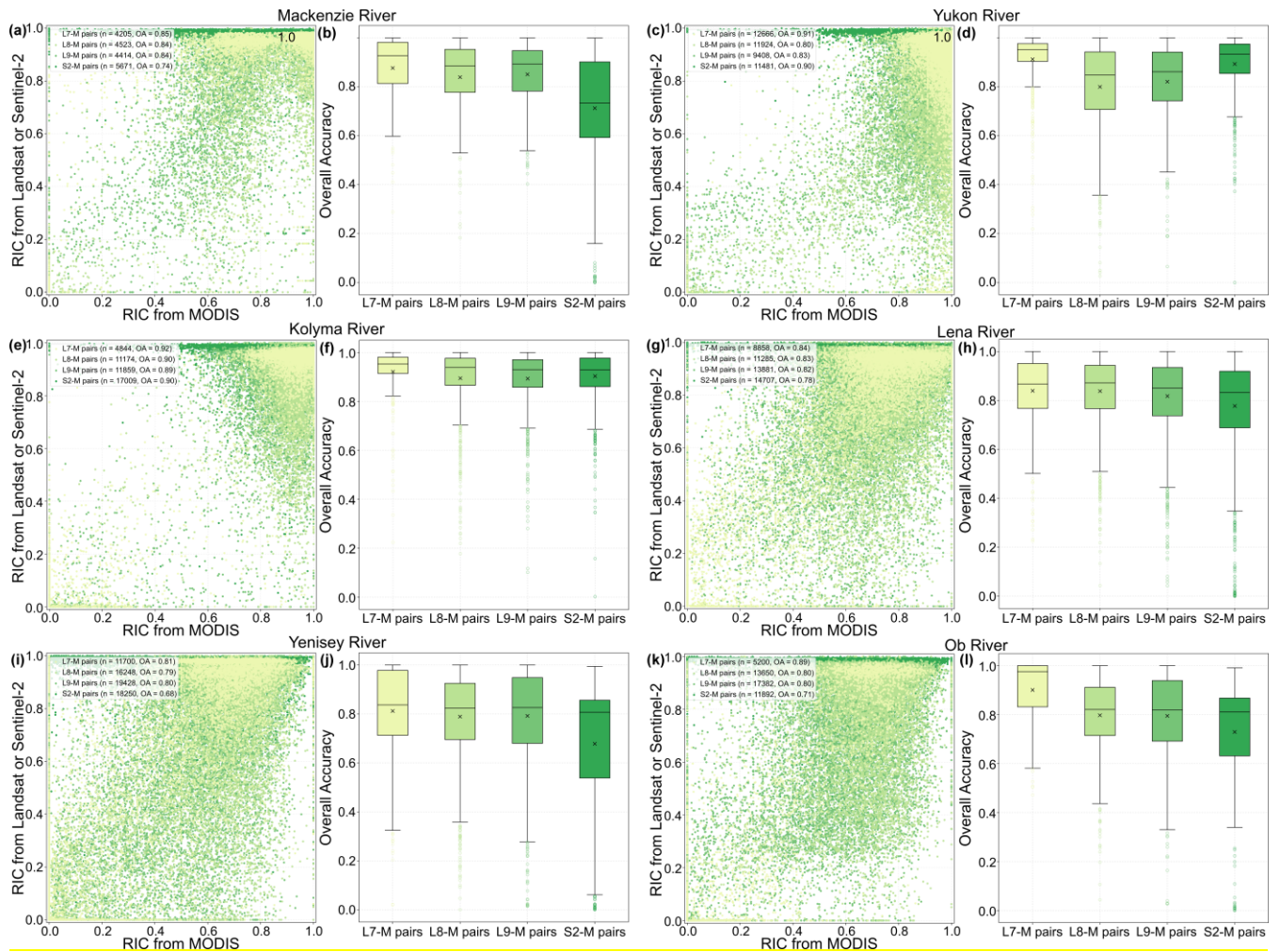
Taken together, this additional analysis indicates that our validation is broadly robust to reasonable variations in river masking. While the buffered corridor may include some non-channel areas, it does not introduce a systematic, one-directional inflation of agreement on a large scale. This is consistent with the fact that the narrow-reach fraction is limited ( $\approx 12\%$  overall) and, importantly, the higher-resolution reference imagery samples the river network only partially and non-uniformly due to swath coverage and cloud screening.

We have now explicitly clarified the masking strategy in the revised manuscript. The corresponding text reads:

Figure 3 summarizes the accuracy evaluation for six major Arctic rivers, comparing MODIS-derived RIC with higher-spatial-resolution reference estimates computed using the same referenced river mask and an identical 3-km grid partition.



**Figure III. Accuracy assessment of MODIS-derived RIC (river ice concentration) against high-resolution reference data from Landsat and Sentinel-2 with strict watercourse mask across six major Arctic rivers. Left panels show pixel-wise scatterplots comparing MODIS-based RIC with higher-resolution estimates from Landsat 7, Landsat 8, Landsat 9, and Sentinel-2. Note the four matched point categories were plotted in a fixed layer order to improve visibility, with S2-M shown in the bottom layer. Right panels present the corresponding validation accuracies for each sensor pairing (L7-M, L8-M, L9-M, and S2-M). In the boxplots, the central line indicates the median, and the cross symbol denotes the mean value. Subplots a, b correspond to the Mackenzie River, c, d to the Yukon River, e, f to the Kolyma River, g, h to the Lena River, i, j to the Yenisey River, and k, l to the Ob River.**



**Figure 3: Accuracy assessment of MODIS-derived RIC (river ice concentration) using high-resolution reference data from Landsat and Sentinel-2 across six major Arctic rivers. Left panels show pixel-wise scatterplots comparing MODIS-based RIC with higher-resolution estimates from Landsat 7, Landsat 8, Landsat 9, and Sentinel-2. Note the four matched point categories were plotted in a fixed layer order to improve visibility, with S2-M shown in the bottom layer. Right panels present the corresponding validation accuracies for each sensor pairing (L7-M, L8-M, L9-M, and S2-M). In the boxplots, the central line indicates the median, and the cross symbol denotes the mean value. Subplots (a), (b) correspond to the Mackenzie River, (c), (d) to the Yukon River, (e), (f) to the Kolyma River, (g), (h) to the Lena River, (i), (j) to the Yenisey River, and (k), (l) to the Ob River.**

Once again, we sincerely appreciate your meticulous review and insightful comments. We hope that our revisions effectively address your concerns and further improve the clarity, rigor, and overall quality of the manuscript.