

Supplement Information

Supplement Information S1. Mapping of MG&IC

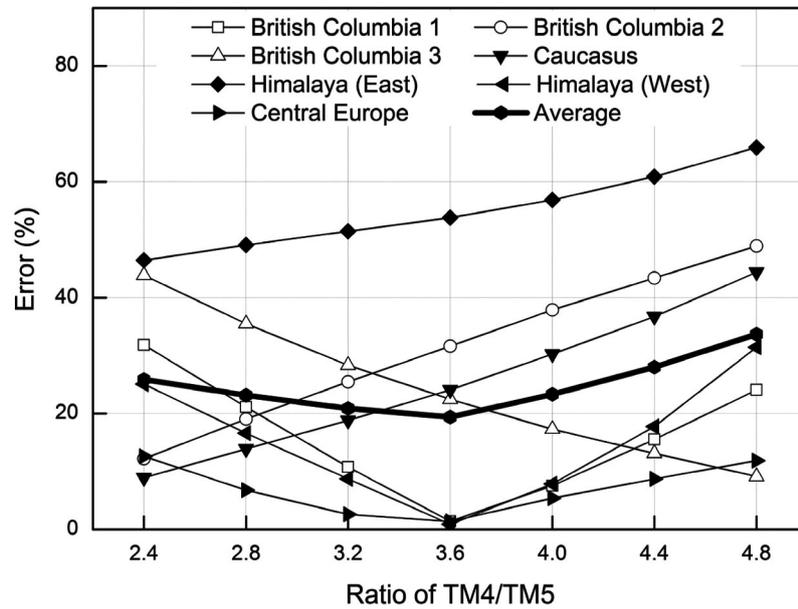
Supplement Figure S1 shows the difference between the number of glacier grid cells between our results and regions where the glacier inventory is complete in the GLIMS Glacier Database. As illustrated in Supplement Figure S1, an uptrend means that too few grid cells are marked as glacier, while a downtrend implies that too many grid cells are so marked. Overall, the error is smallest at the threshold TM4/TM5 of 3.6 compared to other values. The error was smallest at the threshold of 3.6 (19.4%), and other thresholds resulted in more than 20% errors. Hence, glaciers can be best distinguished from other surface types using the threshold value of 3.6.

Supplement Figure S2 shows that some non-glacier areas at the edge of the image were identified as glaciers after the threshold $TM4/TM5 > 3.6$ was applied. Also, some forested areas were identified as glaciers (Supplement Figure S2b). Hence, an additional threshold of TM3 ($DN > 50$) was applied to improve glacier mapping, exploiting the very high reflectivity of ice and snow in the TM3 band. Supplement Figure S2c clearly indicated that the errors at the edge of the image were removed.

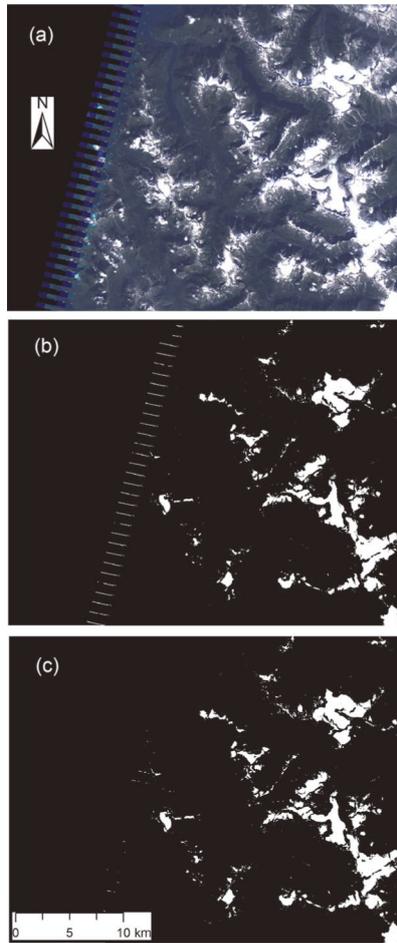
After the two steps mentioned above, we applied a 9×9 pixel average filter to remove misclassification of pixels and noise. In this step, the central grid cell was identified as “glacier” when the area of glacier cells accounts for $> 40\%$ of the surrounding 9×9 pixels and the area of non-glacier cells represents $< 40\%$. Then, isolated pixels were removed and isolated gaps were filled (Supplement Figure S3). As

mentioned above, we applied these steps to obtain glacier pixels from all satellite images automatically. We then used the `r.clump` command of GRASS GIS to define individual glacier masses by cropping contiguous pixels where defined as glacier pixel. Finally, the edge of the mass of glacier pixels was used to define outlines of glaciers using the `r.poly` command of GRASS GIS. Following these steps, the satellite-derived glacier outlines can be extracted globally, which were stored as vector format.

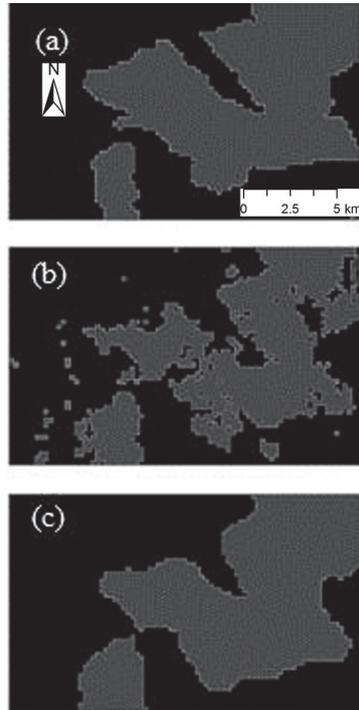
Supplement Figures



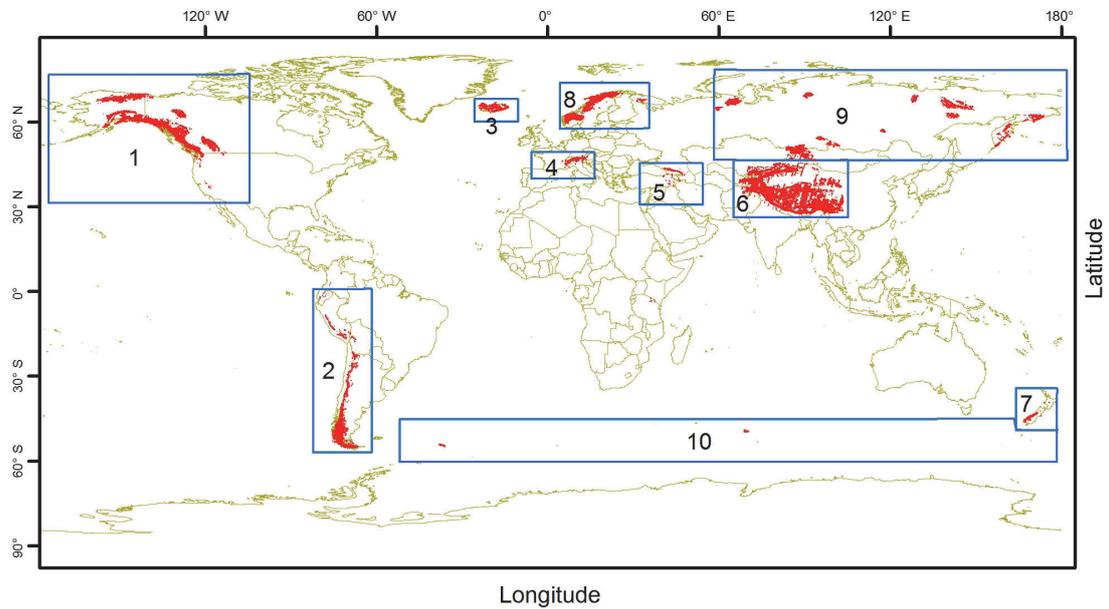
Supplement Figure S1. Difference between the number of mountain glacier grid cells in this study and six regions where glacier inventories in the GLIMS Glacier Database are complete. British Columbia 1, 2, and 3 denotes satellite data acquired at different dates.



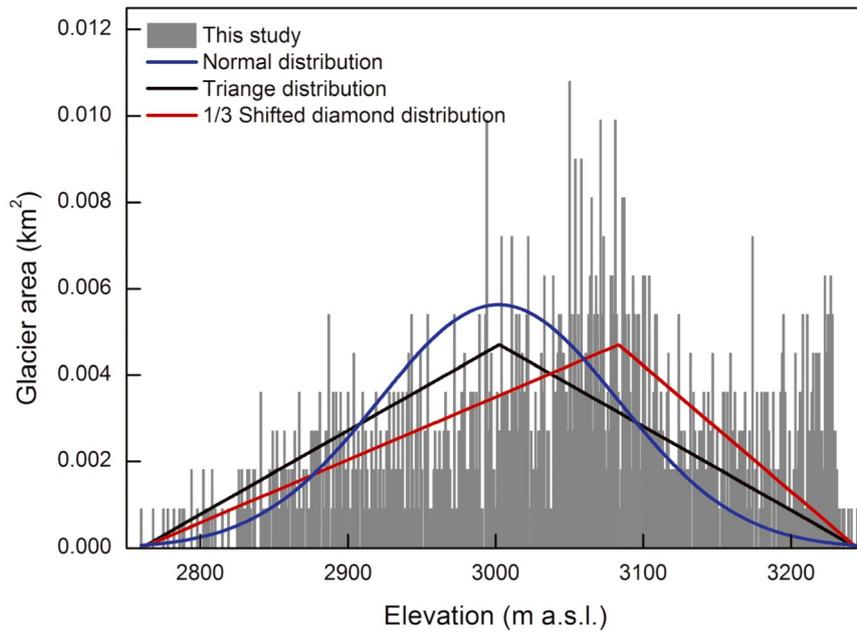
Supplement Figure S2. Distribution of glaciers in (a) the true color image, (b) threshold ratio image where $TM4/TM5 > 3.6$ is used, and (c) where $TM4/TM5 > 3.6$ and additional threshold in band 3 > 50 are used. The image is located at 128.43° W, 53.31° N.



Supplement Figure S3. Glacier distribution (grey) in the part of British Columbia region derived from (a) the GLIMS Glacier Database, (b) before applying 9×9 average filter, and (c) after applying a 9×9 average filter.



Supplement Figure S4. Spatial distribution of MG&IC excluding glaciers in Greenland and Antarctic. Red color denotes glaciers. Blue boxes show the regions and region numbers from 1 to 10 are North America, South America, Iceland, Central Europe, Caucasus, High Mountain Asia, New Zealand, Scandinavia, North and East Asia and sub-Antarctic islands.



Supplement Figure S5. Area-altitudinal distribution for a glacier in the Alps (7.061635° E, 45.9195° N).