Supplement of

Exploring the ability of the variable-resolution CESM to simulate cryospheric-hydrological variables in High Mountain Asia

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Section S1 CLM Glacier-Cover Dataset

For the HMA_VR7b simulation, we updated the CLM glacier-cover dataset to represent glacier and ice sheet cover more accurately. In the original dataset, we found large deviations in parts of HMA between the mean CLM grid cell elevation and the mean glacier elevation derived from the glacier-cover dataset (Figure S1a). These deviations, which were largest in southeastern HMA, are mainly attributable to inaccuracies of the Randolph Glacier Inventory (RGI) version 1 (RGI-Consortium, 2012) glacier outlines used to create the original dataset (Figure S1b).

The updated glacier-cover dataset encompasses three 3-minute datasets: 1) fractional land ice coverage, including both glaciers and ice sheets, 2) distributions of areal glacier coverage by elevation, and 3) distributions of areal ice-sheet coverage by elevation. Figure S2 summarizes the workflow to generate the updated dataset. The fractional land ice coverage and distributions by elevation are derived from global glacier outlines, vector data of ice-sheet coverage, and a global 30-arcsec elevation dataset and land-sea mask. The global glacier outlines are retrieved from the Randolph Glacier Inventory version 6 (RGI-Consortium, 2017), and the vector data for the Greenland and Antarctic ice sheets are retrieved from the masks of BedMachine version 4 (Morlighem et al., 2017, 2021) and version 2 (Morlighem et al., 2020; Morlighem, 2020), respectively. The global elevation data and land-sea mask are obtained from a merged BedMachine/GMTED2010 product in which the higher-resolution BedMachine datasets are conservatively regridded to the 30-arcsec GMTED2010 grid, overwriting the GMTED2010 Greenland and Antarctica values. First, 30-arcsec polygon grids are generated, which are overlaid with global glacier outlines and ice-sheet vector data, respectively, to calculate ice percent cover in each polygon grid cell. The polygon grid cells are then concatenated, followed by the rasterization of the polygon grids. This results in two 30-arcsec land ice masks containing fractional ice coverage for glaciers and ice sheets, respectively. Second, the land ice masks are draped over global

30-arcsec elevation data. In each grid cell, ice fractions are distributed over 70 elevation bins (at 100 m intervals) and an additional bin that includes ice cover above 7000 m, resulting in 30-arcsec distributions of areal ice coverage by elevation for glaciers and ice sheets. Third, the elevation distributions are conservatively regridded to 3-minute resolution and aggregated to generate 3-minute distributions of fractional land ice coverage. Finally, the land-sea mask is conservatively regridded to 3-minute resolution and is corrected by defining grid cells as land where ice cover (including floating ice shelves) is present.

Given the new CLM surface datasets, the distributions by elevation are used to subdivide each CLM glacier land unit into columns based on the 36 ECs defined above. More detailed information about the original glacier-cover dataset can be found in the CLM5 Documentation (https://escomp.github.io/ctsm-docs/). Differences between the original and updated datasets are listed in Table S1.

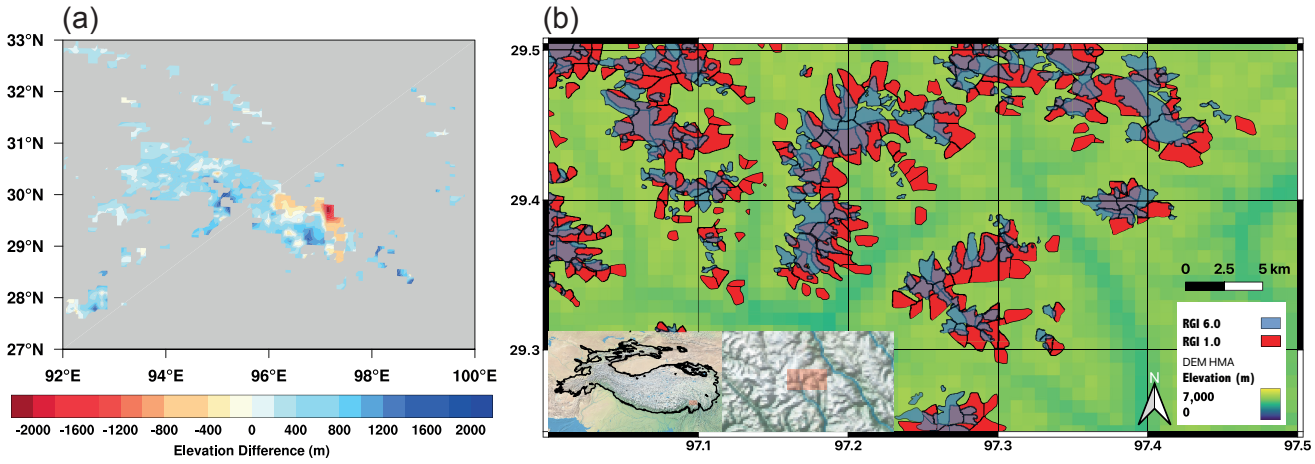

Figure S1. (**a**) Differences between the mean elevation of the CLM grid cell and the mean glacier elevation within the grid cell. (**b**) Glacier outlines retrieved from Randolph Glacier Inventory version 1 (red) and version 6 (blue) (RGI-Consortium, 2012, 2017). The background elevation data is retrieved from Natural Earth. The red box and the black outline in the insets denote the location of the glacier outlines and the outline of High Mountain Asia, respectively, where the HMA outlines are retrieved from the Global Mountain Biodiversity Assessment (GMBA) Mountain Inventory version 1.2 (Körner et al., 2017). The location of the red box is based on the large negative elevation differences in Figure S1a.

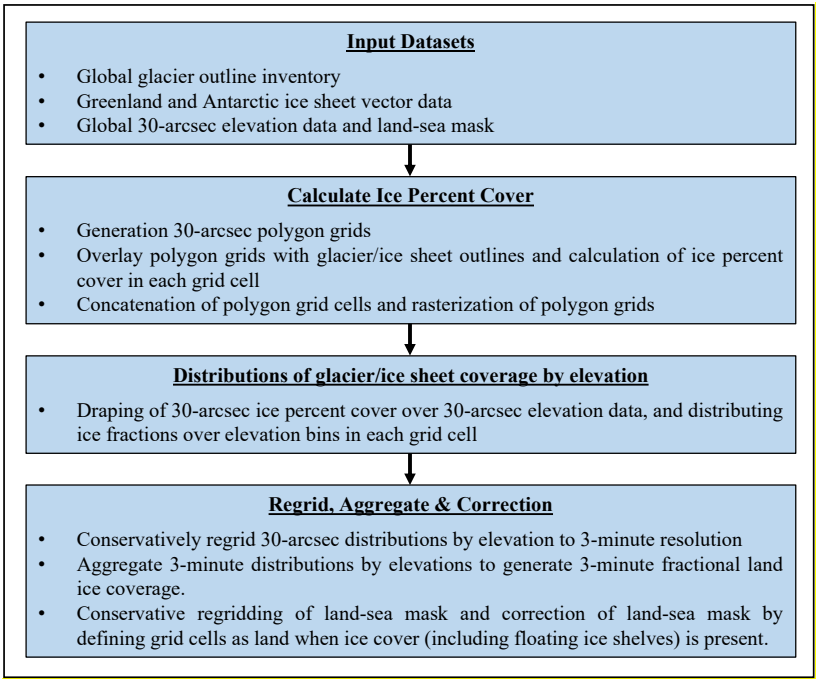

Figure S2. Schematic overview of workflow used for generating the updated CLM glacier-cover dataset.

Table S1. Overview of the input datasets that have been used for the original (v1) and updated (v2) CLM glacier-cover datasets, and the differences in the number of elevation bins that are used among the different glacier-cover datasets.

	CLM glacier-cover dataset v1	**CLM glacier-cover dataset v2**
Glacier outlines	Randolph Glacier Inventory v1 (RGI-Consortium, 2012)	Randolph Glacier Inventory v6 (RGI-Consortium, 2017)
Greenland ice sheet outlines	University of Zurich Raster Data (Rastner et al., 2012)	BedMachine v4 (Morlighem et al., 2017, 2021)
Antarctica ice sheet outlines	SCAR Antarctic Digital Database v5 (ADD Consortium, 2000; Fox et al., 1994)	BedMachine v2 (Morlighem et al., 2020; Morlighem, 2020)
Topography	GLOBE Topography (Hastings et al., 1999)	GMTED2010 (glaciers) + BedMachine (icesheets) (Morlighem et al., 2017, 2020; Danielson and Gesch, 2011)
No. of elevation bins (100 m interval)	60 (< 6000 m) + 1 (6000 – 10,000 m)	70 (< 7000 m) + 1 (7000 – 10,000 m)

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