1 Model concept

We present a model of the global surface mass balance of glaciers, based on the reconstruction and projection of the surface mass balance of all the world’s individual glaciers, excluding the ice sheets in Greenland and Antarctica.

2 Validation

2.1 Individual mass balances

The model is validated using a leave-one-glacier out cross validation scheme using 3997 observed surface mass balances of 255 glaciers (see Fig. 2). The errors are then propagated through the entire model.

2.2 Temporally integrated volume changes

The modeled, temporally integrated volume changes, and the propagated errors are validated against 756 geodetically observed, temporally integrated volume changes of 341 glaciers (see Fig. 3).

3 Results

3.1 Reconstruction of past

When forced with observed monthly precipitation and temperature data, the world’s glaciers are reconstructed to have lost mass corresponding to 114±5 mm sea level equivalent (SLE) between 1902 and 2009.

3.2 Future projections

Using projected temperature and precipitation anomalies from 15 coupled GCMs from the CMIP5 ensemble, glaciers are projected to lose additionally between 148±35 mm SLE (RCP26) and 217±47 mm SLE (RCP85) during the 21st century.

Figure 1 Red are the outlines of all glaciers individually modeled in this study. Blue dots indicate the locations of the 255 glaciers used for the cross validation of the model (see Fig. 2). Green rings indicate the location of the 341 glaciers used for validation of the modeled, temporally integrated volume and area changes (see Fig. 3). Colored outlines indicate region boundaries.

Figure 2 Cross validation results; (a) distribution of the errors of the modeled mass balances; (b) distribution of the model bias; vertical lines indicate the 2nd and 98th percentiles (light gray), 15th and 85th percentiles (dark gray), and median (black); colors indicate regions (see Fig. 1).

Figure 3 Distribution of relative volume errors of non-calving glaciers obtained from the validation of temporally integrated modeled volume changes; colors indicate regions (see Fig. 1).

Figure 4 Cumulative past global surface mass balances relative to the 1986–2005 mean (upper panel), and rates (lower panel). Rates have been filtered with a 5 yr low pass filter for clarity; colors indicate regions (Fig. 1).

Figure 5 Cumulative global surface mass balances relative to the 1986–2005 mean (upper panel), and rates (lower panel) from the model forced with CMIP5 projections, up to the year 2300. Light colored lines: model forced by individual CMIP5 ensemble members, solid lines: means of light colored lines. Crosses on the left (upper panel) indicate mean and range of ensemble for each RCP scenario in the year 2300. Rates have been filtered with a 5 yr low pass filter for clarity.

Reference


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