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観測時代の氷河・氷床の質量収支と気候変化について

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Mass Balance of Glaciers and Ice Sheets during the Observational Period and Climate Change

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Abstract

Glacier mass balance and secular changes in mountain glaciers and ice caps are evaluated from the annual net balance of 161 glaciers from 17 glacierized regions of the world. Further, the annual net balance is split into winter and summer balances for 35 glaciers of 11 glacierized regions. The global means are calculated by weighting glacier and regional surface areas. The area-weighted global mean net balance for the period 1960 to 2000 is -250 mma^{-1} w.e. (-138 km^{3}a^{-1} w.e.), with seasonal components of 1470 mma^{-1} w.e. (810 km^{3}a^{-1} w.e.) for winter and -1725 mma^{-1} w.e. (-950 km^{3}a^{-1} w.e.) for summer balances. The linear-fitted global net balance is accelerating at a rate of -11 mma^{-2}. The main driving force behind this change is the summer balance with a rate of -12 mma^{-2}. The decadal balance, however, shows significant fluctuations: melt reached its peak around 1945, followed by a decrease. The annual net balance, although negative for the global mean, approached equilibrium from the 1960s to 1980s. Some regions experienced a period of positive balance during this time, for example, Europe. The balance has become strongly negative since the early 1990s. These decadal changes correspond to periods of global dimming (for smaller melt) and global brightening (for larger melt). The total radiation at the surface changed as a result of an imbalance between steadily increasing greenhouse gases and fluctuating aerosol emissions.

The mass balance of the Greenland ice sheet and the surrounding smaller glaciers is negative at -74 mma^{-1} with an accumulation of 297 mma^{-1} w.e. (519 km^{3}a^{-1} w.e.), melt ablation -169 mma^{-1} w.e. (-296 km^{3}a^{-1} w.e.), calving ablation -181 mma^{-1} w.e. (-316 km^{3}a^{-1} w.e.) and the bottom melt -21 mma^{-1} w.e. (-35 km^{3}a^{-1} w.e.). At present, it is difficult to detect any statistically significant trends for these components. The total mass balance of the Antarctic ice sheet is considered to be too premature to evaluate.

The estimated sea-level contributions in the 20th Century are 3.7 cm by mountain glaciers and ice caps, 3.5 cm by Greenland, 2 cm by ocean thermal expansion. The difference of 8 cm between these components and the estimated value with tide-gage networks (17 cm) must be caused by the mass balance of Antarctica and other sources that were not considered in the present work, for example, the melt of permafrost.

Key words：glacier, ice sheet, mass balance, climate change, radiation
キーワード：氷河，氷床，質量収支，気候変化，放射

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