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Glacier mass loss commitment limits influence of climate change mitigation on glaciers

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Glacier mass loss is a key contributor to sea-level change. Glaciers have been contributed to around 40% of sea-level rise during the 20th century and will continue to be an important part of sea-level rise during the 21st century (Church et al., 2013). Understanding the causes, mechanisms, and time scales of glacier change is therefore paramount to identifying successful strategies for mitigation and adaption to glacier-related environmental change.

Using an open glacier model (Marzeion et al., 2012) and an updated version of the Randolph Glacier Inventory, we present an update of projections of glacier evolution during the 21st century. For all scenarios. i.e. Representative Concentration Pathways (RCP) 2.6, 4.5, 6.0 and 8.5 from IPCC report, plus RCP2.6 scaled to 1.5K and 2K global warming, glacier mass loss is accelerating until the middle of the century. Different rates of glacier mass loss change between scenarios emerge only around 2040-50. Differences of global glacier mass is visible only after 2060 between RCP8.5 and RCP 2.6 scaled to 1.5K global warming, and no differences emerge before the end of the century between 1.5K and 2K global warming. Glaciers are projected to lose respectively 76 (54 to 97) mm SLE (Sea-Level Equivalent), 84 (54 to 116) mm SLE and 142 (83 to 165) mm SLE under the 1.5K, 2K and RCP8.5 scenarios. Depending on the scenarios and the evolution of other sea-level change components, it will represent between 15 and 35% of sea-level rise at the end of the 21st century.

We also showed that most of this future glacier mass loss is already committed, and will be a response to climate change caused by past greenhouse gas emissions. The glacier mass loss under current climate is estimated to 112 mm SLE (85 to 134) whereas commitments of future ice mass loss are respectively 159 mm SLE (115 to 179) and 191 mm SLE (139 to 205) for 1.5K and 2K global warming. These values represent respectively around 70 and 60% of current climate glacier mass loss, i.e. mass loss commitments originating from greenhouse gases emitted before the Paris Agreement (limited global warming under 1.5 degree at the end of the 21st century).

Mitigating climate change through reduced greenhouse gas emissions therefore only has a limited influence on glaciers in the 21st century, as a large fraction of that mass loss is the realization of past commitments, i.e. the 20th century climate change. Consequently, a significant part of sea-level rise is already committed by the glacier response time to climate change. That idea can be extended to other components of sea-level rise, e.g. ice sheets and steric sea-level, who have a time response even longer than glaciers.