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Potential Impacts of Climate Change on Glacierized Volcanic Systems

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The strong short-and long-term linkages between Earth's climatic and volcanic systems mean that future climate change will impact volcanic systems. At glacierized volcanoes, of which we estimate there are between 180 and 450 on Earth today, these impacts are especially strong, and so these volcanoes will likely experience the largest effects from climate change over the next century. Here we present an integrated view of a glacierized volcanic system based on a composite of known glaciovolcanoes to highlight areas most likely to be influenced by ongoing climate change. Presently on Earth, a wide diversity of volcano-ice systems exists. In the Antarctic, some volcanoes are covered by more than a kilometer of ice, while locally in Iceland, Chile, Alaska, British Columbia, and possibly Kamchatka volcanoes have ice cover that varies from tens of meters to more than 200 m in thickness. Future changes in ice thickness, area and mass could impact volcanic and surrounding glacial systems in at least four ways. (1) Because active volcanic systems are very sensitive to pressure changes, thinning of ice could change eruption dynamics. This will be seen most drastically with respect to volatile-driven fragmentation and explosivity, but also changes in magma buoyancy (e.g., 2010 Eyjafjallajökull; Hoodoo Mountain). (2) Global warming is likely increasing the liquid water at the ice-rock interface at the top of glacierized volcanic systems, which may increase rates of ice transport, destabilize slopes, and increase phreatic activity (e.g., 2013 Kverkfjöll). (3) Overlying ice can increase warning times before an eruption (e.g., 1980 Mt. St. Helens; Katla and Oræfajökull ongoing), so loss of ice could reduce warning times. This may be offset somewhat by lessening of lahar hazards due to ice loss. (4) Changes to global high-level winds (jet streams) will change ash transport and precipitation patterns, which will have positive and negative feedbacks on glacierized volcanoes (e.g., Gigjökull glacier on the northern flank of Eyjafjallajökull). While the impact of climate change of each ice-volcano system is somewhat unique, integration of recent eruption observations, global spatial analysis, and developments in modelling of degassing and fragmentation will help build a generalized model for climate change at glacierized volcanoes.