GLACIER-VOLCANO INTERACTION IN THE KATLA CALDERA: A BOX MODEL OF AVAILABLE MELTWATER

by

MEGHAN SHARP

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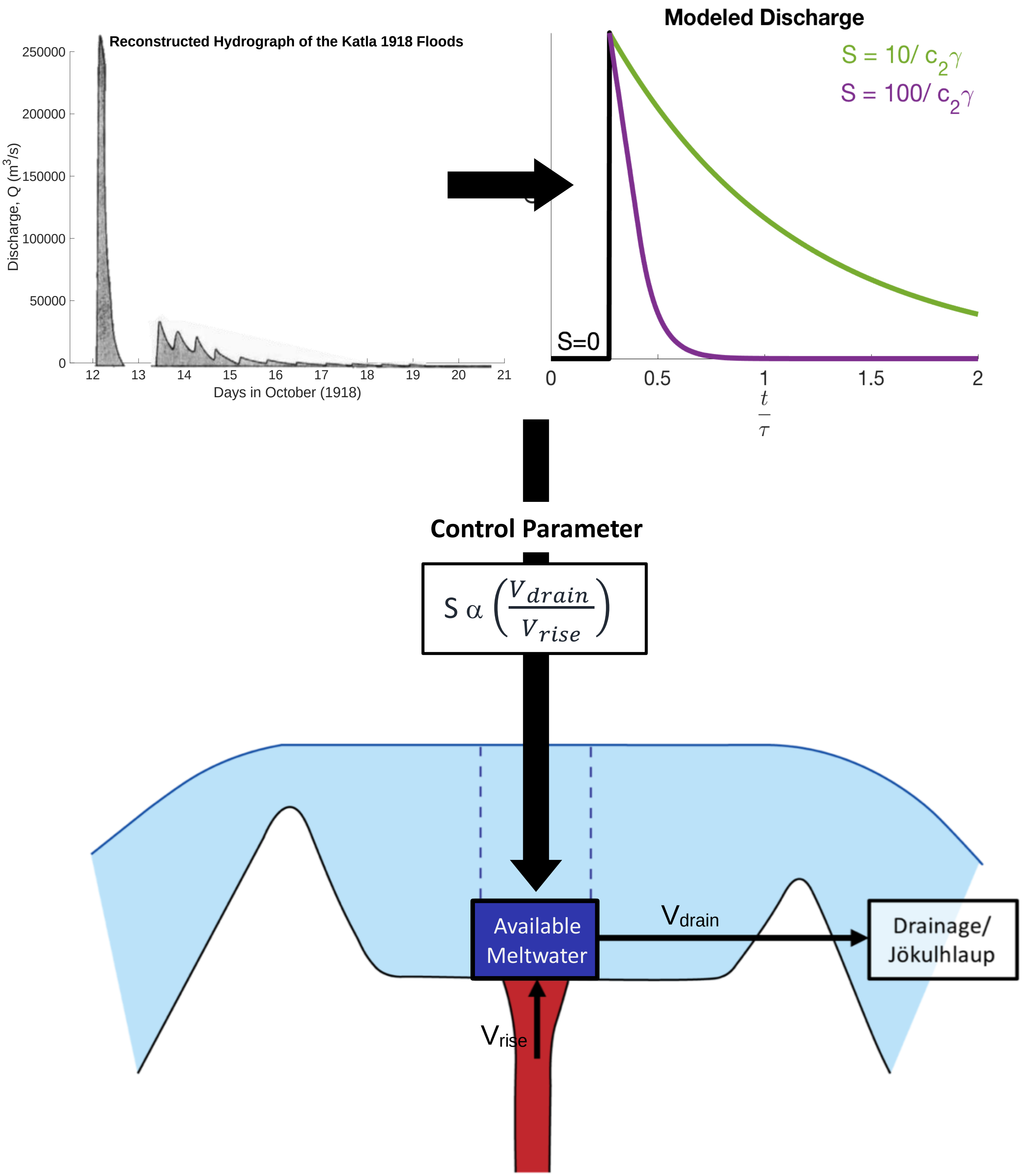
Graphical Abstract



Abstract

The eruption of Katla in 1918 broke through 400m of overlying ice in 2 hours and produced a large jökulhlaup within the first 30 minutes. The observed hydrograph from the floods is not consistent with typical hydrographs explained by the Nye theory, in which a single basal tunnel enlarges due to melting. The 1918 hydrograph, in combination with the geometry of the bed topography in the Katla caldera and ice thickness of the overlying Mýrdalsjökull, is used to estimate the growth of a meltwater lake that accumulates and remains available to the eruption. A system of evolution equations for ice thickness and the thickness of a meltwater lake, developed from a box model, gives rise to a new control parameter: the Storage parameter, S, that is proportional to the rate of drainage and inversely proportional to the rate of meltwater production. The e-folding time from the observed hydrograph sets the S regime based on modeled hydrographs that capture the observed behaviour, yielding S on the order of 10 for the Katla 1918 eruption. The model estimated duration of the subglacial phase of the eruption is on the order of 2 hours and jökulhlaup onset is on the order of 30 minutes, both in agreement with observations. The relationship between meltwater production and meltwater drainage has significant implications for glaciovolcanic hazard assessments, volcanic climate forcing, and astrobiology.