Submitted Abstract

ID IMC22-FSAbstr- 758

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Organisations	University of Britsh Columbia, Canada
Country	Canada
Region	North America
Title	Historic And Future Post-Retreat Land-Cover Evolution And Its Hydrological Consequences At Bridge Glacier, Canada.
Keywords	Hydrology, Vegetation, Glacier, Remote Sensing, Cumulative Impacts
Type	List Of Focus Session
Focus Session ID	72

Abstract

The downstream effects of shrinking glaciers on water supply and water quality have received substantial attention using both empirical analysis of historic data and computer modelling to make future projections under climate-change scenarios. Most modelling studies replaced glacier cover with open or alpine land cover following retreat and have not accounted for vegetation or soil development on deglaciated areas or formation of proglacial lakes. The objective of this study is to quantify the historic and potential future hydrologic impacts of land cover change on a glacierized mountain catchment. The study focused on the catchment area for Bridge River in the southern Coast Mountains of British Columbia, which contains Bridge Glacier, a lake-terminating valley glacier.

Field observations and remotely sensed data are used to document glacier retreat, lake surface temperatures, and the evolution of vegetation in deglaciated forelands and valley walls. Since 1980, the Bridge Glacier terminus has retreated 4.75 km. Glacier area declined from 89 to 74 km2, while the proglacial lake grew from 2 to 7.6 km2 and vegetation cover increased from 33 to 46 km2. While the terminus continued to calve icebergs in 2021, iceberg density in the lake peaked around 2011 and is currently minor. This reduction in iceberg density has been accompanied by increases in remotely sensed lake surface temperatures and river temperatures observed at the gauging station two kilometers downstream of the lake outlet.

The valley sidewalls have exhibited substantial expansion of shrubby vegetation, especially in areas where soil moisture is supported by topographic convergence. Scattered coniferous trees have established in the deglaciated valley wall downslope of subalpine forest above the Little Ice Age trimline. Using satellite-based vegetation indices, field surveys of vegetation, mapped surface exposure ages, and topographic data, we are developing an auto-logistic spatiotemporal model of vegetation expansion. This model will be combined with existing projections of future glacier change to represent future land cover change within the catchment.

The Raven modelling platform will be used to simulate streamflow for historic and projected future conditions. The model will incorporate dynamic land cover, and calibration will be based on a multi-criterial approach involving streamflow, snow cover and glacier mass changes. The calibrated model will be used to diagnose the relative roles of climate change, glacier retreat and vegetation succession on historic streamflow, and to project changes in streamflow under future climate and land-cover change scenarios.