Title: Distribution and biophysical processes of beaded streams in Arctic permafrost landscapes

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Abstract

Beaded streams are widespread in permafrost regions and are considered a common thermokarst landform. However, little is known about their distribution, how and under what conditions they form, and how their intriguing morphology translates to ecosystem functions and habitat. Here we report on a Circum-Arctic survey of beaded streams and a watershed-scale analysis in northern Alaska using remote sensing and field studies. We mapped over 400 channel networks with beaded morphology throughout the continuous permafrost zone of northern Alaska, Canada, and Russia and found the highest abundance associated with medium- to high- ground-ice content permafrost in moderately sloping terrain. In one Arctic Coastal Plain watershed, beaded streams accounted for half of the drainage density, occurring primarily as low-order channels initiating from lakes and drained lake basins. Beaded streams predictably transition to alluvial channels with increasing drainage area and decreasing channel slope, although this transition is modified by local controls on water and sediment delivery. Comparison of one beaded channel using repeat photography between 1948 and 2013 indicate a relatively stable landform and ^{14}C dating of basal sediments suggest channel formation may be as early as the Pleistocene-Holocene transition. Contemporary processes, such as deep snow accumulation in riparian zones effectively insulates channel ice and allows for perennial liquid water below most beaded stream pools. Because of this, mean annual temperatures in pool beds are greater than 2°C, leading to the development of perennial thaw bulbs or taliks underlying these thermokarst features that range from 0.7 to 1.6 m. In the summer, some pools thermally stratify, which reduces permafrost thaw and maintains coldwater habitats. Snowmelt generated peak-flows decrease rapidly by two or more orders of magnitude to summer low flows with slow reach-scale velocity distributions ranging from 0.01 to 0.1 m/s, yet channel runs still move water rapidly between pools. The repeating spatial pattern associated with beaded stream morphology and hydrological dynamics may provide abundant and optimal foraging habitat for fish. Beaded streams may create important ecosystem functions and habitat in many permafrost landscapes and their distribution and dynamics are only beginning to be recognized in Arctic research.