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Fire effects on hydrochemistry of streams draining watersheds with continuous permafrost distribution in Central Siberia

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Wildfires, assumed to be the main disturbance factor in the boreal biome, are tended to increase in frequency and severity under "dry warming" (Conard et al. 2002). Short fire-return interval in larch dominated permafrost terrains of Siberia (Kharuk et al., 2008) exert significant control on ecosystem biogeochemical cycling throughout the complex influences of deforestation, ground vegetation and organic layer combustion as well as deepen soil active layer. Despite extensive research of fire impact on carbon exchange between soil, forest biomass and atmosphere in permafrost affected regions of Siberia, much less is known on the role of fire in control of element transport in rivers and watersheds affected by fire events.

To analyze the effect of fires on chemical composition of surface fluids in permafrost zone, fourteen small forested watersheds (3-25 km2) have been selected in mid-stream of Nizhnyaya Tunguska River (Yenissey basin, Central Siberia, Russia). Analysis of larch trees in forest stands of the area demonstrated that presumably all basins were affected by wildfires in the past. Selected watersheds have been influenced by ground fires (>90% of watershed area) ca 110, 60 and 15 years ago (respectively in 1899, 1947 and 1993). Water sampling campaign has been conducted from snowmelt (mid-May) to the start of freezing (mid-October) on weekly and/or monthly interval in 2006-2009. In this study, we analyzed the dissolved loads for major and trace element concentrations. In terms of concentration changes in the course of the year, concentrations of dissolved organic carbon (DOC as well as associated elements like Fe, Al, Y and REE) and inorganic ions (e.g. DIC, Cl, Ca, Na, Mg etc.) demonstrated opposite tendencies during a frost-free season in all streams. However, basins with recent fire effect exhibited generally lower DOC concentrations in streams along with much more pronounced seasonal increase in concentrations of inorganic compounds. The increased active layer thickness and major element leaching from mineral soil is the most likely cause of inorganic component concentration increase in watersheds affected by fire events. The larger watersheds have also shown talik (permanently unfrozen zones) formation resulting in deep solute appearance in the surface runoff (high concentrations of Na and Cl ions). Decreased discharge and reduced DOC export in fire-affected watersheds have been suggested to result respectively from larger water-holding capacity of the deepening active soil layer, which developed after the fire events, and the combustion of the organic layer, which is the main DOC source. Thus, under a drier climate, fires impose two limitations of DOC release from watersheds: (1) decreasing mobile C-source (combustion of organic layer), and (2) decreased volume of draining water (increased water-holding capacity of soil). Comparable concentrations of elements in streams draining from watersheds burnt 50 and 100 years ago corroborate earlier estimates of a recovery time of 50 years for ecosystem structures of larch forests of the region.