Will Boreal Ecosystems become Wetter or Drier in Response to a Warming Climate

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There is much concern about a potentially "accelerated" hydrologic cycle, with associated extremes in weather and climate-related phenomena. Whether this translates into wetter or drier conditions across arctic landscapes remains an open question. Arctic ecosystems differ substantially from those in temperate regions, largely due to the interactions of extremes in climate and land surface characteristics. Ice-rich permafrost prevents percolation of rainfall or snowmelt water, often maintaining a moist to saturated active layer where the permafrost table is shallow. Permafrost may also block the lateral movement of groundwater, and act as a confining unit for water in sub- or intra-permafrost aquifers. However, as permafrost degrades, profound changes in interactions between groundwater and surface water occur that affect the partitioning among the water balance components with subsequent impacts to the surface energy balance and essential ecosystem processes.

Most simulations of arctic climate project sustained increases in temperature and gradual increases in precipitation over the 21st century. However, most climatic models do not correctly represent the essential controls that permafrost exerts on hydrological, ecological, and climatological processes. If warming continues as projected, we expect large-scale changes in surface hydrology as permafrost degrades (Hinzman et al., 2013). Where groundwater gradients are downward (i.e. surface water will infiltrate to subsurface groundwater), as in most cases, we may expect improved drainage and drier soils, which would result in reduced evaporation and transpiration (ET). In some special cases, where the groundwater gradient is upward (as in many wetlands or springs) surface soils may become wetter or inundated as permafrost degrades. Further, since soil moisture is a primary factor controlling ecosystem processes, interactions between ecosystems, GHG emissions, and high-latitude climate must also be considered highly uncertain. These inter-dependent processes will exert primary controls on several important feedback processes and vary across space and time in some as yet, unknown way.