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Impacts of freeze-thaw processes and transpiration on the magnitude and seasonality of river runoff in Siberia

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The water balance in high-latitude permafrost regions is highly influenced by soil thermal dynamics. Thaw depth impacts directly available water holding capacity of the soil, thus runoff, and the timing of freeze and thaw processes plays a key role for the water balance. The beginning snow melt above a still frozen ground leads to a runoff peak in spring. This amount of water will not be stored in the soil for the vegetation that is starting a few weeks later. In addition, water supply during the growing season is restricted by thaw depth in large regions in Central and Eastern Siberia. This has consequences on the amount of biomass in the different plant compartments. Thus, freeze-thaw processes indirectly impact the water balance through an altered leaf area index. To quantify these effects on a continental to global scale, we incorporate a permafrost module into the Lund-Potsdam-Jena dynamic global vegetation model (LPJ-DGVM). This model mechanistically predicts vegetation structure and distribution, carbon and water exchanges between the land surface and the atmosphere, and daily thaw depth in permafrost regions from climate, atmospheric CO2 and soil texture data. For this, the concept of average individuals is applied to scale the relevant processes to a spatial resolution of 0.5°. In this work, the LPJ-DGVM is coupled with two different global satellite maps providing the vegetation composition and density, to include the heterogeneity of the real land surface in this scaling process. The accumulated runoff in catchments of large Siberian rivers, as simulated by this most enhanced LPJ model version, agrees well with observed river discharge values in both, the seasonality and annual magnitude. The further comparison with results of simulations without the consideration of freeze-thaw processes or satellite-derived vegetation coverage demonstrates the effects of soil thermal dynamics or transpiration on the water balance in Siberia.