Increased winter runoff in Siberia modeled with tree rings as evidence for the recent high rate of permafrost degradation

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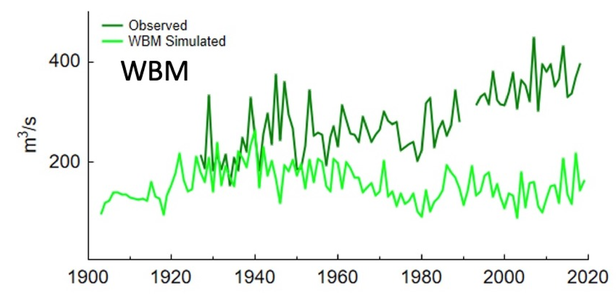
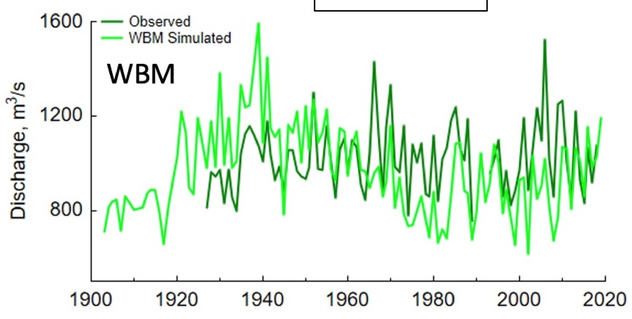
Modeled Discharge of the Yenisei River

Winter



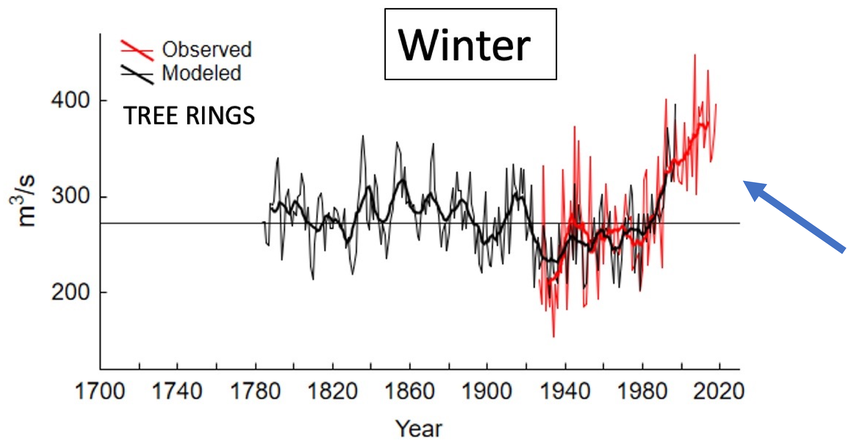
Annual

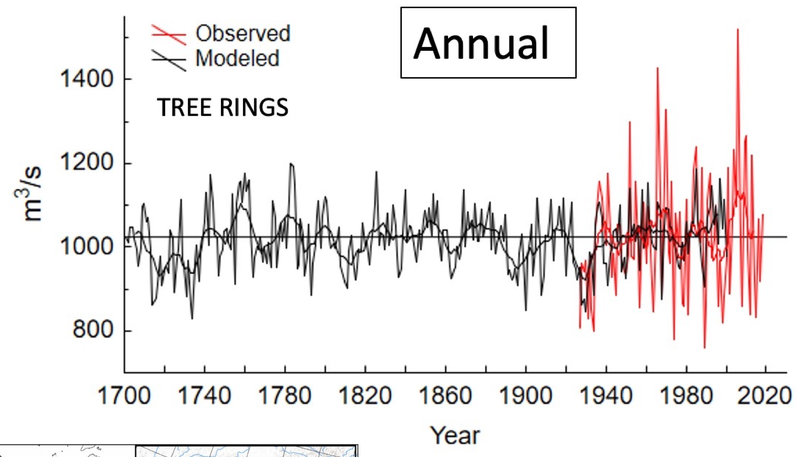


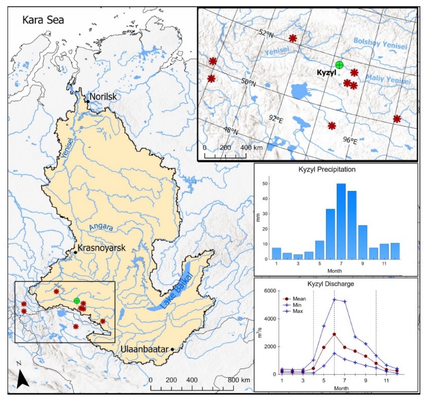
Winter (Nov-Apr) and annual (Oct-Sept) discharge of the Yenisei River at the Kyzyl gauge modeled with the New Hampshire Water Balance Model.

Map of the Yenisei River Basin and tree-ring sites used in the modeling. Hydrograph of the Kyzyl gauge and precipitation at the Kyzyl station. Snow and summer rainfall are the major sources of water in the upper reaches (35% and 42%, respectively). The winter flow relies on the underground water which is 23% of the annual flow. The winter flow measures 12% of the annual discharge and persists longer (140-150 days), while the spring-summer contribution is up to 75%.

Accelerating warming in the Arctic and fast loss of sea-ice cover unfolding over the last 20 years, is known as Polar or Arctic Amplification. **What do we know about the feedback of terrestrial hydrology coupled with the Arctic system?**



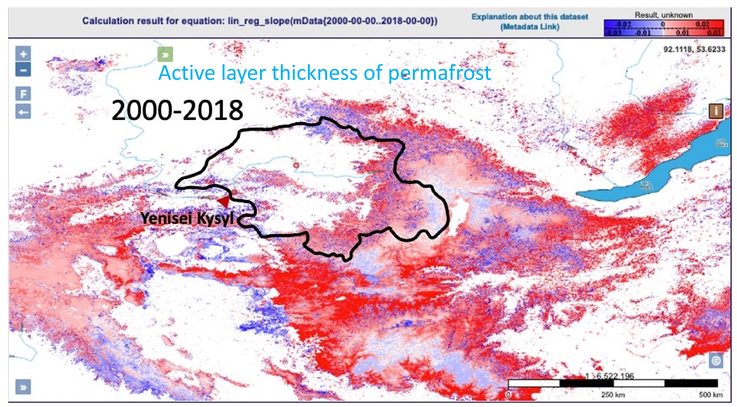




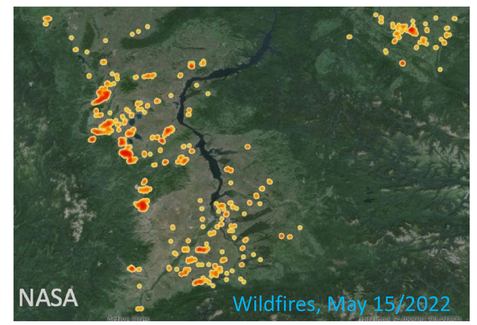
Winter (Nov-Apr) and Annual (Oct-Sept) discharge of the Yenisei River at the Kyzyl gauge reconstructed from larch rings.

We found a remarkable **80% upsurge** in winter flow over the last 25 years, which is unprecedented from 1785. In contrast, the annual discharge shows only a **7% increase** and normal range of variability. Water balance modeling with CRU data indicates a significant discrepancy between decadal variability of the gauged flow and climate data after 1960. Instrumental data shows 7%-20% increase in annual discharge of the major Eurasian rivers like Ob, Yenisei and Lena (1936-2018).

Feedback Loops of Terrestrial Hydrology



As the permafrost degrades, increased connectivity between surface and ground water leads to enhanced ground water discharge and recharge.



As the Polar Vortex wobbles, the weakened Jet Stream causes extreme weather anomalies in the midlatitudes. The long-term impact of wildfire intensity on forest ecosystems and permafrost is another important factor driving the permafrost degradation.