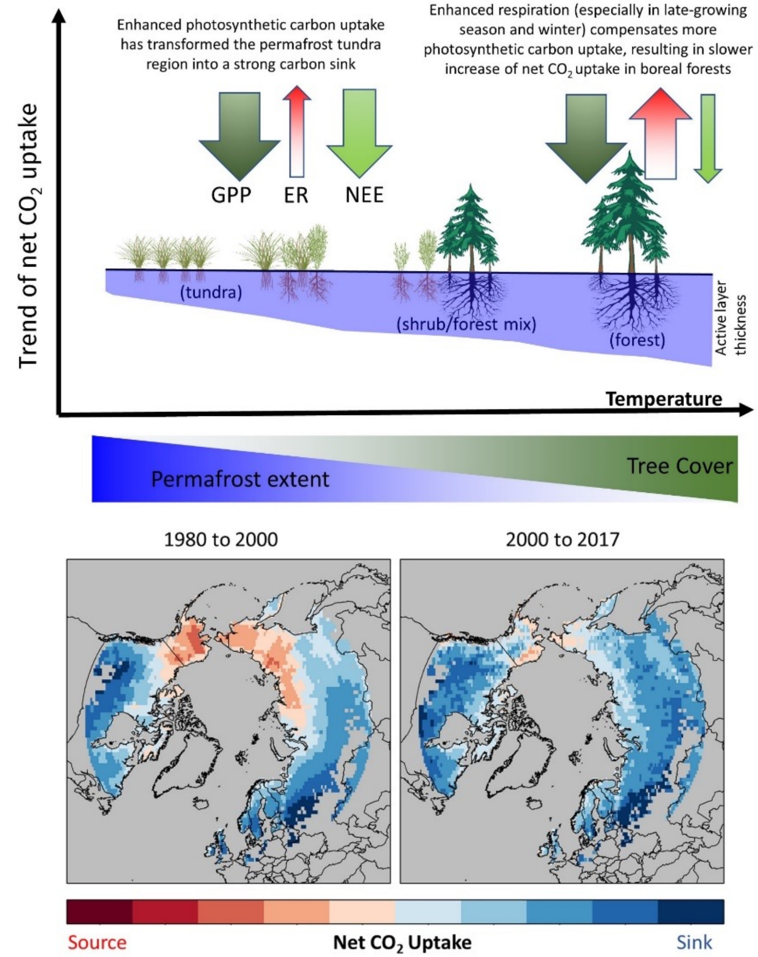
Respiratory loss during late-growing season determines the net CO_2 sink in northern permafrost regions

Background: Amplified warming of the northern high latitudes (NHL, >50 ºN) is driving widespread permafrost (PF) thaw, potentially exposing a large global reservoir of soil organic carbon to enhanced decomposition and carbon dioxide (CO_2) greenhouse gas emissions. However, warming has increased photosynthetic CO_2 uptake, offsetting CO_2 emissions from soil decomposition and respiration, and creating uncertainty about the net CO_2 balance of NHL ecosystems.

Analysis: We conducted an integrated analysis of satellite data, CO_2 flux measurements, Atm. CO_2 inversions, and ensemble DGVM predictions to clarify recent (1980-2017) trends in net CO_2 exchange and underlying drivers along major NHL climate, PF, and land cover gradients.

Findings: The PF tundra region has become a strong CO_2 sink and grown faster than in boreal forest since the 1980's, shifting from near-neutral conditions to a net annual carbon sink at the turn of this century. The driving mechanism is enhanced early growing season CO_2 uptake from photosynthesis outpacing late-season respiratory losses. Greater late season respiration with expanding forest cover weakens the boreal CO_2 sink more than in PF tundra.

Significance: Challenges notions that PF regions are becoming a net CO_2 source, and northern forests as a future carbon sink with global warming.



Top: Illustrated annual net CO_2 uptake variation along the PF tundra to boreal forest gradient; **Bottom**: Atm. CO_2 inversions show NHL annual net CO_2 uptake change from early (1980-2000) to recent (2000-2017) decades; blue (red) shades denote greater CO_2 sink (source) activity.

Liu, Kimball, Ballantyne, et al., 2022. *Nature Communications.*