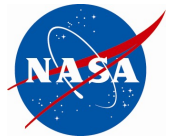




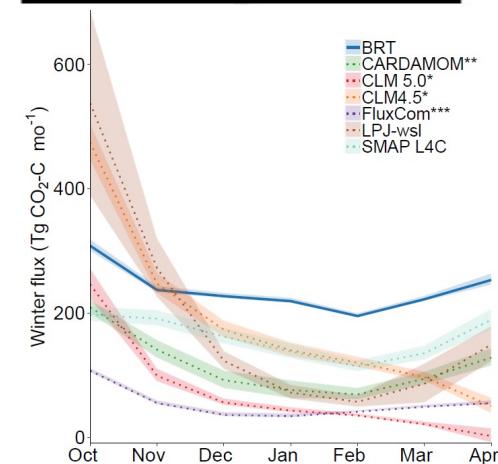
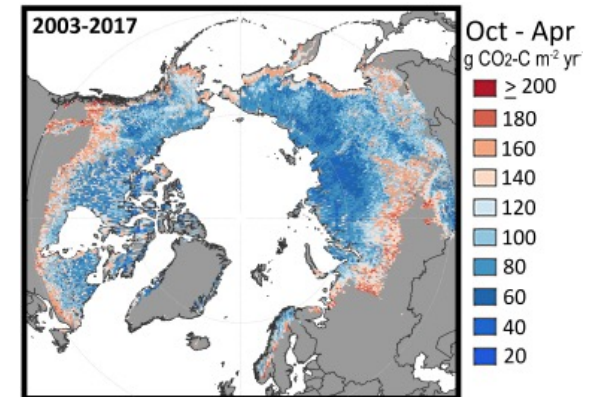
# Large Loss of CO<sub>2</sub> in Winter Observed Across the Northern Permafrost Region



**Problem:** Amplified winter warming in the Arctic is expected to enhance soil CO<sub>2</sub> emissions, but the amount of winter CO<sub>2</sub> loss and its impact on the annual carbon budget is highly uncertain.

**Finding:** Estimated winter CO<sub>2</sub> loss (1662 Tg C yr<sup>-1</sup>) is larger than growing season CO<sub>2</sub> uptake (1032 Tg C yr<sup>-1</sup>). Enhanced soil CO<sub>2</sub> loss from winter warming is degrading the northern carbon sink based on flux observations and SMAP L4-C estimates.

**Impact:** Reduced uncertainty regarding winter CO<sub>2</sub> emissions and their impact on the boreal-Arctic annual carbon budget.



**Top:** Estimated mean winter (Oct-Apr) CO<sub>2</sub> emissions over the northern permafrost zone (2003-2017) derived from machine learning (BRT) upscaling of in situ soil respiration measurements.

**Lower:** Comparison of BRT winter CO<sub>2</sub> emissions with other model & observation estimates, including SMAP L4C.