COS-derived GPP relationships with temperature and light help explain high-latitude atmospheric CO_2 seasonal cycle amplification

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Background:

- The seasonal cycle amplitude (SCA) of atmospheric CO_2 have substantially increased in the north high latitudes. The relative contributions from gross primary production (GPP) and ecosystem respiration (ER) change to this enhanced SCA in high latitudes were unclear. A large part of this unknown was due to inability to quantify GPP separately from ER on large spatial scales.

Analysis:

- We developed a new regional inversion system (CT-L-COS) to quantify regional GPP over the North American Arctic and Boreal region directly from atmospheric COS measurements.
- We further estimated regional ER using GPP and NEE derived from atmospheric COS and CO2 inversions.
- This analysis was compared with satellite remote sensing products (SIF and MODIS NIRv), NASA MsTMIP GPP products, FluxSat, and FluxCom. FluxSat and FluxCom are machine learning products that use satellite remote sensing measurements.
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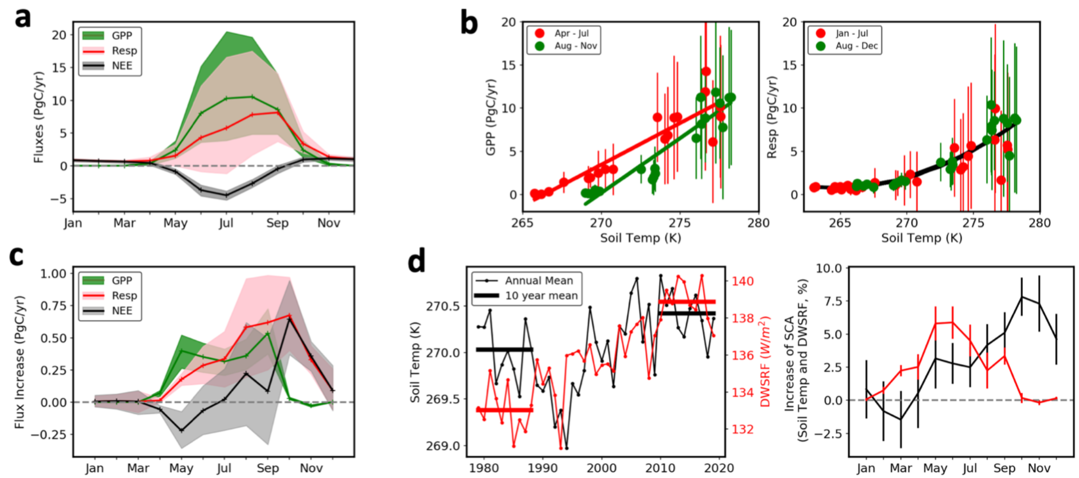

The atmosphere-based estimates of the multi-year average seasonal cycle of GPP, ER, and NEE and estimation of their warming-induced seasonal cycle amplification over the North American Arctic and Boreal region (ABR).

Significance:

Terrestrial ecosystem feedbacks exert a large uncertainty in climate projections. This uncertainty arises in part from poor quantification of gross CO_2 fluxes and their sensitivity to climate change over large spatial scales. Here we demonstrate the usefulness of carbonyl sulfide (COS) for quantifying photosynthetic CO_2 uptake in the Arctic and Boreal ecosystems despite uncertainties in COS sources and sinks. The results highlight how the combination of atmospheric COS and CO_2 observations provides new insights into past terrestrial ecosystem changes and can be utilized as a new tool for direct quantification of these feedbacks impacted by climate change over the Arctic and Boreal ecosystems in the future.

Findings:

- The analysis of atmospheric observations of the novel trace gas carbonyl sulfide has improved our understanding of gross photosynthetic uptake of carbon dioxide in the North American Arctic and Boreal region.
- The COS-derived gross primary production (GPP) shows significant correlations in space and time with satellite-based GPP proxies, solar-induced chlorophyll fluorescence, and near-infrared reflectance of vegetation.
- Results imply past Arctic warming resulted in a larger increase of GPP than ecosystem respiration (ER) in the spring, but smaller increases in the fall due to light restrictions. The changes help explain the increased seasonal variations observed for CO2 in this region over recent decades and should enhance our ability to track changes in these gross fluxes and climate-carbon cycle feedbacks in the future.