Resolving heterogeneous fluxes from tundra halves the growing season carbon budget

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Science Question

- Tundra ecosystems are heterogeneous at multiple scales. Plant functional types, soil moisture, thaw depth, and microtopography, for example, vary across the landscape and influence carbon dioxide (CO_2) and methane (CH_4) fluxes.
- However, landscapes are often assumed to be homogeneous when interpreting eddy covariance (EC) fluxes, which can lead to biases when gap-filling and scaling up observations to determine regional carbon budgets.
- We unmix EC fluxes into constituent land-cover fluxes to investigate how the scale of heterogeneity affects regional carbon budgets.

Analysis

We use three analytical footprint models, high resolution landcover maps (10-m) and Bayesian MCMC to gap-fill and un-mix EC fluxes of CO_2 and CH_4.

Results

- Traditional gap-filling methods performed worse at predicting artificially withheld gaps in CO_2 than those that accounted for heterogeneous landscapes.
- We identified and quantified hot spots of carbon fluxes in the landscape (e.g., late growing season emissions from wetlands and small ponds).
- Scaling while assuming a homogeneous landscape overestimated the growing season CO_2 sink by a factor of 2 and underestimated CH_4 emissions by a factor of 2 when compared to scaling with any method that accounts for landscape heterogeneity.

Significance

EC fluxes are under-utilized or potentially misleading if footprints are not taken into account in heterogeneous landscapes. Accounting for landscape heterogeneity in carbon fluxes could reduce uncertainty in bottom-up carbon budgets and the mismatch with top-down carbon budgets.
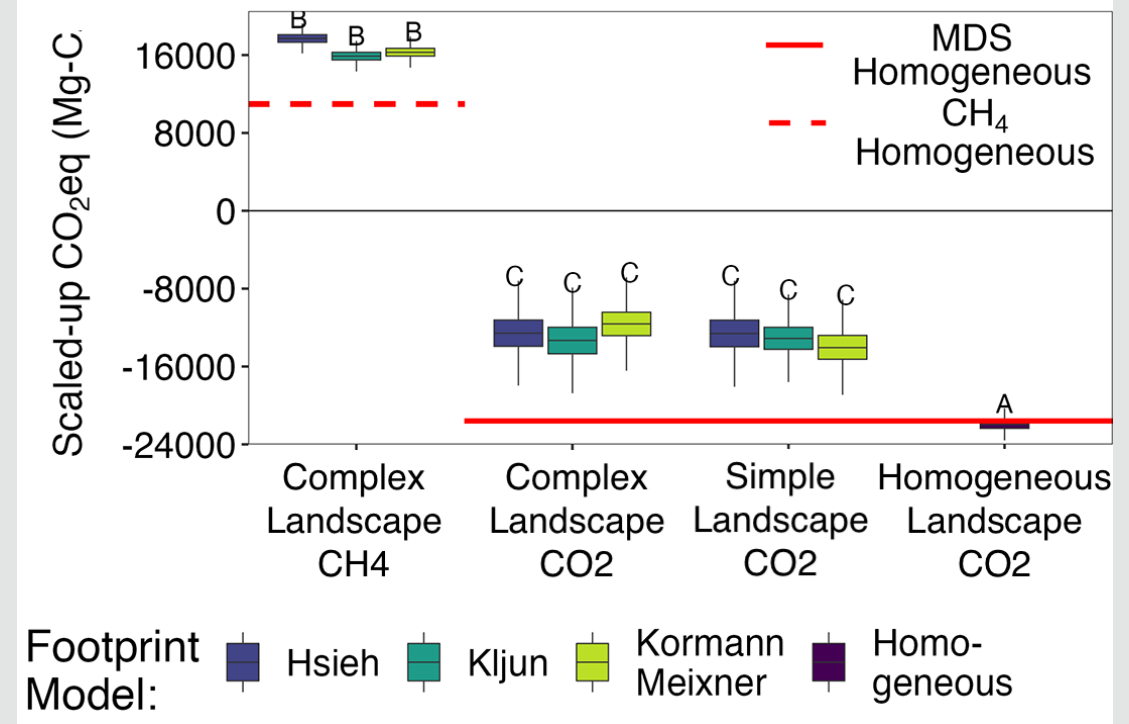
Growing season total carbon budgets for each gap-filling technique. Box-plots are Bayesian MCMC results with various landscape assumptions. Solid red-line is the marginal sampling distribution (MDS) gap-filling, dashed red-line is using diurnal average CH_4.