Methane Emissions from Alaska, Using CARVE 2012-2015 Aircraft Data and the STILT Model

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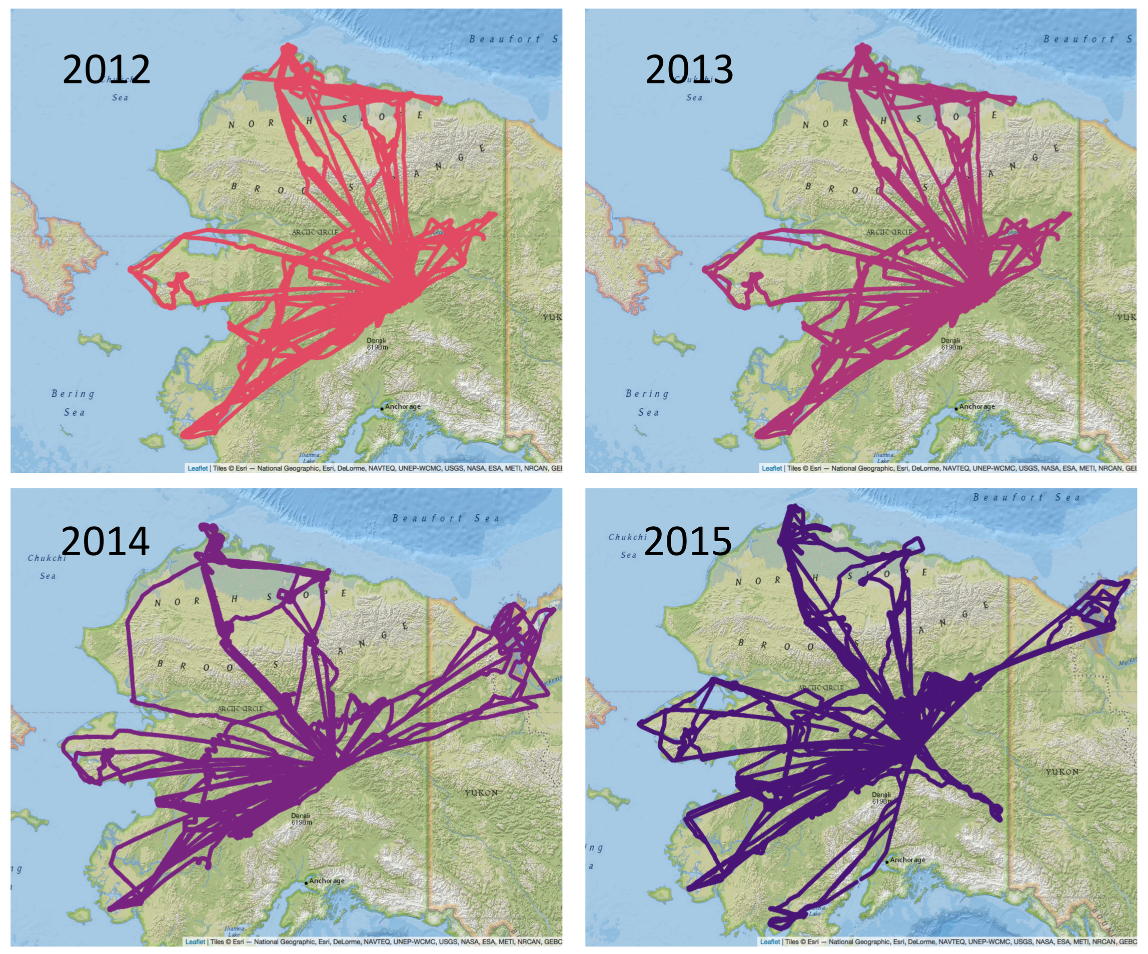


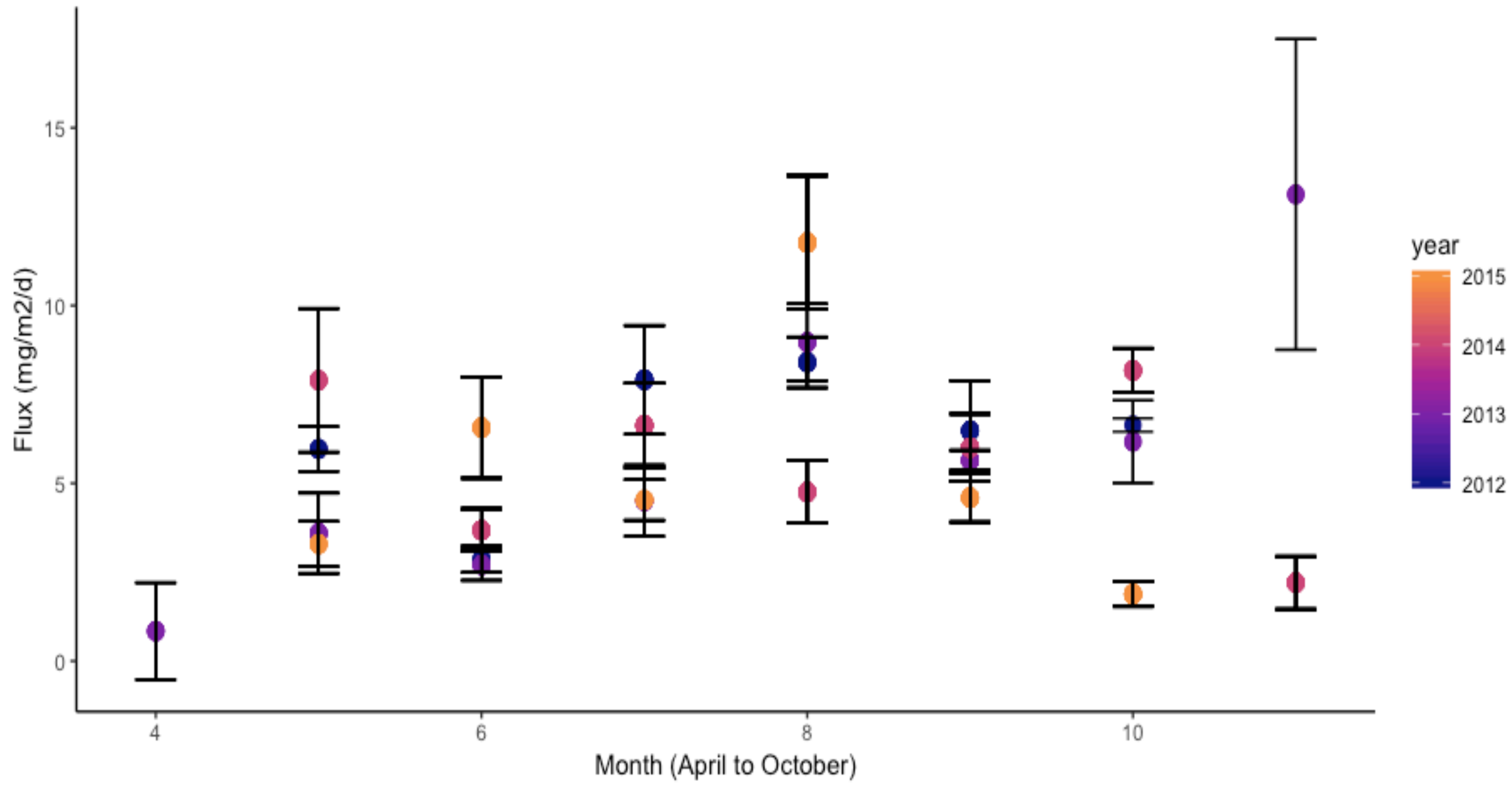
CARVE flight paths for years 2012-2015.

Introduction

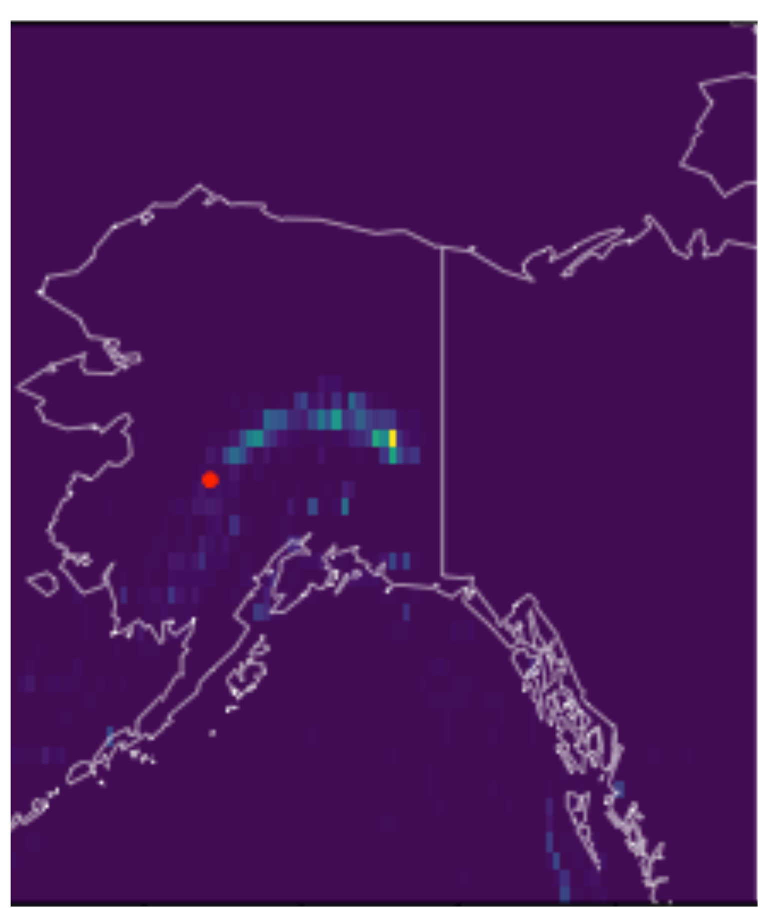
- There is concern for potential emissions from the Arctic due to the region's amplified warming and sizeable soil carbon stores.[1,2]

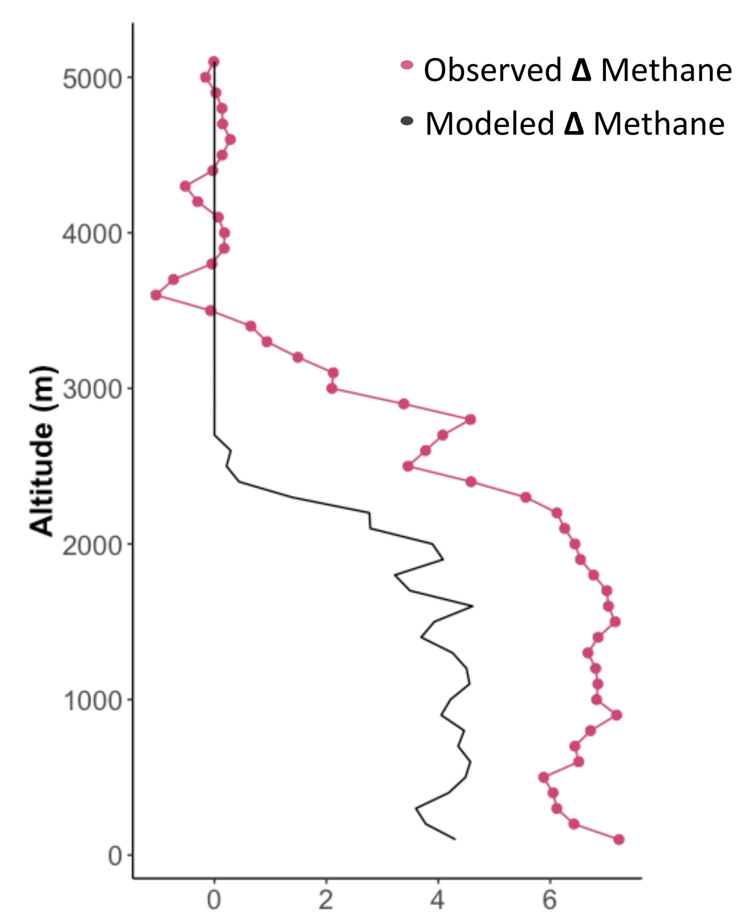
- Following the stabilization of atmospheric CH_4 concentrations (1999-2006), there have been consistent annual increases in CH_4 concentrations which cannot be fully explained by increases in fossil fuel emissions.[3,4]

- We examined seasonal and interannual CH_4 emissions across Alaska to quantify the contribution of biological methane production to the region's carbon budget.



Mean monthly methane flux for each year of CARVE (2012-2015). Observed monthly mean CH4 enhancement divided by monthly mean surface influence to determine mean flux. Two-sample t-test between methane flux from April-June and July-August shows that flux from Spring and Mid-Summer are significantly different, with a p-value of 0.022.





(left) Sample STILT footprint from the CARVE 2014 campaign. Red dot is aircraft receptor point.

(right) Sample vertical profile of observed and modeled CH4 enhancement above background concentration.

Approach

- The Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) conducted airborne atmospheric sampling over Alaska from April to November, 2012-2015.

- The location of the aircraft in space and time (x,y,z,t) was used to provide receptor points for running the STILT model, which determines a footprint of surface influence.

- We determined methane column enhancements over Alaska for each year (2012-2015) of the CARVE campaign by determining the background concentration of methane and the height of the boundary layer. The enhancement of methane above the background level within the boundary layer was density-weighted and integrated.

- Column analysis also applied to the vertical profile of surface influence from the STILT footprints.

- Error was determined by bootstrapping boundary layer height to vary assumed background concentration.

Conclusions

- Mean monthly methane flux peaks in the mid to late growing season, with methane flux from the spring (April-June) and summer (July-August) months showing significantly different flux values (p-value of 0.022 from t-test).

- Methane emissions continue into the fall with sizeable mean monthly methane flux measured as late as November.

- Flux values are comparable to those found by Chang et al. and Hartery et al. for previous CARVE campaigns[5,6] but significantly lower than aquatic chamber flux measurements conducted with the Polaris Project.

- Given that terrestrial fluxes from SW Alaska are close to zero in early summer, the high aquatic flux results highlight the importance of quantifying and incorporating emissions from inland waters.

Nonparametric Relationships between Variables and Observed Methane Enhancement

- STILT footprints have been convolved with masks for ecotype (boreal forest, tundra, taiga, and mountains) and spatial flux fields based on soil temperature, soil moisture and season.

- A generalized additive model using a LOWESS smoothing function will be used to determine dominant variables affecting methane emissions.

Form of a Generalized Additive Model:

$$\mathrm{E}(Y|X_1, X_2, \ldots, X_p) = \alpha + f_1(X_1) + f_2(X_2) + \cdots + f_p(X_p).$$

Literature cited

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