Validation of methane emission model using eddy covariance observations and footprint modeling.

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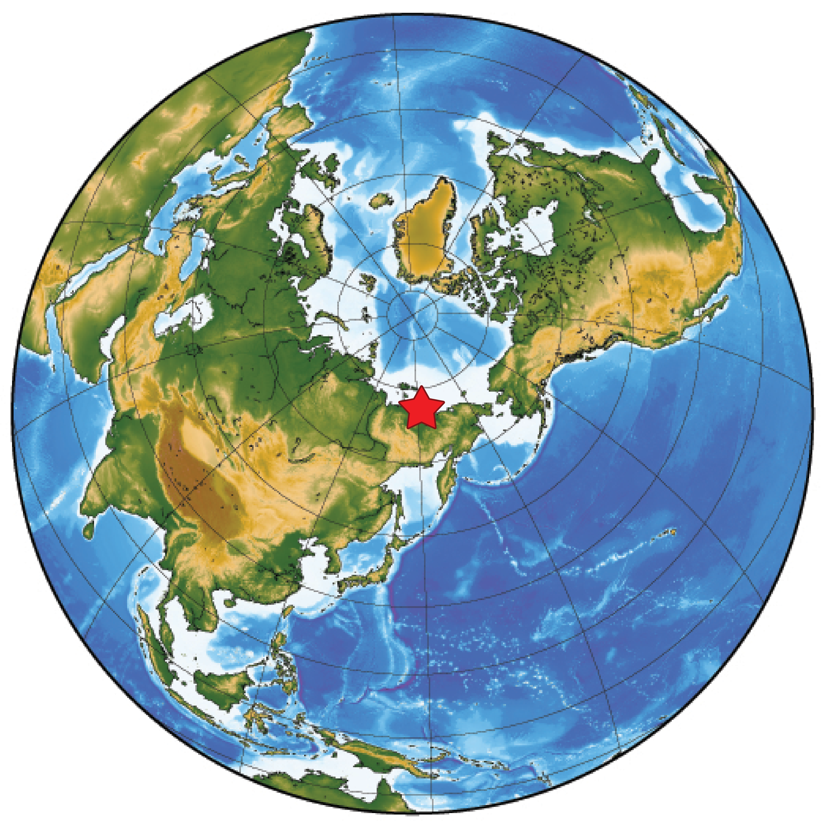
Introduction

Several methane emission models were developed recently (PEATLAND-VU, LPJ-WHyMe, DNDC). However, all of them are currently validated using chamber measurements of methane flux. While being simple and portable solution, chamber method has a number of disadvantages - temporal resolution is relatively low, small footprint (~ 1 m^2), decoupling of the surface from the atmosphere, hard to properly upscale fluxes to larger areas etc.
Eddy covariance (EC) technique on the other hand features a non-intrusive way to measure fluxes with high temporal resolution (measurements of up to 40 Hz) and large footprint (up to several km^2).
To validate the methane emission model on ecosystem scale, eddy covariance observations together with footprint modeling and vegetation mapping were used.

Materials & methods

Site location



The eddy covariance and chamber measurements were performed on the Kytalyk site, located in Indigirka lowlands. It is an Arctic tundra area with continuous permafrost and polygonal structure. The tower is situated in a lakebed of a former thermokarst lake.

Figure 1. The red star indicates the location of the site on the global map.

EC setup description and flux calculation

In this study, the following set of instruments was used: open path LI-7500, closed path LGR DLT-100, ultrasonic anemometer Gill R3-50. All data was collected at frequency of 10 Hz. Half-hourly fluxes were computed following the EUROFLUX methodology (Aubinet et al., 2000).

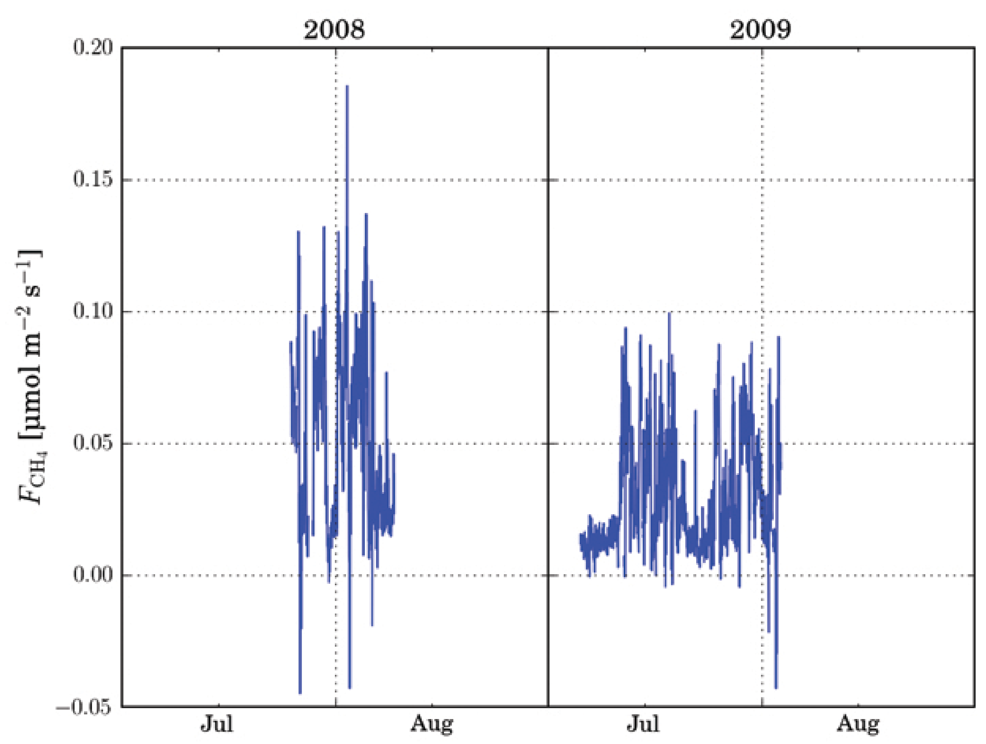


Figure 2. Methane fluxes during 2008 and 2009 calculated from EC data.

Methane emission model

PEATLAND-VU model was used in this study. It is a process based model developed by J. van Huissteden et. al. The model was calibrated with chamber flux measurements from the same site.

Vegetation map

GeoEye-1 image acquired on 19th of August, 2010 was used to produce the vegetation map. 31 georeferenced validation plots were used as training areas.
Classification is done using maximum likelihood classification algorithm implemented in ENVI.

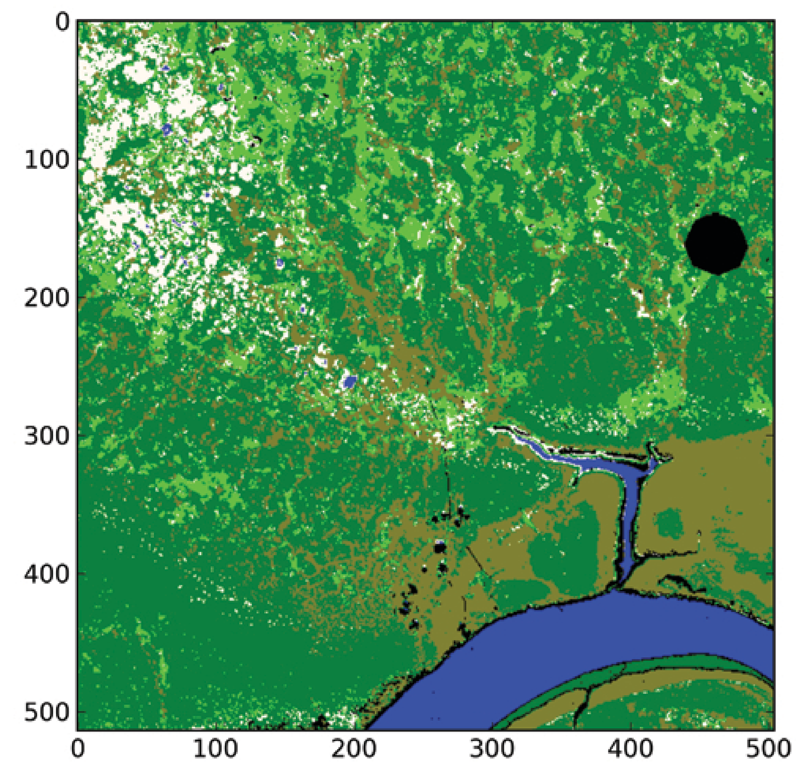


Figure 3. Vegetation map of the site, derived from GeoEye-1 image.

Footprint model

Kormann & Meixner, 2001 footprint model was used to assess vegetation distribution in EC footprint.

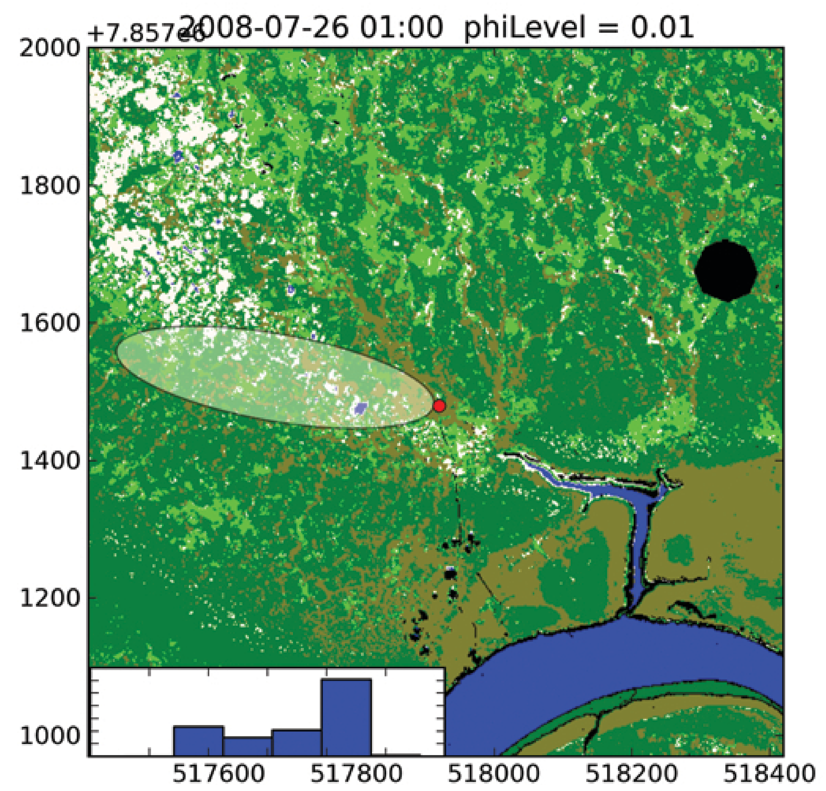


Figure 4. Example of output from footprint model, overlayed on the vegetation map. On the bottom left corner histogram of vegetation distribution inside the footprint is plotted.

Data processing

EC data was screened for these criteria: $-3 < z_m / L < +3$ and $u_\star / u < 1$ since footprint model fails to perform well in too stable or too unstable conditions and in highly turbulent flows.
Output from footprint model was overlayed over vegetation map and subsequently used in methane emission model, to calculate flux.
Eventually, the modelled flux was compared to EC flux.

Result

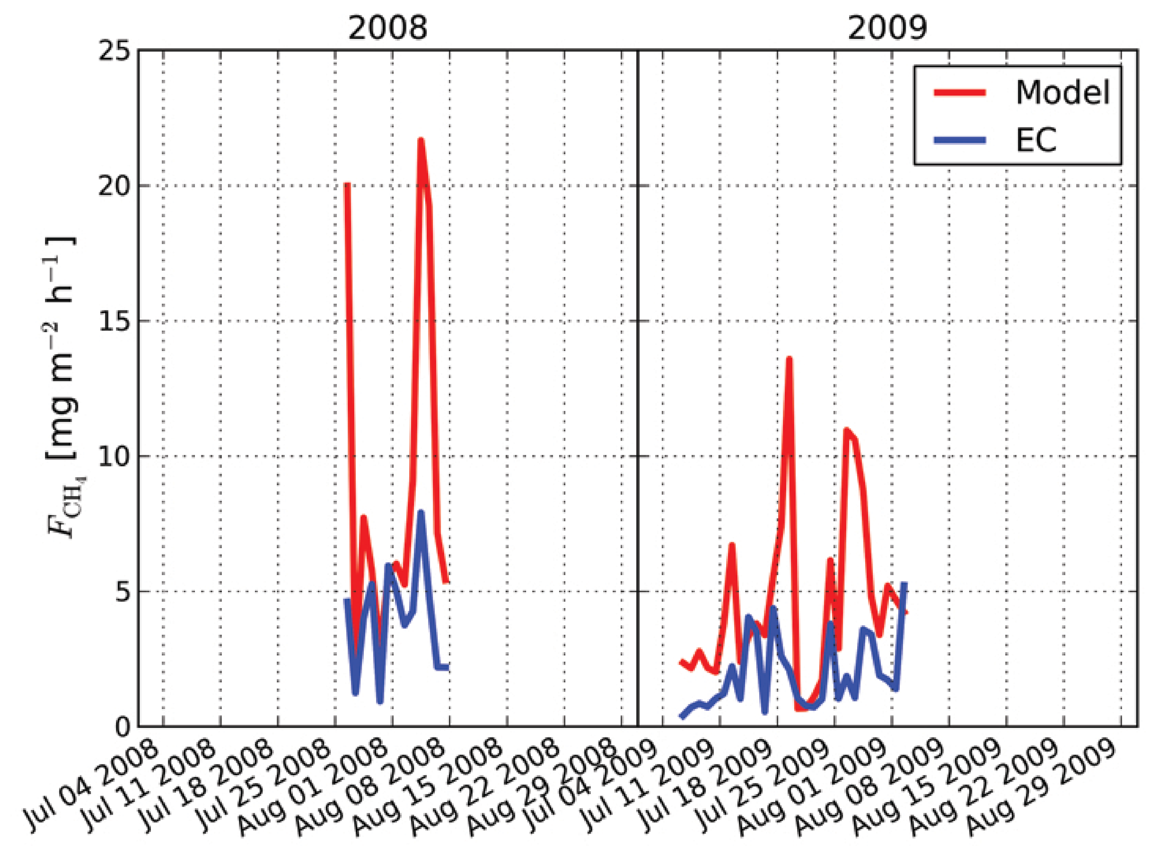


Figure 5. Comparison of modelled flux (red line) vs EC flux (blue line) for years 2008 and 2009.

Preliminary result shows that the model was able to capture temporal dynamics, despite mismatch. We suggest that the reason for this is the different contribution of different vegetation classes inside the footprint to the total flux. This needs to be taken into account in order to make more accurate comparison.

Future directions

Weighting vegetation classes inside the footprint according to footprint function is necessary to properly assess contribution of different vegetation types to total flux.
Take into account change of footprint over 24 hours to prescribe vegetation distribution. Currently, only daytime values were selected.

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