Geophysical Research Abstracts
Vol. 20, EGU2018-18209, 2018
EGU General Assembly 2018

Cold Season CH4 Emissions from Polygonal Tundra in the Lena River Delta, Russia

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Arctic permafrost-affected wetlands substantially contribute to the global methane emissions. A major reason for large uncertainties of the emission estimates for the Arctic is the scarcity of land-atmosphere flux measurements during the long cold season. This study focusses on the contribution of the cold season (September-May) to the annual methane budget of polygonal tundra in the North-Siberian Lena River Delta (72°22' N, 126°30' E). Furthermore, it aims at identifying the major environmental drivers for the methane emissions during different freeze-thaw-related periods of the year. Methane emissions were measured by the eddy covariance method from September 2010 to September 2011. Time series of hourly methane emissions were related to meteorological variables, i.e. soil and air temperatures, wind speed, barometric pressure, friction velocity, and the time derivative of barometric pressure using a stepwise multiple linear regression analysis. A Monte Carlo method with 50,000 iterations was applied to determine the optimal combination of variables explaining the temporal variability of methane emissions and to create a generalized model for methane emissions for the periods that were not covered by data. We split the year into four freeze-thaw-related periods, namely the refreezing (late September - early December), the frozen (early December - mid-May), the early thawing (mid-May – late June), and the growing period (late June – late September). It was found that barometric pressure, air temperature at 10 m, and friction velocity were the best explanatory variables of the methane emissions during the refreezing period. On the other hand, in the course of the growing period, the corresponding drivers were the soil temperature measured at a water-logged polygon center at 0.15 m depth, the soil temperature measured at the drier soil at a polygon at 0.05 m, and the friction velocity. The results showed that the cold season, consisting of the refreezing and frozen period, contributed to 35% of the annual methane budget. With a climate change scenario and continued warming in the Arctic, a potential increase of the active layer depth may lead to increase of the "zero curtain" period duration. For this reason, measurements and modeling of methane emissions beyond the growing season in the Arctic ecosystems will become an even more important issue in the future.