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Methane emission bursts from permafrost environments during autumn freeze-in: new insights from ground penetrating radar

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Large amounts of methane (CH_4) are known to be emitted from permafrost environments during the autumn freeze-in, but the specific soil conditions leading up to these bursts are unclear. We therefore assessed the possibility to complement surface flux measurements with ground penetrating radar (GPR), which can estimate the amounts of ice, water and gas in the soil through their different dielectric properties. We developed an ultra-wide band (UWB) transmission GPR setup operating in the frequency range from 200 to 3200 MHz, which was tested in laboratory experiments on a soil sample during an induced freeze-thaw cycle, and applied in a field campaign in Northeast Greenland during autumn 2009.

In the laboratory case, the GPR signals captured the same dynamics as the surface CH_4 flux, featuring a series of large and sharp peaks during the thawing phase of the experiment. The CH_4 emission peak during the freezing period, however, could not be reproduced in this laboratory experiment.

The results of our field campaign suggest a compression of the gas reservoir during the freezing period in the autumn, which is accompanied by a peak in surface CH_4 emissions. About one week thereafter, there seemed to be a decompression event, consistent with ground cracking which allows the gas reservoir to expand again. This coincided with the largest CH_4 emission, exceeding the summer maximum by a factor of 4.

We argue that subsurface GPR measurements open new possibilities to come to an understanding of tundra CH_4 bursts connected to soil freezing.