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Pressure effects on methane emissions from landfills

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Landfills are one of the major anthropogenic sources of methane (CH_4) emissions to the atmosphere, even years after being inactive. Model-based estimates of CH_4 emission from landfills are inaccurate due to uncertainties in the underlying assumptions regarding gas generation rates, oxidation and recovery parameters. In-situ measurement techniques are more reliable in quantifying CH_4 emissions, with the tracer gas dispersion method (TDM) being one of the best-validated methods. The TDM does however not allow for continuous estimation unless a higher sampling frequency for longer measurement campaigns is being used. Field studies report short-term CH_4 emission variation of several orders of magnitude, which are being driven by changes in meteorological conditions, with changes in barometric pressure being the most important. This variation makes discontinuous measurements more uncertain. In this presentation, we focus on CH_4 emission dynamics under the influence of barometric pressure changes and develop a model that can explain the dynamics.

Landfill methane emissions were measured continuously with the eddy covariance method over several months in an inactive landfill (Skellingsted, Western Zealand, Denmark). The landfill is covered with an 80 cm thick soil layer and vegetated with grassland. Screenings of the site indicate a considerable horizontal heterogeneity of the emissions, which needs to be considered when interpreting continuously measured fluxes.

Measured methane fluxes ranged from 0 to 10 μmol m^{-2} s^{-1}. Periods with decreasing barometric pressure showed highest flux rates, while increasing barometric pressure suppressed the methane flux almost to 0 μmol m^{-2} s^{-1}. However, this dependency had a complex dynamic nature. In most of the cases, the responses of CH_4 fluxes to pressure changes were delayed by 0 to 4 hours. We developed a model concept that is able to explain this behavior, including the pressure gradient driven advective CH_4 transports through the porous soil layer above the source and diffusion between fronts of background air and landfill gas.

The general implications from this work are an estimation of the uncertainty and possibly correction of point CH_4 emission measurements, e.g. with the TDM. Additionally, the increased understanding of gas transport dynamics through terrestrial landfill covers will help to evaluate the efficiency of methane emission mitigation methods that aim at increasing methane oxidation by the establishment of biocovers.