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Using the gradient method to measure soil gas fluxes: limitations and pitfalls

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The gradient method (De Jong & Schappert,1974) can be used to determine gas efflux from the soil, representing an alternative to the widely used chamber methods. In addition, valuable information about the vertical distribution of the sources/sinks of gas (e.g. CO_2, CH4) in the soil can be derived. Although the method seems to be simple, care must be taken whether all assumption and simplifications are made:
(1) Diffusion only: Gas transport can be described by Fick′s law.
(2) 1D vertical gas diffusion: No horizontal concentration gradients.
(3) Gas diffusion in the soil is at steady-state: Changes are negligible.
If the preconditions are not met, the gradient method may yield unreliable results. We tried to address some of these and further issues in different studies. We identified the method used to interpolate the gas concentration profile between the measurement locations as an issue affecting substantially the calculated efflux and vertical partitioning. Another critical issue is deriving the correct soil gas diffusivity. The assumption of steady-state diffusion is not always justified, especially after rain, and may lead to substantial misinterpretation if ignored. We also observed that soil gas transport can be affected by turbulence-driven pressure-pumping, so that the effect of non-diffusive gas transport must be considered. The Temporal and spatial resolution must match the research question and gas species.
The gradient method is a valuable tool , that, Ideally, the GM should be used on well aerated, horizontally homogeneous soils where gas exchange is entirely driven by diffusion. Here the gradient method promises to yield reliable results when soil respiration and methane consumption is studied. Substantial discrepancy in these conditions could lead to increasing uncertainty in the flux estimates