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Coupling above and below ground gas measurements to understand greenhouse gas production in the soil profile

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Natural and anthropogenic changes in climate have the potential to significantly affect the Earth's natural greenhouse gas balances. To understand how these climatic changes will manifest in a complex biological, chemical and physical system, a process-based understanding of the production and consumption of greenhouse gases in soils is critical.

Commonly, both chamber methods and gradient-based approaches are used to estimate greenhouse gas flux from the soil to the atmosphere. Each approach offers benefits, but not surprisingly, comes with a list of drawbacks. Chambers are easily deployed on the surface without significant disturbance to the soil, and can be easily spatially replicated. However the high costs of automated chamber systems and the inability to partition fluxes by depth are potential downfalls.

The gradient method requires a good deal of disturbance for installation, however it also offers users spatiotemporally resolved flux estimates at a reasonable price point. Researchers widely recognize that the main drawback of the gradient approach is the requirement to estimate diffusivity using empirical models based on studies of specific soils or soil types. These diffusivity estimates can often be off by several orders of magnitude, yielding poor flux estimates.

Employing chamber and gradient methods in unison allows for in-situ estimation of the diffusion coefficient, and therefore improves gradient-based estimates of flux. A dual-method approach yields more robust information on the temporal dynamics and depth distribution of greenhouse gas production and consumption in the soil profile. Here we present a mathematical optimization framework that allows these complimentary measurement techniques to yield more robust information than a single technique alone. We then focus on how it can be used to improve the process-based understanding of greenhouse gas production in the soil profile.