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Beyond one-size-fits-all: Estimating effective soil physical parameters for gas flux modelling

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The flux-gradient method (FGM) is a versatile approach for modelling soil gas fluxes from concentration profiles. It is especially useful for continuous and long-term estimations of gas fluxes based on concentrations from permanently installed probes or sensors, focussing on *relative* changes and trends in time. However, there are inherent uncertainties in the parametrisation, e.g. diffusivity estimates or installation depths of probes. This can make it challenging to estimate *absolute* fluxes, as small differences in some parameters can lead to disproportionately high changes in the model output. The relative uncertainty of the input parameters can be assessed by multiple replicate measurements. However, further analysis often requires the use of a single value, where usually the mean or median value is used. Yet, the "effective" parameter value that best describes real-world conditions can deviate from a mathematically precise mean value, so that rather than one-size-fits-all, a range of values (e.g. mean ± standard deviation) should be considered. This can be solved by *calibration* of FGM models on the basis of reference measurements.

The FGM requires estimation of both, gas concentration gradients and diffusivity in the soil. Gas concentration can be measured relatively easily and consistently, whereas diffusivity is often harder to estimate reliably. One possibility is in-situ measurement using a tracer gas. However, due to relatively high cost and work requirement, diffusivity is often modelled from air-filled pore space (AFPS) instead, using soil-specific transfer functions (TF´s). Modelling soil gas diffusivity in turn requires several input parameters, including porosity, soil water content, temperature and barometric pressure. While modelling diffusivity can have satisfactory results when analysed in the laboratory on soil cores, there are far more challenges in the field, which eventually result in a mismatch between the concentration profiles, diffusivity, and modelled efflux. As a result, FGM-modelled efflux may have an offset compared to more reliable chamber measurements.

Hence, rather than following a one-size-fits-all approach, the inherent uncertainties of diffusivity modelling should be accepted and compensated for by finding *effective values* of input parameters that close the gap between concentration and diffusivity measurements. Here, we introduce a procedure to run a sensitivity analysis on FGM models to identify the most influential input parameters, as well as find a suitable model parametrisation of *effective values*. Input parameters of FGM models are varied within a range around the original value and several quality parameters are calculated from the comparison of the model output to reference flux measurements and to the original gas concentration profile. The parametrisation with the “best” quality parameters are then used as “effective” values for the enhanced final model. The process was developed on a dataset of continuous gas concentration measurements in forest soils and is now being applied to long-term datasets as well. This may enhance the quality of FGM models and in turn help to balance gas fluxes in soils.