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Estimating methane fluxes at a landscape scale

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Terrestrial methane fluxes are an important component of peatland carbon budgets. Using a well-studied peatland site in Wales as a case study, we present a variety of approaches to quantifying annual methane fluxes at a landscape scale, with a focus on the comparison between a simple stratification method, an empirical regression-based method and a process-based method.

The simplest approach relies on in situ methane flux measurements which, due to the indirect effects on methane flux from the vascular transport mechanism and co-variation with hydrological conditions, were stratified by vegetation type. Aside from this initial classification, an annual landscape flux was produced through a linear scaling model without attempting to consider any physical, chemical or biological processes known to control methane fluxes.

The regression-based approach attempted to model fluxes using repeated measurements from across the study site over a 12 months period, together with environmental variables from associated locations. This method classifies the landscape by vegetation in a similar way to the first method and also takes into consideration variables commonly known to influence methane flux such as temperature and water table. However, no direct consideration of methane production or consumption is included in this empirical regression model.

In contrast to both the preceding methods, estimates of methane flux using a process-based model were constructed for the same landscape. This method uses the Carnegie-Ames-Stanford Approach (CASA) model (Potter et al., 1993), which has been modified to include a representation of methane dynamics. The model is calibrated with ground-based measurements of net CH_4 flux and water table depth using a Metropolis Hastings Markov Chain Monte Carlo approach.

Comparison of these approaches shows that, while simple methods of stratification and scaling are computationally inexpensive and quick to perform, they are least successful when extrapolated. The methods of empirical regression may improve the annual landscape estimate, but is data rich and without a full exploration of the explanatory variables, extrapolation spatially and temporally is limited without further complimentary ground-based datasets. Process-based models are not only more computationally expensive but are also dataset intensive as they require meteorological data to drive them and ground-based measurements to calibrate them. However, they demonstrate the best potential for wider scale extrapolation.