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Modelling UK upland peatland carbon dynamics – past, present and future

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Current global soil organic carbon (SOC) models are insufficient in modelling C dynamics in peatlands. Over the last 10k years (i.e. Holocene) large amounts of SOC built up in northern hemisphere peatlands during a variable climate with major vegetation changes. However, peatland SOC stocks foster a great potential for both either sequestering or releasing large amounts of C to the atmosphere. As such, understanding their carbon dynamics is fundamental for underpinning better model predictions on their potential role in atmospheric C-cycling and climate feedbacks, specifically considering their role in global methane fluxes. A fundamental shortfall in current models is the lack of accurate water table representation, affecting decomposition and methane fluxes to the atmosphere. Moreover, existing major SOC models do not adequately: (i) allow a long-term 'spin-up' accumulation of SOC based on a variable 'real' past climate and vegetation during the Holocene, (ii) reflect dynamic changes in SOC affecting hydrology and bulk density, nor (iii) consider hydrological impacts (i.e. water table changes) and its influence on plant communities, litter quality and biological activity and effects on C input and decomposition. In the MILLENNIA peatland model, carbon turnover is linked to dynamic changes in hydrology and litter quality, particularly considering water table dynamics and its effects on decomposition. We present preliminary MILLENNIA peatland model runs for the UK modelling SOC stocks, accumulation rates and turnover rates in blanket peatlands commonly found in UK uplands and compare them to field measurements:

(1) We propose an improved litter cohort-based model approach for peatland carbon dynamics, taking account of long-term (Holocene) dynamics in soil physical (e.g. water table), chemical (e.g. litter quality) and biological (plant functional types) factors and their effects on carbon turnover.
(2) We use a simple, but well established, regression based approach for estimating net primary productivity (NPP) and decomposition based on actual evapotranspiration (AET) and consider water table effects on plant functional type composition.
(3) We consider the conceptual issues that soil C is commonly 'spun up' to a preset C content equilibrium, using a static climate and vegetation, before running real C simulations including a reconstructed Holocene climate in our model to accumulate soil C over $\sim$10k since the last glaciation.

We also discuss implementations of other factors affecting carbon build-up in peatlands, such as runoff and effects of aspect and slope. Moreover, results include linking carbon flux predictions (including methane) to the model's intrinsic hydrology and water table dynamics.