Computer modelling of peatland development through the Holocene and into the future

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Background

Northern peatlands are the largest terrestrial carbon store, and could exert an important control on global climate through their role as sinks and sources of atmospheric carbon dioxide and as sources of atmospheric methane (e.g. *Frolking et al.*, 2006, *Baird et al.*, 2009). Because the feedbacks between carbon cycling in peatlands and climate are complicated, a predictive modelling approach is required in which the key processes involved in peatland carbon cycling are explicitly represented.

Peatlands may be considered as consisting of arrays of fundamental units called hummocks, lawns, hollows, and pools (Figures 1 and 2), which typically vary in length from 10^0-10^1 m and which can be separated from each other by their distinctive plant communities and other attributes like water-table depth. We can think of them as fundamental in the sense that they represent the smallest scale at which we can identify plant communities in peatlands; at smaller scales we may find individual species of plant but not groupings of different species. However, more importantly, they are fundamental in terms of their ecohydrological functioning and are the smallest units that have separable and distinctive biogeochemical and water-table behaviour and regimes of net peat accumulation (*Belyea and Clymo*, 2001).The idea that understanding of the functioning of hummocks, lawns, hollows and pools is essential to an understanding of *whole peatlands* was developed by *Belyea and Baird* [2006] who suggested that peatlands behave as complex adaptive systems (CAS). In essence, *Belyea and Baird* [2006] suggested that, to model whole-peatland carbon balance processes, we need a model than considers processes in the fundamental units. This is a significant departure from previous modelling approaches which have tended to ignore intra-peatland variability and have treated the peatland as a simple ‘slab’ of peat with a single vegetation type in which hydrological variations can be described using a simple store and flow modelling approach (a ‘bucket hydrology’), or with Boussinesq-type lateral flows (*Ingram*, 1982; *Kirkby et al.*, 1995).

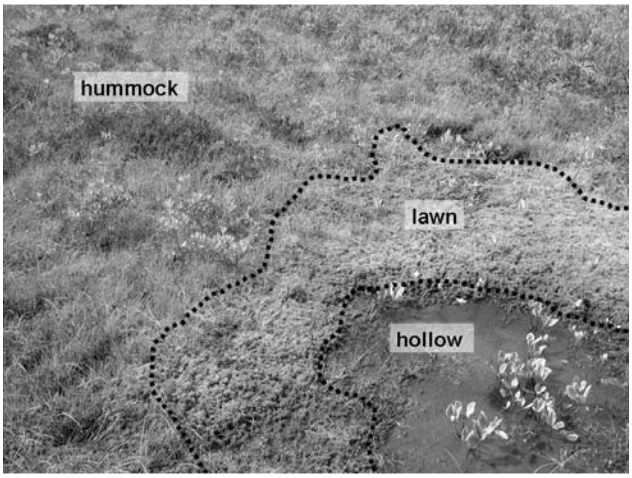

Figure 1. Left: Fundamental units at Cors Fochno, west Wales (length of foreground: 2.5 m) (photo: Andy Baird). Right: Fundamental units and vegetation patterning around bog pool, showing zonation of different *Sphagnum* species, Mannikjarve Bog, Estonia (length of foreground: 11 m) (photo: Nick Kettridge).

Figure 2. Peatland landscape showing larger scale patterns of pools and ridges, Mannikjarve Bog, Estonia (photo: Nick Kettridge).

The project

The successful candidate will work on a model that has already been developed as a prototype: **DigiBog**. **DigiBog** conceptualises a peatland as consisting of square-sectioned columns of peat, which individually, or in small groups, represent fundamental units such as hummocks and hollows. Plant litter (including roots) is added to the top of each column in cohorts every 10 years. Each cohort is tracked through time and will decay; as it does so, its physical properties (hydraulic conductivity, drainable porosity, and bulk density) will change. The model is driven by a hydrological submodel which simulates water-table dynamics. Water may be added to a peatland via precipitation and lost to the atmosphere via evaporation and transpiration. Water may also be lost via subsurface seepage which is simulated explicitly; the model may also be extended to take account of subsurface pipes within the peat. The pictorial and conceptual structure of the model is shown in Figure 3.

The aim of the project is to test the model by running it to represent peatland development during all or some of the Holocene and to compare its predictions with published independent data sets. The test programme will involve detailed numerical experimentation to help establish the principal controls on peatland development. In particular, such testing will help establish the importance of developmental (endogenic) and external (principally climate) controls on peatland development. The final outcome of the programme of work will be a model capable of being coupled (via scaling classifications) to global climate models (GCMs) to simulate the future role of the peatland carbon store in climate change.

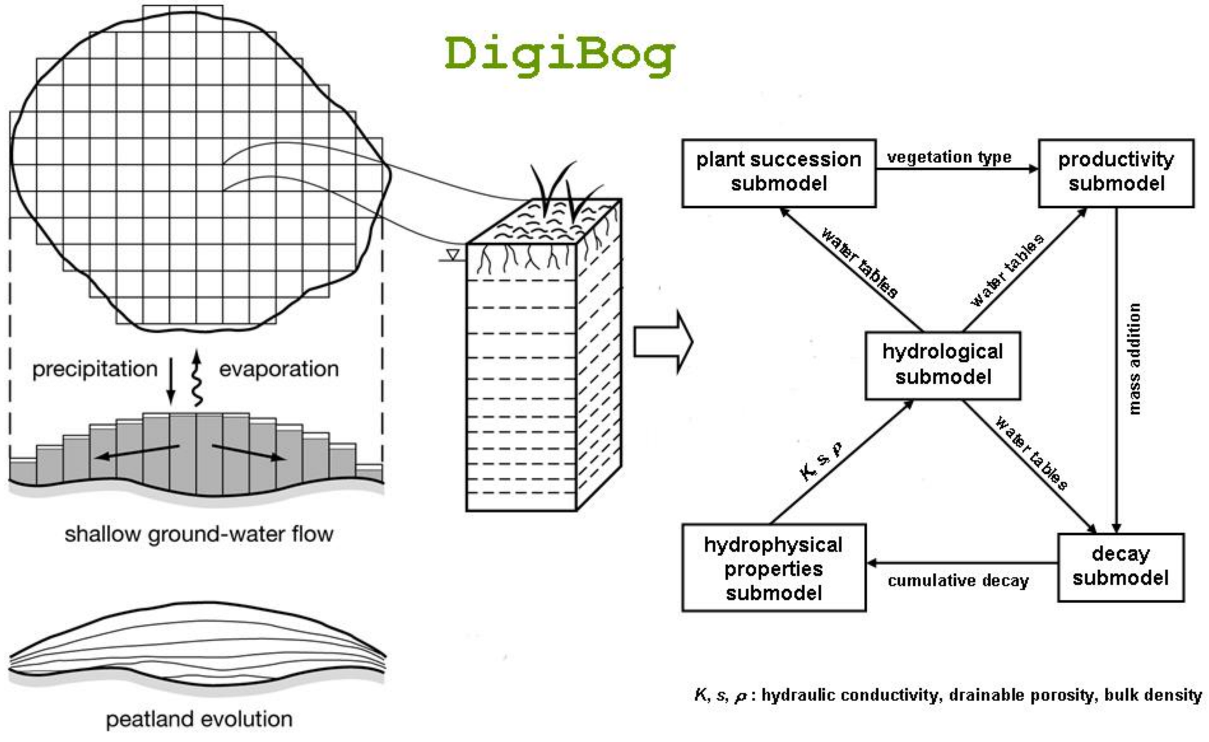

Figure 3. The pictorial and conceptual structure of **`DigiBog`**.

Project partners and training

It is anticipated that the successful candidate will liaise with partner modelling groups at McMaster University in Canada and Wageningen University in The Netherlands. Training will be given in Fortran 95 and the use of high-end computers. The candidate will also visit peatland research sites in Wales and possibly Estonia to gain an appreciation of the systems they will be modelling.

References

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