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Biogeosciences Discussions

Interactive comment on "Peatlands and the carbon cycle: from local processes to global implications – a synthesis" *by* J. Limpens et al.

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This paper provides an overview of some issues around the carbon cycle of peatlands, which provides an introduction to the papers arising from a conference held in April 2007. It is divided into major sections dealing with small-scale processes and plant-soil feedbacks, carbon fluxes at the landscape scale, climate and peatlands before ending in some conclusions and suggestions for further research. It contains almost 150 references, with a large proportion being authored or co-authored by the authors of the Biogeosciences article: there may be a degree of over-self-citation and in some cases some citations are not strictly correct. I have not checked to see whether all references are cited in the text and vice versa.

Covering such a broad field is a large task and the paper does a good job of identifying

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the main issues in this topic, even though the transit from microbial enzymes to global models is VERY broad. It also illustrates, quite nicely, that some of the things at the small scale cannot be included at the global modelling scale and thus one has to be realistic about what the objectives are. Both the understanding at the microbial and micro-pore scale and the global earth system models incorporating realistic peatlands are valid, though the challenge in this (and other fields) is to ensure that there are not two solitudes. Some of the writing is a bit contorted and I think some changes could be made to improve the utility of the paper, as follows.

The Abstract provides an overview of what is included in the paper, but contains few specific components, such as what the REAL issues are.

P 1381 I think it would be useful to start out with what we know in specific terms – for example, the areal coverage of boreal/subarctic and tropical peatlands (one is given as percentage, the other as ha) in km2 and the probable overall storage of C in these two groups. Also, I think we know enough to be able to estimate the contemporary emission of methane to the atmosphere from these two types of peatlands. We also know enough to estimate the contribution of DOC from these peatlands to water bodies (assuming 10 g DOC m2/yr). This situates the peatlands in the global C and methane cycle and sets the stage on what we really know in controlling these processes and how they might change under various disturbances.

1382 line 18 Whilst it is fair to exclude arctic tundra ecosystems, I think the authors have neglected the evidence for changing C cycling in peatlands in permafrost terrain that are undergoing warming. There is now a substantial literature from Alaska, central Canada, Fenno-Scandinavia and Russia/Siberia to suggest that the thawing of permafrost in northern wetlands can lead to increased C fixation and increased methane emission. This seems to be lacking in this paper. The following paragraph mentions across climatic zones though the permafrost zone seems to have been excluded (and is probably the most difficult to model).

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1383 line 9 dissolved organic carbon (DOC)

line 14 delete dissolved organic carbon

1384 Fig. 1 is illegible to my eyes: too small. It is not clear to me how the different parts of this figure are linked together

1385 line 8 relatively small is redundant: small is relative though here we are not sure what small and large are compared with: what is the comparison group to allow the statement that sulphate deposition reduced methane emission rates in these zones?

Line 27 Fig. 1D

1386 line 23 I am not sure what this sentence means: what is an active unsaturated layer (aren’t all unsaturated layers active?) I am not sure what the aerobic decomposition is and I am not sure what role photosynthetically driven root respiration plays here: surely it is part of autotrophic respiration, unless there is a priming effect associated with the rhizosphere.

1388 line 19 what sort of modeling approach is required?

1389 line 18 minerotrophic

1389 From the perspective of plant ecology, knowledge of (let alone understanding of) the belowground activities of plants (roots) lags well behind aboveground activities (biomass, photosynthesis), yet there is a clear regulation on the root mass and distribution by the water table. The belowground weakness of knowledge appears in most ecosystems, but I think is particularly profound in peatlands, where the effect of global change may be through belowground activities

1390 Here we have some nice quantified DOC export from peatlands, which might be used in the initial paragraph to situate peatlands within the global C cycle.

1391 The photo of the peatland pipe is impressive, but I wonder how common this is. Most peatlands have very low topographic gradients and thus low-energy aquatic

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systems, the exception being blanket bogs in hilly terrain, which is where this is from, I guess. This must be a rare phenomenon in the global peatland picture (or not, if we have not looked for it).

1392 line 10 I think these were for Swedish peatland streams.

Line 21 I assume that these measurements were made by eddy covariance systems (the alternative being chambers extrapolated to the annual scale). I think it is worth mentioning that eddy covariance towers do provide year-round measurements though one should not enquire too closely at gap-filling) and observe patterns with a foot-print of several hundred square meters. Of course, one does not know where in the footprint the gas exchanges are occurring and given the high spatial/topographic variability in most peatlands, thee is a need to determine processes within that variability: again the issue of scale.

1393 Given the rather narrow range of observed rates of C accumulation in peatlands, it is interesting to speculate whether there are feedbacks in peatlands which, over sites and years/seasons, effectively work to reduce the variability in C accumulation rates. Comparison of multi-year and multi-site results (such as started by Humphreys and Lindroth etc.) of NEE, CH4 and DOC may identify some interesting and perhaps generalizable patterns, which eddy covariance towers (plus CH4 and DOC measurements) can capture. Here we might be able to generate some hypotheses, based on plant ecology and physiology and testable by towers.

1395 I do think one might include climate change as a perturbation here: it is not as dramatic and as rapid as fire and drainage, but in permafrost environments, there can be profound changes in thermal regime, leading to hydrologic changes, plant composition and C budgets, as shown in Alaska, Canada, Sweden and Siberia.

1396 line 19 is this DOC production, or export? Here we have a rather confusing mixture of concentration and production, whereas the interest seems to be on export. Creating anaerobic conditions probably slows the rate at which DOC is produced within

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a soil.

Line 25 Experience in eastern Canada in restored peatlands shows that you need to get a vascular plant cover to provide the surface roughness/microclimatic niches in which mosses and shrubs can colonize the peat surface. This (particularly cotton grass) creates new biomass but also primes the peat through fresh organic matter, leading to increased rates of peat decomposition, and to increased methane emission rates, before the normal cover of mosses and shrubs develops.

1397 line 25 Thornton

1398 line This sentence is a bit redundant, repeating the Introduction.

1399 line 7 and 9; perhaps a left-handed slip. I think these fluxes should be 1012, not 1015 (teragrams not gigatons or petagrams).

Line 26 I am not sure water balance is the right term. Peatlands can have large inputs and outputs (e,g, tropical) or small (subarctic), and the carbon economy is tied to the exchange of C with the atmosphere (CO2, CH4) and water bodies (DOC and DIC), both of which appear to be related to the water table position, or some similar hydrologic parameter (maybe even residence time of water). I think the community is grappling with water table and water movement as the key connecting elements of peatlands.

1401 I think a way forward (the wish list of things to do) might also include some thought about how to integrate information, and possibly knowledge, at varying scales. The peatland community is rather small (compared to the numbers studying other terrestrial ecosystems) and by nature ranges from those fiddling about with enzymes and biogeochemicals at the scale of a few centimeters, to those dealing with plant communities (a few square meters) to the eddy covariance towers (several hundred square meters) and to those at the regional/continental scales who wish to include peatlands in global system models. A challenge (or way forward) is to ensure some dialogue between these disparate groups, and I think that this conference and this overview paper

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points in some directions whereby the dialogue can be developed.

Tim Moore

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