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Geoscientific Model Development Discussions

Interactive comment on "HIMMELI v1.0: HelsinkI Model of MEthane buiLd-up and emIssion for peatlands" *by* Maarit Raivonen et al.

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Overview:

This paper presents the HelsinkI Model of MEthane buiLd-up and emIssion for peatlands (HIMMELI, v1.0). The model has been developed as a methane module that can be added to or used with peatland carbon cycle models. The model is driven with soil temperature, leaf area index (of aerenchymatous peatland vegetation), water table depth and the anaerobic carbon decomposition rate. It simulates the concentrations and fluxes of CH_4, CO_2 and oxygen (O_2) in a one-dimensional peat column. Sensitivity runs are undertaken and comparison is made with CH_4 flux measurements from one site in Finland.

The Global Methane cycle is currently a topic of much interest following the near-zero growth in atmospheric methane concentrations in the early 2000's and its renewed growth since 2007. Various papers have suggested specific sources, including emis-

sions from wetlands, and more recently changes in the atmospheric CH_4 sinks, as possible explanations. Wetlands globally are the largest single source of methane, anthropogenic or natural. Boreal wetlands are significant and could become more important still with the faster warming of the Arctic and high northern latitudes.

The Wetland Model Intercomparison (cited paper by Melton et al., 2013) highlighted the current performance of wetland models and the large range of wetland areas and methane fluxes simulated by the participating models. The recent paper by Saunois et al. (2016) on the Global Methane Budget removed some of this model uncertainty by prescribing the wetland extent/area.

I was expecting the present paper to make this connection to the bigger picture. From the material presented, it is very unclear what the intended application of this new model is (local, regional, global??), how it would be used in practice (standalone or coupled) and indeed what advantage it offers over those mentioned in the paper (i.e., Peatland-VU, CLM) and those already in the literature (see cited paper by Xu et al.).

Specific Comments:

Model Formulation

The model considers the major CH_4 release pathways to the atmosphere (diffusion, plant vascular transport and ebullition) and includes oxidation by O_2. O_2 is the only electron acceptor considered. What about others?

I am little concerned at the realism of completely oxic layers sitting above the water-saturated anoxic layers. In reality, one might expect a continuous transition, as acknowledged by the authors.

The model runs on a daily timestep. This may be appropriate for large-scale decadal or centennial runs but no justification is given. How was this timestep selected and what are the implications for the modelled methane fluxes?

Many of the model parameters are optimised using the measurements made at a site in southern Finland (see Table 1, p. 30). These results are included in a second paper (Susiluoto et al., 2017), which is in preparation. This makes it hard to assess their significance, especially in the light of the statement *The uncertainty of some of these parameters is rather high, and a more complete analysis can be found in Susiluoto et al. (2017, in prep.)*.

The cited paper by Rinne et al. (2007) shows an exponential dependence of the measured flux on the peat temperature to day 200 (Figure 6 in paper). The lack of a temperature dependence presumably indicates that the temperature dependence is effectively determined by that of the input 'anaerobic carbon decomposition rate'. The temperature-dependence revealed in Fig. 6 is presumably associated with the modelled transport and loss processes.

Many of the key driving variables (soil temperature, leaf area index, water table depth) could be taken either from observations or modelled. It is not clear that this is the case for the anaerobic carbon decomposition rate. If it could be measured, this would improve the utility of HIMMELI.

Comparison versus observations

The model is setup and the modelled CH_4 fluxes are compared to eddy covariance flux measurements of CH_4 made at Siikaneva, a peatland site in Southern Finland. The intake for the CH_4 flux measurements is given as 2.75 m above the peat surface (p. 13). Presumably the surface is fairly homogeneous as no information is given about the footprint nor the prevailing wind direction.

A good fit of the observed and measured fluxes is seen over several annual cycles. This site is effectively used for both model calibration/optimisation and evaluation. This begs the question of how general the derived parameter values are or whether are they specific to this site. There is an obvious need for comparison against measurements from other sites.

Upscaling

It would have been interesting to see upscaled fluxes to the regional/boreal scale and hence an estimate of methane emissions from boreal peatlands.

Code availability

The supplement contains the FORTRAN source code of the model.

Technical comments:

The ellipsis (...) is used throughout the paper for 'to', e.g., page 12, line 14: '10...50 cycles' instead of '10 to 50 cycles'

Intercomparison is used in several places when 'comparison' is sufficient (a) Page 1, line 30; (b) Page 12, lines 20 and 22; (c) Page 17, line 18.

References:

Saunois et al., 2016: The global methane budget 2000-2012, Earth Syst. Sci. Data, 8, 697-751, doi:10.5194/essd-8-697-2016.

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