HIMMELI 1.0 – HelsinkI Model of MEthane buiLd-up and emIssion for peatlands

User manual

This software is provided as supplementary material with:

Raivonen, M., Smolander, S., Backman, L., Susiluoto, J., Aalto, T., Markkanen, T., Mäkelä, J., Rinne, J., Peltola, O., Aurela, M., Lohila, A., Tomasic, M., Li, X., Larmola, T., Juutinen, S., Tuittila, E.-S., Heimann, M., Sevanto, S., Kleinen, T., Brovkin, V., and Vesala, T.: HIMMELI – HelsinkI Model of MEthane buiLd-up and emIssion for peatlands, *Geosci. Model Dev.*, 2017.

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NB: In some special cases, related to the input water table depth (WTD) and peat column thickness, the CH_4 production part of this model version may produce an error. I.e., when the input WTD is at or below rooting depth and, in some situations, when the peat thickness is greater than 2 m.

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1. COMPILING

The software is coded in FORTRAN 90 and consists of the following files:

Makefile	
methane_main.f90	- Main program
methane_parameters.f90	- Contains model parameters and other control of the model run
methane_geometry.f90	- Controls the geometry of the grid, e.g. the movement of the water table
methane_output.f90	- Controls the output of the model

The makefile is for compiling with gfortran. It is run with command **make**. This produces the executable file *model.exe*.

2. PARAMETERS

The set-up of the model runs is controlled via methane_parameters.f90. It contains definitions of:

a) constants (such as the gas constant)

b) model parameter values

c) the set-up of the run. Specifically, you can define:

- peat depth
- layer thickness
- length of the model run, maximum is the length of the input data

3. INPUT FILES

The model requires as input two text files, named in the code *input_data.txt* and *ztemp_data.txt*.

a) *input_data.txt* needs 5 columns:

Column #	1	2	3	4	5
Input variable	**Day #**	**Air temperature** *unit °C	**Water table depth** *positive values below the peat surface *unit: m	**LAI** *unit: m^2 m^{-2}	**Rate of anoxic respiration** *unit: mol m^{-2} s^{-1}

b) *ztemp_data.txt* is the soil temperature profile. Its column number depends on the peat layer structure: there should be daily temperature values for each peat layer, starting from the bottom layer in column 1. No column for time is used.

4. OUTPUT

The model outputs the following text files:

a) *output_methane_water.txt* – time series of methane concentrations in water-filled peat layers
output_co2_water.txt – time series of carbon dioxide concentrations in water-filled peat layers
output_oxygen_water.txt – time series of oxygen concentrations in water-filled peat layers
output_methane_air.txt – time series of methane concentrations in air-filled peat layers
output_co2_air.txt – time series of carbon dioxide concentrations in air-filled peat layers
output_oxygen_air.txt – time series of oxygen concentrations in air-filled peat layers

In these concentration files, there are 4 columns, titled *t*, *y*, *w* and *conc*. Column 1 (*t*) is the day number, column 2 (*y*) is the thickness of the layer [m], column 3 (*w*) is the time step [d], and column 4 (*conc*) is the concentration of the compound [mol m^{-3}]. The daily set of concentrations always starts from the bottom layer.

b) *output_fluxes.txt* – time series of fluxes of methane, CO_2 and oxygen between the soil and the atmosphere, separated to the different transport routes
output_processes.txt – time series of removal and production rates of of methane, CO_2 and oxygen in the total peat column, separated to the different microbial or transport processes

The columns in *output_fluxes.txt* are:

1 t
2 diffusion of methane [mol s^{-1} m^{-2}]
3 plant transport of methane [mol s^{-1} m^{-2}]
4 ebullition of methane directly to atmosphere [mol s^{-1} m^{-2}]
5 total ebullition of methane (including ebullition that is retained in air-filled peat layers above the water table) [mol s^{-1} m^{-2}]
6 diffusion of CO_2 [mol s^{-1} m^{-2}]
7 plant transport of CO_2 [mol s^{-1} m^{-2}]
8 ebullition of CO_2 directly to atmosphere [mol s^{-1} m^{-2}]
9 total ebullition of CO_2 [mol s^{-1} m^{-2}]

10 diffusion of O_2 [mol s^{-1} m^{-2}]
11 plant transport of O_2 [mol s^{-1} m^{-2}]
12 ebullition of O_2 directly to atmosphere [mol s^{-1} m^{-2}]
13 total ebullition of O_2 [mol s^{-1} m^{-2}]
14 methane flux caused by changing water table depth [mol s^{-1} m^{-2}]
15 O_2 flux caused by changing water table depth [mol s^{-1} m^{-2}]
16 CO_2 flux caused by changing water table depth [mol s^{-1} m^{-2}]

The columns in *output_processes.txt* are:

1 t
2 diffusion of methane [mol s^{-1} m^{-2}]
3 plant transport of methane [mol s^{-1} m^{-2}]
4 ebullition of methane directly to atmosphere [mol s^{-1} m^{-2}]
5 total ebullition of methane (including ebullition that is retained in air-filled peat layers above the water table) [mol s^{-1} m^{-2}]
6 methane production in anoxic respiration [mol s^{-1} m^{-2}]
7 methane consumption in oxidation [mol s^{-1} m^{-2}]
8 diffusion of CO_2 [mol s^{-1} m^{-2}]
9 plant transport of CO_2 [mol s^{-1} m^{-2}]
10 ebullition of CO_2 directly to atmosphere [mol s^{-1} m^{-2}]
11 total ebullition of CO_2 [mol s^{-1} m^{-2}]
12 CO_2 production in anoxic respiration [mol s^{-1} m^{-2}]
13 CO_2 production in oxic respiration [mol s^{-1} m^{-2}]
14 CO_2 production in methane oxidation [mol s^{-1} m^{-2}]
15 diffusion of O_2 [mol s^{-1} m^{-2}]
16 plant transport of O_2 [mol s^{-1} m^{-2}]
17 ebullition of O_2 directly to atmosphere [mol s^{-1} m^{-2}]
18 total ebullition of O_2 [mol s^{-1} m^{-2}]
19 O_2 consumption in inhibition of methane production [mol s^{-1} m^{-2}]
20 O_2 consumption in oxic respiration [mol s^{-1} m^{-2}]
21 O_2 consumption in methane oxidation [mol s^{-1} m^{-2}]

These files contain partly overlapping data since the transport fluxes are recorded both in *output_fluxes* and *output_processes* files. However, the signs are different: in *output_fluxes* an emission flux of a compound into the atmosphere is a positive flux while in *output_processes* it is negative, signifying removal of the compound from the peat.