March 2009

Yasso07 user-interface manual

Jari Liski[1], Mikko Tuomi[1,2] and Jussi Rasinmäki[3]

[1]Finnish Environment Institute, Helsinki, Finland
[2]Department of Applied Mathematics and Statistics, University of Helsinki, Finland
[3]Simosol Oy, Riihimäki, Finland

www.environment.fi/syke/yasso

This manual consists of two parts. The first part (A) describes the user-interface of Yasso07 soil carbon model. The second part (B) gives general information on Yasso07 soil carbon model.

A. User-interface of Yasso07 soil carbon model

1 Installation

Yasso07 user-interface can be downloaded from Yasso web pages at www.environment.fi/syke/yasso -> Yasso07 user-interface. It is distributed as Windows and Linux executables. The user-interface is run by unpacking the distributed files to the same directory and running yasso.exe (Windows) or yasso (Linux) file depending on the platform.

2 Structure

Yasso07 user-interface consists of three sheets (Fig. 1). "All data" sheet is used to give input data to the model. "Data to use" sheet is used to select which of the input data given on the "All data" sheet is used in the simulation. "Model run" sheet is used to run the model and select output options. In addition, there is a "Help" sheet.

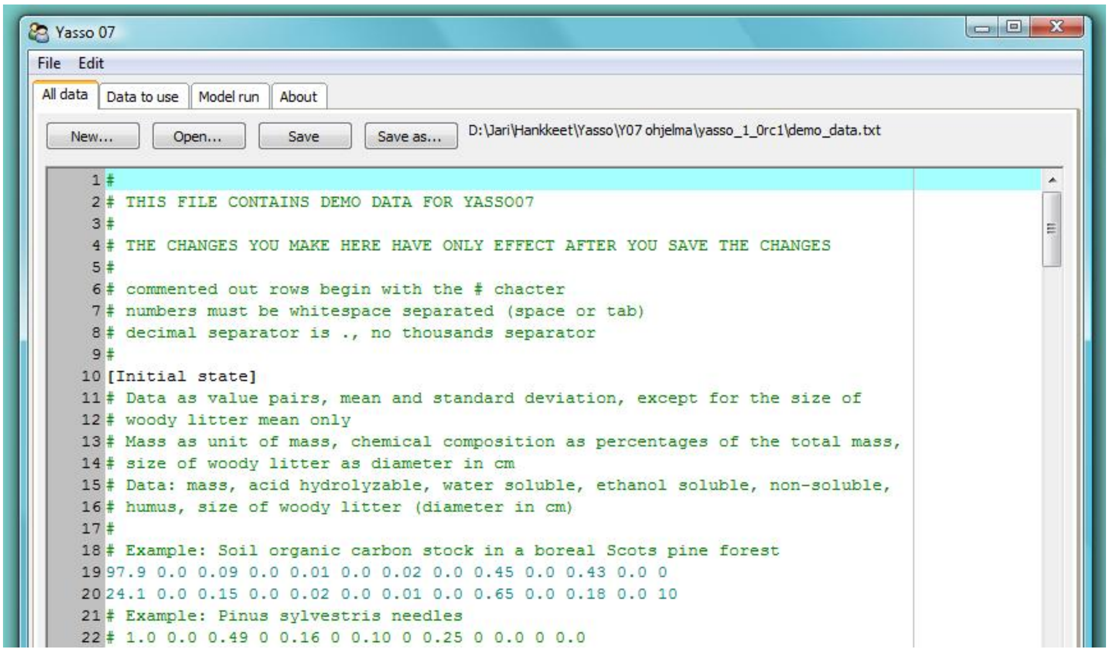

Fig. 1. Opening screen of Yasso07 user-interface.

3 Input information

Input information is given to Yasso07 user-interface on “All data” sheet (Fig 1). Input information to be used in a simulation is selected on "Data to use" sheet (Fig. 2). Any changes made on "All data" sheet must be saved before they take effect on "Data to use" sheet.

Yasso07 user-interface requires three kinds of input information, 1) soil carbon stock in the beginning of the simulation, 2) carbon input to soil during the simulation and 3) climate during the simulation (Fig. 2). In addition, there is an option to give values of relative change in simulated area to account for land use change and the associated removals of soil organic carbon out of the simulated land use class.

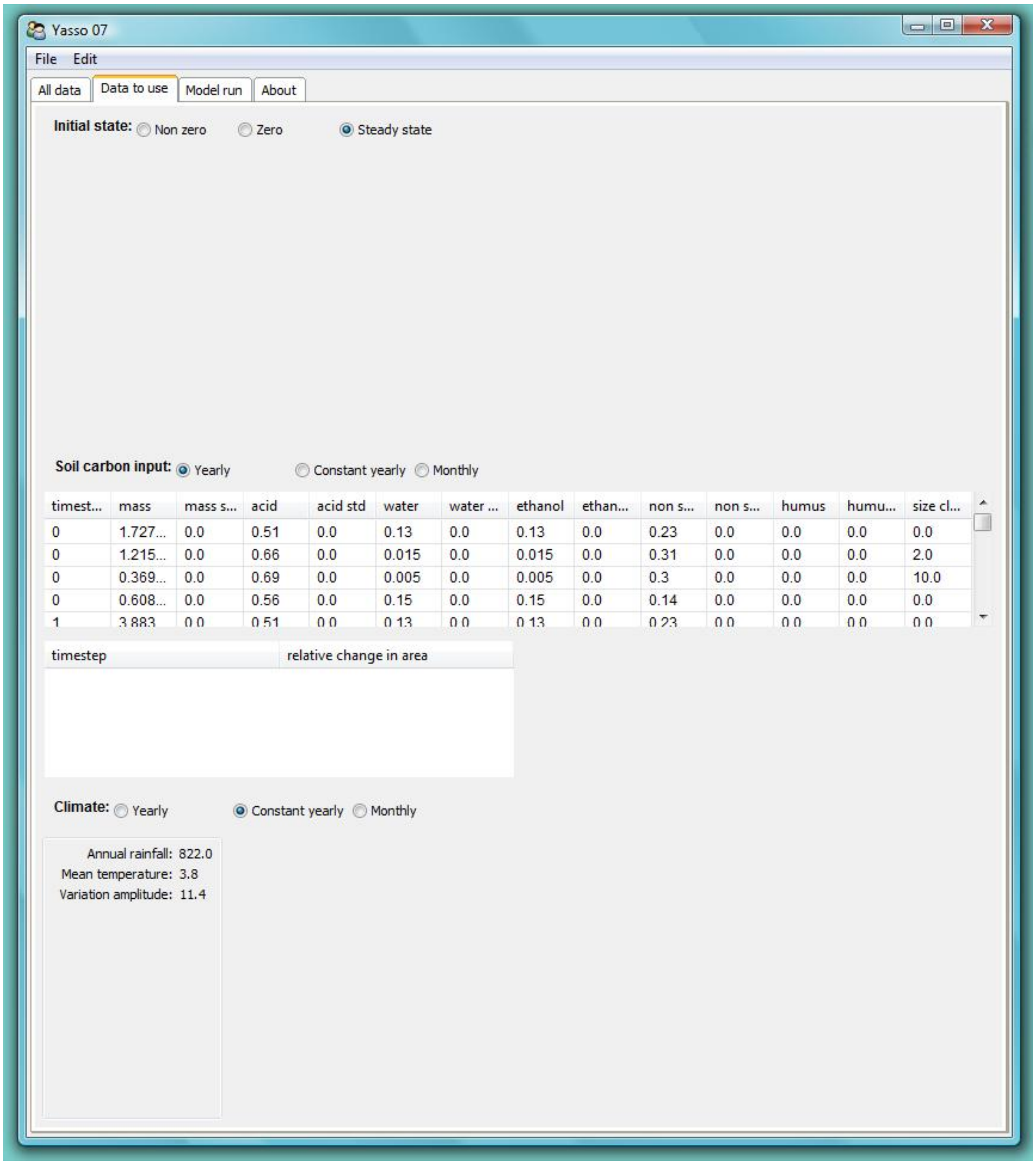

Fig. 2. "Data to use" sheet of Yasso07 user-interface.

3.1 Soil carbon stock in the beginning of the simulation

There are three alternative ways to give the soil carbon stock in the beginning of the simulation to Yasso07 user-interface, 1) the stock specified by user, 2) the stock set equal to zero or 3) use the user-interface to calculate a steady-state stock based on carbon input to soil in the beginning of the simulation (Fig. 2).

The soil carbon stock in the beginning of the simulation needs to be given by the five chemical compartments of Yasso07 soil carbon model (see Fig. 4), i.e. non-polar solvent soluble soil organic carbon (waxes etc.), polar solvent soluble soil organic carbon (sugars etc.), acid hydrolysable soil organic carbon (celluloses etc.), not soluble nor hyrdolyzable soil organic carbon (lignins etc.) and humus soil organic carbon.

If selected, the user-interface calculates the initial soil organic carbon stock assuming a steady-state in the beginning of the simulation. If soil carbon input is given as yearly time series for the simulation (see 3.2), the input values of time step 0 are used to calculate the initial soil organic carbon stock. If input for time step 0 is not defined, input from time step 1 is used to calculate the initial soil organic carbon stock. The input of time step 0 is not used otherwise in the actual simulation. If soil carbon input is given as monthly time series, the steady-state stock is calculated based on the first 12 months.

3.2 Carbon input to soil and climate during the simulation

Soil carbon input and climate information can be given to Yasso07 interface in three alternative ways, 1) yearly time series, 2) yearly constant values or 3) monthly time series (Fig. 2).

Regarding soil carbon input, the information is needed on its quantity and chemical quality, i.e. the division of soil carbon input into the five chemical compartments of Yasso07 model (see Fig. 4). For the part of the input that is woody litter, the physical size of this litter (diameter) needs also to be given. Examples for the chemical quality of different litter types are given in Appendix 1. Soil carbon input from plants does not contain humus. The possibility to take in humus as a part soil carbon input is included in the user-interface to make it possible to simulate land-use change and the associated additions of soil organic carbon to the simulated land-use class (see "3.3. Land-use change below).

To account for the uncertainty in the results of Yasso07 user-interface, which is caused by uncertainty about the values of soil carbon input, there is a possibility to give standard deviation for each soil carbon input value. The total uncertainty about the results is calculated by the user-interface based on these uncertainty estimates and error estimates for the parameter values of Yasso07 model (see "4 Model run").

Regarding climate, the information is needed on air temperature and precipitation. A worldwide set of these data can be found, for example, at the IPCC Data Distribution Centre (www.ipcc-data.org).

3.3 Land use change

Yasso07 can be used to simulate the cycle of soil organic carbon by land use class, for example, as a part of a greenhouse gas inventory. These simulations may involve transfers of land and soil organic carbon between the simulated land use class and other land use classes.

An increase in the area of the simulated land use class and the associated additions of soil organic carbon to this land use class can be accounted for by adding the transfers of soil organic carbon to the times series of carbon input to soil.

To account for a decrease in the area of the simulated land use class, there is a possibility in the user-interface to give values of relative change in the simulated area by time step (Fig. 2). During these time steps of area change, each soil organic carbon compartment of Yasso07 model is reduced by a similar relative amount. During the following time step, the simulation continues from the reduced stock of soil organic carbon.

4 Model run

To run Yasso07 model using the user-interface, user must select 1) the number of parameter combinations to be used, 2) the number of time steps and 3) the length of a time step (Fig. 3).

The parameter combinations are results of a Markov chain Monte Carlo method used to determine the parameter values of Yasso07 model. They represent uncertainty about the parameter values, and the results calculated using the alternative parameter combinations stand for error in the results caused by the uncertainty about these parameter values.

If the simulation run is longer than the time series of climate, the climate time series will be used again from the beginning after reaching the end of the series. In other words, after using the last values of the climate time series, the first ones will be used again for the next time step of the simulation.

5 Results

Yasso07 user-interface shows simulation results on the screen but the results can also be saved to a file (Fig. 3).

On the screen, Yasso07 user-interface shows alternatively the results of soil carbon stock, change in soil carbon stock by time step or carbon flux out of soil (Fig. 3). The graphs illustrate the most probable values and their 95 % error estimates.

Soil organic carbon originating from non-woody and woody-litter are shown separately based on the minimum size given for woody litter on the "Model run" sheet (Fig. 3).

The simulation results can be saved to a file in two formats, 1) raw results based on each parameter combination used for the simulation or 2) statistical characteristics calculated from the raw results (Fig. 3). These files are in text format, and they contain a header describing the contents of the file and settings of the simulation that produced the results.

6 Help

Additional information on Yasso07 soil carbon model and contact address of the research team are found at Yasso web pages at www.environment.fi/syke/yasso.

The window size of Yasso07 user-interface program may lock in some Windowns systems between the minimized and maximized sizes. This problem can be fixed by removing in Windows XP the file
C:\Documents and Settings\<username>\Application Data\Enthought\traits\traits_ui
and in Windows Vista the file
C:\Users\<Your username>\AppData\Roaming\Enthought\traits\traits_ui.

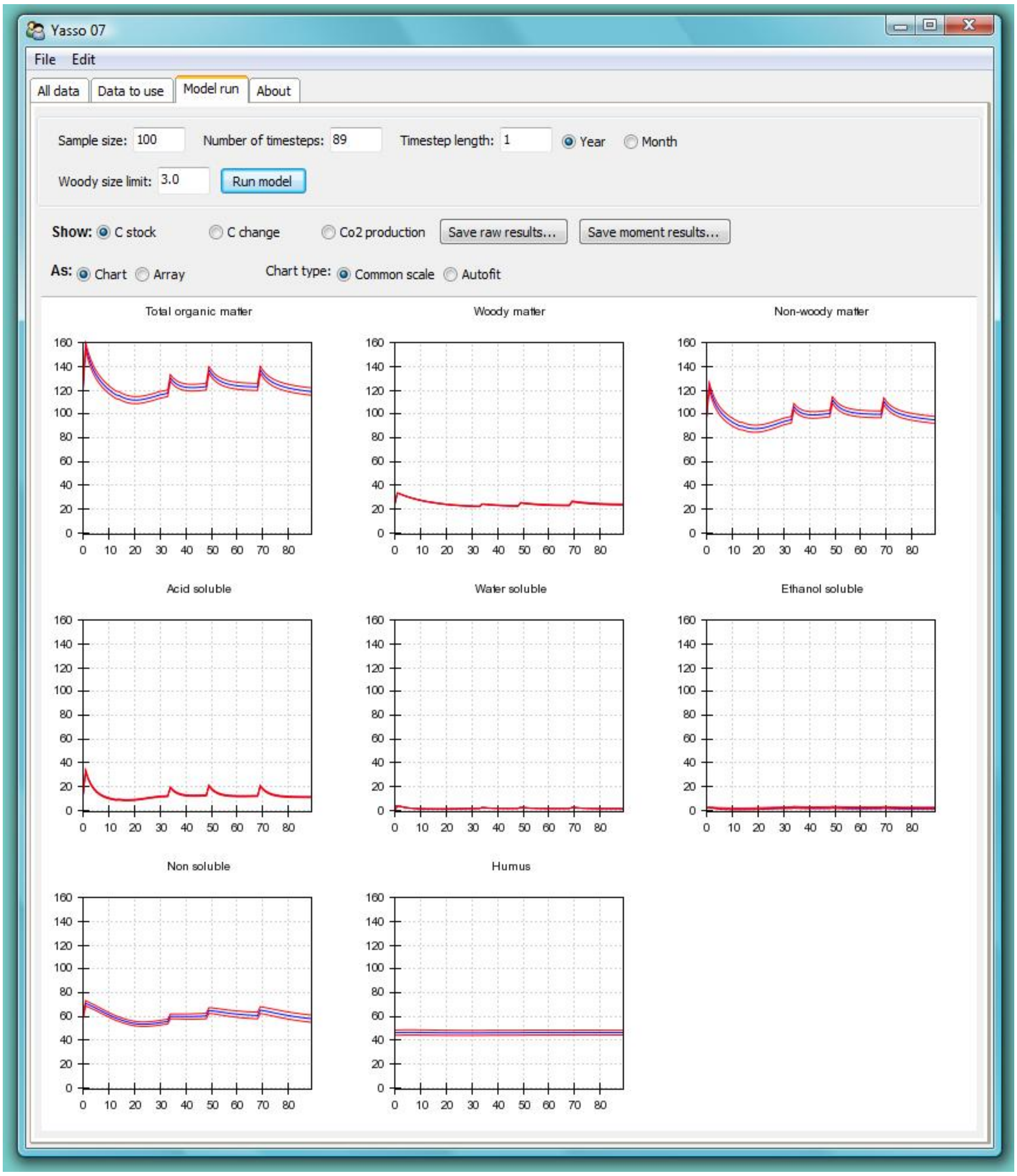

Fig. 3. "Model run" sheet of Yasso07 user-interface.

B. Yasso07 soil carbon model

1 Introduction

Yasso07 model describes cycling of organic carbon in soil (Tuomi et al. manuscripts). It is an improved version of an earlier Yasso model (Liski et al. 2005). Yasso07 is based on a substantially larger number of measurements and more advanced mathematical methods (e.g. Tuomi et al. 2008). In addition, uncertainty estimates are a fixed part of Yasso07 results.

Yasso07 calculates the stock of soil organic carbon, changes in the stock of soil organic carbon and heterotrophic soil respiration.

Applications of Yasso07 include, for example, simulations of land use change, ecosystem management, climate change, greenhouse gas inventories and education.

Yasso07 is a relatively simple soil organic carbon model requiring information only on climate and soil carbon input to operate.

2 Structure and operation

Yasso07 consists of five soil organic carbon compartments (Fig. 4). One is for compounds soluble in a non-polar solvent (waxes etc.), one for compounds soluble in a polar solvent (sugars etc.), one for compounds hydrolysable in an acid (celluloses etc.) and one for compounds not soluble in the solvents nor hydrolysable in the acid (lignin etc.). These four form the group of labile compartments. The fifth compartment contains more stable humus.

Decomposition of the compartments results in carbon flux out of soil and carbon fluxes between the compartments (Fig. 4).

The basic idea of Yasso07 is that the decomposition of different types of soil carbon input depends on the chemical composition of the input types and climate conditions. The effects of the chemical composition are taken into account by dividing carbon input to soil between the four labile compartments explicitly according to the chemical composition (see Fig. 4). Decomposition of woody litter depends additionally on the size of the litter. The effects of climate conditions are modeled by adjusting the decomposition rates of the compartments according to air temperature and precipitation.

A consequence of the basic idea of Yasso07 is that the parameter values of Yasso07 are independent of soil carbon input type, ecosystem type and climate conditions. In other words, the same parameter values are suitable for all applications.

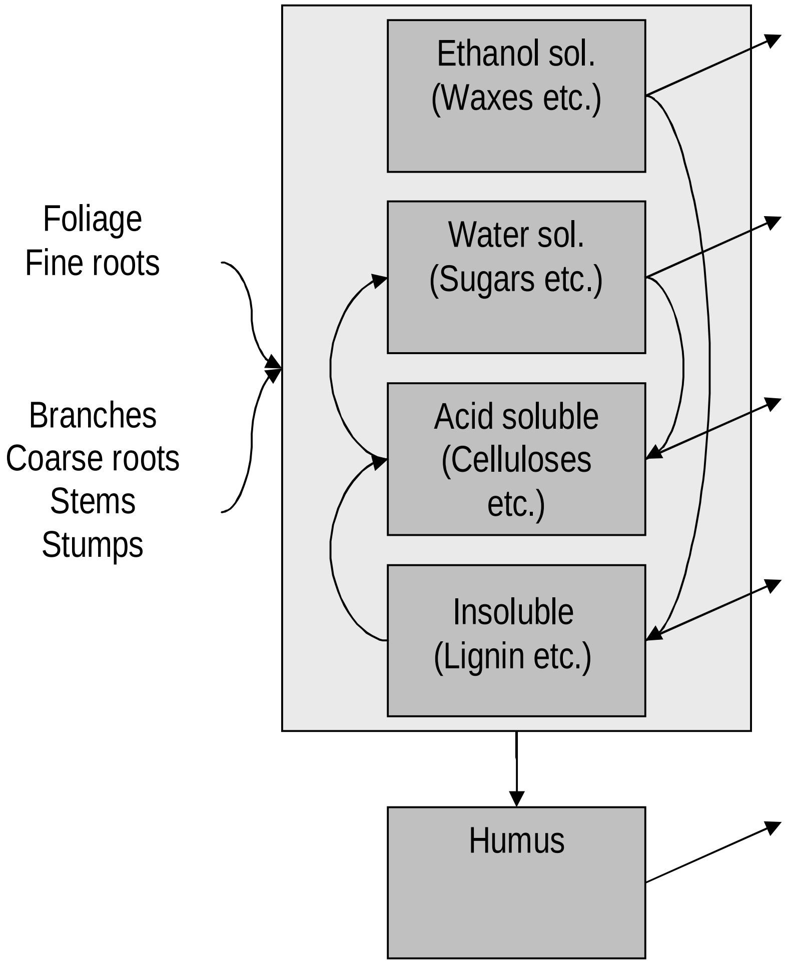

Fig. 4. Flow chart of Yasso07 soil carbon model. The boxes represent soil carbon compartments, the arrows carbon fluxes; only those carbon fluxes are shown that deviate significantly from zero (see Table 2).

3 Parameter values

3.1 Data

The parameter values of Yasso07 are based on different measurements related to cycling of organic carbon in soil (Table 1). An extensive set of litter decomposition measurements was fundamental in developing the model (Fig. 5). This data set covered, firstly, most of the global climate conditions in terms of temperature, precipitation and seasonality, secondly, different ecosystem types from forests to grasslands and agricultural fields and, thirdly, a wide range of litter types.

Table 1. Measurements used to develop Yasso07 soil carbon model.

Measurement type	n	Geographical region	MAT range (°C)	P range (m)	Time series length	Reference
Foliage and fine root litter decomposition (37 species)	9023	Europe, North America, Central America	-10 to 26	200 to 3900	3 to 10 years	Berg et al. 1991a, b, 1993, Trofymow et al. 1998, Gholz et al. 2000
Woody litter decomposition	1919	Finland, Estonia	0 to 5	300 to 600	2 to 72 years	Tarasov and Birdsey 2001, Palviainen et al. 2004, Mäkinen et al. 2006, Vávrová et al. 2008
Soil organic carbon stock	60	Finland	-1 to 4	500 to 600	n.a.	Liski and Westman 1995, 1997
Accumulation of soil organic carbon on a soil age sequence	26	Finland	3	500	5500 years	Liski et al. 1998

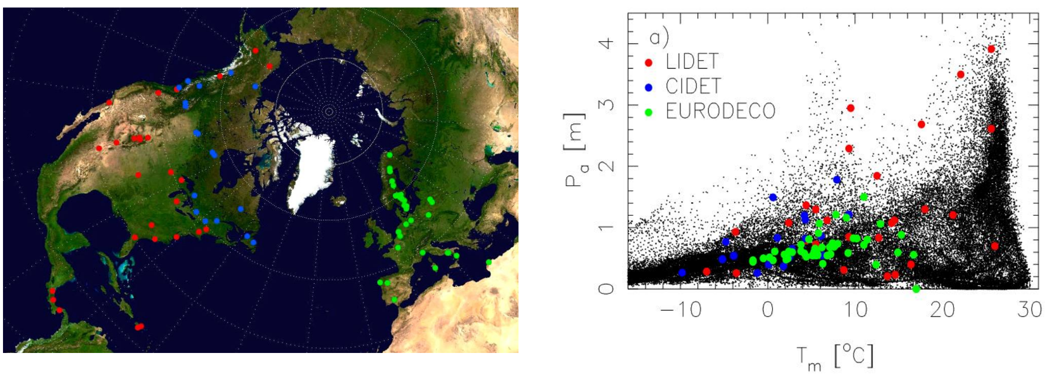

Fig. 5. Sites of taking the foliage and fine root litter decomposition measurements (Table 1), location and climate conditions at the sites vs. the global climate conditions (T_m = annual mean temperature, P_a = annual precipitation).

3.2 Parameter values

The parameter values of Yasso07 were estimated by fitting the model simultaneously to all the data available (Table 1), except for the woody litter decomposition data. Parameter values describing the additional features of woody litter decomposition were determined separately after estimating the other parameter values (Tuomi et al. manuscript "Decomposition of woody litter…").

The parameter values were sampled using Markov chain Monte Carlo to estimate the probability densities of the values and make sure the parameters had unequivocal values, i.e. the model is not over-parameterized given the data (Table 2).

Table 2. Parameter values of Yasso07 model.

Parameter	Value	$\mathcal{D}_{0.99}$	Unit	Meaning
α_A	0.73	[0.62, 0.84]	a^{-1}	decomposition rate of A
α_W	5.8	[5.0, 6.6]	a^{-1}	decomposition rate of W
α_E	0.29	[0.24, 0.35]	a^{-1}	decomposition rate of E
α_N	0.031	[0.027, 0.042]	a^{-1}	decomposition rate of N
p_1	0.48	[0.41, 0.54]	–	mass flow from W to A
p_2	0.01	[0, 0.16]	–	mass flow from E to A
p_3	0.83	[0.60, 0.98]	–	mass flow from N to A
p_4	0.99	[0.94, 1]	–	mass flow from A to W
p_5	0.00	[0, 0.08]	–	mass flow from E to W
p_6	0.01	[0, 0.21]	–	mass flow from N to W
p_7	0.00	[0, 0.004]	–	mass flow from A to E
p_8	0.00	[0, 0.003]	–	mass flow from W to E
p_9	0.03	[0, 0.25]	–	mass flow from N to E
p_{10}	0.00	[0, 0.007]	–	mass flow from A to N
p_{11}	0.01	[0, 0.031]	–	mass flow from W to N
p_{12}	0.92	[0.79, 0.99]	–	mass flow from E to N
β_1	0.096	[0.078, 0.122]	$°C^{-1}$	temperature dependence parameter
β_2	-1.4	[-2.4, -0.8]	10^{-3} $°C^{-2}$	temperature dependence parameter
γ	-1.21	[-1.06, -1.36]	m^{-1}	precipitation dependence parameter
p_H	4.5	[3.7, 5.6]	10^{-3}	mass flow from A,W,E,N to humus
α_H	1.7	[1.4, 1.9]	10^{-3} a^{-1}	humus decomposition coefficient
δ_1	-1.71	[-1.90, -1.50]	cm^{-1}	size dependence parameter
δ_2	0.86	[0.76, 0.96]	cm^{-2}	size dependence parameter
r	-0.306	[-0.321, -0.290]	–	size dependence parameter

4 Results

Particular attention was paid to avoiding systematic error when fitting Yasso07 model to the data and determining the parameter values. When inspecting the outcome as a whole, the results were found to be free of bias with respect to litter type, climate conditions, time since the start of decomposition and ecosystem type.

On these bases, it is concluded that Yasso07 is suitable for making unbiased estimates of soil organic carbon cycle in a wide range of ecosystems and climate conditions. Random-like uncertainty of these estimates, which is caused by uncertainty about the parameter values, is represented by probability densities. These densities are calculated from the vectors of the model parameter values, which were estimated using Markov chain Monte Carlo.

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Appendix 1: Chemical composition of litter types.

Chemical composition of different litter types in terms the compartments of Yasso07 soil carbon model.

Litter type[a]	Plant species	A[b]	W	E	N	H	Code	Notes	Source[c]
bran.	Pinus sylvestris	0.4763	0.0196	0.0870	0.4170	0.0	inva01		vavrova
bran.	Pinus sylvestris	0.4933	0.0105	0.0659	0.4303	0.0	inva02		vavrova
bran.	Pinus sylvestris	0.4289	0.0197	0.1309	0.4205	0.0	inva03		vavrova
bran.	Pinus sylvestris	0.5068	0.0120	0.0506	0.4306	0.0	inva04		vavrova
bran.	Pinus sylvestris	0.4607	0.0107	0.0874	0.4412	0.0	inva05		vavrova
bran.	Pinus sylvestris	0.5047	0.0106	0.0519	0.4328	0.0	inva06		vavrova
bran.	Pinus sylvestris	0.4642	0.0130	0.0840	0.4388	0.0	inva07		vavrova
bran.	Pinus sylvestris	0.5307	0.0126	0.0382	0.4186	0.0	inva08		vavrova
bran.	Pinus sylvestris	0.5256	0.0116	0.0394	0.4234	0.0	inva09		vavrova
bran.	Pinus sylvestris	0.4661	0.0195	0.0996	0.4148	0.0	inva10		vavrova
bran.	Pinus sylvestris	0.5060	0.0180	0.0647	0.4112	0.0	inva11		vavrova
bran.	Pinus sylvestris	0.4941	0.0257	0.0905	0.4456	0.0	inva12		vavrova
bran.	Pinus sylvestris	0.4848	0.0219	0.0633	0.4300	0.0	inva13		vavrova
bran.	Pinus sylvestris	0.4158	0.0295	0.1131	0.4416	0.0	inva14		vavrova
bran.	Pinus sylvestris	0.4605	0.0242	0.0874	0.4279	0.0	inva15		vavrova
bran.	Pinus sylvestris	0.4423	0.0198	0.1101	0.4278	0.0	inva16		vavrova
bran.	Pinus sylvestris	0.4811	0.0242	0.0681	0.4266	0.0	inva17		vavrova
bran.	Pinus sylvestris	0.4434	0.0263	0.1108	0.4195	0.0	inva18		vavrova
bran.	Pinus sylvestris	0.5141	0.0188	0.0561	0.4110	0.0	inva19		vavrova
bran.	Pinus sylvestris	0.4312	0.0218	0.1128	0.4341	0.0	inva20		vavrova
bran.	Pinus sylvestris	0.4867	0.0207	0.0452	0.4474	0.0	inva21		vavrova
bran.	Pinus sylvestris	0.3997	0.0234	0.1161	0.4608	0.0	inva22		vavrova
bran.	Pinus sylvestris	0.4758	0.0176	0.0678	0.4388	0.0	inva23		vavrova
bran.	Pinus sylvestris	0.4741	0.0248	0.0698	0.4313	0.0	inva24		vavrova
bran.	Pinus sylvestris	0.4996	0.0188	0.0470	0.4346	0.0	inva25		vavrova
f.root	Drypetes glauca	0.5215	0.1991	0.1062	0.1613	0.0	indrglr		cidet/lidet
f.root	Picea abies	0.5508	0.1331	0.0665	0.2496	0.0	innspr	!approx.WandE	eurodeco
f.root	Pinus elliottii	0.3594	0.1965	0.0890	0.3490	0.0	inpielr		cidet/lidet
f.root	Pinus resinosa	0.5634	0.0937	0.0609	0.2820	0.0	inpirer		cidet/lidet
f.root	Pinus sylvestris	0.5791	0.1286	0.0643	0.2280	0.0	inspir	!approx.WandE	eurodeco
leaf	Abies lasiocarpa	0.3065	0.3196	0.1943	0.1796	0.0	inablal		cidet/lidet
leaf	Acer saccharum	0.2733	0.4768	0.0818	0.1587	0.0	inacsal		cidet/lidet
leaf	Alnus incana	0.4430	0.1953	0.0976	0.2641	0.0	ingallg	!approx.WandE	eurodeco
leaf	Ammophila breviligulata	0.5690	0.2157	0.0641	0.1440	0.0	inambrl		cidet/lidet
leaf	Andropogon gerardii	0.5937	0.1474	0.0592	0.1868	0.0	inangel		cidet/lidet
leaf	Betula lutea	0.4578	0.1852	0.0793	0.2662	0.0	inbelul		cidet/lidet
leaf	Betula papyrifera	0.3134	0.3715	0.0674	0.2477	0.0	inwbirl		cidet/lidet
leaf	Betula pubenscens	0.4079	0.1980	0.0990	0.2951	0.0	insbilb	!approx.WandE	eurodeco
leaf	Betula pubenscens	0.4600	0.1929	0.0964	0.2507	0.0	insbilg		eurodeco
leaf	Bouteloua eriopoda	0.6433	0.1852	0.0510	0.1553	0.0	inboerl		cidet/lidet

leaf	Bouteloua gracilis	0.6858	0.1384	0.0758	0.0796	0.0	inbogrl		cidet/lidet
leaf	Ceanothus greggii	0.2687	0.4911	0.1072	0.1237	0.0	incegrl		cidet/lidet
leaf	Cornus nuttalii	0.3701	0.5174	0.0912	0.0076	0.0	inconul		cidet/lidet
leaf	Drypetes glauca	0.3982	0.4023	0.0802	0.1091	0.0	indrgll		cidet/lidet
leaf	Fagus grandifolia	0.4847	0.1381	0.0776	0.2996	0.0	inbeecl		cidet/lidet
leaf	Fagus grandifolia	0.4911	0.1625	0.0732	0.2603	0.0	infagrl		cidet/lidet
leaf	Festuca hallii	0.6391	0.1405	0.0989	0.1219	0.0	infescl		cidet/lidet
leaf	Kobresia myosuroides	0.6156	0.2273	0.0535	0.0925	0.0	inkomyl		cidet/lidet
leaf	Larix laricina	0.4283	0.2190	0.0990	0.2537	0.0	intamml		cidet/lidet
leaf	Larrea tridentata	0.4046	0.3154	0.1845	0.0795	0.0	inlatrl		cidet/lidet
leaf	Liriodendron tulipifera	0.3127	0.4362	0.1393	0.0870	0.0	inlitul		cidet/lidet
leaf	Picea abies	0.4826	0.1317	0.0658	0.3199	0.0	innsplb	!approx.WandE	eurodeco
leaf	Picea mariana	0.3852	0.2068	0.1137	0.2943	0.0	inbsprl		cidet/lidet
leaf	Pinus banksiana	0.4355	0.1564	0.0715	0.3366	0.0	injpinl		cidet/lidet
leaf	Pinus elliottii	0.4134	0.1960	0.1734	0.2142	0.0	inpiell		cidet/lidet
leaf	Pinus nigra	0.4790	0.1633	0.0817	0.2760	0.0	incoplb	!approx.WandE	eurodeco
leaf	Pinus pinaster	0.5110	0.0960	0.0480	0.3450	0.0	inmaplb	!approx.WandE	eurodeco
leaf	Pinus pinea	0.4730	0.1211	0.0605	0.3453	0.0	instplb	!approx.WandE	eurodeco
leaf	Pinus resinosa	0.4458	0.2060	0.1531	0.1918	0.0	inpirel		cidet/lidet
leaf	Pinus strobus	0.3968	0.2017	0.1875	0.2059	0.0	inpistl		cidet/lidet
leaf	Pinus sylvestris	0.5180	0.1773	0.0887	0.2160	0.0	inspilg	!approx.WandE	eurodeco
leaf	Populus tremuloides	0.3656	0.3839	0.0948	0.1557	0.0	inaspnl		cidet/lidet
leaf	Populus tremuloides	0.4240	0.2307	0.1153	0.2300	0.0	intaslg	!approx.WandE	eurodeco
leaf	Pseudotsuga menzesii	0.3727	0.2202	0.0854	0.2735	0.0	inpsmel		cidet/lidet
leaf	Pseudotsuga menziesii	0.4442	0.1225	0.1096	0.3237	0.0	indfirl		cidet/lidet
leaf	Pteridium aquilinum	0.5263	0.0969	0.0242	0.3526	0.0	infernl		cidet/lidet
leaf	Quercus prinus	0.3938	0.2722	0.0935	0.2351	0.0	inquprl		cidet/lidet
leaf	Rhododendron macrophyllum	0.3690	0.3627	0.0895	0.1695	0.0	inrhmal		cidet/lidet
leaf	Robinia pseudoacacia	0.4045	0.3377	0.0719	0.1766	0.0	inropsl		cidet/lidet
leaf	Spartina alterniflora	0.5877	0.2675	0.0490	0.0712	0.0	inspall		cidet/lidet
leaf	Thuja plicata	0.3913	0.1127	0.1149	0.3811	0.0	incedal		cidet/lidet
leaf	Thuja plicata	0.3592	0.2231	0.1399	0.2667	0.0	inthpll		cidet/lidet
leaf	Triticum aestivum	0.7315	0.0672	0.0335	0.1621	0.0	intrael		cidet/lidet
stem	Betula pendula	0.6500	0.0300	0.0000	0.3200	0.0	intbb		woody
stem	Betula pendula	0.7800	0.0000	0.0000	0.2200	0.0	inttb		woody
stem	Picea abies	0.6300	0.0300	0.0000	0.3300	0.0	intbs		woody
stem	Picea abies	0.7000	0.0050	0.0050	0.2800	0.0	intts		woody
stem	Pinus sylvestris	0.6600	0.0300	0.0000	0.2900	0.0	intbp		woody
stem	Pinus sylvestris	0.6800	0.0150	0.0150	0.2800	0.0	inttp	!approx.WandE	woody

[a] bran. = branch litter, f.root = fine root litter
[b] AWENH refer to the compartments of Yasso07 model
[c] Vavrova = Vavrova et al. 2008, CIDET/LIDET = Trofymow et al. 1998, Gholz et al. 2000, eurodeco = Berg et al. 1991a, b, 1993