The Yasso07 www interface

The Yasso model

Yasso is a dynamical soil carbon model describing the decomposition of the organic material in soils. Yasso defines the annual soil carbon stock, changes in this stock with decomposition rates and flows between the five mass compartments and the release of carbon into atmosphere using a set of differential equations. To do this Yasso needs estimates of litter production and litter quality (size) and basic climate data. The parameter values for decomposition rates have been determined based on a wide set of litter decomposition and soil carbon content measurements (see e.g. Tuomi et al. 2009).

Official web page with model description and full list of publications is maintained by the Finnish Meteorological Institute in address https://en.ilmatieteenlaitos.fi/yasso.

The Yasso07 program

The Yasso07 program is an implementation of the Yasso07 model. It puts into practice the mathematical model of differential equations in Yasso07 and the analytical solution of these equations for the soil carbon content. The necessary input for the program is:

1) parameters for decomposition rates,
2) simulation time,
3) climate data consisting of temperature, rainfall and temperature amplitude,
4) litter infall,
5) diameter of woody litter (cm),
4) initial carbon stocks

The output of the program is soil carbon stock dynamics for the running period. The carbon stock is expressed with five compartments: A (acid solubles), W (water solubles), E (ethanol solubles), N (none solubles) and H (humus).

The Yasso07 www interface

The need for www interface for yasso07 rose within Luke from the practical need to provide user-friendly user interface for those researchers, who need to use Yasso07, but are not familiar with command line programs or programming.

The implementation was done by Jari Perttunen in autumn 2019 and the team for planning and testing involved Taru Palosuo, Katri Joensuu, Karoliina Rimhanen, Sanna Hietala and Perttu Virkajärvi. The idea of the user interface is to use Excel template that is filled with necessary input data for Yasso07, then upload the template for Yasso07, run the Yasso07 simulation and download the resulting Excel file for further analysis of the results.

The Excel template

The Excel template consists of four sheets:

1) Weather,
2) Litter infall,
3) Initialization data,
4) Parameters

Weather

The annual weather is defined by annual mean temperature (°C), total rainfall (mm) and temperature amplitude (°C) defined as: One half of the difference between the average daily temperature minimum and maximum (i.e., (Tmax-Tmin)/2). Those data including the calendar years to be simulated should be provided in columns A-D, in the Weather sheet.

LitterInfall

The annual litter infall is provided here as inputs divided to A,W,E,N and H compartments in columns A-F including the simulation years. Please note that the simulation years provided in column A should be the same as in the Weather sheet.

For those who use the model for forestry application, please note that the LitterSize (column G) must repeat the same values. Different litter sizes require their own simulation runs, which can then be summed as needed.

The unit used here determines the unit of the output stocks. For example, if the input is provided in kg C ha^{-1} a^{-1}, the calculated stocks are kg C ha^{-1}. Make sure that the unit is comparable to units used in the SpinUp sheet.

InitializationData

The inputs for the Yasso07 initialization are given in InitializationData sheet (Fig 1.). The user can choose to use so called steady state assumption or start with some predefined soil carbon stock. In steady state assumption the Yasso07 model is run with constant litter infall and constant annual weather for a number of years, also called spinup period, until soil carbon stock remains unchanged. Note the sample values presented are taken from the LULUCF GHG inventory and are not generally applicable. However, for steady state assumption, the litter and weather inputs provided should be estimates of the average conditions during the past decades before the actual simulation period.

First, Yasso07 needs the initial soil carbon stock (A0,W0,E0,N0, H0) in columns A-E. Second, the constant annual litter infall (A1,W1,E1,N1,H1) is set in columns F-J. Third, the constant annual climate data is given in columns L-N. Fourth, the spinup time is set in column O. Note the spinup time can be long, say 100000 years, before the steady state is reached. There is no computational penalty for this value due to the analytical solution of Yasso equations in Yasso07. Finally, for forestry applications, the litter size representing for example sticks, twigs and branches is given in column K and must be the same as in LitterInfall sheet. For agriculture litter size is (usually) zero.

If the user wants to start the run from some specific stock figures, and not to apply steady state assumption, it can be done so that one fills the wanted stock figures to columns A-E in the InitializationData sheet and then puts the length of the spinup run (column O) to zero (0).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	StartStock					LitterInfall						Weather			
2	Basically Carbon, but user defines and is responsible of units					As StartStock						Celsius	mm	(Tmax-Tmin)/2	
3	A0	W0	E0	N0	H0	A1	W1	E1	N1	H1	LitterSize	Temperature	Rainfall	Amplitude	SpinUpIterations
4	0	0	0	0	0	8.2359634	0.8931869	0.9298725	9.1277685	44.4027225	0	0.575538467	584.446393	14.57260145	100000

Figure 1. The InitializationData sheet with sample values for Yasso07 to give the initial carbon stock, annual constant litter infall, litter size (forestry), annual constant climate data and spinup time.

Whether the spinup run has reached the steady state, i.e. it was long enough, can be checked from the output sheet InitialState, which shows the difference for A,W,E,N and H values for two consecutive time steps for the last 1000 time steps of the spinup run.

The initial stock and the annual litter infall is a matter of debate and based on assumed values. The weather can be a long term mean, for example the following is NASA definition for Daily Mean Earth Temperature minimum, maximum and amplitude. Minimum is 22-year average of the minimum daily mean earth temperature for each month. Maximum is 22-year average of the maximum daily mean earth temperature for each month and amplitude is defined as (Maximum-Minimum)/2.

Parameters

The Excel file provides two predefined parameter sets, so called Scandinavian parameter set from Rantakari et al. 2012 in column A and the original Yasso07 parameter set from Tuomi et al 2009 in column B (Fig 2.). User may define other sets too to following columns. The parameter set used in the run is marked active with ‘X’ to the row 3, accordingly.

	A	B	C	D	E	F	G	H	I	J	K
1	Parameters										
2	Scandinavian	Tuomi et al	User defined 1	User defined 2							
3	X				Mark with X exactly one set of parameters active, add new parameter sets if needed						
4	-0.5172509	0.73			Used	1-16 matrix A entries 4xk, 12p					
5	-3.551512	-5.8			Used						
6	-0.3458914	-0.29			Used						
7	-0.2660175	-0.031			Used						
8	0.044852223	0.48			Used						
9	0.002926544	0.01			Used						
10	0.9779027	0.83			Used						
11	0.6373951	0.99			Used						

Figure 2. Yasso07 parameters. Scandinavian and the original from Tuomi et. al. 2009 are provided. Scandinavian is marked active with X in line 3. User can define and experiment with other parameter sets.

Please note the Used and Not used and further comments in columns E and F are only for the yasso07 www interface development purposes.

The Excel Results

After yasso07 simulation a new Excel file for the results will be created for download. In addition to the user filled template sheets this Excel file has two new sheets: InitialState and

Yasso07Result. The name of the result file is the template file name appended with the string "_result". In this way it is easy to keep track of Yasso07 input and its corresponding output.

InitialState

If the steady state assumption is not used the given initial stock is shown.

If the steady state assumption is used the A,W,E,N and H values for the up to the last 1000 time steps are shown from the spinup run. The purpose is to show the difference between two time steps (delta columns) and provide information if the model has reached the steady state. The difference between two soil carbon stock states, i.e. difference between each decomposition compartment, should be zero or very close to it towards the end of spinup. The last row shows the initial state of the actual Yasso07 simulation.

Yasso07Result

The results of the actual Yasso07 simulation for annual soil carbon content is presented here. In addition to the results for A,W,E,N and H stocks, also the total soil carbon stock (sum over AWENH), stock change (change between two consecutive years) and the stock change converted to CO_2s are shown. User can then further analyse the results in Excel or elsewhere as needed.

Tips and tricks

The simulation of carbon stock dynamics with constant weather and variable litter infall is done by giving single climate data at row 2 in Weather sheet. The simulation of carbon stock dynamics with variable climate data and constant litter infall is done by giving single litter data at row 2 in LitterInfall sheet. N.B. this is the only permitted exception on the rule that the simulation years must be the same in Weather and LitterInfall sheets.

Instead of repeatedly filling in and submitting a single Excel template file for yasso07 it is also possible to submit several template files and run yasso07 for all of them at once. Download command archives result files into a single zip file.

Finally, a note on the decimal point in Excel. Excel saves values (numbers) with additional data. Whether decimal point ('.') or decimal comma (',') is used Excel will deduce from the users Localization (Language and region settings). When opened a file saved with decimal point as the decimal separator will be automatically displayed with decimal comma as required and vice versa. If the user accidentally uses wrong decimal separator different from the Localization and sends the file for Yasso07 simulations the results are unpredictable. Excel has not saved numbers but plain text.

Happy simulations!

References

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