

# Global identifiability as a prerequisite for model parameterization

## – the case of the soil carbon model Yasso

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**METLA**

### Introduction:

Modelling is one approach for estimating the carbon stocks and fluxes of forest soils for example to meet the reporting requirements set in the Kyoto protocol.

Parameter estimation is an important part of the model development. It determines model's successful implementation, reasonable use and the reliability of the model results.

An essential prerequisite for the numerical estimation of the model parameters from experimental data is a priori global identifiability of the model, which tells whether the available data contain enough information to unequivocally estimate all the unknown parameters of the postulated model.

For soil models especially, this is a justified question, since typically there is the lack of experimentally verifiable counterparts to the conceptual compartments they contain.

In this work, the identifiability analysis was performed for a simple soil carbon model Yasso<sup>1</sup> with respect to the currently measurable soil carbon data.

### Material and methods:

A priori identifiability analysis was done by using XXX<sup>2</sup>, which is based on YYY. Currently, only some of the Yasso's compartments and their sums are measurable<sup>3</sup>. None of the model parameters, decomposition rates etc. can be determined directly.

### Notes & references:

- 1) Liski, J., Palosuo, T., Peltoniemi M. & Sievänen R. 2004. Carbon and decomposition model Yasso for forest soils. Manuscript submitted in August 2004.
- 2) ?Audoly, S., D'Angio, L., Saccomani M.P. & Cobelli C. 1998. Global identifiability of linear compartmental models - A Computer Algebra Algorithm. IEEE Transactions on Biomedical Engineering. 45:36-47.?
- 3) Currently measurable state variables  $X_i$  or their sums, i.e. the measurable output  $y$ , of Yasso:

$$\begin{aligned}y_1 &= X_{ext} \\y_2 &= X_{cel} \\y_3 &= X_{lig} + X_{hum1} + X_{hum2} \\y_4 &= X_{ext} + X_{cel} + X_{lig} + X_{hum1} + X_{hum2} \\y_5 &= X_{ext} + X_{cel} + X_{cel} + X_{lig} + X_{hum1} + X_{hum2} \\y_6 &= X_{cwl} + X_{ext} + X_{cel} + X_{lig} + X_{hum1} + X_{hum2}\end{aligned}$$

- 4) Maser, O.R., Garza-Caligaris, J.F., Kanninen, M., Karjalainen, T., Liski, J., Nabuurs, G.-J., Pussinen, A., de Jong, B.H.J. & Mohren, G.M.J. 2003. Modeling carbon sequestration in afforestation, agroforestry and forest management projects: the CO2FIX V.2 approach. Ecological Modelling. 3237:1-23.

- 5) Hynynen, J., Ahtikoski, A., Siitonen, J., Sievänen, R. & Liski, J. 2004. Applying the MOTTI simulator to analyze the effects of alternative management schedules on timber and non-timber production. Forest Ecology and Management, accepted for publication in August 2004.

- 6) Karjalainen, T., Pussinen, A., Liski, J., Nabuurs, G.-J., Erhard, M., Eggers, T., Sonntag, M. & Mohren, F. 2002. An approach towards an estimate of the impact of forest management and climate change on the European forest sector carbon budget: Germany as a case study. Forest Ecology and Management 162(1): 87-103.

### Soil carbon model Yasso

Yasso calculates the decomposition of soil organic matter, the stock of soil carbon and changes in soil carbon on an annual basis. It needs estimates of litter production, information on litter quality and basic data on climate to run.

Yasso consists of five decomposition compartments and two woody litter compartments. Its parameter values have been determined based on measurements of litter decomposition and soil carbon including anchoring of some parameter values<sup>1</sup>.

Yasso has already been linked to forest stand simulators CO2FIX<sup>4</sup> and MOTTI<sup>5</sup> and a region-scale forestry model EFISCEN<sup>6</sup>.

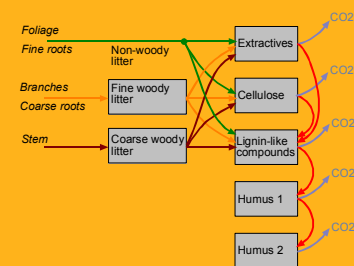


Fig. 1. Flow chart of Yasso

### Results and conclusions:

The identifiability analysis helps to create reasonable model structures and also gives light to the data needs and therefore guides further study.

The prerequisite of the global identifiability of the models should not be overlooked and the parameter estimation should be done carefully to achieve the reliability and verifiability of the model results.

The results of the analysis showed that the current structure of Yasso is not a priori identifiable with respect to the measurable soil carbon compartments. To achieve the identifiability either some parameters needs to be anchored, lignin and humus1 compartments or humus 2 compartment should be measurable or the model structure should be modified.

Study of the modified model structures is not yet completed. The numerical parameter estimation of the different candidate models will be done, the comparison of their performances and precision of their parameter estimates will be evaluated.