Soil carbon stocks and stock changes in national forest carbon inventories

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Research seminar on

Carbon budget of Finnish forests 1920-2000

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METLA

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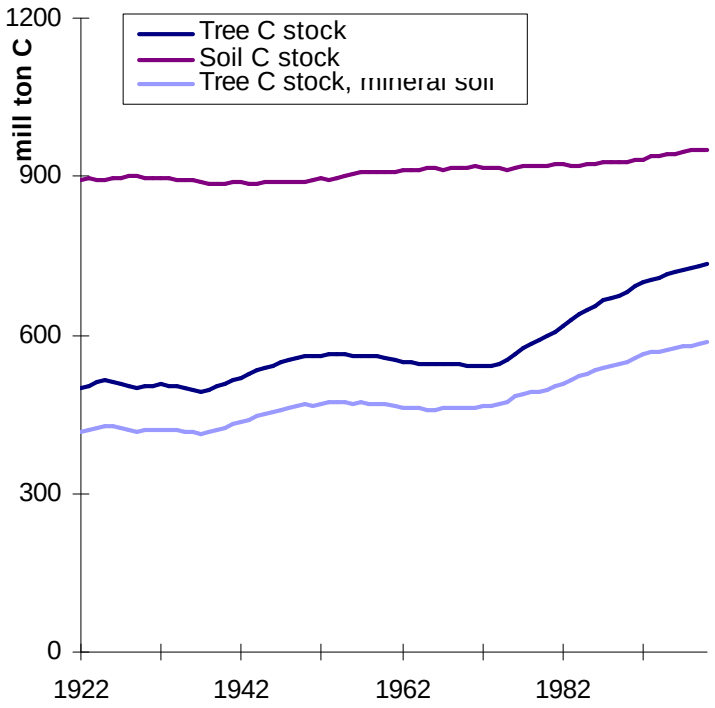
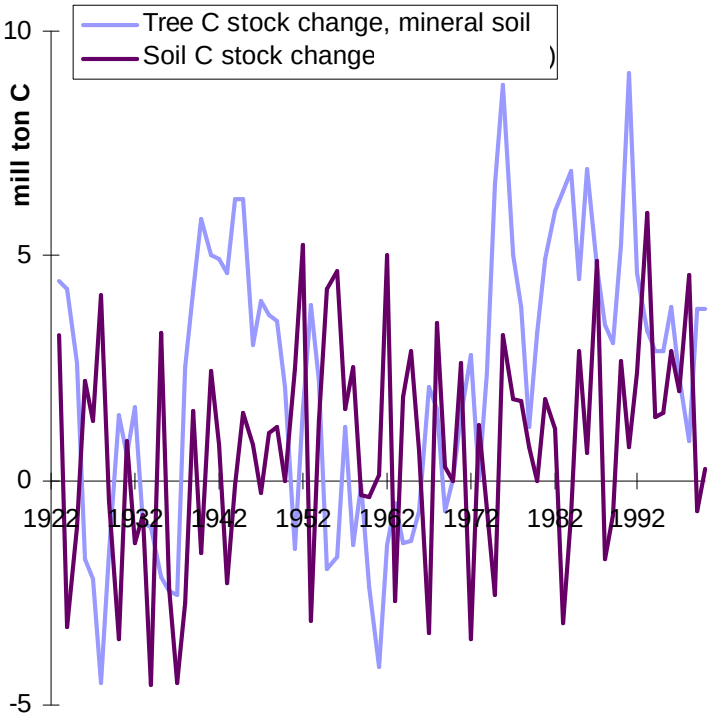
Background

C stocks



C stock changes



Challenges in soil carbon estimation

- stock changes difficult to measure
  - measurements laborious and expensive
  - high spatial variation
  - dynamic character of the stocks

- decomposition processes in soils are complex
  - organic matter consists of innumerable amount of different compounds and compound groups
  - wide range of fast and slow processes

- system boundaries

IPCC Good Practice for soil carbon stock changes

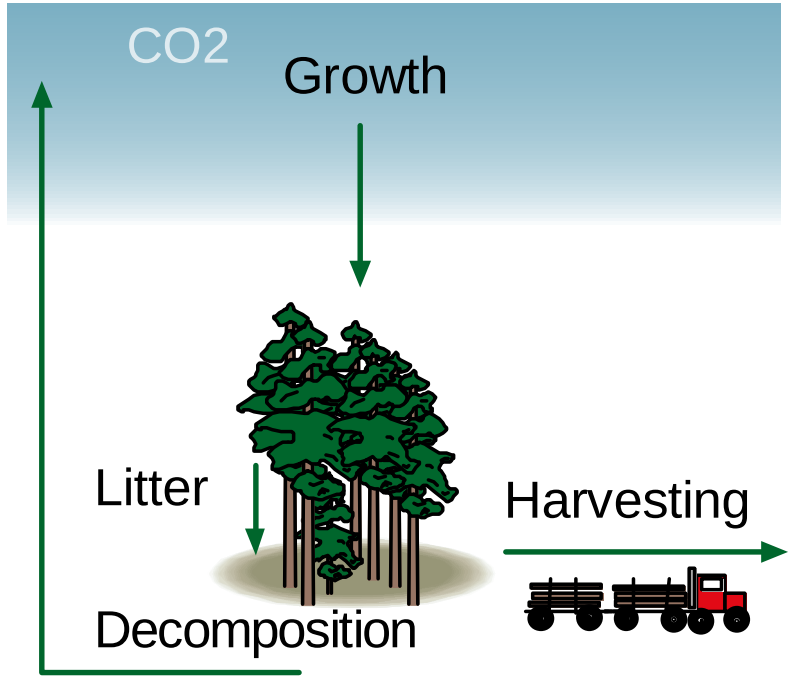
- TIER1: no changes in forest soil carbon stocks as far as land remains forest

- TIER2: soil carbon stocks of different “states” (including factors: forest type, management intensity and disturbance regime) and stock changes comes from the forest area transition between the states

- TIER3: country specific estimation method
  → monitoring scheme or modelling tool

Integrated method - soil

- Tier 3 / modelling
- Calculation of tree carbon and litter input to soil
- Modelling decomposition and carbon accumulation to soil with soil carbon model Yasso



Yasso

Input

- litter input
  - non-woody, fine woody and coarse woody litter
- litter quality
  - extractives, cellulose and lignin-like compounds
- climate data:
  - mean annual temperature or effective temperature sum
  - for the drought index
    - mean monthly temperatures
    - monthly precipitation

Output

- Soil carbon stocks
- Soil carbon stock changes
- Heterotrophic respiration

Applicability

– upland/well-drained forest soils

– climatic restrictions

→ Annual mean temperature

– from -5 to 17 °C

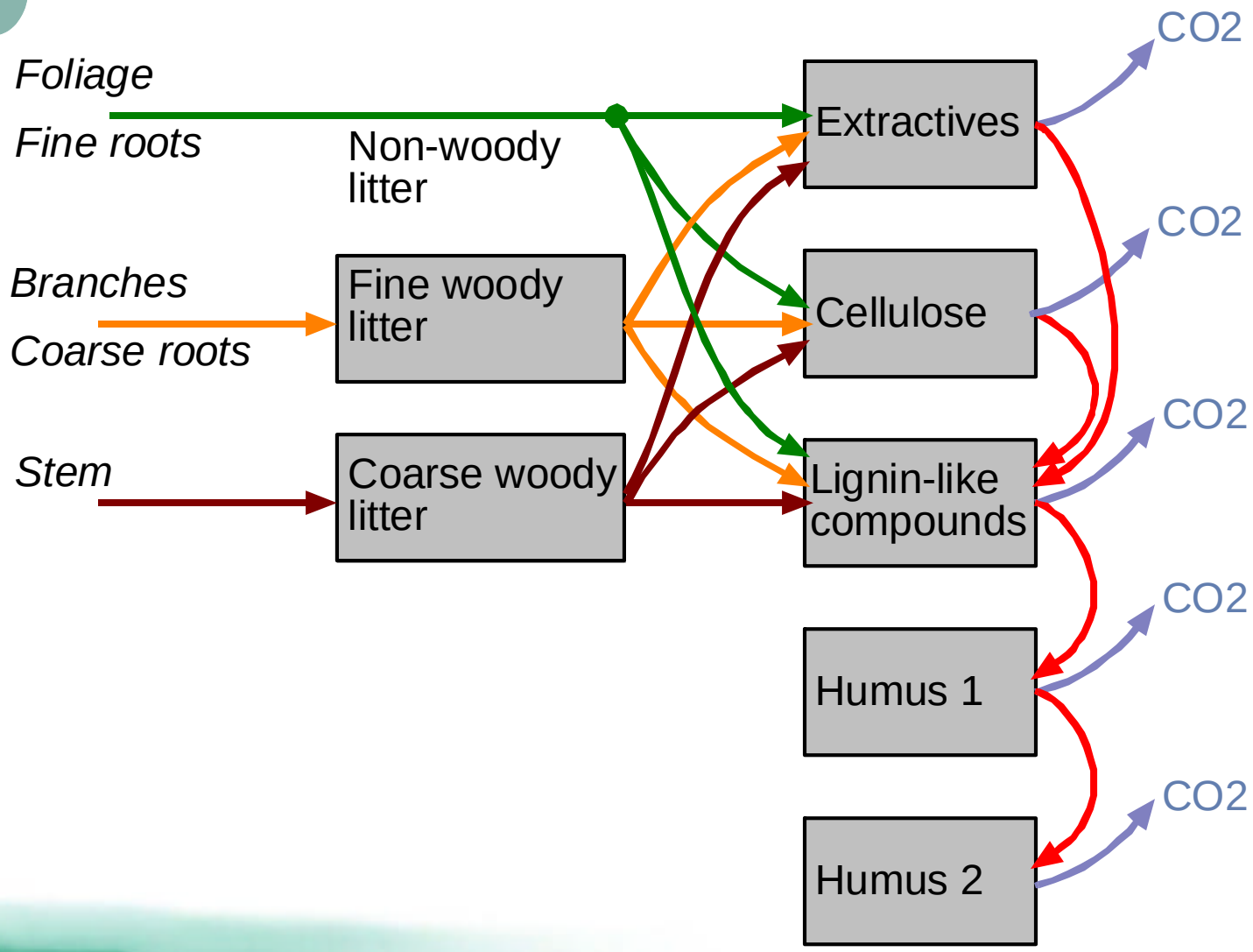
→ Temperature sum (0 °C threshold)

– from 1100 to 6100 °C days

→ Precipitation - PET (May to September)

–from -560 to 180 mm

Model structure



Parameters

Approach

- Model calibration under the southern Finnish - middle Swedish conditions
- Determination of the climatic dependence of the parameter values to calculate the parameter values under other conditions

Data

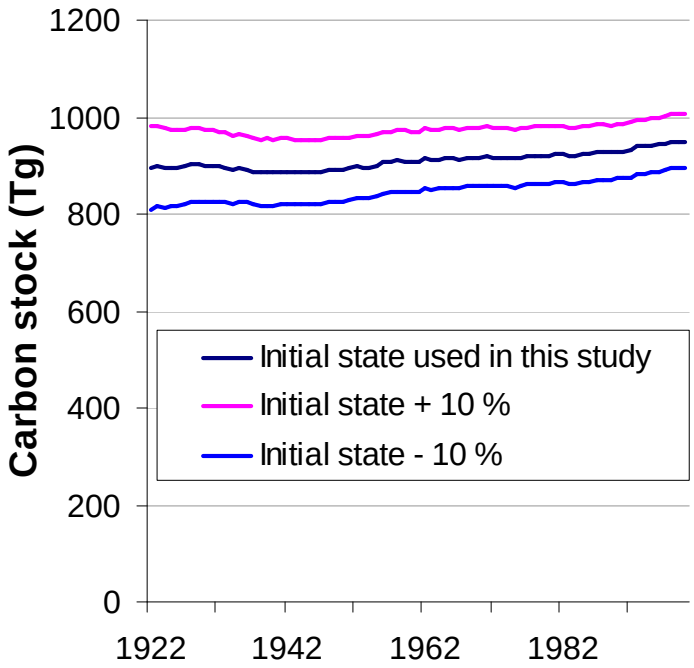
- Basic parameter set:
  - Litter bag experiments
  - Soil carbon measurements from soil chronosequence
  - Litter production estimates
  - Coarse woody debris data
- Climatic control of decomposition
  - Litter bag experiments

Reliability of model results - sources of uncertainty

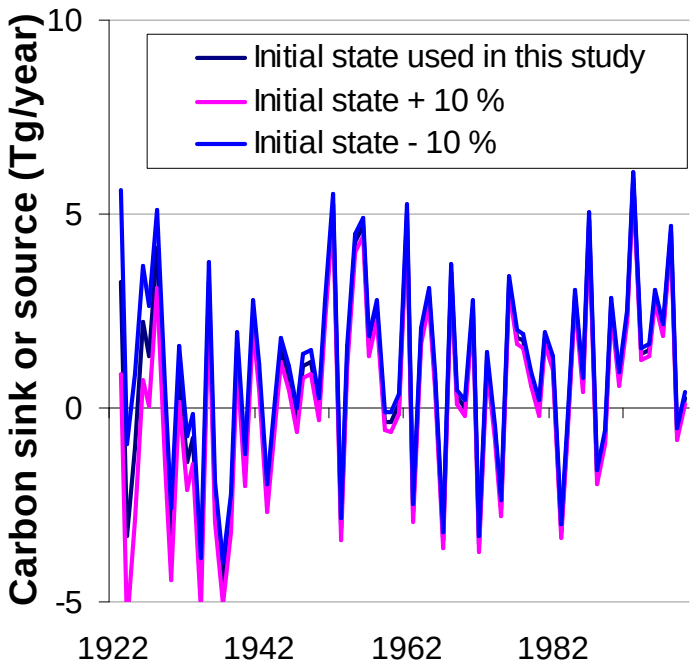
- model input
  - litter input
  - climate
  - initial soil carbon stocks
- model structure
  - description of decomposition processes
  - parameter values

Example: uncertainty of initial soil C stock

C stocks



C stock changes

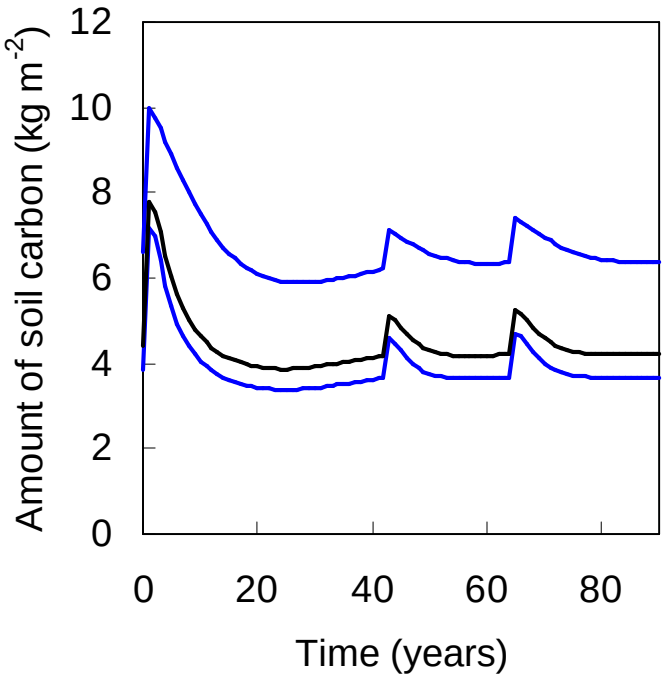


Sensitivity analysis

Variability of the soil carbon stocks and stock changes estimates

(Liski, J. Palosuo, T., Peltoniemi, M. & Sievänen R. Manuscript)

C stocks



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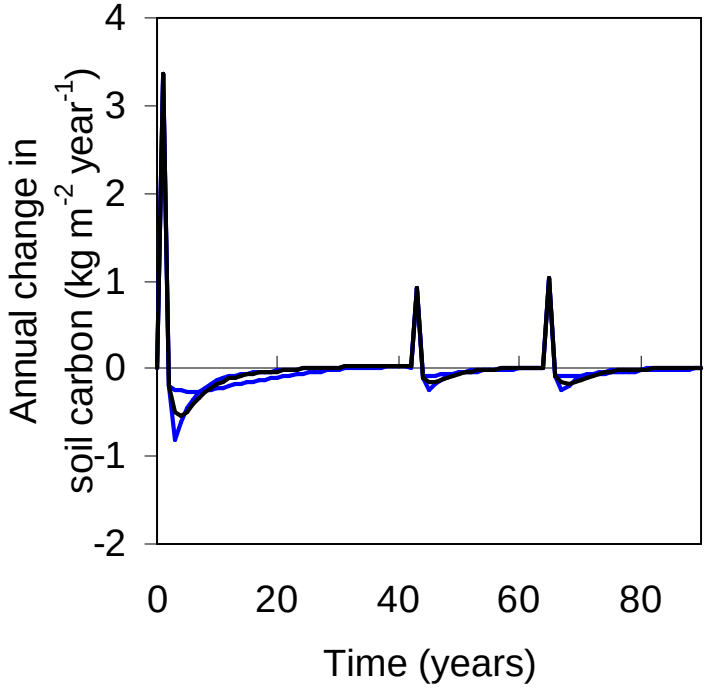
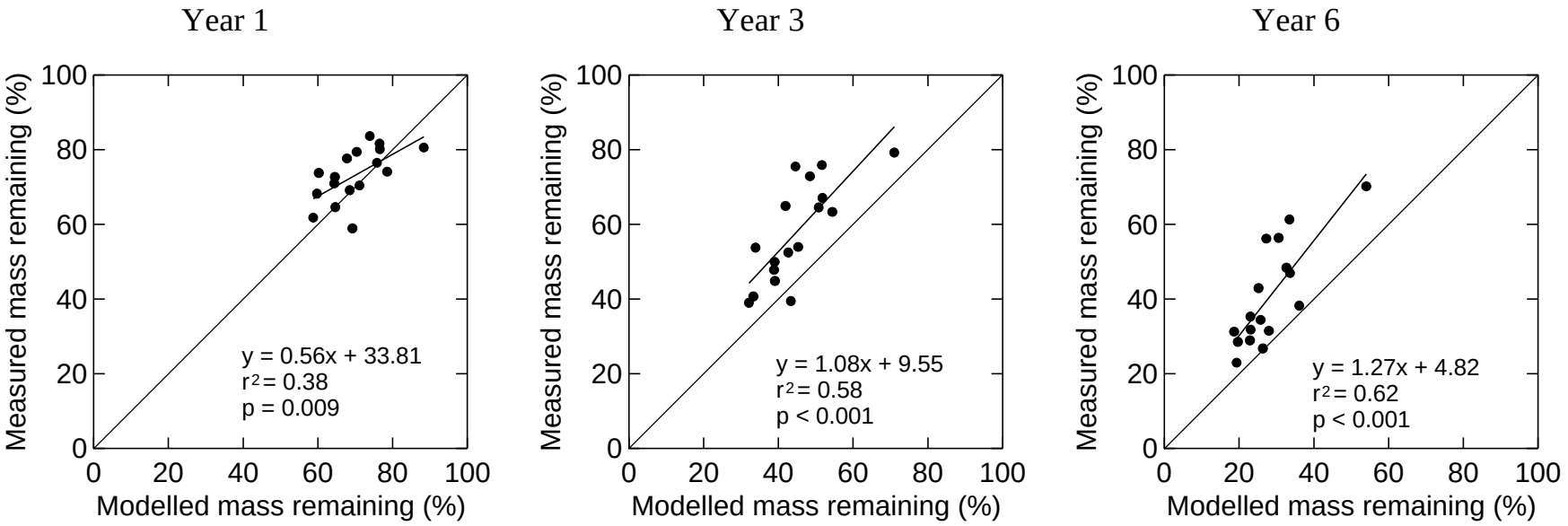


Litterbag experiment

Comparison of model results with Canadian litterbag data

(Palosuo, T., Liski, J., Trofymow, J.A., & Titus, B. Manuscript)



Other studies to validate the model results

- Total soil carbon measurements
  - Peltoniemi, M., Mäkipää, R., Liski, J. and Tamminen, P. Soil carbon increases with stand age - model results tested uning measurements. Submitted manuscripts.
  - De Witt, H., Liski, J., Palosuo, T. & Hylen, G. A carbon budget of forest in southeast Norway: effects of historical litter input and ground vegetation on modelled soil carbon stocks and sinks. Manuscript.
  - Thuerig, E., Bucher, J., Kaufmann, E., & Palosuo, T. The role of storm damage on carbon sequestration in Switzerland. Manuscript.
- Eddy covariance measurements
  - Eggers T. and Liski J. Comparison of forest carbon budgets estimated with an inventory-based method to eddy covariance measurements. Manuscript.

Ongoing and further model development

- uncertainty analysis for the system and the model
  - http://www.efi.fi/projects/uncertainty/
- climatic dependency of the model evaluation and further development
- version for peatlands
  - ongoing work under Research programme "Greenhouse Impacts of the Use of Peat and Peatlands in Finland" by Kari Minkkinen et al.
- soil layers needed

Yasso - applications

- Integrated method
- MOTTI, an empirical tree level stand growth model
- CO2FIX, a general model for estimating carbon balance and carbon sequestration capacity in forested landscapes or regions
- EFISCEN, a forest resource projection model
- International co-operation
  - Norway
  - Switzerland

Strengths and weaknesses

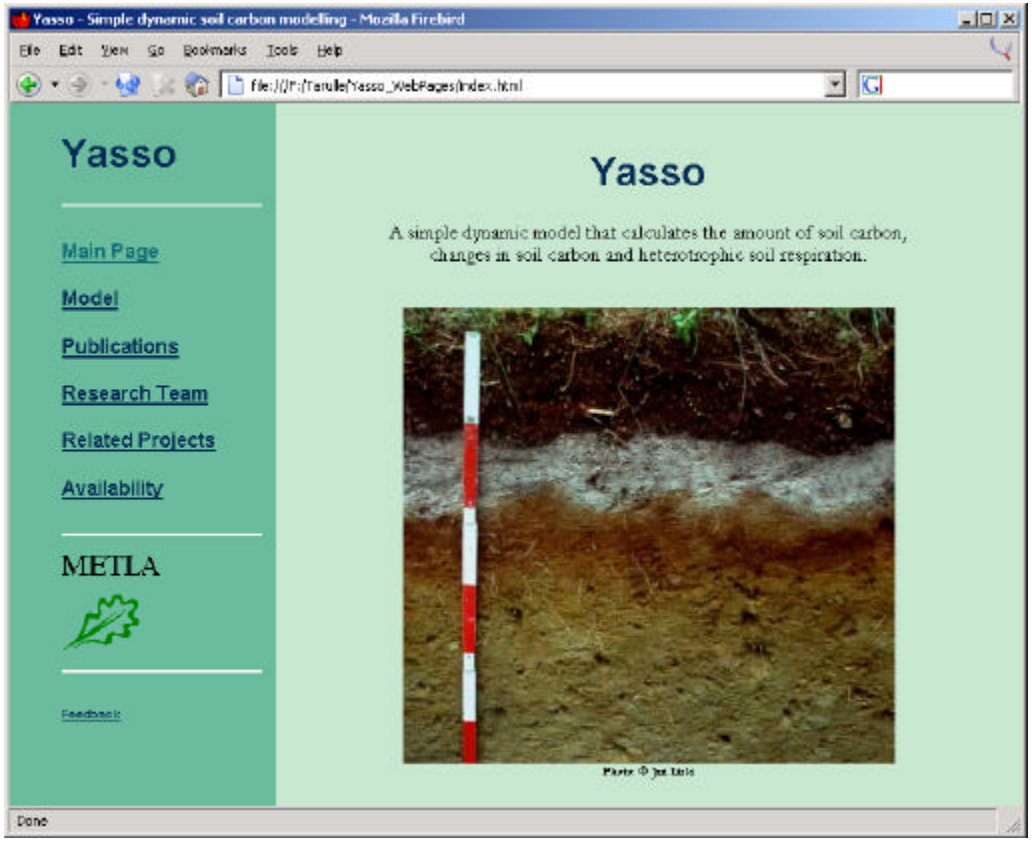
- Weaknesses/challenges
  - high uncertainty in model calculated values
- Strengths
  - simplicity → transparency
  - modelling approach highlights the needs for further study, helps to place various measurements and
  - experimental work in wider framework
  - applicability in different scales: stand level, forest area, country, etc.
  - can be integrated into various methods that are used to estimate forest carbon budgets
  - one year time step

Needs for further study

- Soil carbon modelling
  - development of models with respect to reliable estimation of soil carbon stock and stock changes in general
  - climatic dependency of decomposition
- Dynamics of soil carbon stocks, i.e. stock changes between years
  - driving factors (climate, management, etc.)
  - magnitude of changes
- Development of soil monitoring methods applicable on the large scale
- Litter input to soil, especially fineroots

Further information

http://www.efi.fi/projects/yasso/



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