



HoliSoils

Working together for forest soils

Holistic management practices, modelling & monitoring for European Forest Soils

Horizon 2020 project with 20 partners (May 2021- October 2025)

May
2023

Key products for LULUCF inventories

- Review on the climate smart forestry and its impacts to soil, and evaluating the ability of soil models to account these practises

REVIEW

- Soil model ensemble – for capacity building and GHG invs

SOIL MODEL ENSEMBLE

- Soil property maps for Europe

SOIL MAPS



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco



How does management affect soil C sequestration and greenhouse gas fluxes in boreal and temperate forests? – A review



Raisa Mäkipää^{a,*}, Rose Abramoff^b, Bartosz Adamczyk^a, Virginie Baldy^c, Charlotte Biryol^c, Michal Bosela^d, Pere Casals^e, Jorge Curiel Yuste^{f,g}, Marta Dondini^h, Sara Filipekⁱ, Jordi Garcia-Pausas^e, Raphael Gros^c, Erika Gömöryová^d, Shoji Hashimoto^j, Mariana Hassegawa^k, Peter Immonen^a, Raija Laiho^a, Honghong Li^a, Qian Li^a, Sebastiaan Luyssaert^l, Claire Menival^c, Taiki Mori^j, Kim Naudts^m, Mathieu Santonja^c, Aino Smolander^a, Jumpei Toriyama^j, Boris Tupek^a, Xavi Ubeda^e, Pieter Johannes Verkerk^k, Aleksi Lehtonen^a

^a Natural Resources Institute Finland (Luke), Latokartanonkaari 9, FI-00790 Helsinki, Finland

^b Environmental Sciences Division, Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, TN 37830, USA

^c Aix Marseille Univ, Avignon Univ, CNRS, IRD, IMBE, Marseille, France

^d Faculty of Forestry, Technical University in Zvolen, T.G. Masaryka 24, 96001 Zvolen, Slovakia

^e Forest Science and Technology Centre of Catalonia (CTFC), 25280 Solsona, Spain

^f Basque Centre for Climate Change (BC3), Scientific Campus of the University of the Basque Country, 48940 Leioa, Spain

^g Ikerbasque, Basque Foundation for Science, Bilbao, Bizkaia, Spain

^h School of Biological Sciences, University of Aberdeen, 23 St Machar Drive, Aberdeen AB24 3UU, Scotland, UK

ⁱ Wageningen University and Research, Wageningen Environmental Research (WENR), Droevendaalsesteeg, 3, 6708PB Wageningen, The Netherlands

^j Forestry and Forest Products Research Institute (FFPRI), Muramba 1, Tlokweng, Botswana, 095 0007, Botswana

REVIEW

Policy brief in the EFI www-site



Forest soils can increase climate change mitigation with targeted management

The European Union aims to be climate neutral by 2050 under targets set in the Paris Agreement. Forest soils contain larger amounts of carbon (C) than standing biomass. Forest management can both increase and decrease carbon stock, soil CO₂ emissions, and net exchange of other greenhouse gases (GHG) such as methane (CH₄) and nitrous oxide (N₂O). Increasing the carbon sequestration in forest soils and reducing net GHG emissions is crucial to achieve the target.

REVIEW

Soil model ensemble [Elisa Bruni & Bertrand Guenet]



- Develop an interactive online interface that launches state-of-the-art models to simulate SOC stocks and GHG fluxes at site scale.
- Publicly available for end-users such as land managers, forestry experts and scientists: <https://github.com/elisabruni/Holisoils-multimodel>
- A pre-release version (v0) of web tool is publicly available at the following link: <https://elisabruni.shinyapps.io/test4/>
and was developed using the Shiny app framework (R Core Team, 2022)

SOIL MODEL ENSEMBLE

Soil model ensemble – user interface

Multi-model ensemble

Description

The multi-model ensemble tool

This tool is designed to simulate soil organic carbon (SOC) stocks and greenhouse gas (GHG) fluxes at site scale. The user should input the geographic coordinates of the site they want to simulate, and provide additional data on pedoclimatic and agronomic conditions. Different climate and land-use change scenarios can be chosen, in order to simulate their effect on the system.

What are multi-model ensembles

Multi-model ensembles are defined as a set of model simulations from structurally different models. In soil science, they are used by scientists and policy makers to predict, amongst other, the evolution of SOC stocks and GHG fluxes with time. They can be run under different land-use or climate change scenarios in order to study the effect of such changes on the system.

description

Multi-model ensemble

Description

Models description

A part from SG, all models represent SOC with a conventional multi-compartmental structure that can be summarized with the following equation :

$$\frac{dC}{dt} = I(t) - A \times K \times \xi(t) \times C(t)$$

where: $C(t)$ is a vector describing the masses of SOC of the n compartments as a function of time t ;
 $I(t)$ is the vector of the C input to the soil;
 A is a matrix describing the mass flow within each pool;
 K is a diagonal matrix containing the decomposition coefficients of the compartments;
and $\xi(t)$ is the scalar effect of the pedo-climatic conditions on the decomposition of C.

The models that are included in the first version of the multi-model ensemble are:

- AMG (Andriulo et al., 1999)
- Century (Parton et al., 1988)
- ICBM (Andrén and Kästner, 1997)
- Roth-C (Coleman and Jenkinson, 1996)
- Yasso07 (Tuomi et al., 2009)
- SG (Hashimoto et al., 2011)

model description

Multi-model ensemble

Description

Data

Data input

Insert data to simulate SOC stocks and GHG fluxes at your site.

Simulations setup Soil data Litter input data

GPS LAT (DD) GPS LON (DD)

47.74579 17.03537

Initial simulation date (YYYY – MM – DD)

2022-10-31

Simulation length (year)

10

Time step

Yearly

Historic land – use

Grassland

data input

Multi-model ensemble

Description

Data

Data check

Data input by the user:

Starting simulation date: 2022-10-31

Simulation length: 10 years

Time-step: 1 year

Historical use of the land: Grassland

Clay: 29 %

Silt: 39 %

CaCO3: 284 g/kg

Initial SOC stock: 139.844991221085 MgC/ha

Soil thickness: 25 cm

C:N ratio: 12.925

Bulk density: 1.01698469747428 Mg/m3

Average C input: 5.89 MgC/ha/yr

Lignin:nitrogen ratio : 0.5

data check

SOIL MODEL ENSEMBLE

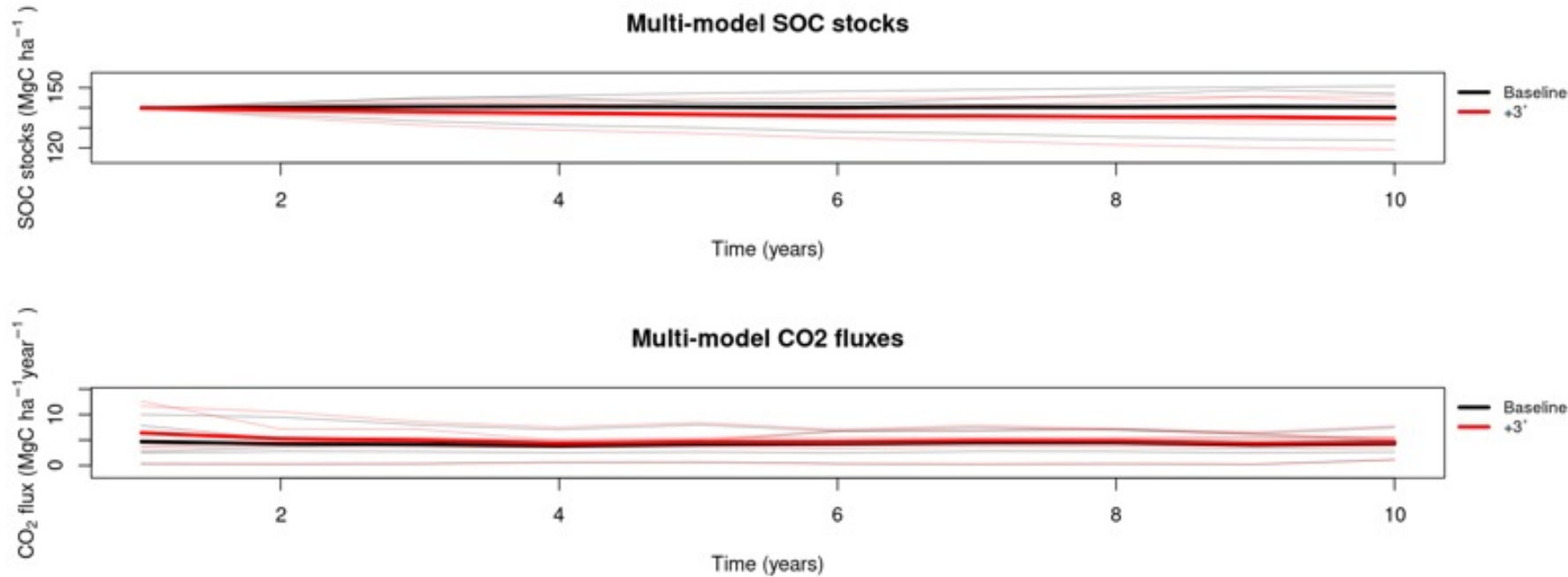
Climate and land-use change scenarios

Generate plots for the selected site under climate and land-use change scenarios

Climate change

Land-use change

Soil model ensemble – UI - results



AMG, Century, ICBM, Roth-C, Yasso07, SG, ...

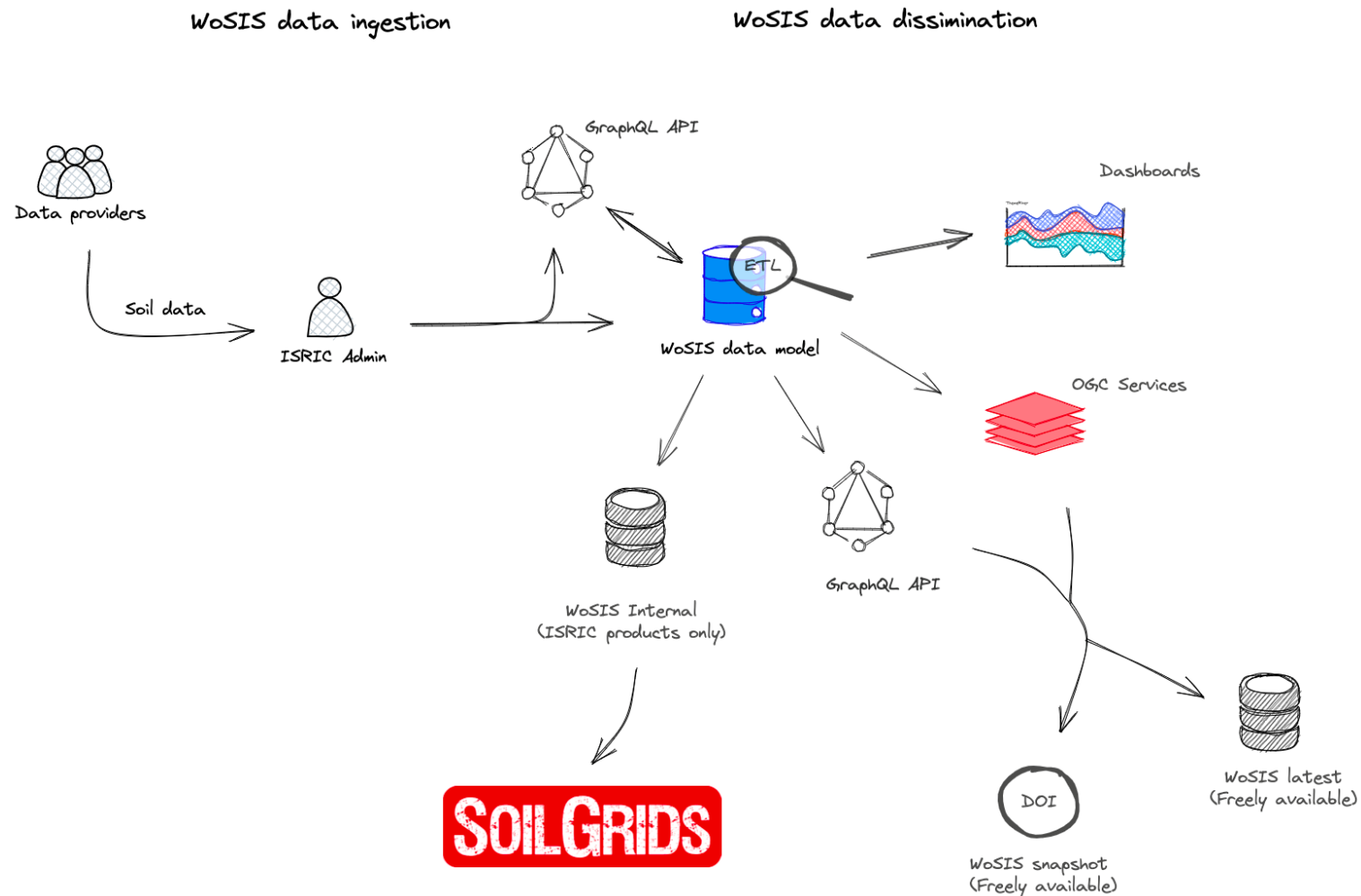
SOIL MODEL ENSEMBLE

Soil model ensemble – summary

- If input data lacks:
 - soil property data are extracted from **ESDAC** maps
 - and climate variables from the **ISIMIP** repository
- Advantages
 - The interface is user-friendly so anyone can use it even without a background in modeling
 - The tool is easily extendable to other land-uses and continents as long as global maps are available
- For capacity building, GHG-invs and future scenarios

SOIL MODEL ENSEMBLE

Soil property maps by ISRIC and TI: WoSIS diagram [Niels Batjes & Nicole Wellbrock]



Datasets received

- Forest soil data for Europe were collated.
- This activity resulted in $\sim 7,200$ profiles (4 datasets), with various license constraints.
 - Open license profiles 2,320
 - Restricted license profiles 4,880
- Challenging positional accuracy aspect on some datasets.
- These profiles are to represent ~ 227 million ha forest soils (~ 3.1 points / 1000 km^2).

Data ingestion, standardisation and harmonisation

- Basic quality/consistency control
- Identify repeated profiles
- Standardise attribute names
- Standardise analytical method descriptions
- Standardise units (incl. conversion factors)
- Plausibility checks (min, max, mean)

➤ **Standardisation** procedures (from WoSIS):

➤ Organic versus mineral soil layer

- Bulk density
- Carbon (Total & Organic)
- Calcium carbonate
- Cation exchange capacity
- Total Nitrogen
- Electrical conductivity (E_{c_x} , $E_{c_{sat}}$)
- pH (H_2O , KCl, $CaCl_2$, NaF)
- Coarse fragments
- Texture (sand, silt, clay)
- Water retention (at specified tensions)
- Available P (specified methods)

Also:

- *Classification*: FAO (year), WRB (year), USDA Soil Taxonomy (year), as provided
- *Horizon designation* (as provided, cleaned only)

SOIL MAPS

Provided data

<https://dashboards.isric.org/superset/dashboard/holisoils>

Filters

+ ADD/EDIT FILTERS

Country

28 options

Dataset

4 options

APPLY FILTERS

CLEAR ALL

Holistic management practices, modelling & monitoring for European forest soils (HoliSoils) Published



This dashboard provides an overview of soil data shared by partners in the framework of the EU Horizon 2020 HoliSoils project.

For more information check [Holisols](#) and [ISRIC-WoSIS](#) webpages

Open License Profiles

2.32k

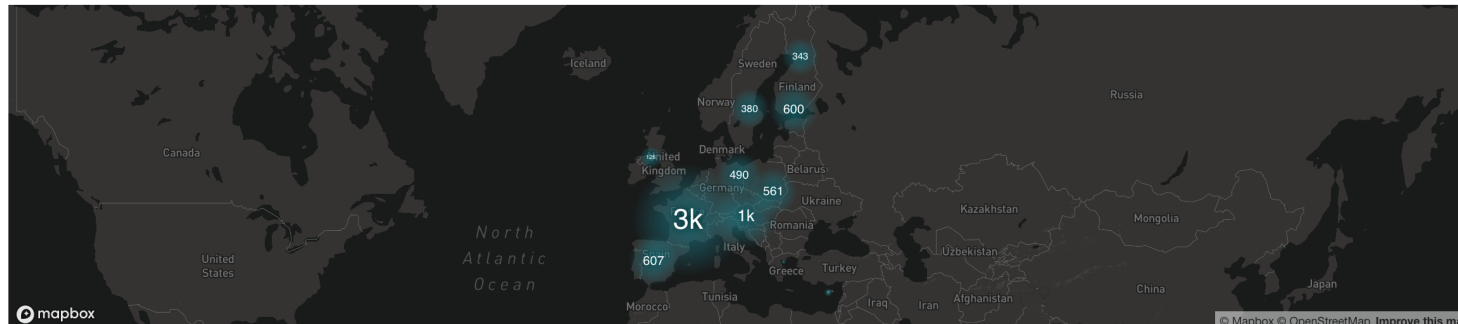
Restricted license profiles

4.88k

Total Layers

29.1k

Profile location map

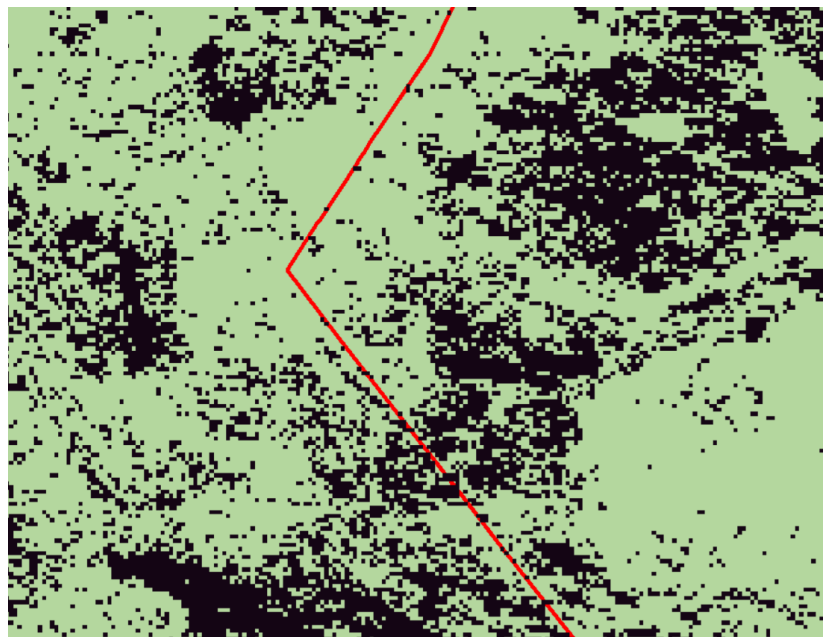


It can take a few seconds (20s –30s) to update, please be patient!

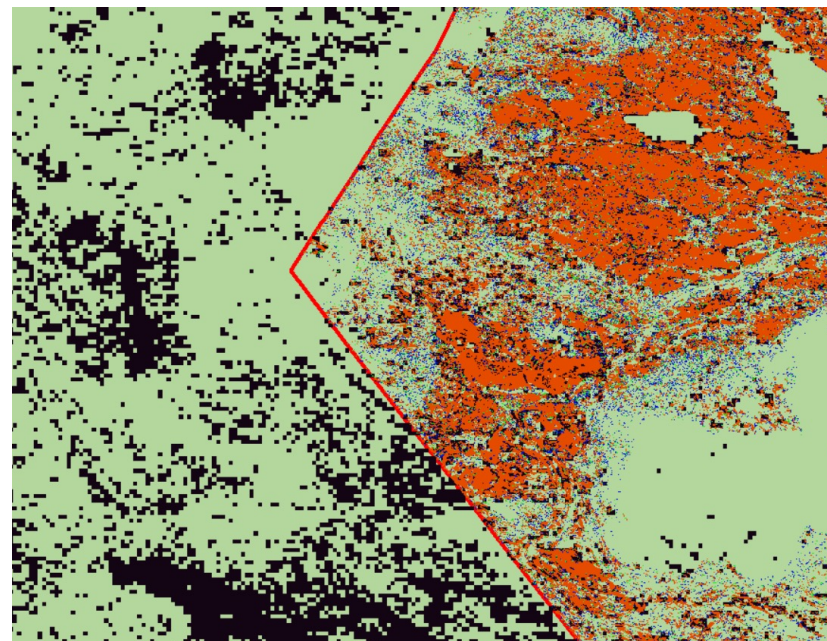
SOIL MAPS

Peatland maps [Aura Salmivaara - Luke]

- Greifswald Mire Center European peatmap in 150m resolution as a baseline
- The baseline map is updated with data from Sweden, Finland, Netherlands, ...
- The Swedish map in 2m resolution (Ågren et al. 2022) was created by machine learning methods utilizing soil wetness index derived from ALS data
- In Finland ML methods are also utilized to produce improved peat map in 50m resolution
- In HoliSoils
 - 1) a 100m peat map will be created and is used as covariate in soil mapping by ISRIC
 - 2) a segmented dataset on drained peatland forests will be created



NORWAY SWEDEN



NORWAY SWEDEN

Ågren, A. M., Hasselquist, E. M., Stendahl, J., Nilsson, M. B., and Paul, S. S.: Delineating the distribution of mineral and peat soils at the landscape scale in northern boreal regions, *SOIL*, 8, 733–749, <https://doi.org/10.5194/soil-8-733-2022>, 2022.

■ peat 30-40 cm
■ peat 40-50 cm
■ > 50 cm peat

SOIL MAPS

Thank you for your attention

aleksi.lehtonen@luke.fi

holisoils.eu

@holisoils