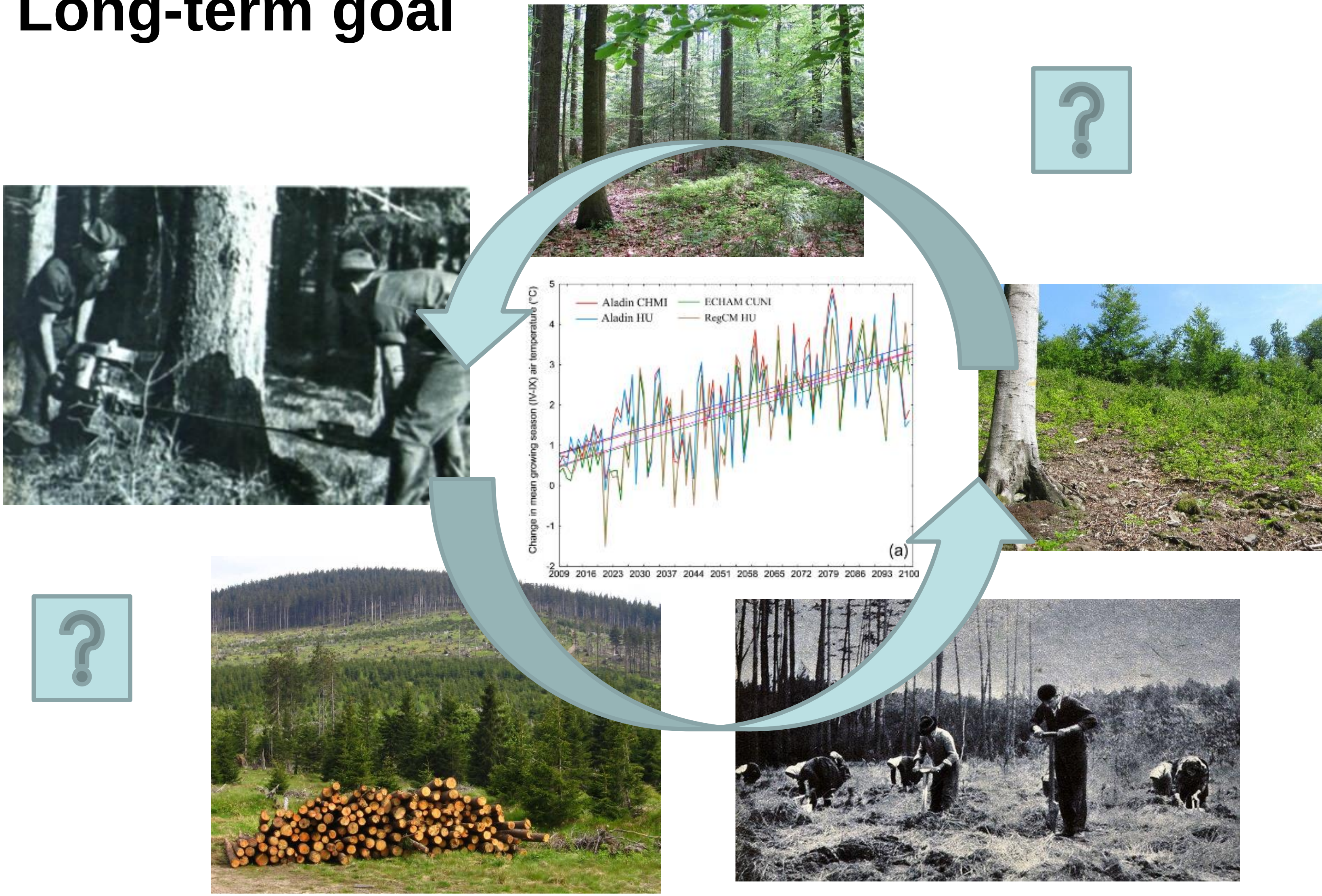
Testing robustness and plausibility of Biome-BGCMuSo simulations at a large scale

K. Merganičová,

J. Merganič, L. Dobor, R. Hollós, Z. Barcza, D. Hidy, Z. Sitková, P. Pavlenda, H. Marjanovic, D. Kurjak, M. Bošeľa, D. Bitunjac, M.Z. Ostrogovic Sever, J. Novák, P. Fleischer, T. Hlásny

Long-term goal



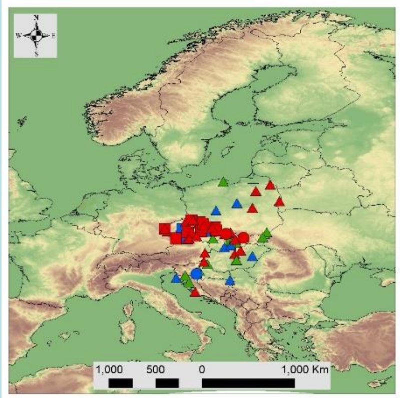
To assess forest productivity drivers and forest ecosystem responses along an extended environmental gradient and changing conditions across Central Europe

MuFfin Framework

Network

ELTE, NLC Zvolen, TU Zvolen, SL TANAPu, IBLES, CFRI, VULHM Opocno

Data - Central Europe



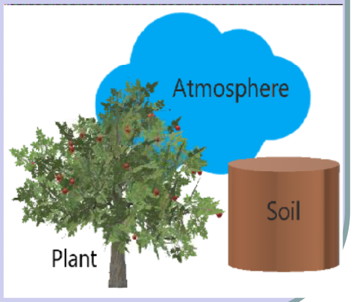
Gradient of site and management

Model

Biome-BGCMuSo version 6.2

(Hidy et al. 2012, 2016, 2022)

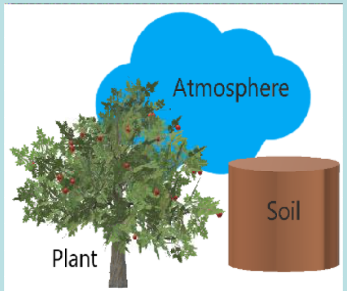
http://nimbus.elte.hu/bbgc/



Regional forest adaptation

Model

Biome-BGCMuSo version 6.2
(Hidy et al. 2012, 2016, 2022)
http://nimbus.elte.hu/bbgc/

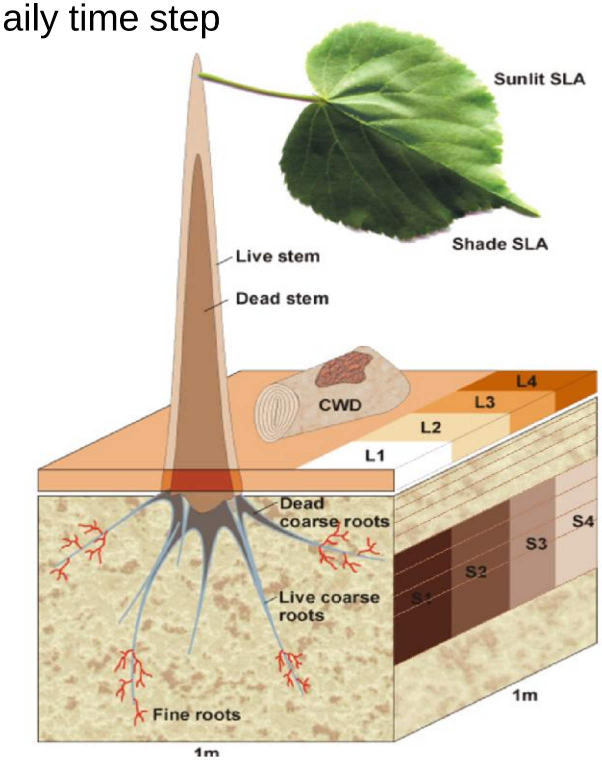


= an extension of Biome-BGC model (Thornton et al. 1998, 2002, Thornton 2000)
http://www.ntsg.umt.edu/project/biome-bgc

- a „big-leaf" process-based model

simulates a representative ecosystem area of $1m^2$

at a daily time step



The model simulates:
- 3 primary biogeochemical (=BGC) cycles of
  - carbon,
  - nitrogen,
  - water,

through vegetation and soil in terrestrial vegetation types = biomes

- primary physiological processes: photosynthesis, evapotranspiration, respiration, decomposition, allocation of photosynthetic assimilate, mortality

Biome-BGCMuSo novel features

Many upgraded or new features:

Layer 1	0-3 cm
Layer 2	3-10 cm
Layer 3	10-30 cm
Layer 4	30-60 cm
Layer 5	60-90 cm
Layer 6	90-120 cm
Layer 7	120-150 cm
Layer 8	150-200 cm
Layer 9	200-400 cm
Layer 10	400-1000 cm

- More detailed specification of soil – Multiple layers in soil – specific soil texture, pH, and soil bulk density

- More detailed soil hydrology - groundwater

- Phenology module - seven phenophases, phase-specific carbon allocation

- Drought related plant senescence

- Management modules – thinning, harvesting, sowing, irrigation, mowing, grazing, ploughing

Data

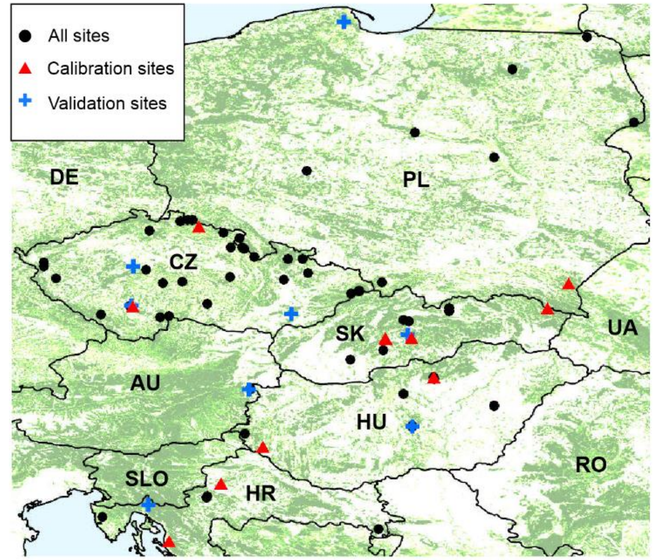
Highly instrumented sites

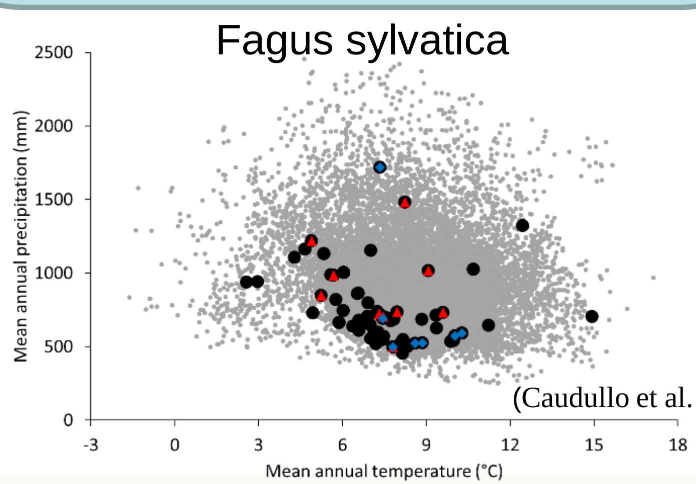
Tree
- Growth
- Water
- C Fluxes

Climate
- Temp
- Prcp
- Rad
- VPD

Soil
- Nutrients
- Water
- Texture

Site
- Position
- Deposition





(Caudullo et al. 2017)

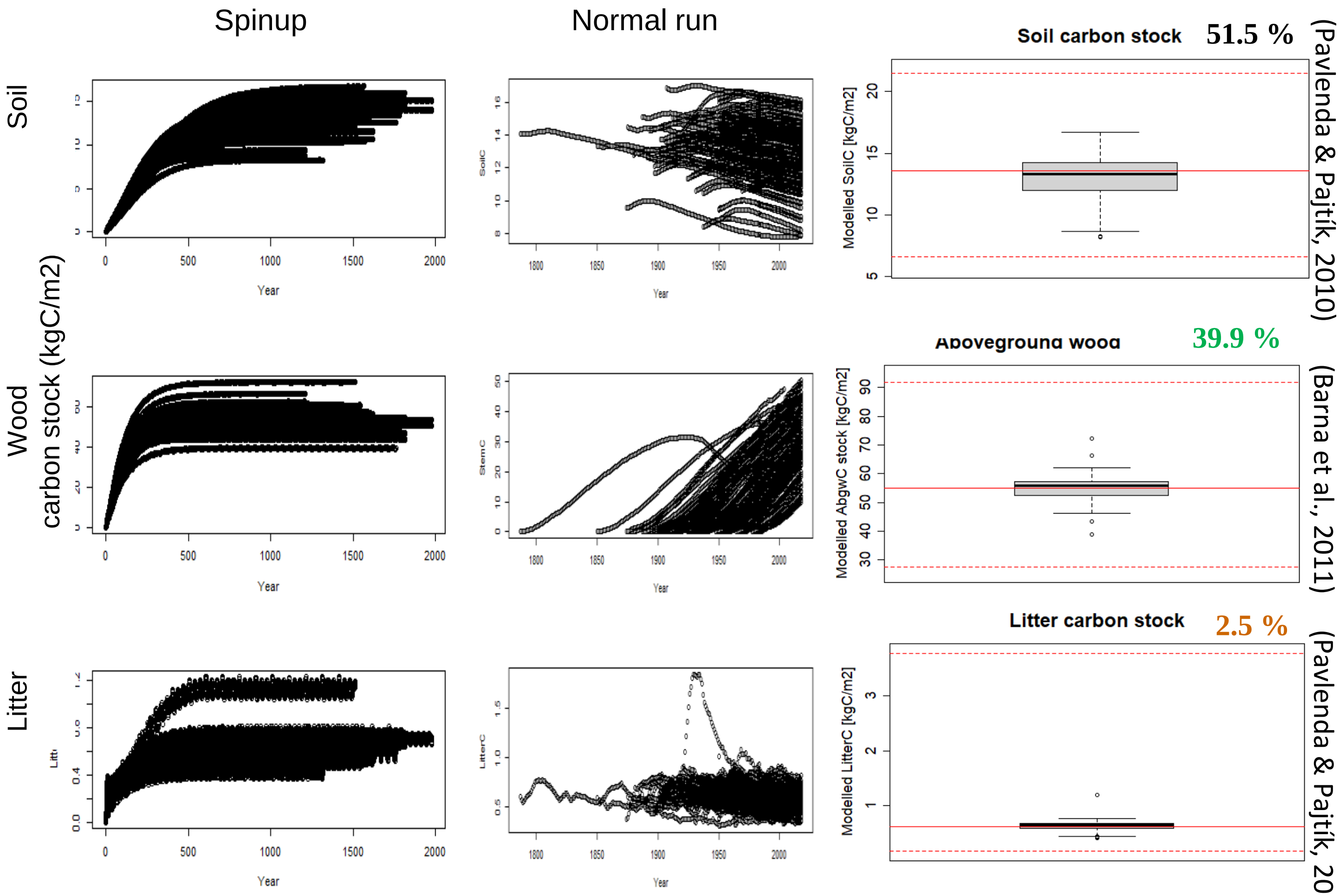
Long-term research plots

ICP Level II forest plots
- Tree
- Climate
- Soil
- Site
- Management

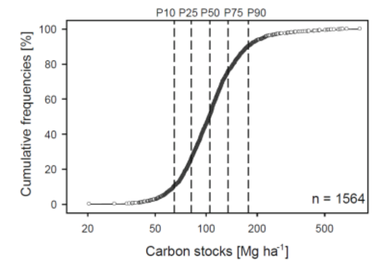
Thinning experiments
- Tree
- Soil
- Site
- Management

Simulations across the spatial domain

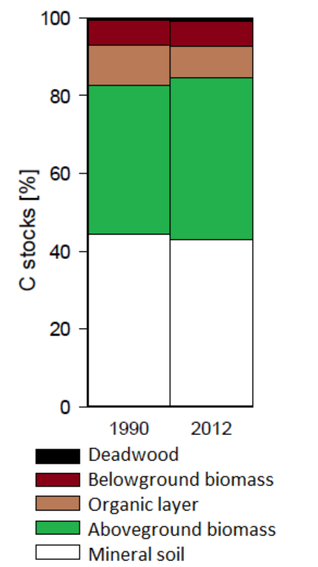
? Robust ? Plausible ?



✔ *Robust* ✔ *Robust* ✔ *Plausible*



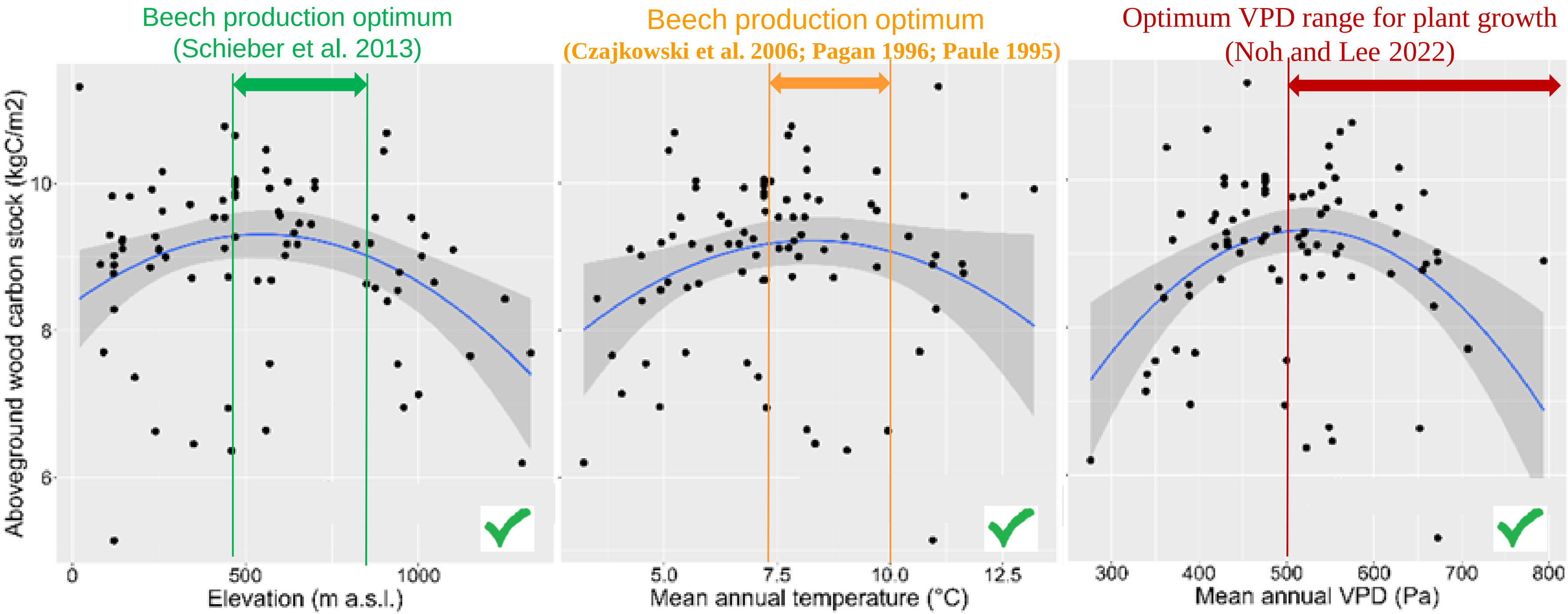
(Grüneberg et al. 2019)



(Welbrock et al. 2017, modified)

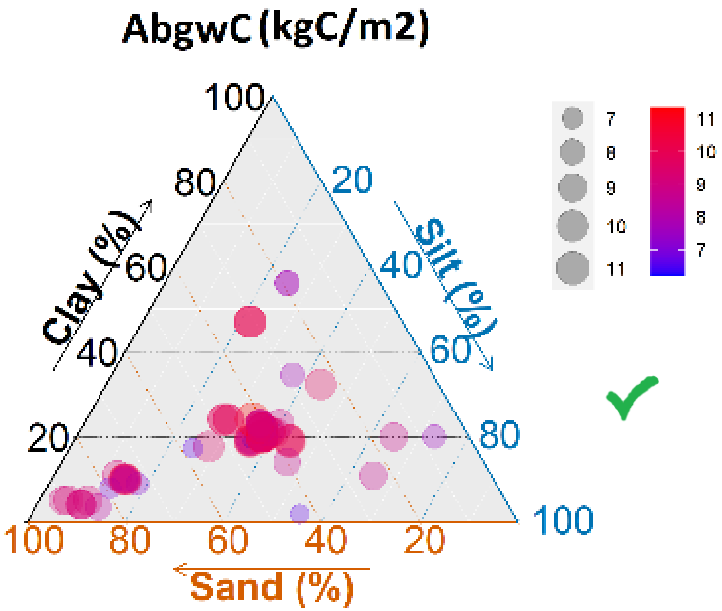
Carbon stock in aboveground wood

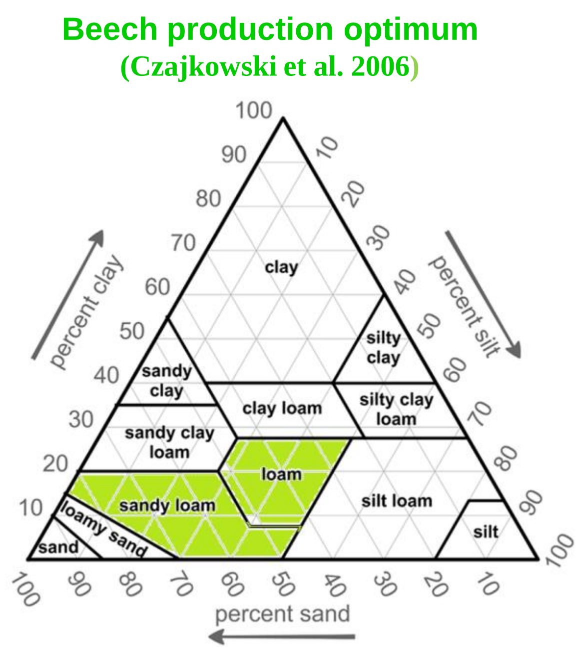
	Elevation	Latitude	TRange	AMTmin	AMTday	AMTmean	AMPRCP	AMVPD	AMSRAD	AMDayLen
R^2	*** **.22**	.001	.24	* **.08**	*** **.20**	*** **.16**	.06	*** **.26**	.04	.004



Carbon stock in aboveground wood

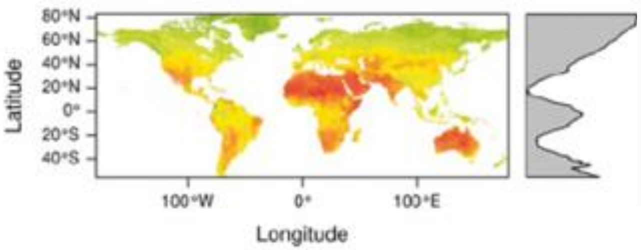
	SoilDepth	Sand	Silt	Clay	SoilpH
R^2	0.02	0.06	0.07	** 0.11	0.003





Carbon stock in soil

	Elevation	Latitude	TRange	AMTmin	AMTday	AMTmean	AMPRCP	AMVPD	AMSRAD	AMDayLen
SOILC	*** 0.46	*** 0.65	*** -0.44	*** -0.66	*** -0.67	*** -0.68	0.08	*** -0.61	*** -0.49	*** 0.43



Home > Soil Carbon > Chapter

Quantitatively Predicting Soil Carbon Across Landscapes

Budiman Minasny, Alex B. McBratney, Brendan P. Malone, Marine Lacoste & Christian Walter

Chapter | First Online: 01 January 2014

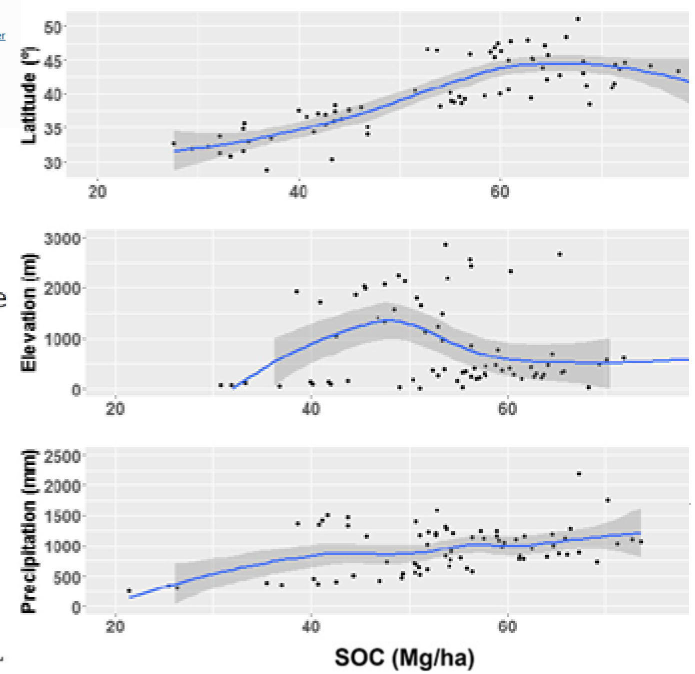
4830 Accesses | 2 Citations

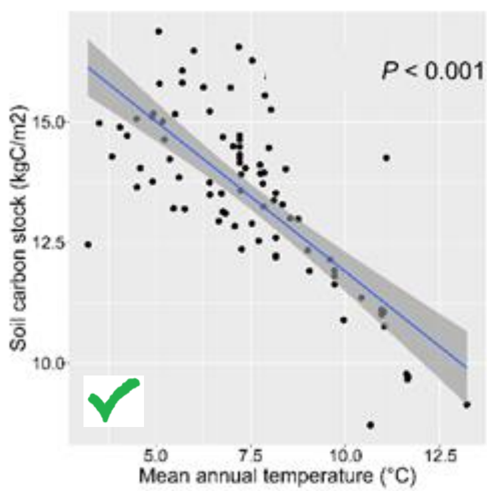
Part of the book series: Progress in Soil Science ((PROSOIL))

Ecological Applications, 27(4), 2017, pp. 1223–1235

Toward inventory-based estimates of soil organic carbon in forests of the United States

G. M. Domke,[1,5] C. H. Perry,[1] B. F. Walters,[1] L. E. Nave,[2] C. W. Woodall,[3] and C. W. Swanston[4]





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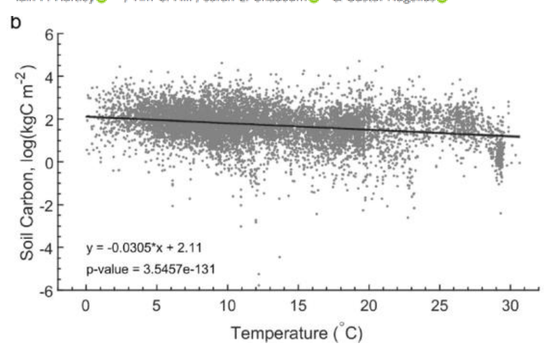
https://doi.org/10.1038/s41467-021-27101-1
OPEN

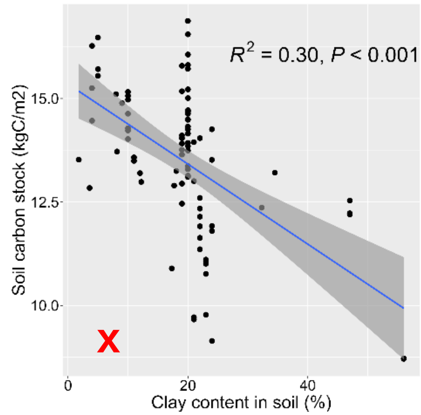
Temperature effects on carbon storage are controlled by soil stabilisation capacities

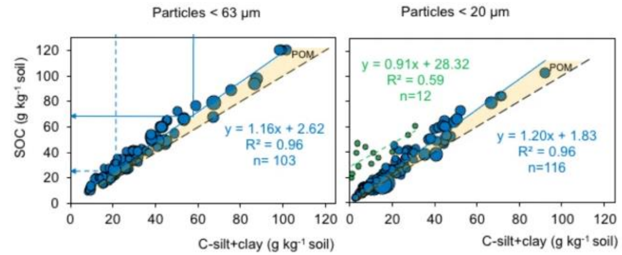
Iain P. Hartley[1✉], Tim C. Hill[1], Sarah E. Chadburn[2] & Gustaf Hugelius[3,4]



Carbon stock in soil

	SoilDepth	Sand	Silt	Clay	SoilpH
SOILC	[illegible]	*** 0.51 x	-0.08	** -0.51 x	*** -0.50 ✓



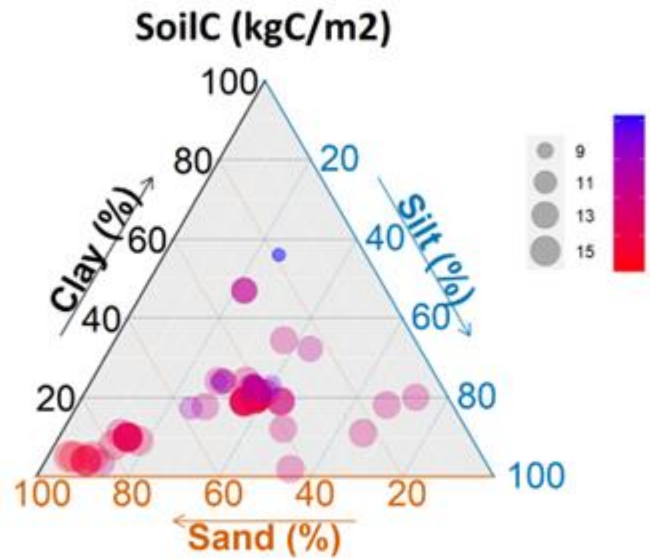


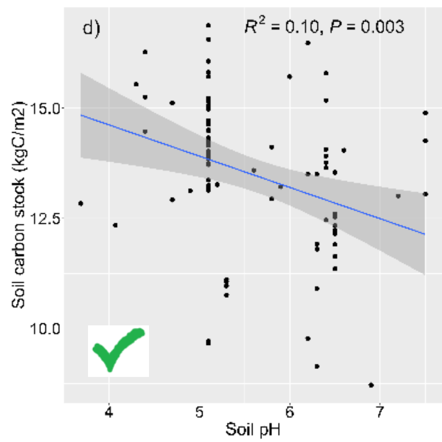
Article | Open access | Published: 19 March 2021

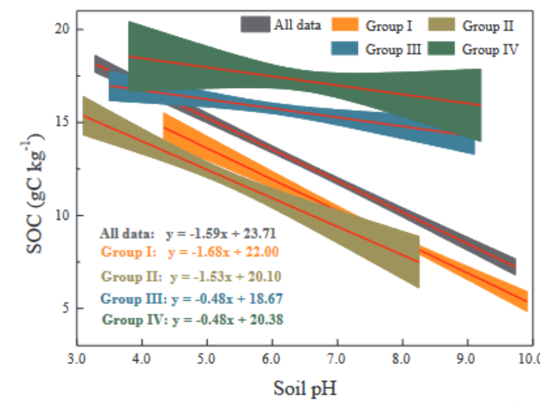
Fine silt and clay content is the main factor defining maximal C and N accumulations in soils: a meta-analysis

Francisco J. Matus

Scientific Reports 11, Article number: 6438 (2021) | Cite this article







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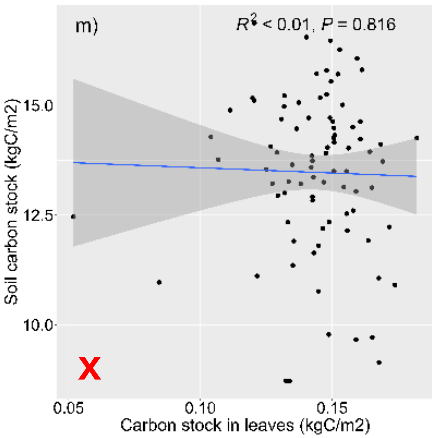
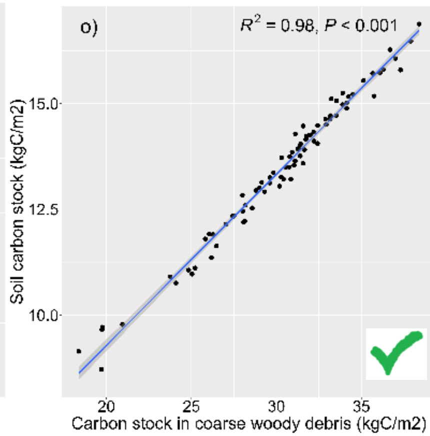
journal homepage: www.elsevier.com/locate/geoderma

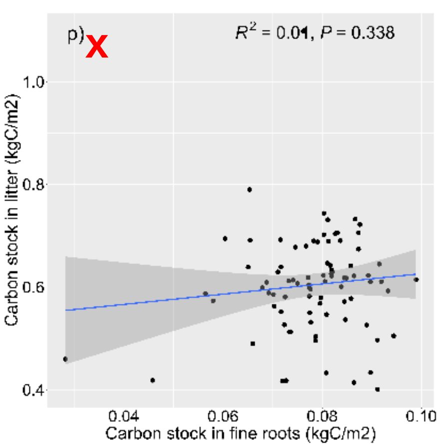
Soil acidification as an additional driver to organic carbon accumulation in major Chinese croplands

Xinmu Zhang, Jingheng Guo, Rolf David Vogt, Jan Mulder, Yajing Wang, Cheng Qian, Jingguo Wang, Xiaoshan Zhang

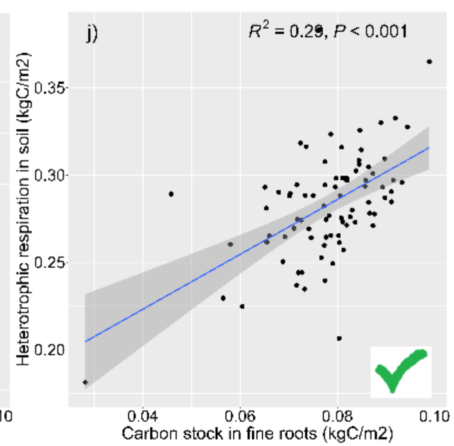
Relationships between stocks and fluxes



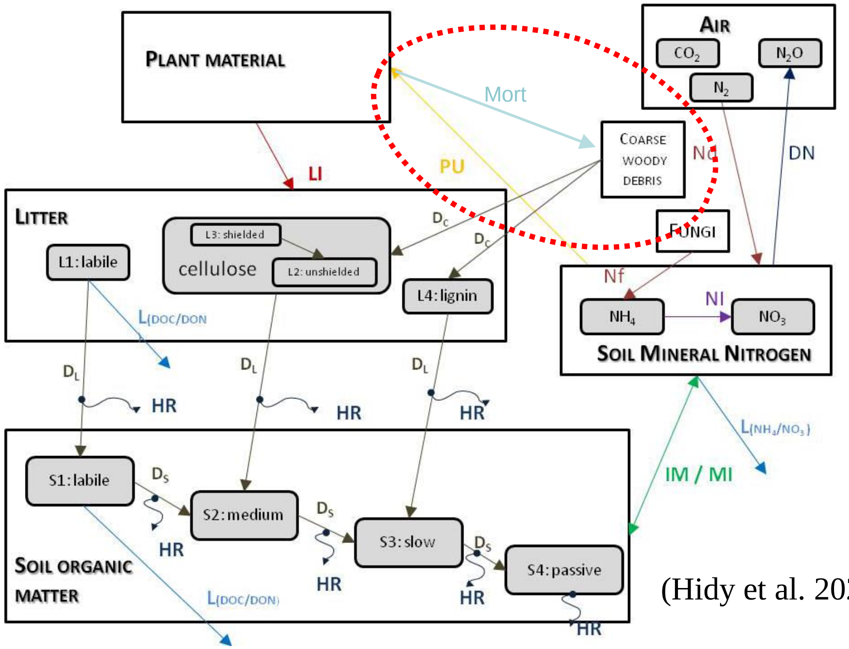




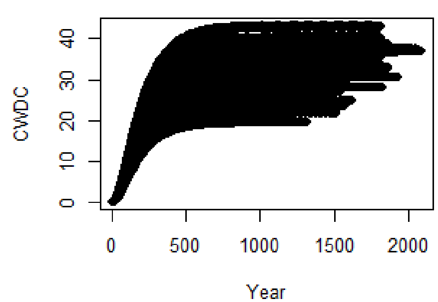
(Meier and Leuschner 2010)

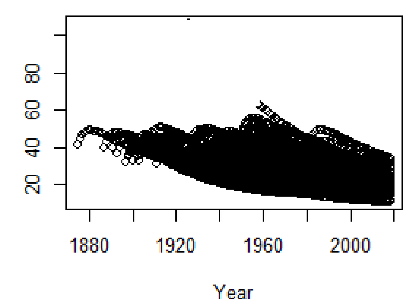


(Čater and Ogrinc, 2011)



(Hidy et al. 2022)





Summary

- Simulations across the geographical domain were robust
- Absolute values of examined carbon stocks were plausible
- Majority of patterns and trends along environmental gradients of carbon stocks and fluxes were consistent with literature

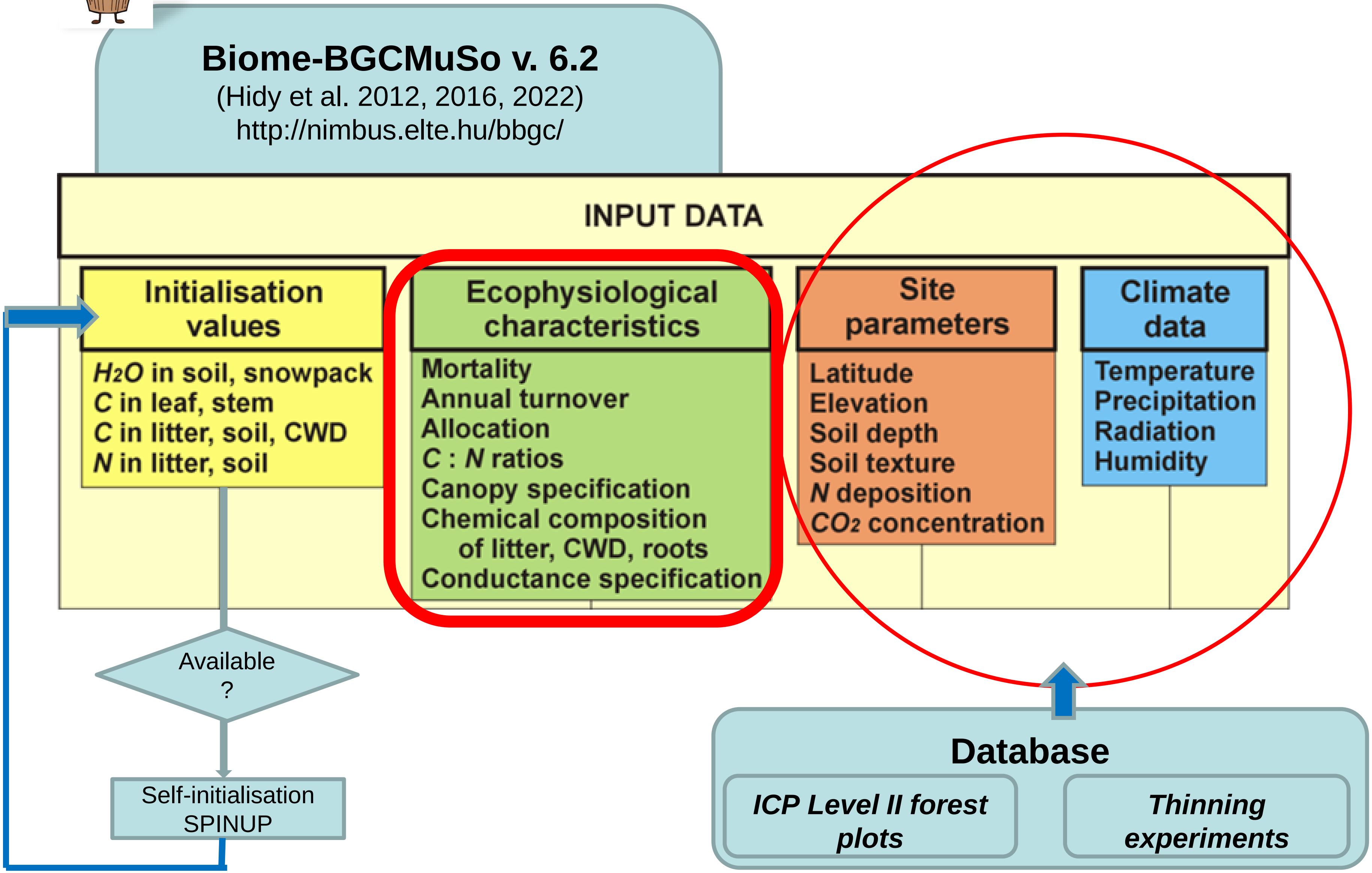
Discrepancies revealed future directions of model development

- water seems to play a minor role in affecting the simulated carbon-related output
- coarse woody debris is overestimated due to the accumulaton during the self-initialisation procedure
- impact of soil texture needs to be examined in more detail

Thank you for your attention

The study was supported by COST PROCLIAS CA19139, grant "EVA4.0", No. CZ.02.1.01/0.0/0.0/16_019/0000803 financed by OP RDEEVA4.0, the Slovak Research and Development Agency, projects No. APVV-21-0412, APVV-18-0305, APVV-22-0001, APVV-19-0183, the Croatian Science Foundation National MODFLUX (HRZZ IP-2019-04-6325), the National Multidisciplinary Laboratory for Climate Change, RRF-2.3.1-21-2022-00014 project, and „TreeAdapt“ funded on the base of contract between the National Forest Centre and Ministry of Agriculture and Rural Development of the Slovak Republic.

Model



Biome-BGCMuSo v. 6.2
(Hidy et al. 2012, 2016, 2022)
http://nimbus.elte.hu/bbgc/
INPUT DATA
Initialisation values
H_2O in soil, snowpack
C in leaf, stem
C in litter, soil, CWD
N in litter, soil
Ecophysiological characteristics
Mortality
Annual turnover
Allocation
$C:N$ ratios
Canopy specification
Chemical composition of litter, CWD, roots
Conductance specification
Site parameters
Latitude
Elevation
Soil depth
Soil texture
N deposition
CO_2 concentration
Climate data
Temperature
Precipitation
Radiation
Humidity
Available ?
Self-initialisation SPINUP
Database
ICP Level II forest plots
Thinning experiments

Ecophysiological parameters

Original Biome-BGC
(Thornton et al. 1998)

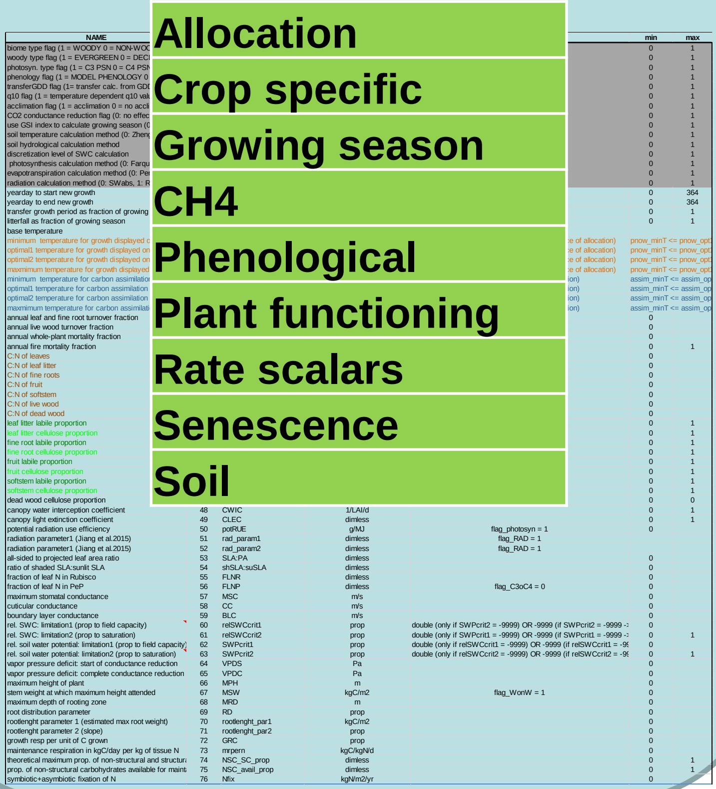
4 *forest* and 3 non-forest terrestrial types of vegetation (biomes)
(White et al. 2000)

BOKU Species-specific parametrisation
Pietsch et al. (2005)
for 6 Central European tree species

Norway spruce, European beech, Scots pine, oak spp., European larch, Cembran pine

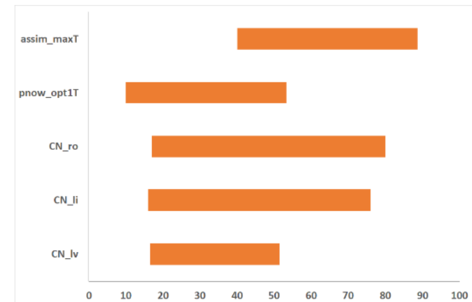
Biome-BGCMuSo
(Hidy et al. 2012, 2016)

New ecophysiological parameters



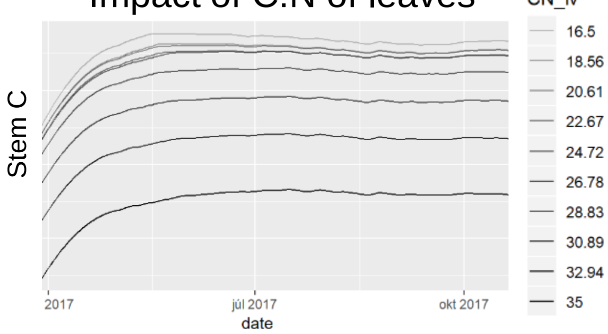
Regional adaptation of Biome-BGCMuSo

1. **Plausible ranges** of individual parameters for main temperate forest tree species
- Beech
- Oak
- Spruce

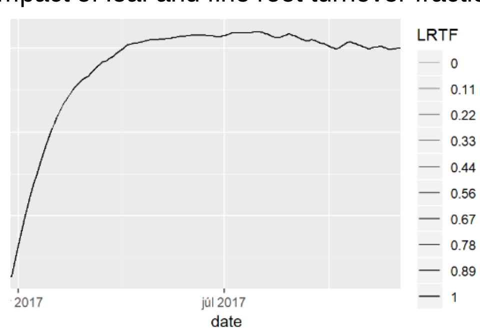


2. **Sensitivity analysis** - Monte Carlo approach (Verbeeck et al. 2006)

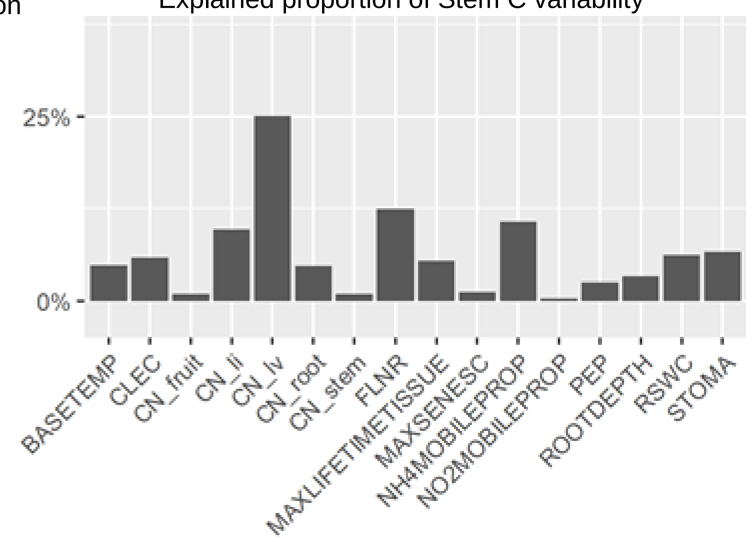
Impact of C:N of leaves



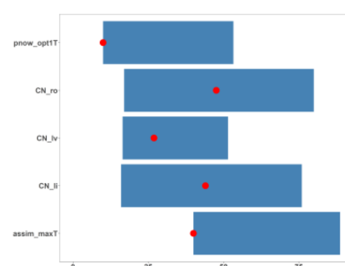
Impact of leaf and fine root turnover fraction



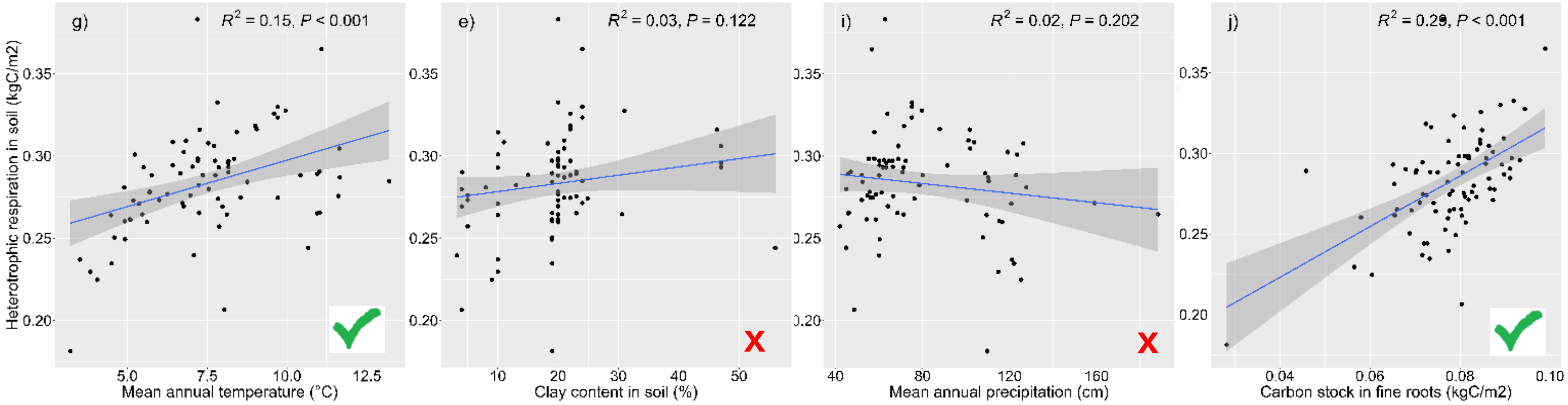
Explained proportion of Stem C variability



3. **Statistical calibration** – Generalised likelihood uncertainty estimation

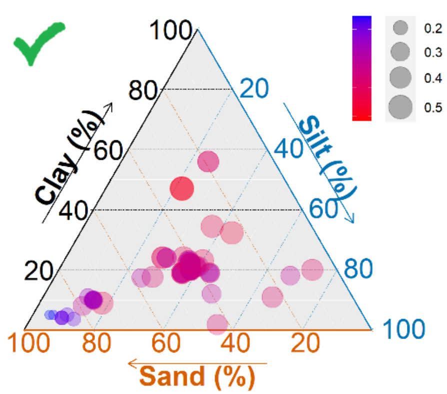


Other stocks and fluxes



(Čater and Ogrinc, 2011) (Hartley et al., 2021) (Čater and Ogrinc, 2011)

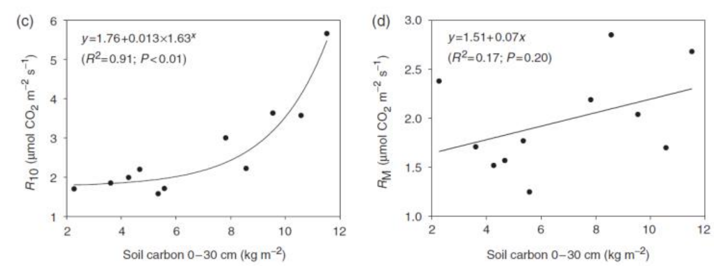
Soil water content
(Kaufmann and Cleveland, 2008)



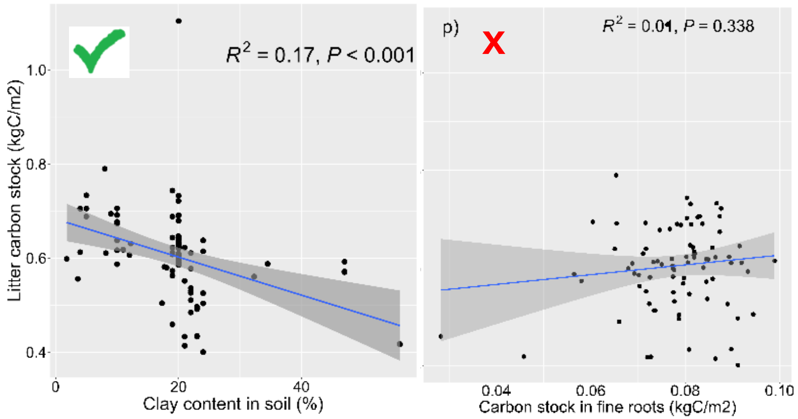
Global Change Biology (2005) 11, 1024–1041, doi: 10.1111/j.1365-2486.2005.00963.x

Main determinants of forest soil respiration along an elevation/temperature gradient in the Italian Alps

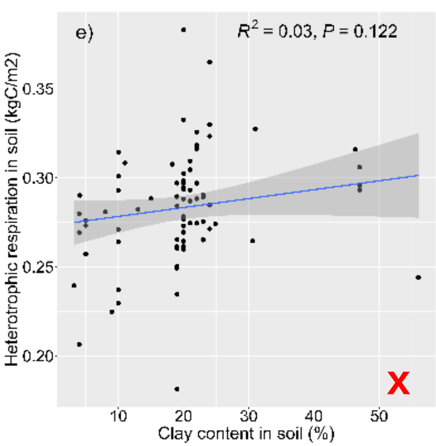
MIRCO RODEGHIERO and ALESSANDRO CESCATTI



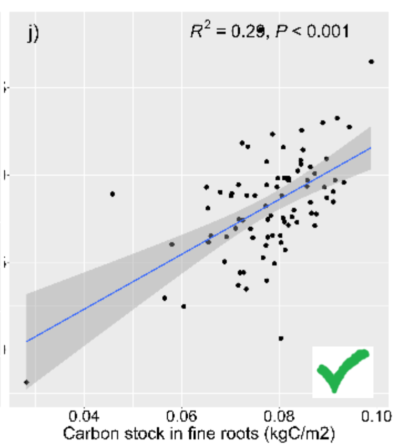
Relationships between stocks and fluxes



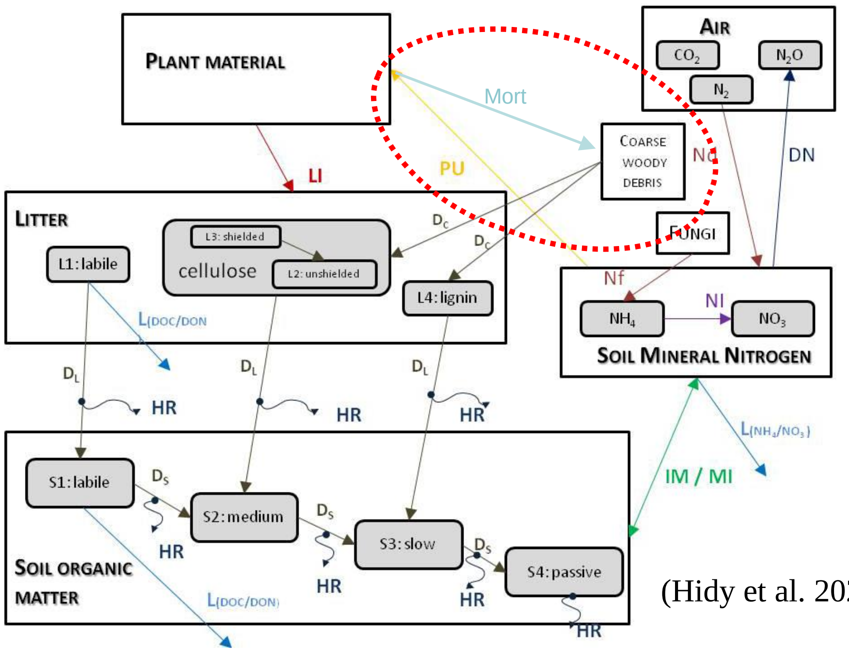
(Vesterdal & Raulund-Rasmussen, 1998)



(Hartley et al., 2021)



(Čater and Ogrinc, 2011)



(Hidy et al. 2022)