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The 23rd World Congress of Soil Science



A model-based tool for supporting sustainable management of soil organic carbon in Swiss croplands

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Humus Balance Calculator

- **Agroscope Humusbilanz:** simple, low-input advisory tool for Swiss farmers
- Similar Tools (VDLUFA, STAND) show **no clear relationship** between **Humus balance & SOC**
- **Humusbilanz tool** is simple, but **no robust estimates of SOC trends** to the farmers

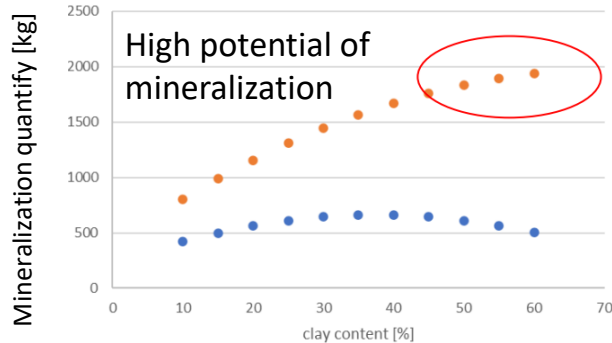

Agroscope Humusbilanz

Parcel name
test1

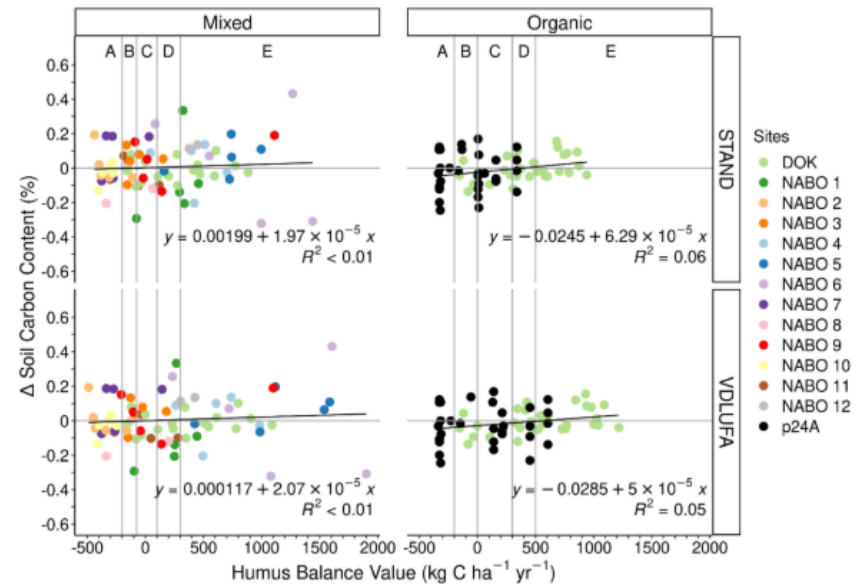
Area (ha)	Clay content (%)
100	20

Humus content (%)	pH (-)
5	5

Mineralization:
 $1.6 - 0.012 \cdot \% \text{clay}$



Stéphane Burgos, HAFL



Rainford et al., 2024

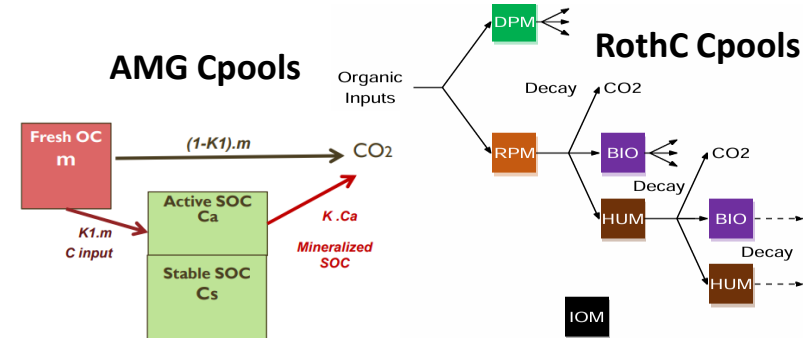
Project goals

- Develop a robust **tool** for **SOC** management in Switzerland
 - Integrate process-based SOC **models**
 - More accurate long-term **predictions** of SOC stock dynamics
 - **Parcel**-specific SOC stocks
- Influence of **management** and/or **climate change** on SOC stocks

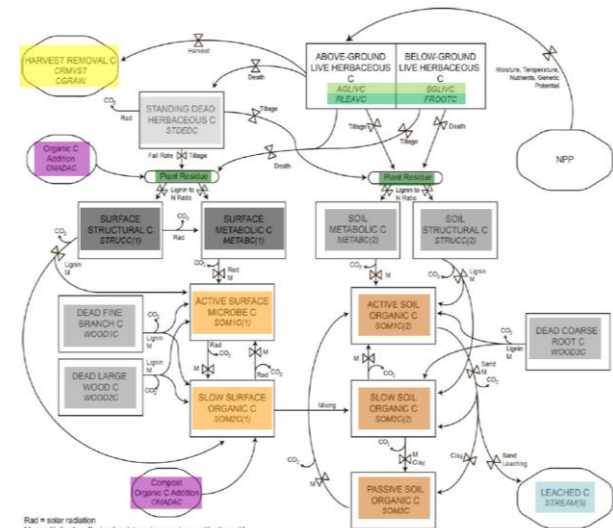
Model basis



Data	AMG (FR)	RothC (UK)	DayCent (US)
Weather	Temp, Precip, ET		
Soil	Texture, SOCstock		
	pH, C/N, CaCO ₃		Hydraulic (SOC)
Manage	Crop types, cover crop		
	tillage	Sow, harv	Sow, harv, irri, tillage
Fertilizer	Types	Cinput	Types, amount, C/N, Organic + Mineral
Yield	Yield	Yield ~ Cinput	



DayCent C pools: Active + Slow + Passive



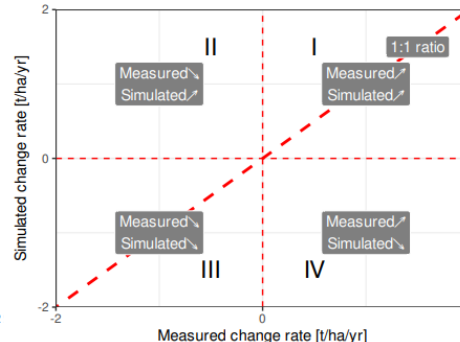
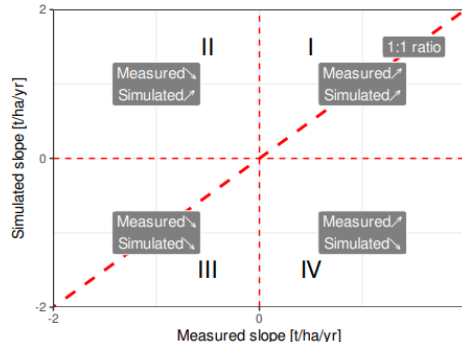
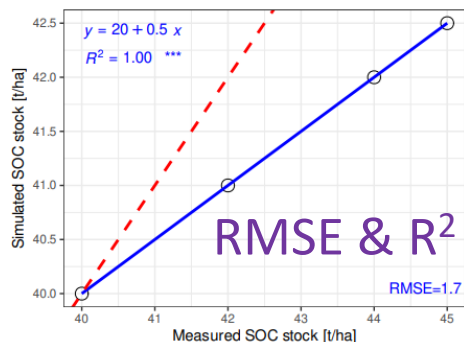
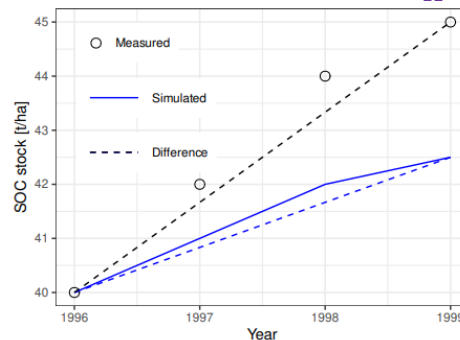
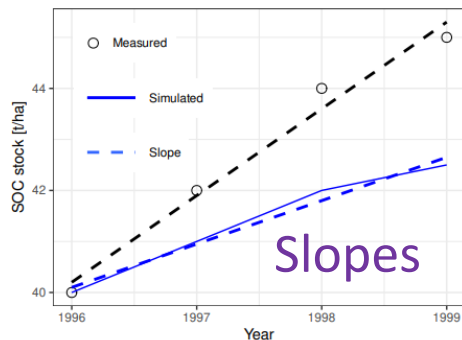
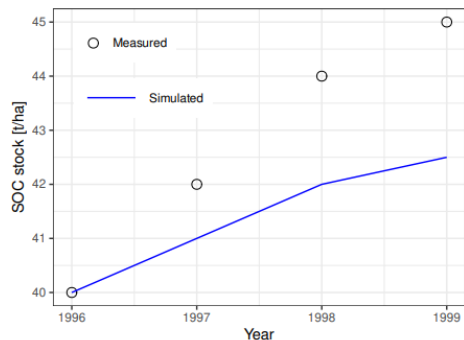
Model initialization & calibration

Model	AMG (Yearly)	RothC (Monthly)	DayCent (Daily)
Initialization	Initial SOCstocks: Initial ratio of active Cpool.	Initial sub-pools of SOC stock: - Pedo-transfer functions - Spinup: 1000 years, average weather, fixed Plant Cinput - Spinup + warmup: 10-20 years warmup, current Cinput & weather	Spinup and warmup: 6000 yr Temperate Deciduous Forest - Fire + plough - Fallow and low manure - Potato and high manure - Intensification - Diverse crop rotation + mineralFert
Calibration	Plant/manure Cinput	Plant/manure Cinput	- Crop/tillage/tree parameters - Site-specific calibration

How to assess the model performance

■ RMSE & R², slopes, change rates

$$\text{Change rates} = \frac{S_n - S_1}{Y_n - Y_1}$$



How to assess the model performance

- **Nash-sutcliffe efficiency (NSE):** whether the modeling is better than mean(measurement)
- **Model bias:** mean (median) difference between observed and simulated values.

$$NSE = \frac{\sum_{i=1}^n (O_i - \bar{O})^2 - \sum_{i=1}^n (S_i - O_i)^2}{\sum_{i=1}^n (O_i - \bar{O})^2}$$

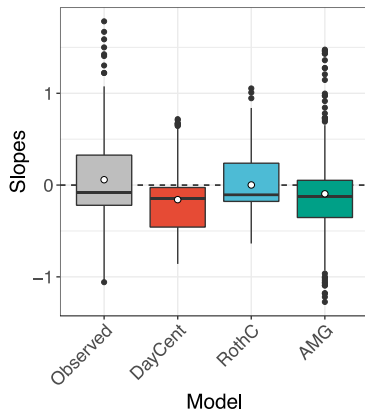
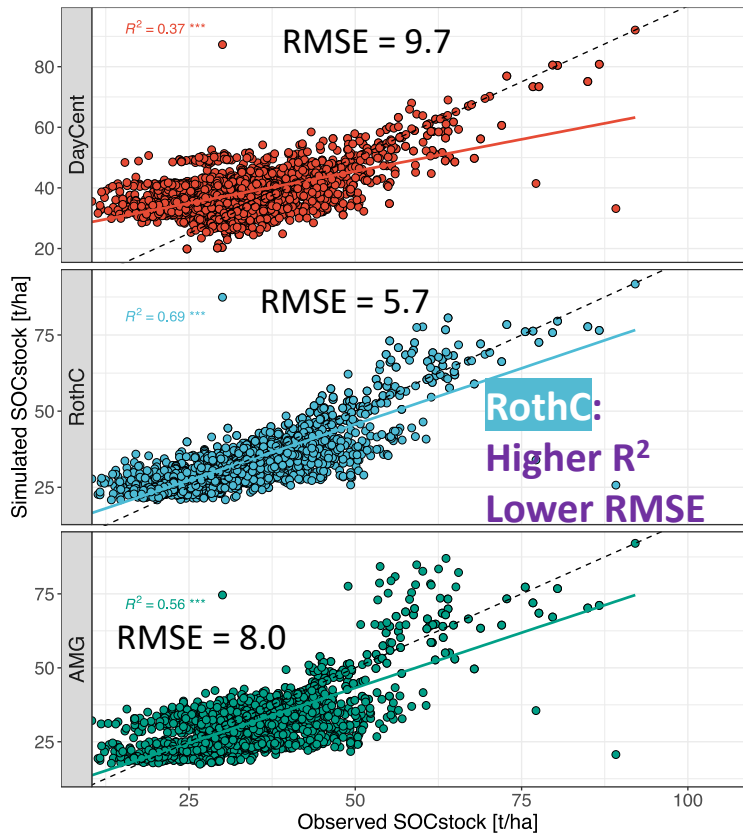
$$Bias = \frac{\sum_{i=1}^n (O_i - S_i)}{n}$$

Available Swiss data for model test and calibration

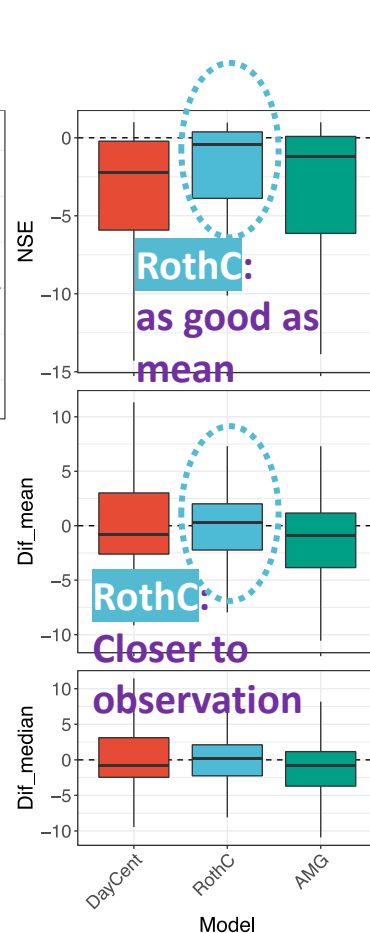
Types	Datasets	Period
Farmer managed croplands from Swiss National Soil Monitoring Network (NABO)	27 sites with crop and temporary_ley rotations	1984(1996)-2020
Long-term trials	60 plots with 12 fertilization treatments: organicFert, MineralFert, control	1949-2017
	24 plots with 4 tillage treatments: no-till, plough	1994-2022

Modeling results: farmer sites & long-term trials

RothC better than **DayCent** | **AMG**



RothC: Similar trends as observation



NSE > 0, modeling better than mean

Dif_mean = obs - sim

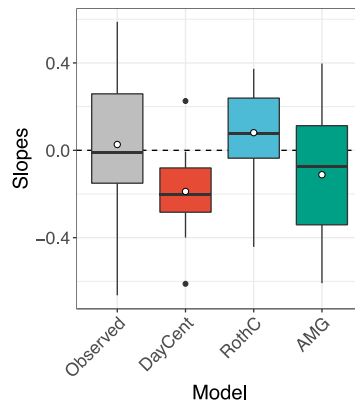
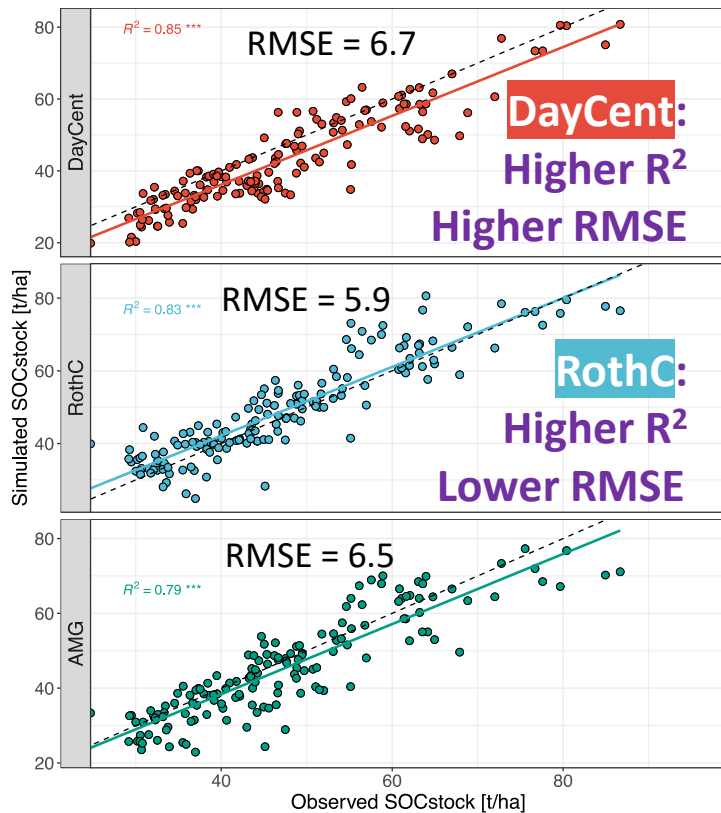
Dif_median = obs - sim

DayCent
RothC
AMG

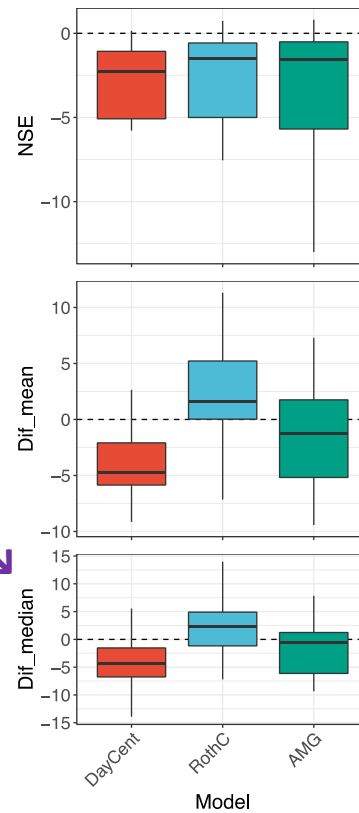
Modeling results: farmer sites

- Varied performance of model with different statistical indicators
- Stable SOC stock across years (trends closer to 0)

DayCent
RothC
AMG



Obs: no change
RothC: $\uparrow$
DayCent | AMG: $\downarrow$

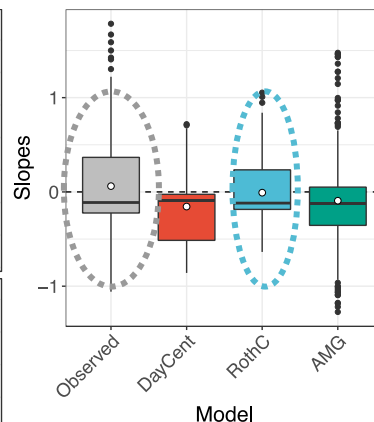
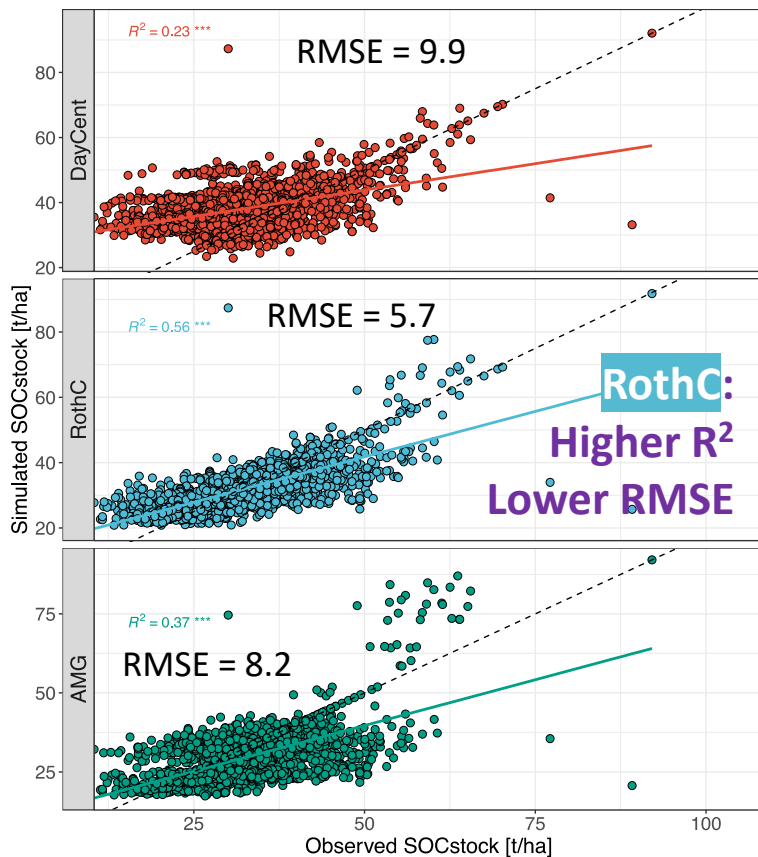


Worse than mean

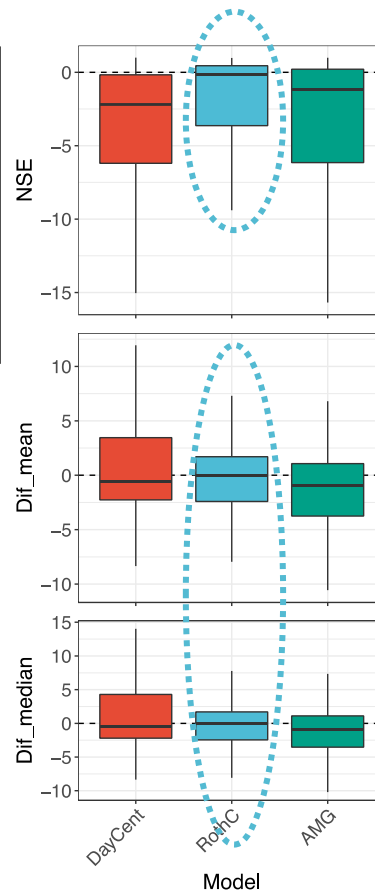
DayCent | AMG: under-estimate
RothC: over-estimate

Modeling results: long-term trials

RothC better than DayCent | AMG



RothC trends closer to obs



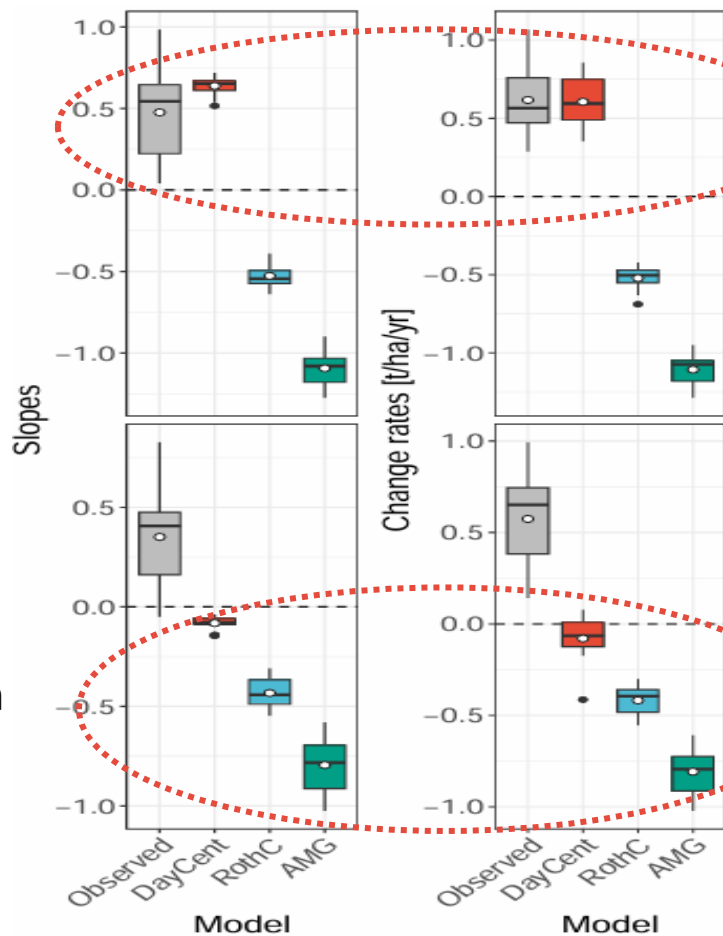
DayCent
RothC
AMG

RothC: As good as mean

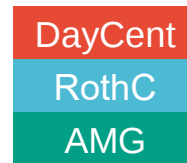
RothC: Closer to obs

Modeling results: no-till vs plough

No-till



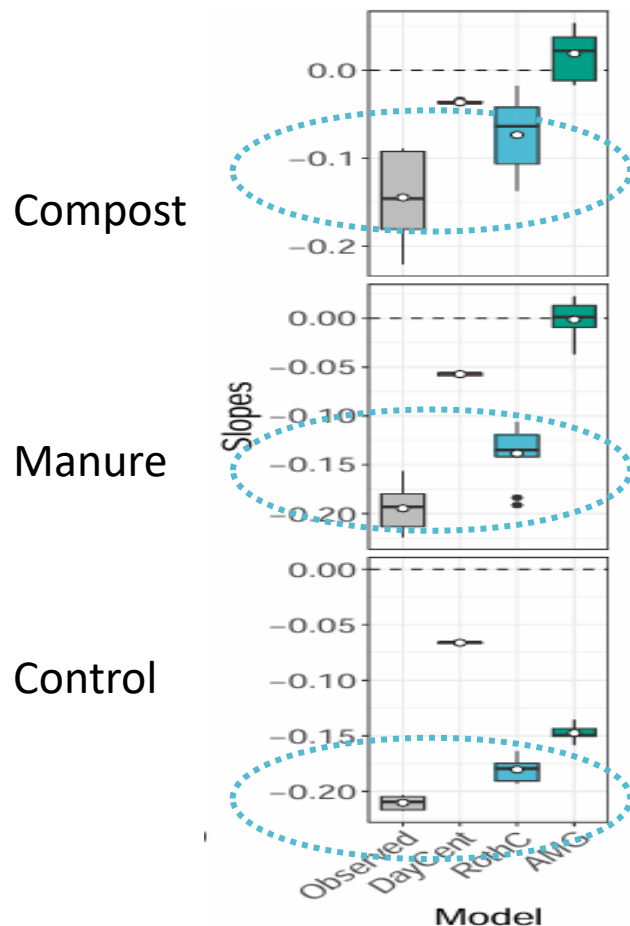
DayCent better capturing trends



Plough

All models indicate **opposite** trends to observation

Modeling results: organic fertilization



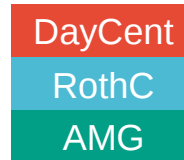
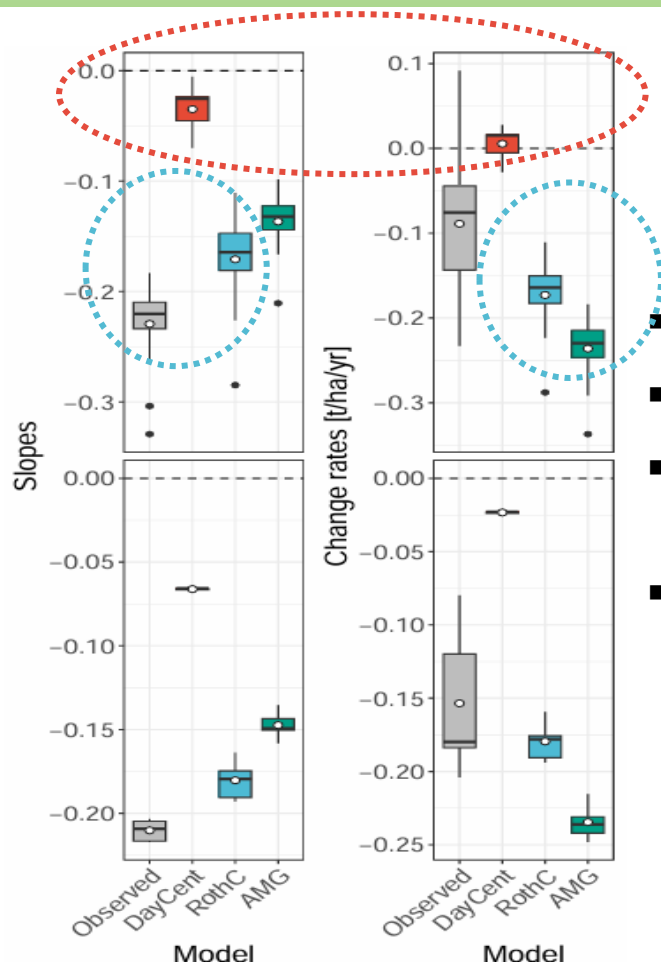
RothC better capturing trends for organicFert treatments

DayCent

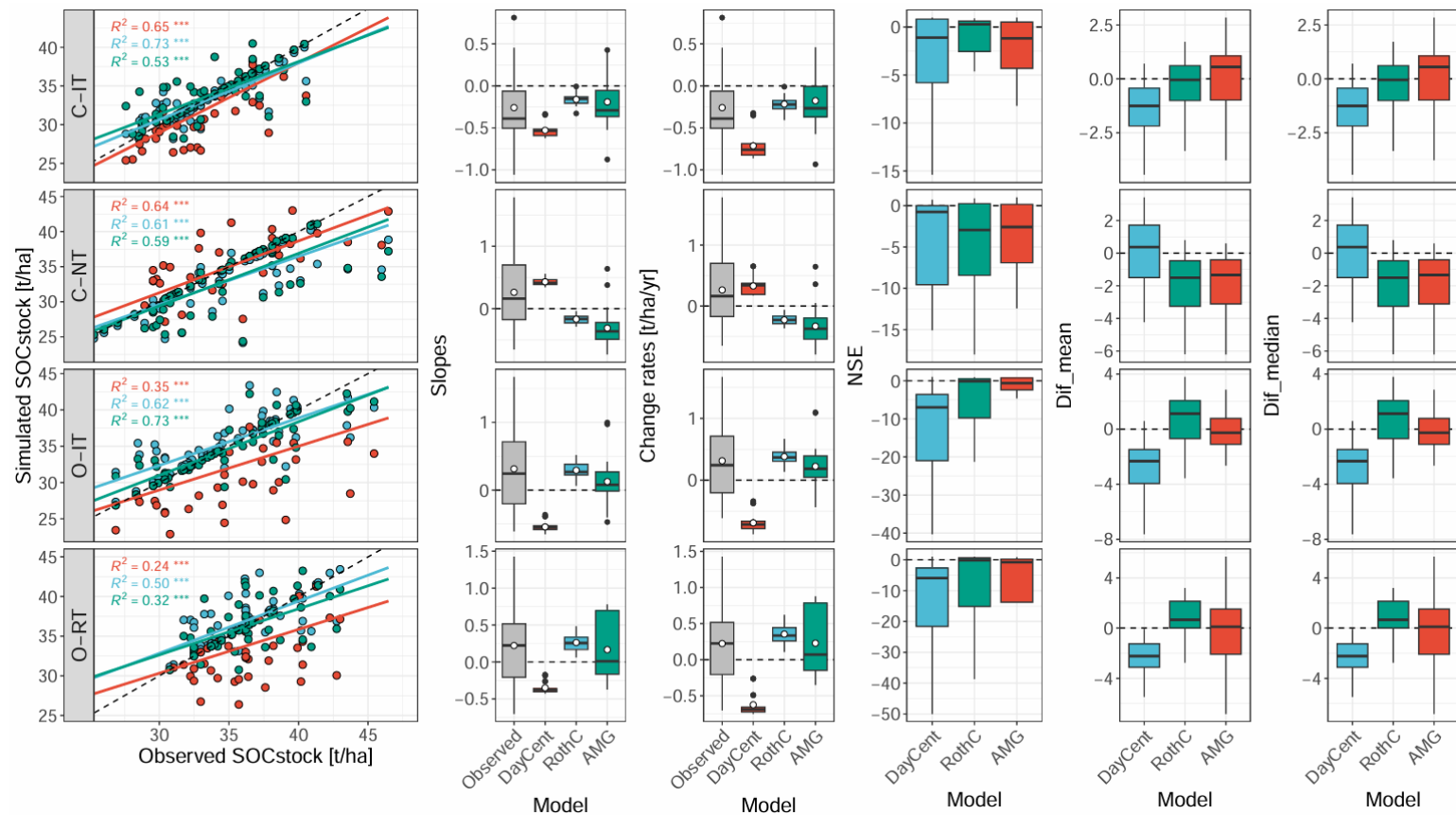
RothC

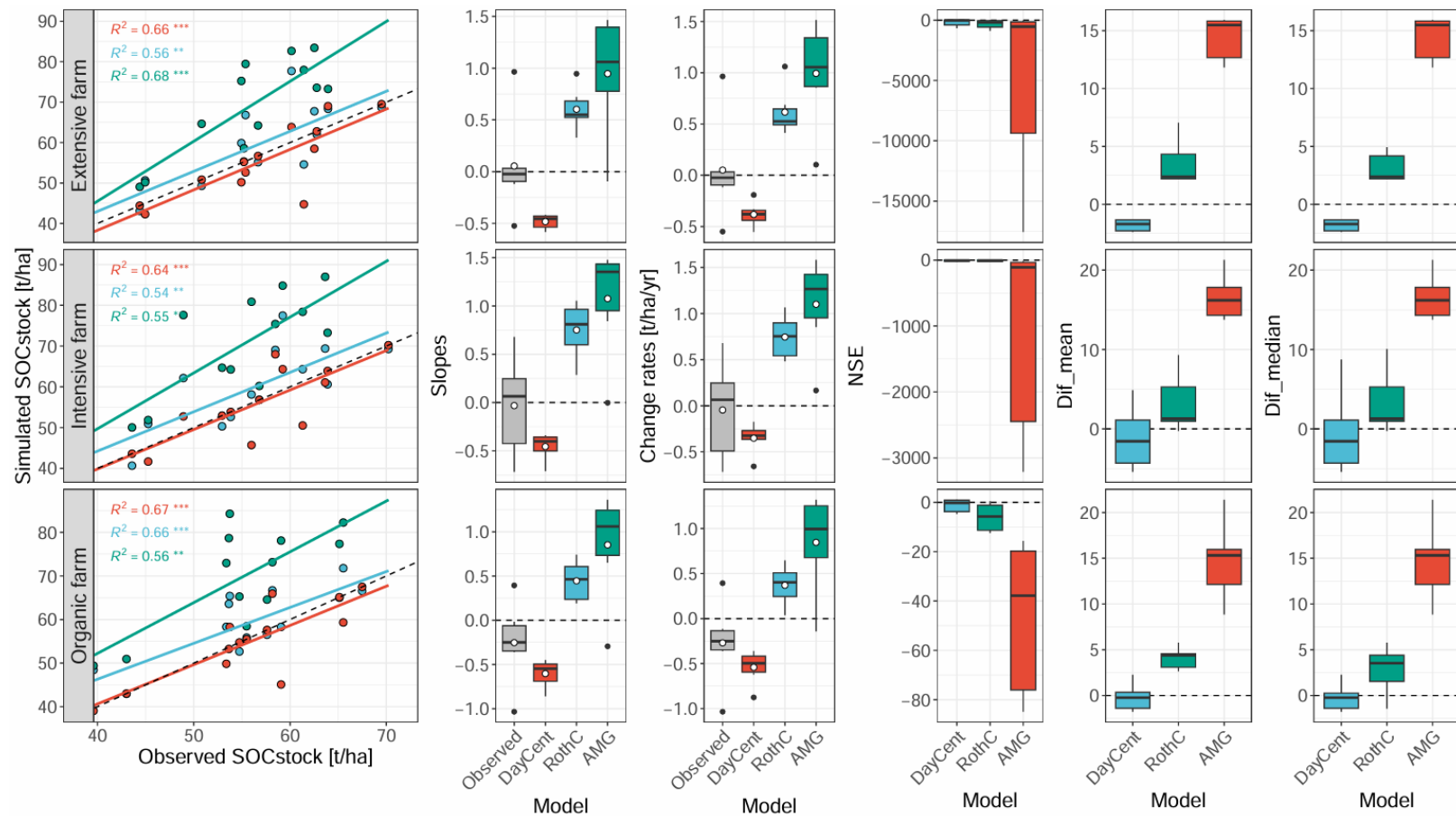
AMG

Modeling results: mineral fertilization



- DayCent considers mineralFert
- RothC / AMG only considers organicFert
- DayCent: slower $\searrow$ of SOCstock compared to observation
- RothC: similar trends as observation



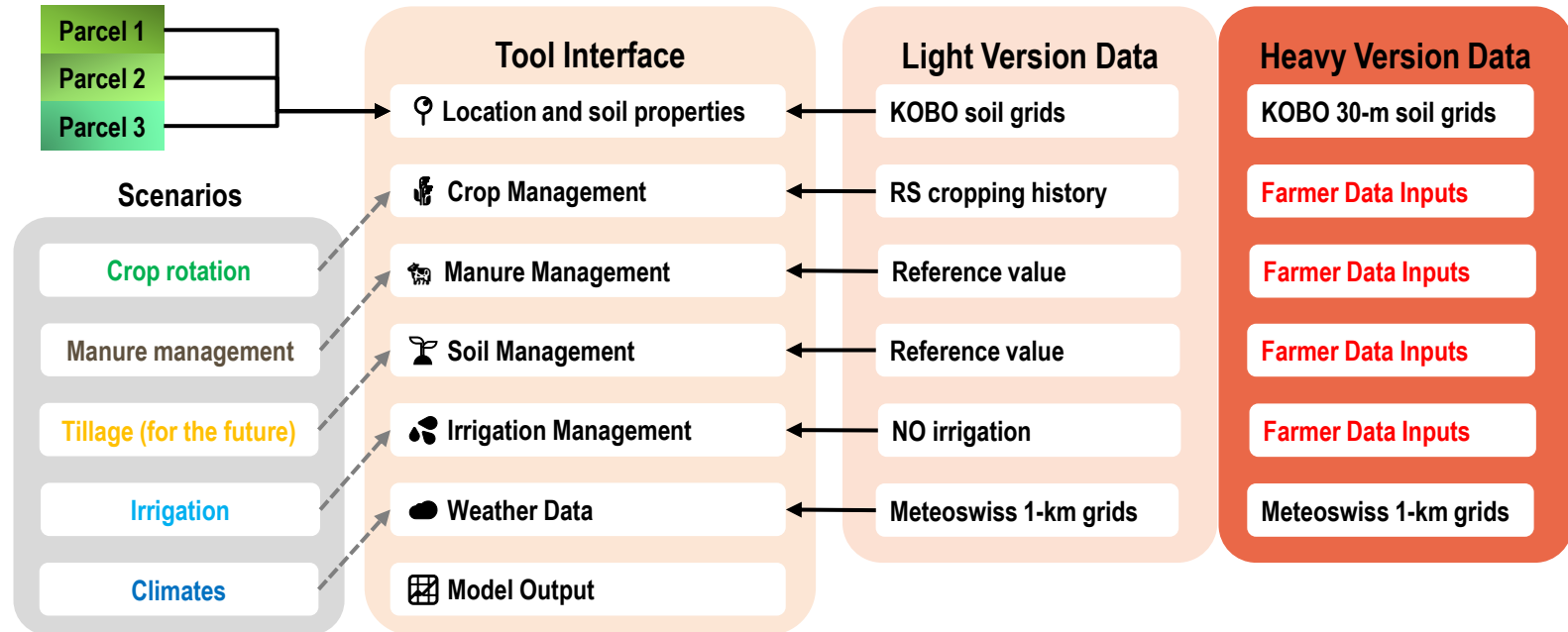


Model summary

- RothC is better to simulate SOCstock dynamics based on TESTS with farmer sites and long-term trials
- But RothC does not consider mineralFert or tillage (possible in the near future)
- DayCent is better for mineralFert or tillage, but needs region specific calibrations. (farmer parcels usually do not have long-term SOC measurements for this)
- RothC based tool for supporting sustainable management of soil organic carbon in Swiss croplands

Flow chart for the tool based on RothC model

- Light version: pre-loaded data
- Heavy version: pre-loaded + farmer data
- Unified system for heavy & light version: farmers can choose between default & own data



Acknowledgements



Agroecology and Environment

Soil Quality and Soil Use

Climate and Agriculture

Water Protection and Substance
Flows

Integrative Agroecology



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra



Bundesamt für Landwirtschaft BLW
Office fédéral de l'agriculture OFAG
Ufficio federale dell'agricoltura UFAG
Uffizi federal d'agricultura UFAG



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Confederaziun svizra
Bundesamt für Landwirtschaft BLW

Swiss Soil Monitoring Network (NABO)



KOBO
CCSols
CCSuolo
Kompetenzzentrum Boden
Centre de compétences sur les sols
Centro di competenze per il suolo



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Meteorologie
und Klimatologie MeteoSchweiz

Zurich Organic Fertilisation Experiment
(ZOFÉ) – The Bedrock of the Long-Term
Trials

