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Challenges and advantages of model-based soil carbon inventories

Sonja G. Keel

11th May 2023

Model-based soil carbon inventory for Switzerland is operational since 2019

- For agricultural, mineral topsoils (0-30 cm)
- For cropland remaining cropland and grassland remaining grassland
- For land use change we apply C stock change approach
- For forest soils Yasso07 is used


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Chloé Wüst-Galley, Sonja G. Keel, Jens Leifeld | December 2019

Internal report

A model-based carbon inventory for national greenhouse gas reporting of mineral agricultural soils

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Contact: Chloé Wüst-Galley
Agroscope
Reckenholzstrasse 191, 8046 Zürich / Schweiz
T: +41 58 468 77 74, F: +41 58 468 72 01
chloe.wuest@agroscope.admin.ch
www.agroscope.ch | gutes Essen, gesunde Umwelt

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Wüst, Keel & Leifeld, Agroscope Science (2020), https://doi.org/10.34776/as105e

Swiss soil carbon inventory

Based on model RothC
(model selection described in Wüst et al. 2020)

Initial input data:

- Soil organic carbon stock
- Clay content of soil

Monthly input data:

- Monthly weather (temperature, precipitation, evapotranspiration)
- C input to soil from harvest residues (calculated based on annual yield statistics)
- C in organic amendments (e.g. manure, slurry; calculated based on livestock numbers, excretion rates etc.)

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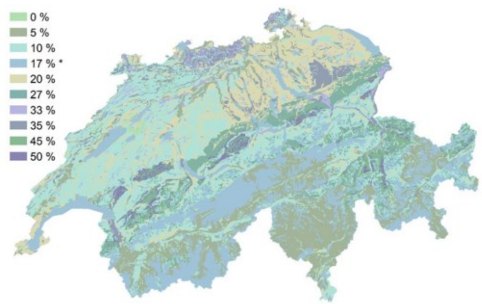
Wüst, Keel & Leifeld, Agroscope Science (2020), https://doi.org/10.34776/as105e

Currently simulations are carried out for 240 strata (units with same conditions)

x



= 240 simulation units

24 regions with similar agricultural management and climate (consistent with forest soil modelling)

x

10 soil categories (clay contents)

-> We are moving towards a grid-based approach

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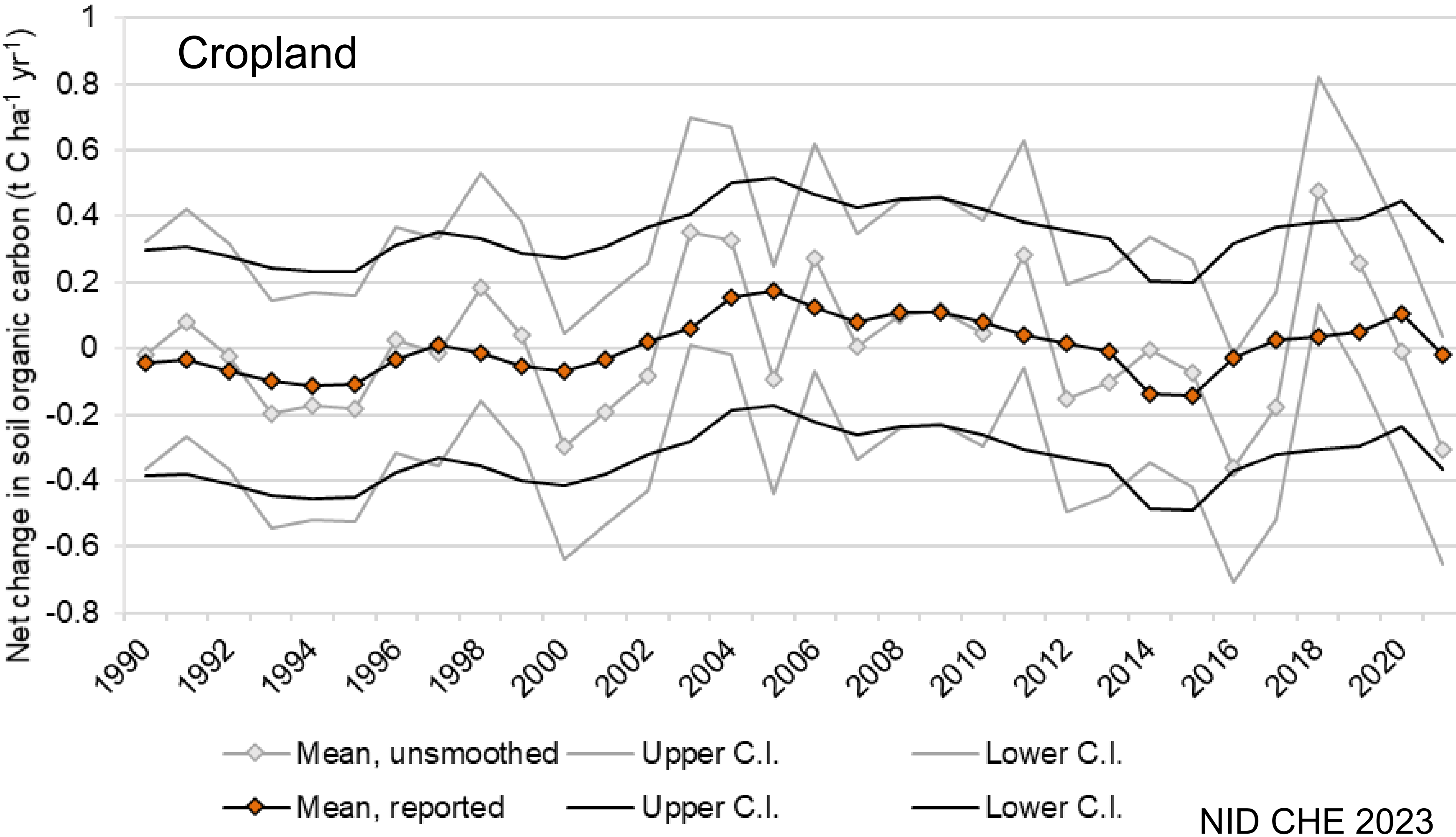
National scale results are weighted means for each simulation unit and crop type/grassland category



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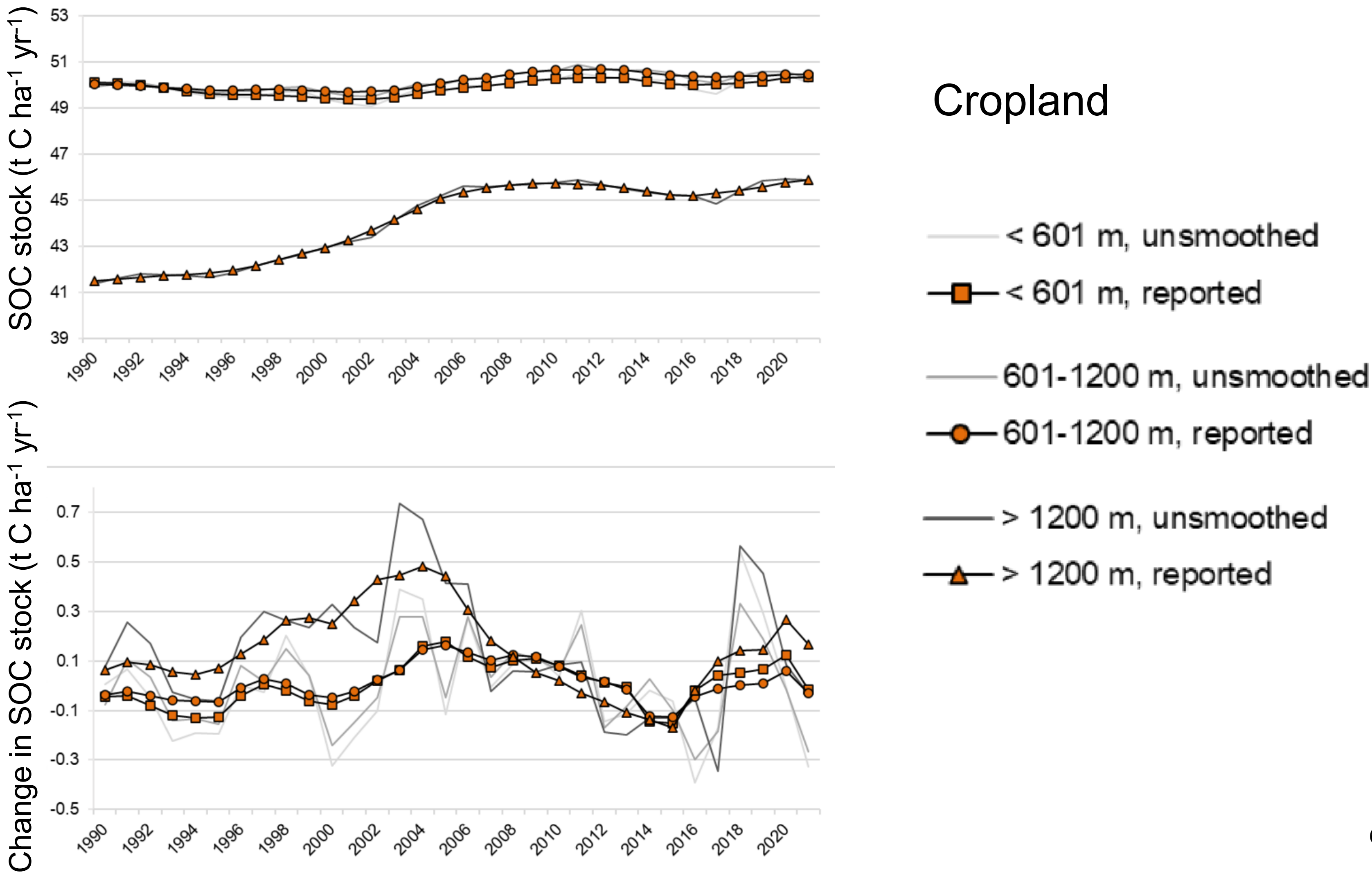
Results in inventory are presented also for three elevation zones



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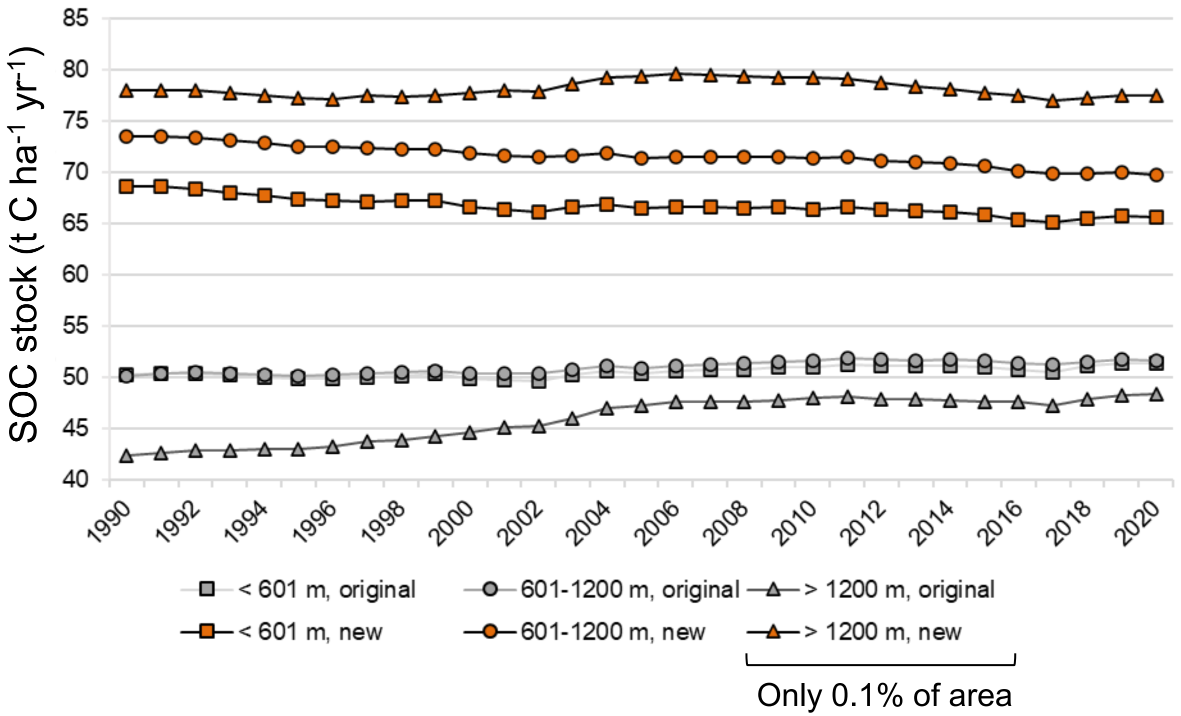
Challenges: new initial SOC map not only changed stocks but also trends – changes postponed

- Currently: initial SOC stocks based on coarse information
- Goal: replace by digital SOC stock map. Intermediate step: use SOC content/clay map based on 10’000 measurements in combination with old information (e.g. bulk density)

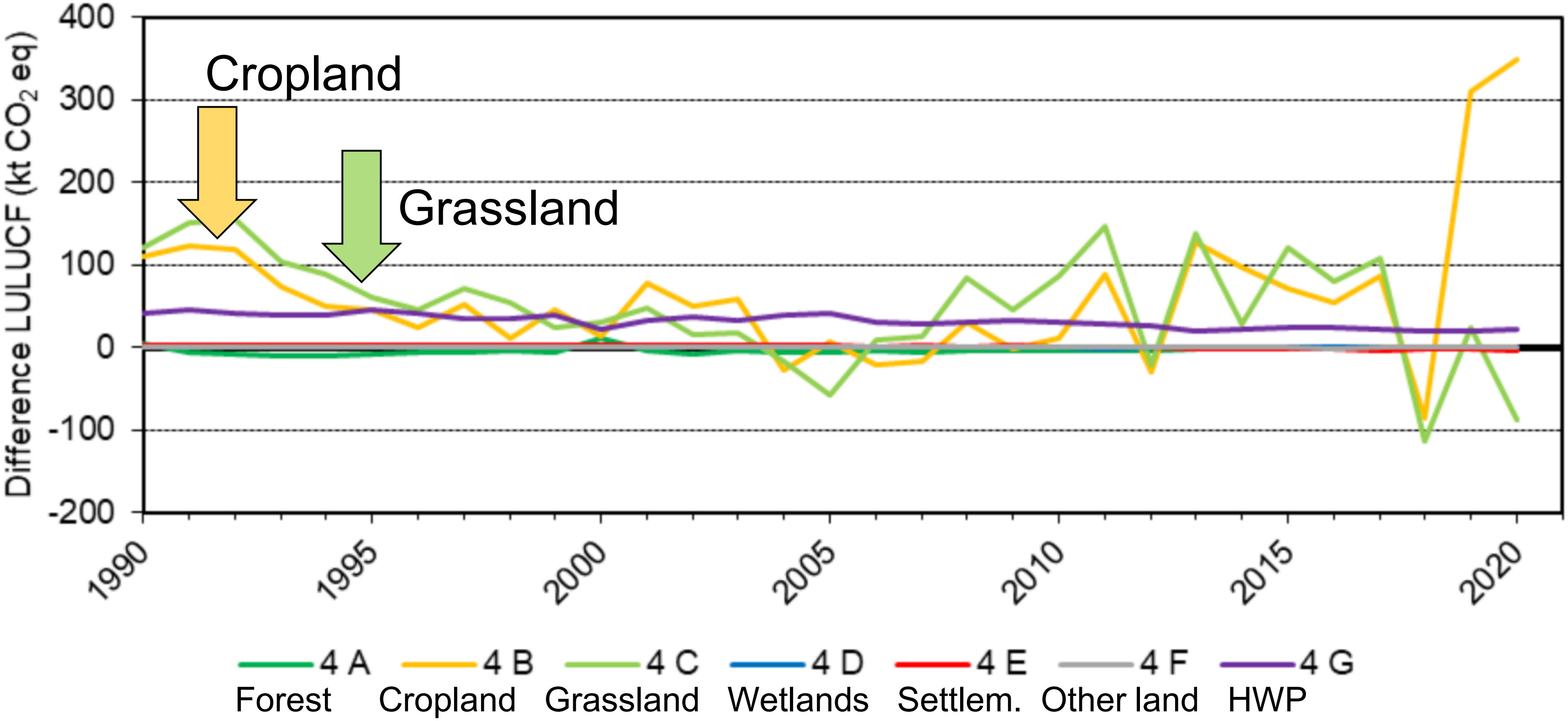


New trend (<601 m): -0.102 t C ha^{-1} yr^{-1}

Old trend (<601 m): 0.042 t C ha^{-1} yr^{-1}

Even small recalculations have huge effect on LULUCF CO_2 budgets due to large cropland/grassland area

- Yield statistics were updated for submission 2023 (no recalculations for forest in this submission)



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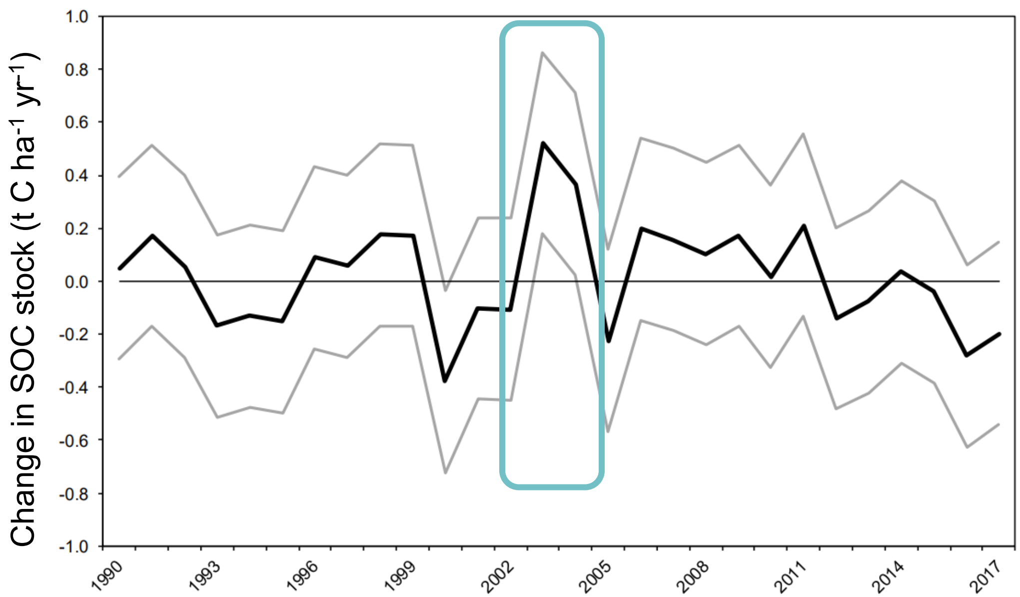
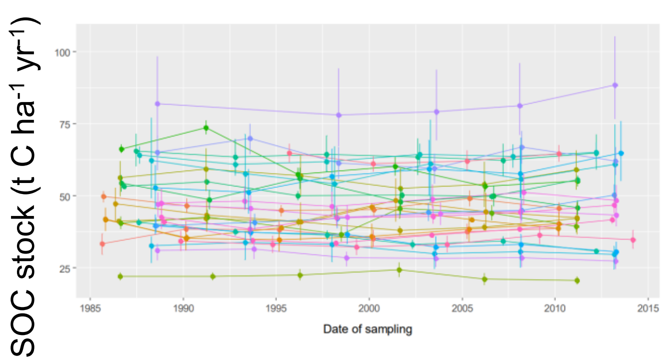
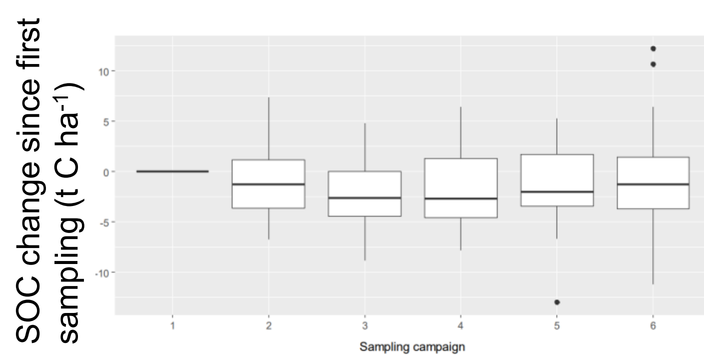
Further challenges: validation is difficult due to lack of measured data



During an exceptionally hot/dry summer, cropland was a significant C sink.

Measurements used for validation have different temporal resolution and are spatially constrained





Measurements at 30 monitoring sites

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Was moving from Tier 1 to 3 worth the big effort?

Tier 1:

EF = 0 for cropland and grassland

Tier 3:

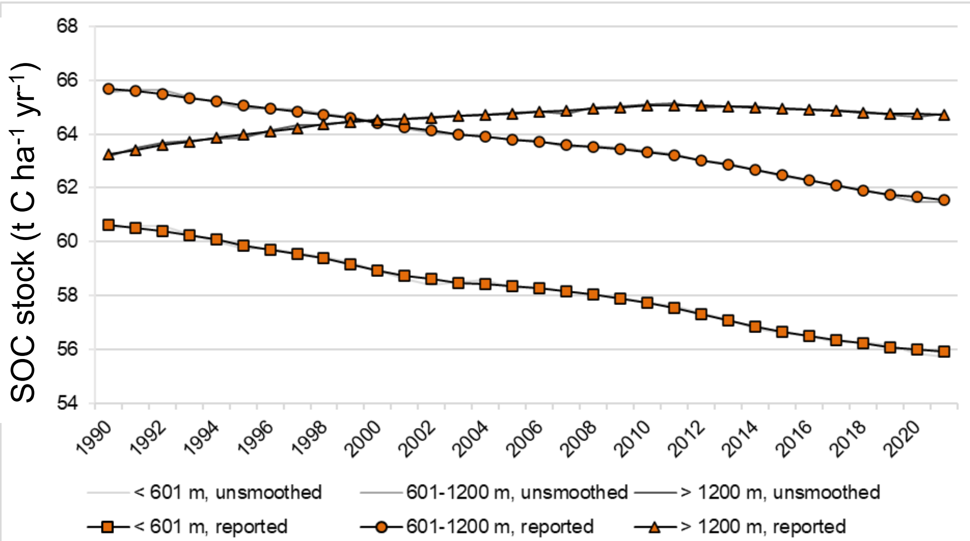
Cropland: 0.006 ± 0.344 t C ha^{-1} yr^{-1}

Grassland: -0.054 ± 0.249 t C ha^{-1} yr^{-1}

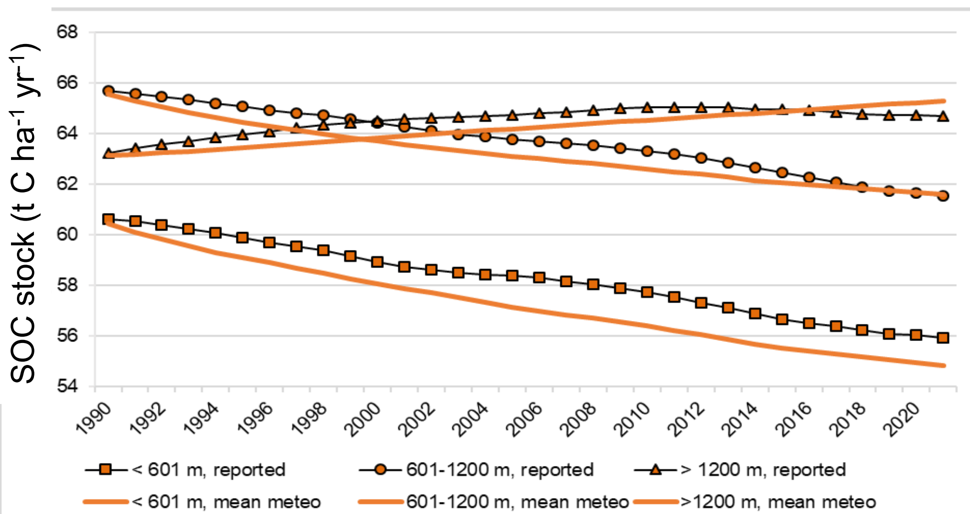
(area-weighted mean across three elevation zones ± absolute uncertainty based on a Monte Carlo analysis)

->Change is similar, but large uncertainty

Advantage: models allow to assess drivers of simulated trends



SOC stocks on grassland (NID 2023)



SOC stocks on grassland simulated with constant climate (orange lines)

-> trends still present. Most likely driven by changes in management

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Advantage: assess effects of management changes more easily

- Cover crop scenario was tested (Keel et al. in review)
- Two biochar pools were implemented in RothC to simulate biochar amendment (Keel et al. in review)
- Expanded version of RothC will be applied by partners within CarboSeq project to estimate potential soil carbon sequestration rates at the European scale

CarboSeq (ejpsoil.eu)

Conclusions

- Model-based inventories are strongly dependent on input data. National-scale data are difficult to obtain
- Improving modelling approaches should go hand in hand with improvement of observational data
- Model-based inventories enable national-scale drivers to be identified

Thank you for your attention

Thank you: Nele Rogiers, Chloé Wüst-Galley

Sonja G. Keel

sonja.keel@agroscope.admin.ch

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