Estimating conversion-induced carbon stock changes in mineral soils - a case study from Hungary

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"LULUCF in transition: present and future challenges for LULUCF reporting and accounting"
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Estimating country-level change of Soil Organic Content (SOC) due to conversions: complicated process; little data, if any

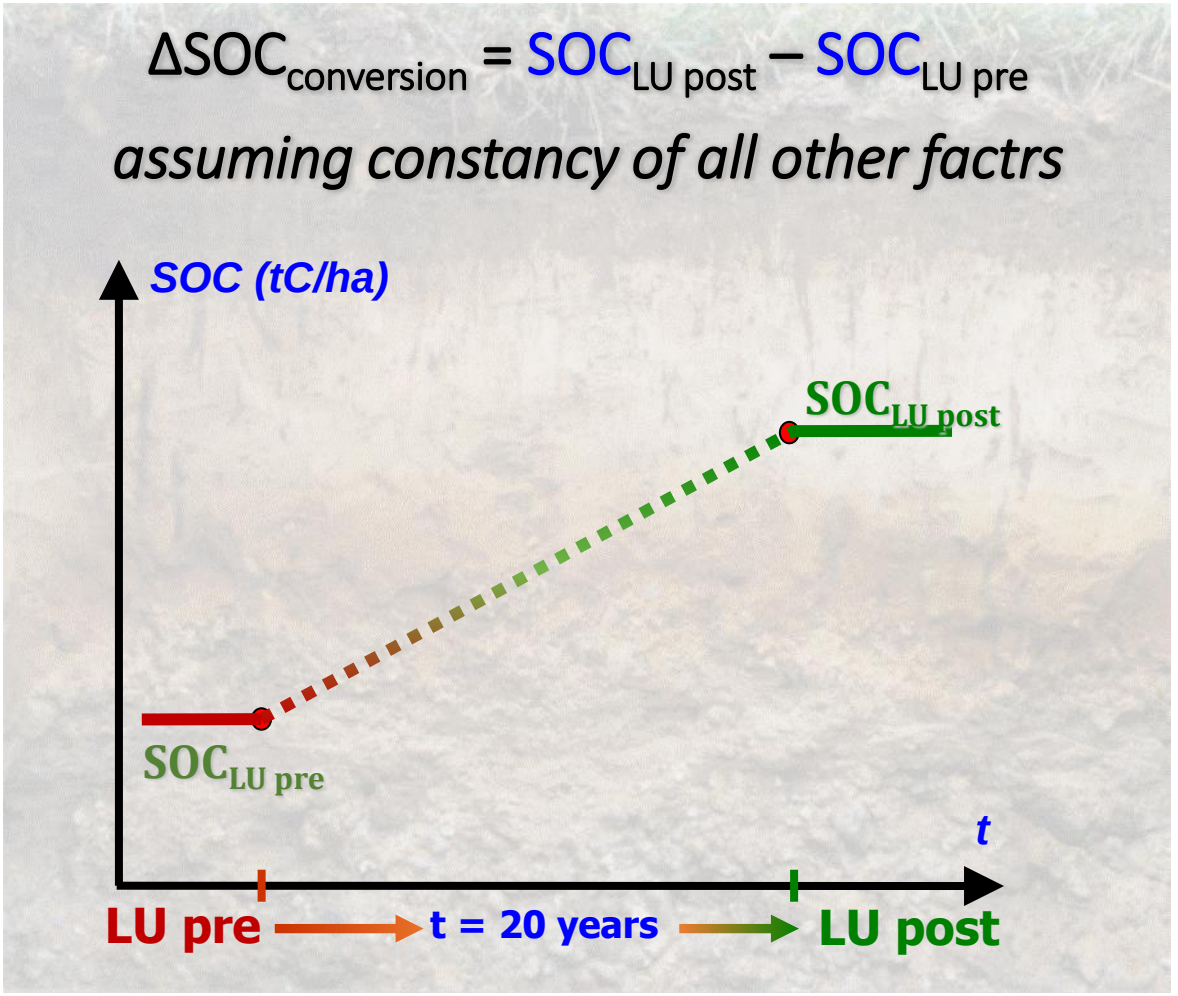
- thousands of hectares a year
- very different conversions
- high diversity of soils (e.g., by type)
- high diversity within a type
- long process until new balance
- both emissions and removals occur

- soils are less „interesting” than biomass
- monitoring is deemed costly; difficult
- any data is difficult to upscale

Theoretical requirements: IPCC, 2006

when developing area-specific ΔSOC, paired plots should be used so that:

„it is *good practice* that the plots being compared have similar histories and management as well as similar topographic position, soil physical properties and be located in close proximity"



Possibilities for the estimation in Hungary

- **very few, scattered, probably unrepresentative *research plots*, no paired plots by LU**

- ***soil monitoring system (TIM):***
  - **1992-2016**
  - **183 plots in forests, 865 plots in CLa, CLp and GL**
  - **repeated measurements on points in a bit unsystematic way**
  - **direct follow-up of the effects of land use change: impossible**
  - ***no paired plots***

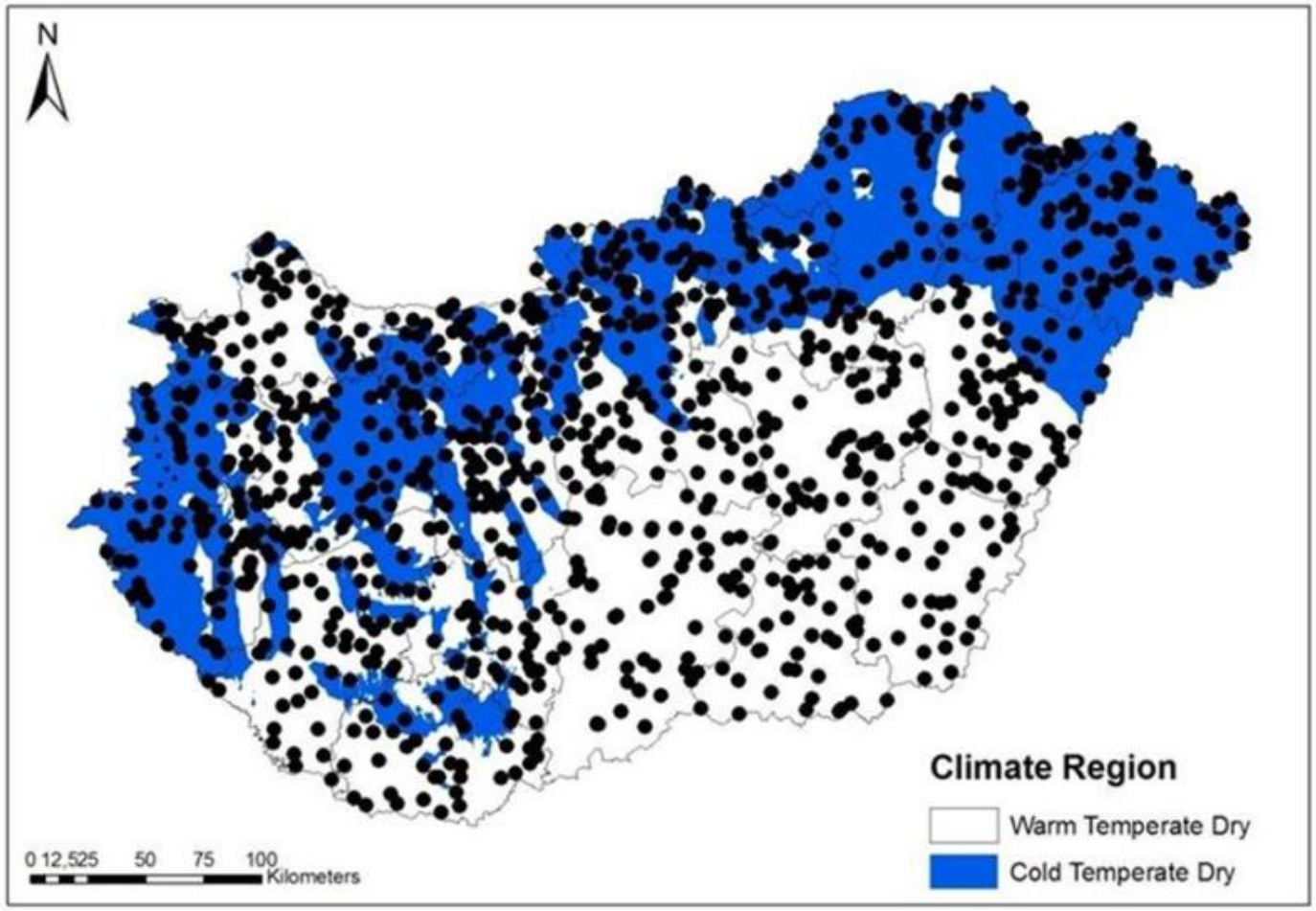
===> second best choice: analyses of TIM data by LU
while ensuring ceteris paribus conditions as much as possible

Methods: TIM

- sampling in representative areas of „geographical units” using expert judgment and considering available local research data

- data for each point ● : *soil type*, depths of layers, *volumetric density*, *Humus%* (and soil chemistry data)

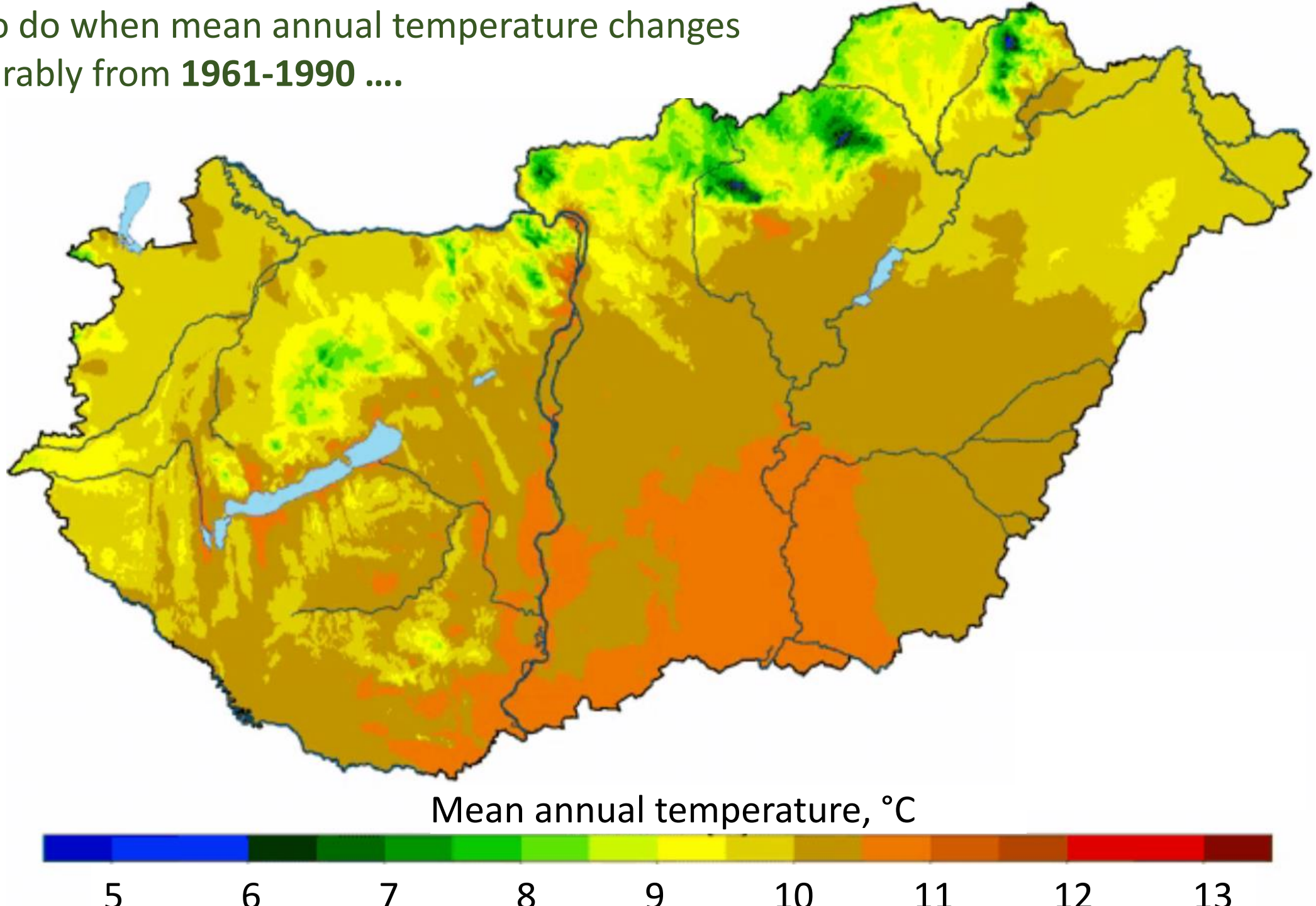
- some data is monitored usually with a frequency of once every three years



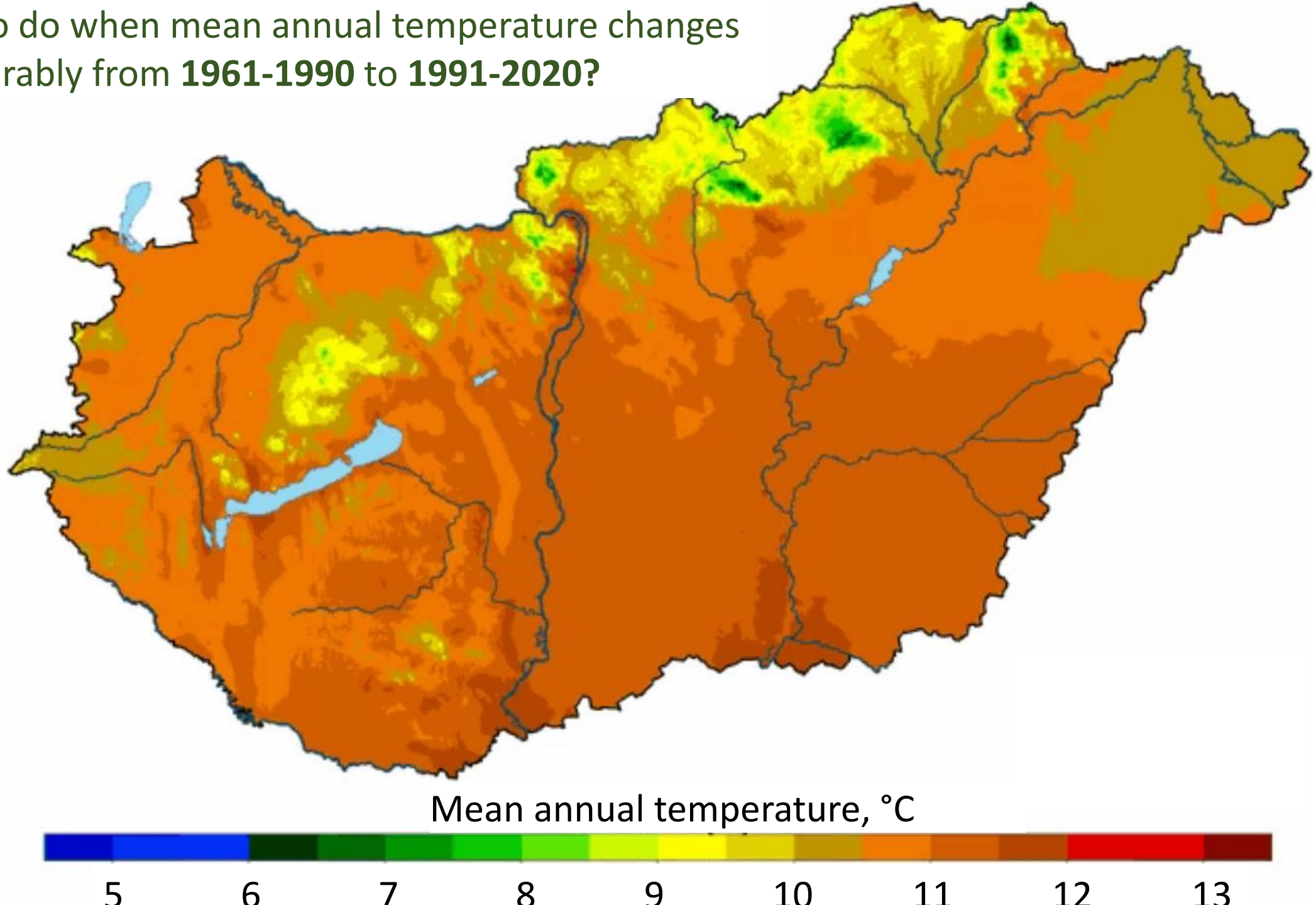
Methods: SOC

- SOC is derived from SOM using the conversion factor 0.58
- for each point, SOC for the top 30 cm layer is the *average* of SOC of repeated measurements to reduce uncertainty
- SOC *for each soil type & LU* sub-category is the *average* of SOC of all points in the sub-category
- SOC *for each LU* is the average of soil type-specific SOC weighted by the share of area by soil type within the LU category
- (climate type will be considered later for categorization; climate type has changed due to climate change - which period to use?)

What to do when mean annual temperature changes considerably from **1961-1990 ….**



What to do when mean annual temperature changes considerably from **1961-1990** to **1991-2020?**



Methods: ΔSOC by conversion type

- exploration: relationship between ΔSOC and SOC at t1

- estimation, 1st step:
  soil type-specific $\Delta SOC_i = SOC_{i\ post\text{-}conversion\ LU} - SOC_{i\ pre\text{-}conversion\ LU}$

- estimation, 2nd step:
  ΔSOC for a LU change category = *weighted mean* of ΔSOC_i where the weight for soil type *i* is equal to its *share by area within a conversion type* (e.g., the area of CL on soil type *i that was converted to* FL 1990-2019)

- the shares in the non-forest related conversions are currently unknown and are, with some confidence, temporarily assumed to be the same for both of the LU categories in a conversion

Methods: other

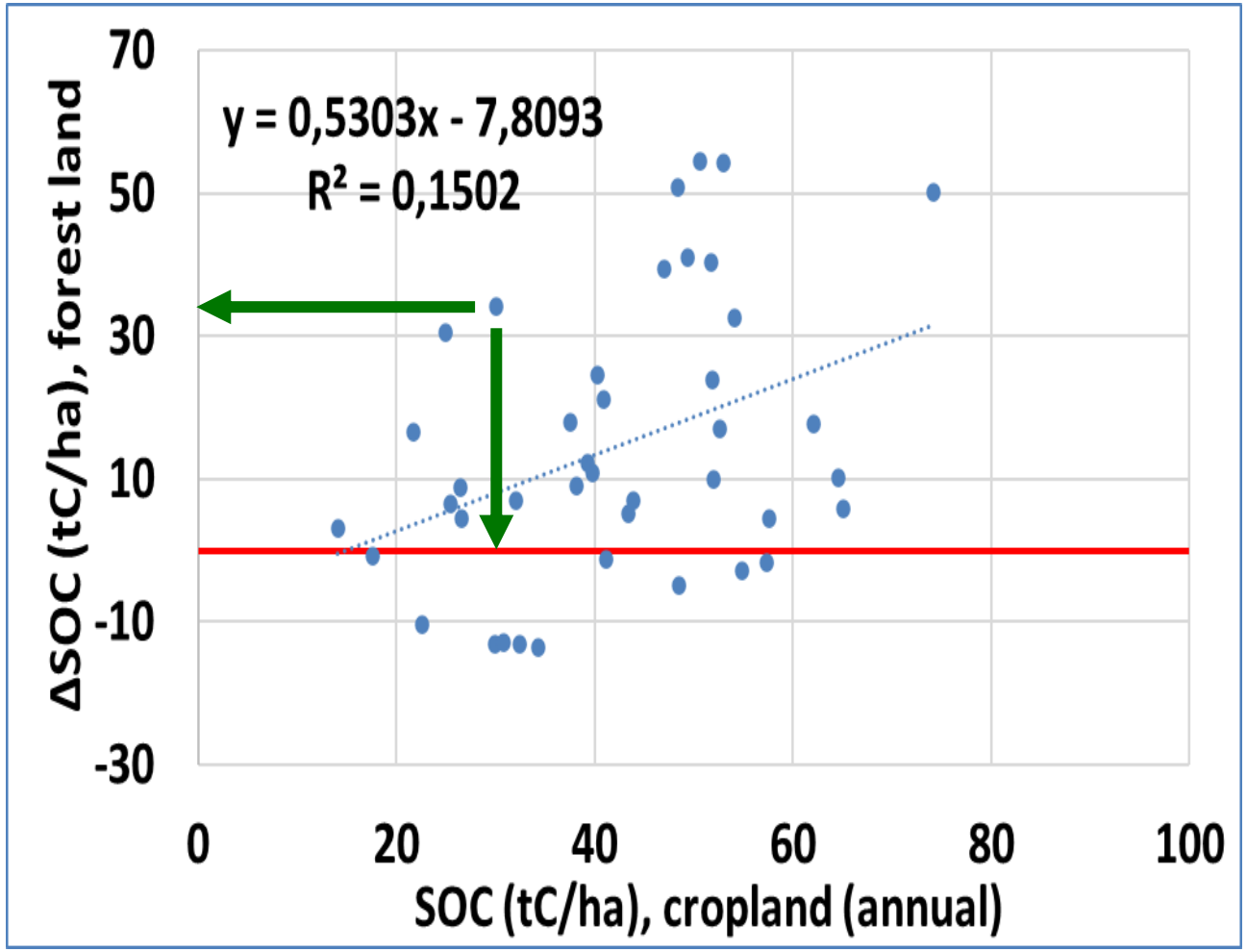
- **ΔSOC is assumed to be equal to the full difference between equilibrium levels; changes are assumed to take place in 20 years**

- ***uncertainty* was estimated in a Monte Carlo simulation (#of runs: 1000) using (1) SD calculated for mean SOC by soil type and (2) SD assumed for area by soil type applying expert judgment**

- for FL-FL, annual ΔSOC was also analysed for each plot from two measurements farthest apart (t1, t2) (=*are mineral soils in forests sinks or sources?*)
- ΔSOC for FL-FL was analysed as a function of SOC at t1, *which is possibly related to high share of former LU change* (i.e., afforestations) and calculated using the share of area by soil type

Results #1*:
CLa – FL conversion

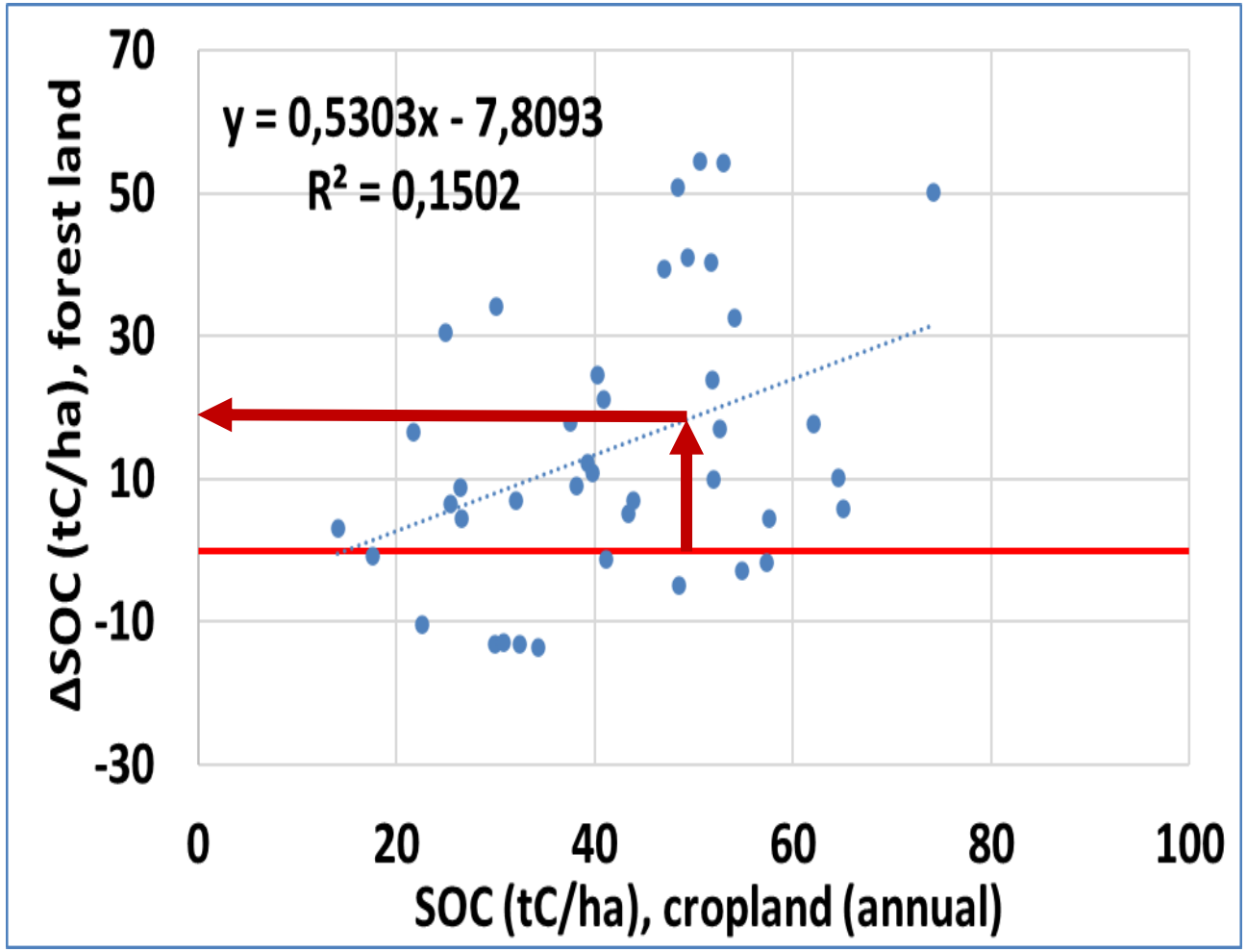
each dot represents mean SOC for a specific soil type for two land-use categories (= „simulated" paired plots)



* preliminary results

Results #1*:
CLa – FL conversion

ΔSOC for a specific SOC can be approximated using the regression line



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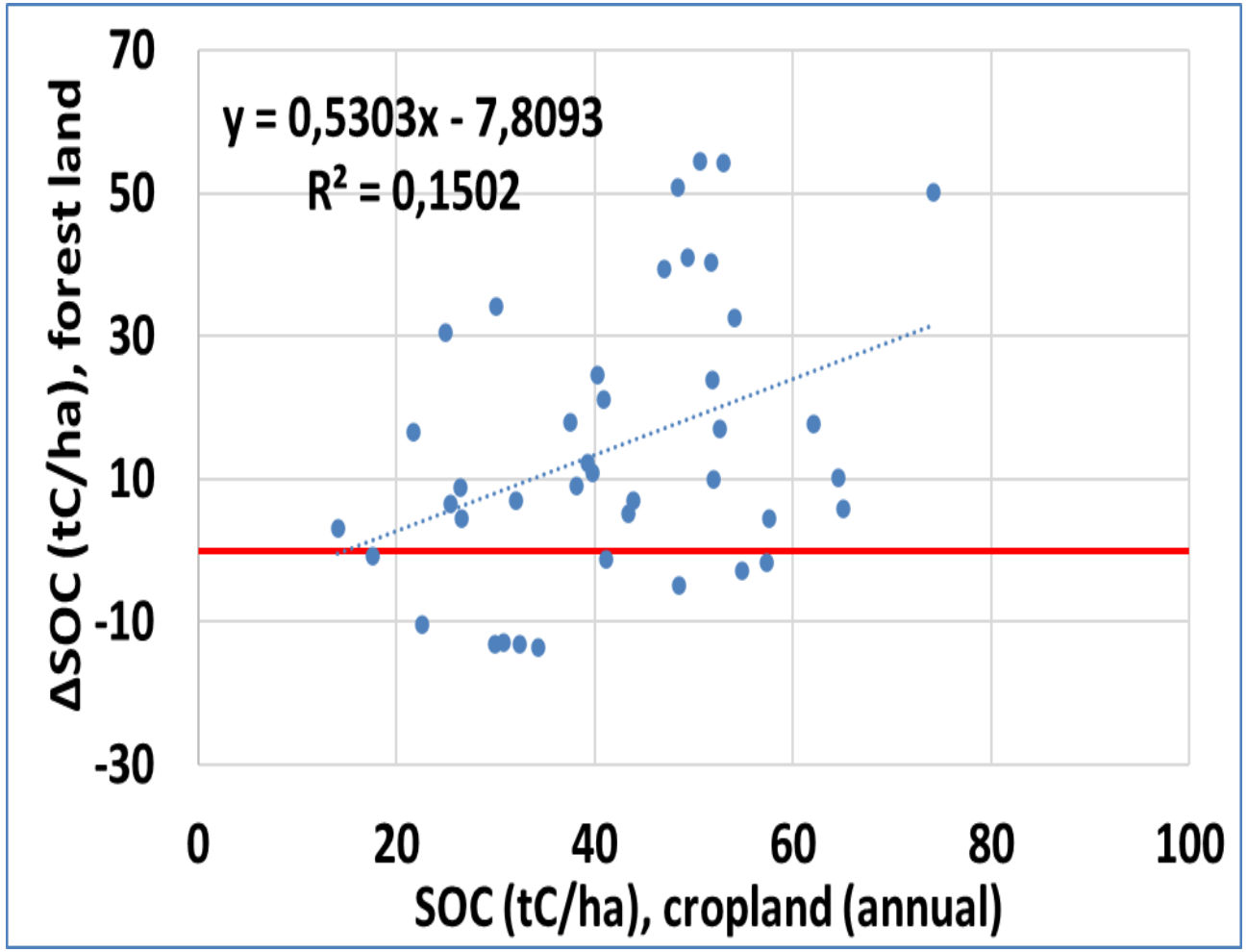
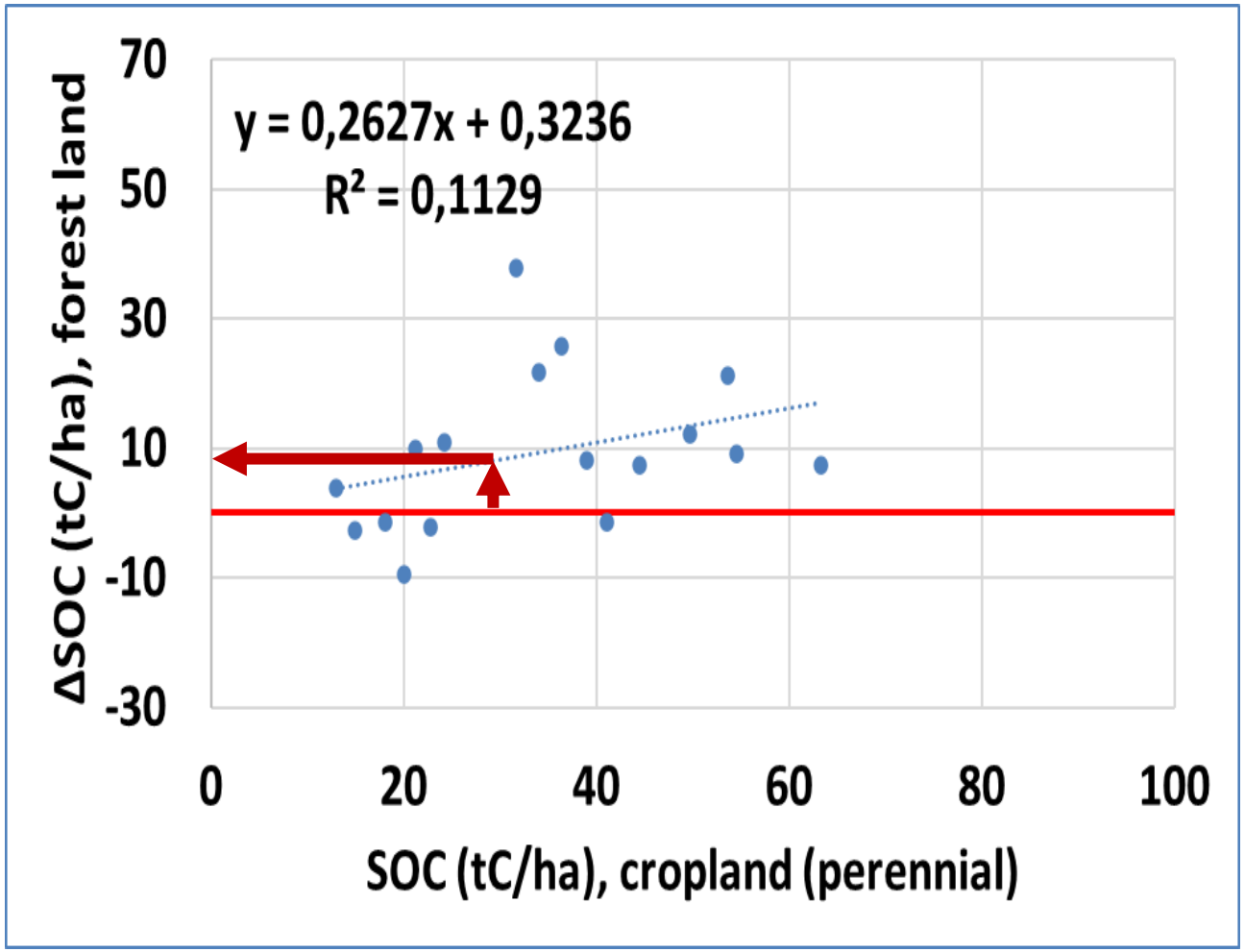


From: To:	FL	CL (annual)	CL (perennial)	GL
FL		↓↓		
CL (annual)	↑↑			
CL (perennial)				
GL				

nature of relationship:

* preliminary results

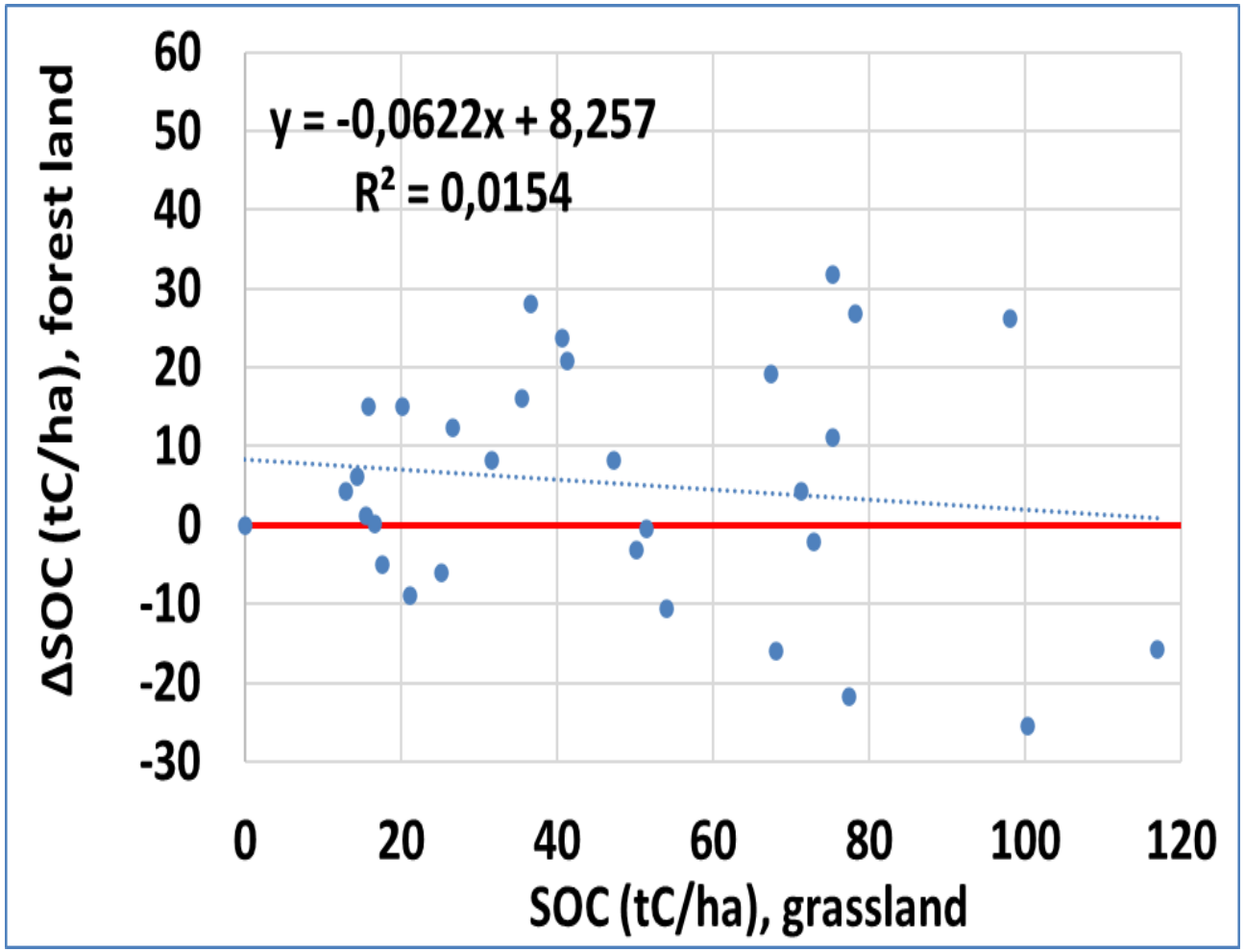
Results #1*:
CLp – FL conversion



From: To:	FL	CL (annual)	CL (perennial)	GL
FL		↓↓	↓	
CL (annual)	↑↑			
CL (perennial)	↑			
GL				

* preliminary results

Results #1*:
GL – FL conversion



From: To:	FL	CL (annual)	CL (perennial)	GL
FL		↓↓	↓	↓
CL (annual)	↑↑			
CL (perennial)	↑			
GL	↑			

* preliminary results

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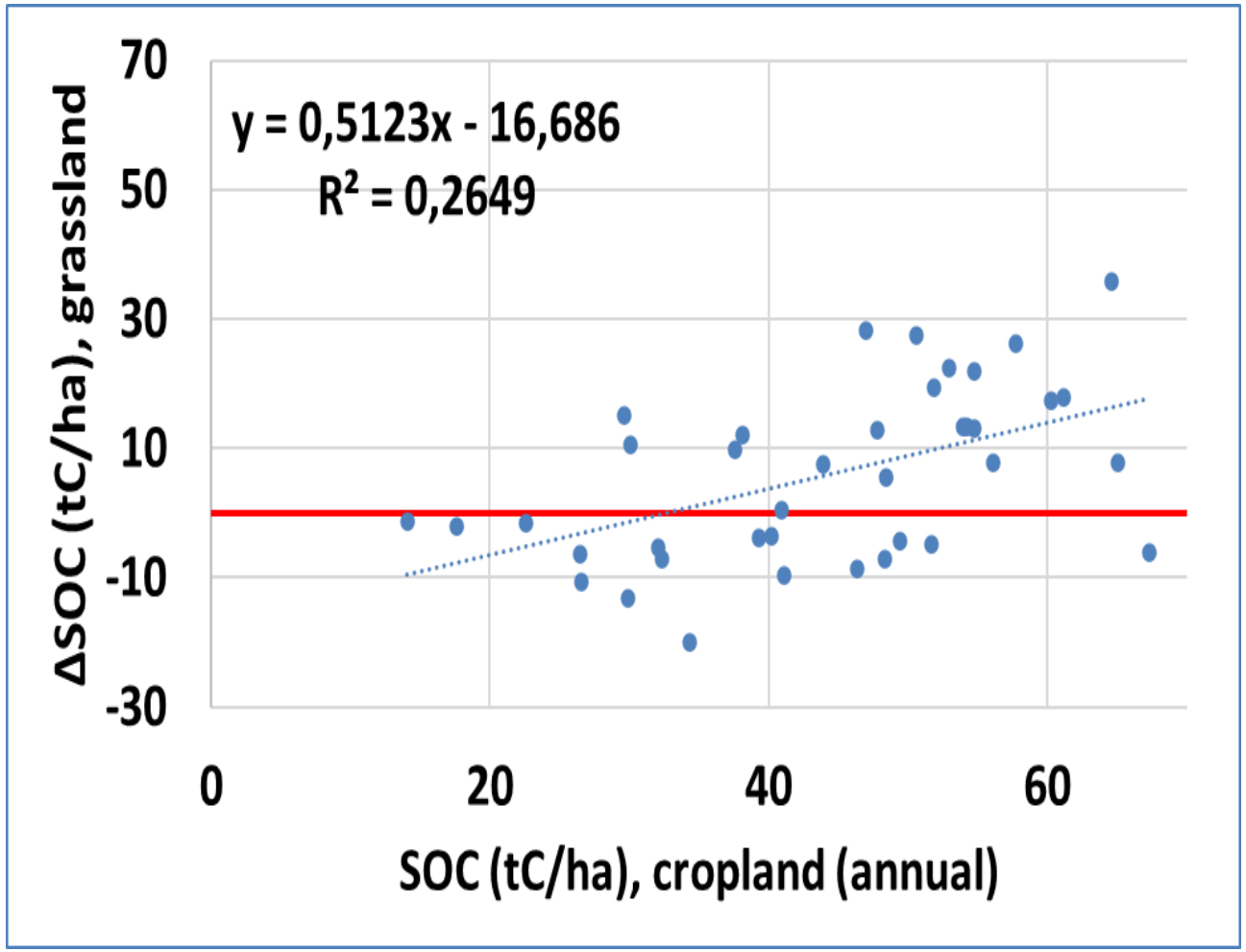
CLa – GL conversion



From: To:	FL	CL (annual)	CL (perennial)	GL
FL		↓↓	↓	↓
CL (annual)	↑↑			↑
CL (perennial)	↑			
GL	↑	↓		

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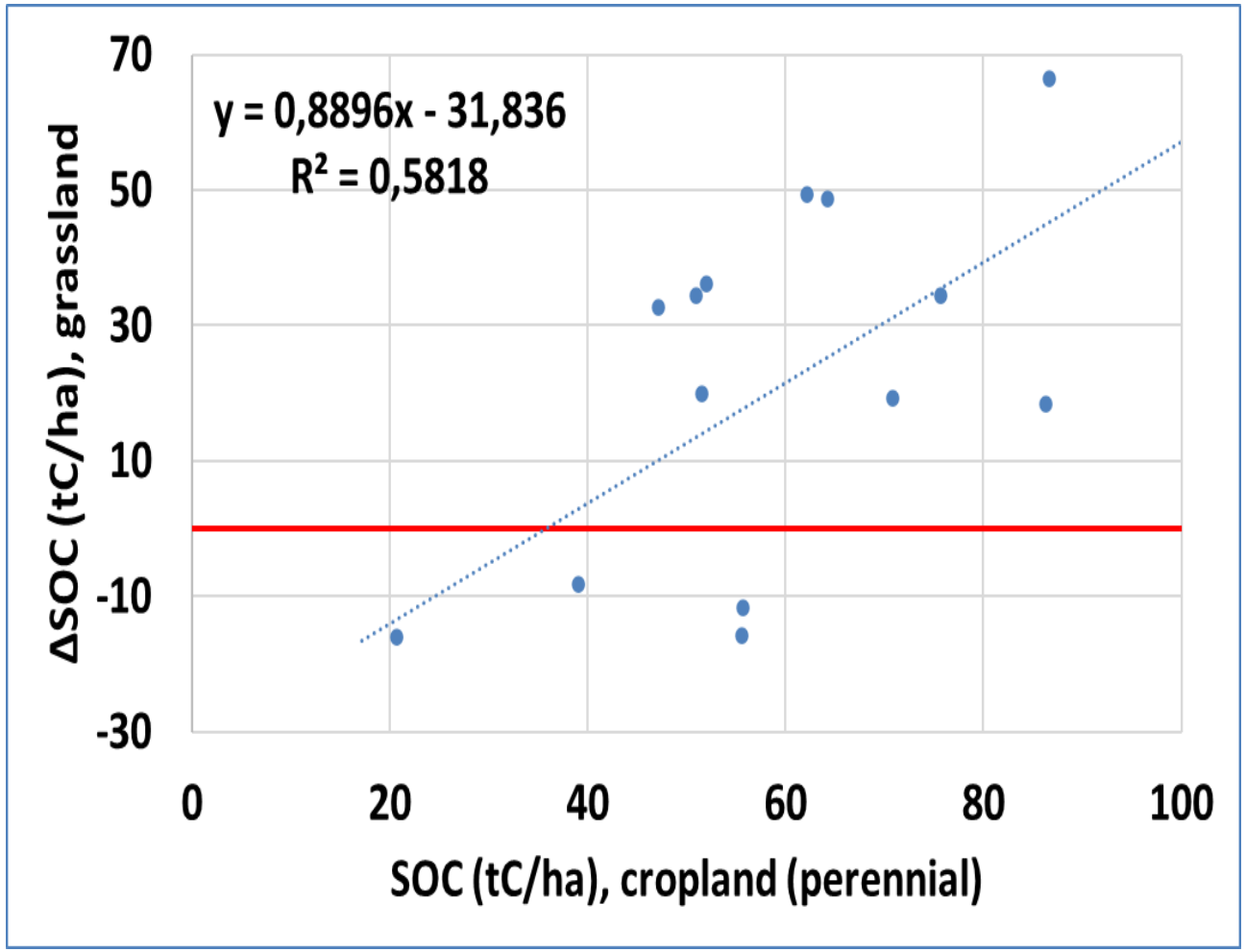
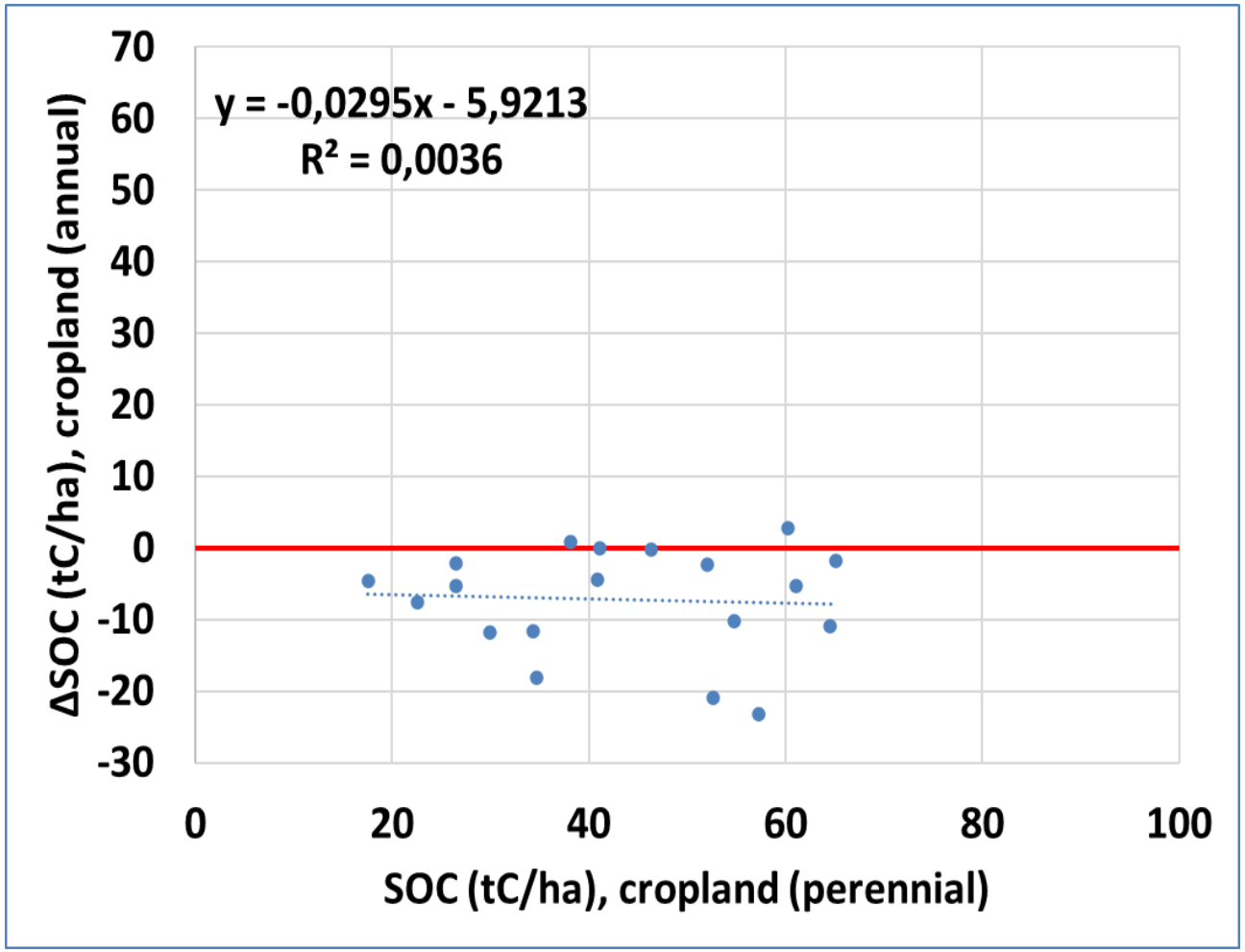
CLp – GL conversion



From: To:	FL	CL (annual)	CL (perennial)	GL
FL		↓↓	↓	↓
CL (annual)	↑↑			↑
CL (perennial)	↑			↑↑
GL	↑	↓	↓↓	

* preliminary results

Results #1*:
CLp – CLa conversion



From: To:	FL	CL (annual)	CL (perennial)	GL
FL		↓↓	↓	↓
CL (annual)	↑↑		↑	↑
CL (perennial)	↑	↓		↑↑
GL	↑	↓	↓↓	

* preliminary results

Results #2*: mean SOC & ΔSOC (tC/ha) weighted by soil type distribution *and their uncertainty*

SOC if the distribution:	L	L-FL					
From: To:	L-L	CLa	FL	CLp	FL	GL	FL
FL	45.1 ± 0.6						
CL (annual)	51.0 ± 0.5	37.0 ± 0.4	41.8 ± 0.6				
CL (perennial)	35.0 ± 0.8			30.6 ± 0.6	41.8 ± 0.6		
GL	54.6 ± 0.8					38.2 ± 0.6	41.8 ± 0.6

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ΔSOC	L-FL
CL (annual)	+4.8 ± 0.7
CL (perennial)	+11.2 ± .8
GL	+3.6 ± 0.8

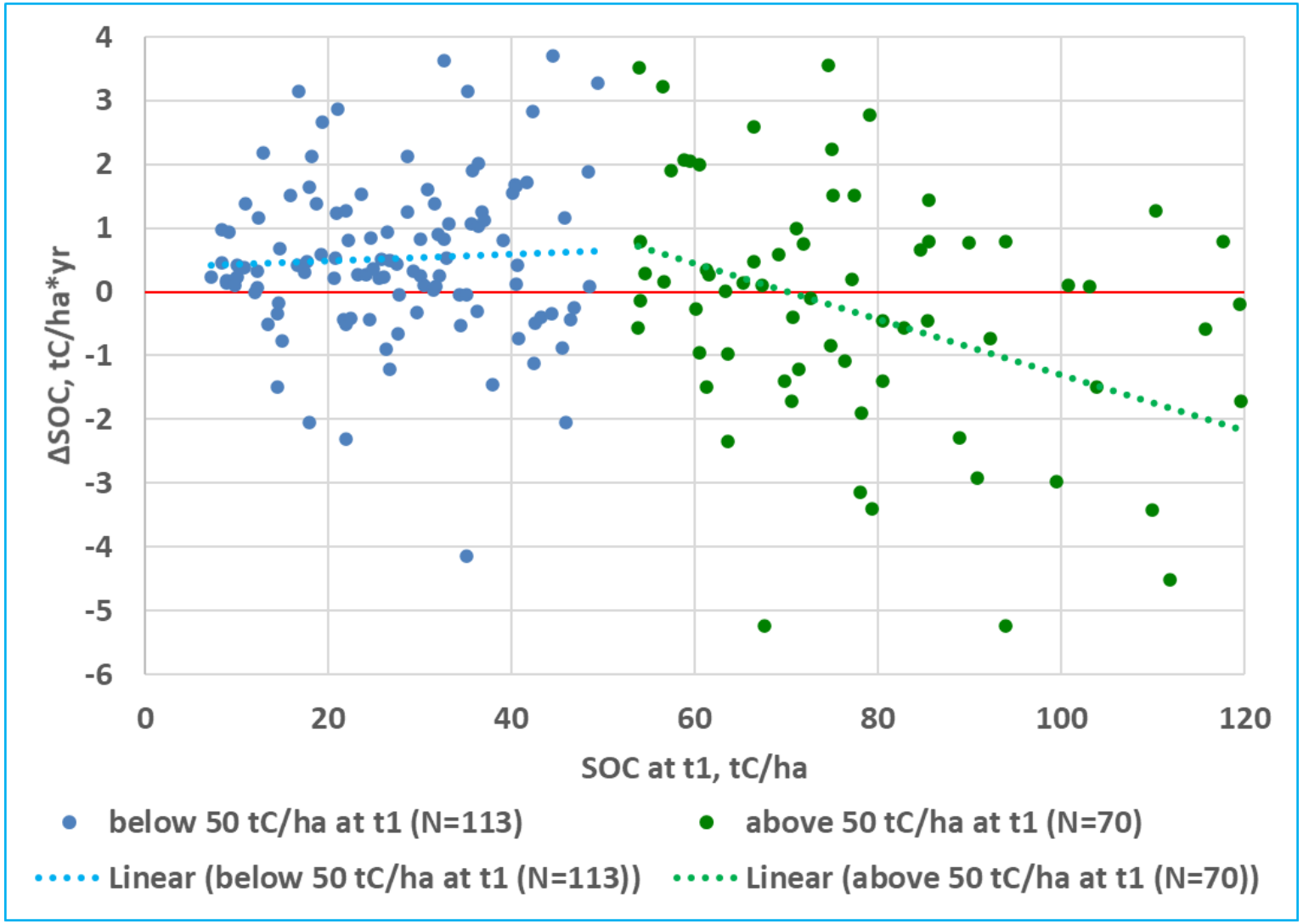
* preliminary results

Results #3*: mean annual ΔSOC *in FL-FL* from repeated measurements (weighted by distribution; mean t2-t1=18.1 years): overall net gain; significant net gain on poor sites; not significant loss on rich sites

ALL forests:
0.34 tC/ha*yr

forests on SOC-poor site:
0.68 tC/ha*yr
due to *high share of post-conversion stands* (?)

forests on SOC-rich site:
-0.43 tC/ha*yr



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