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ESTIMATION OF SOIL ORGANIC CARBON STOCK IN THE GLACIER FORELAND OF MIDTRE LOVÉNBREEN, IN THE HIGH ARCTIC

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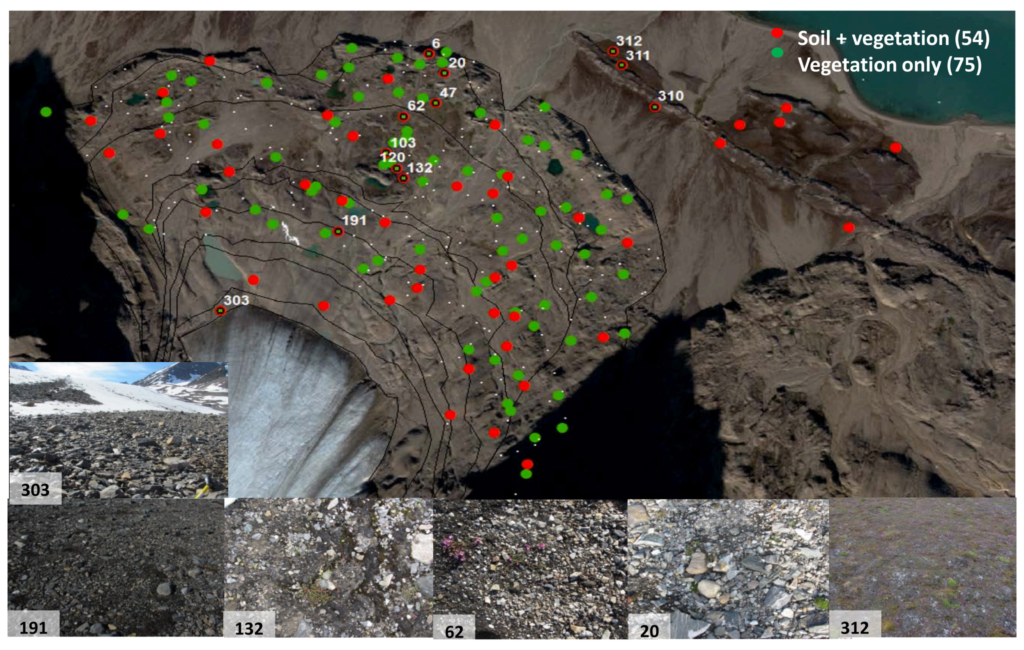
INTRODUCTION

Global warming leads to rapid melting of glaciers in the high Arctic, exposing new soil surfaces. Soil organic carbon (SOC) accumulation in the proglacial environment is initiated along soil chronosequence after microorganisms and plants have settled down. Studies in glacier forelands mostly focused on consequent changes in soil, plants, and microorganisms after glacier recession (Matthews 1998; Hodkinson et al., 2003; Smittenberg et al., 2012). However, the quantity and rate of SOC accumulation are affected not only by time but also by several environmental factors. Furthermore, proglacial land is dynamically reworked by runoff activity of glacier streams. Therefore, we were aiming to understand the distribution pattern of SOC and to produce a map of SOC stock in the foreland of the Midtre Lovénbreen, Spitsbergen, Norway (79°N, 12°W) with a consideration of the deglaciated years and several environmental factors such as microtopography, runoff activity, etc.

MATERIALS & METHODS



- **Study area:** Glacier foreland of Midtre Lovénbreen, Svalbard, Norway (79°N, 12°W)
- **Sampling sites selection**: Stratified sampling with a consideration of X, Y coordinates, runoff, age, slope, and wind among 300 sites of Moreau et al. (2005)
- **Soil sampling:** 45 sites inside moraine
- **Sampling depths:** 0-5, 5-10, 10-20, and 20-30 cm

❖ Vegetation survey

- Coverage of black crust, lichen, bryophytes and vascular plants
- Total vegetation cover: the sum of the above mentioned vegetation's coverage
- Frequency of each plant: the ratio of occurrences of a plant species among twenty-four subplots surveyed in a 2 x 2 m plot

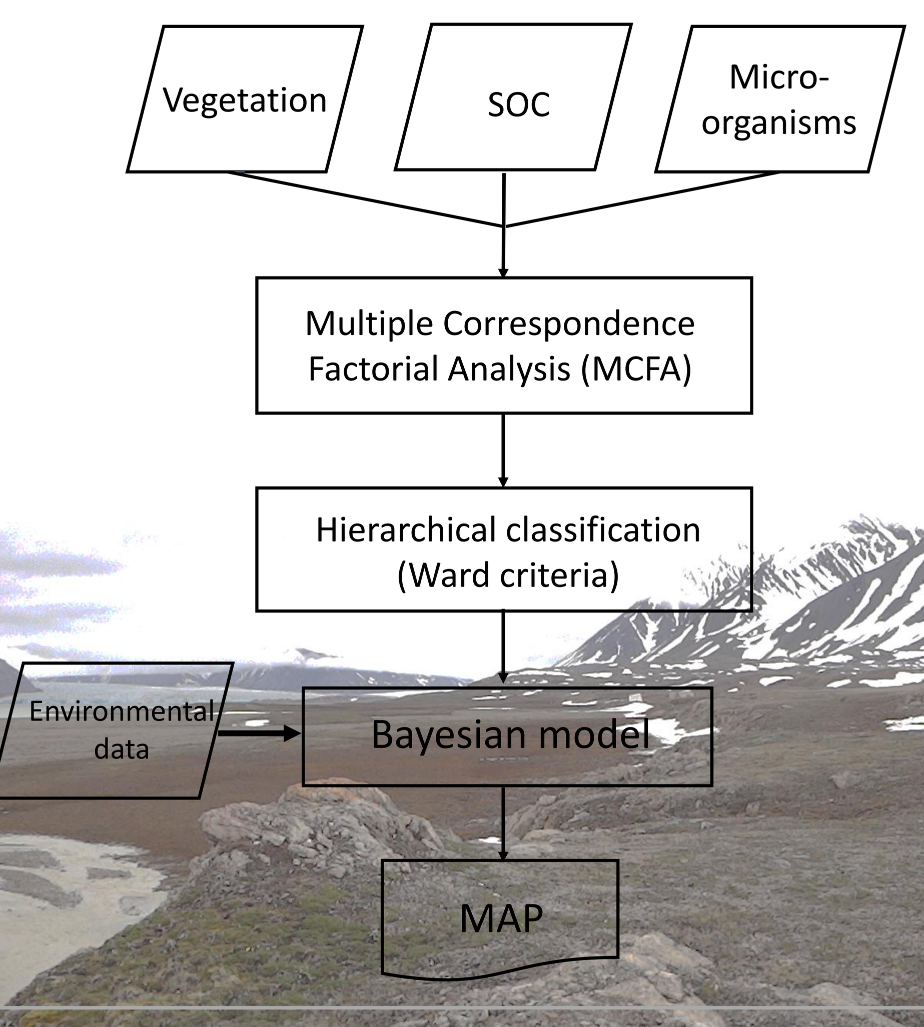
❖ Soil analysis & Calculation

- SOC content: A combustion method at 950 °C after removing inorganic carbon
- Soil texture: Wet-sieving & a pipette method
- Bulk density (ρ_{FE}): Estimated by soil texture using SPAW software (Soil water charac-teristics Ver. 6.02.74; Saxton and Rawls, 2006)
- SOC_{FE} stock: SOC content (Mg C/Mg soil) x ρ_{FE} (Mg soil/m^3 soil) x depth (m)
- SOC_{hybrid} stock: SOC content (Mg C/Mg soil) x ρ_{hybrid} (Mg soil/m^3 soil) x depth (m)
  - ✓ ρ_{FE}: Mass of the fine earth (< 2 mm)/volume of the fine earth in the sample
  - ✓ ρ_{hybrid}: Mass of the fine earth (< 2 mm) in the sample/volume of the entire core

❖ Statistics

- Bivariate correlation between variables
- One-way ANOVA test: the effects of runoff on SOC content and stock

FURTHER WORKS



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RESULTS

- SOC stock for 30 cm depth ranged from 1.5 to 15.4 Mg/ha in the foreland of Midtre Lovénbreen (Table 1).
- The amount of SOC stock was greatly affected by the proportion of gravel to soil. The SOC_{hybrid} stock was about 0.6 times lower than the SOC_{FE} stock (Table 2).

Table 1. Descriptive statistics of soil and vegetation related variables

	SOC content (%)	SOC_{FE} Stock (Mg/ha)	SOC_{hybrid} Stock (Mg/ha)	Black crust	Lichen	Bryo-phyte	Vascular plant	Total coverage (%)	Sum of Frequen-cy
Min	0.07	3.35	1.52	0	0	0	0	0	0
Mean	0.41	8.85	5.49	9.66	1.38	0.85	5.50	17.23	81.31
Max	0.96	22.25	15.42	62.5	12	5	37.5	100	154.2

- SOC content among 5-10, 10-20, and 20-30 cm did not differ, and bulk density through all depths did not vary either. Thus, SOC stock was closely related to the SOC content of the top soil (0-5 cm) (Table 2).
- Among several vegetation related parameters, the sum of vascular plants' frequency showed the highest correlation with the SOC content of top soil and SOC stock (Fig. 2).
- There was no correlation between the SOC stock and soil age (Table 2).

Table 2. Pearson correlation between measured variables

	Gravel	SOC_{con}	Sand	Clay	SOC_{FE}	SOC_{hy}	BC	Li	Bryo	VP	TotCov	Freq	Age
Gravel	1.00												
SOC_{con}	-0.50	1.00											
Sand	0.50	-0.47	1.00										
Clay	-0.52	0.53	-0.82	1.00									
SOC_{FE}	-0.52	0.81	-0.61	0.78	1.00								
SOC_{hy}	-0.58	0.79	-0.63	0.81	0.99	1.00							
BC	-0.19	0.53	-0.22	0.20	0.31	0.26	1.00						
Li	-0.47	0.42	-0.20	0.29	0.48	0.49	0.21	1.00					
Bryo	-0.26	0.50	-0.25	0.31	0.43	0.39	0.73	0.50	1.00				
VP	-0.25	0.48	-0.23	0.28	0.36	0.32	0.87	0.33	0.86	1.00			
TotCov	-0.26	0.57	-0.25	0.27	0.39	0.35	0.97	0.37	0.84	0.95	1.00		
Freq	-0.57	0.62	-0.43	0.54	0.59	0.59	0.52	0.42	0.52	0.58	0.59	1.00	
Age	0.04	-0.38	-0.26	0.08	-0.19	-0.15	-0.04	-0.18	-0.10	-0.01	-0.05	-0.27	1.00

Gravel: gravel to soil ratio; SOC_{con}: SOC content for 0-5 cm depth; Sand: proportion of sand; Clay: proportion of clay; SOC_{FE}: SOC stock of fine earth (< 2 mm); SOC_{hy}: SOC stock calculated by a hybrid method; BC: coverage of black crust; Li: coverage of lichen; Bryo: coverage of bryophyte; VP: coverage of vascular plant; TotCov: the sum of coverage of black crust, lichen, bryophyte, and vascular plant; Freq: sum of each plant frequency; Age: years since deglaciation

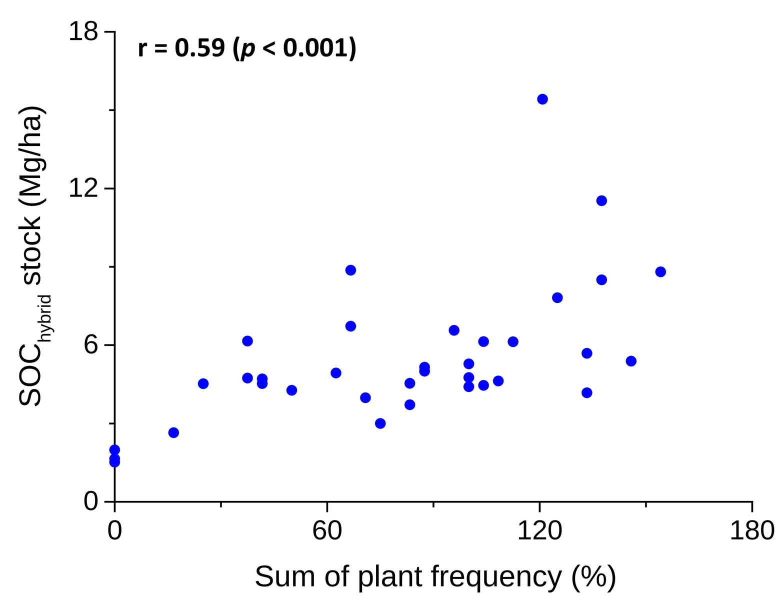

Fig 2. A scatter plot with the sum of plant frequency and SOC_{hybrid} stock

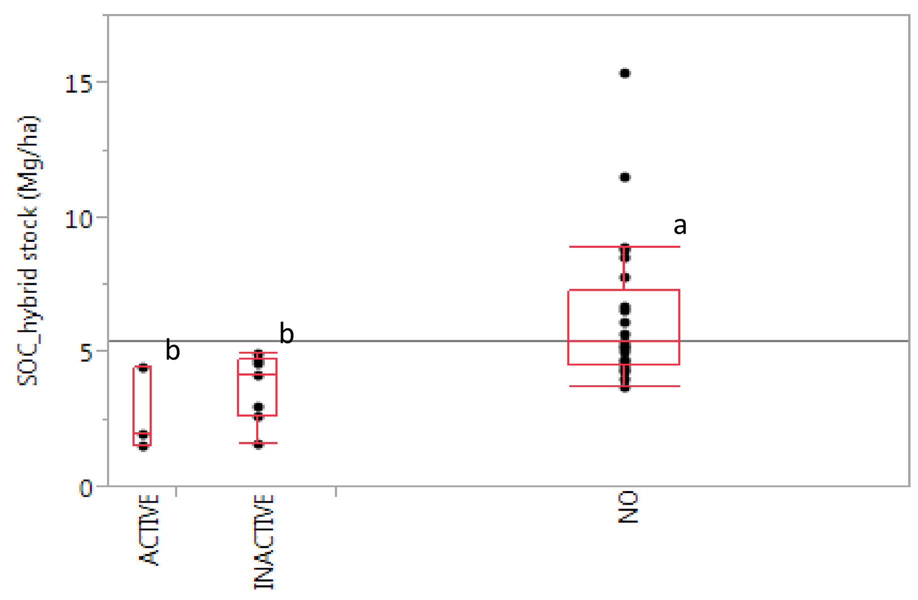

Fig 3. The effects of runoff activity on the SOC_{hybrid} stock

- The active and intermittent runoff sites showed significantly lower SOC content compared to no runoff sites (Fig. 3). Glacier/snow meltwater would have washed out previously established vegetation and accumulated SOC.
- We will approach multivariate statistics to deal with quantitative and qualitative data, and scrutinize the relationship between SOC stock and environmental variables acquired from DEM and remote sensing data in depth as a next step.
- Through understanding the relationship between SOC content/stock and environmental parameters, there is a possibility to quantify and predict SOC distribution by observing vegetation distribution and extracting specific environmental factors.

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