# Predicting the spatial distribution of soil organic carbon stock in Swedish boreal forest using remotely sensed and site-specific variables

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## Introduction

Forest landscapes are characterized by high spatial variability and key drivers of SOC stock might be specific for subareas compared to those influencing the whole landscape. This study investigates whether calibrating separately models with different driving factors for subareas (local models) that collectively cover a target area will result in improved prediction accuracy of soil organic carbon stock (SOC) compared to a single model (global model) that covers the whole area.

Questions addressed are: (1) How do global and local models differ in predicting the humus layer, mineral soil and total SOC stock in Sweden boreal forest? (2) What are the key drivers of SOC stock at a global and local scale in Swedish forest soils?

## Material und Methods

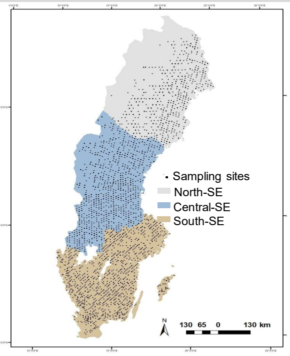
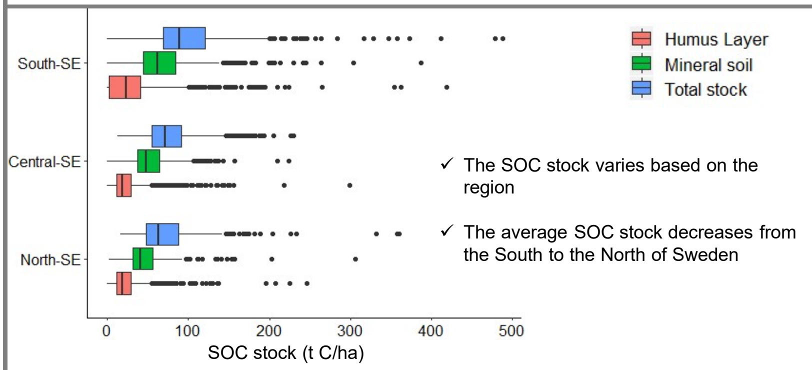



Figure 1: Sampling sites

- Humus layer (n = 4479, max: 30 cm), mineral (n = 2138, 0 - 30 cm) and total SOC stock (n = 2132, 0 – 50 cm) dataset was extracted from the Swedish Forest Soil Inventory (SFSI) database.
- Covariates. Remotely sensed variables (RSV, raster files of 10 m resolution) such as *topography, hydrology, gamma radiometry and geochemical data were used.* Site-specific variables (SSV) consisted in SFSI data of *classes of soil moisture, soil type, soil texture, parent material, Northing and Easting.*
- Modelling with the Random Forest (RF) was carried out by building (1) local models for North-SE, Central-SE, South-SE and (2) global models for the whole Sweden (All-SE). Dataset was split with 80% to train models and 20% for validation for each region. Quantile RF was used to compute the standard deviations of the final maps.

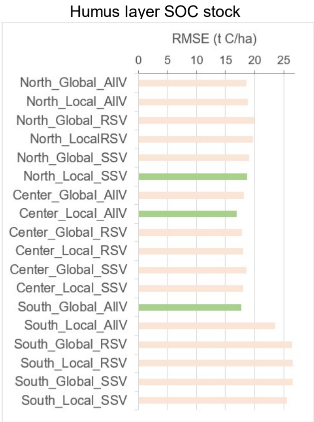


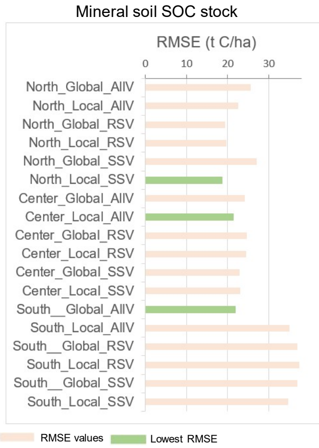

✓ The SOC stock varies based on the region

✓ The average SOC stock decreases from the South to the North of Sweden

Figure 2: Soil carbon stock distribution in Sweden

## Results



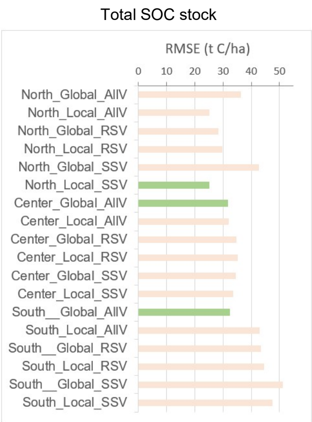




Figure 3: RMSE of the independent validation for humus layer, mineral soil and total SOC stock from the local and global Random Forest models. SSV: site specific variables, RSV: remote sensing variables, AllV: all variables.

✓ Model accuracy with global and local models in predicting the humus layer, mineral soil and total SOC stock is dependent on the type of covariates used for modelling.

✓ Using only site characteristics or their combination with remotely sensed variables resulted generally in lower RMSE compared to using only the latter for local and global modelling.

✓ Local models have a comparative advantage over global models for Northern and Central Sweden when using either only site characteristics alone or the combination of the latter with remotely sensed variables for modelling.

✓ SOC stock in Southern Sweden was better predicted with global model using all the variables suggesting a more complex soil-landscape relationship.

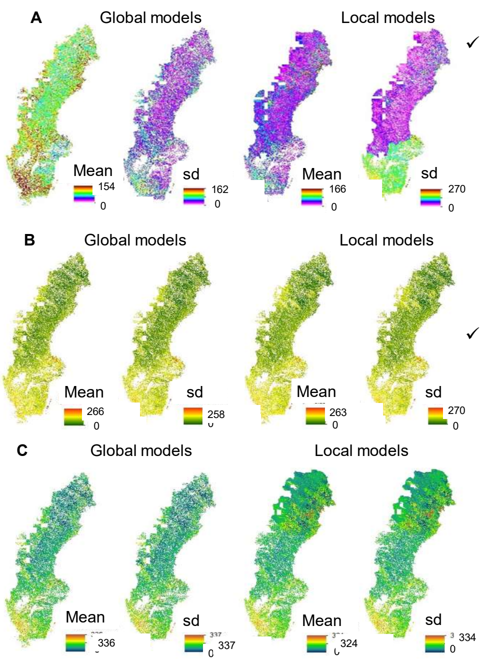



Figure 5: SOC stock (RSV) maps (t C/ha) , A: Humus layer, B: Mineral soil, C: Total SOC.

✓ The predictive maps follow generally the same pattern. Broadly, there is an increasing gradient of SOC stock from North to South for the humus layer, mineral soil and total SOC stock. This can be explained by higher N deposition in Southern Sweden.

✓ No matter the type of SOC stock, the standard deviations show higher uncertainties attached to the prediction of SOC stock in Southern Sweden compared to the remaining areas no matter the type of models. Dataset for Southern Sweden showed higher range and variation (Fig. 2) compared to other areas.

Variable importance (%)

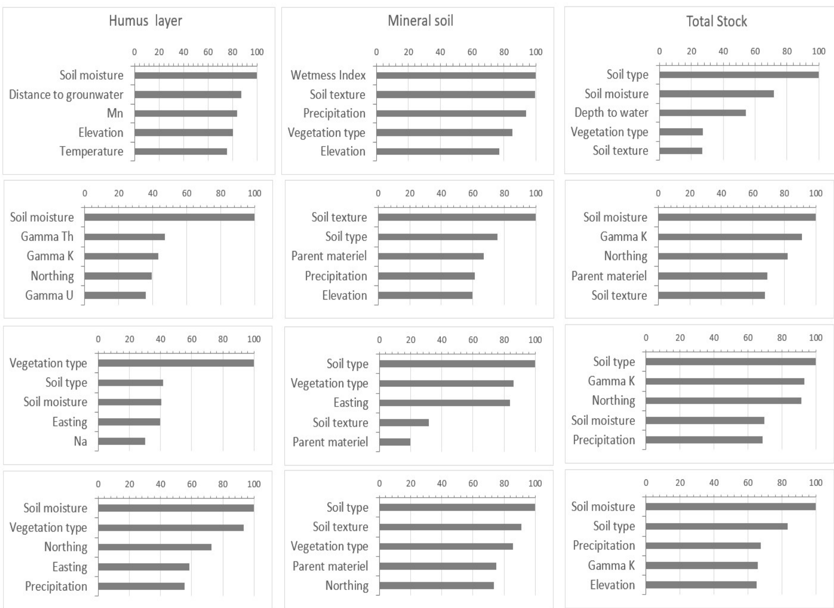



Figure 4: Variable importance (RFR) of the top 5 covariates

Site-specific variables took preeminence over the remotely sensed variables for both local and global models. Soil moisture and vegetation type have high influence on the distribution of the humus layer while soil type and texture affect mostly the spatial variation of mineral SOC stock. The total soil stock was mostly influenced by soil moisture and soil type.

## Conclusion

✓ Performance of local and global models were found to be site specific with the former taking preeminence over the latter except for Southern Sweden which had the highest level of spatial variation. This suggests that highly complex soil-landscape area might require model that learn from a bigger dataset.

✓ Using remotely sensed variables with soil inventory data indicates that such covariates have limited predictive strength but that site specific covariates show better explanatory strength for SOC stocks.

✓ Future studies could focus in the high resolution mapping of the most influential site specific variables (soil moisture, vegetation type, soil type and texture) which have potential for future SOC stock prediction models.

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