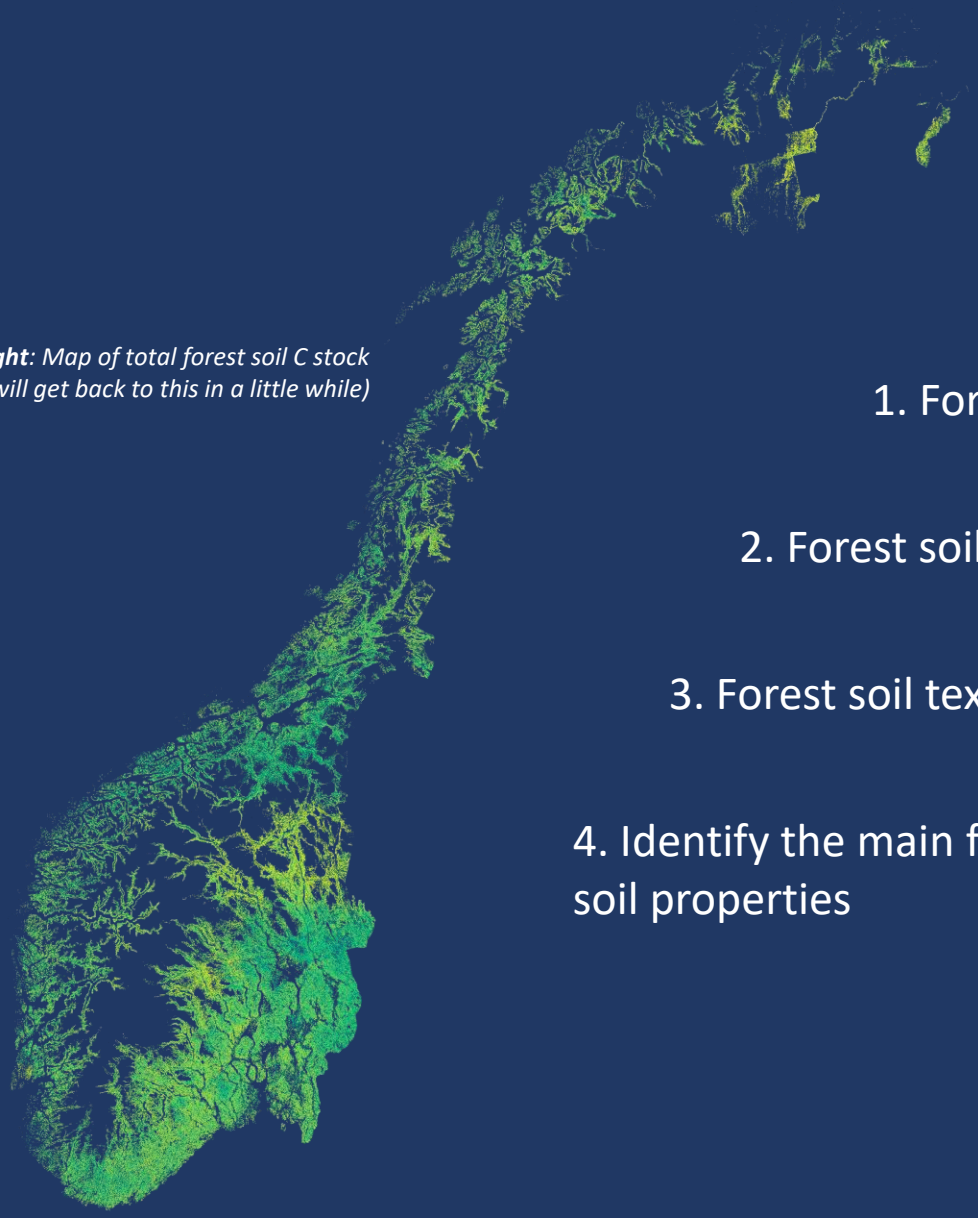
Research group SiMPL

Soil **M**odelling and **P**rediction on **L**and

Jogeir Stokland, Lise Dalsgaard, Stephanie Eisner, Janne Kjønaas, Christian Wilhelm Mohr, Marius Hauglin, **Andreas Hagenbo**

Research objectives

Investigate the spatial distribution of soil properties in Norway



***Right**: Map of total forest soil C stock (I will get back to this in a little while)*

1. Forest Soil C stocks

2. Forest soil depth

3. Forest soil texture

4. Identify the main factors related to variation in the various soil properties

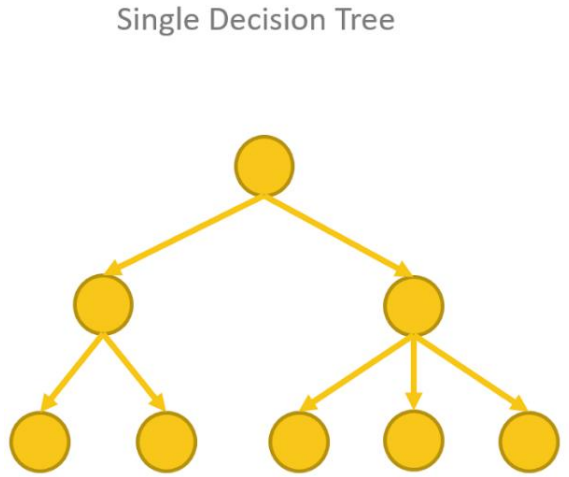
Method – response variables

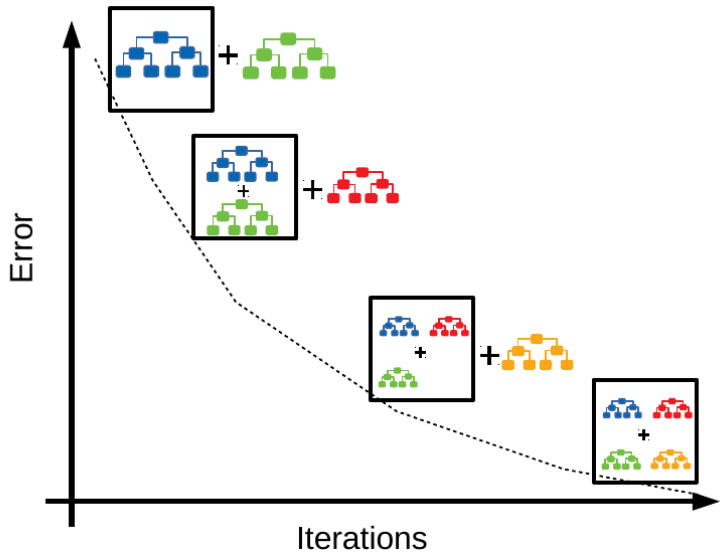
Boosted regression tree (BRT) models

Allows for the predictive modelling of highly non-linear systems where casual mechanisms are poorly understood, such as soils

Response variables from ICP forest level 1:

- Soil C contents (across five different soil layers)
    1. Total soil C
    2. Soil C stock between 0 – 1 m
    3. Soil C stock between *0 – 30 cm*
    4. *LFH horizon C*
    5. *Mineral horizon C stock, 0 – 30 cm*
- Soil depth
- Soil texture frequency of sand, silt and clay + occurrence of rock and gravel. Grouped into 30 texture categories:
    - 5 levels of sand (33% to 92%)
    - 4 levels of silt (6% to 58%)
    - 3 levels of clay (3 to 15%)
    - 4 levels of stone and gravel (vol%: 16% to 76%)





Method – explanatory variables

Two different types of BRT models with two different sets of variables:

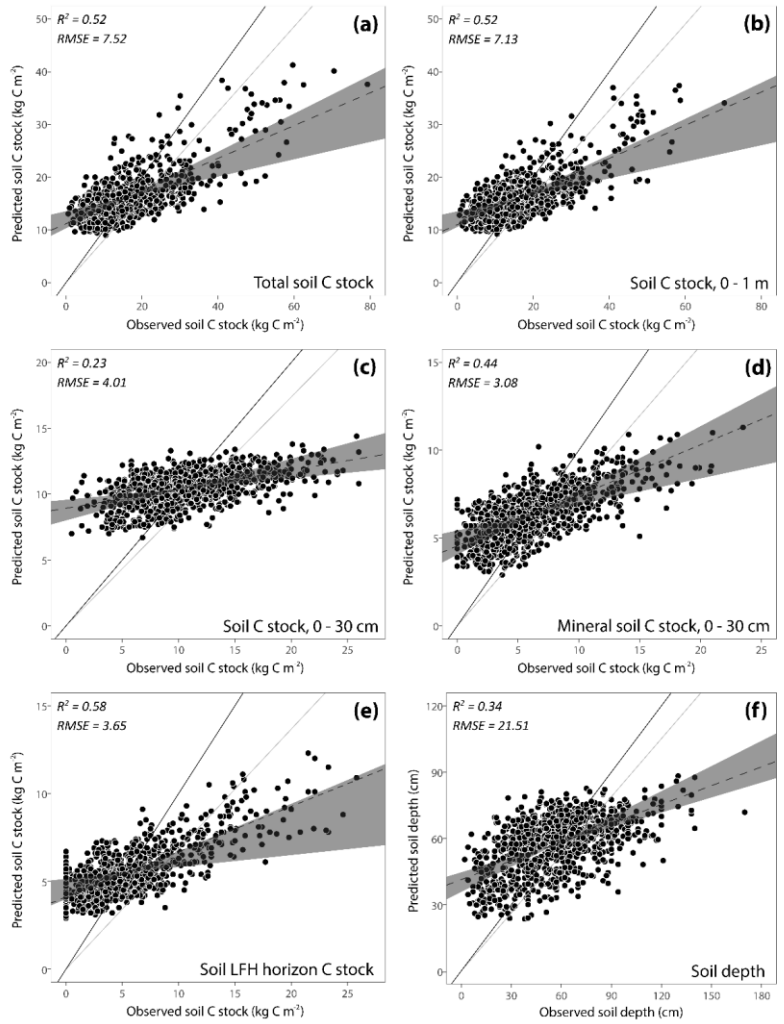
1) Mapping models – used to generate maps of soil properties:

Geographical variables (coordinates), **terrain variables** (e.g. slope, depth to water), **forest properties** (e.g. tree crown cover, stand height), **monthly precipitation**, **monthly temperature**, **remote sensing data from Sentinel 2** (e.g. NDVI), **categorical variables** (AR5, soil parent material)

2) Maximum prediction models – used to assess the maximal predictive capacity we can achieve with the BRT model approach

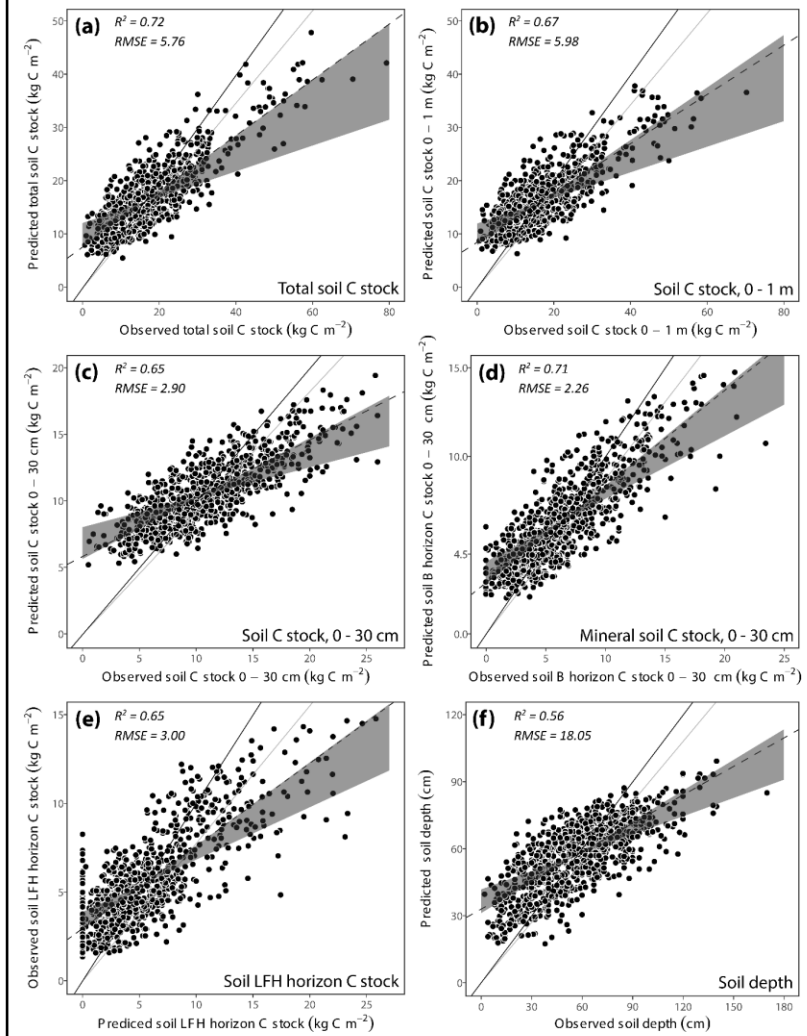
Mappin variables + **variables of soil chemistry** (e.g. kjeldahl N, Olsen P, pH, Al, Mn, S, Zn, etc…) for different depths between 5-15 cm in humus and 5 – 15 in mineral soil layers

Predictions of soil C stocks and depth



Mapping models

Used for generating maps



Maximum prediction models

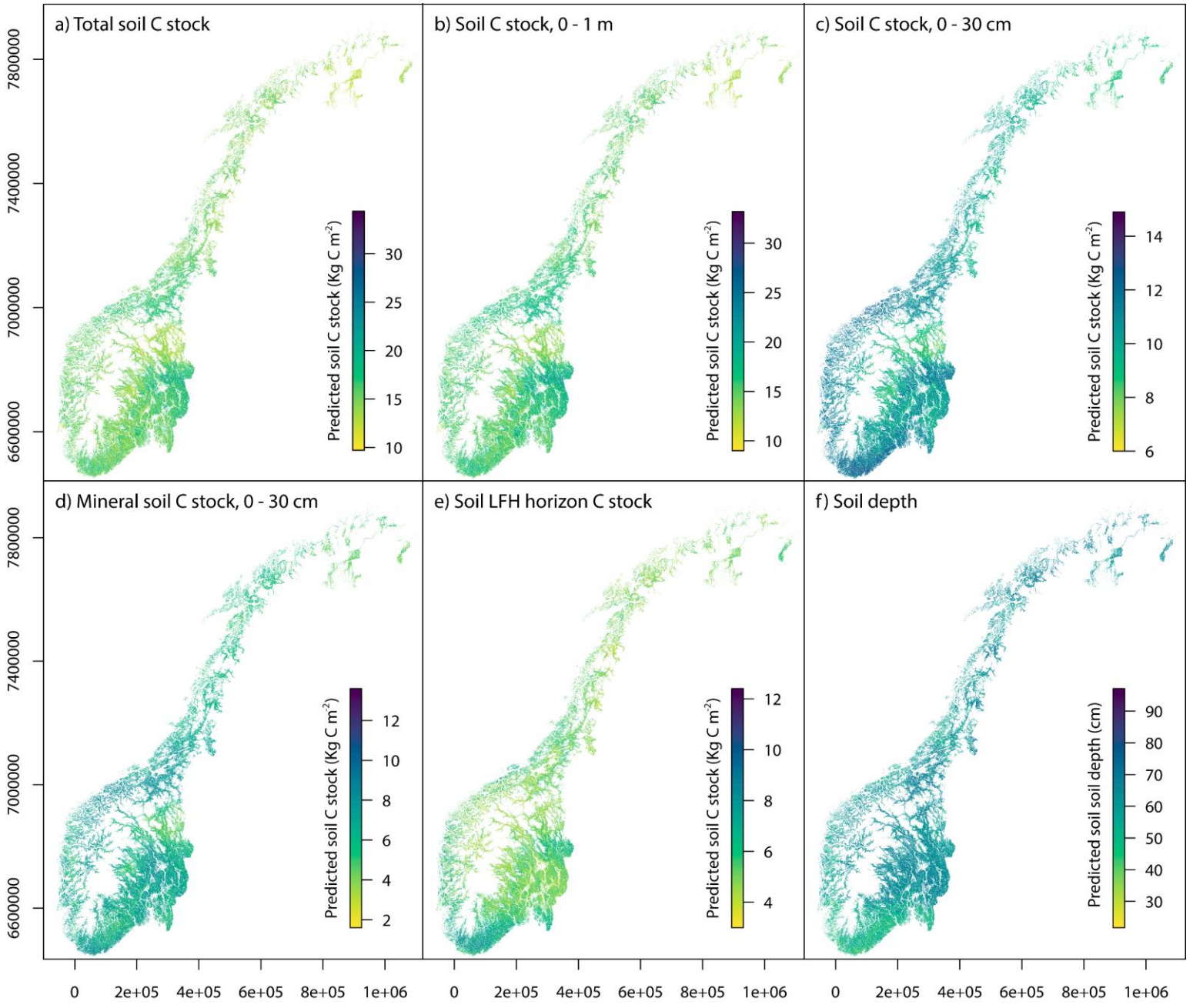
Used to investigating the drivers of soil C

Mapping models

R^2 ranging from 0.58 – 0.34

Maximum prediction models

R^2 ranging from 0.73 – 0.56



Soil C predictions

Means

Total soil C: **15.5** kg C m^{-2} (**155** ton C ha^{-2})

Soil C stock 0 – 1 m: **15.6** kg C m^{-2}

Soil C stock 0 – 30 cm: **10.4** kg C m^{-2}

Means

Mineral soil C stock 0 – 30 cm: **6.6** kg C m^{-2}

LFH horizon C stock: **5.4** kg C kg C m^{-2}

Soil depth: **60.7** cm

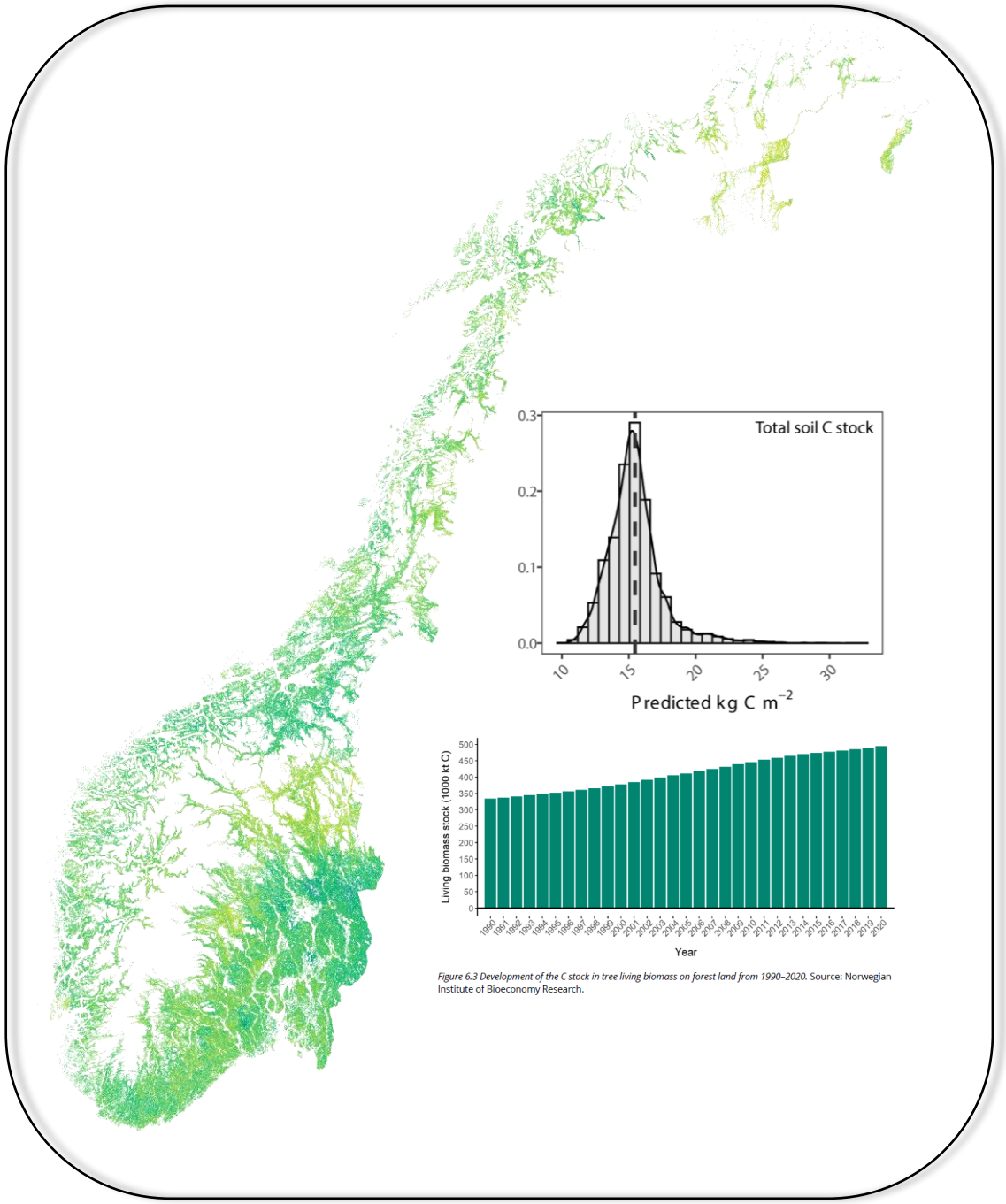


Figure 6.3 Development of the C stock in tree living biomass on forest land from 1990–2020. Source: Norwegian Institute of Bioeconomy Research.

Norwegian forest soils C stock

Mean total soil C: **15.5** kg C m^{-2} (**155** ton C ha^{-2})

Sum total soil C stock: 1.47 Pg C

In perspective:

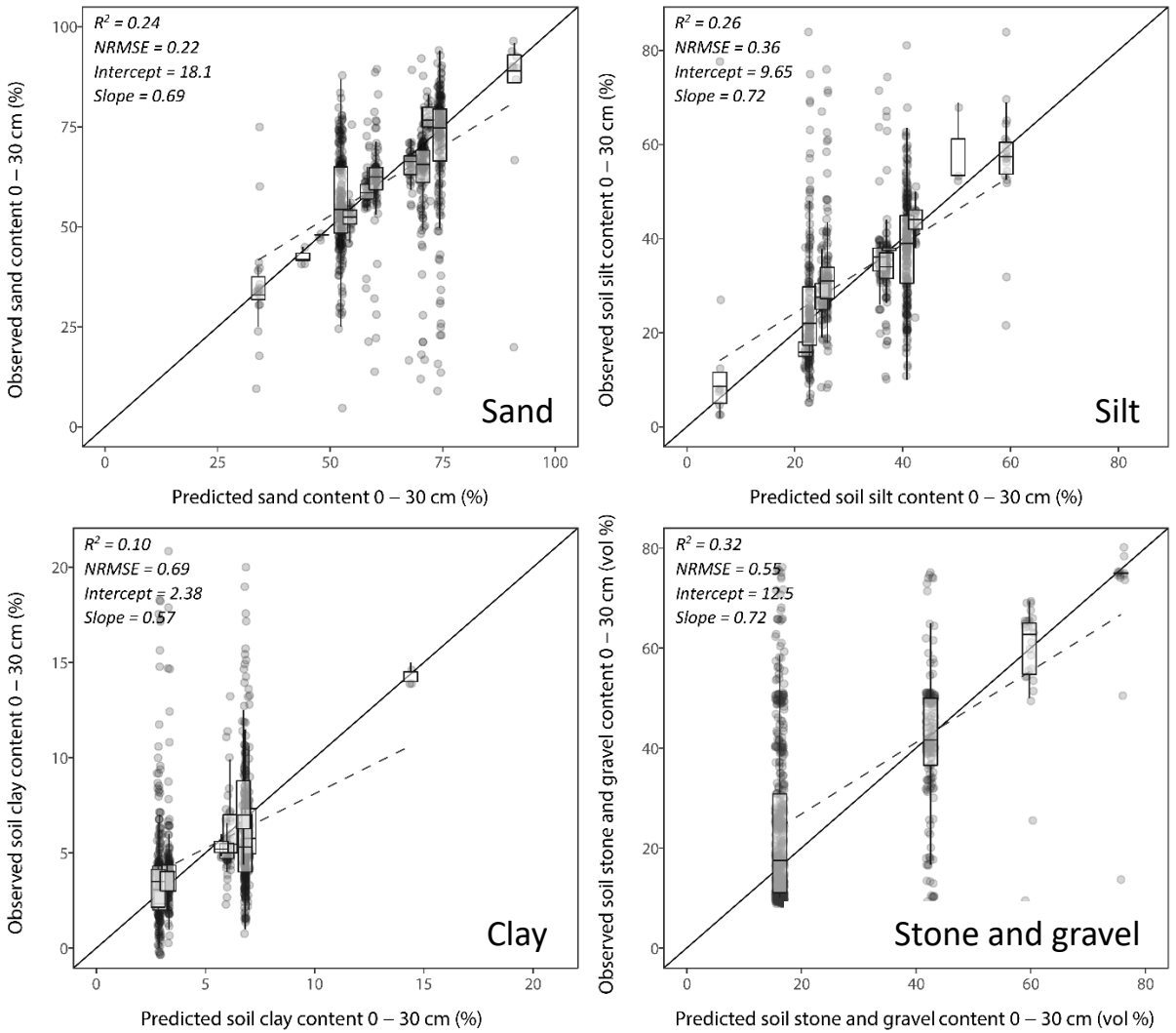
- C stock in tree living biomass in Norway is about 0.5 Pg C

- **Thus, up to 66% of the total forest C stock is in soil**
  Similar to the results of previous studies; 70% (Pan *et al.* 2011)

Did you know?

1.47 Pg C is similar to the the annual emission from tropical land-use (1.3 Pg C yr^{-1} ;Pan *et al.* 2011)...

Predictions of soil texture

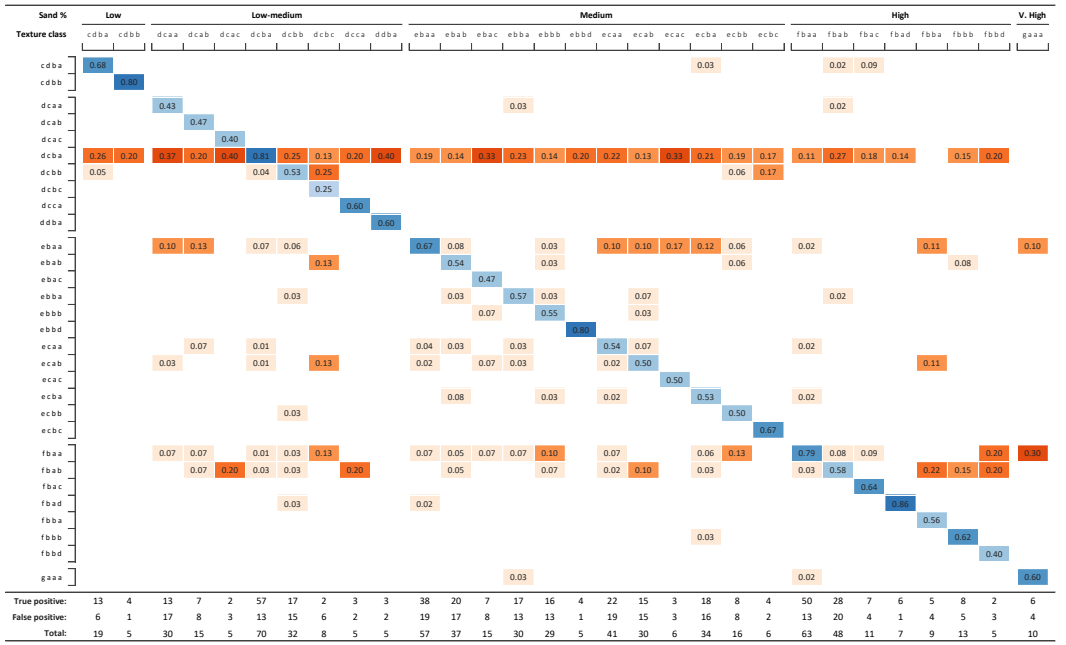


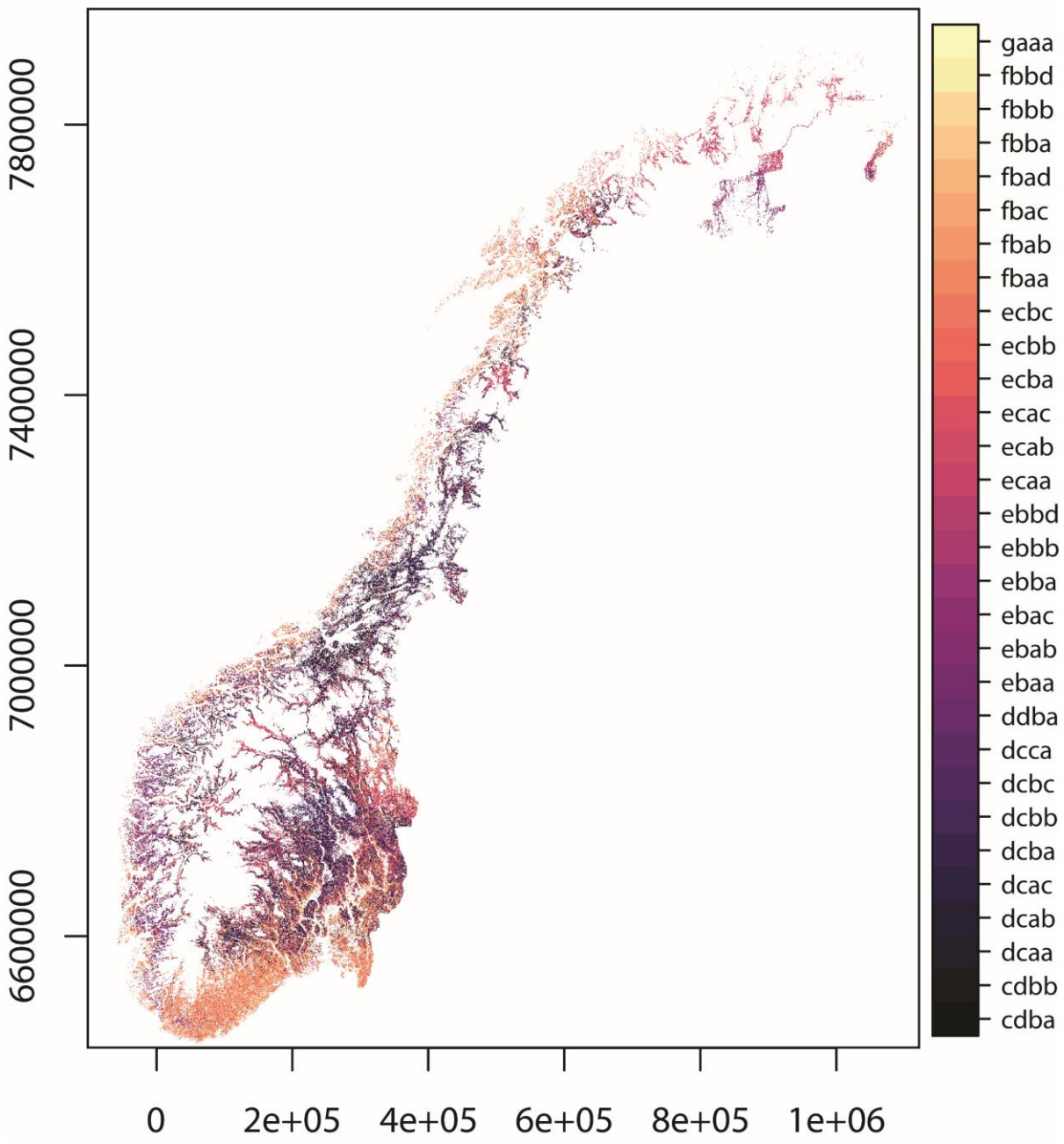
Mapping models

61% success rate in selecting the correct class

R^2 ranging from 0.10 – 0.32

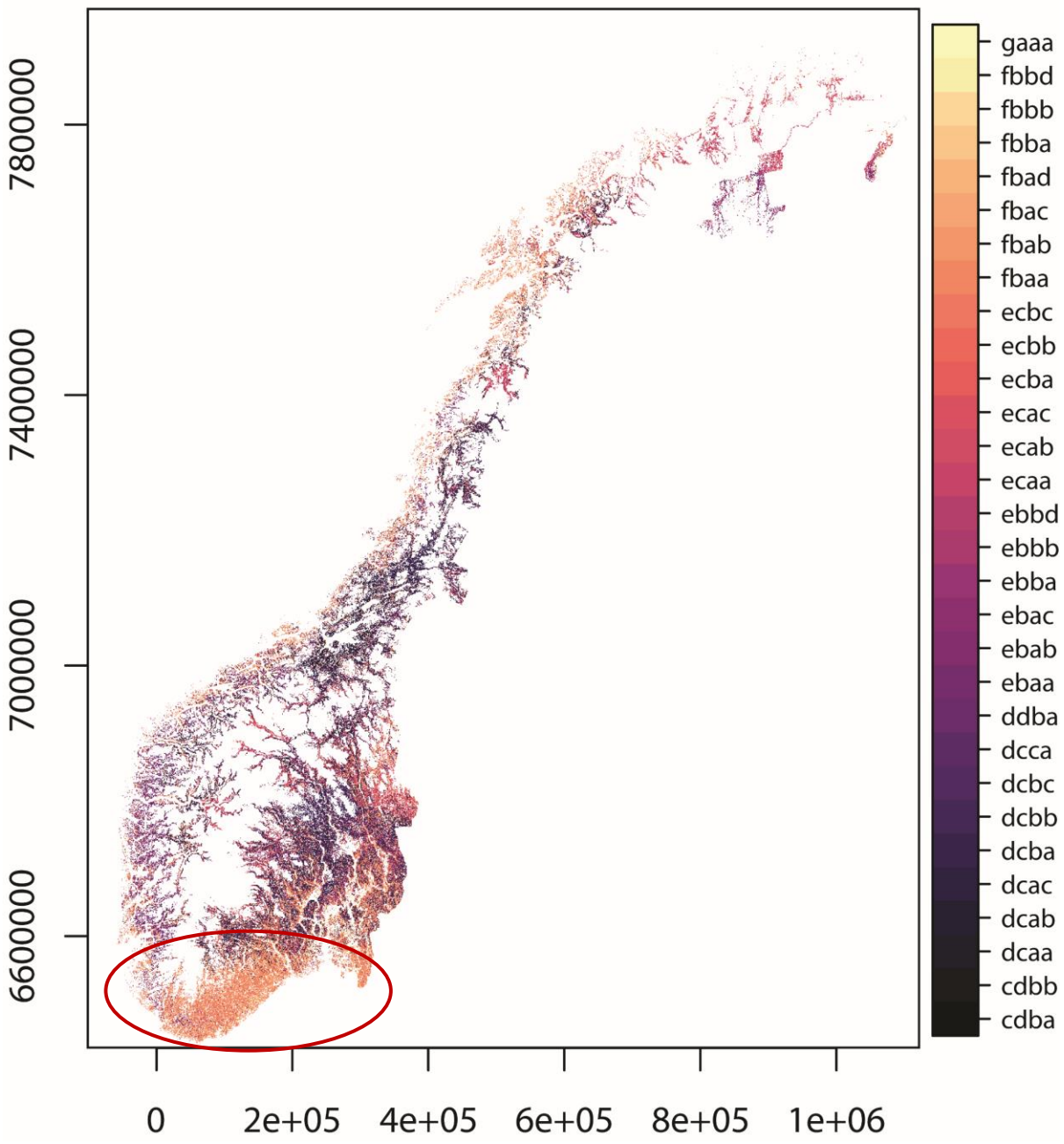
Most of the error stems from the model incorrectly selecting the most common texture class in the data-set





Forest soil texture

- 30 different soil texture classes
- 16 x 16 m resolution



Forest soil texture

- 30 different soil texture classes
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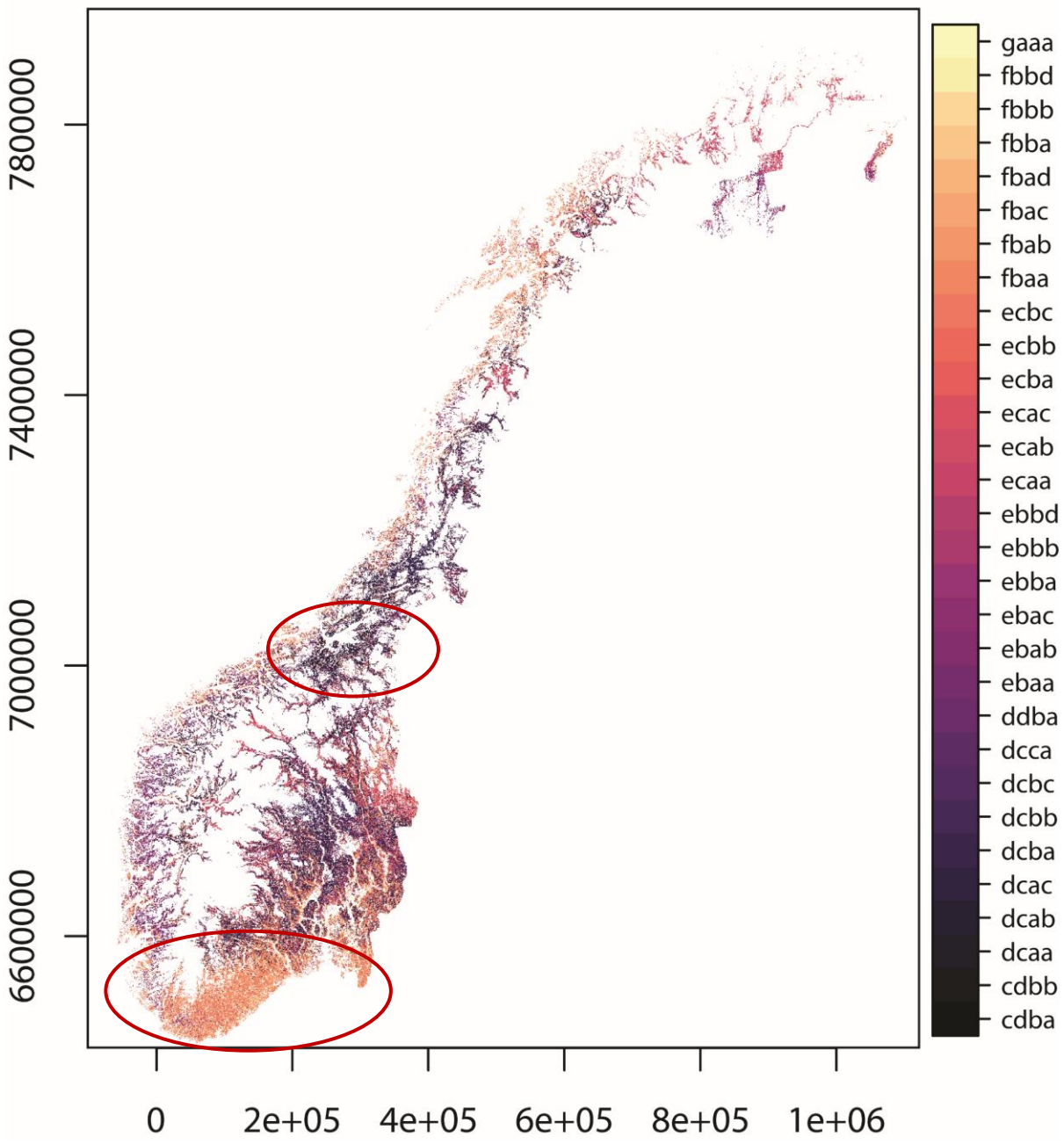
- Sandy soils frequent at the southern coast

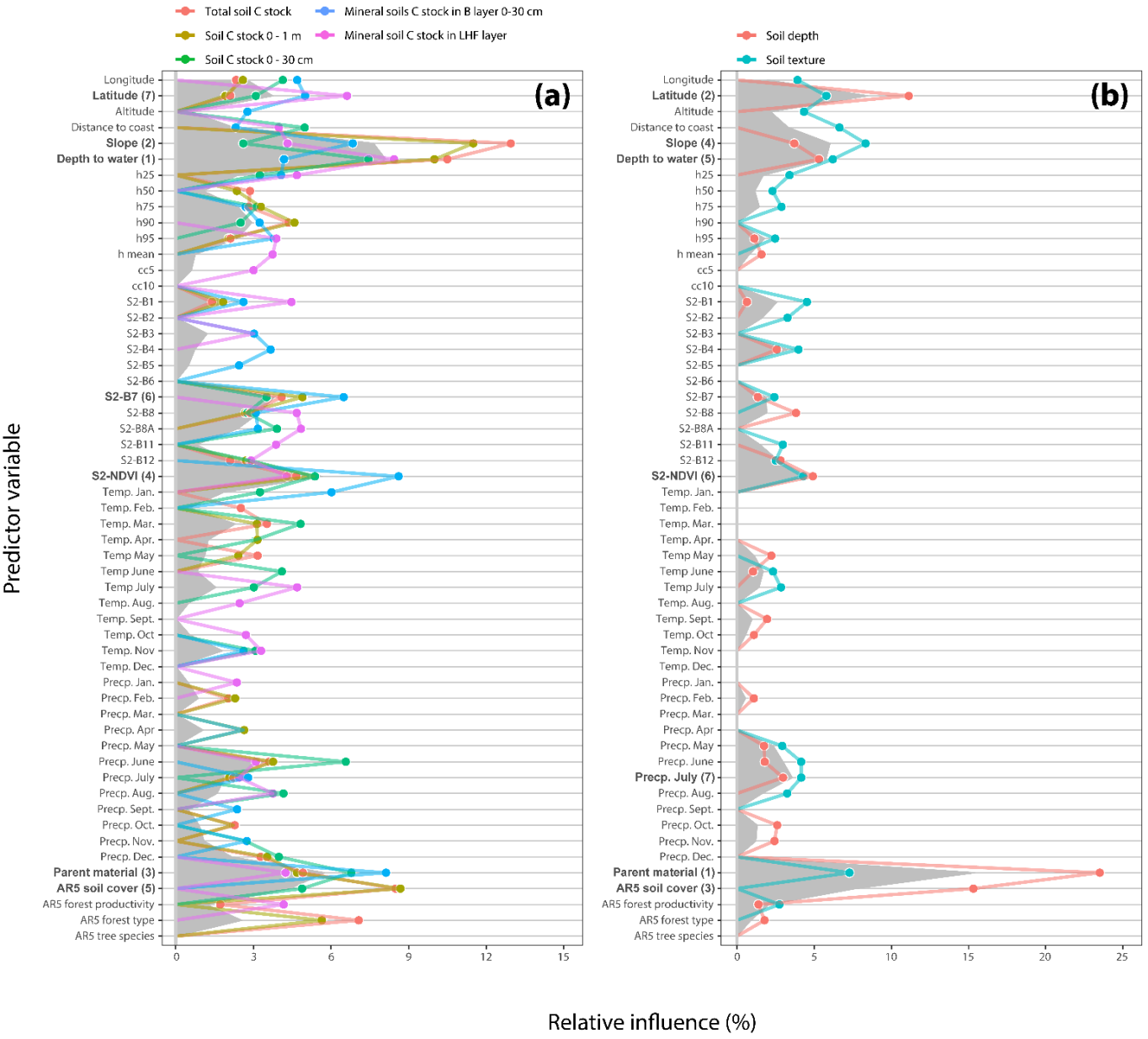
Forest soil texture



- 30 different soil texture classes
- 16 x 16 m resolution
- Sandy soils frequent at the southern coast
- Low sand content in southern Trøndelag (thus more silt and clay)

Relative influence of variables

BRT models used for mapping



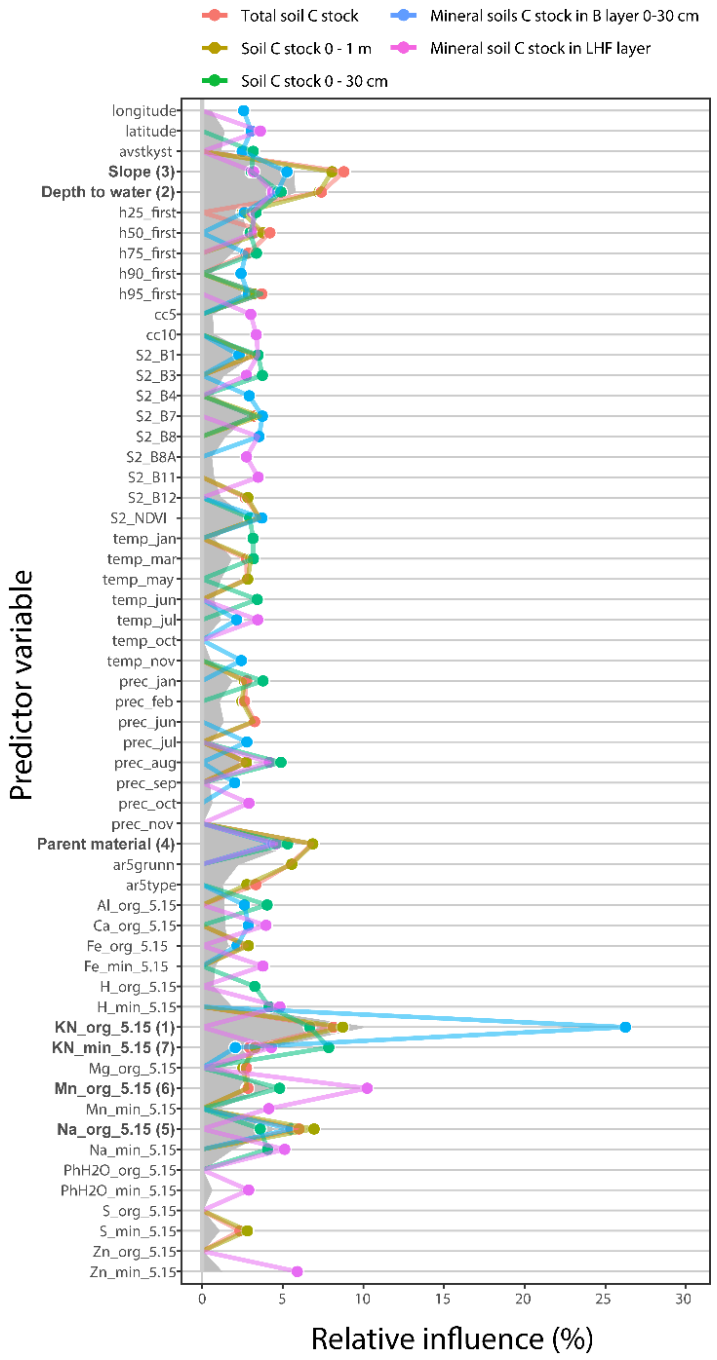
a) Soil C stocks

1. Depth to water
2. Slope
3. Parent material
4. NDVI (veg. index)
5. Soil cover
6. Band 7 (NIR)
7. Latitude

b) Soil depth & texture

1. Parent material
2. Latitude
3. Soil cover
4. Slope
5. Depth to water
6. NDVI
7. July precipitation

Depth to water, slope, NDVI and parent material are important predictors in the mapping models.



Relative influence of variables

BRT models with soil chem. var.

Soil C stocks

1. Humus layer Kjeldahl N (+)
2. Depth to water (-)
3. Slope (-)
4. Parent material
5. Humus Na content (+)
6. Humus Mn content (-)
7. Miner layer Kjeldahl N (+)

Depth to water, slope, and parent material are still strong predictors, but content of N and Mn are also important.

Increase in soil C with Kjedahl N
Decrease in C with Mn

Summary of results

Forest soil C stocks

Total forest soil C stock is predicted at 1.47 Pg C, about 66% of the total forest C stock

Depth to water and slope are the strongest predictors, inclusion of data of soil chemistry improve the predictions, but all models display calibration issues.

Nice to have maps of soil C, but one must consider their restricted predictive performance…