# Mapping the Carbon stock of Zurich's forests

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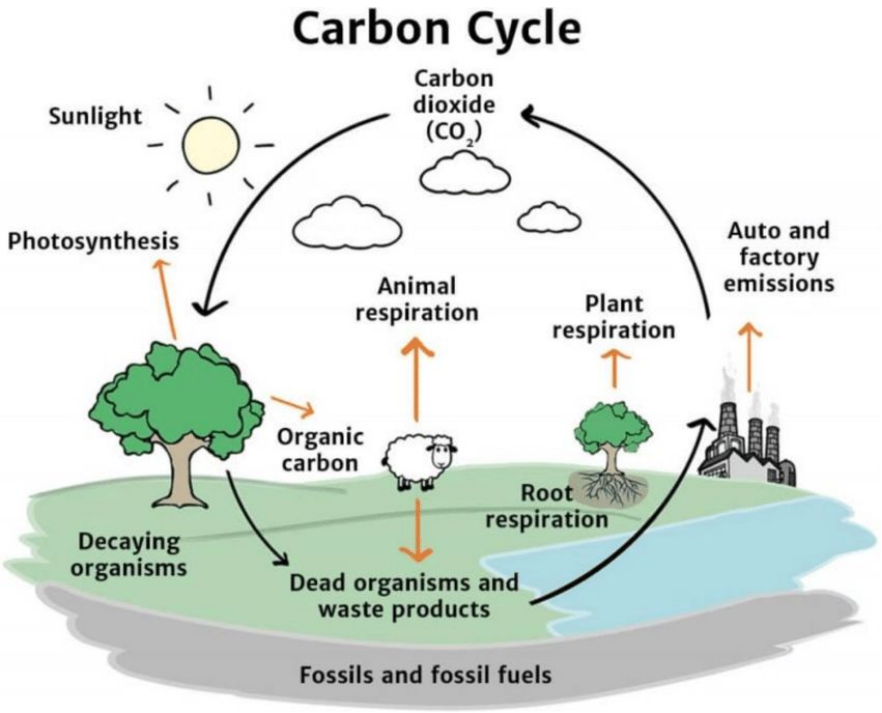
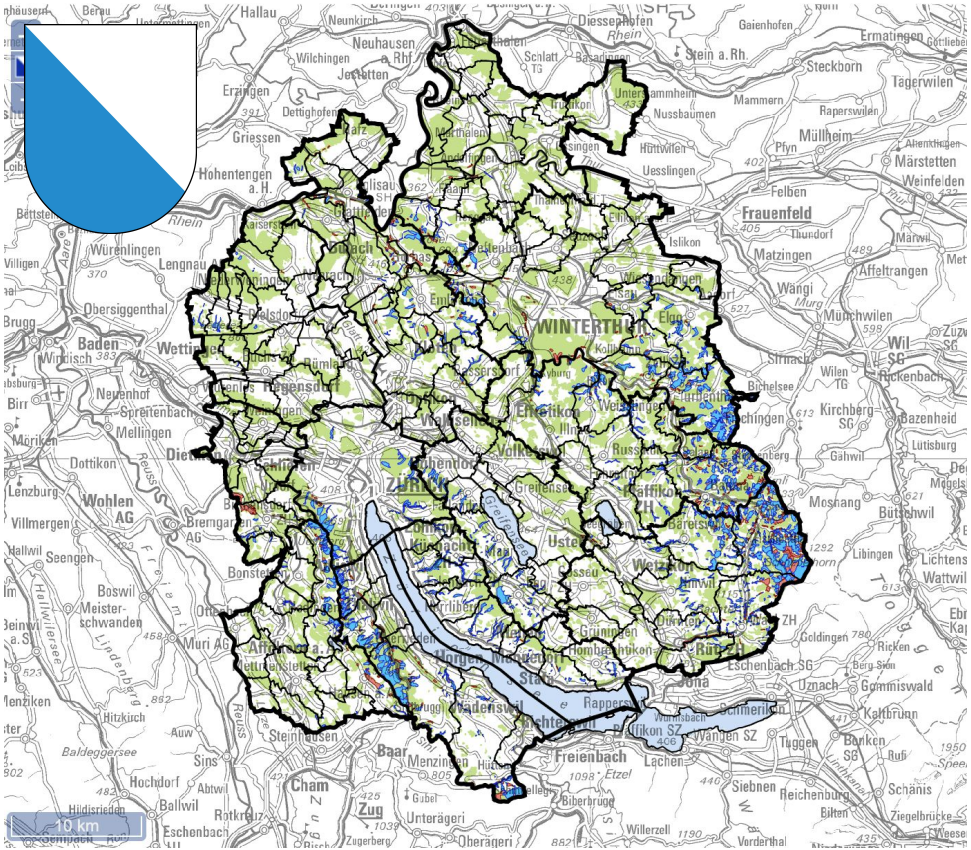
# Motivations




- trees **store carbon dioxide** from atmosphere
- C stock plays important role in **mitigating climate change**
- measuring **effectiveness of climate change mitigation measures** (reforestation / forest conservation)
- help institutions to make **informed decisions** about actions to address climate change

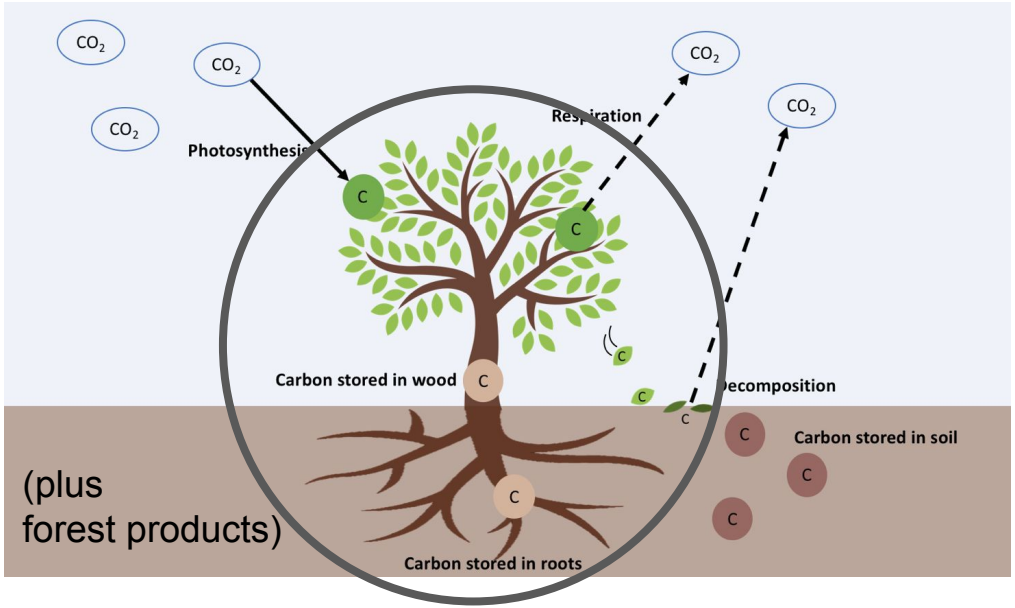
# Challenge




- use available public data to map the carbon stock in forests, in the canton of Zurich

… to the best of our abilities :)

# Where is the carbon stored?




HEIGHT AND DIAMETER

↓

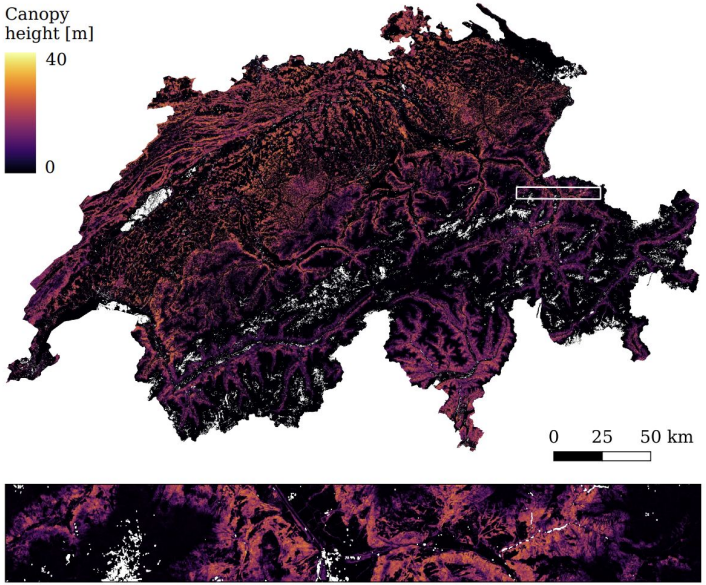
BIOMASS

↓

CARBON STOCK

# How to measure height and diameter of a tree?

N. Lang et al. (2019)




REMOTE SENSING

- Satellite imagery
- LiDAR (Light Detection and Ranging)

(Marina Beck measures the diameter at breast height of a beech with the tree scale. Photo: Simon Speich)

# Datasets

- GIS-ZH

  (Geographic Information System)

- LiDAR data

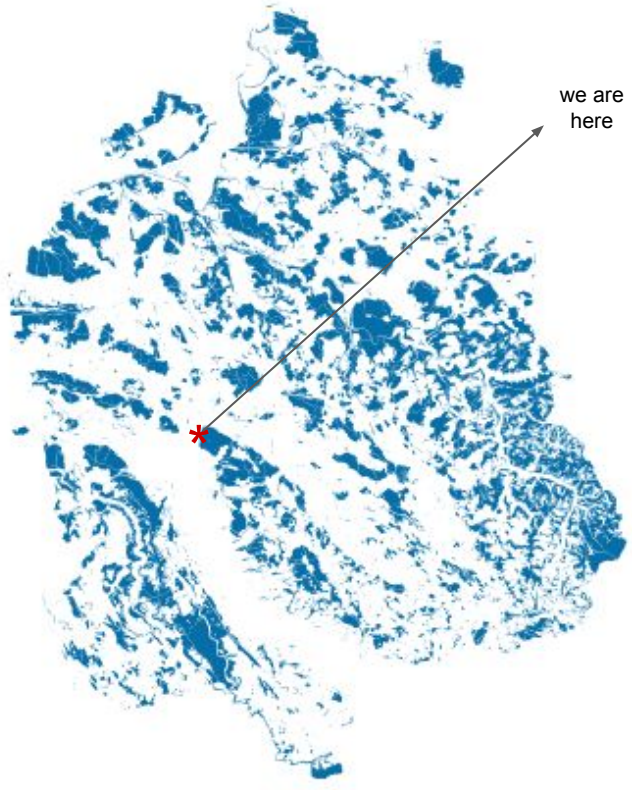
  **HEIGHT INFO**

- WSL Vegetation Height Model

- Field measurements:

  Swiss National Forest Inventory (NFI)

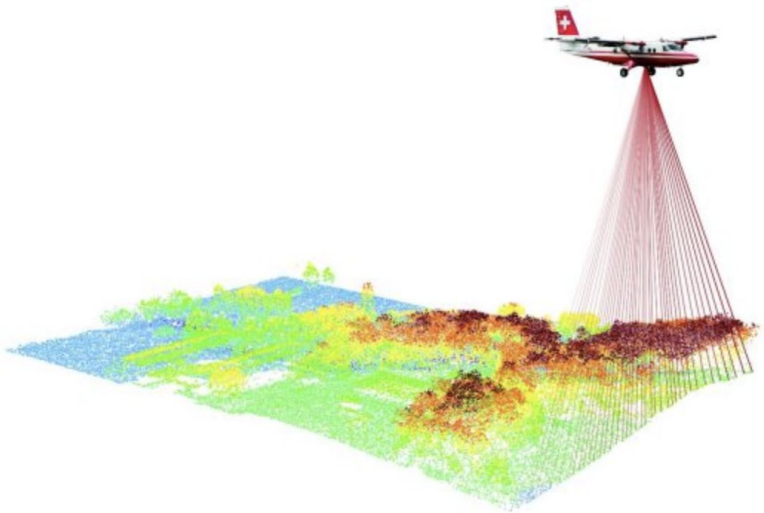
Map of the forest area




maps.zh.ch

# LiDAR data

- Light Detection And Ranging
- Very high resolution (~10-20cm)
- Heavy to download!



Airborne laser scanning topographic survey

swisstopo.admin.ch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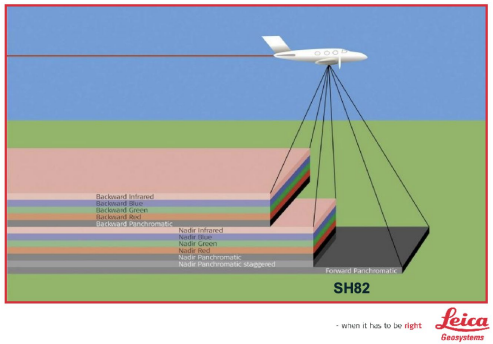
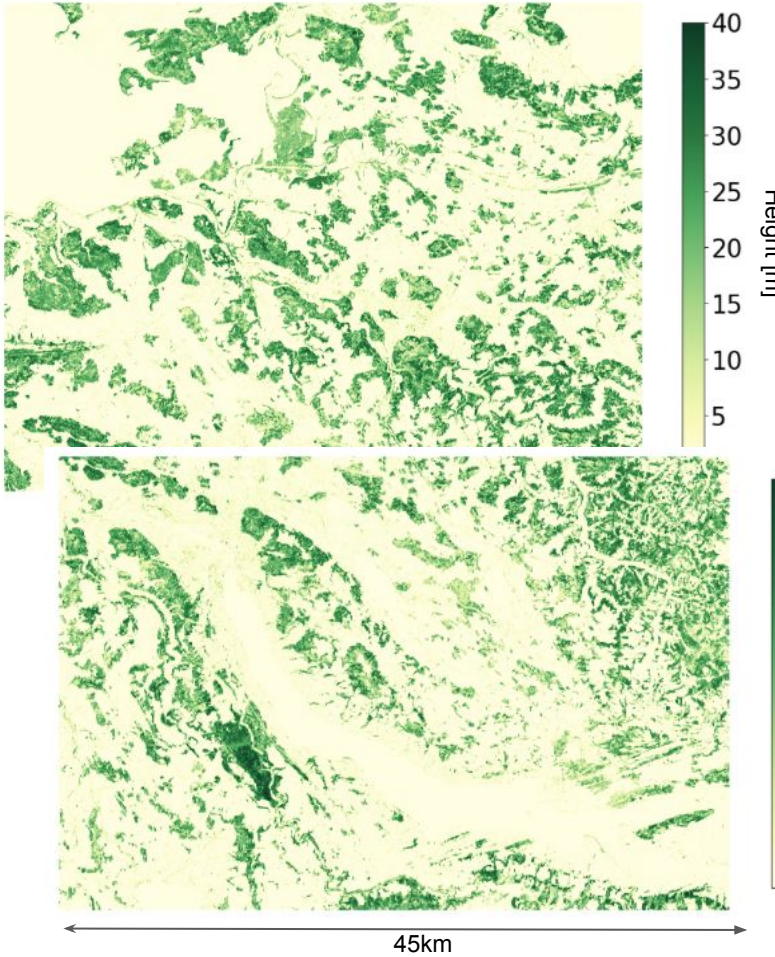
# Vegetation height model

- [WSL data](#)
  (Swiss Federal Institute for Forest, Snow and Landscape Research)
- ADS80 stereo images to create a digital surface model
- Terrain subtracted, buildings masked

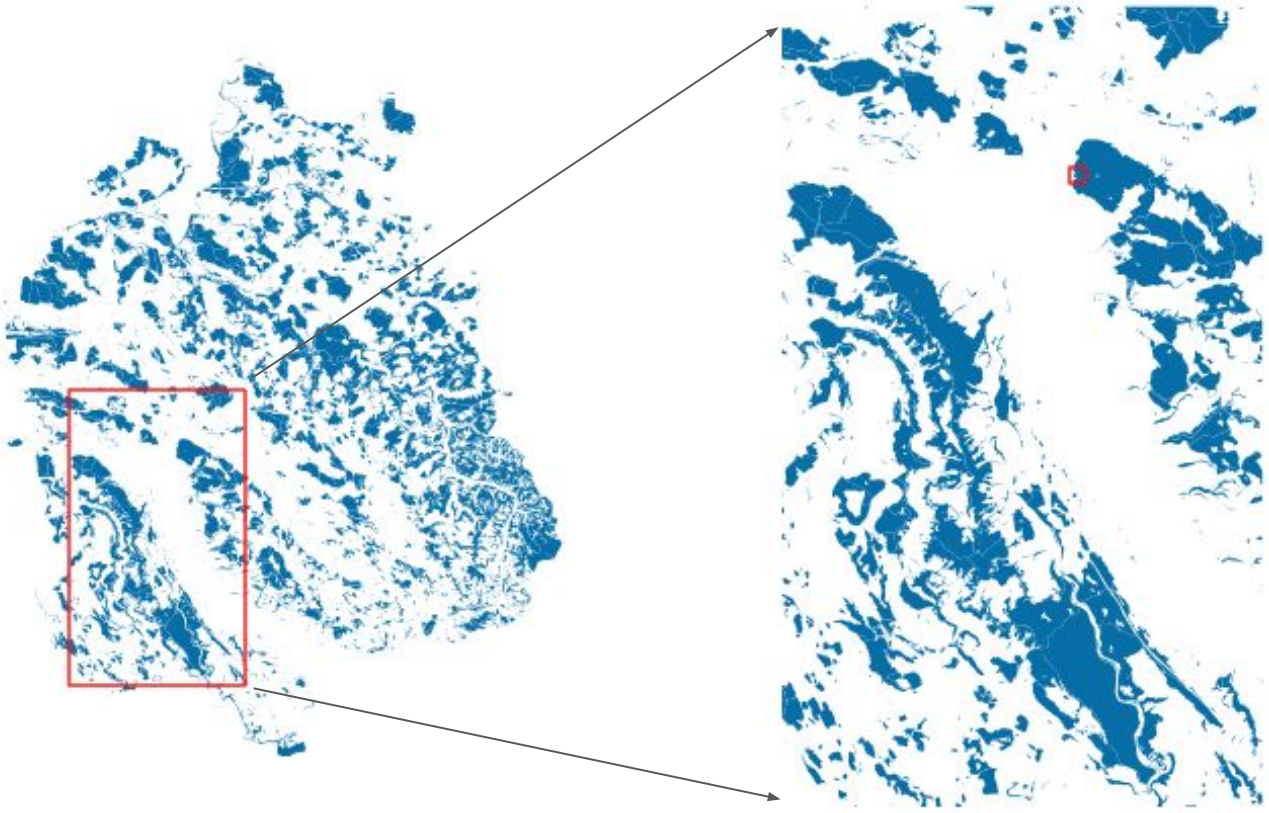



1m resolution

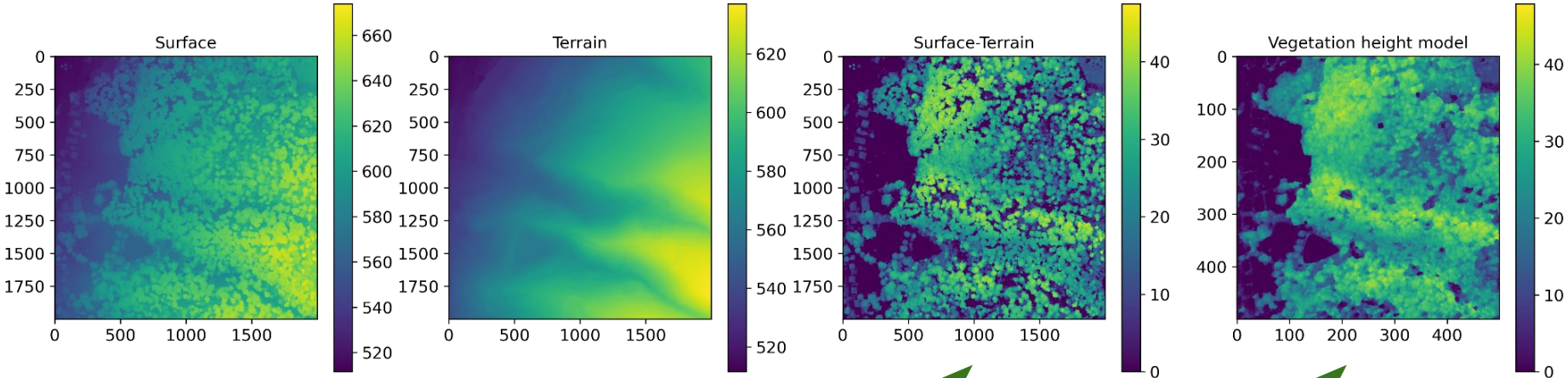
North & South maps Canton of Zurich



# Height comparison



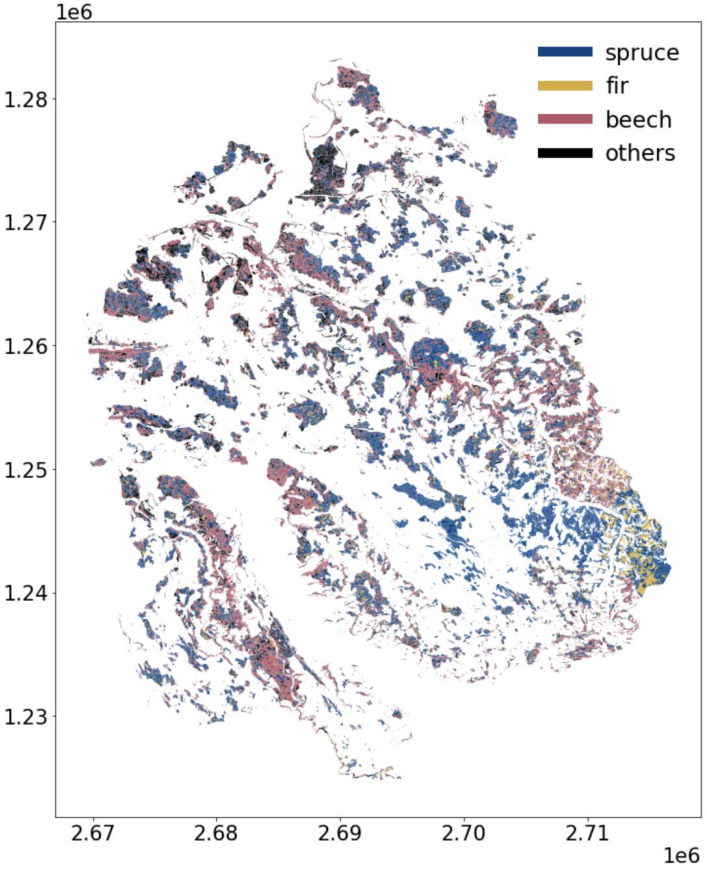
# Height comparison




Consistent Height Maps from **LiDER** data and **WSL** data

→ WSL data **easier to handle** for ‘large-scales’ map

# Model species diversity of Trees in Switzerland




We consider 3 different tree types:

spruce

Fichte (Rottanne)

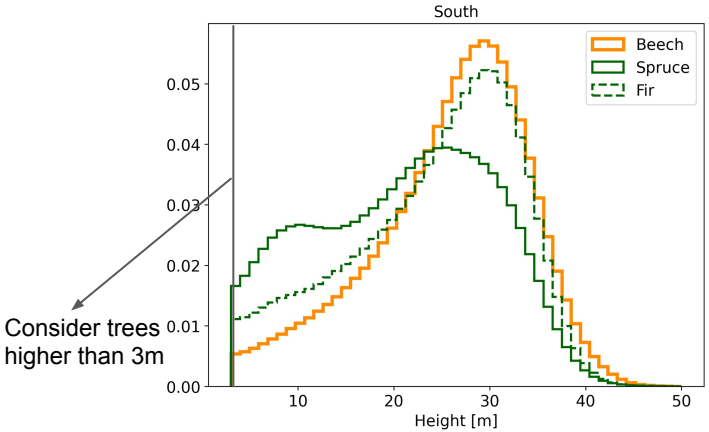
fir

Tanne (Weisstanne)

Buche (Rotbuche)

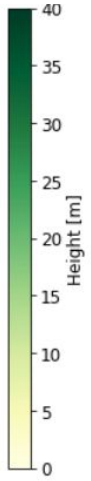
beech

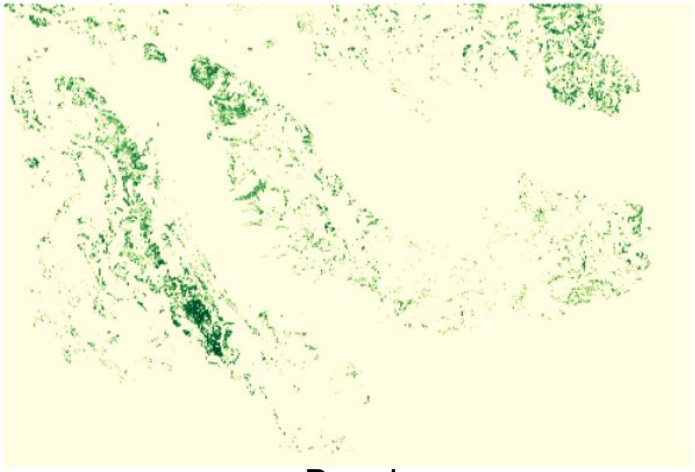
# Height maps

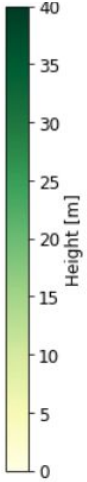



Consider trees higher than 3m

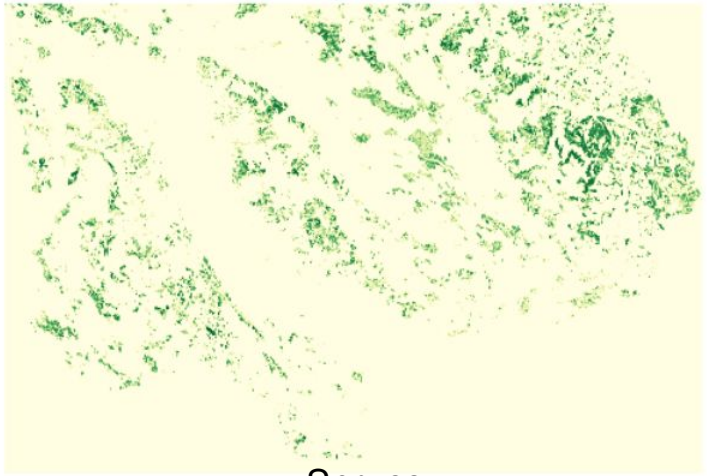
Fir

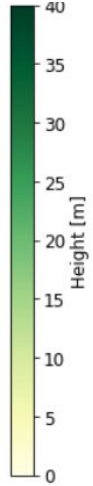





Beech

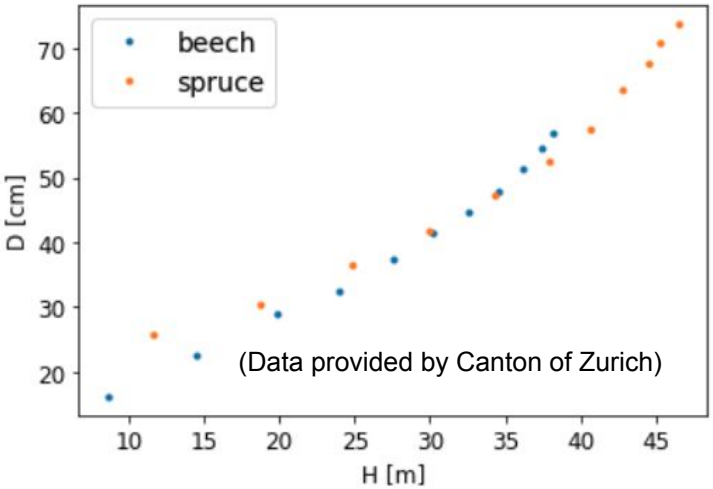





Spruce

# Modelling the above-ground biomass (AGB)

$$\ln(\mathrm{AGB}_i) = \beta_0 + \beta_1 \ln(D_i) + \beta_2 \ln(H_i)$$



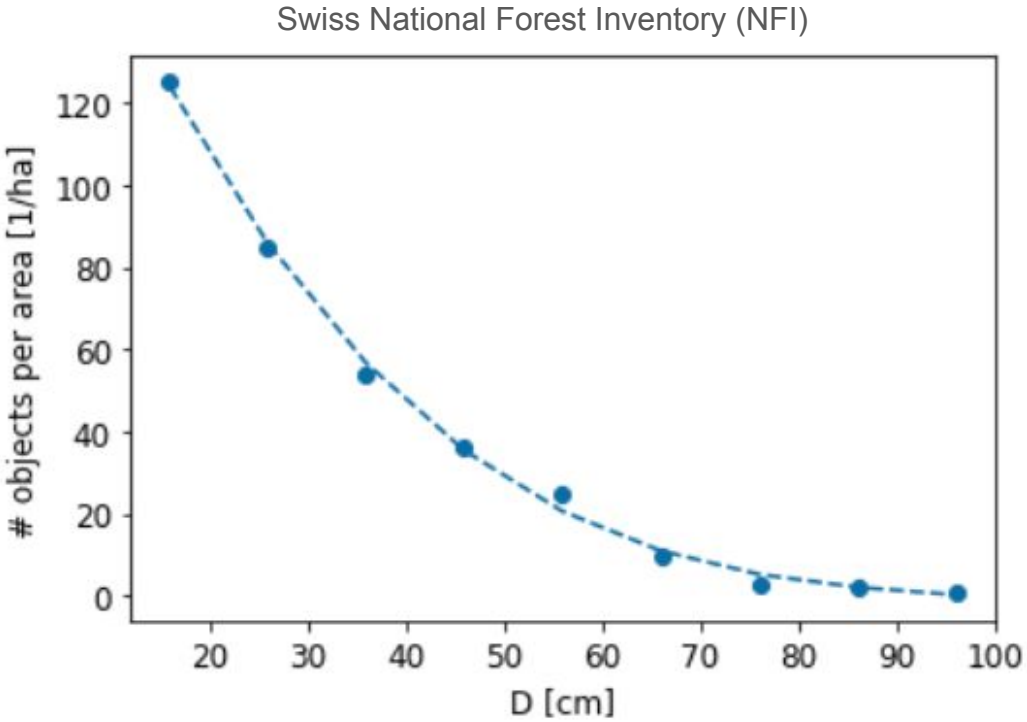

Two ingredients:

- **Diameter - Height relation**
  (provided by Canton of Zurich)
  Assume the same relation for conifers!

- Allometric models to estimate the **biomass of each tree** (literature)

| Type | $\beta_0$ | $\beta_1$ | $\beta_2$ |
|---|---|---|---|
| beech (Dutca et al. 2020) | $-3.1632$ | $2.1468$ | $0.6909$ |
| silver fir (Dutca et al. 2020) | $-2.9856$ | $1.3301$ | $1.4460$ |
| Norway spruce (Fehrmann et al. 2006) | $-2.9188$ | $1.847$ | $0.826$ |

# From biomass per tree to Carbon stock




$$\overline{\mathrm{AGB}}\ [\mathrm{Kg}]$$

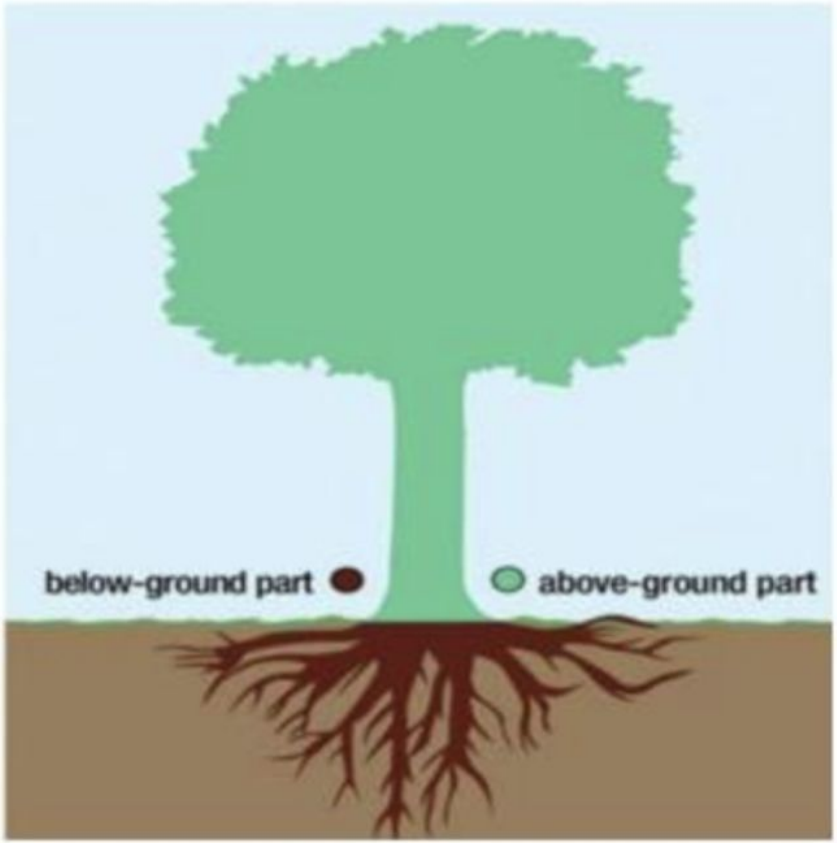
Biomass of a tree with height equal to pixel value

Areal density depends on **density of objects N**, which depends on **diameter**

Assume that Carbon constitute **50%** of biomass

$$\mathrm{C\ stock}[\mathrm{Kg/ha}] = \frac{1}{2} \times \overline{\mathrm{AGB}}\ [\mathrm{Kg}] \times N[\mathrm{ha}^{-1}](D)$$

# Below-ground carbon stock

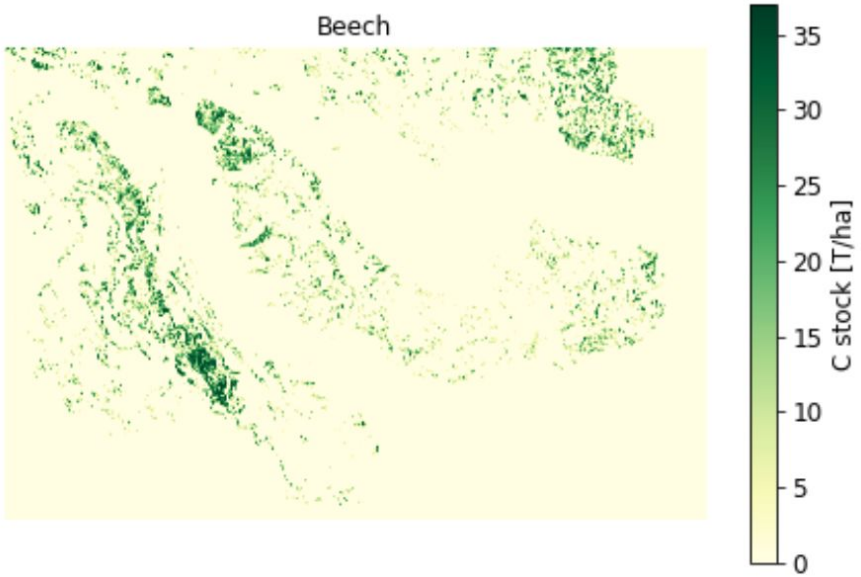


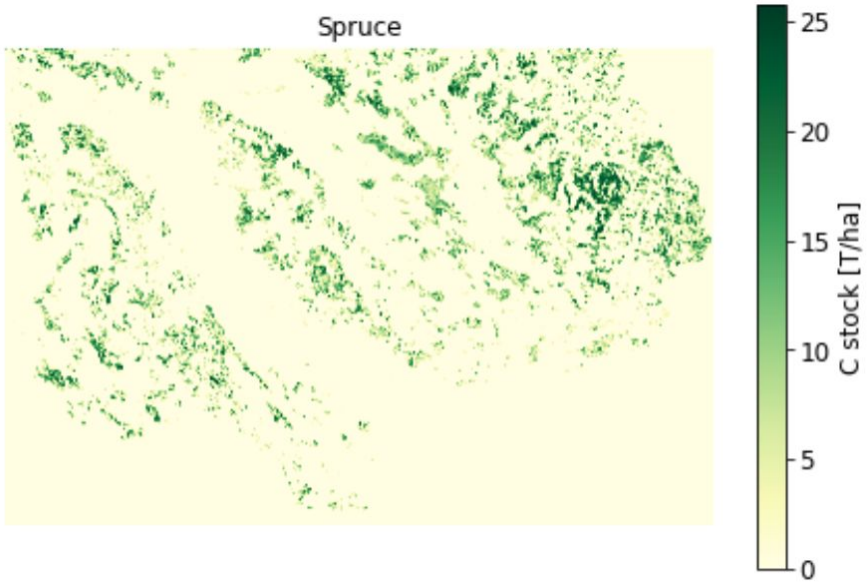

- Difficult to model (requires field measurements)
- NFI values for the root-to-shoot ratio (RTS) in Canton of ZH

CONIFERS : RTS = 0.213
(spruce & fir)

BROAD LEAVES : RTS = 0.138
(beech)

# Carbon stock maps incl. below ground biomass

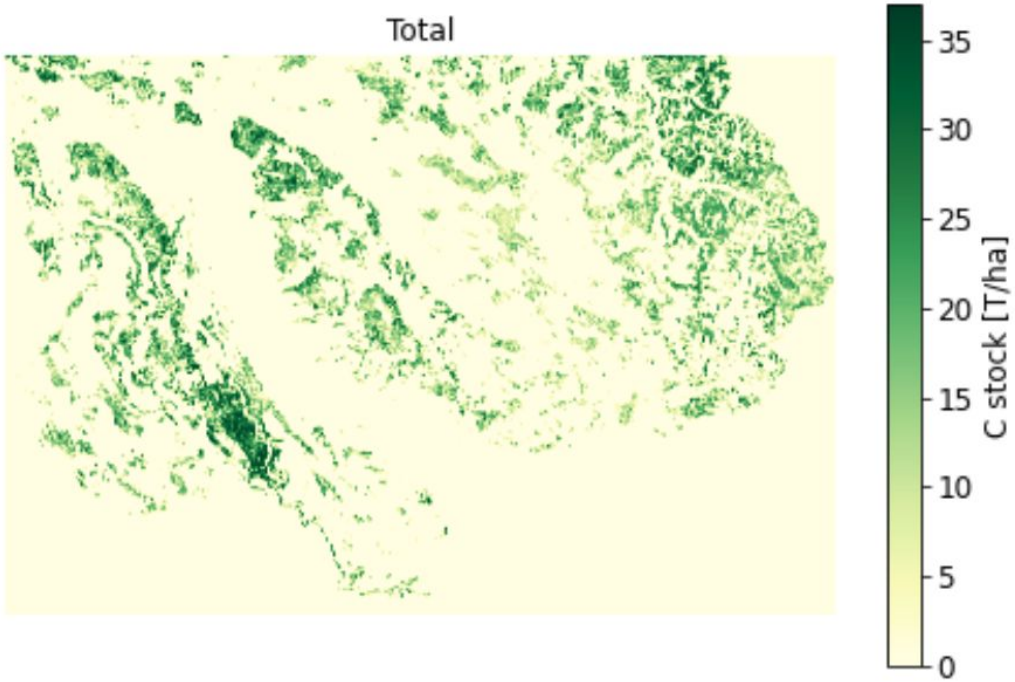


# Carbon stock maps incl. below ground biomass

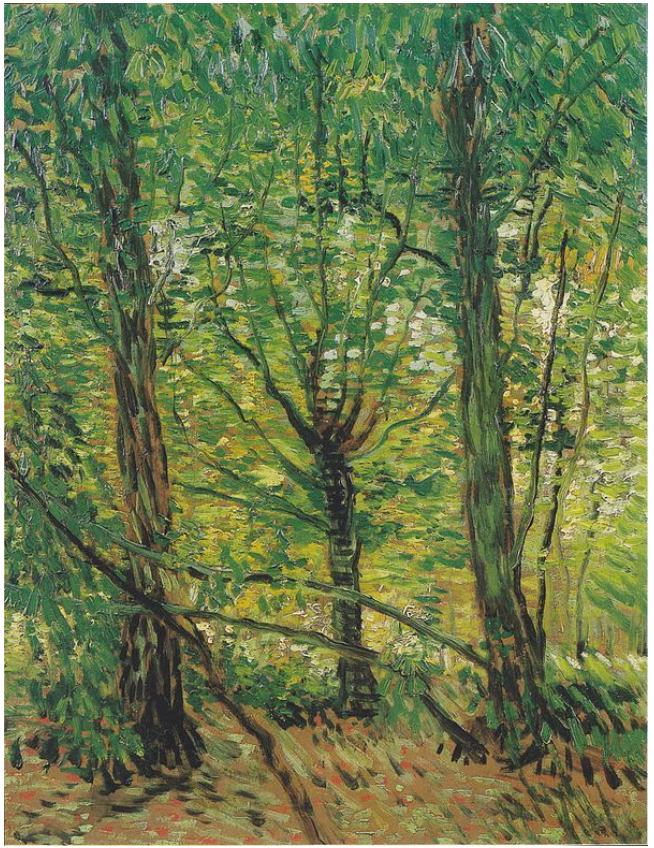
Total C stock in the South part of Zurich:

- Beech ~ 0.2 MT
- Spruce ~ 0.2 MT
- Fir ~ 0.03 MT



# Potential improvements

- Calibration maps
- ZH specific allometric relations
- Include the growth of trees in the model
- Sustainable use of wood products



*Trees and Undergrowth*, 1887,
Van Gogh Museum, Amsterdam

Thank you!

Thanks to Denise, Viktor & Julian for all the help!