Estimating forest carbon fluxes for large regions based on process-based modelling - NFI data and Landsat satellite images

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Results of the Carb-Bal project
(2009-2011, Academy of Finland)

- Goal: to develop a method for predicting carbon fluxes for large regions using NFI data and satellite images
Material

- National forest inventory data (2004-2009)
  - Only the plots which consist of one stand, only the mineral soils

- Satellite images
  - Landsat 5 TM, 2007
Estimating the carbon fluxes

1. Estimates for the NFI sample plots
   - Gross primary production of carbon (GPP)
   - Net primary production of carbon (NPP)
   - Net ecosystem exchange (NEE)

2. Generalising estimates for all the forested areas using k nearest neighbour imputation

**k nearest neighbour imputation**

1. **Teaching data set** is created:
   - (carbon flux) estimates for the sample plots
   - Pixel colours from the satellite image for the same sample plots

2. The *k nearest neighbours* are searched for all the other pixels **in terms of similarity in the pixel colours** in the teaching data set

3. Each pixel is given the (carbon flux) estimate as an **average of the k nearest neighbours’ estimates** (as distance weighted mean etc.)
Generalisation with different imputation parameters

- Testing of
  - Different k:s (k=1…13)
  - Using 1 or 2 images from the same area as independent variables
  - Using DEM as independent variable

Optimal method: k=5, all the bands from 1 image
RESULTS: Reliability of the imputations depends on the location, site fertility and main tree species

- Slightly better results in Central Finland than in Lapland (based on leave-one-out cross validation)

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<th>Central Finland</th>
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<th>Lapland</th>
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Estimations (left) vs. imputations (right) in Central Finland

- Imputations very scattered in the youngest stands, with old stands the estimates start to saturate

Figure 8. Distribution of reference and imputed values of GPP (left) and -NEE (right) in Lapland for 2007. The black bars denote observed values, the thick black line denotes imputations with $k=3$, the thin black line denotes imputation with $k=5$, the thick grey line denotes imputation with $k=7$ and the thin grey line imputation with $k=11$. Bands 1-5 & 7 were used as independent variables.
Eddy covariance measurements: comparisons in Hyytiälä and Sodankylä
The developed method enables production of carbon flux maps with high resolution (30 m)
Development continues in Climforisk project

- Goals
  - To **extend the estimations to cover the whole Finland**
  - To improve the growth model, e.g. by adding the **water model** (Peltoniemi & Mäkelä et al.)
  - To employ additional data sources, e.g. the soil map, local altitude variation and wetness indices to the simulations
Thank you!