Estimating carbon fluxes for large regions by combining process-based modeling, NFI data and Landsat satellite images

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Goal
• To develop a method for estimating forest carbon fluxes for large regions in boreal forests by combining process-based forest growth and soil models with satellite images and national forest inventory (NFI) data.

Methods and material
• The approach was tested for Central Finland and Lapland areas with NFI field data and daily weather data from 2004–2008.
• First the plot level estimates of GPP, NPP and NEE were produced for the NFI sample plots (Fig. 1) utilising a light-use efficiency model, pipe-theory based summary model and Yasso07 soil model.
• The plot-wise estimates were generalized based on Landsat 5 TM image bands for all forested areas on mineral soils using the k nearest neighbour (k-NN) imputation.
• Reliability of the imputations by leave-one-out cross validation.
• The imputed and simulated values were compared with eddy covariance (EC) measurements from Hyytiälä and Sodankylä.

Results
• RMSE of the estimates was slightly better in Central Finland (27%) than in Lapland (36%), the bias staying at a similar level (0.2–0.6%).
• The method worked better in middle-aged forests than in the youngest and oldest ones.
• Based on the EC comparisons, the approach seemed to work rather well with GPP estimates in both areas, but in the north the NEE estimates were remarkably biased.

Conclusions
• The approach allows producing maps of forest carbon flux estimates with high output resolution (30 m) (Fig. 2.).
• The current RMSE of GPP estimates can be potentially reduced by using ancillary data sources, such as soil maps.
• The approach can be utilized in climate change related decision making and research.
• It can be extended to other boreal forest areas if the inventory data is available.

More information

The approach was developed in CarbBal project funded by the Academy of Finland. It will be developed further in EU LIFE+ Climforisk project at the Finnish Forest Research Institute (www.metla.fi/life/climforisk).

Fig. 1. GPP (circles) and -NEE (crosses) as simulated for the field plots in Central Finland (a) and Lapland (c), and as imputed in Central Finland (b) and in Lapland (d). Imputations are based on bands 1–5 and 7 and k = 5 for 2007.

Fig. 2. Imputations of GPP (g C m⁻² yr⁻¹) (left) and -NEE (g C m⁻² yr⁻¹) (right) based on Landsat 5 TM bands 2–4 in the Hyytiälä region with weather data from 2007. The white areas are other areas than forest land. The circle in the middle denotes the area around the Hyytiälä EC tower (24.17°E, 61.51°N).