

Estimating carbon balance in large areas based on satellite images and k-NN imputation

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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



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

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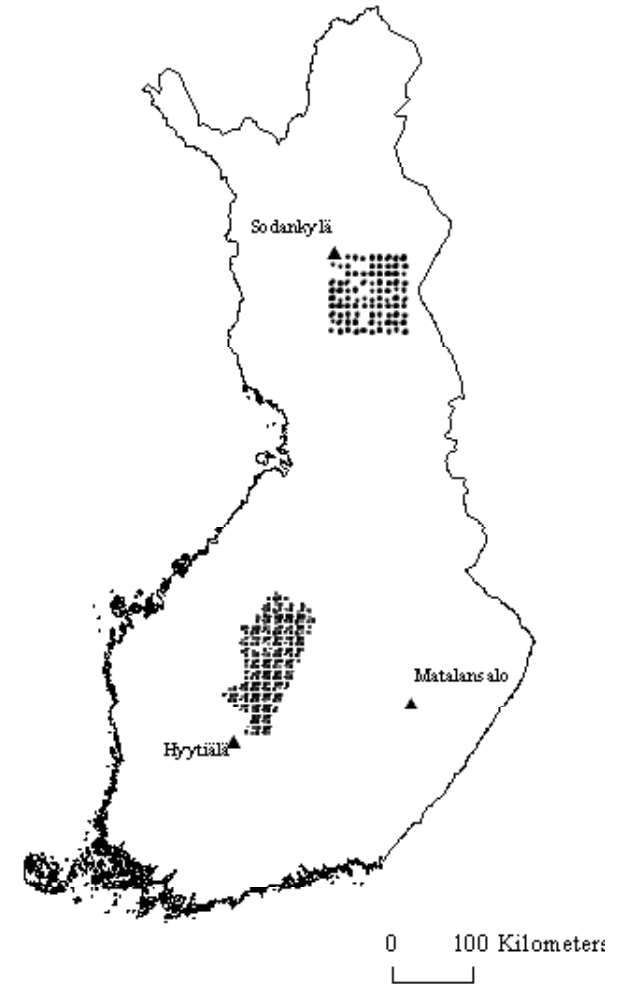
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Material

- 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)

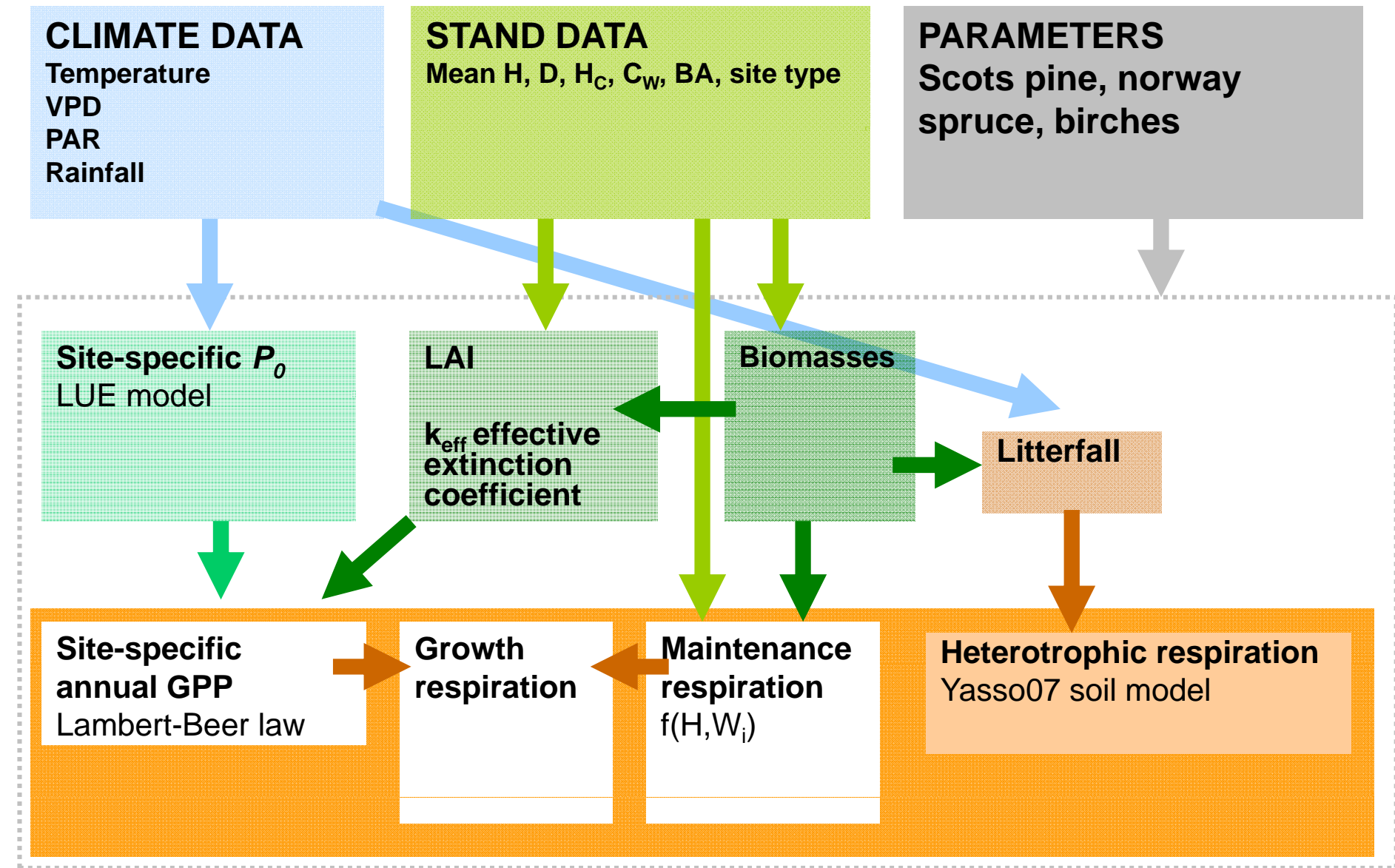
2. Generalising estimates for all the forested areas using **k nearest neighbour imputation**



Härkönen et al. *Estimating forest carbon fluxes for large regions based on process-based modelling, NFI data and Landsat satellite images*, Forest Ecology and Management, in press.

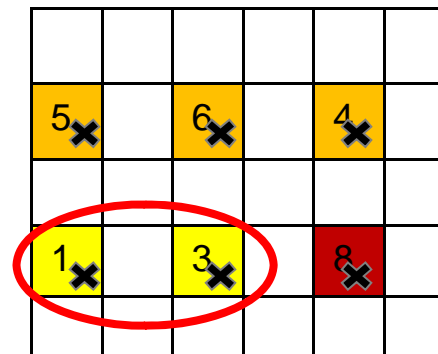
Tuomi, M., Laiho, R., Repo, A., & Liski, J. 2011. *Wood decomposition model for boreal forests*. Ecological Modelling 222 (3): 709-718.

Model structure

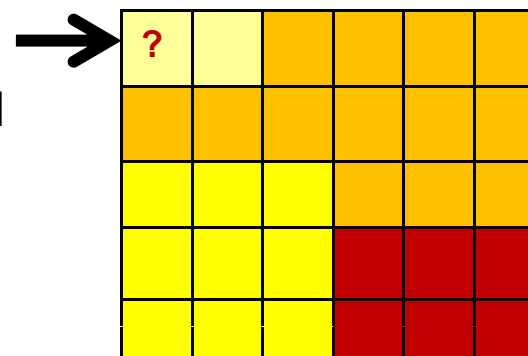


k nearest neighbour imputation

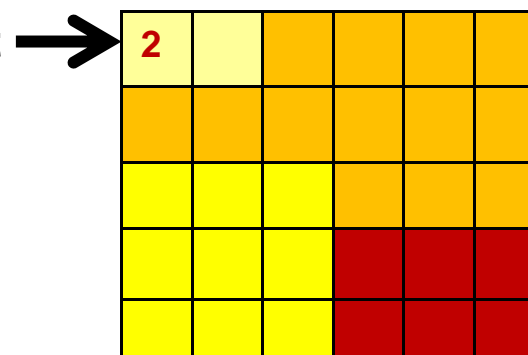
1. **Teaching data set** is created:
 - (carbon flux) estimates for the sample plots
 - pixel colours from the satellite image for the same sample plots



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.)



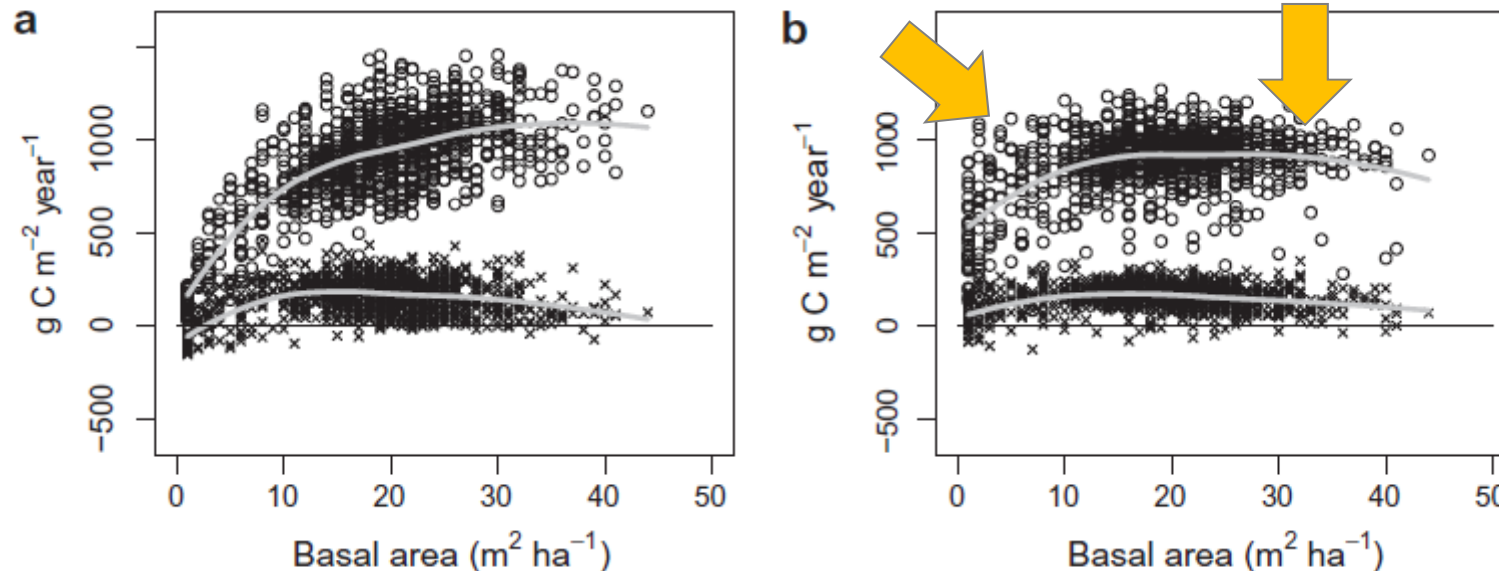
Reliability of the imputations depends on the location, site fertility and main tree species

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

	Central Finland			Lapland		
	BIAS%	RMSE%	<i>n</i>	BIAS%	RMSE%	<i>n</i>
<i>Classified by site fertility</i>						
OMT	5.7	26.7	184	-	-	-
MT	2.1	25.9	566	-0.7	35.7	239
VT	-3.4	27.3	290	2.1	35.7	101
CT	-30.5	49.3	27	3.0	30.6	25
<i>Classified by main tree species</i>						
Scots pine	-0.5	25.9	698	1.4	34.5	290
Norway spruce	-2.0	24.7	230	-16.5	42.1	51
Deciduous	8.2	31.3	144	14.9	35.9	24

Estimations (left) vs. imputations (right) in Central Finland

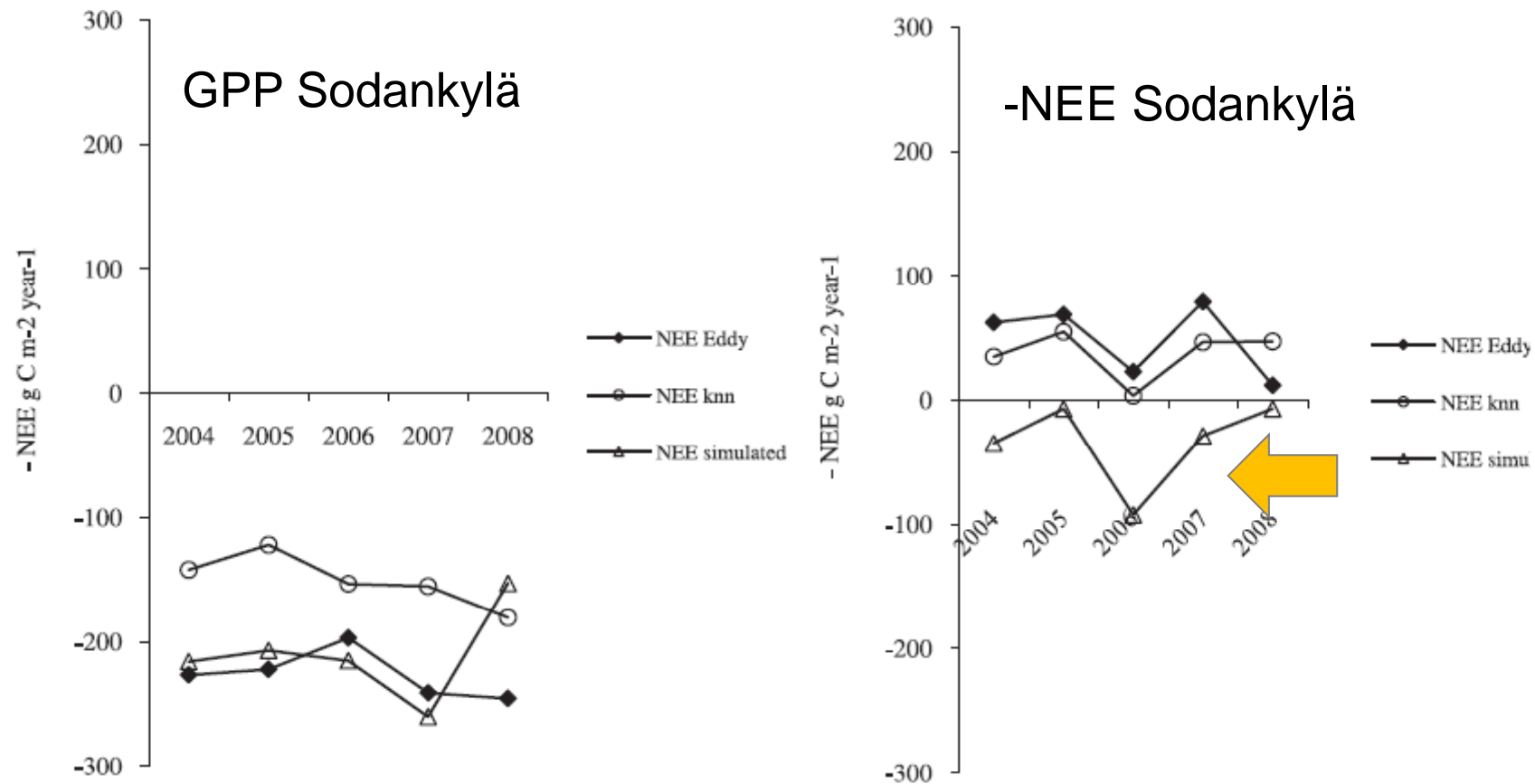
- Imputations very scattered in the youngest stands, with old stands the estimates start to saturate



Härkönen, S., Lehtonen, A., Eerikäinen, K., Peltoniemi, M., Mäkelä, A. Estimating forest carbon fluxes for large regions based on process-based modeling, NFI data and Landsat satellite images. Forest Ecology and Management.

Eddy covariance measurements: comparisons in Hyytiälä and Sodankylä

- In Sodankylä GPP estimates ok, NEE estimates poor; in Hyytiälä better results

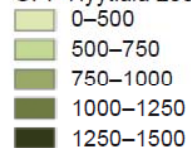


Imputations and EC measurements of annual GPP (g C m⁻² yr⁻¹) in Hyytiälä (a) and Sodankylä (b), and -NEE (g C m⁻² yr⁻¹) in Hyytiälä (c) and Sodankylä (d) during 2008.

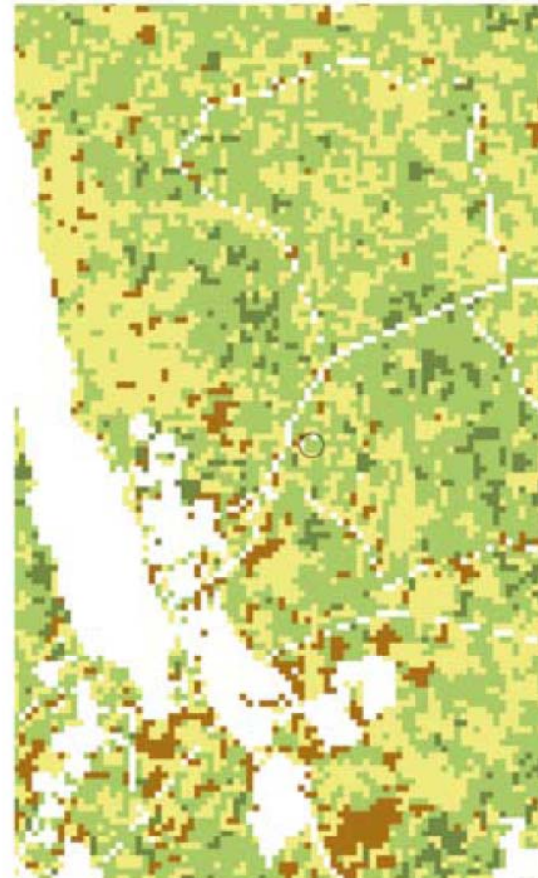
The developed method enables production of carbon flux maps with high resolution (30 m)



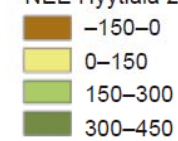
GPP Hyytiälä 2007 ($\text{g C m}^{-2} \text{ year}^{-1}$)



0 260 Meters



-NEE Hyytiälä 2007 ($\text{g C m}^{-2} \text{ year}^{-1}$)



0 260 Meters

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