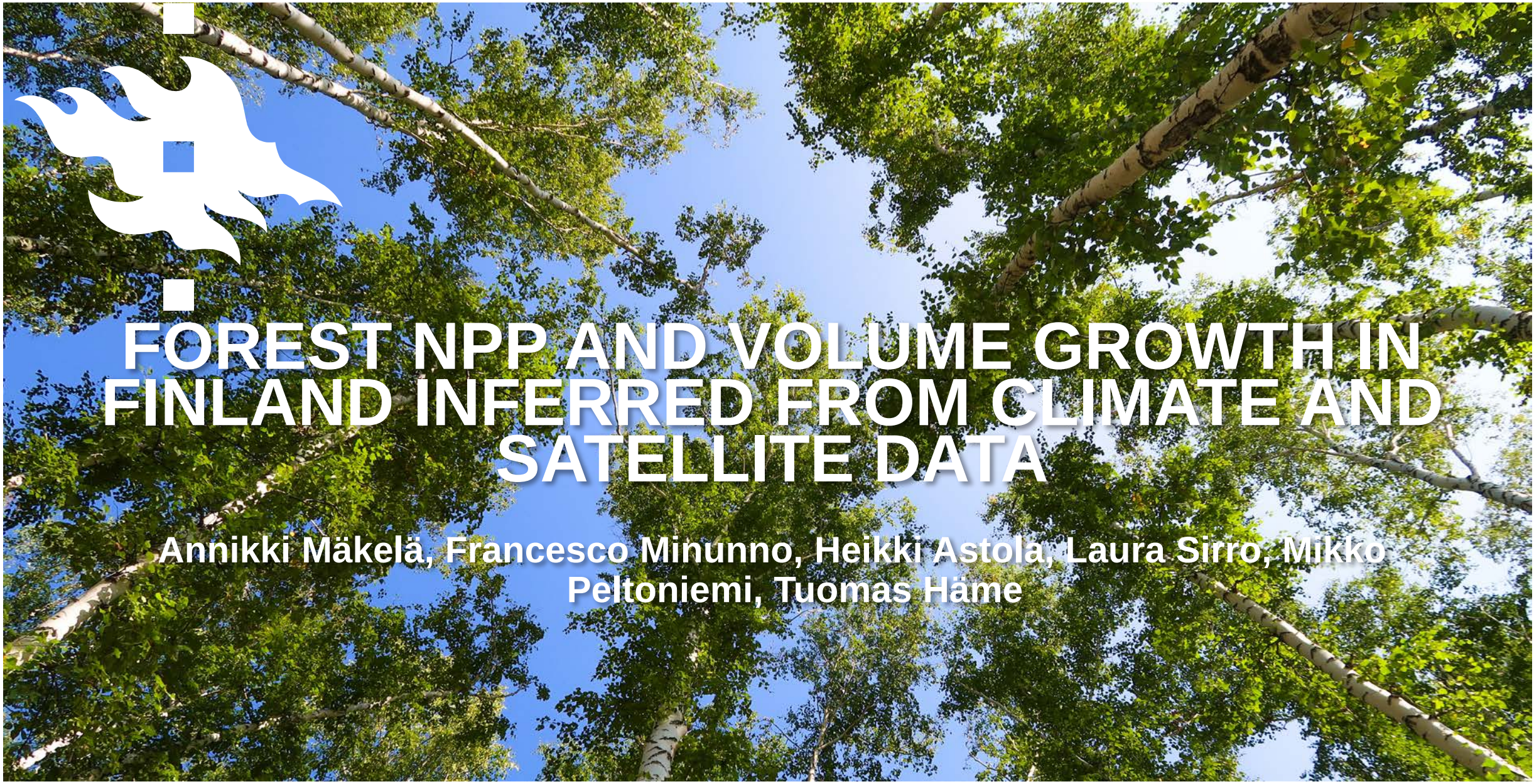
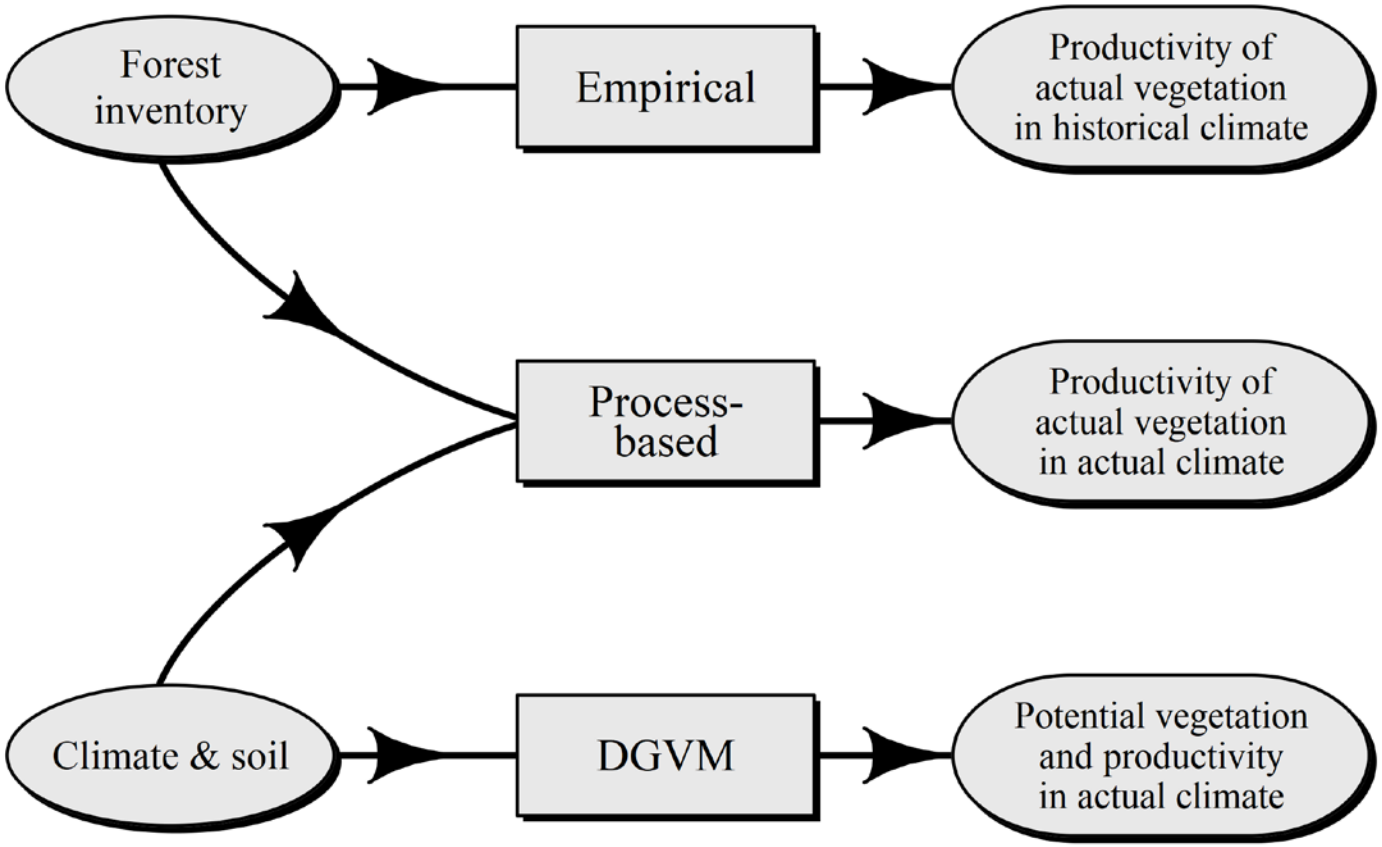


FOREST NPP AND VOLUME GROWTH IN FINLAND INFERRED FROM CLIMATE AND SATELLITE DATA

Annikki Mäkelä, Francesco Minunno, Heikki Astola, Laura Sirro, Mikko Peltoniemi, Tuomas Häme

INTRODUCTION

BACKGROUND



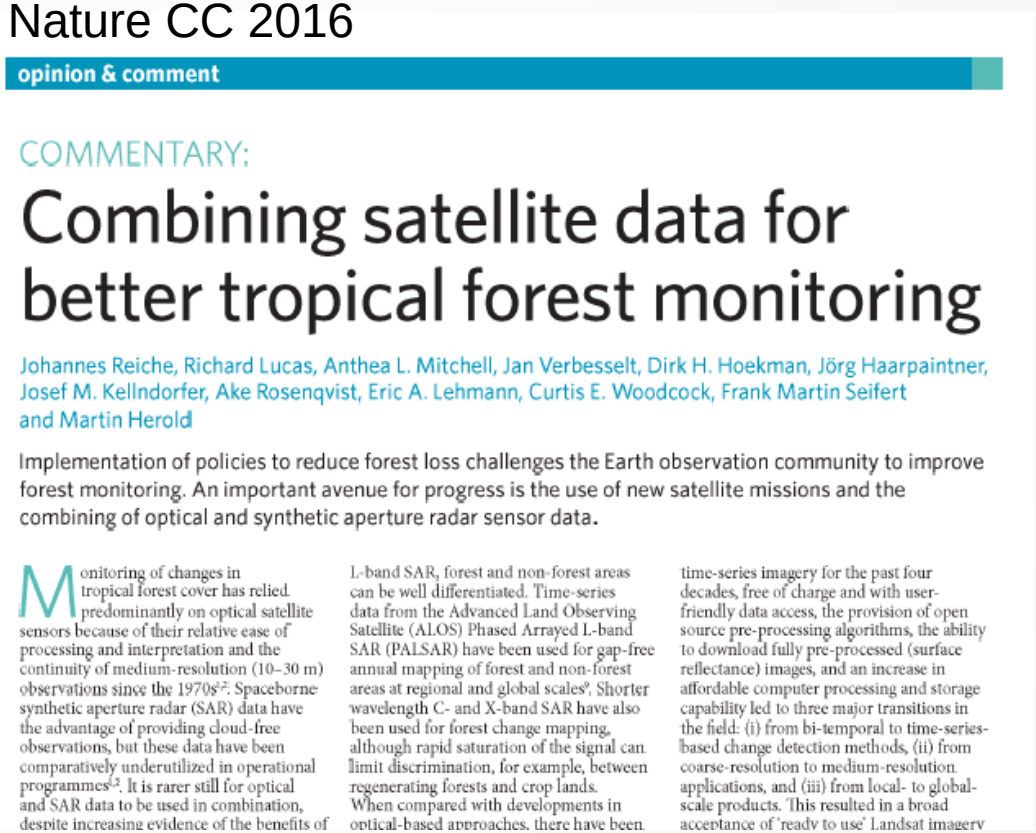
Short-term **Monitoring**

Long-term

BACKGROUND

- Advances in remote sensing technology => should be applied to its full capacity for forest monitoring (Reiche et al. 2016)
- Progress in
  - Land cover
  - Species distribution (Immitzer et al. 2012, 2016)
  - Above-ground biomass (Balzer et al. 2003, Zaki and Latif 2017, ref).

Nature CC 2016



opinion & comment

COMMENTARY:

Combining satellite data for better tropical forest monitoring

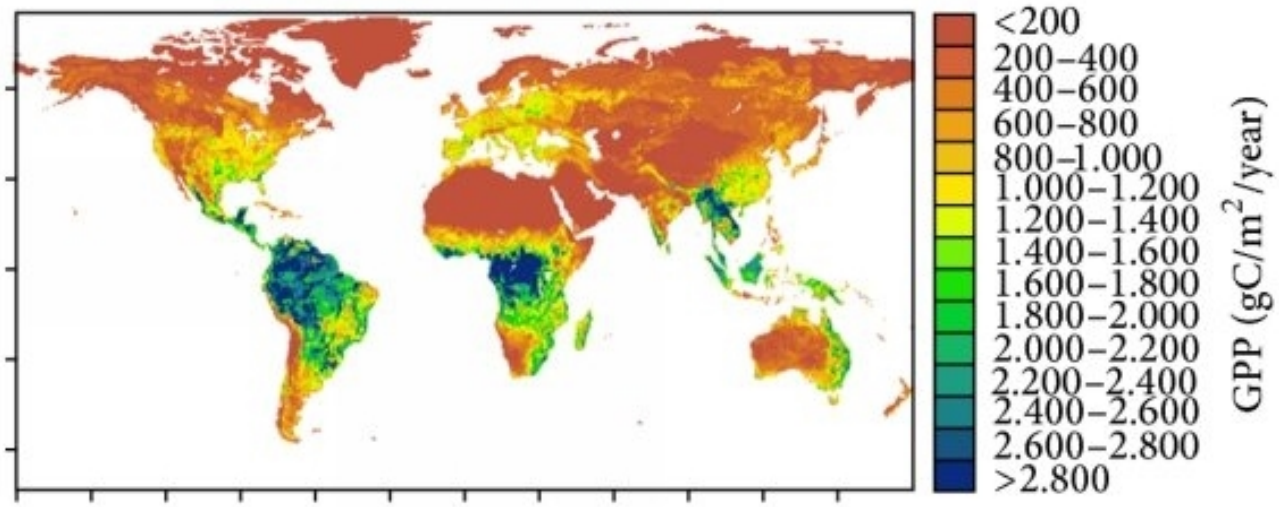
Johannes Reiche, Richard Lucas, Anthea L. Mitchell, Jan Verbesselt, Dirk H. Hoekman, Jörg Haarpaintner, Josef M. Kellndorfer, Ake Rosenqvist, Eric A. Lehmann, Curtis E. Woodcock, Frank Martin Seifert and Martin Herold

Implementation of policies to reduce forest loss challenges the Earth observation community to improve forest monitoring. An important avenue for progress is the use of new satellite missions and the combining of optical and synthetic aperture radar sensor data.

Monitoring of changes in tropical forest cover has relied predominantly on optical satellite sensors because of their relative ease of processing and interpretation and the continuity of medium-resolution (10–30 m) observations since the 1970s[1,2]. Spaceborne synthetic aperture radar (SAR) data have the advantage of providing cloud-free observations, but these data have been comparatively underutilized in operational programmes[1,3]. It is rarer still for optical and SAR data to be used in combination, despite increasing evidence of the benefits of L-band SAR, forest and non-forest areas can be well differentiated. Time-series data from the Advanced Land Observing Satellite (ALOS) Phased Arrayed L-band SAR (PALSAR) have been used for gap-free annual mapping of forest and non-forest areas at regional and global scales[4]. Shorter wavelength C- and X-band SAR have also been used for forest change mapping, although rapid saturation of the signal can limit discrimination, for example, between regenerating forests and crop lands. When compared with developments in optical-based approaches, there have been time-series imagery for the past four decades, free of charge and with user-friendly data access, the provision of open source pre-processing algorithms, the ability to download fully pre-processed (surface reflectance) images, and an increase in affordable computer processing and storage capability led to three major transitions in the field: (i) from bi-temporal to time-series-based change detection methods, (ii) from coarse-resolution to medium-resolution applications, and (iii) from local- to global-scale products. This resulted in a broad acceptance of 'ready to use' Landsat imagery

BACKGROUND

- LAI and PAR radiation
  - GPP (NPP) e.g. MODIS algorithm (Running et al. 2004)



PAN ET AL. 2014 ADVANCES IN METEOROLOGY

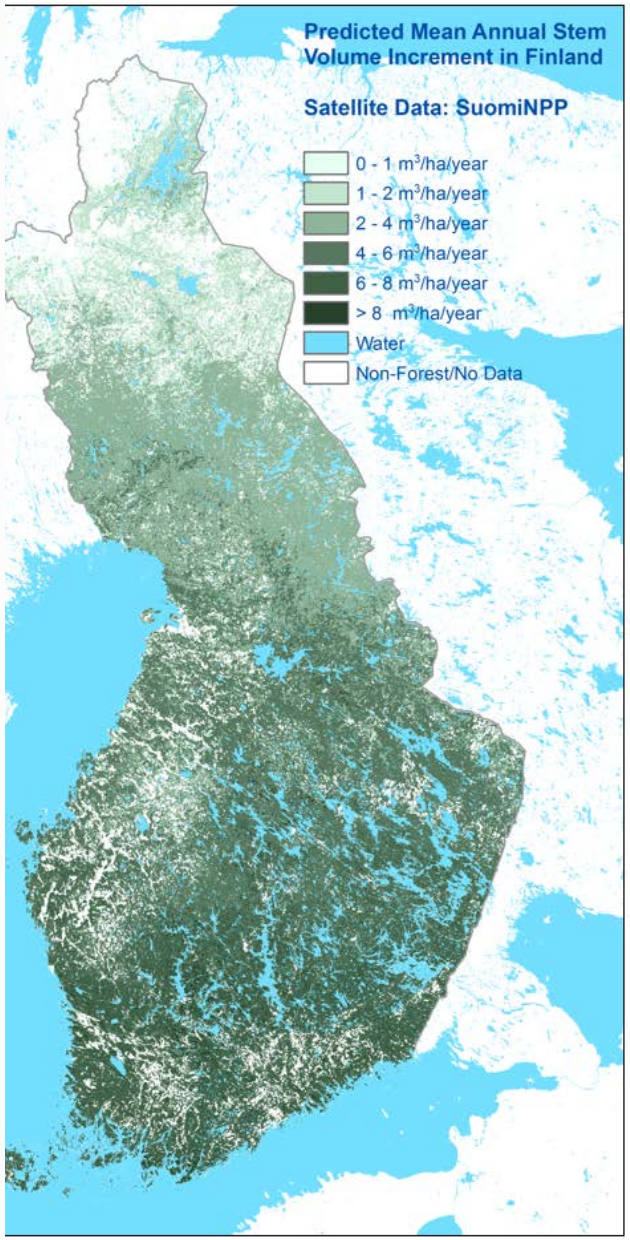
- What about
  - CUE
  - Volume growth
- Depend on forest stock not just LAI

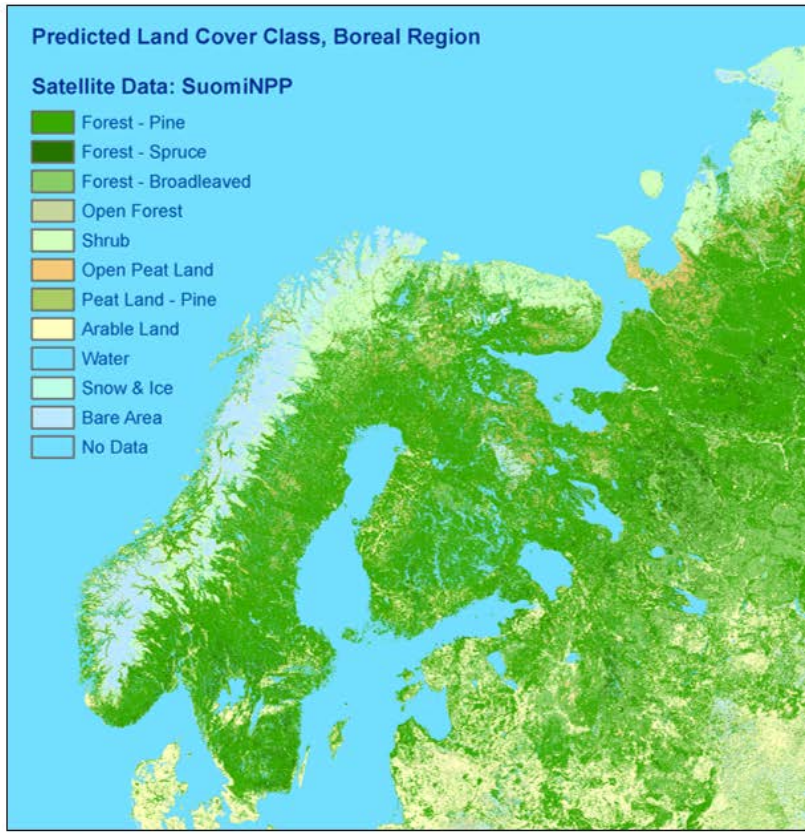
(e.g. COLLALTI ET AL. 2020 GCB)

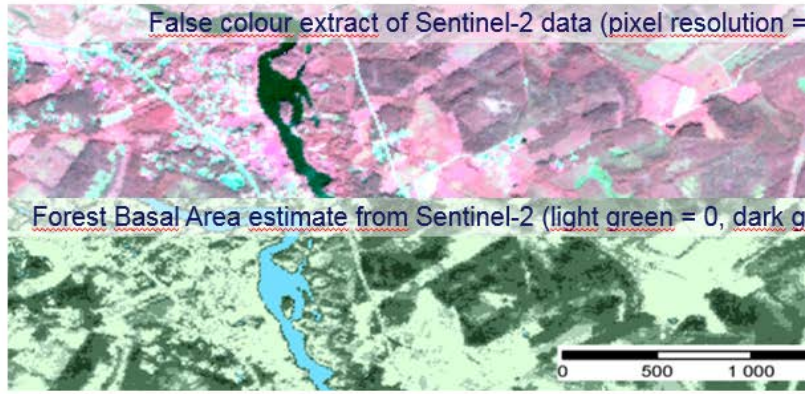
OBJECTIVE

- Use satellite products to
  - Estimate forest variables
  - Assess current C fluxes and volume growth
- Compare use of products with different resolution
- NorthState project EU FP7

  2014-2017



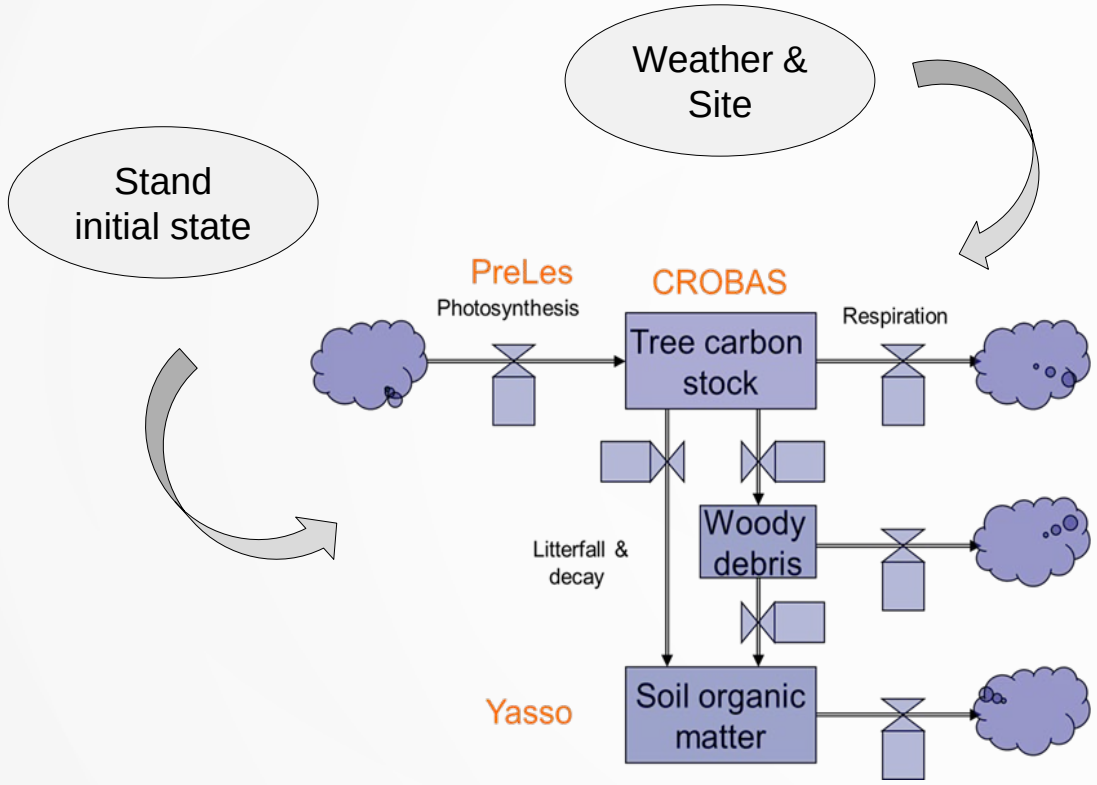


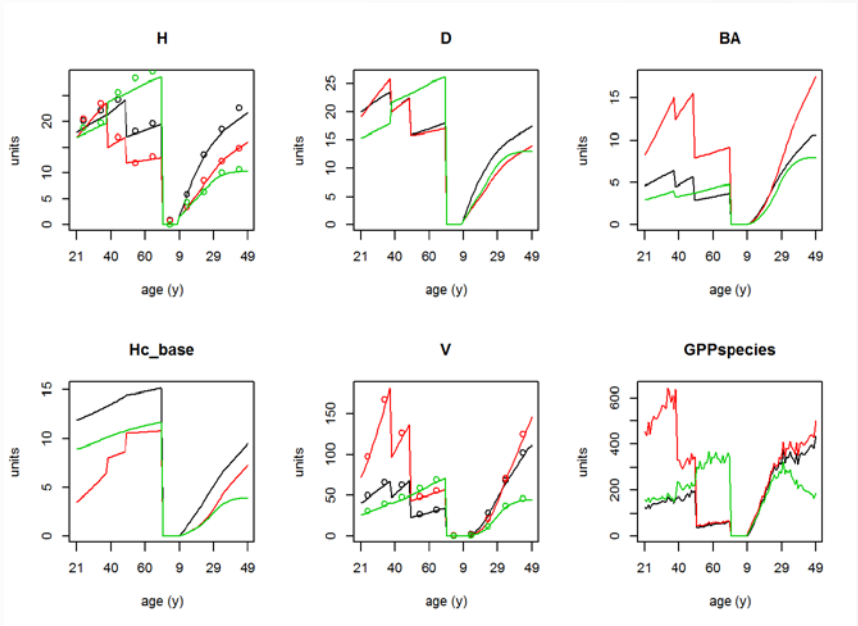


http://northstatefp7.eu/

MATERIAL AND METHODS

C FLUXES FROM GROUND-BASED DATA



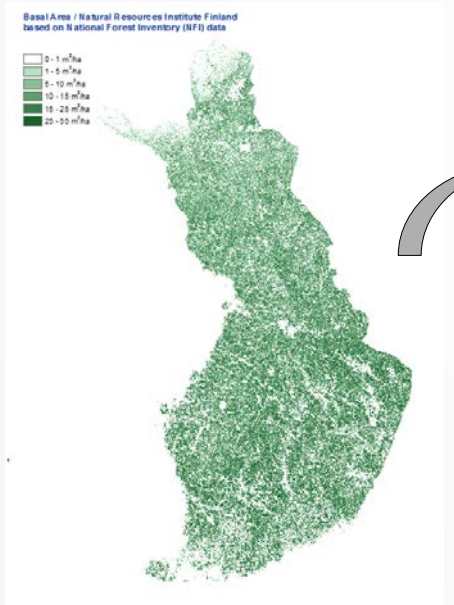


PREBAS

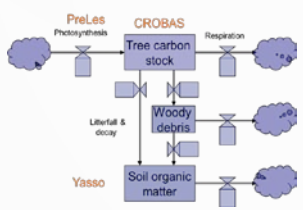
VALENTINE & MÄKELÄ 2005 TP

C FLUXES FROM GROUND-BASED DATA

Multi-source inventory data



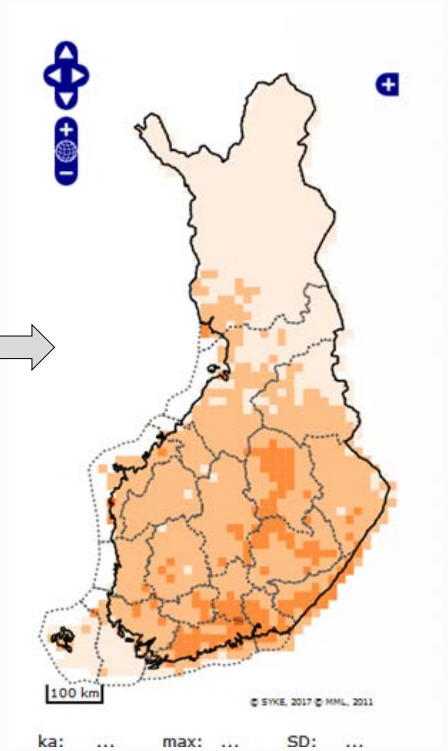
Gridded Weather data



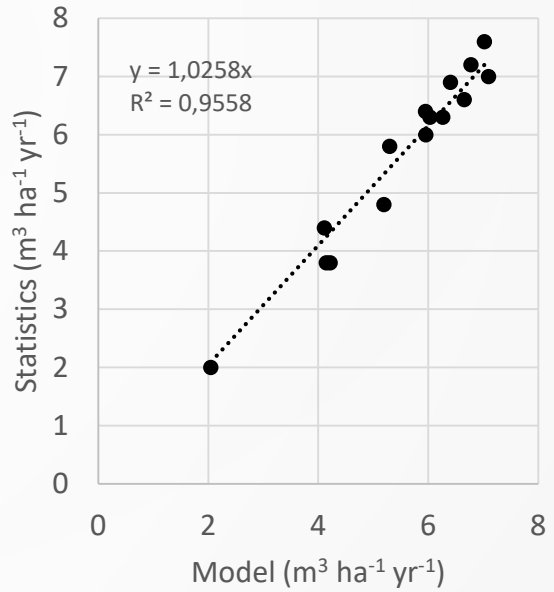
PREBAS

MINUNNO ET AL. 2019 FORECO

Growth rate



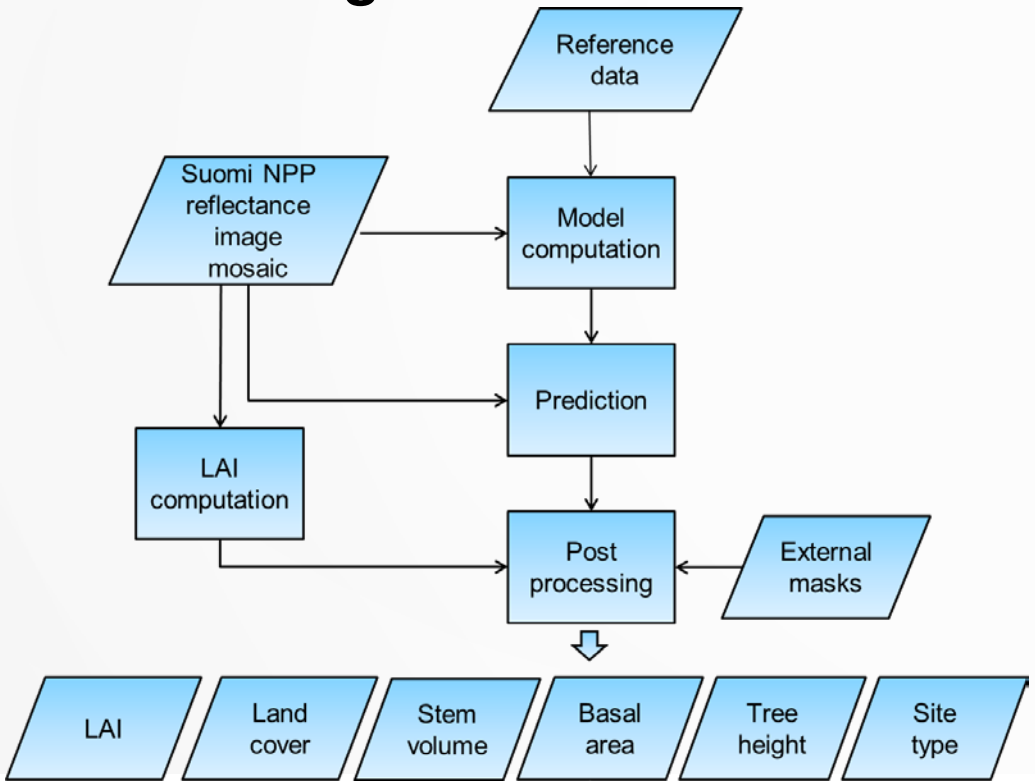
Mean annual growth in forestry regions



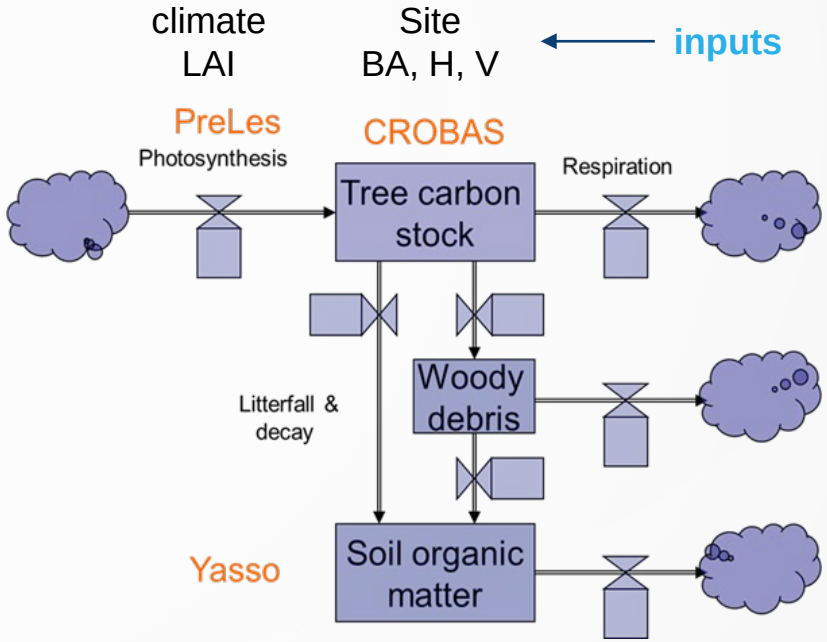
HOLMBERG ET AL. 2019 FRONTIERS IN PLANT SC

METHOD

A. Forest variable prediction from satellite images



B. Carbon flux prediction from forest variables and climate data



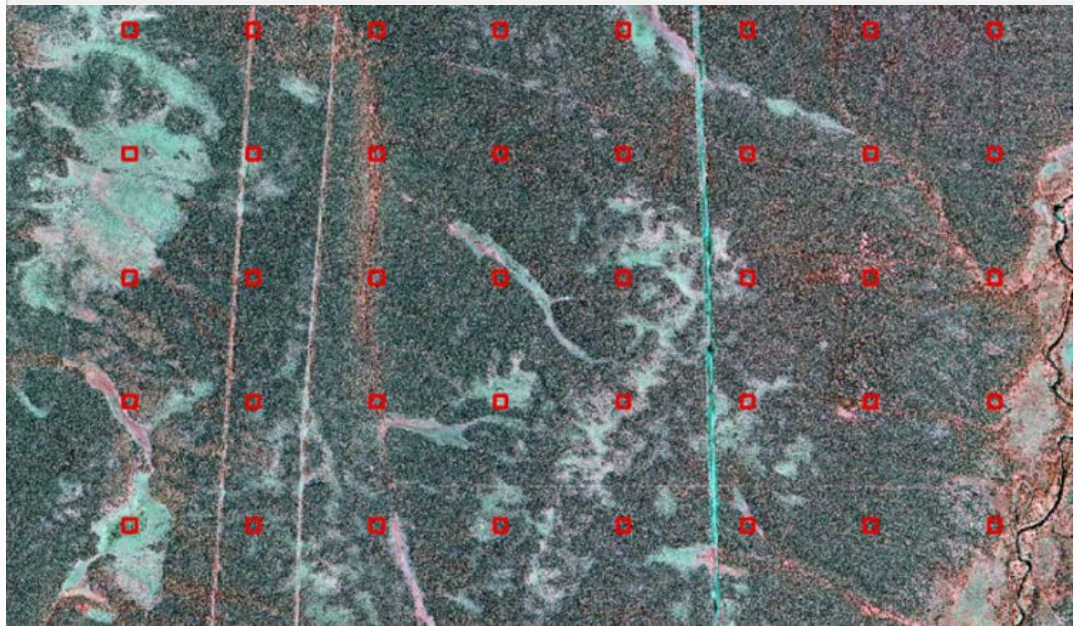
MÄKELÄ 1997, VALENTINE AND MÄKELÄ 2005, PELTONIEMI ET AL. 2015, MINUNNO ET AL. 2016, 2018, TIAN ET AL. 2020

MATERIAL

- Prediction data
  - Suomi-NPP
    - Finland wall-to-wall
    - Resolution 500 x 500 m
    - > 200 images May – Sep 2016
  - Sentinel 2
    - Hyytiälä, Sodankylä
    - Resolution 10 x 10 m
    - 79 images summer 2016

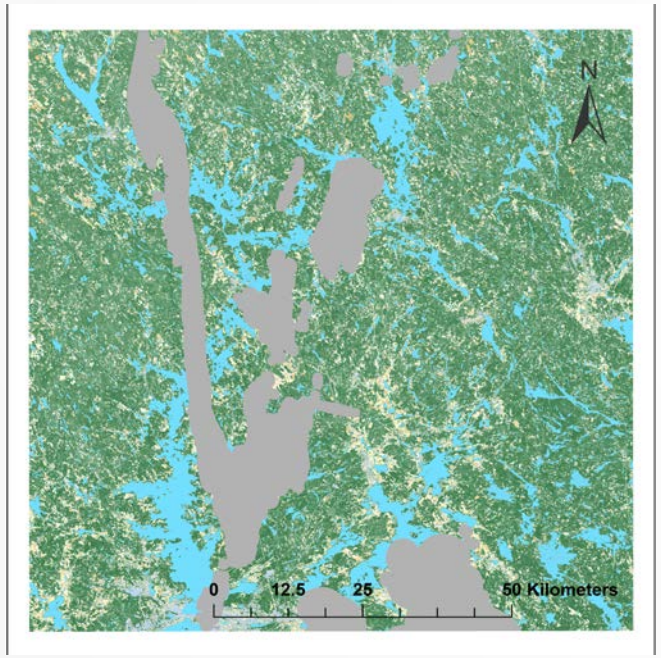
MATERIAL

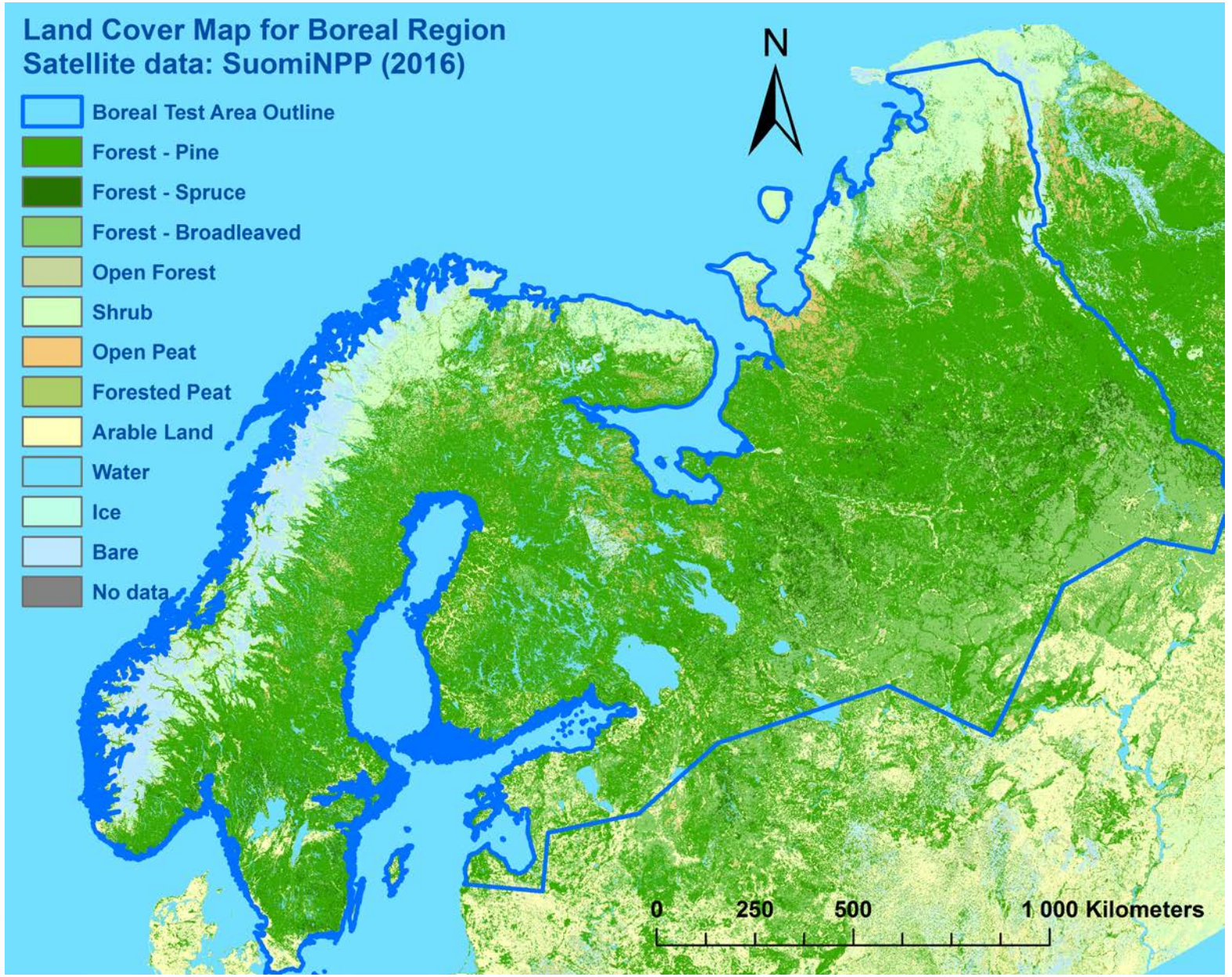
- Reference data
  - Suomi-NPP
    - – Luke thematic maps, average 500x500m
  - Sentinel 2
    - – Ground data from National Board of Forests
- Test data
  - – Samples from Very High Resolution data
  - – Forest statistics; part of training data set
- Climate data
  - – FMI gridded data 1 km x 1 km 1980 – 2010
  - – PAR, T, P, VPD daily



RESULTS: FOREST VARIABLES

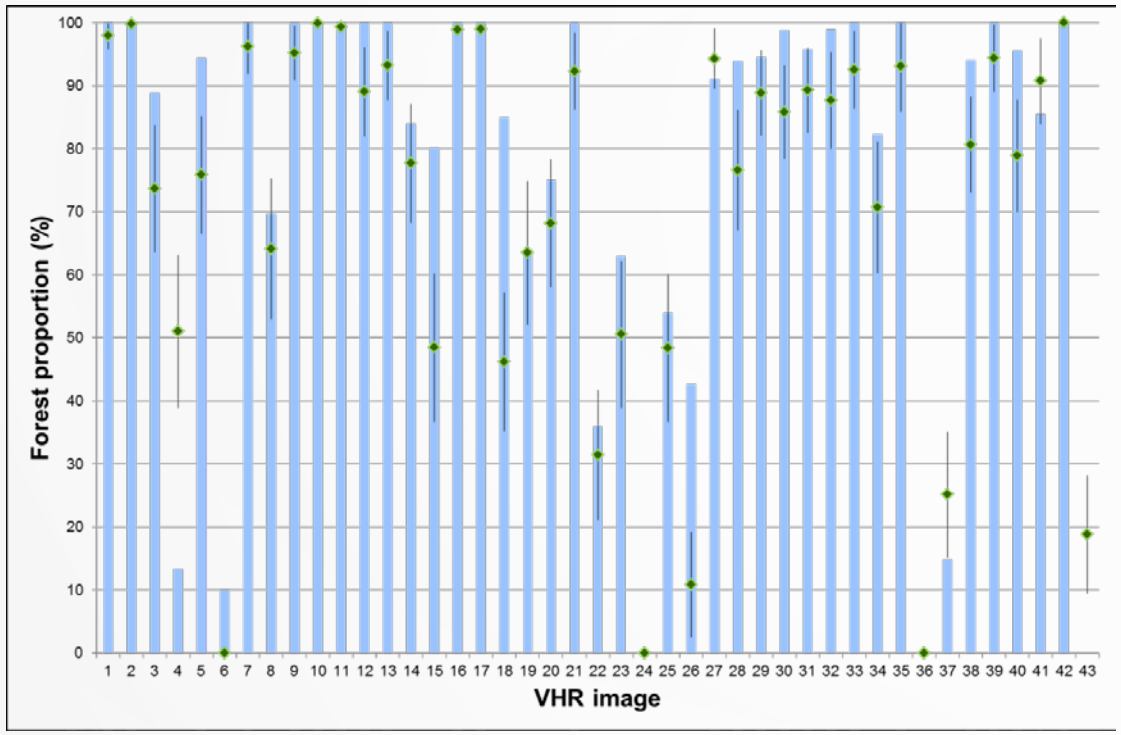
Forest variables
Suomi NPP
Sentinel-2



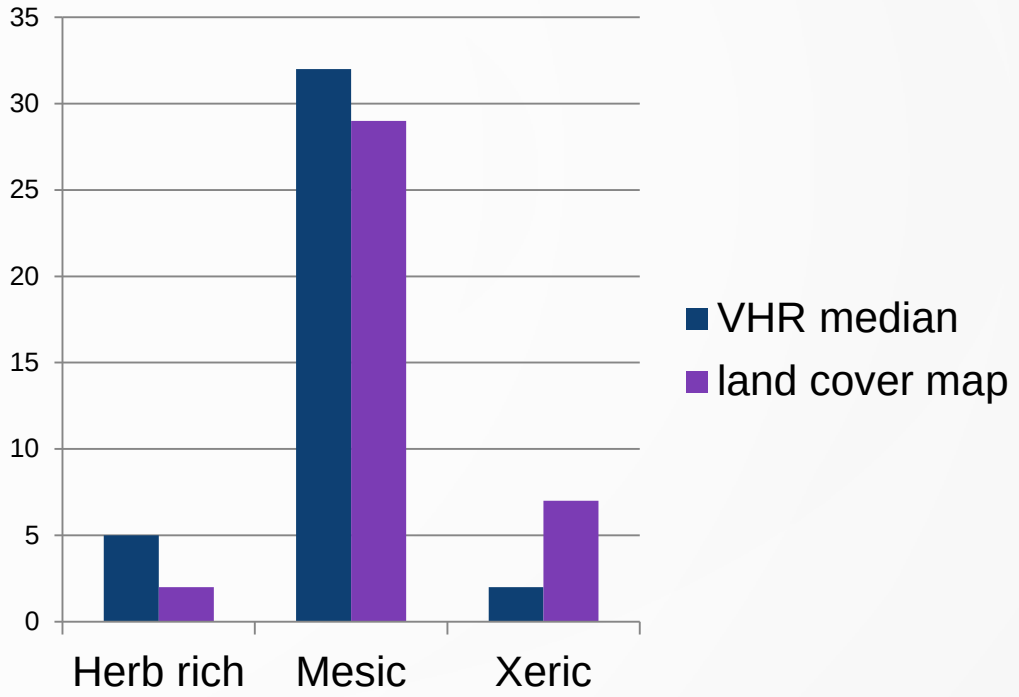


LAND TYPE ACCURACY, SUOMI NPP

Forest area

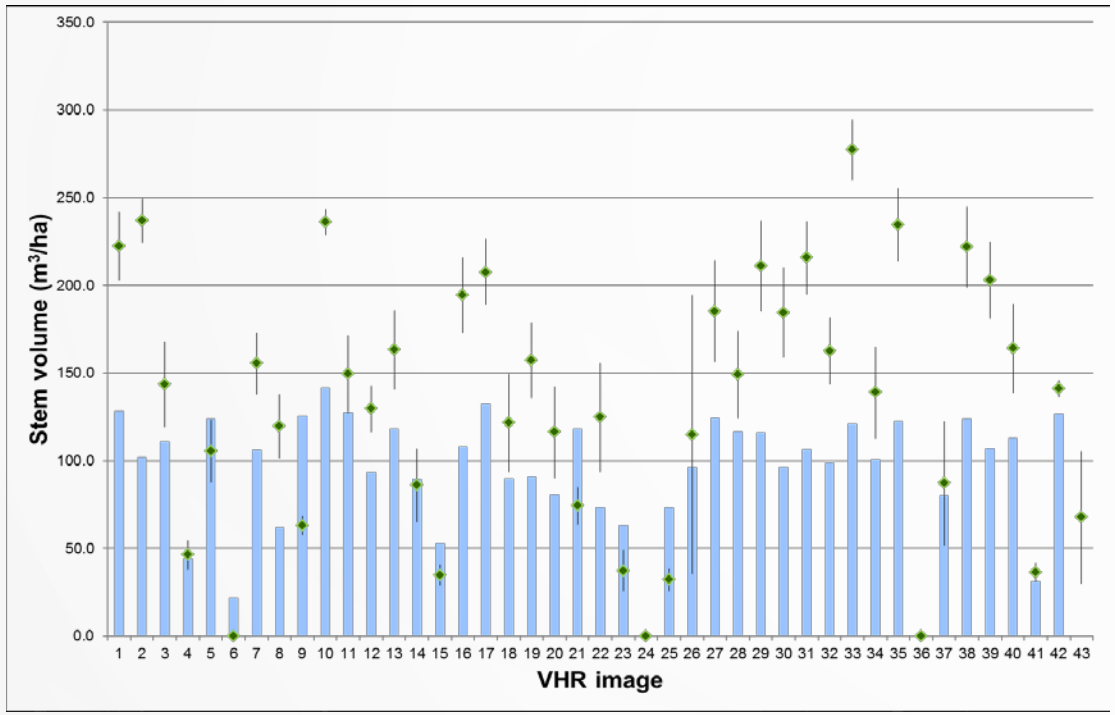


Site type

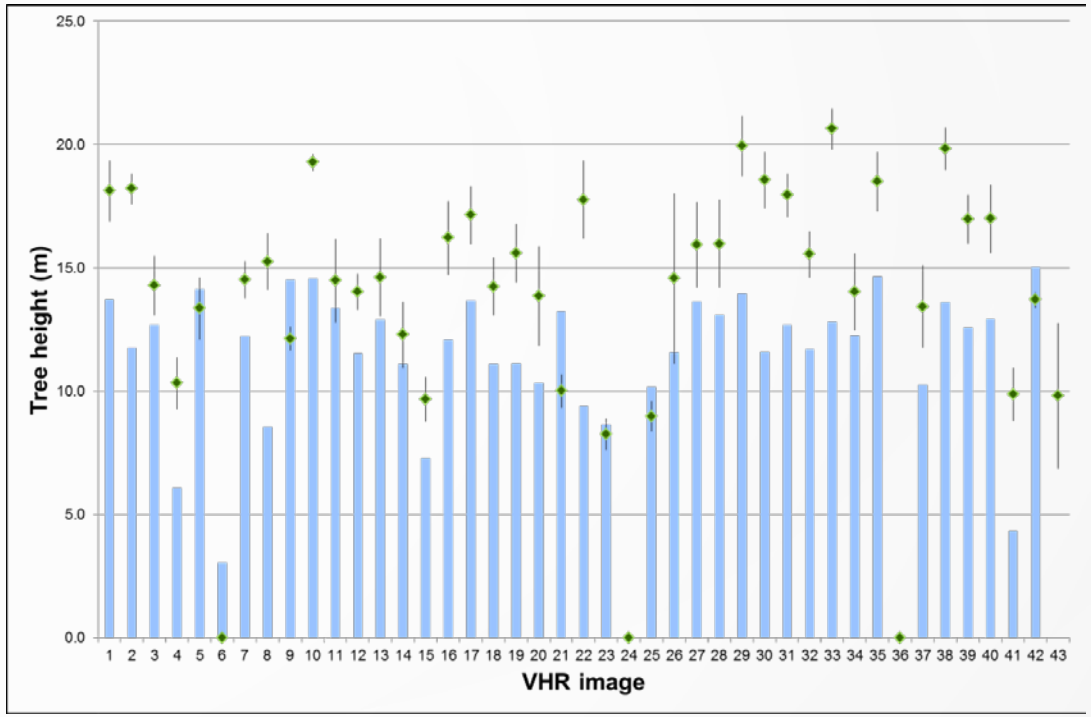


TREE VARIABLE ACCURACY, SUOMI NPP

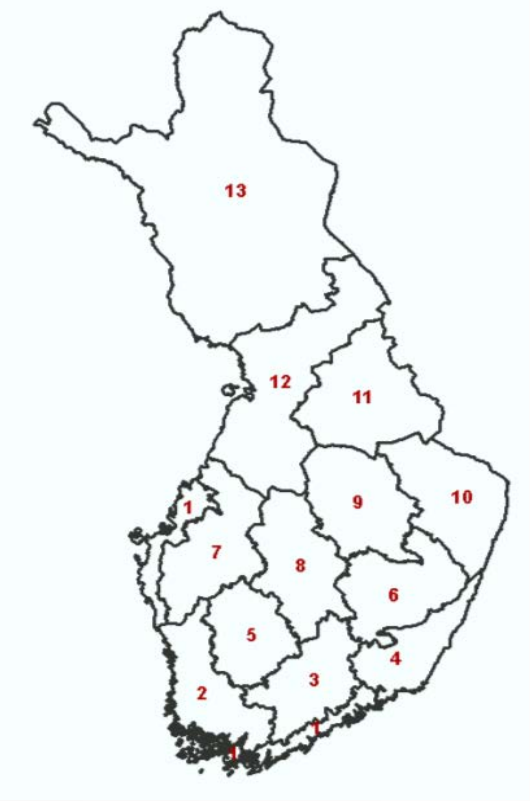
Stem volume



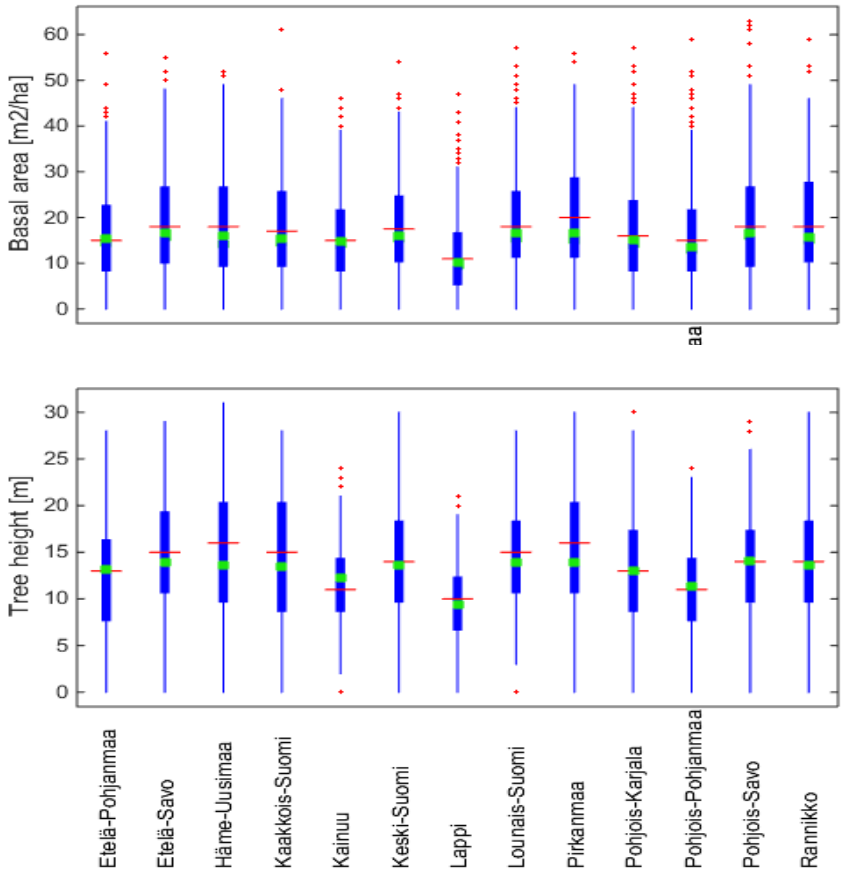
Tree height



TREE VARIABLE ACCURACY, SENTINEL 2



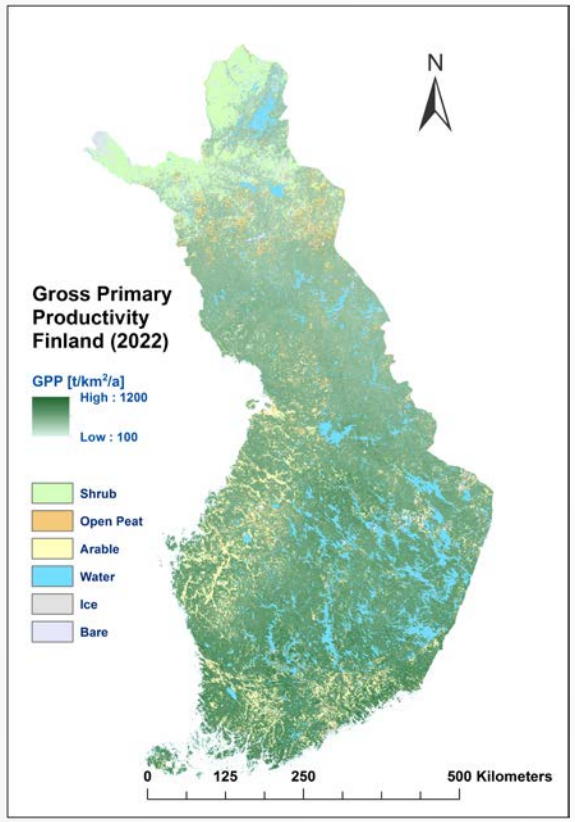
Comparison with NFI in forestry districts



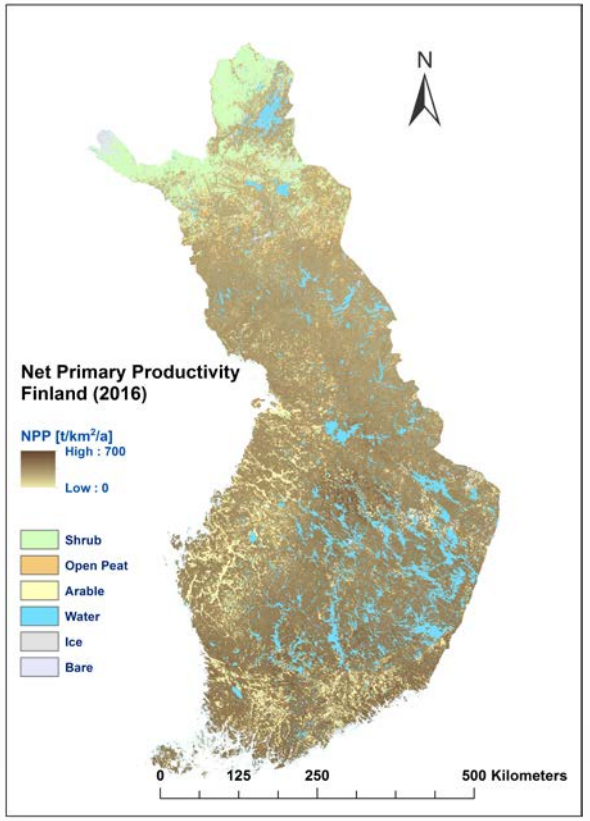
RESULTS: C FLUXES

SUOMI NPP

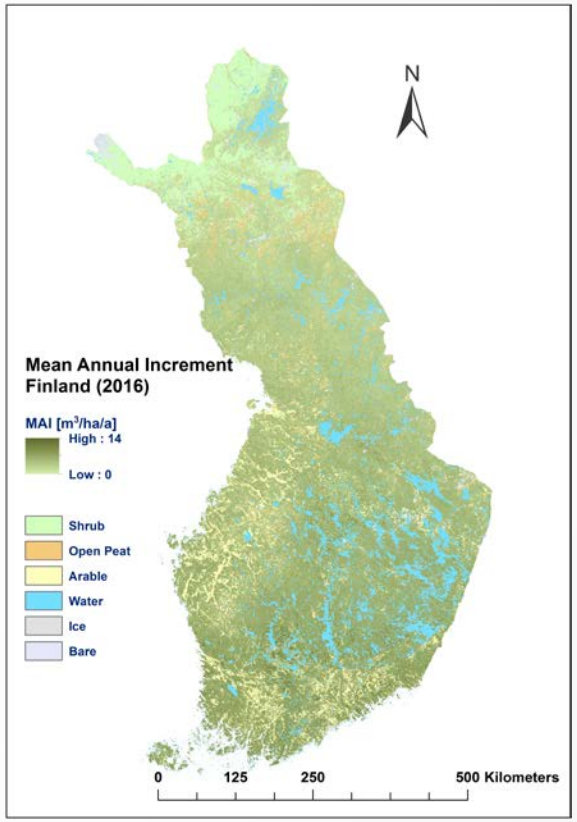
GPP



NPP

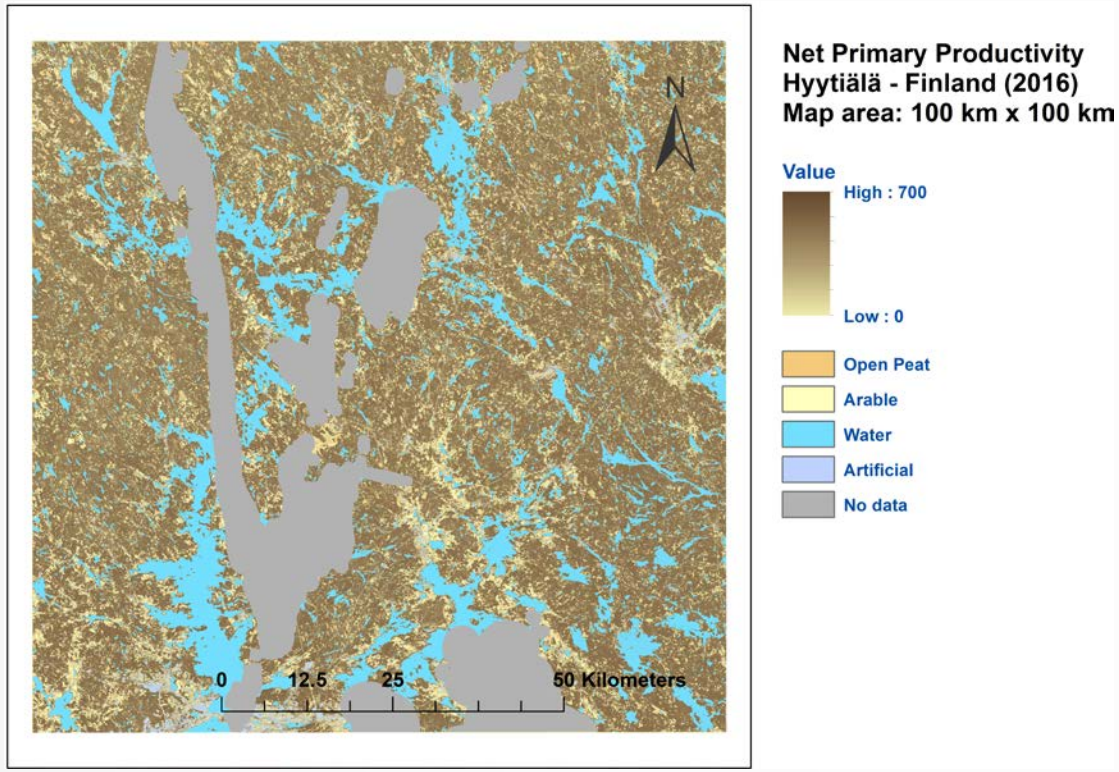


CAI

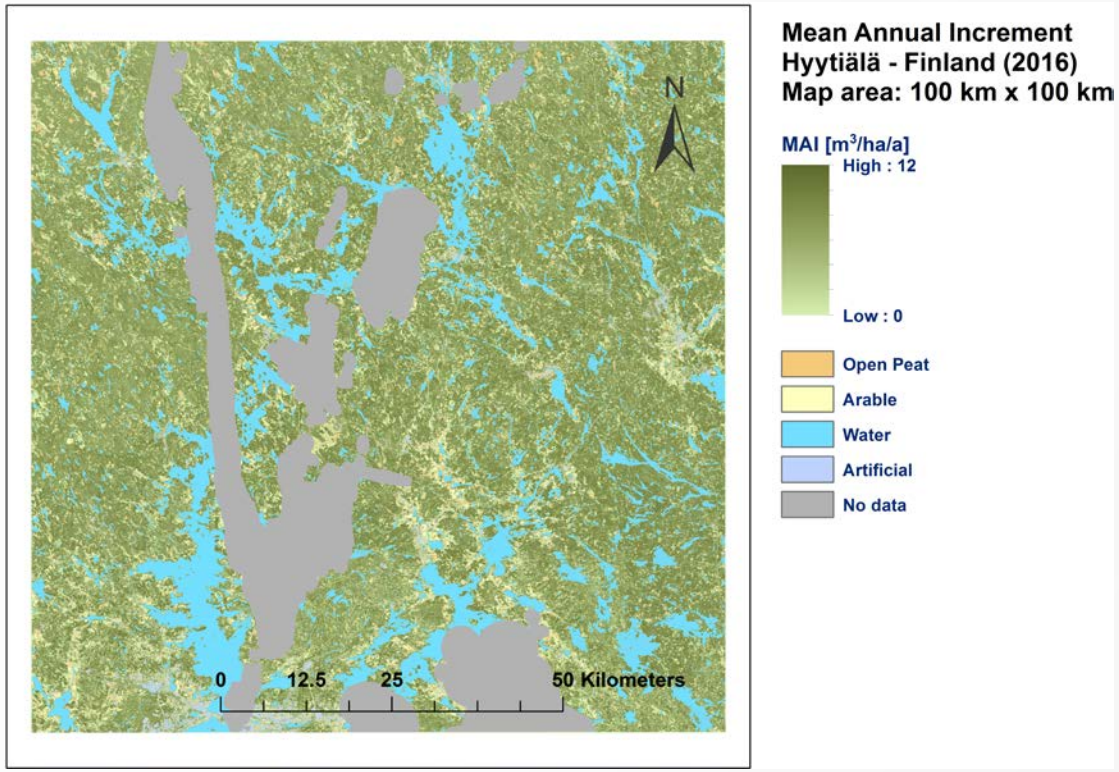


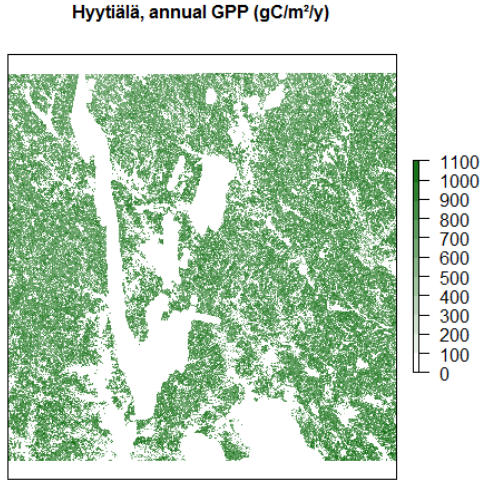
SENTINEL 2

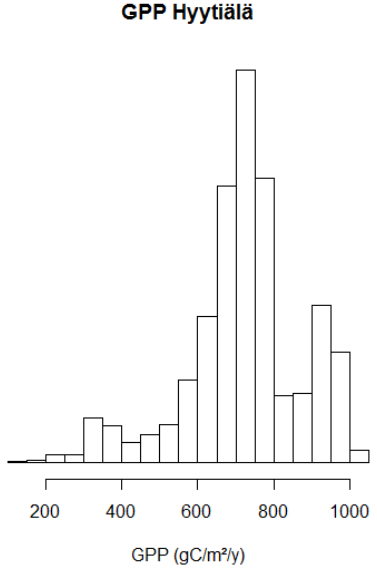
NPP

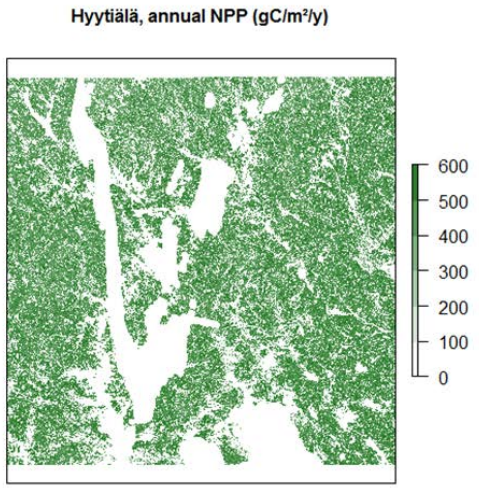


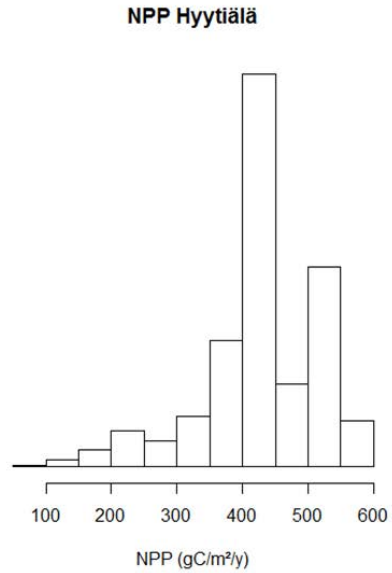
Current Annual Increment

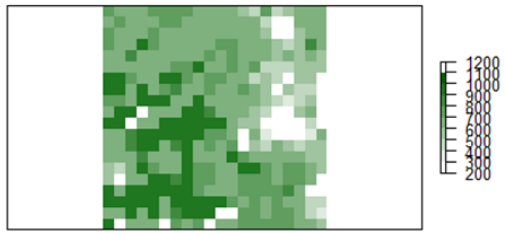


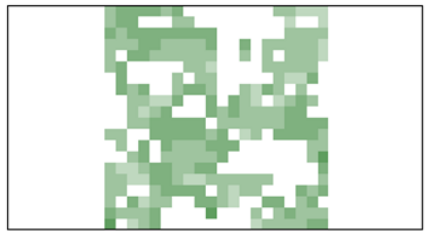

Hyytiälä, annual GPP (gC/m²/y)
1100
1000
900
800
700
600
500
400
300
200
100
0

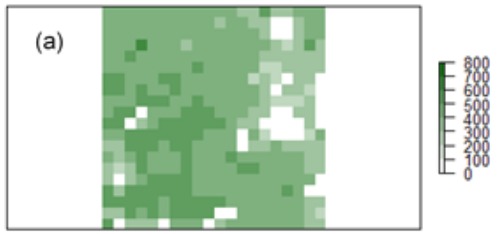

GPP Hyytiälä
200
400
600
800
1000
GPP (gC/m²/y)


Hyytiälä, annual NPP (gC/m²/y)
600
500
400
300
200
100
0

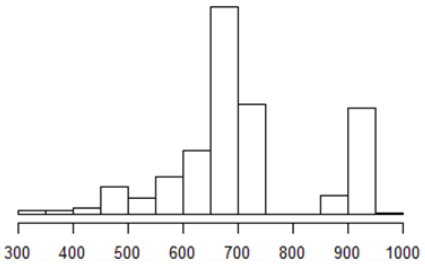

NPP Hyytiälä
100
200
300
400
500
600
NPP (gC/m²/y)

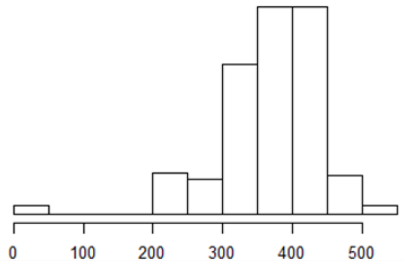

1200
1100
1000
900
800
700
600
500
400
300
200

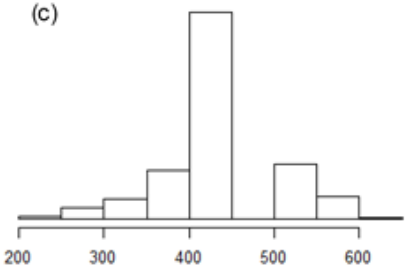


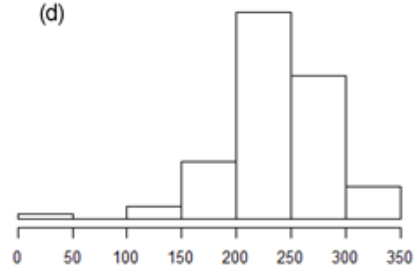

(a)
800
700
600
500
400
300
200
100
0


(b)

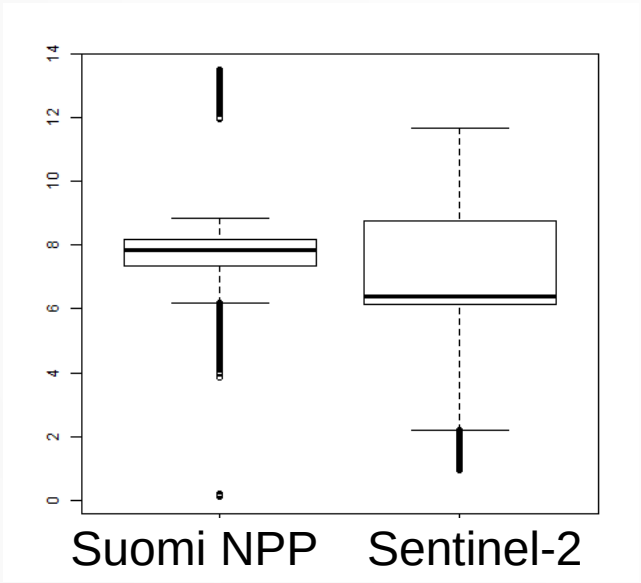

GPP Hyytiälä
300
400
500
600
700
800
900
1000

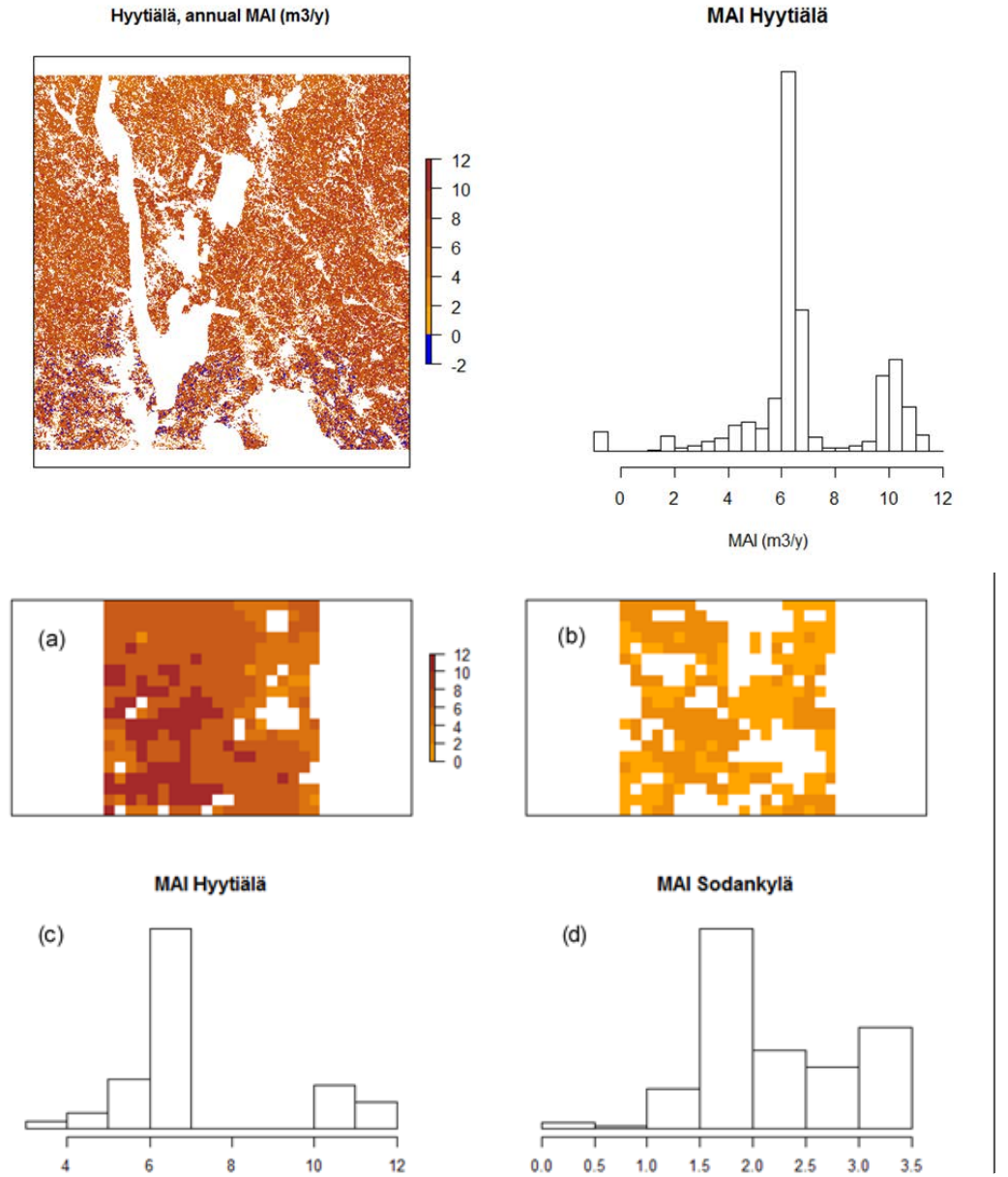

GPP Sodankylä
0
100
200
300
400
500


NPP Hyytiälä
(c)
200
300
400
500
600

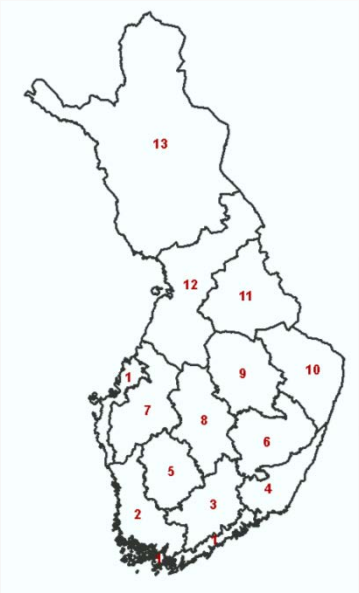

NPP Sodankylä
(d)
0
50
100
150
200
250
300
350

CAI Hyytiälä

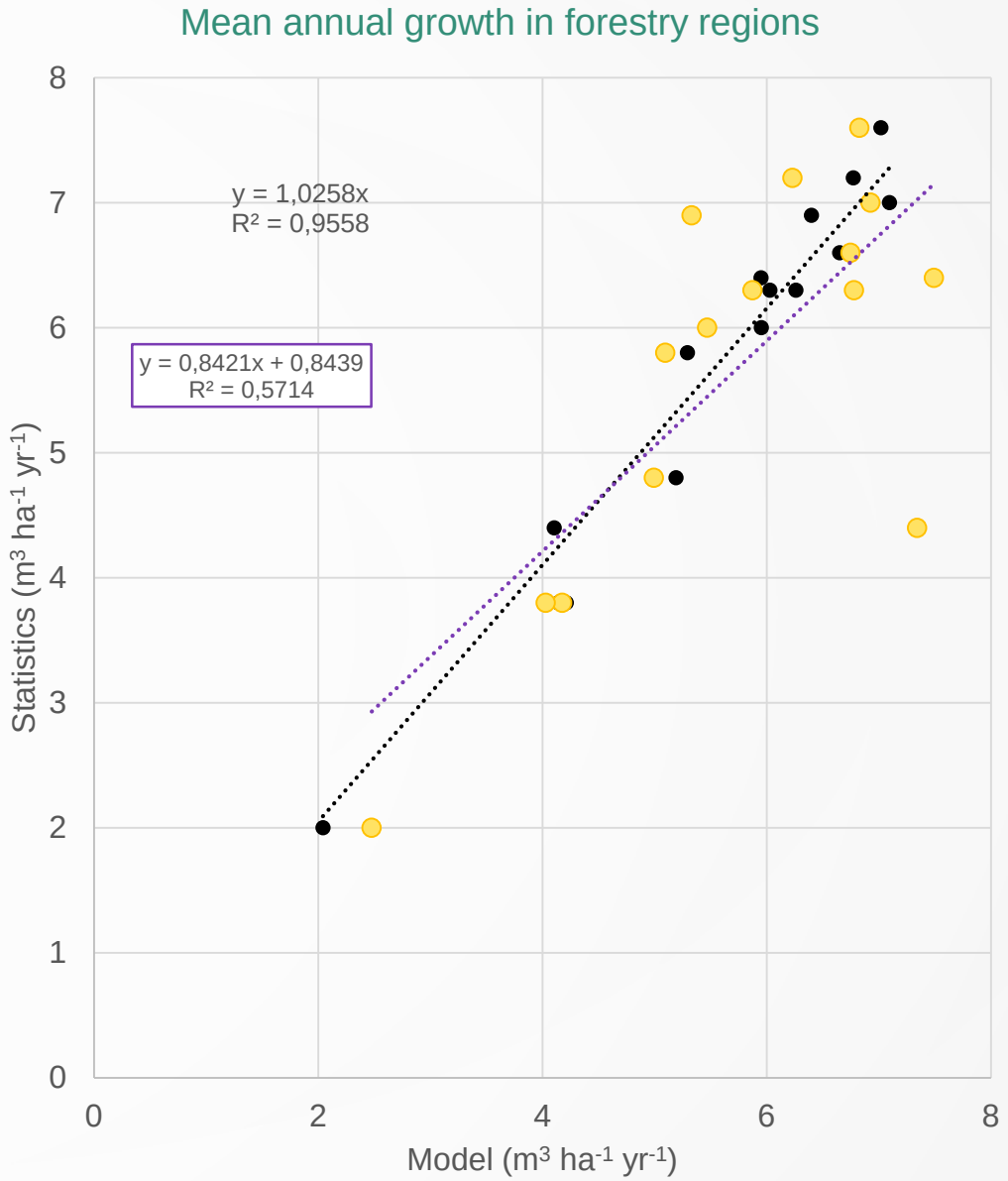




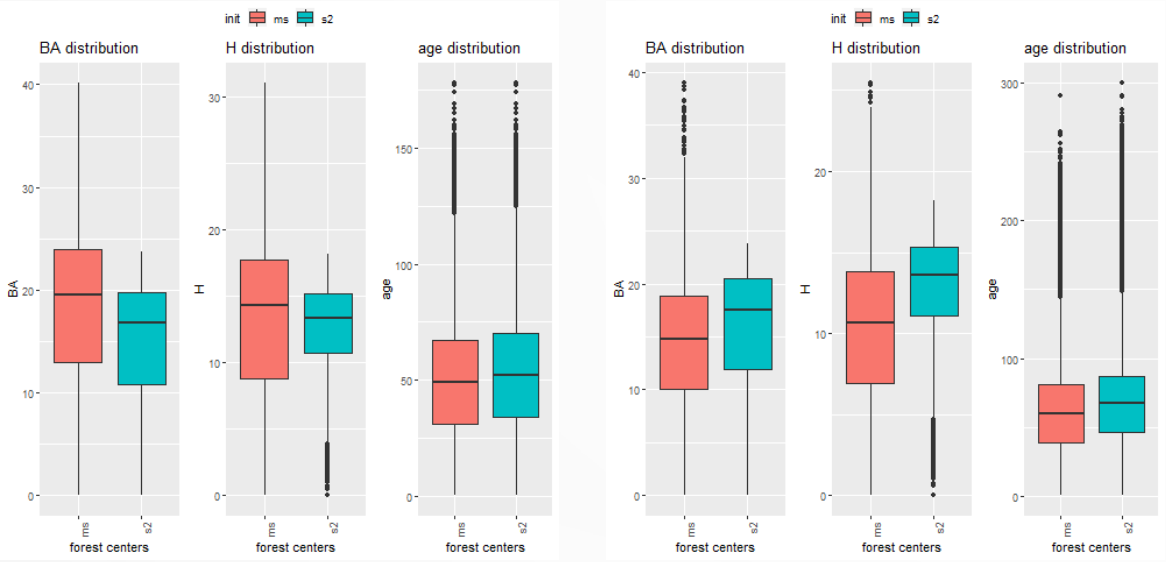
MEAN ANNUAL GROWTH IN FORESTRY REGIONS: SUOMI NPP

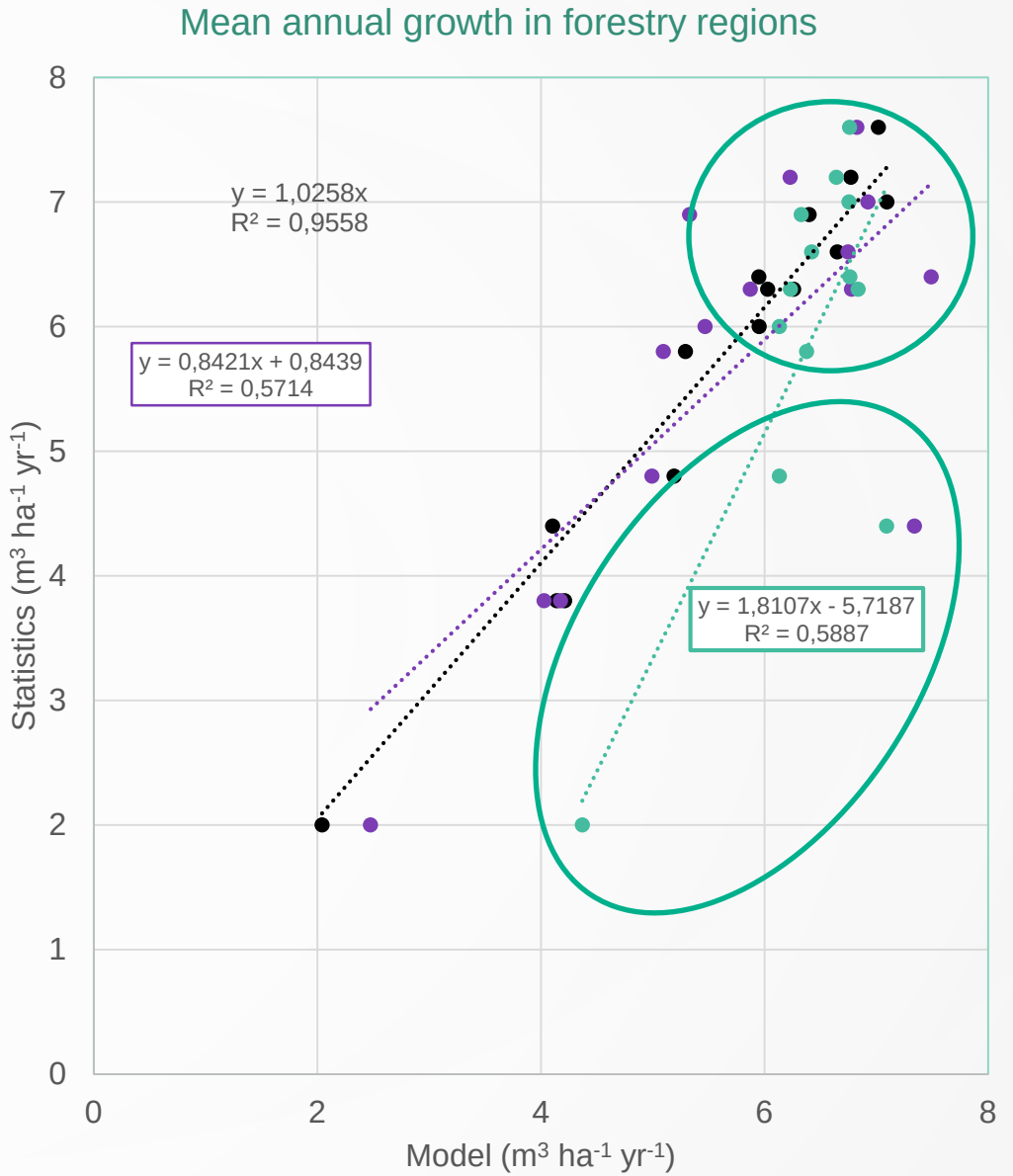


- Small bias
- Poor accuracy

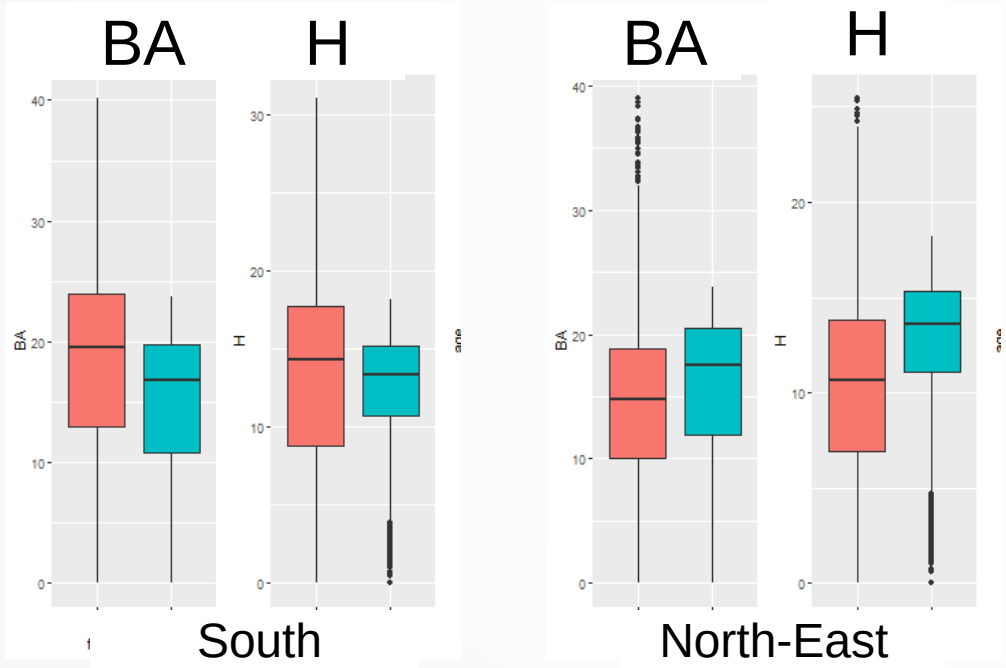


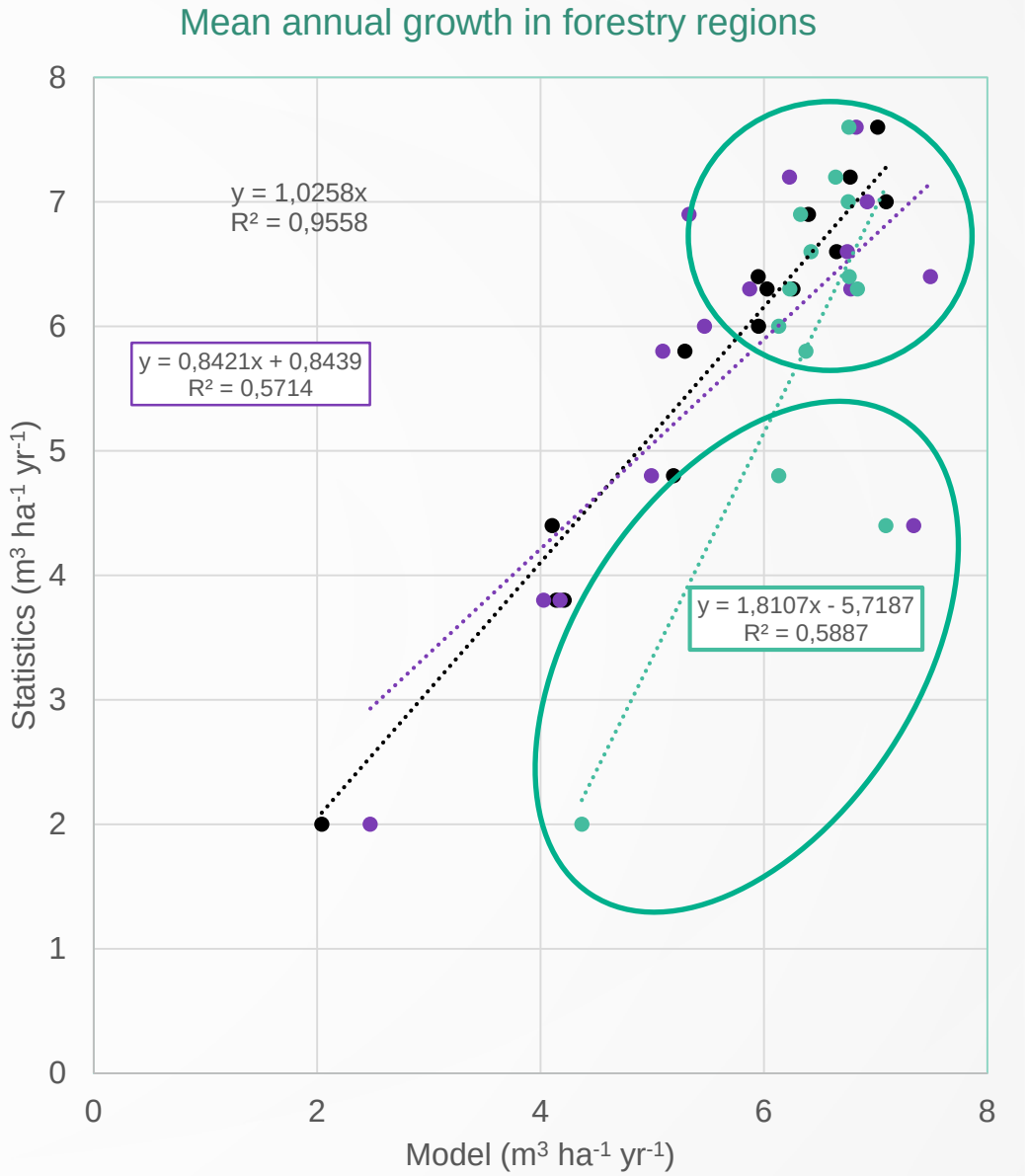
MEAN ANNUAL GROWTH IN FORESTRY REGIONS: SENTINEL-2





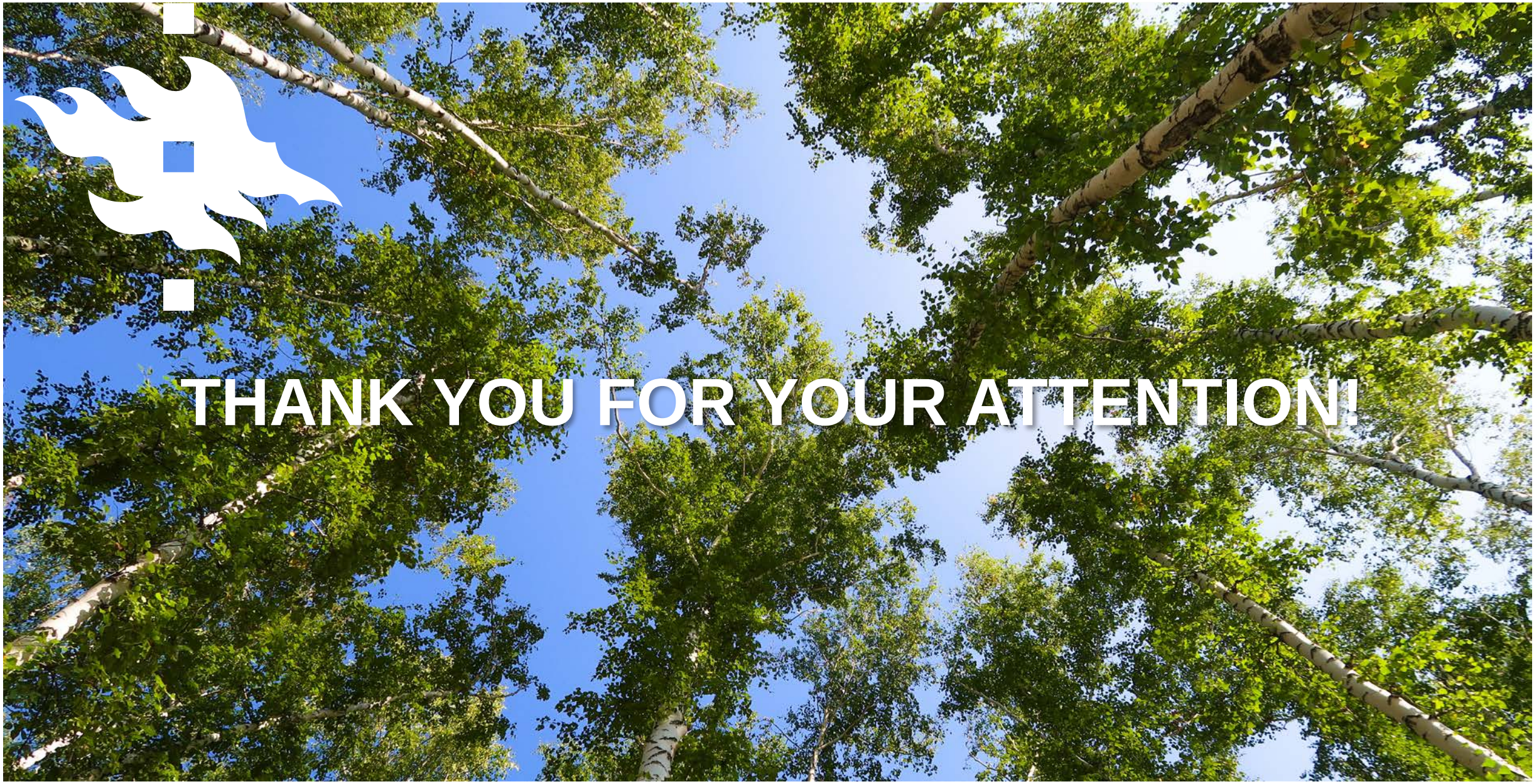
MEAN ANNUAL GROWTH IN FORESTRY REGIONS: SENTINEL-2





DISCUSSION & CONCLUSIONS

- Growth rate predictions are sensitive to initial state and site type
- Best accuracy does not necessarily lead to best predictions
  - Scale issues
- Ongoing research to improve results (ESA)
  - Forest variable estimation
  - Contribution of soil carbon => NEE
  - Detection of change in forest cover
  - European boreal region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