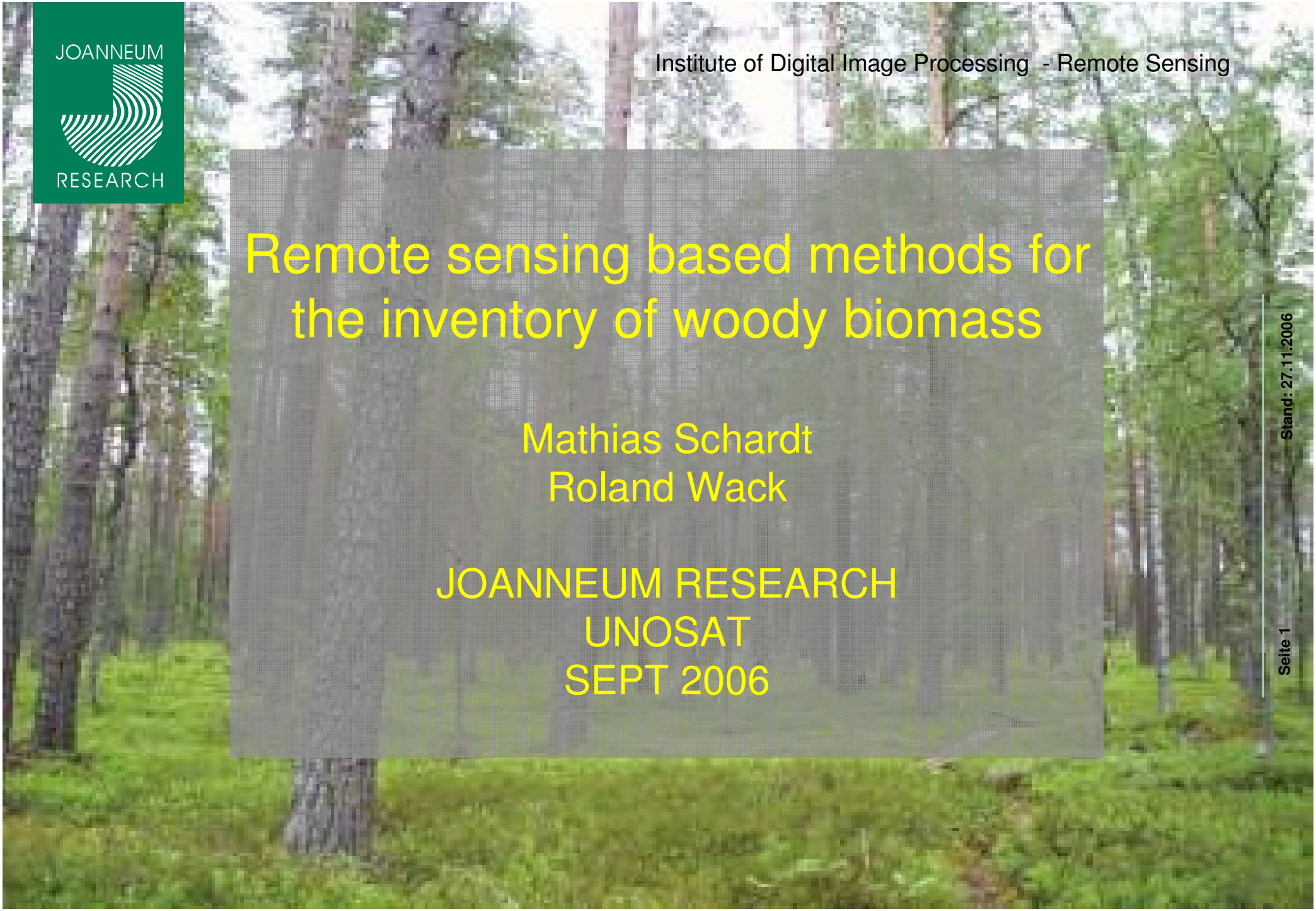
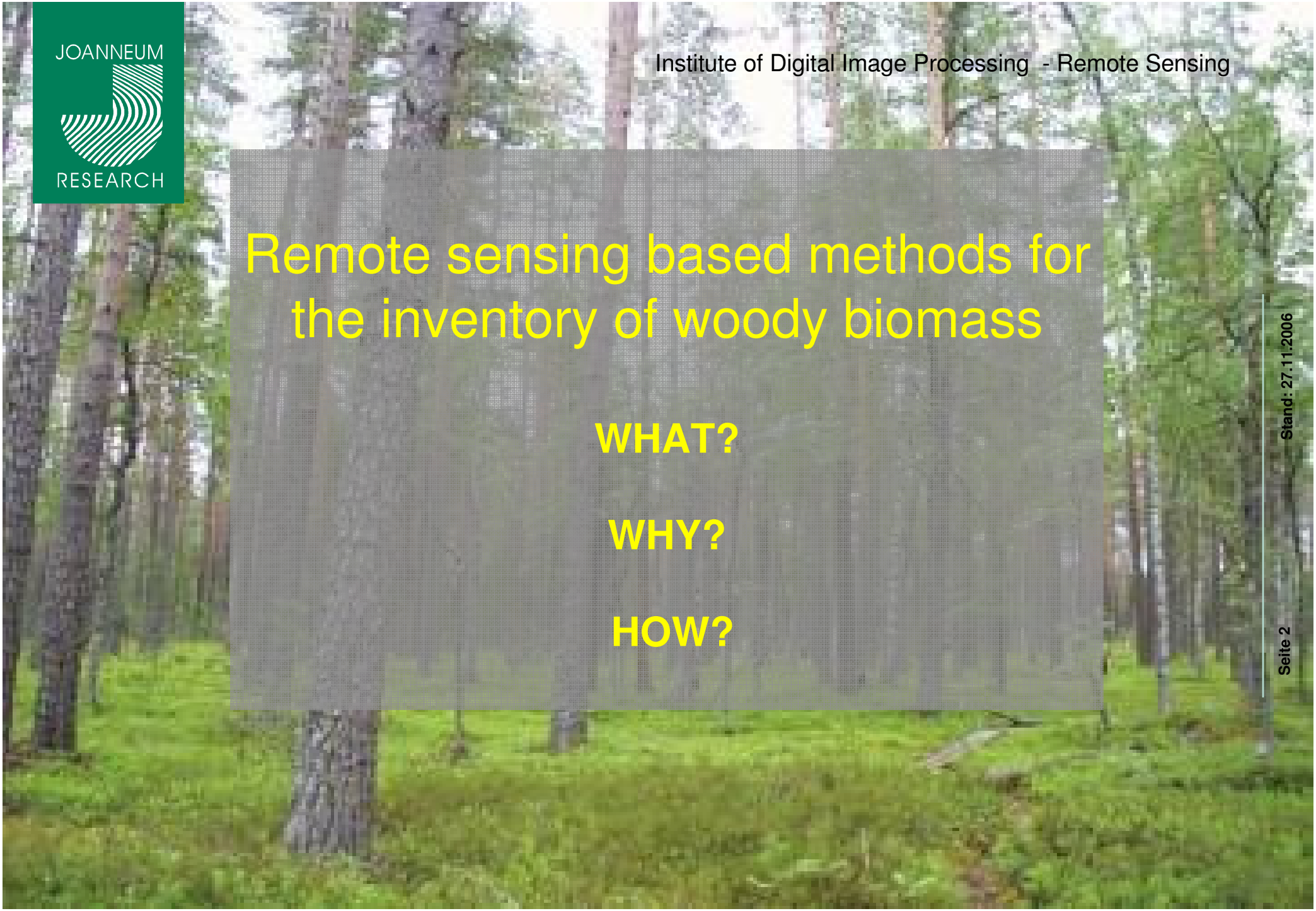


Remote sensing based methods for the inventory of woody biomass

Mathias Schardt
Roland Wack

JOANNEUM RESEARCH
UNOSAT
SEPT 2006



Remote sensing based methods for the inventory of woody biomass

WHAT?

WHY?

HOW?

WHAT ?

WOODY BIOMASS

„….is the trees and woody plants, including limbs, tops, needles, leaves, and other woody parts, grown in a forest, woodland, or rangeland environment“
(USDA Forest Service)

woody biomass * x = Carbon

WHY ?

WOODY BIOMASS

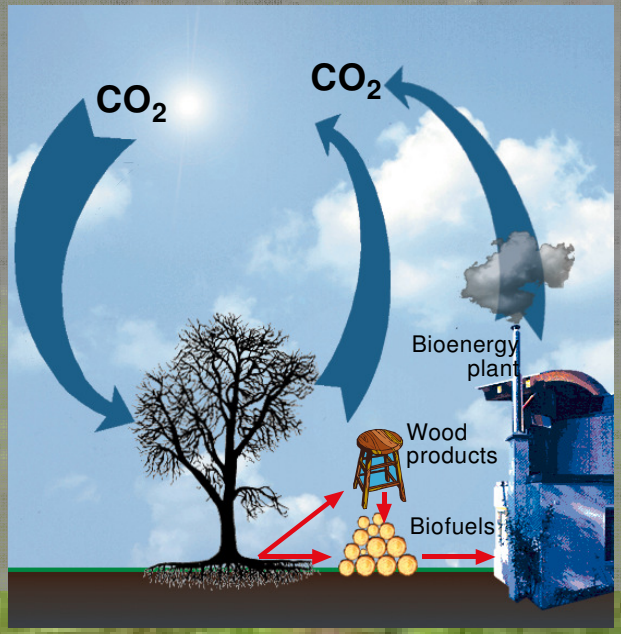
- carbon stock

  Kyoto Protocol – carbon balance reporting
  - natural carbon cycle : 60 G tC/a
  - possible absorption : ~ 1.5 G tC/a
  - current disruption : ~ 6.3 G tC/a

- Energy

  • Balance trade deficits
  • Bolster rural economics

  Austria: GDP 221 Bil €/a
  Energy 25 Bil €/a (11 %)



HOW ?

How much woody biomass to we have ?

Statistics

-> National forest inventory data
-> biomass expansion factors (bef)

Austria: ~ 11.000 plots
revisit: 10 years
costs: ~ 10 M€

Austrian C balance 1990

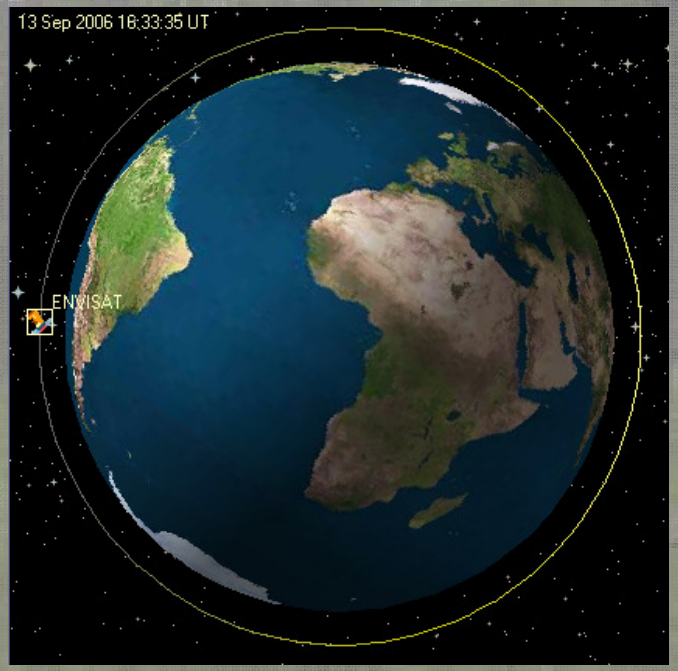
320 +/- 43 Mt C (biomass)
463 +/- 185 Mt C (soil)
(UBA)

HOW ?

Problems

-> spatial distribution ?
-> no NFI data available ?
-> costs
-> time

⇒ REMOTE SENSING !



(ESA - ENVISAT locater)

HOW ?

Remote sensing based methods for the inventory of woody biomass

Data sources

-> active sensors(RADAR, LIDAR), passive sensors (cameras)
-> airborne, spaceborne
-> scale

direct – indirect methods

HOW ?

Direct methods for the estimation of woody biomass

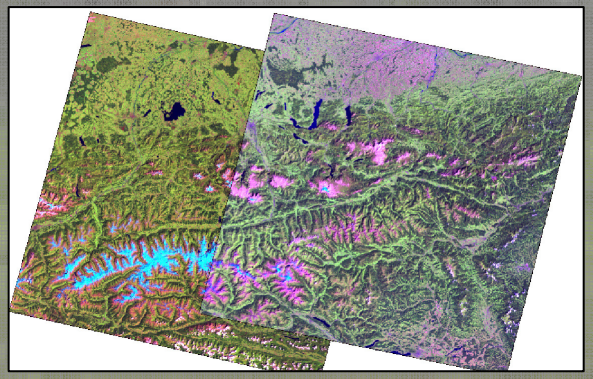
The signal characteristics are directly correlated with the woody biomass of the forest

- visible to midinfrared wavelength satellite imagery
- SAR - L band backscattering amplitude

Direct methods for the estimation of woody biomass

Example: visible to midinfrared wavelength satellite imagery (Eu-project CarboEurope)

- sample plots (e.g. NFI + BEF)
- classification / knn Method
- Satellite imagery (medium to low resolution)



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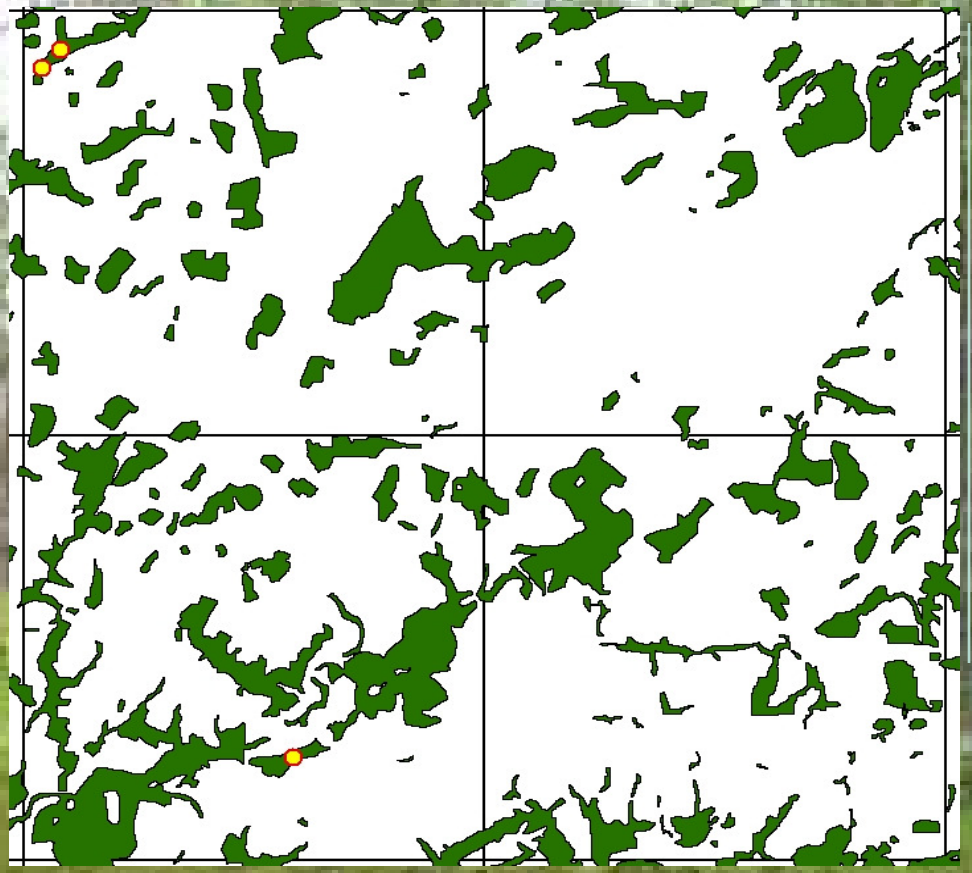
Landsat ETM – Satellite Imagery
National Forest Inventory – Plots: Yellow Circle

Forest – Non-Forest Classification - Result



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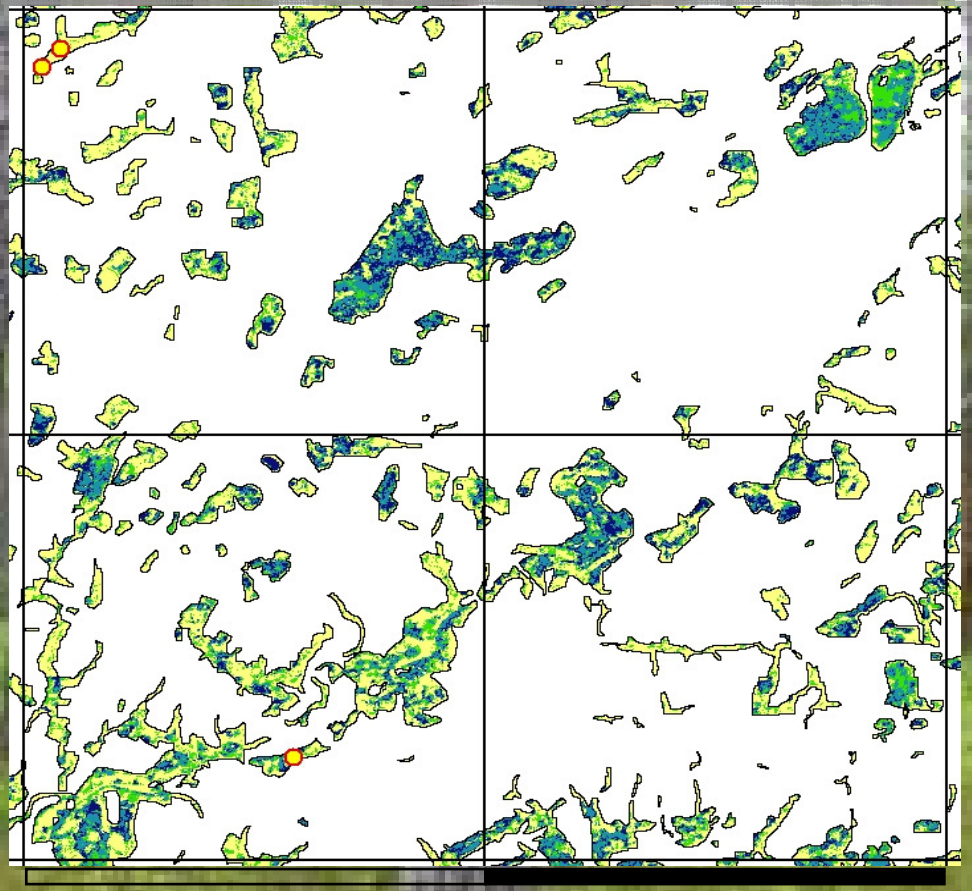
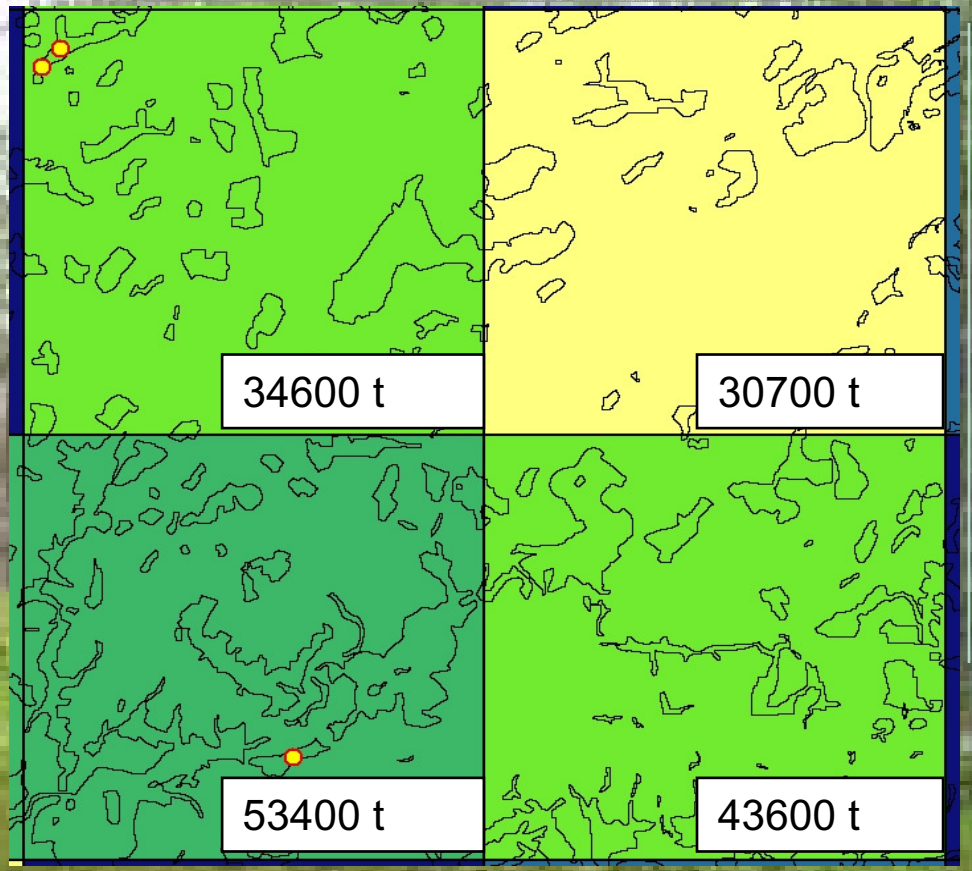
Forest biomass estimate
Pixel - Level



Forest biomass estimate
Eurogrid 5km by 5 km Raster



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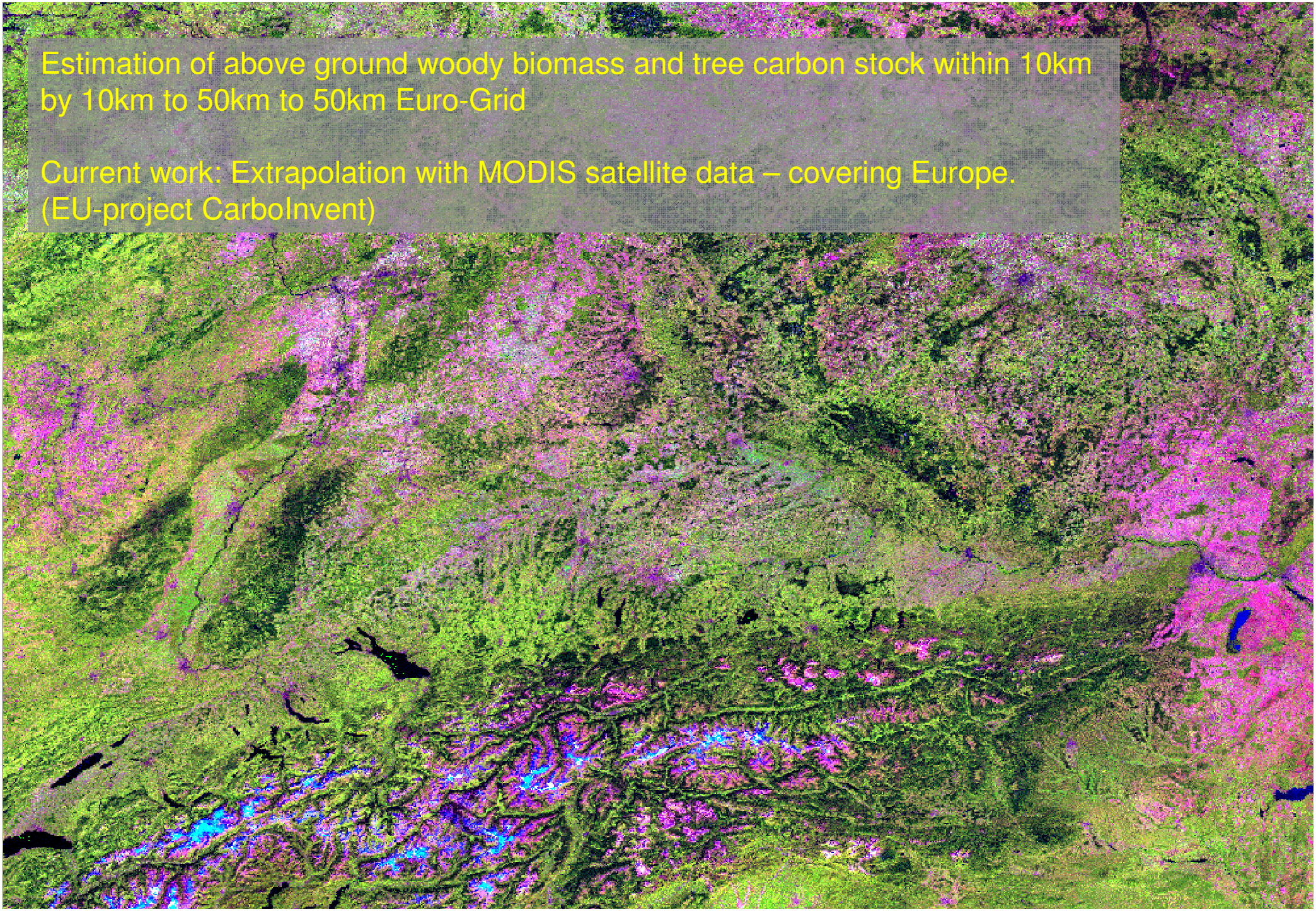
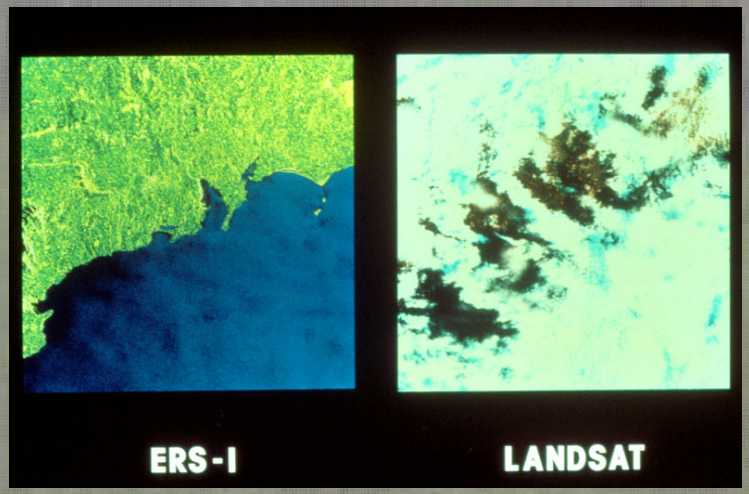
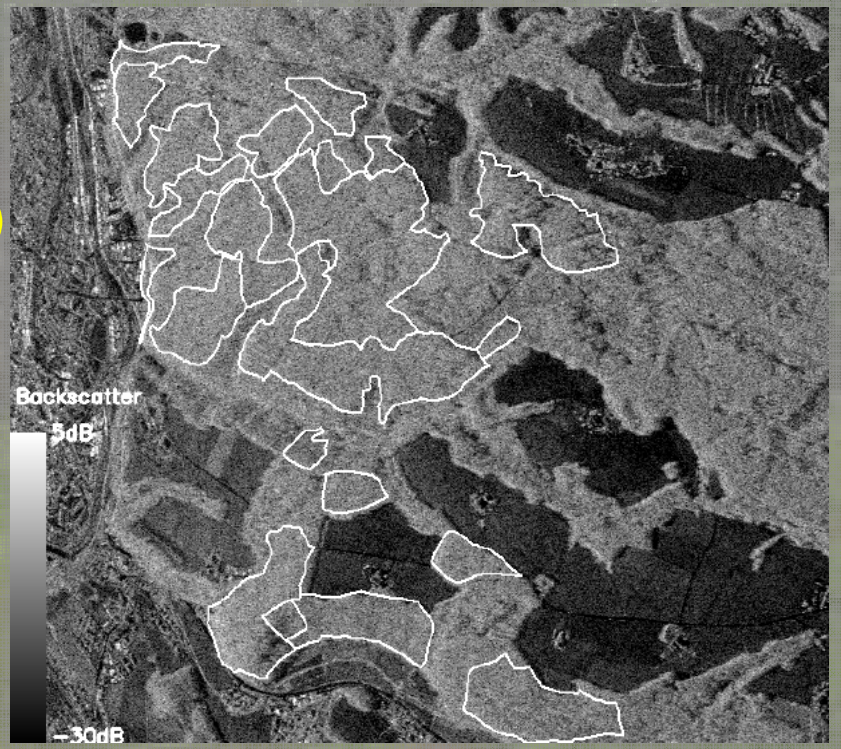

Estimation of above ground woody biomass and tree carbon stock within 10km by 10km to 50km to 50km Euro-Grid
Current work: Extrapolation with MODIS satellite data – covering Europe. (EU-project CarboInvent)

Direct methods for the estimation of woody biomass

Example: SAR - L band backscattering amplitude

- sample plots (e.g. NFI + BEF)
- classification / knn Method
- SAR L Band data
  - spaceborne: e.g. Jers
  - airborne: e.g. (E-SAR)

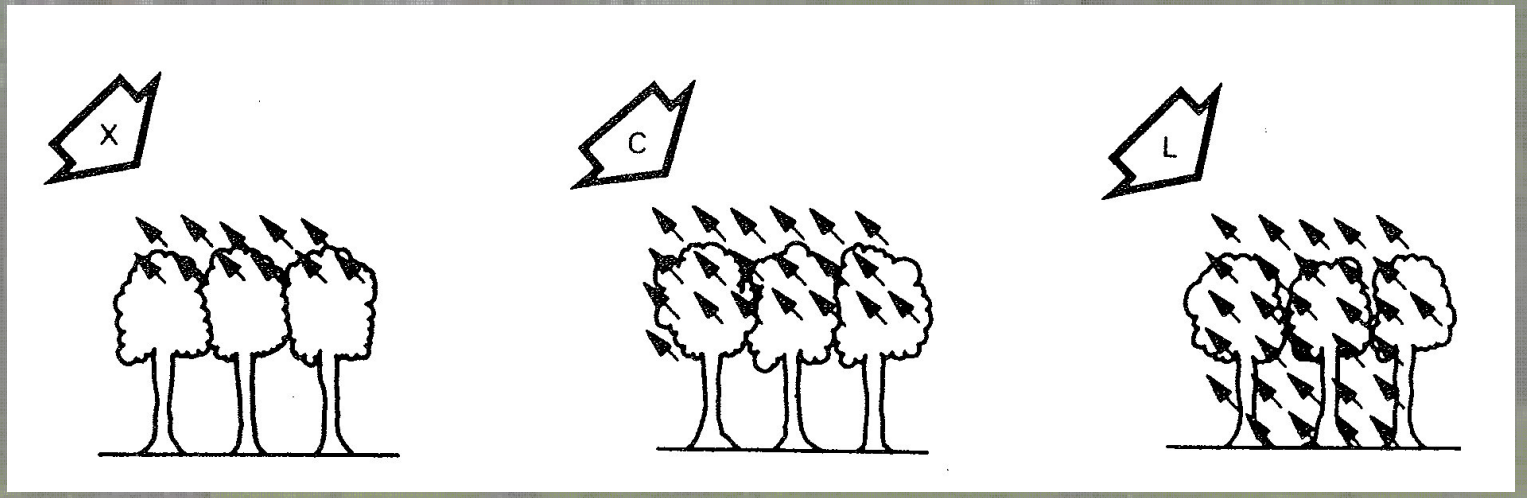




Direct methods for the estimation of woody biomass

Example: SAR - L band backscattering amplitude

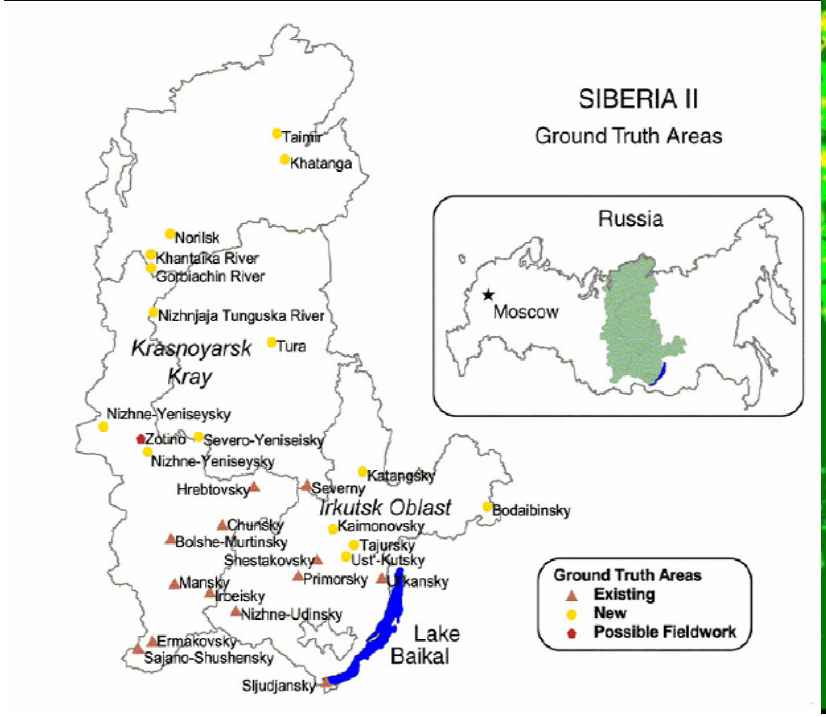
different wavelengths – different penetration



Application

SIBERIA II - Project

ASAR WS Biomass map (2004)



Schmullius (2004)

HOW ?

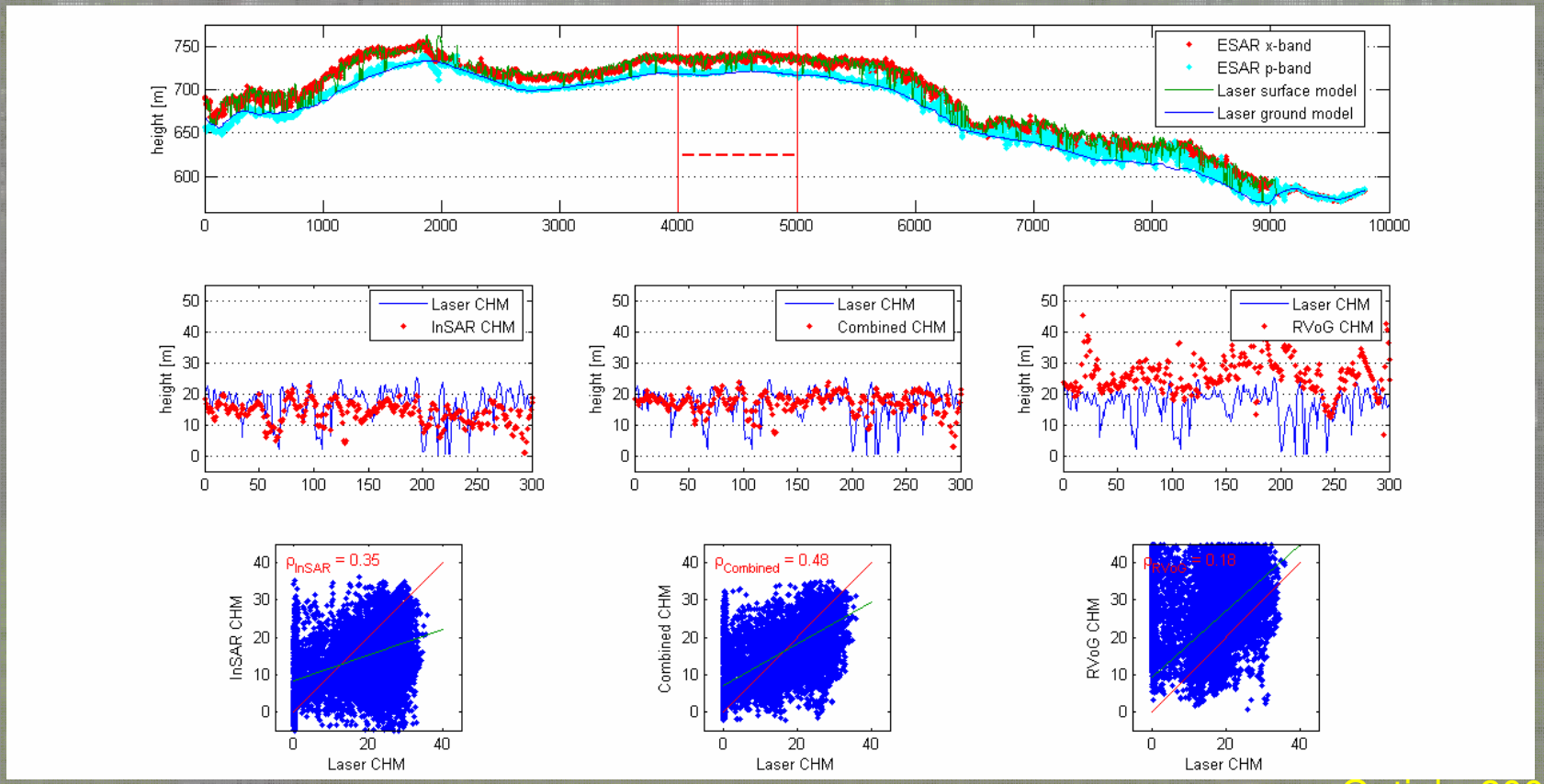
Indirect methods for the estimation of woody biomass

The biomass is estimated based on forest heights (allometry)

height = Digital surface model(DSM) - Digital terrain model(DTM)

- InSAR (x - band / P – band) or PoI InSAR (e.g. L-band)
- stereo satellite imagery
- airborne LIDAR

Direct methods for the estimation of woody biomass
InSar with X - band / P – band
Example - project MountainNet
test site Kobernausser forest



Gutjahr 2006

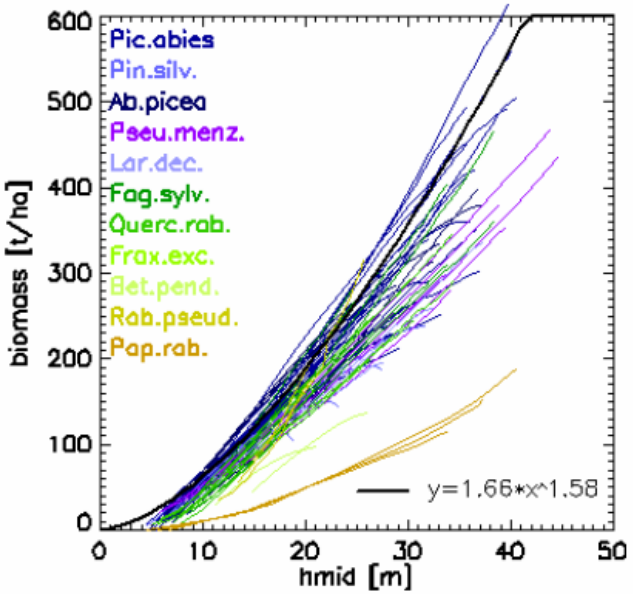
InSar with X - band / P – band

Allometry: height to biomass

$$Biomass = 1.66 \cdot height^{1.57}$$

Variability

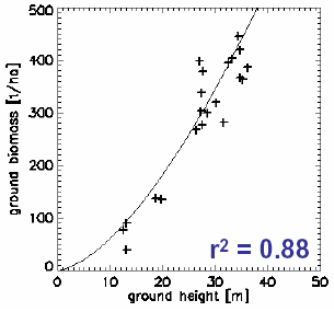
- ~15% site conditions
- ~20% between climax species, not poplar/birch
- unlimited reduction due to thinning/ management concept



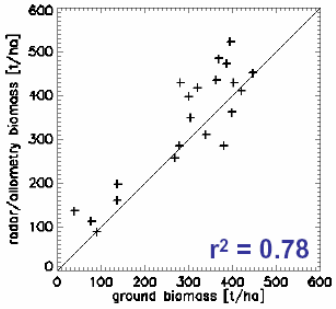
Mette 2006

InSar with X - band / P – band

Allometry: Pol-InSAR to biomass



Performance of height-biomass allometry from the ground measurements



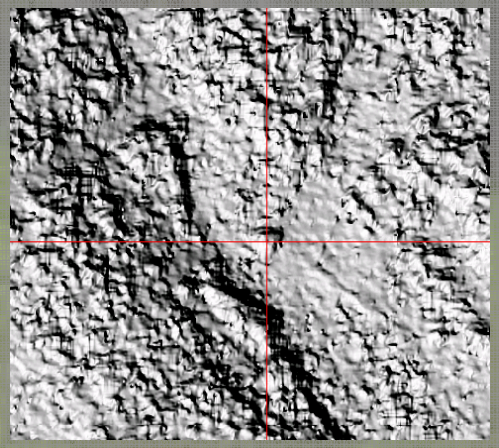
Biomass estimation from Pol-InSAR heights and an assumed height-biomass allometry

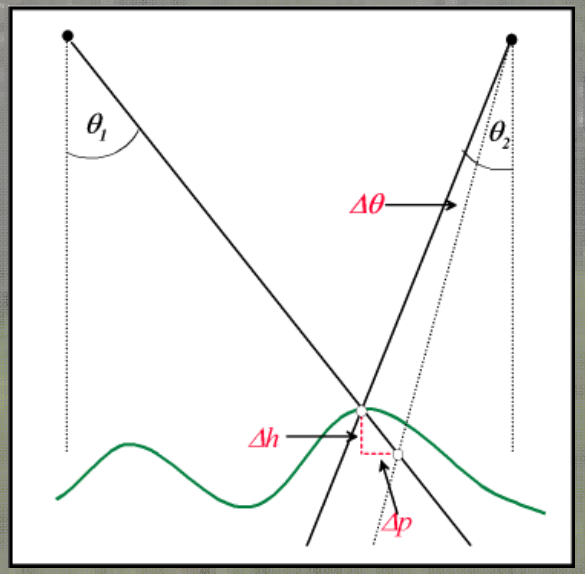
Mette 2006

Direct methods for the estimation of woody biomass

Example: stereo satellite imagery
EU project Fireguard

- high resolution stereo satellite imagery (Quickbird, Ikonos, SPOT V)
- generation of a DSM
- DTM via filtering





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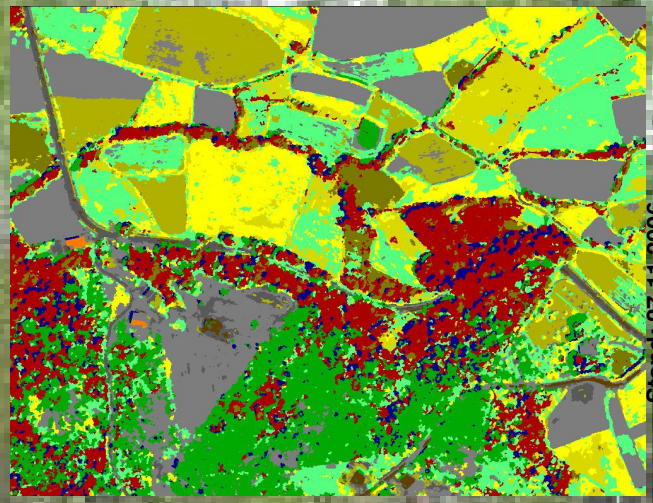
Vegetation height mapping

Surface model

Quickbird fused



Land use

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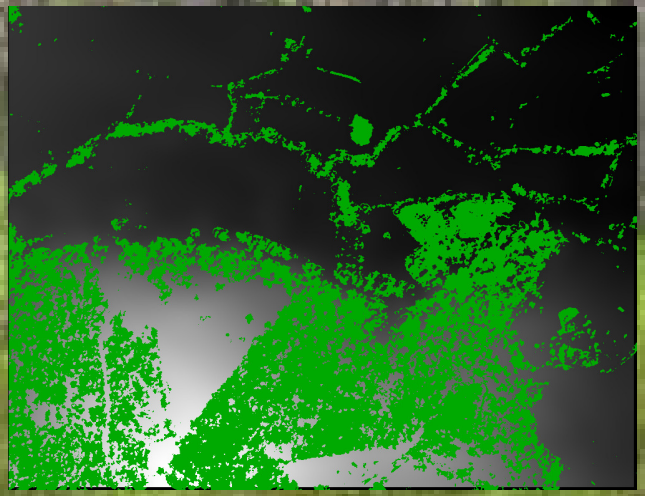
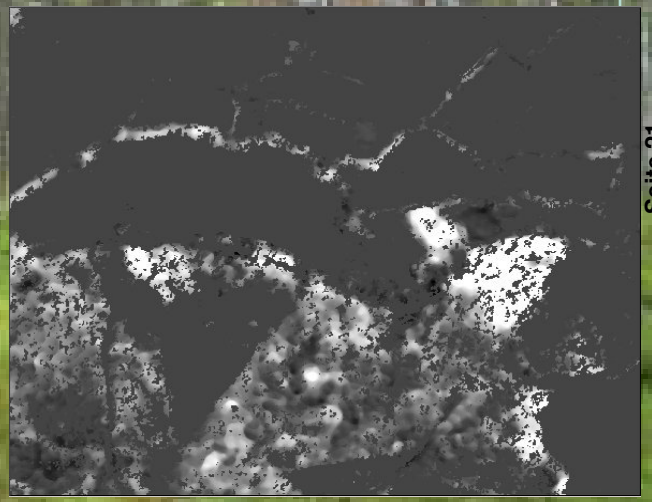
Ground model



Forest mask



Forest heights

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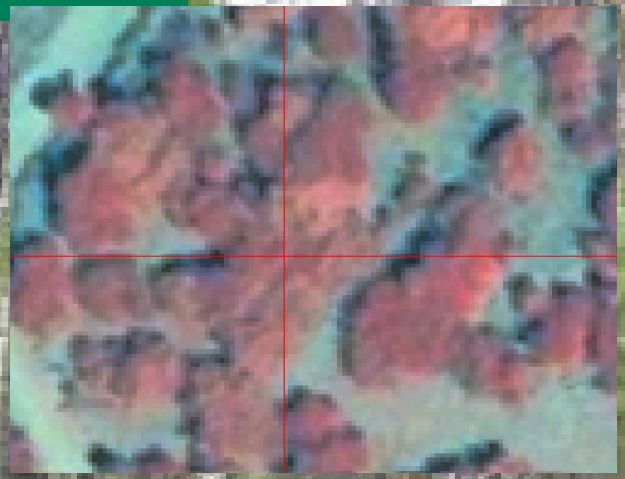
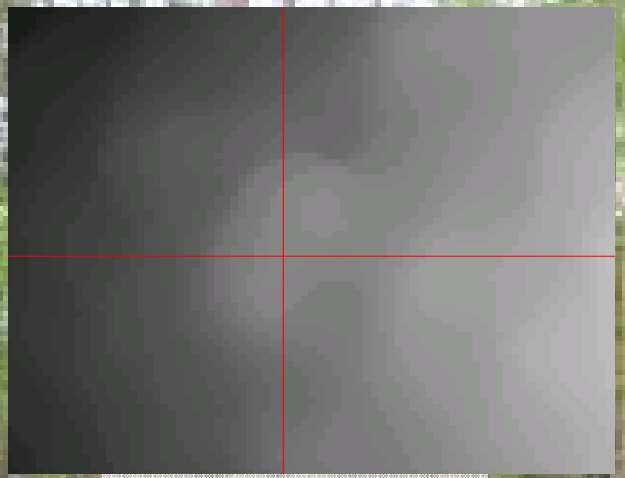
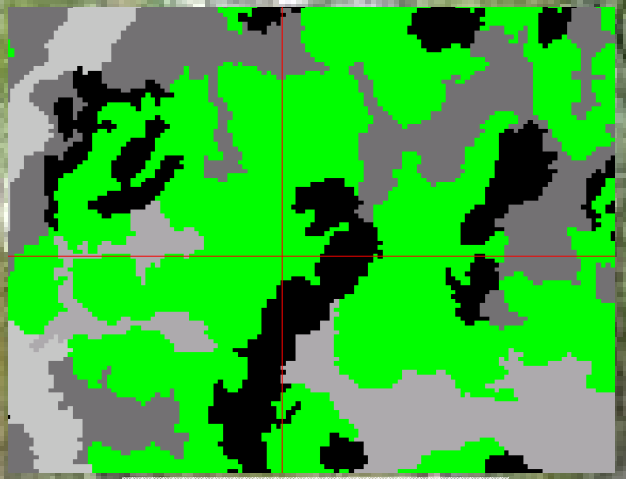
Biomass Estimation



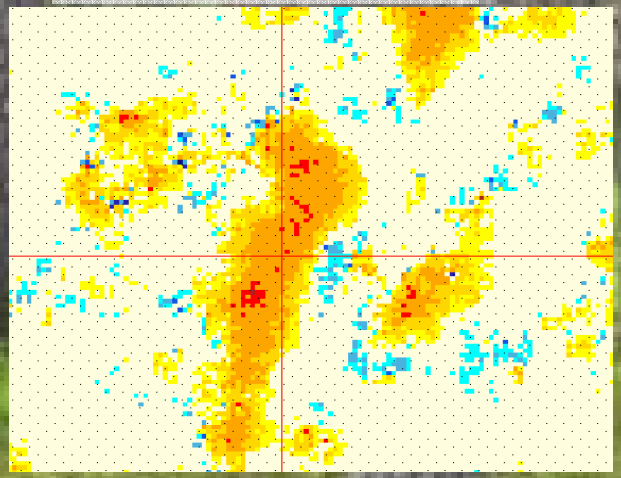
pansharpened



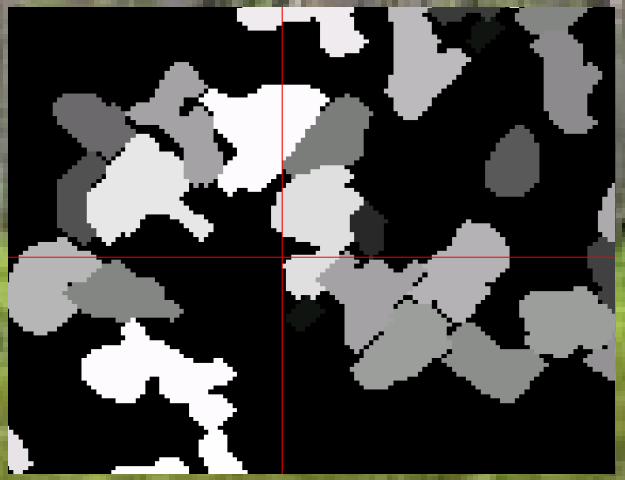
DSM



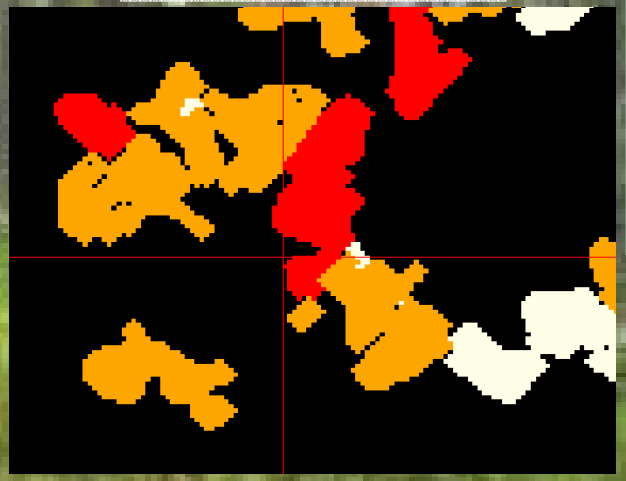
classification



vegetation (stereo)



segmentation



biomass

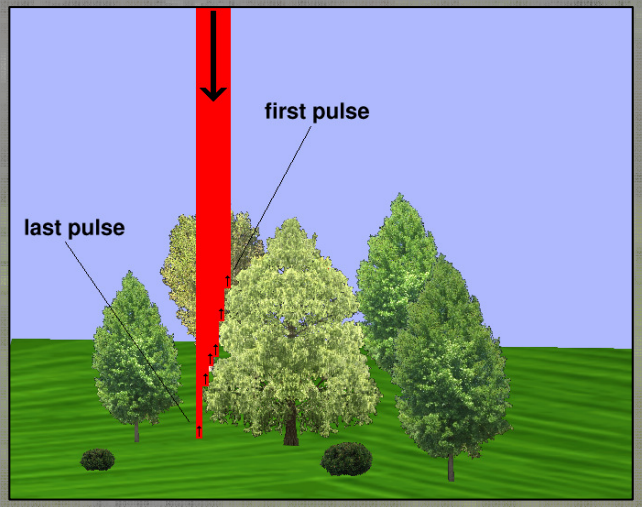
Stand: 27.11.2006

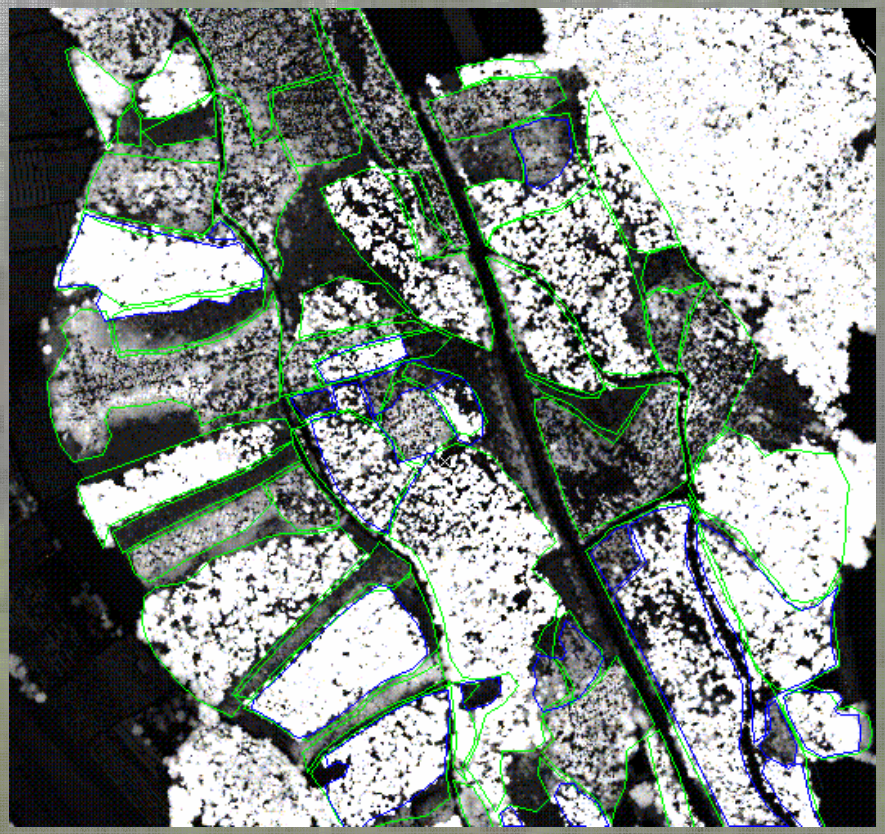
Seite 22

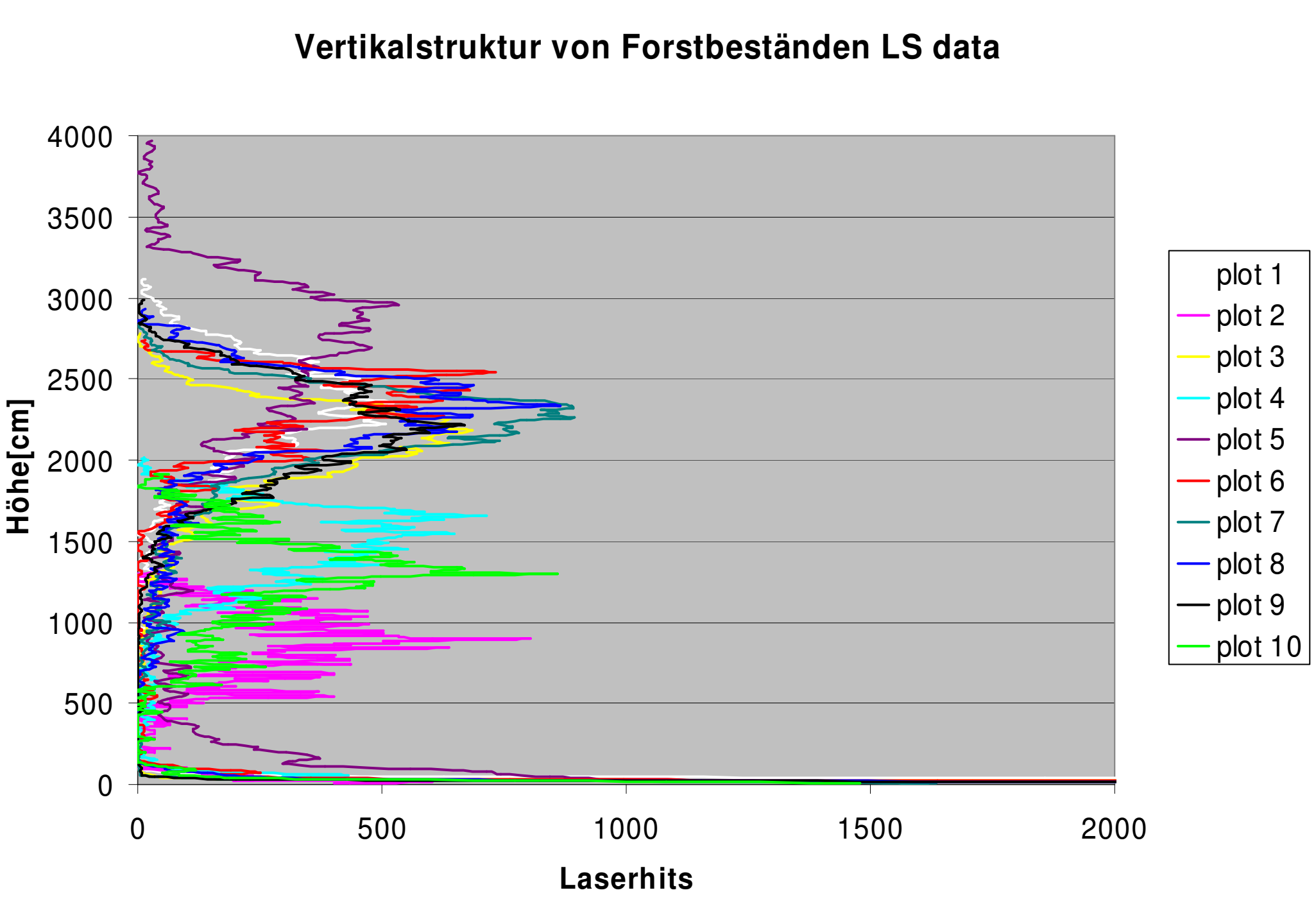
Direct methods for the estimation of woody biomass

Example: standwise small footprint LIDAR data ‚waveforms'

- airborne sensor
- laser pulses – 1pt/m²
- 3d point clouds






Vertikalstruktur von Forstbeständen LS data
Höhe[cm]
4000
3500
3000
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
Laserhits
plot 1
plot 2
plot 3
plot 4
plot 5
plot 6
plot 7
plot 8
plot 9
plot 10

Direct methods for the estimation of woody biomass

Example: standwise small footprint LIDAR data ‚waveforms'

results of a linear regression analyses based on sample plots

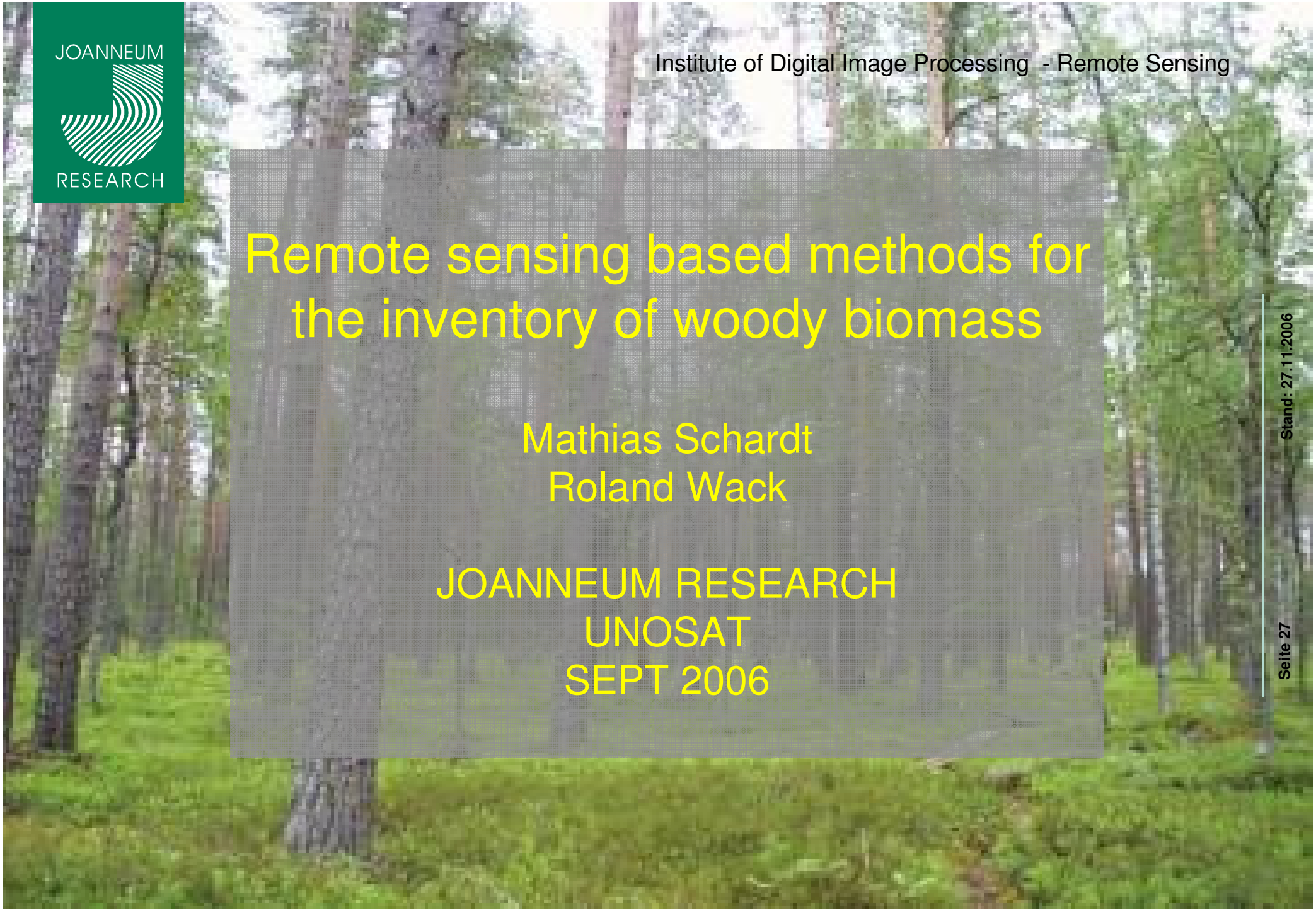
	all plots (43) [r^2 / rmse%]	coniferous only(33) [r^2 / rmse%]	over 50% deciduous (9) [r^2 / rmse%]
timber vol./ha	0,88 / 24 %	0,97 / 16 %	0,99 / 5 %
tree number/ha	0,93 / 21 %	0,96 / 15 %	0,93 / 30 %
basal area/ha	0,93 / 15 %	0,96 / 13 %	0,98 / 4 %
biomass/ha	0,96 / 14%	0,96 / 14%	0,99 / 4 %

SUMMARY

- direct methods
  - SAR (C and L - band) boreal forests
  - satellite imagery

- indirect methods
  - InSAR no spaceborne P band sensors
  - stereo data
  - LIDAR

scale
- single tree to Euro Grid 50 km
- coverage: regional to continent



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