Remote sensing based methods for the inventory of woody biomass

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JOANNEUM RESEARCH
UNOSAT
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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!
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
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)
Landsat ETM – Satellite Imagery
National Forest Inventory – Plots: Yellow Circle

Forest – Non-Forest Classification - Result
Institute of Digital Image Processing - Remote Sensing

Forest biomass estimate
Pixel - Level

Forest biomass estimate
Eurogrid 5km by 5 km Raster

0  5  10 km

34600 t  30700 t
53400 t  43600 t
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


Schmullius (2004)
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 Pol 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
Allometry: height to biomass

\[ \text{Biomass} = 1.66 \cdot \text{height}^{1.57} \]

Variability

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

Surface model

Quickbird fused

Land use

Ground model

Forest mask

Forest heights
Biomass Estimation

- pansharpened
- DSM
- classification
- vegetation (stereo)
- segmentation
- biomass
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]

Laserhits
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

<table>
<thead>
<tr>
<th></th>
<th>all plots (43) [r² / rmse%]</th>
<th>coniferous only (33) [r² / rmse%]</th>
<th>over 50% deciduous (9) [r² / rmse%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>timber vol./ha</td>
<td>0,88 / 24 %</td>
<td>0,97 / 16 %</td>
<td>0,99 / 5 %</td>
</tr>
<tr>
<td>tree number/ha</td>
<td>0,93 / 21 %</td>
<td>0,96 / 15 %</td>
<td>0,93 / 30 %</td>
</tr>
<tr>
<td>basal area/ha</td>
<td>0,93 / 15 %</td>
<td>0,96 / 13 %</td>
<td>0,98 / 4 %</td>
</tr>
<tr>
<td>biomass/ha</td>
<td>0,96 / 14%</td>
<td>0,96 / 14%</td>
<td>0,99 / 4 %</td>
</tr>
</tbody>
</table>
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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