



Precise Measurements of Peatland Topography and Tree/Canopy Height with a High-Resolution Airborne Laser-Scanner to calculate Carbon- and Bio-Mass

by

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presented at Global Carbon Science-Workshop, Pekanbaru, Sumatra, Indonesia, 24-26. Jan 2006

Content

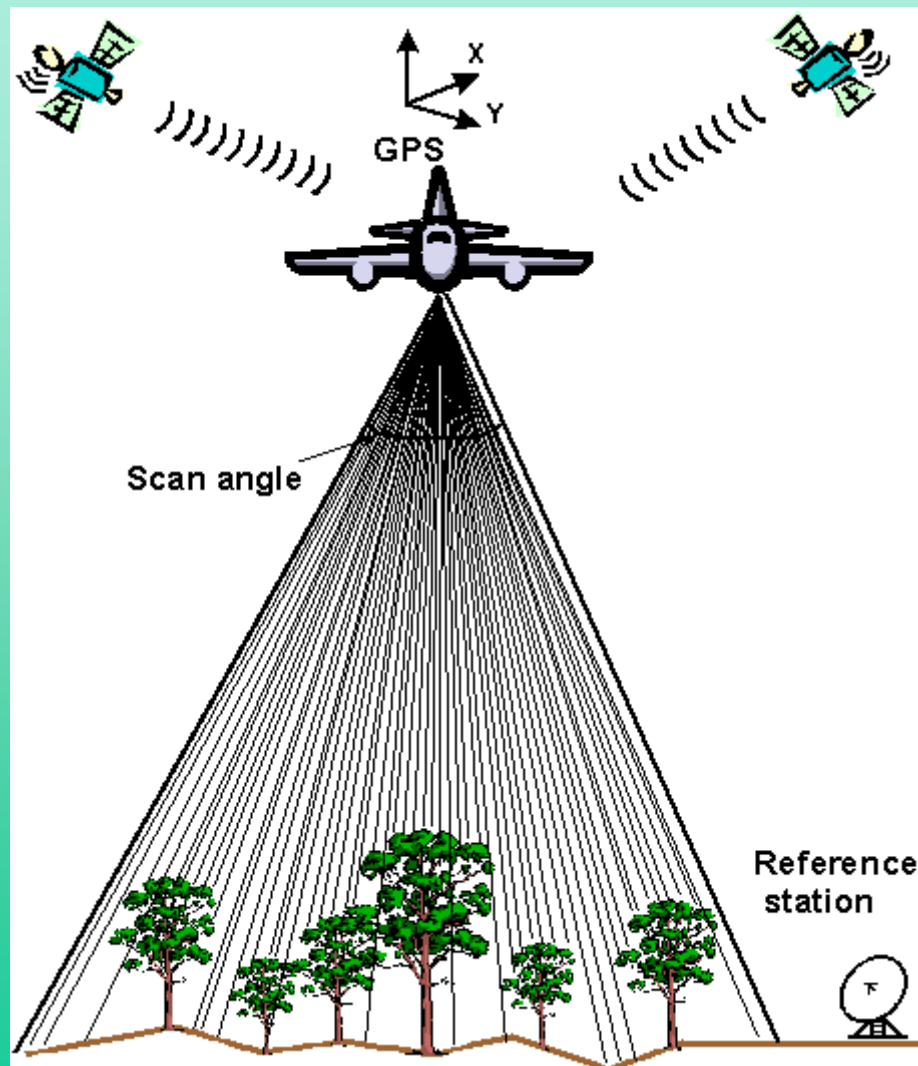
Precise Measurements of Peatland Topography and Tree/Canopy Height with a High-Resolution Airborne Laser-Scanner

- Applications of airborne Laser-Scanner for peatland
- Logging and illegal logging
- 3D Measurements with Laser Scanner, DEM, DSM, DTM
- Peatland Hydrology with DTM + Carbon Precise Measurements
- Project: Land cover and use of Peatland north of Sebangau
- Way ahead

**High-Resolution Airborne Laser-Scanners (ALS)
installed in Helicopters or Fixed Wings
have increased the z-Range-Resolution (height)
Measurement to a Value
of better then 0.15m
(Including all corrections)
over the last Ten Years.**

Airborne Laser-Scanner, EU - High-Scan Project:

Aug-1998 – Aug-2001



The main objective of the **HIGH-SCAN** project was to explore and test methods of laser scanner for small-area (regional and stand-wise) at the retrieval of the following **forest attributes**:

1. Timber Volume [m^3/ha]
2. Tree Species Proportions
3. Mean Tree Height
4. Stand Density/Basal Area
5. Structure of natural Age Classes
6. Soil Type and Fertility Classes
7. Crown Area, and
8. Stand Boundaries.

With airborne Laser-Scanner precise, dense and geo-referenced 3D-measurements (x, y and z) demanding applications are now possible, such as:

- Forest Inventory and Bio-Mass Monitoring of PSF;**
- Inventory of Precise Topographic Maps and Land Use Mapping**
- Finding Illegal Logging Activities including Channels**
- Flood Plain Mapping and Costal Monitoring**
- Peat Growth and Peat Loss measurement (Multi-Temporal)**
- Peatland Hydrological Simulations and Hydrological Models**

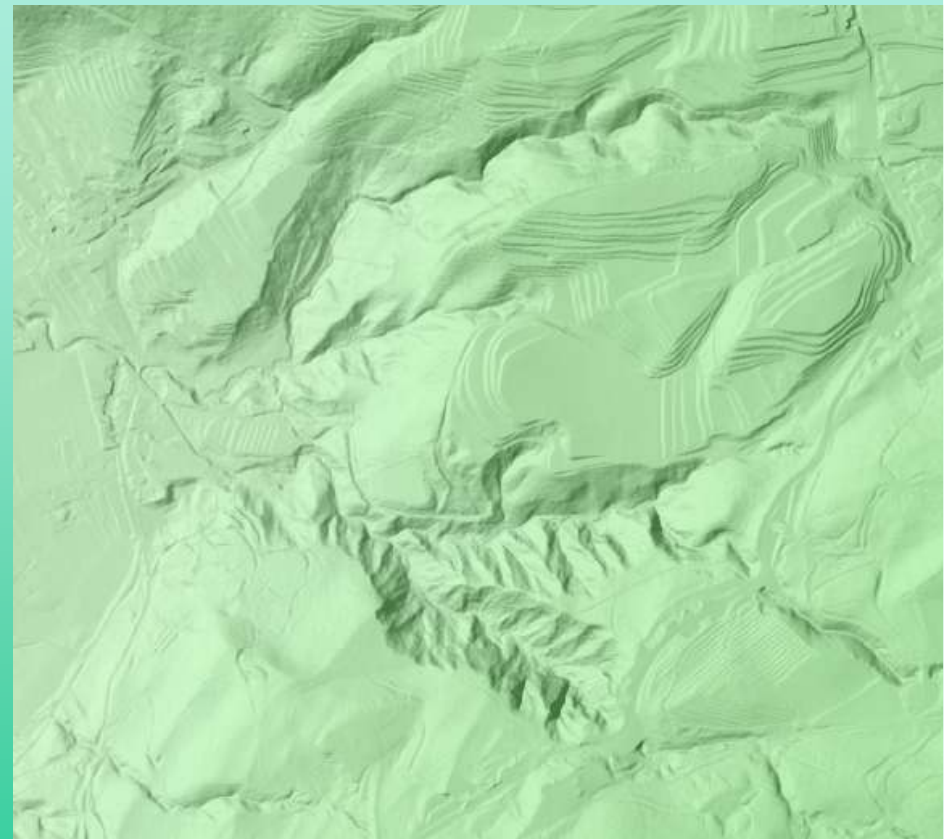
Airborne Laser-Scanner applications, continuation:

- **Urban, Pipelines and Wireless Network Planning and City Models**
- **Power Line and Power Pole Mapping and Forest Growth Monitoring near Power Lines**
- **Monitoring of Disposals and Mines**
- **Archaeology and Change Detection**
- **Environmental Protection, Disaster Management, Erosion Measurements**
- **Calibration of Airborne or Satellite SAR Products**

Laser-Scanner Standard Products

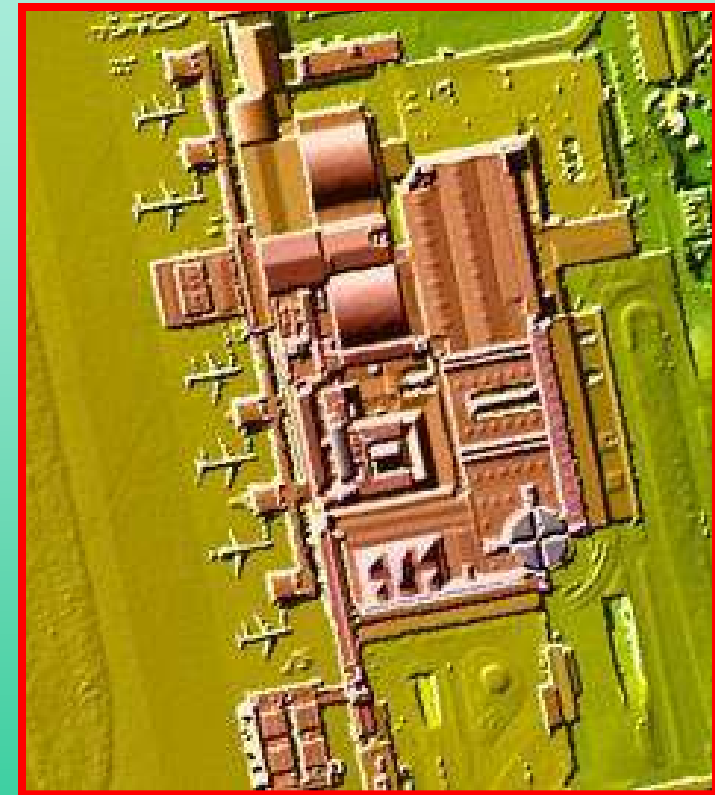


Digital Surface Model (**DSM**) derived from Laser Scanner raw data with forests and buildings



Digital Terrain Model (**DTM**) derived from Laser Scanner raw data showing the relief and topography

3D-City DSM-Model



Airport Lisbon

1 m raster DSM,
area about 1 km²

Application – Flood Simulation – Viewwaldstätter See – Hydrological Model



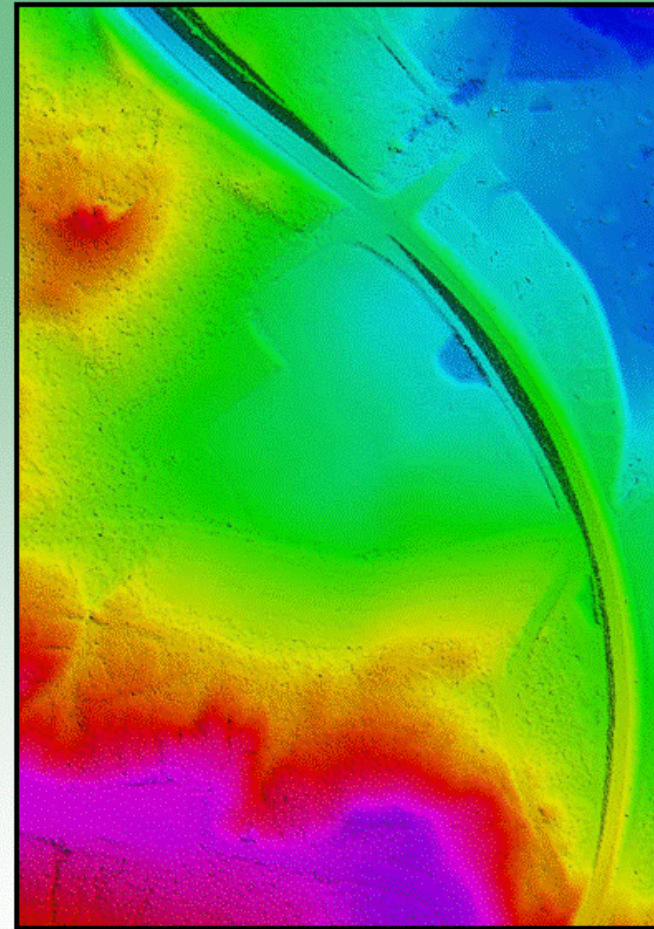
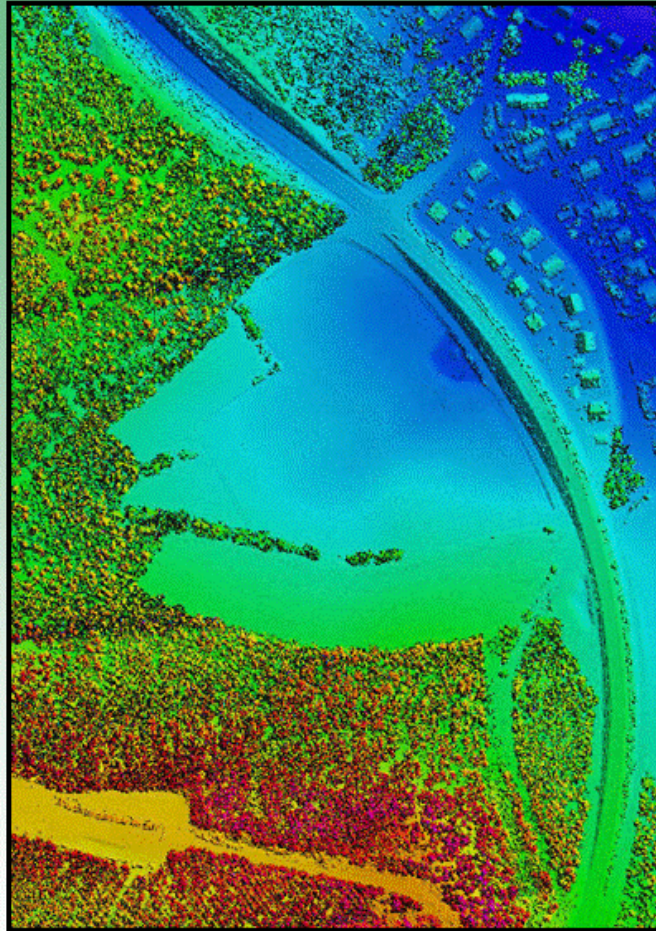
3D-DSM Models

Harbor of Hamburger Airbus Industries near the River Elbe with Dikes



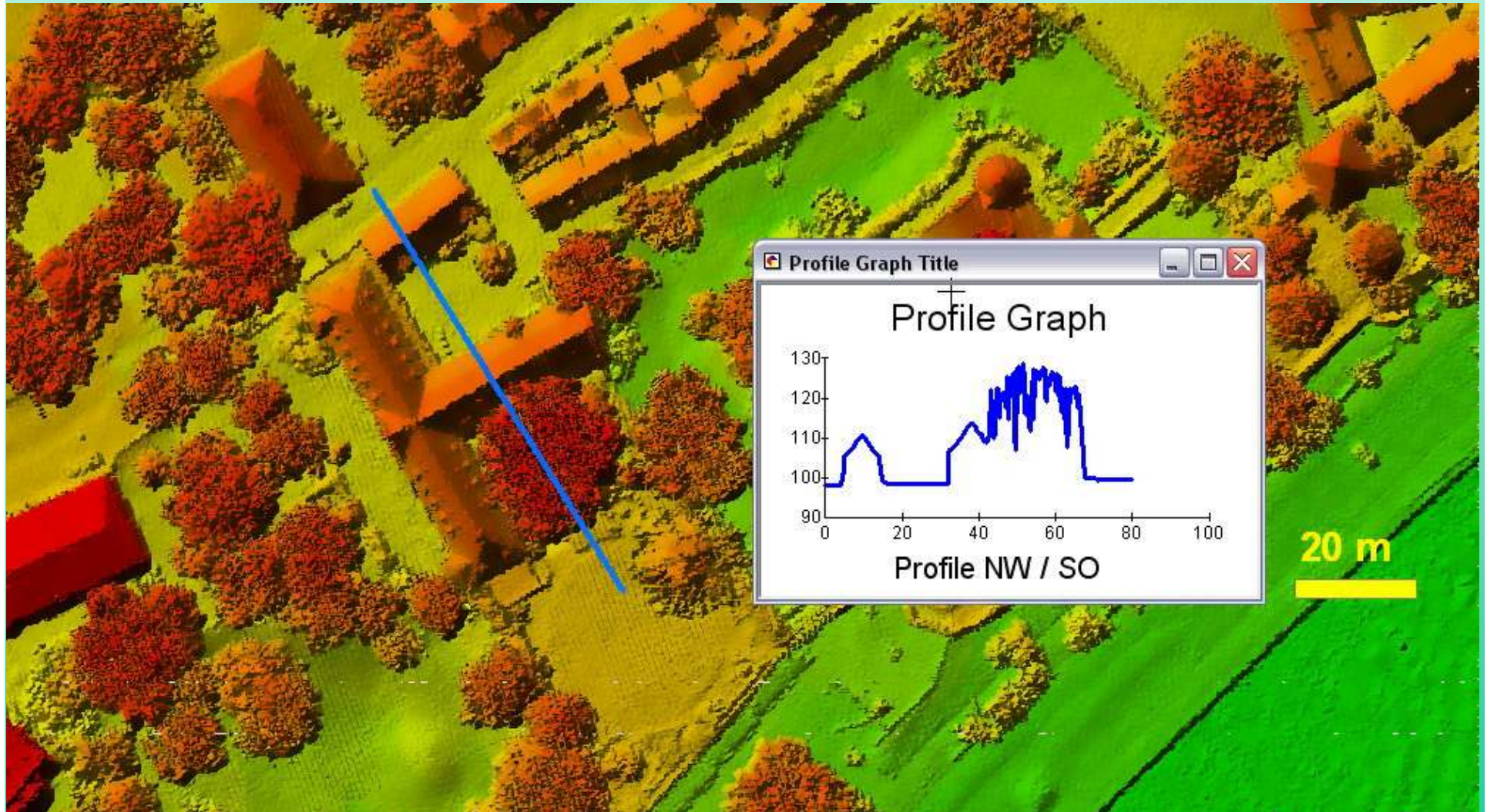
DSM and DTM

ALS50



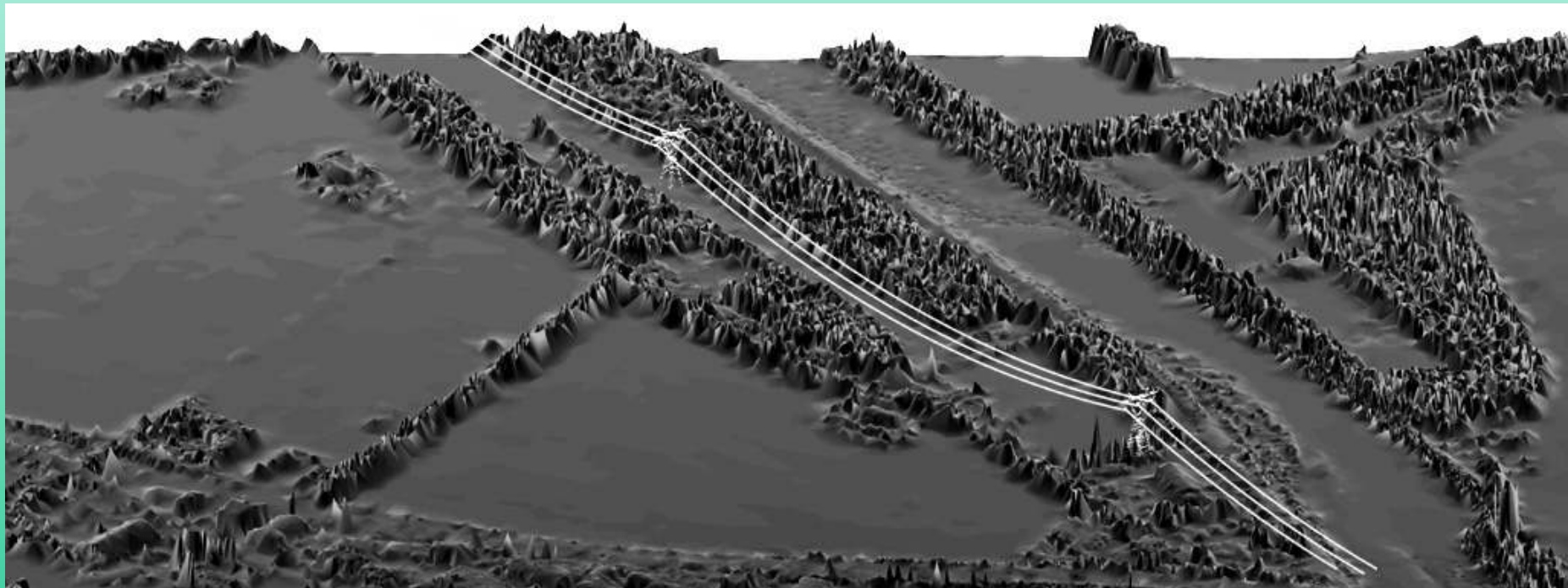
Augsburg, Germany 1,7 measurements/m²

terra
digital 



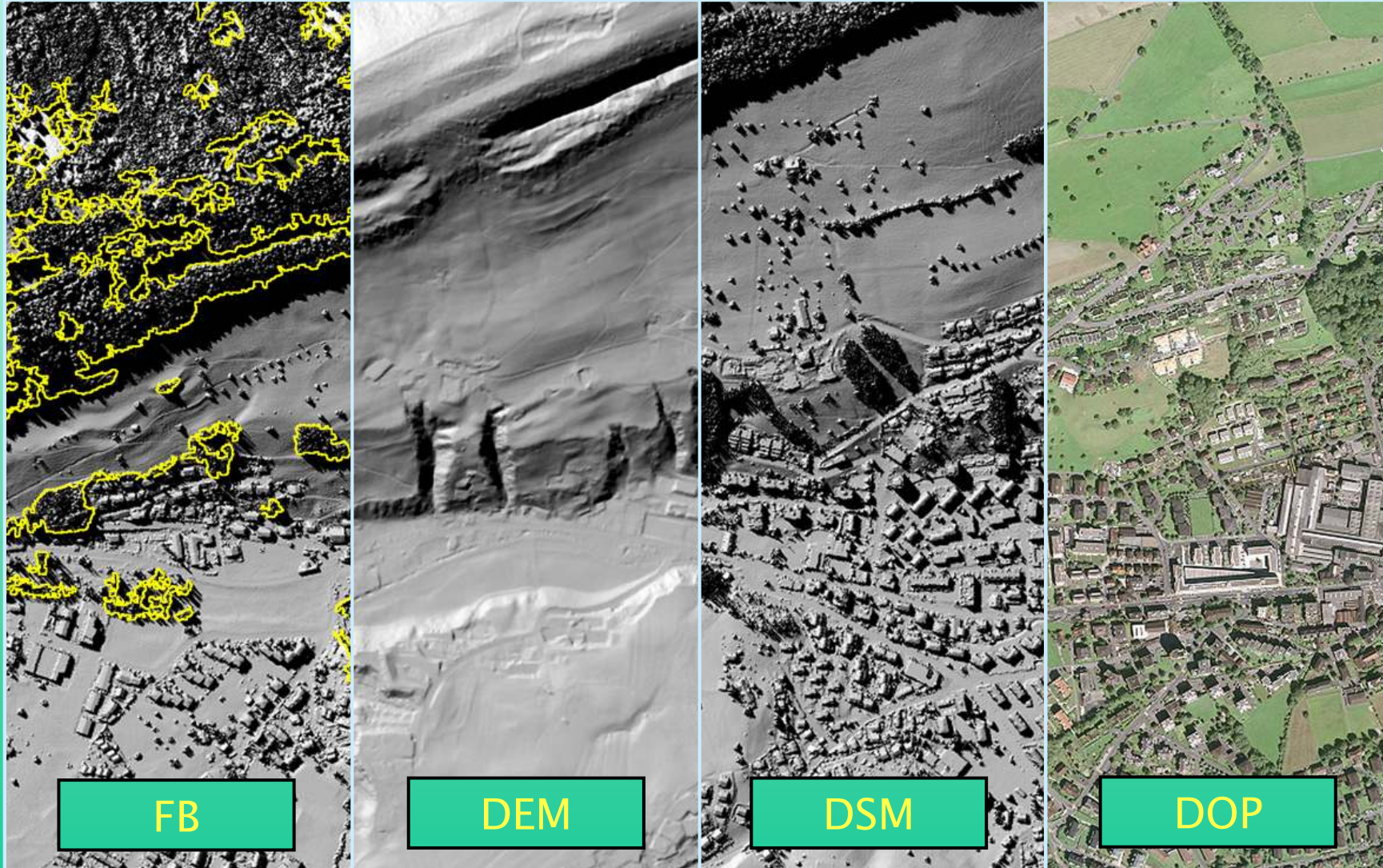
DSM taken with ALS50 from Leica

3D- DSM-Model with forestry



Digital Surface Model (DSM) in perspective view, not coloured

Base products Laserscanning (Swiss Project)

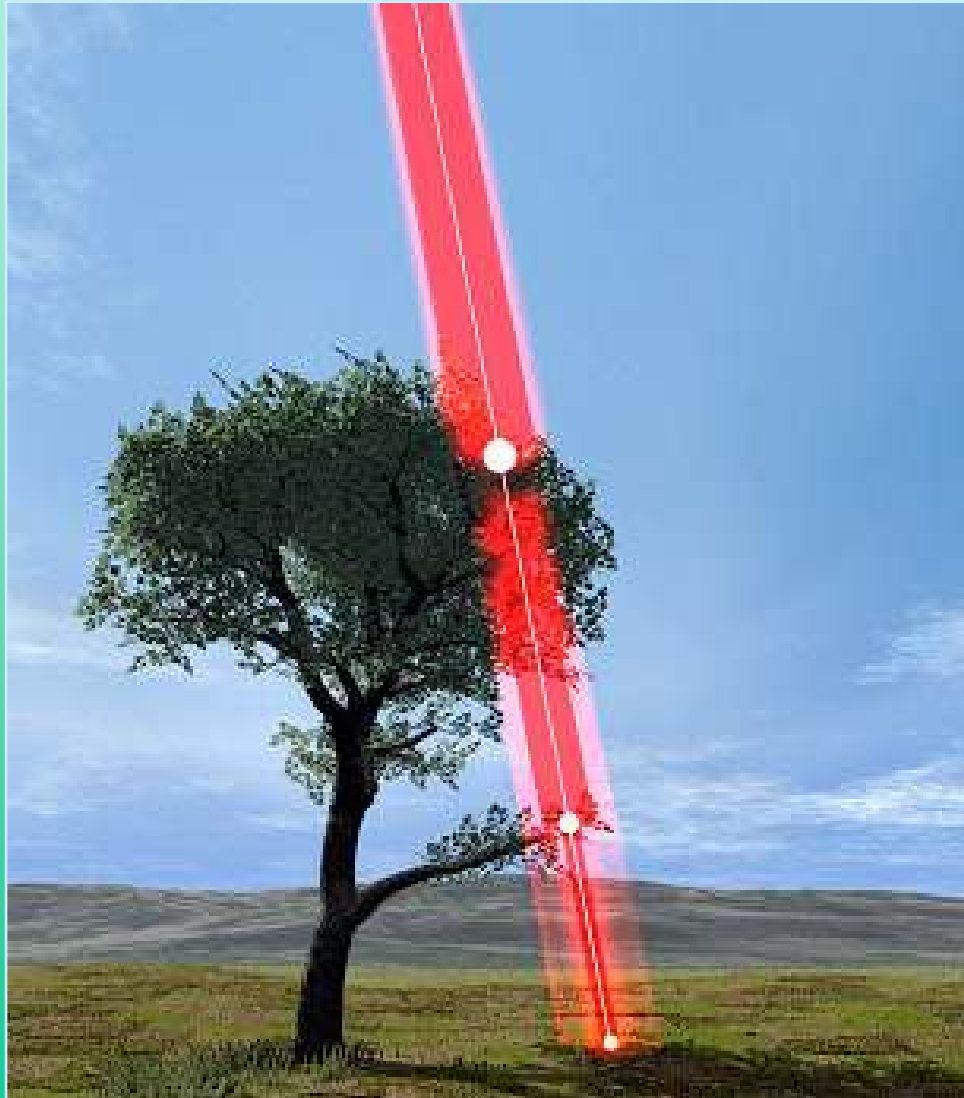


Application – Digitizing Forestry Roads



**Application
for
Monitoring
Illegal
Logging
Roads
and
Channels
in Peatlands**

3D- DSM/DTM-Model for forestry

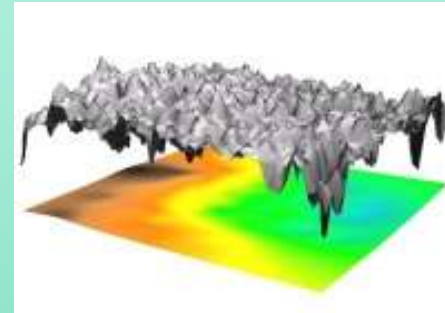


Tree Height Measurement
with First (FE),
Medium and
Last Laser Echo (LE)
or

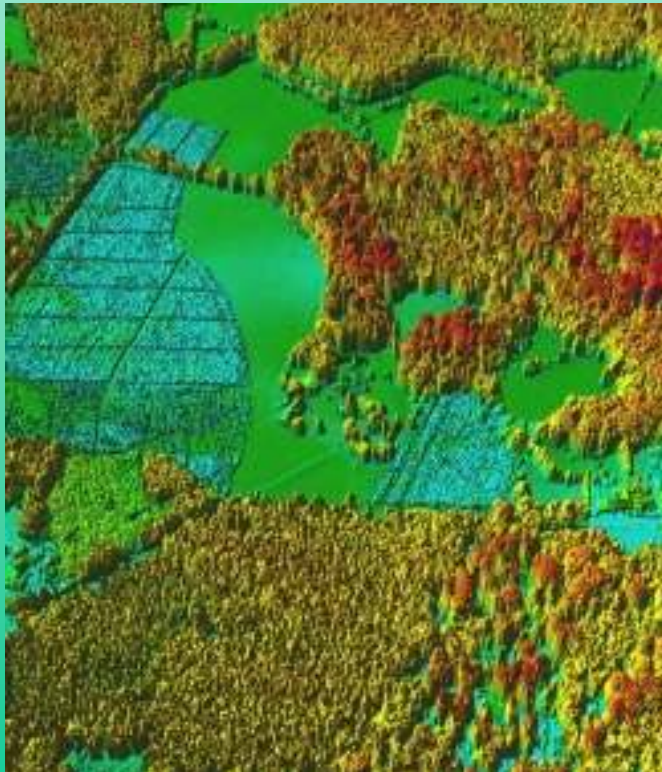
with
Full Waveform Digitization

Digital Elevation Model (DEM) for Forest Management

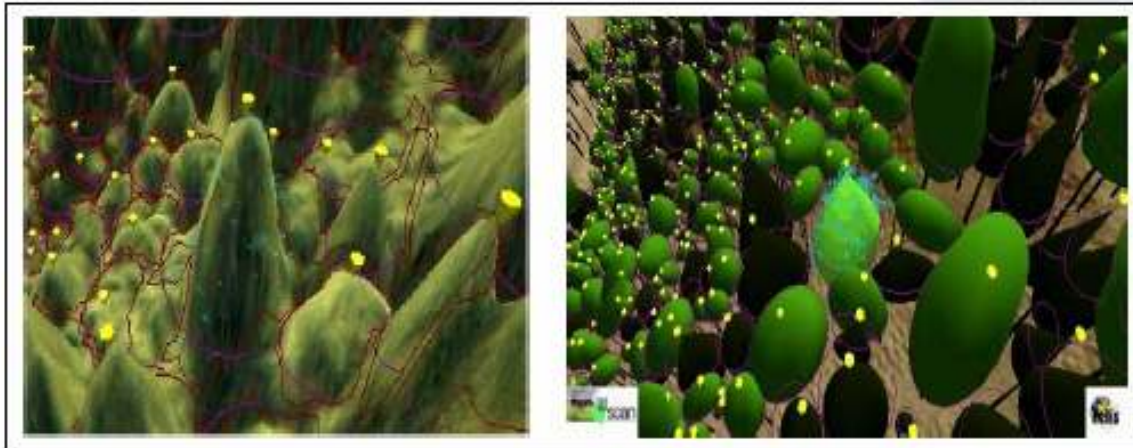
Proposal for forest height measurement with an eye safe Airborne Laser Scanner to procure accurate 3D-Information: DSM (below), DTM (small image)



Canopy Inform.
Ortho Image



TOPOSYS Canopy measurement with Airborne Laser Scanner



**New TreesVis-SW realised
within NATSCAN-Project**

Proposal for forest height
measurement with an eye safe
Airborne Laser Scanner to
procure accurate 3D-Models
for the Tropics

The standard products of the TopoSys Falcon system, the **Digital Surface Model (DSM)** and **Digital Terrain Model (DTM)**, several application-oriented data products such as canopy models, multiple echo difference models and volumes are easily generated. In addition to that, the following stand- and tree related parameters can be extracted directly from the laser scanner data:

- Height of single trees and forest stand
- Segmentation of single trees and crown diameter
- Number of trees and density of stand
- 3D coordinates of tree tops
- Classification in deciduous trees and conifers

Furthermore, diameter at breast height, timber volume, timber growth and species of trees can be accurately appraised.

TOPOSYS Canopy measurement with Airborne Laser Scanner



**New TreesVis-SW realised
within NATSCAN-Project**

Proposal for forest height
measurement with an eye safe
Airborne Laser Scanner to
procure accurate 3D-Models
for the Tropics

For forest inventories and management customer can benefit from:

- Cost efficient acquisition of precise laser and image data at the same time
- Easy extraction of forest-related parameters from laser and image data
- Analyses for single trees as well as for complete forest stands
- High resolution basic data set for extrapolation and change monitoring
- Easy integration in forest information systems and imaging software
- Effective tools available for visualization and forest-specific analysis of data

Laser-Scanner Standard Products

Digital Surface Models (DSM)

0.5, 1.0, 3.0 and 5.0 meter resolution

Res. 1:2,500; 1 :5,000, 1:15,000 and 1:25,000

Digital Terrain Models (DTM)

0.5, 1.0, 3.0 and 5.0 meter resolution

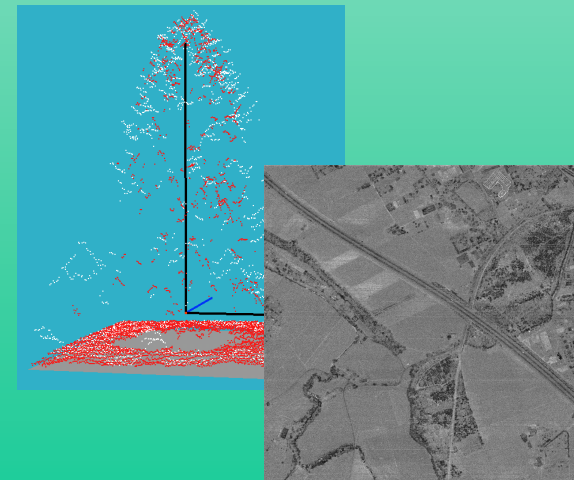
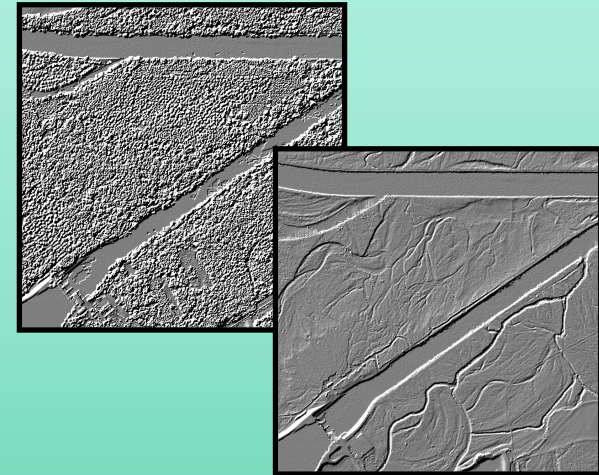
Res. 1:2,500; 1 :5,000, 1:15,000 and 1:25,000

Laser data point cloud

First echo data (FE)

Last echo data (LE)

Intensity



Laser-Scanner Standard Products

True ortho images as option
0.25 to 1.0 meter resolution

RGB



CIR



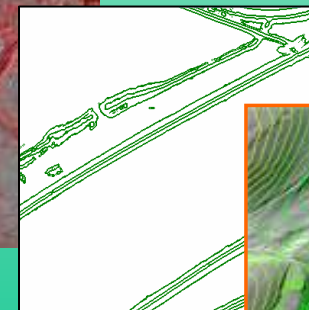
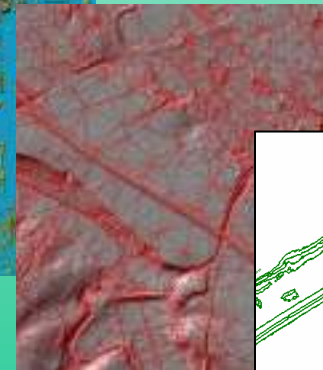
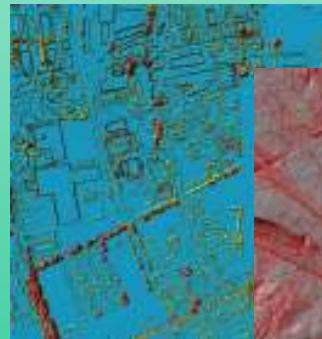
Derived products

Difference models

TIN's

Breaklines

Contours



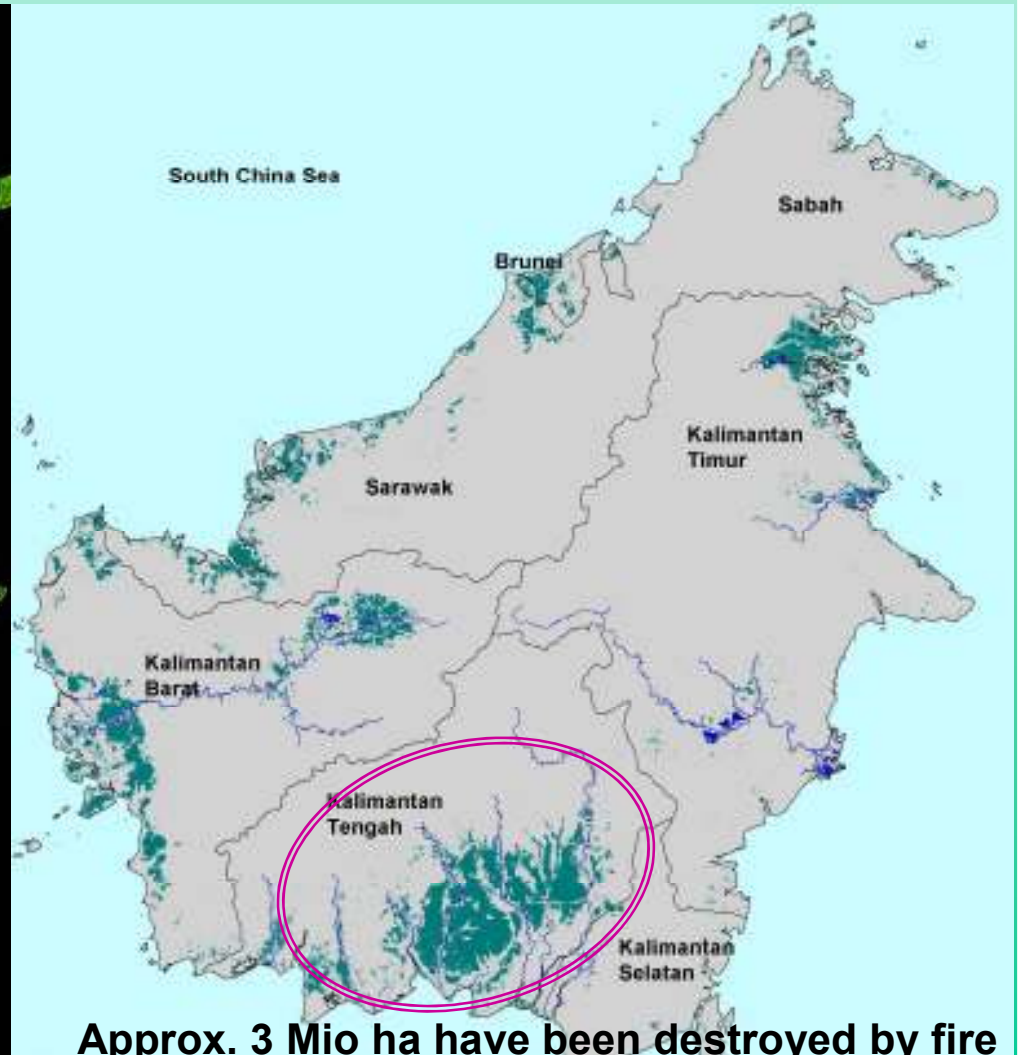
Borneo Peatland

ALS application for Borneo Peatlands

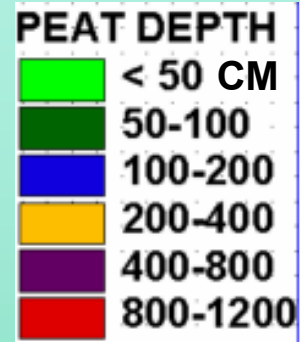
**Cloud free 60 MODIS images
mosaic of Borneo (2003)**



**Distribution of peat swamp
forests in Borneo (2003)**

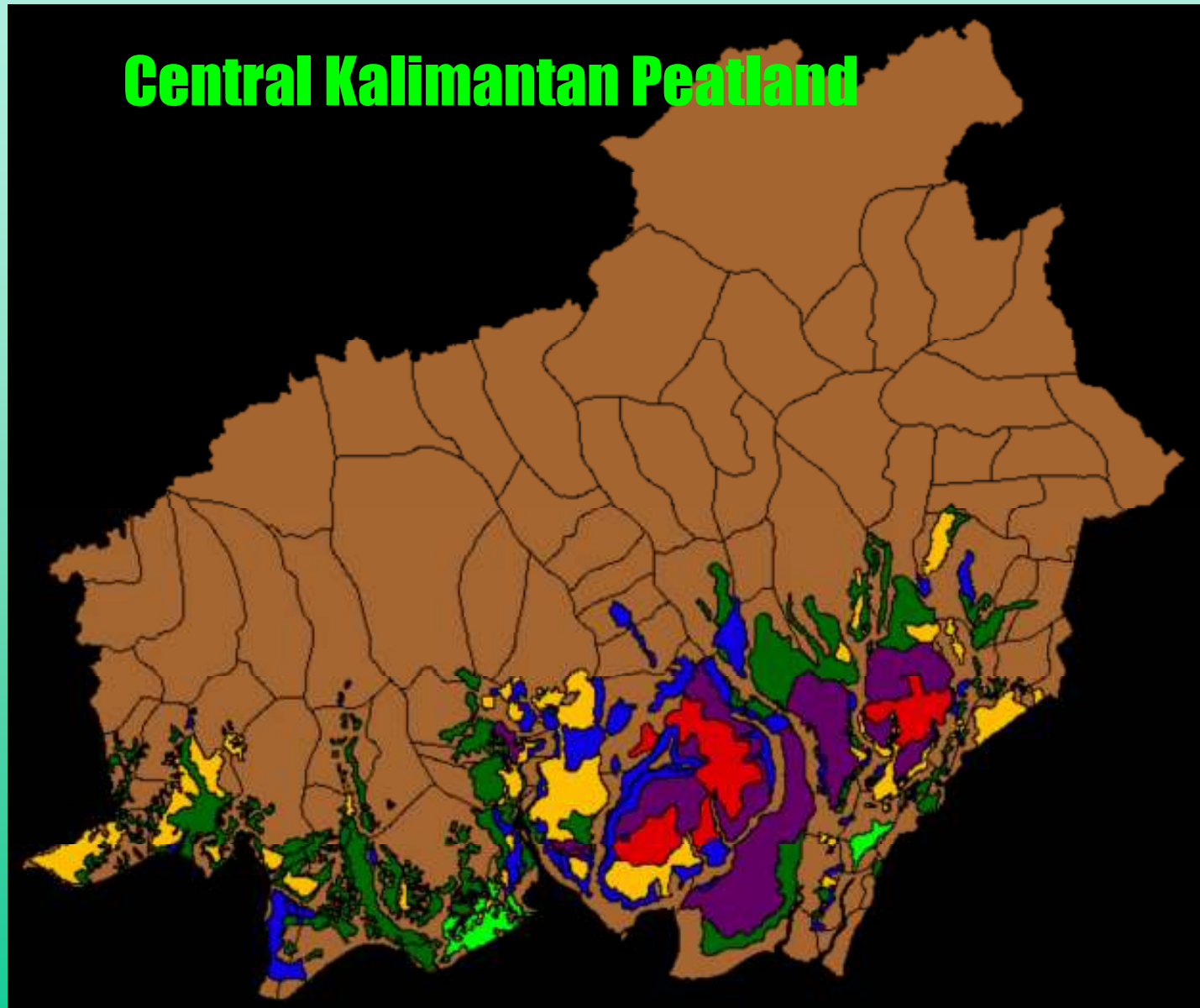


Central Kalimantan Peatland



from
Governor
Presentation
on 22.9.2005 during
International Peat
Symposium,
Palangka aya

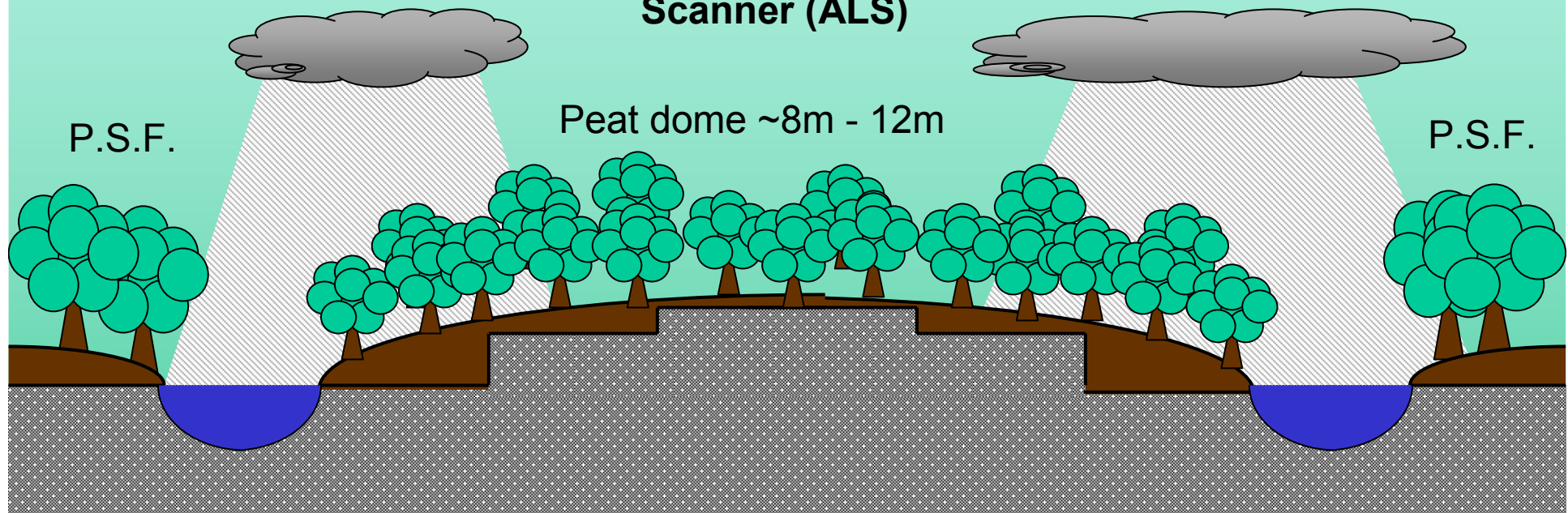
Test with
ALS if
peatland
areas are
correct



Why sluces are necessary in MRP?

Proposal:

Measurement of Forest Height and Peat Dome with Airborne Laser Scanner (ALS)



River A

**Hydrology Models of Peatlands with high
Peat Dome
have to be improved with the help of ALS
supporting international conventions such as:
CBD, Ramsar, Kyoto protocol (2005-2010)**

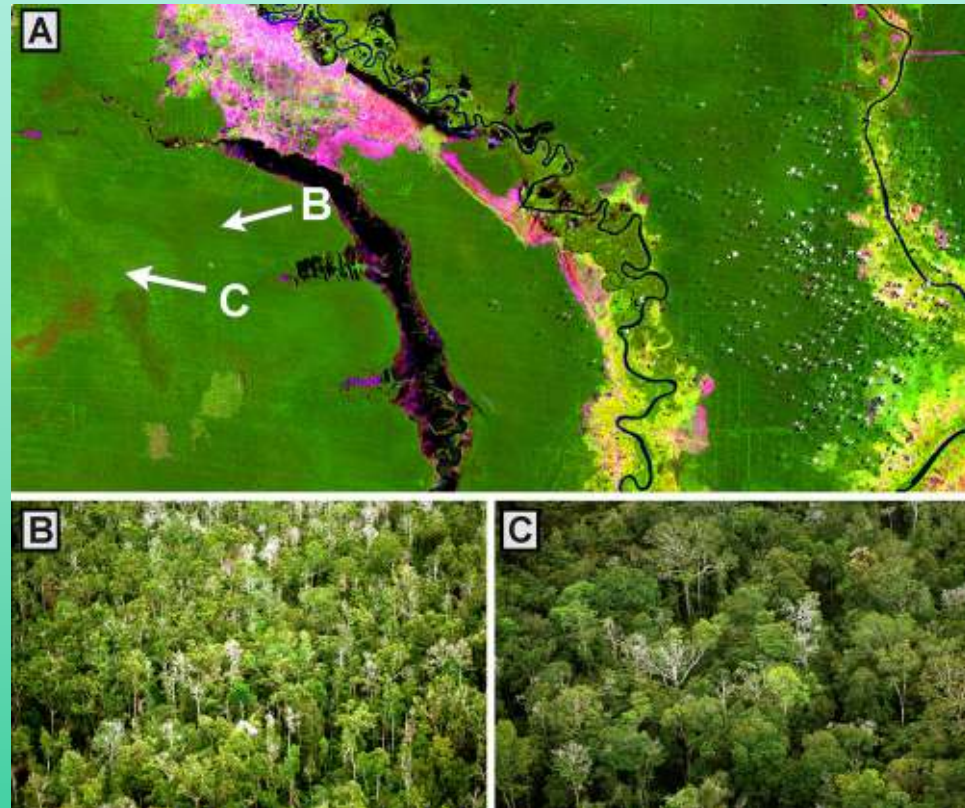
River B

Land use change in Central Kalimantan 1996

Results:

Classification of forest types based on Landsat TM, ERS and ground surveys.
24 vegetation and land use classes.

- ▶ **Biomass**
- ▶ **Status of Forests (burnt, logged over, pristine)**
- ▶ **Inputs for Land Use Management**
- ▶ **Hydrology**
- ▶ **Peat Depth**
- ▶ **Forest Protection**



- A. Landsat Image 1996
- B. Degraded PSF
- C. Tall PSF

- A. Degraded PSF
- B. Tall PSF
- C. MRP BlockA
- D. Farmer Pangkok BlockC
- E. Catchment Sebangau Illegal Logging

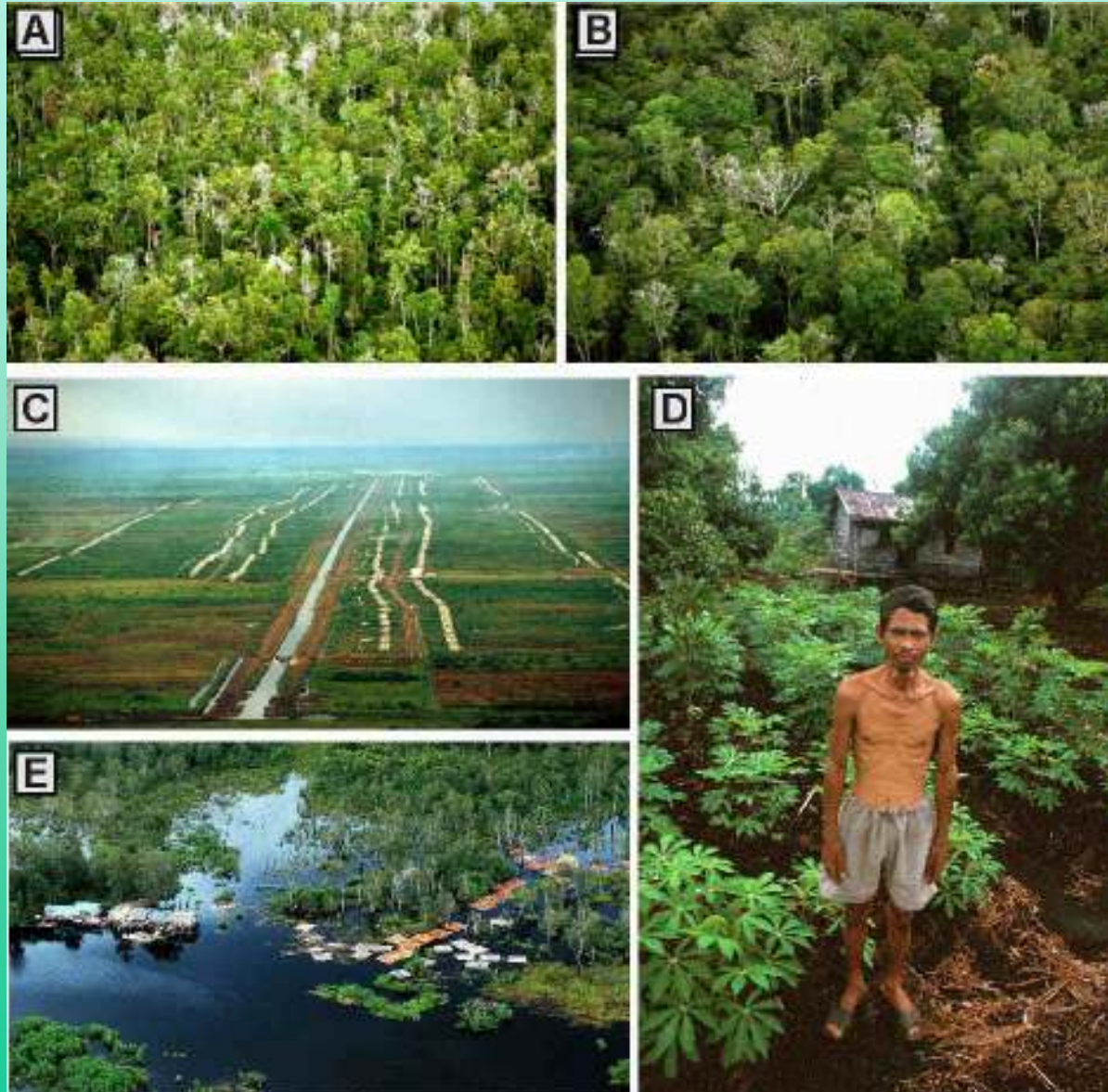


Fig. A: Aerial Photo with Young Oil Palm Plantation

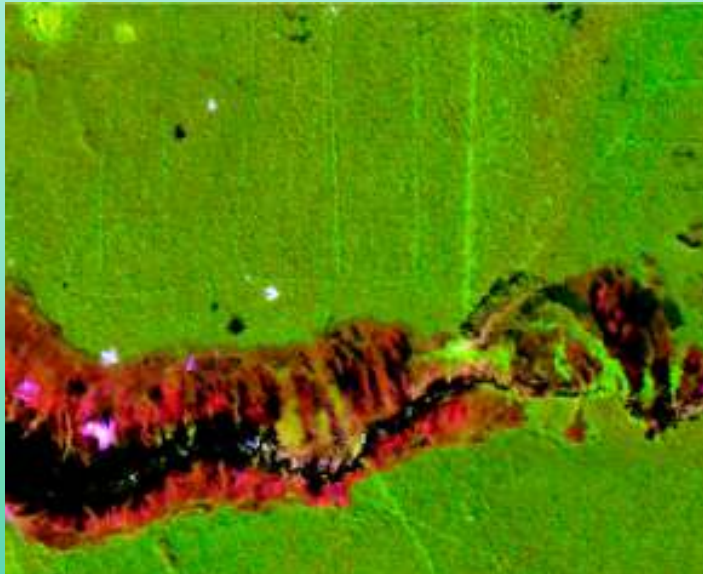
Fig. B: Older Oil Palm Estate in Central-Kalimantan



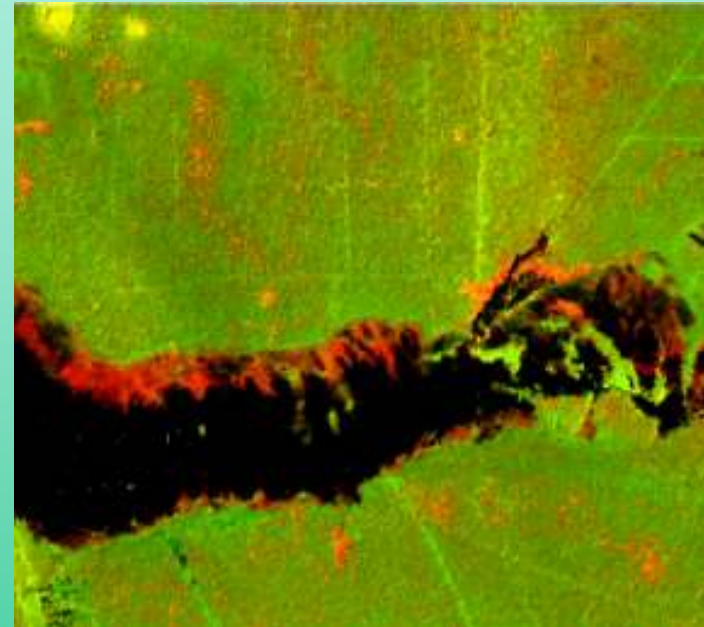
Measure with ALS the existing Terrain of Oil Palm Plantations

Landsat ETM7 shows (illegal) Logging

1997 (alread logged over)



2000



1 km



Regular Pattern (railways):
Irregular Pattern (channels):

Legal Logging
Illegal Logging

Further detailed information is needed with ALS!

Aerial Survey in Central Kalimantan

Sebangau-Bulan Area:

- A) Opened PSF
- B) Thousands of Logs at **Bulan catchment**
- C) Inside Sebangau-PSF with **illegal logging**



Aerial Survey in Central Kalimantan

Sebangau-Katingan Area:

- A) Strongly opened PSF
- B) Mill at Katingan River
- C) Mill at Sebangau with PSF



Three companies, who offer **flight services** with Airborne Laser Scanners and providing the DSM- and DTM-products have been contacted and compared (**LIDAR Service Business**):

- Swissphoto (Switzerland),
- Terra Digital (Germany) and
- TopoSys (Germany).

Four Laser Scanner devices are:

- **ALTM 3100** from Optech, Canada, with a Rotating Mirror Scanner;
- **ALS 50** from Leica, Switzerland, with an Oscillating Mirror Scanner;
- **Falcon II/III** from TopoSys, Germany, with a 128/300 Fiber Scanner;

The measurement rate is 83kHz/125KHz;

Calibration of the Scanner is required only once.

- **Harrier 56** from TopoSys (LMS-Q560), Germany, with Polygon Scanner;
Full Waveform Digitization

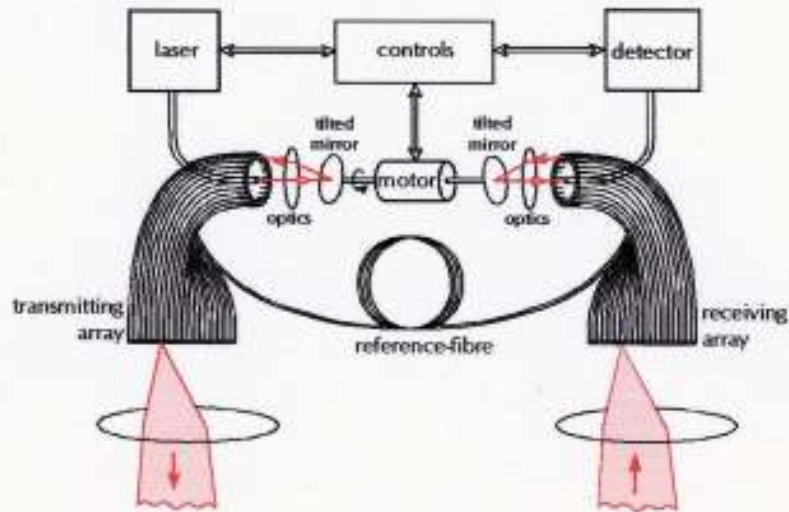


Figure 1. Fiber-based laser scanner

Falcon II and III from TopoSys
 spot distribution + swing mode, right

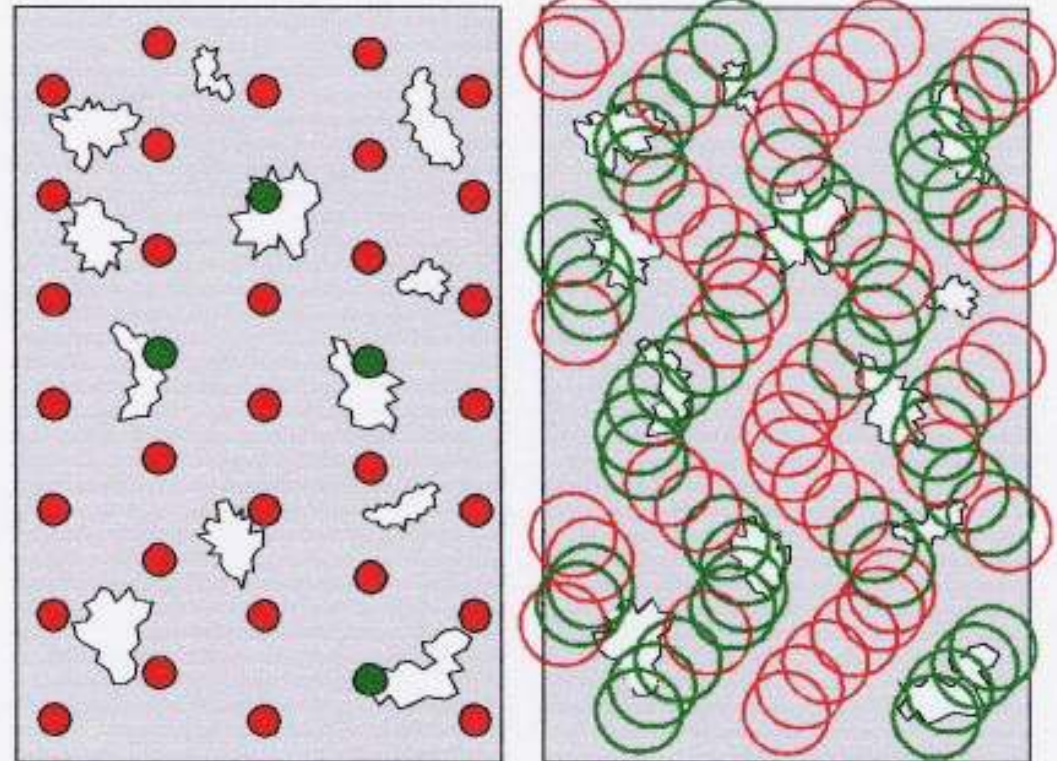


Figure 3. Forest penetration with narrow beam (left) and wide beam (right)

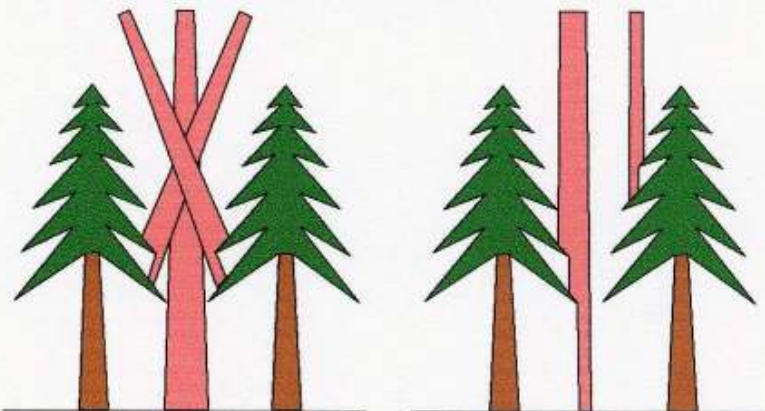


Figure 4. Effects of wide viewing angle (left) and beam divergences (right)

Bugetary costs

Complied ALS HW-costs between **0.8 Mio€** and **1.5 Mio€**
including

Laser Scanner, Digital Camera or Line Scanner, Inertial Navigation System (INS; e.g. Positioning system: Applanix POS/AV410, D-GPS), Operator Consol, Computer Rack, complete SW-package and SW-training to produce DSM, DTM and RGB- or CIR-true-ortho-images; GeoTiff

Derived products: Difference Models, TIN's, breaklines, contours.

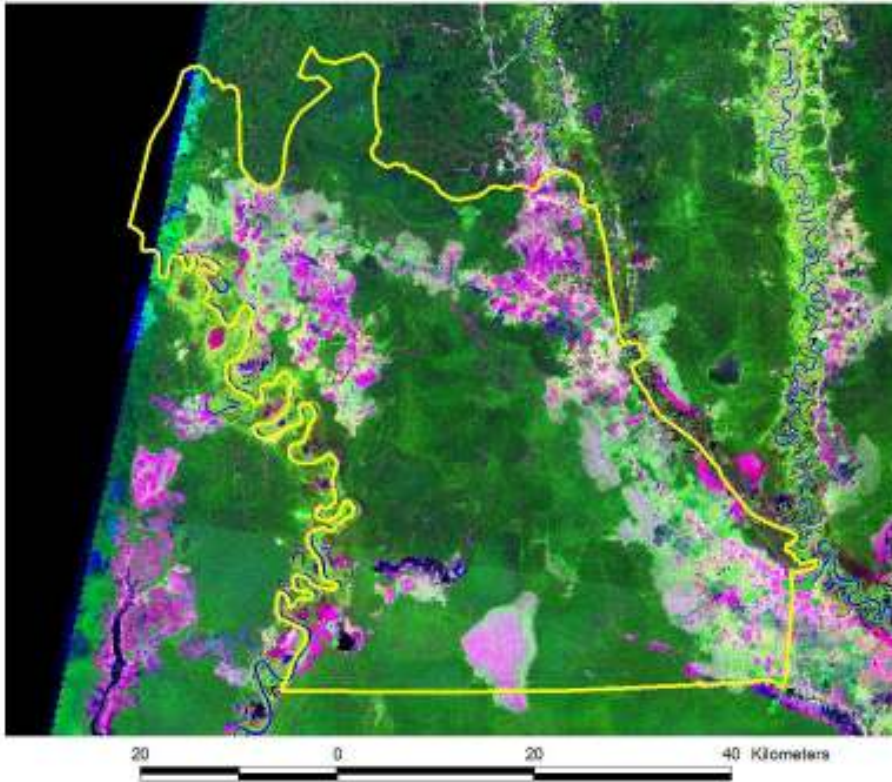
or

LIDAR Service support with rented plane and equipment

for **3 to 6 €/ha** depending on laser-pixels/m², necessary map-scale (e.g. 1:2,500 or 1:25,000), area size of inventory/monitoring and non recurring costs. Products: Elevation models and ortho images

Proposed ALS-Pilot Peatland Project: Northern Part of Sebangau Area

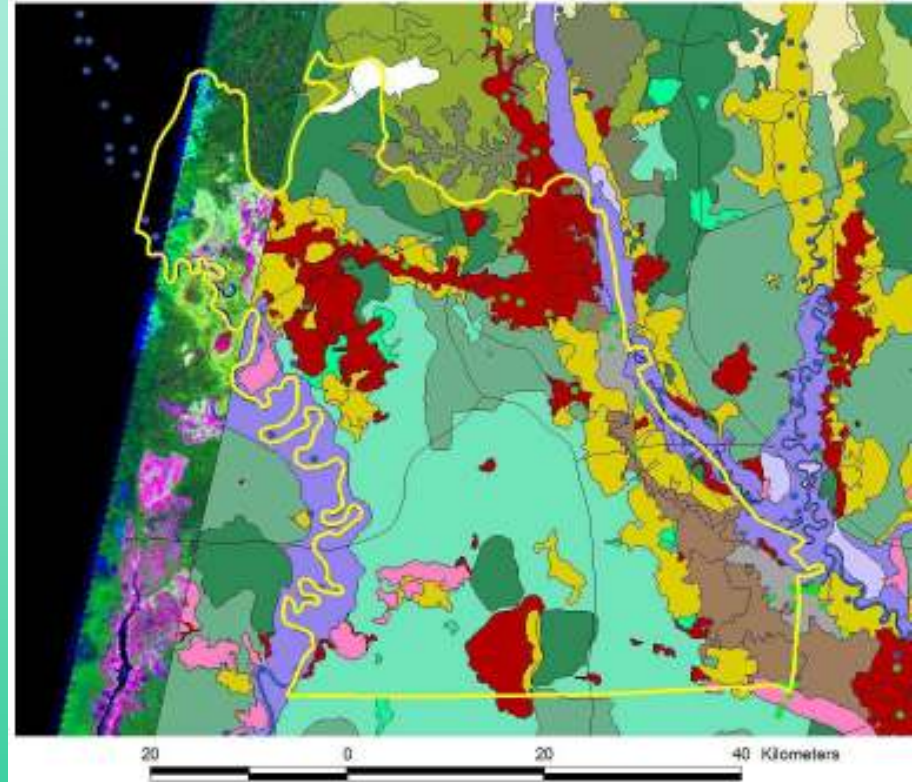
Sebangau Catchment North
 with PSF and degraded Peatland
 between Katingan and Rungan,
 Landsat image from 16. July 2000
 processed 12. Oct 2005



Peat-Map between
 Katingan and Rungan River
 using GIS, LS 16.7.2000



Sebangau Catchment North
 with PSF and degraded Peatland
 between Katingan and Rungan,
 classified Landsat image from 16. July 2000
 processed 12. Oct 2005



Classified Peat-Map between
 Katingan and Rungan River
 using GIS, LS 16.7.2000




Conclusion – Action Plan

Action Plan for 2006 – Way ahead

- Airborne Laser-Scanner Technology (ALS) has come out of the Research Phase and is now fully Mature.
- Cooperation between; K.C., UNPAR and other interesting groups?...
- Select a suitable ALS to measure tropical PSF
- Campaign with ALS to measure DEM, DSM, DTM at the **Sebangau – Katingan Area** and prepare precise Topographic Maps with Peat Dome and to measure the remaining Bio-Mass, PSF Height, the Illegal Logging Roads and Channels **or/and other Peatland Areas**
- To establish with DTM a better Hydrological Model of the Peatland
- Selected Peat Drilling with UNPAR to find the Peat Depth and to estimate in combined with DTM the Amount of Carbon Storage
- To promote a PhD-Thesis of Peatland/PSF with ALS, GIS and DEM!
- Training of Local People in ALS, DEM, GIS and Remote Sensing!
- Find Funding and Financial Sources for the ALS-Campaign (...)

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- Dr. Boehm Kalteng Consultants 24. Jan. 2006 at Pekanbaru, Carbon Workshop



Thank you for your Attention



MRP-Black Water River 1998

- A. ERS image 1997 from MRP
- B. Landsat image 1997
- C. Main Channel at Mentangai
- D. Mentangai - MRP
- E. Mentangai burnt trees 1997
- F. MRP-Transmigration

