CzechGlobe

Quantitative assessment of forest ecosystems from airborne data

Global Change Research Centre

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Technical facilities for quantitative RS at CG

CG tasks related to forest ecosystems assessment

Technical background

- Airborne segment **FLIS** (Flying Laboratory of Imaging Systems)
- Ground field segment
- Ground black-lab segment

Technical background

Flying Laboratory of Imaging Systems

Visible and near infra-red imaging spectroscopy

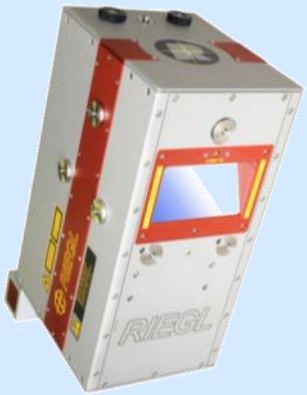
CASI-1500

SASI-600

Thermal imaging spectroscopy

TASI-600

Laser scanning



Riegl LMS – Q780

Complementary field equipment

VNIR spectroscopy

ASD FieldSpec

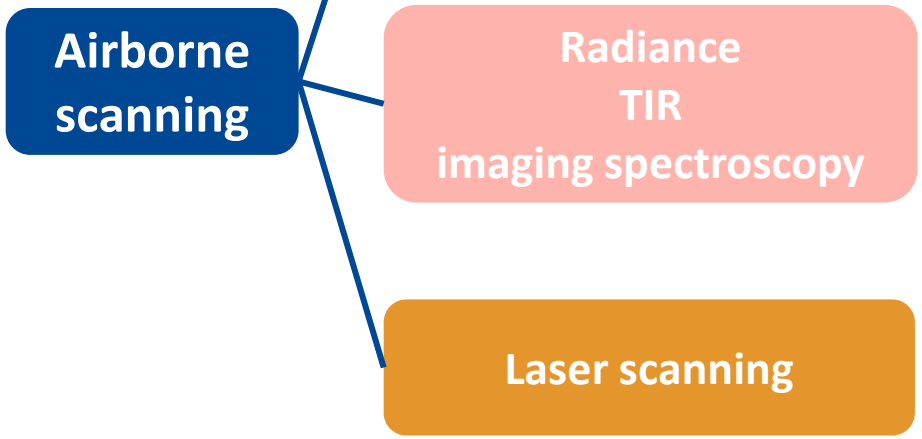
Thermal spectroscopy

FT-IR Spectrometer

Terrestrial laser scanning

Riegl VZ-400

Quantitative assessment of vegetation – data types and topics



Properties/traits of vegetation

Chl, N, water - VIs, modelling Prospect, DART

Vegetation fluorescence – stress, LUE

Landscape/vegetation thermal regime

Vegetation stress

Structural characteristics of vegetation

Estimation of biomass

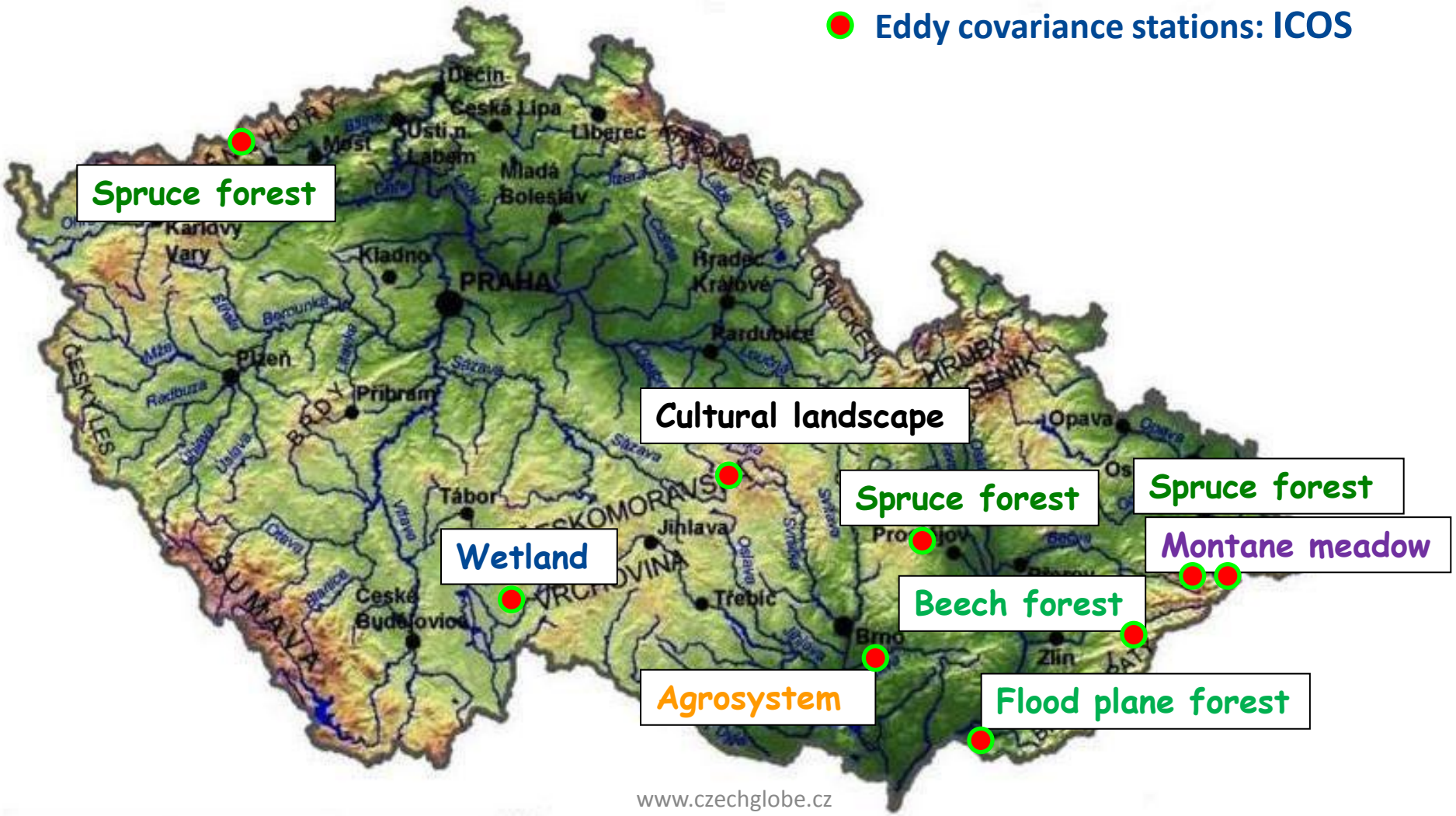
Canopy density

Tree and crown parameters

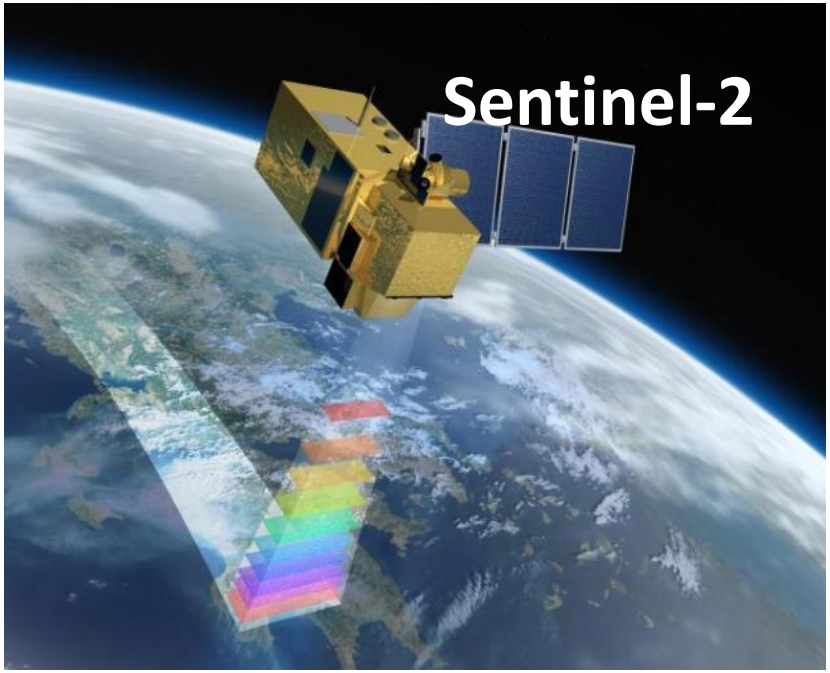
3D tree modelling

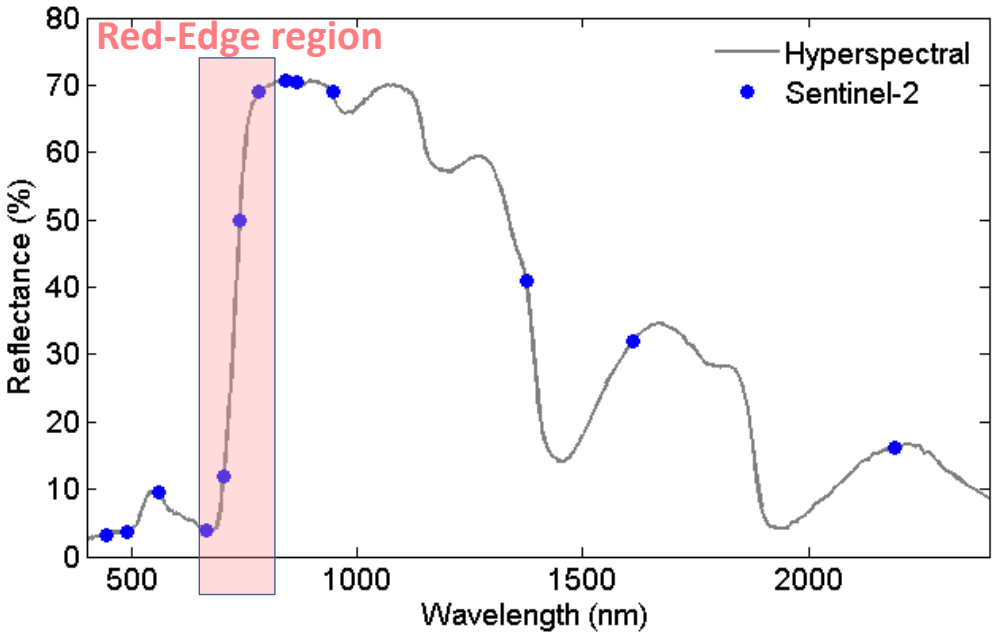
- parametrization of models

Distribution of permanent monitoring sites of the CzechGlobe



Red Edge Positioning Techniques for Earth Observation Optical Missionsproject





Test sites

Spruce forest

Beech forest

Quantitative assessment of vegetation – physical based approach

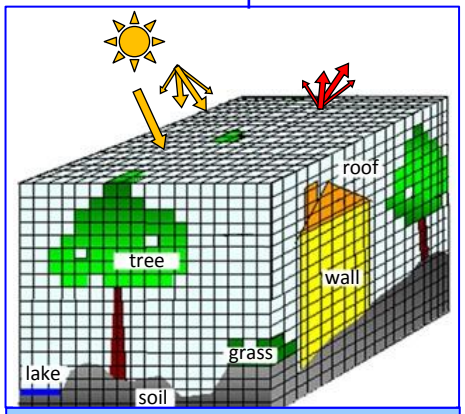
RT modelling

Support vector machines

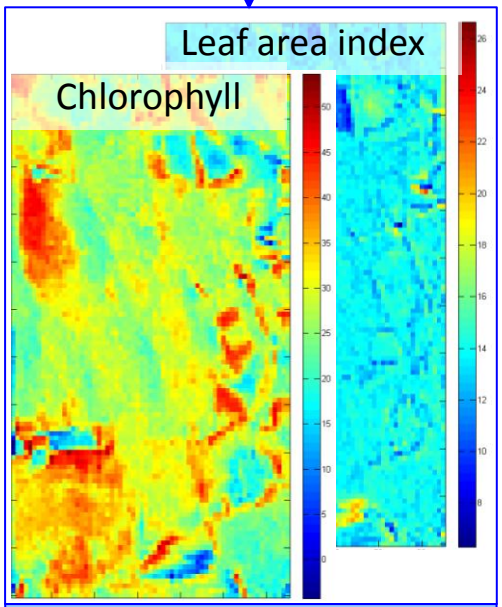
Retrievals

Simulated spectra
Look-up tables

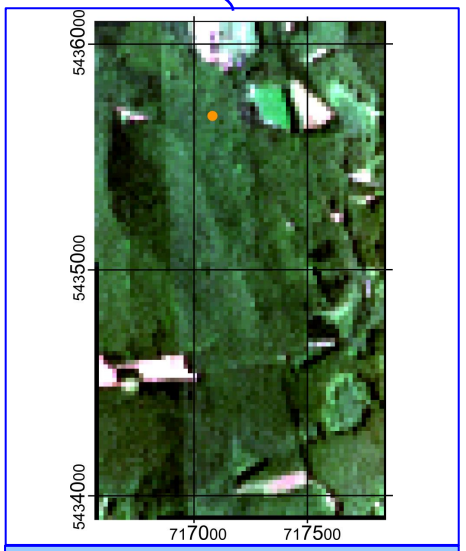
Simulations



DART & PROSPECT



Quantitative vegetation parameters



Simulated S-2 images

Post-processing

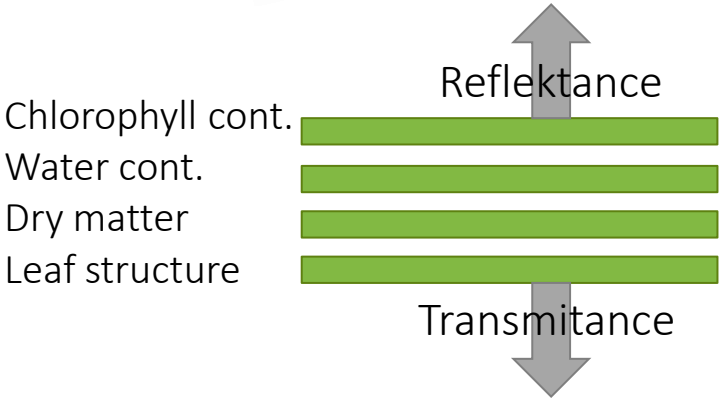
Airborne hyperspectral images

Parameterization

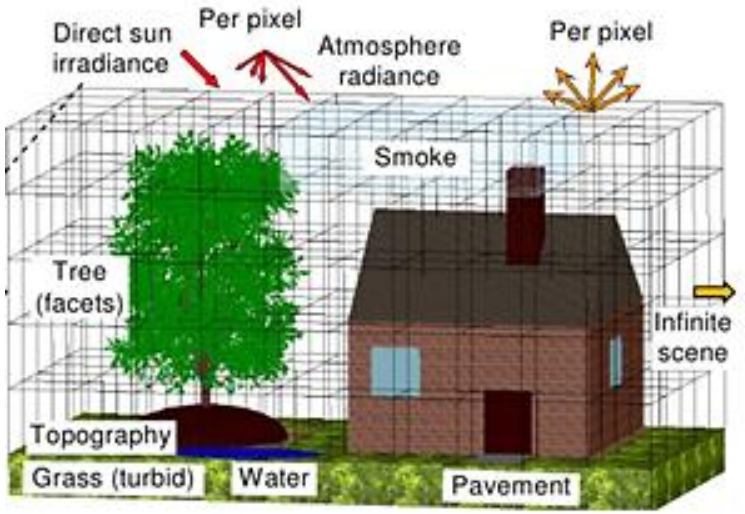
Field measurements

Methods of vegetation cover assessment – physical based approach

Leaf level
PROSPECT



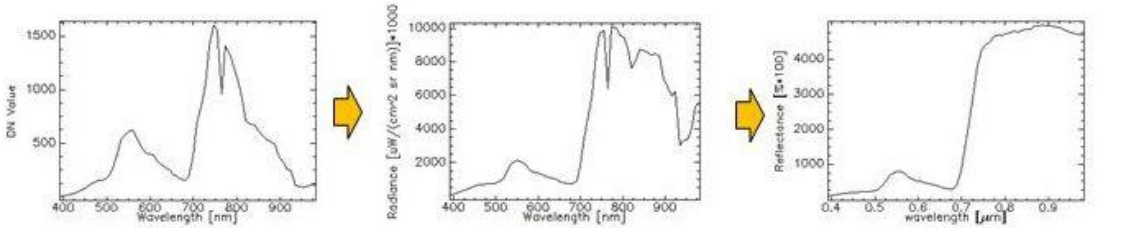
Canopy level
DART



Quantitative assessment of vegetation data post-processing

Hyperspectral data post-procesing

- **Radiometric corrections - calibration to radiometric values - CaliGeo**
- **Geometric corrections – geo-orthorectification - PARGE**
- **Atmospheric corrections – elimination of atmosphere contribution - ATCOR4**

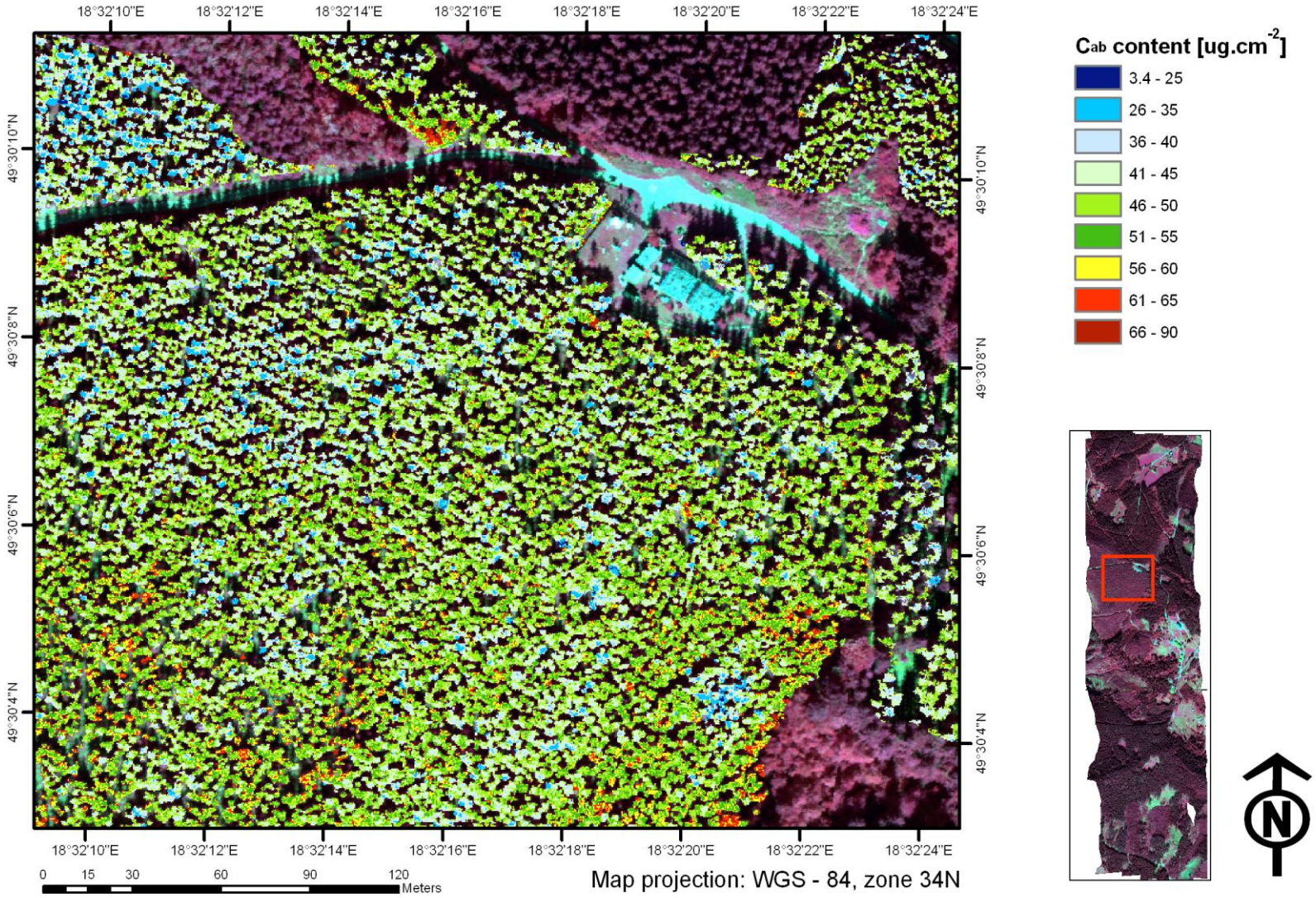


Digital numbers
Graph is displaying spectral profile of one acquired raw data pixel

Radiance
Graph is displaying spectral profile of one acquired data pixel after radiometric corrections

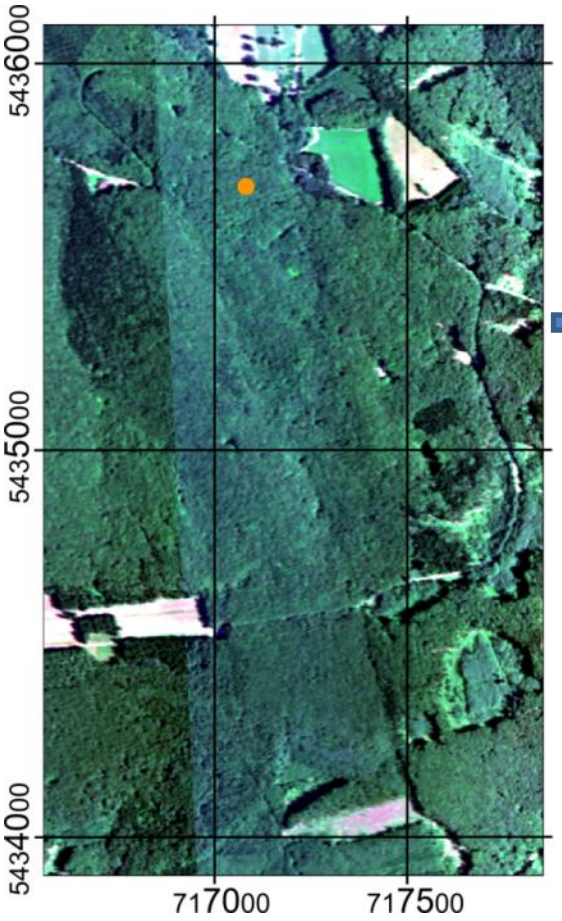
Reflectance
Graph is displaying spectral profile of one acquired data pixel after atmospheric corrections

Quantitative assessment of vegetation – site level from airborne data

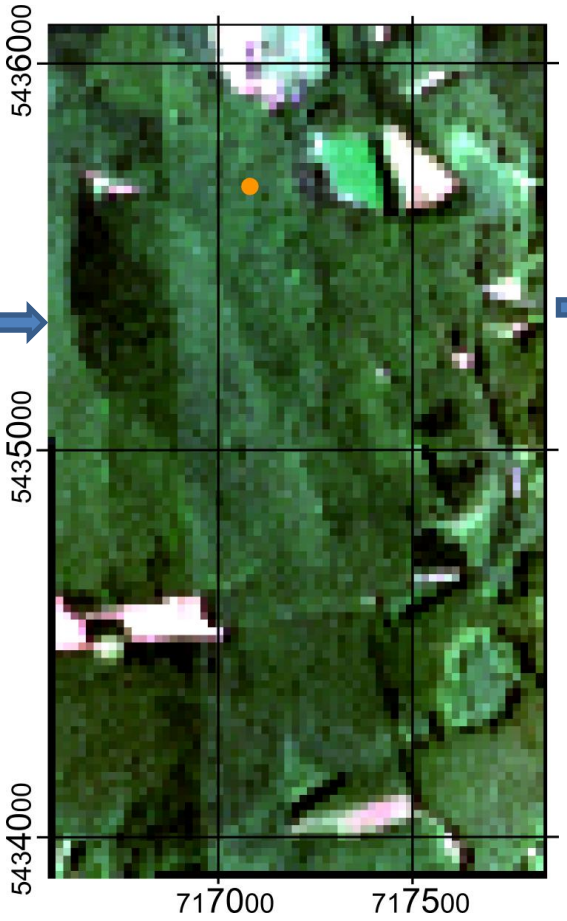


Quantitative assessment of vegetation – site level for simulated SENTINEL-2

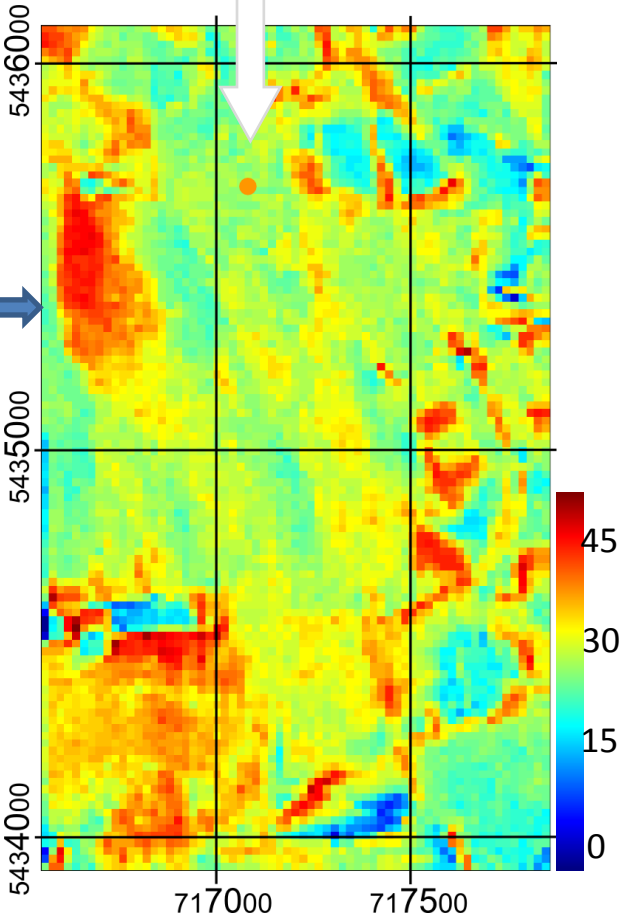
Field measurements of chlorophyll: 25 – 35 µg cm^{-2}



Airborne image (2.5m)



Sentinel-2 image (20m)



Chlorophyll map (20m)

Structural characteristics of vegetation – GLS, ALS

Instrumentation

GLS – Ground LiDAR Scanning

ALS – Airborne LiDAR Scanning

Application

GLS - Structural parameters of a single tree for 3D tree modelling

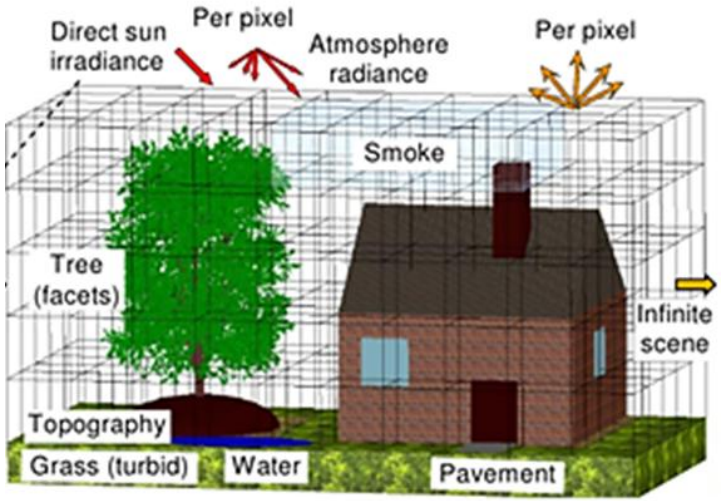
- Height of tree, vertical shape of crown, branching and other allometric parameters
- Estimation of biomass

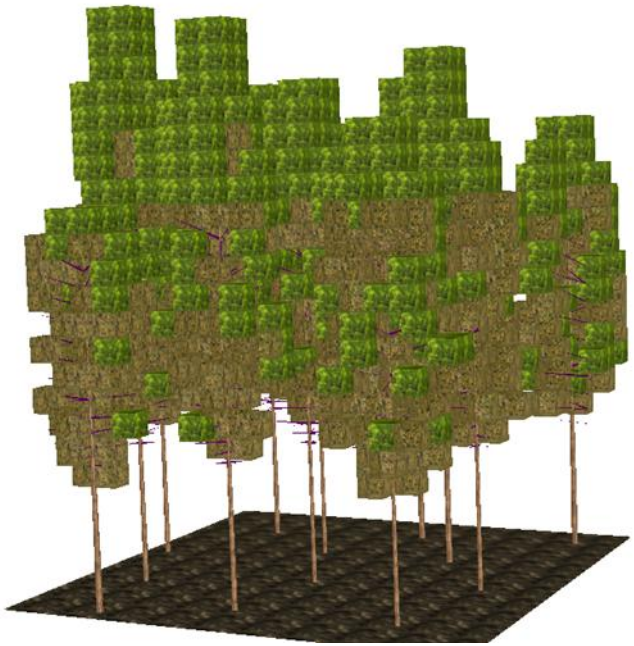
ALS – DEM, DSM, structural parameters of trees and forest

- Height of trees/canopy, identification of trees, projected shape of crown, canopy density,…
- Estimation of biomass

Structural characteristics of vegetation – GLS, ALS

GLS – structural parameters of trees for 3D tree modelling and allometry

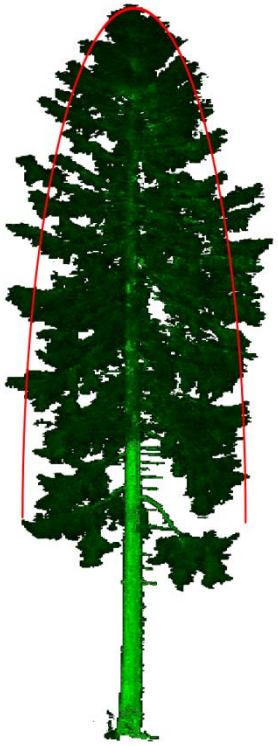


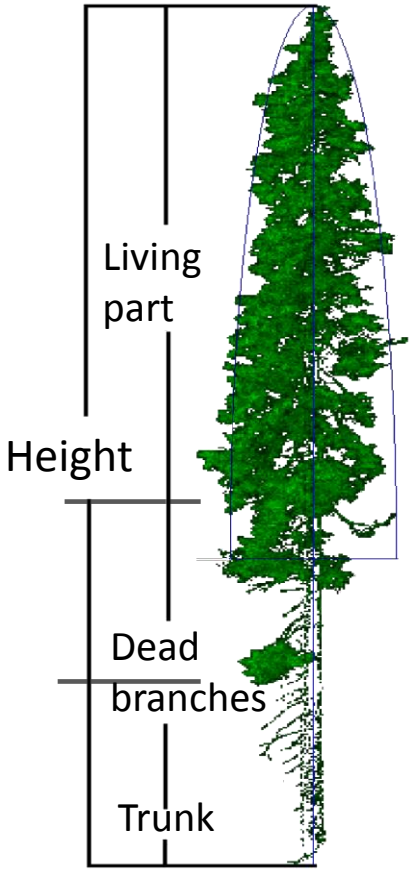


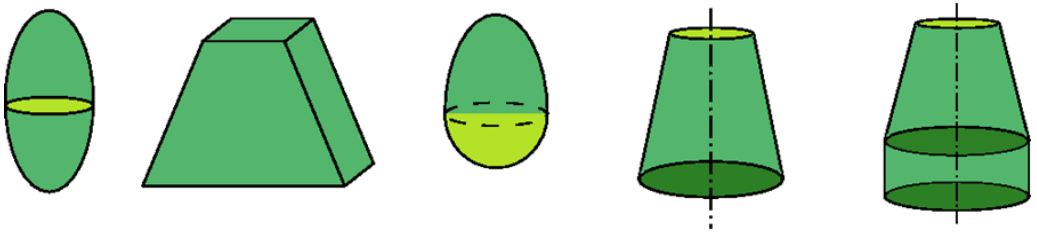
Structural characteristics of vegetation - GLS

GLS

Shapes and structure of a tree

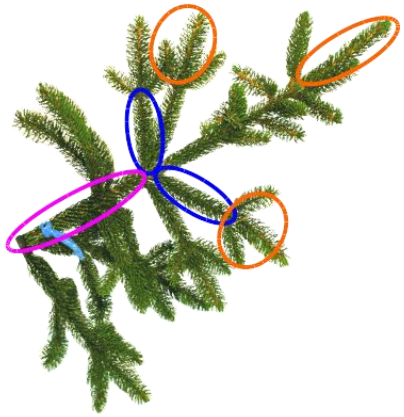


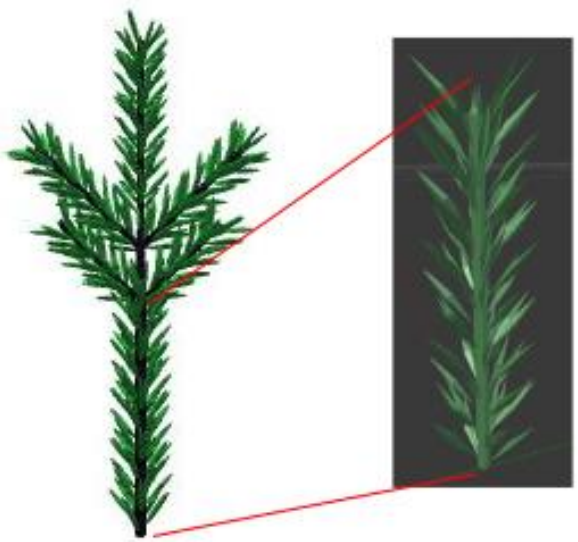


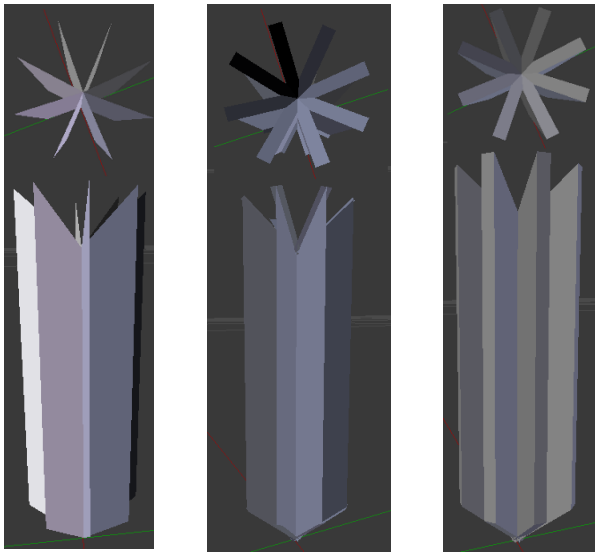


Structural characteristics of vegetation – modelling approach

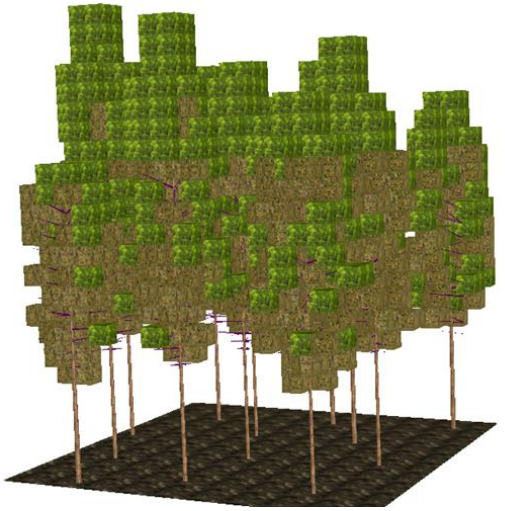
Modelling differently aged branches/shoots





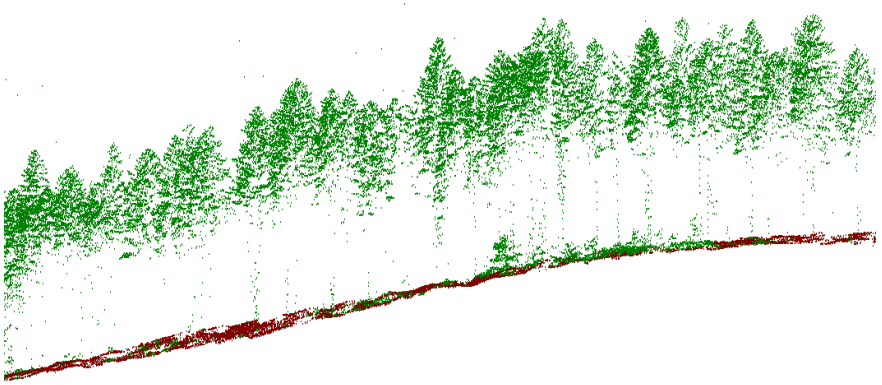


Turbid models

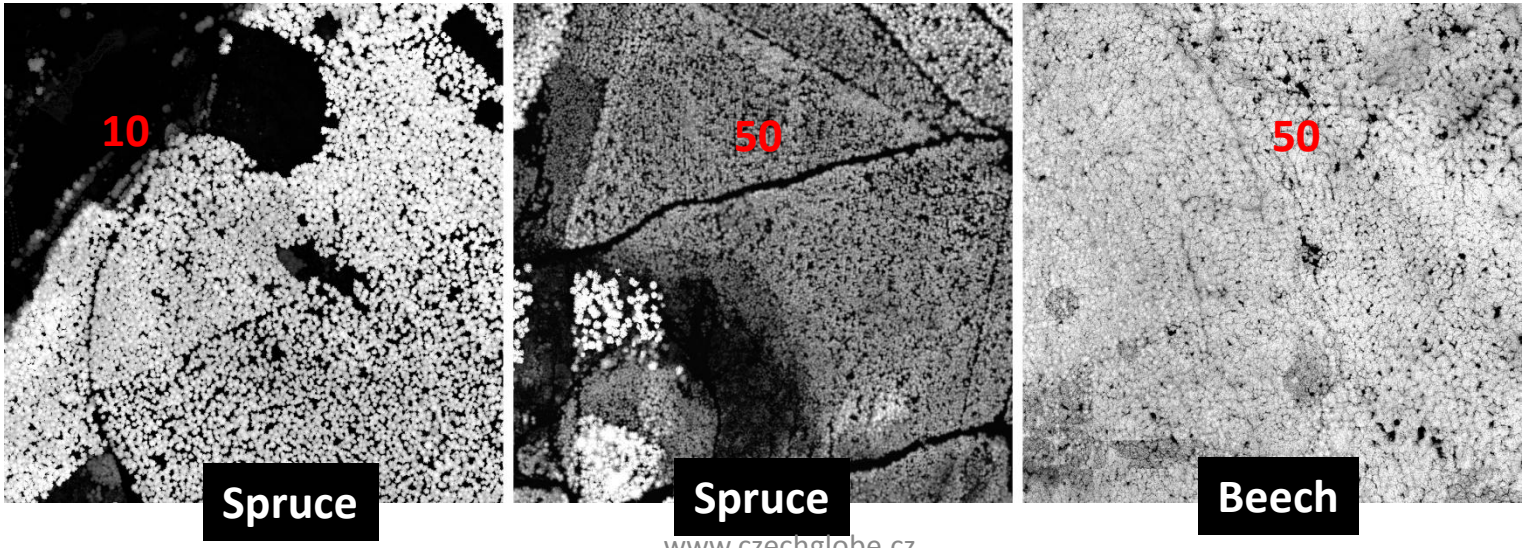


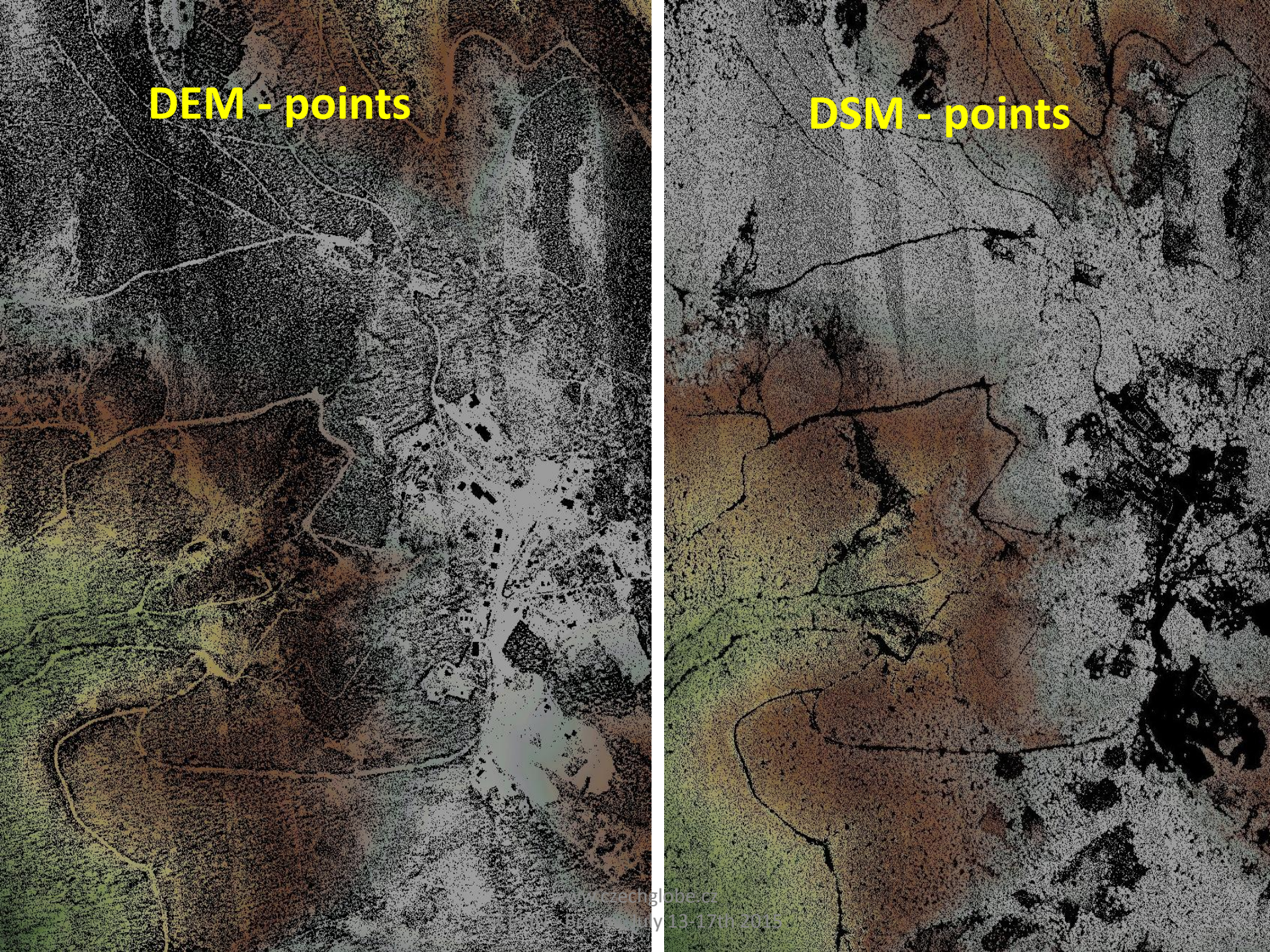
Structural parameters of forest - ALS

Height of vegetation

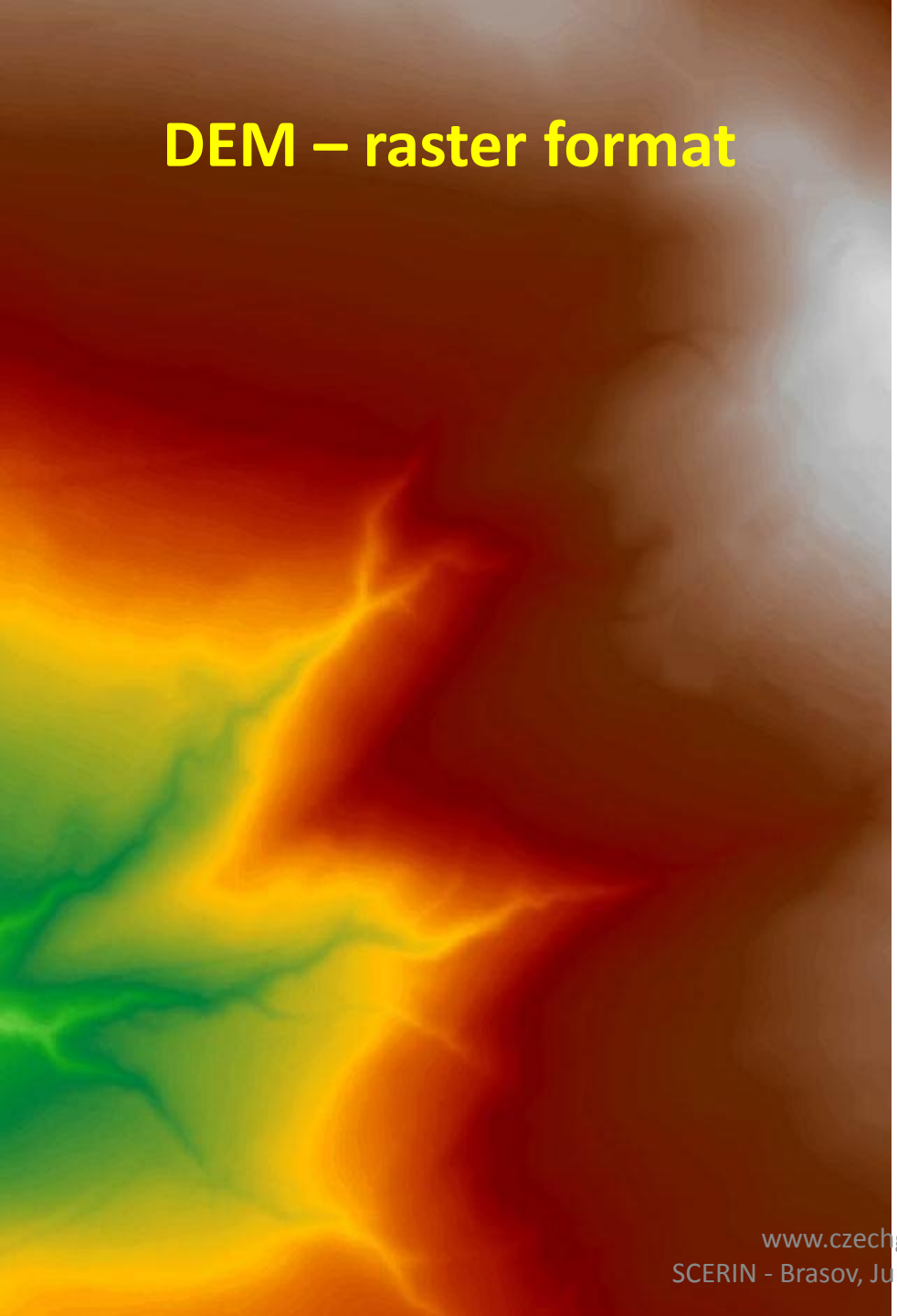


- **DEM - triangulation/interpolation of ground X,Y,Z points**
- **DSM - triangulation/interpolation of above ground X,Y,Z points**
- **nDSM = DSM - DEM**

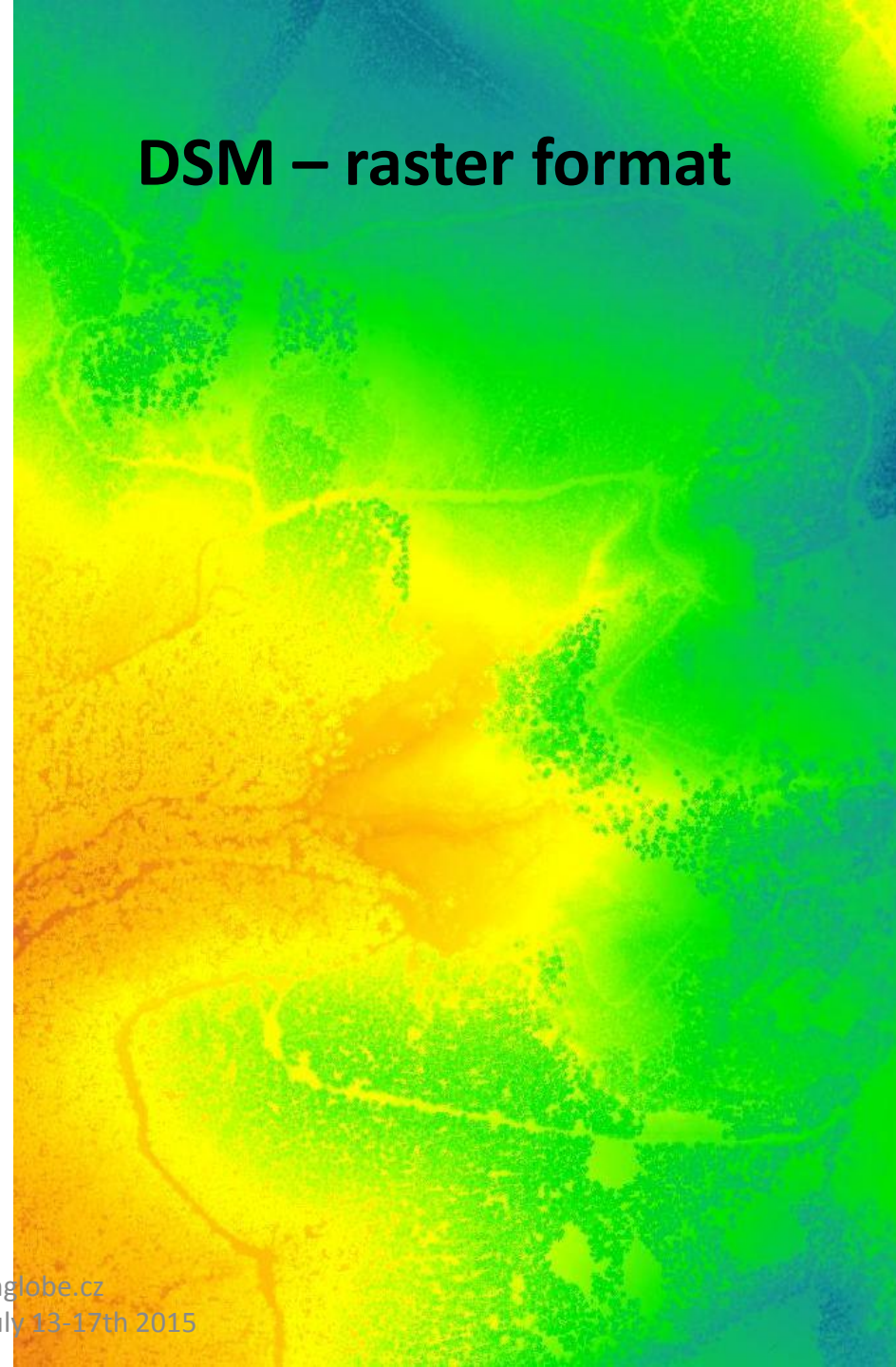



DEM - points
DSM - points

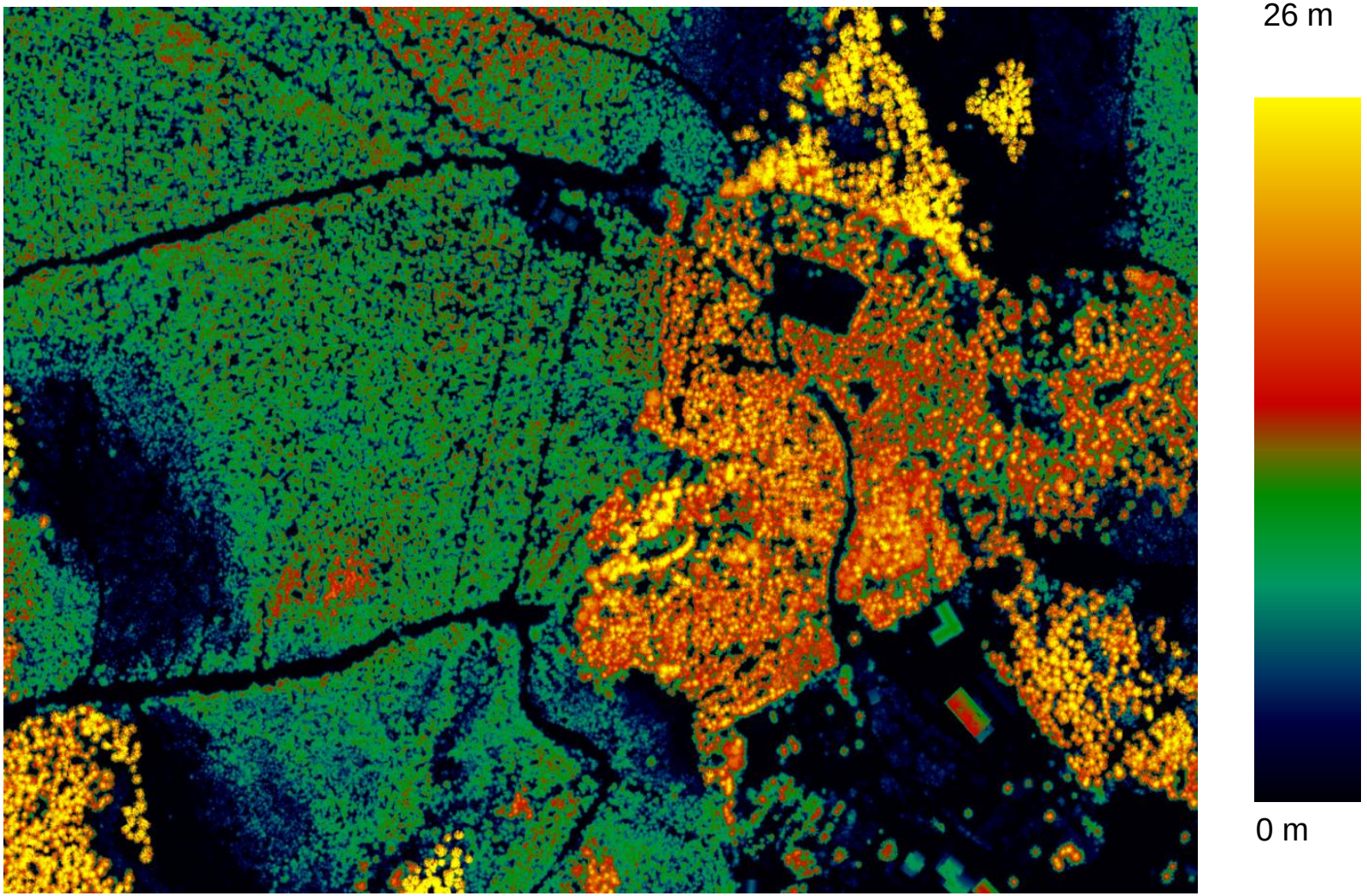
DEM – raster format



DSM – raster format

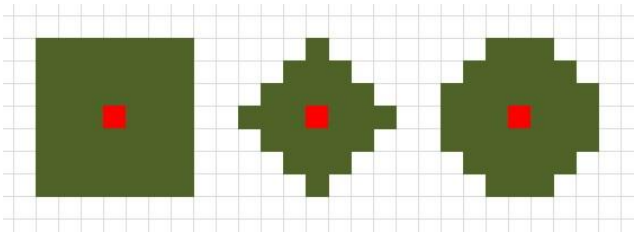


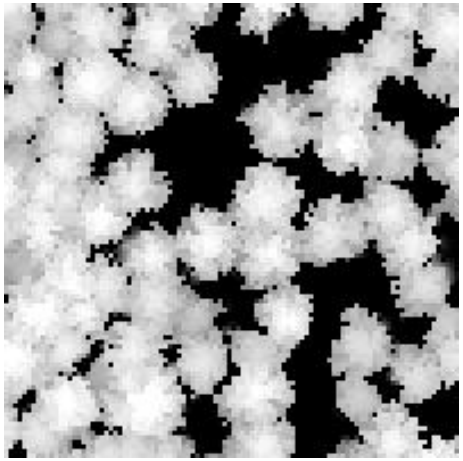
Height of aboveground objects

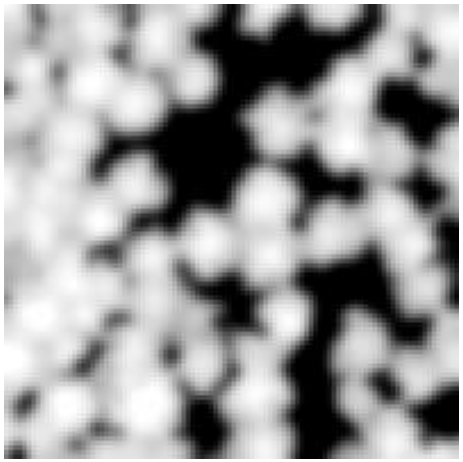


Local Maxima Approach

- Preprocessing = Gaussian filtering
- Local maxima detection
  - Size of a neighborhood
  - Shape of a neighborhood
  - Minimal height threshold







Crown delineation

- **Watershed algorithm**
  - flooding of inverted structure from seed points
  - stopped at watershed ridge or height threshold
- **Valley following / Minima network**
  - boundary network built from local minima points
  - Voronoi diagram as the first iteration, then to move the boundaries down to local minima
- **Seeded region growing**

Region growing + Active contour

- In each step a candidate grown crown has assigned energy value:

$$E = A_H \cdot E_H + A_B \cdot E_B + A_S \cdot E_S + A_N \cdot E_N$$

- E_H is a component derived from a height of boundary pixels
- E_B is a component derived from a boundary length
- E_S is a component derived from a crown shape
- E_N is a component derived from a distance to neighboring crowns

- E_H is driving the boundary downwards
- E_B and E_S are keeping the crown in natural shapes
- E_N is preventing the overlaps between neighboring crowns

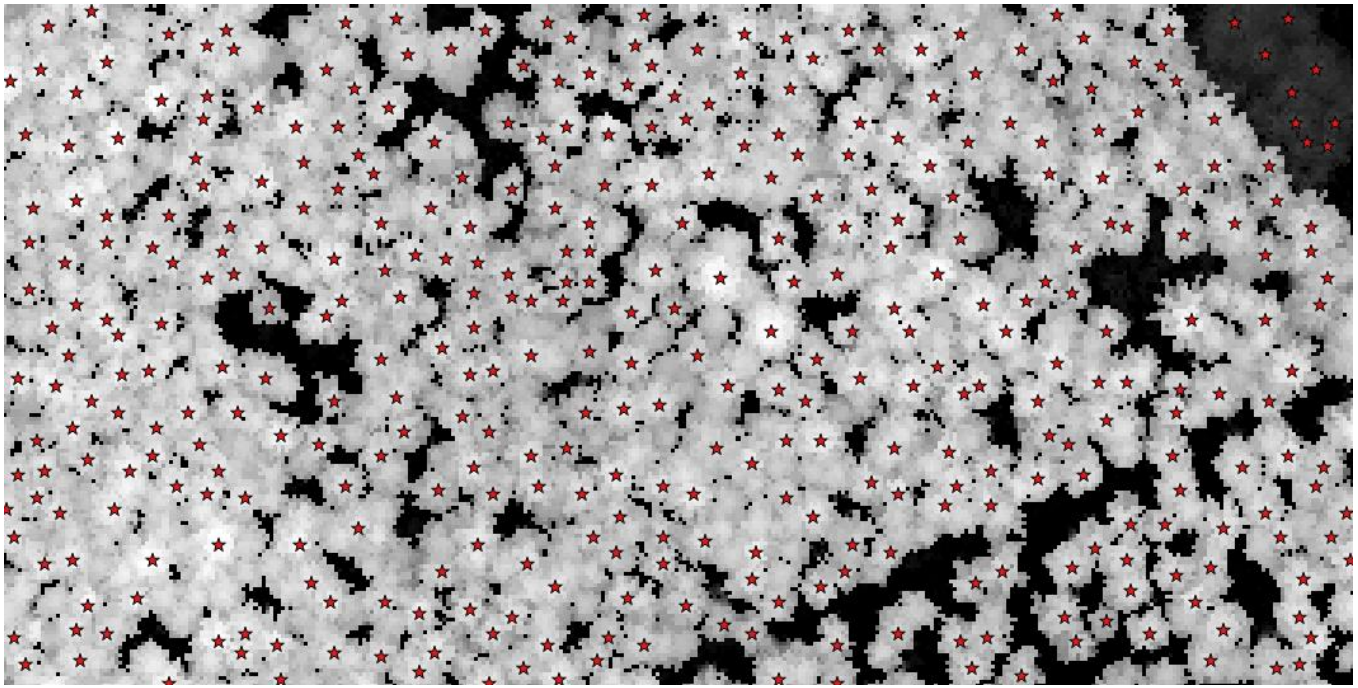
Region growing + Active contour

Processing steps

1. Parameterization based on age/species composition
2. Order of growing based on height/area ratio
3. Growing iterations
4. Stopping conditions: $E_{n+1} > E_{max}$ or $E_{n+1} - E_n > dE$

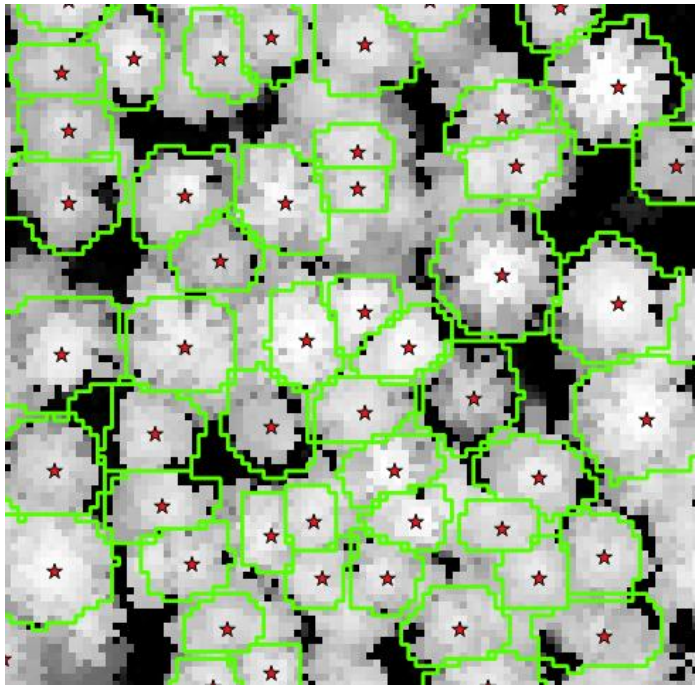
Results: Tree detection

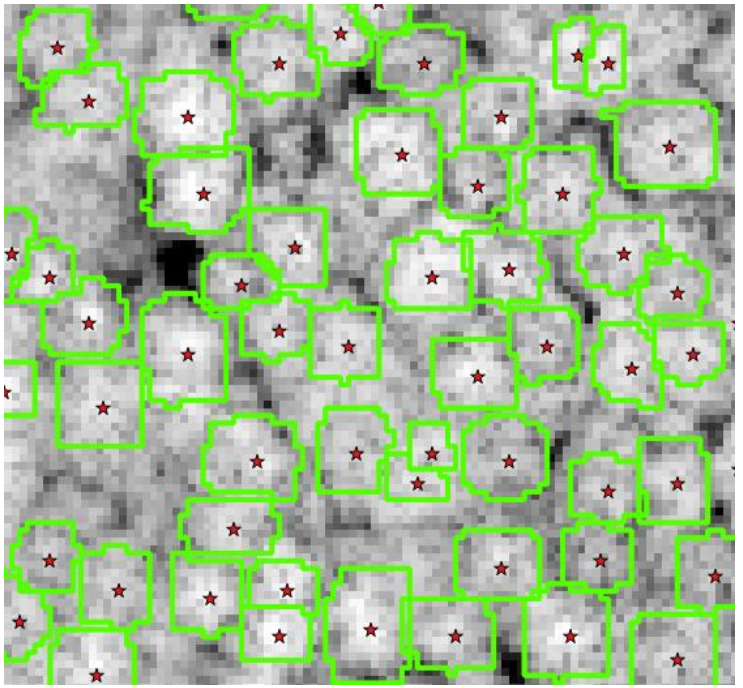
Test of accuracy: randomly selected trees



Locality	correct	omitted	efficiency	Locality	# of trees	height stats
Bílý Kříž	315	59	85.1 %	Bílý Kříž	5305	11.9 ± 3.8 m
Rájec	372	53	87.5 %	Rájec	4538	27.6 ± 4.1 m
Štítná	405	80	83.5 %	Štítná	6204	26.9 ± 2.6 m

Results: Crown Delineation



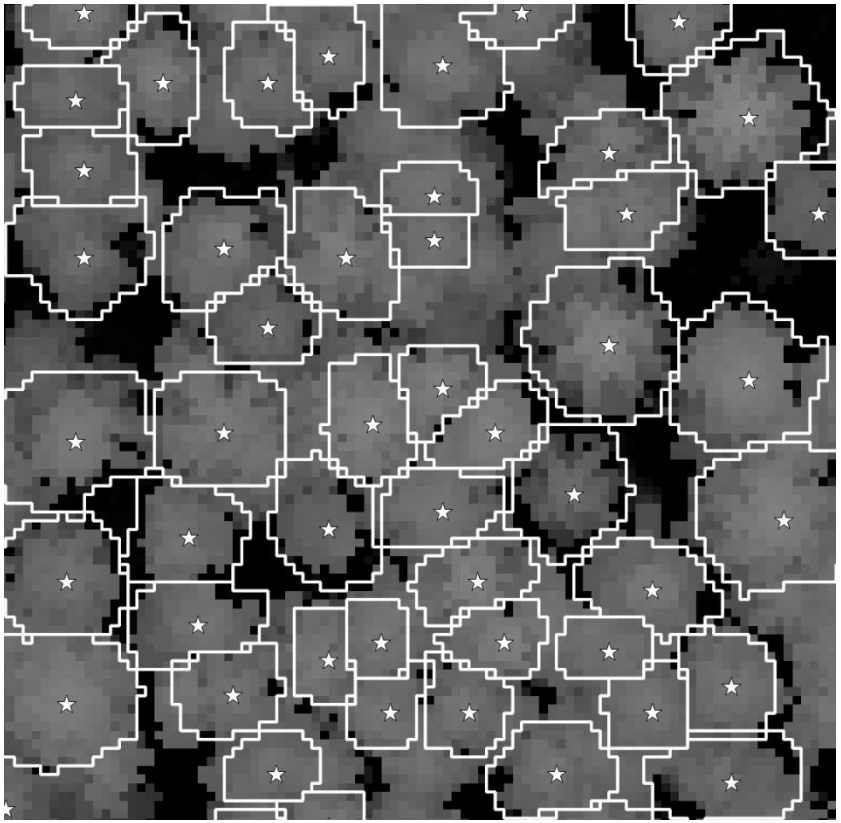


Test of accuracy: random selection trees

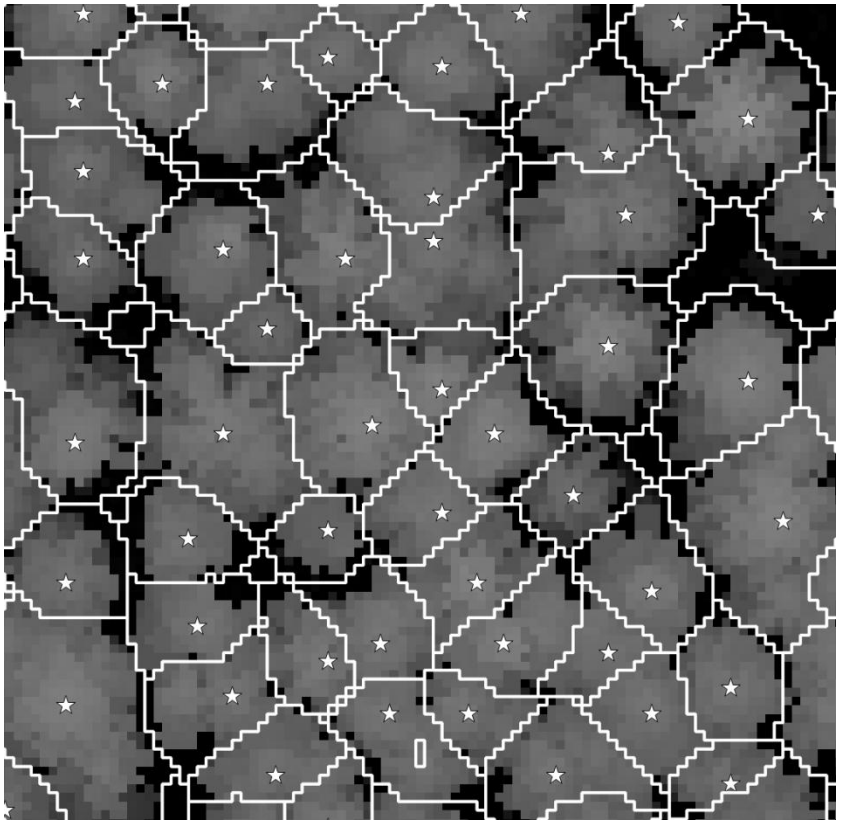
Percentage of agreement in crown shape

Locality	95 %	75 %	50 %	25 %	accuracy
Bílý Kříž	122	176	54	4	76.8 %
Rájec	177	188	53	10	79.0 %
Štítná	169	294	21	1	80.8 %

Comparison: SRG vs. Watershed



Seeded Region Growing



Watershed Algorithm

Estimation of tree/canopy biomass

Allometric equations

a/ level of individual trees

$$\boldsymbol{AGB = a * b * exp(c * ln(DBH) - d)}$$

$$DBH = -b/log[(H - 1.3)]/a$$

b/ level of a plot

$$\boldsymbol{AGB = aH + bCanDen + c(H + CanDen)}$$

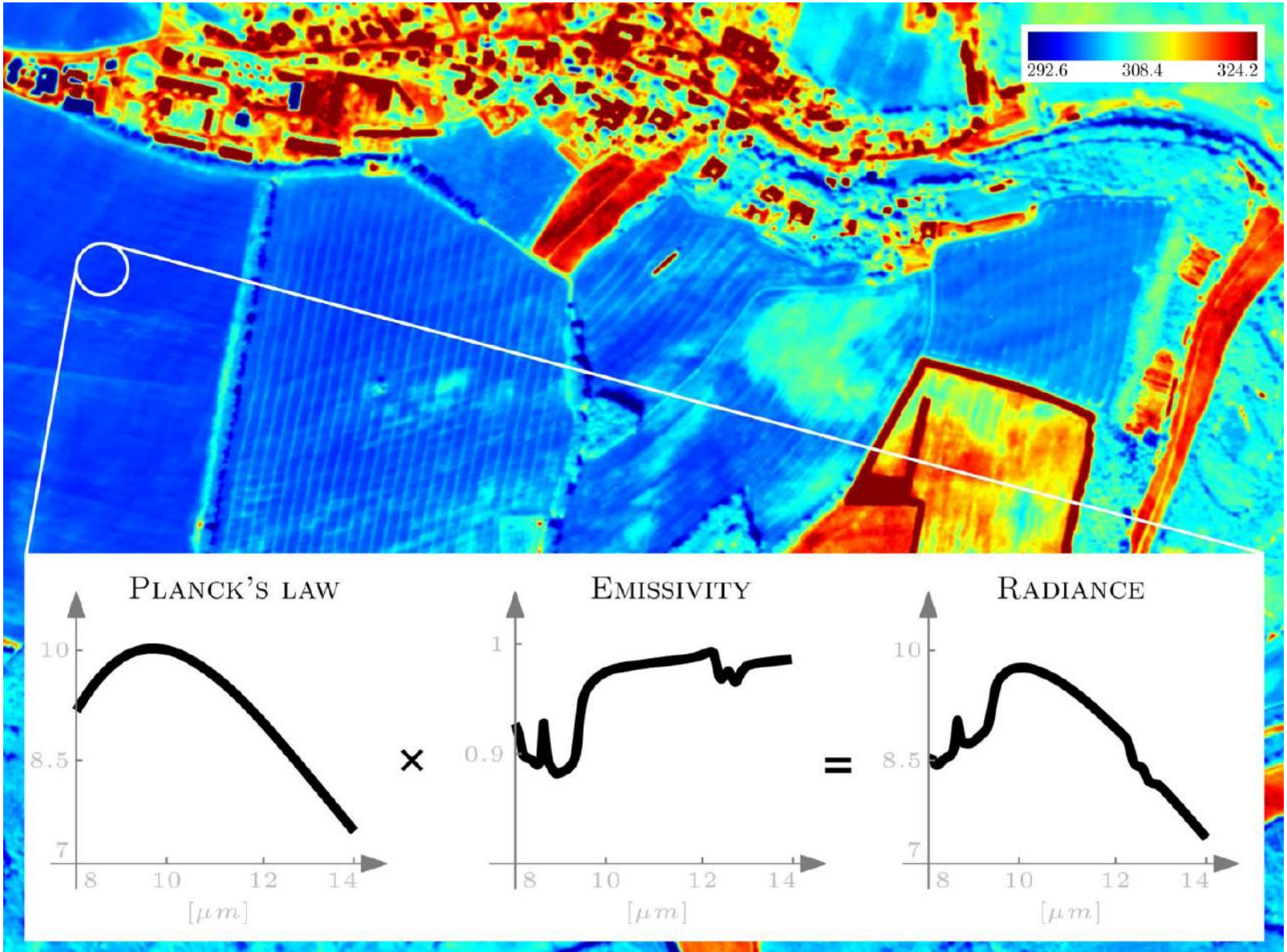
DBH – Diameter at breast height

H – Height of tree

$CanDen = Tree\_pix/Total\_area$

Hyperspectral imaging thermography

Thermal regime of urban areas and landscape



MORE INFO ABOUT CG RS TEAM ACTIVITIES

http://hydap.czechglobe.cz/

http://mapserver.czechglobe.cz/

zemek.f@czechglobe.cz

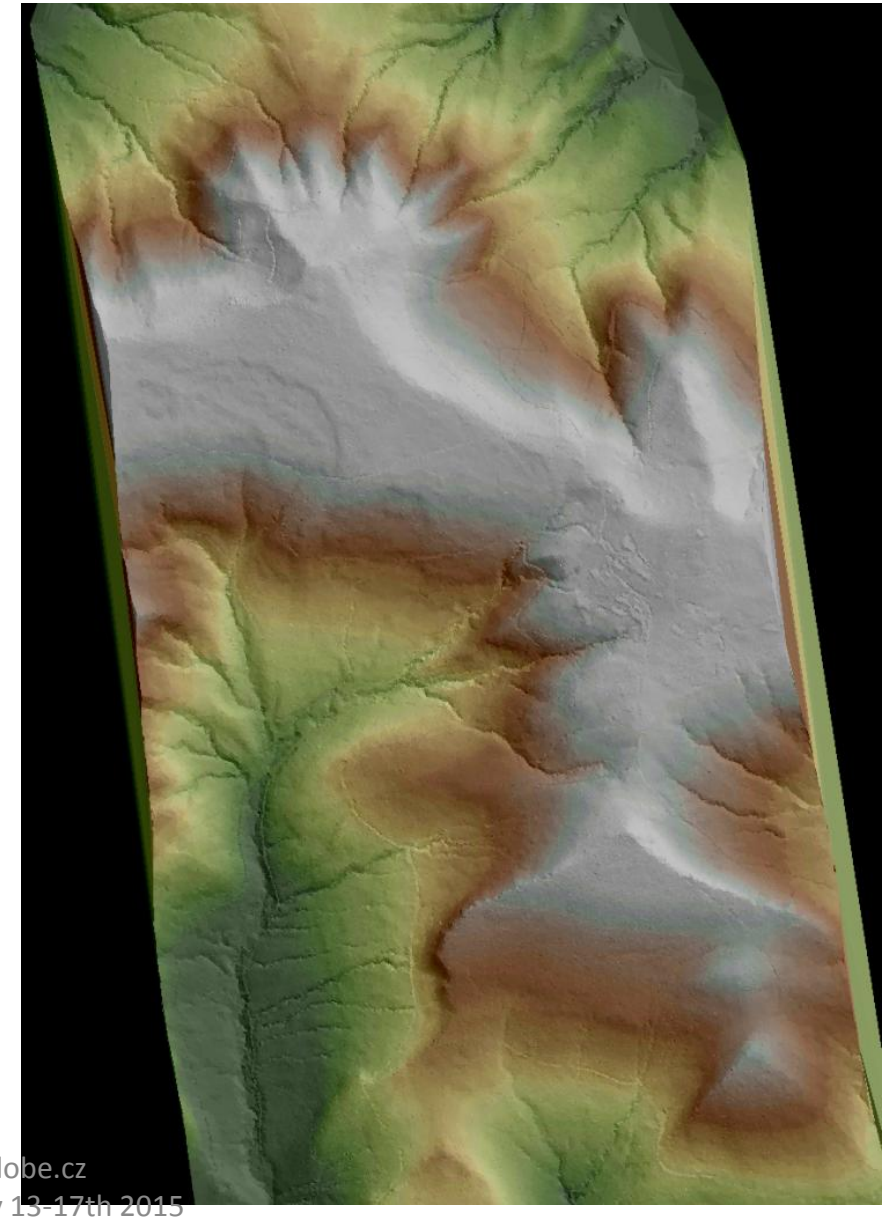
Thank you for your attention

Future steps:

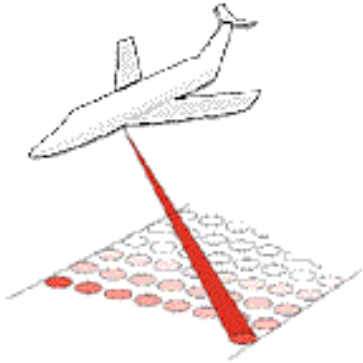
More precise parametrization for RT modelling
Biomass estimation: species classification from reflectance and Lidar structure – coupling ASL and GSL; thermal regime of urban landscape; Drought in landscape

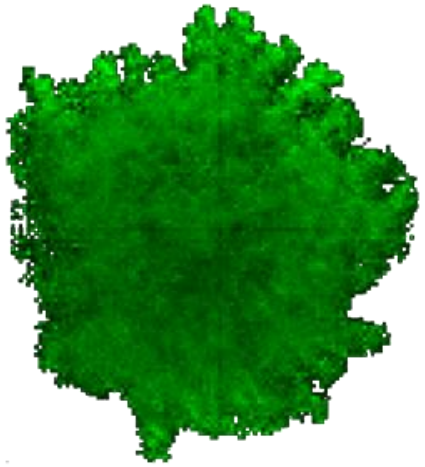
DEM – sun lighted

3D view of DEM



ALS





Building RS infrastructure – available technical facilities

FLIS components:

- Cessna Grand Caravan with two gyrosystemes
- HS scanners
- Ground measurement instrumentation

Building RS infrastructure

CASI-1500 SPECIFICATIONS

FIELD OF VIEW	40° Across-Track over 1500 pixels
SPECTRAL RANGE	650nm between 365 and 1050nm
SPECTRAL SAMPLES	Programmable, up to 288 (<3.5 nm FWHM)
APERTURE	F/3.5 to F/18.0
DYNAMIC RANGE	16,384:1 (14 bits)
NOISE FLOOR	< 2.0 DN
SIGNAL TO NOISE RATIO*	1095:1 peak
DATA RATE (MB/SEC)	20

Building RS infrastructure

SASI-600 SPECIFICATIONS

FIELD OF VIEW	40° across-track over 600 pixels
SPECTRAL RANGE	950 to 2450nm
SPECTRAL SAMPLES	100 at 15nm intervals
APERTURE	F/2
DYNAMIC RANGE	16,384:1 (14 bits)
NOISE FLOOR	6.0 DN
SIGNAL TO NOISE RATIO	Contact ITRES for SNR calculations
DATA RATE (MB/SEC)	16 (Mode 1) 9.6 (Mode 2: Preferred data rate for optimal image quality)

Building RS infrastructure

TASI-600 SPECIFICATIONS

FIELD OF VIEW	40° across-track over 600 pixels
SPECTRAL RANGE	8 to 11.5µm
SPECTRAL SAMPLES	32 at 0.25µm intervals
APERTURE	F/1.5
DYNAMIC RANGE	16,384:1 (14 bits)
NOISE FLOOR	6.0 DN
SIGNAL TO NOISE RATIO	Contact ITRES for SNR calculations
DATA RATE (MB/SEC)	13.25
NEDT	0.2° at 300K

Airborne segment FLIS

Photogrammetric aircraft

- Cessna Caravan 208B
- gyro stabilisation platform Somag GSM 3000
- navigation system Applanix POS AV 410

HS scanners

- CASI 1500 (spectral range 380-1050 nm)
- SASI 600 (spectral range 950-2450 nm)
- TASI 600 (spectral range 8-11,5 um)
- AISA Eagle (spectral range 400-1000 nm)
- LiDAR Riegl LMS – Q780

Ground field segment

Carriage

- Field laboratory – Pajero car
- Cherry picker

Instruments

- FieldSpec 3&4 ASD
- Cimel sunphotometer
- Microtops II Sunphotometer
- Thermal camera FLIR SC 660
- Thermal FTIR 100
- TLS – terrestrial Lidar Riegl VZ 400

Ground black-lab segment + software

- Integration sphere for measurement of optical properties

- Integration sphere for radiometric calibration of sensors

Software

- ATCOR, ATCOR-4, Parge, CalliGeo
- ENVI+IDL, Geomatica, Ecognition developer & server
- LasTools, EnviLidar, OPALS
- GIS Idrisi, ArcGIS
- Statistica, Mathematica, Matlab