CzechGlobe

New technical facilities and trends in quantitative assessment of forest ecosystems from airborne data

Global Change Research Centre

Academy of Sciences of the Czech Republic

Brno, Czech Republic

Frantisek ZEMEK

Miroslav PIKL, Jan NOVOTNY

Contents

Building RS infrastructure – state of art

– call for cooperation

Forest quantitative assessment continues

CzechGlobe

Building RS infrastructure

Key components of RS infrastructure

Flying Laboratory of Imaging Systems (FLIS) + field campaign instrumentation + educated staff

FLIS

- Photogrammetric **aircraft** with two acquisition open slits for imaging RS instruments
- Airborne imaging **spectroradiometer** with sensors visible and near infrared (**VNIR**) short wavelength infrared (**SWIR**), thermal infrared (**TIR**) of EM spectral regions
- **IMU/GPS** units
- Full-waveform Light Detection And Ranging (**LiDAR**) airborne laser scanner for mapping the geometrical characteristics of the Earth surface objects (provided and operated by project AdMaS)

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

CzechGlobe

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)

CzechGlobe

Building RS infrastructure

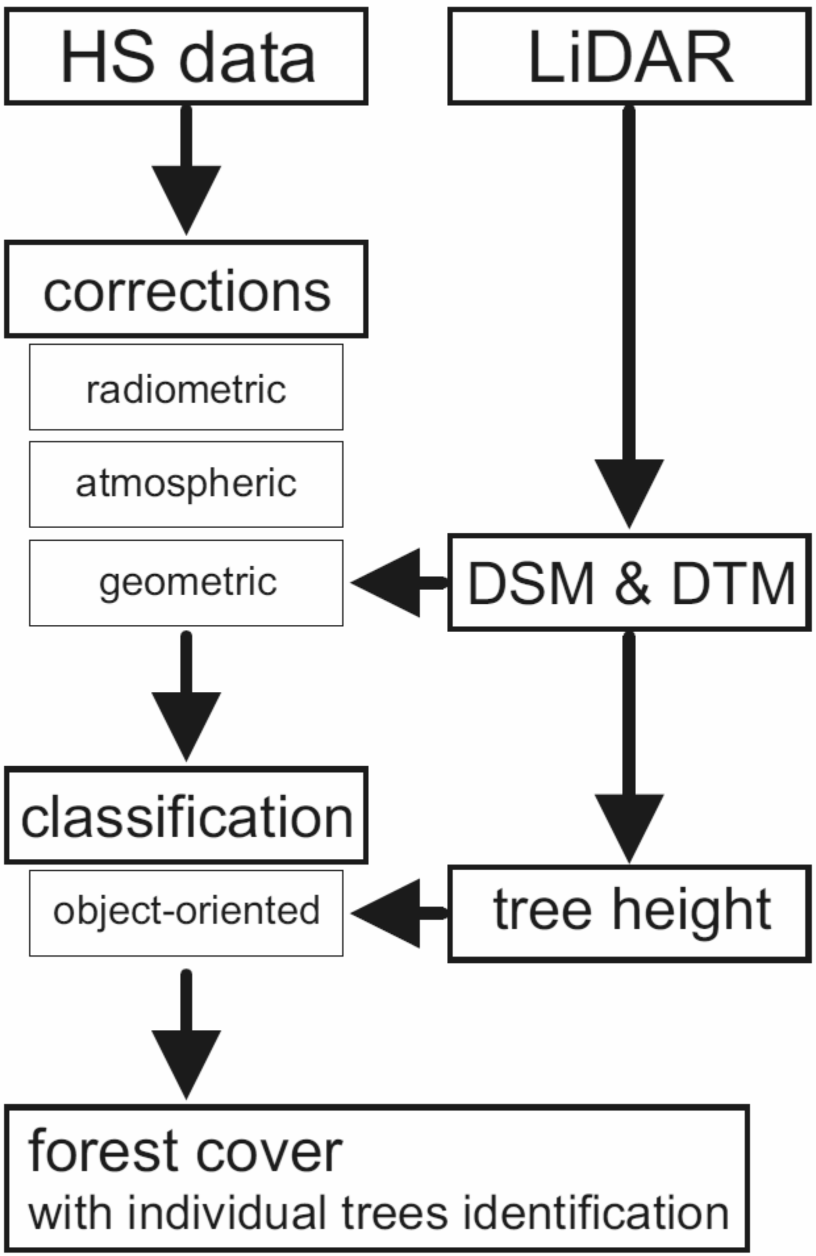
TASI-600 SPECIFICATIONS

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

Story from Prague SCERIN meeting continues – forest recovery from the Bark Beetle calamity

CzechGlobe

What vegetation cover is now there?



Hyperspectral data
AISA Eagle, August 2009
spatial resolution 0.4 m, spectral resolution 10 nm and spectral range 400-1000 nm

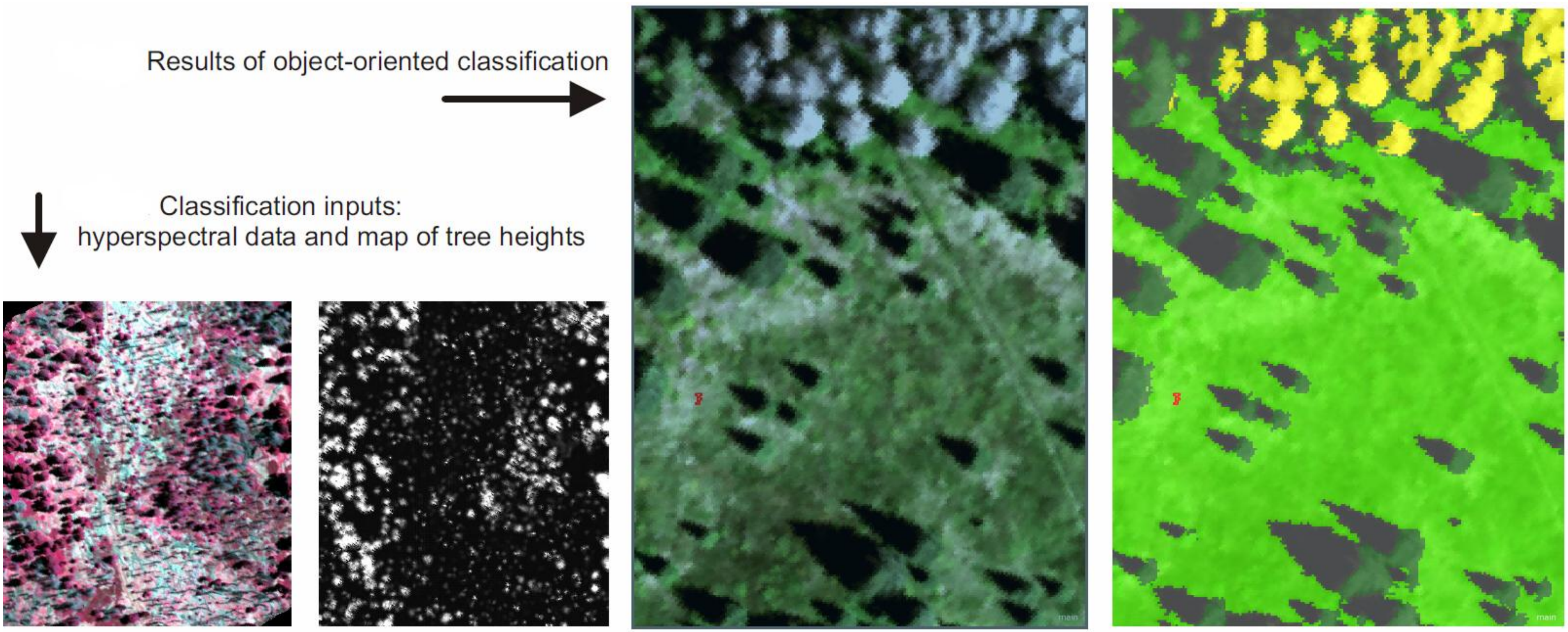
LiDAR data
TopEye Mk II 1064 nm, October 2010
cloud density 1 point / m2

Image segmentation

Object oriented classification

spectral information - from HS data (PCA transformation)

structural information - tree height derived from LiDAR data



Problems which arouse from the BB experience

- Low point cloud density of LiDAR data
    - Difficult to derive tree matrix (height, tree identification, crown structure and crown projection)

- Not enough accurate corregistration between LiDAR and HS data

Newly tested approaches

Different point cloud density of LiDAR data: 1, 5, 10, 50

Improvement in tree matrix:

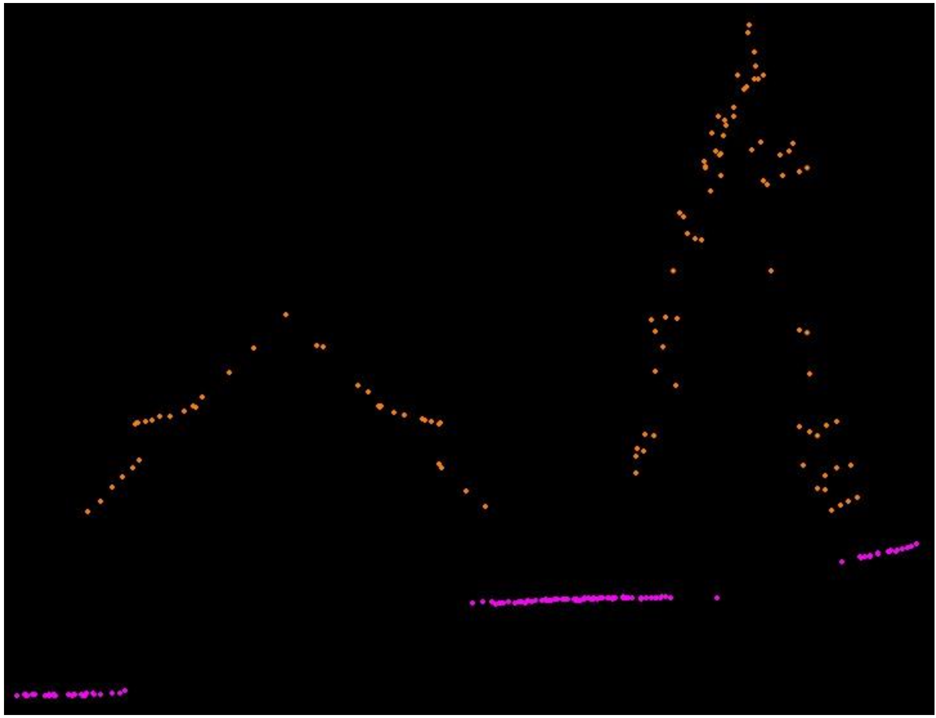
1. Identification of individual trees
2. Calculation of individual crown tree projection
3. Above ground biomass estimation, allometric equations for individual species

$$AGB = aH + bCanDen + c(H + CanDen)$$

where: H – height, CanDen – canopy density

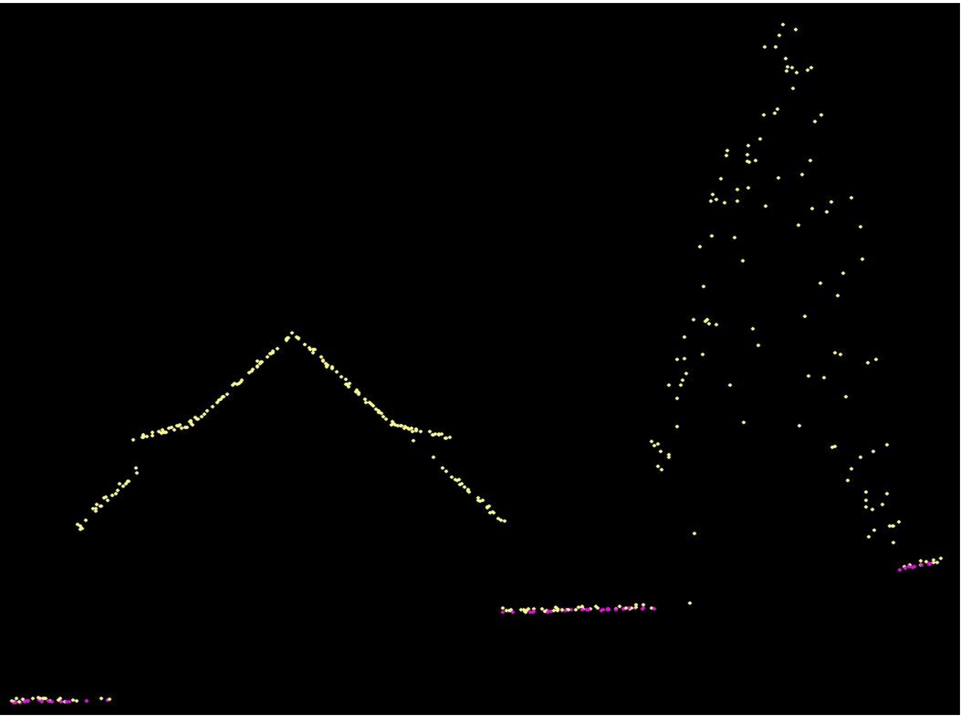
Examples of different point cloud density

1 point/m^2

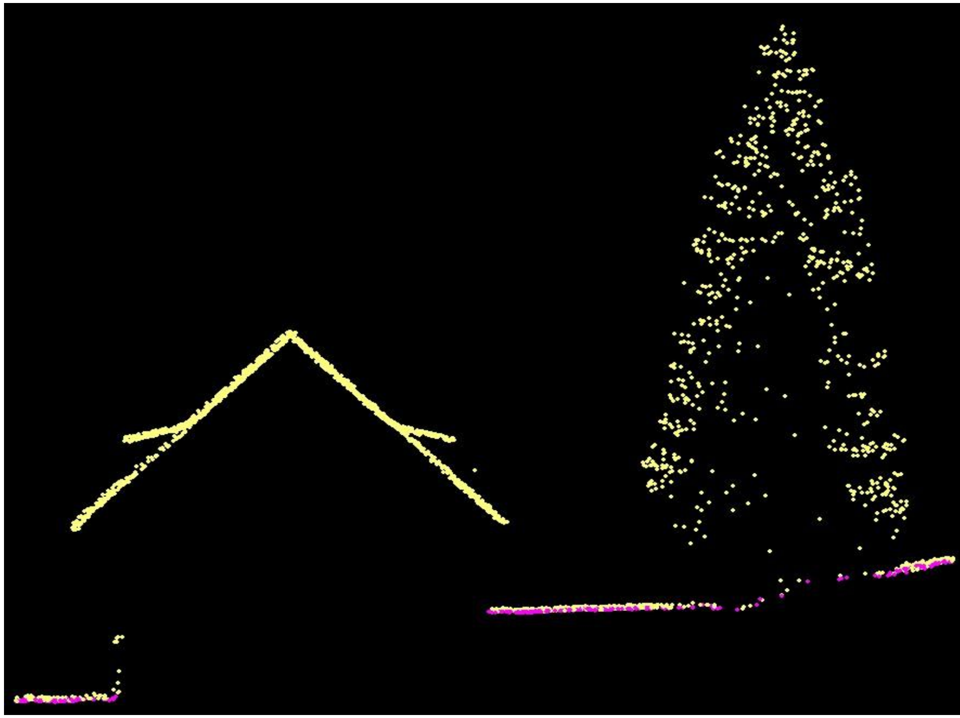


5 points/m^2

Examples of different point cloud density

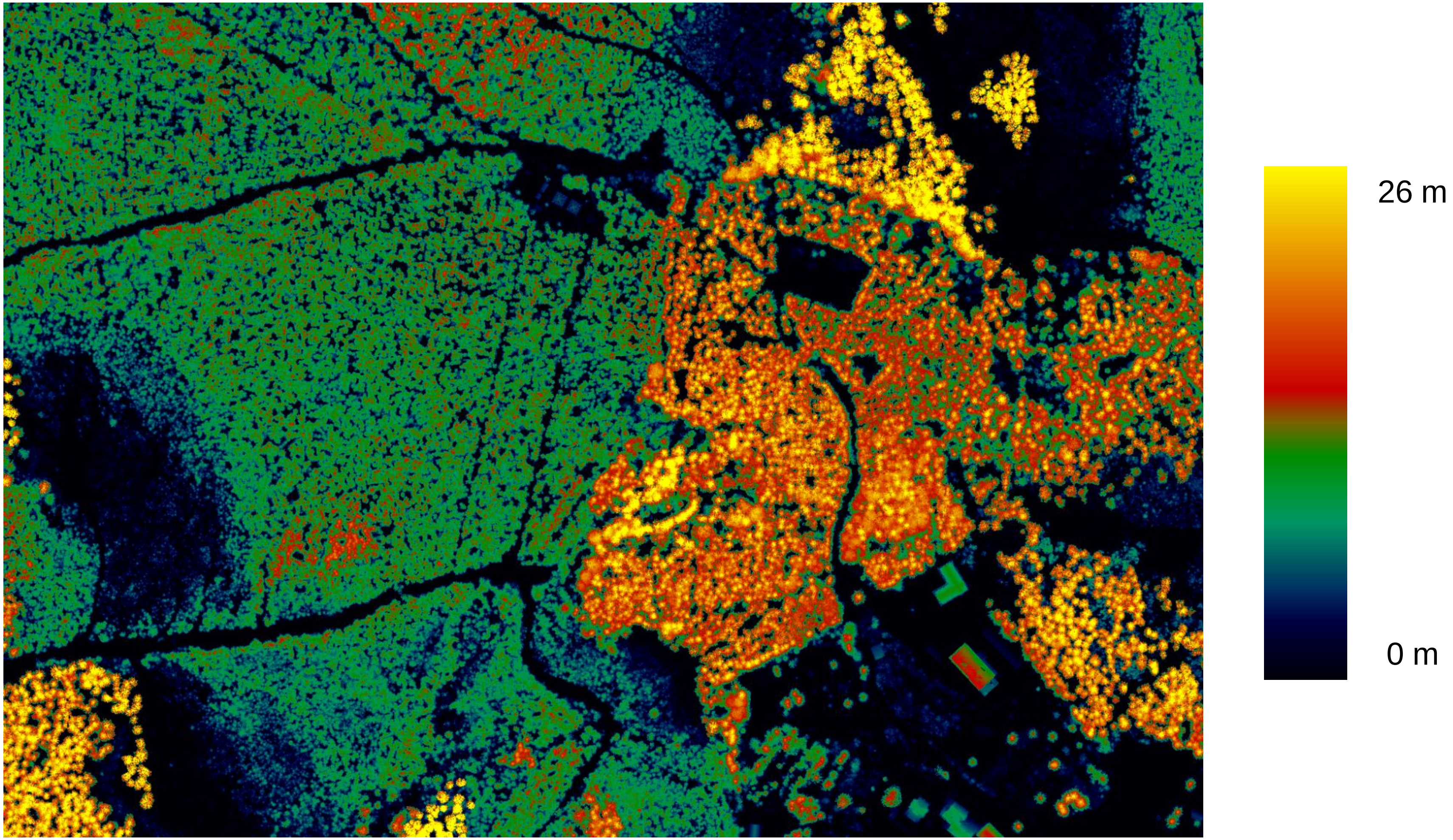


9 points/m^2



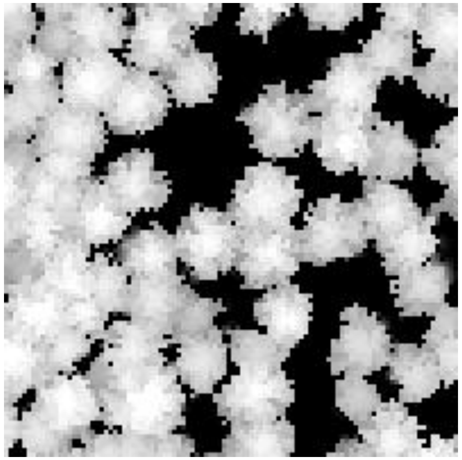
36 points/m^2

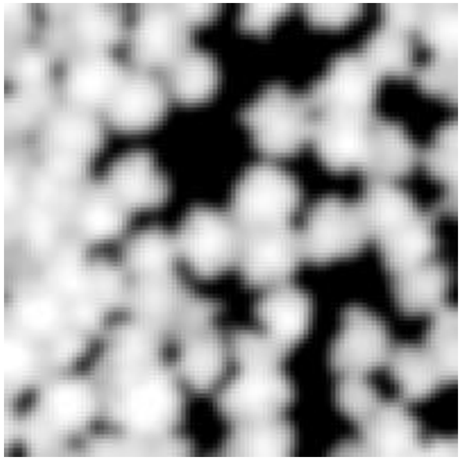
Height of aboveground objects

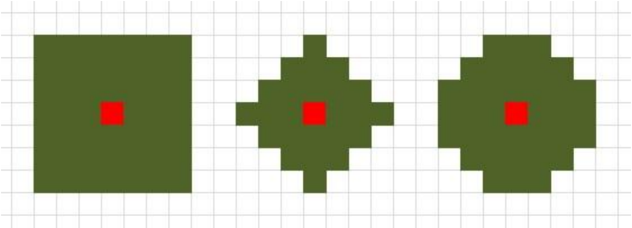


Tree Detection

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

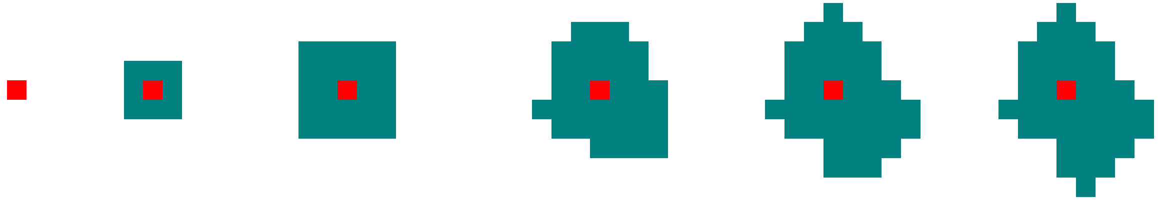






Crown Area Delineation

- 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
  - innovation: Voronoi diagram as the first iteration, then we move the boundaries down to local minima
- Seeded region growing



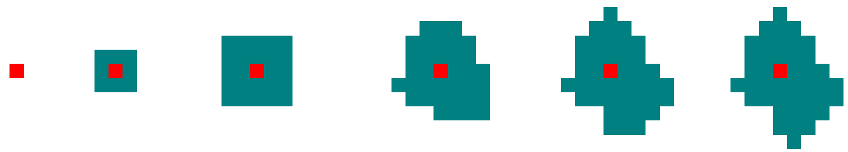
Region growing + Active contour

based on similar approach as the Snake Algorithm

- 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

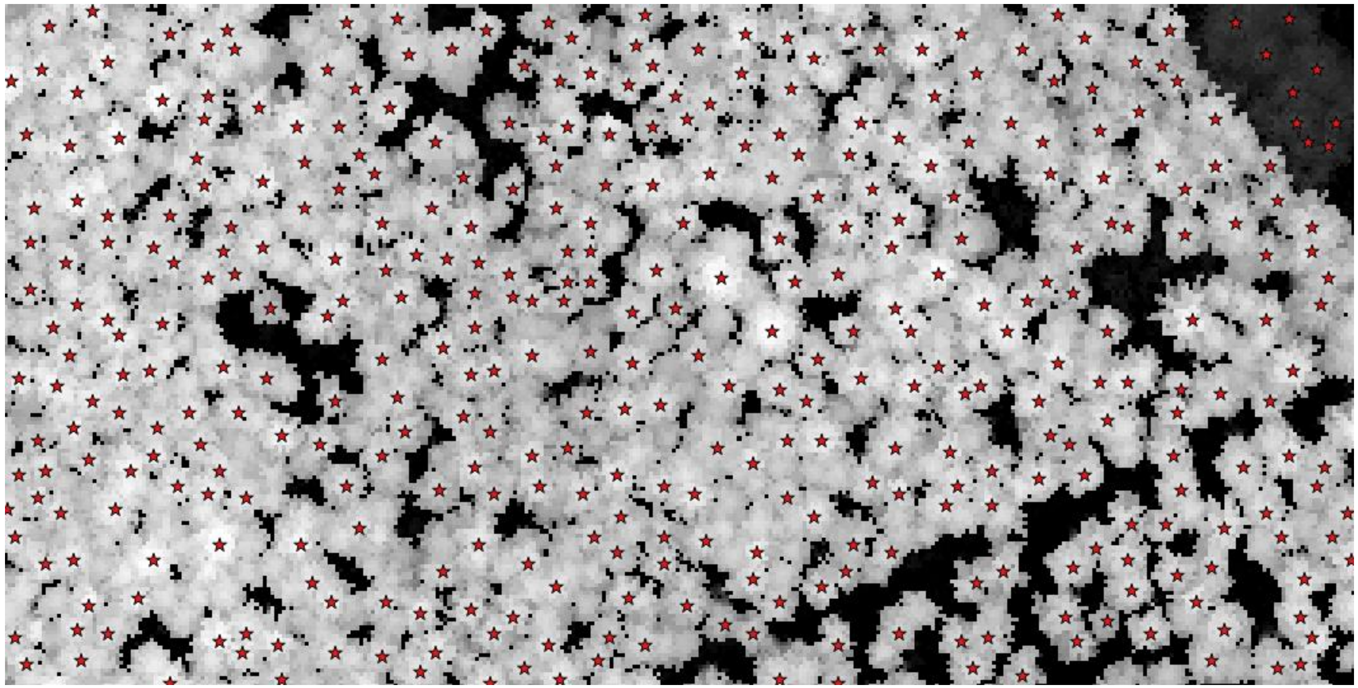
Region growing + Active contour

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 $E_{n+1} – E_n > dE$

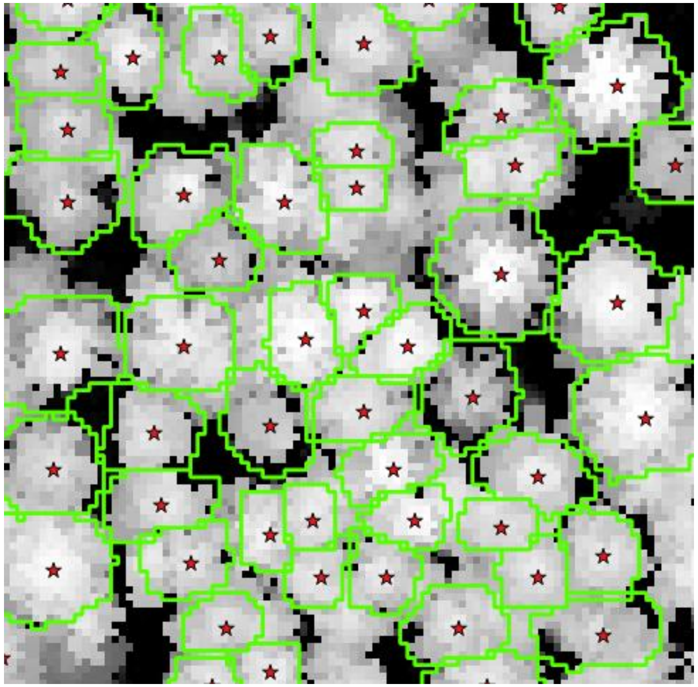
Results: Tree detection

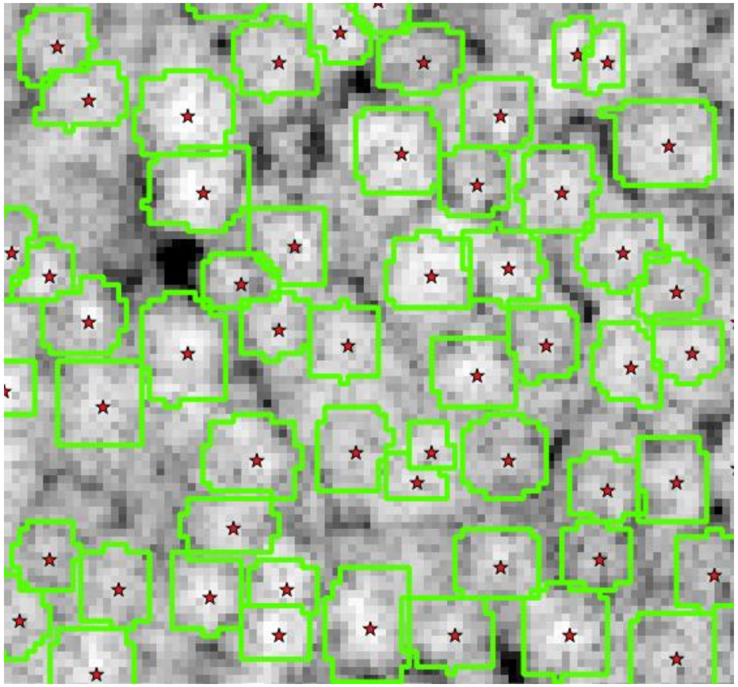
Test of accuracy: random selection trees



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





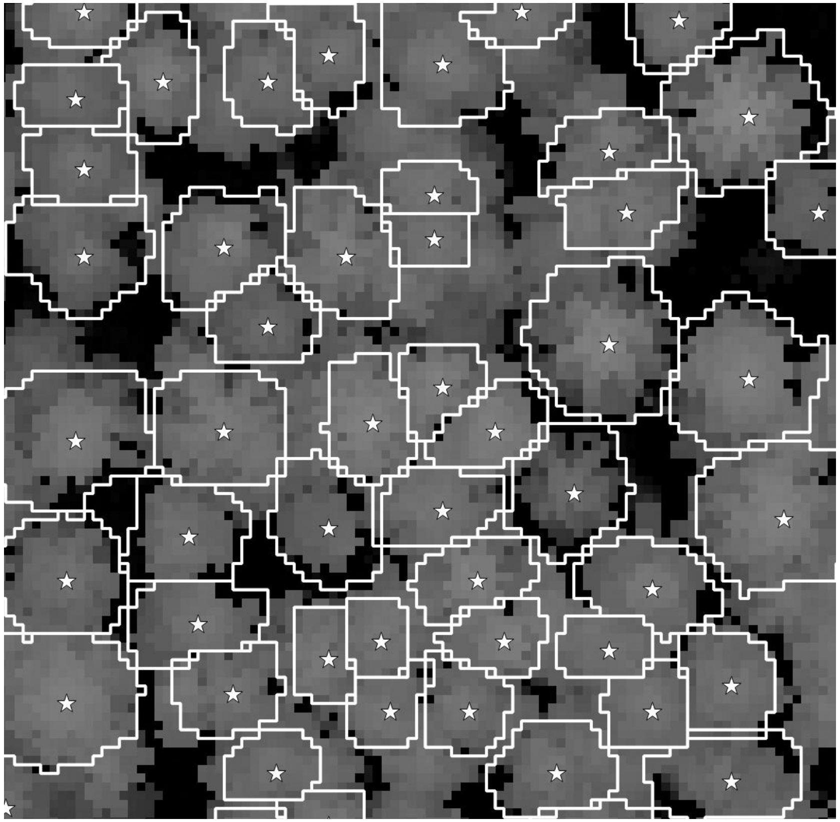
Test of accuracy: random selection tree

Percentage of agreement in crown shape

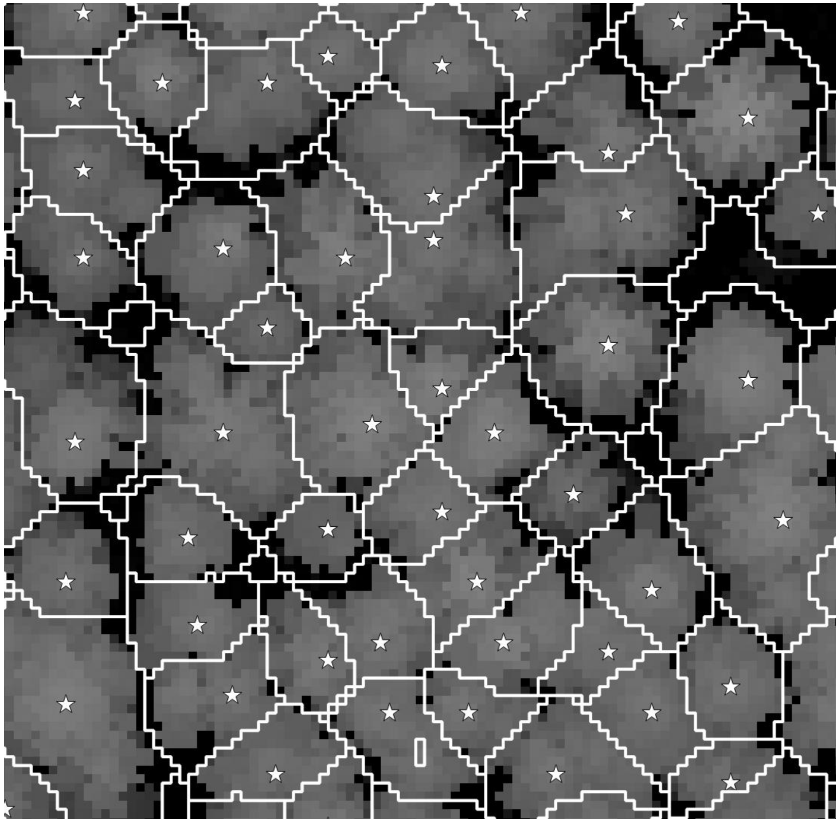
Locality	95 %	75 %	50 %	25 %	accuracy
Bílý Kříž	122	176	54	4	76.8 %
Rájec	177	188	53	10	79.0 %
Štítná	169	294	21	1	80.8 %

CzechGlobe

Comparison: SRG vs. Watershed



Seeded Region Growing



Watershed Algorithm

MORE INFO ABOUT CG RS TEAM ACTIVITIES

http://hydap.czechglobe.cz/

http://mapserver.czechglobe.cz/

zemek.f@czechglobe.cz

FUTURE

CzechGlobe RS team welcomes any good
cooperation in research/applications of airborne hyperspectral and LiDAR data in ecosystems assessment

Thank you for your attention