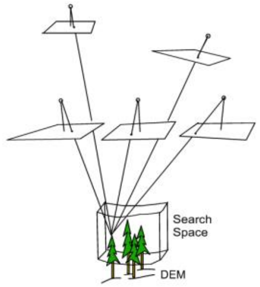
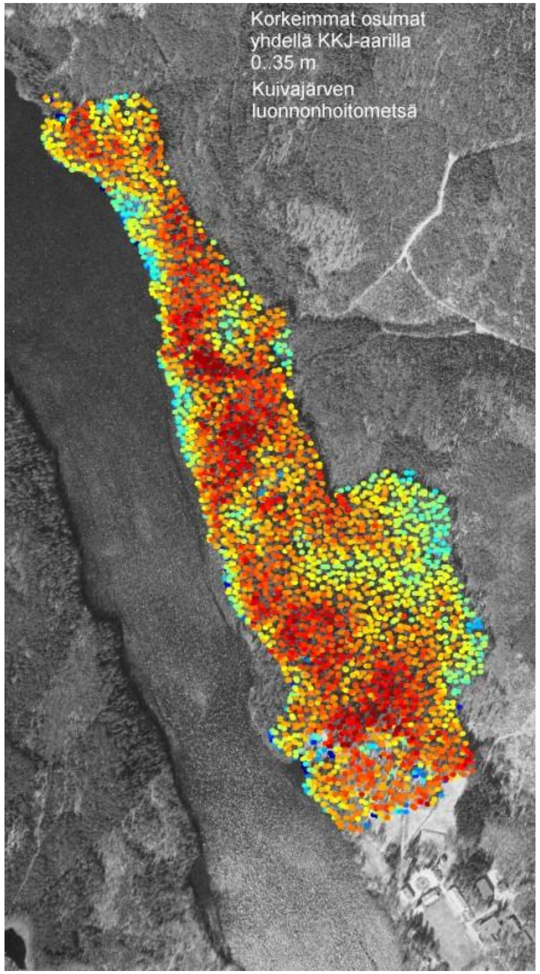
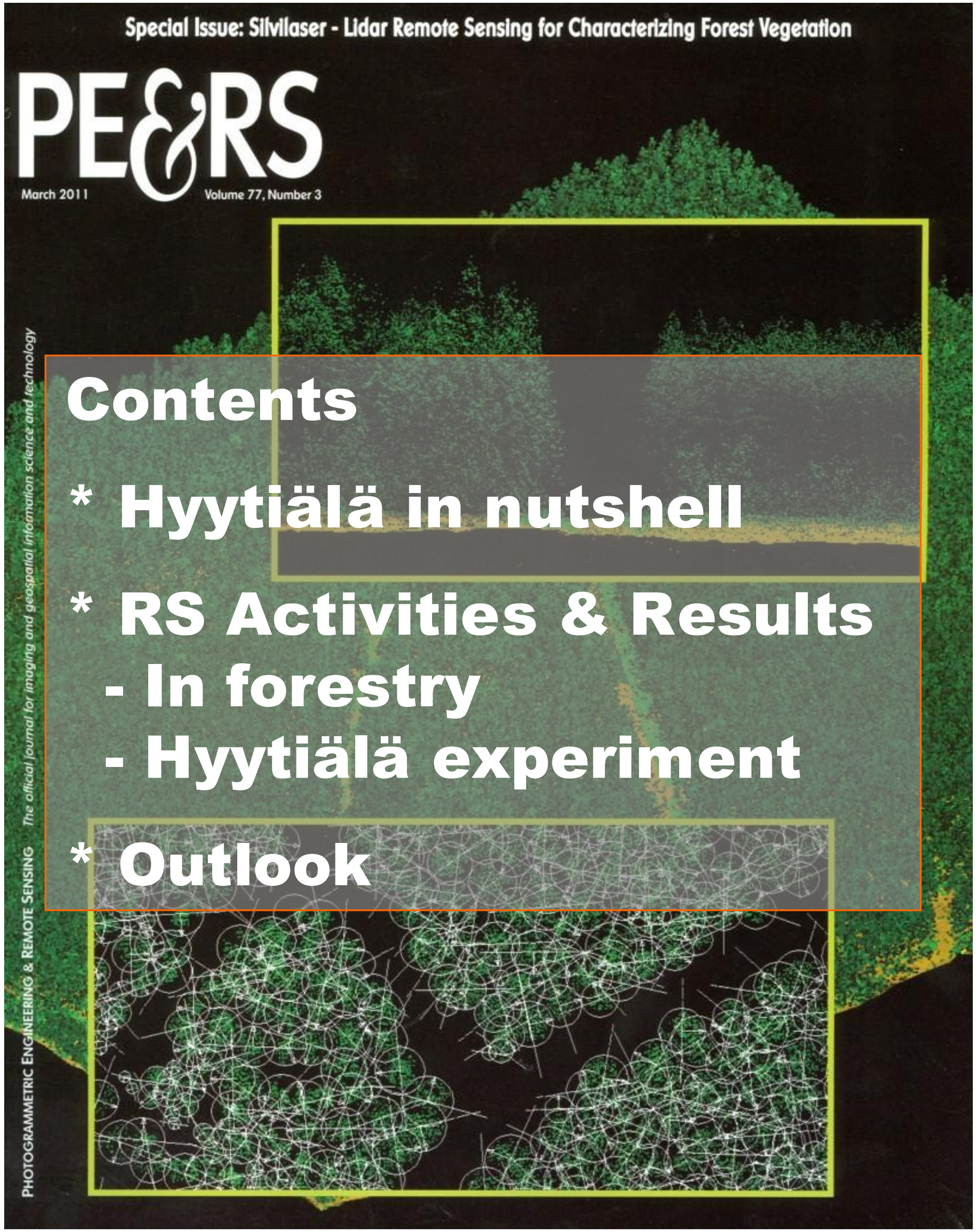
Optista lentokonekaukokartoitusta Hyytiälän metsissä ja soilla 1997–2011

Ilkka Korpela (UH, EUF) - FGI March 22, 2011







Contents

* Hyytiälä in nutshell

* RS Activities & Results
  - In forestry
  - Hyytiälä experiment

* Outlook

PERS 3/2011

Hyytiälä

Forest field station of UH, 1910–
(2010- Dept. of Forest Sciences)

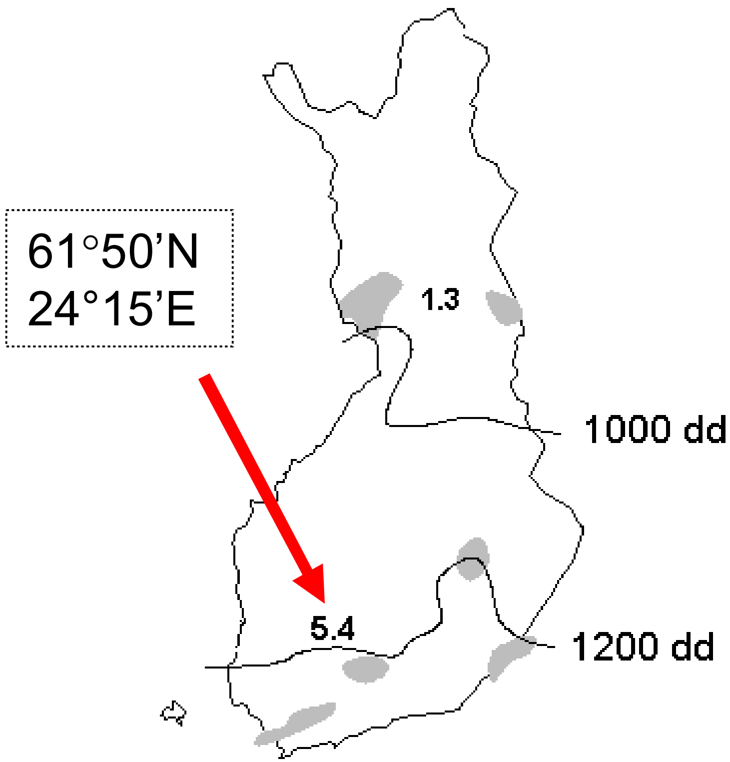
130–200 m a.s.l.

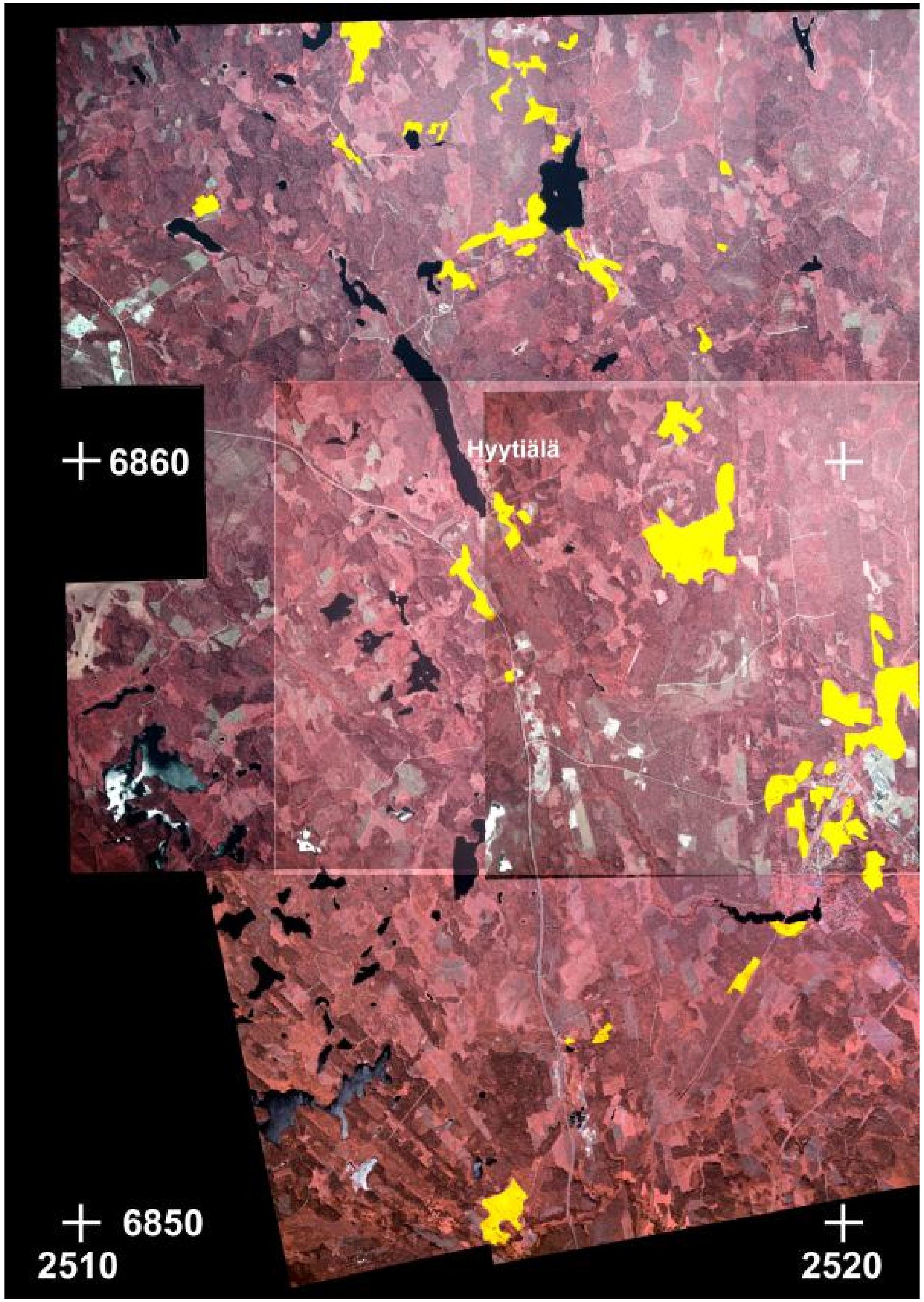
EFTP 60, EFJY 100, EFHF 200 km

Field teaching:
forestry, environmental sciences,
metheorology (physics).

Research:
SMEAR II (Sunphotometer, etc.)
Peatlands
Optical RS (forestry + theoretical RS)

State-owned land (mostly).
Experimentation possible.





Hyytiälä




Remote Sensing in Forestry

Forest inventory and monitoring in a nutshell

Forest

Infinite indexing (relevant) $\mathbf{y} = (y_1,\ldots,y_\infty)$
Biological and abiotic processes, $\mathbf{y}_t,..,\mathbf{y}_{t+a}$

Measure-ments

Sampling

Models

Options

Costs & benefits

Spatial-temporal aspects

Indirect nature of measurements and models

'Forest' in information systems

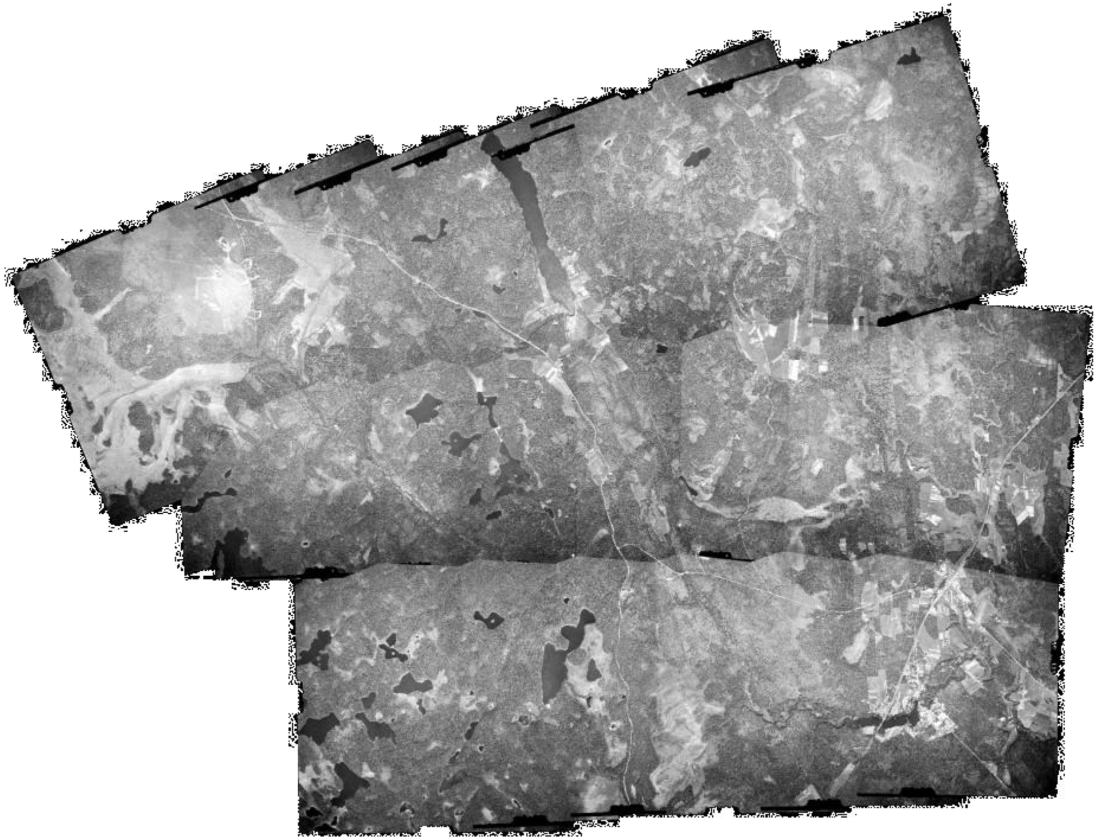
Forest(ry) models
Finite storage & computational resources

Decisions

'No aims or activity' vs.
'Multitarget-oriented activity' (max)

INFRASTRUCTURE FOR FORESTRY (Local – National)

Some (inaccurate) Historical Notes



(1946) First aerial image block from Hyytiälä

- Aerial photo interpretation for forestry since 1930s
- CIR film in Finland 1975 $\Rightarrow$
- Digital orthoimages ~1995 $\Rightarrow$ (non-stereo intrepretation)
- First trials with satellite images since early 1970s (multi-stage/phase sampling)
- National Forest Inventory adopted sat. images for coarse generalization (1980s, 1990s)
- Digital photogrammetry & LiDAR surfing (2000–)

Some early names in Finland:

Aarne Nyyssönen, Simo Poso, Kunnallistekniikka, Risto Kuittinen, VTT, Tuomas Häme, …

Airborne Remote Sensing Activities in Hyytiälä 1997–

Empirical Research

"Making implications of X in population Y through observations "

Method Development

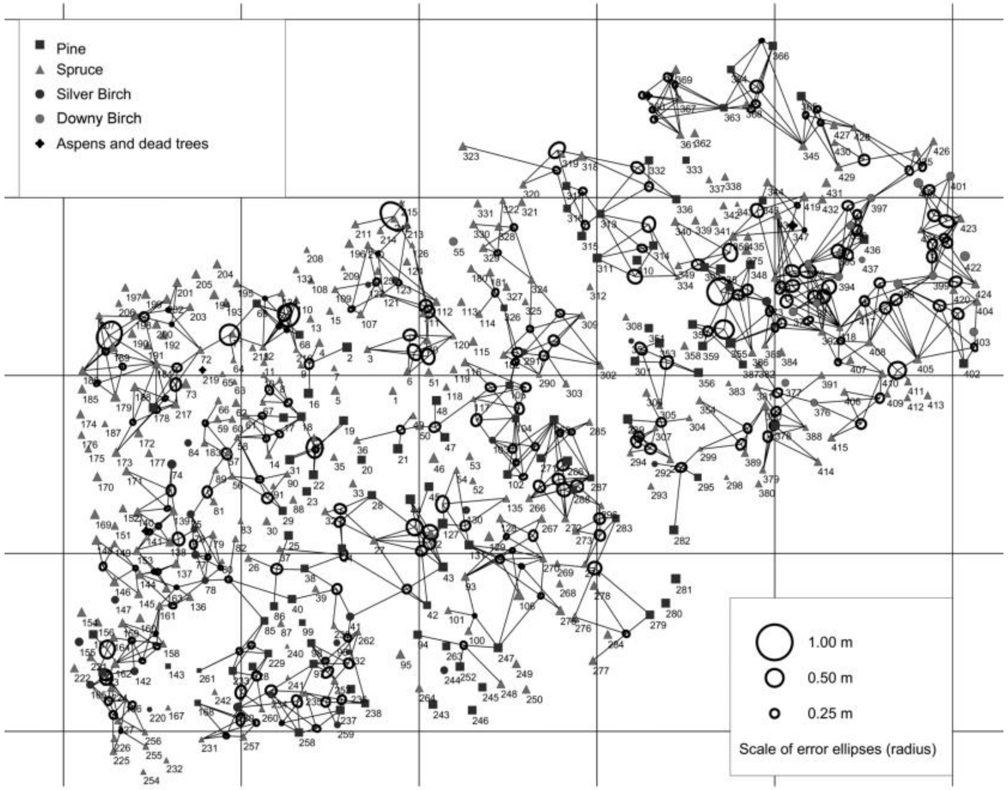
"Assuring that developed solution is robust"

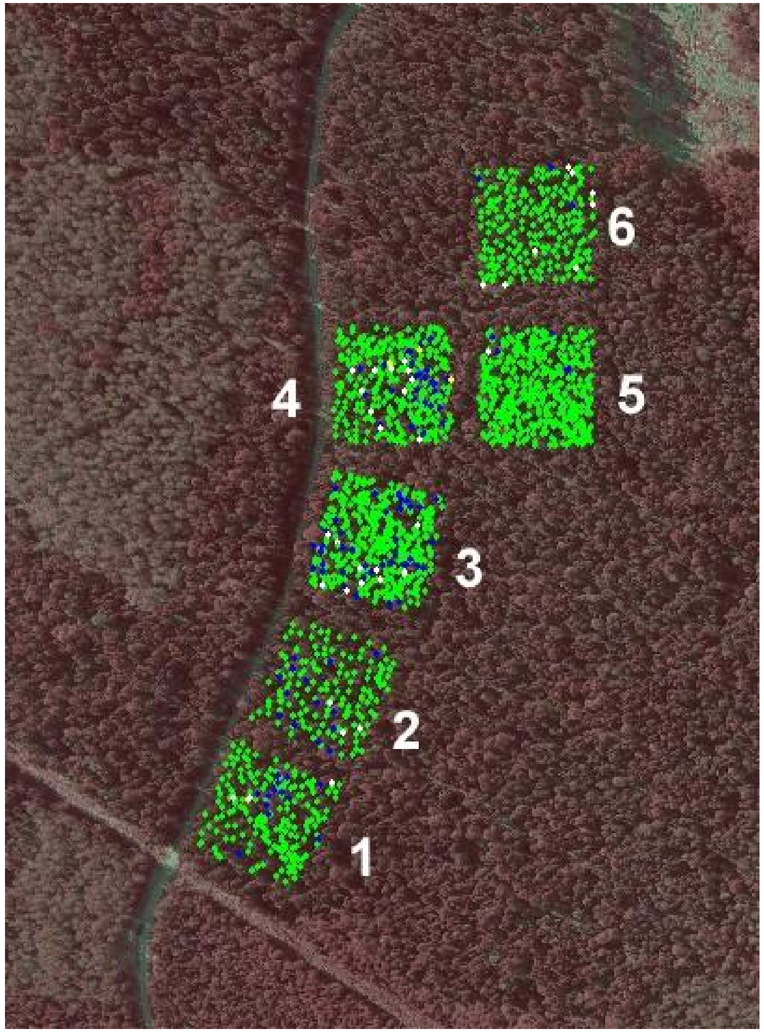
Keywords:

Good Observations, Representative sampling, Controlled effects,
Big N and redundancy, Consortia, Sharing.

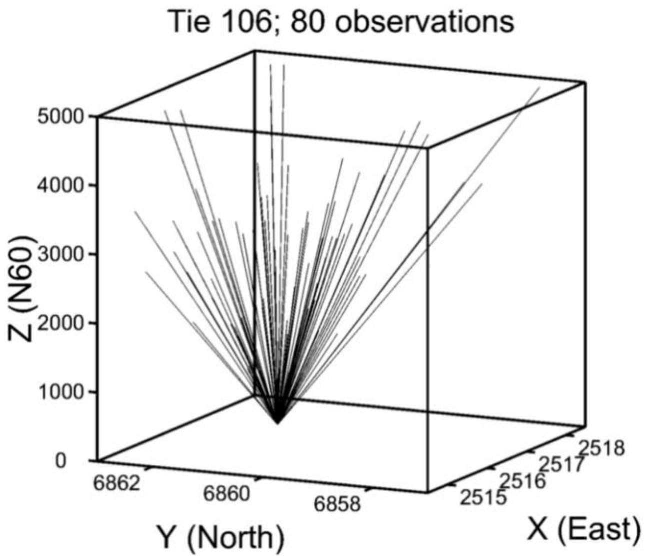
Network of permanent forest plots (1994-)

* efficient “photogrammetric-geodetic” tree mapping method applied since 2006.

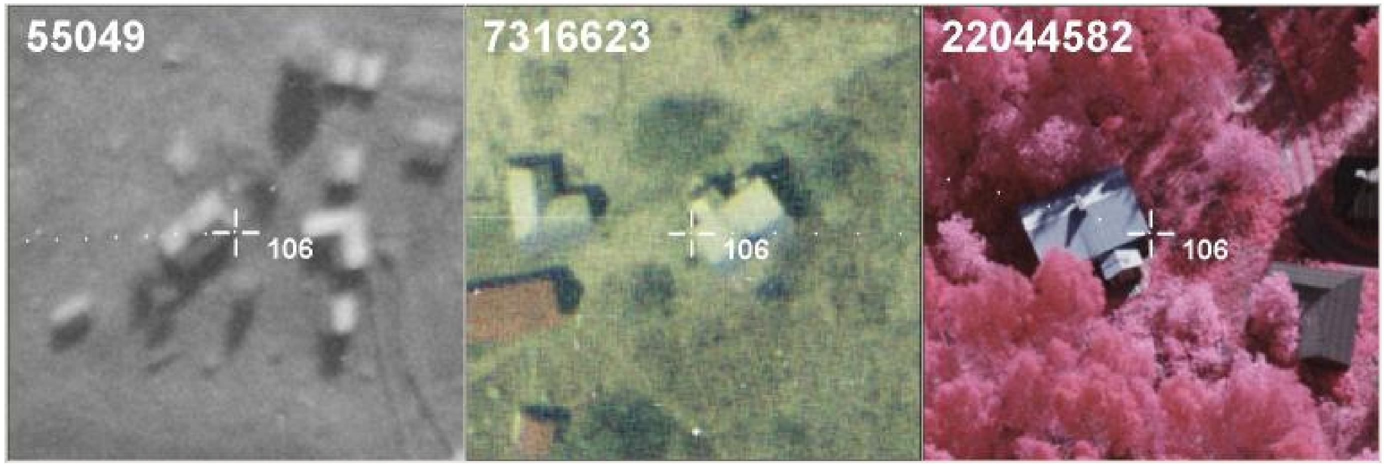




1985 1:10000 CIR

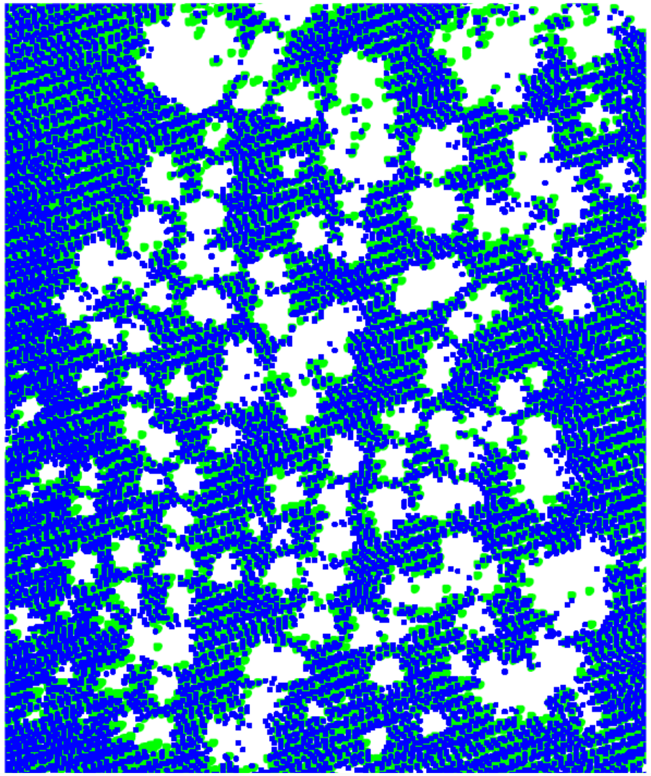


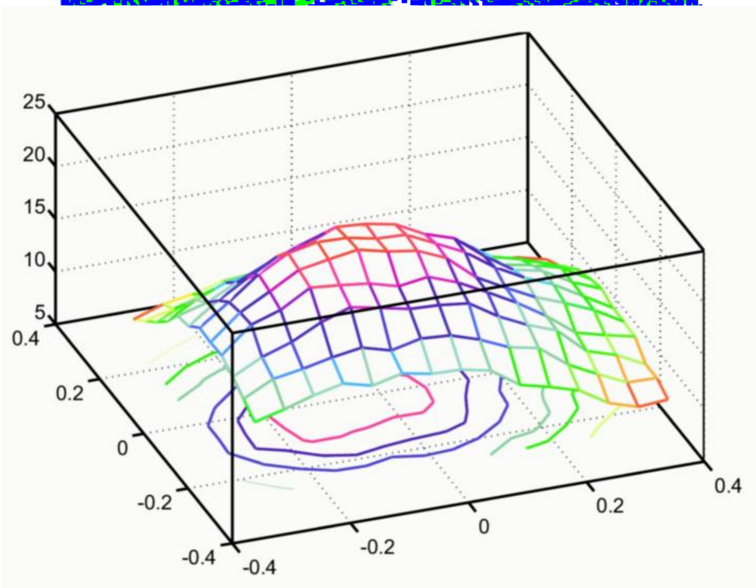
High geometric reliability over time – ground truth, images & LiDAR

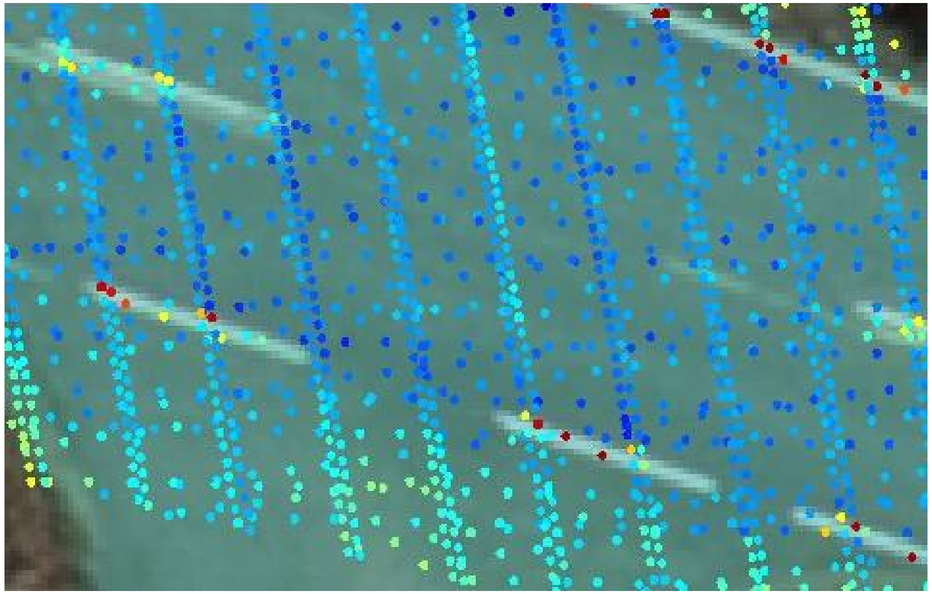


LiDAR 2004–

Set	Date	Sensor	Over-lap %	Scan angle	Pulse density	PRF, kHz
2004-1km	5.8.	ALTM1233	25%	±15°	1-3	33
2006-1km	25.7.	ALTM3100	55%	±14°	6-8	100
2007-1km	4.7.	ALS-50	55%	±15°	6-10	116
2008-1km	23.8.	ALS-50	30%	±32°	2.7	-
2008-2km	23.8.	ALS-50	30%	±32°	1.6	-
2008-3km	23.8.	ALS-50	30%	±32°	0.5	-
2008-4km	23.8.	ALS-50	30%	±32°	0.2	-
2010-1.2km	19.7.	ALS-60 1-nsec	60%	±15°	8	174
2010-2km	19.7.	ALS-60 1-nsec	30%	±15°	2	-
2010-2km	19.7.	ALS-60 2-nsec	30%	±15°	2	-
2010-3km	19.7.	ALS-60 1-nsec	30%	±15°	1	-
2010-3km	19.7.	ALS-60 2-nsec	30%	±15°	1	-




25
20
15
10
5
0.4
0.2
0
-0.2
-0.4
-0.4
-0.2
0
0.2
0.4

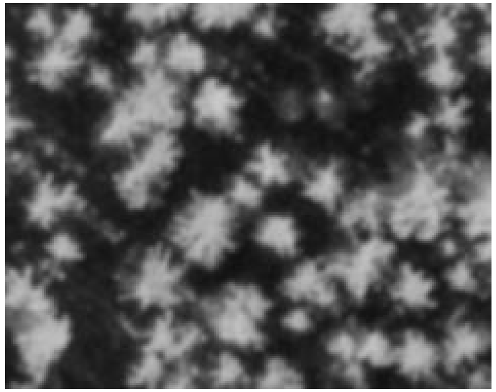


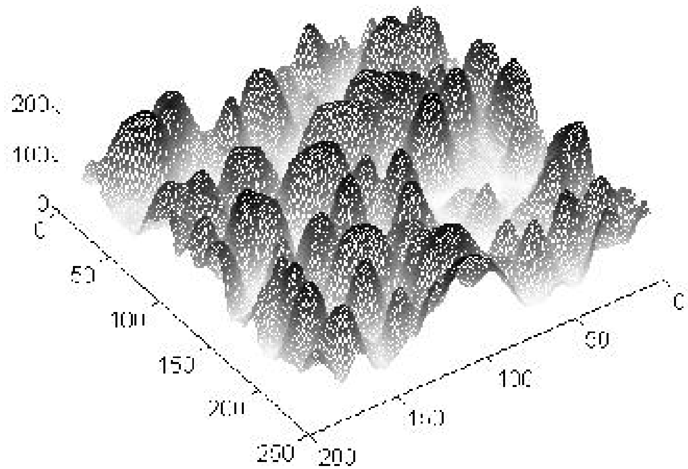
1997–2004

Digital aerial images and digital photogrammetry.

1989 Hannu Salmenperä had written a DPW in C together with Prof. Poso. “YPNIT”.

- binary scanning (20 MB HDD) of 9”×9” film for IO
- sub-image scanning for EO ⇒ “Piecewise fotogrammetry?”





In Austria Axel Pinz, in Denmark Kim Dralle – monoscopic crown detection in scanned film images. Mats Eriksson in Sweden.

In Canada F. Cougeon (MEIS sensors)

1997–2004

Digital aerial images and digital photogrammetry.

Single-tree photogrammetry tried in digital images (not novel as such, e.g. Nyyssönen 1955, Juri Talts 1977)

Many worked with near-nadir or very-high resolution data, which of course is not feasible.

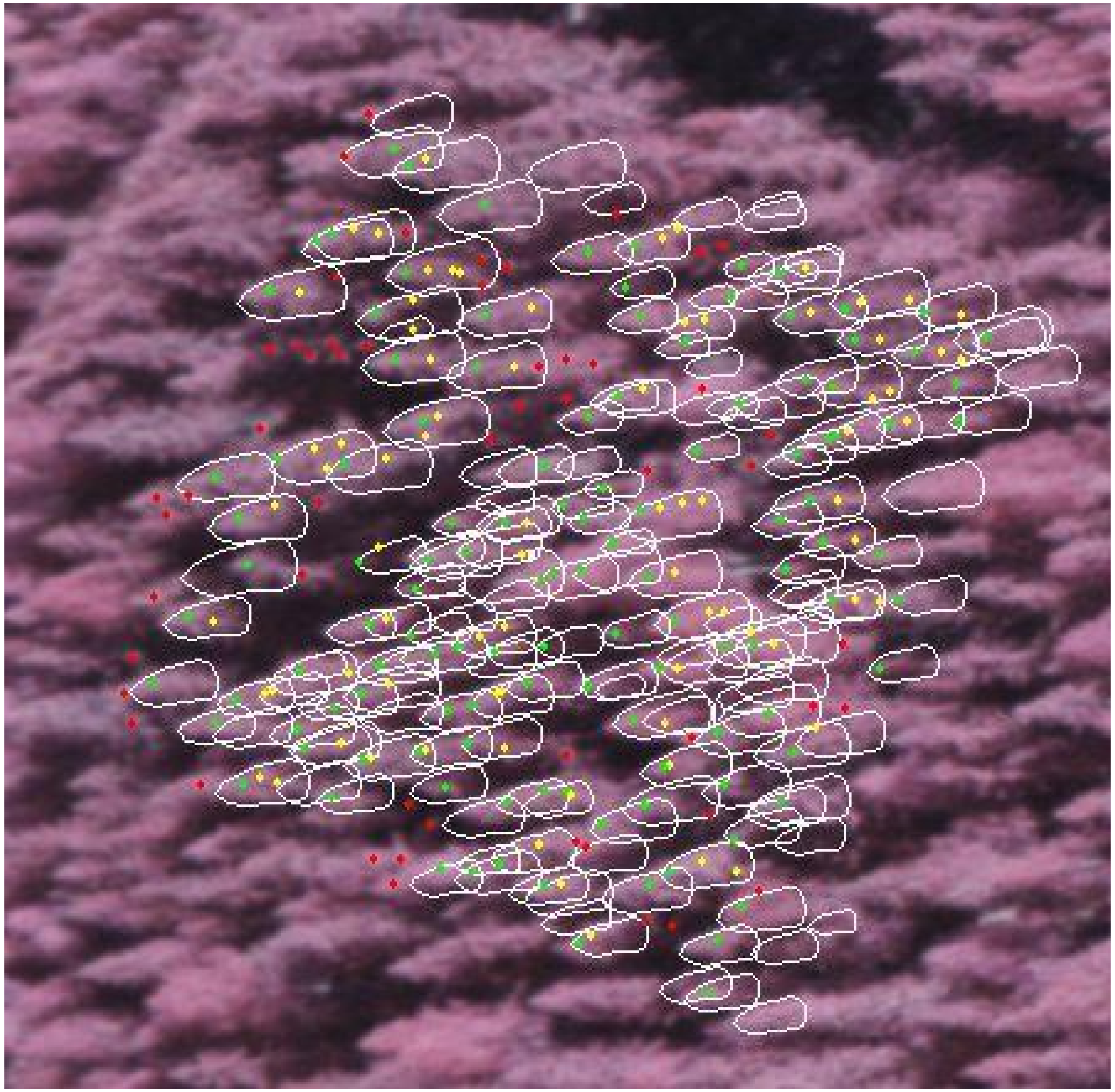
Area-based estimatation
Texture-features for “areas” were tried (cf. area-based LiDAR features).

Scanned film artifacts

Lessons learned (in Hyytiälä):

Occlusion and shading are inherent properties

Tree crowns are not 2D



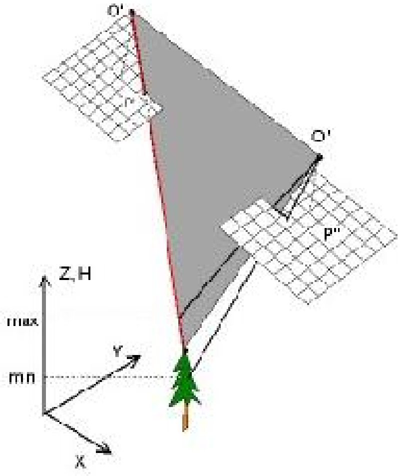
Lessons learned (in Hyytiälä):

Occlusion and shading are inherent properties

Tree crowns are not 2D

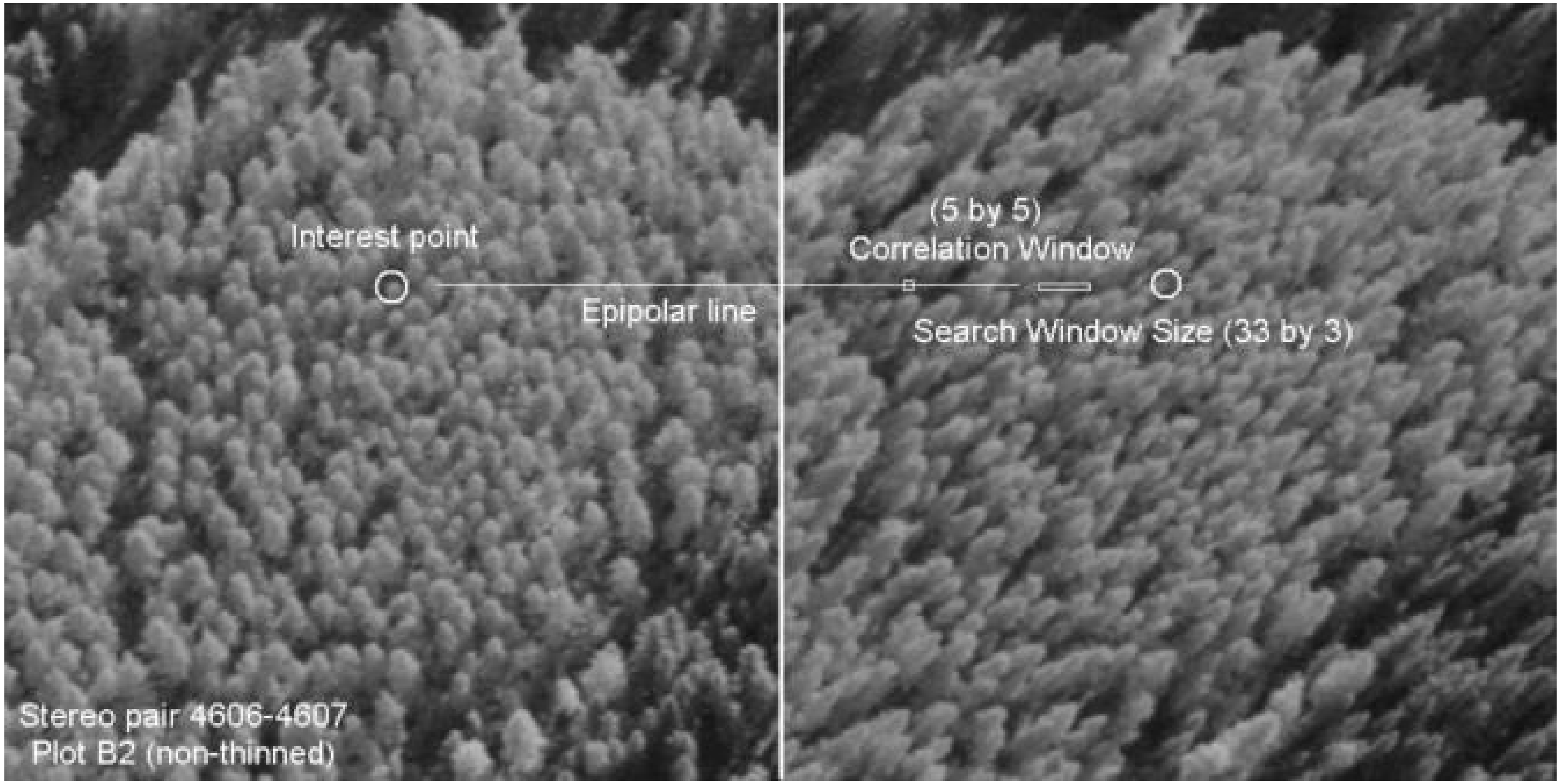
INT. J. RS (2004)

Monoscopic crown detection in off-nadir (θ_v ~ 35°) front-lit ($\phi_{s,v}$ ~ 180° image data (14 um scanning, 1:20000 CIR film)



PJF (2004)

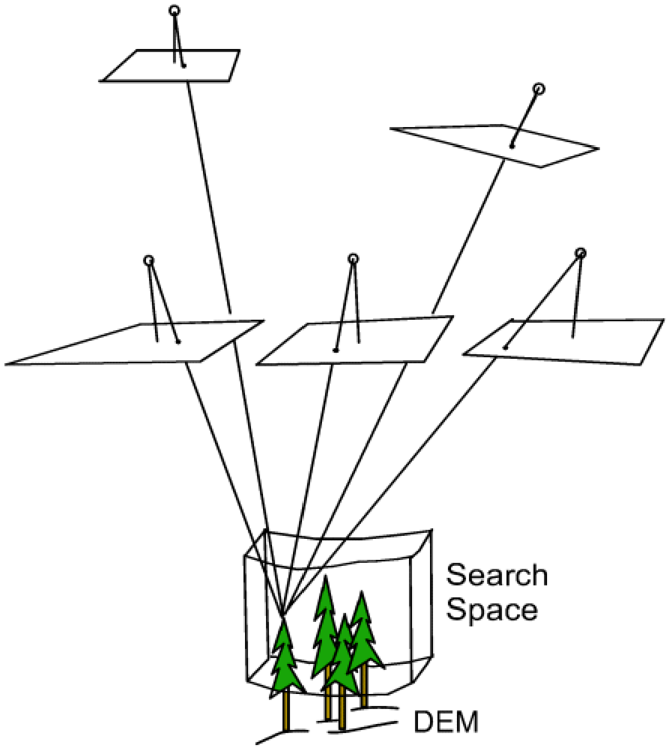
“Trees are such 3D creatures that feature/area-based image-matching fails”

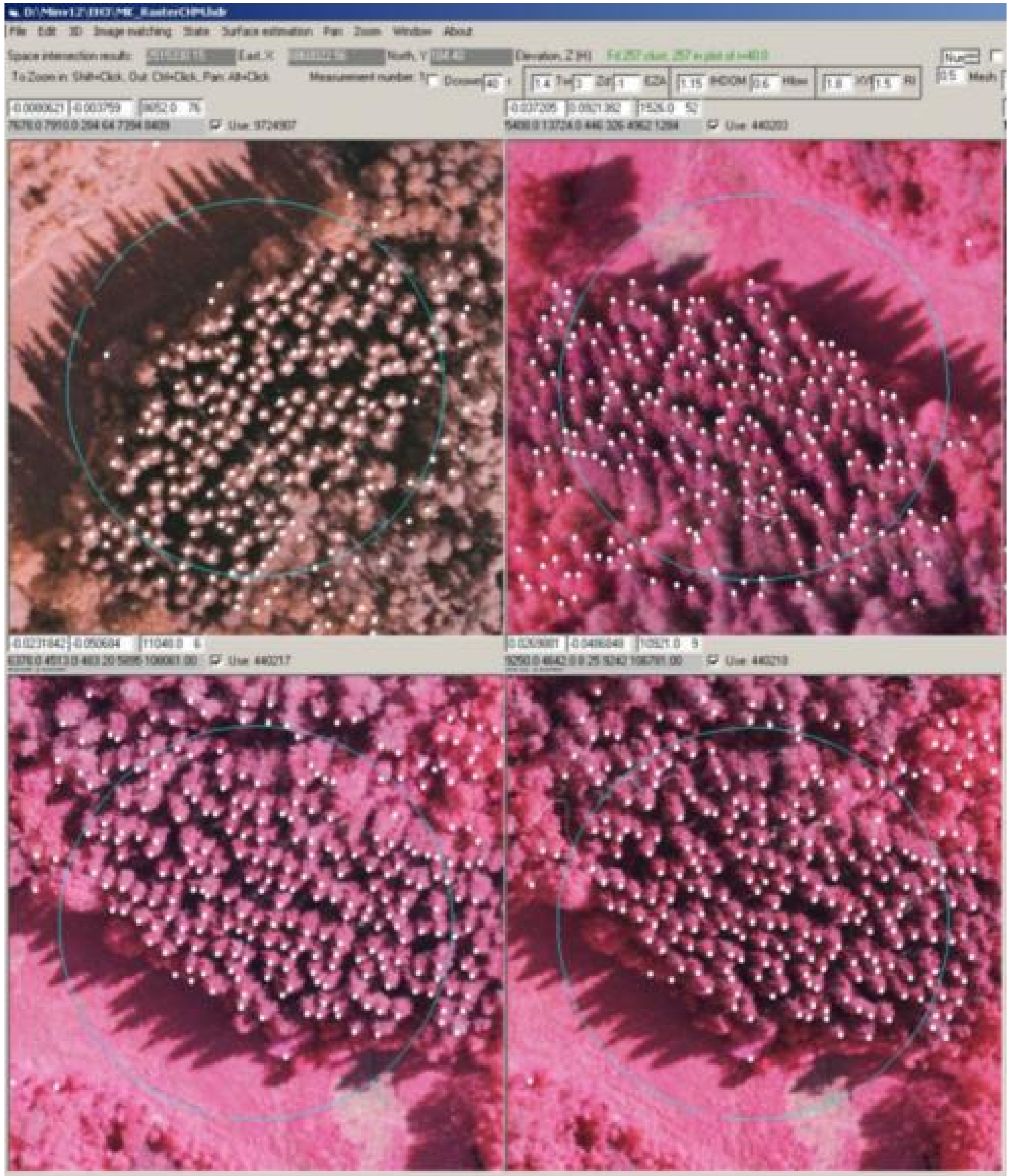


Silva Fennica 2004, PFG 2007

Single-tree RS

“Trees are such 3D creatures that feature-based matching + constraining are required

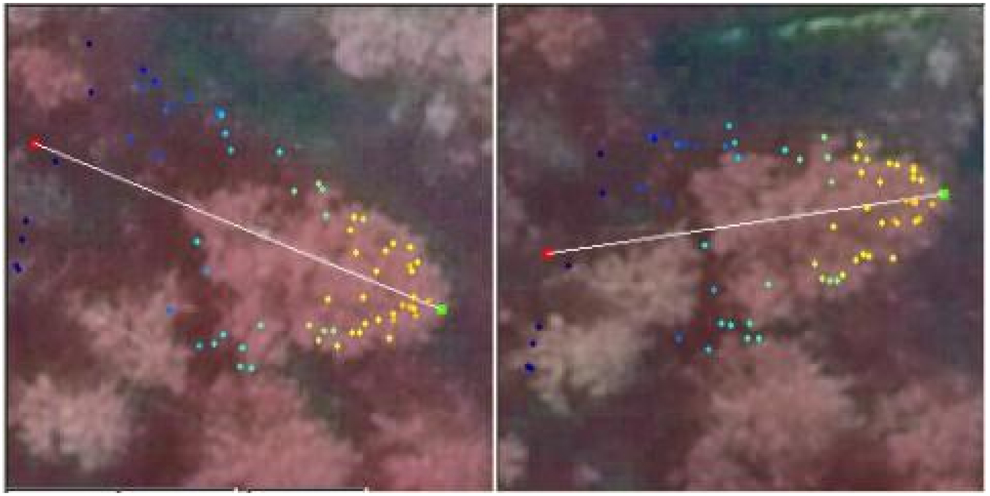


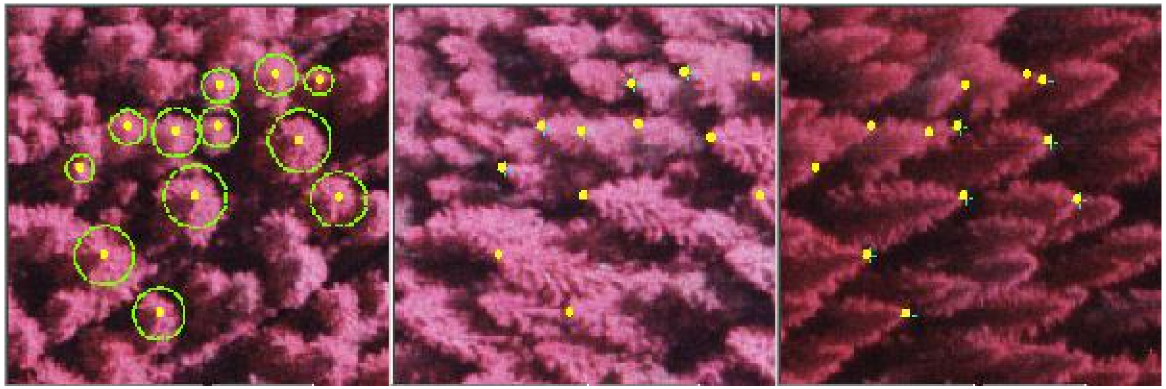


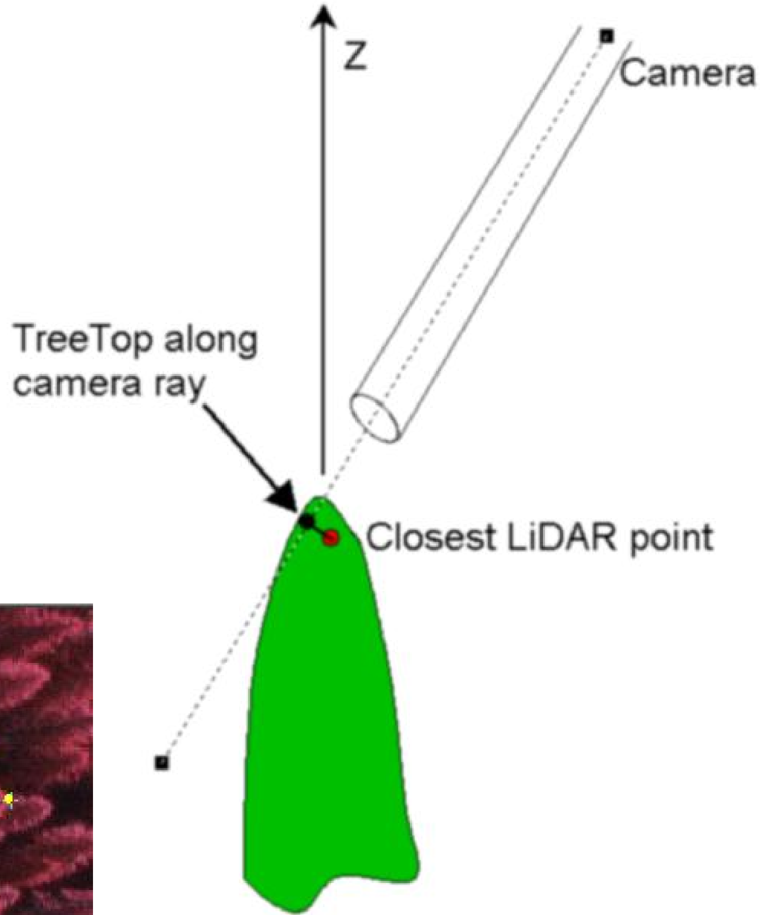
LiDAR over Hyytiälä 2004 –

From image-matching viewpoint (LiDAR is):

1) Short-cut to geometric constraining
2) Great, since it sees the ground!







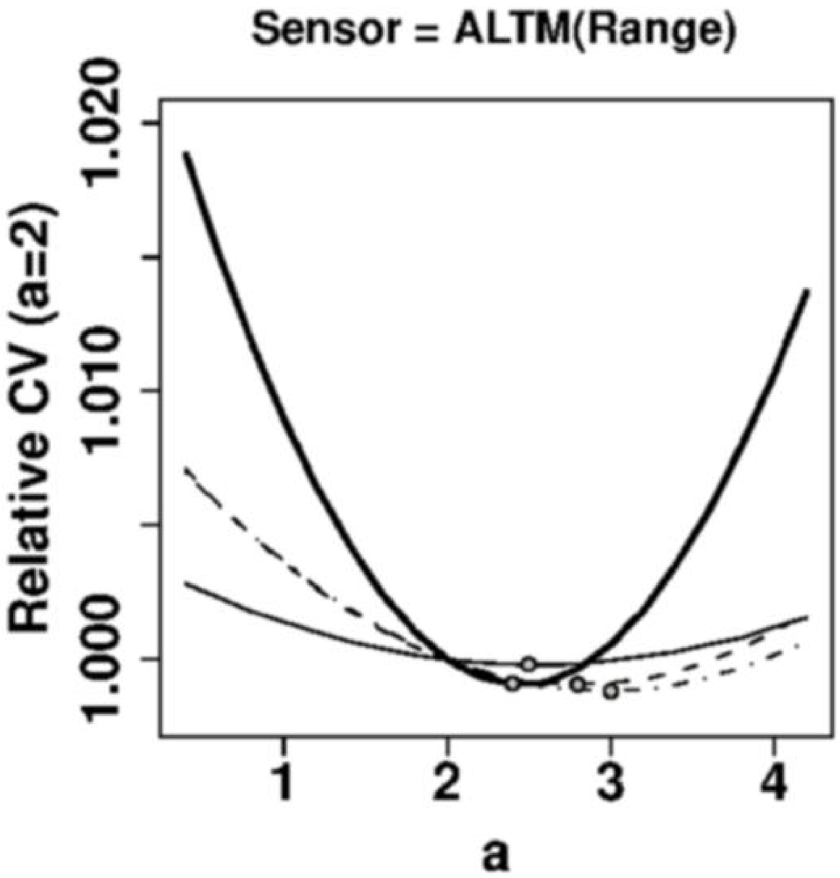
LiDAR activity in Hyytiälä (2004-)

- Multitemporal time-series of aerial photos & LiDAR
- Co-use LiDAR & images in 3D tree top positioning
- DEM accuracy of leaf-on data
- Discrete-return data in tree crown shape reconstruction
  (links to canopy shape and illumination conditions modeling for image analysis of reflectance calibrated ADS40 images) *).
- Intensity data in tree species classification *)
- Range and AGC normalization of intensity data *)
- Single-tree remote sensing
- Mire habitat characterization
- LAI and canopy cover estimation. Ground-lichen mapping.
- Modeling transmission losses in intensity data
- Understory tree mapping. Change detection (snow breaks), Tree growth
- Waveform data: transmission losses, tree species, seedling stnds, DEM-estimation *)

*) with FGI

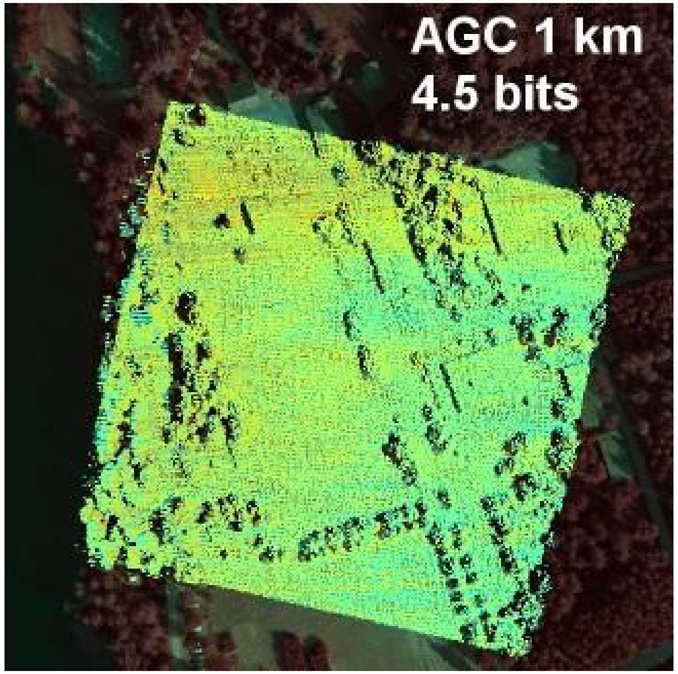
Some pics from most interesting findings

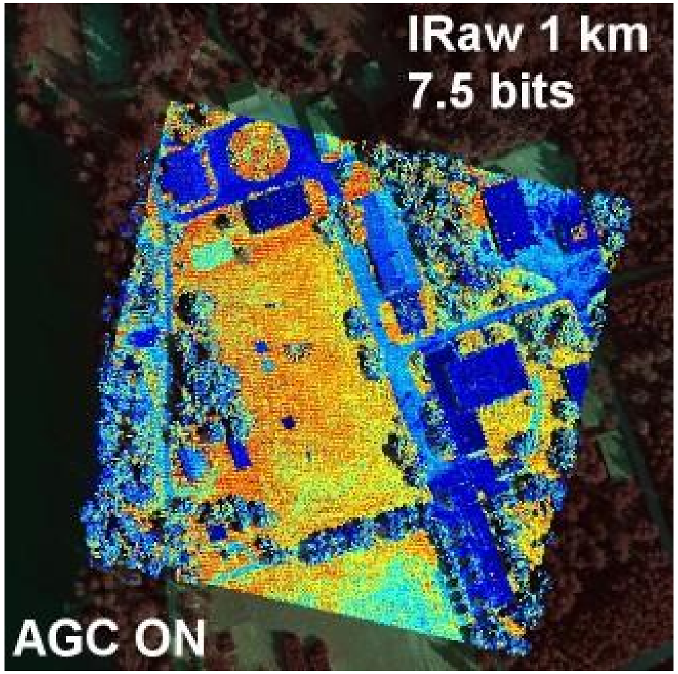
Ambiguity of intensity range normalization in forest canopies



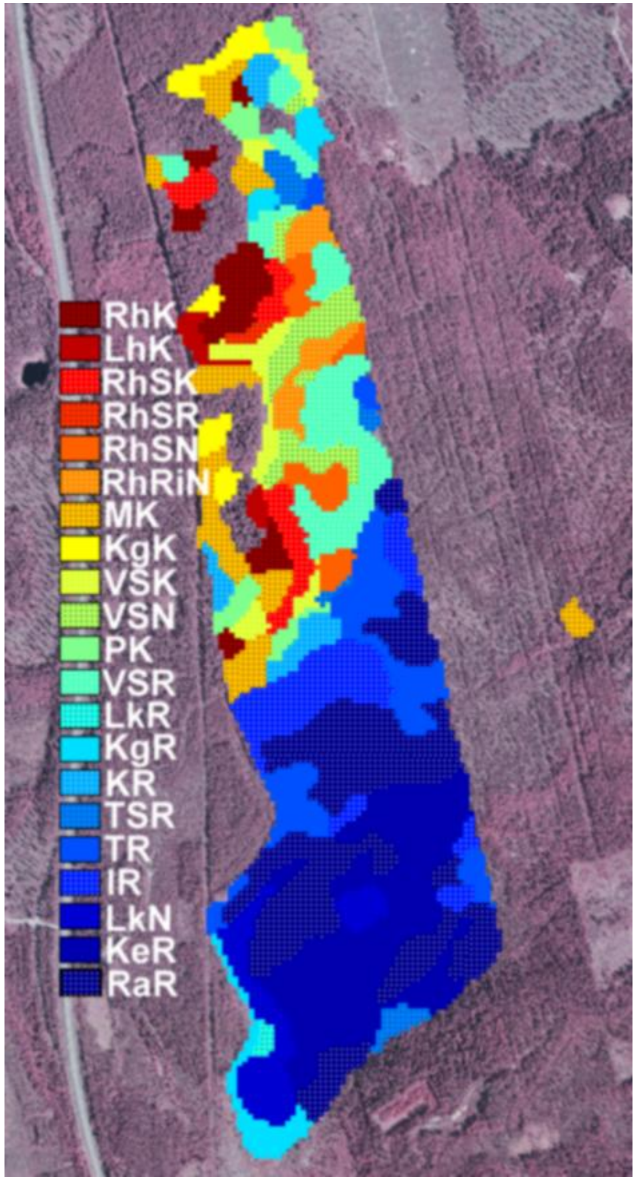
$$I_{corr} = I_{raw} \times (R/R_{ref})^{a}$$

Reverse-engineering the LEICA ALS5/6# agc-circuit (2007-)





Making RF decision tree to deduce mire characteristics from area-based features

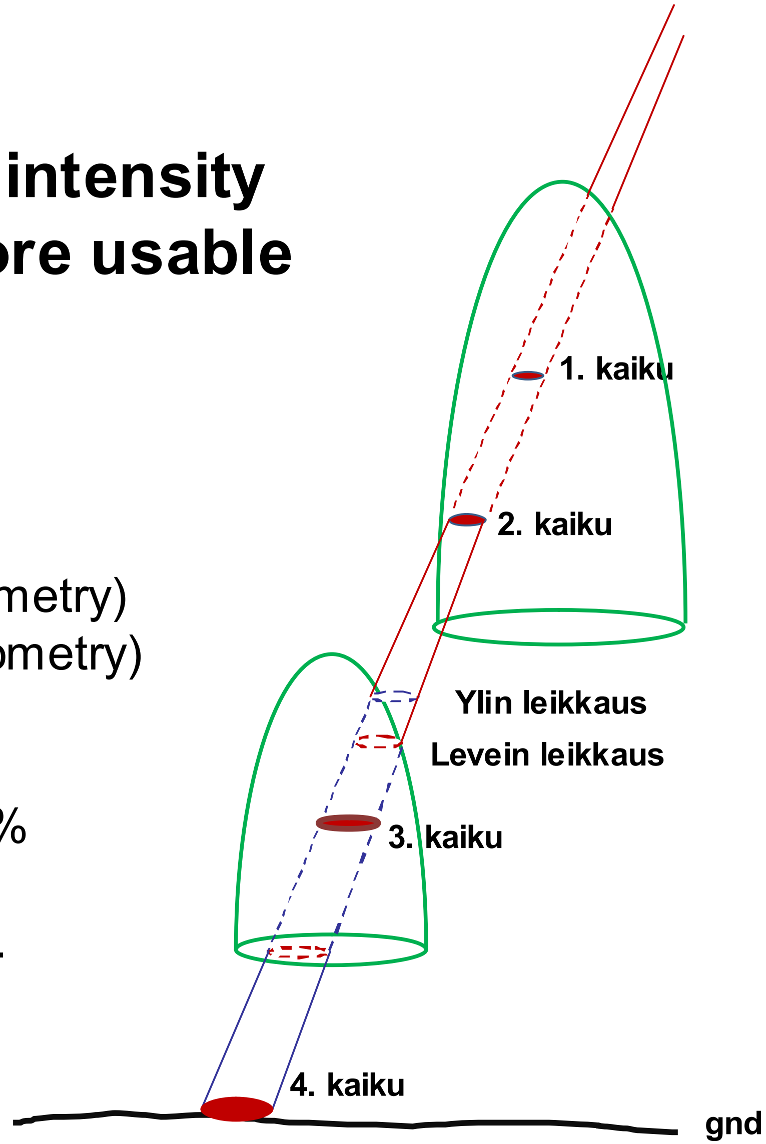


Making echo #2, #3 and #4 intensity data (in the understory) more usable

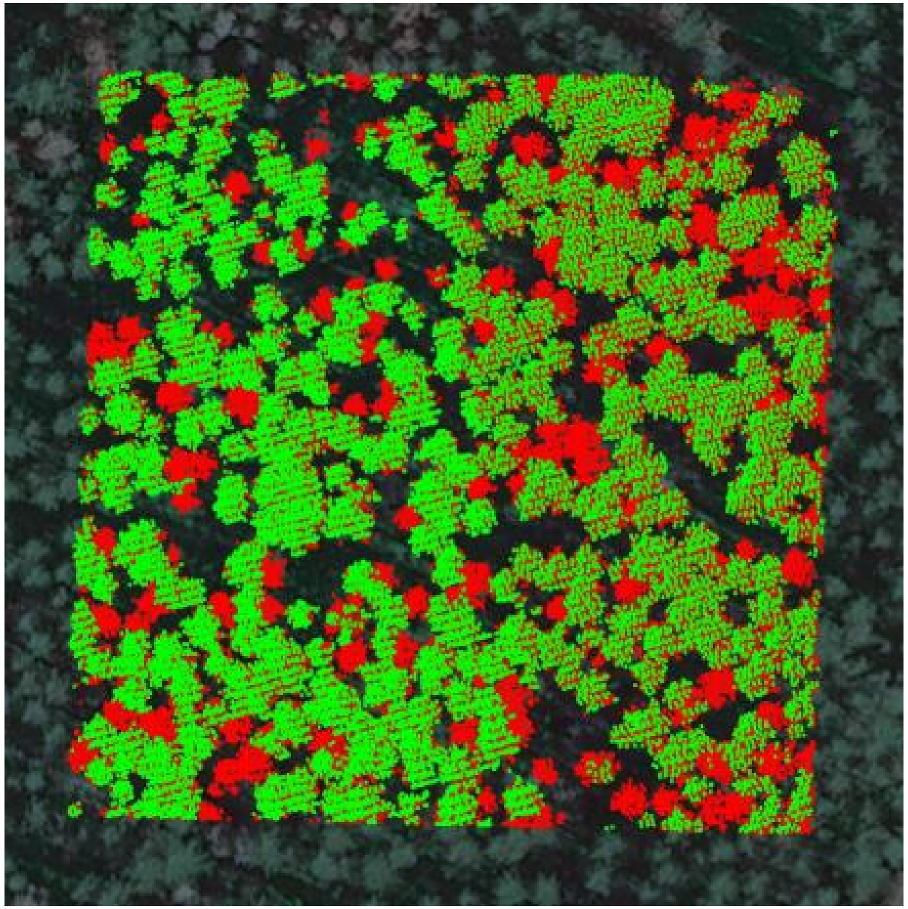
- With Felix Morsdorf, LSR Zurich

- Invisible losses (Below SNR) ~ *f* (geometry)
- Blind zone / extended echoes ~ *f* (geometry)
- Previous echoes

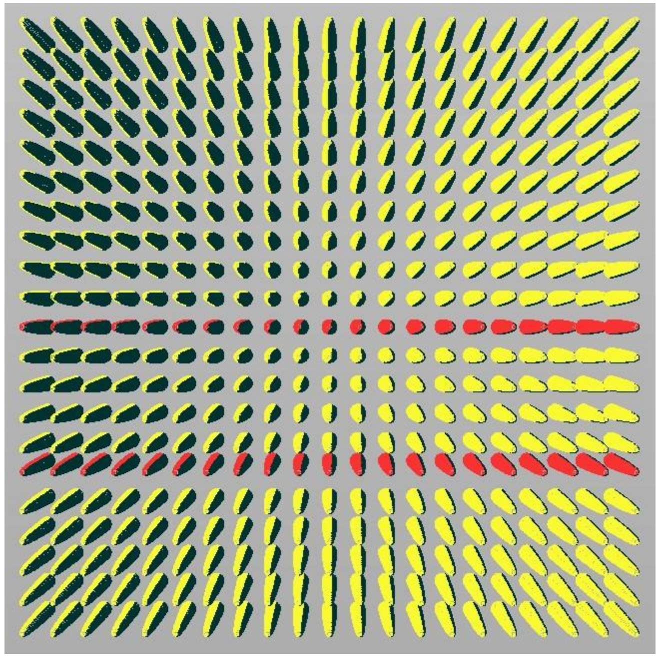
E.g. echo #2 raw intensity data has 70% CV per species, after model correction, 48%. Echo #1 raw intensity data ~40%.

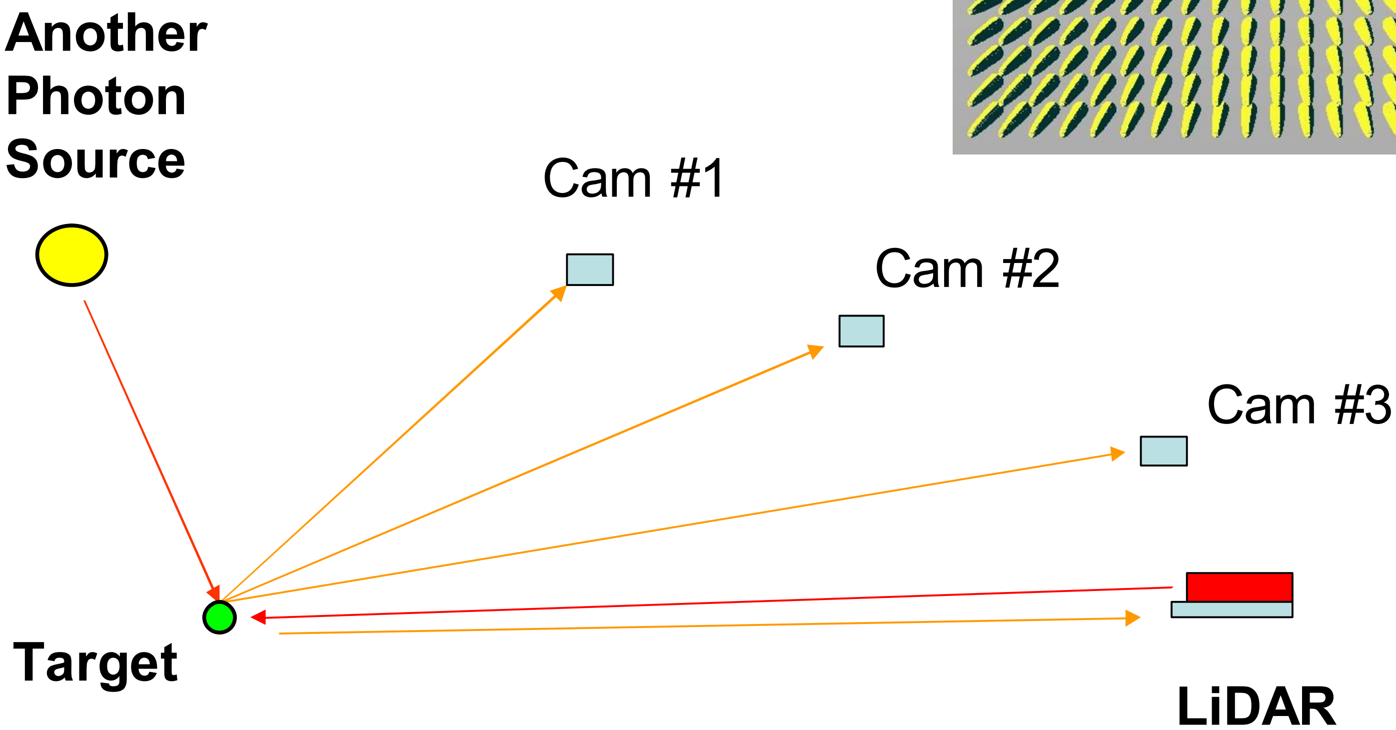


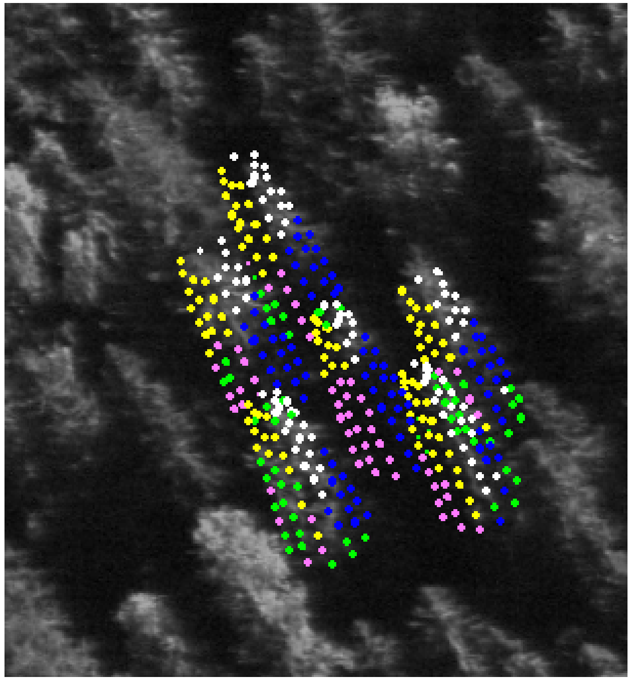
Detection of Snow Breaks in bi-temporal LiDAR data

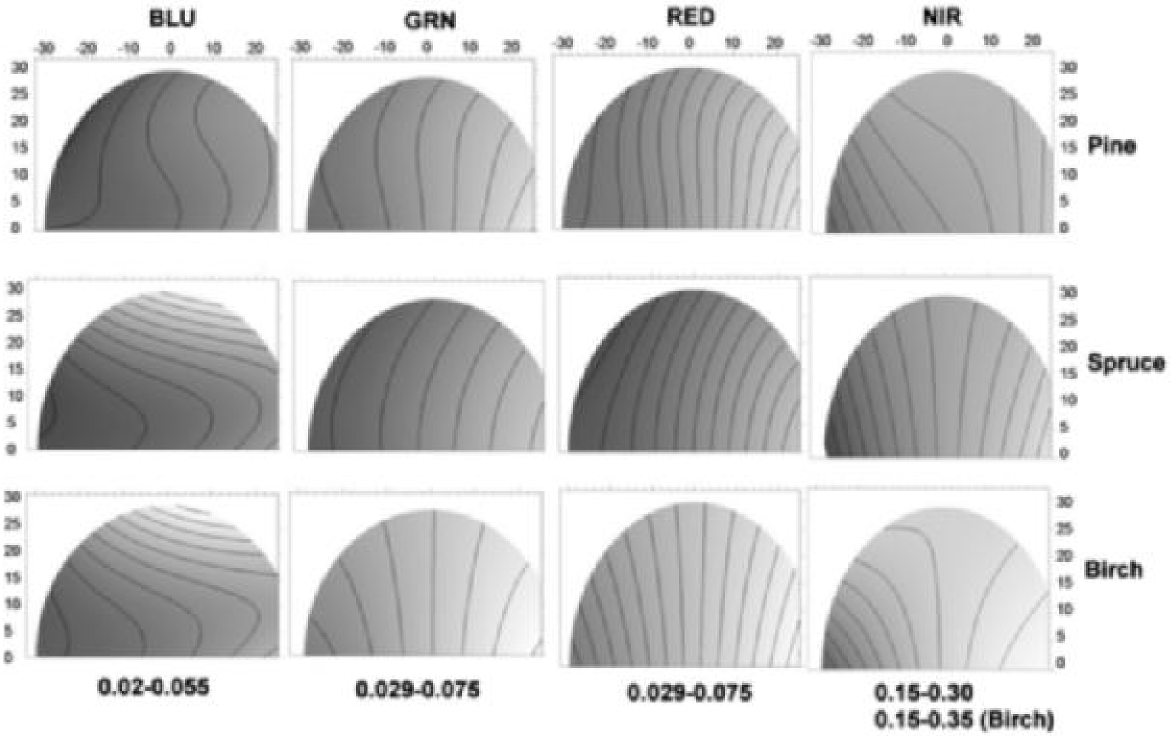


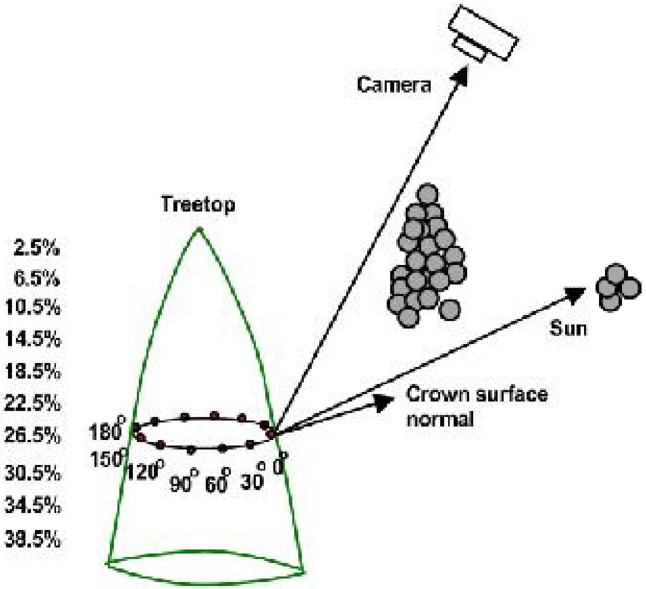
2008 – Attempts at Radiometrically Quantitative optical remote sensing











- **Attempt to derive BRDFs for trees/crowns.**

Outlook

ASR-calibrated aerial images are coming:

- Within-block modeling / normalization for the BRDF (and atmospheric) effects
- Reflectance calibration – can it ever be accurate enough to e.g. make model inversion (theoretical RS) feasible (or campaign-to-campaign calibration for that matter)?
- RGBN + red-edge (700-nm) cameras, shoud more effort be put to defining optimal radiometric sampling?
- Even if reflectance or at-sensor radiance observations are perfect, trees exhibit extreme within-class variation (due to structure, bk-gnd)

Waveform-sampling pulsed LiDAR systems

- 4-9-ns waves sttill restrict the level-of-detail that can be reconstructed from the returning waveforms.
- Low vegetation & DEM estimation – is the gain enough to pay the costs of data storage and analysis.
- On-the-fly feature extraction (waveform not saved) should be strived for.

THANK YOU!

Ilkka Korpela, b. 1968.
University Lecturer (Forest Information Systems)

MSc 1993 - UH.
Thesis: “Forest Grrowth Study in the Vicinity of a Petrochemical Complex”

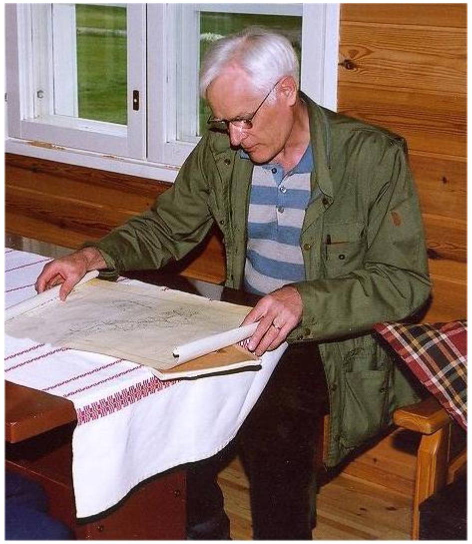
PhD 2004 – UH.
Thesis: “Individual Tree Measurements by Means of Digital Aerial Photogrammetry”.

Yrjö Ilvessalo Prize 2004.

Hansa Luftbild Award 2008.

Elmers: Risto Ojansuu, Helena Henttonen, Simo Poso, Aarne Nyyssönen, Keijo Inkilä, Jan Heikkilä, Pekka Savolainen, Timo Tokola, Annika Kangas, Ulrich Beisl,..

“Guru” - Dr. Ulrich Beisl – Leica Geosystems’ Sensor Engineer.



Prof. emeritus Simo Poso – He presented the sampling and estimation techniques used currently in LiDAR inventories. Simo used aerial & satellite photos.