Airborne LiDAR and Hyperspectral Data for Flux Tower Sites

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Introduction

We present a method to attribute CO_2 and H_2O flux signals measured at flux towers in forested terrain to high-resolution vegetation characteristics. The approach combines flux data with airborne LiDAR, hyperspectral imaging and footprint model results and is applied to several trans-continental flux-tower sites of varying degrees of heterogeneity.

Methodology

Airborne Survey
LiDAR, hyperspectral imaging, digital aerial photography

Ground Truth
tree physiology, digital hemispherical photography, field spectroscopy

Flux Tower Observations
meteorology, turbulence, fluxes

Raster Maps
vegetation structure and topography: canopy height, fractional cover, leaf area index, elevation changes, etc.

Footprint Climatology
footprint model (Kljun et al. 2002, 2004), rasterized footprints with geographical coordinates

overlay, extract

Footprint weighted vegetation characteristics and topography as source area of flux tower observations. Re-interpret flux data for within-site heterogeneity.

References

Chasmer, L., N. Kljun, C. Hopkinson, et al., 2011: Characterizing vegetation structural and topographic characteristics sampled by EC within two mature aspen stands using LiDAR and a flux footprint model: Scaling to MODIS. *J Geophys. Res. G.*, in press.

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Kljun, N., P. Calanca, M.W. Rotach, et al., 2004: A Simple Parameterisation for Flux Footprint Predictions. *Boundary-Layer Meteorol.* 112, 503-523.

Kljun, N., M.W. Rotach, H.P. Schmid, 2002: A 3D Backward Lagrangian Footprint Model for a Wide Range of Boundary Layer Stratifications. *Boundary-Layer Meteorol.* 103, 205-226.

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Study Sites, Objectives, and First Results

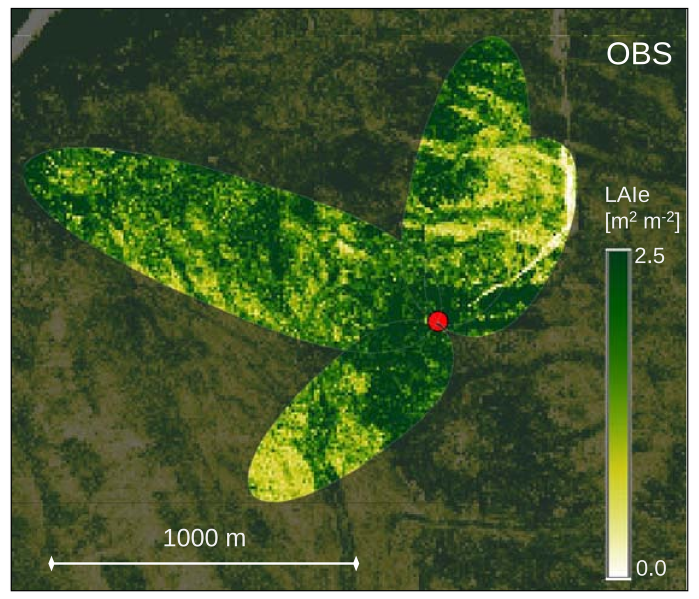
BERMS (Southern Boreal Forest, Saskatchewan, Canada):

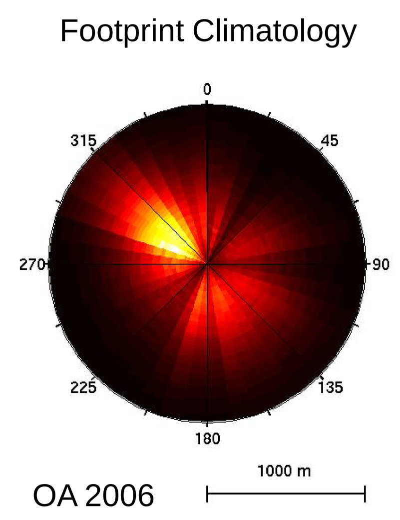
Objectives: Study impact of small-scale within-site variability of vegetation structure and topography on CO_2 and H_2O fluxes.

Sites: Old Aspen, Old Black Spruce, Old Jack Pine; flat terrain, relatively homogeneous forest stands

Findings: Vegetation structure and small changes in elevation significantly impact net fluxes (Chasmer et al. 2008). Accounting for within-site variability by weighting of fluxes may improve upscaling of fluxes (Chasmer et al. 2011). POSTER: Chasmer et al. "Using a Flux Footprint Model and Airborne LiDAR..."

Deviation from Site-Average of LAIe for Top 50% of Growing Season Fluxes





LAIe	OA	OBS	OJP
2005	-3%	-9%	+40%
2006	-8%	-3%	0%
2007	-3%	-3%	-9%
2008	-6%	4%	
Site Ø [m^2/m^2]	3.1	2.0	1.8

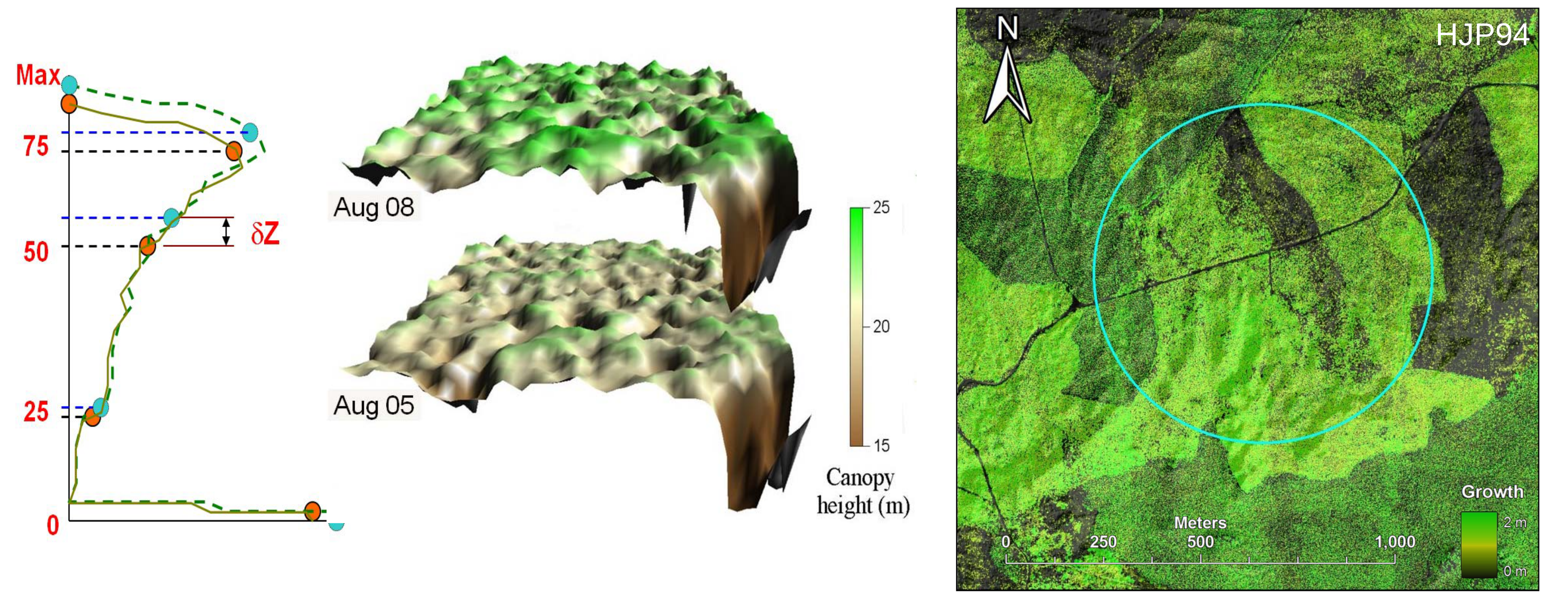
Jack Pine Chronosequence (Saskatchewan, Canada)

Objectives: Determine growth rates using LiDAR data. Compare differences in biomass with differences in fluxes.

Sites: Four jack pine stands; 9, 17, 36, ~82 years old; relatively flat terrain. Airborne surveys in 2005 and 2008.

Findings: Three years between data collections for statisticaly significant growth estimate with +/- 10% accuracy.

Canopy Growth 2005 - 2008

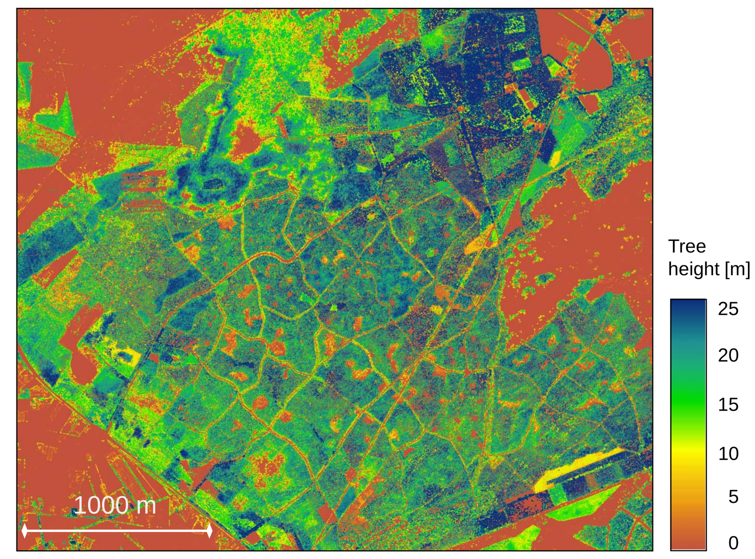


Loobos (The Netherlands), Tharandt (Germany), Norunda (Sweden)

Objectives: Test approach for heterogeneous forests typical for Europe.

- Within-site elevation changes (Loobos, Tharandt)
- Allocate CO_2 and H_2O fluxes to specific tree species within a mixed forest (Tharandt, Norunda)
- Impact of disturbance (thinning, Norunda; storm felling, Tharandt)
- Combine tower data with airborne flux measurements (Loobos)

Heterogeneous Forest Site



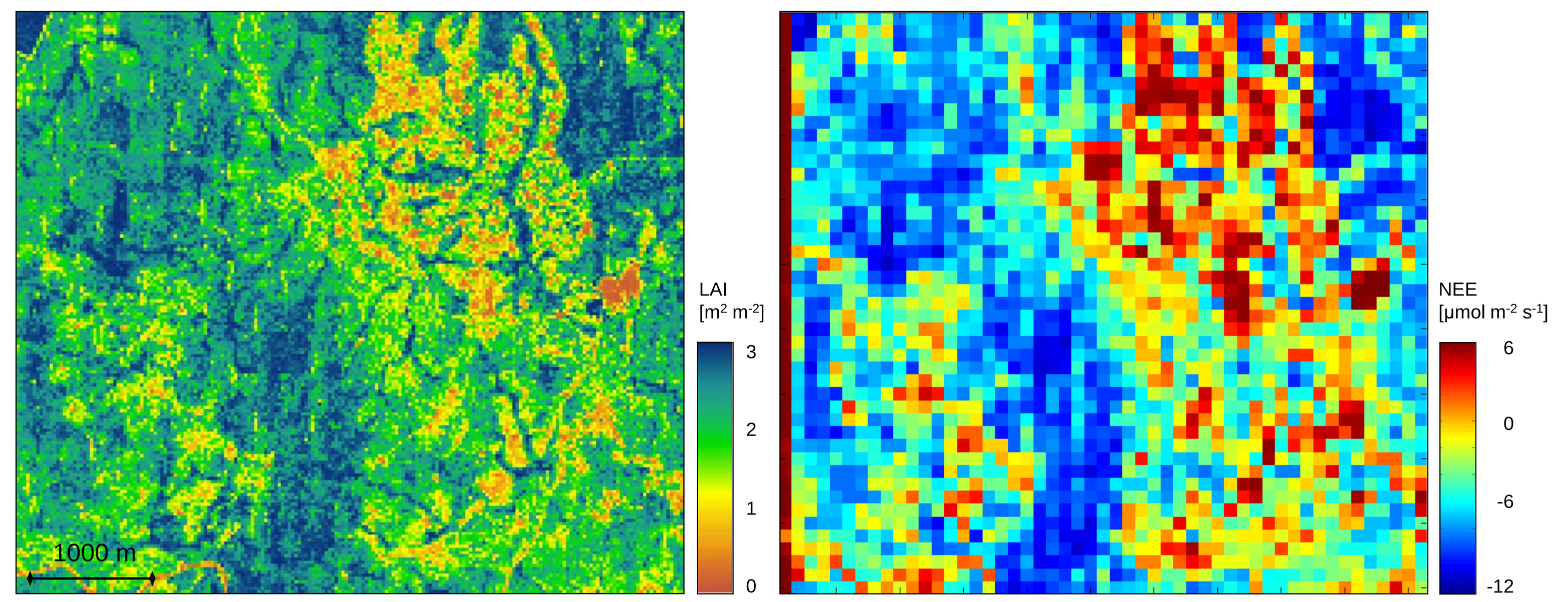
Tumbarumba, (New South Wales, Australia)

Objectives: Test maps of leaf area index, reflectance, maximum carboxylation rate, and potential rate of electron transport as input for land surface models.

Site: Eucalyptus stand situated in complex topography; selective and partial logging during recent past

Findings: Surface atmosphere transfer model used to generate map of net ecosystem exchange. Results are validated with footprint weighted observations from flux tower. POSTER: Berni et al., "Mapping Pigment Concentration and Leaf Area Index...". Penman-Monteith model used to estimate land surface evaporation. Results are validated with footprint weighted observations from flux tower. POSTER: van Gorsel et al., "Use of High Resolution LiDAR and Hyperspectral Data to Detect Changes in ... "

Modelled Leaf Area Index and Net Ecosystem Exchange



Take Home Message

The results highlight the importance of accounting for within-site heterogeneity when linking flux-tower observations to remote sensing products to obtain realistic regional or global estimates of net ecosystem exchange and ecosystem productivity.