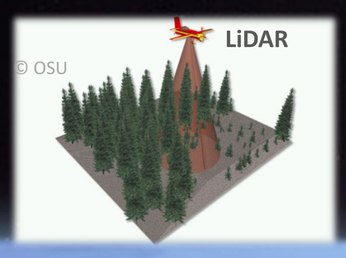
Comparison of Sentinel-2 and Landsat 8 in the Estimation of Boreal Forest Canopy Cover and Leaf Area Index



© ESA

© NASA

© airbusdefenceandspace

Lauri Korhonen[1], Hadi[2], Petteri Packalen[1], Miina Rautiainen[2,3]

[1] University of Eastern Finland, School of Forest Sciences, Joensuu, Finland
[2] Aalto University, School of Engineering, Department of Built Environment, Finland
[3] Aalto University, School of Electrical Engineering, Department of Electronics and Nanoengineering, Finland

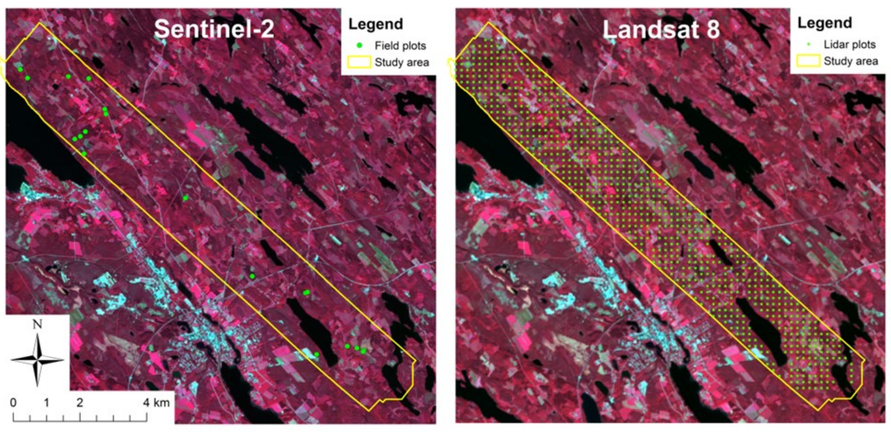
* Korhonen et al., 2017. Remote Sens. Environ. 195, 259-274. doi:10.1016/j.rse.2017.03.021

Introduction

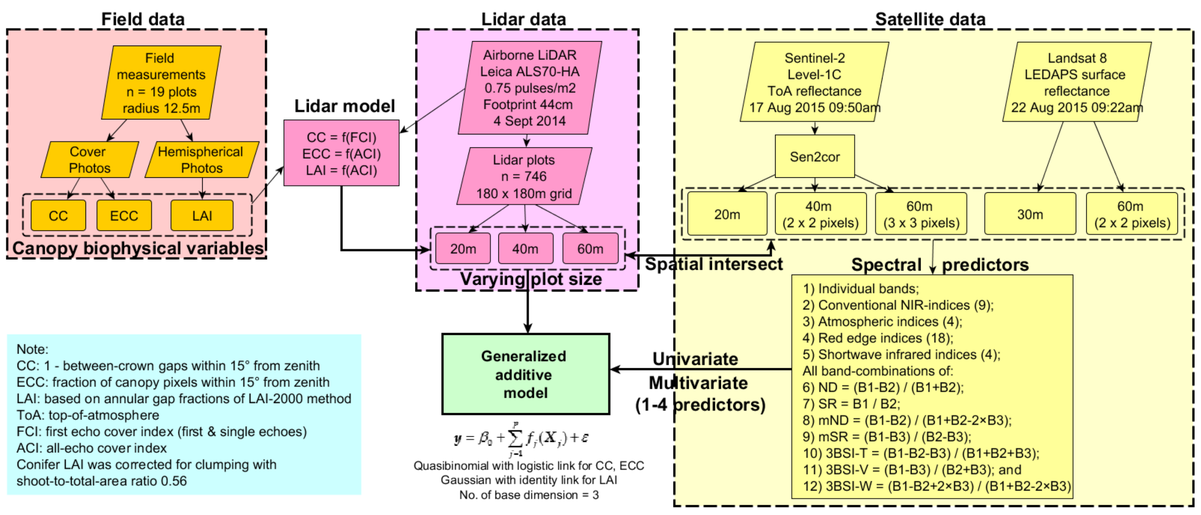
- The vegetation remote sensing community has high expectations that the three new Sentinel-2 red edge spectral bands (705, 740, and 783nm) would improve the accuracy of estimating various biophysical variables.
- The advantages of using these bands in vegetation mapping have already been evaluated based on hyperspectral data sets over agricultural fields (e.g., Frampton et al., 2013) and simulations for forests (Majasalmi & Rautiainen, 2016).
- We present the first comparison of Sentinel-2A (S2) MSI (Multi-Spectral Instrument) and Landsat 8 (L8) OLI (Operational Land Imager) image data in the retrieval of forest canopy cover (CC), effective canopy cover (ECC), and leaf area index (LAI).
- A combination of airborne lidar data and field plots was used to calculate CC, ECC and LAI (Korhonen et al., 2011) for a set of 746 systematically placed lidar plots. We additionally tested the effects of lidar plot size on the estimation accuracy.

Materials and methods

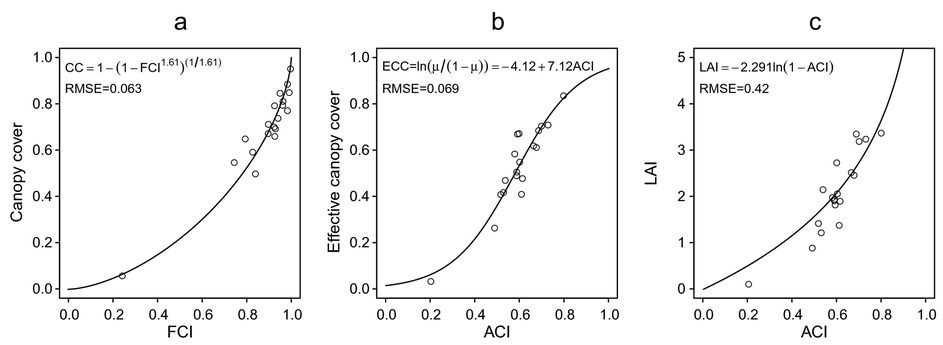
Study area and data. The following shows Sentinel-2A image of the study area (left) overlaid with field plots, and the corresponding Landsat 8 image (right) with the systematic grid of lidar plots. The area with lidar coverage is outlined in yellow. The large number of lidar plots cover diverse forests with different heights, densities, species compositions, understory vegetation types, as well as seedling stands and peatlands.



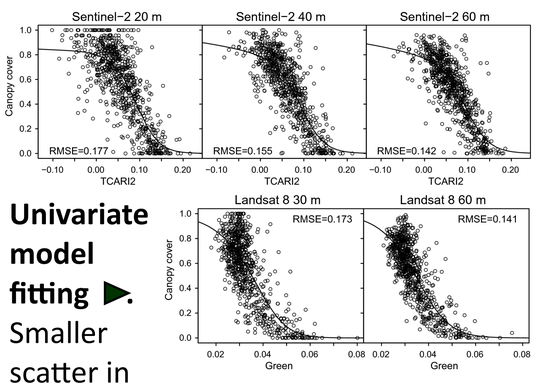
Methods: integrating field, lidar, and satellite data



Note:
CC: 1 - between-crown gaps within 15° from zenith
ECC: fraction of canopy pixels within 15° from zenith
LAI: based on annular gap fractions of LAI-2000 method
ToA: top-of-atmosphere
FCI: first echo cover index (first & single echoes)
ACI: all-echo cover index
Conifer LAI was corrected for clumping with shoot-to-total-area ratio 0.56

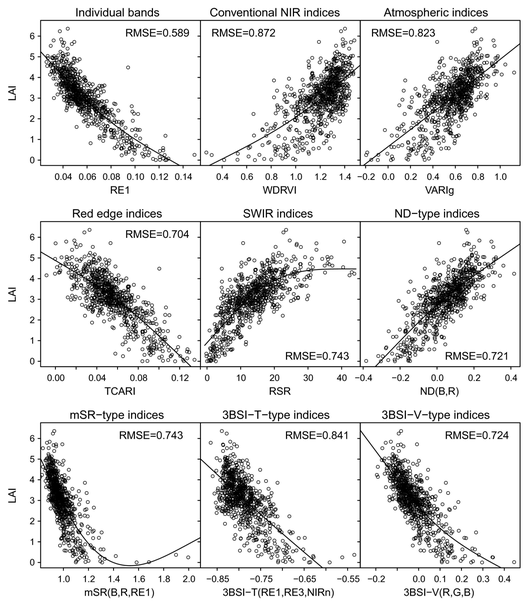


Results

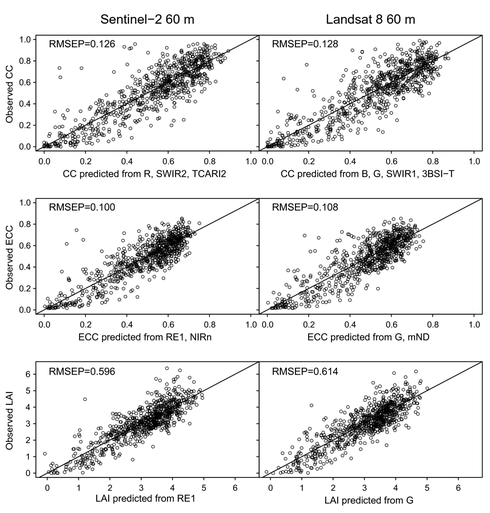


Univariate model fitting ▶. Smaller scatter in the relation and better model fit at larger plot size. S2 TCARI2 and L8 Green best across plot sizes.

Best S2 predictor from each **spectral variable group**: relationships with LAI using 60 m plot size▼



- Individual band performed very well compared to multi-band indices▶
- Conventional NIR-indices performed poorly▶



◀ **Multivariate prediction models and accuracy assessments** (ten-fold cross-validation). On the left are best-performing multivariate models for each sensor and response variable at shared 60 m plot size. Full results in Table below▼. RMSEP decreases and R^2 increases with increasing plot size for all response. LAI was predicted most accurately, followed by ECC and CC.

Variable	Sensor	Plot size	Variable(s)	RMSEP	RMSEP-%	R^2
CC	S2	20 m	G, 3BSI-V(B, RE3, RE1)	0.163	28.9	0.700
	S2	40 m	RE1, 3BSI-V(RE1, RE3, B)	0.141	25.9	0.727
	S2	60 m	R, SWIR2, TCARI2	0.126	24.0	0.746
	L8	30 m	B, G, SWIR1, 3BSI-T(NIR, SWIR1, SWIR2)	0.157	28.6	0.690
	L8	60 m	B, G, SWIR1, 3BSI-T(NIR, SWIR1, SWIR2)	0.128	24.5	0.743
ECC	S2	20 m	RE1, NIRn	0.126	26.2	0.691
	S2	40 m	RE1, NIRn	0.109	22.4	0.733
	S2	60 m	RE1, NIRn	0.100	20.8	0.741
	L8	30 m	G, 3BSI-V(B, NIR, R)	0.128	26.6	0.664
	L8	60 m	G, mND(B, R, NIR)	0.108	22.4	0.712
LAI	S2	20 m	RE1	0.800	26.0	0.664
	S2	40 m	RE1	0.660	21.4	0.727
	S2	60 m	RE1	0.596	19.6	0.734
	L8	30 m	G, ND(B, R)	0.728	23.9	0.693
	L8	60 m	G	0.614	20.2	0.725

Conclusions

- Model accuracies were better for 60 m lidar plots intersecting nine (S2) or four (L8) image pixels.
- Multivariate models utilizing S2 red edge bands yielded 1.6–7.2% lower RMSEs than L8 OLI data.
- The marginally better performance of S2 models may be related to the 705 nm red edge band, which frequently occurred among the selected predictors.
- When using more conventional indices (i.e. which did not include red edge bands), the differences between S2 and L8 data in estimating the canopy biophysical variables were negligible.
- In agreement with previous S2 simulation results for boreal forests, indices designed for S2 (S2REP and IRECI) were not among the best-performing red edge indices. These indices were originally developed for agricultural fields characterized by a dark background.

References

- Majasalmi, T., & Rautiainen, M. (2016). The potential of Sentinel-2 data for estimating biophysical variables in a boreal forest: A simulation study. Remote Sensing Letters, 7, 427–436
- Frampton, W.J., Dash, J., Watmough, G., Milton, E.J. (2013). Evaluating the capabilities of Sentinel-2 for quantitative estimation of biophysical variables in vegetation. ISPRS Journal of Photogrammetry and Remote Sensing, 82, 83–92
- Korhonen, L., Korpela, I., Heiskanen, J., & Maltamo, M. (2011). Airborne discrete-return LIDAR data in the estimation of vertical canopy cover, angular canopy closure and leaf area index. Remote Sensing of Environment, 115, 1065–1080

Acknowledgements & further information

This study was funded by the Academy of Finland (grant 288142) and Aalto tenure track funds. Landsat 8 image is courtesy of U.S. Geological Survey and NASA, Sentinel-2A courtesy of European Space Agency. Developer team of Sentinel Application Platform (SNAP) and Sentinel-2 Toolbox is acknowledged. For more information about the study contact corresponding author at lauri.korhonen@uef.fi.

UNIVERSITY OF EASTERN FINLAND

Aalto University School of Engineering