CHARACTERIZING FOREST STRUCTURE USING LIDAR AND MULTI-FREQUENCY SAR REMOTE SENSING

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INTRODUCTION

Research Question: Which SAR frequency and polarization allows best to characterize forest structural metrics?

Motivation: Research in ecology and biomass estimations often requires data often requires information on forest structure. LiDAR point clouds can provide that, if they are available. Therefore, we investigate if and how forest structure can be modelled from more readily accessible SAR backscatter.

METHODS

LiDAR metrics were computed for a 25m x 25m pixel grid:

- **Fractional cover**, derived from ratio of vegetation to ground point counts
- **Fractional cover**, derived from ground and vegetation return intensities according to Hopkinson & Chasmer 2009
- **Standard deviation** of the height distribution
- **Skewness** of the height distribution
- **Vertical Complexity** index as defined by Van Ewijk et al. 2011

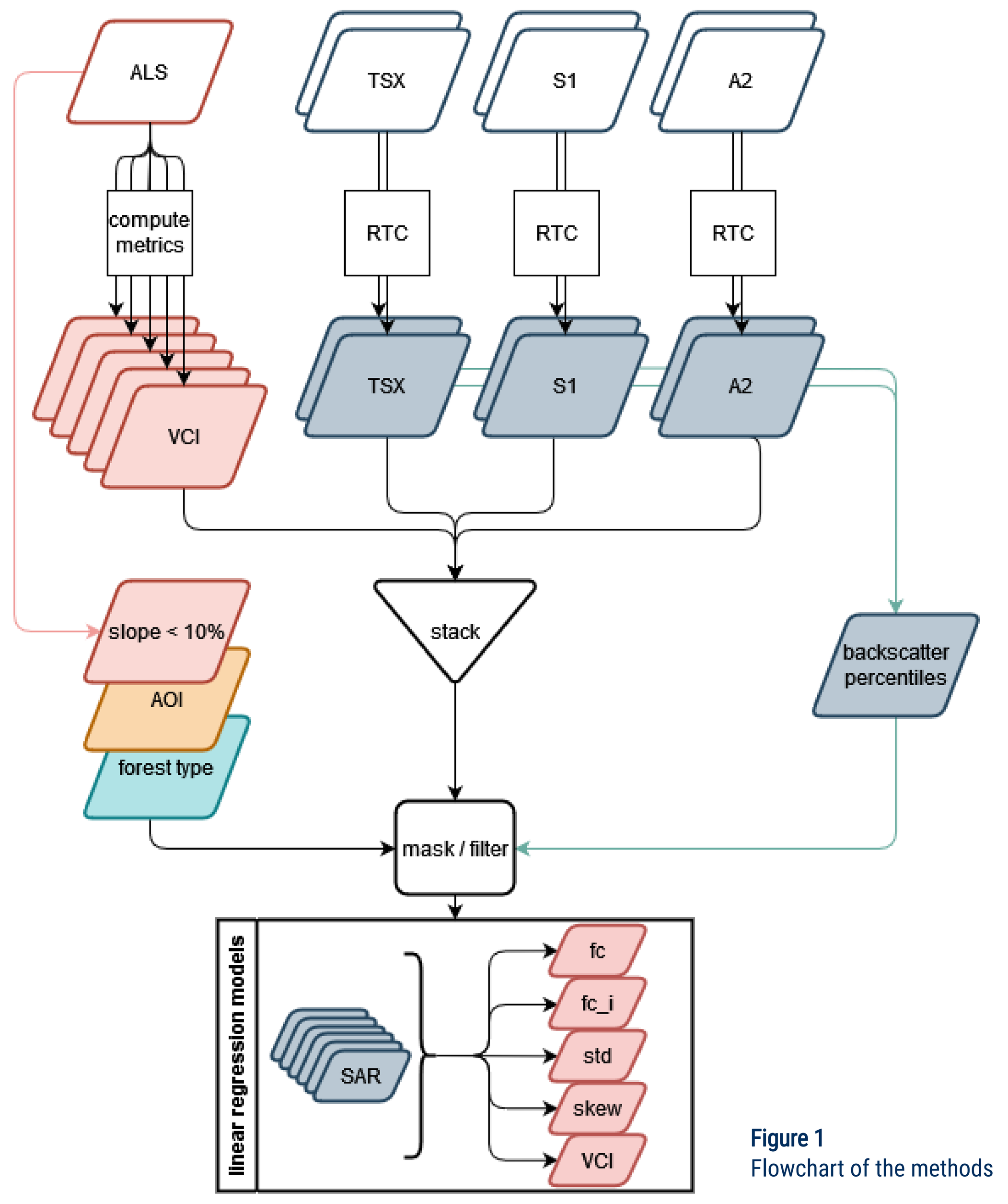

Figure 1
Flowchart of the methods

Model selection using stepwise linear regression:

- At each step, one predictor which decreases Akaike Information Criterion (AIC) the most is added
- Leveling-off of AIC change indicates which predictors are used to build a smaller model.

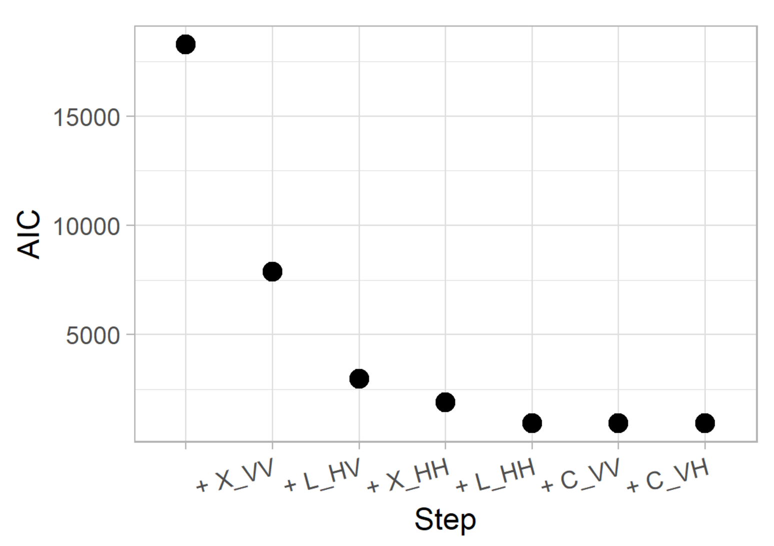

Figure 2: Stepwise regression model build for skewness
Example for stepwise linear regression: improvement of AIC with additional predictors, beginning with a null model.

STUDY AREA AND DATA

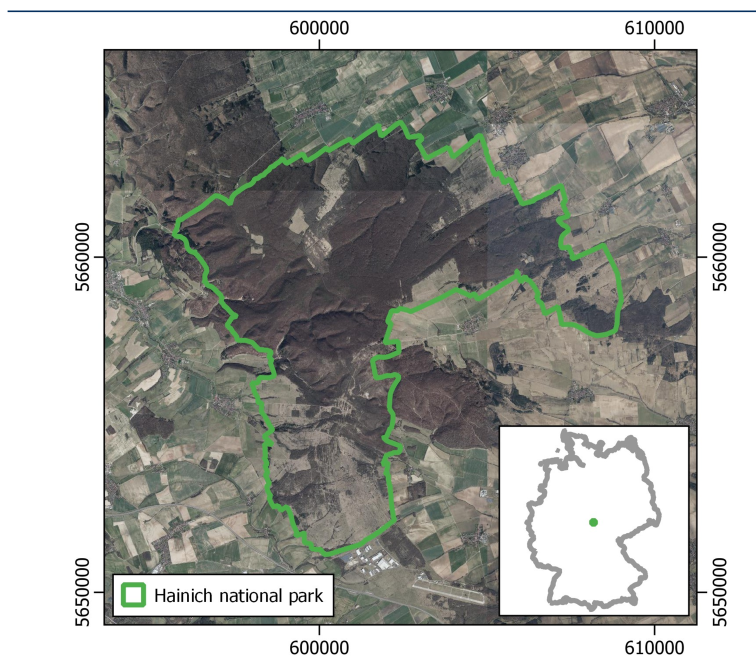

Figure 3: Study area
Hainich National Park (Orthophoto: © GDI-Th; Shapes: ©OpenStreetMap contributors, Natural Earth)

sensor	band, mode + polarization	date
DLR TerraSAR-X	X band SM VV, HH	2013-03-13
Copernicus Sentinel-1	C band IW VV, VH	2017-02-23
JAXA ALOS-2	L band FBD HH, HV	2016-02-24
Riegl LMS-Q780 airborne LiDAR (operated by Thuringian State Office for Land Management and Geoinformation)		2017-02

- Only **deciduous broadleaved forest**, as indicated by the Copernicus Forest Type map, was investigated.
- Scenes are from **leaf-off conditions;** SAR data match the LiDAR acquisition dates as closely as possible.

RESULTS

	full model		Smaller models		
	R^2	RSE	Predictors from stepwise linear regression	R^2	RSE
log(1-fc)	0.22	0.18	L_HV, X_VV	0.20	0.18
fc_i	0.22	0.06	X_VV, L_HV, X_HH	0.21	0.06
std	0.22	1.69	L_HV, X_HH	0.21	1.70
skew	0.23	1.00	X_VV, L_HV, X_HH, L_HH	0.23	1.00
VCI	0.06	0.07	X_VV, L_HH, X_HH	0.06	0.07

R^2 and R^2_{adj} are equal in the first three digits, thus only one is reported.

- **The best predictors** were **L-band HV** and **X-band VV.**
- The **best prediction** was achieved for the **skewness** of the point distribution.
- Overall, linear relationships were weak to moderate, but very low for vertical complexity.
- Combining frequencies improved the explained variation of the model.

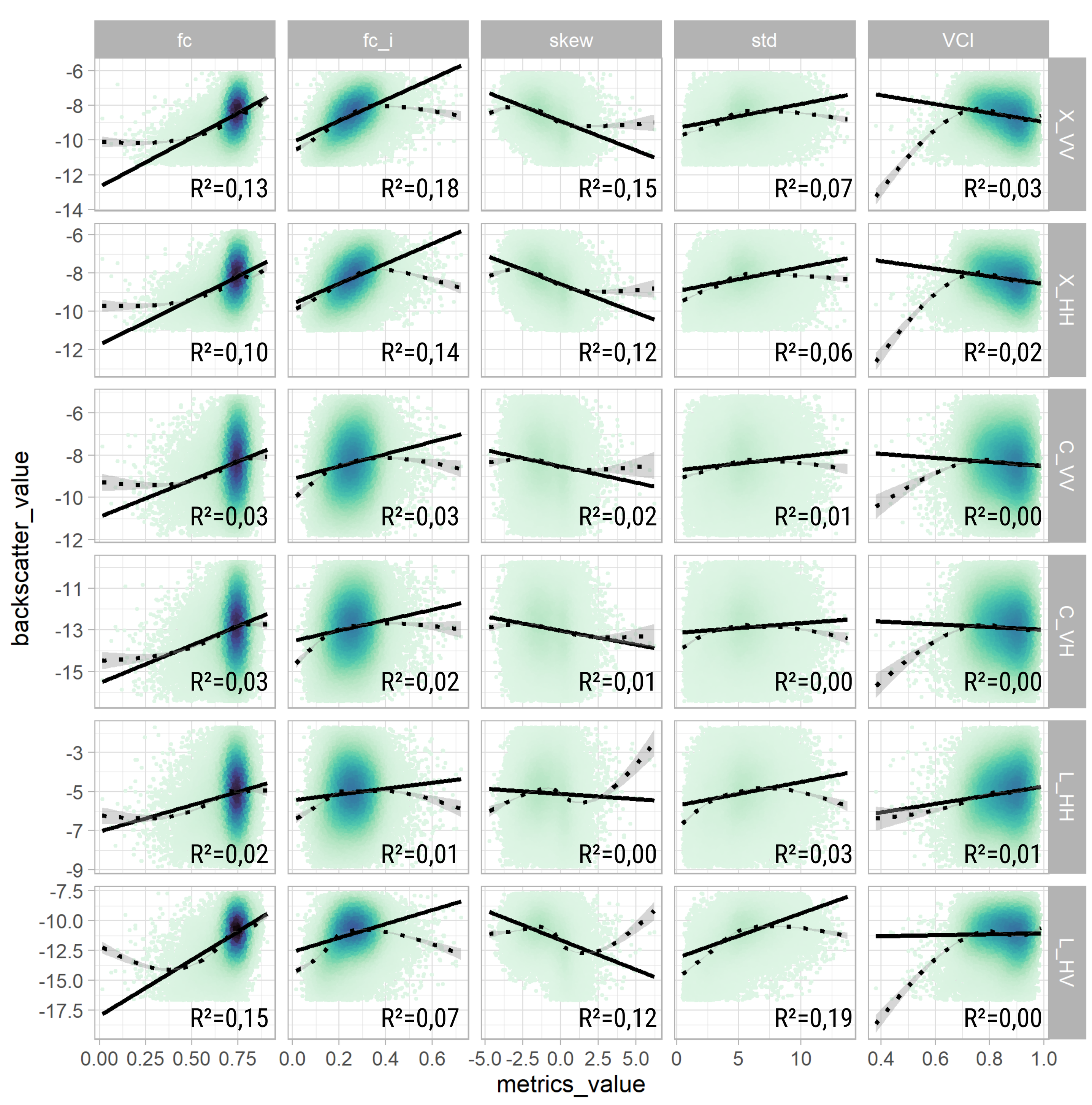

Figure 4: Bivariate relationships between metrics and backscatter
Scatterplots with fitted line (solid) and spline smoother (dashed line). Darker colour indicates higher point density.

DISCUSSION

- X– and L-band provide complementary information.
- High contribution of X-Band probably specific for leaf-off conditions.

Limitations:

- Some relationships, especially to L-band HV, exhibited nonlinearity.
- Only one broadleaved forest site was investigated —> limited structural diversity.
- Leaf-off period is not ideal for fractional cover estimation

CONCLUSIONS

Most forest structure is reflected in L-band HV backscatter plus X-band, while C-Band showed the smallest association.

Based on these results, modelling forest structure purely from SAR backscatter seems not advisable. However, they point to a proportion of structure-determined backscatter variation that should be taken into account, for example in biomass studies.

References

Van Ewijk, K. Y., Treitz, P. M., & Scott, N. A. (2011): Characterizing Forest Succession in Central Ontario using Lidar-derived Indices. Photogrammetric Engineering & Remote Sensing, 77(3), 261–269. DOI: 10.14358/PERS.77.3.261

Hopkinson, C., & Chasmer, L. (2009). Testing LiDAR models of fractional cover across multiple forest ecozones. Remote Sensing of Environment, 113(1), 275–288. DOI: 10.1016/j.rse.2008.09.012

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