CHALMERS

Boreal Forest Biomass Mapping with P-band SAR Backscatter

Maciej J. Soja[(1)], Gustaf Sandberg[(1)], and Lars M. H. Ulander[(1,2)]

[(1)] Chalmers University of Technology, Gothenburg, Sweden
[(2)] Swedish Defence Research Agency, Linköping, Sweden

Introduction

One of the most promising tools for accurate, global scale biomass mapping is P-band synthetic aperture radar (SAR). A new, fully polarimetric P-band SAR satellite system called BIOMASS has been proposed to European Space Agency (ESA) for the 7th Earth Explorer mission. In this paper, a new model for biomass retrieval from polarimetric SAR is presented. A more thorough study can be found in [1].

Data

The data were acquired within two BioSAR campaigns performed in Sweden. The test sites are located approximately 720 km apart and represent two different cases of boreal forest. For both test sites, high quality *in-situ* and lidar measurements were available.

BioSAR 2007 was conducted in Remningstorp in southern Sweden. Remningstorp is a production forest with stand-level biomass up to 300 tons/ha and very little topographic variation. Two objectives of the experiment were to assess the potential of P-band SAR for biomass estimation in boreal forest and to study temporal stability. The latter was addressed with three separate acquisitions from March to May.

BioSAR 2008 was conducted in Krycklan in northern Sweden. Krycklan is representative of higher latitude boreal forests with stand-level biomass reaching up to 200 ton/ha. Topographic variations are significantly larger than in Remningstorp, with stand-level slopes as high as 19 degrees. The main objective of this study was to evaluate the influence of topography. In order to address that, multiple heading data were collected.

All stand-level backscatter data for both Remningstorp and Krycklan are plotted against biomass in **Fig. 1**.

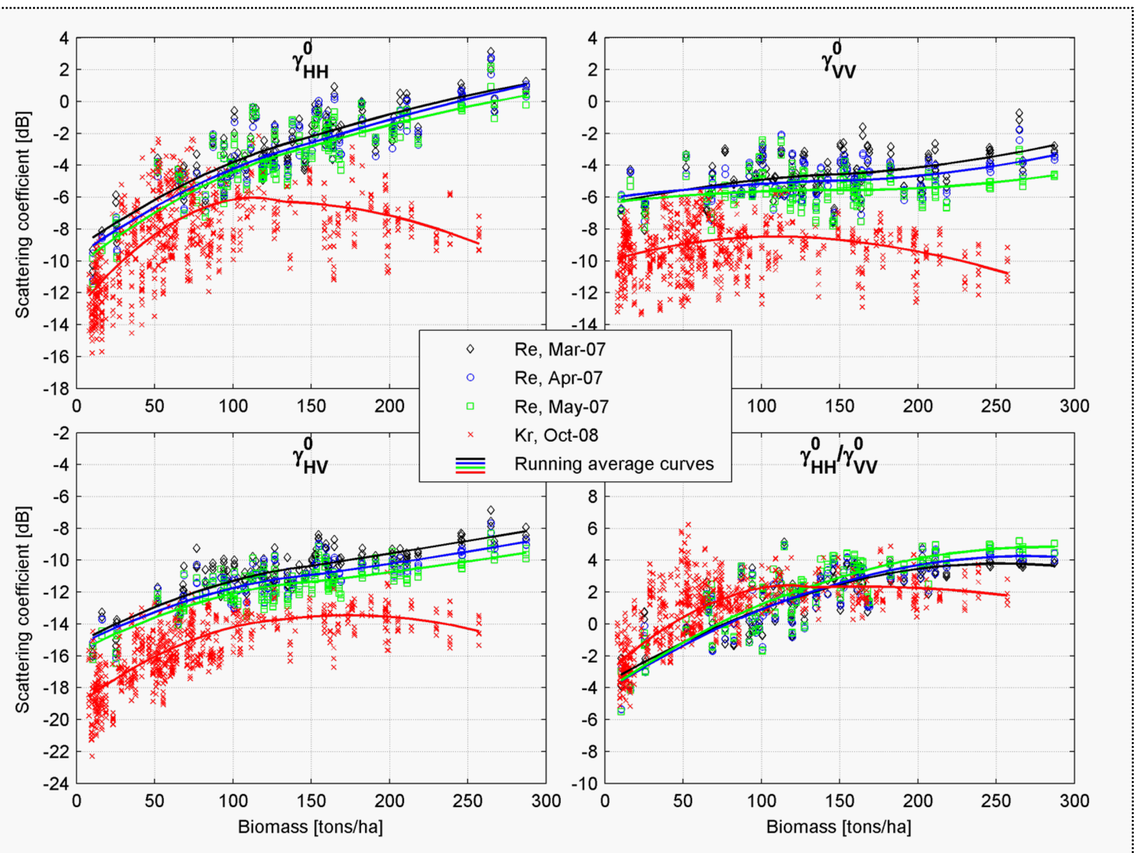

Figure 1: Scattering coefficient gamma nought (in dB) plotted against biomass for all Remningstorp and Krycklan stand-level data.

Model

A new regression model is derived. The model consists of HV-backscatter normalised to gamma nought, and the HH/VV-ratio. A topographic correction is derived by fitting of reference models to subsets of Krycklan data with similar topography, and by studying the estimated parameters against topographic parameters. Two model parameter setups are derived for mapping purposes, one for Remningstorp (Re) and one for Krycklan (Kr):

$$\text{Re: } \log_{10} B = 2.97 + 0.093 \cdot [\gamma^0_{HV}]_{dB} + 0.056 \cdot ([\gamma^0_{HH}]_{dB} - [\gamma^0_{VV}]_{dB}) + 0.71 \cdot u \cdot ([\gamma^0_{HH}]_{dB} - [\gamma^0_{VV}]_{dB})$$
$$\text{Kr: } \log_{10} B = 3.13 + 0.093 \cdot [\gamma^0_{HV}]_{dB} + 0.020 \cdot ([\gamma^0_{HH}]_{dB} - [\gamma^0_{VV}]_{dB}) + 0.61 \cdot u \cdot ([\gamma^0_{HH}]_{dB} - [\gamma^0_{VV}]_{dB})$$

Here, B is biomass, u is the ground slope angle, and γ^0_{PQ} is the scattering coefficient for polarisation PQ. In **Fig. 2**, retrieval results using the Krycklan model are shown.

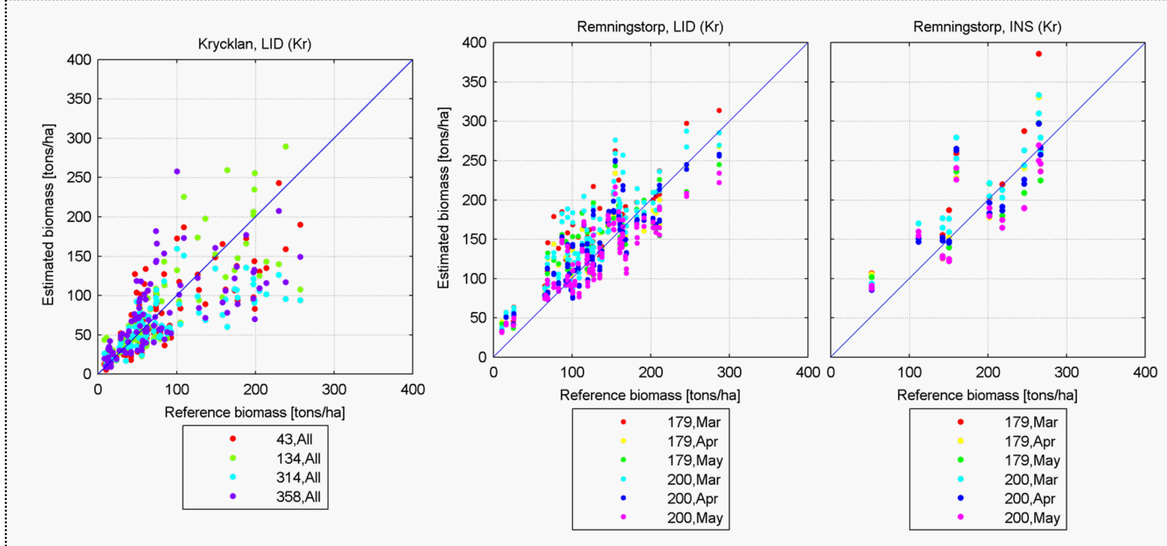

Figure 2: Stand-level biomass retrieval results in Krycklan and Remningstorp (using Krycklan model). RMSE for Remningstorp: 22-36% (LID), 22-32% (INS).

Results

Biomass mapping performance is shown in **Fig. 3**. For Remningstorp and Krycklan, the SAR-based maps consist of an average of 6 and 4 estimates, respectively. Around 35-50% of all pixels are estimated with relative difference from lidar map lower than 25%.

Three areas of disagreement in Remningstorp have been studied and the following conclusions were made: **A** remaining understory vegetation boosts HV, **B** isolated trees and double bounce in slightly sloping terrain boosts HV (also, an underestimation in lidar map is observed), **C** isolated trees and double bounce in flat terrain boosts HH/VV ratio.

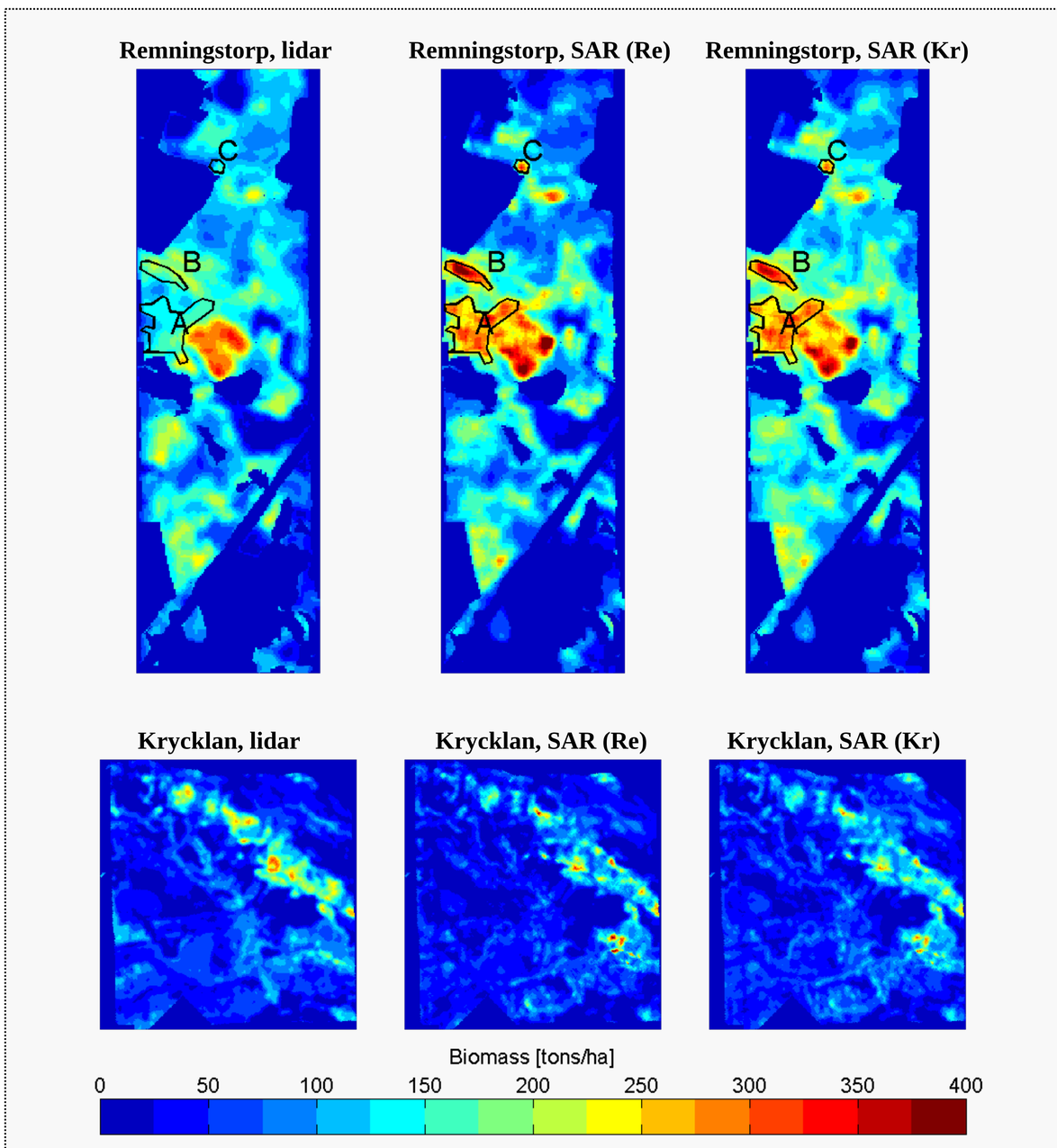

Figure 3: Comparison between biomass maps estimated from lidar data and SAR with two parameter setups: (Re) for Remningstorp and (Kr) for Krycklan.

Conclusions

The new model shows good performance in biomass mapping. The HH/VV-ratio is less sensitive to the differences between acquisitions. The inclusion of surface slope angle u effectively boosts the ratio in topographic terrain. The new model shows lower retrieval bias and higher robustness to temporal, topographic, and biome change. In some regions the model overestimates biomass, but that can be explained with basic forest scattering properties.

Acknowledgements

This work was financially supported by the Swedish National Space Board and European Space Agency. SAR data were provided by German Aerospace Center. Field data were provided by Swedish University of Agricultural Sciences.

References [1] Soja, M. J.; Sandberg, G. & Ulander, L. M. H. ”Regression-Based Retrieval of Boreal Forest Biomass in Sloping Terrain using P-band SAR Backscatter Intensity Data”, under review for *IEEE TGRS*, July 2012.

Contact

Department of Earth and Space Sciences
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden
E-mail: maciej.soja@chalmers.se
Internet: www.chalmers.se/rss