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Using ALOS/PALSAR backscatter to estimate above-ground forest biomass: a case study in Western Siberia

for K&C Phase 2

within the framework of Forest Carbon Monitoring System (FCMS) Research Project

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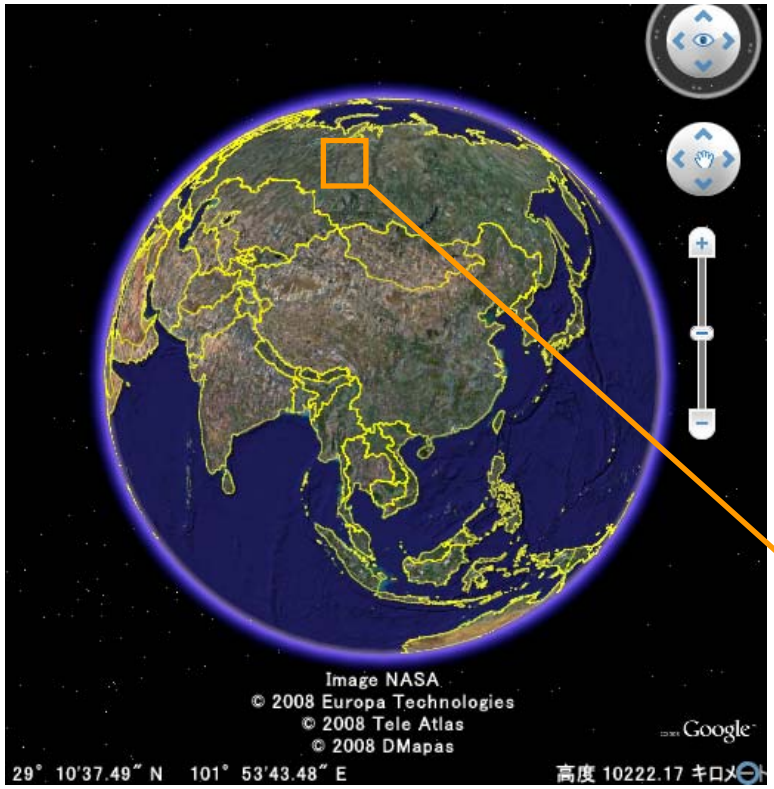
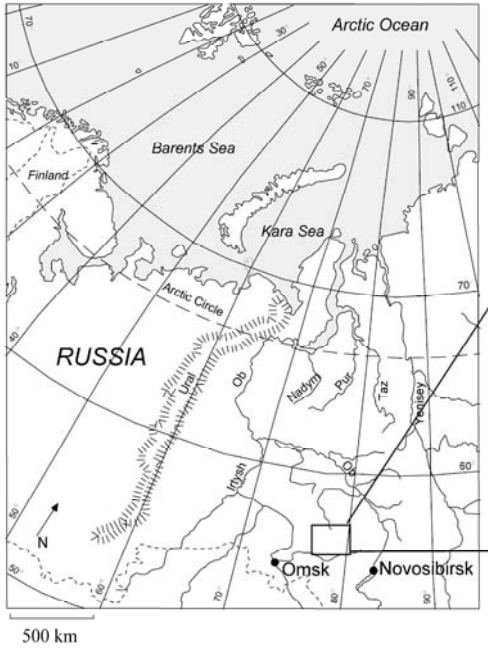
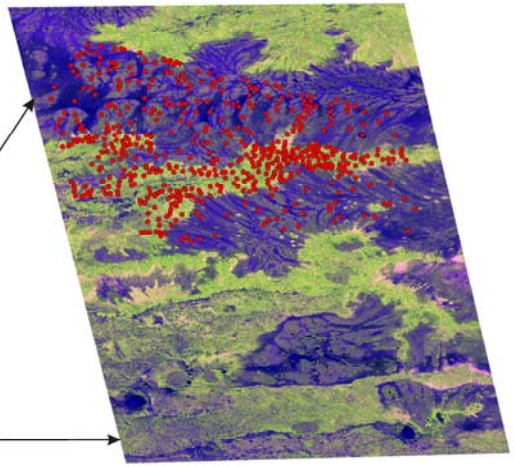
FCMS project in Northern Eurasia: prototype area in Western Siberia

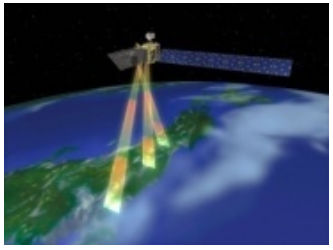




The target
Icha-Tara test site
South of boreal region



Spatial distribution of ground observation plots (440) at ALOS/PALSAR, scene 2007/07/16:
R-HH
J-HV
B-HH/HV



ALOS/PALSAR-based study:

- Forest biomass estimation
- Boreal forest monitoring (land-cover change analysis)
- Tracking Carbon

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Upland deciduous forest

Peat swamp forest

Forested peatland

Open peatland (fen)

Mixed forest

Wet grassland (reed bush)

Dry grassland (meadow)

Ridge-hollow-pool bog

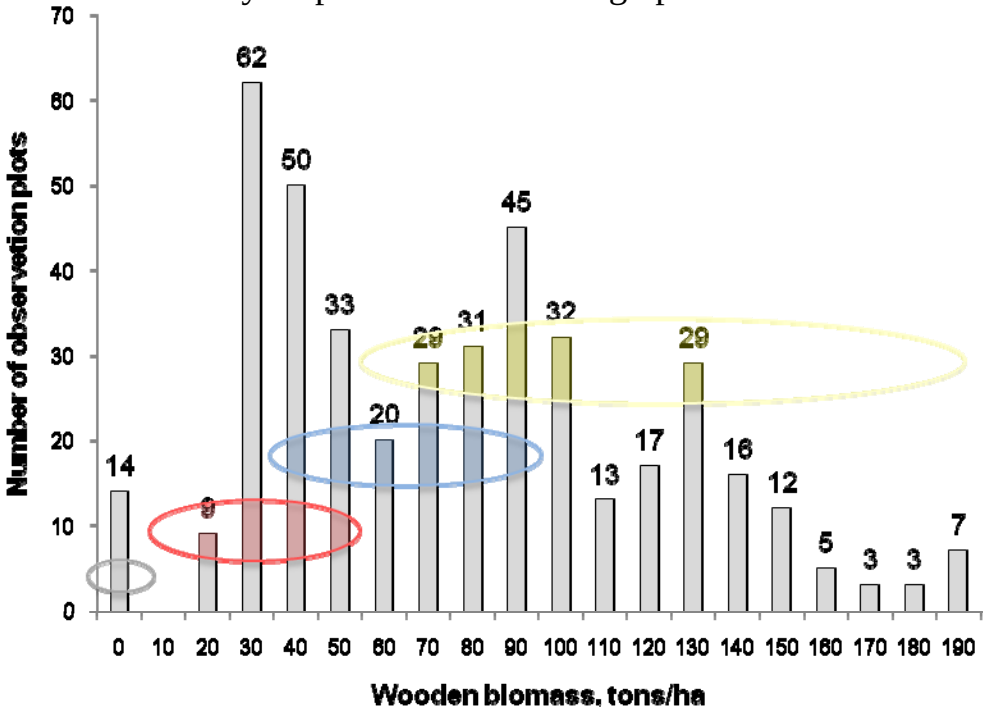
Distribution of AGB by field observation plots

440 observations:

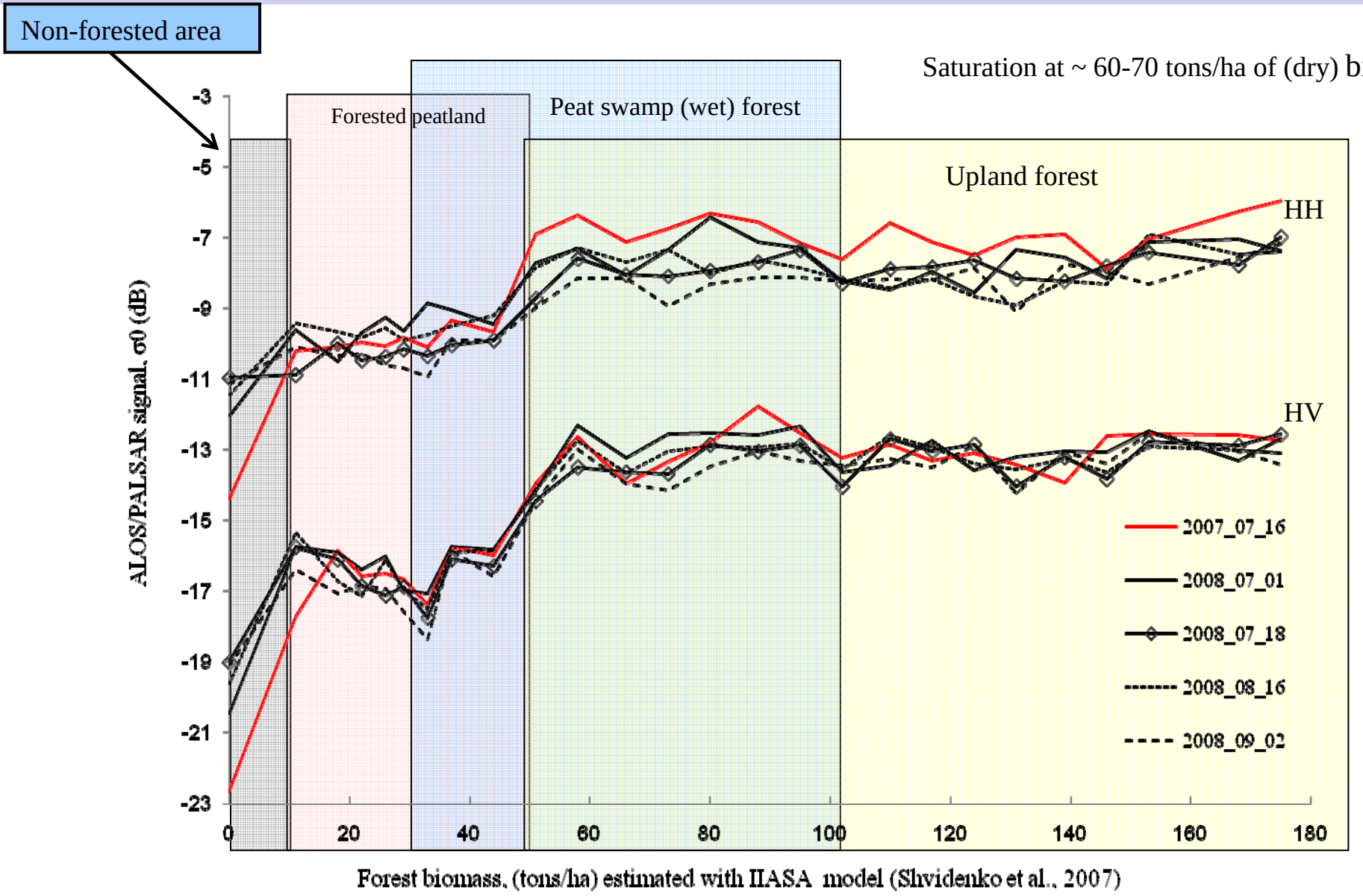
Average biomass 73 (SD±44) tons/ha.

Middle range biomass values dominate in the data set.

All analyses performed excluding open water fraction.



Average mean ALOS/PALSAR backscatter: distribution by ecosystem type



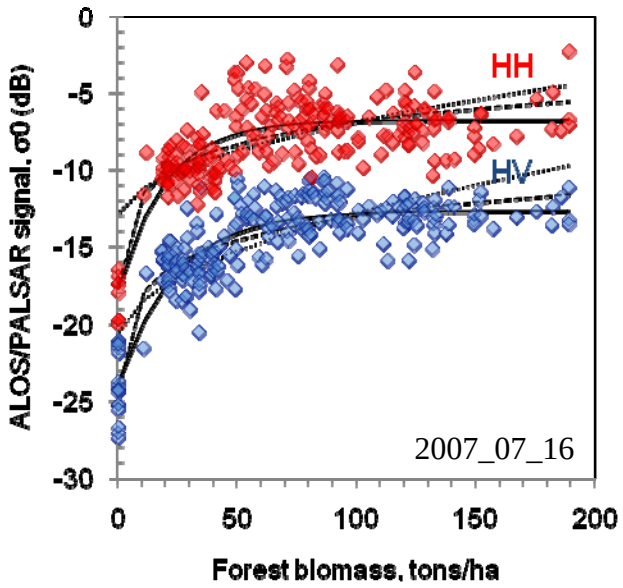
Saturation at ~ 60-70 tons/ha of (dry) biomass.

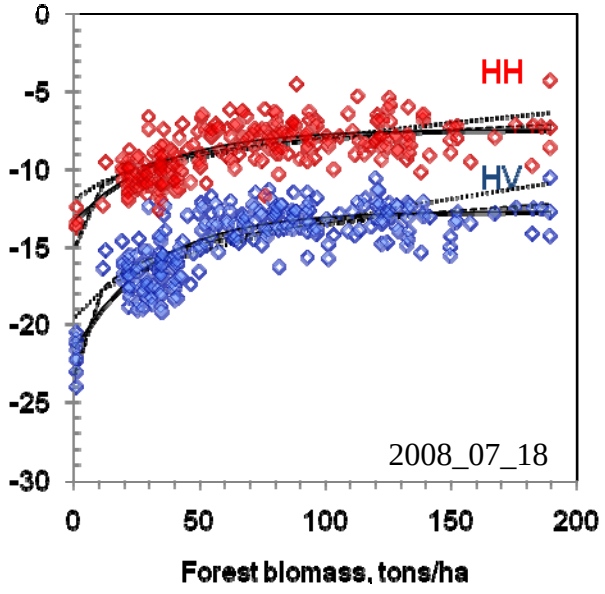
(Forward) modeling of PALSAR backscatter

R^2 (coeff. of determination) from all five PALSAR scenes (HH/HV polariz.), when estimated the value of PALSAR backscatter (σ^0) as different functions of above-ground biomass (AGB).

Backscattering models	16 July 2007	01 July 2008	18 July 2008	16 Aug. 2008	2 Sept. 2008
(*a*) $\sigma^0=\beta_0+\beta_1 AGB$	0.31/0.44	0.18/0.36	0.38/0.47	0.24/0.38	0.37/0.44
(*b*) $\sigma^0= \beta_0+\beta_1 \ln(AGB)$	0.63/0.76	0.34/0.55	0.47/0.65	0.39/0.55	0.45/0.59
(*c*) $\sigma^0=\beta_0+\beta_1 \ln(AGB)+\beta_2(\ln(AGB))^2$	0.64/-	-/-	0.49/0.66	-/-	0.45/0.59
(*d*) $\sigma^0= \beta_0+\beta_1 SQRT(AGB)$	0.45/0.62	0.26/0.49	0.46/0.60	0.32/0.50	0.43/0.53
(*e*) $\sigma^0= \beta_0+\beta_1 \exp^{(\beta 2*AGB)}$ (*)	**0.68/0.81**	**0.45/0.68**	**0.54/0.71**	**0.49/0.67**	**0.49/0.65**

* - the Water Cloud Model, - ln square term was not significant.





Water Cloud Model (e)
for combined summer data set:

$\sigma^0= -12.6-10.19 \exp^{(-0.03*AGB)}$

$R^2 = 0.72$

Inverse model for forest biomass estimation / validation

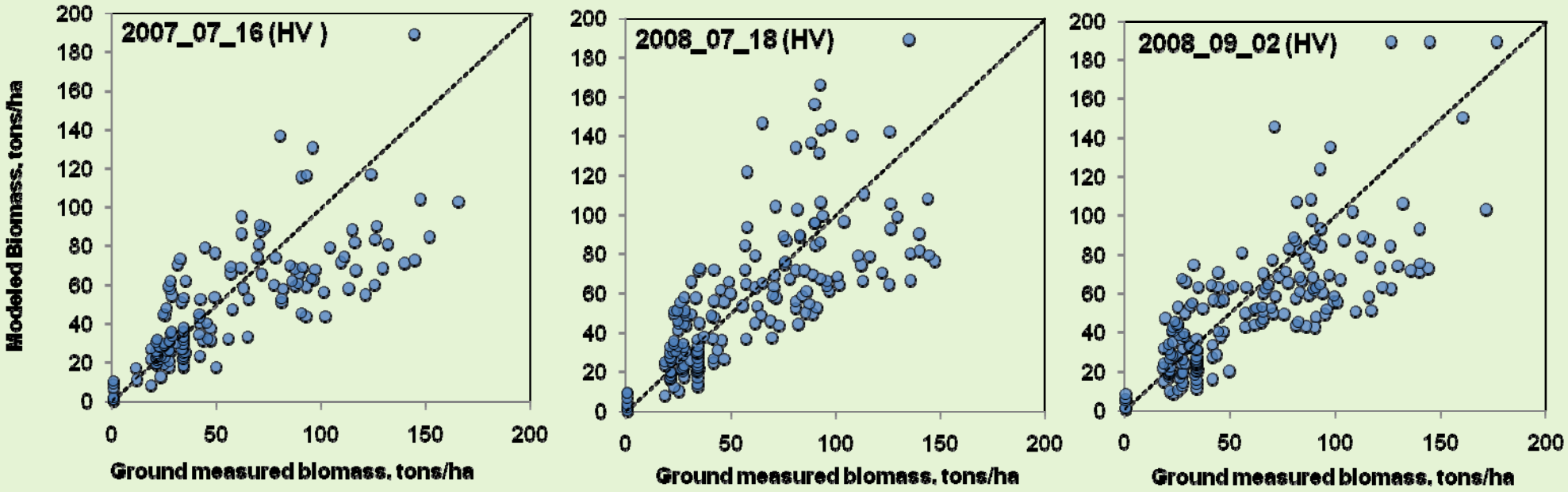
$$AGB = \frac{1}{-0.03}\ln\left(\frac{\sigma^0 + 12.6}{-10.19}\right)$$

ALOS/PALSAR Scene	whole range of signal (σ^0)		For σ^0<-12.6 dB	
	R^2	RMSE	R^2	RMSE
2007-07-16	0.47	54.98	0.60	25.44
2008-07-18	0.49	46.28	0.55	26.17
2008-09-02	0.35	52.22	0.59	26.12
2008-07-01	0.40	49.78	0.70	23.68
2008-08-16	0.43	52.66	0.72	21.23
All combined	**0.42**	**51.20**	**0.60**	**25.10**

The prediction error ±~35% for whole range of biomass.

There is a tendency toward underestimation.

Ground-measured vs. SAR-estimated biomass by 208 validation plots



Conclusions

- The “Water cloud model” was most adequate in the capacity of biomass modeling.

- The SAR-based estimates were found uncertain for mature forests, but demonstrates the potential for assessment of wooden biomass in sparse, low productive, or young forests, especially in near wetland area. These forests are omitted in the Rus. Forest Inv. Focusing on SAR-applications in these ecosystems would give more details to total C-accounting.

Outlook

- As these results were verified in a single study site, the biomass function should be validated in a larger dataset.

- Implementation of winter coherence could improve an accuracy of biomass estimates, but we do not have enough PALSAR scenes.

K&C deliverables

Papers and Reports

1. Published

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2. Submitted/in preparation

- Peregon A., and Y. Yamagata (2011), Using ALOS/PALSAR backscatter to estimate above-ground forest biomass: case study in Western Siberia, *J. Remote Sensing of Environment,… (under revision)*

- Peregon A., and Y. Yamagata (2011), The effect of environmental conditions on biomass estimates with ALOS PALSAR in Siberian forests *(in preparation)*