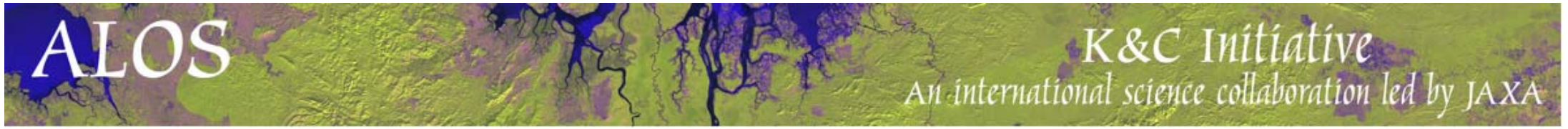

K&C Phase 3 – progress report

Coupling radar-based estimates of forest information with biosphere models for improved carbon flux estimation

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Advances in forestry applications using satellite ALOS PALSAR images

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esa

Projects objectives

- To develop and validate methods for large-scale biomass mapping (base year 2010) using PALSAR data
- The methods and algorithms that will be developed aim to demonstrate the large-scale forestry monitoring goals of the JAXA's ALOS Kyoto & Carbon Initiative. Synergy between the two K&C Phase 3 project is explicitely addressed.
- Common study area: Sweden
- Additional areas for carbon flux estimation from PALSAR biomass are located in Finland, Germany, Siberia, Brazil
- Both mosaic and strip data are used and evaluated for biomass retrieval

Project areas

Test sites:

- Remningstorp
- Krycklan

Counties:

- Västra Götaland
- Västerbotten

Country:

- Sweden

(45 million ha – 50% forest)

Remningstorp

- Area: 1,200 ha. Flat topography.
- Selection of 56 forest stands.
- Size: 1 – 11 ha; average: 3 ha
- Stem volume: 35 - 617 m^3/ha;
- Average: 295 m^3/ha
- Inventory: 2004. Stem volume updated with yearly growth factors
- Coniferous and deciduous hemi-boreal forest

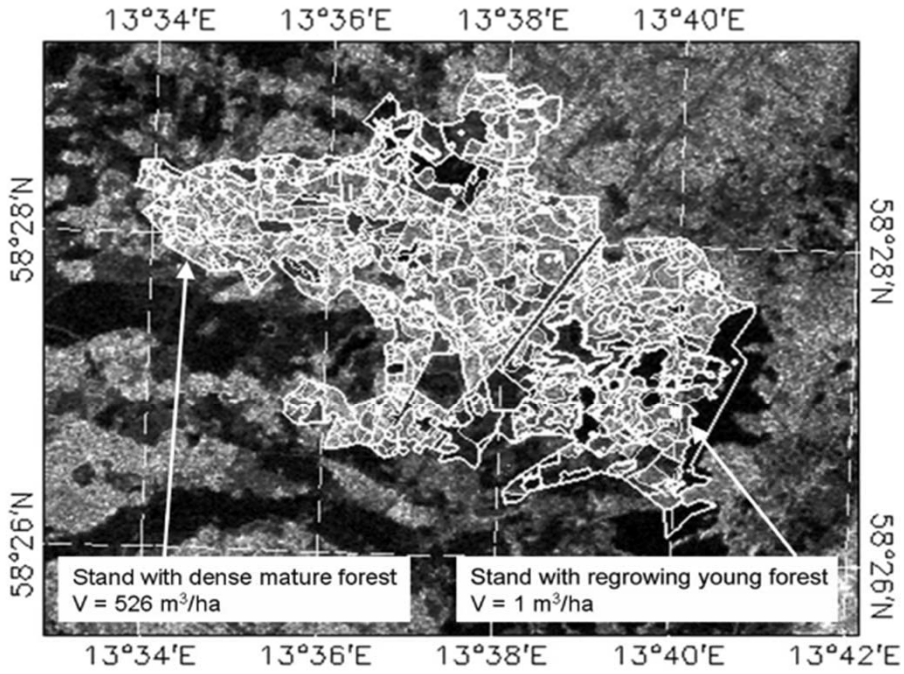


Fig. 4. FBD34 HV gamma-nought image acquired on August 1, 2007 over the Remningstorp test site overlaid with the forest-stand boundaries. The area covered by this image is 9 km wide and 7 km long.

Krycklan

- Area: 6,800 ha. Hilly topography.
- 1,131 forest stands
- Size: 0 – 64 ha; average: 4 ha (95th percentile: 15 ha)
- Stem volume: 0 - 525 m^3/ha;
- Average: 134 m^3/ha
- Inventory: 2007-2008
- Coniferous and deciduous boreal forest

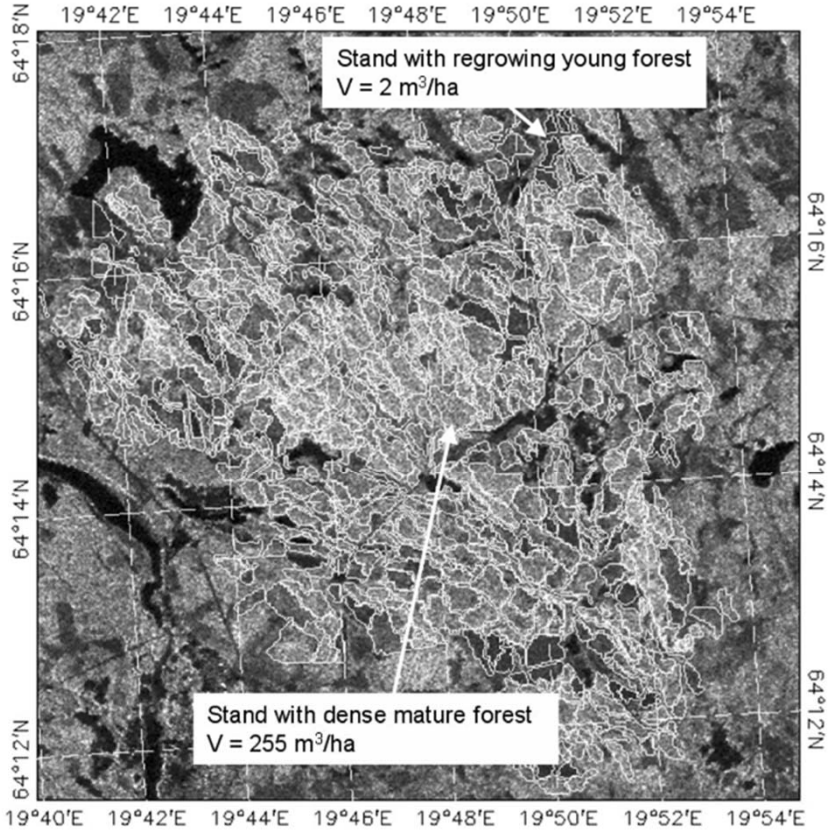
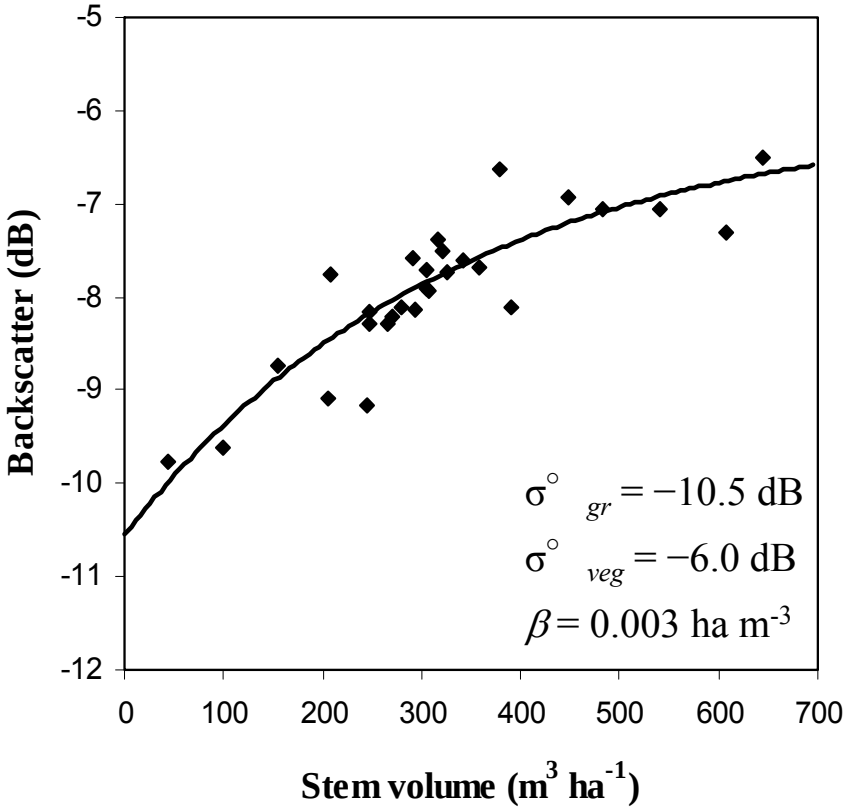


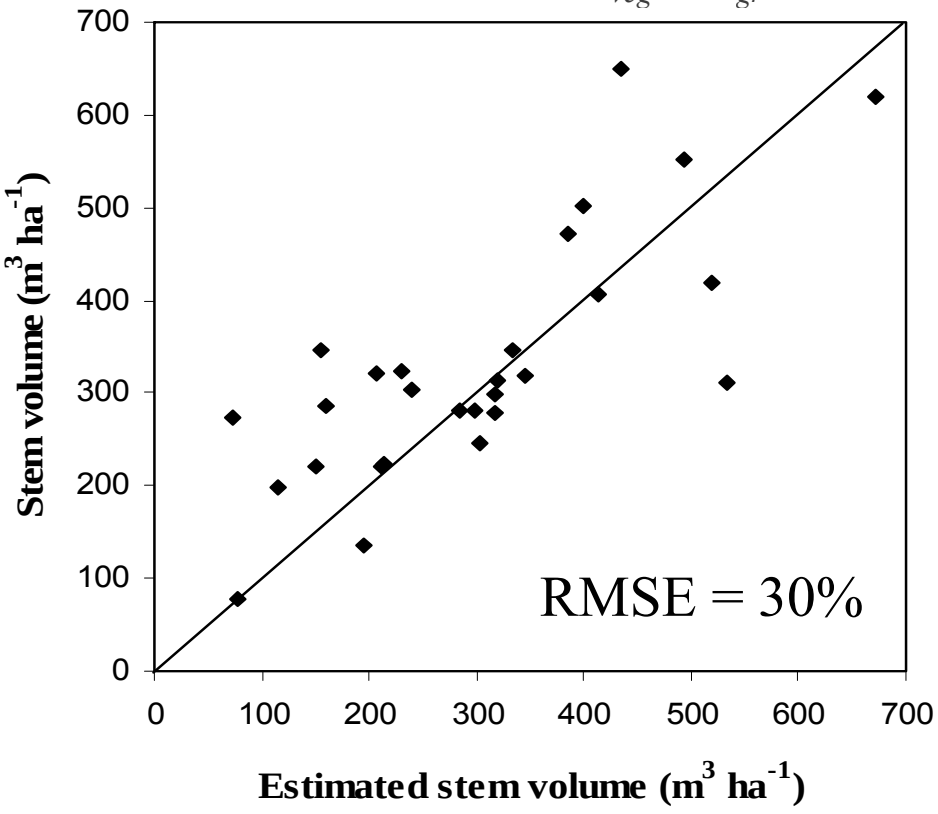
Fig. 5. FBD34 HV gamma-nought image acquired on August 22, 2007 over the Krycklan test site overlaid with the forest-stand boundaries. The area covered by this image is 12 km wide and 12 km long.

Stem volume estimation from SAR backscatter

$$\sigma^{\circ}_{for} = \sigma^{\circ}_{gr} \times e^{-\beta V} + \sigma^{\circ}_{veg} \times (1 - e^{-\beta V})$$

$$\hat{V} = -\frac{1}{\beta} \times \ln\left(\frac{\sigma^{o}_{veg} - \sigma^{o}_{for,meas}}{\sigma^{o}_{veg} - \sigma^{o}_{gr}}\right)$$





FBS 34.3° HH, 2007-01-29 (best case – Remningstorp test site)

Multi-temporal retrieval of stem volume

$$\hat{V}_{mt} = \frac{\sum_{i=1}^{N} \frac{w_i}{w_{\max}} \hat{V}_i}{\sum_{i=1}^{N} \frac{w_i}{w_{\max}}}$$

- With one observation, biomass retrieval is less accurate compared with using many observations
- Having available many observations implies that random fluctuations can be filtered out to obtain an estimate that is more closely related to the true value

SAR dataset - Remningstorp

Remningstorp		
Polarization / look angle	Years	Images
HH 21	2006	2
HH 21 (PLR)	2006-2009	13
HV 21 (PLR)	2006-2009	13
VH 21 (PLR)	2006-2009	13
VV 21 (PLR)	2006-2009	13
HH 23 (PLR)	2009	1
HV 23 (PLR)	2009	1
VH 23 (PLR)	2009	1
VV 23 (PLR)	2009	1
HH 34	**2006-2009**	**30**
HV 34	**2007-2009**	**12**
HH 41	2006	6
HV 41	2006	3
HH 50	2006	2
HV 50	2006	2
Total		113

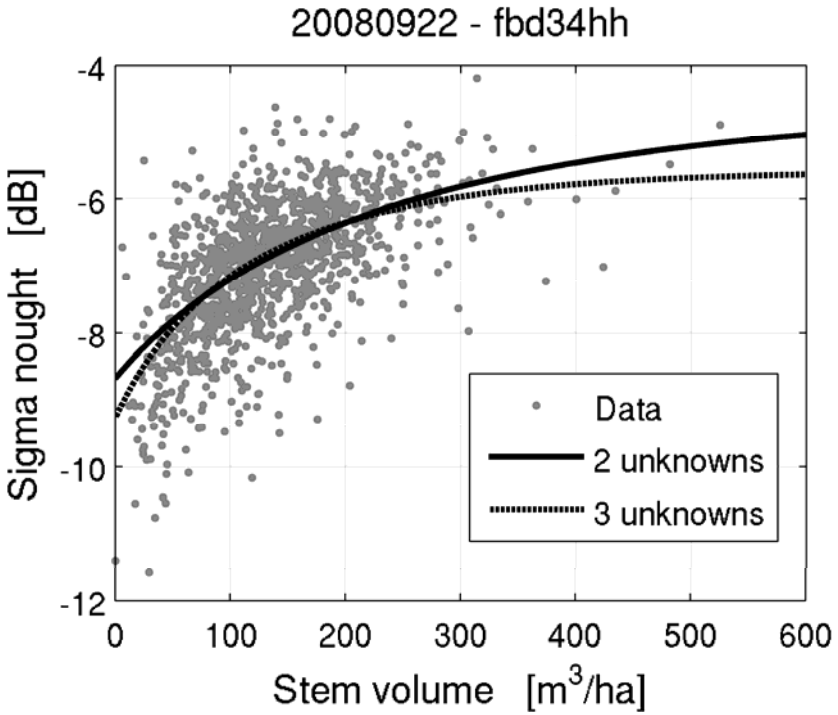
- Large dataset available in the main FB 34 modes (summer/fall and winter)
- Multiple combinations of look angle / polarization → effect on retrieval?

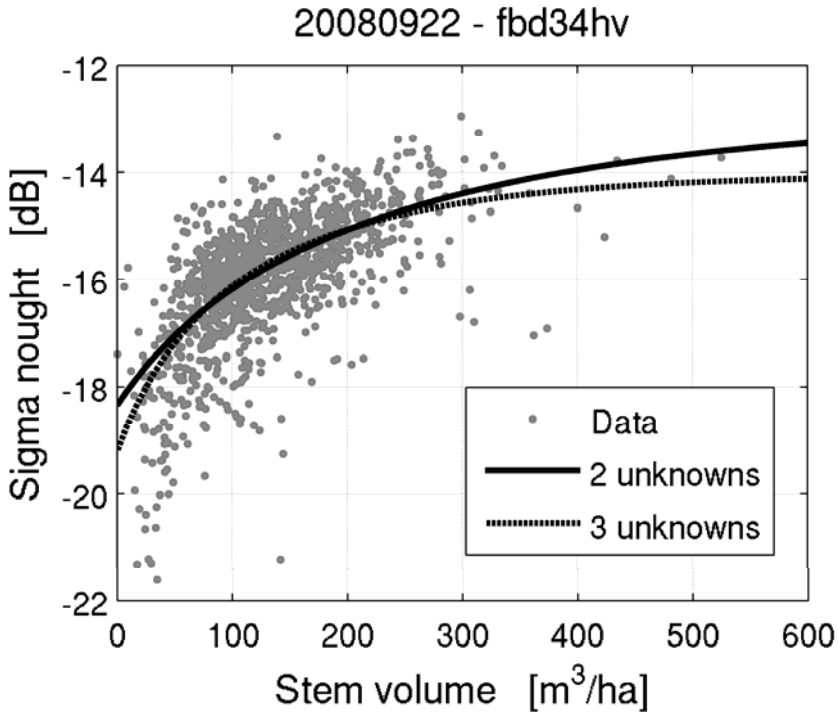
SAR dataset - Krycklan

Krycklan		
Polarization / look angle	Years	Images
HH 21	2006	2
HH 21 (PLR)	2006-2009	6
HV 21 (PLR)	2006-2009	6
VH 21 (PLR)	2006-2009	6
VV 21 (PLR)	2006-2009	6
HH 23 (PLR)	2009	1
HV 23 (PLR)	2009	1
VH 23 (PLR)	2009	1
VV 23 (PLR)	2009	1
HH 34	**2006-2010**	**56**
HV 34	**2007-2010**	**25**
HH 41	2006	9
HV 41	2006	3
Total		123

- Large dataset available in main FB 34 mode (summer/fall and winter)
- Several observations in FB 41 modes (summer/fall)

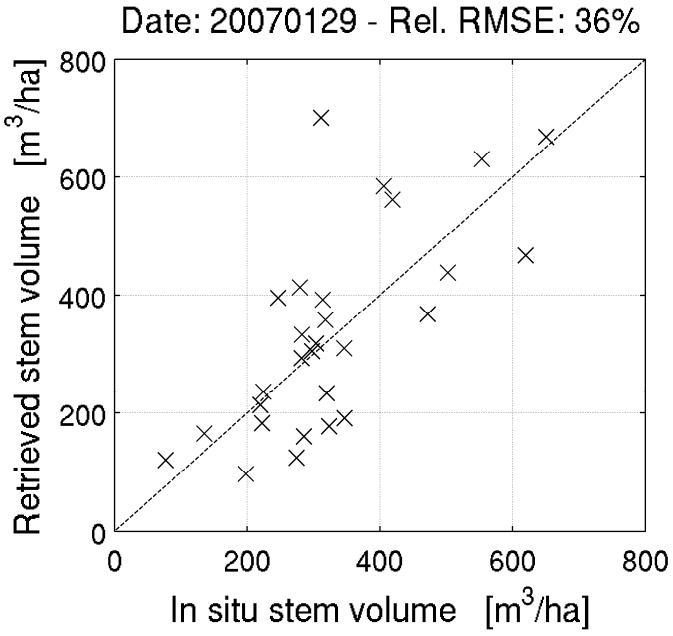
Backscatter modeling

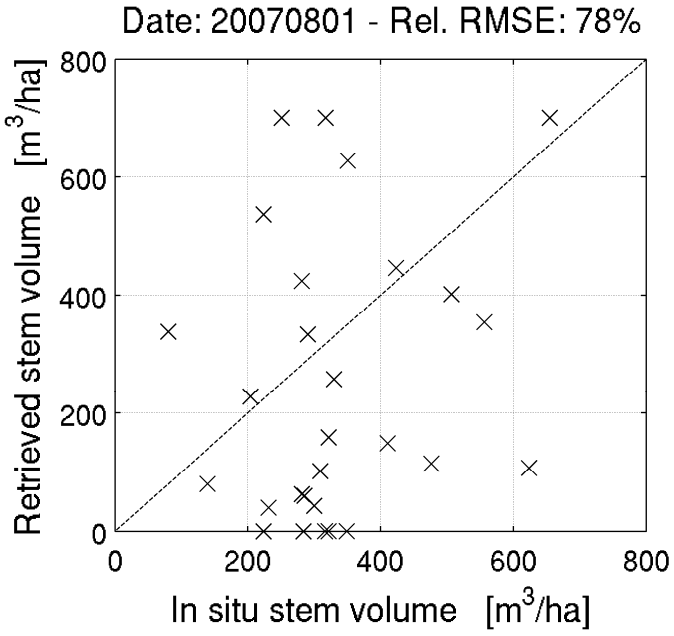


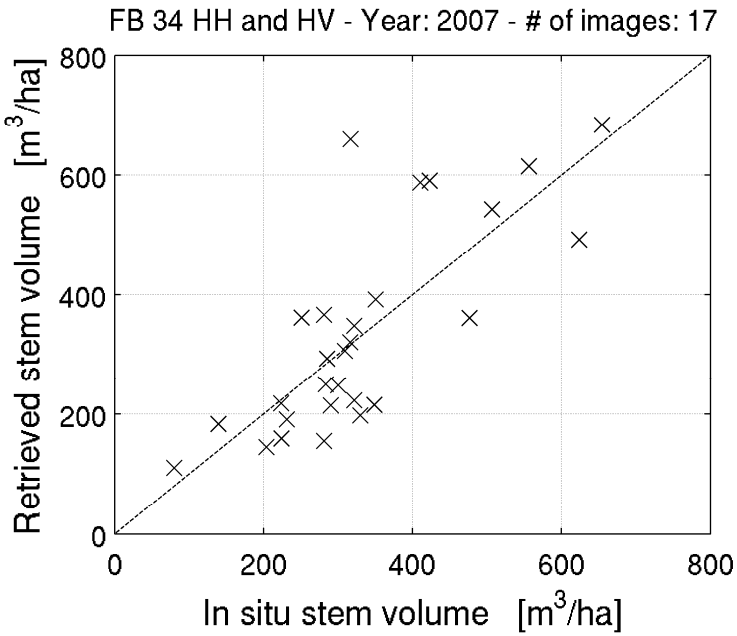


- Model training with 2 or 3 degrees of freedom (dof) performs similarly
- Significant spread implies uncertainty of the model parameters → better to have 2 dof
- Tests for all datasets indicated that $\beta = 0.003$ ha/m^3 is a realistic assumption

Retrieval of stem volume – Remningstorp – FB 34

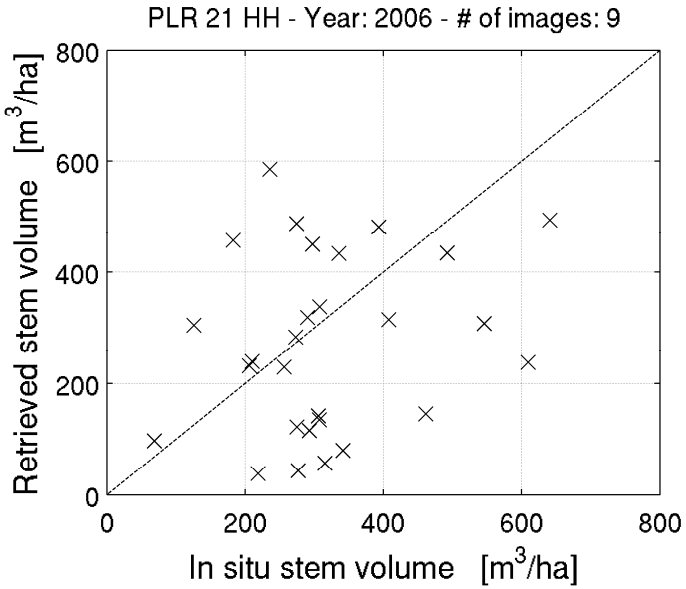


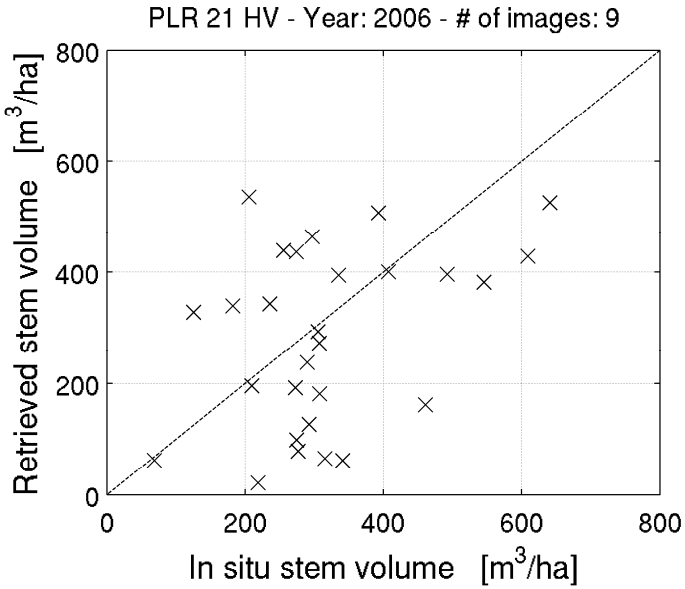


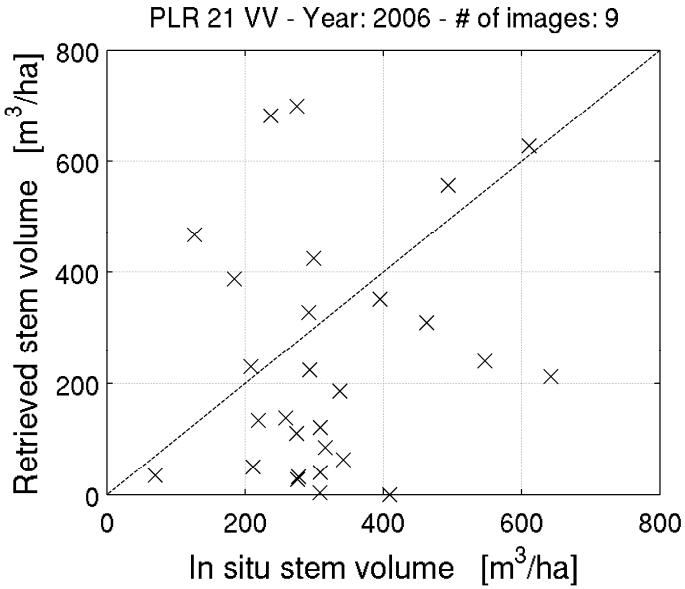


- Retrieval of stem volume from a single image is poor
- Multi-temporal combination retrieval error (in this example): 32%
- Dominant contribution: winter-time HH data (sub-zero temperature, snow cover)
- Consistent results every year

Retrieval of stem volume – Remningstorp – PLR modes

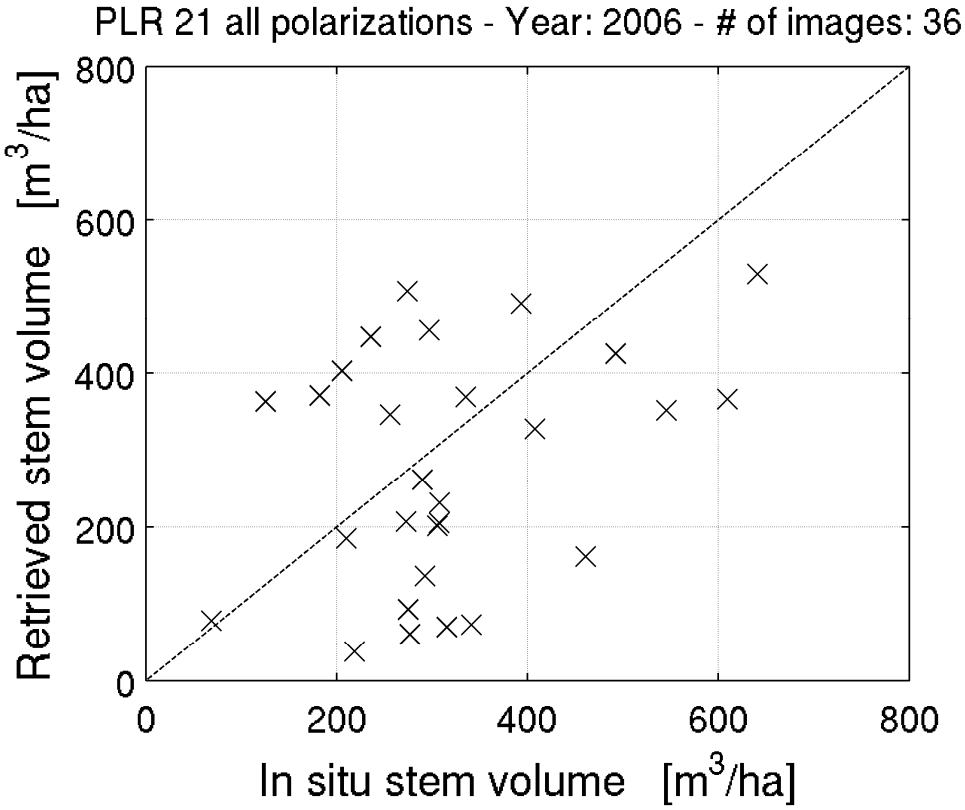






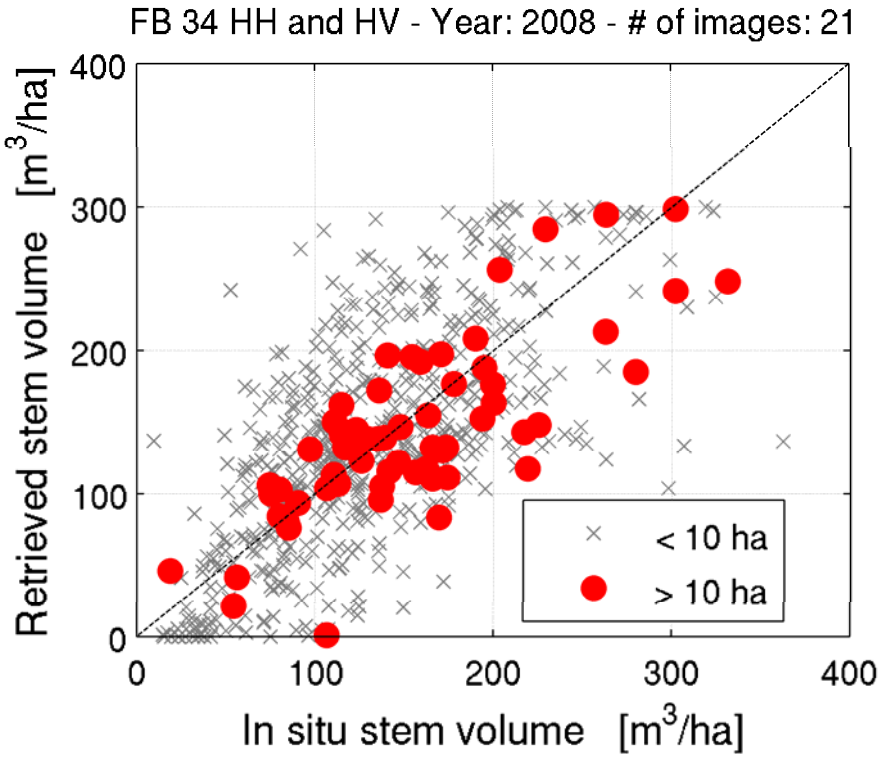
- Relative RMSE: 59% (HH), 52% (HV), 74% (VV), 51% (all)

Retrieval of stem volume – Remningstorp – PLR modes



- Relative RMSE: 59% (HH), 52% (HV), 74% (VV), 51% (all)

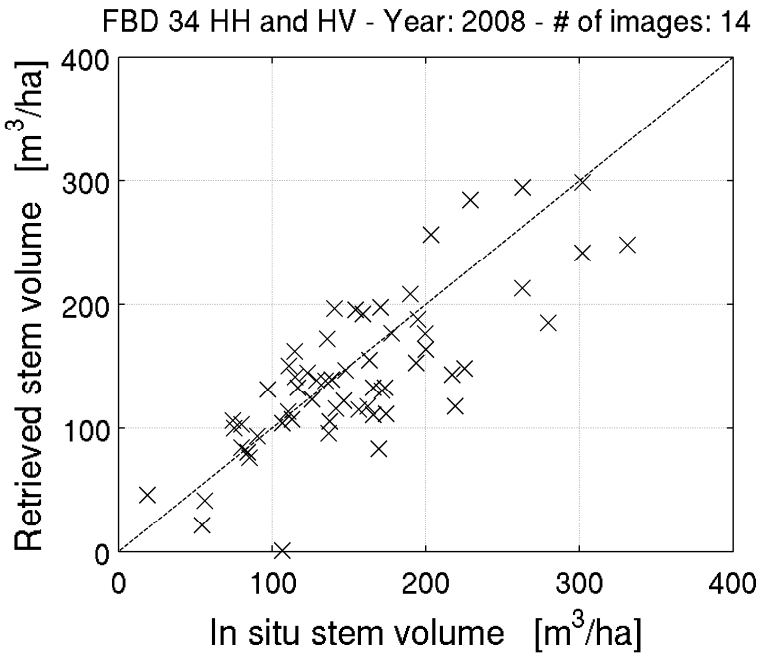
Retrieval of stem volume – Krycklan – FB 34

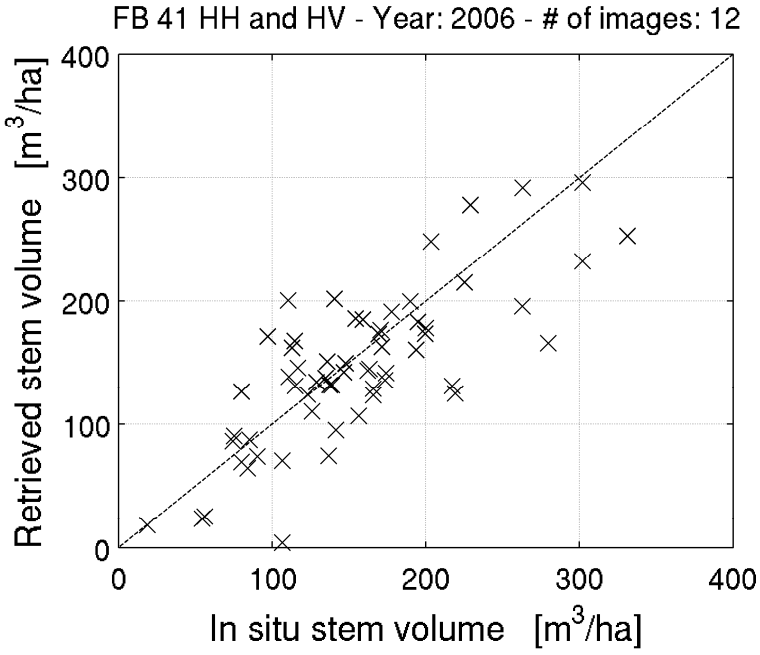


Min size (ha)	Min. # of pixels	Number of stands	Relative RMSE (%)	R^2
0.04	1	565	43	0.46
1	25	425	38	0.48
2	50	299	34	0.54
4	100	175	30	0.64
5	125	141	29	0.66
10	250	60	28	0.61
20	500	16	27	0.74

- Retrieval statistics strongly affected by the size of the stands
- Dominant contribution: summertime HV data, then summertime HH data
- Consistent results every year

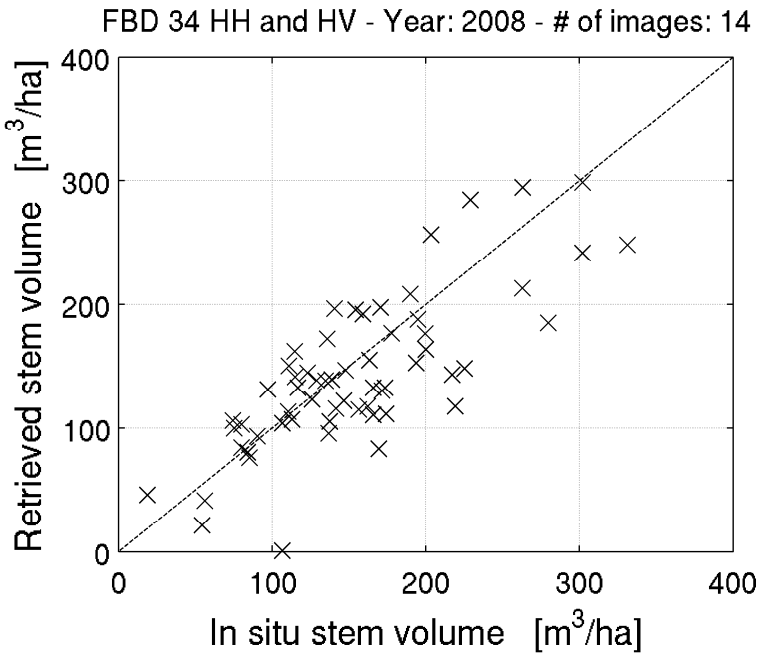
Retrieval of stem volume – Krycklan – FB 34 vs. 41

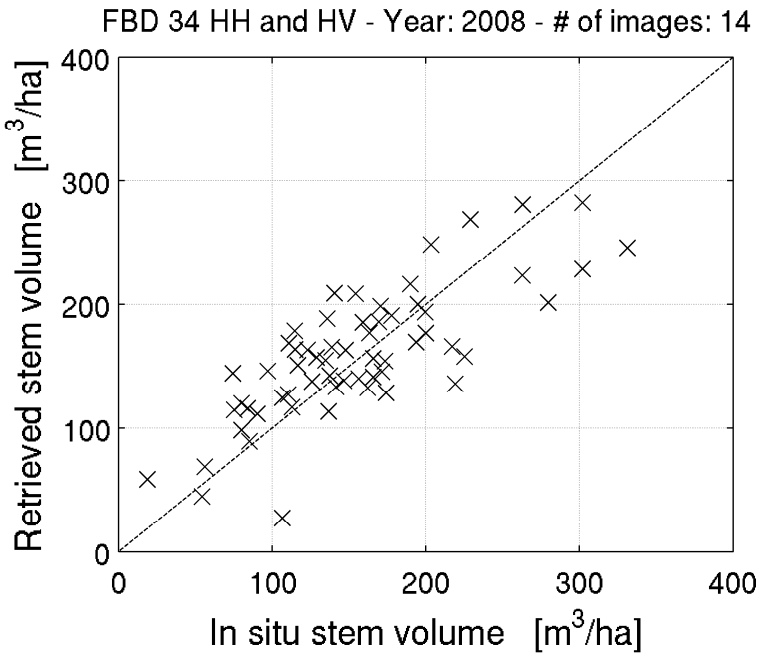




- No significant difference of retrieved stem volume between 34° and 41° look angles
- Relative RMSE: 27%; R-squared: 0.60

Retrieval of stem volume – Stand-wise vs. pixel-wise retrieval





- Working at pixel level (and then aggregating at stand level) performs similarly to stand-wise averaging of backscatter

Project schedule (status)

Biomass mapping:

- Investigations of the methodology: almost concluded
    - Water Cloud Model with fixed transmissivity approach: satisfactory
- Assessment of pixel size, modes, weather data: almost concluded
    - Work at highest pixel size available; then, aggregate at desired scale
- Automation of retrieval approach (modeling): ongoing
    - Porting BIOMASAR algorithm from low-res to high-res

- Future: study area mapping and delivery of products