Kyoto & Carbon (K&C) Initiative - Forest Theme: Current Status of Projects

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GAMMA REMOTE SENSING

Outline

(a) Definition of your K&C "products"

(b) Processing status and data provided so far

(c) Time schedule for all

(d) Problems and/or bottle necks

(e) Results obtained so far

1. Processing results and quality of data
2. Analysis of PALSAR data
3. Conclusions
4. New publications relating to ALOS

(a) Definition of the K&C "products"

Product names:

- Boreal Land Cover Classification and Land Cover Change (LCM6/FCM5) (with JRC)
- Boreal Disturbance Mapping (FCM6)

Description:

- Thematic classification for Siberian Taiga based upon dual polarisation PALSAR data, with 2007 being the intended base year at high resolution
- Mapping of boreal forest disturbances in Central Siberia at high resolution using multi-temporal multi-polarisation data.

PALSAR mode:

- Fine Beam HH-pol (winter, for interferometry)
- Fine Beam HH-HV pol (summer)

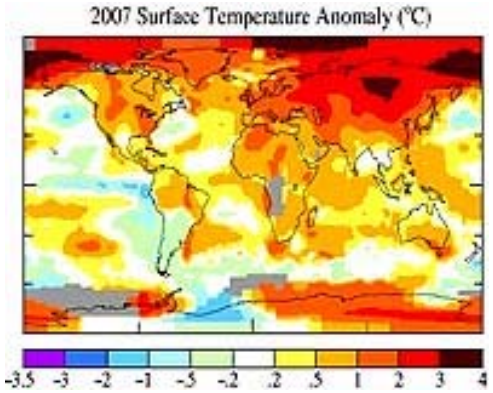
Observation cycles:

- 8,9 (winter 2007) 12,13,14 (summer 2007) 16, 17 (winter 2008) 20, 21 (summer 2008)

Production schedule:

- Test area analysis (2007)
- Central Siberia mapping (2007 - 2008) (two maps of disturbances for 2007 and 2008)
- Siberian taiga mapping (2009-2010) (extension)

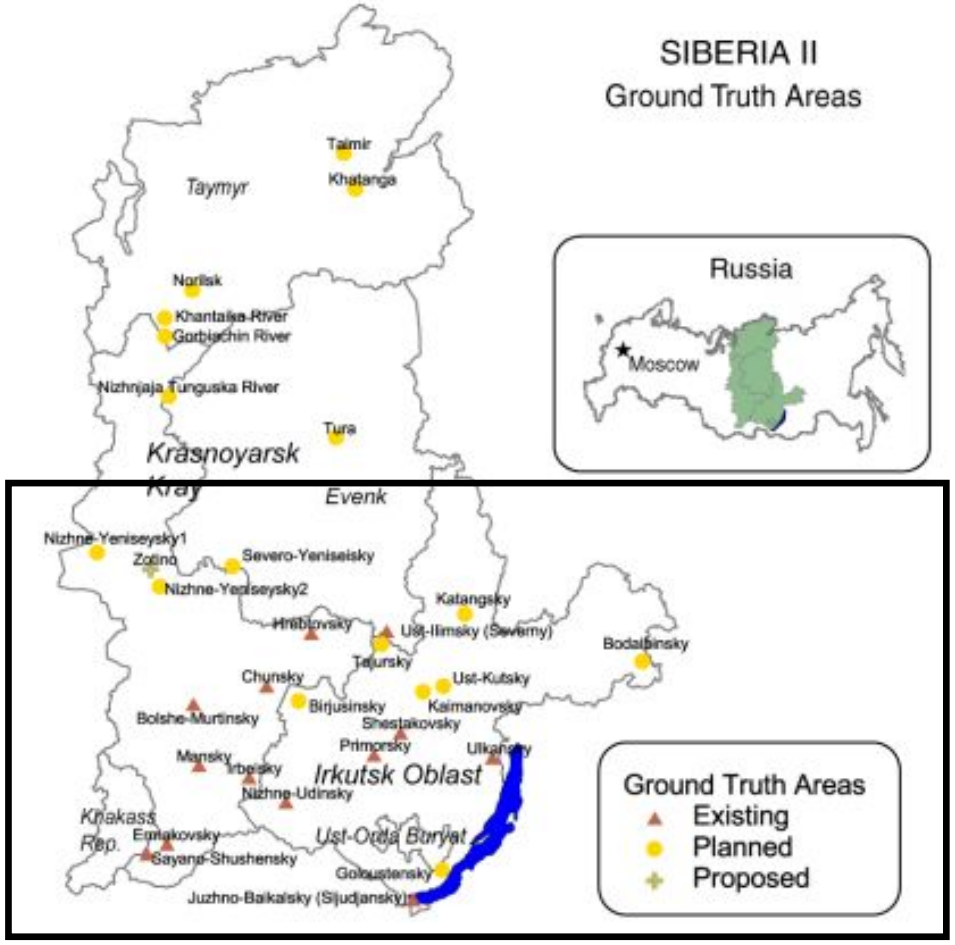
Prototype area



Temperature anomalies for 2007 relative to the 1951-1980 mean. Largest increases were in the northern hemisphere. Credit: Goddard Institute for Space Studies (GISS) (from www.terradaily.com , 2008-01-17)

Prototype area:

50-65 deg N, 85-110 deg E



Proposed product (disturbance mapping)

Prototype area:

50-65 deg N, 85-110 deg E

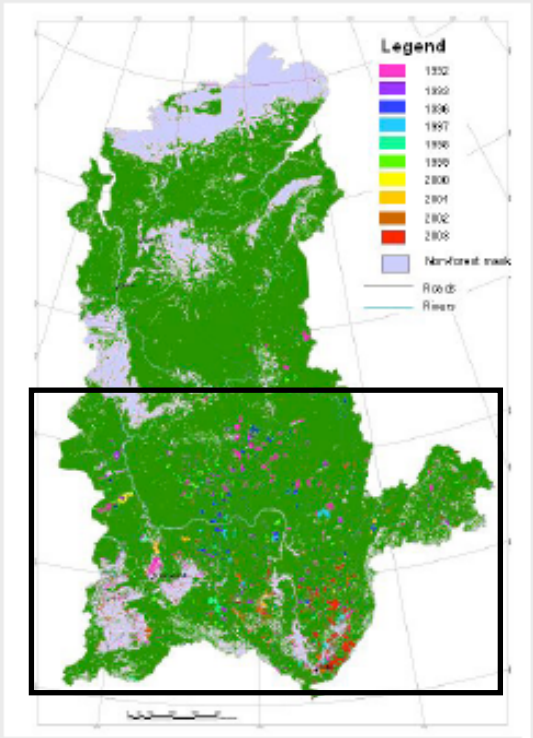
Product Box F-9 – Boreal Disturbance Mapping

K&C product: (FCM6) Maps of boreal forest disturbances

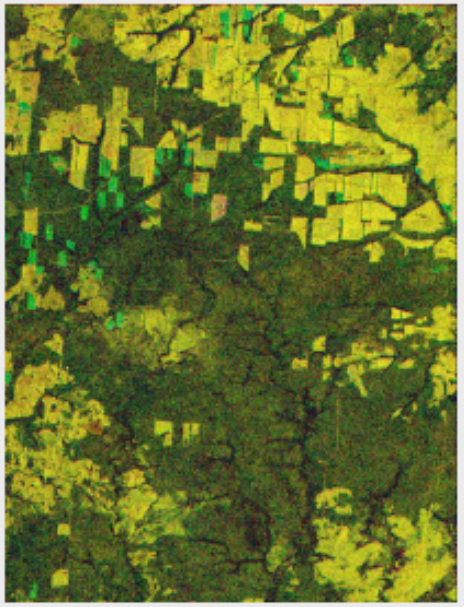
Intended use: High resolution maps of forest disturbances of the type shown below (right) will assist local forest authorities for forest cover changes monitoring and carbon balance computation. The maps will also be used for land cover and land cover change assessments both within the K&C Initiative and in other activities within the global change research community. The maps will also be integrated with land cover maps to improve regional products.

Prototype areas: Central Siberia (SIBERIA-II project area: N50°-78°; E80°-120°).

Input data: ALOS PALSAR Path Images, 50 m resolution



Yearly fire scar map of a 3 Million sq.km area in Central Siberia using MODIS, SPOT VGT and AVHRR data (courtesy of CEH, SIBERIA-II Project).



Land cover classification and forest changes in Chunsky, Central Siberia, as detected using multi-temporal winter JERS-1 SAR backscatter and interferometric SAR coherence (R – coherence winter 1993-1994, G – coherence winter 1995-1996; B – ratio of mean intensity for each image pair). Clear-cuts before 1994 appear in yellow; forests in dark green; areas deforested between 1994 and 1996 appear in light green.

Product Developer:

Christiane Schmullius Friedrich-Schiller University Jena, Germany

Amount of data provided

Data requested: K&C data strips in slant range geometry (Fine Beam, 50 m)

50 full resolution Fine Beam and Polarimetric datasets (mainly for inteterferometry and polarimetric signatures analysis)

Amount of K&C data strips requested

Cycle #8 – FBS (5 Dec '06 – 19 Jan '07)

Cycle #12 and 13 – FBD (7 Jun – 6 Sep '07)

along every 2nd path in RSP interval 445 – 499 (= 28 RSP paths)

Amount of K&C data strips delivered (in terms of RSPs):

Cycle #8: 11 out of 28 – delivery stopped during 2007 and never resumed

Cycle #12: 17 out of 28 (not always full N-S extent)

Cycle #13: 18 out of 28 (not always full N-S extent)

HOLES in the data coverage? Strips appear as processed in AUIG so maybe there is just a delivery delay…

Processing status

Processing chain:

- generation of geocoded backscatter images from strip and full-res data
- generation of geocoded coherence images from InSAR winter pairs

Processing status:

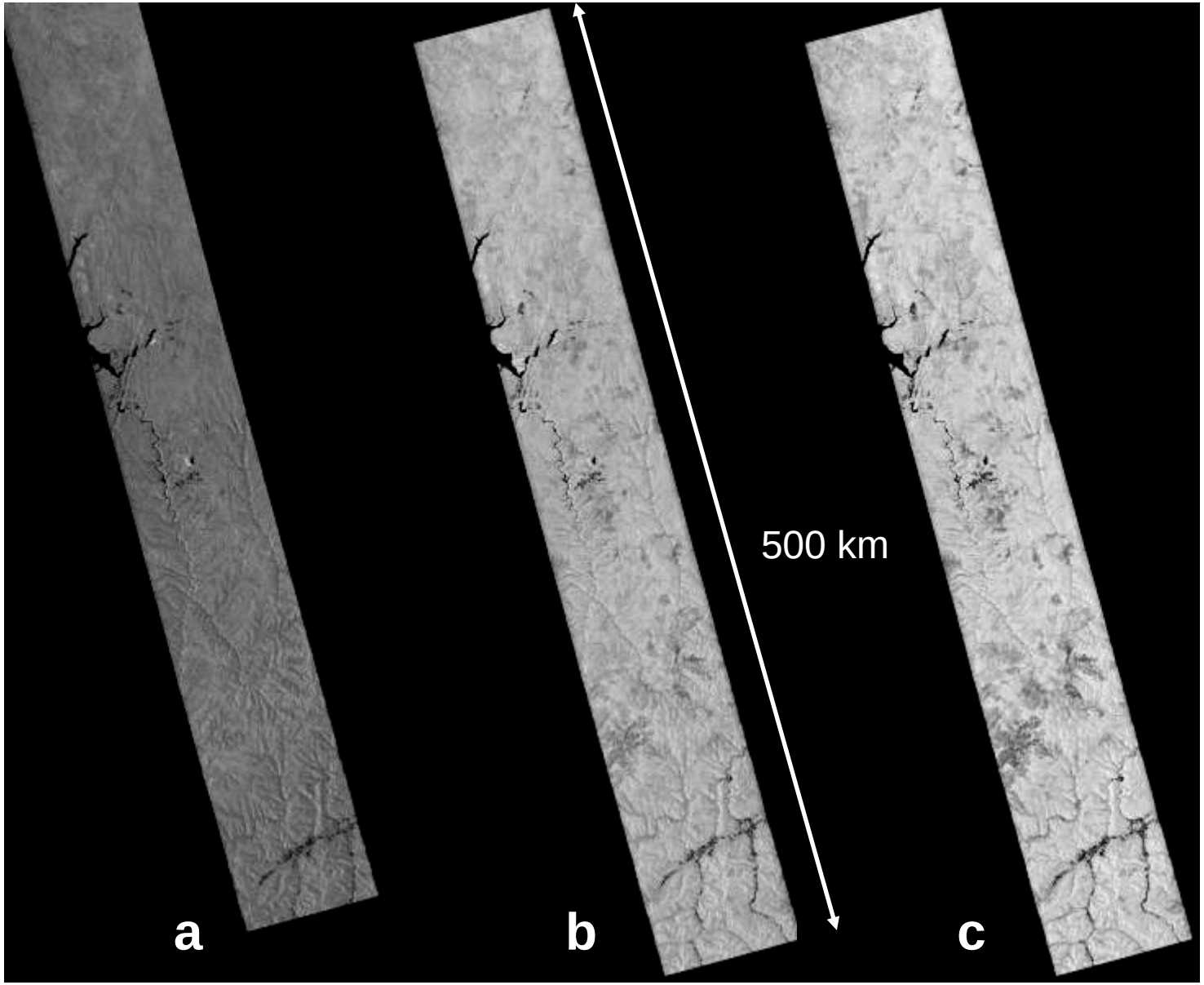
- full resolution data processed and used (e.g. GSE Forest Monitoring Project - FSU)
- K&C data strips periodically geocoded to low resolution to check data coverage (Gamma)
- Generation of K&C data products at full resolution to be started soon at FSU or maybe Gamma (staff funding necessary → this is currently only bottleneck)

(c) Time Schedule for all [Forthcoming activities / projects related to PALSAR data]

- FRA-SAR 2010 (DLR Project): Combination of PALSAR & TerraSAR-X [march 2008]
- Permafrost (ESA ITT Project) [end of 2008]
- GSE-FM (ESA GMES Project): Introduction of PALSAR data into map production [march 2008]

(e) Results obtained so far

- Processing results and quality of data
- Analysis of PALSAR data
- Conclusions
- New publications relating to ALOS



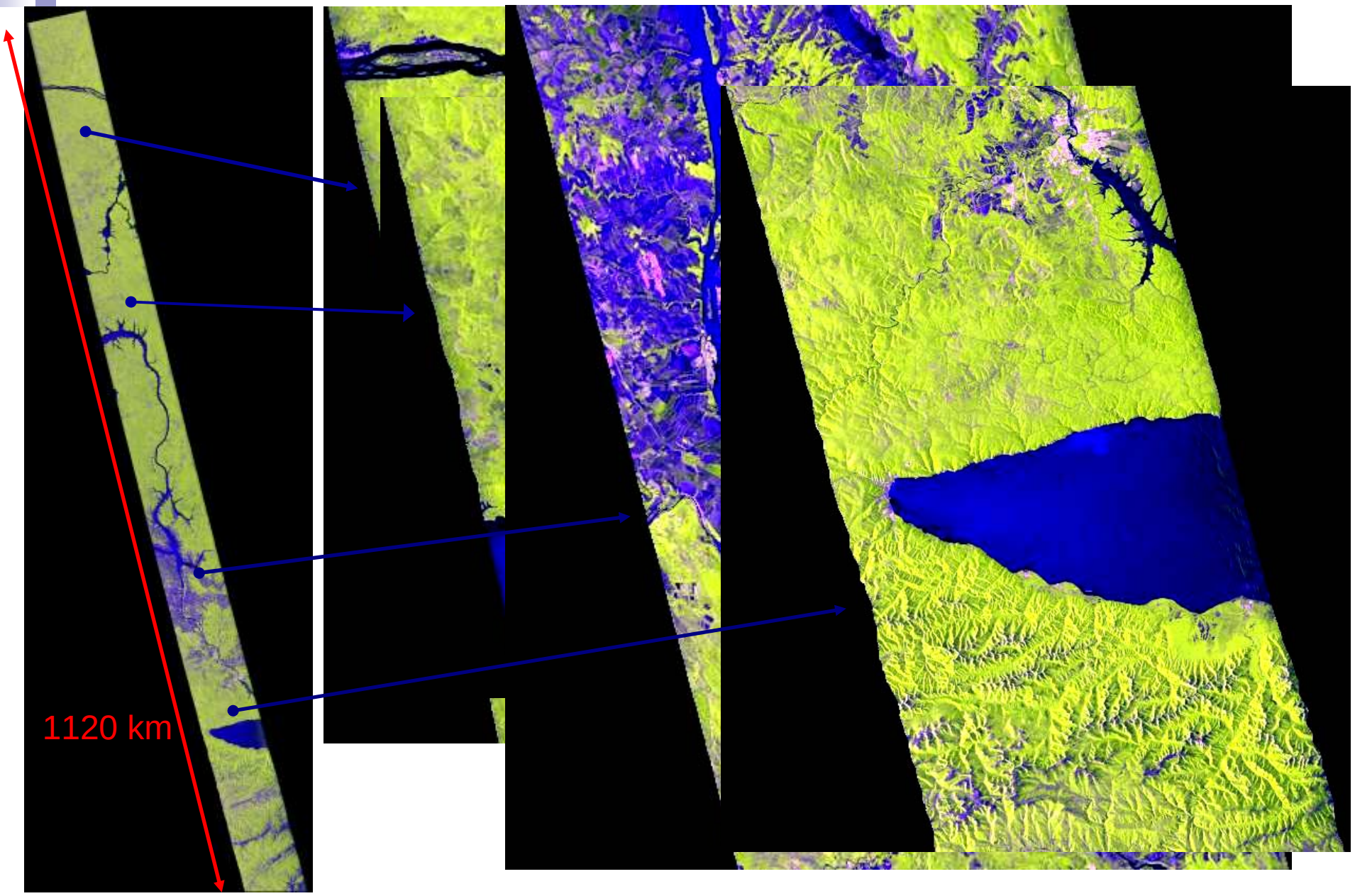
Geocoded PALSAR strip at 50 m x 50 m posting

RSP 462

a) 27 Dec. 2006, HH

b) 14 Aug. 2007, HH

c) 14 Aug. 2007, HV

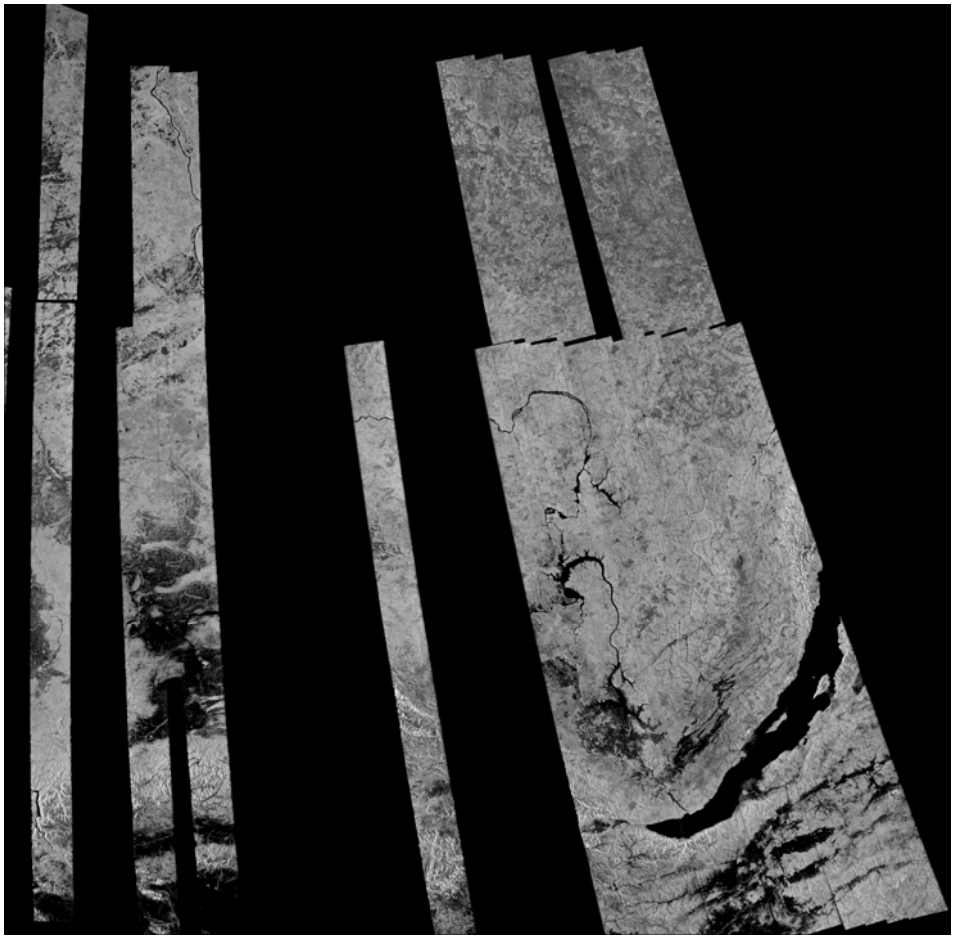


R = HH-pol, G = HV-pol, B = HH/HV ratio – RSP 465 – 19 Aug. 2007

Mosaics of cycle #13 FBD data

Cycle 13 (23 Jul – 6 Sep 2007)

HH

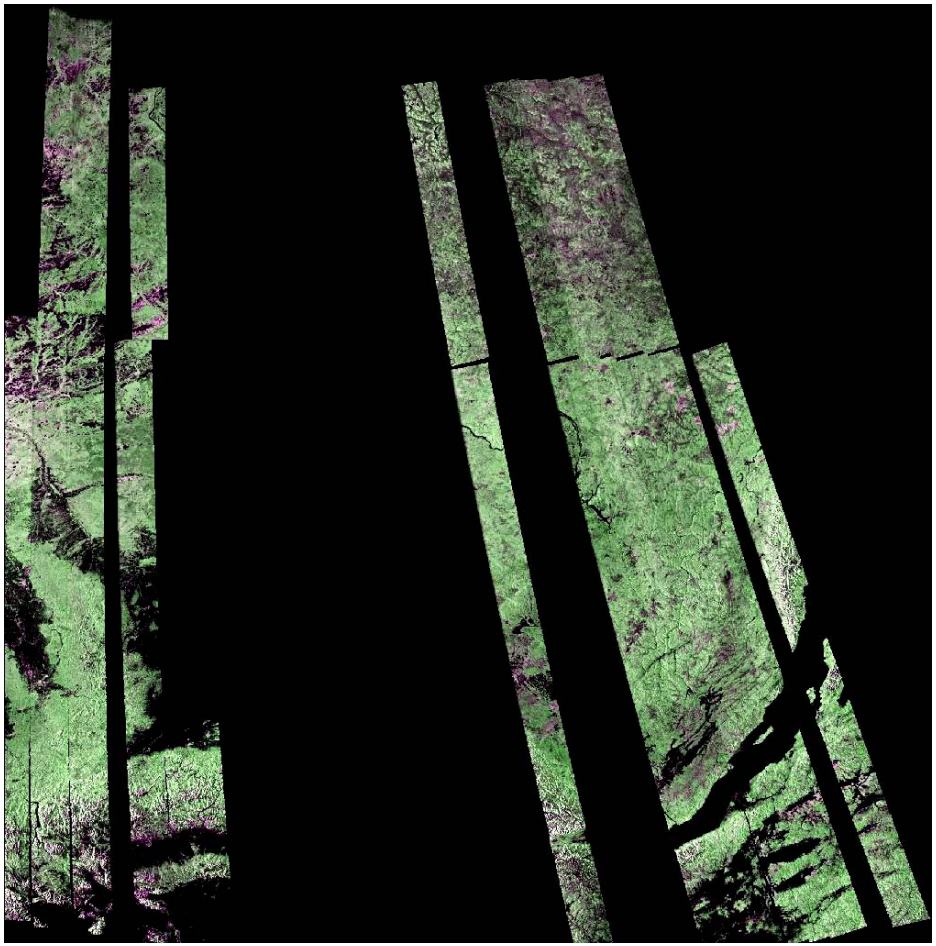


Cycle 13 (23 Jul – 6 Sep 2007)

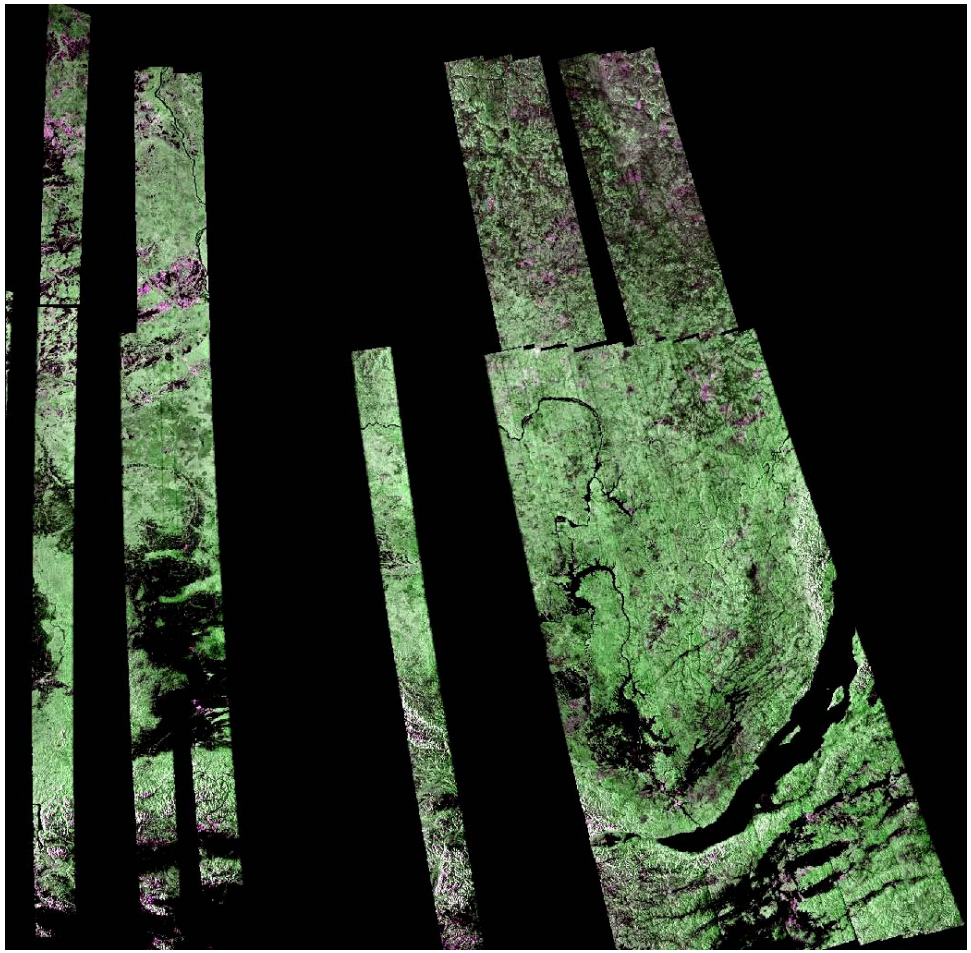
HV

Albers Conical Equal Area projection (as in SIBERIA-II Project), 250 m pixel size

Mosaics of cycles #12 and #13 FBD data



Cycle 12 (7 Jun – 22 Jul 2007)

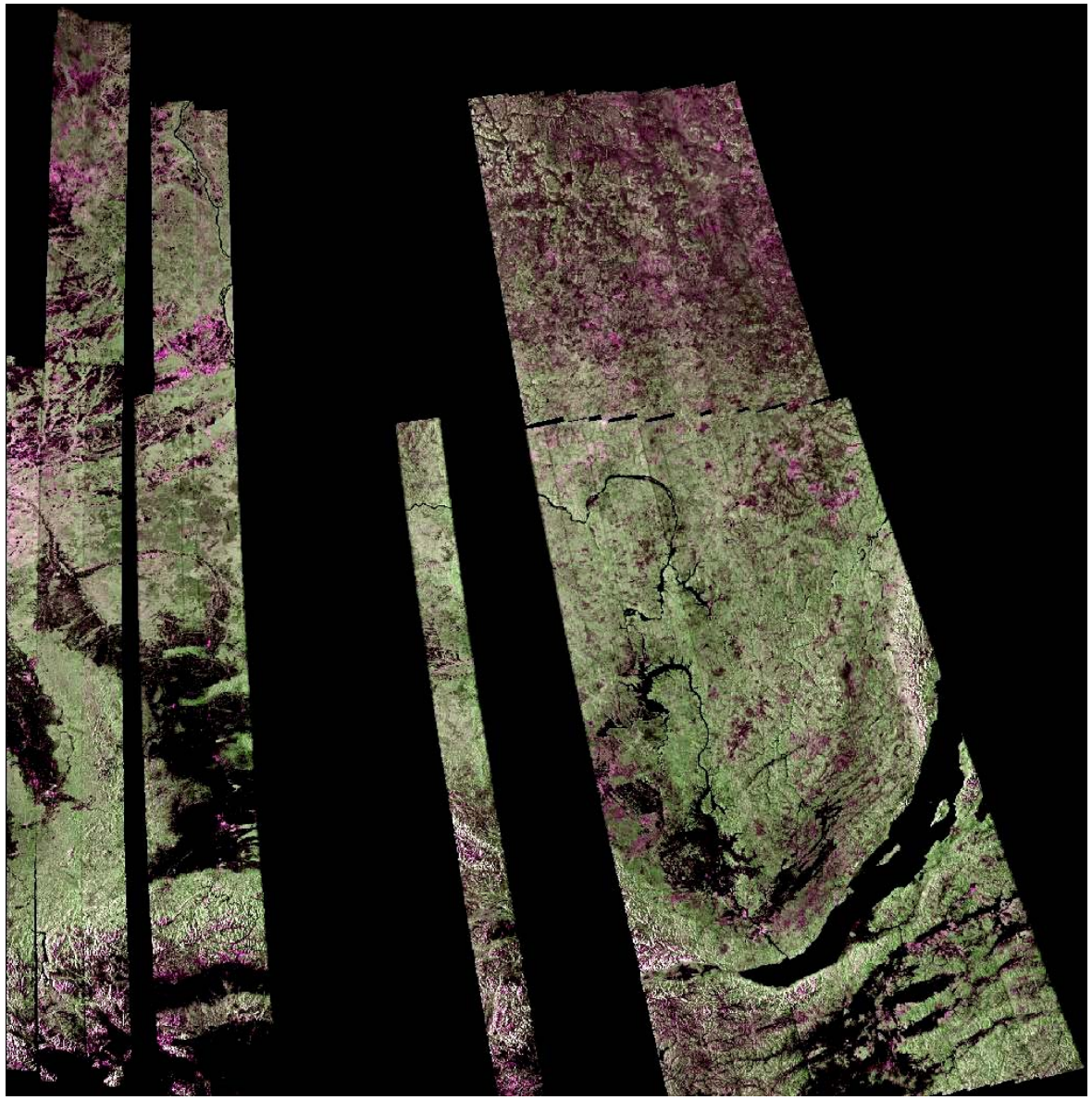


Cycle 13 (23 Jul – 6 Sep 2007)

R = HH-pol backscatter, G = HV-pol backscatter, B = HH-pol backscatter

Albers Conical Equal Area projection (as in SIBERIA-II Project), 250 m pixel size

Mosaics of cycles #12 + #13



Cycles period: 7 Jun – 6 Sep 2007

R = HH-pol backscatter

G = HV-pol backscatter

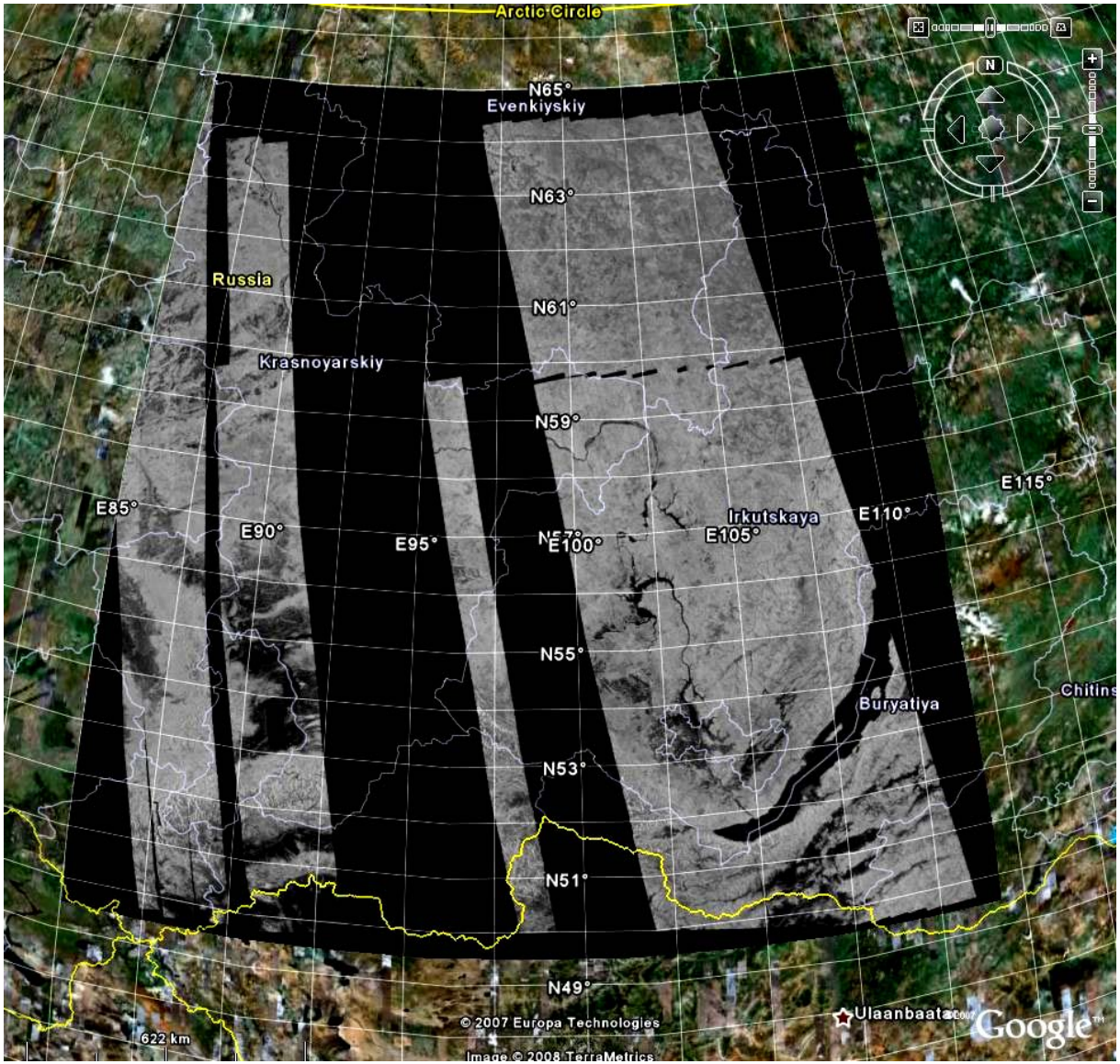
B = HH-pol backscatter

Albers Conical Equal Area proj.

(as in SIBERIA-II Project)

250 m pixel size

Coverage of K&C data - cycles #12+#13



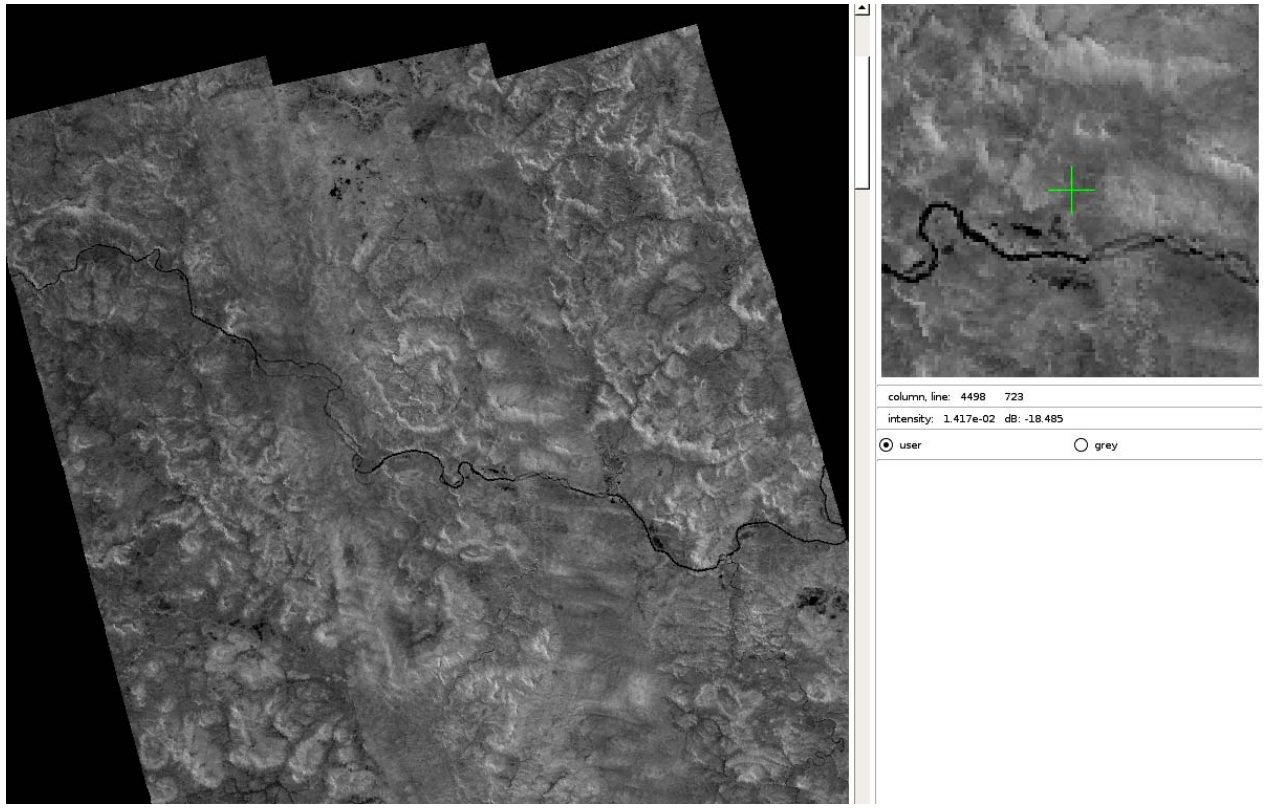
Example on geolocational errors

Geocoding needs a refinement → orbital data do not seem to be sufficient

Geocoding refinement done with cross-correlation with another (reference) dataset. Typically simulated SAR image from DEM used. If the area is flat another dataset can be used (e.g. optical)

Geocoding refinement can be problematic > 60 deg N and where available optical data (Landsat) does not present similar features as the PALSAR data

Example of mismatch between neighbouring tracks. Refinement based on Landsat data (downsampled to 250 m pixel size)



Summary of processing analysis

- Processing chain for PALSAR full res and K&C data strips in place
- All datasets are of **EXCELLENT** quality → thank you!
- For K&C data need to check refinement of geocoding to decide on strategy for best geocoding (SRTM only, optical only, SRTM+ optical)
- No data for central part of prototype area delivered so far
- Search in AUIG (beginner mode) does not show frames after March 2007. The problem does not occur in expert mode →JAXA please solve this
- In some cases strip data stops at 60 deg N, in some other cases gaps along a strip appear at 60 deg N (because of cutting)
- To complete coverage of prototype area for 2007 for missing data maybe data strips from cycle #14 could be of help. Maybe make them available?

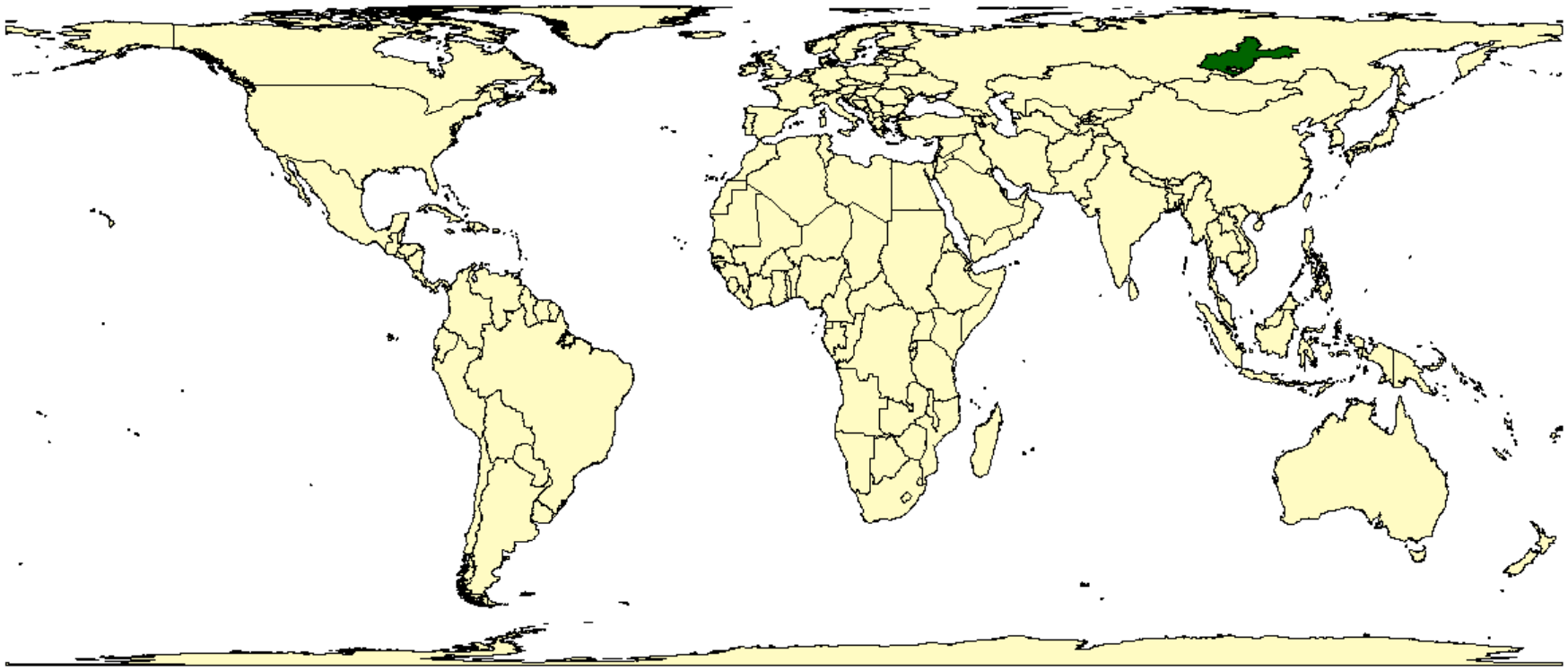
(e) Results obtained so far

- Processing results and quality of data
- Analysis of PALSAR data
- Conclusions
- New publications relating to ALOS

Analysis of PALSAR data

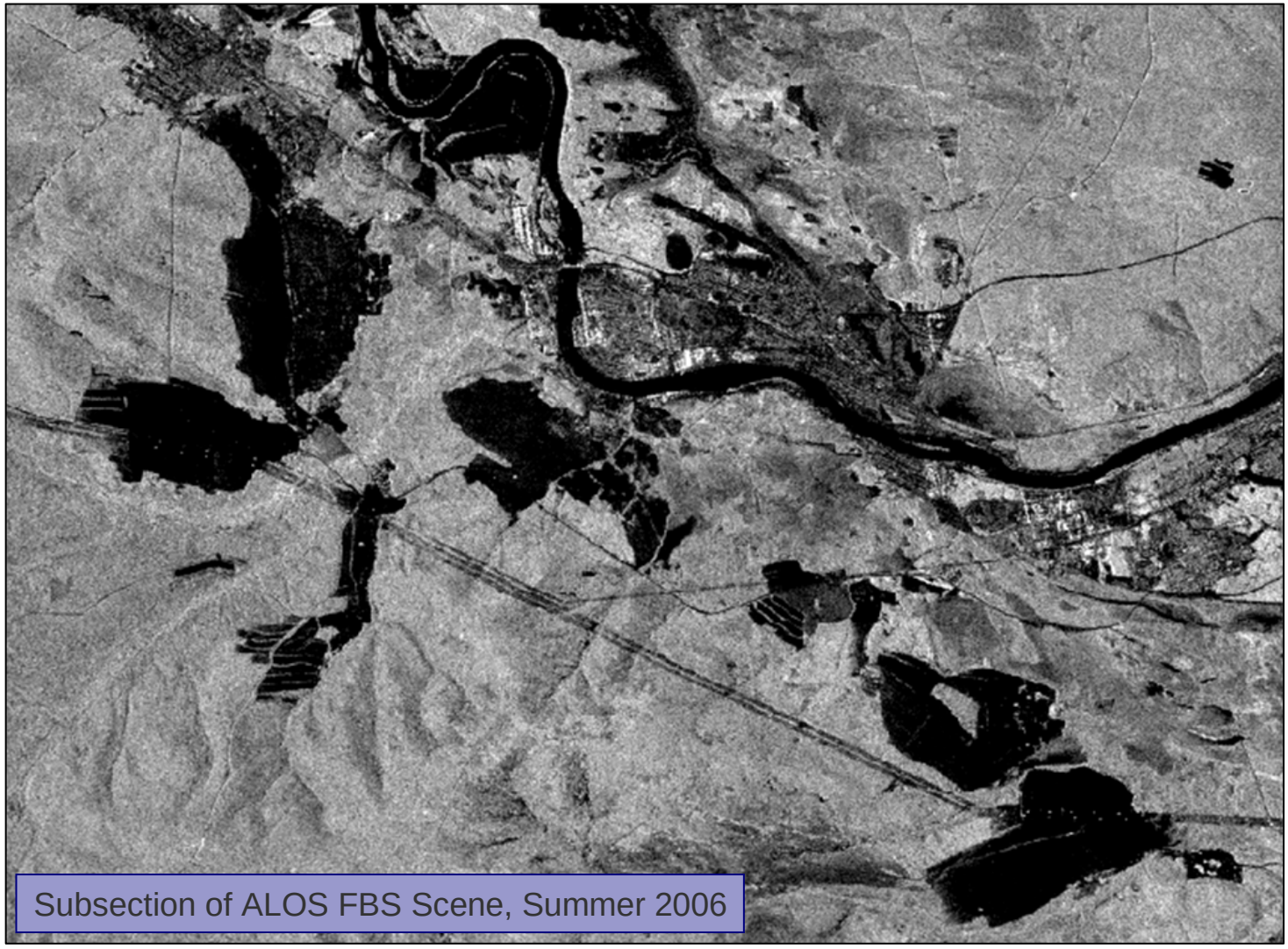
- … regarding forest/non-forest discrimination
- Data
  - FBS Intensity
  - PLR Intensity
  - Coherence (Winter)
  - Polarimetric Parameters (decomposition parameters)
- Signature analysis (mean, min, max)
  - Based on image objects (segments)
- Separability analysis (normalised Jefferies-Matusita distances)
  - Based on pixels

Irkutsk Oblast in Siberia - The Test Area



Projection: Equal Area (Behrmann)

Analysis of PALSAR data - FBS

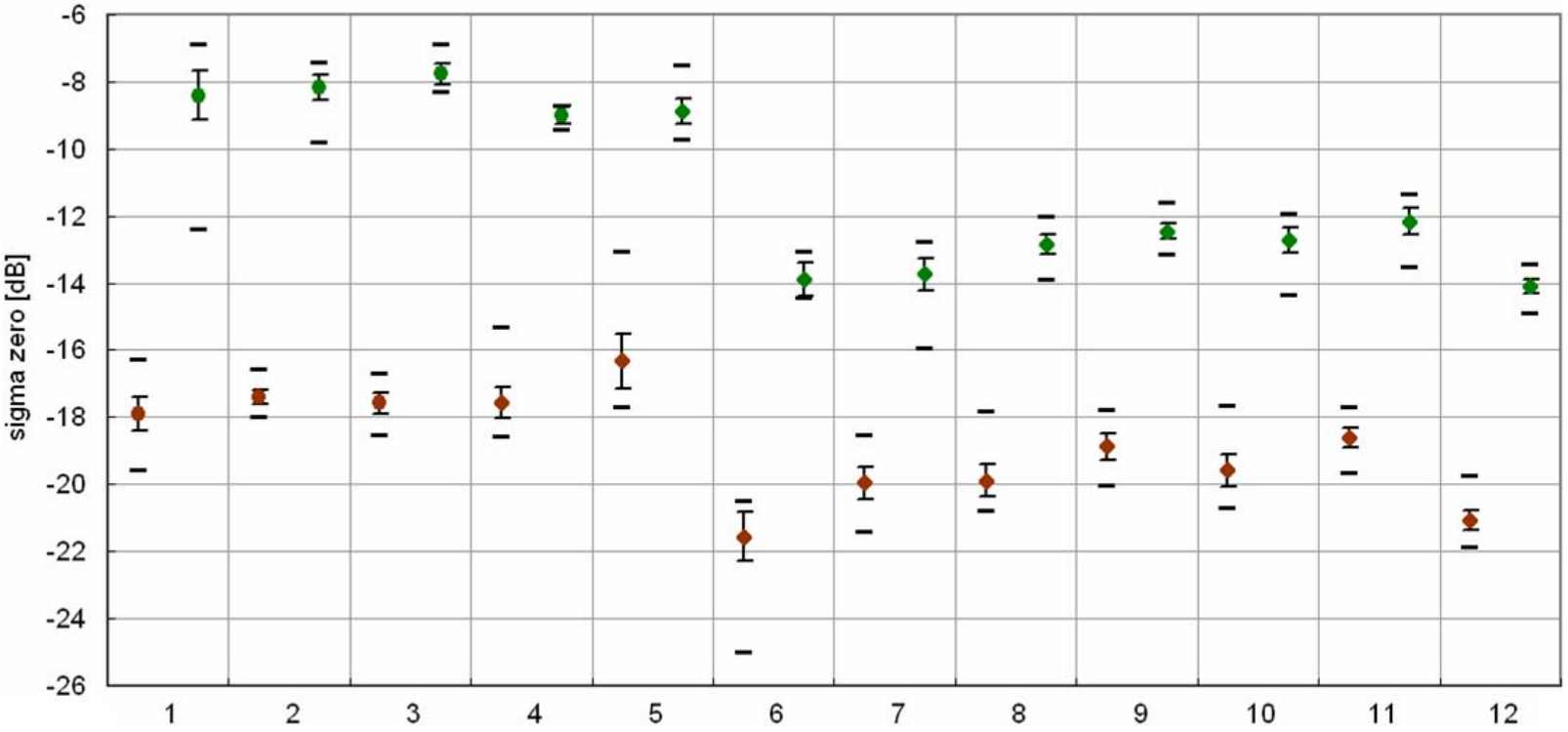


Subsection of ALOS FBS Scene, Summer 2006

Analysis of PALSAR data - FBS

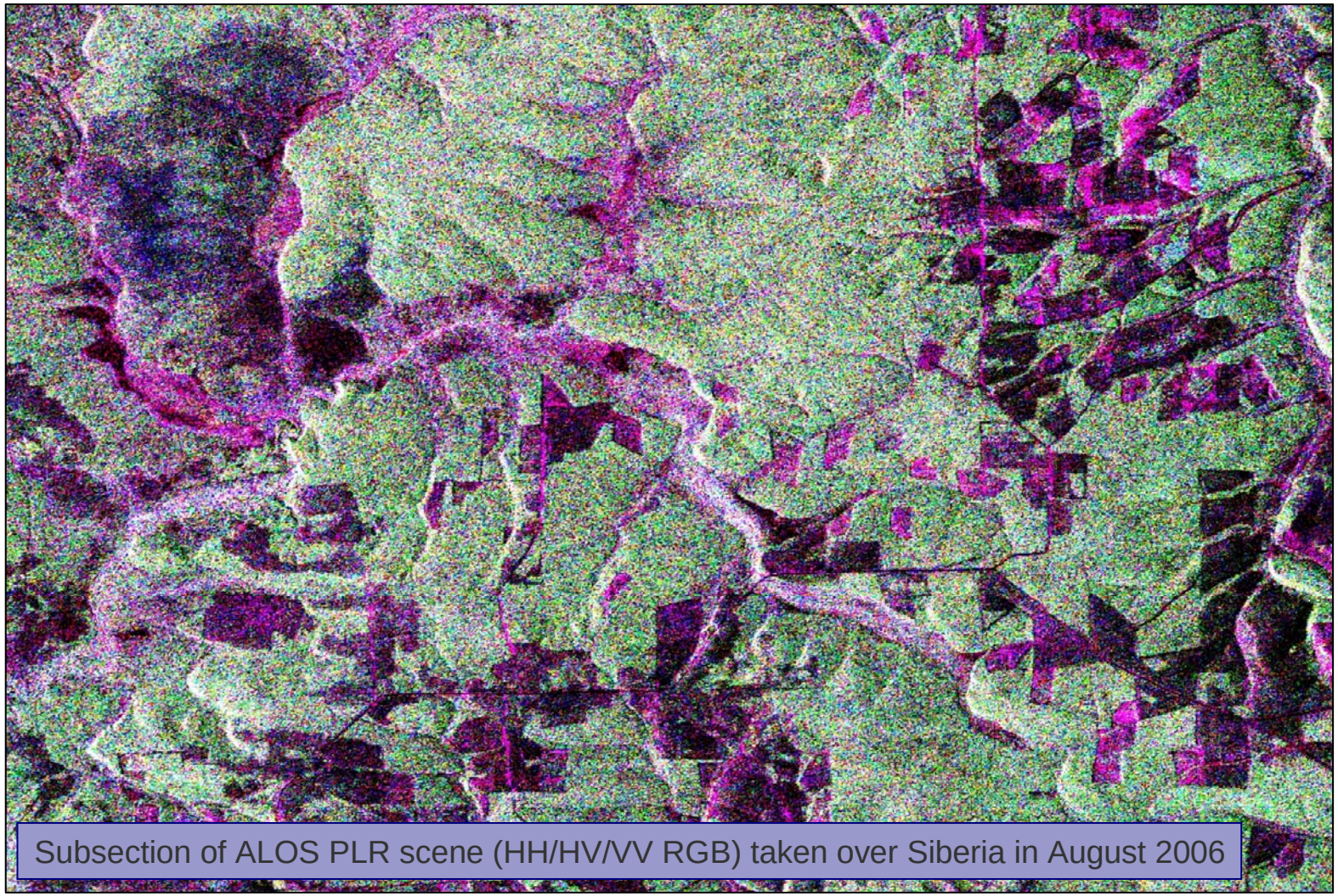
date	mode	position	separability: pixel / object	
19MAY06	FBS	54°12'N 99°94'E	**0.97**	**1.00**
19MAY06	FBS	55°59'N 99°58'E	**0.99**	**1.00**
19MAY06	FBS	56°08'N 99°46'E	**0.99**	**1.00**
14AUG06	FBS	54°12'N 101°56'E	**0.99**	**1.00**
14AUG06	FBS	54°61'N 101°44'E	**0.93**	**1.00**
27DEC06	FBS	56°84'N 104°16'E	**0.94**	**1.00**
27DEC06	FBS	57°33'N 103°99'E	**0.93**	**1.00**
13JAN07	FBS	56°83'N 103°62'E	**0.97**	**1.00**
13JAN07	FBS	56°83'N 103°62'E	**0.94**	**1.00**
11FEB07	FBS	56°84'N 104°18'E	**0.95**	**1.00**
11FEB07	FBS	57°33'N 104°02'E	**0.93**	**1.00**
28FEB07	FBS	56°84'N 103°64'E	**0.96**	**1.00**

Analysis of PALSAR data - FBS



Class signatures basing on image objects including standard deviation and min/max:
brown = clear cut (HH), green = forest (HH), X-axis labels test cases

Analysis of PALSAR data - PLR

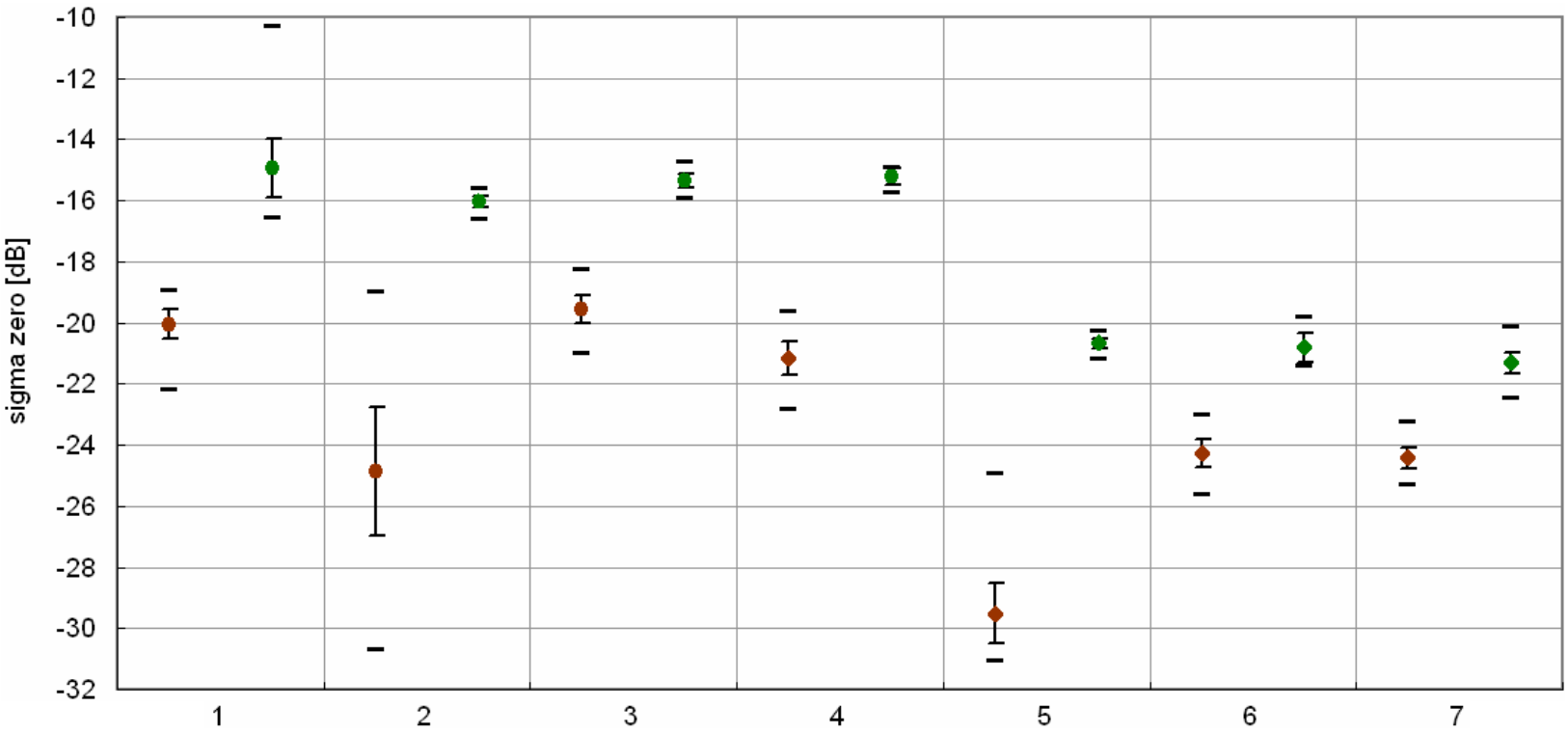


Subsection of ALOS PLR scene (HH/HV/VV RGB) taken over Siberia in August 2006

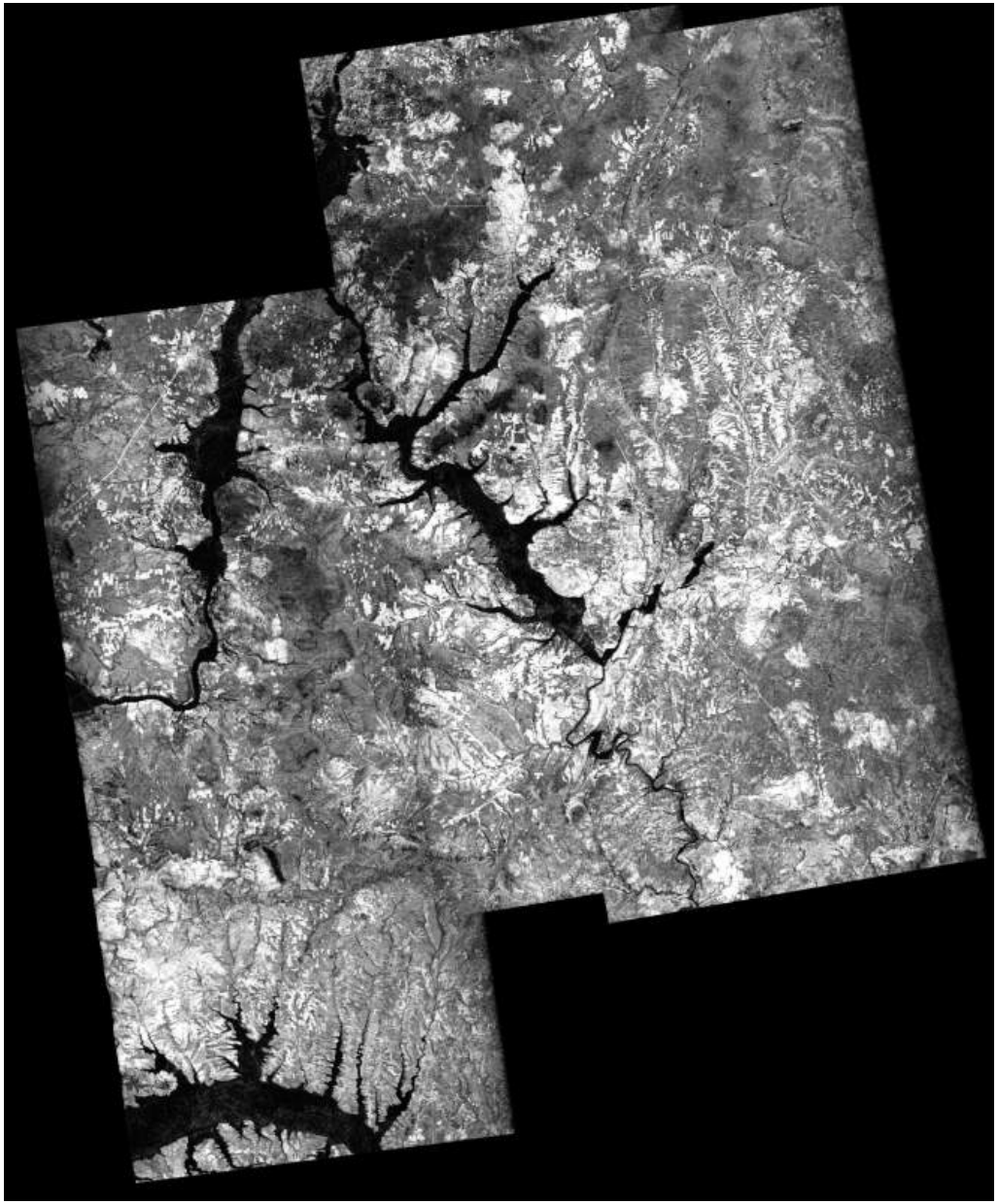
Analysis of PALSAR data - PLR

date	mode	position	separability: pixel/object	
28AUG06	PLR	56°93'N 99°96'E	**0.50 (HH)** **0.88 (HV)** **0.53 (VV)**	**1.00 (HH)** **1.00 (HV)** **1.00 (VV)**
28AUG06	PLR	57°42'N 99°78'E	**0.51 (HH)** **0.93 (HV)** **0.43 (VV)**	**1.00 (HH)** **1.00 (HV)** **1.00 (VV)**
14SEP06	PLR	56°44'N 99°63'E	**0.64 (HH)** **0.85 (HV)** **0.59 (VV)**	**0.86 (HH)** **1.00 (HV)** **0.82 (VV)**
14SEP06	PLR	54°12'N 101°56'E	**0.75 (HH)** **0.94 (HV)** **0.75 (VV)**	**1.00 (HH)** **1.00 (HV)** **1.00 (VV)**
13OCT06	PLR	57°41'N 99°75'E	**0.65 (HH)** **0.99 (HV)** **0.39 (VV)**	**1.00 (HH)** **1.00 (HV)** **1.00 (VV)**
17MAR07	PLR	56°45'N 99°67'E	**0.31 (HH)** **0.74 (HV)** **0.32 (VV)**	**0.92 (HH)** **1.00 (HV)** **0.92 (VV)**
17MAR07	PLR	57°42'N 99°25'E	**0.27 (HH)** **0.71 (HV)** **0.24 (VV)**	**0.83 (HH)** **1.00 (HV)** **0.81 (VV)**

Analysis of PALSAR data - PLR



Class signatures basing on image objects including standard deviation and min/max:
brown = clear cut (**HV**), green = forest (**HV**), X-axis labels test cases



PALSAR coherence

Mosaic of 9 coherence images

Period:

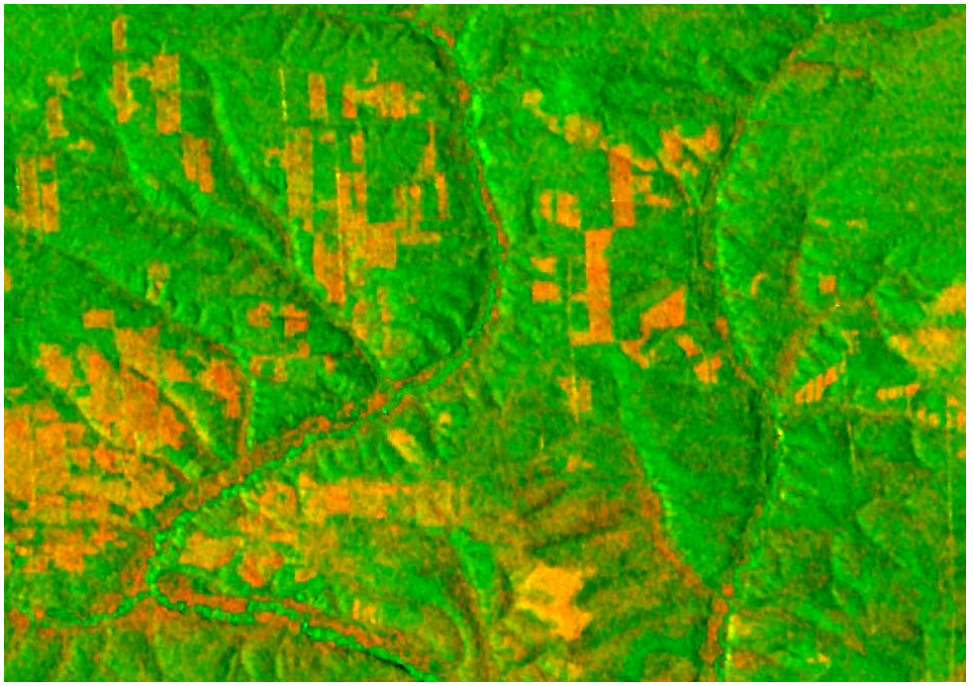
December 2006 – February 2007

Source:

Full resolution PALSAR Level 1.1 data

Analysis of PALSAR data
FBS - Coherence

Google Earth

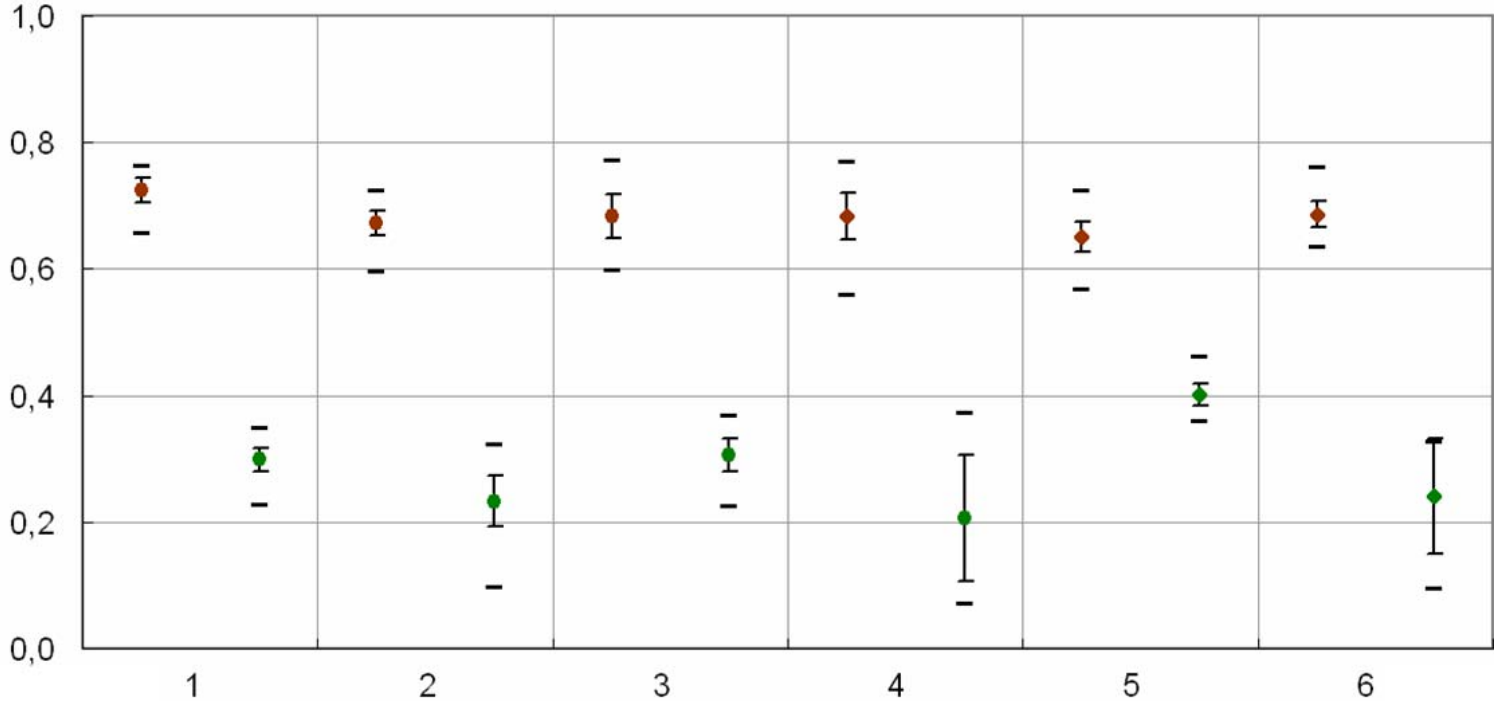


PALSAR coherence product

Analysis of PALSAR data
FBS - Coherence

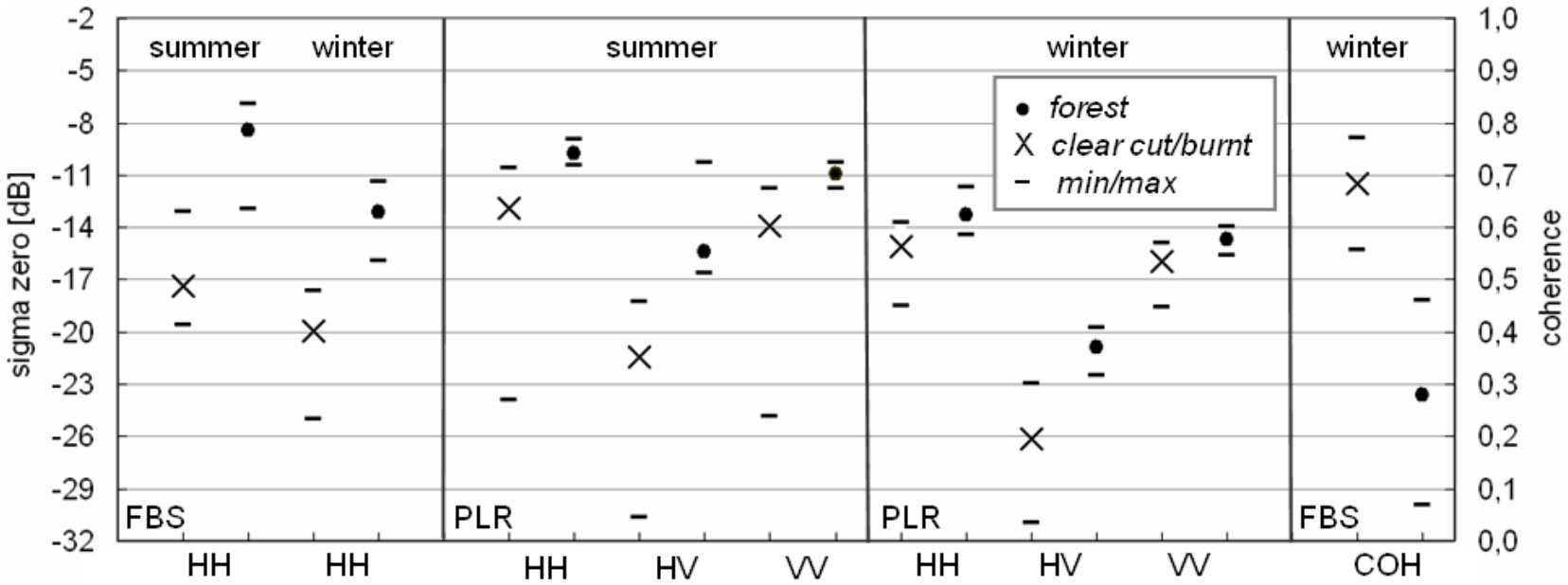
date	mode	position	separability: pixel / object	
27DEC06 11FEB07	FBS Coh.	56°84'N 104°16'E	**0.99**	**1.00**
27DEC06 11FEB07	FBS Coh.	57°33'N 103°99'E	**0.99**	**1.00**
13JAN07 28FEB07	FBS Coh.	56°84'N 103°62'E	**0.98**	**1.00**
13JAN07 28FEB07	FBS Coh.	57°33'N 103°45'E	**0.98**	**1.00**
01JAN07 16FEB07	FBS Coh.	56°35'N 102°69'E	**0.98**	**1.00**
01JAN07 16FEB07	FBS Coh.	56°84'N 102°54'E	**0.99**	**1.00**

Analysis of PALSAR data
FBS - Coherence



Class signatures basing on image objects including standard deviation and min/max: brown = clear cut (coherence), green = forest (coherence), X-axis labels test cases

Analysis of PALSAR data



Object based signatures: forest, burnt/clear-cut

- ***Summer intensity seems slightly better suited than winter intensity*** (concordant with the literature)
- Relatively ***poor separability basing on PLR intensity*** is ***owing to the higher noise and speckle effect*** and to the ***reduced resolution***
- ***Coherence data shows very good separability***

Investigated Polarimetric Parameters

1. Intensities
2. Polarimetric HHVV Coherence
3. Cloude decomposition parameters
4. Freeman decomposition parameters
5. Krogager decomposition parameters

Class signature analysis

6. Summary of separability measures

Summary of separability measures

	1 - 2	1-3	1 -4	2 - 3	2 - 4	3 – 4
σ^0 HH	0,34	0,20	0,40	0,23	0,08	0,29
σ^0 HV	0,49	0,45	**0,91**	0,07	0,69	0,74
σ^0 VV	0,32	0,13	0,41	0,32	0,11	0,42
$\lvert\rho_{HHVV}\rvert$	0,20	0,44	0,78	0,28	0,72	0,54
Alpha	0,27	0,57	**0,91**	0,38	**0,88**	0,72
Entropy	0,32	0,58	0,89	0,35	**0,88**	0,80
Pv	**0,71**	0,65	**0,99**	0,15	**0,91**	**0,95**
$\lvert kd\rvert^2$	**0,72**	**0,70**	**0,99**	0,13	**0,90**	**0,95**

1 = recent clear-cut, 2 = former clear-cut
3 = fire scar, 4 = forest

Normalised Jefferies-Matusita distance
(1.0 = signatures separable; 0.0 = signatures inseparable)

Summary of separability measures

	1 - 2	1-3	1 -4	2 - 3	2 - 4	3 – 4
σ^0 HH	0,34	0,20	0,40	0,23	0,08	0,29
σ^0 HV	0,49	0,45	**0,91**	0,07	0,69	0,74
σ^0 VV	0,32	0,13	0,41	0,32	0,11	0,42
$\lvert\rho_{HHVV}\rvert$	0,20	0,44	0,78	0,28	0,72	0,54
Alpha	0,27	0,57	**0,91**	0,38	**0,88**	0,72
Entropy	0,32	0,58	0,89	0,35	**0,88**	0,80
Pv	**0,71**	0,65	**0,99**	0,15	**0,91**	**0,95**
$\lvert kd\rvert^2$	**0,72**	**0,70**	**0,99**	0,13	**0,90**	**0,95**

1 = recent clear-cut, 2 = former clear-cut
3 = fire scar, 4 = forest

Normalised Jefferies-Matusita distance
(1.0 = signatures separable; 0.0 = signatures inseparable)

Conclusions

- This initial PALSAR data intensity analysis proves the high potential of L-band for forestry applications
- Especially the usage of winter coherence with summer intensity (cross-polarisation in particular) will allow precise forest cover mapping
- The combination of PALSAR and ASAR could extend the Service Portfolio (new products) of GSE FM
- Noise negatively affects the separability and noisier parameters will seem less suited (e.g. HHVV Coherence) → adapted study required when mapping on segment level
- SAR polarimetry offers great potential to extent the data base for forestry applications
- Strong seasonal dependency
- Summer acquisition clearly preferable for backscatter
- Some of the polarimetric parameters enable distinction of two clear-cut classes → sensitivity for forest biomass

New publications relating to ALOS

- CH. THIEL, CA. THIEL, J. REICHE, R. LEITERER & C. SCHMULLIUS (2007): Analysis of ASAR and PALSAR data for Optimising Forest Cover Mapping – A GSE Forest Monitoring Study.-In: Proceedings CD of ForestSat 2007, 05. – 07. November, Montpellier, France.
- CH. THIEL, CA. THIEL, J. REICHE, R. LEITERER, T. RIEDEL & C. SCHMULLIUS (2007): Service Portfolio Evolution – The Instrument for Keeping the Services of GSE Forest Monitoring up to Date.-In: Proceedings CD of ForestSat 2007, 05. – 07. November, Montpellier, France.
- CH. THIEL, CA. THIEL, J. REICHE, R. LEITERER, M. SANTORO & C. SCHMULLIUS (2007): Polarimetric PALSAR SAR data for forest cover mapping in Siberia.-In: Proceedings CD of First Joint PI Symposium of ALOS Data Nodes for ALOS Science Program, 19. – 23. November, Kyoto, Japan.
- M. SANTORO, C. SCHMULLIUS, O. CARTUS, C. THIEL & U. Wegmüller (2007): Observations of forest cover and forest growing stock volume in Siberia from PALSAR SAR and interferometric SAR data.-In: Proceedings CD of First Joint PI Symposium of ALOS Data Nodes for ALOS Science Program, 19. – 23. November, Kyoto, Japan.
- CH. THIEL, CA. THIEL, T. RIEDEL & C. SCHMULLIUS (2008): Object based classification of SAR data for the delineation of forest cover maps and the detection of deforestation – A viable procedure and its application in GSE Forest Monitoring. In: T. Blaschke, S. Lang & G. Hay [Eds.], Object-Based Image Analysis - Spatial concepts for knowledge-driven remote sensing applications, pp. NN. (in print)