EC ENVIRONMENT AND CLIMATE PROGRAMM

THEME 3: SPACE TECHNIQUES APPLIED TO ENVIRONMENTAL MONITORING

AREA 3.3: CENTER FOR EARTH OBSERVATION

1st Progress Report

SIBERIA

SAR IMAGING FOR BOREAL ECOLOGY AND RADAR INTERFEROMETRY APPLICATIONS

February 1999

List of Partners:

Country	DE	FR	UK	FI	SE	AT	RU	CH
Teams	2	1	3	1	1	1	3	1

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Abbreviations

CEO	Centre for Earth Observation
CESBIO	Centre d´Etudes Spatiales de la Biosphere
DEM	Digital Elevation Model
DLR-DFD	Deutsches Zentrum für Luft- und Raunfahrt, Deutsches Fernerkundungsdaten-zentrum
DLR-HF	Deutsches Zentrum für Luft- und Raunfahrt, Institut für Hochfrequenztechnik
EC	European Commission
ERS	European Remote Sensing Satellite
GAMMA	Gamma Remote Sensing Research and Consulting AG
GEC	Geocoded Ellipsoid Corrected Image
GIM	Geocoded Incidence Angle Mask
GIS	Geographical Information Systems
GTC	Geocoded Terrain Corrected Image
IIASA	International Institute for Applied System Analysis
JERS	Japanese Earth Resources Satellite
NASDA	National Space Development Agency of Japan
NERC	Natural Environment Research Council
PRI	SAR Precision Image
SAR	Synthetic Aperture Radar
SCEOS	Sheffied Center for Earth Observation Science
SFA	State Forest Account (Russian forest inventory system)
SIBERIA	CEO Project "SAR Imaging for Boreal Ecology and Radar Interferometry Applications"
SLCI	SAR Single Look Complex Image
SSC	Swedish Space Corporation
UWS	University of Wales, Swansea
VTT	VTT Technical Research Centre
WP	Work package

EXECUTIVE SUMMARY

This report describes the progress made and the problems encountered in the first six months of the SIBERIA project (August 1998 to January 1999). The aim of SIBERIA is to generate valuable information about the state of Siberian forests for dedicated Russian customers based on state-of-the-art satellite data and remote sensing techniques. More specifically, the objectives are 1) to demonstrate the capabilities of microwave remote sensing for monitoring criteria and indicators for sustainable development, and 2) for retrieving information needed for reliable estimations of economic, ecological and social roles of Russian forests under transition conditions.

Direct interaction with potential customers of such information is given through the participation of IIASA and institutions from the Russian forestry sector in the project. Within the project, the tasks of IIASA and its Russian partners are the definition of the structure and content of the foreseen forest data base, and the establishment of a reference in-situ data base. The collection and compilation of the reference data is underway.

SIBERIA uses the advantages of dual-frequency, interferometric, and multi-temporal SAR products from the ERS and JERS missions. Thanks to a recent international effort, that ensured the systematic acquisition of ERS and JERS imagery plus ERS-Tandem images over Siberia, these data became available. Despite of the principal availability of ERS and JERS data, the delivery of SAR products to the Methodological Team has been retarded. In case of ERS, the problem has been that good-quality reference topographic maps are needed for the generation of digital elevation models (DEMs) and terrain-corrected SAR products. These maps were more difficult to obtain than expected and became available in January 1999. In case of JERS, NASDA has technical problems reading the JERS raw data which were recorded at the mobile receiving station in Mongolia. Therefore the JERS-1 spring 1998 data (which would be the best data set for SIBERIA) could not yet have been made available to the team. The team is still seeking for a solution to this problem. As a backup solution, archived JERS data have been ordered.

The limited data availability has hampered methodological development and has caused a delay of approximately three months. Nevertheless, preparatory work and first tests based on sample imagery from two regions (Ust-Ilimsk and Krasnojarsk) have been performed. It is, however, too early to draw conclusions.

With respect to organisational matters, the drop-out of one partner of the original consortium, Infocarto (Spain), has caused a delay in the finalisation of contractual matters with the EC. In December 1998 SSC Satellitbild (Sweden) took over the responsibilities of Infocarto. Despite this has caused administrative problems for some partners, it posed no threat to the overall project objectives and planning. All partners were able to approve the recruitment of new staff, or to assign permanent staff members to SIBERIA before the contract was signed.

Good communication and progress monitoring is secured mainly by regular e-mail contacts and the monthly progress reports. Also the web sites established by IIASA and UWS have proven to be efficient tools to support the exchange of information and data. Two meetings have been held so far: the kick-off meeting in Laxenburg, Austria, August 10-11, 1998, and the first progress meeting in Toulouse, France, December 14-15, 1998. The next meeting will be held in Swansea, Wales, April 19-20, 1999.

SUMMARY REPORT

1. Introduction

This report describes the progress made and the problems encountered in the first six months of the SIBERIA project. The aim of SIBERIA is to generate valuable information about the state of Siberian forests for dedicated Russian customers based on state-of-the-art satellite data and remote sensing techniques.

The one major source of information concerning all Russian forests is the State Forest Account (SFA), which is an accounting inventory based on field observations, aerotaxation, and satellite remote sensing. Even if the Russian inventory system is better than in many other countries, it is not able to monitor the criteria and indicators for sustainable development of forests introduced by the Russian Federal Forest Service. Also, it does not support the information needed for reliable estimations of economic, ecological and social roles of Russian forests under transition conditions.

The approach of SIBERIA is to identify the customer’s key problems and policy issues and then to develop a remote sensing technology based on these demands in order to achieve a real implementation and service to the policy settings. In this process the constraints of current operational satellite systems have to be clearly identified and addressed.

SIBERIA uses the advantages of the availability of dual-frequency, interferometric, and multi-temporal SAR products from the ERS and JERS missions. These data became available thanks to a recent international effort that ensured the systematic acquisition of ERS and JERS imagery plus ERS-Tandem images over Siberia.

2. Customer Needs

Transition of the world's forest management to sustainable development requires significant improvement of information currently available describing the forest resources. The creation of an Integrated Information System for Russia to meet these needs is proposed. This system would provide information that is highly accurate, operational, comprehensive, inexpensive and suitable for sustainable forest management. The information utilised by this system would include field-based measurements, existing inventory data, aerial photos and data from passive and active satellite sensors.

Remote sensing methods used in an Integrated Information System, designed in a holistic way, can be decisive in achieving sustainable development of the Russian Forest Sector. Remote sensing can be applied to forest inventory and monitoring, planning and control of management and assessing the state and dynamics of forest resources, ecosystems and natural landscapes.

The Russian forestry needs the following information about the forest measured:

- Forest composition
- Tree species & non-forest communities’ structure
- Disturbances, forest age, etc.
- Biomass
- Productivity (primary)

The Russian forestry and IIASA have two main expectations from the SIBERIA project: methods of how to use SAR data to provide the needed information and knowledge of the capabilities of SAR gained from general results in the test areas.

3. Administrative Issues (WP 1000)

3.1. Change of Consortium

The project started officially August 1, 1998. Unfortunately, one industrial partner of the original consortium, Infocarto, was not able to sign their contracts with the EC, which did not allow the finalisation of contractual matters between the consortium and the EC. Since a solution to this problem was not in sight even after four months after the start of the project, it was decided to search for a new partner. Three potential partners were identified, and after consultations with all partners from the consortium, SSC Satellitbild was chosen.

3.2. Financial Status

The delay in guarantee of funding due to the drop out of Infocarto caused considerable administrative difficulties for many partners. Only in December 1998, the final contract was signed, and the first rate of payments was received by the project co-ordinator on January 10, 1999. In the meantime all partners have received the first rate.

3.3. Personnel

Despite the delay in the finalisation of contractual matters, all partners were able to approve the recruitment of new staff or to assign permanent staff members to SIBERIA before the signature of the contract. However, a number of personnel started working on SIBERIA only a few months after the start of the project. Table 3-1 shows the list of appointed personnel.

Partner	Personnel	Position	Starting Month
DLR-HF	Andrea Holz	Ph.D. student (full time)	August 1998
	Jan Vietmeier	Ph.D. student (full time)	August 1998
	Wolfgang Wagner	Scientific assistant (3/4)	January 1999
DLR-DFD	Ursula Marschalk	Staff (1/2)	August 1998
	Nico Adam	Staff (1/2)	January 1999
IIASA	Anatoly Shvidenko	Professor, Staff	August 1998
	Alf Oeskog	Staff	August 1998
	Michael Gluck	Scientific assistant (full)	August 1998
CESBIO	Malcolm Davidson	Scientific assistant (1/2)	October 1998
	Didier Dendal	Scientifc assistand (1/2)	October 1998
SCEOS	Jiong Jiong Yu	Ph.D. student (full time)	August 1998
UWS	Kevin Tansey	Senior research assistant	October 1998
NERC	Heiko Balzter	Scientific assistant (full)	August 1998
VTT	Toumas Häme	Staff	Aug-Dec 1998
	Yrjo Rauste	Staff	January 1999
Gamma	Tazzio Strozzi	Scientific assistant (full)	August 1998
	Andreas Wiesmann	Staff	December 1998

Table 3-1: List of personnel appointed for the SIBERIA project. The list does not include the Principal Investigator at the consortium partners. The numbers in the brackets in the third column show how much of their time the personnel works on SIBERIA.

3.4. Meetings

3.4.1 Kick-off Meeting

The kick-off meeting was hosted by IIASA and was held in Laxenburg, 10-11 August, 1998. All partners of the consortium and representatives of the EC (DG 12D, JRC-CEO) participated in the meeting. From the Russia customer side Dr. Rozhkov from the V. V. Dokuchjaev Soil Institute, Dr. Skudin from the East Siberian State Forest Inventory and Planning Institute, Dr. Sokolov from the V. N. Sukachev Institute of Forest of the Russian Acadamy of Sciences, and Dr. Vachtchouk from the Irkutsk Forestry Board were able to attend.

Besides presentations of all partners and discussions on technical points the meeting included:

1. a Radar Short Course (WP 1400) on radar remote sensing and digital image processing techniques for the customers, to supply them with the necessary background for the lay-out of their classification requirements.
2. a Presentation of Customer Requirements (WP 4100 and 4400) that included a description of the current Russian inventory system, the forest data base, and potential problems in the future.

The presented material and hand-outs were collected and printed as a workshop report. Copies were distributed to all partners, the Russian customers, and the EC.

3.4.2 First Progress Meeting

The first progress meeting was hosted by CESBIO and was held in Toulouse, 14-15 December, 1998. The following major team decisions were made:

1. The methodology hand-over is postponed, due to bad data situation. This will probably cause a three months delay of the project end.
2. Team cannot longer wait for solution on availability of JERS-1 data acquired during spring 1998 in Ulaanbaatar (although team agrees, that this would be best data set for SIBERIA). Gamma will start to order JERS archived data of ground-truth sites. Where satisfactory baselines are available, archived repeat-pass pairs will be ordered.
3. Gamma JERS-Products: full resolution products for ground-truth sites, other project area 50m-products.
4. 20-look coherence maps will also be included in analysis, in addition to 64-look map.
5. Team agrees on motto: quality over quantity! IIASA prefers good test area results rather than large-area map of lesser quality. Consequence for DLR-DFD: GTC processing emphasised - takes time!
6. IIASA performs geo-coding of GIS vector data to UTM coordinates.
7. Additional Methodology Meeting in March/April in Swansea, UK.

Based on the analysis at CESBIO and followed by checks at DLR of the ERS interferometric products, major improvements were undertaken in the algorithms for the interferometric processing chain. The DLR-DFD interferometric processor is now adequately adopted to SIBERIA's special requirements.

3.4.3 Next Meetings

The next meeting of the methodological team is being prepared by UWS, and is scheduled for the second week of April. This meeting was not planned originally, but became necessary because of the delay in the availability of the SAR data.

The mid-term meeting will be held in Siberia, organised by IIASA and their Russian associates. A field survey will be organised to demonstrate the techniques used to collect the forest database and to acquaint the consortium with the geographic characteristics of the area. The meeting is planned for the period May 30 – June 12, 1999.

4. Communication and Web Sites

Good communication, progress monitoring, and data transfer is secured by following means:

1. Regular e-mail contact between all partners. E-mail distribution lists for the entire SIBERIA team and the methodological development group exist.
2. Monthly progress reports of the methodological team. The individual monthly partner reports are collected by SCEOS who write and distribute a summary monthly report.
3. Currently UWS (WP 5050) and IIASA (WP 4000) are maintaining web sites. In the near future also DLR-HF will establish a Main SIBERIA Web Site (WP 7300) and will update the EC project webpage at EWSE/ES (WP 1300):

   UWS: http://sunset.swan.ac.uk/siberia/

   IIASA: http://www.iiasa.ac.at/Research/FOR/siberia/index.html

   EWSE/ES: http://ewse.ceo.org/anonymous/construct/build.pl/689503
4. FTP Servers at UWS, DLR-DFD, and IIASA.
5. Regular phone calls.

5. Data Acquisition and Processing Status

5.1. ERS SAR (WP 2000)

About 250 SAR Single Look Complex Image (SLCI) scenes have been ordered from ESA and, to a large extent, received. In general, an autumn 1997 tandem pair and a spring 1998 scene are available.

SAR interferometric processing has been started at DLR-DFD according to a priority list that has been established by the methodological team. The DLR-DFD interferometric SAR processing chain was modified regarding three functionalities:

- The consideration of a third data set (co-registration of spring data);
- The improvement of the fine registration results for low coherent data;
- The improvement of the coherence estimation.

Where interferometric coherence allows, DLR-DFD produces geocoded terrain corrected (GTC) co-registered imagery: amplitude images of the two autumn 1997 and spring 1998 scenes, one coherence image, the digital elevation model (DEM), and a geocoded incidence angle mask (GIM). When low coherence does not allow the generation of a DEM then the data sets are processed to geocoded ellipsoid corrected products (GECs).

So far, 23 tandem pairs including the corresponding spring data sets were processed. Only three scenes could be further processed to GTC products.

The interferometric derivation of DEMs requires the improvement of the imaging parameters with an adjustment method based on tie-point information. Such tie-points can be derived from topographic maps, which, unfortunately, have been difficult to obtain for Siberia. DLR-DFD received colour copies of such topographic maps on January 18, 1998. This late availability has caused a delay in SAR product delivery to the methodological team members of approximately three months.

The generated amplitude images still need to be calibrated, which can be done with the public domain program "calit" developed by DLR-DFD. The tool was modified by DLR-DFD to support the output of the interferometric processing, and thoroughly tested by DLR-DFD itself and the methodological team members.

5.2. JERS SAR (WP 3000)

Despite JERS has acquired full coverages of Siberia in 1998, it not yet been possible to make these data available to the SIBERIA project. The problem is that NASDA, who have promised to carry out the SAR processing, have had technical problems reading the storage media at which the JERS raw data were stored at the mobile receiving station in Mongolia. On the other hand, at DLR-DFD these data could be read and processed, but no budget has been foreseen for this task.

Because the 1998 JERS data were unavailable it was decided at the progress meeting in Toulouse to order additional JERS data from previous years. This may cause problems in the comparison of the classified SAR scenes and the in-situ forest inventory. A list of ordered JERS SAR scenes can be found in the individual progress report of GAMMA.

So far only data of 2 JERS orbits of the same track over Bratsk have been available. SAR processing of the corresponding 17 JERS raw data frames was completed. Unfortunately, the track separation of the two orbits is around 8 km and therefore the data are not appropriate for interferometric processing.

6. Classification Requirements and Ground Truth (WP 4000)

Based on a review of criteria for indicators for Sustainable Forest Management by the Federal Forest Service of Russia, current forest inventory manuals, and accuracy assessment criteria, IIASA has defined the structure and content of the up-to-date forest data base to be created. It is suggested to use the land cover / land use categories currently in use in the Russian forest inventory as targets for forest variables to be measured (Table 6-1).

Forest Lands	Non-Forest Lands
forested areas*	arable lands
plantations (unclosed)	hayfields
nursery & seed orchards	pastures
natural sparse forest	water reservoirs
unforested areas	roads, kvartal boundaries
burns	urban
dead stands	bogs
cut areas	sand
grassy glades	glaciers
	rocks, steep slopes

*Table 6-1: Current land cover / land use categories from Russian forest inventory (excluding forested areas. *See Figure 6-1 for forested area classification.*

Characteristics of forest areas can be organised hierarchically, however, this organisation should not be considered constraint on the classification process (i.e. classification can start at any level of this hierarchy). If all levels of this classification were identified then there would be 60 boxes.

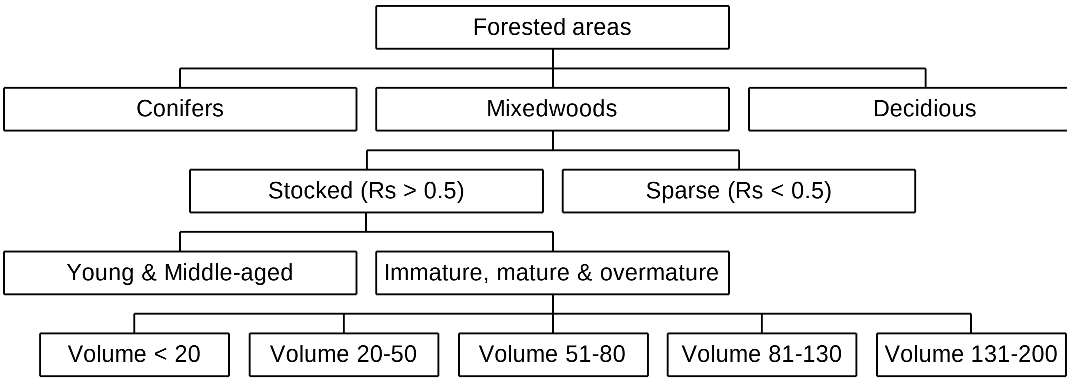

Figure 6-1: Proposed forest area classification possibilities. Forested area is organised (top to bottom) by species composition, stocking (Rs = relative stocking), age and volume.

IIASA and its Russian partners have also selected test site locations, and reference data selection and compilation is under way.

The basic principles used in selecting areas with ground reference information were that there should be 4 to 7 test territories ranging from 300,000 ha to 1,500,000 ha each, containing 20 to 35 key test areas 20,000 ha to 100,000 ha each. The Test territories were chosen subjectively to represent:

- specific zonal regularity of forests & vegetation
- impact of macro-relief (mountains)
- impact of human transformation of vegetation

Test areas were chosen to represent:

- landscape diversity
- basic-land-use categories
- main forest association
- diversity of human impact
- forest diversity (productivity, stocking, etc.)

So far, reference data for twelve test areas for three test territories have been produced in ArcInfo format. The data are available on request for the Project partners and on the Internet site http://www.iiasa.ac.at/Research/FOR/siberia.

7. Methodological Development (WP 5000)

The development of methodological tools for forest classification and extraction of relevant information for the Russian State Forest Account is the critical technical issue in this project. Methodological development is carried out by the “methodology team” DLR-HF, CESBIO, SCEOS, UWS, NERC, and VTT. Three test sites have been selected on the basis of importance to the customers and upon availability of ground truth information. The work of the methodology team is co-ordinated by SCEOS who review the progress on a monthly basis.

So far, methodological questions have been investigated based on sample imagery. For the Ust-Ilimsk study area GEC products from ERS and JERS became available end of November/beginning of December. For the Kasnoyarsk study area GTC products from ERS could be produced because a map had been available at DLR-HF. The limited data availability has hampered methodological development, but preparatory work and first tests have been performed.

Because of the large area of interest, the large number of consortium partners, and the many possible combinations of hard- and software in use at the various partners, it is necessary to define common methods and strategies to secure compatibility and comparability of the work done at the various partners. It is the objective of work packages 5010 to 5050 to define common methods on various aspects:

- SAR Geometry, DLR-HF (WP 5010)
- Information Content, CESBIO (WP 5020)
- Pre-processing and Classification, SCEOS (WP 5030)
- Accuracy Assessment, NERC (WP 5040)
- Computational Issues, UWS (WP 5050)

7.1. SAR Geometry (WP 5010)

Because of the side-looking geometry of SAR systems, topographic correction methods are important for calibration, classification, and co-registration. A prerequisite for topographic correction is the availability of a DEM that will be produced in all areas where the coherence of the tandem pairs allows doing so.

The measure of evaluation of the information content of a SAR-intensity image is the backscattering cross section per area unit or backscattering coefficient s^0. To calculate s^0 using the intensity values of an intensity image one must take into account SAR sensor characteristics and the size of the illuminated surface area for each pixel. The size of the illuminated area changes in dependence of the inclination of the surface relative to the look direction of the sensor (actual incidence angle). If topographic information is available then the calculation of s^0 corrected for the local topography is possible. Otherwise only an incidence angle for a flat area can be used. Additional problem caused by topography are layover and shadow, the extreme cases for the change of the size of the illuminated area of each pixel for which the received information is unusable for evaluation. It is desirable to solve these problems also within the calibration process.

For the calibration of the SAR imagery it was decided during the kick-off meeting in Laxenburg that each partner carries out the calibration himself. As a standard software the calibration program “calit“ developed by DLR-DFD has been adopted and tested by the Team. The program “calit” is designed to handle PRI products as well as SLC products. Additionally, DLR-DFD altered the program to calibrate already geometric corrected intensity images. Besides the sensor specific radiometric corrections for intensity SAR images “calit” is able to carry out the radiometric correction using the actual incidence angle. The actual incidence angle is stored in an image file called geocoded incidence angle mask (GIM), which can be generated from a digital elevation model (DEM). Therefore we have to generate a GIM based on the DEM, if available. As a suggestion to solve the problem a c-program “inci” has been written by Mr. Jan Vietmeier of DLR-HF to generate a GIM in the appropriate format (Figure 7-1). The program calculates separately for each image pixel the incidence angle dependent on the satellite and pixel position and the incidence angle dependent on the topography. The program adds both angles, compares the result with a threshold for layover and writes the result including the layover information to the GIM file. The occurrence of shadow is very seldom due to the look angle of ERS. So it has been neglected for our purposes. The program “inci” has still to be tested and compared with other methods, to reach a decision on which method for GIM generation will be used by the team.

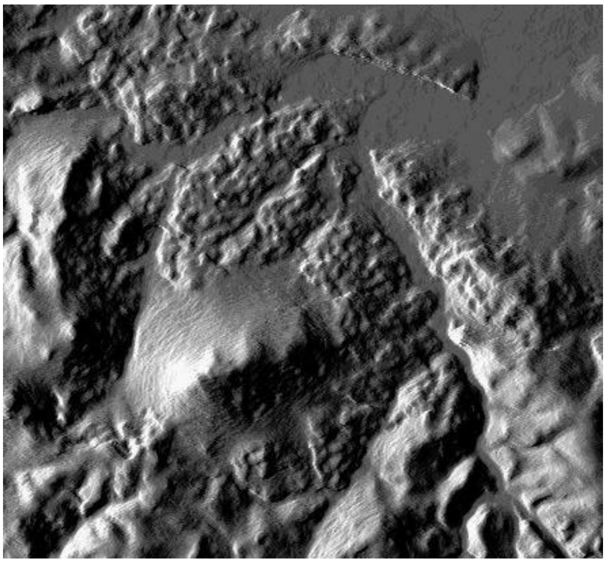

Figure 7-1: Geocoded Incidence angle mask (GIM).

7.2. Information Content (WP 5020)

A preliminary analysis of the information content has been carried out based on the sample data from Ust-Ilimsk and Kasnoyarsk. For example, Figure 7-2 shows a comparison of the forest map of the Ust-Ilimsk Forestry Enterprise with a coherence map from ERS produced with the interferometric processor of CESBIO.

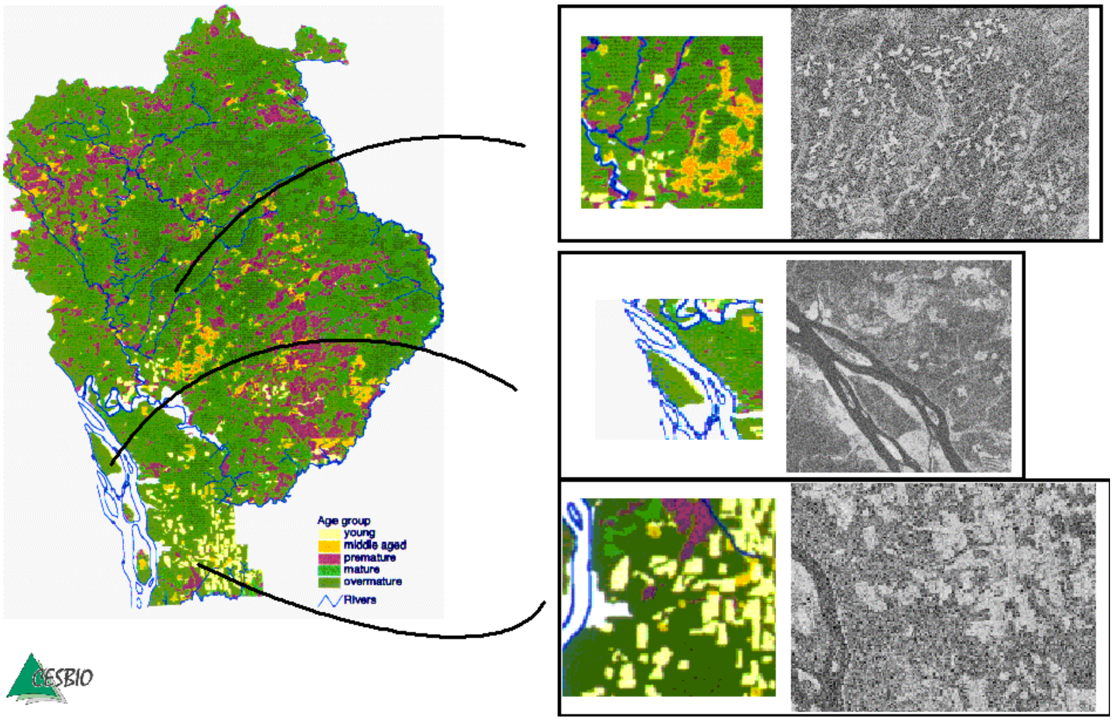

Figure 7-2: Illustration of the correspondence between land-use categories found in the Ust-Ilimsk Forestry Enterprise map and ERS interferometric coherence. The young forest stands are characterised by a high coherence (bottom right) whereas the coherence of mature forest stands is low (see island in middle right image). Finally, what are presumed to be newly-cut forest stands are visible in the upper right coherence image but not in the map, highlighting at the same time the need for updated maps in the validation of classification results as well as the potential of ERS coherence information to help in such task.

It is too early to come to conclusions, but a number of observations were made:

- Despite some differences exist, a consistency between SAR data and already available reference maps could be observed. The highest information content was so far found in the L-band amplitude images of JERS and the C-band ERS coherence images.
- Some of the differences were attributed to new clearcuts that were visible in the SAR images of 1997/98 but not in the reference maps. This demonstrated the need for up-to-date ground data as a prerequisite for methodological development and accuracy assessment.
- Differences in the coherence values computed with interferometric SAR software packages of DLR-DFD and CESBIO were observed. Further checking of the processing chains is required.

7.3. Pre-processing and Classification (WP 5030)

SCEOS has carried out a survey of filtering and classification methods available to the SIBERIA team. Preliminary suggestions have been made, but results of the data analysis should be awaited, and the transferability of the methods needs to be clarified. Not all the desired methods are immediately available to the team. At the moment SCEOS is preparing a discussion note for general consideration on filtering and classification.

SCEOS has also been actively involved in testing the “calit” software for the calibration of SAR amplitude images, and has investigated the suitability of fuccy c-mean clustering algorithms and appropriate multi-channel speckle reducing filters.

7.4. Accuracy Assessment (WP 5040)

NERC is responsible for the definition of common methods to assess the accuracy of the classification methods. NERC has performed an extensive literature review and has defined the minimum requirements for an accuracy report:

- Geometric accuracy: standard deviation in x and y directions during co-registration;
- Classification accuracy: coefficient of agreement (CA) for training areas to assess their quality;
- Map accuracy: Co-occurrence map, class specific errors of commission and omission, overall accuracy and CA between classification and ground data (up-to-date GIS database).

Software was written to estimate the *a priori* and the *a posteriori* coefficients of agreement t and k, and the respective 95 % confidence intervals. Another software programme was completed to compare these coefficients of agreement. The software is available in *C* and has been used to test the accuracy of first supervised classification results in the Usk-Ilimsk test area.

7.5. Computational Issues (WP 5050)

Since the many possible combinations of hard- and software may impair the transfer of algorithms and data between the consortium partners, UWS has evaluated the available systems. The found that, concerning hardware, access to UNIX and PC systems is universally guaranteed.

Concerning software, the range of applications is diverse which will require monitoring of the data products. This will include for example the testing of the compatibility of SAR processing steps that are carried out using different software applications, or the recommendation of common software for the co-registration of ERS and JERS GEC products. So far, software tools for specific algorithms have not been addressed, because of the delay in data delivery and the consequent delay in methodological development.

E-mail distribution lists, web pages, and FTP servers for data, software, and document transfers have been established.

8. Work Packages and Deliverables

Different types of progress monitoring tools for the Work Packages have been defined for this project:

1. external reports and comments to the EC,
2. internal deliverables (intermediate reports, data products, methodological tools),
3. internal milestones (conclusion of a WP, which is essential for the project's progress),
4. external deliverables for third parties.

The following deliverables were due in the reporting period August 1998 – January 1999 and are contained in the hand-out material of the kick-off and 1. Progress meeting.

In addition to the Deliverables contained in the Meeting Reports, monthly progress reports have been delivered to the Methodology Coordinator at SCEOS. They are summarised in Chapter 7.

8.1. Internal Deliverables

Item #	**Title**	**Work Packages**	**Due Date**
	Deliverables		
1	2-monthly Processing Prioritisation (1.1 - 1.10)	1150	T0-T19
2	Classification Requirements I	4100	Kick-off
3	Test Site Locations	4200	Kick-off
4	Co-Registration Procedure I	5010	Kick-off
5	Computational Issues I	5050, 5150, 5250, 5350	Kick-off
6	Reference Data I (Assessment)	4300, 5040	Kick-off
7	Contribution to Customer Workshop	5010-5050	Kick-off
8	Co-Registration Procedure II	5010	T3
9	Computational Issues II	5050, 5150, 5250, 5350	T3
10	Filtering Requirements and Methodology	5030	T3
11	Processing Status I	2100-2200, 3100-3200	T5/6
12	Classification Requirements II	4100	T5/6
13	Reference Data II	4300	T5/6
14	Co-Registration Procedure III	5010	T5/6
15	Quantification of Image Info I	5020, 5120, 5220, 5320	T5/6
16	Classification Methodology I	5030, 5130, 5230, 5330, 4200, 4300	T5/6
17	Accuracy Assessment Methods I	5040, 5140, 5240, 5340, 4200, 4300	T5/6
20	Computational Issues III	5010-5050, 5150, 5250, 5350	T5/6
Work Shop	Customer Support	1400	T0

Table 8-1: Deliverables and Milestones.

8.2. External deliverables for EC

Item	#	Title	Work Packages Involved	Due Date
Reports	1	1st Progress	1100, 1150, 1400, 2100, 2200, 3100, 3200, 4100, 4200, 4300, 5000-5050, 5110-5130, 5140, 5210-5230, 5240, 5310-5330, 5340	T0 + 6
Deliverable	31	Customer Requirements Baseline Doc.	4100	Kick-off Meeting

Table 8-2: Reports to EC.

8.3. External deliverables for Third Parties

Deliverable #	Title	Work Packages	Due Date	Responsible Partner
34	EWSE Advertisement	1300	T1	DLR - HF

Table 8-3: External deliverables (for further details see WP description).

The ***Customer Requirement Documents*** are contained in
Deliverables 2 and 12: Classification Requirements I and II,
Deliverables 3: Test Site Locations,
Deliverables 17, 25 and 28: Accuracy Assessment I, II and III,
Milestone 1: Forest Database Structure,
Milestone 7: Classification Methodology Revised,
Milestone 13: Cost Efficiency Evaluated, and
Milestone 15: GIS Map Implementation.

The ***Technology Implementation Plan*** consists of
Deliverables 4, 8 and 14: Co-Registration Procedure I, II, III and Milestone 2: Co-Registration Strategy;
Deliverables 5, 9, and 20: Computational Issues I, II, and III;
Deliverables 16 and 26: Classification Methodology I and II, Milestone 7: Classification Methodology Revised and Major Milestone 1: Methodology Synthesis; and
Deliverables 17, 25 and 28: Accuracy Assessment I, II and III, and Major Milestone 2: Map Assessment.

9. Encountered Problems

Three main problems have been encountered in the first phase of the SIBERIA project:

- The **change of the consortium** has caused a delay in the finalisation of contractual matters, and consequently has created administrative and financial problems for most partners. This problem is solved now.
- **Late availability of topographic maps**: For the production of DEMs from ERS tandem pairs, and consequently for the generation of GTC products, reference topographic maps are needed. Unfortunately, maps of sufficient quality have been difficult to obtain. Thanks to IIASA's good connections, maps for the entire study area were delivered in January directly from Russia. Despite the fact that the maps are colour copies of the originals which can result in large displacements, it was decided to use these maps as base for the DEM and GTC production because the late availability of data has already created problems for the methodology team.

- **Ordering of JERS SAR Scenes**: Despite considerable effort, it has not been possible to obtain JERS SAR scenes from 1998, acquired at the DLR mobile receiving station in Mongolia. Because the methodological team has an urgent need for JERS data over the main test areas, historical JERS scenes from the NASDA archives have been ordered as backup solution. The first interferometric JERS scenes are expected to become available to the methodological team in the middle of February.

The problems have created a delay of approximately three months. This will mainly influence the start of the hand-over period for the operational classification methodology to SSC. This delay causes no threat to the overall project objectives and planning.

10. Outlook

Since the delivery of interferometric ERS products has started successfully (but delayed) in January 1999 and the throughput at DLR-DFD is fast (3-5 frames per week), the prerequisites for the methodological team to catch up with the delayed analysis are promising.

An additional Methodology Team Meeting has been decided to take place at UWS on April 19-20, 1999. This meeting is necessary due to the delay of data delivery described above. It will contain a continuation of the discussions about the methodological Work Packages, started during the Toulouse Meeting.

11. Publications

The following two papers contain preliminary results and have been published in conference proceedings:

SIBERIA - First ERS Tandem Results from the IGBP Boreal Forest Transect, C. Schmullius, A. Holz, R. Zimmermann, IGARSS 98, Proceedings Vol. IV, S. 1815-1817.

Poster SIBERIA, Workshop „Retrieval of Bio- and Geophysical Parameters“, ESTEC, Noordwijk, 20.-22.10.98, http://www.estec.esa.nl/CONFANNOUN/98c07/

ANNEX

INDIVIDUAL PARTNER REPORTS

12. Institut für Hochfrequenztechnik (DLR-HF)

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Personnel: Mrs. Andrea Holz, Mr. Jan Vietmeier, Dr. Wolfgang Wagner

12.1. Objective

The tasks of DLR-HF are:

- Project Co-ordination, CEO and Customer Support (WP 1000);
- SAR Geometry: Evaluate topographic correction mechanisms for calibration and classification and suggest ERS and JERS co-registration approach (WP 5010);
- Analysis and Validation at IGBP Transect (WP 5100);
- WWW-Documentation and satellite image database (WP 7300).

Work on the first three tasks has been continuously performed and is reported below. An overview of SIBERIA was implemented at EWSE/ES:

ULR: http://ewse.ceo.org/anonymous/construct/build.pl/689503.

12.2. Administrative Issues

12.2.1 Personnel

Two Ph.D. students, Mrs. Andrea Holz and Mr. Jan Vietmeier, have been working on SIBERIA since the start of the project in August 1998. Funding for Mr. Vietmeier is guaranteed for a period of two years (with a possible third year extension). The current grant of Mrs. Andrea Holz will expire 30.11.1999.

Dr. Wolfgang Wagner has been appointed on a ¾ contract extending from 01.01.1999 to 31.07.2000. His main task is to support Dr. Christiane Schmullius in the co-ordination of the project.

12.2.2 Meetings

The kick-off meeting in Laxenburg was attended by Dr. Christiane Schmullius, Dr. Wolfgang Wagner, and Mr. Jan Vietmeier. Dr. Christiane Schmullius, Mr. Jan Vietmeier, and Mrs. Andrea Holz participated in the first progress meeting in Toulouse.

12.2.3 Monthly Progress Reports

Monthly reports on the methodological progress have been submitted to SCEOS.

12.3. Project Co-ordination (WP 1000)

Due to major difficulties considerable effort has been put in project management. As detailed in the summary report, following urgent problems had to be tackled:

- Finding a substitute for Infocarto, as soon as it became clear that Infocarto would not be able to sign the contracts with the EC;
- Finding of suitable reference topography maps for the entire SIBERIA project area;
- Finding of solutions to obtain JERS imagery.

Further tasks carried out include data acquisition and processing prioritisation (WP 1050), EWSE/ES advertisement (WP 1300), organisation of SAR Workshop at the kick-off meeting at IIASA (WP 1400), compilation of first progress report R1, and representation of SIBERIA to the outside.

12.4. SAR Geometry (WP 5010)

Because of the side-looking geometry of SAR systems, the topography of the landscape is an important factor for the interpretation of SAR imagery and needs already be accounted for in the calibration and co-registration procedures.

The measure of evaluation of the information content of a SAR-intensity image is the backscattering cross section per area unit or backscattering coefficient s^0. To calculate s^0 using the intensity values of an intensity image one must take into account SAR sensor characteristics and the size of the illuminated surface area for each pixel. The size of the illuminated area changes in dependence of the inclination of the surface relative to the look direction of the sensor (actual incidence angle). If topographic information is available, the calculation of s^0 corrected for the local topography is possible. Otherwise only an incidence angle for a flat area can be used. Additional problem caused by topography are layover and shadow, the extreme cases for the change of the size of the illuminated area of each pixel for which the received information is unusable for evaluation. It is desirable to solve these problems also within the calibration process.

A standard software for radar image processing should be able to process these radiometric corrections, also called calibration, but the intensity images processed by DLR-DFD are special in some regards:

- The images are generated from SLC products. Normally the basis for calibration is the ESA PRI product.
- Normally, the order of processing is first the calibration and then the geocoding and resampling of the image. Within the project the order has to be changed because the calibration is not foreseen to be carried out by DLR-DFD. Therefore the basis for calibration is either a GEC or a GTC image, that means an already geocoded and resampled image.

Most of the standard image processing software the partners have, do not support the calibration of GEC or GTC products generated from SLCs. Also, taking into account the actual incidence angle, normally described in an incidence angle mask, is a problem for the geocoded DLR-DFD products.

Even if each partner of the methodology team has an appropriate software doing the calibration, the software packages are not similar and therefore the results of the calibration would be different. For the development of the methodology it is recommendable, that all partners have the same data base. So it is necessary to use the same software to carry out the calibration. There are two possibilities to solve the problem:

1. One partner has the appropriate software and carries out the calibration for the whole team.
2. All partners get the same software. In this case all partners would be able to carry out the calibration by themselves.

During the kick-off meeting it was decided to adopt the second solution. The calibration program “calit“, developed by DLR-DFD, is designed to handle PRI products as well as SLC products. Additionally, DLR-DFD altered the program to calibrate already geometric corrected intensity images. For that reason and because the program is freeware, it has been adapted by the team for calibration purposes. Besides the sensor specific radiometric corrections for intensity SAR images “calit” is able to carry out the radiometric correction using the actual incidence angle. The actual incidence angle is stored in an image file called geocoded incidence angle mask (GIM), which can be generated from a digital elevation model (DEM). Therefore we have to generate a GIM based on the DEM, if available.

As a suggestion to solve the problem a c-program “inci” has been written to generate a GIM in the appropriate format (Figure 12-1). The program calculates separately for each image pixel the incidence angle dependent on the satellite and pixel position and the incidence angle dependent on the topography. The program adds both angles, compares the result with a threshold for layover and writes the result including the layover information to the GIM file. The occurrence of shadow is very seldom due to the look angle of ERS. So it has been neglected for our purposes. The program “inci” has still to be tested and compared with other methods, to reach a decision on which method for GIM generation will be used by the team.

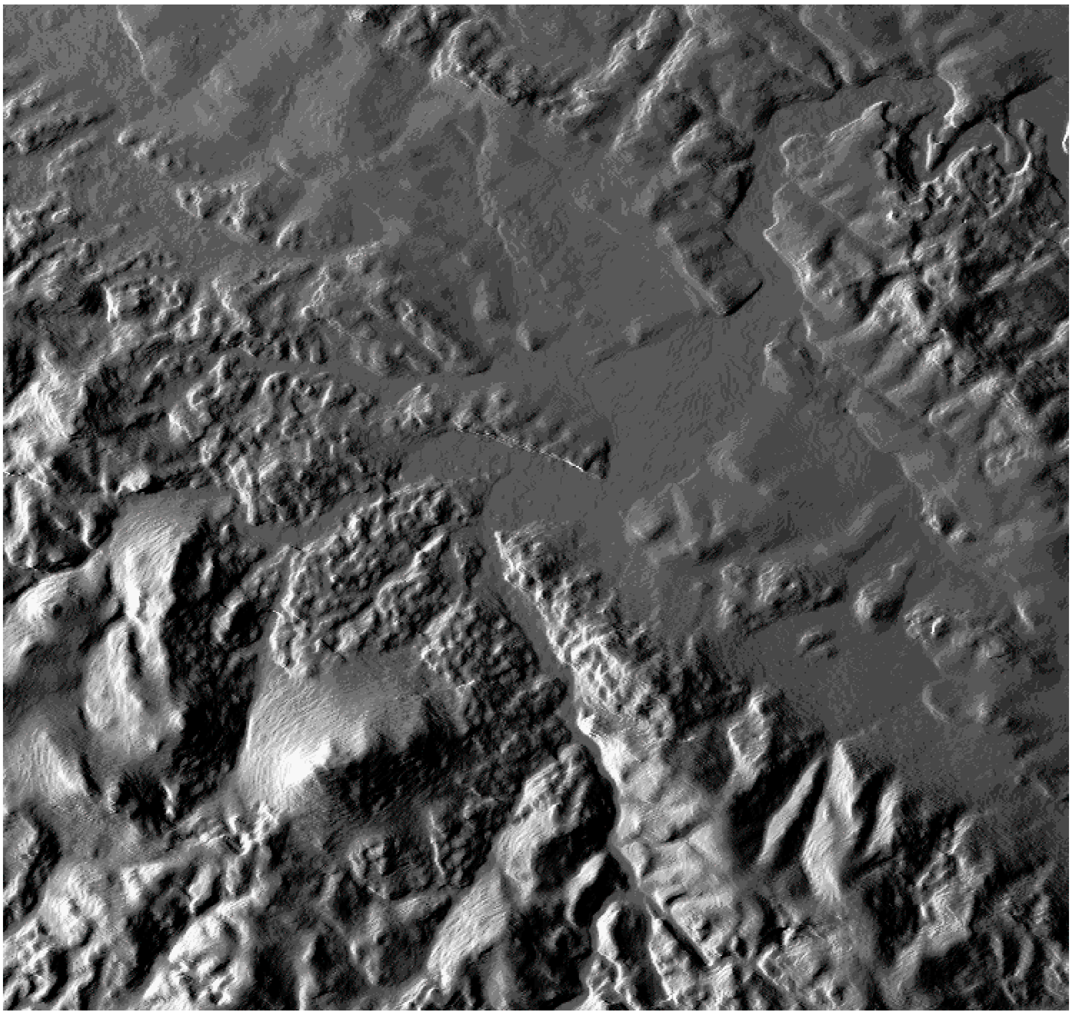

Figure 12-1: Geocoded incidence angle mask (GIM).

12.5. First Analysis at IGBP-Transect (WP 5100)

Based on two ERS-scenes from the Angara River at Brastk/Ust-Ilimsk and a region south-east of Krasnojarsk a first classification scheme has been tested. For the first area a GEC, and for a second area a GTC were available. A threshold test was chosen which referred to the amplitude and coherence products. The threshold used were taken from the literature (LeToan, Wegmueller, Luckman). It was noticed that coherence is not a firm value but can change from case to case. The following classes have been distinguished:

1. forest
2. open field
3. water
4. not classified areas

Additionally, two vegetation density categories (light and dense vegetation) were estimated. The classes and the vegetation density estimation were combined, so the following classes were determined:

1. light forest
2. dense forest
3. light vegetated open field
4. dense vegetated open field
5. water
6. not classified area

The threshold procedure has been applied to the acquisitions from fall 1997 and spring 1998. Furthermore, a correction of the incidence angle (GIM) was implemented and tested. A comparison between the images corrected for the incidence angle and the uncorrected images was made. As the GIM has been available as a test version, only first test results could be presented. Further work has to be undertaken.

13. Deutsches Fernerkundungsdatenzentrum (DLR-DFD)

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Personnel: Mrs. Ursula Marschalk, Mr. Nico Adam

13.1. Administrative Aspects

The personal assigned to the project is available. No hiring was required.

13.2. Technical Aspects

13.2.1 Progress

- *Modification of Processing Chain*

  The processing system was modified regarding three functionalities:

  - the consideration of a third data set (co-registration of spring data);
  - the improvement of the fine registration results for low coherent data;
  - the improvement of the coherence estimation.

- *Adaptation of calibration tool "calit"*

  DLR-DFD developed a public domain SW tool named "calit". It can be used to calibrate SAR data of the ERS and X-SAR sensors. The tool was modified in order to support the output of the interferometric processing. The tool was tested and the results documented in a technical note. "calit" is now available to all project partners and therewith enables a "standardised" calibration.

- *Integration of cartographic and geodetic parameters of the Russian maps*

  The map projection and geodetic datum parameters were acquired and integrated into the coordinate transformation package.

13.2.2 Problems

- *Availability and quality of topographic maps*

  The interferometric derivation of digital elevation models requires the improvement of the imaging parameters with an adjustment method based on tie-point information. The tie-points are derived from topographic maps. Commercial providers could not deliver the maps in the required precision and reasonable prices. The project partner IIASA initiated a map delivery directly from Russia. The maps arrived on January 18th, 1999 and are currently integrated.

The map unavailability hindered the operational generation of terrain corrected interferometric products. Only sample products could be produced. This causes a delay of the product delivery of approximately 3 months.

13.2.3 Project Documents and Technical Notes

The following reports describing project related investigation were generated:

- Rabus, N. Adam; Amplitude Image Generation of the Interferometric Processing, Technical Note
- N. Adam, M. Hubig; Coherence Estimation – Adaptive Vs. Constant vs. Adaptive Window Size, Technical Note
- W. Knöpfle, U. Marschalk; Calibration of ERS SAR Amplitude Images With Tools “getit” and “calit”, Technical Note
- Format and Interface Descriptions

13.3. Interferometric Processing of Tandem Pairs (WP 2100)

13.3.1 Progress

- *Co-registration of spring data*

  Differing from the proposal the interferometric processing chain was modified regarding the consideration of a third ERS data set acquired during the spring season 1998. This optimises the co-registration of the spring to the autumn 1997 tandem data regarding geometric quality as well as the required effort. The spring data set is registered to the tandem pair with pixel accuracy. The spring data therewith fit to the interferometrically derived DEM and the orthorectification of all data sets is performed in one step.

  As compensation of this additional effort 4 co-registered data sets are charged against one interferometric tandem processing (agreed between partners).

- *Fine registration of interferometric data (tandem data)*

  The interferometric processing of SAR data requires a fine registration of the involved data sets to a sub-pixel accuracy. Misregistrations lead to a loss of coherence. The fine registration of low coherent data sets (e.g. forested areas) failed in approximately 50% of all processing cases. This requires an enhanced procedure regarding robustness which was implemented during the reporting period and is currently tested.

- *Coherence estimation*

  The coherence map contains information of the similarity of the tandem data sets (ERS-1 and ERS-2). As the land coverage influences the coherence values this map is utilised to achieve the project goals. The quality of the coherence value depends amongst other factors on the number of looks (number of samples). A study was performed to investigate the dependency of the estimation result and the considered number of looks. It turned out that 64 is a suitable number of looks. Additionally the coherence value is corrected for the topography’s influence.

13.3.2 Processing Status

23 tandem pairs including the corresponding spring data set were processed. Only 3 of them could be further processed to geocoded data sets.

13.4. DEM and Slope Map Generation (WP 2200) and Geocoding of Amplitude Images and Coherence Map (WP2300)

13.4.1 Processing Status

Due to the limited availability of topographic maps only 1 DEM, the corresponding 3 GTCs, the coherence and a slope map were processed. Two other data sets were processed to ellipsoid corrected products (backup procedure).

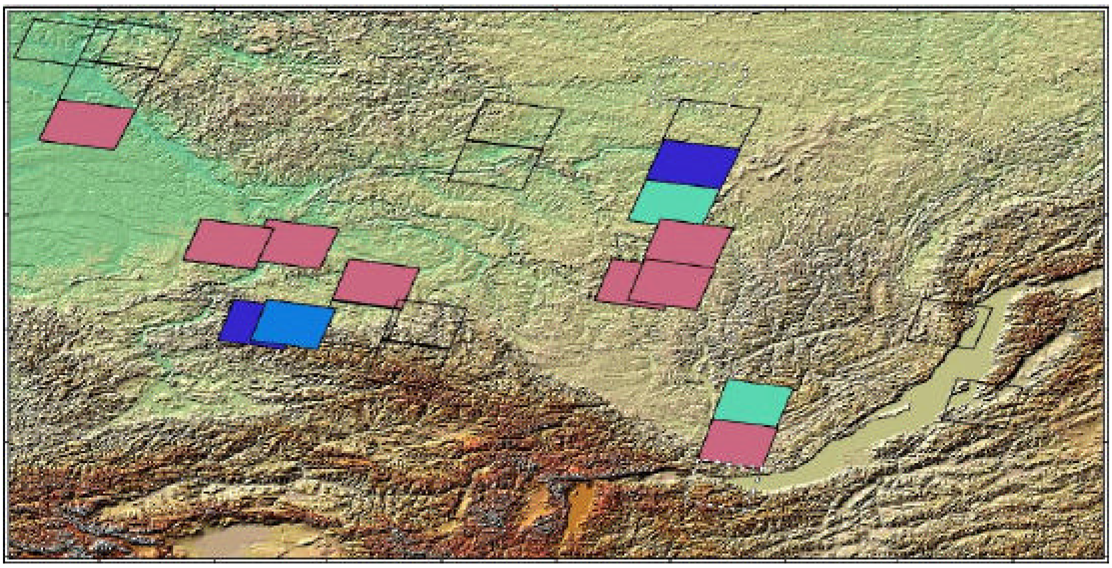

Figure 13-1: The image shows the SIBERIA test area between 88° and 112° east and 50° to 62° north, overlaid with the interferometrically processed frames (Status third week of January 1999). The frames processed to geocoded products are filled in blue, red are areas where the coherence is high enough for a DEM derivation and green indicates frames showing low coherence. Not filled frames require a reprocessing due to the fine registration problem addressed in the report of WP2100.

13.5. Archiving of interferometric ERS SAR products (WP 2400)

No progress.

13.6. Examples

The following examples show the different terrain corrected products of the Krasnojarsk test area.

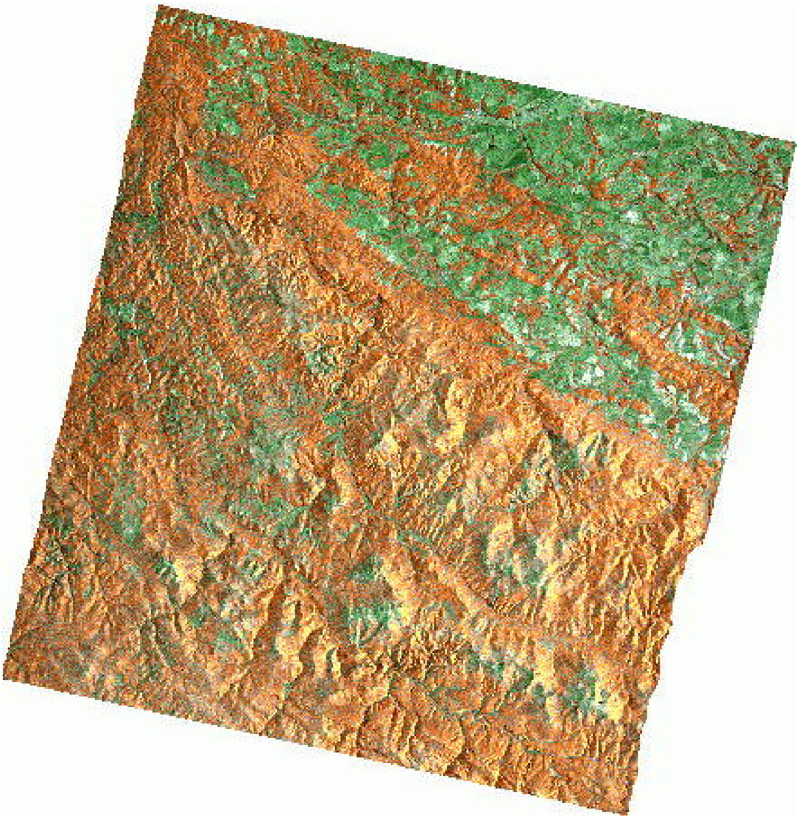

Figure 13-2: Amplitude images of ERS-1/ERS-2 tandem pair and coherence map. Areas of low coherence (e.g. forests) appear in red values while high coherence values causes green areas.

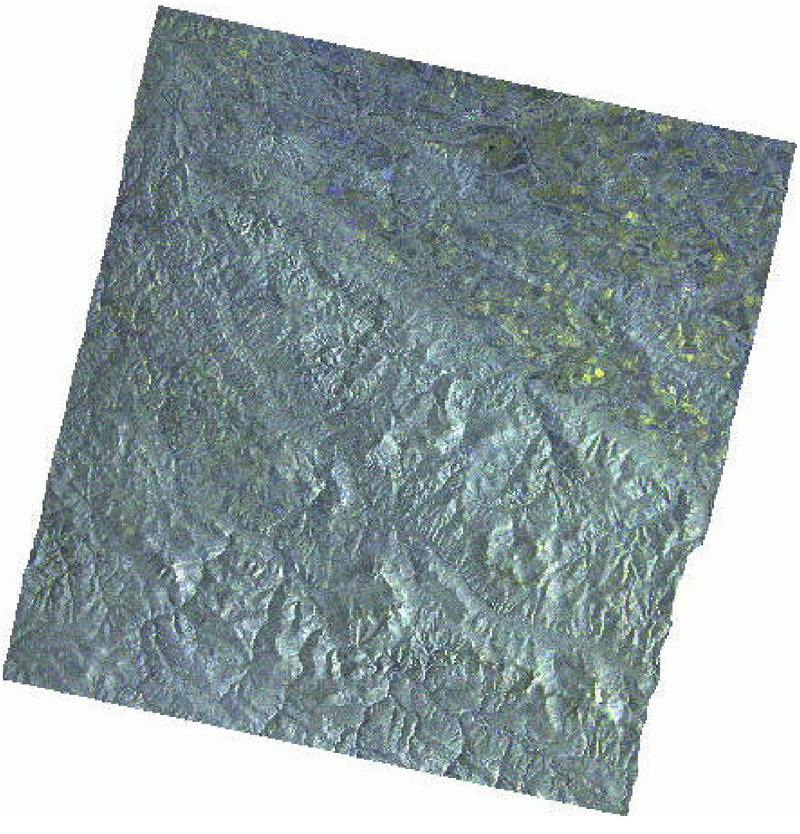

Figure 13-3: Multi-temporal amplitude images of ERS-1/ERS-2 tandem pair and ERS-2 spring data.

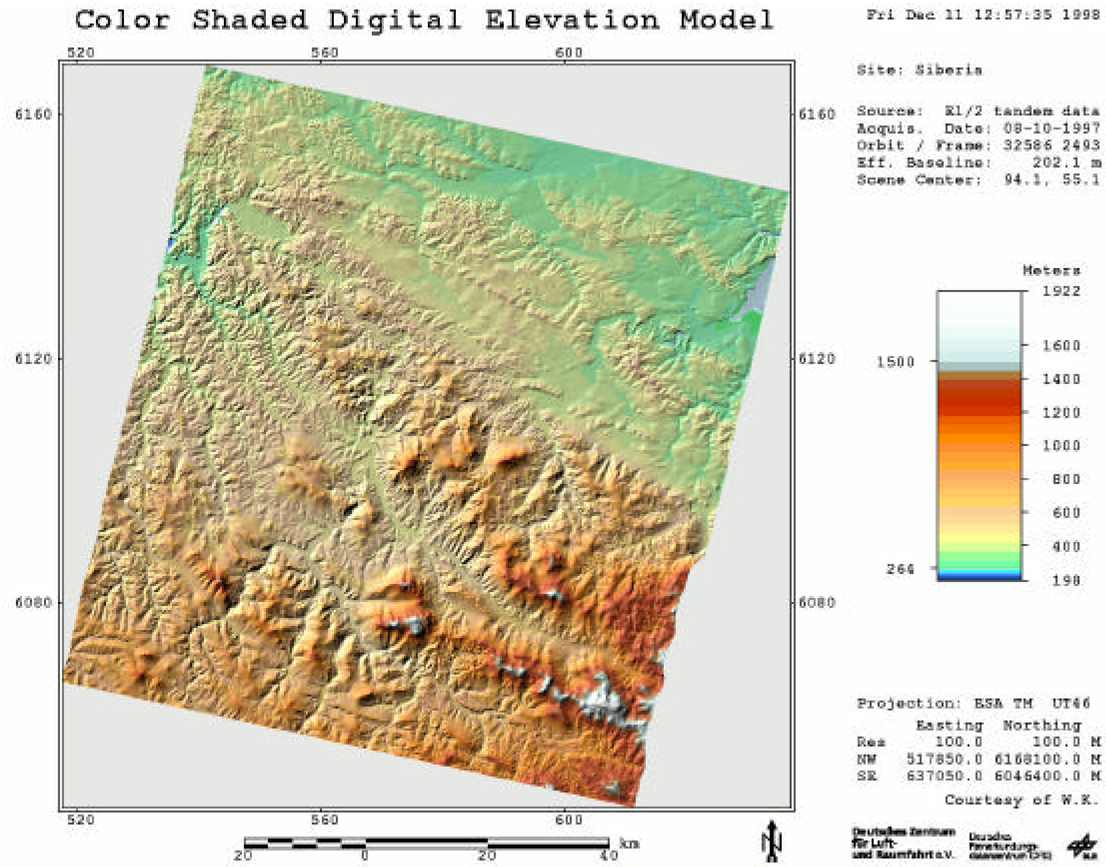

Figure 13-4: Digital Elevation Model interferometrically derived from ERS-1/ERS-2 tandem pair.

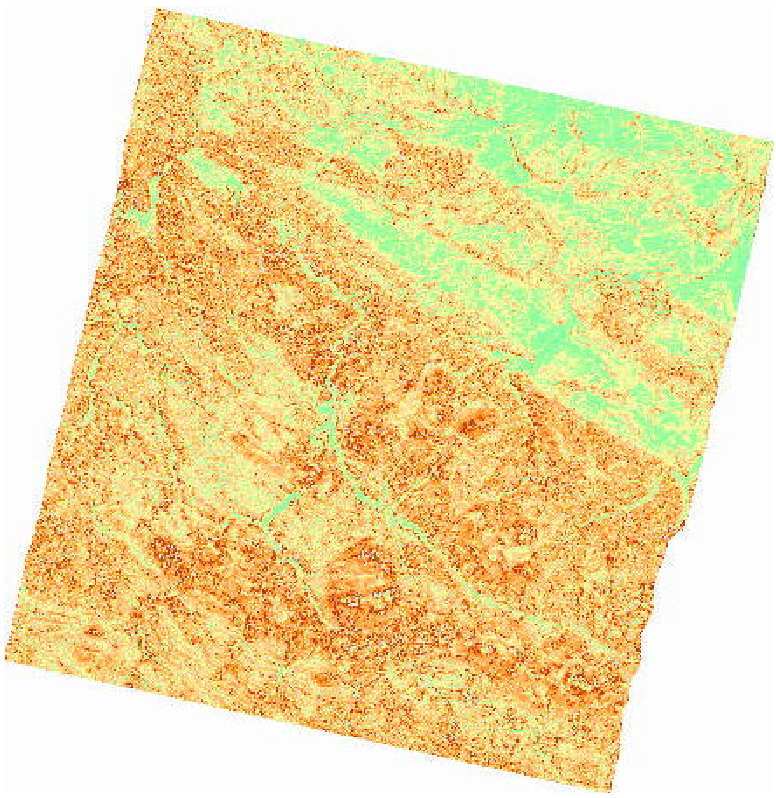

Figure 13-5: Slope map derived from interferometric Digital Elevation Model.

The following example shows an ellipsoid corrected product of the Bratsk test area.

Figure 13-5: Amplitude images of ERS-1/ERS-2 tandem pair plus corresponding coherence map

14. International Institute for Applied System Analysis (IIASA)

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14.1. General Issues

Transition of the world's forest management to sustainable development requires significant improvement of information currently available describing the forest resources. The creation of an Integrated Information System for Russia to meet these needs is proposed. This system would provide information that is highly accurate, operational, comprehensive, inexpensive and suitable for sustainable forest management. The information utilised by this system would include field-based measurements, existing inventory data, aerial photos and data from passive and active satellite sensors.

Remote sensing methods used in an Integrated Information System, designed in a holistic way, can be decisive in achieving sustainable development of the Russian Forest Sector. Remote sensing can be applied to forest inventory and monitoring, planning and control of management and assessing the state and dynamics of forest resources, ecosystems and natural landscapes.

The Russian forestry needs the following information about the forest measured:

- Forest composition
- Tree species & non-forest communities structure
- Disturbances, forest age, etc.
- Biomass
- Productivity (primary)

The Russian forestry and IIASA's has two main expectations from the SIBERIA project: methods of how to use SAR data to provide the needed information and knowledge of the capabilities of SAR gained from general results in the test areas.

14.2. Progress on Specific Work Packages

14.2.1 Design & Definition of Structure & Content of Forest Database: Determination of Forest Variables (WP 4100)

The objectives of WP 4100 are to design and define the structure and content of the up-to-date forest database to be created. Specifically, what are the land cover/ land use categories and what are the forest variables to be classified and estimated? The following information have been utilised to answer this question:

- Criteria for indicators for Sustainable Forest Management by the Federal Forest Service of Russia.
- Current forest inventory manuals

- Accuracy assessment requirements.
- Optical Spot XS and Resurs MSU-E data.

Progress to date

We suggest the land cover/ land use categories currently in use in Russian forest inventory as targets for forest variables to be measured (Table 14-1).

Forest Lands	Non-Forest Lands
forested areas*	arable lands
plantations (unclosed)	hayfields
nursery & seed orchards	pastures
natural sparse forest	water reservoirs
unforested areas	roads, kvartal boundaries
burns	urban
dead stands	bogs
cut areas	sand
grassy glades	glaciers
	rocks, steep slopes

*Table 14-1. Current land cover/ land use categories from Russian forest inventory (excluding forested areas. * See Figure C-1 for forest area classification.*

Characteristics of forest areas can be organised hierarchically, however, this organisation should not be considered constraint on the classification process (i.e. classification can start at any level of this hierarchy). If all levels of this classification were identified then there would be 60 boxes.

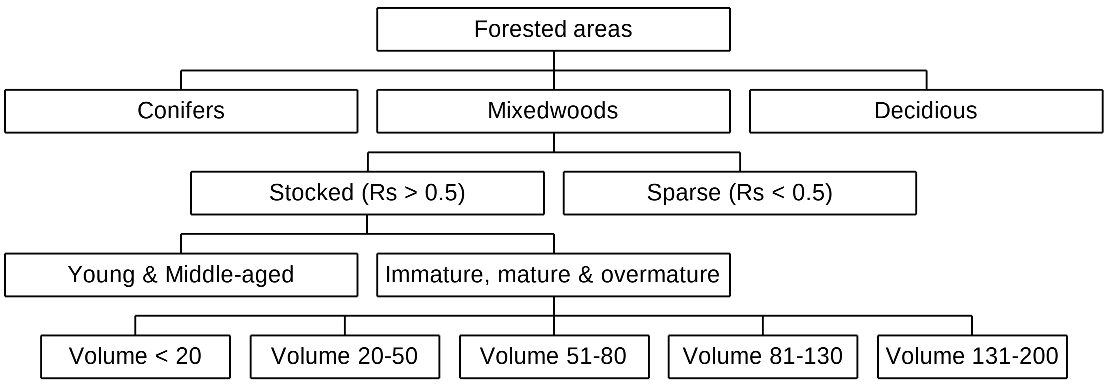

Figure 14-1. Proposed forest area classification possibilities. Forested area is organised (top to bottom) by species composition, stocking (Rs = relative stocking), age and volume (m^3).

14.2.2 Determination of Test Site Locations (WP 4200)

The objectives of WP4200 are to determine the location of ground reference areas within the test sites and to evaluate data supporting methodological development & validation.

Progress to date

The basic principles used in selecting areas with ground reference information were that there should be 4 to 7 test territories ranging from 300,000 ha to 1,500,000 ha each, containing 20 to 35 key test areas 20,000 ha to 100,000 ha each (Figure 14-2). The Test territories were chosen subjectively to represent:

- specific zonal regularity of forests & vegetation

- impact of macro-relief (mountains)
- impact of human transformation of vegetation

Test areas were chosen to represent:

- landscape diversity
- basic-land-use categories
- main forest association
- diversity of human impact
- forest diversity (productivity, stocking, etc.)

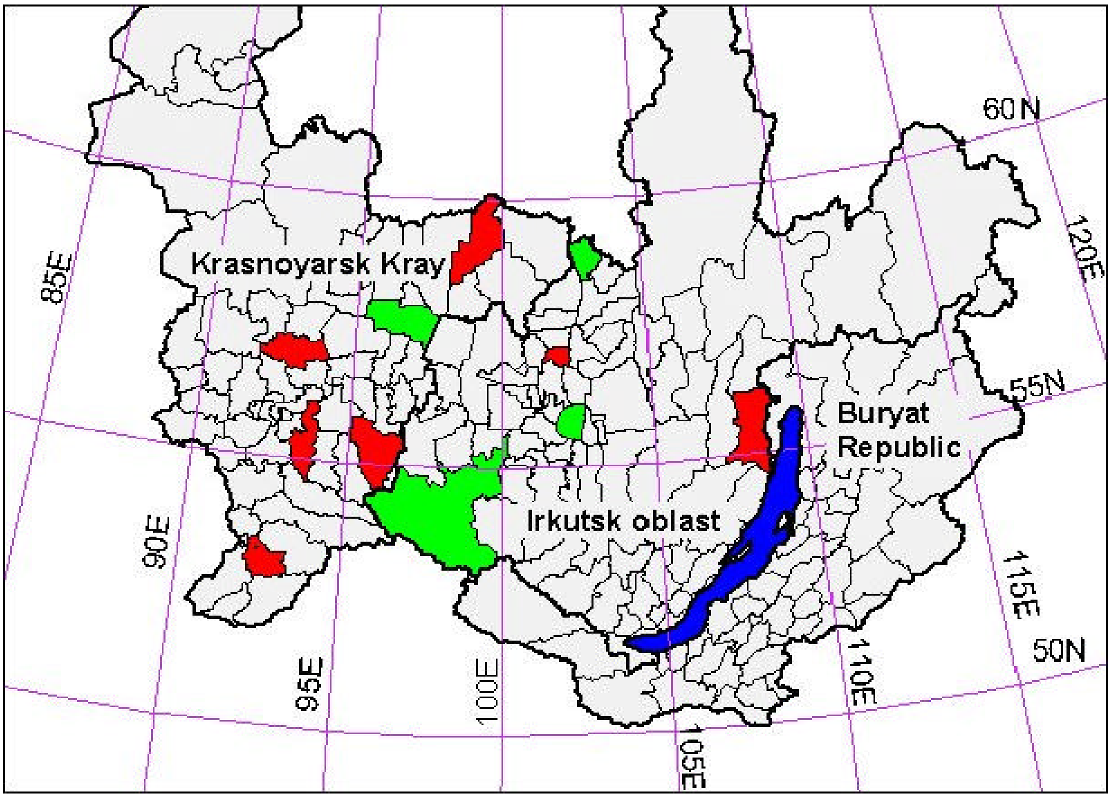

Figure 14-2. The location of the test territories and the test areas in SIBERIA are presented above. Test territories with test territories and available reference data are coloured in green. Test territories presently (Jan. 18th) without reference data are presented in red. Test areas indicated by black dots.

14.2.3 Work Package 4300: Reference Data Collection & Compilation

The objectives of WP4300 are to collect, compile, standardise, describe and distribute existing reference data and complimentary data. Reference data will be used as input to the methodology development work (WP5000) and to represent the variables to be classified & estimated for the test areas.

Progress to Date

Twelve test areas are currently available for 3 test territories (forest enterprises). In addition, digital landscape, vegetation & soil maps available for test all test territories. All forest maps are produced in ArcInfo format (shapefile or coverage) and are geographically based or UTM projected. A standard forest attribute database in dbase format, with a single record per forest stand has been created for each test territory. All reference data is available on request for the Project partners and an Internet site for information transfer has been created at http://www.iiasa.ac.at/Research/FOR/siberia.

14.3. Next Steps for IIASA

In the sort-term, IIASA will be focussing on completing WP4300 while addressing issues regarding the following work packages:

- WP 4500: Accuracy Assessment with Russian State Forest Account. What is the best combination of satellite measurements to classify & estimate the selected forest variables?
- WP 7100: Implementation of Forest Geographic Information System. Deliver, test & validate delivered database on site in Siberia operational on an enterprise level simulate FIMS & implementation.
- WP 7200: Assessment of Forest Database. Criteria development, functionality, efficiency & value

15. Centre d'Etudes Spatiales de la Biosphere (CESBIO)

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Personnel: Dr. Malcolm Davidson, Mr. Didier Dendal

15.1. Administrative issues

- We have been notified that the contract has now been registered at the University Paul Sabatier on 14 December 1998. The funds are expected in January-February 1999.
- We hosted at CESBIO the first progress meeting, 14-15 December 1999

15.2. Technical issues

During the past period, the work has been carried out for both the two following Work Packages:

- WP5020 Quantification of ERS/JERS SAR Information content:
- WP5200 Analysis and Validation at Bratsk/ Ust-Ilimsk

WP5021-5023:

- We attended the KO meeting and User Workshop (Laxenburg, Vienna)
- We presented a contribution to User workshop on the information content of ERS, JERS SAR and InSAR data with respect to the forest information requirements.

WP 5024, WP 5200:

We attended the First Progress Meeting (Toulouse) where we presented our contribution on the assessment of procedures for SAR measurement extraction. Our main task during the first stage has been to assess the coherence extraction procedure:

- The following SLC data have been received from DLR, one ERS1/ERS2 pair on each of these three frames of the Ust-Ilimsk site:

Orbit	Frame	Date	Lat*	Lon*
32371	2403	970923	59°09	102°22
32371	2421	970923	59°17	101°58
32371	2439	970923	57°24	101°35
12698	2403	970924	59°09	102°22
12698	2421	970924	59°17	101°58
12698	2439	970924	57°24	101°35

* first coordinates given

- We have realised Interferometric processing of the three pairs, using the DIAPASON software, with different outputs (slant range, projected, different widow sizes)
- We have digitised the forest map of the Ust-Ilimsk Forestry Enterprise, and compared with the coherence map. Although the two maps are in different geometry, it can be observed (e.g. in Figure C-1) that in general, there is consistency between the two maps, however, some differences exist. As an example, there are more clearcut in 1997 shown by the coherent map than indicated in the forest map established based on information collected in 1991. As a conclusion, a more thorough analysis requires an updated forest map.

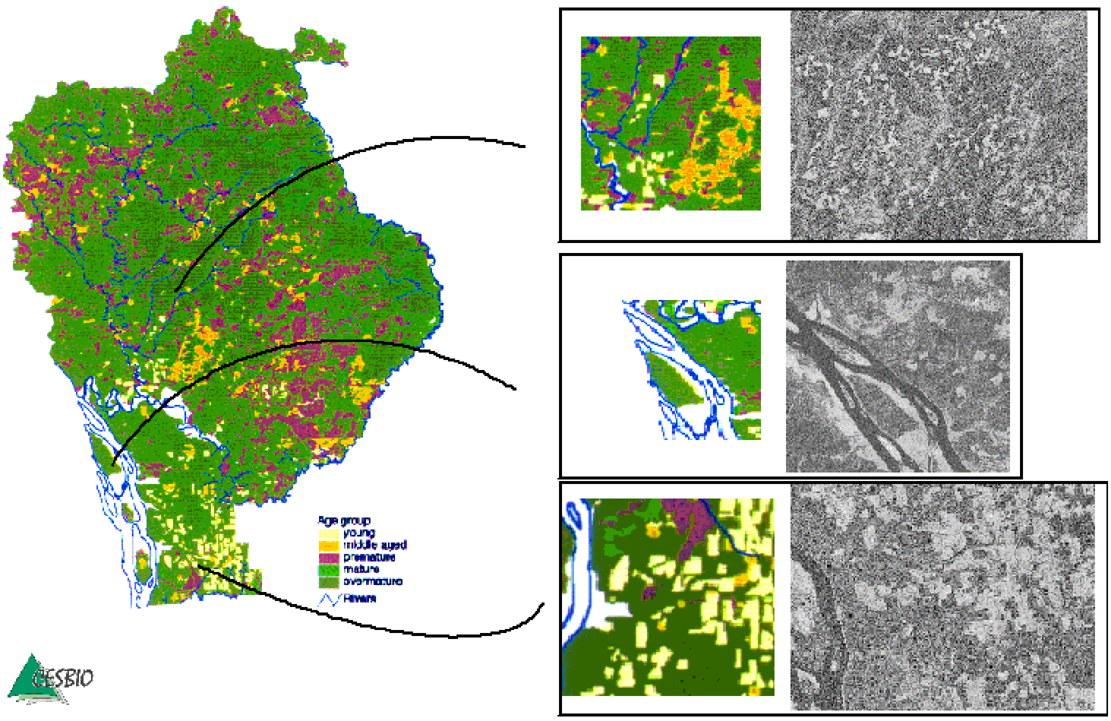


Figure 15-1: Illustration of correspondence between land-use categories found in the Ust-Ilimsk Forestry Enterprise map and ERS interferometric coherence. The young forest stands are characterised by a high coherence (bottom right) whereas the coherence of mature forest stands is low (see island in middle right image). Finally what are presumed to be newly-cut forest stands are visible in the upper right coherence image but not in the map, highlighting at the same time the need for updated maps in the validation of classification results as well as the potential of ERS coherence information to help in such tasks.

- The coherence estimation has been assessed as a function of the window size: from 5 (azimuth) x 2 (range) to 30x6. The window 10x2 has been found a good compromise between the coherence estimation and geometric resolution, in particular to preserve boundaries of clearcut areas which can be of small size (Figure 15-2).
- The coherence estimates at window size of 10x2 have been extracted from the main surface types. The same extraction has been performed on the 64-look coherence data provided by DLR. As expected, the standard deviation at 64 looks is much reduced compared to that at 20 looks. However, some differences in the extracted coherence mean values (e.g. young forest in Figure 15-3) and the differences in visual quality of the products required further check of the processing chain in both cases.
- We have sent the coherence data processed at CESBIO , frame 2421, 23/24 September 1997, with window size of 10x2, 20x4, 30x6 to DLF FD for comparison and to SCEOS for examination.

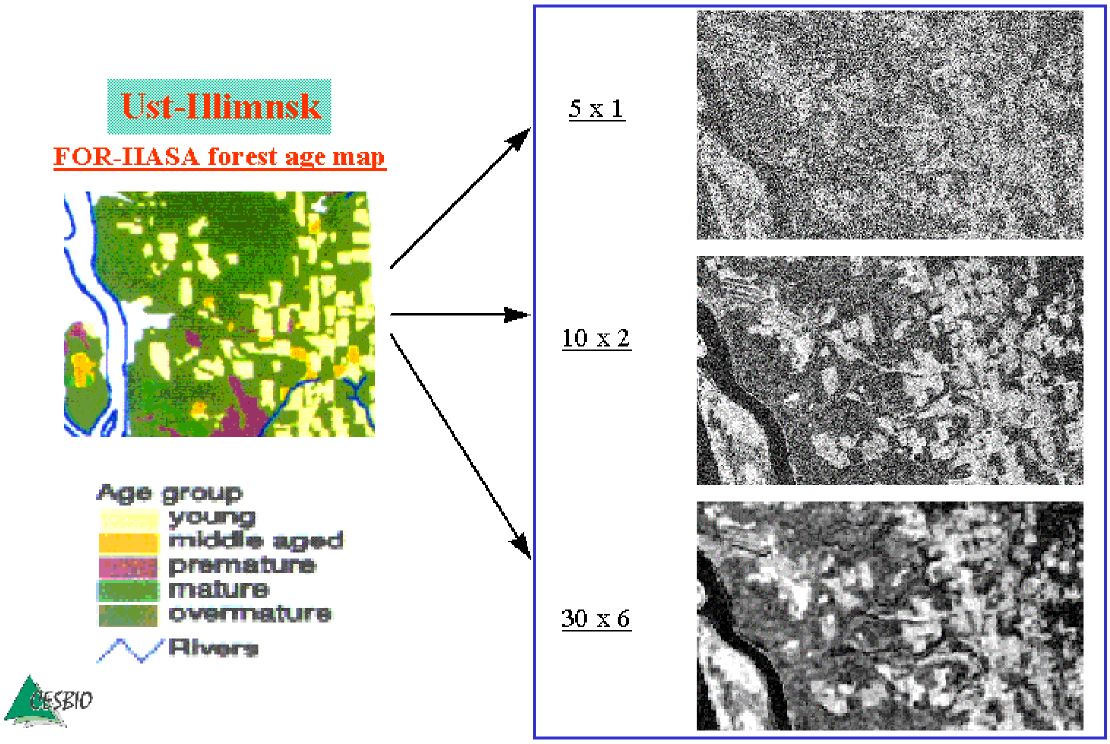
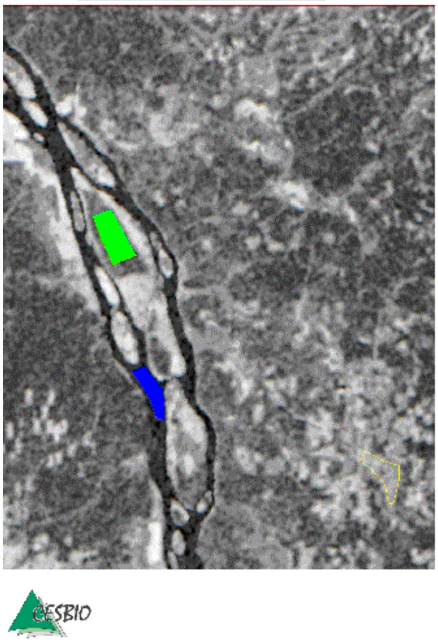


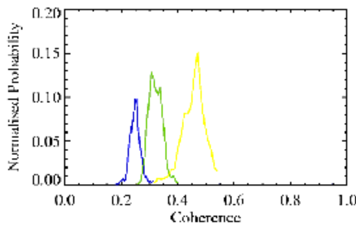
Figure 15-2: Illustration of the correspondence between the information contained in the forest map and coherence images as a function of the window size over which coherence values are averaged. If the window is too small the coherence information is obscured by noise (upper right) whereas is the window is too large some of the detailed information, for instance concerning forest stand boundaries is washed out (lower right). Here the 10 x 2 window size appears to be an appropriate window size.

DLR coherence image



DLR coherence estimates

Land-use	Avg. Coherence	Standard deviation
Mature forest	0.32	0.03
Young forest	0.46	0.03
Water	0.25	0.02



Diapason coherence estimates (10 x 2 window)

Land-use	Avg. Coherence	Standard deviation
Mature forest	0.3	0.1
Young forest	0.6	0.1
Water	0.2	0.1

Figure 15-3: Illustration of the mean coherence values for different land-use categories taken from the Ust-Ilimsk forest map. N.B. the different average values for the different classes. The standard deviation in values is lower for the DLR coherence product because a larger averaging window was used. However the differences in the average coherence estimates require further investigation and verification.

- We have requested the updated and geolocated forest map of Bratsk/Ust-Ilimsk site for more detailed analysis.
- The data analysis is underway on the calibration and extraction of intensity data on PRI ERS images

15.3. Problems and Comments

- During the past period, the work has been to set up work structure and link with different teams. The proper data analysis will start with the availability of data, both ground data and radar data.
- Links with other methodology teams are important in order to avoid duplication of effort. In particular links with SCEOS to ensure consistency of datasets and also to agree on the approach to data analysis at Bratsk-Ilimsk.

16. Sheffield Centre for Earth Observation Science (SCEOS)

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16.1. Administrative issues

1.1. One member of staff, Ms Jiong Jiong Yu, was appointed on a contract extending from 1/8/98 to 31/7/2000.

1.2. We defined the reporting procedure and provided report templates for team members involved in WP 5000.

1.3. Monthly progress reports were supplied to the WP5000 coordinator. Clarification was sought from Team members on aspects of their reports which were unclear and this was used in providing monthly summary reports to the Methodology Team and Project Coordinator.

16.2. Technical issues

2.1. We attended the kick-off meeting (Laxenburg, Vienna) and First Progress Meeting (Toulouse) and during them provided a top level view of the processing chain and the interaction of the parts, including critical testing and quality assurance points. Figure 16-1 summarises this structure.

2.2. Considerable time was spent on assessment and testing of the “calit” calibration program, including clarification of the documentation and understanding of its use. Here we interacted particularly with DLR-DFD and UWS and reported on the activity to the rest of the team.

2.3. A survey was made of filtering and classification methods available to the team. Preliminary suggestions were made on the range of algorithms we should consider in the classification procedure, but this needs further thought once the results of data analysis (especially WP 5020) are available. Not all the desired methods are immediately available within the team. As a result, we have verbal agreement with the following research groups and colleagues that they would be willing to provide software and/or do test runs for us on data we provide:

(a) J. Askne and P. Dammert (University of Chalmers): unsupervised classification methods based on fuzzy c-means clustering;

(b) L. Bruzzone (University of Genoa): neural net methods to test optimality of feature based methods;

(c) M. Delves (N A Software) to provide latest versions of multi-channel segmentation and filtering software. This is to help us in making sensible choices on the methods to finally adopt.

2.4. Background research on the fuzzy c-means clustering algorithm was performed to assess its likely suitability for the project. This is still under consideration (see 2.3); for example, are there strong reasons to prefer this to ISODATA, for example. This whole aspect of the work relies on thorough investigation of the data, which has been hampered by unavailability of data.

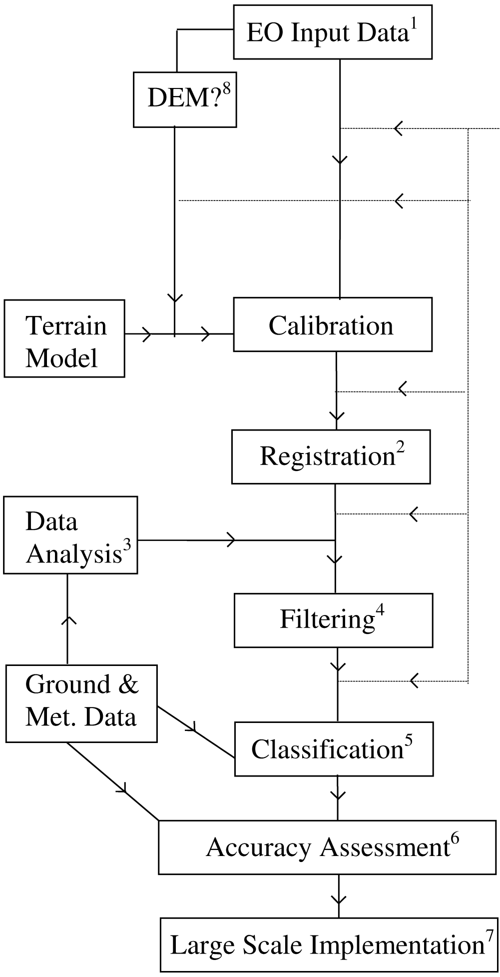


Figure 16-1: Processing flow chart. The boxes on the left indicate inputs into definition or implementation of the algorithms forming the central processing chain. Quality checking is essential for the principal elements of the chain, as indicated.

Notes:

1. *At the testsites, the range of input EO data is more extensive than for the whole area to be mapped. It will be used to assess the best possible performance and how this is likely to degrade for the restricted dataset used in large area map production.*
2. *Image-image, image-map registration.*
3. *Data analysis will provide the problem understanding needed to define the filtering and classification methods.*
4. *Multi-channel and spatial.*
5. *Rule-based and data-driven methods will be considered.*
6. *The meaning of accuracy needs to be defined in context.*
7. *Hardware and software issues in large scale implementation may constrain possible methods, hence there may be feedback from this box.*
8. *The DEM is available from the data only if interferometric data is available and coherence is sufficiently high.*

2.5 We provided UWS with feedback on the set-up of the SAR image acquisition table at the SIBERIA website.

2.6 The registration of the JERS and ERS images over the Bratsk/Ust-Ilimsk area is being investigated. Because both images have been geocoded, translation is all that should be needed to match the images, using recognisable points in two images. This method was used to produce the overlay of a JERS (Figure 16-2a) and a ERS (Figure 16-2b) image shown here as Figure 16-2c. The overlap between the 2 images is in the lower part of the figure. Close examination reveals evidence for slight misregistration in Figure 16-2c, since the river features are yellow towards the left and blue towards the right, indicating that the ERS image is displaced to the right relative to the JERS image. This can be improved by using more accurate translation, perhaps based on correlation techniques.

2.7 We have derived the appropriate form of the appropriate multi-channel speckle reducing filter to be used when combining Tandem (correlated) PRI data with 35 day (uncorrelated) ERS data. We are also examining whether it is meaningful to jointly filter ERS and JERS data and, if so, whether the available filtering tools are suitable. The need for technical development will be assessed following this investigation.

2.8 We have performed a limited test of the adaptive spatial filtering and change measure (mva) algorithms using ERS and JERS data at the Bratsk/Ust-Ilimsk site, but the results are not particularly useful at this stage.

16.3. Problems and Comments

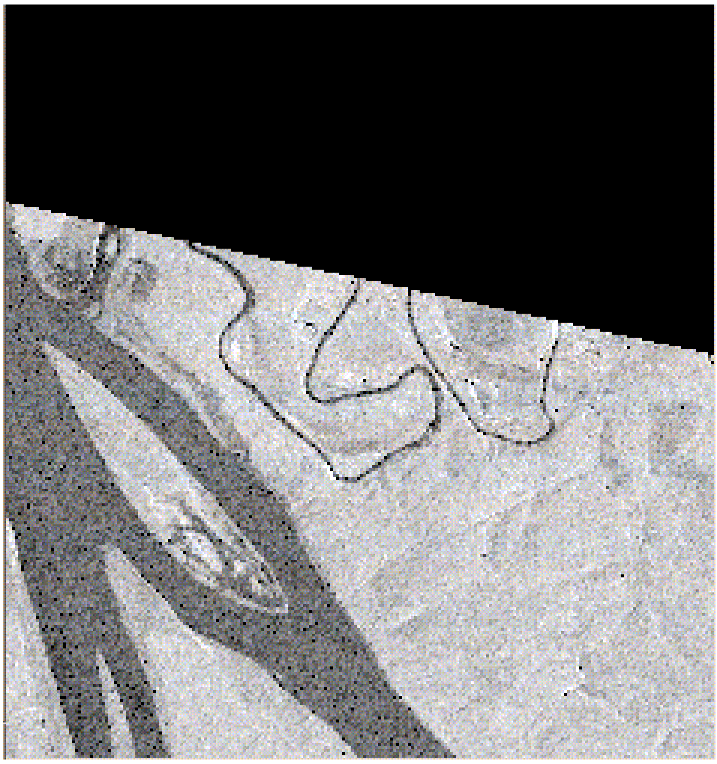
3.1 At this stage, most of our work has been in setting up structures and clarifying issues rather than carrying out data analysis and arriving at conclusions. This is because of data problems, both as regards availability and quality.

3.2 On WP 5000, we have been active on all aspects of Team Coordination and in encouraging communication. Information on both satellite and ground data was very confused in the early part of the project and is still an issue (ground data at Bratsk-Ilimsk, for example).

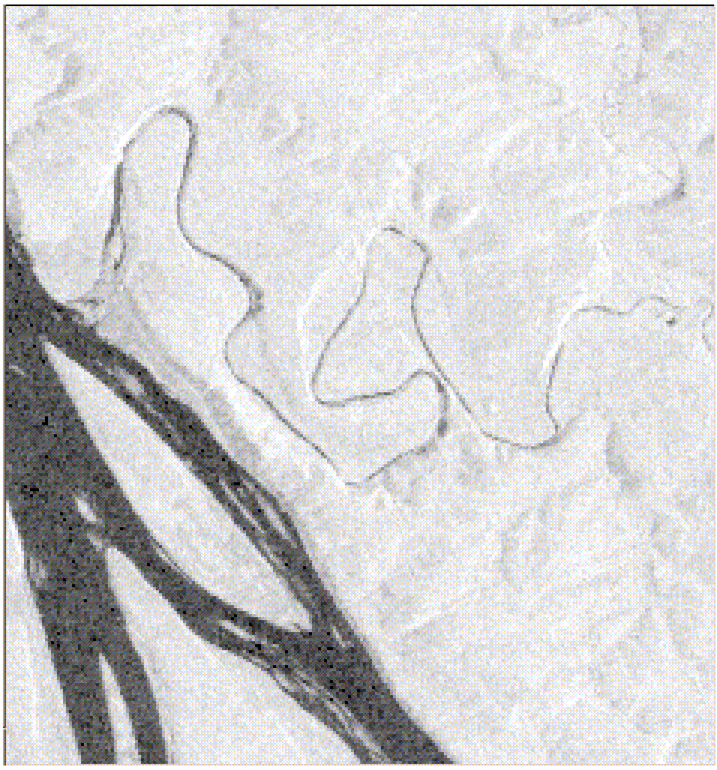
3.3 We feel that brief working notes and discussion documents should be used more actively. DLR-DFD have provided several such notes and Swansea have made a good job of involving the Team in their decisions as regards the Website and ftp site. The copied OHPs of some of the presentations in Toulouse are also very informative. SCEOS is in process of producing a discussion note on general considerations for filtering and classification.

3.3 In WP 5030, most of the tasks require input from elsewhere, either data or other WPs, which are currently unavailable. As a result we are trying to learn about the data using not the best methods in an effort to be prepared when data starts to flow properly. This is also what is hampering most of the other WPs which will provide input to us.

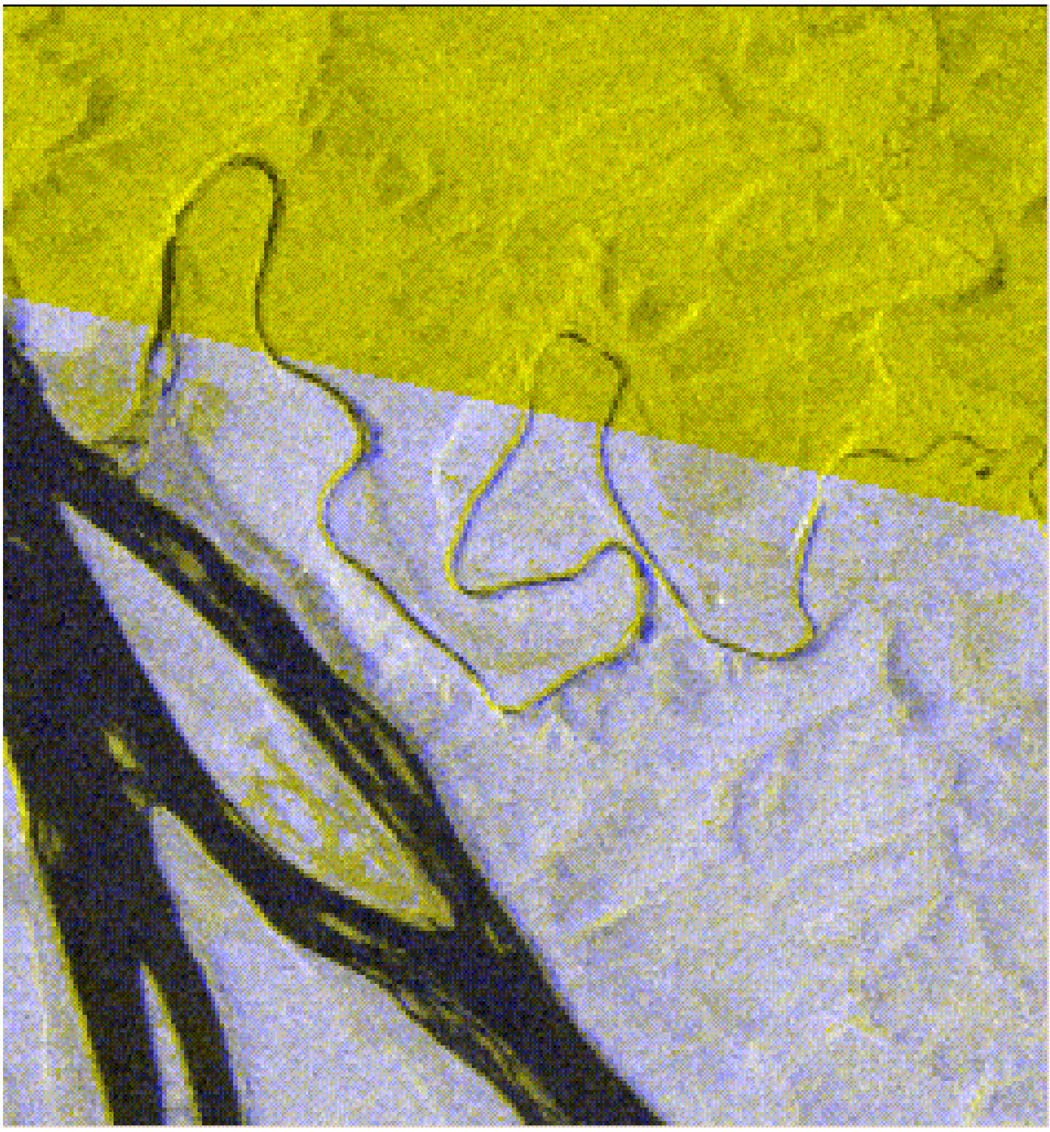
3.4 Links with CESBIO are particularly important in order to avoid duplication of effort, to ensure consistency of datasets and also to agree the approach to data analysis at Bratsk-Ilimsk. This involves discussion both at WP manager and at contract staff level; recent discussions are likely to make this link much firmer.



(a)



(b)



(c)

Figure 16-2: (a) JERS (4/5/97), (b) ERS (23/9/97), (c) Overlay of (a) in blue and (b) in red and green. The overlap between the 2 images is in the lower part of the image.

17. University of Wales Swansea (UWS)

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17.1. Introduction

Apart from those tasks for which all partners have responsibility, the tasks specifically assigned to UWS are:

1) Work Package 5050: Computational Issues (sole responsibility)

2) Work Package 5300: Computational Issues (lead partner sharing responsibility with NERC)

This document describes the progress made in these work packages towards the overall aim of the SIBERIA project as well as the developments in administrative aspects of this project within UWS.

17.2. Administrative Aspects

The greatest administrative difficulty encountered on the project has been the delay in guarantee of funding and subsequently the delay in actual funding experienced mainly as a result of the change of partner make-up late in 1998. Despite being nominally in the sixth month of the project, to date no funds have been received by UWS. As a result, equipment has had to be borrowed from other projects within the Geography Department at UWS and individuals are awaiting reimbursement of travel expenses which were met privately as an interim solution. We hope and expect this situation to be rectified soon.

Fortunately, despite the delay in funding, the University was able to approve, and support in advance, the recruitment of a Senior Research Assistant to carry out the duties assigned to UWS. Dr. Kevin Tansey, formerly of Leicester University, started work on 1st October 1998. The discrepancy between Kevin's start date and the beginning of the project means that the choices in managing personnel expenses at UWS are:

1. Use only 22 months of the total possible 24 months granted salary.
2. Employ another person in parallel for 2 months to work on the project.
3. Request a 2 month extension to UWS's involvement in the project.
4. Seek transfer of funds from personnel, for example into travel expenses.

A decision on which course to take has yet to be investigated.

At the 1st SIBERIA progress meeting in Toulouse in December, it was decided that an extra meeting of the methodological development team was necessary to help make up for delays in data delivery. UWS offered to host this meeting in early March and look forward to welcoming all methodological partners to Swansea. The organisation of this meeting is underway.

17.3. Computational Issues (WP 5050)

The deliverables for this Work Package due at or before the 1st progress report on month 6 include:

1. Email distribution list;
2. FTP server;
3. Specification for common data transfer formats and methods;
4. Specification for appropriate software packages or tools.

Items 1 and 2 have been fully satisfied. The latest solution to managing email distributions is a series of lists available on the UWS SIBERIA web-site. The UWS FTP server is operational and has already proved to be a vital resource for partners sharing image, document and meta-data information.

Items 3 seems to have been satisfied since the FTP-site solves methods of data transfer and formats are largely defined by the sources of all SAR data in the project, namely DLR-DFD and GAMMA. We believe that all relevant partners have been able to read and process data from these sources and that the formats used are therefore adequate.

Item 4 depends on both the software tools and systems available at partner sites, and on the algorithms specified by members of the methodology team. Information on available tools was collected by questionnaire and is summarised in Table 17-1.

Points to note are:

- UNIX is universally used. All partners have access to PC's.
- The range of software applications is diverse. Monitoring of data products from the processing at DLR (Sun-raster) to final map producers preferred software (ERDAS, ARC-INFO, VEXCEL, IDL) is required.

For software development C is familiar by all partners, although C++ is preferred by SSC.

Since methodological development has been held up by delays in data delivery, software tools for specific algorithms have not yet been addressed. However, discussion at the 1st SIBERIA Progress Meeting in Toulouse yielded the following recommendations which will be pursued as part of this Work Package:

- Establish the compatibility of similar SAR processing steps that are carried out using different software applications.
- Investigate the use of Gamma software for specific processes such as co-registration of ERS-1 and JERS-1 GEC products.
- Continue investigation for public-domain tools and applications.
- Investigate legal aspects of sharing source code between partner institutions.

In addition to addressing the deliverables agreed at the start of the project, considerable progress has been made on developing a web-site for cataloguing of data, distribution of documents and meta-data and charting the progress of all aspects of the project including data delivery, processing and field data delivery. The feeling at the Toulouse meeting seemed to be that this was a valuable tool for the SIBERIA consortium and should continue to be the focus of the Computational Issues Work Package (WP5050).

Summary of partner's computational hardware, software and software development tools.

PARTNER	HARDWARE			SOFTWARE			SOFTWARE DEVELOPMENT		
	Preferred	Available	Not Available	Preferred	Available	Not Available	Preferred	Available	Not Available
DLR-DFD	UNIX	UNIX PC	MAC Linux	Internal INSAR Processing	ERDAS ARCINFO IDL ENVI Internal INSAR Processing	PCI TNT MIPS Gamma RS HIPS	C C++	C C++ FORTRAN IDL	Yorick
	COMMENTS: None								
ITE MONK's WOOD	UNIX MAC	UNIX PC MAC	Linux	PCI Gamma RS	PCI Gamma RS ERDAS ARCINFO TNT MIPS IDL ENVI	HIPS	C	C FORTRAN IDL DELPHI 2.0	C++ Yorick
	COMMENTS: Lots of disk space available								
SCEOS	UNIX	UNIX PC		HIPS	HIPS ERDAS ARCINFO	TNT MIPS Gammas RS IDL ENVI	C	C C++ FORTRAN	IDL Yorick
	COMMENTS: None								
IIASA	UNIX	UNIX PC		ERDAS ARCINFO	ERDAS ARCINFO ARCVIEW	PCI TNT MIPS Gamma RS IDL ENVI HIPS		C C++ FORTRAN	IDL Yorick
	COMMENTS: None								
VTT FINLAND	UNIX PC - NT	UNIX PC - NT		ER MAPPER In-house software	ER MAPPER In-house software	ERDAS PCI ARCINFO TNT MIPS Gamma RS IDL ENVI HIPS	C	C C++ FORTRAN	IDL Yorick
	COMMENTS: They have peripheral storage devices, CD's EXABYTE's etc.								
UWS	UNIX LINUX	UNIX PC LINUX	MAC	PCI Gamma RS IDL ENVI	PCI Gamma RS IDL ENVI ARCINFO HIPS Alaska SAR SPANS	ERDAS TNT MIPS	C	C C++ FORTRAN IDL Yorick Gnu	
	COMMENTS: DAT drives, writeable CD's (forthcoming), EXABYTE readers etc.								
SSC Sweden	UNIX	UNIX PC	LINUX MAC	ERDAS ARCINFO VEXCEL	ERDAS ARCINFO VEXCEL SOCET SET	PCI ENVI TNT MIPS Gamma RS HIPS	C C++	C C++ IDL	FORTRAN Yorick
	COMMENTS: VEXCEL comprises Ortho SAR and MSP; IDL available only on SUNS, not ENVI								

Table 17-1: Summary of partner's computational tools.

The WEB site at http://sunset.swan.ac.uk/siberia/ contains the following information:

- Links to all partner institutions and to the `request for field data' web-site at IIASA.
- A `WHAT'S NEW' page that lists all the recent developments on the SIBERIA project.
- E-mail distribution list details.
- Instructions on how to access the UWS-based FTP server.
- Listings of all SIBERIA processed SAR data. Separate tables are included for ERS and JERS SAR data. Distinction between images is made in the first instance by frame followed by track and then orbit. Following a link from the frame number, further important attribute information can be accessed (data location, geographic location, data format etc.).

- Fully interactive thumb-nail images linking to samples images of intensity and coherence where interferometric products are obtainable).

Provision is made for searching the data archives by geographical region. This enables the user to ascertain whether processed data are available for their particular region of interest.

An example of the Web site interface is shown in Figure 17-1 and an example of the meta-data available for each thumbnail within this image is shown in Table 17-2.

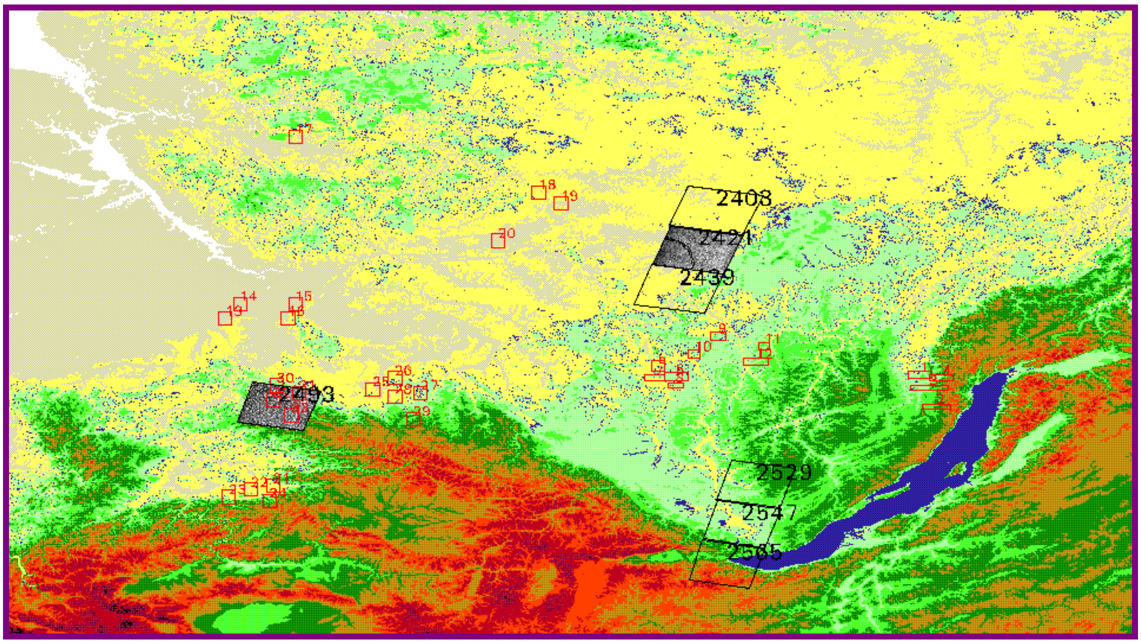

Figure 17-1: Interactive image location picture to aid locate images in the SIBERIA project area.

Satellite	Orbit	Format	Acquisition date	Product type	Pixel spacing	Location of data	Distribution date	Columns/lines of data
e1	32357	Amplitude	19970922	GEC	50 by 50m	ftp site: images/32357_2493_0/*	19981119	2380/2456
e2	12684	Amplitude	19970923	GEC	50 by 50m	ftp site: images/32371_2493_0/*	19981119	2380/2456
e2	16692	Amplitude	19980630	GEC	50 by 50m	ftp site: images/32371_2493_0/*	19981119	2380/2456
2493_32357_12684		Coherence		GEC	50 by 50m	ftp site: images/32371_2493_0/*	19981119	2380/2456
2493_32357_12684_phase		Phase				ftp site: images/32357_2493_0/*	19981119	

Table 17-2: Second level attribute information on the Web-site.

17.4. Lake Baikal (WP5300)

Progress of the methodological development in the Lake Baikal region has been severely hampered by data availability. Three images are available (Figure 17-2). They have not been ellipsoid corrected, no DEM is available and certain locations suffer from high relief (as the shaded DEM shown in Figure 17-1 shows). Taking into account these regions of intense relief, the Baikal study area has been reduced in size mainly focusing on the western side of the lake. Ground data is restricted to the northern section of the Baikal region. A priority frame list for processing by DLR will include data covering the Baikal region.

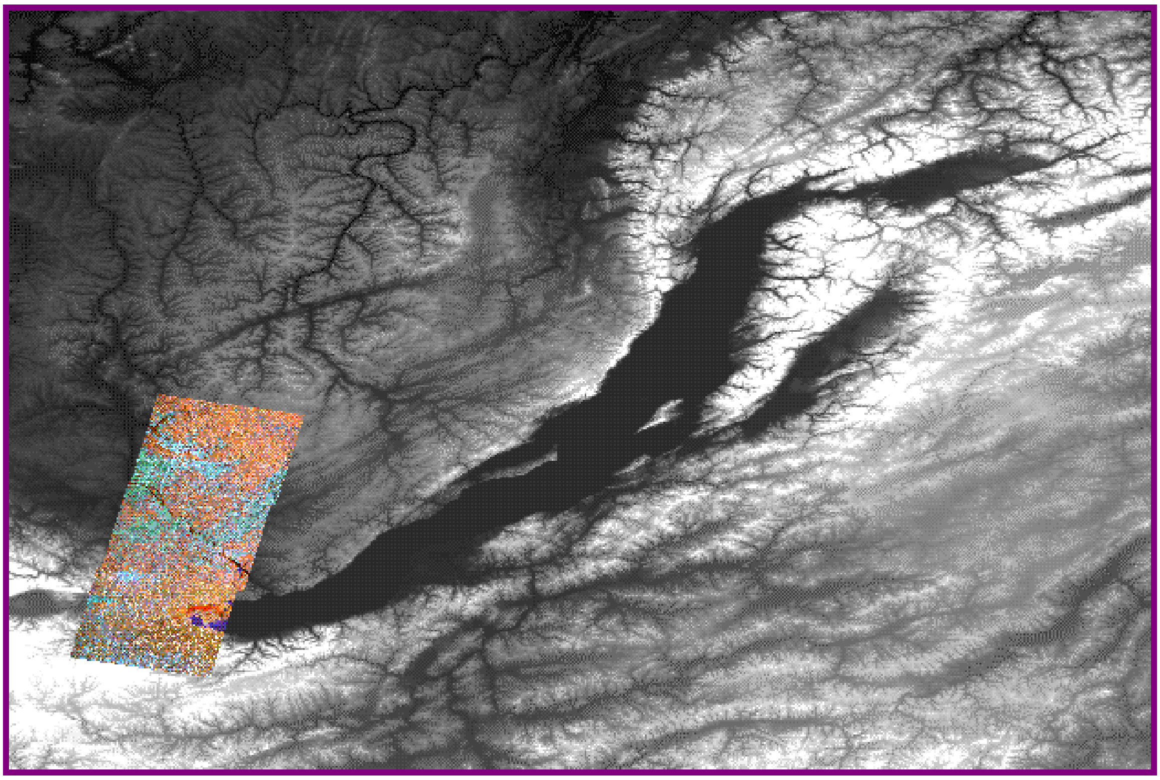

Figure 17-2: Lake Baikal region (800km x 800km) GTOPO30 DEM (1km resolution) overlaid by 3 available ERS scenes (amplitude and coherence composite).

18. Natural Environment Research Council (NERC)

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18.1. Objectives

The tasks assigned to NERC are WP 5040 (Accuracy Assessment) and participation in WP 5300 sharing responsibilities with UWS. The objectives of WP 5040 according to the Technical Annex are the definition of methods for accuracy assessment of the classification methodology, and the physical and statistical implications of the methods; the synthesis of the assessment of results on a training test site; an analysis of the implications for large scale mapping and methods for accuracy assessment of the global map.

18.2. Technical Aspects

18.2.1 Methods of Accuracy Assessment

A literature search on accuracy assessment was performed, to get an overview of available techniques and statistical methods. Minimum requirements for an accuracy report are

- geometric accuracy: standard deviation in x and y direction during co-registration;
- classification accuracy: coefficient of agreement (CA) for training areas to assess their quality;
- map accuracy: co-occurence matrix, class-specific errors of commission and of omission, overall accuracy and CA between classification and ground data (up-to-date GIS database).

An *a priori* coefficient of agreement for nominal data is τ. It estimates the expected chance agreement from *a priori* knowledge about the expected class frequencies. If nothing is known *a priori*, each class is assumed to occur with equal probabilities.

An *a posteriori* coefficient of agreement is κ. It estimates the expected chance agreement from the observed marginal distributions of the co-occurrence matrix. Although a final recommendation of which coefficient to use can not yet be made, κ is fairly common and could be used by all project partners in the SIBERIA project.

Some image processing software packages offer accuracy assessment methods. However, the applicability of these methods is rather restricted and not very flexible. To implement accuracy assessment, a C programme (KAPPA.C) has been written to estimate τ, κ, their 95% confidence intervals, standard deviations and significance probabilities, and to print a co-occurence matrix between two 8 bit images.

Another C programme (COMPARE2KAPPAS.C) has been completed to compare two coefficients of agreement and test the statistical significance of them being different. This bears the opportunity to check whether two classification algorithms produce different accuracies.

18.2.2 Assessment of Geometric Accuracy

As data availability has been limited, we started working on the Ust-Ilimsk test site. All images and GIS layers were co-registered to ERS_32371_2421 (GEC product) using around ten ground control points. The intersection between GIS, ERS_32371_2421 and JERS_28593_201/202 is covering approximately 2800 km2. The following database in UTM geometry has been set up (Table 18-1). GIS variables represent the year 1991, and were recently updated to the requirements of the customers.

Database channel	Orbit and frame number
amplitude ERS-1 23/09/1997	32371_2421
amplitude ERS-2 24/09/1997	32371_2421
amplitude ERS-2 27/05/1998	32371_2421
1 day coherence 23-24/09/1997	32371_2421
amplitude JERS-1 04/05/1997	28593_201, 28593_202
amplitude JERS-1 31/07/1997	29911_202
forest type (coniferous, mixedwood, deciduous)	
relative stocking (2 classes)	
forest age (2 classes)	
total growing stock per hectare (6 classes)	

Table 18-1: Structure of the database of SAR images and GIS layers.

The standard deviation of the coordinate transformations in x- and y-direction varied between 21 m and 34 m, which is less than the pixel spacing of 50 m. Nearest neighbour resampling was used.

18.2.3 A first Supervised Classification at Ust-Ilimsk

18.2.3.1. Assessment of classification accuracy

A first supervised maximum likelihood classification (classes: forest, non-forest, river) was undertaken using all satellite channels except the second JERS pass. The highest information content was found to be in L-band amplitude of JERS-1 and the C-band ERS coherence. The signature separability was measured by the Bhattacharrya distance (scaled to $0 \leq B \leq 2$), and was greater than 1.94 for each pair of classes (very good separability). The overall accuracy of the training areas was 97.3% and $\kappa = 0.95$.

18.2.3.2. Demonstration of techniques for map accuracy assessment

The overall accuracy of the classification was 71.5%, $\kappa = 0.75$, $s_\kappa = 0.00057$. However, from the co-occurence matrix between the classification and the GIS (Table 18-2), the reason for this low overall accuracy lies in the low consumer's accuracy of non-forest (14.01%). A high proportion of forest classes in the GIS have been classified as non-forest. As the time lag between the GIS and the remote sensing data acquisition is 6-7 years, it is highly likely that new clearcuts have been made. The effects of misclassification and land use change combine in this co-occurence matrix and make it inadequate for an assessment of classification accuracy.

reference class classified as	forest	non-forest	Σ	consumer's accuracy
forest	749 752	14 336	764 088	98.12%
non-forest	305 060	49 684	354 744	14.01%
Σ	1 054 812	64 020	1 118 832	
producer's accuracy	71.08%	77.61%		

Table 18-2: Co-occurence matrix of pixels in the classified image and the GIS. Pixel spacing is 50 m.

18.2.4 Conclusions

The results discussed above show the urgent need for up-to-date ground data as a prerequisite for accuracy assessment. The methods and technical procedures for accuracy assessment are in an operational stage, and once sufficient remote sensing images (preferably GTC products) and GIS data are provided, the accuracies of different classification methodologies can be assessed.

It has yet to be examined how textural information may improve the classification accuracy. ERS-SLCI and JERS-3 look-images have recently been received and will be used to investigate this issue.

The applicability of the techniques has been demonstrated for the Ust-Ilimsk test site. However, reduced data availability is still the primary problem which is causing considerable delay. The implications of the suggested methods for accuracy assessment for the global map have yet to be analysed.

18.3. Administrative Aspects

NERC's involvement in SIBERIA is carried out by the Section for Earth Observation at the Institute of Terrestrial Ecology at Monks Wood. John Baker is responsible for the project until his retirement at the end of March 1999. Steve Plummer will then be in charge of the project. However, the continuity of work is ensured by the continuous allocation of Heiko Balzter to the project, who is employed from 50% EU and 50% NERC funds.

ITE contributed towards both project meetings in Vienna and Toulouse. Regular monthly WP reports were submitted to the methodology team coordinator, Shaun Quegan.

18.4. References

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19.1. Administrative Issues:

Personnel: In December 1998 Andreas Wiesmann started to work on the project after finishing his Ph.D. at the Institute of Applied Physics of the University of Berne.

Financial status: All the required material was sent to the Swiss Federal Office for Education and Science, the funding agency for the Swiss participation in EC Env. and Climate Program of the 4th Framework. Because of the late availability of the EC Contract we did not yet receive our first payment, but it is expected soon.

Meetings: Participation at the "Kickoff Meeting" (T. Strozzi) and at the "Toulouse Meeting" (U. Wegmüller).

19.2. Introduction

Within the Siberia Project Gamma Remote Sensing is mainly responsible for the JERS data processing. Therefore our progress report is focusing on the JERS processing related subjects.

19.3. JERS data acquisition status

19.3.1 JERS data received

One of the main problems we encounter is the delay in the JERS raw data availability. So far only data of 2 JERS orbits of the same track over Bratsk are available (Table 19-1). The spatial track separation of the two orbits is around 8 km and therefore this data is not appropriate for interferometry.

Date	Orbit	Rows	Comments
21-Sep-98	28593	200-209	Bratsk
13-Oct-98	29911	202-205,207-209	Bratsk

Table 19-1: JERS data availability (status 14 Jan. 1999)

19.3.2 JERS data order

At the "Toulouse-Meeting" it was decided to order additional JERS data from NASDA. Based on the JERS catalogue JERS data were selected for the main test sites taking into account test-site location, acquisition date, and possibilities for interferometric and multi-temporal intensity analysis. Concerning the acquisition time we tried to select at least one summer acquisition in 1997 or 1998. Then, if possible, we added at least one pair with a 44 days acquisition interval and a short baseline below 1000m for interferometric analysis (coherence, height retrieval). For the multi-temporal intensity analysis we tried to achieve, if possible, 3 images of different seasons or different years. These criteria lead to the following selection:

Test-Area 1: (2 tracks with 2 acquisitions each)

1998/06/18 04:51:34.613 RSP: 148 ROW: 200 to 210
1998/08/01 04:52:22.027 RSP: 148 ROW: 200 to 210
1998/06/20 04:55:57.899 RSP: 150 ROW: 200 to 210
1998/08/03 04:56:43.939 RSP: 150 ROW: 200 to 210
Master Epoch: 1998/06/18 04:51:34.613 RSP-Row (D):148-208
Slave Epoch B (m) Bp (m) Bh (m)
1998/08/01 04:52:22.027 692.03 689.37 60.59
Master Epoch: 1998/06/20 04:55:57.899 RSP-Row (D):150-208
Slave Epoch B (m) Bp (m) Bh (m)
1998/08/03 04:56:43.939 370.28 358.93 -90.95

Test-Area 2: (3 tracks with 4 acquisitions each)

1994/07/23 03:54:41.595 RSP: 130 ROW: 200 to 209
1994/07/25 03:59:08.125 RSP: 132 ROW: 200 to 209
1994/07/27 04:03:34.351 RSP: 134 ROW: 200 to 209
1995/01/15 03:59:14.485 RSP: 130 ROW: 200 to 209
1995/02/28 04:00:11.588 RSP: 130 ROW: 200 to 209
1995/01/17 04:03:41.800 RSP: 132 ROW: 200 to 209
1995/03/02 04:04:35.291 RSP: 132 ROW: 200 to 209
1995/11/23 04:12:49.557 RSP: 134 ROW: 200 to 209
1996/01/06 04:13:12.729 RSP: 134 ROW: 200 to 209
1998/07/14 04:12:17.610 RSP: 130 ROW: 200 to 209
1998/07/16 04:16:44.318 RSP: 132 ROW: 200 to 209
1998/07/18 04:21:09.935 RSP: 134 ROW: 200 to 209
Master Epoch: 1995/01/15 03:59:14.485 RSP-Row (D):130-206
Slave Epoch B (m) Bp (m) Bh (m)
1995/02/28 04:00:11.588 1614.75 1185.64 1096.21
Master Epoch: 1995/01/17 04:03:41.800 RSP-Row (D):132-206
Slave Epoch B (m) Bp (m) Bh (m)
1995/03/02 04:04:35.291 740.07 479.50 563.72

Test-Area 3: (2 tracks with 5 acquisition each)

1994/08/27 03:36:17.901 RSP: 121 ROW: 202 to 214
1994/10/10 03:37:32.565 RSP: 121 ROW: 202 to 214
1994/08/29 03:40:45.236 RSP: 123 ROW: 202 to 214
1994/10/12 03:41:58.884 RSP: 123 ROW: 202 to 214
1998/01/10 03:49:20.700 RSP: 121 ROW: 202 to 214
1998/02/23 03:50:18.408 RSP: 121 ROW: 202 to 214
1998/01/12 03:53:46.643 RSP: 123 ROW: 202 to 214

1998/02/25 03:54:41.615 RSP: 123 ROW: 202 to 214
1998/07/05 03:52:42.257 RSP: 121 ROW: 202 to 214
1998/07/07 03:57:08.263 RSP: 123 ROW: 202 to 214
Master Epoch: 1994/08/27 03:36:17.901 RSP-Row (D):121-208

Slave Epoch	B (m)	Bp (m)	Bh (m)
1994/10/10 03:37:32.565	1808.82	23.39	1808.67

Master Epoch: 1994/08/29 03:40:45.236 RSP-Row (D):123-208

Slave Epoch	B (m)	Bp (m)	Bh (m)
1994/10/12 03:41:58.884	1761.16	256.42	1742.40

Master Epoch: 1998/01/10 03:49:20.700 RSP-Row (D):121-208

Slave Epoch	B (m)	Bp (m)	Bh (m)
1998/02/23 03:50:18.408	456.82	272.54	366.61

Master Epoch: 1998/01/12 03:53:46.643 RSP-Row (D):123-208

Slave Epoch	B (m)	Bp (m)	Bh (m)
1998/02/25 03:54:41.615	961.61	959.85	58.16

The north-south extensions of the selected data strips cover the entire north-south extension of the complete Siberia project area and not just the main test-sites, in order to avoid later re-ordering of data of the same orbits. The ordered data is well suited for the intended tasks.

19.4. JERS SAR processing

19.4.1 Processing status

SAR processing of the available 17 JERS RAW data frames was completed using the Gamma Modular SAR Processor (MSP). An overview of the processed data is shown in Figure 19-1.

19.4.2 Delivery to methodology team

In a first delivery a small JERS image section was sent to the methodology team with a catalogue of questions concerning data format, scaling, geometry, and spatial resolution. In a second delivery the entire available data were sent to the methodology team. In addition to the proposed 50m resolution products in GEC geometry full resolution data in slant range geometry was supplied to allow investigations on aspects as data filtering, geometric transformation, and the addition of a image texture layer.

19.4.3 Radiometric calibration

A special effort is made to ascertain good radiometric calibration of the JERS processing. The MSP processor accounts for (a) JERS sensitivity gain control (STC), and (b) automatic gain control (AGC). In addition it corrects for (c) JERS range antenna pattern and applies (d) radio frequency interference (RFI) filtering. Gain saturation correction is not applied.

Masanobu Shimada kindly made JERS RAW data and information on 2 active calibrators available to determine the calibration factor required for the absolute radiometric calibration of JERS SAR processing with the MSP. In our JERS calibration experiment these data were processed. The active calibrators could be identified and used to determine the required absolute calibration factor. It is planned to further test the calibration.

19.5. JERS Interferometry

19.5.1 Processing status

So far we do not have access to JERS data over Siberia which is appropriate for interferometric analysis. Such data is ordered, though, and will hopefully soon become available.

19.5.2 Methodological issues

Thanks to a co-operation with Chalmers Technical University (Askne, Dammert) we have access to interferometric JERS data over a boreal site in Sweden. We used these data for methodological development. Currently we are evaluating the accuracy of a JERS interferometric DEM over boreal forest and the effect of the forest on the height estimates by comparison of the interferometric DEM with a conventional DEM.

Based on JERS data over Sweden, Finland, and Brazil we concluded that acquisition intervals of 44 days with short baselines are preferred for the interferometric use of JERS over Siberia.

19.6. Image geometry

19.6.1 SAR geocoding

With our processing software we are able to provide the JERS data in slant-range, ground-range, Geocoded Ellipsoid Corrected (GEC), and if a DEM is available also in Geocoded Terrain Corrected (GTC) geometry. For the geocoding the Krassowski 1940 ellipsoid, the Plokovo 1942 datum, and the Russian map coordinates (Transverse Mercator) zones 46-48 will be used.

Coarse height information based on a global DEM is available for Siberia. It's use for the SAR geocoding and interferometric analysis will be tested.

19.6.2 ERS/JERS registration

After the discussions at the Toulouse Meeting we concluded that ERS/JERS cross-registration has to take place in the map geometry. The use of the global DEM is expected to improve the registration accuracy as compared to GEC products. Software for geocoding, automated cross-registration and resampling of image data is available at Gamma and was offered to the interested partners.

19.7. Problems

In spite of the already available JERS data, including the data available from other research projects, the limited access to the required JERS data turns more and more into a problem. In particular the methodology team has an urgent need for JERS data over the main test areas.

After the discussions at the Toulouse Meeting Gamma selected appropriate JERS data using the NASDA catalogue. To proceed without further delay the order was sent to Victor Taylor on 23-Dec-98 with a copy to Chris Schmullius. Unfortunately, we did not yet get any kind of confirmation if we will receive the data or when we will receive the data.

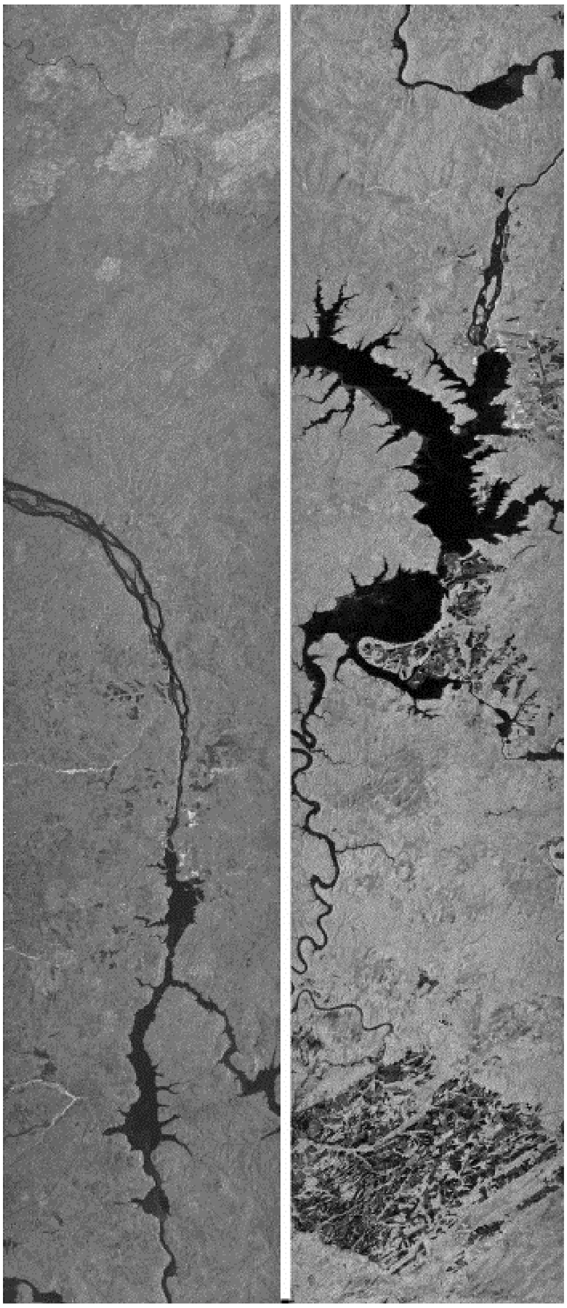

Figure 19-1: Survey over 10 processed JERS frames (Oribt 28593, Bratsk).