Closing the Gap - a Siberian Boreal Forest map with ERS-1/2 and JERS-1

Christiane Schmullius

DLR - Institute for Radio-Frequency Technology, P.O. Box 11 19, 82230 Wessling, Germany,

E-mail: chris.schmullius dlr.de

http://www.op.dlr.de/ne-hf/Willkommen.html

Ake Rosenqvist

Earth Observation Center, National Space Development Agency of Japan, 1401 Numanoue, Ohashi, Hatoyama-machi, Hiki-gun, Saitama 350-03, Japan,

E-mail: ake heoc.eoc.nasda.go.jp

Abstract

Radar remote sensing of boreal forest ecosystems has shown sensitivity of the radar backscatter values to the freeze/thaw-cycle, forest fires and logging. Using C-band data in combination with L-band from the operational radar satellites ERS and JERS-1 has shown great potential for vegetation mapping, despite the limitation to co-polarization only. JERS-1 and ERS-1 and -2 Tandem data will be acquired "simultaneously" between July 1 and August 15, 1997 from the central Siberian boreal forests (90-140 deg E, 53-70 deg N). No ERS-data could be collected from this area until today. For this purpose, a DLR X-band receiving station will be located in Ulan Bator, Mongolia.

Keywords: *Boreal Forest, Radar Remote Sensing, ERS, JERS, DLR Receiving Station.*

Introduction

Radar remote sensing of boreal forest ecosystems has become an increasingly important tool for understanding the biophysical mechanisms such as evaporation and CO2-exchange with the atmosphere. ERS-1 SAR results have shown sensitivity of the radar backscatter values to the freeze/thaw-cycle, forest fires and logging. The C-band wavelength, however, is too short to penetrate the vegetation canopy enough to enable forest type discrimination. Results from the two SIR-C/X-SAR radar shuttle campaigns in 1994 indicated the great advantage of using polarimetric L-band data in combination with C-band for vegetation mapping (Schmullius & Evans, 1997). These findings were supported using the images from the operational radar satellites ERS and JERS-1, despite their limitation on co-polarization only (LeToan *et al.*, 1997, Kellndorfer *et al.* 1997).

Data Acquisition

Since the successfull launch of the ERS-1 satellite in 1991 and its successor ERS-2, a number of data gaps exist over the globe due to missing receiving stations. The German Aerospace Research Establishment (DLR) has helped in closing these gaps through the deployment of mobile receiving stations e.g. in Libreville, Gabun and Cordoba, Argentina. In summer 1997, a cooperative initiative will start between NASDA, JRC and DLR. JERS-1 and ERS-1 and -2 Tandem SAR data will be acquired "simultaneously" between July 1 and August 15, 1997 from the central Siberian boreal forests (90-140 deg E, 53-70 deg N). The DLR station will continue to operate until the end of 1997, enabling temporal coverage of selected sites also. No ERS-data could be collected from this area until today. For this purpose, a DLR X-band receiving station will be located in Ulan Bator, Mongolia. Figure1 shows the current coverages of ERS receiving stations, the thick circle represents the coverage for Ulan Bator.

The JERS-1 acquisitions, which cover the entire Eurasian boreal zone, are recorded by using the on-board tape recorder. JERS-1 data has already been collected between 53 to 70 degrees Northern latitude and West of the Ural mountains in February and March 1997, recording is continued in April and May between 43 and 60 degrees Northern latitude and 90 to 140 degrees Eastern longitude. In the time frame June to August 1997 the boreal areas between 53 to 70 degrees Northern latitude and 60 to 140 degrees Eastern longitude are covered. The image swaths are consecutively acquired from East to West.

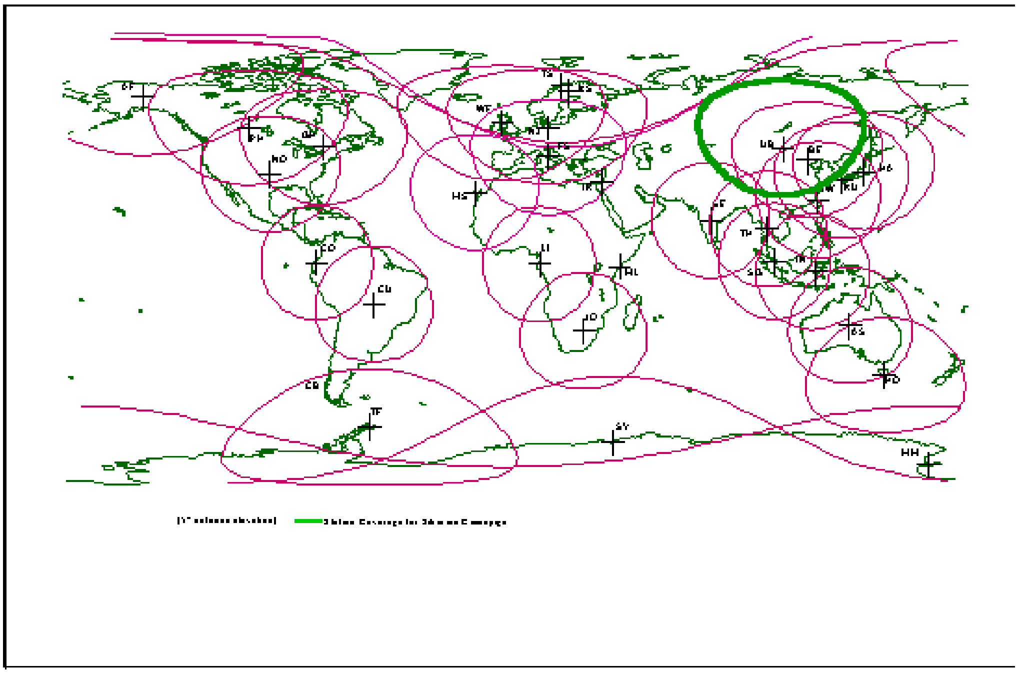

Figure1: 5 deg antenna elevation coverage of operational ERS receiving stations (thick green line: planned Siberian coverage).

Scientific Rationale: The Siberian Taiga

The global boreal forest biome represents one of the major carbon storage pools. Its northern and southern boundaries, as well as the absolute amount of plant growth, are sensitive to temperature changes. Recently an increase of photosynthetic activity of terrestrial vegetation between 1981 to 1991 has been published (B. Myneni *et al.*, 1997). The regions of greatest increase lay between 45°N and 70°N.

The boreal forests of central and western Siberia represent the largest unbroken tracts of forest on Earth. For this reason, the region is receiving increasing interest from organisations with conservational, climatological as well as political background. "Siberia's forests, comprising about one-fifth of the world's total forests, make a crucial contribution to the stability of local, regional, and global ecosystems. They also play a key role in future international trade, as the global supply of commercial wood and fiber decreases... Sustainable approaches are essential for long-term management of forests, for biodiversity conservation, and for mitigation of climate change impacts" (excerpt from the Sustainable Boreal Forest Resources Project, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria). IGBP studies of high-latitude regions are being undertaken in the framework of the programs Global Change and Terrestrial Ecosystems (GCTE), High Latitude Ecosystems as Sources and Sinks of Trace Gases (HESS) and, specifically relevant for this project, the Boreal Forest Transect Case Study (BFTCS).

Boreal forests consist of conifers (larch, spruce and pine) with birch as the major hardwood species. The selected region of the Central Siberian Plateau is of special interest because it belongs to the best Taiga habitats with the highest canopy density values > 80% (Atlas of the Forests of the UDSSR, 1973; Wismann, V. *et al.*, 1996). The time frame for the mutual ERS/JERS-acquisition covers the short Siberian summer with monthly mean temperatures above 0 deg C and full vegetation development. The acquired radar images will establish an initial data set to support resesarch about the natural dynamics of boreal ecosystems through fire and insects, or anthropogenic stress factors such as deforestation. Long-term monitoring may in the future be accomplished through a Russian receiving station.

Tandem Campaign

ERS-Tandem data enable the generation of coherence images, which are used as helpful input to landcover classifications, and - depending on the degree of coherence- the generation of digital elevation models (DEM). The coherence is dependent on the magnitude of surface changes, eg. the type, state and amount of vegetation.

Forest canopy height information can be extracted in suitable terrain if the coherence is sufficiently high (Solaas et al., 1996).

During a tandem campaign ERS-1 and -2 are operated together, such that the time between acquisitions can be reduced to ensure an adequate coherence between successive SAR scenes. This means that the same swath on ground is acquired by ERS-2 one day after ERS-1. The majority of land areas have already been covered. In particular (apart from Siberia) latitudes above 60º N and S are covered by at least one acquisition (see Figure 2).

In September 1999, the Shuttle Radar Topography Mission (SRTM) will be launched to produce a digital topographic map with 30 m resolution of 80% of the Earth's land surface. Because it is based on the Space Shuttle, which can be launched to a maximum inclination of 57 degrees, areas of the Earth poleward of about 60 degrees latitude will not be mapped (see red line in Figur x). However, ESA's ERS satellites have already acquired significant amounts of data which can be processed to digital topographic maps over these areas. The Ulan Bator station is necessary to supply the missing interferometric data sets for a complete global digital elevation model.

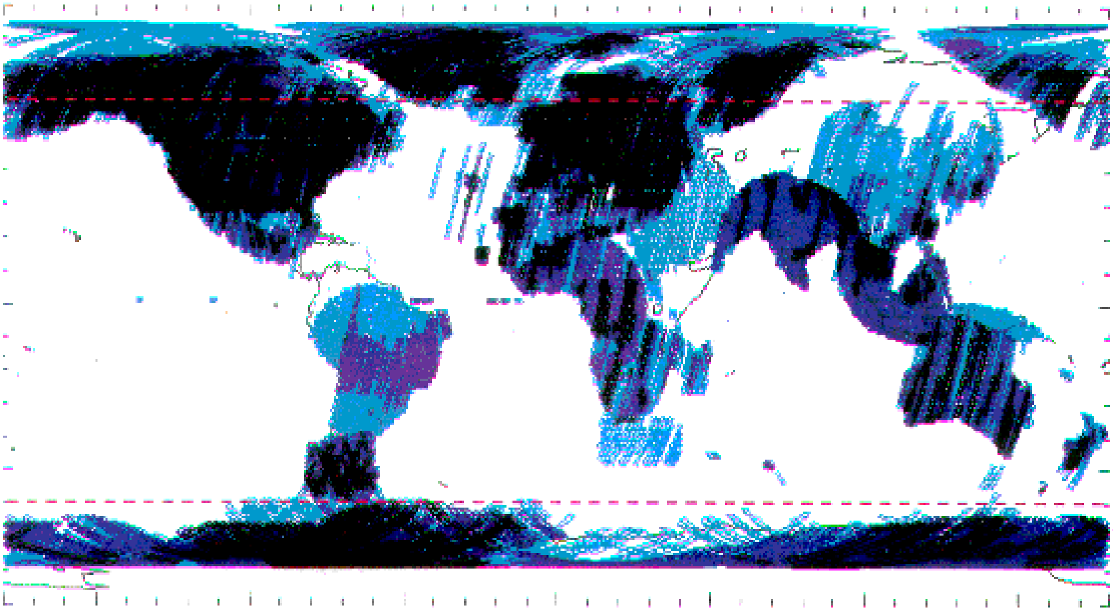

Figure 2: Mercator projection of tandem acquisitions with baseline between 50m and 300m.

White = No tandem acquisitions, Turquoise = One tandem acquisition,

Blue = Two tandem acquisitions, Black = Three or more tandem acquisitions

(copyright http://gds.esrin.esa.it/earlyres1, G.Solaas et al., 1996).

Data Handling

The approximately 4000 image scenes per sensor shall be geocoded and mosaicked accordingly to the procedures developed during the on-going Global Rain Forest Mapping Project (GRFM) with JERS-1 (Rosenqvist, 1997). Accordingly, the JERS project is titled Global Boreal Forest Mapping (GBFM). Eventually, a 2-frequency composite and forest classification map is aspired. This map will be a unique, up-to-date source of information for foresters, as well as for geoscientists and climatologists. A project proposal is being developed.

Figure 3 shows a composite image of the river Selenga similar to the satellite products expected. This scene was acquired with the SIR-C/X-SAR instruments on-board the Space Shuttle Endeavour on October 7, 1994 (red: C-band, VV-polarization; green: L-band, HH-polarization; blue: inverted L-band, HH-polarization). The area is near the city Kudara in Russia on the southeastern shore of Lake Baikal. The image reveals the capabilities of a C- and L-band composite for landcover mapping. Although the temperatures were below

0 deg C and the vegetation in the senescious stage, different cover types are recognizable: natural forest in the mountains (green), cultivated forest (turquoise, regrowth: magenta) and agricultural fields (brown and orange) in the lowlands, several types of flood-plain communities (forests: light green, marshland and meadows: shades of orange).

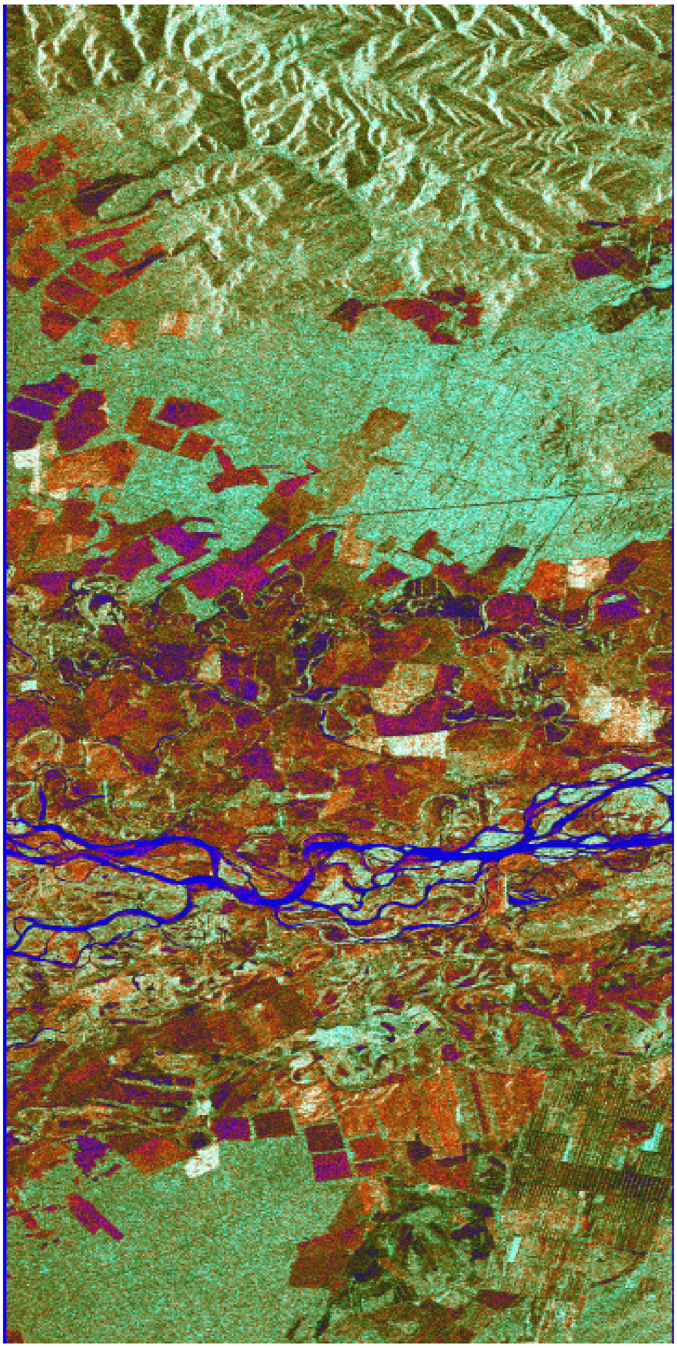

Figure 3: SIR-C/X-SAR CVV and LHH composite East of Lake Baikal.

Conclusions

Through the the deployment of the DLR-DFD receiving station complete ERS interferometric data acquisition of Central Siberia will be made available. Due to the JERS-coverage at the same time frame, dual frequency images of the largest contineous area ever covered by radar satellites will be collected.

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