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The German Antarctic Receiving Station within the International Ground Segment for Remote Sensing

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Summary: The article gives an overview of the technical configuration of the German Antarctic Receiving Station (GARS) at O'Higgins, located on the Antarctic Peninsula, and a summary of nine years of operation. The main task of this facility is the acquisition of Synthetic Aperture Radar (SAR) data of the European Remote Sensing ERS satellite for a wide range of scientific applications. GARS is part of the international ground segment for remote sensing operated by the German Remote Sensing Data Center DFD of the German Aerospace Center DLR. Precision processing and long-time archiving of all acquired data is performed by the D-PAF (German Processing and Archiving Facility) according to ESA standards (ESA 1992) and under ESA contract. Special products and the support of individual projects can be arranged in cooperation with national and international users.

Zusammenfassung: Der Bericht gibt einen Überblick über die auf der Antarktischen Halbinsel gelegene Deutschen Antarktis-Empfangsstation bei O'Higgins und eine Zusammenfassung des Betriebs während der letzten neun Jahre. Hauptaufgabe dieser Anlage ist die Akquisition von SAR-Daten (Synthetic Aperture Radar) der Europäischen Fernerkundungssatelliten (ERS) für einen weitgefächerten Bereich von wissenschaftlichen Anwendungen. GARS ist Teil des internationalen Bodensegments zur Fernerkundung und wird vom Deutschen Fernerkundungsdatenzentrum (DFD) des Deutschen Zentrums für Luft- und Raumfahrt (DLR) betrieben. Präzisionsprozessierung und Langzeit-Archivierung aller aufgezeichneten Daten erfolgt durch das D-PAF (German Processing and Archiving Facility) gemäß ESA Standards (ESA 1992) und unter einem ESA-Kontrakt. Spezielle Produkte und die Unterstützung von individuellen Projekten kann in Kooperation mit nationalen und internationalen Nutzern vereinbart werden.

HISTORY, LOCATION, STATION CONCEPT

Starting in 1983 DLR planned to design and implement a transportable receiving station for the acquisition of data from remote sensing satellites to support scientific projects outside the coverage of existing ground stations, especially in developing countries and remote regions like Antarctica. With the launch of the first European Remote Sensing Satellite ERS-1 1991, followed by ERS-2 in 1995, and the requirements of the German national research program for the Antarctica these plans became reality. Due to the orbital characteristics (polar orbit at 780 km altitude) and the high data rates generated by the Synthetic Aperture Radar (SAR) sensor (105 Mb/s data rate), onboard storage of the sensed data was not possible, requiring the location of a receiving station in the area of investigation. The long term aspects of the research programs, the demand for data acquisition throughout all seasons of the year and the additional task to support geodetic research with VLBI (Very Long Baseline Interferometry) and GPS methods led to a modified concept of the station which now has become a fixed ground station with VLBI capability. Consequently the originally idea of a transportable station was abandoned.

The area of investigation focuses on the Antarctic Peninsula with the surrounding Weddell and Bellingshausen Seas as central area of interest, the Peninsula itself and the southern cone of South America. GARS forms together with the ground stations at Syowa (Japan) and McMurdo (USA) a set of ground stations which covers all of the Antarctic continent and the surrounding water bodies (Fig. 1).

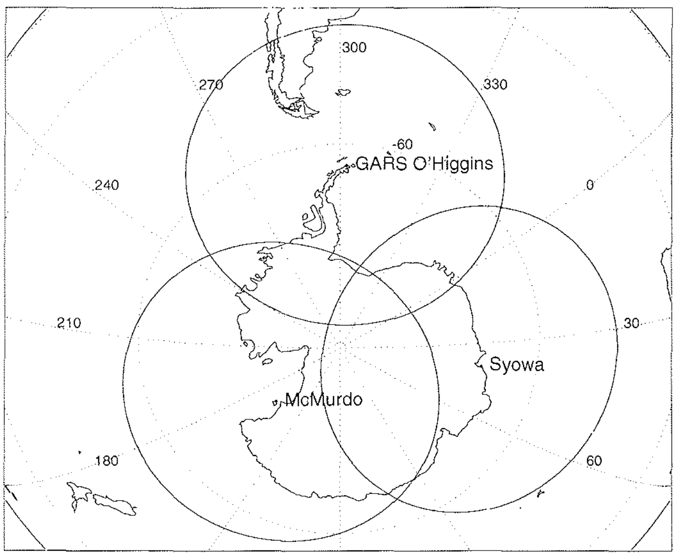

Fig. 1: Ground station coverage of X-band-receiving stations in Antarctica for ERS-1/2 (visibility circles).

Abb. 1: Abdeckung (Sichtbarkeitskreise) der X-Band-Bodenstationen für ERS-1/2 in der Antarktis.

Although satellite data reception could basically be performed at any location on the Antarctic Peninsula, logistic and financial constraints required close connection to an already existing base, and the geodetic applications of the station demanded the selection of a tectonically stable position on the Antarctic plate. Only a few already existing Antarctic bases on the Peninsula could fulfill this requirement. Finally, and in cooperation with the Instituto Nacional Antártico Chileno (INACH) of Chile, it was decided to install the satellite receiving station in the close vicinity of the existing Chilean Antarctic base "General Bernardo O'Higgins" at 63°19'16" S, 57°54'04" W.

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Fig. 2: The German Antarctic Receiving Station (GARS) at O'Higgins Base.

Abb. 2: Die Deutsche Antarktis-Empfangsstation (GARS) an der O'Higgins-Station.

The main construction phase was completed in September 1991, followed by regular acquisition campaigns (REINIGER et al. 1992). The station operates exclusively on a campaign basis and during requested time periods of the year in accordance with ESA/ESRIN, which is responsible for ERS satellite operation, and with the user community. Between acquisition campaigns the station is switched down to a hibernating survival state, monitored by the permanent staff of Chile's O'Higgins base.

During the operational periods GARS is widely self-sufficient regarding the scientific and technical equipment, infrastructure and operation. Logistical support for transportation of material and persons, medical assistance and emergency help is provided by the O'Higgins base as part of the cooperation agreement with Chile, whose primary purpose is to enable scientific evaluation of the acquired data.

GARS O'Higgins station operates as a satellite receiving station of DFD in a world-wide ground station network to acquire ERS-SAR and other remote sensing data (Fig. 2).Up to date information about this network is available from the INTERNET (http://www.dfd.dlr.de).

SCIENTIFIC AND TECHNICAL INSTALLATIONS

Due to the technical and scientific requirements, but especially regarding the environmental conditions of Antarctica with its extreme wind velocities and low temperatures, a nonstandard construction of a high precision tracking pedestal was selected (Fig.3). The technical solution was to realize the elevation movement by means of two hemispheres with an oblique rotation axis and which can be rotated one against the other. This axis of rotation is inclined at 47°.

The antenna drives, the servo electronics as well as the microwave subsystem are contained in the antenna tower. The antenna system is of the Cassegrain type with coaxial arrangement of the reflectors and the feeds. The main reflector, constructed as a parabolic dish (9 m diameter with an overall surface precision better than 0.5 mm, rms.), and the hyperbolic subreflector (1.33 m diameter; surface precision better than ±0.25 mm, rms.) focus the incoming wavefront into a multi-frequency and multimode feedhorn for all receiving bands, X / S / L. To minimize the effect of snow, ice and wind, the main reflector is built up as an encased steel frame with composite reflector front panels including a heating system for the reflector surface and a composite rear cover. A detailed description is given in REINIGER (1997).

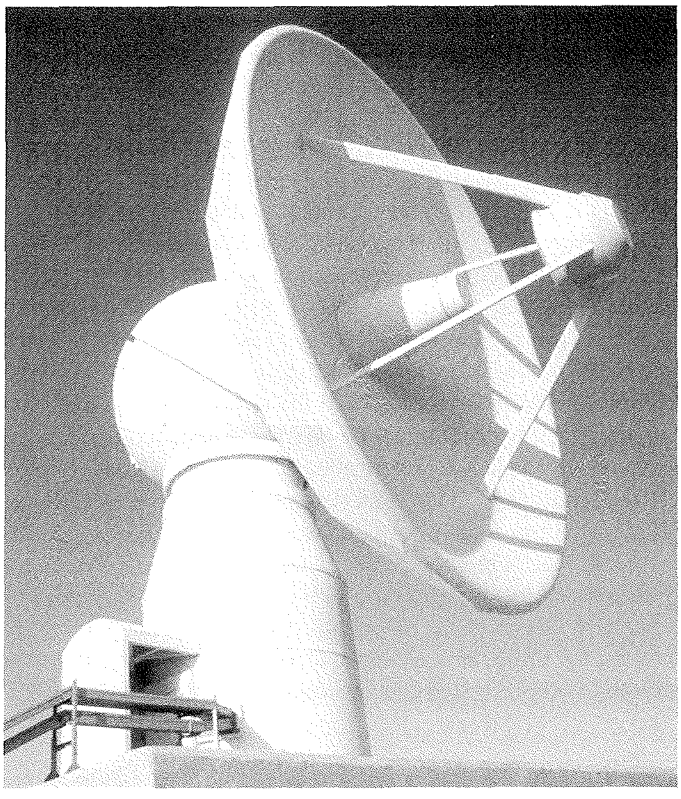

Fig. 3: Antenna design of X-band receiving station GARS.

Abb. 3: Aufbau der GARS X-Band-Empfangsantenne.

The verified receiving figure of merit G/T is >31.5 dB/K in X-band and >22.1 dB/K in S-band at 5° elevation and at 273 K.

For satellite tracking the system is equipped for program- and auto-tracking modes in both reception bands. A special receiver which includes a cryogenic liquid helium cooled low-noise amplifier (REINHOLD et al. 1995, IHDE et al. 1997) is dedicated to the VLBI operations. The redundancy concept for improved operation reliability and availability includes a hot (tape recorders, receivers) and a cold (LNAs) standby and extended spare part supply. Quality control and evaluation (in a limited scope) of received data is possible with a SAR real-time processor (SCHOTTER 1991), which is used also for the production of reduced resolution (100 m) quicklook images.

INFRASTRUCTURE AND LOGISTICS

The concept of the infrastructure and logistic of the station is based on close cooperation with the Chilean partner and the support given by its "General Bernardo O'Higgins" Antarctic Base. However, the technical performance and the complex operational schedules required the set-up of an almost complete and independent infrastructure, which was realized with prefabricated elements and integrated into 20-foot standard shipping containers. Except for the antenna tower, the station is assembled as two arrays forming:

- the main station, housing the operation rooms and the living area (14 containers) and
- the engineering support area of a group 16 containers for electric power generation, fuel storage, sea water desalination, sewage water treatment, workshops, storage space and service rooms.

Access to GARS is possible by aircraft via Frei Base on a landing strip at a glacier nearby, by ship with an icebreaker throughout the year, or with common vessels during the Austral summer season (November to March).

A further infrastructural extension of GARS is not foreseen; however upgradings for new satellites (e.g. ENVISAT) and improved data and communication (Internet) infrastructure will be realized in the near future.

OPERATIONAL RESULTS

During the past nine years of work with 680 operational days, a total of 4087 passes of ERS-1 and ERS-2 with more than 70000 scenes were acquired. Table 1 gives an overview of all performed ERS acquisition campaigns. The SAR data archive at D-PAF is relevant for applications calling for:

- multiple coverage of all Antarctic areas within the visibility circle depicted in Figure 4, with the number of interferometric data pairs three and higher in blue, two in magenta and one in green,
- complementary overlap in the visibilty circles of the neighboring ERS X-band stations, located at Syowa (Japan) and

name	period	campaign goal	satellites	acquired passes
TF910901:	24.09.91-12.10.91	test acquisition campaign	ERS-1	40
TF920103:	10.01.92-15.03.92	acquisition campaign	ERS-1	349
TF920701:	01.07.92-31.07.92	acquisition campaign	ERS-1	204
TF921101:	02.11.92-09.12.92	acquisition campaign	ERS-1	121
TF930103:	10.01.93-24.02.93	acquisition campaign	ERS-1	173
TF930801:	15.08.93-12.09.93	acquisition campaign	ERS-1	187
TF940103:	20.01.94-20.03.94	acquisition campaign	ERS-1	400
TF950102:	15.01.95-16.02.95	acquisition campaign	ERS-1	206
TF950300:	05.03.95-10.03.95	special acquisition request	ERS-1	5
TF951001:	15.10.95-20.11.95	tandem acquisit. campaign	ERS-1/2	418
TF960103:	15.01.96-24.03.96	tandem acquisit. campaign	ERS-1/2	879
TF961001:	15.10.96-18.11.96	acquisition campaign	ERS-2	118
TF970103:	25.01.97-20.03.97	acquisition campaign	ERS-1/2	285
TF970601:	27.06.97-18.07.97	acquisition campaign	ERS-2	118
TF980103:	15.01.98-24.02.98	acquisition campaign	ERS-2	135
TF990103:	13.01.99-23.02.99	acquisition campaign	ERS-2	149
TF991001:	28.10.99-21.11.99	acquisition campaign	ERS-1/2	111
TF000103:	29.01.00-24.03.00	acquisition campaign	ERS-1/2	189
Next campaigns planned:				
TF001001:	01.10.00-04.11.00	acquisition campaign	ERS-2	(tbd)
TF010103:	13.01.01-17.03.01	acquisition campaign	ERS-2	(tbd)

Tab. 1: ERS Acquisition Campaigns at GARS O'Higgins.

Tab. 1: ERS Akquisitionskampagnen in GARS O'Higgins

Fig. 4: Interferometric coverage. Number of interferometric data pairs: blue >= 3; magenta = 2; green = 1.

Abb. 4: Interferometrische Abdeckung. Zahl der interferometrischen Datenpaare: blau >= 3; magentarot = 2; grün = 1.

McMurdo (USA), in order to provide full coverage of the Antarctic continent and its surrounding ocean bodies,

- coverage of the Bellingshausen and Weddell Seas, the Drake Straite as well as the southern cone of Latin America (Patagonia, Falkland, etc.),
- continuing SAR data availability mainly during Antarctic summer and for large areas also from other seasons,
- continuity of observation over long time periods, extending now a time series of nine years of data, relevant to analyze morphological changes like movement of glaciers and shelf ice and the calving of large icebergs,
- availability of interferometric data sets (3 or more pairs), derived from data during the ERS-1/2 tandem mission,
- data acquired from additional satellites (JERS, Landsat 5, NOAA),
- complementary geodetic measurements (VLBI, PRARE, permanent GPS, tide gauge and other) (THORANDT et al. 1997),
- capability of immediate support for special projects and/or survey groups working in the field with selected data products (sea ice coverage, iceberg drift, ship routing etc.). Figure 5 shows the breakoff of three large mesa icebergs (center in grey) at the Filchner ice shelf (top, light color) and the sea ice (lower left) with the location of the former German "Filchner Station" (lower right). This image was acquired from ERS-2 orbit 20016 on February 17, 1999 10:35 UT. The quicklook image shows a clip of data of 80 • 105 km with a range resolution of 100 m.

PROSPECT

The present planning assumes a continuation of the current activities for the next four to five years. This includes improvement for new satellites, in particular the necessary upgrade for ENVISAT (launch projected for 2000) to be performed during the next campaign in Austral summer 2000 and providing a smooth transition from ERS-SAR to ENVISAT-ASAR. Cooperation in international and national projects remains an important task.

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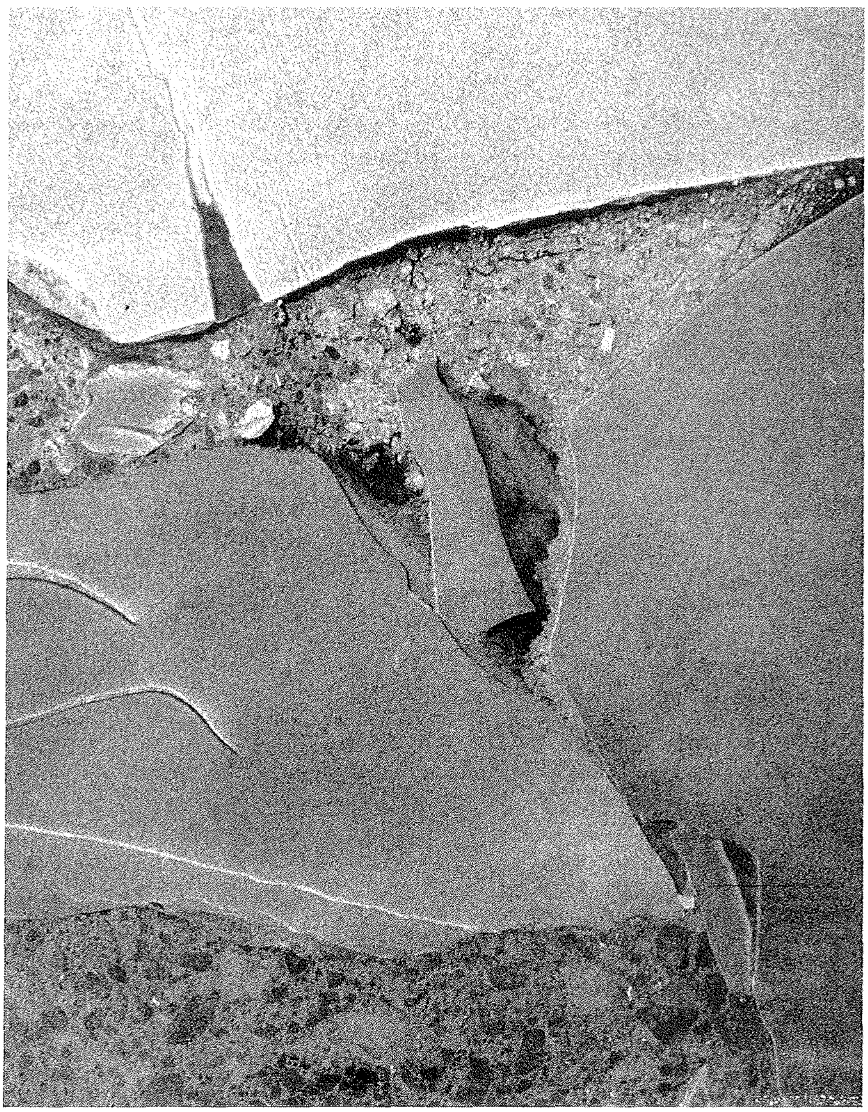

Fig. 5: ERS-2 SAR Quicklook image of Filchner Ice Shelf.

Abb. 5: ERS-2 SAR "Quicklook"-Bild vom Filchner-Schelfeis.