20 Years

ANTARCTIC RESEARCH STATION GARS O'HIGGINS

ABSTRACTS & PROGRAM

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Instituto Antártico Chileno
Ministerio de Relaciones Exteriores
Gobierno de Chile

Bundesamt für Kartographie und Geodäsie

20 Years
ANTARCTIC RESEARCH STATION GARS O'HIGGINS

Symposium, 12-15 November 2011, Punta Arenas, Chile

www.gars-ohiggins.info

Program

Venue: Hotel DREAMS, O'Higgins 1235 (on the Punta Arenas waterfront, next to the Port's Antarctic terminal)

	Saturday, November 12	
17:00 – 18:30	Symposium registration, *at Hotel DREAMS (use moving stairs to 2nd floor)*	
19:00	**Icebreaker / Welcome reception, *at INACH***	

	Sunday, November 13	Symposium "20 years GARS O'Higgins"
	SU.1: Symposium opening / GARS O'Higgins – Past, present & future perspectives, *Session chair: S. Dech, DLR*	
08:20 – 08:50	S. Dech, *DLR, Germany (25')* / H. Schuh, *IAG & IUGG / TU Vienna, Austria (5')*	Address of welcome & introduction to DLR's Earth Observation Center (EOC) / Greetings of IAG Vice-President
08:50 – 09:20	J. Retamales, *INACH, Chile*	The Chilean Antarctic Scientific Program *(working title)*
09:20 – 09:40	K. Reiniger, *DLR, Germany*	GARS, a unique scientific tool to support geophysics and geodetic research at the Antarctic Peninsula and its surrounding bodies
09:40 – 10:00	E. Diedrich et al., *DLR, Germany*	Current Activities at the German Antarctic Receiving Station GARS O'Higgins and Future Perspectives
10:00 – 10:20	Coffee break	
	SU.2: Geodesy & astrometry – VLBI at GARS O'Higgins, *Session chair: H. Schuh, IAG & IUGG/TU Vienna*	
10:20 – 10:50	H. Schuh et al., *TU Vienna, Austria*	Geodetic VLBI at O'Higgins station and the next generation VLBI system
10:50 – 11:20	D. Behrend et al., *NASA/GSFC NVI, U.S.A.*	The Antarctic VLBI Station O'Higgins as a Network Station of the IVS
11:20 – 11:40	U. Schreiber, *BKG, Germany*	The importance of truly global networks for GGOS
11:40 – 12:00	H. Hase, *TIGO/BKG, Chile*	20 years GARS O'Higgins, 10 years TIGO Concepción, what comes next?
12:00 – 13:20	Lunch break	
	SU.3: Earth observation & space geodesy – State-of-the-art SAR technology & applications, *Session chair: T. Fritz, DLR*	
13:20 – 13:50	T. Fritz et al., *DLR, Germany*	TanDEM-X DEM Generation and First Applications
13:50 – 14:20	N. Adam et al., *DLR, Germany*	Differential Interferometry Applications
14:20 – 14:40	U. Steinbrecher et al., *DLR, Germany*	Experimental Radar Modes with TerraSAR-X and TanDEM-X
14:40 – 15:00	G. Riegler, *ASTRIUM, Germany*	Digital Elevation Model based on TerraSAR-X and TanDEM-X Data
15:00 – 15:20	Coffee break	
	SU.4: Earth observation & fieldwork – Focus Antarctic Peninsula, *Session chair: M. Braun, University of Erlangen*	
15:20 – 15:40	I. Hebel et al., *UMAG, Chile*	Antarctica's Vegetation: past and current evidence
15:40 – 16:10	M. Braun, *University of Erlangen, Germany*	Combining field surveys and SAR remote sensing to study Antarctic Peninsula glaciers
16:10 – 16:40	P. Skvarca et al., *IAA, Argentina*	Surface elevation changes and glacier variations in key sites of Antarctic Peninsula and Patagonia
16:40 – 17:00	F. Fernandoy et al., *AWI, Germany*	Stable water isotopes of precipitation and firn cores from the northern Antarctic Peninsula region as a proxy for climate reconstruction
17:00 – 17:20	C. Cardenas et al., *UMAG, Chile*	Surface Ice velocity information at the surroundings of O'Higgins and GARS station in the Antarctic Peninsula
17:30 – 18:30	**SU.P: Poster session**, *Session chair: T. Klügel, BKG*	
	W. Lengert et al., *ESA/ESRIN, Italy*	20 years ERS in Antarctica
	H. Rott et al., *ENVEO, Austria*	Downwasting of glaciers after disintegration of northern Larsen ice shelf
	J. Kohler et al., *NPI, Norway*	Sub-shelf morphology of the Fimbul Ice Shelf, Antarctica
	W. Rack et al., *University of Canterbury, New Zealand*	Interferometric SAR analysis in Dronning Maud Land, Antarctica: precision and accuracy of glaciological products
	M. Baessler et al., *TU Dresden/DLR, Germany*	Estimation of horizontal ice flow velocities and tidal deformation from combined interferometric and feature tracking analyses
	A. Wendt et al., *CECs, Chile*	Ice velocity and ice elevation changes at Fleming Glacier, Antarctic Peninsula
	E. Johnson et al., *UMAG, Chile*	Sea Ice Classification by means of ENVISAT alternating polarization medium resolution images
	S. Kraus et al., *SERNAGEOMIN, Chile*	Geochemical signatures of tephras from Antarctic Peninsula volcanoes
	O. Mustafa et al., *ThINK, Germany*	Monitoring of changes in the spatial distribution of a 3-species penguin rookery at Ardley Island (South Shetland Islands).
	E. Kühmstedt et al., *BKG, Germany*	Rebuilding the Tide Gauge Systems at the Geodetic Observatory GARS O'Higgins / Antarctica
	A. Zimmer et al., *DLR, Germany*	Operation of GARS O'Higgins in the view of technical facilities and mission requirements
	C. Plötz et al., *BKG, Germany*	The German Antarctic Receiving Station O'Higgins - recent status and perspective
18:30 – 19:30	**A. Contreras, *Antarctic explorer, Chile***	**30 years flying into the Antarctic interior - the other world**

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ANTARCTIC RESEARCH STATION GARS O'HIGGINS

	Monday, November 14	Symposium "20 years GARS O'Higgins" / Workshop "Chile-EU research opportunities under FP7" *Joint sessions day*
	MO.1: Climate change – Evidence of ecological responses, *Session chair: L. Bravo, UFRO*	
08:20 – 08:30	J. Retamales, *INACH, Chile*	Introduction to workshop „Chile-EU research opportunities under FP7"
08:30 – 09:00	E. Poulin et al., *Universidad de Chile, Chile*	Diversification processes in the Southern Ocean
09:00 – 09:30	L. Cavieres et al., *Universidad de Concepción, Chile*	Effects of Climate Change on Plant Biota in the Arctic and Antarctic: facts and perspectives
09:30 – 10:00	H. Linderholm, *University of Gothenburg, Sweden*	Dendrochronology studies in Southern Patagonia
10:00 – 10:20		Coffee break
	MO.2: Climate change – Earth observation: Unveiling glaciological processes by SAR, *Session chair: I. Joughin, University of Washington*	
10:20 – 10:50	I. Joughin et al., *University of Washington, U.S.A.*	Contributions to Ice Sheet Research from TerraSAR-X and O'Higgins Ground Station
10:50 – 11:20	A. Humbert, *University of Hamburg, Germany*	Unveiling glaciological processes by means of high-resolution radar imagery
11:20 – 11:40	D. Floricioiu et al., *DLR, Germany*	Ice Dynamics in the Patagonia Icefields derived from TerraSAR-X and TanDEM-X satellite data
11:40 – 12:00	A. Shepherd et al., *University of Leeds, U.K.*	A review of the 2011 ERS-2 3-day campaign
12:00 – 13:20		Lunch break
	MO.3: Climate change – Glaciological & microbiological approach, *Session chair: A. Rivera, CECs*	
13:20 – 13:50	J. Simões et al., *UFRGS, Brazil*	From the tropics to the Antarctic Peninsula: Brazilian satellite remote sensing investigations of ice masses
13:50 – 14:10	R. Jaña et al., *INACH, Chile*	ASTER derived DEMs and ice drainage basins delineation on Fallieres Coast, Antarctic Peninsula
14:10 – 14:40	A. Rivera et al., *CECs, Chile*	Recent expeditions to the interior of Antarctic Ice Sheet
14:40 – 15:00	M. Gonzalez, *INACH, Chile*	Microbiological approach to study the impact of climate change in Antarctica
15:00 – 15:20		Coffee break
	MO.4: Climate change – Geodetic techniques: Sea level rise & isostatic rebound, *Session chair: W. Bosch, DGFI*	
15:20 – 15:50	W. Bosch, *DGFI, Germany*	From global sea level rise to regional and meso-scale sea level kinematic – most recent results from geodetic space techniques
15:50 – 16:10	T. Klügel et al., *BKG, Germany*	Gravity measurements and tide gauge operations at GARS O'Higgins
	MO.5: Earth observation programs –Chile's upcoming SSOT mission & the Belgian remote sensing research focus, *Session chair: E. Diedrich, DLR*	
16:10 – 16:55	R. Alvarez, *FACh/C.O.S., Chile*	Chile's Earth Observation Satellite System: at the service of the country's development
16:55 – 17:15	J. Vandenabeele, *BELSPO, Belgium*	The Belgian remote sensing research programme
19:00		**Patagonian barbecue, *at "El Galpon"***

	Tuesday, November 15	Symposium "20 years GARS O'Higgins" / Workshop "Chile-EU research opportunities under FP7" *Parallel sessions day*
	TU.1_GARS: Antarctic research – The challenge for logistics, *Session chair: J. Arata, INACH*	
08:20 – 08:50	P. Correa, *Armada de Chile, Chile*	Antarctic research – the challenge for the Chilean Navy *(working title)*
08:50 – 09:20	J. Arata, *INACH, Chile*	Supporting the Chilean Antarctic Science Program: needs and challenges for a greater collaboration
09:20 – 09:40	R. Castillo, *DAE, Chile*	20 years support and co-operation DLR – O'Higgins
09:40 – 10:00	D. Mengedoht, *AWI, Germany*	AWI as neighbor and user of O'Higgins facility
	TU.1_FP7, *Session chair: M. Leppe, INACH*	
08:20 – 08:50	J. Carrasco, *Dirección Meteorológica, Chile*	Climate Change: Evidences in the Antarctic Peninsula derived from Chilean Weather Stations
08:50 – 09:20	A. Fischer, *University of Innsbruck, Austria*	Glaciological, hydrological and ecological monitoring: a perspective towards Antarctica
09:20 – 10:00	J. Retamales et al., *INACH, Chile*	INACH's general view on new perspectives for Antarctic research
10:00 – 10:20		Coffee break
	TU.2_GARS: Earth observation – SAR applications for civil security, *Session chair: L. Lara, SERNAGEOMIN*	
10:20 – 10:50	L. Lara et al., *SERNAGEOMIN, Chile*	The ongoing 2011 eruption of Cordón Caulle (Southern Andes): evolution and hazards assessment
10:50 – 11:20	A. Twele et al., *DLR, Germany*	Satellite-based crisis information: Methods and applications for supporting disaster management
11:20 – 11:40	S. Lehner et al., *DLR, Germany*	Monitoring of Meteo-Marine Parameters of the Southern Oceans using SAR
11:40 – 12:00	E. Schwarz et al., *DLR, Germany*	Detection of Ships using SAR Images
	TU.2_FP7, *Session chair: J. Arata, INACH*	
10:20 – 10:45	A. Jeldres, *CONICYT, Chile*	Internationalization of Chilean research: Cooperation opportunities and funding schemes
10:45 – 11:10	W. Fischer, *MCT, Brazil*	Brazilian Bureau for Enhancing the International Cooperation with the European Union
11:10 – 11:35	I. Meneses, *PIA-CONICYT, Chile*	The Chilean Antarctic "Rings" Program (PIA: Associative Research Program)
11:35 – 12:00	M. Vancauwenberghe, *BELSPO, Belgium*	Belgian Antarctic Research Program
12:00 – 13:20		Lunch break
	TU.3_GARS: Astrometry & satellite geodesy – TANAMI, SSA, GPS & GALILEO, *Session chair: R. Ojha, NASA/GSFC*	
13:20 – 13:50	R. Ojha et al., *NASA/GSFC, U.S.A*	Importance of the O'Higgins and TIGO telescopes to the TANAMI program
13:50 – 14:20	C. Plötz et al., *BKG, Germany*	Very Long Baseline Interferometry (VLBI) operations on the Antarctic continent
14:20 – 14:40	M. Weigel et al., *DLR, Germany*	Performance criteria for a space debris and detection tracking radar
14:40 – 15:00	P. Steigenberger et al., *TU München, Germany*	O'Higgins as Part of the IGS and CONGO Network
	TU.3_FP7: Roundtable, *Moderator: J. Retamales, INACH*	
13:20 – 15:00	All FP7 workshop participants	Roundtable with INACH, PIA, DRI, MCT Brazil, BELSPO, University of Innsbruck, CNRS France
15:00 – 15:20		Coffee break
	TU.4: Symposium closing, *Session chair: U. Schreiber, BKG*	
15:20 – 15:30	M. Glotzbach, *German Ambassador, Germany*	Greetings of German Ambassador
15:30 – 16:00	S. Dech, DLR, Germany *(10')* U. Schreiber, BKG, Germany *(10')* J. Retamales, INACH, Chile *(10')*	Closing remarks

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SU.1: SYMPOSIUM OPENING GARS O'HIGGINS – PAST, PRESENT & FUTURE PERSPECTIVES

SESSION CHAIR: S. DECH, DLR

The German Antarctic Receiving Station GARS, a unique scientific tool to support geophysic and geodetic research at the Antarctic Peninsula and its surrounding bodies

Klaus Reiniger

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GARS is a consequence of the scientific objectives and the remote sensing situation in Europe at the end of the 1980s. At this time Europe planned its first Synthetic Aperture Radar satellite ERS, able to perform imaging of large areas not sensible by optical sensing sensors due to the lack of solar illumination and/or cloud cover almost throughout the year. Furthermore the international programs on geodynamics lacked an observation point for their VLBI measurements at the Antarctic continent to determine the continental drift of this continent.

Based on a study (TRAFES) on the global requirements on the availability of remote sensing data, the German Ministry for Research and Technology BMBF decided in 1988 to finance a project for the installation of a scientific instrument to support remote sensing in the context of the ERS satellite program and allow VLBI measurements at the in the Antarctica peninsula.

DLR, responsible for the space R&D and operations, IFAG, responsible for the national geodetic program and VLBI (Very Long Baseline Interferometry) measurements and AWI, as the German national institution responsible for Antarctic Affairs became the executors for the project. On international level, INACH in Chile became the highly valuable cooperation partner in the project.

The goal on was to make available, for the first time, radar imagery as large scale information from the northern part of the Antarctic, the Antarctic peninsula, the Weddel- and the Bellingshausen sea, all areas of interest of the German Antarctic research program The objective to perform high precision continental drift measurements of the Antarctica became the other primary task of the station. Since the start of operation a wide variety of further scientific instruments and operational tasks were added to the original design of the installation, like the acquisition of GOME ozone data, and the inclusion of the station into the international GPS network etc.

The presentation reflects the design of the station placed by both primary requirements, the technical, logistic and organizational difficulties, encountered during its installation and operation at one of the most remote locations of the world as well as some operational and scientific results achieved during the first 15 years of operation.

Current Activities at the German Antarctic Receiving Station GARS O'Higgins and Future Perspectives

Erhard Diedrich[1] , Ruslan Artemenko[1], Salomon A. Cerda[2], Eugenio J. Cortez[2], Pierre Lagadrilliere[1], Ulf Lind[3], Marcelo Morais[1], Robert Metzig[1], David Pereira[2], Hector Pereira[2], Ralf Reissig[1], Alexander Scherbachenko[1], Michael Specht[1], Werner Ziegltrum[1], Alfons Zimmer[1]

[1] DLR, German Remote Sensing Data Center (DFD), Oberpfaffenhofen, Germany
[2] SERVIMET, Punta Arenas, Chile
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The German Antarctic Receiving Station (GARS) O'Higgins was and is a multi purpose facility and is utilized mainly the German Bundesamt für Karthographie und Geodäsie (BKG) and German Aerospace Center (DLR). The maintenance, upgrade and usage of the station is based and ruled on the one hand on the German co-operation of the both institutions mentioned above. On the other hand it is also based on an international co-operation. Since the major activity over the year is performed for DLR's context in the field of Earth Observation (EO) satellite communication for the German part DLR is leading the overall station operations. On the international level the main partner is the Instituto Antartico Chileno (INACH) but also the further partners and their roles will be shortly described in the presentation.

One of the main changes in the recent years was the change from a campaign operations schedule with roughly half year station operation towards a year round full operation scheme. The presentation shows how this is achieved and discusses the prerequisites in terms of infrastructure operations, logistics, technical aspects and personal aspects.

While the BKG activities are described in different presentations the focus here is given to DLR activities. Since the main driver for this year round operation was the German EO mission TanDEM-X also the context of this TanDEM-X operations and the worldwide station network in use for this mission influenced and changed the EO data reception of GARS O'Higgins. Network connectivity, remote operations data transfer and the Station Monitoring, Control and Scheduling System SMCS are important corner stones.

The results of roughly the first year of TanDEM-X operations from a station point of view shows up with a remarkable amount of data collected, a high reliability and the first experience with routine remote operations. Nevertheless, especially the high reliability can still only be achieved with a fully manned station. Applications like commanding of satellites or the service for the very early orbit phases (LEOP) of satellites have a special requirement for the reliability and required a manned station.

Furthermore especially also the European ERS-2 mission was supported and in 2011 the number of satellite passes recorded reached a level never achieved before. Further missions and future perspectives are discussed.

There is the intention to further broaden the purpose of the facility usage in the future and as an example DLR's participation in a pilot study for penguin monitoring with satellite data is to be named. So the 20th anniversary of the first satellite data reception at GARS O'Higgins is both, looking back to a remarkable history of station set up and long term station operations (see presentation of Klaus Reiniger) as well a the high level of activity in the present and the future perspectives.

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SU.2: GEODESY & ASTROMETRY VLBI AT GARS O'HIGGINS

SESSION CHAIR: H. SCHUH, IAG & IUGG/TU VIENNA

Geodetic VLBI at O'Higgins station and the next generation VLBI system

Harald Schuh[1], Dirk Behrend[2], Jing Sun[1], Hana Spicakova[1], Johannes Böhm[1]

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Very Long Baseline Interferometry (VLBI) is the unique technique for measuring the orientation of the Earth in inertial space. As such it is an essential element of the Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG). The current geodetic VLBI network, developed mainly in the 1970's and 1980's, has achieved extraordinary success and the O'Higgins station plays an essential role within this network due to its location at a high southern latitude. Results of geodetic parameters of sessions including the O'Higgins station will be shown and its important contribution will also be demonstrated by specific simulation runs with and without the radio telescope O'Higgins. In 2003, the International VLBI Service for Geodesy and Astrometry (IVS) initiated a Working Group to study the requirements of a next generation geodetic VLBI system, called VLBI2010. The goals of the new system are to achieve (on global scales) 1-mm position accuracy over a 24-hour observing session, 0.1-mm/yr velocity accuracy, continuous observations, and delivery of initial results within 24 hours after taking data. The challenging nature of these goals requires a completely new technical, operational, and analytical design of VLBI measurements. Based on extensive simulation studies, strategies have been developed to improve IVS product accuracy through the use of a network of small (~12-m) fast-slewing antennas, a new method for generating high precision delay measurements and a more homogeneous network distribution with emphasis on new sites in the Southern Hemisphere. As of November 2011, the construction of twelve new VLBI2010 sites has been funded. These will improve current network geometry and provide an important step towards a global VLBI2010 network. Proposals for several more radio telescopes have been submitted to relevant funding agencies. Based on a station survey and questionnaire the projected global VLBI network will be presented.

The Antarctic VLBI Station O'Higgins as a Network Station of the IVS

Dirk Behrend[1], Harald Schuh[2], Chopo Ma[3], Ed Himwich[1], Cynthia Thomas[1]

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The International VLBI Service for Geodesy and Astrometry (IVS) was founded in 1999 as an international collaboration of organizations which operate or support Very Long Baseline Interferometry (VLBI) components. IVS is a recognized service of the International Association of Geodesy (IAG) and the International Astronomical Union (IAU), and it has applied for membership with ICSU's World Data System (WDS). The scheduling of VLBI observations is carried out by the IVS Coordinating Center supported by NASA. The Network Station GARS O'Higgins is a founding member of IVS and predates the service by about seven years: the first successful VLBI experiments were carried out in January 1992. During the pre-IVS time from 1992–1999, O'Higgins participated in 44 internationally scheduled VLBI sessions. The main purposes of these sessions was the determination of the terrestrial reference frame (TRF) in the southern hemisphere (station positions), Earth orientation parameters, crustal dynamics, and the celestial reference frame (CRF; quasar positions) in the southern sky. Following the establishment of the IVS, O'Higgins participated in 93 observing sessions. In the early years of the IVS, these carried forward the observing scheme of the 1990s. With the start of the observing program prescribed by the final report of the "IVS Working Group on Product Specification and Observing Programs" in 2002, O'Higgins participates in two observing bursts every southern summer. This results in about 8–10 sessions yearly. It forms the anchor station of the OHIGGINS sessions, which tie together the IVS sites in the southern hemisphere. Because these sessions concentrate on the southern sites exclusively they yield a very accurate regional TRF around the South Pole. At the same time, they improve the CRF in the southern sky. In order to help to tie the southern region to the global TRF, O'Higgins participates about twice a year in the global IVS-T2 sessions. We will describe in more detail the IVS observing program, the impact of O'Higgins, and selected results obtained with its participation.

The importance of truly global networks for GGOS

Ulrich Schreiber

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A homogeneous distribution of target objects is essential for the realization of fundamental star catalogs, which are historically used for orientation and navigation. The same condition applies to the catalog of quasars, which forms the observation basis for the International Celestial Reference Frame (ICRF). In contrast to star catalogs fundamental observing stations form the respective counterparts on the Earth. In modern space geodesy a sufficiently dense and homogeneously distributed network of stations with multiple techniques is highly desirable in order to achieve the demanding goals of a Global Geodetic Observing System (GGOS). Stations like GARS O'Higgins are of particular value in this context.

20 years GARS O'Higgins, 10 years TIGO Concepción, what comes next?

Hayo Hase

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The presentation is a review of the past 20 years. The author started its professional career with the installation and first VLBI-operation at GARS O'Higgins. Due to the 20th anniversary some of the particularities of this project are worth to be remembered. Likewise technological developments changed the possibilities of geodesy, the global coverage of fundamental geodetic sites became more and more important. One example of it is the TIGO-project, which after its construction during the 1990's, is already since 10 years operating in Concepción, Chile. Since then it is complementing the geodetic activities at GARS O'Higgins and vice versa. The example of TIGO has led to the challenge to setup a Global Geodetic Observing System (GGOS) as the geodetic contribution to the Global Earth Observing System of Systems (GEOSS). The goals of GGOS itself translate back to improve the method of Very Long Baseline Interferometry (VLBI). A global effort is undertaken within the implementation of the VLBI2010 vision of the International VLBI Service (IVS).

The presentation will be mixture of historical facts, personal experiences and a vision for the future.

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SU.3: EARTH OBSERVATION & SPACE GEODESY STATE-OF-THE-ART SAR TECHNOLOGY & APPLICATIONS

SESSION CHAIR: T. FRITZ, DLR

TanDEM-X DEM Generation and First Applications

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Since July 2010, the two satellites TerraSAR-X and TanDEM-X jointly acquire interferometric data for the TanDEM-X Mission. Starting their common commissioning phase with a so called pursuit monostatic configuration with 3 seconds time lag between the two passes, they were later put in a close formation, acting since then as the first freely configurable single pass bistatic SAR interferometer in space. The TanDEM-X mission has as primary objective the generation of a global DEM following the high standard accuracy HRTI-3 which specifies (relative) point-to-point height errors below 2m (90%) for any two points within a 1 x 1 degree DEM tile for moderate terrain. The bistatic acquisition mode yields a surface reconstruction nearly free of atmospheric and temporal decorrelation with a reduced use of the instruments resources. Downlinking of the large amount of data is done to a network of ground stations - including GARS O'Higgins - at which a quality screening is also performed. All acquisitions were processed from instrument raw data to DEMs from day one of the data taking on by one single operational processing system: the Integrated TanDEM-X Processor (ITP) in Oberpfaffenhofen. Data take analysis, common parameter calculation, synchronization, bistatic focusing, filtering, co-registration, phase unwrapping, geocoding and final quality control are all performed in one sequence inside this processor. This approach allows a high precision processing by passing all applied corrections and determined parameters from one step to the next. Specifically the geometric & phase accuracy and stability of the instruments, the processor and the auxiliary data (i.e. the millimetric precision of the baseline products) provide an unprecedented level of relative and absolute geometric accuracy in the bistatic operation. The drawback of this mode is a very complex interrelationship of combined instrument delays, propagation effects and differential phase offsets which require a differential instrument calibration at submillimetric level. While many challenges of bistatic processing of the TanDEM-X data were encountered in the first months of operation, the benefits of this single pass acquisition mode can be used to derive additional information from the data itself for further processing. For example, the very small image shifts originating from the parallaxes of the stereo viewing geometry are used to derive low resolution but highly accurate radargrammetric absolute height information for pre-calibrating the interferometric phases of the so called RawDEMs to an absolute height accuracy of clearly below 10m compared to SRTM and ICESat reference heights. This pre-calibration relays solely on the data itself, is thus independent of any reference information and hence allows precise DEM generation specifically in regions outside the SRTM-belt, namely the polar regions. The overall mission concept foresees at least two coverages of the earth and additional ones for complicated terrain. The final calibration of all overlapping data from different mission phases to eliminate residual drifts and baseline offsets is performed by an additional dedicated processing chain during the final mission phases. However, the intermediate product quality is already high and the repeatability of the absolute height offset of the pre-calibrated RawDEMs is found mostly be within 2m only. This enables already in the early phase of the mission the use of this preliminary data for applications as

- Detecting DEM height changes in between acquisitions and with respect to historic DEM data without tie-pointing. Such changes are very stable indicators for changes on ground which do not require any coherence between the two passes and are thus ideally suited

Differential Interferometry Applications

Nico Adam, Fernando Rodriguez Gonzalez, Alessandro Parizzi and Michael Einender

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The persistent scatterer interferometry (PSI) is a well established radar technique to monitor the Earth's displacements with millimetre accuracy. In recent years, the high resolution PSI and on the other hand the wide area PSI (WAP) are two directions of development. DLRs operational interferometric system PSI-GENESIS has been adapted to support both contrary processing techniques and different SAR sensors. PSI uses men made features typically made of metal (persistent scatterers) given by chance to form interferometric phase time series spanning many years. Typically, its application is limited to urban areas only because of the high density of usable persistent scatters. In the course of ESA's Terrafirma project, a wide area product (WAP) PSI mapping is demonstrated by DLR. Subject is to map countries and continents based on the PSI technique. The WAP is foreseen to be a standard level 1 product for the future Sentinel-1 mission with its TOPS mode acquisition scenario. However, many technical problems need to be solved in order to extend the PSI mapping area from urban areas to rural and even mountainous regions. This paper reports on the wide area product, the technical challenges and their algorithmic solutions. It also provides examples and the characteristic of the high resolution spotlight PSI.

Experimental Radar Modes with TerraSAR-X and TanDEM-X

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The TerraSAR-X and TanDEM-X SAR satellites provide a wide variety of standard SAR products with different ground coverage and resolutions. The flexible commanding of the TerraSAR-X SAR instrument on an experimental base enables the acquisition of DataTakes those properties go beyond the limitations of standard SAR products. The scientific work in the field of glaciology and oceanology could benefit from these experimental acquisitions.

DataTakes with Increased Coverage: One limitation of standard ScanSAR products is the fix number of four elevation beams. ScanSAR experiments with 8 standard elevation beams, i.e. 200 km swath width, show still a good radiometric performance with decreased resolution. In addition to the number of beams, also elevation beams with a wider range antenna pattern can be used. With these acquisition modifications, DataTakes exceed the swath width of nominal ScanSAR DataTakes more than a factor of 3.5. However the resulting UltraWideScanSAR images have a strong decreased performance in radiometry, ambiguity and resolution.

DaTATAKES for Interferometric and Speckle Tracking Methods: The second focus is laid on experimental data acquisitions for velocity estimation in glaciology and oceanography applications. Here the measurement of target movement by means of along-track interferometry or speckle tracking is of special interest. An ATIS (Along Track Interferometry by aperture Switching) called method uses the experimental ability of the SAR instrument to switch between two beams from pulse to pulse. By applying a strong attenuation on the fore half of the receiving antenna for one pulse and on the rear half for the other pulse, DataTakes having two phase centers in along-track can be acquired. Since the full antenna is transmitting for SNR reasons, an along-track baseline of about 1 m, i.e. 1 ms time lag, can be formed. By means of large area averaging to increase the SNR, even slow velocities like ocean currents can be measured.
A significantly bigger azimuth time separation of 3 seconds between the two DataTakes of the TerraSAR-X and TanDEM-X was available during the commissioning phase of the TanDEM-X satellite. Beside stripmap acquisitions also burst synchronous ScanSAR DataTakes have been acquired during this phase. The estimation of the velocity and rotation vector for ships (stripmap), as well as ice (ScanSAR) has been demonstrated during this "20 km" pursuit monostatic phase.
Another increase of azimuth time separation to 6 s can be achieved by using only one satellite with a special BiDirectional azimuth steered beam. The two simultaneous azimuth look directions are about 2° into and 2° opposite to the flight direction. The signals of both directions can be separated in the spectral domain. This implies the need of a high PRF for this BiDiSAR mode.
Even if there is a repeat cycle of 11 days for the TerraSAR-X and TanDEM-X satellites, it is possible to obtain "quasi" repeat-pass interferometric acquisition pairs under crossing orbits with a time lag of 1 or 5 or 6 day separation in Polar Regions, i.e. 84.5° to 88° northern latitude

Digital Elevation Model based on TerraSAR –X and TanDEM-X Data

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The TerraSAR initiative resulted in a Public-Private-Partnership (PPP) between the German Aerospace Center (DLR) and Astrium GmbH. The TerraSAR-X radar satellite started its operation in 2008. Since then, the sensor has demonstrated its suitability in a broad range of applications thanks to its capacity for collecting cloud as well as day/night independent information of the earth's surface. Due to the high reliability of TerraSAR-X data acquisition and geolocation accuracy the data can be used for generating digital elevation models (DEM) based on radargrammetric processing, which requires the collection of stereo data pairs. To ensure high quality, data pairs from two look directions are collected. Two different kinds of DEM products are offered: the Digital Surface Model (DSM) includes "first surface" elevations (including vegetation and man-made structures) and the Digital Terrain Models (DTM) that represents the bare earth elevation (vegetation and man-made objects are removed). Due to the high accuracy of the TerraSAR-X data, no ground control points are necessary for production. This is a significant benefit which allows the provision of elevation data all over the world even for inaccessible areas. Precise elevation data is the initial foundation of any accurate geospatial product, and diverse applications ranging from topographic mapping and ortho-rectification of satellite images, through crisis intervention management, all the way to a targeted preparation of defence and security related missions. Project based data acquisition guarantees up-to-date information which is essential in cases of events like earthquakes and tsunamis where the landscape is changed within hours. Many various commercial projects in Latin America and other places demonstrate the high quality and benefit of the Digital Surface and Terrain Models based on TerraSAR-X radar data. The significant market interest in elevation data, along with a high scientific potential, led to a PPP extension for the TanDEM-X Mission. The main goal of the mission is the generation of a seamless Digital Elevation Model that will be available for the Earth's complete land surface (150 Mio. km²) in 2014.

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SU.4: EARTH OBSERVATION & FIELDWORK FOCUS ANTARCTIC PENINSULA

SESSION CHAIR: M. BRAUN, UNIVERSITY OF ERLANGEN

Antarctica'S Vegetation: past and current evidence

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To commemorate 20 years of the Antarctic Research Station GARS O`Higgins, we provide a summary of early explorations to Antarctica where botanist scientists took an almost anonymous role. Based on their multiple observations of vegetation they evidenced and recorded, we review the knowledge available at the end of the nineteen century to discuss the contemporary scientific believes; connecting them, with current observations we have collected in our field work. Using the late 50`s decade aerial photography on sites we have visited, it is noted that arising opportunities for the understanding of colonization phenomena on areas where ice is retreating are offered. Account of research on colonization of new ice-free areas is analyzed as well as how the molecular genetics try to decrypt and to find early settlements. Finally, an analysis of conservation in Antarctica is provided and its outlook discussed.

Keywords: Sanionia uncinata, moss, niche conservation, ice free areas

Combining field surveys and SAR remote sensing to study Antarctic Peninsula glaciers

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Multi-frequent SAR imagery enable mapping of various glaciological parameters. With the operation of ERS-1 and GARS various climatological and glaciological project were initiated and continued to date. On the main ice cap of King George Island a comprehensive field programe covered field measurements of ice dynamics, ice thickness and surface mass balance. Remote sensing provided spatial coverage for ice retreat as well as surface velocities based on ERS-1/2 InSAR as well as from TerraSAR-X feature tracking. Currently, this work is continued and expanded to surface mass balance and melt modeling as well as measurements of energy fluxes over the glacier with the ESF IMCOAST framework. TerraSAR-X imagery supports these efforts with mapping of glacier and snow cover extent from summer coherence imagery, snow facies maps on the glacier as well estimates of mass flux from the combined ice velocities and ice thickness data. Further south analysis of time series of SAR data from ERS, ENVISAT, ALOS and TerraSAR-X enable the derivation of surface velocity variations (e.g. on former Larsen-A tributaries) as well as monitoring of the break-up on Wilkins Ice Shelf. For latter the dense time series considerably contributed to an improved process understanding.

Surface elevation changes and variations of glaciers in key sites of Antarctic Peninsula and Patagonia.

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Ice masses on north-eastern Antarctic Peninsula (NEAP) and south-western Patagonia (SWP) suffered drastic changes in past two decades. Recent behaviour of tidewater and freshwater calving glaciers and few terminating on land is analyzed in both regions in response to either dynamic or climatic forcing.

In SWP we have selected two major contrasting freshwater calving glaciers, i.e. Glaciar Moreno (GM) and Glaciar Upsala (GU), ongoing an increased calving rate, ice-thinning and volume loss. Field measurements of surface elevation changes carried out since 1990 on GM responding to change in mass-balance, may explain the recent ice-dam formations. On GU, surface profiles measured in the field in 1990-1993 revealed average thinning of 11.1 m a^{-1}. This large thinning rate could not be explained by climate change but was most probably triggered by reduction of back stress. GU has been retreating since 1978. From 1981 to 1999 the glacier retreated 6.2 km (326 m a^{-1}), being relatively stable until early 2008. Since then to early 2011 GU has drastically retreated 3 km, at a rate of 1.0 km a^{-1}. The thinning/ice-loss of GU during the 10 yr period over the lower 52.6 km^2 was derived from SRTM and ALOS PRISM DEMs. From early 2000 to late 2006 GU thinned 44.8 m at a rate of 6.6 m a^{-1}, loosing 2.36 km^3 (0.35 km^3 a^{-1}). From late 2006 to 21-04-2010 thinning increased 3 fold at 20.2 m a^{-1}, loosing additional 3.1 km^3 (0.9 km^3 a^{-1}) of ice, in synchronism with observed glacier acceleration. Recent fast calving rates are probably due to increase in ice velocity and overdeepening of the lake bottom nearby the ice front.

Antarctic Peninsula is subject to increased atmospheric warming, which is affecting drastically the ice masses. Two glaciers terminating on land (Glaciar Bahía del Diablo-GBD) and Glaciar Cabo Lamb on Vega I. show a consistent surface lowering since 1984 of ca. 1.0 m a^{1}. Thinning of GBD is due to negative mass-balance. The net mass-balance is well correlated to mean summer temperatures. However, the major changes are still affecting strongly the tributary glaciers which have nourished the former northern Larsen ice-shelf sections after 16 years of their removal, in response to non climatic factors. With an aid of several images and DEMs available since the beginning of ASTER missions were derived the thinning rates and variations of major glaciers on NEAP. Surface at Dinsmoor-Bombardier Edgeworth (DBE) lowered by 40.5 m (7.8 m a^{-1}) between 02-10-2003 and 02-12-2008 (5.2 yr) with loss of 5.6 km^3 (1.1 km^3 a^{-1}) over 138 km^2. DBE glaciers, which surged in 2001 have strongly retreated from 2006 to 2007, then advanced again in surging mode 2.4 km until 2010. Early 2011 GPS survey reveals that DBE glaciers are still advancing in relation to Feb 2010. On DEMs and images are clearly visible surge waves. At Hektoria-Green-Evans the DEMs from Nov. 2001 and Nov. 2006 reveal surface lowering of 83 m with additional 67 m to Jan. 2011 at same rate (16.3 m a^{-1}). A large retreat of 31.6 km^2 occurred between late 2010 and early 2011. The surface of Crane Glacier lowered 126.2 m at a rate of 25.2 m a^{-1} from Nov. 2001 to Nov. 2006, slowing down considerably to 5 m a^{-1} (total 20.8 m) until Dec. 2010. Since then the glacier advanced slightly.

Repeated DEMs of TanDEM-X mission will improve our understanding of the dynamic behavior of large tidewater calving glaciers and assess better the loss of ice-masses in both critical cryospheric regions to evaluate more reliably their contribution to sea-level rise.

Stable water isotopes of precipitation and firn cores from the northern Antarctic Peninsula region as a proxy for climate reconstruction.

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In order to investigate the climate variability in the north Antarctic Peninsula region, the relationship between stable isotope content of precipitation and firn, and main meteorological variables (air temperature, relative humidity, sea surface temperature, and sea ice extent) was investigated. Our results demonstrate that the combination of stable water isotope analyses with different meteorological data sets offer a valuable proxy for paleo-climate reconstruction for this region. Isotope analysis ($\delta^{18}O$ and δD) of precipitation samples and firn cores collected between 2008 and 2010 from Frei and O´Higgins stations and surrounding areas, highly reflect the meteorological variability of the region. Mean monthly $\delta^{18}O$ and deuterium excess (d excess) values highly correlate with the air temperature oscillations on a seasonal to sub-seasonal scale. The d excess show a strong correlation to humidity and sea surface temperature of the surrounding ocean (r = 0.7 to 0.8 for both parameters); as well as a correlation to the sea ice cover is observed (r = 0.5 to 0.7), explained by the influence of sea ice directly on the air temperature and ocean-atmosphere interaction. Low absolute d excess and the synchronous variation of both d excess and air temperature imply that the evaporation of moisture occurs in the adjacent Southern Ocean. The $\delta^{18}O$–air temperature relationship is complicated and significant only at a (multi)seasonal scale. Backward trajectory calculations show that air-parcels arriving at the region during precipitation events predominantly originate at the South Pacific Ocean and Bellingshausen Sea. A firn core retrieved at the Laclavere Plateau (1030 m a.s.l.), which was explored for the first time in 2010, represent very promising conditions for future glaciological investigations: restricted melt evidence of firn and snow, a high accumulation rate which ensures that a high resolution archive is stored in the ice cover. These investigations will be used as a calibration for on-going and future research in this region.

Surface Ice velocity information at the surounding O'Higgins and GARS station in the Antarctic Peninsula

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Objective: to show the potential use of the radar images to determine surface ice velocity in complement with local measurement.

The GPS data collected in January 2011 campaign next to the Chilean Base Station O'Higgins and GARS (63°19´S, 57°51´W) are present. The objective these measurements were to install stakes and georeferenced with a GPS of topography quality to determinate the surface ice velocity of sector near to the stations. To improve the quality of the geodetic-information this stakes were used two GPS´s of the same characteristics, one as base station and a second as movil station, both GPS´s captured position information simultaneously and stored into the data-logger, for further data-processing in differential mode. Other possibility to determinate surface ice velocity is trough the radar image satellite, that in complement with the local measurement allow to correlation the information between both data. This correlation to validate the information of surface ice velocity.

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SU.P: POSTER SESSION

SESSION CHAIR: T. KLÜGEL, BKG

20 years ERS in Antarctica

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The ERS satellites, operating from 1991 to 2011, needed to rely on a global station network for the high rate data transmission of SAR data (105 Mb/s). With ERS-1, as being the first European SAR satellite, international collaboration with the global X-band satellite receiving stations needed to be established on technical levels well Memorandum of Understanding (MoU) needed to be signed. With the help of DLR, being a Space Agency of an ESA Member State, the exploitation of ground stations in several remote regions of the world was a very efficient way to enrich the ERS data archive and therewith to contribute significantly to the success of the mission.

The failure of the Low Bit Rate (LBR) recorders onboard ERS-2 in July 2003 reduced the observation coverage of the GOME, Scatterometer, Radar Altimeter and ATSR mission by some 80 %. Thanks to the global station network the observation coverage could quickly be increased. An important role in the recovery of the LBR was thanks to the O'Higgins station, who acquired 8 to 9 passes a day. These data have been send to ESA in some 40 minutes after sensing, allowing that the data will be considered for data assimilation, however also for satellite piloting support, since the satellite is operated since end 2001 with on open-loop attitude control using science data.

This paper will outline the outstanding importance of the O'Higgins station for the ERS mission over the last 20 years helping to establish an Antarctic science community, advancing science, and also supporting the mission overall.

Downwasting of glaciers after disintegration of northern Larsen ice shelf

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Comprehensive SAR data sets of the northern Larsen Ice Shelf region have been acquired during the last two decades by satellites of ESA and DLR, including ERS-1 SAR (1991-2000), ERS-2 SAR (1995-2011), ERS-1/ERS-2 one day repeat pass Tandem data (1995-1999), Envisat ASAR (2002-), TerraSAR-X (2007-), TanDEM-X (2010-). These data provide an excellent basis for estimating ice fluxes and studying the dynamic response of glaciers after collapse of the three northernmost sections of Larsen Ice Shelf: the Larsen-A, Larsen-B and Prince Gustav Channel (PGC) ice shelves. After the collapse of these sections in 1995 and 2002, respectively, the outlet glaciers of the Antarctic Peninsula, previously feeding the floating ice shelves, became tidewater glaciers. The new boundary conditions resulted in significant acceleration and increased ice export. Interferometric ERS Tandem data, acquired in 1995 to 1999, have been the basis for analysing the pre-collapse ice flow conditions for the glaciers above Larsen-B Ice Shelf. For the glaciers above Larsen-A and PGC ice shelves the Tandem data show significant acceleration during these years. Since the launch of Envisat in March 2002 the retreat of glacier fronts has been analysed by means of ASAR images. 35-day repeat pass SAR amplitude data were used for mapping the ice velocity of large glaciers by means of image correlation techniques. The launch of TerraSAR-X in June 2007 opened up excellent new capabilities for detailed mapping of glacier velocities. Repeat pass images over time intervals of 11, 22, 33 days in stripmap mode with 30 km swath width and a spatial resolution of about 3 meters have been used for mapping the ice velocities of all outlet glaciers above northern Larsen Ice Shelf. The TerraSAR-X data confirm that the accelerated ice flow on the glaciers of the Larsen-A and PGC embayments is still maintained 15 years after the collapse. Presently the frontal velocity of different glaciers is 1.5 times to 5 times higher than in the pre-collapse state. Under the assumption of balanced mass budget of the glaciers in the pre-collapse period, the cross sections of the calving gates are estimated to compute the calving fluxes. Due to dynamic thinning, the calving cross sections of several major glacier are partly at floating and decreasing in size, resulting in reduced ice discharge. New data indicate for some glaciers a weak trend of slow down near the calving front, for other glaciers further acceleration. This stresses the need for studying time series of ice motion to document the dynamic response of individual glaciers, taking into account also seasonal variations in velocity. Based on these data sets, the present contribution to sea level rise due to imbalance of glaciers above the previous northern Larsen Ice Shelf sections is estimated to be about 3% of the total cyrospheric contribution. Ongoing work deals with further exploitation of SAR data archives, in order to document in detail the temporal behaviour of glacier flow since ice shelf collapse up to the present day. Of particular interest for updating the estimates of mass fluxes are digital elevation data of the TanDEM-X mission, in synergy with ice velocity maps retrieved from repeat-pass TerraSAR-X data.

Sub-shelf morphology of the Fimbul Ice Shelf, Antarctica

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This study focuses on ground based radar profiles, surveying the fast-flowing main shelf region of the Fimbul Ice Shelf, Antarctica. The profiles are oriented perpendicular to ice flow between the grounding line and the shelf front revealing changes in the sub-shelf morphology.

The basal morphology is found to be rough close to the grounding line, with large basal troughs oriented along flow direction. These troughs become less pronounced towards the shelf front. Internal reflectors are identifiable in the radar profiles 20-100 m above the basal troughs, suggesting a continuation of the troughs upwards through the ice column.

A visible correlation between basal troughs and surface flow stripes in satellite radar imagery is found. A mosaic of TerraSAR-X radar scenes, acquired between 2008 and 2010, serves as a base for the detection of surface flow stripes. As flow stripes are observed to form a network of bifurcating troughs, we expect a similar picture for the sub-shelf morphology. The surface flow stripes and the characteristics of the basal troughs allow interconnecting sub-shelf features between the individual radar profiles.

Interferometric SAR analysis in Dronning Maud Land, Antarctica: precision and accuracy of glaciological products

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The coast line of Dronning Maud Land, largely in the Atlantic sector of Antarctica, is almost entirely bordered by a number of comparatively small ice shelves. The narrow continental shelf in this area permits a strong interaction of ice shelf water with the coastal current and associated heat transports into the ice shelf cavities. This characteristic geographic setting could make ice shelves in this location notably susceptible to rising ocean temperatures, either by ocean warming or increased upwelling of warm circumpolar deep water. In this study we present an analysis of glaciological products based on ERS SAR interferometry establishing a baseline for change detection.

Differential interferometric SAR (DInSAR) is by now routinely employed to measure ice sheet elevation and glacial movement. We applied DInSAR processing to a wealth of ERS SAR image data originating from various SAR processors. In the generation of Digital Elevation Models, surface heights from ICESat served as ground control. Systematic deviations to validation data are related to the SAR processing history, atmospheric processes, and to variations in penetration depth of the radar wave in snow. For the interferometrically derived ice flow, GPS measurements serve as ground control and for data validation. Using the satellite analysis as input, we estimated the spatial variability in the basal melt rate of one ice shelf based on the assumption of mass continuity. Additional input data are ice thickness data from radio echo sounding and surface accumulation measurements.

This presentation provides information on the spatial resolution of ice sheet properties using the available data sets, as well as elucidates precision and accuracy of glaciological relevant satellite products as a baseline to detect potential future changes in ice sheet mass balance.

Estimation of horizontal ice flow velocities and tidal deformation from combined interferometric and feature tracking analyses.

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The knowledge of accurate surface topography heights and ice dynamics are two key issues for mass flux and mass balance calculations. The potential of InSAR to address these topics has been frequently demonstrated in the past years. However, some variables of interest such as topography, horizontal ice flow velocities, vertical deformation at the grounding zone or height changes due to ocean tides mix and superimpose in the interferogram. Different processing methods are therefore combined in the frame of this study in order to derive the above named parameters from ERS-1/2 and ALOS SAR data for parts of the Western Dronning Maud Land, Antarctica.

In a first step differential InSAR is used to estimate surface topography heights for grounded regions. ICESat data is hereby used to improve the precisely required baseline information. ICESat heights are additionally utilized as an absolute height reference. All separately derived DEM's are finally merged with the Antarctica-wide existing Bamber DEM which also provides surface elevations for the floating ice shelves.

Secondly, surface flow velocities are determined interferometrically from ascending and descending satellite-passes based on a surface parallel flow assumption. The previously derived DEM is hereby used to remove topographic effects from the interferograms but also to obtain the needed precise surface slopes of the terrain. This approach can only be applied to grounded regions since the vertical changes due to ocean tides and the inverse barometer effect (air pressure) vary for different epochs and therefore affect ascending and descending orbit differently.

A least squares based speckle tracking is performed in pairs of 46 days separated ALOS SAR images. In order to calibrate possible offsets, a few characteristic features (crevasses) are additionally tracked in LANDSAT images which cover a significantly longer time span. The resulting flow velocities have a slightly smaller spatial resolution then the interferometrically derived velocities but are exclusively two dimensional and cover both, grounded and floating areas as well as the transition area of the grounding zone where deformations due to ocean tides occur.

These deformations and the absolute values of the vertical displacement itself are of spezial interest in example for the validation of ocean tide models. The projection of the horizontal flow velocities onto the Radar's line of sight allows the generation of a synthetic phase image containing this component only. If this image is subtracted from the interferogram and the remaining phase values are unwrapped, absolute height difference changes with respect to the grounded area are the result. Finally, height difference predictions of twelve different ocean tide models are compared to the InSAR measured height differences and used to verify the quality of the models.

Ice velocity and ice elevation changes at Fleming Glacier, Antarctic Peninsula

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The Antarctic Peninsula is one of the hot spots in climate warming with air temperature trends well above the global average. Ice shelves in the region are known to have retreated and collapsed during the last decades with the retreat of Wordie Ice Shelf in the 1980s as one of the first well-documented events. Since then, the retreat has continued reducing the original surface area of about 2000 km2 in the 1960s to less than 100 km2 in 2010 that still survive as two small and isolated ice tongues. Fleming Glacier, the largest glacier draining into Wordie Bay, has lost all its floating part and its glacier front is situated upstream of its 1996 grounding line. We investigate Fleming Glacier in order to determine how the change in the buttressing force at its terminus affects the flow behaviour.

Ice velocities at the lower reaches of the glacier were determined using image correlation techniques applied to optical and radar satellite data (LandSat, Envisat ASAR, TerraSAR-X) acquired between 1989 and 2010. The results show an acceleration of the glacier of between 30 and 60 % within this time span. During the summer season 2008/2009 GPS measurements were conducted at an altitude of about 900 m a.s.l. and a distance of 40 km from the glacier front where velocity data from the 1970s are available. The data demonstrate that acceleration also affects the upper reaches. A detailed analysis of 10 month of continuous GPS data reveals an acceleration signal even within this short time period.

A comparison of airborne laser scanning data acquired between 2002 and 2008 revealed a surface lowering all along a longitudinal profile starting at an elevation of 1100 m down to the ice front where maximum elevation change rates of -4.1 m per year were detected. Elevation trends determined from ICESat data (2003-2009) confirm the former result. In summary, negative ice elevation trends together with the acceleration of the ice flow indicate that Fleming Glacier has not yet reached a new equilibrium and is still losing mass due to enhanced ice flow.

Sea Ice Classification by means of ENVISAT alternating polarization medium resolution images

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The radar images are principally an electromagnetic wave polarized, and the backscattered polarization brings information related to the geometrical structure and geophysical properties of the reflective media. In order to obtain a classification and characterization of the sea ice we must analyze this information. The sea ice classification represents an important knowledge in ship and boat safety on Antarctica.

Main Objective: Classification of sea ice according to his polarization and entropy.

Secondary Objectives: Analyze the viability of the medium resolution images in sea ice monitoring

Future Work: Develop an automatic processing chain and Validate the method by in field measurements.

Geochemical signatures of tephras from Antarctic Peninsula volcanoes

(Signaturas geoquímicas de tefras de volcanes de la Península Antártica)

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In the northern Antarctic Peninsula area, at least 12 Late Pleistocene / Holocene volcanic centres could be potential sources of tephra layers in the region. We present unique geochemical fingerprints for ten of these volcanoes using major, trace, rare earth element, and isotope data from 95 samples of tephra and other eruption products.

The volcanoes have predominantly basaltic and basaltic andesitic compositions. The Nb/Y ratio proves useful to distinguish between volcanic centres located on the eastern (Larsen Rift) and those situated on the western side (Bransfield Rift) of the Antarctic Peninsula. In addition, the Sr/Nb ratio (for samples with SiO_2 < 63 wt%), along with Sr/Y, Ba/La, Zr/Hf and Th/Nb are suitable to unequivocally characterize material erupted from every studied volcanic centre. Microprobe analyses on volcanic glass show that the samples are generally very poor in K_2O, and that glass from Bransfield Rift volcanoes is enriched in SiO_2, while that of Larsen Rift volcanoes tends towards elevated alkali contents. We propose an algorithm for the identification of the source volcano of a given tephra layer using the new geochemical fingerprints. This will contribute to the development of a regional tephrochronological framework needed for future correlations of tephra in climate archives (e.g., marine, lacustrine and ice cores).

Keywords: Late Pleistocene, Holocene, explosive volcanism, tephra geochemistry, source volcano identification, geochemical fingerprinting.

Monitoring of changes in the spatial distribution of a 3-species penguin rookery at Ardley Island (South Shetland Islands).

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The western part of Ardley Island is one of the few places in the Maritime Antarctic where Pygoscelis adeliae, P. antarctica and P. papua breed sympatrically. The changes in population size of the three species are monitored by annual census. Therefore nests and chicks were counted from 1979 to 2011. To observe the spatial dynamics of the rookery the distribution of nesting groups is mapped regularly. Beginning with aerial photographs in the 1980s and hand drawn maps now GPS-mapping is the method. The poster will show some results derived from those long-term monitoring data: After some fluctuations the number of P. papua still increases. In difference, the number of P. adeliae decreases noticeable. The population of P. antarctica almost completely broke down. Surprisingly, the changes in number of breeding pairs seem to have no direct correlation to the spatial extent of the nesting groups. The dataset will be an important part of a study on satellite based remote sensing techniques to prepare an Antarctic-wide monitoring program of changes in penguin colonies.

Rebuilding the Tide Gauge Systems at the Geodetic Observatory GARS O'Higgins / Antarctica

Abstract Poster

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In February 2011, the tide gauge system of the GARS O'Higgins station was rebuilt. This new system consists of two main instruments: i) the absolute pressure gauge with additional temperature, conductivity and air pressure sensors and ii) the radar tide gauge combined with a GPS antenna. The design of the tide gauge system shall contribute not only to the determination of short-term sea level variations, e.g. tidal and seasonal variations. With the redesign of the tide gauge system in O'Higgins, special emphasis was placed on maintaining a stable long-term time series and on the determination and monitoring of the tide gauge zero level with respect to local and global reference frames taking into account the specific conditions at GARS.

The absolute pressure gauge is the main sensor for the determination of the sea level heights. It can be operated all-the-year. Nevertheless, a long-term stable monumentation of the gauge on the sea bottom is hardly possible at GARS. This disadvantage shall be compensated by the second tide gauge. The combination of radar gauge and GPS antenna enables reliable sea level measurements and the monitoring of the zero level of the radar gauge, both at the same time, nearly at the same place and with a high temporal resolution. However, due to the ice drift they can be operated only seasonally. The zero level of the pressure gauge will be determined by comparing the sea level measurements of both tide gauges. In this respect, radar gauge and GPS replaces the time-consuming and less accurate leveling, which would be necessary otherwise. The availability of sea level measurements from two different and independent sensor systems is an additional advantage for the error estimation.

Details about the GARS tide gauge system and results of first measurements will be presented in the poster.

Operation of GARS O'Higgins in the view of technical facilities and mission requirements

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A main goal of GARS O'Higgins was to support international, European and German missions of Earth observation Satellites, especially ERS1, ERS2, JERS, LANDSAT, and others. The constraints of these missions were fulfilled as well by the equipment components as the operational procedures.

Regarding the functional parts there are various device groups, which are nearly unmodified since the installation of the station in 1990/1991. In detail, these are the mechanical antenna parts and some basic electric and electronic subsystems: parabolic dish, gears and servo system (motors, servo amplifiers, analogue servo control unit, programmable logic controller PLC, HF components, down converters). Regular service and maintenance (only the replacement of few defect modules was necessary) kept the antenna system on a high functional level. The digital antenna control unit (ACU) was replaced by an equivalent state-of-the-art device (with better integration into the LAN, better monitoring and control options, increased functionality, increased reliability). The X-band tracking receiver was replaced, and a second tracking receiver is preinstalled as a back-up device as well for the old original S-band tracking receiver as the X-band tracking receiver. The monitor and control unit (MCTU) resides in the original state, whereat in previous times the local mode was used (antenna configuration, HF switches, tracking mode, etc. was handled manually by the operator), however currently the remote controlled mode is in use, i. e. the SMCS (station monitor and control system) software masters the MCTU as well as most of the other subsystems completely.

For the data reception two mission specific demodulators (ERS HR demodulator; ERS LR demodulator) were in use up to the end of the ERS mission in July 2011. In the late nineties multimission capable demodulators became the predominant technology – we used ALCATEL demodulators with preconfigured configurations for ERS, ENVISAT, LANDSAT5, TERRA, AQUA, etc. From 2007 especially in view of TSX and TANDEM-X mission CORTEX demodulators showed the most versatile and stable functions and are therefore now in operational usage. Also the data recording technology went through three generations with overlapping operational phases: high density tape recorders (Honeywell) – MDA-DAS (initially based on DEC ALPHA workstation, later COMPAQ-HP- workstation with INTEL processors) and DLT tape cassettes – at present MDA-DAS with LTO, however regular archiving is carried out on a database system with 10 TB RAID and LTO-4 media for transportation. Starting from 1992 a SAR Quicklook processor (reduced resolution) showed ERS1/ERS2 images, helpful for quality control and special applications like sea ice monitoring for ship routing. 2002 the DORNIER SAR Quicklook processor was replaced by a SAR processor from ACS able to provide ERS high resolution images. In 2005 the station was upgraded in order to perform uplink capability, initially tested and approved with CHAMP, later GRACE-1 and GRACE-2. Uplink/TT&C is now a standard task within the TANDEM-X project. Furthermore the progress of data communication is reflected in the networking capability of GARS: in the early nineties only telephone and fax was available, later supplemented by a data link capability on a slow rate (INMARSAT). A 2.4 m antenna equipment and a Chilean communication provider (Chilesat – Telmex – Claro Chile) assures the access to standard communication systems including INTERNET (medium data rate 64 … 512

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M0.1: CLIMATE CHANGE EVIDENCE OF ECOLOGICAL RESPONSES

SESSION CHAIR: L. BRAVO, UFRO

Diversification processes in the Southern Ocean

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The diversity, abundance and composition of taxonomic groups in the Southern Ocean differ from elsewhere in the planet. The biogeography in this region reflects the complex interactions of tectonic, oceanographic, climatic and biological elements since the Eocene. High levels of faunal affinities are particularly clear between Antarctica and the southern tip of South America, commonly known as the Antarctic-Magellan connection. The traditional interpretation for this affinity is that these regions were contiguous until the Drake Passage opening and were progressively separated by deep waters from the Eocene/Oligocene. Nevertheless, new molecular evidences in other groups of marine invertebrates, especially in those with high oceanic dispersive capacity, suggest more recent divergence processes than the expected under the vicariant hypothesis and provide evidence for the importance of long-distance dispersal in the distribution of the Southern Ocean marine benthic fauna. Moreover, recent observations of non-Antarctic anomuran and brachyuran larval stages in King George, Antarctic Peninsula, indicate that some groups can travel across the ACC. Similarly, records of non-Antarctic lithoid crabs in deep-water off the Antarctic continental slope suggests that these crabs could be returning to this region. These findings challenged the permeability of the Polar Front in space and time raising questions about how organisms got to Antarctica and how often do these processes happened in the past. To answer to these questions, it is now necessary to evaluate if the ACC constitutes an effective oceanographic barrier for larval dispersal between Subantarctic and Antarctic Provinces of the Southern Ocean to estimate since when it operates. For this purpose, we are evaluating the levels of molecular divergence between congeneric species of marine invertebrates and fishes from Antarctic Peninsula and southern South America. The information contained in their DNA sequences will permit us to estimate rhythms and trends in the biogeography of marine benthic organisms in this Region. Such project requires a sampling program at a large geographic scale among the most remote locations of the world. It will be achieve only through an international collaborative effort among the countries involved to the Antarctic Science.

Effects of Climate Change on Plant Biota in the Arctic and Antarctic: facts and perspectives

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Polar Regions are experiencing a rapid warming and the most dramatic effects on their landscape and biota worldwide. Plant diversity of the Arctic and Antarctic tundra is mainly comprised by shrubs, herbs, mosses and lichens. However due to the lower ice-free area available for plant colonization and the higher isolation of the Antarctica which limits species migration and colonization there are important differences in the diversity between both polar regions. For instance, whilst ca. 1700 vascular plants can be found in the arctic tundra, only two vascular plants are known in the Antarctic. Most of the Antarctic is covered by ice and snow, the lost of albedo as ice and glaciers retreated is increasing the effect of warming. In Antarctica the highest rate of warming is occurring in the west cost of the Antarctic Peninsula and associated Island. According to the literature, longer growing seasons with higher temperatures, increases in the free-ice area and higher frequency of rains has determined the expansion of D. antarctica and C. quitensis populations during the last 20 years. It has been assumed that the increase in temperature and longer growing seasons influenced the formation of reproductive structures favoring sexual reproduction, generating larger number of viable. However recent surveys have found that whilst the expansion range of these species is an undergoing process, the disappearance of some populations suggests that processes other than the simple colonization of bare areas by sexually produced propagules are playing a role in the recruitment of these species. We have found that facilitative interactions with mosses are important for growth of Deschampsia antarctica, challenging previous tenets about the importance of competitive interactions with mosses as the key process ruling the spatial distribution of the Antarctic tundra. The importance of facilitative interactions in the Antarctic tundra contrast with the more widespread examples of competitive interactions reported in the arctic tundra. Experimental warming studies in the Arctic have found that warming increased height and cover of shrubs and graminoids, decreased cover of mosses and lichens, and decreased species diversity. The scarce published studies of experimental warming in the Antarctica indicate contrasting results for components of the Antarctic tundra: increases for C. quitensis, decreases in mosses and no changes in D. antarctica. Nevertheless, if mosses declines, D. antarctica could be threatened in the long term as mosses facilitates it growth. However, these studies are of short-duration: < 3 years which contrast with the >15 yrs. of experimental warming studies in the Arctic. Thus, long-term studies are vital to fully understand Antarctic plant responses to global warming, and to establish a strong comparative framework with the arctic. A comparative effort would allow the emergence of generalization about the future response of the polar biota to the ongoing and future climate changes.

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M0.2: CLIMATE CHANGE EARTH OBSERVATION: UNVEILING GLACIOLOGICAL PROCESSES BY SAR

SESSION CHAIR: I. JOUGHIN, UNIVERSITY OF WASHINGTON

Contributions to Ice Sheet Research from TerraSAR-X and O'Higgins Ground Station

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Twenty years ago when the O'Higgins Ground Station was installed, Interferometric Synthetic Aperture Radar (InSAR) and speckle tracking had not yet been applied to the ice sheets of Greenland and Antarctica. Soon after using data downlinked through O'Higgins, Goldstein et al. (Science, 1993) successfully demonstrated the use of InSAR to map ice sheet flow, which at that time was believed to be relatively steady with little change on decadal time scales. Since then, much of Antarctica and Greenland have been mapped repeatedly, revealing a startling degree of change. Data from O'Higgins was instrumental in revealing the large speedups on Pine Island and other Amundsen coast glaciers, a record which today is continued by TerraSAR-X acquisitions. The technical advances in InSAR and speckle tracking enabled by data collected through O'Higgins have led to the widespread application of ice sheet velocity mapping using the international constellation of SAR satellites. Particularly for ice sheets, TerraSAR-X is an important part of this constellation. Its fine resolution makes it ideally suited to measuring change on fast flowing glaciers in Greenland and Antarctica. We describe several results where data from O'Higgins and TerraSAR-X have been important to advancing our knowledge of how ice sheets respond to climate change.

Unveiling glaciological processes by means of high-resolution radar imagery

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There is a two-fold motivation to study glaciological processes: Ice sheets, glaciers, ice streams and ice shelves play a key role in the climate system, as their extent and stability influences the climate system, which raises the demand to study their dynamics and consequently also processes influencing their dynamics. Secondly, the study of glaciological processes is still fundamental research. Among the major unknowns in glaciology are large scale processes, like the mechanism of calving and ice shelf break-up and the impact of subglacial water on the mass balance and dynamics of ice sheets, as well as small scale processes like the effect of inhomogeneities, damage and anisotropy on the rheology of ice. High-resolution radar imagery opens the possibility to study a range of glaciological processes on a continuous, weather independent basis over a large spatial area.

Among these processes is the calving of tabular icebergs, the final consequence of a fracture propagating though an ice shelf. As calving is a singular event at locations where sequences of fracture propagation form over decades large icebergs, which are finally detached, while at other locations, small icebergs are calving off on a rather continuous base. High-resolution radar imagery allows determining calving rates with a high accuracy, as well as the analysis of the load situation that leads to the iceberg formation.

The penetration of the radar signal into the upper few metres of ice opens the possibility to study the structure and thus the homogeneity of the ice masses. Using further observational techniques it was shown that inhomogeneous ice shelf surfaces are reflecting a rough base and internal structures. Thus radar imagery of the ice surface even allows inferences on the structure of base of the floating ice mass. Combined with the calving rates, this allows studying a possible link between the style of calving and homogeneities.

High-resolution radar imagery allows studying crevasse fields and in particular changes in crevasse patterns that are a first sign of changes in the dynamics of ice masses. The pattern of fracturing allows inferences of the mechanical load situation. This applies to ice streams as well to ice shelves. One of the prominent example is the Wilkins Ice Shelf, which experienced break-up events in the past years. High-resolution radar imagery gave insight into the temporal evolution of this three-stage process.

The presentation aims to give an overview of these applications of high-resolution radar imagery with particular examples from ice shelves around Antarctica.

Ice Dynamics in the Patagonia Icefields derived from TerraSAR-X and TanDEM-X satellite data

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The Patagonia Icefields are the largest mid-latitude ice masses in the Southern hemisphere. The ice masses of the Northern and Southern Patagonia Icefields (NPI & SPI) are drained by outlet glaciers with fronts calving into fresh water lakes or Pacific fjords. Both ice fields were affected by significant downwasting in the last decades.

Interferometric ice motion data have been obtained for outlet glaciers of SPI and NPI from 24h repeat pass L-band SIR-C data of SRL-2 in October 1994. ERS-1/-2 SAR tandem data could be applied for ice motion mapping only on few glaciers because of rapid decorrelation of the signal due to adverse meteorological conditions (snowfall, rain, melting) or strong shear in the terminal parts of the ice streams. With TerraSAR-X areal changes and ice motion are monitored since 2008. High resolution 2D velocity fields derived by means of amplitude correlation technique reveal interesting features of ice motion and deformation on the Patagonia glaciers. In June 2010 a second spacecraft, almost identical to the TerraSAR-X satellite, was launched to enable operation of the bistatic SAR mission TanDEM-X. The data acquired by the single pass interferometer formed by the two satellites in close formation serve to generate high resolution DEMs as well as to fulfil scientific objectives related to experimental applications. For glaciology the two satellite missions offer unique opportunities: the detailed ice flow patterns from TerraSAR-X combined with topographic information derived from the TanDEM-X DEMs represent the basis for retrieving changes in the glacier mass and calving flux.

In our present work we used bistatic TanDEM-X data acquired in 2011 to reconstruct the latest 3D-glacier topography of some of the main outlet glaciers in Patagonia. The TanDEM-X DEM was compared to the X-band SRTM (Shuttle Radar Topography Mission) DEM from February 2000 in order to measure the surface lowering of the last decade. Examples of velocities and DEM generation will be shown for Perito Moreno and Ameghino glaciers. Here accurate ground control points from field work are used to validate the SRTM DEM from 2000. On Upsala Glacier an ongoing large scale calving event accompanied by strong acceleration has been monitored with TerraSAR-X since late 2008. Complex flow patterns of the tidewater glaciers Pio XI and San Rafael are revealed by TerraSAR-X.

Our study demonstrates the excellent capabilities of high resolution, short revisit time X-band InSAR for assessing the dynamic state of glaciers combining surface velocity information and elevation (volumetric) changes. These first results of the TanDEM-X DEMs deliver important information about the system performance in areas with complex topography.

A review of the 2011 ERS-2 3-day campaign

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The 3-day orbit repeat cycle missions of ERS-1 and ERS-2 have proven to be of wide benefit for a range of scientific applications due to the high degree of phase coherence that is maintained over short time periods. The data are useful for mapping rates of ice motion over wide areas and over short intervals, glacier grounding lines, and for studies of interferometric coherence as a precursor to the Sentinel-1 mission.

This presentation reviews the main scientific achievements of the 2011 ERS-2 3-day campaign, including studies of rapid and decadal variations of the principal outlet glaciers in Greenland and Antarctica. In Antarctica, we observe increased retreat of the Pine Island Glacier and Larsen-B ice shelf grounding lines over the period 1992-201, and in Greenland we observed further retreat of the Petermann Glacier grounding line over the same period. We also present a study of short-term ice velocity fluctuations of Jacobshavn Isbrae in Greenland, revealing an apparent strong coupling between calving events and changes in glacier speed.

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M0.3: CLIMATE CHANGE GLACIOLOGICAL & MICROBIOLOGICAL APPROACH

SESSION CHAIR: A. RIVERA, CECS

From the tropics to the Antarctic Peninsula: Brazilian satellite remote sensing investigations of ice masses

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The Brazilian program for investigating ice masses from space started almost together with the glaciological activities of the Brazilian Antarctic Programme in the early 1990s. During that decade, activities were based mainly on using aerial photographs, SPOT and Landsat imagery for delimitation of glacier frontal positions and catchment areas of the South Shetland Islands (Antarctica). With the launching of the China-Brazil Earth Resources Satellite (CBERS) in 1999, it was possible to expand our activities to glacier inventorying in Cordillera Tres Cruces, Bolivian Andes. During the first decade of the XXI century, a scientific cooperation with the University of Freiburg in Germany was responsible for the training of Brazilian glaciologists in the use of synthetic aperture radar (SAR) imagery for glacier monitoring, this resulted in the first Brazilian PhD thesis on the cryosphere remote sensing (2007). During this period, we surveyed Joinville and Brabant islands using Landsat imagery, and monitored glacier zones boundaries variations on the Antarctic Peninsula employing active (ERS 1/2 SAR, Envisat ASAR) and passive (SMMR, SSM/I) radar data. With the creation of the Brazilian National Institute for Cryospheric Sciences in 2009, a national laboratory specialized on the remote sensing of the cryosphere was established and a research program is now carried out on the Andean and Antarctic Peninsula glacier dynamics (e.g., variations in glacier velocities, frontal positions, and boundaries of glacier zones) with the use of Envisat ASAR, COSMO-SkyMed, TerraSAR-X, SMMR, SSM/I, Terra ASTER, Landsat TM/ETM+, and CBERS data. Resources of the Brazilian Institute for Cryospheric Sciences allowed us to set up the Regional Centre for the Antarctic Peninsula in the project Global Land Ice Measurements from Space (GLIMS) in Brazil. Recently, a joint program with Instituto Antártico Chileno (INACH) expanded the study areas of our remote sensing laboratory to the Southern Patagonian Ice Field.

ASTER derived DEMs and ice drainage basins delineation on Fallieres Coast, Antarctic Peninsula

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In the Antarctic Peninsula (AP) region changes in glacier geometries such as thinning or thickening of ice volumes, advances or retreats of frontal positions, and shrinking or expansion of ice area coverage, are related to climate changes. To assist monitoring of these changes in the variety of elements that characterize the AP glacial system, a systematic analysis of an inventory of present glaciological features is required. This inventory is also an expected contribution to the Global Land Ice Measurements from Space (GLIMS) international project. Some methods that use space-borne optical sensor data to retrieve such parameters have been tested mainly for alpine and temperate glacier regions. Nevertheless, in the AP some factors related to the specific characteristics of this polar environment (e.g., cloudiness, high reflection of snow covered surfaces, morphology of the terrain, etc.) render the application of these digital image processing methods difficult. Consequently, investigation, testing and adaptation of these traditional algorithms for application on the AP are required. With this focus, we have investigated the use of near infra-red stereo pairs acquired by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument for topographic data generation along the AP. The ASTER visible/near infra-red bands sub-system offers 15 m of spatial resolution. This work presents a methodology and results for ice drainage basin boundaries delineation semi-automatic processing on part of Fallières Coast in front of the Marguerite Bay area. Main method components are: the generation of a digital elevation model (DEM), based on image matching technique of two stereo pairs for a multi-temporal set of ASTER scenes; the employ of an adapted scheme used conventionally to delineate watersheds in hydrology, performed on a geographical information system environment; and the validation and clustering of resulting sub basins, controlled by inspection under 3-D visualization of the topography draped by both ASTER image and contour lines. Products show the good quality of our generated DEM compared to other two independent DEMs: RAMP DEM and Technical University of Darmstadt Digital Terrain Model (TUD DTM). Delineated basin boundaries show good agreement with topography under landscape's visual inspection and we assure that results of processing procedures are reproducible and enable the estimation of errors due to inaccuracies of the various input data sets.

Keywords: Ice drainage basins, ASTER images, Digital elevation models

Recent expeditions to the interior of Antarctic Ice Sheet

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New exploration routes have been surveyed by CECs in Antarctica in recent years, including Patriot Hills - South Pole in 2004 and 2007/2008; Patriot Hills - Subglacial Lake Ellsworth (SLE) in 2006; Patriot Hills - Union Glacier in 2008, and Union Glacier - SLE in 2010. The Union Glacier Blue Ice Area (79 ° 46' S / 83° 24' W), has been transformed into the main hub for airplane operations in this part of Antarctica, which has been mainly used by the private company Antarctic Logistics and Expeditions (ALE), who has provided logistic support to CECs including tractors and convoys, that were equipped with dual frequency GPS receivers and radar systems built and designed in Valdivia. The aims of these missions have been mapping surface and subglacial topography of the ice sheet; determining the internal structure of the ice; detecting hidden crevasses near the glacier surface; measuring surface snow accumulation and calculating ice velocities, among several other tasks. The collected data have also been used to estimate the present mass balance of this part of the ice sheet, the stability of the ice divides and the characterization of subglacial lakes, especially of SLE, where a Consortium of UK universities, the British Antarctic Survey and other international institutions including CECs, is planning to drill the ice until collecting water samples from the lake in the coming years. This summer, the Consortium is beginning operations in the area, sending cargo by plane and then onboard heavy tractor to SLE. An overview of the recent expeditions will be presented, including the most important scientific results.

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M0.4: CLIMATE CHANGE GEODETIC TECHNIQUES: SEA LEVEL RISE & ISOSTATIC REBOUND

SESSION CHAIR: W. BOSCH, DGFI

From global sea level rise to regional and meso-scale sea level kinematic – most recent results from geodetic space techniques

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Since nearly two decades the sea level is precisely observed by at least two, sometimes up to five satellite altimeter systems with complementary sampling characteristics. This constellation provides a unique opportunity for monitoring the complex sea level kinematics with variability spread over nearly all space and time scales. A careful processing and cross-calibration of the multi-mission altimeter data allows to generate time series which give not only a reliable estimate of the current sea level rise, slightly above 3mm/year – rather consistent with the figure given in the fourth Assessment Report of IPCC. The altimeter time series also show that on regional scale the sea level exhibits considerably higher rate of changes with positive and negative signs. At some areas the sea level rises or falls by up to 20cm within a period of only six years! Up to now these spatially varying patterns are only partly correlated with density changes of the upper layer waters. Changes in trade winds are another possible cause for these phenomena – a challenging subject for further research. Although the repetition rate of altimeter systems is only 10 or 35 days multi-mission altimetry also allows to empirically estimate ocean tides with dominant frequencies around 12 and 24 hours. The most recent global ocean tide models provide considerable improvements over previous models in particular over extended shallow water areas like the Patagonian or the North-West European shelf. Most challenging however is the synergy with the latest GOCE gravity field missions. The dramatic improvements in the knowledge of the Earth gravity field allow for the first time to estimate significant pattern of the dynamic ocean topography, a small deviation of the sea level from a geopotential reference surface, which manifests itself by ocean circulation. Today we can estimate the dynmaic ocean topography by subtracting the geoid undulations (from GOCE) from altimetry derived sea surface heights. Geoid and sea surface heights have different spectral properties and require to apply a consistent filter. The latest GOCE gravity fields allow to shorten this low pass filter down to a filter length of some 70km, thus approaching mesoscale resolution. We show a 17 years animated time series of the dynamic ocean topography with meso-scale resolution.

Gravity measurements and tide gauge operations at GARS O'Higgins

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The German Antarctic Receiving Station (GARS) O'Higgins is one of the few places on the Antarctic continent where absolute gravity and tide gauge measurements are performed. In combination with the geodetic space techniques VLBI and GNSS, which allow the monitoring of crustal movements, reliable data of mass related gravity changes and sea level variations can be gained.

A pressure gauge yielding water height, water temperature and salinity is in operation since 1999. However, a continuous time series, allowing the determination of an apparent sea level change, is not available, since floating ice shifted or even destroyed the installation several times. In order to obtain absolute, space referenced sea level data, an additional radar gauge referenced by an GNSS antenna has been installed in 2011. Although this installation is operated campaign-wise, the well defined reference allow the determination of long term trends. First data yield promising results.

A first absolute gravity measurement has been done in 1997. The second measurement in 2011 yielded a significant lower gravity, being in accordance with the vertical uplift measured by the geodetic space techniques GNSS and VLBI.

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M0.5: EARTH OBSERVATION PROGRAMS CHILE'S UPCOMING SSOT MISSION & THE BELGIAN REMOTE SENSING RESEARCH FOCUS

SESSION CHAIR: E. DIEDRICH, DLR

The Belgian remote sensing research programme

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The Belgian Science Policy Office (BELSPO) has been financing remote sensing research programmes since 1984. The common thread has always been:

- to support the scientific use of data acquired by instruments Belgium had invested in;
- to build and support Belgian expertise in the field of remote sensing.

Throughout the years more and more emphasis has been put on

- the development of applications;
- interaction with users;
- knowledge transfer to administrations and industry;
- raising the visibility of the Belgian remote sensing research.

The latest phase of the Belgian remote sensing programme, STEREO II, started in 2006 and will run until mid-2014. The total budget is 25,85 m€.

The thematic priorities are:

- global monitoring of vegetation and evolution of terrestrial ecosystems;
- management of the local and regional environment (coastal zones, inland water and soil, forests and biodiversity, agricultural areas, urban and peri-urban areas, cartography, ...);
- health and humanitarian aid;
- security and risk management.

There are 3 major axes: scientific research, development of products and services and scientific support, education and promotion.

Within the axis scientific research, there are both large multiannual multidisciplinary thematic projects and small innovation projects. Collaboration with international partners is encouraged and is even obligatory for the large projects. Up to 10% of the project budget can go to an international partner.

There are currently 17 finished projects, 21 ongoing projects, with an additional 12 projects to start at the end of the year.

In addition to the main national research programme, smaller programmes have been financed dedicated to the use of data from a specific instrument, the latest being the PROBA-V Preparatory Programme.

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TU.1: *PARALLEL SESSIONS - GARS*

ANTARCTIC RESEARCH THE CHALLENGE FOR LOGISTICS

SESSION CHAIR: J. ARATA, INACH

AWI as neighbour and user of O'Higgins facility

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Since decades projects of the German Antarctic program have been realised in the neighbourhood of GARS.

At King George Island, the Dallmann Laboratory at the Argentinean Base Jubany is operated during Antarctic summer season as an international laboratory funded by the Instituto Antártico Argentino, the Netherlands Council of Earth and Life Sciences and the AWI.

The Dallmann Laboratory was established in 1994. Since then DNA/IAA, NWO and AWI provide support for technical and scientific installations. Research is focussed on marine and terrestrial biological studies, solar UV and ecophysiological investigations as well as geological field works. German research projects include investigations, which are in parallel carried out at Base AWIPEV in the Arctic, as a bipolar approach.

Furthermore I will show scenarios where AWI has taken benefit for operational purposes by remote sensing GARS has offered. Satellite images of Atka Bay showing the development of ice coverage support the adjustment of timing of schedules in expedition planning and supply.

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TU.1: *PARALLEL SESSIONS - FP7*

CHILE-EU RESEARCH OPPORTUNITIES UNDER FP7

SESSION CHAIR: M. LEPPE, INACH

Climate Change: Evidences in the Antarctic Peninsula derived from Chilean Weather Stations

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It is well know that the Antarctic Peninsula is the region where the increased air temperature is the highest registered on the planet during the last few decades (Din et al. 2011). In contrast, the rest of the Antarctic continent does not show the same rate of warming but rather a slight cooling (Doran et al. 2002). However, an analysis of the mid-tropospheric air (above the inversion layer) the whole Antarctica shows an increase in temperature (Turner et al 2005). This behavior has been related with the southward displacement of the westerlies which allows more relatively warm air passing over the Antarctic Peninsula. Results from the Chilean stations data for the 1970-2010 period show the same overall upward trend in air temperature, but this warming is driving by the minimum air temperature rather than maximum air temperature. In fact the diurnal temperature range (daily temperature oscillation) shows a decrease over the period. However, one intriguing result is that the air temperature reveals a decrease during the last decade. The same behavior is also observed at Faraday/Vernasdky station but not at Rothera. An indication, that this change is only taking place in the northern tip of the Antarctic Peninsula.

Analysis of the foggy days at Frei station reveals an increase in the number of days for which there was a fog event registered in the datalog. Fog usually forms around the time when the minimum air temperature occurs and the water vapor content reach the saturation point. Fog can also be seemed as proxy for presence of low cloud in the area. Therefore, the upward trend in the minimum temperature can be associated with increase in cloudy nights.

Precipitation results for the 1970-2010 period, show a large interannual variability with an overall positive, however, e-filter analysis revels un upward trend from 1970 to around 1990, them a decline period until around 2000 and them an increase here after. Evaluating the daily precipitation type (snow days and rain days), it is found a decrease in the number of snow days and an increase in the number of rain days. The overall increment in precipitation and the increase liquid precipitation concur with a warmer environment in the Antarctic Peninsula region. Although, analysis of the last decade still need further analysis.

Glaciological, hydrological and ecological monitoring: a perspective towards Antarctica

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Long term networks for monitoring hydrosphere, cryosphere and biosphere have a tradition in the European Alps und are currently used for developing models and methods for monitoring climate change and its effects. A major future aim is to test the performance of those methods in other regions with different climatic conditions. This will broaden our knowledge and make use of the results of the long time series in the Alps also for regions with a shorter research history.

Our network is based on measurements of mass and energy balance, glacier mass balance and length changes, glacier area and volume, runoff, precipitation, meteorological parameters, energy balance and biota.

The monitoring of glacier mass balance is important for local and global hydrology, as well as for local biota. Direct mass balance measurements require the maintenance of stakes and the measurement of snow accumulation, but allow the control the results of geodetic mass balance, which are often biased by errors in early elevation models in remote regions, where geodetic ground control points are sparse and the contrast in photogrammetric images often is low as a result of snow cover. Direct mass balance measurements could help to quantify the liquid water available for the biota and the error bars of the glacier mass changes calculated from volume change.

Energy balance stations a distributed network of precipitation gauges were used in the Alps to develop models of glacier mass balance and runoff from seasonal snow cover as well as from glaciers. The installation and maintenance of automatic weather stations provide meteorological input data to drive the models on one hand, and on the other hand allows the comparison to the performance of global models for driving models.

The GLORIA network is a global observation research initiative to monitor the biota in alpine environments (*www.gloria.ac.at*). The species (vascular plants) are recorded in 16 1x1 m² areas around summits. The network of participants is growing since 1994, when the first site was set up. The network also comprises also sites in North America, but currently no site exists South of Temuco.

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TU.2: *PARALLEL SESSIONS - GARS*

EARTH OBSERVATION
SAR APPLICATIONS FOR CIVIL SECURITY

SESSION CHAIR: L. LARA, SERNAGEOMIN

The ongoing 2011 eruption of Cordón Caulle (Southern Andes): evolucion and hazards assessment

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On June 4, 2011, at 18:45 UTC, Cordón Caulle volcano (Southern Andes, 40.52ºS, 72.14ºW) erupted explosively after 51 years of quiescence. The last eruption occurred in 1960 and was triggered by the great M_w 9.5 Chile earthquake. The ongoing eruption started after 2 months of increased shallow seismicity as recorded by OVDAS (the volcano observatory at Sernageomin). This close monitoring effort allowed a timely eruption forecast with at least 3 hours of warning, which facilitated the crisis response. In addition to this successful performance, for the first time in Chile volcanic hazards were assessed in advance supporting the emergency management. In particular, tephra dispersal was daily forecasted using the ASHFALL advection-diffusion model and potential lahars and PDC impact zones were delineated according to numerical approaches. Terrasar X images were useful to locate the eruptive vent in this explosive phase where the area was osbcured by the abundant ash. Precise locación of the vent is key para meter for tephra dispersal modeling. The first eruptive stage lasted 27 hours. It was characterized by ca. 15-km strong Plinian-like column, associated with the emission of 0.2 - 0.4 km^3 of magma (DRE). Tephra fallout mostly occurred in Chile and Argentina, although fine particles and aerosols circumnavigated the globe twice, causing disruptions on air navigation across the Southern Hemisphere. The second eruptive stage has been characterized by persistent weak plumes and lava emission at effusion rates in the range of 20 and 60 m^3/s, which total volume is estimated <0.20 km^3 (at the end of July 2011). Eruptive products have virtually the same bulk composition as those of the historical 1921 and 1960 eruptions, corresponding to phenocryst-poor rhyodacites (67 - 70% SiO_2) for what a pre-eruptive temperature of ca. 920ºC could be inferred. Again, TerraSAR X images and other remote sensing products were useful to map the growing lava flow and the overall evolution of the eruptive cycle, especially when instrumental (seismic) parameters seems to be insensitive the shallow processes.

This episode is a good case of successful eruption forecast and hazards assessment but it is also an important case-study of silicic eruptions in an arc segment where mostly mafic magmas have been erupted during the Holocene.

Satellite-based crisis information: Methods and applications for supporting disaster management

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Due to an increasing occurrence of natural disasters, humanitarian emergency situations and threats to the civil society, there is a rising need for timely geo-spatial information to support disaster management and decision-making. The German Remote Sensing Data Center (DFD) as part of the German Aerospace Center (DLR) has been active in the field of crisis analysis for nearly a decade and operates the Center for Satellite Based Crisis Information (ZKI) as a 24/7 service for the rapid provision, processing and analysis of satellite imagery during natural and environmental disasters, for humanitarian relief activities and civil security issues worldwide. ZKI serves as interface and front-end for the comprehensive satellite data acquisition, processing and analysis capacities available within the Earth Observation Center (EOC) of DLR in order to serve the operational civil protection and humanitarian relief communities. Besides crisis response activities, ZKI also focuses on geoinformation products for crisis prevention, early warning and reconstruction activities. ZKI operates in national, European and international contexts, closely networking with public authorities (civil protection and civil security) and non-governmental organizations (NGO's such as humanitarian relief organizations and the United Nations), as well as satellite operators and space agencies.

In order to optimize the time-critical analysis process of earth observation data for the early crisis response phase, the main emphasis of research and development activities at DLR has been on the most frequently occurring disaster types, i.e. floods, forest fires and earthquakes. Within the context of flood mapping, a hybrid multi-contextual Markov model for unsupervised near real-time flood detection in SAR data has been developed. The Markov model is initialized by an automatic tile-based thresholding procedure and incorporates scale-dependent and optional spatio-temporal contextual information into the segment-based classification process. The method is integrated into the software tool RaMaFlood, which is operationally being used during operational disaster mapping activities at DLR/ZKI.

Object-based classification workflows are also being used for the detection of burned areas based on optical as well as SAR data. The optical part of the algorithm used at DLR/ZKI employs a fuzzy classification approach based on index calculation such as MSAVI, BAI and NDSWIR in either single-temporal approaches, or their temporal differences in multi-temporal approaches (Bernhard et al. 2011). Since clouds, cloud shadows or smoke plumes of active fires can preclude burned area detection based on optical earth observation data, also SAR data was recently considered. An analysis of pre- and post-disaster TerraSAR-X data shows that vegetation removal due to wildfires generally results in a backscatter increase which varies with radar polarization and pre-fire vegetation density. The simultaneous use of both measurements potentially allows an all weather and daytime independent burned area detection.

Monitoring of Meteo-Marine Parameters of the Southern Oceans using SAR

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Twenty years of O´ Higgins Antaractic Station means as well dealing with the adverse weather conditions of the area especially considering transport across the Drake passage.

We use Synthetic Aperture Radar (SAR) imagery that show the sea surface independent from weather conditions and sunlight illumination to investigate the roughness of the Sea surface and thus give an estimate of the wind field and the sea state in the area. We use data from both ESA satellites (ENVISAT ASAR) and the new high resolution X band data from TerraSAR-X.

We use these data to cover a journey of the German Antarctic research vessel Polarstern imaging the local meteorological, sea state and sea ice conditions. A case of severe parametric rolling of the Polarstern is documented. We as well investigate several ship accidents in the area.

Methods to derive wind speed and the sea state by simple empirical models from SAR data are presented and applied for use in high resolution numerical modeling for coastal application. The new radar satellite TerraSAR-X (TS-X) images the sea surface with a high resolution up to 1m. So not only the wind information, integrated sea state parameters but also individual ocean waves with wavelengths down to 30m are detectable. Two-dimensional information of the ocean surface retrieved using TS-X data is validated for different oceanographic applications: derivation of fine resolved wind fields (XMOD algorithm) and integrated sea state parameters (XWAVE algorithm). The algorithms are capable to take into account fine-scale effects in the coastal areas. The wind and sea state information retrieved from SAR data are applied as an input for a wave numerical spectral model (wind forcing and boundary condition) running at fine spatial horizontal resolution of 100m. The results are compared to collocated buoy measurements. The studies carried out for varying wind speed and comparison against waves, simulated using original TS-X derived wind, show sensitivity of waves on local wind variation and thus the importance of local wind effects on wave behavior in coastal areas. Examples for Antarctic Waters are shown.

The TS-X satellite scenes render well developed ocean wave patterns of well developed swell at the sea surface. Refraction of individual long swell waves at a water depth shallower than about 70m is caused by the influence of underwater topography in coastal areas is imaged on the radar scenes. A technique was developed for tracking of wave rays depending on changing of swell wavelength and direction. We estimate the wave energy flux along the wave tracks from deep water to the coastal line based on SAR information: wave height and wavelength are derived from TS-X data.

Detection of Ships using SAR Images

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An application for ship detection based on satellite image data of synthetic aperture radar (SAR) has been implemented at the DLR site in Neustrelitz. The processing chain supports the fusion of the ship detection products with auxiliary data like Automatic Identification System (AIS) data from terrestrial and satellite sources. The near real time service was successfully demonstrated by the ESA project European Maritime Security Services (MARISS) and in different test campaigns for users like European Maritime Safety Agency (EMSA) or the Joint Research Centre (JRC). The ship detection service is currently implemented for the SAR sensors onboard the satellites ERS2, ENVISAT and TerraSAR-X. Dependent upon the spatial resolution of satellite image data, image and other products can be delivered within 15 minutes.

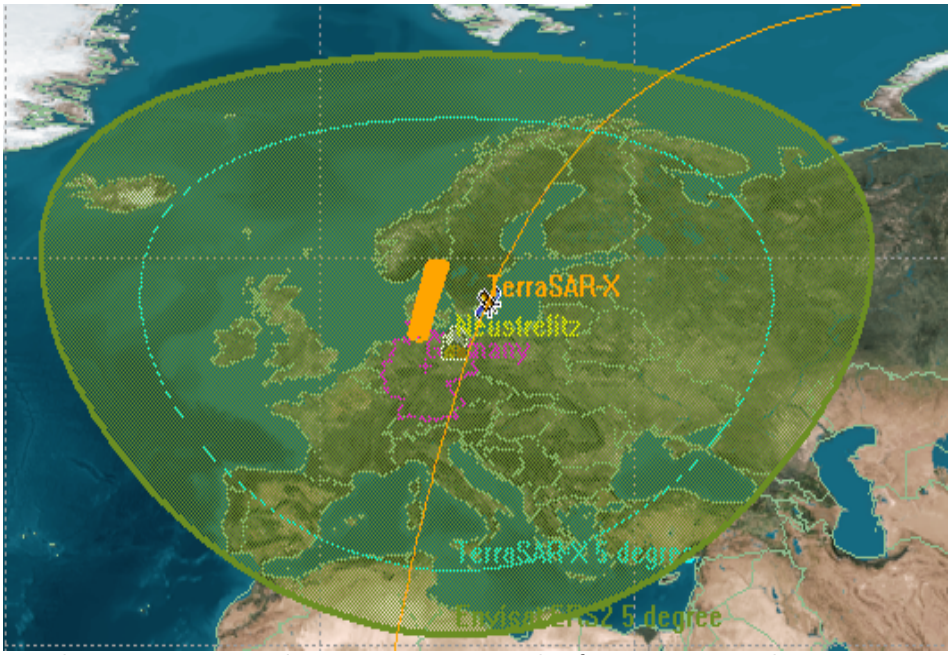

Figure: Ground Station Neustrelitz, acquisition circle for Envisat and TerraSAR-X; 5 degree elevation.

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TU.2: *PARALLEL SESSIONS - FP7*

CHILE-EU RESEARCH OPPORTUNITIES UNDER FP7

SESSION CHAIR: J. ARATA, INACH

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TU.3: *PARALLEL SESSIONS - GARS*

ASTROMETRY & SATELLITE GEODESY
TANAMI, SSA, GPS & GALILEO

SESSION CHAIR: R. OJHA, NASA/GSFC

Importance of the O'Higgins and TIGO telescopes to the TANAMI program

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The TANAMI (Tracking AGN with Austral Milliarcsecond Interferometry) program (Ojha et al. 2010 Astron. Astrophys. 519, A45) provides parsec scale monitoring of extragalactic gamma-ray sources of the southern sky. The German Antarctic Receiving Stations at O'Higgins located on the Antarctic Peninsula and TIGO (Transportable Integrated Geodetic Observatory) located in Concepcion, Chile, provide unique and irreplaceable baselines to the other antennas in the TANAMI array, dramatically improving its uv-coverage. This translates to significantly higher fidelity TANAMI images of AGN (Active Galactic Nuclei). Since the launch of the Fermi Gamma Ray Space Telescope, multi-wavelength observations across the electromagnetic spectrum are revolutionizing our understanding of AGN. VLBI observations are an essential part of such studies as they are the only way to spatially resolve the sub-parsec level emission regions where the high-energy radiation is believed to originate. VLBI observations are also the only way to directly measure the relativistic motion in AGN jets, allowing us to calculate intrinsic jet parameters such as jet speed, Doppler factor, opening and inclination angles. The vital role that data from O'Higgins plays motivates a strong desire to include O'Higgins more frequently in the TANAMI observation program when this is logistically possible.

Very Long Baseline Interferometry (VLBI) operations on the Antarctic continent

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The 9m radio telescope at O'Higgins is used as ground segment station for Earth observation satellite missions as well as for global geodetic measurement in terms of VLBI. The intention of the VLBI measurements in O'Higgins is to monitor the Earth observation parameters (EOP), the length of mostly intercontinental baselines and its change over time between O'Higgins and other involved VLBI observing stations with a precision of few centimeters over baseline lengths of thousands of kilometers. The geodetic measurements are organized in the framework of the International VLBI service (IVS) located in Washington D. C.

Until now, the VLBI measurement campaigns are performed in the Antarctic summer season. Usually there are two measurement campaigns, one from October to December and one from January to February. The sessions have to be registered at the IVS coordinating centre a long time in advance. There are mainly two session types, namely "OHIG" and "T2". The first one focuses on measuring the southern hemisphere ties around Antarctica. The second one intends to realize a global solution of the VLBI measurements, thus contributing to the terrestrial reference frame. Additionally, when O'Higgins is operational with the VLBI system, it takes also part in the TANAMI sessions tracking. TANAMI aims to measure the jet stream emissions of the black hole in the Centaury star system.

The outstanding importance of O'Higgins is due to its location on the Antarctic plate, among few stations in the southern hemisphere. This improves the resolution of radio interferometric observations. In contrast to other geodetic techniques as GPS, only VLBI delivers a full set of global observables.

Performance criteria for a space debris and detection tracking radar

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The population of man-made non functional objects in Earth orbit, space debris, represents an increasing threat for current and future space operations. The most probable impact velocities range from 10 to 15 km/s in low Earth orbits, creating risk even from small space debris, e.g. damage on sub-system level for collisions with objects in the regime of millimetres. The estimated number of space debris with diameters larger than 1 cm exceeds 600.000 objects, potentially causing the end of the mission. Collisions with objects of decimetre may further lead to total spacecraft fragmentation and respectively negative impacts on the overall environmental situation. With an assumed detection threshold of 10 centimetre about 22.000 active and inactive space objects are currently tracked and catalogued by the US Space Surveillance Network.

To reduce the generation rate and finally the number of space debris three actions are proposed: demonstrating compliance with international mitigation guidelines, improving collision avoidance efficiency by extending surveillance capabilities, and developing technology for active debris removal. Although the German Aerospace Centre DLR showing activity in all three areas, this paper is focused on the development of sensor capabilities and gives a presentation on a future DLR Radar system for space debris tracking and detection.

A recently proposed Radar system concept for space debris detection combines a reflector antenna with digital beam-forming techniques located at Weilheim. The utilization of multiple digital feed elements allows illumination of a larger survey zone compared to the relative narrow pencil beam of conventional tracking Radars. Signal processing from independent digital channels preserves a high antenna gain on the reception path and is a prerequisite for the implementation of an advanced and operational Track-While-Scan mode.

The tracking and survey performance are directly linked to the geographic location of the Radar system, extension of the survey zone, amount of transmitted power, characteristic of observation data and operational procedures. The influence of these parameters has been quantified by an evaluation of Weilheim station passes for the USSTRATCOM catalogue of Two-Line-Elements and a consider covariance analysis for exemplary orbit determination scenarios. It is investigated how additional Radar ground stations can improve the performance of the system.

Key words: Space Debris, Radar Tracking, Digital-Beamforming, Orbit Determination Error Analysis.

O'Higgins as Part of the IGS and CONGO Network

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In 1995 the first permanent Global Positioning System (GPS) station was installed at GARS O'Higgins by the German Bundesamt für Kartographie and Geodäsie (BKG). Since the very beginning of the GPS activities at O'Higgins, the station has been part of the global tracking network of the International Global Navigation Satellite System Service (IGS) and the data are freely accessible for the scientific community. The tracking data are used by the IGS analysis centers for the generation of precise orbit and clock products as well as ionosphere maps. In 1999 a second receiver was installed also able to track signals of the Russian GLONASS system. The two receivers currently active at O'Higgins are also multi-GNSS receivers operated remotely from the Geodetic Observatory in Wettzell, Germany.

Due to its location in Antarctica where the IGS network is quite sparse and due to the colocation with a geodetic VLBI (Very Long Baseline Interferometry) antenna, O'Higgins is an important station for the realization of the International Terrestrial Reference System (ITRS). The importance of O'Higgins is also reflected by the fact that the station is one of core stations of the latest IGS reference frame IGS08. But also the estimation of clock and ionosphere parameters benefits from a densification of the tracking network in the Antarctic region. Due to these advantages of the location, the setup of a Galileo Sensor Station at O'Higgins would be desirable. However, only a GPS station at O'Higgins is included in the current plans for the Galileo Terrestrial Reference Frame (GTRF).

End of 2009 a receiver of the Cooperative Network for GIOVE Observation was installed at O'Higgins. This receiver provides dual-frequency tracking capability of the Galileo In Orbit Validation Element (GIOVE) consisting of the two satellites GIOVE-A and GIOVE-B. The receiver is also capable of tracking signals of the future European navigation system Galileo. The CONGO network was initiated by Deutsches Zentrum für Luft- und Raumfahrt (DLR) and BKG and later joined by Deutsches GeoForschungsZentrum (GFZ) and Centre National d'Etudes Spaciale (CNES). It consists of currently 23 globally distributed stations transmitting their data in real time. For such a sparse network, a homogeneous distribution of the stations is mandatory for an accurate orbit and clock determination of the current GIOVE as well as future Galileo satellites. Together with a CONGO station at Davis, O'Higgins significantly improves the satellite visibility of the CONGO stations on the southern hemisphere. Recent results of the GIOVE orbit and clock determination will illustrate the potential of the future Galileo system and emphasize the importance of the O'Higgins station for the CONGO network.

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TU.3: *PARALLEL SESSIONS - FP7*

ROUNDTABLE

SESSION CHAIR: J. RETAMALES, INACH

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TU.4: SYMPOSIUM CLOSING

SESSION CHAIR: U. SCHREIBER, BKG

ABSTRACTS & PROGRAM
compiled by R. Metzig