

The GlobeSAR-2 University Exchange Program: Successes and Lessons Learned in Canada and Latin America

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ABSTRACT

The GlobeSAR-2 program, led by the Canada Centre for Remote Sensing, and supported by the Canadian International Development Agency was developed in an effort to build a capacity in radar remote sensing in participating Latin American countries, and to demonstrate applications of RADARSAT for local natural resource management. Further, GlobeSAR-2 has been working to establish useful linkages between Latin American universities and their Canadian counterparts. The main technical goals of the GlobeSAR-2 program were achieved and concluded with a final symposium in Buenos Aires in May 1999. Since then, continued program support has been focused on university exchange projects. Universities are a key component of the GlobeSAR-2 program, as they will provide the foundation for the future use of radar remote sensing in Latin America. Thus, the GlobeSAR-2 program has endeavoured to facilitate a university-based, stand-alone training capability in each participating country in Latin America. The program has supported collaborative research and educational projects between Canadian and South American educators, internships for Canadian students with South American industry and organisations, South American graduate student project work, publication by South American researchers in international journals, professional enrichment, and radar curriculum development. A core group of specialists and students now have radar expertise and are training the next generation of remote sensing users and educators. This paper will discuss the GlobeSAR-2 University program in terms of achievements and lessons learned.

Results of several exchange projects will be discussed, as well as how the GlobeSAR-2 University program may impact the future of radar remote sensing education capabilities in Latin America.

INTRODUCTION

The past decade has seen a significant increase in technical and scientific collaborations between Canada and Latin America. Many disciplines of space science are being integrated into academic institutions in both geographic areas, and a solid base of expertise is rapidly developing. The GlobeSAR-2 program has endeavoured to contribute to this trend by establishing useful collaborations between Canadian and Latin American researchers and institutions, focusing on the use of radar remote sensing for local natural resource management in Latin America.

The original GlobeSAR program was established by the Canada Centre for Remote Sensing (CCRS) in 1993 and funded by the Canadian International Development Agency, with remote sensing technology transfer activities between Canada and several countries world-wide, including China, Jordan, Kenya, Malaysia, Morocco, Tanzania, Thailand, Tunisia, Uganda and Vietnam. This program focused on the use of airborne SAR data for natural resource management and resulted in the establishment of radar expertise in many of these countries.

In 1992, CCRS partnered with the European Space Agency (ESA) on the South American Radar Experiment (SAREX) project. The CCRS SAR-equipped aircraft (CV-580) collected data

over Brazil, Costa Rica, Guyana, Colombia, French Guyana and Venezuela. With funding from the Canadian International Development Agency (CIDA), the SAREX project developed into continued collaboration between Canada and Brazil, under the ProRadar initiative. Based on the results of these earlier collaborations on radar remote sensing, there was a clear demand for further technology transfer programs in Latin America.

Building on the success of the GlobeSAR-1/ProRadar programs, the GlobeSAR-2 program was developed to foster further expertise in radar remote sensing in Latin America. This program was also funded by CIDA, with additional funds for work in Central America from Canada's International Development Research Centre (IDRC). Between 1996 and 1999, the Canada Centre for Remote Sensing (CCRS) has worked with over 80 investigators in 11 Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Honduras, Panama, Peru, Venezuela, and Uruguay) on various projects using the Canadian earth observation satellite, RADARSAT-1. The results of these projects were presented at the GlobeSAR-2 Final Symposium in Buenos Aires, Argentina, May 1999. Since then, many investigators in South America have continued their collaborations with Canada under the GlobeSAR-2 University Exchange Program. This university exchange initiative has forged many strong partnerships between Canadian and Latin American universities.

GLOBESAR-2 UNIVERSITY EXCHANGE PROGRAM

Specific objective of this exchange program is to establish linkages between universities in Canada and South America by supporting collaboration on radar remote sensing projects. With this, it was anticipated that the program would greatly contribute to the integration of remote sensing into the local education programs and to the production of results of benefit or interest to others in the region.

There are 21 GlobeSAR-2 University exchange projects, which are outlined in Table 1. The selection of these projects was based on a proposal submitted to CCRS by each

investigator. Proposals were accepted and funded based on the following criteria:

- 1) Projects must contribute to improved natural resource management, capacity building, and development of linkages between South American and Canadian institutions.
- 2) Projects must have a high probability of success, establishing or contributing to implementation of the use of RADARSAT data in application areas of national or regional priority.
- 3) Projects must be innovative, adding to the existing radar remote sensing knowledge base.
- 4) Institutions must be prepared to contribute "in kind" resources to the program.
- 5) Canadian partners must demonstrate that they have the required in-house capacity and commitment to participate in radar applications development under this program.
- 6) Projects that show how they would increase training capacities for radar remote sensing in South American countries are accorded higher priority.

Although there was an effort to establish university exchange projects in the 8 GlobeSAR-2 South American countries, proposals were only received from Argentina, Bolivia, Brazil, Chile, Colombia and Uruguay. Figure 1 illustrates the geographic distribution of the GlobeSAR-2 University exchange projects by South American country. Countries with several projects had strong institutional support from the national coordinating agency and a high level of interest generated in the university community by the GlobeSAR-2 applications projects, particularly in Argentina where the Final Symposium was held. Individuals who had participated in earlier GlobeSAR-2 training activities and workshops submitted the majority of proposals.

Projects covered a wide range of applications areas, including agriculture, forestry, hydrology, land use, geology, oceans, mapping and education. Application specific projects generally related to a study site in South America and focused on a natural resource issue that is of particular national importance. For example, one

Table 1: GlobeSAR-2 University Exchange Projects

ID	South America		Canada		Title
	PI	University	PI	University	
UAR-1	S. Navone	University of Buenos Aires	D. Barber	University of Manitoba	Evaluation of Land Degradation in Semi-arid Inter-mountain Valleys in Argentina with RADARSAT and GIS
UAR-2	H. Salgado	University of Buenos Aires	M. Bernier	Université de Québec	Soil Surface Moisture Mapping using SAR images and distributed Hydrologic Models
UAR-3	C. Cotlier	National University of Rosario	G. B. Hall J. Piwowar	University of Waterloo	Integration of RADARSAT Imagery With a Geographic Information System (GIS) for the Identification, Analysis of Structural Change and Demographic composition of Pockets of Urban Poverty
UAR-4	M. Presutti	National University of La Plata	S.E. Franklin	University of Calgary	Forest Inventory and Crop Monitoring in the South East of Buenos Aires Province, Argentina
UAR-5	G. Martinez	National University of Mar del Plata	H. J. Gwyn	Université de Sherbrooke	Geomorphology and Land Use Using Remote Sensing Techniques in S.E. Buenos Aires Province, Argentina
UAR-6	G. Salinas de Salmuni	National University of San Juan	J. Bugden, P. Howarth,	University of Waterloo	RADARSAT Crop Identification and Rural-Urban Change in the Tulum Valley, Argentina
UAR-7	D. Marchionni	National University of La Plata	F. Cavayas	Université de Montreal	Aplicaciones de un Par Esterescopico de Imagenes SAR de RADARSAT Para El Estudio Geologico-Estructural Del Macizo Del Deseado, Provincia De Santa Cruz, Argentina.
UAR-8	H. Karszenbaum	University of Buenos Aires	K. Thomson / I. Cumming	Université de Laval / University of British Columbia	Evaluation and Dissemination in Argentina of the Radar Remote Sensing Core Curriculum Developed by Canadian Universities
UAR-10	M. Raed	National University of Lujan	J. Wang	University of Western Ontario	Multitemporal and Multispatial Change Detection Digital Data in the Visible, Infrared and Microwave spectral Range on Centre and South Areas of Argentina
UAR-11	P. Kandus	University of Buenos Aires	P. Howarth	University of Waterloo	Multidate and Multisensor RADARSAT and Optical Data for Improved Wetland Information: A Case Study from the Parana River Delta, Argentina

UBO-2	J.L. Lizeca	SERGIOMIN	W.Moon	University of Manitoba	Geomorphological and Tectonic Study using RADARSAT Images (Area of Sud Lipez)
UBO-3	R.L.C. Chávez	University of Mayor de San Simon	P. Howarth	University of Waterloo	Agricultural Crop Identification and monitoring in Bolivia Using RADARSAT Data
UBO-4	S. Moreau	ABTEMA	D. Barber	University of Manitoba	Quantification of Surface Roughness and Evaluation of its Influence on Soil Moisture and Biomass Backscatter
UBR-1	M. Barbosa	Federal University of Paraiba	D. Barber	University of Manitoba	Integration of SAR and Optical Wavelength EO data for Drought Assessment in North-eastern Brazil
UBR-3	A. Crosta, E. Pedroso	State University of Campinas	B. Rivard	University of Alberta	Geologic Mapping and Exploration in the Tapajos Gold Province Using RADARSAT/SAR Data
UCH-1	C. Silva	Catholic University of Valparaiso	P. Larouche	Institut Maurice-Lamontagne	Application of Imagenes RADARSAT in Studies of Oceanic Processes and Distribution of Recursos Pelagicos
UCH-2	R. Richardson	University of Santiago de Chile	M. Fox	Carleton University	Comparative analysis of land resource issues in Chile and Canada with special reference to the use of RADARSAT digital image processing
UCO-2	E. Possada	CIAF (IGAC)	S. E. Franklin	University of Calgary	Evaluation of Landuse and Landcover with emphasis on Forestry Applications, through RADARSAT Image Interpretation in the Savanna Area of Bogota, Region Andina of Colombia
UCO-3	A. Cristancho	IGAC	R. Desjardins	University of Quebec in Montreal	Geologic Analysis and RADARSAT Images Interpretation in a Mountainous Area – Manizales Region, Colombia
UCO-4	S.Bolaños, G. Leclerc	CIAT	T.Toutin	CCRS	Web-based Spanish Tutorial on generation of DEMs from RADARSAT data
UUR-1	G. Carballo	National University of Uruguay	P. Fieguth	University of Waterloo	SAR Interferometry

of the projects in Chile focused on studies of oceanographic processes which is of direct relevance to the fisheries industry in Chile (UCH-1).

Figure 2 shows the distribution of projects by application. A fairly balanced distribution between application areas is seen, with several more projects focusing on geology and land use. Geology projects were carried out in Bolivia, Colombia, Brazil and Argentina and considered

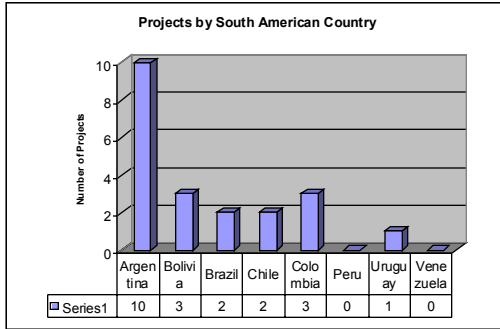


Figure 1: Number of GlobeSAR-2 University Exchange Projects by Latin American country

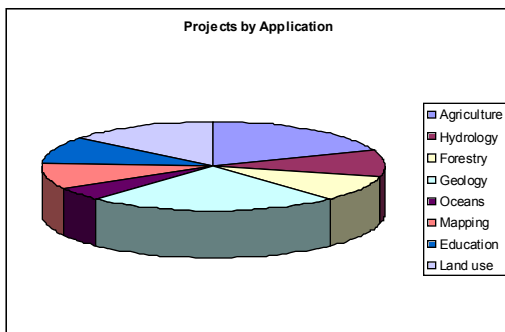


Figure 2: Number of GlobeSAR-2 University Exchange Projects by Application.

the use of RADARSAT technology for geological hazard mapping (UBO-2), exploration (UBR-3) and geological structure mapping (UAR-7 and UAR-5). In terms of land use, several projects investigated land resource issues (UCH-2) and land degradation concerns (UAR-1). In Argentina, one of the projects considered the use of RADARSAT images for identifying areas of urban sprawl around Rosario, Argentina (UAR-3). Projects relating to agriculture monitoring with radar remote sensing included studies on crop identification (UAR-6) and soil moisture (UAR-2). Within the broad application of hydrology, the UBR-1 project looked at the use of SAR for drought assessment in Brazil, and UAR-11 used RADARSAT in combination with optical data to map a wetland area in Argentina. Forestry projects were carried out in Buenos Aires Province (UAR-4), looking at forest inventory applications, and in Colombia (UCO-2) on forest cover evaluation.

Several project investigators analysed the use of RADARSAT for mapping applications such as change detection (UAR-10), generation of digital elevation models (UAR-7), integration of

different data sets (UBR-3), and SAR interferometry (UUR-1). Two projects focused on education (UAR-8, UCO-4).

RESULTS

The primary measure of any projects success is whether it has achieved its objectives. Several of the projects have been highly successful and sustainable, resulting in several publications and continued collaboration beyond the boundaries of this program. Only three of the 21 projects closed early due to problems: illness stopped one project, on participant left the organisation before completing the project, and one project was ended by mutual agreement.

Most of the researchers have already compiled publishable results and made effective use of information dissemination networks. Table 2 outlines the resulting publications from 15 of the GlobeSAR-2 projects. A few projects are still in progress. Published results have been presented at symposia and workshops throughout Canada and Latin America. Several papers have been published in international journals and presented at conferences in Europe (UAR-7). The opportunity for Canadian researchers to publish in Latin American venues, and vice versa allowed for a broadening of publication networks for the participants, which was noted by some as a welcomed benefit of the program.

In Argentina, Haydee Karszenbaum (UAR-8) of the University of Buenos Aires partnered with several Canadian Professors to evaluate a full radar remote sensing curriculum package. The results of this practical evaluation were provided to CCRS along with suggestions for improvement of the curriculum. Where possible, the improvements were incorporated and the training material will be made freely available on CD-ROM in English, French, Spanish and Portuguese. The GlobeSAR-2 Radar Training CD will become an important and valuable fundamental curriculum development resource for building educational capacity in the GlobeSAR countries and beyond.

Sandra Bolaños and Grégoire Leclerc of Centro Internacional de Agricultura Tropical (CIAT) in Colombia, working in collaboration with Thierry Toutin of CCRS, have produced two distance learning products in Spanish, namely “Asesor de Estéreo” -- an interactive Web tool intended to

Table 2: List of Publications from GlobeSAR-2 University Exchange Project Investigators

Project	Authors	Publication
UAR-1	Navone, S.M. , Palacín, E, Introcaso, R. and Hochkeim, K	"Landforms Identification In Santa Maria Valley Using RADARSAT Image Enhancement", in progress, to be submitted to ISPRS 2001.
UAR-2	Hector Salgado , Leopold Génova, Alejandro Paolini, Brian Brisco and Monique Bernier	"Surface Soil Moisture Estimation in Argentina using RADARSAT Data". Submitted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UAR-2	Jean-Pierre Fortin, Monique Bernier , Héctor Salgado , Jorge Nielsen	"Complimentarity of Satellite Images and Hydrological Models for Water Balance in Watersheds", to be presented in AQT Congress, Québec, Canada, August 2001
UAR-3	N. W. Malcolm, J.M. Piwowar, G. Brent Hall , Carlos Cotlier and Alejandro Ravenna	"An Integration of RADARSAT and Landsat Imagery to Identify Areas of Urban Poverty in Rosario, Argentina". Accepted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UAR-4	M. E. Presutti , L. M. Moskal, E. E. Dickson and S. E. Franklin	" Supervised Classification of Landsat TM, RADARSAT W2 Data, and Texture derivatives for Agricultural Crop Mapping in Buenos Aires Province, Argentina" in Proceedings of the 22 nd Canadian Symposium on Remote Sensing, Victoria, BC, August 2000.
UAR-4	M. E. Presutti , L. M. Moskal, E. E. Dickson and S. E. Franklin	" Supervised Classification of Landsat TM, RADARSAT W2 Data, and Texture derivatives for Agricultural Crop Mapping in Buenos Aires Province, Argentina". Accepted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UAR-5	Gustavo A. Martinez , Jorge Martinez Arca, Q. Hugh J. Gwyn and Maria V. Bernasconi	"Geomorphology and Land Use Using Remote Sensing Techniques in SE Buenos Aires Province, Argentina Combined Use of RADARSAT-1 and LandSat TM data for Geomorphological applications in Lowlands of Buenos Aires Province, Argentina". Accepted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UAR-6	Bugden, J.L. , G. Salinas de Salmuni , and P.J. Howarth	"RADARSAT vineyard identification in Tulum Valley, San Juan, Argentina". Canadian Remote Sensing Symposium, Vol. 2, June 21-24, 1999. Ottawa, pp.375-382.
UAR-6	Salinas de Salmuni, G. , G.. Ibanez, J.L. Bugden , M.I. Lund, J. Mareca, and J. Maraz	"Land use and land cover of the irrigated zones in the Provinces of San Juan and Mendoza in Argentina", GlobeSAR-2 University Symposium, May 1999, Buenos Aires, Argentina.
UAR-7	Marchionni, D. , Cavayas, F. y Roller, E.	"Potentiel de Détection des Traits Structuraux d'un Territoire Semi-Désertique sur des Images RADARSAT : Le cas du Macizo del Deseado, Argentina". CEOS-SAR Workshop (CNES-ESA). Toulouse, Octobre de 1999. Pp: 479-484.
UAR-7	Marchionni, D. , Cavayas F , Alperín, M and Del Blanco, M.	"RADARSAT Image Validation from field Surface Roughness Measures in a Semi-Desertic Territory: The Case of the Macizo del Deseado, Argentina". 8 th Symposium on International "Mesures physiques et signatures en teledetection". Aussois, France, 2001. Pp: 161-166.

UAR-7	Marchionni, D., Cavayas, F., Schalamuk, I. and D'lorio, M.	"Linear and textural patterns extraction from RADARSAT imagery for geological and structural mapping. The case of the Macizo del Deseado, Argentina". Submitted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UAR-10	Mirta Raed, Jorge Gari, Jinfei Wang, Xulong Peng, Brian Brisco, Alicia Sedeno, Raul J. Peredo, Daniel Bernal and José Candia	"Land Cover Mapping in the Magellanes Peninsula and Glacier Region of Southern Argentina with RADARSAT". Submitted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UAR-10	Mirta Raed, Jorge Gari, Jinfei Wang, Xulong Peng, Alicia Sedeno, Raul J. Peredo	"RADARSAT Ortho-Image Classification over Calafate area and its Mountainous surroundings" in Proceedings of the IX SELPER Conference, Iguazu, Argentina, November 2000.
UBO-2	José Luis Lizeca, W.M. Moon, C.A. Hutton, L. Wu, C.W. Lee	"Investigation of Pastos Grandes (Bolivia) Volcanic Features with RADARSAT" in Proceedings of IGARSS'99, Hamburg, 28 June - 2 July, 1999
UBR-1	Marx Prestes Barbosa, David Barber, Cicero de Oliveira Lima	"TM/Landsat-5 and SAR Image Digital Processing Applied to Identify Salt Affected Soils Zones in the Baixada de Sousa, State of the Paraíba, Brazil", in Proceedings of the IX SELPER Conference, Iguazu, Argentina, November 2000.
UBR-3	Pedroso, E.C., B. Rivard, A. Crosta, C. De Souza Filho, and F.P. De Miranda	"Data integration applied for geologic mapping and exploration in the Tapajos gold province using SAR imagery and airborne geophysics". 31st Intern. Geol. Congress, Rio de Janeiro, August 7-17, 2000.
UBR-3	E. C. Pedroso, B. Rivard, A. P. Crosta, C. R. de Souza Filho and F. P. de Miranda	"Reconnaissance geologic mapping in the Tapajos mineral province, Brazilian Amazon, using spaceborne SAR imagery and airborne geophysics". Accepted to Canadian. J. of Remote Sensing (special GlobeSAR issue), 2001.
UCH-1	M. A. Barbieri, C. Silva, P. Larouche, K. Nieto and E. Yanez	Detection of mesoscale oceanic features using Radarsat-1, AVHRR and SeaWiFS images and its association with jack mackerel (<i>Trachurus murphyi</i>) distribution in central Chile. Submitted to Canadian J. of Remote Sensing (special GlobeSAR issue), 2001.
UCO-2	E. Possada, L.M. Moskal, E.E. Dickson, S.E. Franklin and B.A. Wilson	"Classification of RADARSAT and Landsat TM Imagery in the Savanna Region of Colombia" in Proceedings of the 22 nd Canadian Symposium on Remote Sensing, Victoria, BC, August 2000.
UUR-1	G.F. Carballo, P.W. Fieguth	"Probabilistic Cost Functions for Network Flow Phase Unwrapping" in IEEE Transactions on Geoscience and remote sensing, September 2000.
UUR-1	G.F. Carballo, P.W. Fieguth	"Multi-resolution Network Flow Phase Unwrapping" in IEEE Transactions on Geoscience and remote sensing, September 2000.

specify a pair of RADARSAT-1 SAR images for use in creating a digital elevation model (DEM) and for improving the extraction of thematic information and "Generación de MDE con

RADARSAT" -- a Web-based tutorial which describes and illustrates the process of radargrammetry and its application to generation of digital elevation models (DEMs) using

RADARSAT images. These products can be found at:

<http://www.ccrs.nrcan.gc.ca/ccrs/imgserv/advisor/advpg1se.html> or

<http://www.ciat.cgiar.org/dtmradar/>

SUCSESSES

For this section and the following one on lessons learned, the participants were asked for their views of the university exchange program. The publication of project reports in respected journals and conference proceedings indicates the quality of scientific results that was produced from GlobeSAR-2 projects. Increased international visibility typically has positive consequences both for career advancement and financial remuneration.

For many of the participants, the GlobeSAR-2 program offered a first opportunity to analyse RADARSAT data for their given application. The complexity and cost associated with radar remote sensing has often limited its use in many parts of the world, particularly for unproven applications. A program like GlobeSAR-2 offers a unique opportunity to investigate the applicability of radar under a low-risk, fully funded umbrella program. Many of the researchers identified this as a main success of the program, which allowed for continued use of radar beyond their GlobeSAR-2 projects.

For those participants with SAR experience, the GlobeSAR-2 University exchange program offered an opportunity to learn more on advanced SAR topics and techniques. As an example, Professor Steve Franklin with the University of Calgary worked with Miriam Presutti of the University of la Plata (UAR-4) to learn more about SAR-TM classification, texture and “what can and cannot be done with SAR”.

Ryerson and Quiroga (2001), in their assessment of remote sensing initiatives in developing countries, note that academic institutions are the most suitable forum for useful exchange of remote sensing technology. The participants are generally enthusiastic, dynamic individuals who are willing and able to develop the new technology to a level that would be sustainable and transferable to other sectors of a countries economy based on demonstrated relevance to national development priorities.

The sustainability of many of the projects is an important success of the programme. Follow-on collaborations beyond the exchange project have continued in many cases, as most of the participants developed good working relationship with partners. Professor Steve Franklin notes the benefits to other students at the University of Calgary who had the opportunity to work on his project with Miriam Presutti (UAR-4) of the National University of La Plata. For his university, participation in the GlobeSAR-2 program proved to be a successful exercise in effective technology exchange, rather than simply one directional technology transfer. Many investigators plan to continue to work together, either further developing the research carried out under GlobeSAR-2 or developing new initiatives together.

Issues of gender and language were also addressed with success under the GlobeSAR-2 project. The overall gender distribution for the GlobeSAR-2 project investigators showed an equal distribution between men (12) and women (10). In Argentina however, there were far more female (7) investigators than male (3), indicating a strong participation of women in remote sensing applications in Argentina.

Language barriers were not considered a constraint in most projects. The Latin American participants benefited from the opportunity to further their English or French skills and many of the Canadian participants appreciated the opportunity to learn or practice Spanish or Portuguese. The radar remote sensing project documentation and training materials produced during ProRadar and the GlobeSAR-2 earlier phase are being widely used in universities, and are available in English, French, Spanish and Portuguese.

In terms of direct benefits to Canada, the GlobeSAR-2 University exchange program has provided a forum for Canadian radar experts and Canadian remote sensing capacity to gain visibility in South America. For instance, the radar curriculum CD produced under the GlobeSAR-2 program made use of the Canadian expert community, and clearly acknowledges their contributions. In addition, the programme allowed for promotion and the development of commercial opportunities for RADARSAT-1 data distribution to South America. In fact, significant commercial sales of RADARSAT-1

data to South America have direct links to the GlobeSAR-2 program.

South American University participants have benefited from professional development activities and the expansion of scientific knowledge in their particular application of interest. Radar remote sensing has been introduced into university courses in most of the GlobeSAR-2 countries. All participating universities have broadened their base of radar expertise, and a few have sought partners in operational agencies, local industry and environmental NGOs and made their expertise accessible to them in some manner. The professional networks and local expertise established during the GlobeSAR-2 project have demonstrated their effectiveness in accessing and capacity for using RADARSAT data in times of national disasters. To encourage further networking, a web-based radar discussion list was initiated by Dr. Haydee Karszenbaum (University of Buenos Aires), providing a forum for information exchange within the SAR community. This discussion group is mainly populated with GlobeSAR-2 investigators, although other world experts in SAR have participated in on-line discussions.

Visit <http://www.iafe.uba.ar/SAR/index.html> for more information.

LESSONS LEARNED

For the GlobeSAR-2 university exchange project, there were several notable lessons learned, specifically relating to links between academia and operational agencies, need for continuity and flexibility of funding and support, and the need for a strong and stable institutional framework.

There is a clear need for increased attention to end-user requirements. University researchers need to be encouraged to look beyond the scientific and technical merits of their work and seek to better understand how their research can address specific social, economic and environmental needs of the country. Strategic partnerships established with government organisations, industrial users or environmental NGOs greatly enhances the value of their research and development.

Fundamental to success, the institutional infrastructure of participating countries needs to be strong and stable, willing and able to accept and implement new technology, with eyes to the future and innovative approaches. When the participating institutions are undergoing major re-organisation or budget cuts, immediate priorities focus on job security and organisational health. In such cases, special attention to institutional infrastructure and strengthening it is necessary for successful implementation of new technology.

It is not accurate or appropriate to assume a basic link between a country's social, economic and political state and the successful implementation of a technology exchange initiative, although there is a clear correlation with respect to the GlobeSAR-2 program. The expertise and enthusiasm exists in the countries where no university exchange projects were developed, and strategic promotion to potential participants is needed.

There is always a need for more funding and support. The GlobeSAR-2 University exchange projects were no exception. Many of the investigators indicated a need for more funding for actual research rather than strictly travel and related expenses. Many funding opportunities do not address the expenses associated with completing the research at the home institution. Many investigators commented that increased flexibility in financing would help address this limitation and allow the partners to plan better and support those working on the project sufficiently. With this, could be a more effective focus on actual results and impacts and perhaps less dependence on financial accounting.

There was also an generally expressed desire for follow-on support to assist with continued research. The limitations of resources and funding proved to be the cause of termination of several areas of useful research. Pierre Larouche of the Institut Maurice-Lamontagne (UCH-1) noted the benefits of his participation in the GlobeSAR-2 program, but indicated that further research will be put on hold until resources are available to support it. It was suggested that a follow-on multi-year initiative would be appropriate for the GlobeSAR-2 projects offering the greatest potential for success and benefits. Building on the successes of the university exchange projects, funding opportunities (jointly supported by Canada and Latin American

countries) could allow for the continuation of targeted research. These ideas need to be pursued and developed in order for the advances and opportunities obtained in the university exchange projects to become sustainable.

There was a surprising difficulty in finding appropriate Canadian counterparts in some areas of expertise related to the Latin American interests. There is an obvious need for wider promotion of the program to Canadian experts in order to establish appropriate partnerships. Further, Robert Desjardins (UCO-1) of the Université du Québec emphasised the need to ensure compatibility of partnerships and suggested implementing limited scope pilot-projects initially, with opportunities for multi-year follow-on projects for the most successful pilot projects and partnerships.

CONCLUSIONS

In general, the GlobeSAR-2 University exchange Universities are a key component of the GlobeSAR-2 program, as they will provide the foundation for the future use of radar remote sensing in Latin America. In general, the collaborative research and educational projects undertaken in the GlobeSAR-2 University exchange program have been an appropriate and effective means of exchanging radar remote sensing knowledge and technology with Latin America. There have been many noted successes, including the development of sustainable partnerships that produced valuable scientific results. A core group of specialists and students now have radar expertise and are training the next generation of remote sensing users and educators.

As anticipated, the 21 GlobeSAR-2 University exchange projects obtained varying levels of success and most of the projects have published scientific results and continue established collaborations. The projects were generally found to be of benefit to both the Canadian and Latin America partners, in terms of information and technology exchange, international visibility and long-term collaborative relations. On a national level, the participating countries benefited by a unique opportunity to broadening their radar remote sensing expert

population. For Canada the program also provided strategic promotion of national technology such as RADARSAT in Latin America.

The lessons learned have indicated a need for careful and early consideration of end needs as they vary by application and by country. Both the partnerships and the research applications need to be suitable and appropriate to the needs and existing capacities of the participating country.

There was an expressed desire to continue the GlobeSAR-2 University exchange program with increased funding and support to successful research initiatives. It is clear that most investigators, both Latin American and Canadian, found benefits to their involvement in GlobeSAR-2 and would like to see a follow-on activity. Building on the successes of the GlobeSAR-2 program, and integrating the lessons learned, future related activities should prove to be even more fruitful in terms of direct impact, sustainability and reinforcement of linkages between Canadian and Latin American institutions.

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