WinSAR Strategic Plan

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Executive Summary

At the Unavco Science Workshop in Boulder, Colorado from 11-13 March 2008 a Special Interest Group was convened to review and discuss the current status of InSAR science and the WinSAR group. The objectives were to identify the challenges and opportunities in the next decade. The recommendations of this Special Interest Group are summarized in this document.

InSAR data have become an important source of information to solve significant problems in the Earth Sciences. The top priority in the coming years is to increase the data holdings and to improve data access in a near-real-time fashion. The community's vision for the future is a multi-satellite *subscription-based data system* in which complete data sets for given geographical regions (such as the WinSAR core region) are readily available to the WinSAR members. A subscription-based system is a significant progress over the current, user-based ordering system with commonly several weeks delay between identifying, ordering and arrival of new SAR data. A subscription-based system will significantly broaden the user community because no specific knowledge about data catalogues and ordering procedures is required. A subscription-based system will lead to community-generated, multi-satellite InSAR-displacement time series comparable to continuous GPS which are key to mayor new scientific discoveries.

Given Unavco's very good relations with the European Space Agency (ESA), and the Japanese Space Agency (JAXA) a limited, subscription-based ordering system seams feasible within a one-to-two-year time frame. Coordinated by Unavco, NASA's Data Active Archive Center (DAAC) at the Alaska Satellite Facility (ASF) could contribute ALOS imagery in a subscription-type fashion. The principal recommendations of the workshop participants are:

(1) to gradually implement a subscription-based data ordering system;
(2) to prepare for a twenty-fold increase in data volume expected in 2011 with the launch of Europe's Sentinel satellites.
(3) to work towards full integration of WinSAR support into the next Unavco proposal (possibly with a separate proposal for imagery costs).
(4) to provide leadership to the global InSAR community with a first-class data sharing system that can serve as a prototype for global SAR data networks for the DESDynl era

Much of the recent progress of WinSAR was made using GeoEarthscope funding which ends in September 2008. To follow through with these recommendations, the funding level for FY 2009 needs to be increased. One rationale behind these recommendations is that the European Space Agency (ESA) shares our vision a data subscription for the WinSAR region. ESA wishes to collaborate with one strong U.S. partner (Unavco) to serve the entire U.S. InSAR community.

Action Plan, Update September 2008

Since the first draft of this document has been circulated we have developed an action plan of how to achieve the goals outlined in this document.

1. **A total of $327,589/yr is required to cover the costs of data subscription for Envisat and ERS for the WinSAR core region (**until the end of the Envisat mission in 2011, 3 years, in addition to the current WinSAR budget; this includes satellite tasking, purchase of new and archived imagery, and supporting personal, see Appendix A), of which $267,589/yr is for imagery only.
2. Unavco and the ASF have submitted a proposal to NASA's ROSES-08 Advanced Information Systems Technology (AIST) program to develop a seamless SAR data catalogue. This proposal is entitled "Development of Web Services Infrastructure for Enhanced Access to Synthetic Aperture Radar (SAR) Data". The WinSAR EC enthusiastically supports this proposal because it addresses the SAR catalogue issues described below.

Science

Interferometric Synthetic Aperture (InSAR) radar has taken an important role in a variety of Earth Science disciplines. InSAR is a standard technique for the study of earthquakes and volcanic eruptions and of slow tectonic and volcanic processes. InSAR is also an important tool to study sub-surface and surface hydrologic processes. InSAR-measurements of urban land subsidence and of water level changes in wetlands calibrates ground-water and surface-water models. Recently, a new application of InSAR related to Global Change emerged. Studies of land subsidence in New Orleans and Seattle show that InSAR can identify areas that will be most heavily impacted by future sea level rise. These type of studies are key for the urban planning of coastal areas.

Key Requirement

Critical for all InSAR applications are temporally dense, long SAR time-series without temporal gaps. Decade-long, multi-satellite time series can detect ground deformation at the mm/yr level. For example, with a 30-year, multi-satellite data set of 500 SAR images we will be able to see the loading of tectonic faults in Seattle, something that can't be resolved using current datasets. WinSAR and Unavco need to assume a pro-active role to acquire SAR data sets suitable to address important Earth Science problems. The Space agencies don't do this because the satellites are designed with 5-10 years lifetime.

Future Challenges

By 2020 we expect that there will be ten or more orbiting SAR satellites, all designed and launched with different objectives, providing imagery in many different formats with different access policies. WinSAR's responsibilities are:

(1) To ensure the acquisition of long SAR time series for the WinSAR core region in the Western U.S.
(2) To provide the community with rapid, near-real time access to this diverse, multi-satellite SAR imagery (new and archived) over a unified data portal.

(3) To provide seamless access to datasets of retired satellites for decades to come (users need the capability to access several hundred, multi-satellite imagery within several hours download time).
(4) To broaden the user community and to encourage the wide use of SAR data by simplifying complex data access procedures and catalogues
(5) To facilitate the development of the InSAR technology by organizing expert workshops, and workshops bringing together related communities such the InSAR, GPS, GPS-Meterology and weather modelers.

WinSAR today

WinSAR currently has 58 member institutions with 50 of them from the U.S with full data ordering and voting privileges. About 10-20% of the U.S. members can be considered as "power users" with active InSAR research groupsß, and actively involvement in the WinSAR organization, such as the WinSAR Executive Committee. The remainders are Earth scientists from a variety of disciplines who only occasionally use InSAR data for their research ("occasional users").

1. Current satellites. The principal data holding are from the European *ERS* and *Envisat* satellites. *Radarsat* imagery is available from GeoEarthscope. For these satellites the archive works very well thanks to the efforts by the Unavco engineers and programmers. *ALOS* data are distributed by the ASF through the L1-data pool. The ordering procedure has been significantly simplified since the ASF accepts data subscriptions for given geographic areas. The data access, however, is still unsatisfactory because the data pool is frequently offline. One of the urgent tasks is to improve the access to the ALOS data and to integrate the L-1 data pool with the WinSAR database. The requirements of the WinSAR community regarding ALOS are summarized in Appendix B.

2. Ordering procedures. The current mode of data ordering at WinSAR is a user ordering system (users submit files produced with ESA's ordering software to Unavco). Orders are executed only if enough funds and quota are available. Many users had rejected orders because of a lack of either of them. Rejected orders are very discouraging and counter-productive to our goal of broadening the community. ß

3. Catalogue jungle. Each satellite has its own data catalogue with complex, different, and constantly changing ordering procedures. Most flight agencies spend little efforts on a user-friendly ordering system. In general, only "power users" have the knowledge to select and order the imagery they need. In fact, ordering procedures are so complex that even "power users" specialize in one satellite. For the occasional users the catalogues are jungles in which they get lost without understanding the search and ordering procedures. As a result, most occasional users work only with imagery which is available from WinSAR without going through the trouble of ordering new data. The user would greatly benefit from a seamless, one-stop data portal for all relevant satellites.

WinSAR tomorrow

1. Data Subscriptions. An important priority is the implementation of a multi-satellite subscription-based ordering system. In this system, the imagery is acquired immediately after satellite overflight. For a given geographic region all archived data will be available from WinSAR. There is no need for specific catalogue searches or data ordering. A subscription-based ordering system will broaden the user community because of the ease to access complete data sets. The recent 2008, M6.0 Wells, Nevada earthquake demonstrates the power of a subscription-based system. Unavco ordered the relevant data immediately after the images were taken and informed the community with a broadcast e-mail message. As a result, many groups analyzed this earthquake. Events outside of the subscription areas will still require the regular search and ordering procedures and WInSAR resources should be set aside for this.

2. Future satellites. The next satellites important for the WinSAR community are be Sentinel-1a and b satellites, a European C-band constellation with the first satellite to be launched in 2011 (the Envisat successors). One of the challenges will be the data volume; the Sentinels will deliver about 20 times the imagery of Envisat. The data acquisition strategy and data policy has not yet been decided. It is important to stay on top of the developments to ensure optimal data acquisition for the WinSAR region.

Current mission opportunities include the German TerraSarX and the Italian CosmoSkymed constellations (each 2 X-band satellites). Although WinSAR has an excepted TerraSarX proposal there are hardly any acquisitions planned for the WinSAR region, largely because the WinSAR data request could not be reconciled with the available satellite resources. This underlines the importance of frequent interactions with the flight agencies at management level in order to better represent the interests of the WinSAR community.

3. Science support. The organization of the U.S. InSAR community through WinSAR is limited. There are no regularly scheduled meetings (except an annual lunch at the AGU fall meeting). One important priority thus is a better coordination of the InSAR community. From the GPS experience at Unavco we know that the clear identification of problems and limitations (e.g. software) in combination with facility support can lead to a timely resolution of issues and advance the research enterprise.

4. Processing software. The processing software package of choice for most WinSAR members is the ROI_PAC package. Some institutions use SIOSAR, Gamma and DORIS. ROI_PAC has been developed by JPL and is maintained in a non-coordinated fashion by JPL and University scientists. Unavco could take a pro-active role in coordinating software improvements. This includes the organization of expert workshops for the developers, professional advice for software design, organizational developer support (e.g. hosting a multi-institutional CVS), the commissioning of software improvements to contractors or in-house programmers (e.g. pre-processors for new satellites).

5. Vector displacements. Most InSAR studies in the western U.S. are based on ERS and Envisat imagery from descending orbits only. These data provide displacement measurements in one direction (in radar line-of-sight) and the interpretation requires assumptions about the direction ground motion (e.g. horizontal motion for strike-slip faults). Geoearthscope has tasked Envisat to acquire ~2 years of ascending data. One of the top priorities is to continue the acquisition of ascending data so that vector displacements can be resolved.

6. Technology. The ever-increasing computer power and improved Internet connectivity provides new opportunities for InSAR research. Unavco's leadership is required to educate the community about the benefits of these new technologies and to facilitate their use. Examples include the near-real time data delivery and processing, the implementation of application programming interfaces (APIs) and web services into the WinSAR archive.

7. Collaboration with atmospheric scientists. It is well known that the accuracy of InSAR measurements can be improved by removing atmospheric delays using atmospheric models. However, these techniques are not much used, largely because the community is not used to work with these type of models There is a need to facilitate the collaboration between the InSAR and the atmospheric communities such as by organizing a dedicated workshop. A possible outcome of this workshop could be routine atmospheric modeling for InSAR corrections.

8. Education and Outreach. The user community could be significantly broadened by annual beginner's workshops which require organizational infrastucture A first workshop organized by GeoEarthscope is planned for summer 2008 at Unavco.

Funding

WinSAR is funded by the NSF, NASA, and the USGS, through a proposal with the NSF Earth Sciences Instrumentation and Facilities program (EAR/IF). The current funding level of WinSAR is $100k/year. This includes data purchase and personal costs. The level of funding for GPS and Seismology is by factors of 45 and 175 larger than for WinSAR (Unavco facilities, $4 million/yr and IRIS, $17.5 million/yr).

1. GeoEarthscope. Much of the recent progress at WinSAR was achieved through the GeoEarthscope program (~$400k/yr) which terminates in September 2008. At the Geoearthscope funding level all the goals outlined in this document could be achieved within a 1-2 years time frame. One of the top priorities is to bring WinSAR on the Geoearthscope funding level.

2. NASA. The WinSAR EC expects that most of the new activities will be covered by NASA. NASA is committed to develop a prototype SAR data-sharing system to prove the concept of the DESDynI mission, the planned U.S. SAR satellite (projected launch in 2015-2016, 700 million dollar price tag). It seems prudent to start today preparing WinSAR for tomorrow's data stream from DESDynl.

Most of NASA's SAR-related activities are funded from the Distributed Active Archiving Center (DAAC) program and are conducted at the Alaska Satellite facility. NASA's contribution to Unavco is funded from the Solid Earth and Natural Hazard program. Unavco and the ASF have already successfully collaborated on the GeoEarthscope project. Continued collaboration is encouraged. It will be benefitial for both, Unavco and the ASF with the WinSAR scientists being the winner.

3. NSF. The NSF's instrumentation and facilities program likely will agree to an increase of the funding level for WinSAR because the NSF recognizes the importance of long geophysical time series for fundamental research. Furthermore, an investment into WinSAR clearly falls within the NSF's broader impact criteria of enhancing the infrastructure for scientific research. It is interesting to note that the annual NSF support for WinSAR is similar to the contribution to one moderate-sized PASSCAL experiment.

4. USGS. The USGS has a budget to purchase SAR imagery for the monitoring of the U.S. volcanoes. One of the top-priorities for WinSAR is to acquire Envisat imagery for the volcanoes in near-real time so that the USGS can contribute this budget fully to WinSAR. The USGS requirement for selected volcanoes is comparable to the data subscription we envision for the entire WinSAR area.

5. Infrastructure versus imagery costs. The last years have shown that investments in the WinSAR infrastructure lead to a reduction of the per-scene costs for SAR imagery. ESA (the principal data provider) is an inter-government institution which distributes SAR imagery at reproduction costs. It offers discounts for large-volume users. A well-working, fully-automated subscription likely will lead to an additional cost reduction by a factor of two or more. ESA has explicitly expressed their interest in working with Unavco to supply the U.S. Science community with a complete dataset of the WinSAR region. The challenge we are facing is to fit the uncertainty associated with SAR imagery costs into the rigorous funding scheme of U.S. government agencies.

Appendix A: Costs for data subscription of ESA data

Summary

The WinSAR EC has estimated the costs for a subscription of ESA data for the area of interest for three different scenarios. The geographical areas covered are shown in Fig.1 and the costs in table 1. Scenario 1 is a continuation of the GeoEarthscope program and includes satellite tasking and data purchase for the GeoEarthscope area (green and red shadings in Fig. 1). Scenario 2 includes satellite tasking and data purchase for the WinSAR core area (red shadings in Fig. 1). Scenario 3 covers the WinSAR core area but excludes satellite tasking. All three scenarios include the purchase of a large amounts of imagery which was tasked for by GeoEarthscope but could not be purchased because of lack of capacity at the ESA production capacity. ESA increased the capacity in March 2008 but by then most of the GeoEarthscope was already committed for satellite tasking.

The funds required do conduct the three scenarios (data, personal and IT) are $762,312/yr, $327,489/yr and $105,056/yr, respectively (Table 1). The actual costs for each scenario are higher but a significant portion ($100,000/yr) is covered by the current WinSAR budget (details below). The preferred scenario is the first scenario. Given budgetary realities we request support for scenario 2.

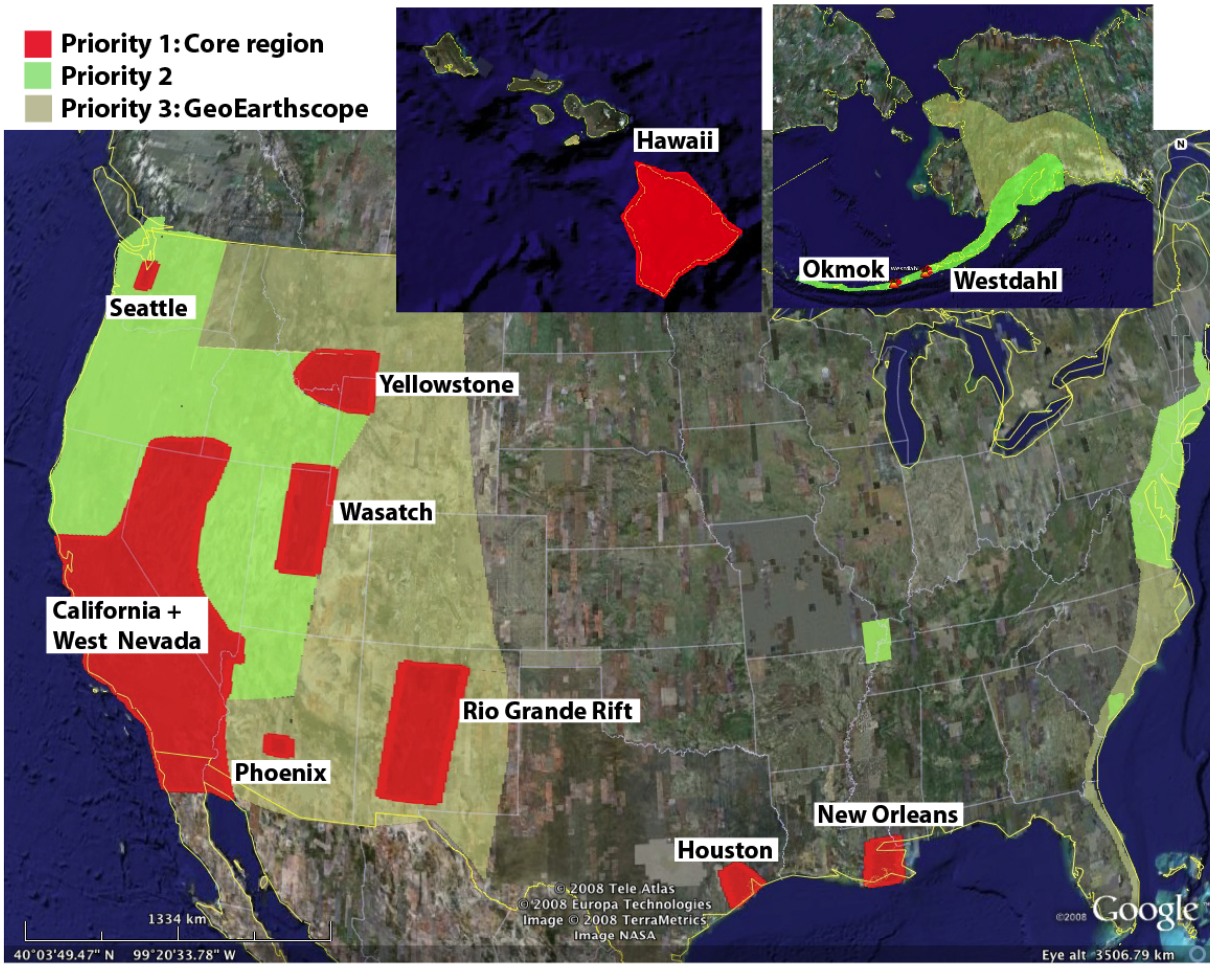

Figure 1. *WinSAR core region (priority-1, red) and Geoearthscope region (priority-3, green). The top priority is to achieve a data subscription for the WinSAR core region. ESA has indicated that with a subscription for the priority-1 region we will we able to obtain the imagery for the priority-2 or priority-3 regions.*

Estimating the costs for a data subscription of ESA data is a complex undertaking. It is a great progress that we are now able to do this. Future WinSAR proposals likely will include the costs for full data subscriptions. ESA is very supportive and has indicated that with a subscription we can expect further price reductions because of the reduced overhead. Although ESA can't commit to details we expect that with a subscription of the WinSAR core region we will be able to cover a larger region (such as the priority 2 region in Fig. 1.)

	Subscription scenario	Data/yr[(i)]	Personal+IT/yr[(ii)]	**Total /yr[(iii)]**
1.	**GeoEarthscope area**	567,312	195,000	**762,312**
2.	**WinSAR-core area with tasking** (13EUR/scene)	267,489	60,000	**327,489**
3.	**WinSAR-core area without tasking**	101,067	5,000	**105,067**

Table 1: Subscription costs *for ESA data for three scenarios (in US Dollars/year): (1) Geoearthscope continuation, (2) WinSAR-core area with tasking, (3) WinSAR-core area without tasking. Scenario 3 assumes that all data are acquired through the background mission. The columns list the costs for (i) satellite tasking and purchase of tasked and archived imagery (details in table 2), (ii) personal and IT hardware costs (details in table 3), and (iii) the total which is the sum of (i) and (ii). This budget takes funds available from the current WinSAR proposal into account.*

Subscription scenarios: budget details

Scenario 1: GeoEarthscope area. The GeoEarthscope area includes the western U.S., Hawaii, the southern part of Alaska, the Aleutians, and the metropolitan areas in the northeast and south (the green and red areas in Fig. 1, labeled priority 3). The total costs for this scenario (ascending and descending data) is $762,312/yr, with about three quarts for satellite tasking and data purchase ($567,312/yr, table 2), and 1 quart for personal and IT costs (table 3). The latter includes funding for daily operations as well as for improving the catalogue system, what is also covered by Unavco's pending NASA-ROSES proposal. The ASF personal costs cover the Envisat tasking which was done for GeoEarthscope in contract with the ASF. The data costs include $75,000/yr to purchase imagery of the Western US not yet in WinSAR (table 2). This is historic ERS1,2 imagery and Envisat imagery tasked by GeoEarthscope. GeoEarthscope does not have enough funds to purchase all the tasked imagery. The GeoEarthscope working group gave a higher priority to tasking hoping that WinSAR would be able to acquire this imagery.

Scenario 2: WinSAR-core area with tasking. The WinSAR-core area includes California and western Nevada, Yellowstone, the Wasatch fault zone, the Rio Grande Rift, and the Seattle. Phoenix, Houston and New Orleans metropolitan areas, Hawaii, and Okmok and Westdahl volcanoes in Alaska (red areas in Fig. 1). The total costs are $327,489/yr with about two fifth for satellite tasking ($141,960, table 2), another two fifth for new and archived imagery (table 2), and one fifth for personal and IT. The personal costs at Unavco and the ASF follow the GeoEarhscope and WinSAR model but at a lower level (table 3). At Unavco partial FTE support for a project manager, software developer, data engineer and archivist is required and at the ASF partial support for a project manager and student helpers. The ASF will be responsible for the satellite tasking similar to GeoEarthscope (a ASF project manager was partly employed by GeoEarthscope). The WinSAR EC is requesting funding for this scenario.

Scenario 3: WinSAR-core area without tasking. This scenario is similar to scenario 2. It covers the same area but does not include any budget for satellite tasking. This scenario assumes that all imagery will be acquired by Envisat's background mission.

We don't know whether the background mission would acquire sufficient imagery of the WinSAR core region. ESA's policy is that the background mission acquisition requests have low priority. Tasking requests of Category-1 users would overwrite the background mission plan at any time. The experience suggests that background acquisitions are not sufficient for the western U.S. Only about 2 orbits/year were acquired prior to the GeoEarthscope tasking. Given the uncertainties associated with this scenario the WinSAR EC strongly recommends scenario 2.

Subscription scenario	Tasking/yr[(i)]	New data/yr[(ii)]	Archived data/yr[(iii)]	Total/yr[(iv)]	**Requested/yr** Total-70,000 from WinSAR[(v)]
(1) GeoEarthscope continuation	356,275	206,037	75,000	637,312	**567,312**
(2) WinSAR core area with tasking (13EUR/scene)	141,960	87,215	75,000	337,489	**267,489**
(3) WinSAR core area without tasking		87,215	75,000	162,215	**101,067**

Table 2: Data costs *for subscription of ESA data for the three scenarios (yearly costs). Costs for (i) Envisat tasking, (ii) purchase of new, tasked data, (iii) purchase of archived 1992-2008 data, (iv) the sum of (i,iii,iii), and (v) the requested amount after substracting 70k/yr available from the current WinSAR project. Internal note: the estimate for scenario (1) is a rough estimation by Rick Guritz in 6/2008. The estimate for scenario 2 is based on a detailed estimate from 7/31/08 assuming an image cost of EUR13/scene and an exchange rate of 1EUR=1.5USD. Guritz originally estimated using an image cost of 25EUR/scene for (i) and (ii) 94,640EUR and 111,818EUR, respectively.*

Subscription scenario	Unavco/yr[(i)]	ASF/yr[(ii)]	IT hardware/yr[(iii)]	Total/yr[(iv)]	**Requested/yr** Total-30,000 from WinSAR[(v)]
(1) GeoEarthscope area	150,000	40,000	35,000	225,000	**195,000**
(2) WinSAR core area with tasking (13EUR/scene)	50,000	20,000	20,000	90,000	**60,000**
(3) WinSAR core area without tasking	20,000	0	15,000	35,000	**5,000**

Table 3: Personal and IT costs *for the three scenarios (yearly costs). (i) Personal at Unavco (project manager, software developer, data engineer and archivist). (ii) personal at ASF (project manager, software developer and student helpers), (iii) computer hardware (disk space and servers) at Unavco, (iv) sum of (i),(ii) and (iii), and (v) required amount after substracting $30,000/yr available from the current WinSAR proposal.*

Appendix B: ALOS data requirements

The WinSAR EC has polled the WinSAR membership about research areas and has submitted the results of this poll in form of U-pass proposals and data requests to the ASF. This plan has been positively received by NASA. Up to now most, if not all, U-pass proposals submitted by WinSAR members have been accepted. Details are available on request and will be posted on the WinSAR website shortly. Given that the ASF has also agreed to data subscriptions (archived and future data for given geographic areas are automatically placed into the L1-data pool) the future prospects are very bright. We will have access to all

ALOS data for given areas of interest, something what the community has been pushing for since many years. However, there are currently serious technical issues with the L1-data pool discussed below.

Appendix C: WinSAR todo and wish list

Todo list

1. Improve ALOS data quality and access. Currently many of the data files in the L-1 data pool at the ASF are corrupt (missing metadata or incomplete data files). Furthermore the access to the L-1 data pool is intermittent and slow. The top priority is to fix current data quality and data access problems.
2. rsync capability for ALOS. The access to the L-1 data pool currently involves manual login on the ASF Internet data portal and issuance of an "access key" which is valid for a few days to weeks. There is no possibility to automatically download ALOS data using the rsync command or similar commands. This is the preferred for many WinSAR members to access data from Unavco.

A possible solution to these problems is to establish a mirror of the data pool at Unavco. This could be done in collaboration with the NASA DAAC and would provide a long-term solution to Internet connectivity issues with Alaska.

Wish list

1. ***Standing Order for SAR data.*** The seamless access to SAR data would be facilitated with scripts to automatically download new data for a given area once they have arrived at Unavco. A possible syntax would be

```
find_SAR_data.pl  –RSAT –ENVISAT –ALOS –time_start 2002.0 Hawaii.kmz
```

with Hawaii.kmz a file containing a geographic polygon. This perl script would automatically download all Radarsat, Envisat and Alos imagery within the polygon starting in 2002 to the user's desktop. Similar tools already exist for the Unavco's GPS community and for the IRIS community (Standing Order for Seismic Data (SOD)).

2. Simcat-type catalogue. The Permanent Scatterer company TRE in Milano provides a Google Earth-based catalogue SAR imagery catalogue (Simcat) that allows rapid assessment of the availability ERS, Envisat and Radarsat imagery for a given region (number of images per sensor, viewing geometry and date) (http://www.simcat.it/ the username and password are available on request from Unavco). The community wishes a similar tool for the WinSAR data base which should be interfaced with find_SAR_data.pl to initiate data downloads.

3. Global data access. P.I.s generally use individual Category-1 proposals with ESA to obtain SAR imagery for areas outside the WinSAR region. Unavco should build on the good relations with ESA to enable access to imagery for other parts of the world. For example, a PI interested in an Iranian earthquake should be able to order imagery from Unavco instead of having to go to the Space Agencies. A possible route to achieve this goal would be a global Unavco Cat-1 project with ESA and a mini-cat-1 process between the PI and Unavco similar to GeoEarthscope.

4. InSAR support request forms. For GPS projects NSF and NASA-funded PI's obtain support from Unavco by filling a project support form. A similar way of interaction is desirable for the InSAR community. This would include support for the access to SAR imagery (within and outside the WinASR region), as well as support for data analysis. For example, the PI interested in the Iranian earthquake would only need to fill out this form and Unavco would take care of obtaining the ESA and ALOS data.