Discovery and Delivery of Space Geodetic Data Products from Distributed Archives

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Contents

Scientific/Technical/Management

Objectives

Three premier US space geodetic data centers, NASA's Crustal Dynamics Data Information System (CDDIS), Scripps Orbit and Permanent Array Center (SOPAC), and UNAVCO, all of which hold substantial and growing NASA-supported space geodetic data collections, have been collaborating for over ten years to exchange metadata about their Global Satellite Navigation System (GNSS) holdings through a mechanism developed by SOPAC and UNAVCO called the GPS Seamless Archive Centers (GSAC) (*Scharber et al*., 2003). The data, products, and collection metadata, along with the metadata exchange technology employed by the current GSAC is due for an overhaul and expansion using modern information technology methods.

This proposed effort will expand and modernize metadata exchange definitions and technologies for space-based geodetic techniques, thereby facilitating comprehensive user access to a broad range of NASA- and community-supported space geodetic data. This effort supports the NASA Earth Sciences Focus Area: Earth's Surface and Interior. The three partnering data centers will provide the technical expertise to develop metadata definitions for a set of data-exchange Web Services. A new Web Services enabled Seamless Archive ("GSAC-WS") will be enacted to remove limitations, improve efficiency, and enable new applications that fall well outside the scope of the current, aging GSAC system. A science partner (University of Nevada, Reno) will test these Web Services by incorporating them into their daily GNSS data processing scheme. The effort will include quality assessment of current and legacy data that will be a product of the analysis/testing phase performed by the science partner.

The three partner archives directly support users of NASA and community distributed GNSS data (*Noll et al*., 2009). NASA has invested heavily in space geodetic techniques beyond GNSS to support ongoing realizations of the improved International Terrestrial Reference Frame (ITRF) and to support the Global Geodetic Observing System (GGOS). These techniques include Very Long Baseline Interferometry (VLBI), laser ranging (satellite, SLR, and lunar, LLR), and Doppler Orbitography and Radiopositioning Integrated by Satellite **(**DORIS); the products from legacy and ongoing acquisitions for these techniques are held in the CDDIS archive. These techniques are receiving increased attention because of their expected contribution to future highly stable and precisely known reference frames. The NASA REASoN project INDIGO provided support for standards in information and information sharing to the community-supported space geodetic services (International VLBI Service, International Laser Ranging Service, International GNSS Service, International DORIS Service). This project will utilize the catalogs and products of INDIGO and will also enable incorporation of previously omitted (from the current GSAC) space geodetic data and products into the proposed GSAC-WS system. Access to the legacy collection and future data acquisitions for these methods will become increasingly important, as will the co-location site tie and site characterization information that is planned for "fundamental" space geodesy sites that will host multiple space geodetic instruments and will involve expanded footprint GNSS stations for local and regional stability characterizations. Metadata for these sites will need to be documented in minute detail and the information shared among an internationally collaborating set of investigators in order to realize the mm-scale reference frame envisioned (see http://ilrs.gsfc.nasa.gov/docs/TLS_2008Workshop_Report.pdf).

The objective of improving user access and inter-archive machine-to-machine communication and transfer of metadata will be achieved principally by adapting the current GSAC metadata exchange schema, and augmenting this with SOPAC's XML schemas for GNSS observations metadata and GeodeticML schemas for coordinate time series. Schemas for exchanging additional GNSS products and other space geodesy data and products and metadata from VLBI, laser ranging, and DORIS observations will also be incorporated. By applying modern technology (e.g. Web Services based on SOAP/XML and other methods such as RESTful Web Services in a Service Oriented Architecture (SOA)) to replace the flat file exchange used by the current GSAC, access will improve for users of all three data centers. Both SOPAC and UNAVCO have implemented Web Services (to achieve other, separate objectives) that partially encompass the metadata exchanged within the existing GSAC. For SOPAC and UNAVCO, the proposed effort will be an expansion of existing Web Services. Thus far, CDDIS has not been able to devote resources to Web Service development. The proposed effort will allow CDDIS to gain Web Service experience through close collaboration with SOPAC and UNAVCO in order to add this enabling technology to the capabilities of this NASA data center. Though often a project such as this one will incorporate an overarching Web user interface or portal, for reasons of sustainability and usability described later, no new interface for this purpose alone is proposed. Instead, partner data centers will make these Web Services available through their existing interfaces.

The science team will actively use the modernized metadata exchange system for their daily data processing system both to enhance their data access and to test the system from a science user perspective. This effort will facilitate further expansion of the GSAC-WS metadata to allow for (1) documentation of factors affecting GNSS products such as local events resulting in offsets (2) inclusion of a site-specific, time-varying site quality control (QC) produced by the science team.

Significance

Relevance to NASA Mission

Since 1994, when the International GNSS Service (IGS) became operational (*Beutler et al*. 1994; *Dow et al*., 2005), the analysis of the global GPS network has consistently delivered high accuracy satellite orbit positions, ground station positions and velocities, Earth rotation parameters, atmospheric water vapor, and ionospheric total electron content (*Moore*, 2007). In turn, the IGS satellite parameters have enabled scientists to process data from regional GPS stations and determine coordinates with millimeter-level precision. Today, there are several thousand geodetic quality GPS stations being processed every day, delivering products useful to many scientific disciplines. These products have enabled scientific discoveries and monitoring capabilities, with contributions to plate tectonics, the earthquake cycle, glacial isostatic adjustment, crustal and mantle rheology, angular momentum exchange with the atmosphere and oceans, and surface mass redistribution, to name but a few applications.

Moreover, the integration of all space geodetic techniques within the GGOS framework provides an accurate (<1 cm) reference frame for tide gauges, airborne laser altimetry, low Earth orbiting altimeters and gravity sensors that are used to monitor global change in sea level, the Greenland and Antarctic ice sheets, redistribution of terrestrial water, and atmospheric water vapor. GGOS products are central to NASA's primary method of precision low-Earth orbit determination, and implicitly assist inter-planetary missions by monitoring the orientation of the Deep Space Network in inertial space.

The primary outcome of our proposed project will be improved access to geodetic data from around the world along with QC parameters to guide the scientific user as to which data might meet the requirements of specific applications. Users will be more quickly and accurately informed as to which data are available to address the application at hand (e.g., to measure displacements associated with earthquakes), which in turn will result in more timely and accurate interpretation of the scientific problem at hand.

Our proposed development is therefore central to stated goals and objectives of NASA by improving the ability of scientists to address one of NASA's main science questions: "How is the global Earth system changing?". To answer this question requires accurate measurements, and therefore scientists need information to assess which measurements are sufficiently accurate for their investigations. Improvement in the accuracy of geodetic analysis will not only improve the return of current Earth Science investigations, but will also improve the ITRF (International Terrestrial Reference Frame) which is essential for monitoring global change, such as global sea-level rise.

Applicability to ACCESS Program Goals

The ACCESS Program goals are: (1) improving Earth science user access to Web Services and service registries and (2) improving knowledge of NASA's Earth science data quality and production legacy. The proposed work addresses both of these goals.

*Improving Earth science user access to Web Services and service registries***.** The principal outcome of this effort will be simpler, more comprehensive, and more efficient metadata and data access for space geodetic data. At the level of the geophysicist or geodesist who directly uses GNSS data, this effort will lead to improved base data and metadata for their modeling and analyses.

When GSAC-WS is enabled, the partner centers and other geodetic data centers will be able to present more comprehensive space geodetic data availability to their customers transparently. The data delivery will allow for machine-to-machine queries and data delivery. New data fitting user criteria will potentially be identified without human interaction. Users will have new ability to setup station quality criteria that will allow them to narrow selected stations based on their study needs, such as local base station, regional tectonics, hazards, high precision geodesy, etc.

Improving knowledge of NASA's Earth science data quality and production legacy. The incorporation of a broader set of space geodetic techniques into GSAC-WS will enhance knowledge of NASA's legacy space geodesy data products. Broadening the GSAC-WS to include QC information about sites through the processing of the science team will provide data quality visibility. Each of these will allow better utilization of space geodetic data products. The broader impact of this work will be realized through time as the NASA-supported fundamental space geodesy sites come to fruition and the mm-scale terrestrial reference frame is realized.

Participating Institutions

NASA GSFC CDDIS

The CDDIS is NASA's data archive and information service supporting the international space geodesy community. For over 25 years, the CDDIS has provided continuous, long term, public access to the data (mainly GNSS, laser ranging, VLBI, and DORIS) and products derived from these data required for a variety of science observations, including the determination of a global terrestrial reference frame and geodetic studies in plate tectonics, earthquake displacements, volcano monitoring, Earth orientation, and atmospheric angular momentum, among others. The specialized nature of the CDDIS lends itself well to enhancement to accommodate diverse data sets and user requirements. The data center is dedicated to the support of space geodesy data and products for the international community, providing straightforward and timely access to a variety of data, products, and information about them. Supporting information, such as spacecraft and instrument specifications, measurement station characteristics, site co-location details, etc., is also available through the CDDIS. The CDDIS serves as one of the primary data centers and core components for the geometric services (IGS, ILRS, IVS, and IDS) established under the International Association of Geodesy (IAG), an organization that promotes scientific cooperation and research in geodesy on a global scale. All data sets are accessible through ftp and the web.

Scripps Orbit and Permanent Array Center

The Scripps Orbit and Permanent Array Center (SOPAC) operating for nearly 20 years are located at the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics (IGPP) *(Jamason et al*., 2004). SOPAC's extensive data archive, Web Services, data portal, and data products (e.g., coordinate time series) support high precision geodetic and geophysical measurements using GPS, particularly for the study of earthquake hazards and early warning systems, tectonic plate motion, plate boundary deformation, and meteorology.

SOPAC has been a major participant in the IGS since its inception, serving as a Global Data Center and a Global Analysis Center. With funding from NASA, NSF, USGS, and the William M. Keck Foundation, SOPAC developed the data infrastructure for the 250-

station Southern California Integrated GPS Network (SCIGN). Under contract to UNAVCO, SOPAC developed and continues to maintain the first GPS seamless archive (GSAC). Other major SOPAC projects include the California Spatial Reference Center (CSRC) and the California Real Time Network (CRTN). Over the last few years, with funding from NASA, SOPAC has been working with the Jet Propulsion Laboratory to develop a modern geodetic cyberinfrastructure for crustal deformation, including Web Services, GPS Explorer data portal, a hierarchy of data products, on-line modeling tools, and early warning systems.

UNAVCO Data Center

The UNAVCO GNSS Archive, part of the UNAVCO Data Center, was created in 1992 as part of the UNAVCO mission to support and promote Earth science by advancing high-precision techniques for the measurement of crustal deformation. UNAVCO is supported principally through Grants from and Cooperative Agreements with the National Science Foundation and NASA. The Archive provides secure long-term storage for data and products from crustal deformation measurements with metadata held in a searchable database. Data and metadata are freely available to the scientific community and the public. GNSS holdings are comprised of three and a quarter million data files (8 Terabytes) from over 10,000 globally distributed sites. A major segment of the GNSS Archive data holdings are from the 1100-station Plate Boundary Observatory. The Archive distributes fifteen million files per year, about six Terabytes. The Data Center also holds and distributes the WInSAR and GeoEarthScope InSAR data collections.

Nevada Geodetic Laboratory, University of Nevada, Reno

The Nevada Geodetic Laboratory (NGL) conducts research in the field of space geodesy to study scientific problems that have both regional and global significance. NGL uses the Global Positioning System (GPS) to study tectonic and geothermal activity across Nevada and to study global patterns in surface mass loading and global-scale plate tectonic problems.

NGL is at University of Nevada, Reno, within the Nevada Bureau of Mines and Geology, and interacts closely Department of Geological Sciences and the Nevada Seismological Laboratory.

Technical Approach

The IT development proposed involves revamping the current GSAC, including server and client sides. To understand the direction this proposed work will take, first we give a brief overview of the existing GSAC architecture and operations, followed by the proposed new architecture. Finally, the application of this system for GNSS analysis with resulting QC metadata is described.

Overview of the Current GSAC Architecture

The current GSAC evolved from the conceptual stages in 1997, when the GSAC structure and data exchange formats document was agreed upon. GSAC became operational in

2001 when SOPAC and UNAVCO began routine publication of the flat files containing holdings information and introduced a query-response system. CDDIS, Northern California Earthquake Data Center (NCEDC), and Pacific Northwest Geodetic Array (PANGA) began publishing holdings flat files soon thereafter. Figure 1 shows the current GSAC IT configuration and the opening page of the GSAC Wizard, the web GUI tool developed for the interactive query and discovery function of the GSAC. In GSAC terminology, a "Data Provider" is an entity collecting data files from a GPS installation; a "Data Wholesaler" is a Center or Archive that distributes GPS data and, as part of its participation in the GSAC, "publishes" flat files with holdings information by maintaining designated flat files in a designated location on an ftp server. A "Data Retailer" collects the holdings information from all the Wholesalers into a data base and runs software that responds to queries from either the GSAC Wizard web user interface, or Perl language command-line programs. The queries are handled in a client-server communication interface using a SOPAC-designed communication method based on HyperText Transfer Protocol (HTTP) and a simple Common Gateway Interface (CGI) request/return strategy.

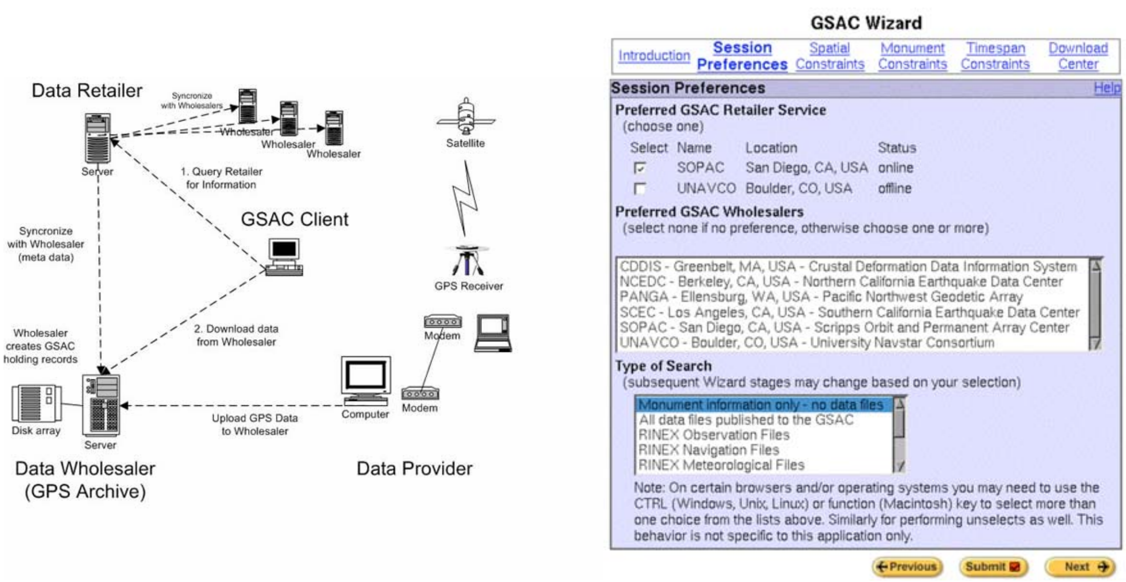

Figure 1. Current GSAC IT architecture (left) and opening page of the GSAC Wizard web GUI (right).

The software development for the GSAC was performed by SOPAC with funding from a sub-award from UNAVCO. Additional details of the GSAC can be found on the UNAVCO and SOPAC GSAC websites: http://gsac.ucsd.edu/index.html and http://facility.unavco.org/data/gsac/gsac.html. A GSAC final report prepared by SOPAC is available at http://gsac.ucsd.edu/docs/GSAC_FinalReport.pdf and provides a comprehensive description of the system.

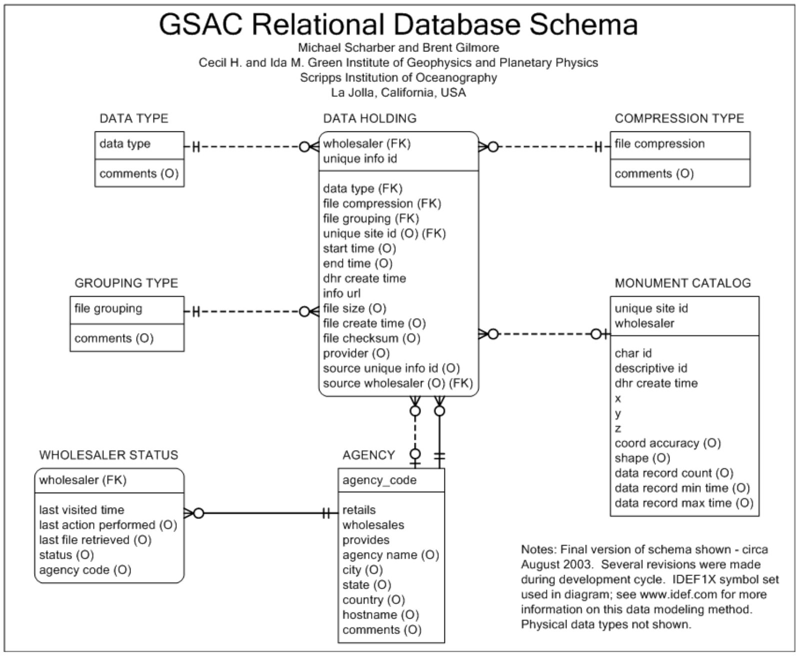

Figure 2. The GSAC relational database schema is utilized by the GSAC Retailer and represents the information collected from the Wholesaler flat files, plus supporting lookup tables for allowed data types, etc.

The GSAC schema, used by the Retailer database and shown in Figure 2, illustrates the scope of metadata encompassed in the current GSAC. This metadata is limited to information about the files available through the GSAC, and about the GNSS monuments – sites where GNSS data are collected or to which processed solutions pertain. The file types allowed in the current GSAC are: raw GNSS data files from the receiver, RINEX (Receiver Independent Exchange) format GNSS data files, IGS site log files containing site and collection metadata, SP3 orbit information files, and SINEX processed solution files.

Proposed GSAC-WS Architecture and Content

The Information Technology goals for this proposed effort include both an expansion of the metadata exchanged through the proposed GSAC-WS, and converting the information exchange mechanism from a passive asynchronous pull of Wholesaler flat files by the Retailers to an active query process described below.

The metadata of the existing GSAC (Figure 2) will continue to be a part of the proposed GSAC-WS. The planned expansion of the GSAC includes the addition of new space geodesy domains beyond GNSS as well as new file type for the GNSS domain (shown in Table 1).

Table 1. Current and Expanded GSAC Data Types (shaded rows indicate proposed data type to be included in the expanded GSAC-WS system)		
Data Type	**Domain**	**Description**
Raw GNSS	GNSS	data
RINEX GNSS	GNSS	data
Quality Control (QC)	GNSS	data QC
IGS Site Log	GNSS	metadata
Orbit	GNSS	orbit
GNSS Position	GNSS	solution
Position time series	GNSS	solution
Station quality time series	GNSS	solution QC
Station velocities	GNSS	solution
URL (to available real-time data streams)	GNSS	realtime service
Troposphere zenith path delay (ZPD)	GNSS	solution
Ionosphere total electron content (TEC)	GNSS	solution
Satellite predictions	Laser ranging	solution
Normal point	Laser ranging	data
Full-rate	Laser ranging	data
ILRS site logs	Laser ranging	metadata
ILRS satellite information	Laser ranging	metadata
Station positions	Laser ranging	solution
Orbits	Laser ranging	solution
Correlated experiments	VLBI	data
Station positions	VLBI	solution
Earth Orientation Parameters (EOP)	VLBI	solution
Radio source positions	VLBI	solution
Troposphere ZPD	VLBI	solution
IVS site logs	VLBI	metadata
DORIS RINEX	DORIS	data
IDS site logs	DORIS	metadata
IDS satellite information	DORIS	metadata
Station positions	DORIS	solution
EOP	DORIS	solution
Orbits	DORIS	solution
Geocenter	DORIS	solution
Ionosphere TEC	DORIS	solution

In addition to expanding the file types represented by the GSAC-WS, it is a priority goal of this proposed work to incorporate data collection metadata into the information exchange. For GNSS data, this would include, for example, the elements of the formatted text file used throughout the International GNSS Service (IGS) for more than a decade, the IGS Site Log (*Noll et al*., 2009). SOPAC has defined an XML version of the IGS Site Log, shown in Figure 3, which can form part of the XML schemas utilized by the data center partners for the GSAC-WS as described below. SOPAC, as part of its GPS

Explorer data portal development with JPL, has also defined a GeodeticML format for GNSS position time series described at http://sopac.ucsd.edu/projects/xml/measures/index.html. For space geodesy data types such as VLBI, laser ranging and DORIS these do not yet exist; therefore, part of the work plan will involve planning time among the Technology teams to develop XML schemas that encompass these data types and the relevant data collection metadata.

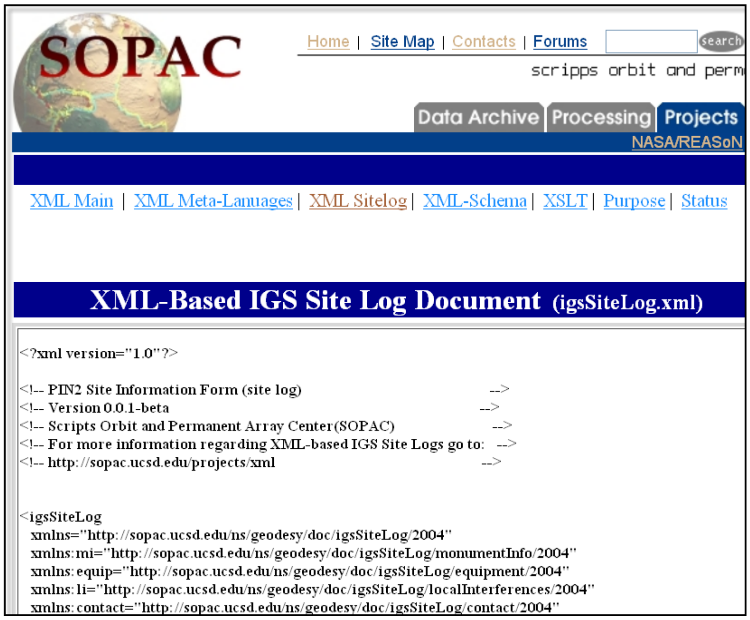

Figure 3. SOPAC's XML site log schema. This schema will be reused as part of the proposed GSAC-WS for exchange of GNSS site and data collection metadata.

The GSAC-WS metadata exchange will be through XML (eXtensible Markup Language) and SOAP (Simple Object Access Protocol) Web Services using Web Services Description Language (WSDL) elements, all of which are well-established industry-tested technologies. The data centers will create and/or or expand their current Web Services technologies to meet the agreed upon GSAC-WS metadata elements to be exchanged. The candidate technologies to be used include Apache Tomcat for Java Server Pages (JSP) and Java Servlet technology (Figure 4).

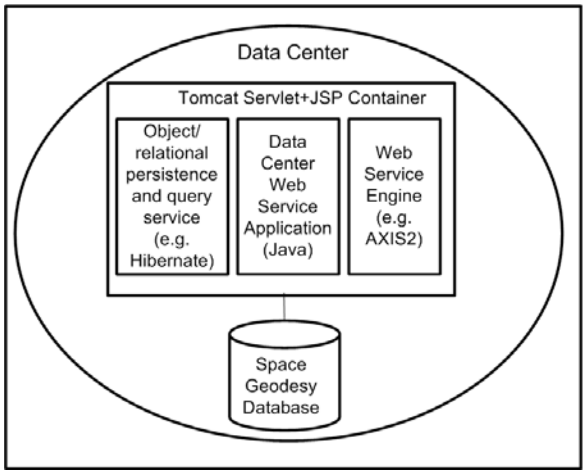

Figure 4. Proposed Web Services architecture to be employed by the partner data centers.

For access to the expanded information, the partner data centers will integrate methods to query the GSAC-WS Web Services within their existing web user interface or other query methods. For example, UNAVCO's Data Archive Interface (DAIv2) web user interface and Java clients (http://facility.unavco.org/data/dai2/dai2.html) will be expanded to include queries to GSAC-WS Web Services at SOPAC and CDDIS. Similarly, SOPAC's SOMI map interface and GPS Explorer portal will be expanded to include queries to GSAC-WS Web Services at UNAVCO and CDDIS. As described later, we believe this will provide for a degree of built-in sustainability for this proposed work because each data center will continue to maintain its primary interfaces under their current funding model.

Software such as the command line, query oriented gsac-client from the current GSAC will be retooled to encompass the new GSAC-WS exchange mechanism. Technology used in the current GSAC such as the program gsac-sync and the Postgres database (*Scharber et al.*, 2003) will be retained in a limited way to be able to continue to include archives which have established this exchange mechanism as part of their ongoing processes and may not yet be ready to migrate to Web Services based metadata exchange. Documentation and assistance will be offered to these archives should they choose to provide their metadata through the new GSAC-WS mechanism.

User Interfaces and Sustainability

Each partner data center will incorporate GSAC-WS metadata and queries into their existing primary web UI systems to allow for their user community to access all three data centers through the interface that is most familiar to them. This is counter to the usual practice nowadays, where major efforts to build new comprehensive data portals that incorporate relatively complex web user interfaces with the goal of providing a one-stop shopping experience for numerous data types are the current trend. These portals tend to limit queries to time and space filters because more complex metadata-based queries are difficult to define and handle within a broad over-arching interface. This proposed effort takes a different approach, one that we expect will lead to greater sustainability and lower risk. Instead of building a single, new portal that becomes unsupported once this effort is complete, these new Web Services will be incorporated into existing web user and other interfaces at each data center. These interfaces tend to be well-endowed with the complex metadata-based queries needed by the target user communities. An example is UNAVCO's DAIv2 web Graphical User Interface (http://facility.unavco.org/data/dai2/app/dai2.html), shown in Figure 5, which has been developed to provide maximum flexibility for the users search for data and metadata at UNAVCO.

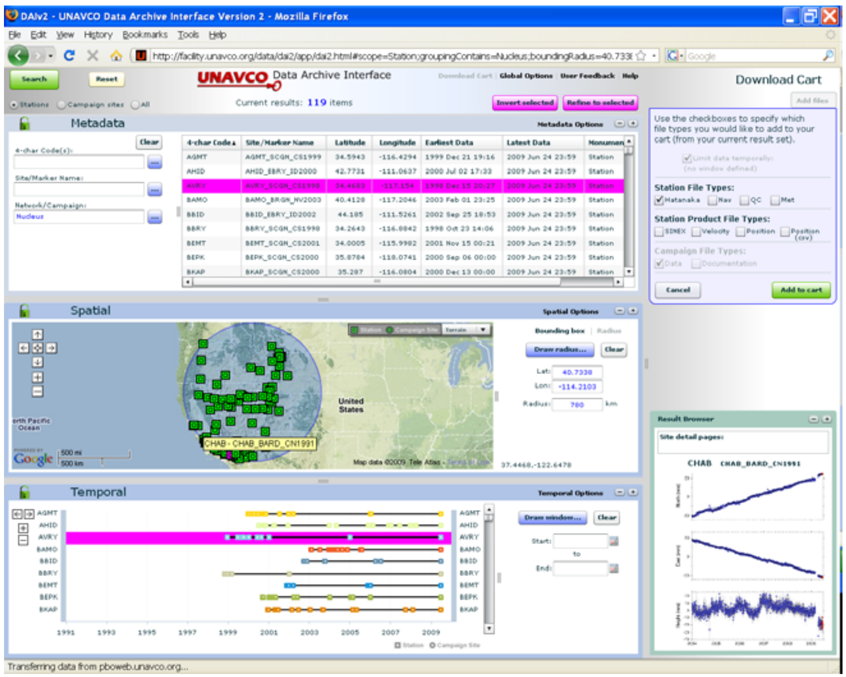

Figure 5. UNAVCO's Web Services-backed Data Archive Interface (DAIv2) uses multipanel search input/result output capability to provide powerful, flexible access to the UNAVCO Archive of GPS data and metadata. The interface includes an integrated data cart with file download manager.

All user interface systems require long-term investments to keep them running and to enhance them as needs arise; these efforts are ongoing at established data centers. Our assumption is that the data centers have ongoing funding to support and continually update their primary data search mechanisms, and the most cost-effective, sustainable approach is to enable these user interfaces to query the GSAC-WS system. A further advantage of the use of existing interfaces is that users do not need to discover yet another interface. Instead each user will go to the interface that serves their unique needs; through this development effort, they will find more comprehensive data and metadata there. New users can start at any of the partner institutions to find all of the data at the other partners. As part of this UI model, the Retailer component of the current GSAC will eventually be retired as participating data centers embrace a Web Services model such as the GSAC-WS system. Because the sustainability model for this project is based on very modest or negligible incremental ongoing costs to each data center, the total life-cycle costs for this project are equivalent to the funding requested for this effort.

GPS Analysis at the Nevada Geodetic Laboratory

The Nevada Geodetic Laboratory at the University of Nevada, Reno (UNR), routinely processes GPS data from almost all (~3,500) publicly available continuous GPS (CGPS) stations around the world. The majority of the data is downloaded weekly from the UNAVCO, SOPAC, and CDDIS archives. Station names and approximate coordinates in the RINEX file headers are automatically checked and corrected as the data is downloaded. The data are then processed using the precise point positioning method of the GIPSY-OASIS II software package (*Zumberge et al*., 1997). Satellite orbit and clock parameters, and daily coordinate transformation parameters into ITRF2005 reference frame are provided by the Jet Propulsion Laboratory (JPL). Custom spatial filters and transformation parameters into various regional reference frames (including Western U.S., North America, and Eurasia) and are computed and applied to the resulting time series of positions. Carrier phase ambiguities are successfully resolved across the entire network using an algorithm based on a fixed-point theorem that closely approximates a full-network resolution (*Blewitt*, 2008), resulting in up to a factor of ~2 improvement in precision (mainly for the East component). Only with this new algorithm has it recently been possible to obtain a global ambiguity-resolved network results, which precludes the need to process (and combine) ad-hoc sub-networks. Besides the daily ambiguity-resolved station coordinates, the UNR analysis yields other estimated parameters including tropospheric zenith bias, tropospheric gradients, station clock bias time series, pseudorange multipath time series, and carrier phase residuals, all of which could be used to develop QC parameters.

Analysis-Based QC

As part of this project, we propose to use the UNR analysis results in order to define and distribute quality control metrics of each station through GSAC-WS. These metrics will include the formal position standard deviation and daily repeatability as a function of time. Other measures would include the RMS misfit from a model describing a rate and seasonal variability (typically described by annual and semi-annual sinusoids). We would make the seasonal signal parameters available, as they are strongly indicative of the stability of the station and thus its usability, for example, in tectonic studies. To estimate the rate and seasonal signal, a complete set of offsets is required. A fairly complete set of epochs with offsets is already known (e.g., through SOPAC) but will be supplemented with offsets found in the UNR analysis. With the epochs of offsets known, the amplitudes will be determined simultaneously with the other parameters and made available through GSAC-WS. We will develop a ranking system that would take into account these various QC measures. Based on this ranking system, users will have a guide in deciding which stations would be appropriate to use in their analysis, depending on the type of study. For example, when an earthquake occurs, a user may need to know all available stations in the near-field to estimate static offsets, but may want to limit its analysis of far-field stations to only those with the highest quality.

A specific target for quality control is the proposed fundamental stations. Until those stations are operational, we will focus on the existing multi-technique IGS stations and develop the procedures and metrics needed to fully evaluate the performance of the various GPS receivers and antennas that are present at these stations. In the inter-technique comparisons, it is particularly important that any noise inherent to the GPS system is minimized. The quality control measures listed above would allow one to rank the GPS receivers/antennas, but all stations would still be affected by noise that is regionally consistent and could come from GPS satellite orbit variations (affecting the reference frame), and incorrectly estimated ionospheric/tropospheric/atmospheric parameters. There are various approaches to estimate this “common-mode” noise depending on the spatial footprint of interest. For this project, we will estimate the common-mode noise time-series for selected IGS stations by stacking position residuals of high-quality regional stations. For this procedure we will likely use regional networks that may not (yet) be archived through this project, but that are processed by UNR.

Participation in the ESDSWG

The Technology Infusion Working Group seeks to “define approaches and processes to infuse new technologies into the evolving Earth science data systems.” The technologies proposed for this effort are new in the sense that they are yet-to-be-applied in an enabling manner to the geodetic data and products arena. Therefore, the Technology Infusion Working Group is the appropriate venue for participation for this effort. The UNAVCO Project Manager to be hired will be selected in part based on their ability to contribute to the Technology Infusion Working Group.

Project Management

UNAVCO will provide the overall project management including participation in the Technology Infusion Working Group of the ESDSWG. Twice per year, face-to-face planning and progress update meetings will be held at UNAVCO in Boulder and will keep the project on track to bring the work to completion. The Project manager will visit the other data centers and the science team when needed. UNAVCO will assemble and submit project reports and will coordinate publications and presentations at meetings.

Project Personnel and Roles

UNAVCO

Dr. Frances Boler, PI: Dr. Boler is the Data Center Manager; her role will be as supervisor to the Project Manager/Software Engineer (to be hired) who will carry out UNAVCO’s work plan.

UNAVCO Staff Member (to be hired), **Project Manager/Software Engineer:** A software engineer with project management and development experience in Service Oriented Architecture, preferably applied to a science domain, will be hired.

NASA GSFC CDDIS

Ms. Carey Noll, Collaborator: Ms. Noll is the manager of the CDDIS and will provide guidance on implementation of metadata from the space geodesy data sets available through the archive into the GSAC-WS framework. She will also implement the underlying GSAC-WS metadata structures in the CDDIS. The effort by CDDIS for this proposal will be modest and will be supported through their existing funding sources; no budget is requested for CDDIS participation.

SOPAC

Prof. Yehuda Bock, Co-I: Dr. Bock is the director of SOPAC and will oversee the development work at Scripps Institution of Oceanography. He will also interface with the PI and Co-I's from the other institutions, and be the liaison with collaborative NASA-funded projects with JPL.

SOPAC Staff Member, Programmer/Analyst: Programmer/analysts (total of 0.75 FTE) at SOPAC will be assigned to this project. This will include Paul Jamason who was working at SOPAC when the first GSAC was developed, and a new PA III who will be hired.

University of Nevada, Reno

Prof. Geoffrey Blewitt, Co-I: Dr. Blewitt will be responsible for processing ~3,500 RINEX files every day through precise point position analysis using GIPSY OASIS II and Ambizap, and will write scripts to extract relevant statistics for QC. He will also explore the use of carrier range data and kinematic positioning to develop new QC parameters and quantify the effect of carrier phase multipath on apparent station motion during the day.

Dr. Corne Kreemer, Co-I: Dr. Kreemer will be responsible for downloading all GPS RINEX data from the archive to the analysis center at the University of Nevada, Reno. He will also download additional data from regional data centers that is not (yet) archived through this project. He will prepare the data for the precise point position analysis. He will create time-series of the north, east, and up position estimates, and analyze those for noise content, daily scatter, and a seasonal component. He will use these parameters and rank each station based on the chosen ranking scheme. He will feed all QC parameters as metadata back into the archive. For the fundamental stations he will determine time-series of the regional common-mode error, based on the position residuals of stations surrounding the fundamental station.

Project Work Plans

Year 1 Tasks

- UNAVCO sets up Project Management scheduling, coordination, and communication for the project through a Wiki, with partner organization project staff as subscriber/participants.

- UNAVCO, SOPAC, and CDDIS collaborate to expand upon current GSAC schema, SOPAC's site log XML and GeodeticML schema, and other resources to define the GSAC-WS XML schemas.
- SOPAC, UNAVCO, and CDDIS build corresponding Web Services accessing GSAC-WS metadata from their respective archive databases.
- UNAVCO enables its DAIv2 Java client software to utilize metadata and data queries to GSAC-WS Web Services.
- SOPAC retools the original gsac-client software to utilize metadata and data queries to GSAC-WS Web Services.
- UNR incorporates UNAVCO's Java clients into their processing data stream as a mechanism for query and data download from partner archives.
- UNAVCO Project Manager participates in ESDSWG.
- Project members publicize plans and progress at UNAVCO Science Workshop and Fall AGU in 2010.

Year 2 Tasks

- SOPAC and UNAVCO implement data and metadata queries to GSAC-WS Web Services running at each institution into their interface web tools, SOMI and GPS Explorer (SOPAC) and DAIv2 (UNAVCO).
- SOPAC develops GSAC-WS Web Services for the GSAC Retailer database as an option for GSAC participants continuing to use flat file publication.
- UNR produces daily quality assessment information products for pickup by GSAC-WS partners and ingestion.
- UNAVCO Project Manager participates in ESDSWG.
- Project members create documentation and presentations for dissemination and demonstration of progress at EarthScope National Meeting and AGU in 2011

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