THE LANDSAT IMAGE MOSAIC OF THE ANTARCTICA WEB PORTAL

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ABSTRACT

People believe what they can see. The Poles exist as a frozen dream to most people. The International Polar Year wants to break the ice (so to speak), open up the Poles to the general public, support current polar research, and encourage new research projects.

The IPY officially begins in March, 2007. As part of this effort, the U.S. Geological Survey (USGS) and the British Antarctic Survey (BAS), with funding from the National Science Foundation (NSF), are developing three Landsat mosaics of Antarctica and an Antarctic Web Portal with a Community site and an online map viewer. When scientists are able to view the entire scope of polar research, they will be better able to collaborate and locate the resources they need. When the general public more readily sees what is happening in the polar environments, they will understand how changes to the polar areas affect everyone.

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1 THREE LANDSAT MOSAICS

The USGS Center for Earth Resources Observation and Science (EROS) and BAS are producing three new Landsat composites. The first is a 30-meter resolution natural color composite of Landsat-7 Enhanced Thematic Mapper Plus (ETM+) bands 4, 3, and 2, to be used for identifying vegetation and rock. The second is also a 30-meter resolution color composite of Landsat-7 ETM+ but with bands 3, 2, and 1, which are considered better for characterizing ice and snow. The third is a 15-meter resolution, grayscale composite of the panchromatic band. These composites are generated from 1,028 hand-selected scenes, terrain-corrected before being mosaicked into the final product.

The Landsat composite products will be made available online for direct access as an OpenGIS consortium Web Mapping Specification (WMS) and Environmental Systems Research Institute (ESRI) ArcIMS image map service. These products will also be available to download in several formats from the USGS Seamless Data Distribution System (SDDS), also known as The Seamless Server. In addition, the original 1,028 Landsat scenes will also be hosted online for direct download using the Tiled Data Distribution System (TDDS).

2 ANTARCTIC WEB PORTAL

The target community for this effort is largely composed of two parts: the general public and research scientists. The public generally is not familiar with Antarctic research or locations. For the research scientists, the Antarctic region is a truly unique international research environment, and coordination among the many entities involved can be difficult.

We are creating specific tools to meet the needs of the entire target community. The three major features of the Antarctic Web Portal listed below will enable research scientists to collaborate more effectively by sharing results, techniques, and challenges, and locating needed information. The general public will learn more about Antarctica as well as about specific research projects and their locations.

- Online Map Viewer. This viewer will allow any user to view the Landsat composites, hosted datasets, and remote datasets. The viewer will have basic map functions, such as zooming, panning, and identifying features. There will be an interactive map layer of points that identify the location of current and historical research activities in the Antarctic. Scientists will submit these points as well as pictures of those locations and relevant research. The map viewer will also act as a gateway for downloading seamless and tiled data.

- Community Site/Collaborative Content. Research scientists will be able to create and maintain collaborative content. One key element of the created posts, pages, events, and links is that each can be marked with location information, or geotagged. This information will also be linked to the map viewer.

- Data Hosting/Metadata. USGS EROS will use metadata—data about the datasets—to register each dataset with external sites such as geodata.gov, National Spatial Data Infrastructure (NSDI) clearinghouses, and other metadata-based tools such as GeoNetwork open source. This will allow for much more extensive data search and access beyond what simple data hosting provides.

USGS EROS has developed many methods of distributing satellite and aerial data. We deliver more data in volume than any other U.S. Department of the Interior facility. USGS EROS has the second and third largest databases in the world for "All Environments, Scientific, Archive, and other" according to the Winter Corporation 2005 Top Ten Program (http://www.wintercorp.com/VLDB/2005_TopTen_Survey/TopTenWinners_2005.asp). The systems used to host the data and the Antarctic Web Portal are capable of handling millions of requests per day and transferring terabytes of data. USGS EROS can host all IPY development/research datasets.

Additionally, USGS EROS has a long background in working with raster datasets such as Landsat. We can create specialized products to assist scientists and the general public in visualizing Antarctic research in support of the IPY. This includes 3D visualization and fly-throughs, or, for conferences or large gatherings, display of the data through Geo-Wall technology.

3 LANDSAT MOSAICS

3.1 Landsat Scene Selection

To create the cloud-free Landsat mosaics of Antarctica, we compiled a list of 1,028 scenes from the Landsat-7 archive. Most of the scenes had already been identified in previous work by the National Aeronautics and Space Administration (NASA). The selection criteria focused first on temporally continuous strips with no or limited cloud cover (to simplify mosaicking), and second on cloud-free single scenes to cover as much of the remaining space as possible. We filled the remaining coverage gaps, or areas with cloud cover, with scenes that were free of clouds in the exact areas needed; this required mosaicking at the sub-scene level. Although cloud cover was almost always the determining factor in the selection, we attempted to select scenes within the narrowest possible range of sun elevations, especially in mountainous areas. For the very smooth large ice shelves, we also tried to keep the scenes within a narrow temporal range.

Whenever possible, we chose images from the Landsat-7 Enhanced Thematic Mapper Plus (ETM+) archive prior to May 31, 2003 when the instrument was switched to the "SLC-off" mode. To fill some cloudy areas, a small number of SLC-off images were used. In the Antarctic Peninsula, two ASTER scenes were selected. We have acquired new Landsat scenes during the 2005-2006 austral summer to replace these less-desirable scenes and to eliminate the small regions of remaining cloud. (See Figure 1 for coverage diagram.)

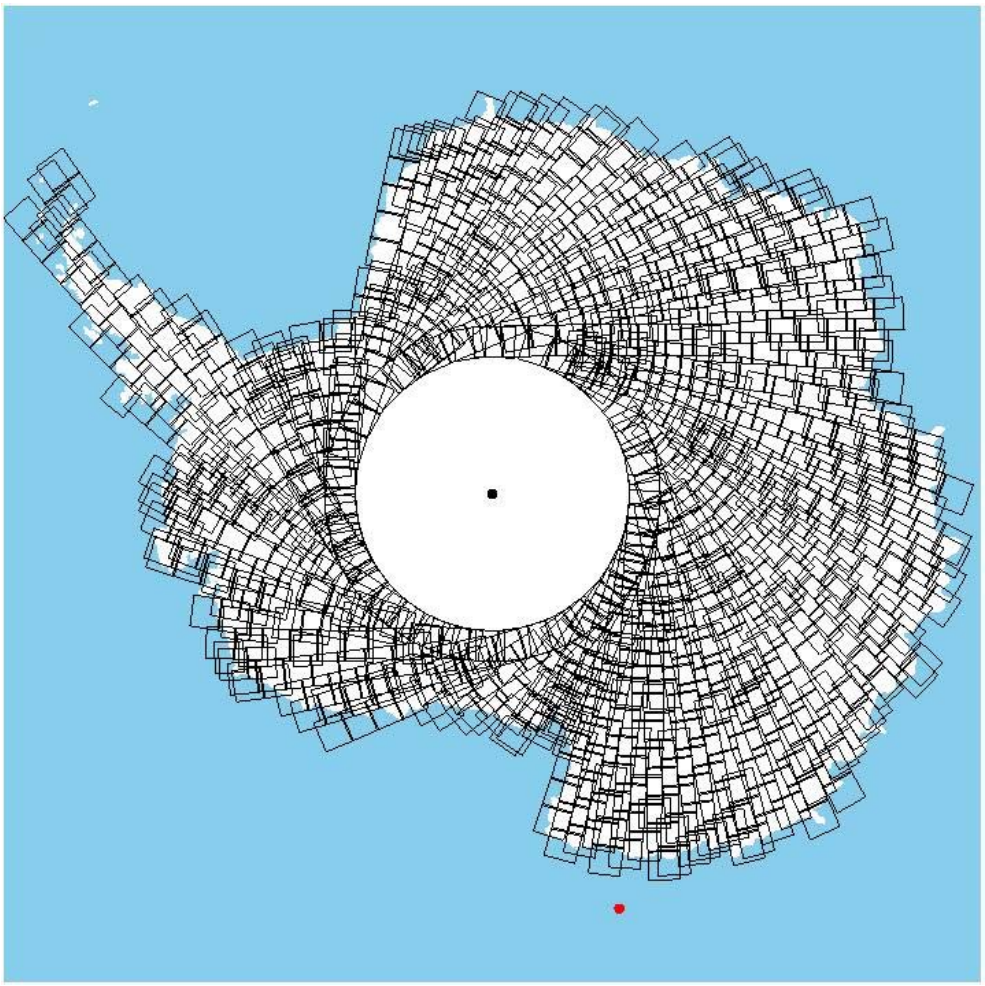

Figure 1. Landsat Scene Selection Coverage shows the 1,028 scenes selected for the final mosaic.

3.2 Landsat Data Preparation

Each of the 1,028 Landsat scenes identified for the Antarctic mosaic currently exists in a raw, unprocessed format in the archive at USGS EROS. This data contains alternating areas of duplicated scan lines and has not been radiometrically or geometrically corrected. The 1,028 scenes must be processed to a Level 1Gt, systematic terrain corrected format, prior to mosaicking. Systematic terrain correction applies geometric corrections to adjust for elevation effects but does not correct for geometric errors induced by uncertainty in the position and attitude of the spacecraft. USGS EROS has begun processing the Landsat data on the National Landsat Archive Production System (NLAPS).

The Level 1Gt product is not typically available for public distribution as current policy restricts access to terrain corrected products to U.S. government and affiliated users. The USGS is currently in the process of changing this

policy to explicitly include terrain corrected products in the definition of unenhanced data to guarantee that IPY scientists will be able to use these Landsat scenes.

To perform terrain correction, USGS EROS is using a new digital elevation model (DEM) of Antarctica derived from Ice, Cloud and Elevation Satellite (ICESat) data, and produced at the NASA/Goddard Space Flight Center. In practice Landsat-7 ETM+ systematic corrected Level 1G products have demonstrated residual location errors at nadir that are better than one pixel when definitive ephemeris has been applied, which exceeds the documented specification of 250 meter (1 sigma). However, at scene edges a 10 to 1 shift can occur as a result of terrain induced effects; e.g., a 3000 meter elevation equates to a 300 meter shift equaling ten 30-meter pixels. Because this shift is in opposite directions between adjacent scenes, the net result would be a 20-pixel offset between the adjacent scene edges. With terrain correction, this offset is reduced to the level of the vertical precision of the DEM.

The ICESat DEM is reported to be the most accurate topographical survey ever undertaken of the Antarctic continent with more than 65 million points collected by the Geoscience Laser Altimeter System (GLAS) orbiting on NASA's ICESat. The precision of the ICESat DEM is reported to be more than 10 times better than previous surveys (500 meter horizontal postings with a vertical precision of 0.1 meters), owing to the very narrow beam of this laser altimeter instrument.

Given the reported precision of the ICESat DEM, the Level 1Gt products processed through the NLAPS with terrain correction based on the ICESat DEM are expected to achieve a nominal scene-wide residual error approaching one pixel.

The proposed processing methodology includes the following:

- 1. All scenes are processed on the NLAPS system as Level 1Gt products (SLC-on or SLC-off gapped).

- 2. All scenes are processed to the same parameters selected prior to submitting scenes for bulk processing. The Landsat engineering staff will build a processing template based on these parameters and it will be applied consistently to all Landsat scenes used in the mosaic. The following parameters are anticipated to be used but will be verified prior to the start of processing:

Grid cell sizes	15, 30, 60	(pan, reflective, thermal)
Orientation	NUP	
Resampling method	NN	
Projection	Polar Stereographic	

- 3. All scenes are pre-selected and the information for the required scenes is provided to the engineering point-of-contact in an Excel spreadsheet.

- 4. All output products from the NLAPS are written to DLT. Scenes are stacked on the tapes to minimize the number of tapes needed to deliver the data.

3.3 Landsat Mosaicking Process

USGS EROS will format the processed scenes into three 1,028-scene (circa 2000) Landsat-7 mosaics. USGS EROS will assemble both mosaics using Level 1Gt systematic terrain corrected Landsat-7 ETM+ data collected prior to May 31, 2003; data will be in the Polar Stereographic projection (Figure 2). The first mosaic will be a 30-meter resolution 3-band image with ETM+ bands 4, 3, and 2 shown in red, green and blue respectively (Figure 3). The second is also a 30-meter resolution color composite of Landsat-7 ETM+ but with bands 3, 2, and 1, which are considered better for identifying ice and snow. The third mosaic will be a 15-meter panchromatic image with ETM+ band 8 (Figure 4). We will mosaic the scenes using traditional histogram-matching techniques to achieve radiometric balance between scenes. Because of the coverage density at these latitudes, scene overlaps and scene cut-lines will be used to advantage to achieve near seamless cloud-free mosaics.

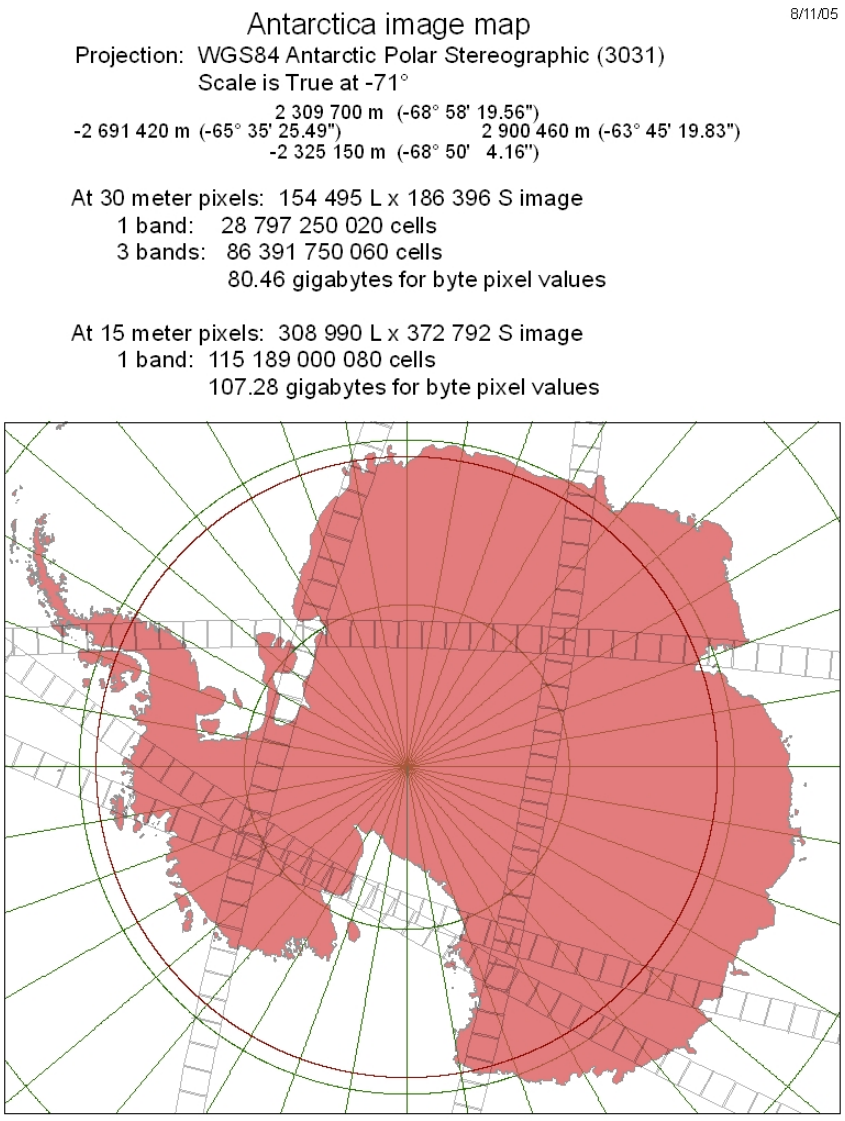

Figure 2. WGS84 Antarctic Polar Stereographic Projection

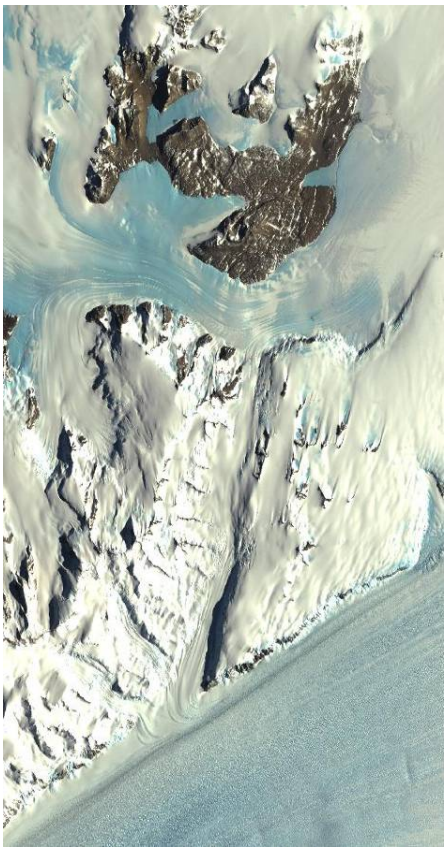

Figure 3. ETM+ [4,3,2] as R,G,B Landsat sample image

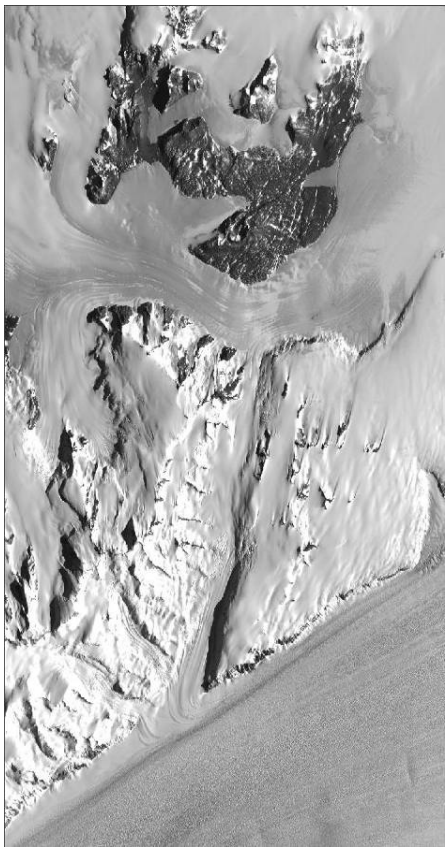

Figure 4. ETM+ [8] panchromatic Landsat sample image

USGS EROS will create the Antarctic mosaics with Environment for Visualizing Images (ENVI) 4.2 software, augmented with a GUI-based application prepared by ITT Visual Information Solutions. The British Aerial Survey (BAS) will contribute to the data purchase as well as to the mosaicking of the data. They have also agreed to purchase and mosaic all data associated with the Antarctic Peninsula. The area of coverage will include all data for the peninsula down to 76 degrees south latitude. BAS and USGS EROS will work together to provide a seamlessly represented product at the join area between our respective products. (See Attachment 1 for a graphic representation of BAS coverage area.)

The interior of Antarctica from the pole to 82.5 degrees south latitude has no coverage from Landsat (Figure 1). This area will not be filled within the mosaic. MODIS satellite data will fill in this area for viewing. We will have the MODIS data accessible on the web and available for download.

4 HOW TO ACCESS THE MOSAICS

The three Landsat mosaic products and the previous RADARSAT mosaic product will be available online at full resolution on the map viewer. We will place the dataset into an ESRI ArcIMS image map service. Every map service published will also have support for access using the OpenGIS consortium WMS standard (http://www.opengeospatial.org/standards/wms).

By default, these services will be available only in the Polar Stereographic projection (See Figure 1). While some support for reprojection exists, this will not be considered a main feature of these services. Figure 5 shows the following WMS request for the test Landsat data loaded.

http://imsdemo.cr.usgs.gov/wmsconnector/com.esri.wms.Esrimap/USGS_EDC_Antarctic_Data?request=getMap&version=1.1.1&bbox=317397.28%2C-1284725.5%2C340236.16%2C-1260221.3&srs=EPSG%3A3031&layers=ANTARCTICA_LSAT_IMAGES_30M&format=image/jpeg&height=400&width=500&styles=

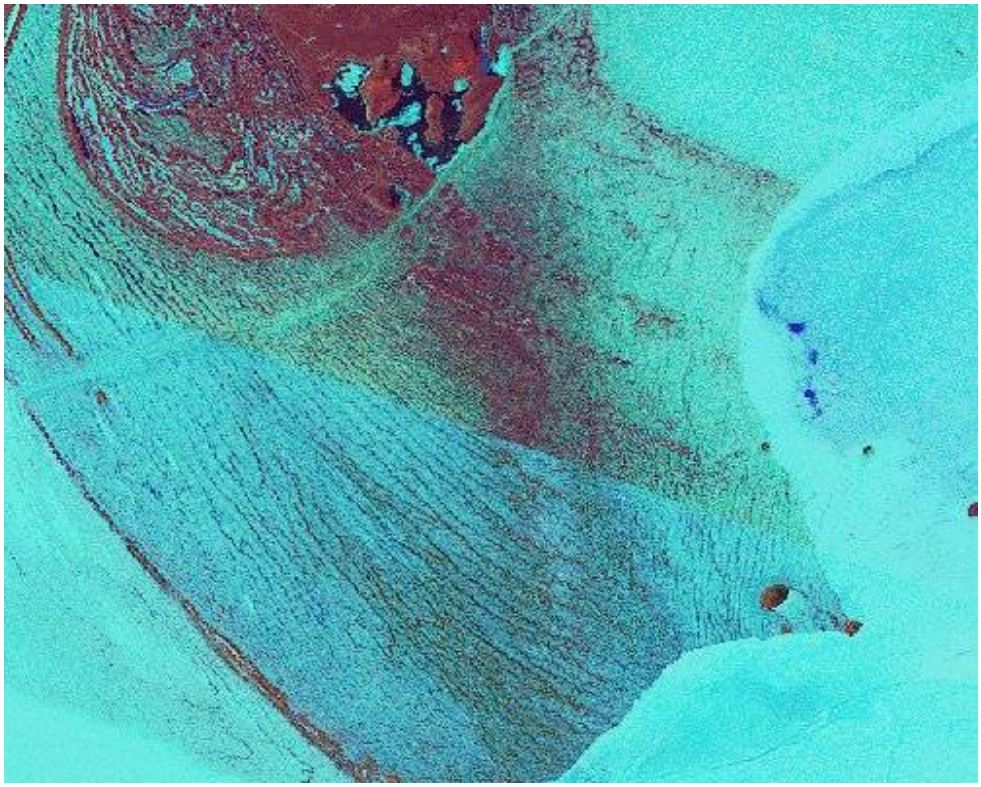

Figure 5. Sample Landsat WMS Request

4.1 Seamless Data

The Seamless Server (http://seamless.usgs.gov) is an HTML/JavaScript-based map viewer that allows users to preview and download datasets hosted at USGS EROS. The Seamless Server displays multiple map layers simultaneously and allows users to identify specific areas of interest. Users select layers to download and specify the download area by using a template, by drawing on the map, or by manual input. All downloads through this system are seamless (edge matched). Downloads are clipped to the user's specified requested area, and if the download is broken into multiple pieces, the pieces will align when loaded into GIS software. Users can download data in a variety of formats and add processing steps or run models for the specified download area.

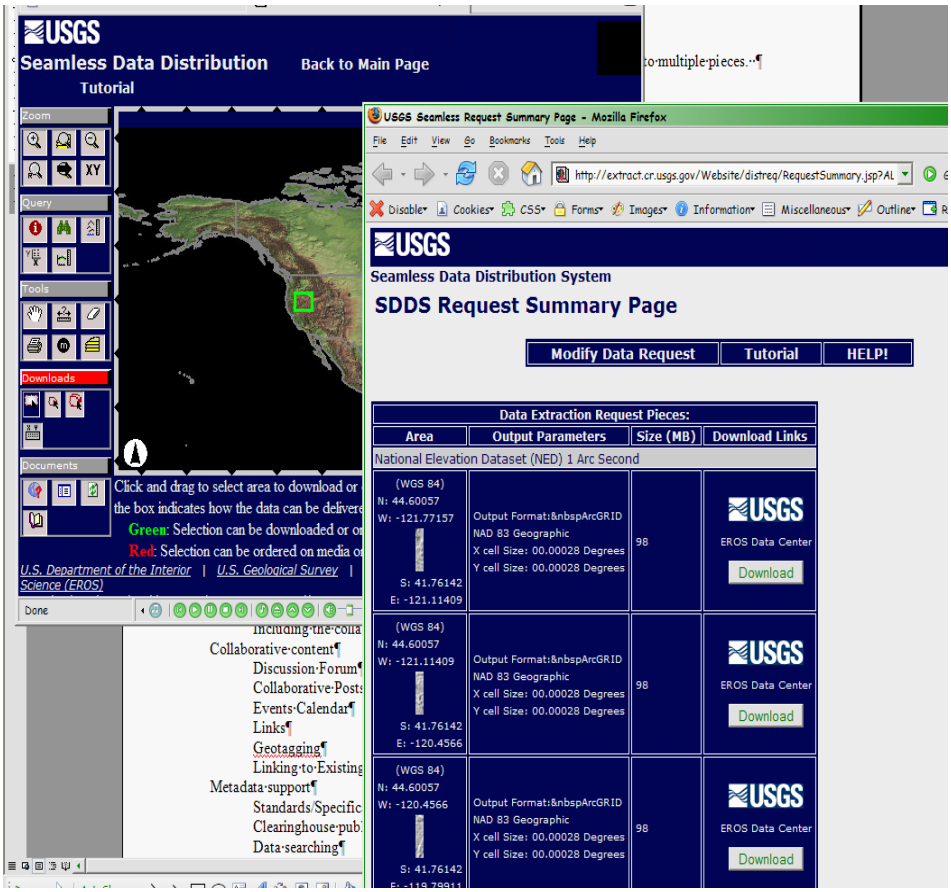

Figure 6. Seamless Data Distribution System Download

Figure 6 shows The Seamless Server with a download that has been broken into multiple pieces. The system will create multiple download pieces as needed. Users control the size of these pieces. Users may also choose different data formats and metadata types to include with the data. Although not often used, The Seamless Server also hosts downloads from multiple systems.

4.2 Tiled Data and Historical Landsat Scenes

The key difference between the Tiled Data Distribution System (TDDS) and The Seamless Server is the ability of SDDS to do partial downloads. With Seamless, users can do partial downloads as an option, but with TDDS, the dataset must be pre-packaged into discrete pieces as a requirement. Also, an index of the pieces is created that users interact with within the map viewer. TDDS uses the same online map interface as The Seamless Server to select a download area, but the user is unable to view the data online or extract smaller areas of interest. Unlike tiles on The Seamless Server, TDDS tiles may overlap, and the user can only retrieve the data in the pre-packaged format.

The USGS EarthExplorer system (http://earthexplorer.usgs.gov/) is another method of obtaining data in discrete, predefined packages. The primary difference between the EarthExplorer system and the TDDS is that EarthExplorer is based upon metadata searching, rather than index searching. EarthExplorer also includes more data than the TDDS. The Landsat historic archive and many other products are included in EarthExplorer's metadata catalog. Figure 7 shows the EarthExplorer login screen.

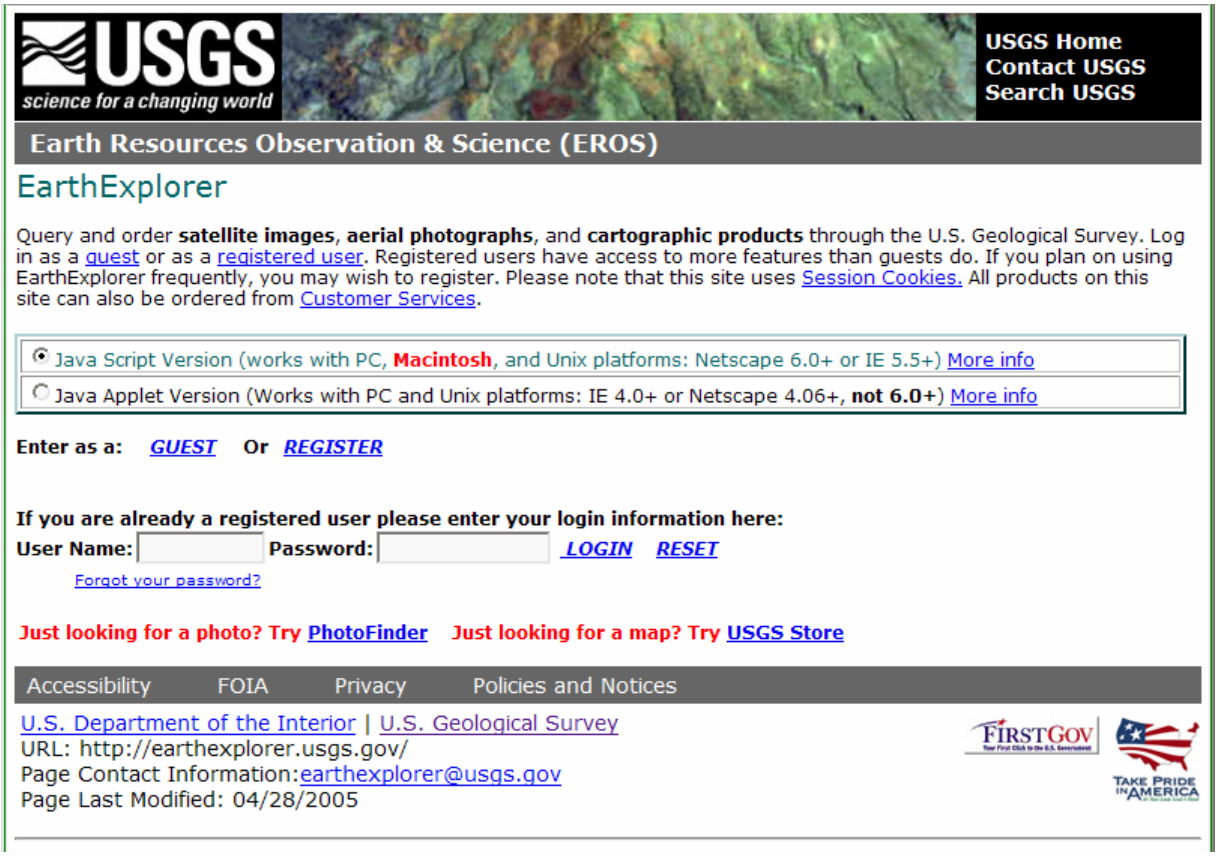

Figure 7. EarthExplorer Ordering System

5 ANTARCTIC WEB PORTAL

Increasing scientists' ability to collaborate is a key element of the Antarctic Web Portal Community site. This collaboration is bi-directional. The research scientists will have an active role in creating content for the site, and there will be many ways for scientists to connect this site with online social networking tools, such as the ability to bookmark this site in an online bookmark tool such as Yahoo by simply clicking a button or adding the site, or a feed from the site, to the Google toolbar. This will enable research scientists to share detailed information and allow the general public to discover what scientists are learning about the Antarctic.

The research in Antarctica is done by scientists from many different countries, in a variety of disciplines. These scientists are often focused on particular project goals and funded through disparate sources. The different goals and project funding contrast sharply with the work environment that often encourages or requires the scientists to work closely together. The end result is a group of scientists who are familiar with each other and each other's research. However, new researchers or others outside of this group can find it difficult to gather data and coordinate research. The communication tools within the Antarctic Web Portal will provide polar researchers with access to a much larger audience.

5.1 Antarctic Map Viewer

The Landsat mosaics are accessed through the online map viewer. The viewer itself actually uses the WMS access to the map service to build a map view. The best analogy for describing how this viewer works is to compare it to an overhead projector that uses transparencies (or foils). By layering multiple transparencies, the projector combines all the transparencies into a single final image. The image below shows a screen capture of the initial prototype that was set up to show how the map viewer can work over the Antarctic region.

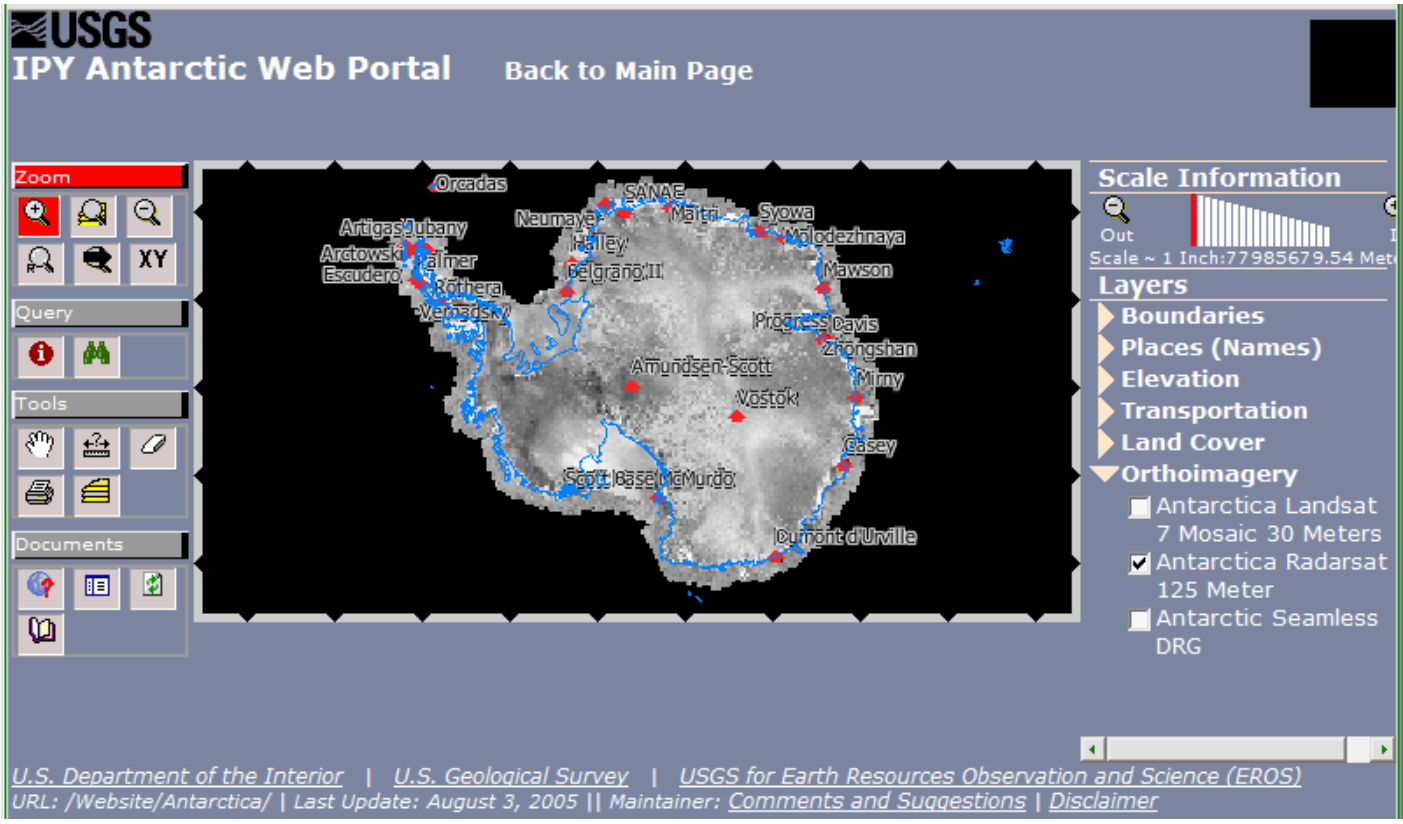

Figure 8. Antarctic Viewer Prototype

This viewer is also the main vehicle to access the Landsat mosaics (and other datasets) for download. It has specific map tools that define download areas and passes those into The Seamless Server or the TDDS.

The viewer used in the Antarctic Web Portal will be based upon the same code base as the map viewer used in The Seamless Server. It will have very similar basic map functions to zoom, pan, and identify, as well as some of The Seamless Server's more advanced functions, such as Gazetteer and U.S. National Grid Query. As The Seamless Server develops and the viewer gets updated, the Antarctic viewer will also be updated.

The design of the map viewer allows for the stack of map images to have individual images pulled from multiple locations. IPY partners who have their own hosting solutions can have their data layers merged into the map just as the layers hosted at USGS EROS. In addition, any content that has spatial content and can be rendered using WMS-like syntax can be merged into the map. The Antarctic Web Portal will have special geotagging support built into it that allows for this type of rendering. This is very similar to the mashup style (combining multiple external services) of development that many of the public mapping services allow.

5.2 Collaborative Content

The Antarctic Web Portal Community Site will be built around a central idea that almost all content is posted by privileged users. Ideally, the privileged users will become the research scientists working on Antarctic science; however, users will initially be composed of selected people from the USGS and the BAS. The posted content will consist of several different types of media, including "blog" posts, online pages, event notifications, links, and even data files or data. For the most part, this type of community content is common online, and the core of this site will use existing solutions. It is the content itself, combined with the additional capabilities mentioned below, that will make this site an important tool for the Antarctic research community.

USGS EROS will integrate into all content types the concept of geotagging. A good online example of this type of tagging is exhibited by the Platial API (http://platial.com/). It might even be possible to use the Platial API to handle the actual location information and add additional layers to the API, to allow for integration into the map viewer, conversion to Antarctic Polar Stereographic coordinates, and some additional searching capabilities. Figure 9 shows an example of how geotagging may appear within content posted by researchers.

Figure 9. Sample Article with Locations shown in sidebar

Where possible, this Antarctic Web Portal will use external API's or have pre-established connections to existing community-based services available online. These will range from the addition of buttons or links that will register the Antarctic Community site content with external API's to add functionality directly into the Antarctic Web Portal. Some possibilities under consideration (besides the Platial one mentioned above) include Google related sites, MetaCarta spatial indexing, Y!Q tagging, and many geospatial mapping services. These tools will be focused on what the Antarctic research scientists are using rather than the general public and will be adapted to the tools that are actually in use.

6 METADATA CLEARING HOUSE

The Antarctic Web Portal will not be the only location online for users to find geospatial data. In fact, the data hosted on the Antarctic site is actually intended to be accessible through multiple interfaces. Behind the map services and dataset downloads, there will be metadata that USGS EROS will catalog and maintain. These metadata and the access to the catalog will support multiple methods of searching, querying, indexing, and harvesting. There are several standards, such as those of the Federal Geographic Data Committee (FGDC) and International Standard Organization (ISO), which specify how to format metadata and how to access catalogs of metadata. Metadata cataloged in the Antarctic Web Portal will be compliant with these standards, and several external sites will be configured to harvest from the catalog. This will enable searching for Antarctic data through interfaces entirely separate from the Antarctic Web Portal.

For example, the geodata.gov site currently indexes over 100,000 different metadata sources. Datasets hosted in The Seamless Server are harvested automatically into this site, allowing users to discover the seamless datasets without accessing The Seamless Server directly. Figure 10 below shows some of the seamless datasets that come up in a search on the geodata.gov site. Another example of an index of metadata that users can search is the National Spatial Data Infrastructure (NSDI) clearinghouse system; USGS EROS has many datasets included on this system via a local clearinghouse node.

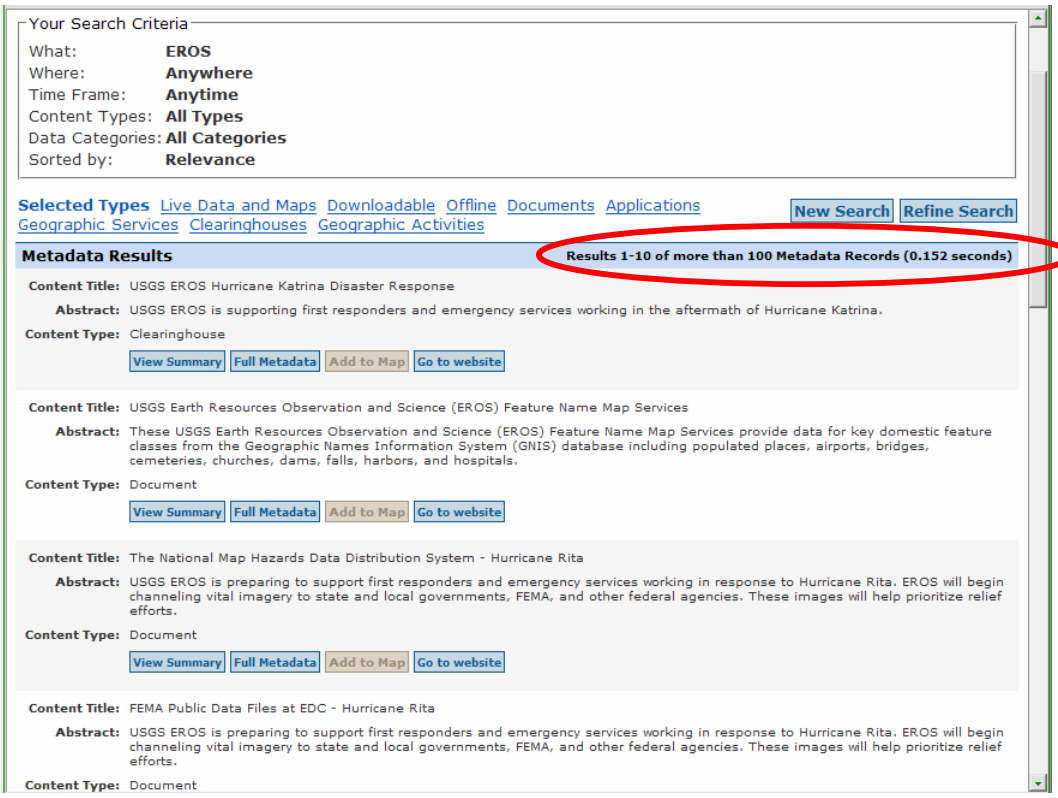

Figure 10. Metadata Search on Geodata.gov for USGS EROS

6.1 USGS EROS Infrastructure and Services

There is a significant amount of existing infrastructure at USGS EROS that will be used to support the access, distribution, and archiving of the individual Landsat scenes, mosaic data, ancillary information, and other scientific information. As the individual Landsat scenes are processed to a systematic terrain correction, they will be placed on a silo that sits near-line to the web. Scientists will be able to identify and download these scenes prior to the mosaic being completed. These scenes will remain near-line for access throughout the IPY. Once the mosaic is completed, it will be loaded to Solaris/Oracle database servers and made available as ArcIMS and OpenGIS Consortium Web Map Services. Web access to these data is managed by many dual processor windows boxes. These systems are designed for high volume traffic and are currently averaging half a million maps rendered per day and have, on occasion, delivered almost 3 million maps in a single day.

The following is a detailed list of the physical environment and capabilities of USGS EROS:

General Facility Capabilities

- Commercial source of electrical services (multi-path)

- 24 x 7 electrical service conditioning with in-line UPS (Uninterruptible Power Supply)
- Diesel generated electrical services as failover to commercial interruption
- A restricted access as applicable to USGS EROS computer room access control guidelines
- 3 environmentally controlled computer room environments (air conditioning, humidity control, fire control)

Networking Capabilities

- System interface (LAN) speeds supporting all media (copper, fiber, wireless where applicable) 10/100/1000 Mbps (any combination)
- USGS VPN support in accordance with usage and security policies
- USGS EROS-assigned IP addresses and host names
- Network LAN and WAN connectivity for access and associated services, including Firewall protection, Domain Name, and Network Time Protocol services, their configuration and operation
- Networks managed by four employees
- Local area networks (LANs) consisting of a combination of 100Mb/sec Ethernet and Gigabit Ethernet, comprising over fifteen subnets with approximately 1500 local network connected devices
- Wide area network (WAN) connections utilize T1 frame-relay, DS-3 ATM, OC-3 Sonet, and OC12 ATM circuits
- Aggregate available bandwidth of approximately 1.0 Gbit/sec.
- Connections to Internet and Internet2, International Research Networks, ESN (Department of the Interior Enterprise Services Network), BIA EDnet (Bureau of Indian Affairs educational facilities), various NASA networks, and the SDREN (South Dakota Research and Education Network)
- General statistics include the following:

Total aggregate (all networks) outbound capacity	= 1.0 Gbit/sec
Total ave. (daily) outbound usage	= 1.1 GBytes/day
Total aggregate (all networks) inbound capacity	= 1.0 Gbit/sec
Total ave. (daily) inbound usage	= 950 GBytes/day

Data Warehousing, Data Archival, and System Recovery and Backup Capabilities

- Legato backup services
- StorageTek near-line mass storage capabilities (Robotic Silos)
- Local offsite storage (populated media for continuity of operation requirements)
- USGS EROS long term archive requirements (offsite storage in North Carolina)

USGS EROS designed the architecture for hosting The Seamless Server and associated pages to be cost-effective and reliable. Redundancy is implemented at several levels and for critical datasets can be expanded. The diagram below (figure 11) shows the layers of technology used to deliver data online.

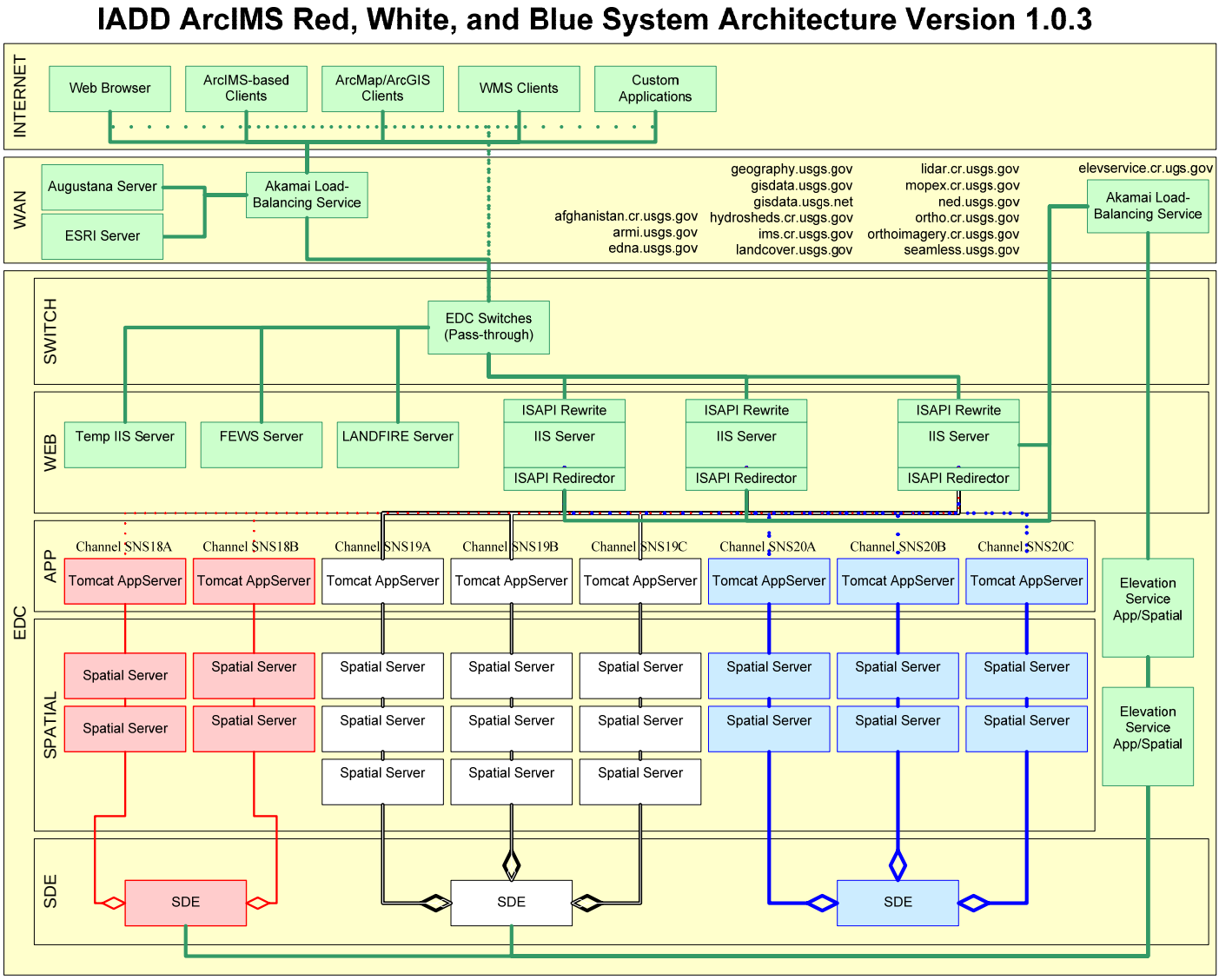

Figure 11. Architecture used to run The Seamless Server and related sites

6.2 USGS EROS Services

The Seamless datasets are hosted in spatial databases that use the Spatial Database Engine (SDE) from Environmental Systems Research Institute (ESRI). The SDE software is running on top of an Oracle database that is running on Solaris servers. The map data sets are accessed through a combination of ESRI ArcIMS and custom

built applications that run on dual CPU Windows machines. The database servers can support hundreds of simultaneous requests, and the applications servers are easily expandable with commodity hardware. All public access is controlled through replicated Windows/IIS servers. At the very top of any request, Akamai services are used to load-balance requests and trigger a fail-over to offsite contingency servers in the event of an emergency.

The Seamless Server relies upon the capabilities of SDE in order to access data. USGS EROS is capable of hosting any data that can be processed and loaded into SDE. Once loaded, the data can be indexed and added to The Seamless Server very quickly. Datasets that cannot be loaded into SDE, or projects that do not need online visualization, can be packaged into preset bundles and loaded into near-line storage. Data are indexed to enable spatial queries based on geographic extent. This index is added to The Seamless Server system to support TDDS queries.

IPY partners interested in adding their data to the USGS EROS hosting solution and including it in the Antarctic Web Portal should contact USGS EROS. Data sets do not need to be hosted at USGS EROS in order to be part of the community site. Each IPY partner that wishes to host data at USGS EROS would need to contact USGS EROS regarding that data.

Scientists and technical staff at USGS EROS will prepare specialized products upon request. The datasets involved with visualization can be quite large and expensive, both in access time and local disk space required. USGS EROS will produce and host products to aid in the visualization of Antarctic research. As discussed earlier, the Antarctic Web Portal will host a map layer of points that identify locations of current and historical research activities in the Antarctic. IPY research scientists will be able to submit these points as well as pictures of locations and relevant research materials. When the point layer is displayed in the interactive map viewer, users will be able to click on a point to view photos and links to associated research details. Three common visualization services that USGS EROS can offer are 3D visualizations, 3D fly-through movies, and the use of a GeoWall system to display datasets for large gatherings or conferences. Samples of these products will be included in the Antarctic Web Portal. To promote collaboration on the Antarctic Web Portal, any IPY partners can advertise capabilities or request specialized products.

To contact USGS EROS, please use the following:
Customer Services
USGS EROS
47914 252nd Street
Sioux Falls, SD 57198-0001
Tel: 800-252-4547
Tel: 605-594-6151
Email: webmapping@usgs.gov

7 SUMMARY

The combined efforts of USGS EROS and BAS to produce the new Landsat mosaics of Antarctica will provide the backdrop or basis for a whole new level of scientific collaboration and understanding of research results and challenges. The general public will be able to visualize the Antarctic environment and place ongoing and historical research in a new context. The Antarctic Web Portal, with its online map viewer, collaborative content, and hosted metadata will provide the polar research community and the general public with new vehicles for critical communication about Antarctic research. The Landsat mosaics and the Antarctic Web Portal fulfill, in part, the International Polar Year goals "to engage the upcoming generation of young Earth System scientists and to get the public to realize just how much the cold ends of the sphere we all live on really do influence us" (http://www.ipy.org/start/index.php/site/about).

Work performed under U.S. Geological Survey (USGS) Contract 03CRCN001

8 IMPORTANT LINKS

BAS Site = http://www.antarctica.ac.uk/
ENVI Software = http://www.ittvis.com/index.asp
GeoNetwork Open Source = http://sourceforge.net/projects/geonetwork
Google API's = http://code.google.com/
IPY Site = http://www.ipy.org/start/index.php/site/about
MetaCarta Spatial Indexing API = http://metacarta.com/
NSF Office of Polar Programs = http://www.nsf.gov/dir/index.jsp?org=OPP
OpenGIS WMS Standard = http://www.opengeospatial.org/standards/wms
Platial = http://platial.com/
The Seamless Server = http://seamless.usgs.gov/
USGS Antarctic Web Portal = http://usarc.usgs.gov/
USGS EarthExplorer = http://earthexplorer.usgs.gov/
Winter Corporation = http://www.wintercorp.com/VLDB/2005_TopTen_Survey/TopTenWinners_2005.asp
Yahoo API's = http://developer.yahoo.com/