GROUP ON
EARTH OBSERVATIONS

Polar Ecosystems Biodiversity Scenario Engineering Report
GEOSS Architecture Implementation Pilot, Phase 2

Version 1.0

Revision History

Version	Date	Editor and Content providers	Comments
0.8	12 June 2009	Xuanang Cheng Yuqi Bai	Initial Draft
0.9	20 July 2009	Douglas Nebert	Full review and update.
1.0	21 July 2009	Doug Nebert	Final version

Document Contact Information

If you have questions or comments regarding this document, you can contact:

Name	Organization	Contact Information
Douglas Nebert	US Geological Survey	ddnebert@usgs.gov
Liping Di	Center for Spatial Information Science and Systems (CSISS), George Mason University	ldi@gmu.edu

Table of Contents

Table of Figures

Table of Tables

GEOSS AIP-2 Polar Ecosystems Biodiversity SBA Engineering Report

1. Introduction

1.1 Scope of this document

This AIP-2 ER will describe the user scenario entitled "Polar Ecosystem Vegetation Changes Scenario". The ER describes how the GEOSS-based system was tested to prototype the detection of extent and degree of vegetation changes in response to climate change in arctic ecosystems, and in particular, the boreal-tundra ecotone. The architecture, workflow of the developed system is presented, and the standards-based GEOSS components and services are highlighted.

1.2 GEOSS AIP

The GEOSS Architecture Implementation Pilot (AIP) leads the incorporation of contributed components consistent with the GEOSS Architecture using a GEO Web Portal and a Clearinghouse search facility to access services through GEOSS Interoperability Arrangements in support of the GEOSS Societal Benefit Areas. AIP is a GEO task for elaborating the GEOSS Architecture under the purview of the GEO Architecture and Data Committee.
This Engineering Report (ER) is a key result of the second phase of AIP. AIP-2 was conducted from July 2008 to June 2009. A separate AIP-2 ER describes the overall process and results of AIP-2 and thereby provides a context for this Community SBA ER.[1]

2. Community SBA Objectives

Monitoring the extent of climate change impacts is important to northern peoples and the fauna and flora that inhabit the landscape. The characterization of climate change or global warming based on point observation of weather does not adequately depict the terrestrial extent and variability of its effect. Just as climate is a measure of long-term weather patterns and values, vegetation also responds to key long-term factors that either enable or inhibit growth and dispersion. Perceptible changes in vegetation (extent, density, diversity) as sensed by Earth Observation instruments can be used as a potential marker to quantify the effects of climate change in the boreal-tundra ecosystems, and to document the extent of potential terrestrial vegetation change in the polar region.

The estimation of current climate variables mapped across the polar terrain can be useful in understanding trends and patterns of permafrost and engineering effects, energy requirements for heating/cooling, growing season for native and cultivated plants, habitat suitability, and other areas of application.

This scenario demonstrates and offers an easy-to-use image download, sub-setting, and classification tool linked to the Landsat archive that can be used for vegetative change detection. The central hypothesis of the scenario is that the extent of ecosystems and vegetation signature -- northern boreal forest, treeline, tundra ecotone – is changing as a result of climate change at scales that should be visible and quantifiable in moderate to high-resolution imagery. This scenario will establish the technical framework by which the hypothesis can be tested for a variety of Arctic test sites.

[1] A listing of all AIP-2 Engineering Reports: http://www.ogcnetwork.net/AIP2ERs

3. Scenario

3.1 Actors

The actors in this scenario are:

- A Biological Scientist with interest in estimating the Polar Ecosystems: "Scientist"
- A Data Center offering access to Landsat imagery via online services: "Data Center"
- Client Application for use by the biological scientist: "Client"
- Processing Services for sub-setting and classification tool for vegetative change detection: "Processing Services"
- Catalogue to which the Scientist can publish results form the analysis: "Catalogue"

3.2 Context and pre-conditions

The biological scientist is aware moderate to high-resolution imagery can be used to view and quantify the extent of ecosystems and vegetation change. The scientist aims to test this hypothesis using Landsat Imagery.

The scientist is aware that an archive offers on-line access to imagery for registered users. The scientist has used a client application to access other data centers and anticipates that through GEOSS Interoperability Arrangements (common standards) the client will work with the archive and a set of tools to manipulate the imagery.

3.3 Scenario Events

Table 1 lists the steps in scenario that result in the creation of information products for evaluating the polar ecosystems and vegetation signature.

The steps in the scenario are accomplished through Use Cases. The transverse technology use cases describe reusable functionality of the GEOSS service oriented architecture implemented through Interoperability Arrangements. It is a goal that the SBA scenarios are implemented using the generalized transverse technology use cases. In the interim, Specialized Use Cases are defined to meet some particulars of the scenario and the community's current implementation. The Transverse Technology use cases are summarized in the appendix to this ER and defined in detail in a separate AIP-2 Engineering Report. The Specialized Use Cases are contained in later sections of this ER.

Table 1 – Steps in the Polar Ecosystem Scenario

Step	Description	Trans. Tech Use Case	Specialized Use Case
1	Using the Client, the Scientist registers with the Data Center		User Registration
2	The Scientist needs to discover Landsat data in the polar region of interest. Using the Client a search is made of the Landsat holdings of the Data Center The Scientist reviews the search response in the Client and selects a dataset from the query result.	4. Search for Resources 3. Harvest & Query via Clearinghouse	Image Discovery
3	Using the Client, the Scientist requests data from the Data Center. The request specifies a specific geographic region, a date and time and selected bands of the imagery. The subsetted Landsat image is returned from the Data Center to the Client.	5. Present Services and Alerts 6. Interact with Services	Image Download
4	Next the Scientist invokes the NDVI Processing Service to perform an analysis of the image producing an NDVI product image.	5. Present Services and Alerts 6. Interact with Services	Image Analysis
5	The Scientist reviews the NDVI product image to determine if it provides an assessment of the vegetation in the geographic area.	7. Exploit Data Visually and Analytically	Result Image Evaluation
6	The User publishes the NDVI product to a catalogue service for others to view.	1. Register Resource.	Image Publication

3.4 Post-Conditions

After the scenario is complete the new NDVI product image showing the vegetation in the polar region is available for other GEOSS users to discover and access.

4. System Model of the Scenario

4.1 System Architecture

Figure 1 shows the components involved in the implementation of the the Polar Ecosystem Senario using specific components from USGS and George Mason University.

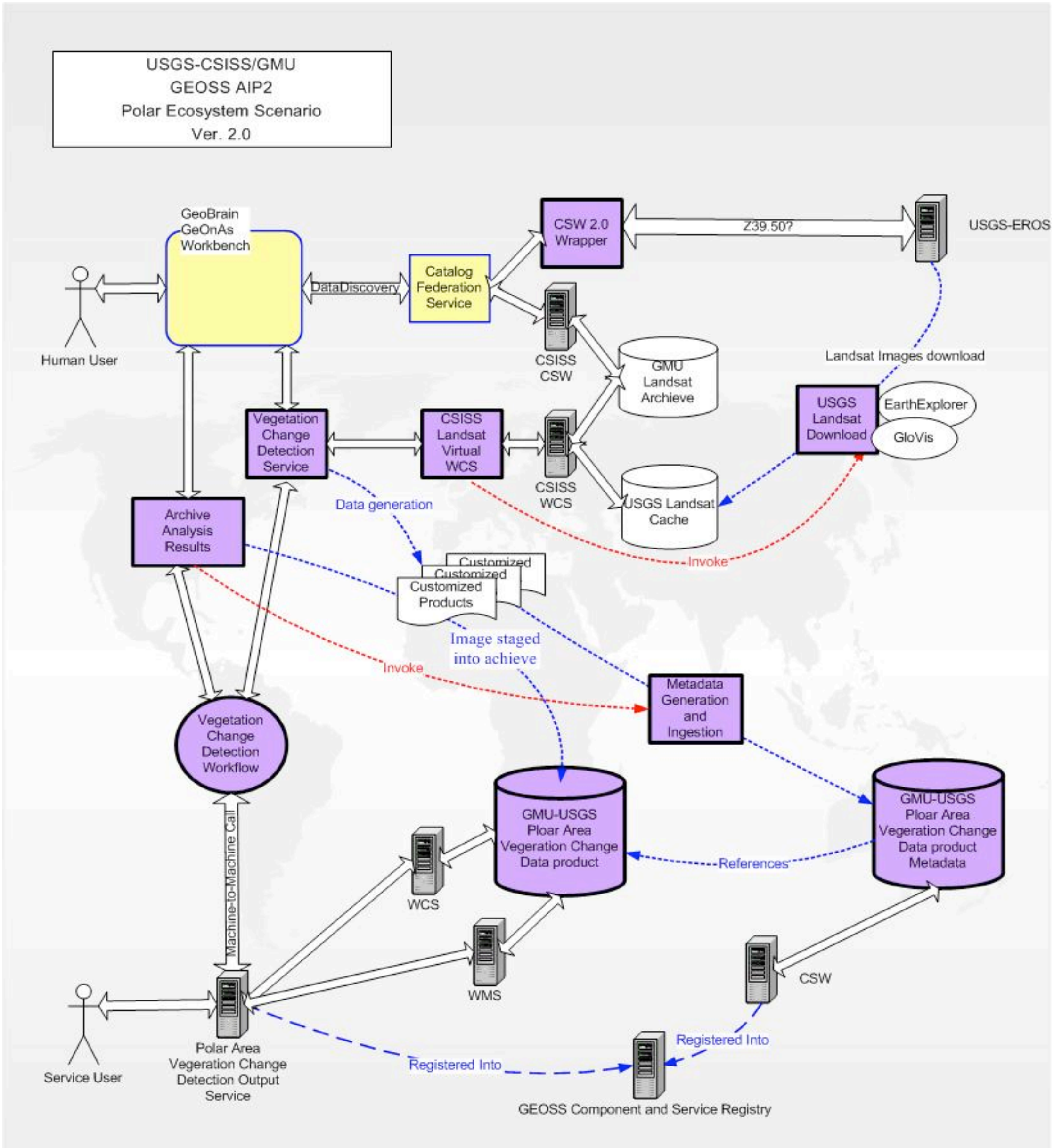

Figure 1 – System architecture

4.2 Involved GEOSS Data and Service Components

The following components participated in the scenario

- USGS-EROS Landsat Archive – GloVis software package

GloVis package is used to support live USGS Landsat data download functionality (registration and search).

- GeoBrain product - George Mason University (GMU CSISS)

GeoBrain ONline Analysis System (GeOnAS), a web-based GUI interface for geospatial data discovery and online analysis, is used as the interface for science users.
GeoBrain Catalog Federation, an OGC catalog service standards-compliant solution, is used to provide an integrated access point to both GMU Landsat Catalog, and the NASA ECHO system for image discovery.

GeoBrain Catalog, an OGC catalog service standard-compliant service, is used to host a dedicated Polar Area Vegetation Change Detection Data Product metadata catalog.
GeoBrain WCS and WMS services are used to provide standards-compliant access interfaces for the generated Polar Area Vegetation Change products.

5. Specialized Use Cases

This section contains descriptions of the specialized use cases referenced in the SBA scenario. The Specialized scenarios are considered as specializations of the AIP-2 Use Cases. The process of refining the specialized and general use cases will occur over a series of iterations.

The specialized use cases are:

- User Registration
- Image Discovery
- Image Download
- Image Analysis
- Result Image Evaluation
- Image Publication

The sequence diagrams for each of these steps are listed below.

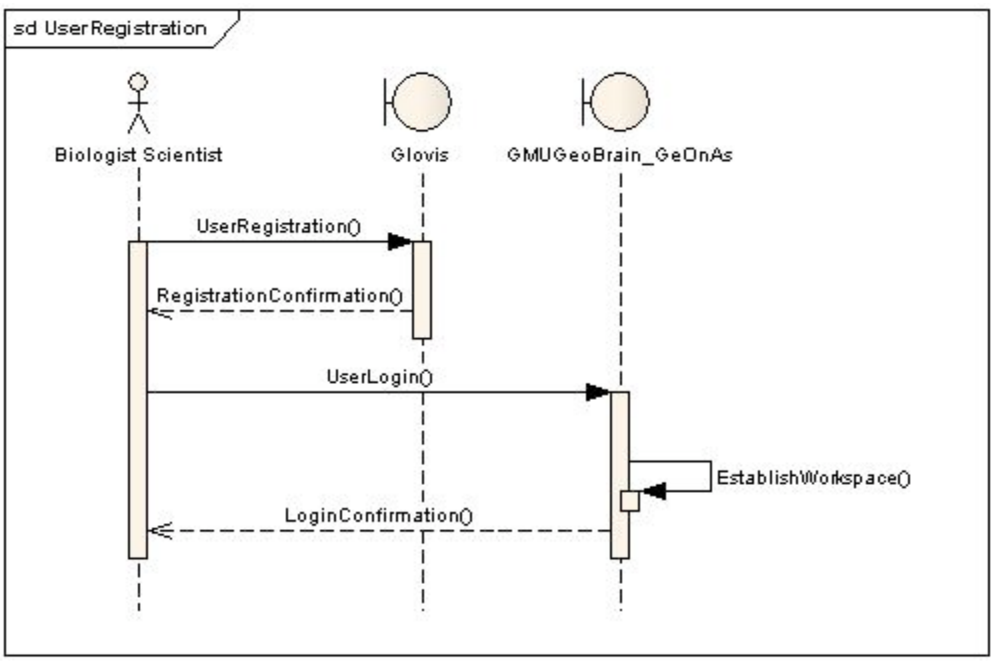

Figure 2 – User registration use case

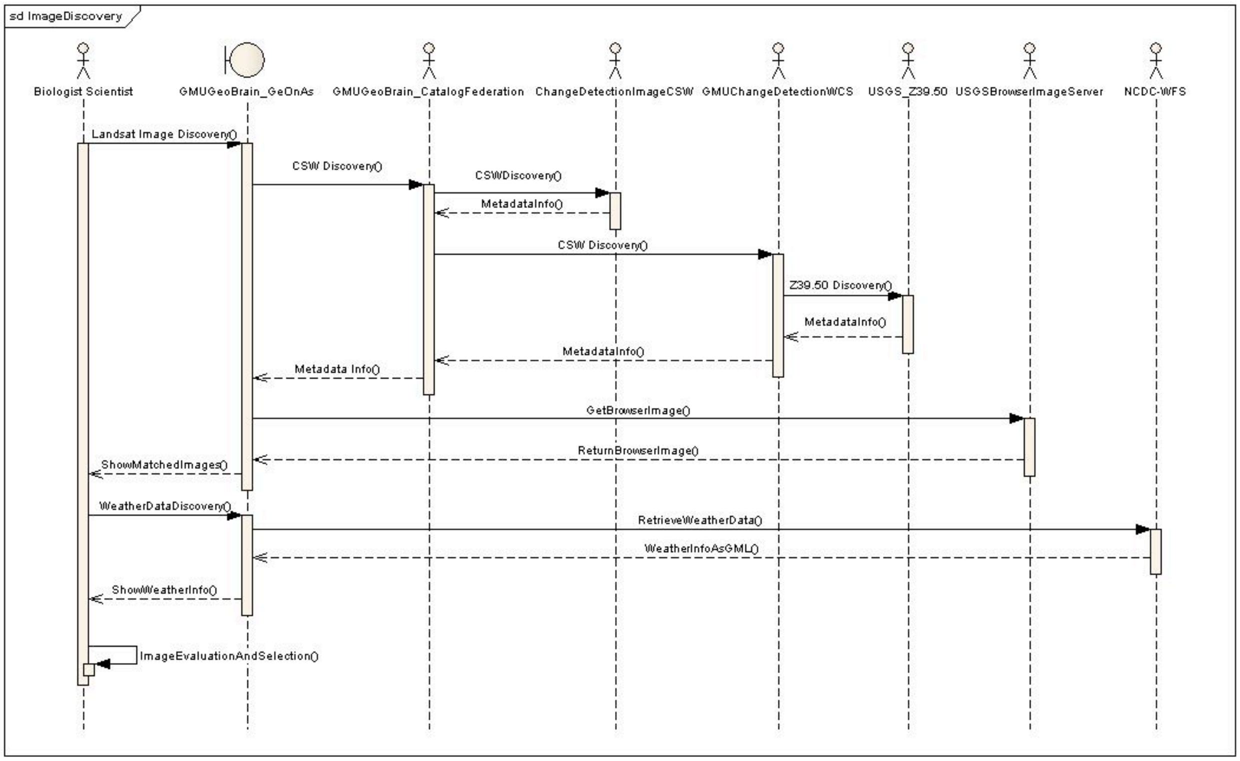

Figure 3 – Image discovery use case

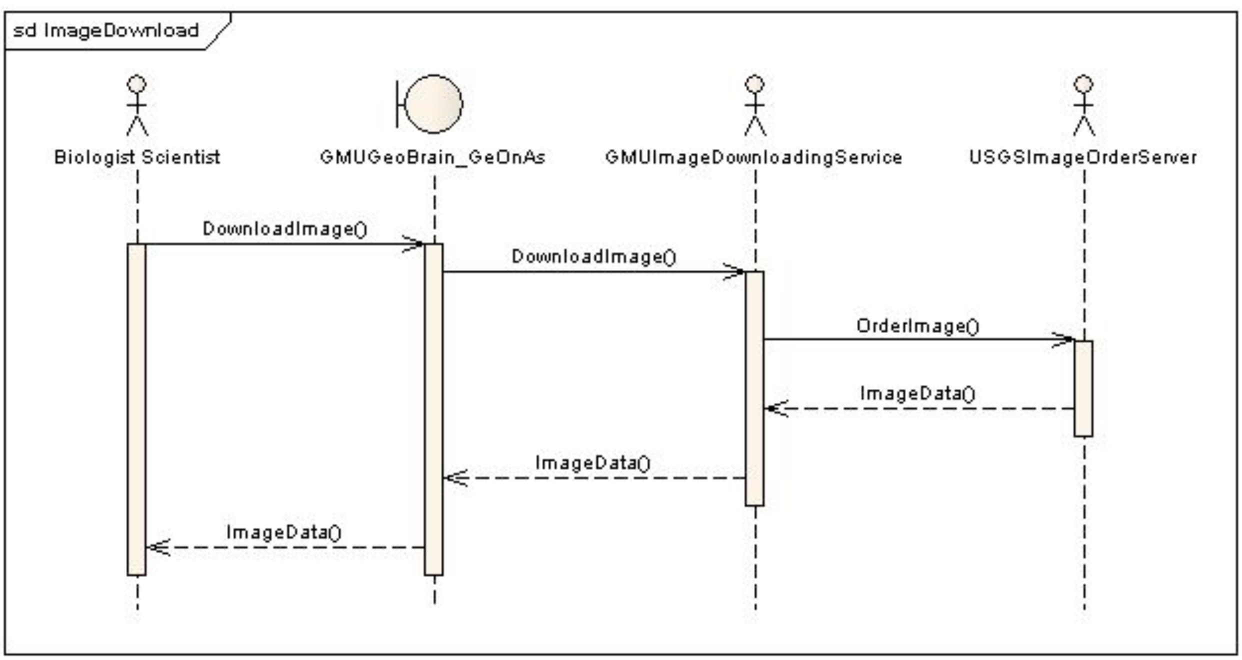

Figure 4 – Image download use case

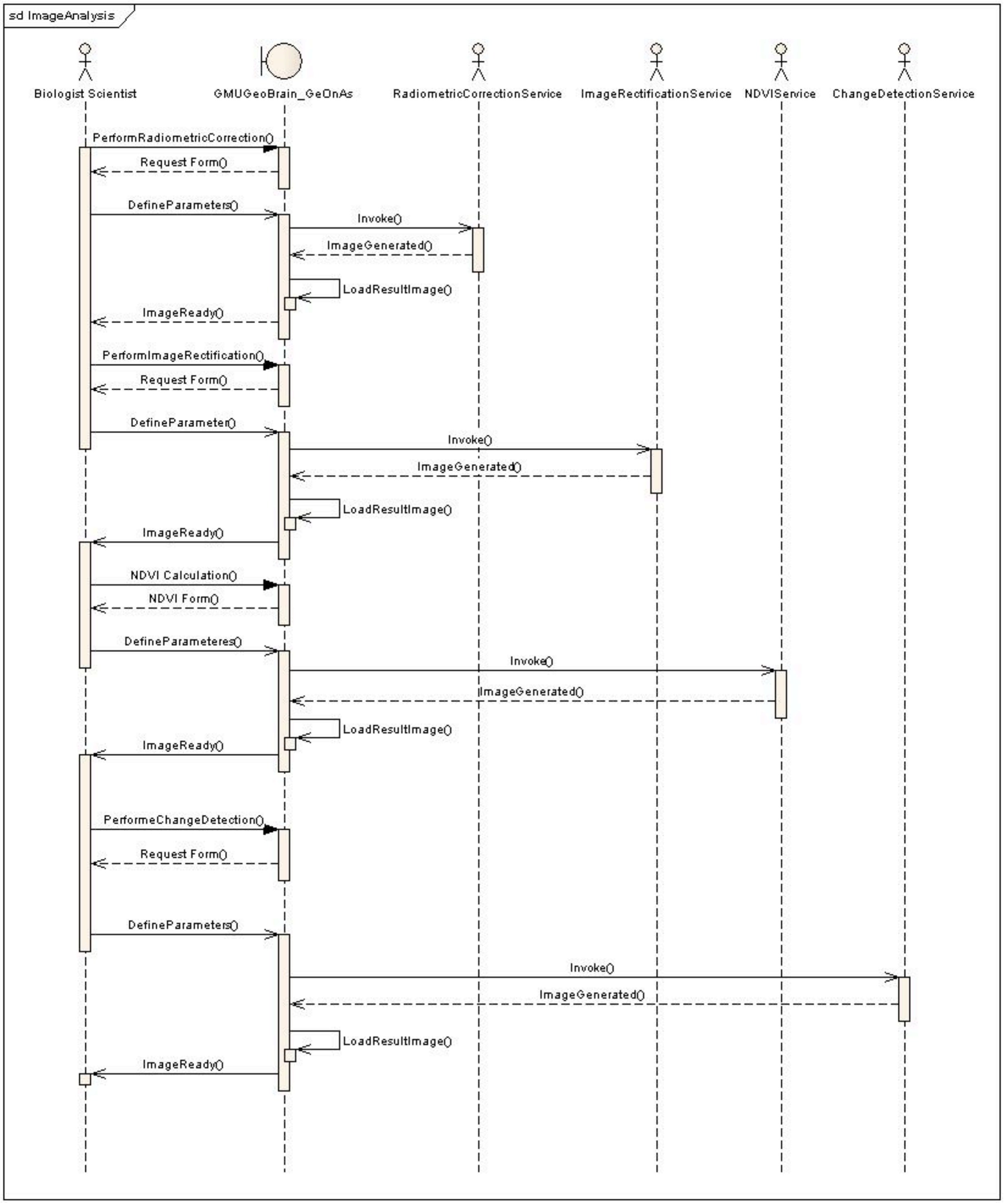

Figure 5 – Image analysis use case

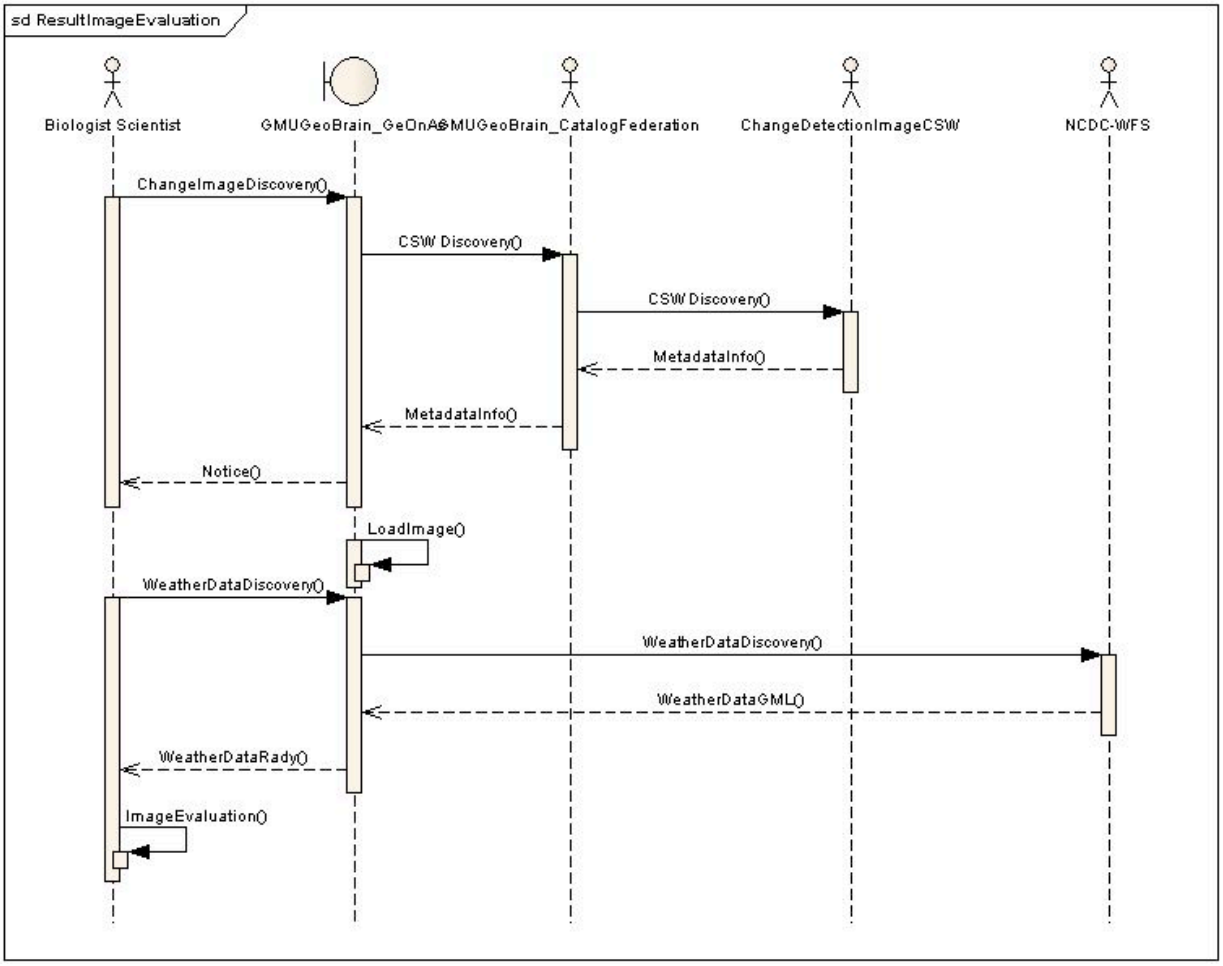

Figure 6 – Result image evaluation use case

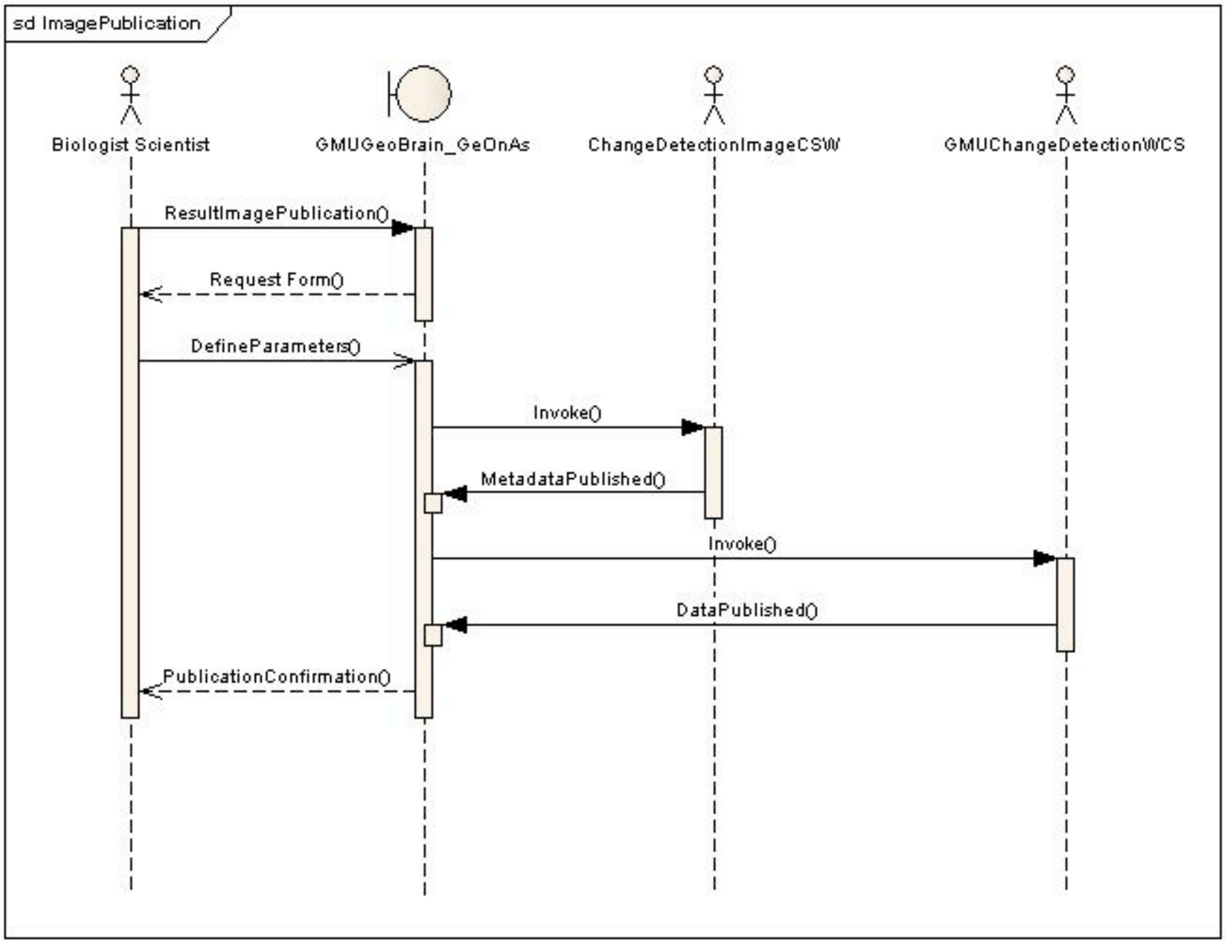

Figure 7 – Image publication use case

6. Achievements and Demonstrations

6.1 Achievements

The scientific workbench software adopted for this scenario is GMU GeOnAS. It is capable of discovering Landsat data for the interested study area from Landsat archive, cache it on the GMU server and perform Normalized Difference Vegetative Index (NDVI) analysis using a registered NDVI computational service.

The United States Geological Survey (USGS) EROS Data Center archives all the public available Landsat data and supports limited electronic data access to the archive. One goal of this project is to integrate access to the EROS Landsat archive with the GMU GeOnAS workbench so that any user could access and execute image processing functions on Landsat images in the workbench environment.

EROS Landsat archive metadata search is available via its GloVis and EarthExplorer client/catalog software (ANSI Z39.50) as well as through a CSW query to the NASA Earth Observing System (EOS) Clearinghouse (ECHO). However, even if a data access URL was returned from the metadata search, a USGS-issued user credential is still required by current EROS system to track users and enable download of the actual data. The authentication process that requires human interaction has been the main obstacle of integrating GeOnAS with EROS Landsat archive.

An EROS Landsat data download plug-in for GeOnAS workbench has been developed to reduce human interaction in search and download EROS Landsat data in the workbench. This plug-in takes the username, password and data access URL returned from GloVis, EarthExplorer or NASA ECHO CSW as an input parameter and acts as an EROS client to get credential and physical URL of the data for user. Since it could be run in the background and process multiple data URLs in a single request, human interaction is reduced when accessing EROS Landsat data in the workbench. This plug-in has been deployed on the GeOnAS server and is under testing.

The NDVI product results of the workflow are also catalogued and published in a CSW through the GeOnAS. By publishing the NDVI result computed in the workbench and registering the CSW with GEOSS Component and Service Registry System, the result can be discovered by anyone interested in that research area for future study.

6.2 Demonstrations

An introduction website for this project is available at:
http://laits.gmu.edu/geossaip2demo

Video demo capture is available at:
http://laits.gmu.edu/geossaip2demo/Demo%20AIP-II%20V5.htm

All AIP-2 Videos are available at:
http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP2/index.html

7. Summary of Polar Ecosystems Biodiversity SBA

7.1 Lessons learned

The following problems have been identified during this project:

- It is hard to find suitable Landsat image locations with 30 years of data coverage with similar instrument characteristics and no cloud cover. It is hoped that as more Landsat imagery is brought online from other ground station archives that more Arctic coverage will be available for continued inspection.

- Images recorded in the beginning years of Landsat coverage (for example: Landsat 1-3 images in 1970s) take a long time to be processed if they are not currently electronic accessible. As claimed by EROS, it typically takes 12 weeks to process order of Landsat 1-3 images, although new online processing flows at EROS have shortened the average request to 13 hours. This latency is a result of the archival, rather than data access, focus of the Landsat collections. When an online access system for EROS is developed to complement the archive, real-time access to Landsat data products through open interfaces will be enabled.

7.2 Activities after AIP-2

GeOnAS workbench will be offered to USGS EROS system to discover, download and analyze EROS Landsat archive, with a focus on imagery that is tagged as 'online' (actionable download URL).

A Web Feature Service will also be provided to analyze climate data for comparison with relevant scenes through the GeOnAS workbench. This WFS will also be registered with the GEOSS Component and Service Registry System.

8. References

Appendix – AIP-2 Transverse Technology Use Cases

As with the Internet, GEOSS is envisioned as a global and flexible network of content and service providers enabling decision makers to discover, access and integrate an extraordinary range of earth observing related information within their applications. To achieve this vision, the GEOSS architecture must provide an easy and reusable process to leverage the GEOSS Common Infrastructure (GCI) and components in support of many SBA communities. The AIP defined and piloted such a process for using and augmenting the GEOSS Common Infrastructure to meet SBA community needs. The reusable process is based on implementing community-defined scenarios using transverse technology use cases. The community scenarios are narrative descriptions of SBA community needs with minimal discussion of the implementation architecture. The transverse technology use cases, on the other hand, describe reusable functionality of the GEOSS service oriented architecture implemented through Interoperability Arrangements.

In AIP-2, the transverse technology use cases supporting the community scenarios were grouped in five categories, as shown in Figure 8 and in Table 2. The use cases are described in detail in a separate AIP-2 Engineering Report.[2]

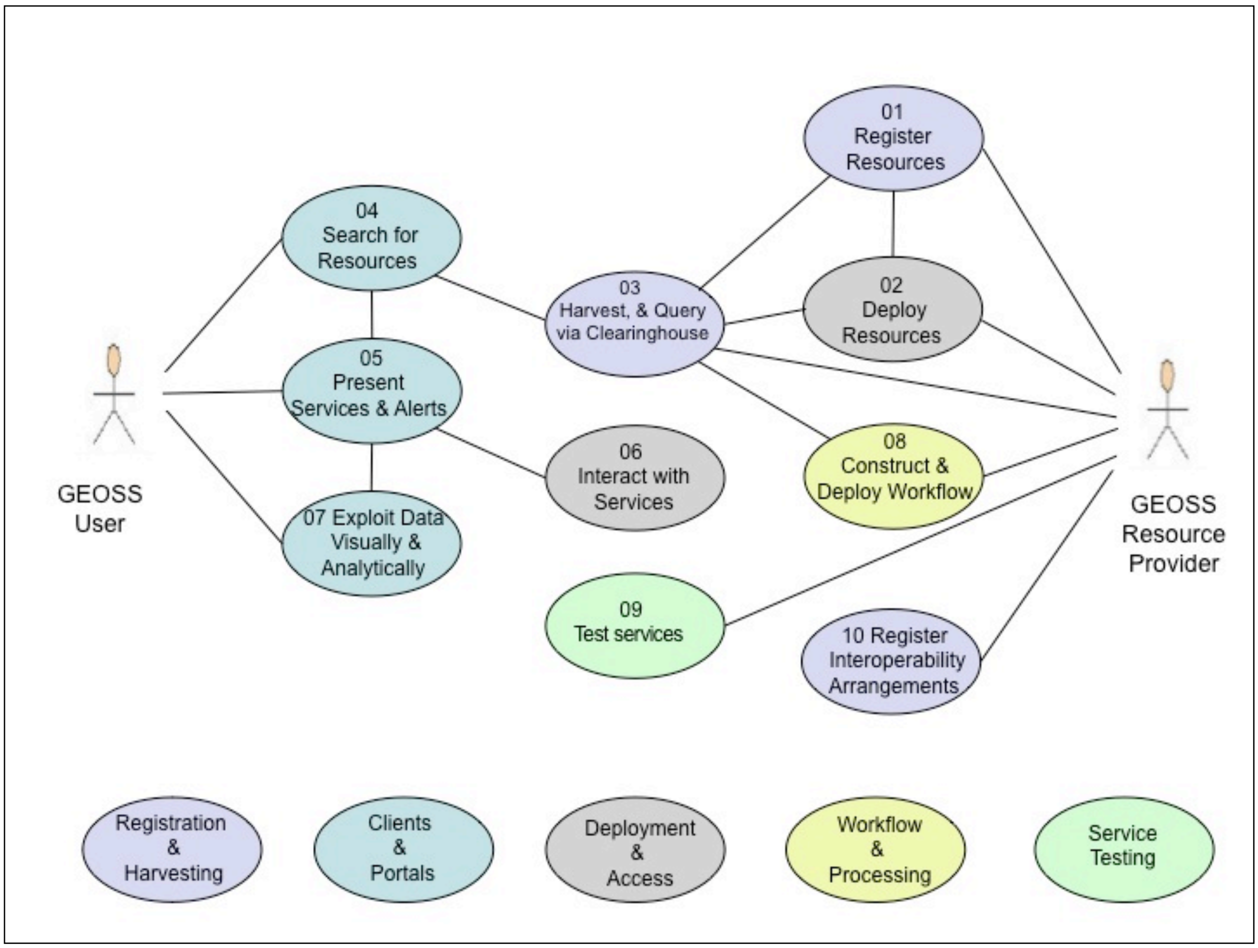

Figure 8 GEOSS Transverse Technology Use Cases

2 http://www.ogcnetwork.net/AIP2ERs#UseCases

Table 2 – AIP-2 Use Case Summaries

Use Case	Title	Actors and Interfaces
Registration and Harvesting Use Cases		
1. Register Resources	Register resources in GEOSS Components and Services Registry (CSR) or Community Catalog	# Service Provider # Components and Services Registry # Community Catalog Provider
10. Register New Interoperability Arrangements	Register, in the GEOSS Standards and Interoperability Registry (SIR), new and recommended interoperability arrangements) as well as utilized standards.	# Service Provider # Components and Services Registry # Standards & Interoperability Registry # SIF Moderator
3. Harvest & Query via Clearinghouse	This use case describes the steps for harvesting and/or querying service or content metadata from community catalogs or services via a GEOSS Clearinghouse	# Service Provider # GCI Registry # GEOSS Clearinghouse # Client Application
Clients and Portals Use Cases		
4. Search for Resources	Steps for portals and application clients to support the GEOSS user in searching for resources of interest via the GEOSS Clearinghouse or Community Catalogs	# GEOSS User # Portals and Client Applications # GEOSS Clearinghouse # Community Catalog
5. Present Services and Alerts	Present GEOSS User with services and alerts as returned per the user's search criteria	# GEOSS User # Portals and Client Applications # GEOSS Service Providers
7. Exploit Data Visually and Analytically	Steps for exploitation in Client Applications of datasets served through Web Services and online protocols as used within GEOSS.	# GEOSS User # Components and Services Registry # GEOSS Service Providers # Portals and Client Applications
Deployment and Access Use Cases		
2. Deploy Resources	Deploy Resources for use in GEOSS	# Service Provider # Components and Services Registry
6. Interact with Services	Interact with Services	# Service Provider # Portals and Client Applications
Service Testing Use Cases		
9. Test Services	Service Provider tests its service using a proper Test tool discovered in the GEOSS CSR.	# Service Provider # Components and Services Registry # Test Facility/Tool # Relevant Standards Authority
Workflow Use Cases		
8. Construct and Deploy Workflow	Design, deploy and execute a workflow. described in Business Execution Language (BPEL) or any other script language.	# GEOSS Integrator # Client Application # Service Provider