SeaWEB: A WEB PORTAL FOR THE CenSSIS SeaBED TESTBED

by

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Report submitted in partial fulfillment of the requirements for the degree of

MASTER OF ENGINEERING
in
COMPUTER ENGINEERING

UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS
2006

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ABSTRACT

SeaBED is a facility developed at the NSF Center for Subsurface Sensing and Imaging Systems (CenSSIS) to study applications of hyperspectral imaging to aquatic subsurface sensing. This report describes SeaWEB, a web based client/server software project that emerged from the need to have a tool to organize, search and display data, metadata, field data and images generated by SeaBED. SeaWEB project provides researchers of CenSSIS with single entry point to those data sources, using a Web browser. The web server application based is on Java Servlet technology and the client on Macromedia Flash. These components are based on the Terrascope system, which is a Web-based Earth Science Database Middleware System, developed at the University of Puerto Rico, Mayaguez.

RESUMEN

SeaBED es una facilidad creada por el NSF *Center for Subsurface Sensing and Imaging Systems* (CenSSIS), para estudiar las aplicaciones de percepción remota bajo la superficie acuática usando imágenes hiperespectrales. Este reporte presenta a SeaBED, un proyecto de software cliente/servidor que surgió de la necesidad de organizar y mostrar data, metadata, data de campo e imágenes generadas por SeaBED. SeaWEB provee a los investigadores de CenSSIS con un portal en donde pueden acceder a esta data usando un navegador de WEB. La aplicación del servidor esta basada en la tecnología de *Java Servlets*, y el cliente en Macromedia Flash. Ambos componentes están basados en el sistema Terrascope. Este es un Sistema de Base de Datos Distribuido de Ciencia de la Tierra basado en Web, desarrollado en la Universidad de Puerto Rico, Mayagüez.

ACKNOWLEDGMENTS

During the progress of my graduate studies in the University of Puerto Rico, several persons and institutions collaborated directly and indirectly with my research. Without their support it would be impossible for me to finish my work. That is why I wish to dedicate this section to recognize their support.

I would like to thanks my advisor Dr. Miguel Velez for giving me the opportunity to work with him, for his support, help and commitment to this project; Dr. Bienvenido Velez for letting us use the Terrascope software for this research and for being part of the graduate committee, and to Dr. Nestor Rodriguez for his advice, and for being part of the graduate committee.

Thanks to the CenSSIS project, part of the NSF Engineering Research Program under award number EEC-9986821 and The Tropical Center for Earth and Space Studies (TCESS) a NASA University Research Center under grant NCC5-518, for their financial support and use of the facilities during this project.

Thanks the Department of Electrical and Computer Engineering at University of Puerto Rico Mayagüez Campus for this great opportunity to pursue graduate studies.

Finally, to all of those who encourage me to pursue graduate studies and inspired me to find new goals in life, to all my friends here at the University of Puerto Rico at Mayagüez, and to my family a special thanks.

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1 INTRODUCTION

1.1 Justification

The Center for Subsurface Sensing and Imaging Systems (CenSSIS) is developing algorithms using hyperspectral imaging to extract subsurface information in coastal environments. As part of CenSSIS, a testbed facility has been created for algorithm validation, called SeaBED. The main objective of SeaBED is to develop testing facilities and data sets for researchers to use in assessing the analysis capabilities of subsurface aquatic remote sensing, with a particular focus on coral reef habitats.

The SeaBED project is collecting a significant amount of data in the field. This required a tool to present and retrieve this data in a well-organized manner. The problem is that the amount of data generated by the project is constantly growing and some times stored in different places. In this project, we created a web portal called SeaWEB, to aid CenSSIS researchers to access SeaBED data using a graphical user interface.

1.2 Objectives

The main goal of this project was to develop a web portal for the SeaBED testbed to make the data available to CenSSIS researchers and collaborators.

The goals of the SeaWEB project were the followings:

- To create a web portal for CenSSIS researchers to find information to be used in their work.
- To extend the Terrascope Image Navigator prototype to provide data related to the search area, like images, field data, etc.
- To modify the Terrascope Search and Retrieval Engine to add the capability of the retrieving information related to the image or area.
- To create a web based graphical interface for data input.

This was done by adapting and enhancing Terrascope image retrieval/browsing systems that is being developed at the University of Puerto Rico Mayaguez [2][3].

1.3 Outline

This project report is organized as follows. Chapter 2 presents the literature review and background information. Chapter 3 presents an overview of the SeaBED Testbed. Chapter 4 presents an overview on the methodology used to complete the project. Chapter 5 describes the SeaWEB implementation. Chapter 6 presents the systems functional specifications and user guide. Chapter 7 presents the conclusions and future works.

2 LITERATURE REVIEW AND BACKGROUND

This chapter presents the literature review of the Terrascope project and its components. Related software is also discussed in this chapter.

2.1 Terrascope

Terrascope is a Web based Earth Science Distributed Database Management System, with a Peer-to-Peer architecture where multiple data sources can communicate with each other. Data access is done with an interactive image browser. This system was developed by the Advance Data Management Group (ADMG) with the collaboration of the Earth and Science community of the University of Puerto Rico Mayaguez (UPRM).

The main objectives of Terrascope are:

- To search and recover geospatial data from different sources, with different formats and characteristics
- To use a single point of access to the system
- To have the data accessible from everywhere on the internet.
- To support distributed servers that can be added and removed dynamically from the system.

Terrascope consist of the typical client-server architecture components, the client is the Terrascope Image Navigator and the server is the Search and Retrieval Engine, see Figure 2.1.

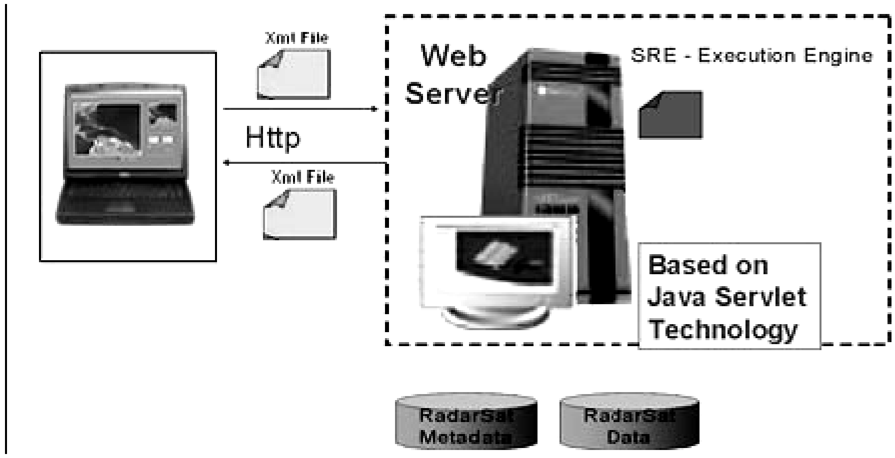


Figure 2.1 Terrascope Architecture [3]

2.1.1 Terrascope Image Navigator

The Client or Terrascope Image Navigator (TIN) [3] is an interactive image browser designed to achieve spatial exploration in combination with the Search and Retrieval Engine. Using Flash MX, XML and Servlet technology it delivers satellite images with their corresponding metadata. TIN can be access from any web browser and may perform operations such as pan, zoom in, and zoom out over the image and display specific metadata for the image. TIN allows a mixture of parameters for querying data using an easy to use graphical user interface, parameters include, sensor, source, date and spatial region. Figure 2.2 Terrascope Image Navigator search main screen and Figure 2.3 Selecting an area to perform a search.

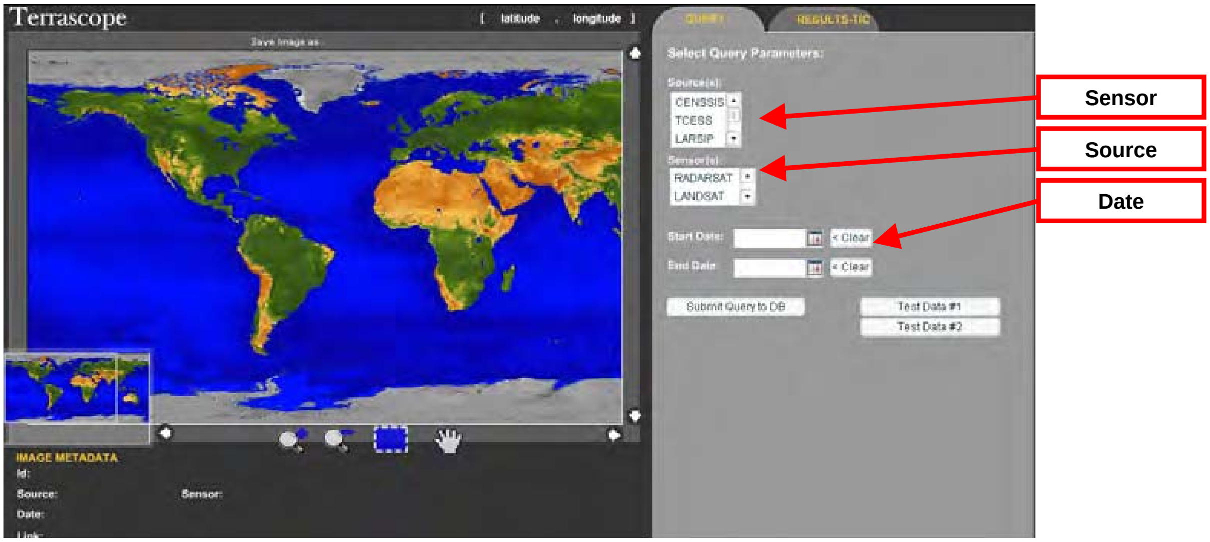


Figure 2.2 Terrascope Image Navigator search main screen

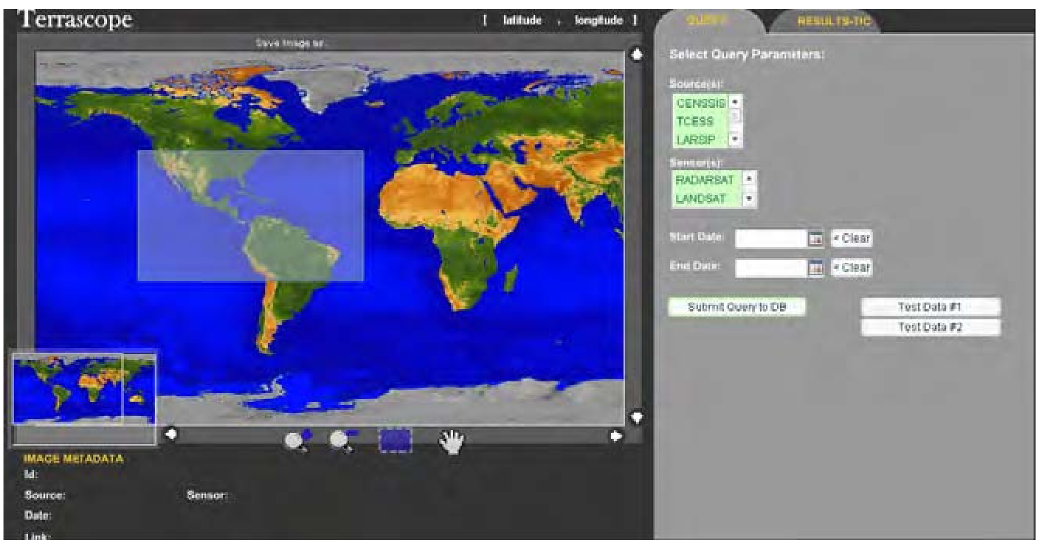


Figure 2.3 Selecting an area to perform a search

Once a search has been performed and the retrieved the results are show in the center map and also in a tree like structure on the right of the screen as shown in Figure 2.4 Results, the user may simply browse and select the desired image.

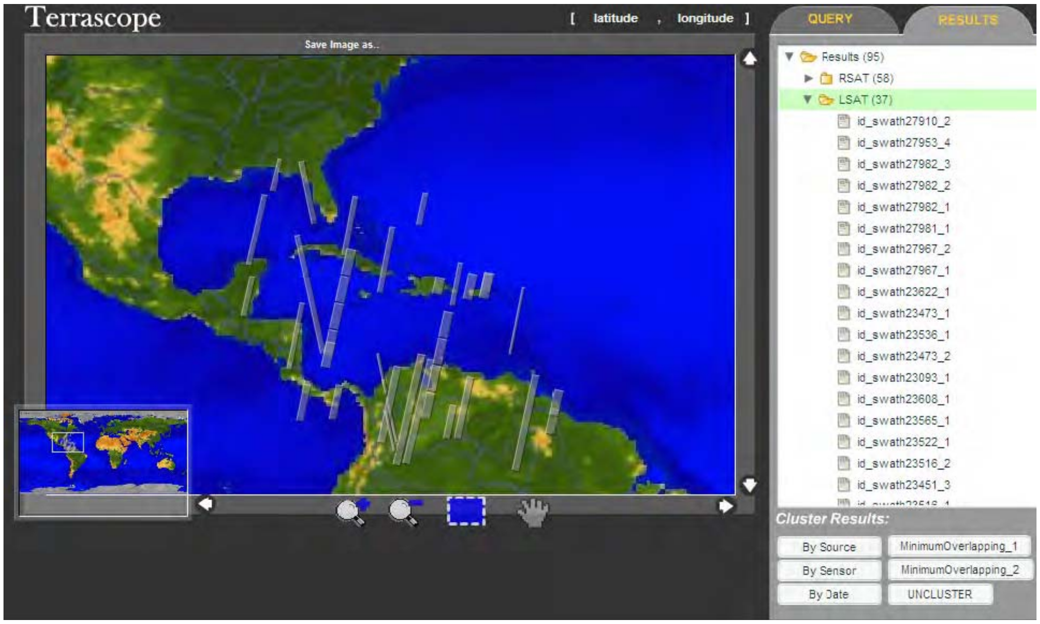


Figure 2.4 Results

2.1.2 Search and Retrieval Engine

The web server of Terrascope is called the Search and Retrieval Engine (SRE) [2], is a spatial database middleware system composed by a group of servlets developed with JAVA Servlet Technology. They support the execution of different queries that permit the collection of information stored at all data centers, despite the fact that they could have different formats or characteristics. The data can be satellite images, metadata, GIS characteristics, as well as any other type of outstanding information. There can be many SRE in different locations each one connected to a data source. These servlets communicate with each other and with the client using XML language.

When a request is sent to the SRE by the client interface, each of the servlets produces a different function to process the request, and obtain the data from various data sources that the server has access to. After the results are gathered from the SRE's, they are sent to the client where they are displayed.

The SRE have three main components as shown in Figure 2.5 SRE Components:

1. *Client Access Servlet* – is the servlet that interacts directly with the petitions requested by the clients.
2. *Data Broker Servlet* - its main functions are processing, controlling and coordinating the communication process between all the others Data Broker Servlets that are located or distributed in the others web-servers, independently of the level of connectivity (remote or local).
3. *Information Gateway Servlet* - that allows us to access and retrieve data requests from its associate database.

The SRE have two main configuration files the *terrascope.xml* and the *broker.xml* these files are used to tell where the other SRE's are located, and were and how to connect with the database.

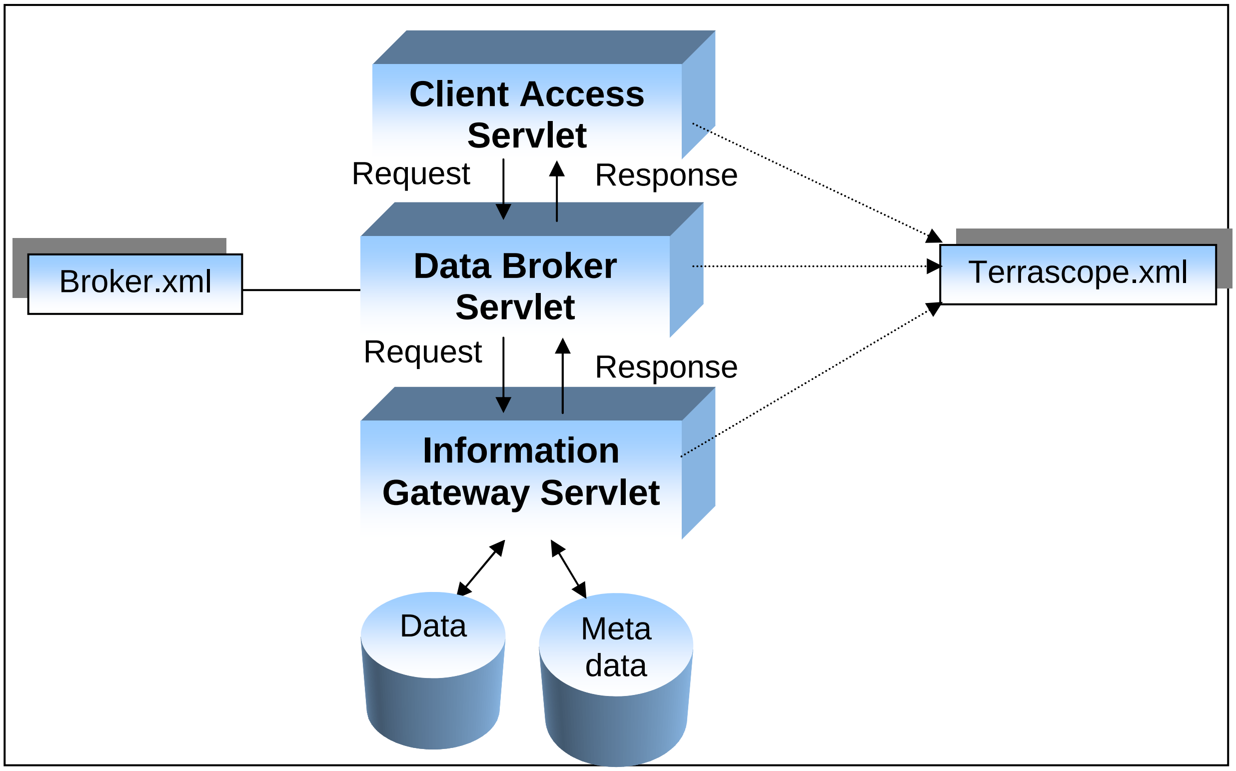


Figure 2.5 SRE Components

2.2 Related Software

Many research centers, universities and corporations have developed systems to search and organize images and data. Several of these systems perform a similar job as Terrascope, but most use static databases and there is no source code available to modify these systems to meet SeaWEB requirements. This section covers existing software that with comparable functionality as Terrascope.

The **Quicklook Swath Browser** is a web based satellite image browser developed by the Canada Centre for Remote Sensing [8]. Similar to Terrascope it retrieves images and metadata according to the selected area as shown in Figure 2.6 Quicklook Swath Browser; it also provides hyperlinks of the images. On the other hand, it does not provide recursive navigation like Terrascope and does not provide much information about the image. SeaBED cannot use this software because it only uses a static database hence not capable to connect or search our databases, and cannot support other type of data.

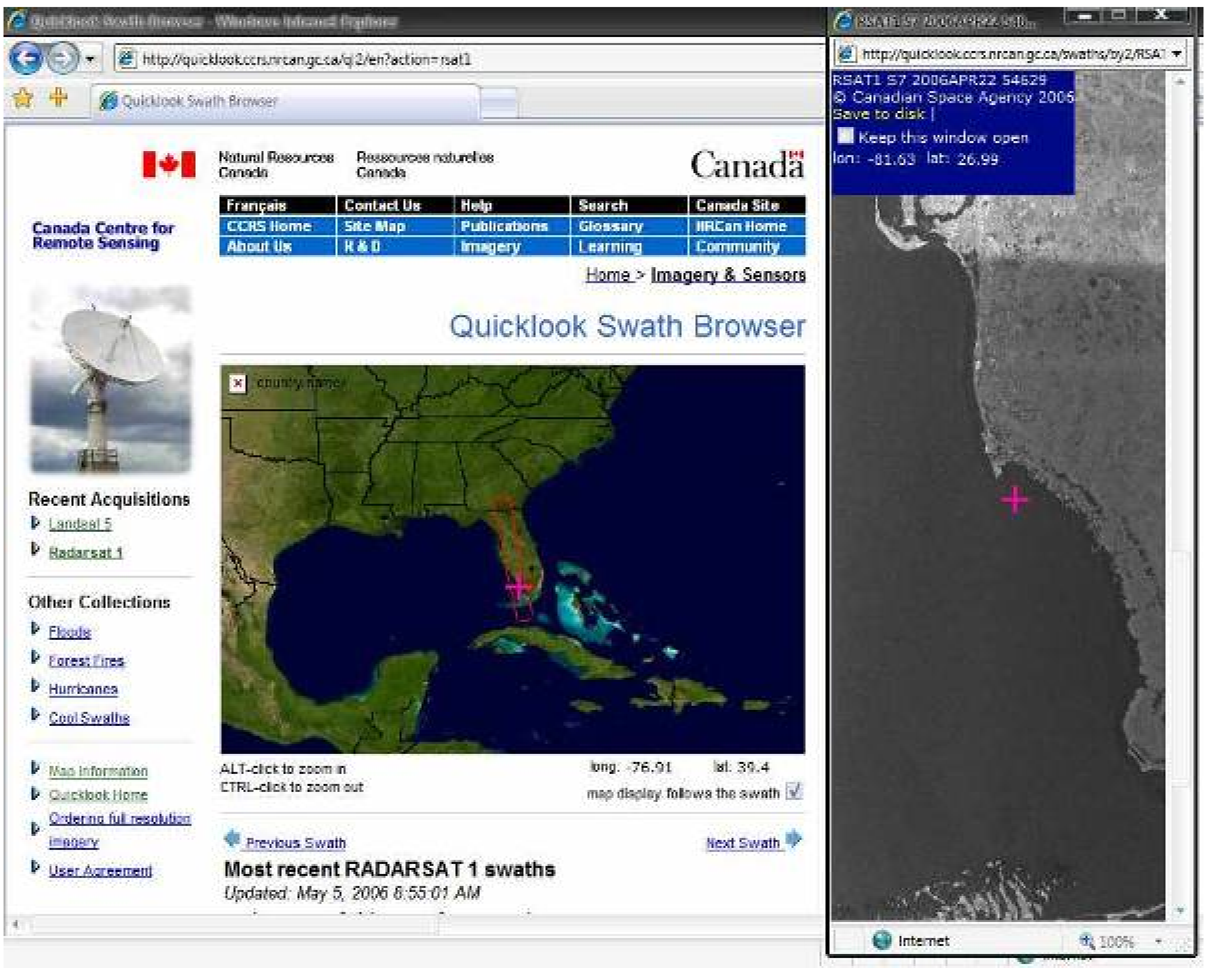


Figure 2.6 Quicklook Swath Browser web interface; image of Florida's west coast

The **USGS Global Visualization Viewer** (GloVis): is a web based image search tool, developed by the United States Geological Survey agency [9]. GloVis images are organized by sensors, and have the capability of applying layers on top of images (see Figure 2.7), like location of cities, water and protected areas. The information about the images is very limited. As with Quicklook, this software cannot be used to search other databases outside their system or search other types of data.

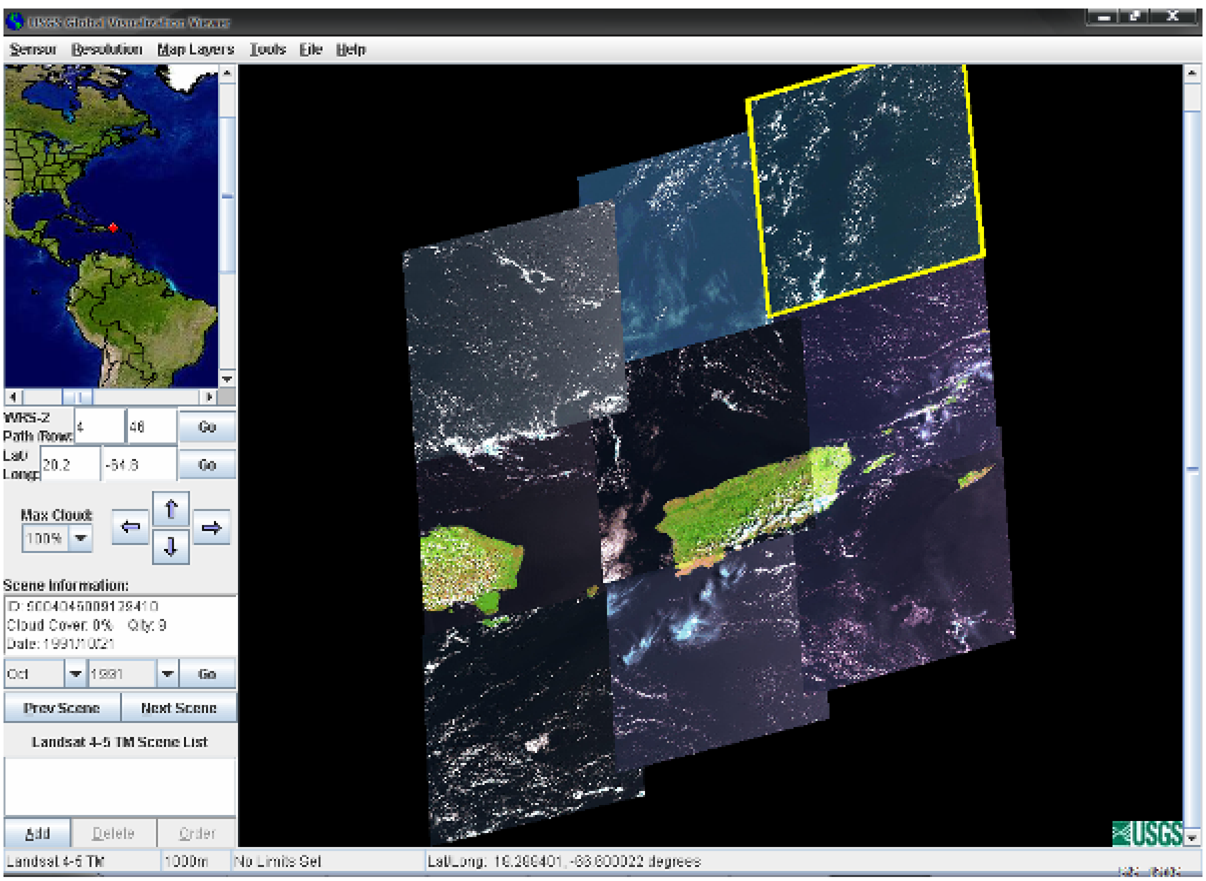


Figure 2.7 USGS Global Visualization Viewer web based interface: LANSAT layered images of Puerto Rico.

ArcIMS & ArcView are GIS software created by ESRI for visualizing, managing, creating, and analyzing geographic data [10]. ArcView has the capability of creating maps, making Spatial Analysis and geo-processing (overlay, buffer and data conversion). This indeed is a powerful application to process images and map creation, but in contrast, the purpose of our software is to have a central place to store search and retrieve research data, not to processes information or to create maps.

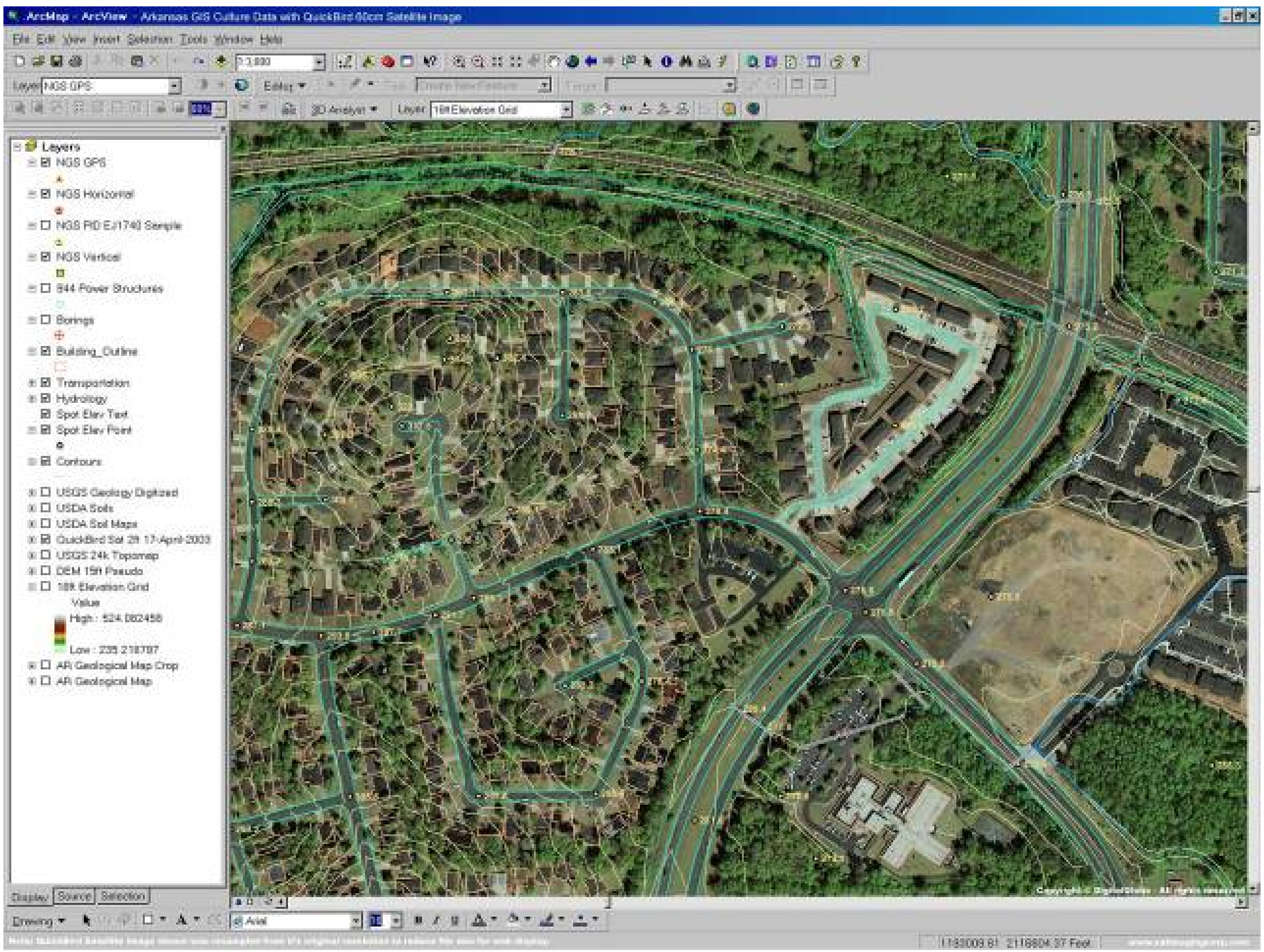


Figure 2.8 ESRI ArcView Application

Microsoft Terraserver is another web based image repository [11]. Users can locate imagery by clicking on a map, entering the name of a location, or entering a U.S. street address. Like the rest of the software in this section, Terraserver only supports the search of images and cannot search other types of data.

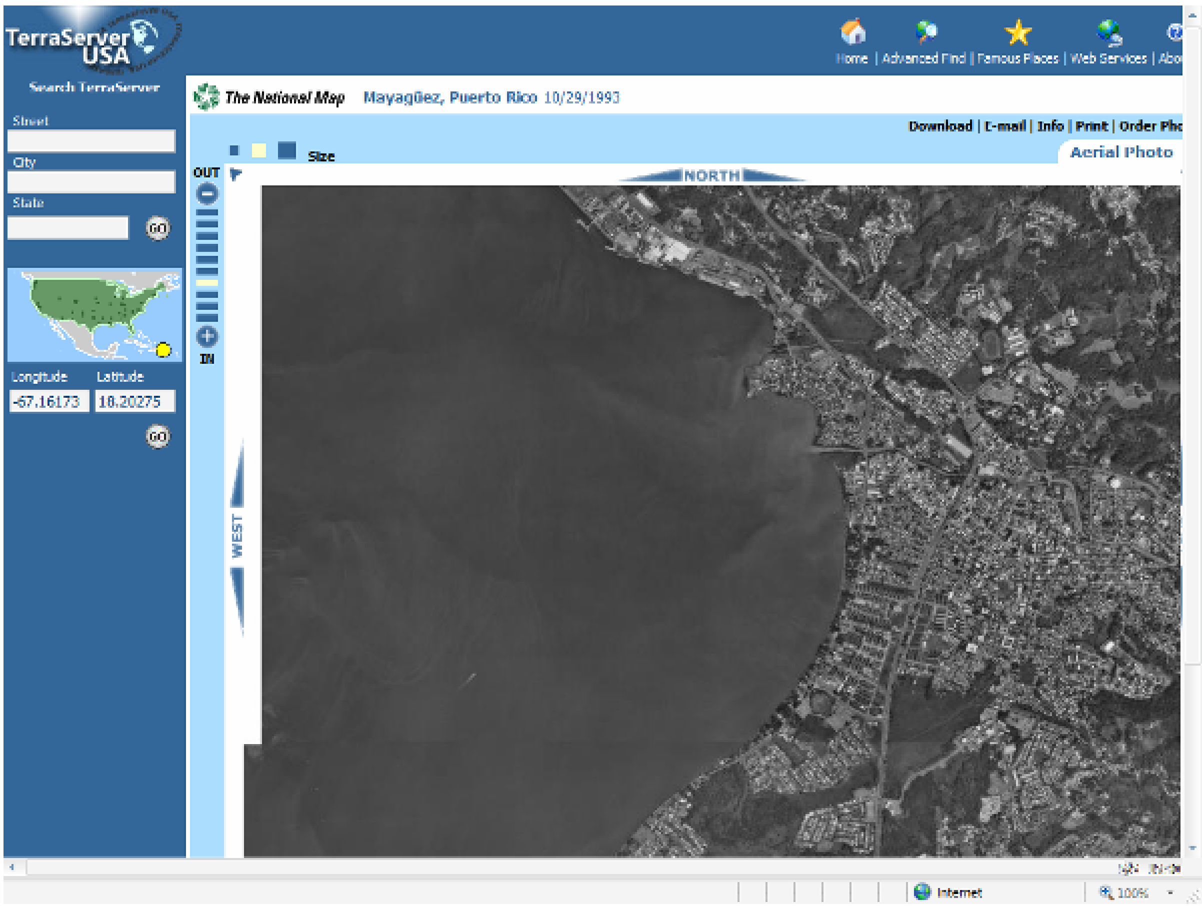


Figure 2.9 Image of Mayaguez bay in Microsoft Terraserver web interface.

Another web based system is the WWW Image Processing Environment (**WIPE**) [12]. This system is currently in use in one of the research centers of UPRM (http://wipe.uprm.edu). WIPE is an Image Processing and Geographical Information System, develop by Applied Coherent Technology (ACT) that performs manipulation of geo-spatial/temporal data associated to Earth observing sensors. The end users of WIPE can perform high level searches on the metadata to interactive access and download to the actual data or virtual data products. With WIPE it was possible to integrate, organize and search SeaBED data sets. But there are some downsides to this system; the source code is not available to modify it to our specific needs, and we have to rely on the economic capacity of the research center for the renewal of WIPE license which is extremely costly. Figure 2.10 shows WIPE's end-user interface.

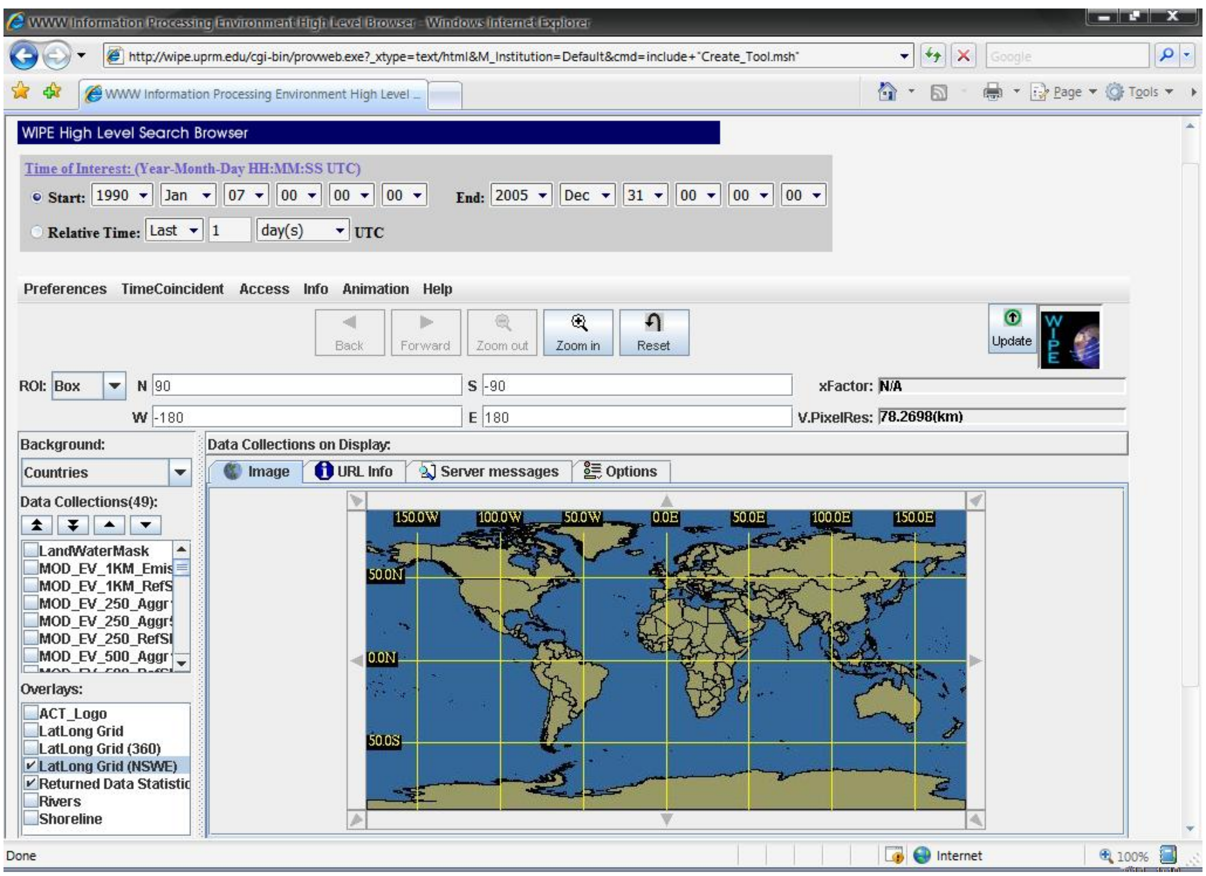


Figure 2.10 WIPE end-user interface

3 SeaBED

SeaBED is an algorithm validation testbed, developed at UPRM as part of Center for Subsurface Sensing and Imaging Systems (CenSSIS), a NSF Engineering Research Center [4]. CenSSIS extracts information from surfaces or subsurfaces using Hyperspectral Imaging (HSI), and then SeaBED validates the information obtained by CenSSIS from the object or area analyzed, using controlled testbed environments. SeaBED validates physical models, inversion algorithms, feature extraction tools and classification methods for hyperspectral data generated by the CenSSIS [1].

SeaBED is composed of the following collection systems:

- A small laboratory-based tank (Figure 3.1a)
- A larger outdoor tank (Figure 3.1b)
- A field site located on a reef in southwest Puerto Rico (Figure 3.2)

3.1 Indoor and Outdoor Tank

The laboratory and outdoor tank testbeds are controlled environment collection systems for investigating and validating subsurface spectral algorithms. These spectral algorithms correct variables in HSI like the variation in illumination conditions, viewing geometry, water optical properties and benthic composition. These tanks provide SeaBED the ability to acquire both sensing imagery and ground truth information needed for the algorithm validation.

(a) (b)

Figure 3.1 SeaBED test instruments; (a) Indoor tank; (b) Outdoor tank. [1]

3.2 Field Area of Study

The main focus of SeaBED is the management of the Cayo Enrique Reef data. This reef is the field study area (Figure 3.2), which is a located close to the UPRM Department of Marine Sciences field station in southwest Puerto Rico. The reef contains a mixture of benthic habitats, including areas of seagrass, sand, algae and coral. In contrast to the tanks testbed, the field site provides SeaBED with a real world environment to extract spectral, optical and image data, from an actual reef system. Using the data collected at Cayo Enrique reef is possible to verify different levels of image processing algorithms like atmospheric and sunglint correction.

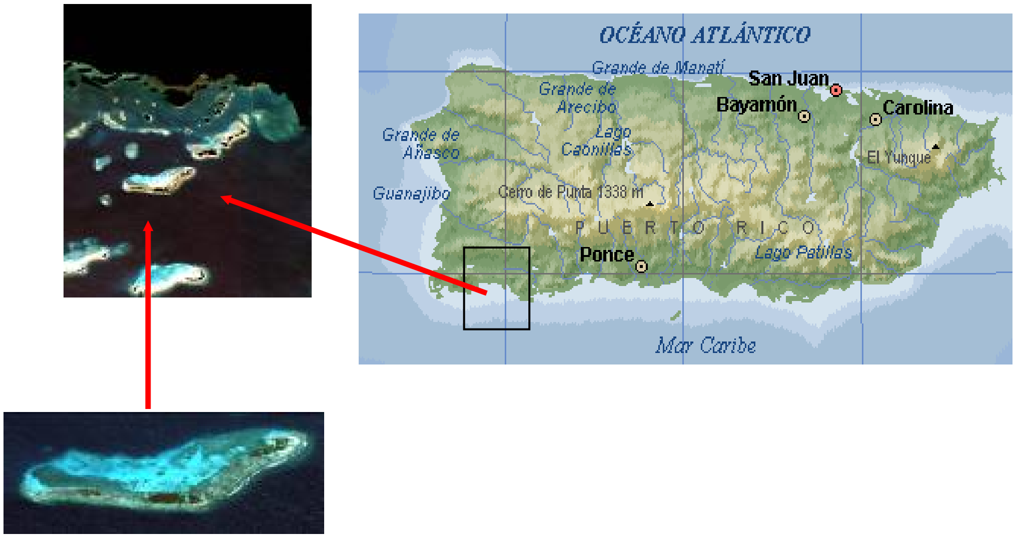


Figure 3.2 SeaBED Field site; Enrique Reef southwestern Puerto Rico (Top Left), IKONOS image of Enrique Reef (Bottom). [6]

3.3 SeaBED Data

The data collected in Enrique field includes field data like in situ optical water properties and reflectance measurements and satellite and airborne imagery.

3.3.1 Field Data

Field data collected is used to validate the image processing algorithms. Transects of 20 meter width were formed for each habitat group at Cayo Enrique [6]. Each transects is compose of ten quadrants of 1 square meter with and separated by a meter of each other (Figure 3.3 left). Global Positioning System (GPS) locations and pictures were taken for each quadrant. Above water and bottom albedo measurements were collected with a GER-1500 spectroradiometer (Figure 3.3 right). The GER-1500 Spectroradiometer is an instrument from

Geophysical and Environmental Research Corporation. It is a lightweight, single beam field spectrometer that has a spectral range from 0.3 to 1.1 μm with a spectral sampling of 1.5 nm.

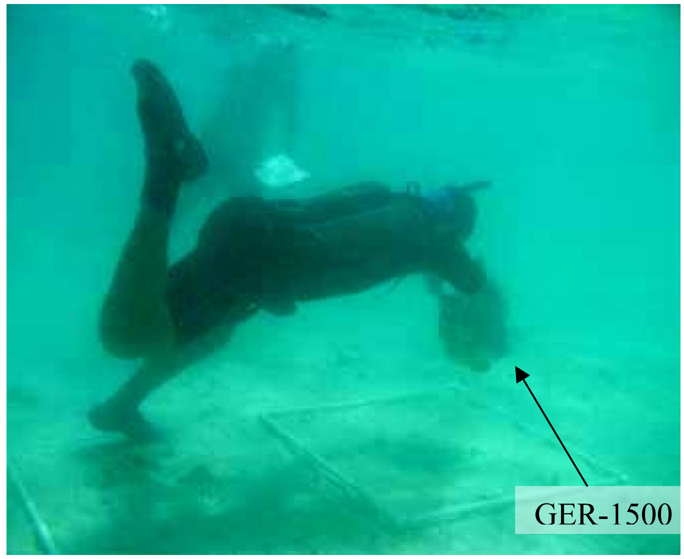


Figure 3.3 Underwater quadrant station for sea grass (left) and bottom albedo measurements with the GER-1500 Spectroradiometer in a waterproof housing (right). [6]

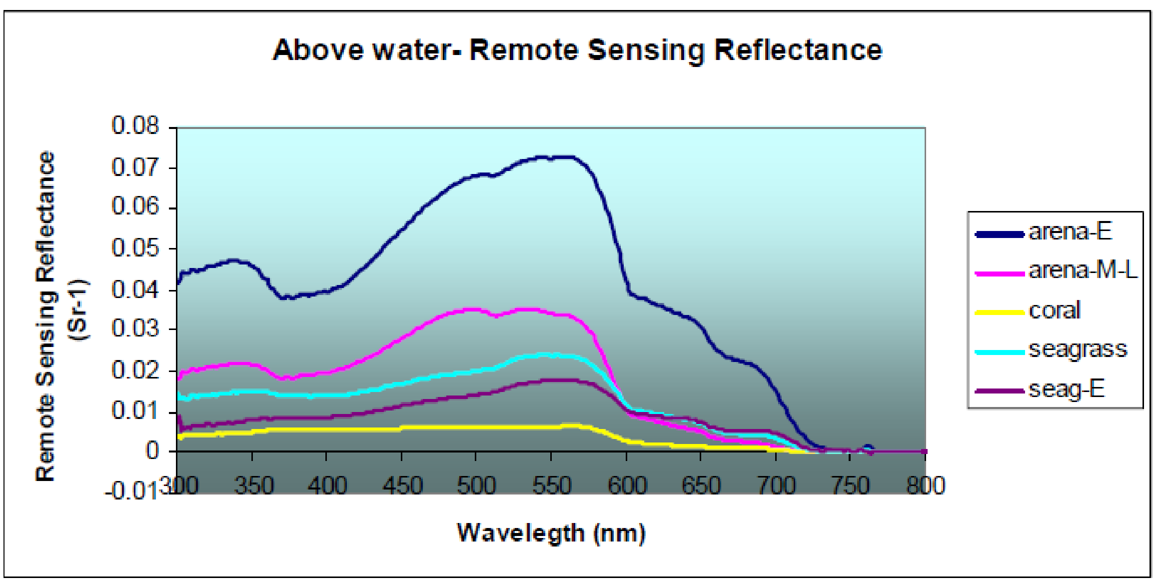


Figure 3.4 Average of above water Remote sensing reflectance measurements for sea grass and sand and coral taken at transects for validation of sensors [6].

Figure 3.4 shows remote sensing reflectance measurements taken at transects. This measurement along with a description of the benthic composition and GPS data from each transects are used to validate the image classifications algorithms created by CenSSIS. Measurements for sea grass were taken in Cayo Enrique and Media Luna, sand in Cayo Enrique and Media Luna, and coral in Cayo Enrique.

3.3.2 Image data sets

Research at CenSSIS includes the extraction of information about aquatic subsurface objects using HSI. In HSI hundreds of images are taken at narrow and contiguous spectral bands providing us with high spectral resolution data sets that can be used to distinguish objects based on their spectral signature.

HSI data can be used to determine benthic habitat composition. The sensors used are AVIRIS (Airborne Visible Infrared Imaging Spectrometer), HYPERION (Hyperspectral Imager) and IKONOS. Figure 3.6 and Figure 3.6 shows samples of satellite images taken with Hyperspectral imagery (HSI) sensors.

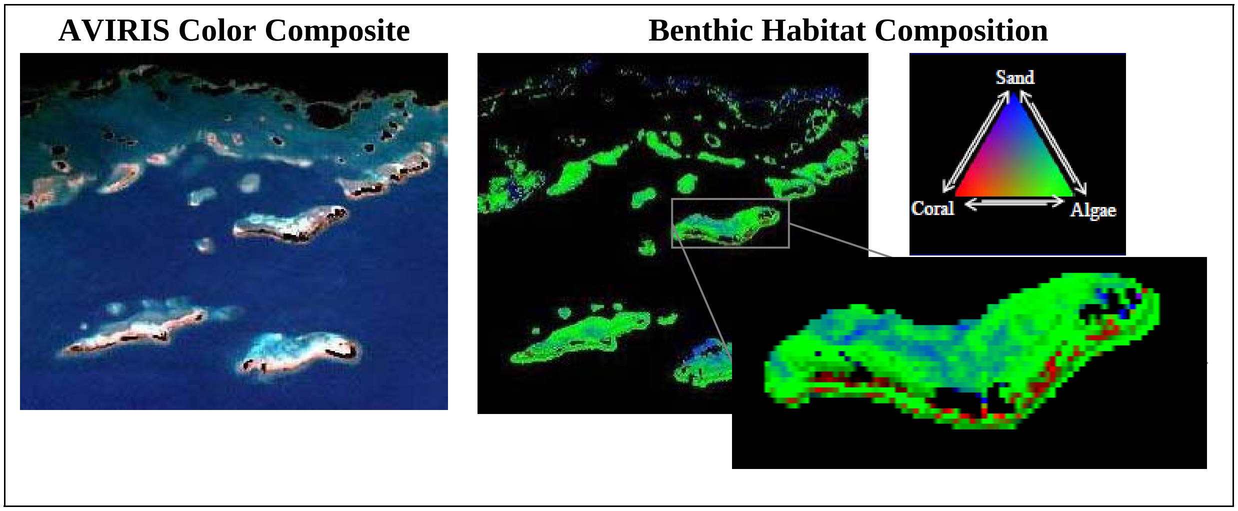


Figure 3.5 Example of AVIRIS image (left) and a derived product (right)

Table 3.1 shows the HSI Images data sets available for SeaBED, the different sensors and the date of the acquisition. Table 3.2 shows the HSI sensors characteristics. Table 3.3 shows detail of one of the AVIRIS Missions and the flight path.

HYPERION Images	AVIRIS Images	IKONOS Images
• August 15, 2002 • January 15, 2003 • March 13, 2004 • March 29, 2004 • September 5, 2004 • February 17, 2006	• August 19, 2004 • December 12, 2005 • December 13, 2005	• 2002 Composite

Table 3.1 Available HSI Images

Sensor	Bands	Spectral Range	Spatial Resolution	Image area	Sensor technology	Orbit	Inclination
AVIRIS	224	10 µm	4-20 m	2-11 km wide	"Whisk broom" scanning	airborne	---
IKONOS	4	0.45-0.90µm	1 m	11 km x 1000 km	Linear array Pushbroom	681 km	98.10^0
HYPERION	8-57 79-224	0.4-2.4 µm	30 m	7.5 km x 100 km	Pushbroom spectroradiometer	705 km	98.2^0

Table 3.2 HSI Sensor Characteristics

a. IKONOS b. Hyperion

Figure 3.6 HSI Image Examples

AVIRIS mission in Puerto Rico:

- August 19, 2004
- 8 Flight lines
- Altitude ~20.1 km
- Pixel Size ~17 m
- Total Length 750 km
- Total Area 8500 km2

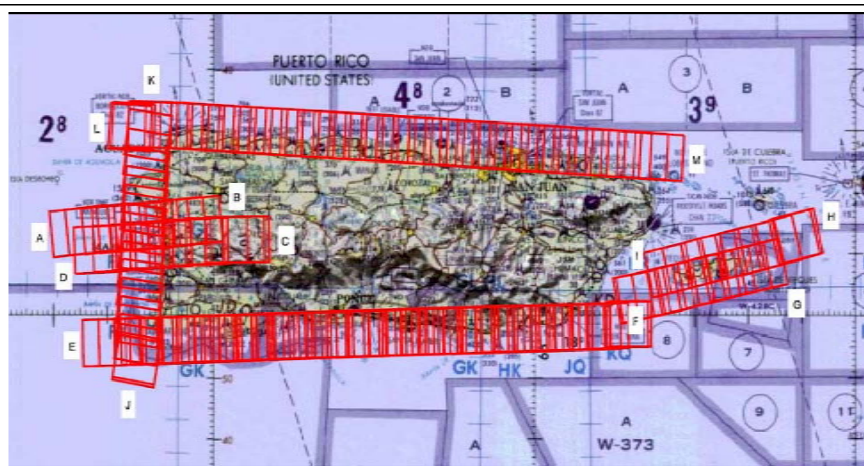


Table 3.3 Details of the AVIRIS Mission of August 2004 [5]

4 DESIGN METHODOLOGY

This design has followed the classic life cycle phases of a Software Engineering project although with a different approach. These phases consist of: requirement analysis, design, coding, and testing phase [7]. The approach followed in the development for this project was a variation of the *Iterative and Incremental development* process. The basic idea behind iterative development is to develop a software system incrementally. Starting with a simple implementation of a section of the software requirements and iteratively enhancing the evolving sequence of versions until the full system is implemented. In every iteration, design modifications are made and new functional capabilities are added. Developers that follow this process, treat the iterations like a small project with all the phases of the software life cycle. But since SeaWEB was develop by one person only it was not necessary to follow all the cycle each time. Instead the phases that iterated were the coding and testing.

4.1 Requirements Analysis

The first essential task in the development of this software was the understanding of the requirements for SeaBED. The focus on this phase is the "what" of the problem, and not "how" it was solved. In general, the requirement analysis phase of a software engineering project contains more steps than the ones we needed for this software. Including economic analysis, and extensive system analysis, but in our case we were modifying existing software and many of the requirements analysis were not needed.

During this phase the majority of the research activities took place, including literature review and the investigation of software that performs comparable tasks as our project. Based on those finding the Chapter 2 “Literature Review and Background” and Chapter 5 “SeaWEB Architecture” chapters were produced.

4.2 Design Phase

In this phase of the project, we answered the question of “how” to implement the solution of the problem we defined in the requirement phase.

The software design phase was focused on four distinct attributes of the software: data structure, software architecture, interface representation, and procedural details. All these designs require completion before the coding starts.

Taking in consideration what type of new data was required to be added to the system and how to present it was part of the design in order to modify and reuse and the Terrascope system.

In addition in this phase, it was defined what approach was to be follow for the design and development of the project, the Iterative and Incremental development was selected since it is of one the most adequate when modifying code of an already available working software.

Based on the works of this phase Chapter 5 was created, in that chapter the new database structure is explained, and all the changes needed to the SRE and the client to implement the new functionality into SeaWEB.

4.3 Software Development

The coding phase was accomplished following the results of the design phase. As part of the coding process, comments were added to the code to take in consideration the readability of the code and the maintainability of the software. Since we followed the Iterative and Incremental development process when a feature was added it was tested before continuing to the next part.

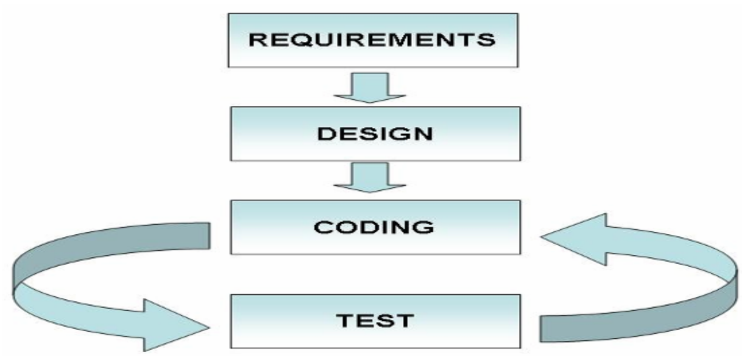


Figure 4.1 Customized Iterative and Incremental software development process

Tomcat was used to support Java servlet, which is a Servlet Container. The servlet were modified using Eclipse JAVA Development Kit (JDK) 3.1 [13] with the Sysdeo Eclipse Tomcat Launcher plugin [14].

4.4 Software Testing

The testing phase consists of conducting tests to find errors and make certain that the output of the software is correct. A test case was done resembling the normal use of the software to ensure all its parts were working correctly. In every modification to the software, we tested all the functionality to ensure that the new and previews functionality was working.

5 SeaWEB IMPLEMENTATION

The SeaWEB software is based on Terrascope. The reason behind this is because Terrascope has been proven to be efficient in searching spatial data and the base of the system was developed at UPRM. Both of its main components the SRE and TIN were used as a base for SeaWEB. The SRE is the component that deals with the distributed database that stores and searches for heterogeneous spatial data taken from satellite ground stations. TIN enables the user to retrieve images and related information from the distributed database using a graphical interface and deals with the effective presentation of this kind of data to the user. TIN allows recursive navigation of the image space by dynamically embedding retrieved sub images as spatial hyperlinks inside other retrieved images.

The interface and the servlet basic functionality for search and presentation of images were already coded in the Terrascope project. New modifications were made to fit the requirements of the data to be read and handled by SeaWEB.

5.1 Client modifications

The client application is the graphical user interface (GUI), where the user interacts with the system. The SeaWEB client has multiple options to find images and data that are stored in the web server. The TIN based SeaWEB, was implemented using an interactive movie authoring environment (Macromedia Flash MX Pro [15]) and XML (eXtensible Markup Language) to communicate queries and retrieve data and metadata from the server.

One of the many advantages that this client has is that it can run in almost any computer. To make use of this client application the user just need to access a URL using a web browser i.e. http://localhost:8080/seaweb and the application loads itself and will be ready to be used immediately.

The client application was designed to find and present information of any image in the database, based on its respective data and metadata. But the main feature of SeaWEB is the ability to process and present other type of data, such as field measurements. SeaWEB was modified to provide an efficient way to display those kinds of information. To distinguish the different type of data that can be displayed SeaWEB, we have added a new representation for points and linear measurements. Those representations are symbols to distinguish point measurements from linear measurements and images.

Also, since the data being collected for SeaBED is in southwester Puerto Rico, we change the scope of the search to be more specific to the area. Instead of having a map of the world like Terrasope, we place a map of the area of La Parguera. When the system presents the results of field data in the screen appears larger that they are, if presented scaled with original dimension it would be difficult to distinguish on the screen because of they have a small size.

The source list (SRE's) was removed because it was not necessary in our implementation. In addition the *url* that appears at the bottom of the map now points to the complete data set, before it pointed to a preview of the selected image.

5.2 Web Server modification

The SeaWEB web server is based on Terrascope Search and Retrieval Engine (SRE). Web servers are computers on the network that host websites and data, serving the information to viewers upon request. The web server is the most vital part in any Internet site. The web server manages requests submitted by the clients. The web server or SRE is composed of various servlets.

An applet runs in a web browser, performing actions it requests through a specific interface. A servlet does the same type action, but the servlet is running on the web server. The requests from clients are sent through the GUI encoded with XML format, and sent to the web server via a URL [3]

The Terrascope SRE as it was only retrieved geospatial images with its metadata. The web server was modified to include the capability of searching other type of data related to that spatial data such as:

- Field measurements (transects and points)
- Research documents and any other document

The Terrascope's SRE have three main components the *Client Access Servlet, Data Broker Servlet* and the *Information Gateway Servlet.* To meet the project requirements, the *Information Gateway Servlet* (*GatewayServlet.java*) was modified so it could handle the new data types. The function of the *Information Gateway Servlet* is to access and retrieve data requests from its associate database. Changes were made in the method that manages the database request because of a new database structure.

Communication between client and server is done using XML language, and new elements were added to the XML data structure so the client could recognize and handle the different types of data sent by the SRE. This function is also performed by *Information Gateway Servlet*..

Figure 5.1 shows the architecture of the SRE. We can see that each Web Server contains a group of the main servlets that cooperate between them, forming the SRE.

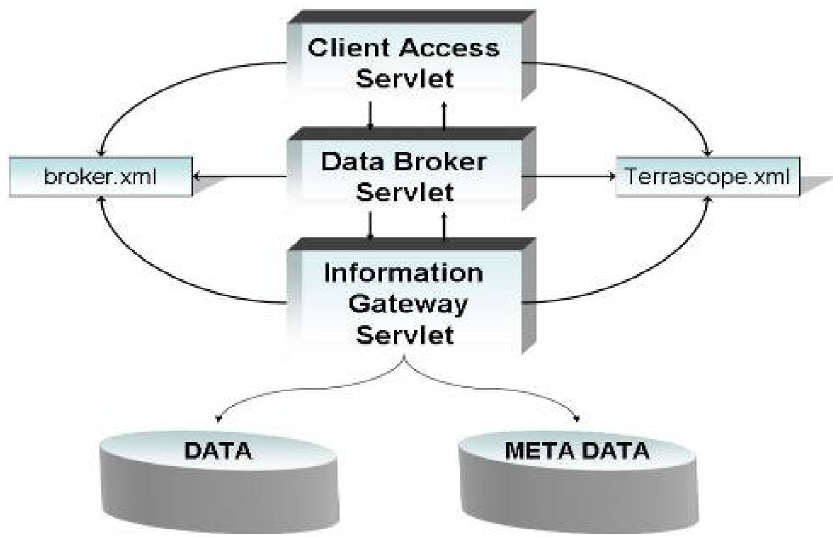


Figure 5.1 SRE Architecture

5.2.1 Database modification

The data is stored in the PostgreSQL database system, this database was used in Terrascope because it supports spatial indexes that facilitate the search of that type of data. Originally the Terrascope database was used for storing the data and metadata for each one of the images. It was formed of various tables where information that corresponds to each of images was stored.

In order to store various types of data, a new database was created. This database contains a different structure, and an additional table. The original design only had one table for the image data. The new structure has two tables. The first one is to store the images, points and linear transects information. An example of a new element is the *object_type,* this was added because the client application needed to differentiate each object in order to handle it correctly. The second table is for additional details that only the satellite image data contains. See Table 0.1 in the Appendix 1.D for the database structure.

6 SeaWEB USER GUIDE

This chapter describes how to use the features of SeaWEB. The client application is the main entry point of the system, where the user interacts with software. It can be used from any computer connected to the internet using a web browser such as MS Internet Explorer by typing the address of the location of the software. For this discussion we will assume that SeaWEB is installed in a local machine: http://localhost:8080/seaweb. The SeaWEB main screen should appear the screen (See Figure 6.1).

6.1 Performing a Search

The user can state the parameters of the search (query). These queries can be expressed in terms of:

- *Spatial Data*: It is an exact query that looks for spatial objects determined by their location
- *Sensor type* or some other characteristics
- *Date*

Let's say that we want to search data from CenSSIS, from a certain area on the map. First, select the desired sensor from the list. The next step is to select the area from the map, using the mouse. The last step is to click the "Submit Query to DB" button.

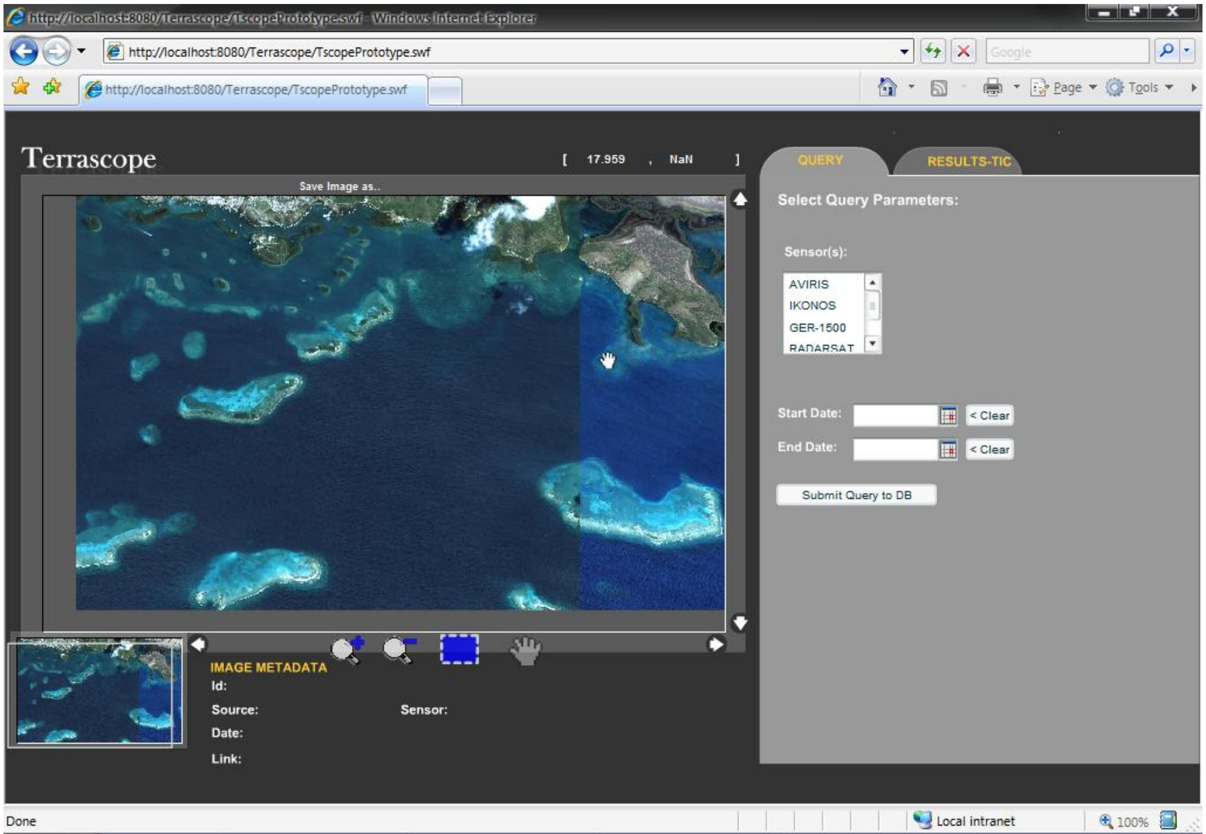


Figure 6.1 SeaWEB client application main screen

After a few seconds the results show up and the screen changes. Now the right side of the screen changes to show the list of results and on the map symbols representing ground data and images are displayed according to its location (See Figure 6.2).

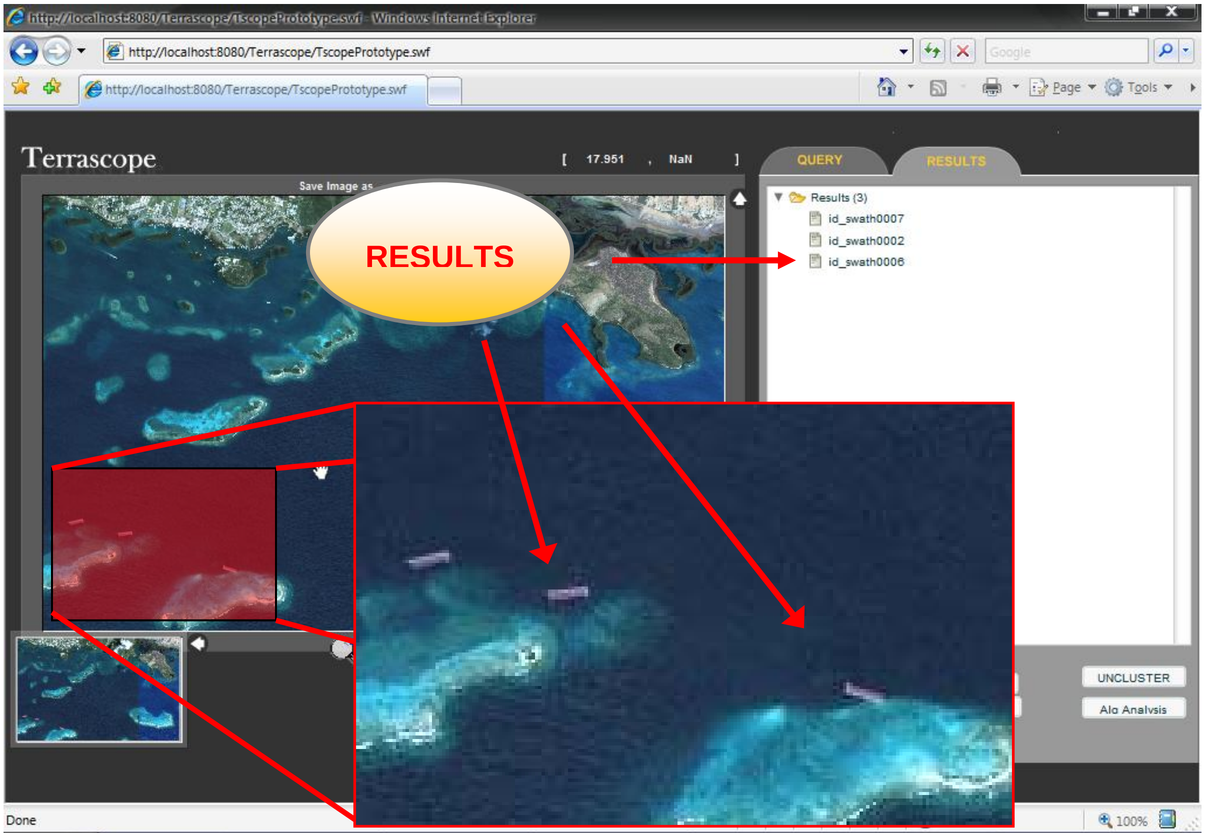


Figure 6.2 SeaWEB client application result screen

If you pass the mouse over a symbol, a description appears below, with a link to view or download the data. See Figure 6.3. Alternately is also possible to select an object from the list result on the right side of the screen. If and object is selected, if available a preview of the data can be viewed by clicking the object. Figure 6.4 shows a preview of that particular point, a reflectance measurement graph of that area. Also, is possible to access the complete data set of that object. In order to download the data, follow the link provided in the details area of the object. Figure 6.5 shows an example of the complete data, in this case an excel document that contains more specific reflectance measurements.

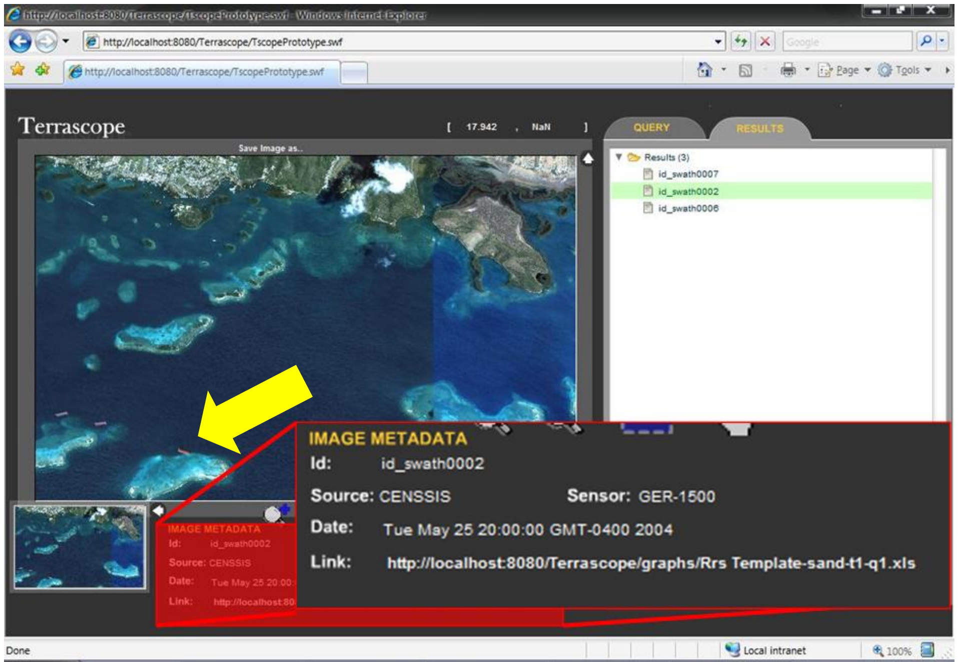


Figure 6.3 Details of an object

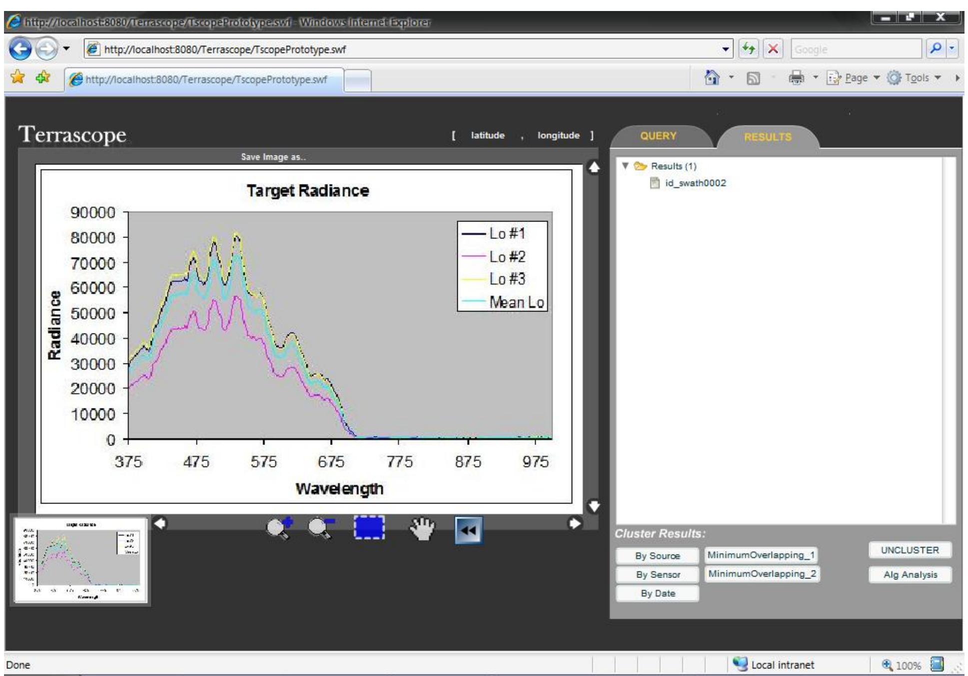


Figure 6.4 Graph representing the remote sensing reflectance data of the location

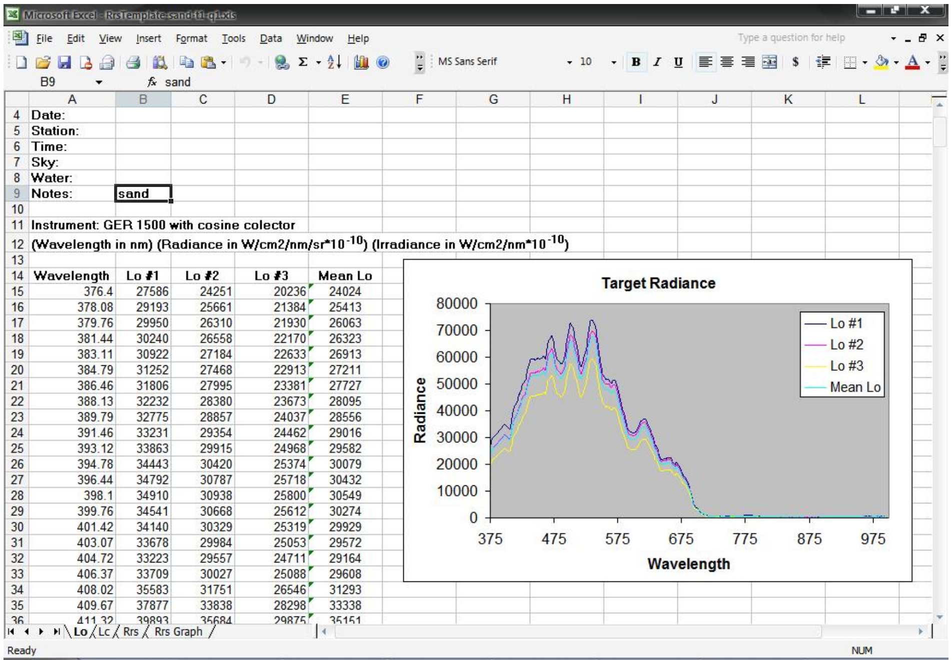


Figure 6.5 Excel document with measurements of the area

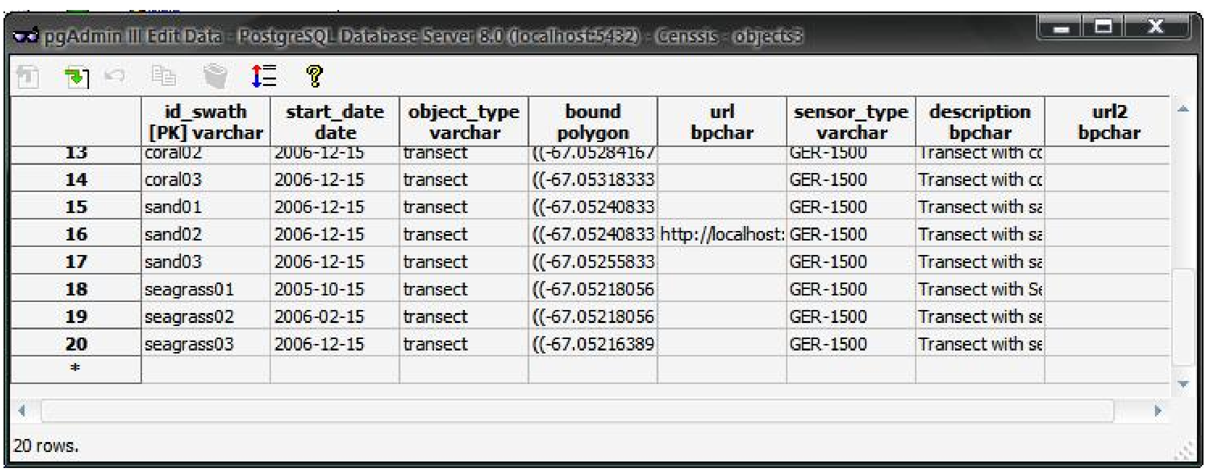
6.2 Data Input

Data is entered on the database using the PostgreSQL database management tool called PgAdmin. There are various ways to input and edit data; one is when using the "view data" feature, it is possible to add a new row of data, like in a spreadsheet, see Figure 6.6. Also is possible to use the SQL query language using the *INSERT* command, and finally there is another command *COPY* that allows the input the data from a text file to the database.

To enter a new object in to the database is necessary to know its attributes. The database fields are described in Table 6.1 along with examples.

Object information		
Field name	Description	Example
id_swaths	Unique identifier for the object	coral04, sand01
start_date	Date the information was collected	2006-06-01, 2004-12-25
object_type	Classification of the object	transect, point, image
bound	This is the spatial coordinates of the object, this is stored in decimal format enclosed in parenthesis, starting with the longitude and latitude of the NW point followed by the NE, SE and SW.	((-67.05218056,17.95495556), (-67.05203056,17.95484722), (-67.05203056,17.95484722), (-67.05218056,17.95495556))
url	Link to download a preview of the data	Http://localhost:8080/Terrascope/image.jpg
url2	Link to download the complete data set of the object	Http://localhost:8080/Terrascope/transect.zip
sensor_type	This is the instrument or sensor used to capture the information	IKONOS, AVIRIS, GER-1500
description	Description of the object or were is located	Transect at Enrique contained with coral and sand

Table 6.1 Database data entry guide



	id_swath [PK] varchar	start_date date	object_type varchar	bound polygon	url bpchar	sensor_type varchar	description bpchar	url2 bpchar
13	coral02	2006-12-15	transect	((-67.05284167		GER-1500	Transect with cc	
14	coral03	2006-12-15	transect	((-67.05318333		GER-1500	Transect with cc	
15	sand01	2006-12-15	transect	((-67.05240833		GER-1500	Transect with sa	
16	sand02	2006-12-15	transect	((-67.05240833	http://localhost:	GER-1500	Transect with sa	
17	sand03	2006-12-15	transect	((-67.05255833		GER-1500	Transect with sa	
18	seagrass01	2005-10-15	transect	((-67.05218056		GER-1500	Transect with Se	
19	seagrass02	2006-02-15	transect	((-67.05218056		GER-1500	Transect with se	
20	seagrass03	2006-12-15	transect	((-67.05216389		GER-1500	Transect with se	
*								

20 rows.

Figure 6.6 PostgeSQL PgAdmin tool, data view window

7 CONCLUSIONS AND FUTURE WORK

7.1 Conclusions

SeaWEB was developed by extending the functionality of Terrascope. New functionality was added to store and access field data.

- The SeaBED tool will effectively aid researchers to find data quickly by means of spatial queries or data characteristics, this in Terrascope has been proven successfully in a study from reference [2] that searched and retrieved data from different data sources.
- SeaWEB presents query results graphically, in a map with symbols that represent the different kind of data available, along with a textual listing of the results. This list can be sorted by data type, date and sensor. Each result includes a URL to download a complete data set available, and a sample of the data.

SeaWEB project now provides CenSSIS researchers from different institutions outside the campus an improved way to use and share of information, creating an access to interact with SeaBED data, in a simple and usable way,

7.2 Future Work

Future efforts could continue, focusing on the development of analysis of the information within the SeaWEB application. The information available now includes more information, than what is displayed in SeaWEB. For example for each transect there are 10 quadrants, and each one have an excel document with a graph. This information could be presented in a new section in the client, instead of one graph of each transect. For example, all graphs and MS excel spread representing the reflectance measurements, photos taken at the location, research papers, etc.

Also since this tool can handle large amounts of different kinds of data, more of the data available already available to CenSSIS could be added to the SeaWEB, for researchers.

In addition the new functionality could be added to the client to allow data entry using client application, instead of entering directly in the database, this will facilitate this process.

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[10] *ESRI ArcView sostware*: http://www.esri.com/software/arcgis/arcview/index.html

[11] *Microsoft TerraServer:* http://terraserver.microsoft.com/

[12] The WWW Image Processing Environment (WIPE): http://www.actgate.com/home/products/wipe.htm

[13] *Eclipse Java Development Tools:* http://www.eclipse.org

[14] *Sysdeo Eclipse Tomcat Launcher plugin:* http://www.sysdeo.com/eclipse/tomcatplugin

[15] *Macromedia Flash Pro MX:* http://www.macromedia.com/software/flash/flashpro/

[16] *PostgreSQL Technical Documentation:* http://techdocs.postgresql.org/

Appendix 1. Installation and Configuration of SeaWEB

This section is a guide to help the user in the installation and configuration of SeaWEB, and all it components.

A. SeaWEB client requirements

These are the minimum recommended specifications for the software client. The following table lists system and browser requirements for Flash Player 7.

Platform	Browser
Windows (x86, 32-bit)	
Windows 98, 2000, XP	Microsoft Internet Explorer 5.x, Netscape 4.7, Netscape 7.x, Mozilla 1.x, Mozilla Firefox 1.x, AOL 8, and Opera 7.11
Macintosh (PPC, 64-bit)	
Mac OS 9.x	Microsoft Internet Explorer 5.1, Netscape 4.8, Netscape 7.x, Mozilla 1.x, and Opera 6
Mac OS X 10.1.x, or Mac OS X 10.2.x	Microsoft Internet Explorer 5.2, Netscape 7.x, Mozilla 1.x, AOL 7, Opera 6, and Safari 1.0 (Mac OS X 10.2.x only)
Linux (x86, 32-bit)	
RedHat Enterprise Linux WS v. 3	Mozilla 1.2 and later, Netscape 7.1
RedHat Linux 9	
Sun Java Desktop System 1.0	
Solaris (x86 and Sparc)	
Solaris 8, 9	Mozilla 1.4
Solaris 10	Mozilla 1.4, Mozilla 1.7

B. SRE System Requirements (servlet and database)

In general PostgreSQL and Tomcat are supported on any UNIX, Linux and Windows 2000, XP and 2003 operating systems. But it's recommend that the system have at least a CPU of 300 MHz and 256MB of RAM.

C. Web Server Installation

The first step is to install Tomcat Servlet container and PostgreSQL database, detailed documentation and downloads for software installation can be found at the products web site http://tomcat.apache.org and http://www.postgresql.org respectively.

The second step is to configure Tomcat and SRE. The configuration file in Tomcat is: *\<install directory>\Tomcat 5.5\conf\server.xml*. For each SRE a new line needs to be added at the end of the file, see Figure 2.2 for an example.

```
<Context path="/Terrascope" reloadable="true" docBase="C:\eclipse\workspace\Terrascope"
workDir="C:\eclipse\workspace\Terrascope\work" >
</Context>
      </Host>
    </Engine>
  </Service>
</Server>
```

Figure 0.1 End of file of Tomcat configuration server.xml

D. PostgreSQL Database configuration

After the installation of PostgreSQL, there is little configuration needed. It is necessary to create a database, exactly like the one in Table 0.1.

Table: objects	
Field name	Data type
id_swaths	varchar(10)
start_date	date
object_type	varchar(24)
bound	polygon
url	char(256)
url2	char(256)
sensor_type	varchar(256)
description	char(256)

Table: swath_detail	
Field name	Data type
id_swaths	varchar(10)
start_time	time(8)
duration_swath	varchar(10)
number_orbit	varchar(4)
condition	varchar(25)
perc_coverage	varchar(4)
km2_coverage	varchar(4)
mro_cycle	varchar(10)
duration_swathunit	float4
type_adquisition	char(12)
latitude_center	float4
longitude_center	float4
condition_point	varchar(2)
id_frame	varchar

Table 0.1 Database structure

E. SRE Configuration

Some configuration needs to be made in the SRE in order for SeaWEB to work. There are two (2) configuration files that are in the ROOT directory of the servlets:

a) ***Terrascope.xm:***.This configuration file indicates where each SRE is located . It has some specifications such as:

Location of the servlet that compose the SRE, the JDBC database driver name and address of the database, the user name and password to the database, the name the source (it self) and the controlling number of hops (called ttl). Figure 0.2 shows and example of the file

```
<?xml version="1.0"?>
<setting>

<ClientAccessServlet>http://host:8080/Terrascope/servlet/ClientAccessServlet</ClientAccessServlet>
    <DataBrokerServlet>http://host:8080/Terrascope/servlet/DataBrokerServlet</DataBrokerServlet>
    <GatewayServlet>http://host:8080/Terrascope/servlet/GatewayServlet</GatewayServlet>
    <databrokersxmlfile>C:\eclipse\workspace\Terrascope\broker.xml</databrokersxmlfile>
    <driverName>org.postgresql.Driver</driverName>
    <user>postgres</user>
    <password>psadm1n</password>
    <databaseName>jdbc:postgresql://host:5432/Censsis</databaseName>
    <source>CENSSIS</source>
    <ttl>4</ttl>
</setting>
```

Figure 0.2 Terrascope.xml

b) ***Broker.xml:*** Contains the addresses of the other Data Brokers which are part of the system. For example if there are others SRE’s connected to other databases this is the place to add them. Figure 0.3 shows and example of this file.

```
<?xml version="1.0"?>
<terrascope>
   <broker>
      <source>
        <CENSSIS>http://host:8080/Terrascope/servlet/DataBrokerServlet</CENSSIS>
      </source>
   </broker>
</Terrascope>
```

Figure 0.3 Broker.xml