

## A THICK WEB COVERAGE CLIENT (WCC) OF NASA HDF-EOS WEB GIS SOFTWARE SUITE (NWGISS)

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Commission II, WG II/3

**KEY WORDS:** Data access, Data Interoperability, Data inter-use, Public use of EOSDIS data, Data analysis and visualisation

### ABSTRACT:

NASA Earth Observing System (EOS) program is producing huge amounts of data that are vitally important for global human, economy and environment. However since these data are in HDF-EOS format, and can not be interoperated with and ingested by many GISs, thus it is highly desirable to make HDF-EOS data accessible to GIS users through Internet. GMU is pioneering the effort in developing OGC-compliant software, such as a software package NASA HDF-EOS Web GIS Software Suite (NWGISS), for making NASA EOS data available to general publics. This paper describes an important component of NWGISS, the Web Coverage Client (WCC). It enables the access of multi-dimensional and multi-temporal geospatial data from multiple coverage servers in the form that exactly matches users' requirements, regardless the original forms of the data in the servers. The easy-to-use and easy-to-install thick web client is the first web-based client in the world for GIS users to access the HDF-EOS data as well as other formatted data in a unified way, greatly enhancing the interoperability and public use of EOS data. Coupled with the NWGISS Server packages, WCC makes HDF-EOS data available to GIS users based on Open GIS Consortium's (OGC) interoperability protocols.

### 1. INTRODUCTION

Geographic Information System (GIS) has been widely used in many aspects of modern society, including natural resource exploitation, environment monitoring, and facility and infrastructure management. NASA EOS program currently collects huge amount of Earth remote sensing data daily. Those data are managed and distributed by EOS's Data and Information System (EOSDIS). The EOS data are not only vital to the global change research but also important to the daily economic and social activities of the human society. One of important tools for analyzing EOS data is GIS. Therefore, making the EOS data easily accessible to GISs will greatly enhance the usage of EOS data. However, current GISs use different internal formats and are very difficult to interoperate with each other and with EOSDIS. Therefore, interoperability becomes one of the urgent issues in the GIS community.

To address the interoperability issue, a not-for-profit membership organization, the Open GIS Consortium, Inc. (OGC), was formed in 1994 (OGC Homepage). NASA is one of OGC's principal members. OGC's mission is to give the world's information systems a new connection to physical reality by making georeferenced data behave like just another standard data type in systems of all kinds.

OGC has successfully implemented three web mapping testbeds, including Web Mapping Testbed I (WMT I), Web Mapping Testbed II (WMT II), and Open Web Services 1.1 (OWS-1.1) and produced a set of web-based interoperability specifications (WMT Public Page ). The WMT I was finished in 1999 and produced an OGC Web Mapping Specification (WMS) version 1. WMS allows interactively assembling maps from multiple servers. The WMT II was finished recently and produced a set of new interoperability specifications. One of the most important specifications for NASA from WMT II is the Web

Coverage Service (WCS) specification. It allows a WCS client to access real multi-dimensional, multi-temporal data from WCS servers. WCS provides an interoperable way of accessing geospatial data, especially those from remote sensing. The WCS developed in the WMT I was used as the baseline specification for OWS -1.1, which was finished in March 2002. The OWS-1.1 further developed the WCS, enabling a client to request data in different map projection, resolution, and format. The WCS specification also moved from XML DTD based capability description to XML schema-based one. The current version of WCS specification is WCS Interoperability Program Report (IPR) version 0.7.

The WCS defines the communication protocols between a client and a server for the client to obtain any subsets of a multi-dimensional and multi-temporal geospatial data for a specific geographic region from the server. This requires a WCS server to have the capabilities of spatial, temporal, and parameter-based subsetting and subsampling. WCS defines the known formats for servers to return coverage data to clients. The most commonly used coverage encoding formats defined in WCS include HDF-EOS, NITF, and GeoTIFF. The later two can only handle georectified data (i.e., NASA EOS level-3 data). For NASA EOS level 1 and 2 data, their usages are limited because they are not capable of handle geolocation information in swath data. For handling NASA EOSDIS swath data effectively, HDF-EOS is the only choice.

OGC Web Mapping specifications have been widely accepted by the GIS software vendors as the industry standards for Geographic Information Interoperability. Many NASA-involved programs, such as Digital Earth, Committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services (WGISS) Test Facility (WTF), and EOS Data Pools, have selected OGC specifications as their interoperability standards (CEOS WTF-GOFC; Digital Earth

Alpha version; NASA ESIP). All those programs need well-developed coverage client to access data in the coverage servers.

In order to study the applicability of OGC interoperability technologies in NASA's data environment, NASA and OGC funded LAITS at George Mason University to design and develop a prototypical NASA HDF-EOS Web GIS Server (NWGISS). The NWGISS was a part of WMT I, II and OWS 1.1 Testbeds. Currently NWGISS consists of a map server, a coverage server, a catalog server, a coverage client, and a toolbox. The NWGISS servers are the only generic HDF-EOS server in the world that can serve all types of HDF-EOS data and provide HDF-EOS, NITF, and GeoTIFF coverage encoding formats. The NWGISS client is the only client in the world that can fully handle the coverage encoding formats of both HDF-EOS and GeoTIFF. The general description of NWGISS system can be found in (DI, *et al.*, 2001). This paper provides the details description of the NWGISS web coverage client (WCC).

## 2. REQUIREMENTS AND ARCHITECTURE

NWGISS WCC is intended to be a general OGC WCS compliant client that works with not only the NWGISS coverage server but also all other OGC-compliant Web Coverage Servers. Therefore, it has to comply with all WCS protocols in the client-server communication for the coverage access. The OGC WCS is intended to provide an interoperable way for users to obtain the real multi-dimensional and multi-temporal data from servers. The natural extension to this notation is the users should also be able to obtain the data in the form that they want, in term of the geographic locations, format, map projection, and resolution so that the data are ready to be integrated and analyzed. This required the services of subsetting, resampling, reprojection, reformatting, and georectification to be provided by either the WCS clients or servers. The OGC WCS implies that an OGC WCS compliant server has to provide the subsetting and resampling services but all other services are optional. Therefore, those optional services have to be provided by NWGISS WCC transparently. The combination of NWGISS WCC and the OGC-compliant web coverage servers can provide interoperable, personalized, on-demand data access and services required by many data users (DI, *et al.*, 2002). Once users obtain the data in the form they want, the next steps users normally want to do include the data visualization and analyses. Therefore, the NWGISS WCC has to provide data visualization and analysis functions too. All those service, visualization, and analysis functions cannot easily be implemented in a web-browser based thin client. Therefore, we decide to implement WCC as a standard-alone Java based application, a thick client. Figure 1 shows the architecture of the NWGISS WCC.

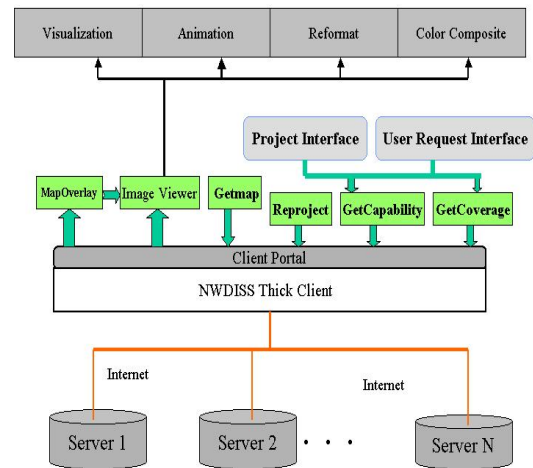


Figure 1. A view of NWGISS Client architecture

## 3. MAJOR COMPONENTS

The major functional components (objects) of the client are detailed as follows.

### 3.1 HDF\_EOS Image Viewer

This component functions as a general file viewer for displaying HDF-EOS Dataset/file. It is based on Java HDF viewer (JHV). It can open local or remote HDF-EOS data files and shows the tree structure, image view and spread sheet view. When user save the file, it allows user to choose the data format they desire. The data format conversion is transparent to users (Figure 2).

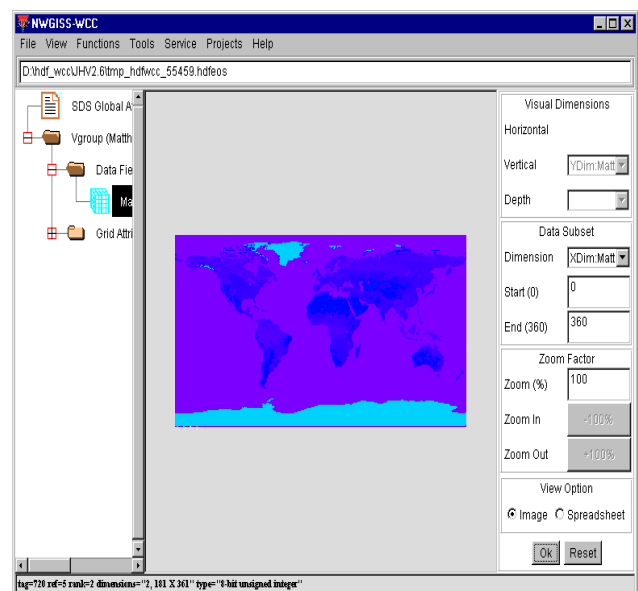


Figure 2. A screenshot of the client main interface

### 3.2 WCS Client Portal

This virtual object functions as a portal for all information in and out of WCC, providing basic WCS client-server communication, coverage access, visualization, and user interaction. The OGC WCS has two mandatory interfaces, GetCapabilities and GetCoverage, and one optional interface,

DescribeCoverageType. The NWGISS WCC has implemented the mandatory interfaces but not the optional one. A typical user session starts with the client issuing GetCapabilities request to coverage servers listed in the client's coverage server list. The servers then return XML-encoded documents containing information about the server capabilities as well as the data available in the servers. The client parses the XML documents and lists information about data availability in the graphic user interface for the data layer selection (Figure 3). The graphic user interface allows users to select the geographic region, the map projection, temporal range, the parameters, and the data format they need.

Based on the user's input, the client then formulates a GetCoverage call to the server to obtain the user-requested data. Since a coverage server may not be able to provide data with user-specified map projection and format, the client first converts the user requirements to the equivalent requirements acceptable by the servers and forms a GetCoverage request. Once the data are returned, the client will arrange the reprojection, reformatting, and/or georectification functions automatically to convert the data to meet user specifications.

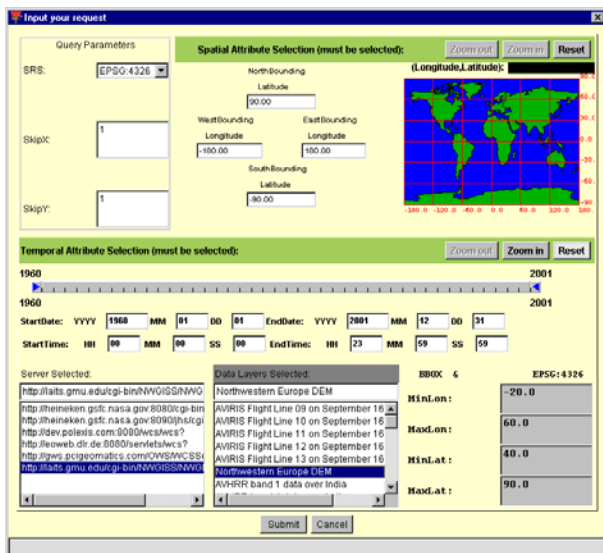


Figure 3. A screenshot of the component for WCS client-server connection in the NWGISS.

### 3.3 Reprojection

The reprojection will convert grid data (i.e., georectified data) from one map projection to another. It is one of fundamental step for integrated analysis of multi-source data. The NWGISS WCC supports all HDF-EOS supported map projections. Because WCS specification does not require a server to serve data in multiple projections, if the user-selected projection is not available in the server the client will automatically reproject the data to the user-specified map projection.

### 3.4 Georectification

Some of OGC-compliant coverage servers, such as NWGISS coverage server, are capable of serving swath data in either grid or original swath form. But many other servers are only able to serve the swath data in the original swath form with returning data in HDF-EOS format. The HDF-EOS swath data model requires the attachment of geolocation information to the data.

The geolocation information can be used to georectify the swath data into grid data. In our implementation, if a user specifies a map projection for the swath data returned from server, the georectification processing will be automatically applied to the swath data to georectify the data to the specified map grid. After georectification, the swath data will become grid data and is ready for co-registration with other grid data. Of course, users also can request the raw swath data without georectification by specifying the returned data in its native swath coordinate system.

### 3.5 Reformatting

WCS defines known coverage encoding formats in the Capability DTD and/or Schema. The currently defined known encoding formats include HDF-EOS, NITF, GeoTIFF, DTED, etc. Servers are only required to implement at least one of the coverage encoding formats for the returned coverage data. Therefore, a user requested data format may not be available in the server side although these known formats are quite popular in GISs. Therefore, we have to provide the format conversions between those defined formats so that through NWGISS WCC any OGC compliant server can provides all WCS defined formats for users to select. In addition to those known formats, the client also provides other commonly used formats for users to selection, such as binary and ASCII.

### 3.6 Visualization

The client provides the visualization functions to view the coverage data. For the two dimensional coverage data, it provides the pseudo color and gray scale display with linear and histogram equalization data-scaling methods. Many different palette manipulations and stretch functions are also provided. Because OGC WCS also intends to provide for accessing multi-dimensional and multi-temporal data, the common way of converting the data into two-dimensional image for display is not very effective for multi-dimensional and multi-temporal data. Therefore, we implemented the animation for multi-temporal data and color composite display for multi-band remote sensing data.

### 3.7 Project Interface

This GUI interface will let users to specify and build a project that includes multiple data layers from multiple servers. For each layer users can specify its dimension parameters. The client can build the project at once by obtaining the data layers from the servers at the same resolution, projection, and format so that the data can be ready to analyze. The client also let users to open a previously saved project to edit.

## 4. CONCLUSIONS AND FUTURE PLAN

This study has successfully developed a comprehensive and powerful web coverage client (WCC) for general public to access the HDF-EOS data in multiple coverage servers based on OGC standards. The NWGISS WCC meets the urgent client needs of many NASA programs (e.g., GOF, Digital Earth, ESIP, and EOSDIS). The easy-to-use and easy-to-install thick web client is the first web-based client for GIS users to access the HDF-EOS data. The adoption of the client thus greatly enhances the interoperability and public use of EOS data. Coupled with the NWGISS Server packages, WCC makes HDF-EOS data available to GIS users based on Open GIS Consortium's (OGC) interoperability protocols.

NWGISS is still under continuous development. We intend to evolve the NWGISS WCC into an integrated multi-protocol geoinformation client that will handle OGC Web catalog, map, coverage, and feature protocols. Currently we are implementing the OGC Web Map Services (WMS) protocol and a prototype of the integrated coverage and map client is available. In addition, we will also implement some image processing and data analysis functions in the client.

#### ACKNOWLEDGEMENTS

This project was supported mainly by grants from NASA Earth Science Technology Office (ESTO). Additional funding was also provided by Open GIS Consortium (OGC).

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