Serving global datasets over the Internet: the ICEDS[1] project

C. Giovando[1], N. Gil[2], J. Morley[2], JP. Muller[2]
[1]San Diego State University, Department of Geography, San Diego, US
[2]University College London, Geomatic Engineering Department, London, UK

SUMMARY

Existing imagery data acquired by Earth Observation (EO) sensors play an important role as a frequently updated source of data and information for Geographical Information Systems (GIS) for different applications and types of analysis. The availability of this data, not only in terms of its transfer but also in its format, is however an important factor to bear in mind. Concerning transport, an easy and global means of dissemination, such as the Internet, is the best, easiest and swiftest way of providing and disseminating data. As far as the format is concerned, and introducing the concept of interoperability, a universal format would be the wisest choice. This means that everyone and every processing or displaying system could easily display and acquire these data, presenting no obstacles in its further distribution.

Unfortunately, the above mentioned ideal solution is still not an absolute reality. Several organisations and a dynamic user-community are working together in order to achieve a stage where no barriers exist to the interchanging and processing of geographic information. This project comes in this context and gives a contribution towards facilitating EO data availability and processing, through the implementation of a World Wide Web GIS prototype based on Open Geospatial Consortium (OGC) and International Organization for Standardization(ISO) specifications.

KEYWORDS: *Interoperability, Web Map Service, Web Coverage Service, Landsat, SRTM*

INTRODUCTION

The ICEDS (Integrated CEOS European Data Server) project is a well successful prototype that aims at supporting CEOS (Committee On Earth Observation Satellites) agencies to assist the UN and Non Governmental Organisations in developing countries with Internet access to global mosaics of Landsat and SRTM data, through the provision of a number of integrated, but distributed data servers. The exploitation of Open Geospatial Consortium (OGC) and ISO interoperability standards is a fundamental to the success of the project, defining an open, scalable and sustainable system architecture.

The research activity includes data preparation, geo-processing, improvement of large datasets handling and implementing Web Map serving alternatives, using both commercial and open source software. The current implementation is based on the Web Map Service (WMS) (OGC, 2004) and Web Coverage Service (WCS) (OGC, 2003) specifications.

DATA PROCESSING AND DATABASE ARCHITECTURE

The data preparation phase in the ICEDS project included the processing of four main global or near-global spatial datasets, freely available from different sources and agencies. The SRTM (Shuttle Radar Topographic Mission) digital elevation model (DEM) for Europe and Africa and Landsat 5

---

[1] http://iceds.ge.ucl.ac.uk

Thematic Mapper (TM) image data for Africa are the two main remote sensing products processed and published. Both the SRTM and the Landsat 5 data were made available to the project as mosaics. The SRTM data was downloaded by ftp from the USGS and is the "unedited" form of the data, meaning that data gaps due to poor radar characteristics have not been filled. The Landsat 5 mosaic was kindly provided by Nevin Bryant of the Cartographic Applications Group at JPL. The other two datasets used in ICEDS (the MODIS Blue Marble global mosaic, and a land/sea mask derived from the Global Self-consistent, Hierarchical, High-resolution Shoreline (GSHHS) database from NOAA) have been used only for meta-processing or as reference layers.

The objective of the data processing was to convert the datasets from their original format into something more suitable for being published with a map server. There are two main techniques for storing large volumes of spatial information in a digital archive when they need to be indexed and easily accessible: the first and the most common is to use a spatial database, such as Oracle, MySQL or PostGre. These require advanced knowledge of database management and often the software is quite expensive and not easy to be setup. The other way consists of storing single files in a hierarchy of directories and providing some form of index file to allow access to the appropriate data to fulfil a request. Typical index file formats are an XML or binary file, naming the individual files according to their geo-reference information, or a shapefile containing the filenames as polygon feature attributes. This indexed directories option was adopted for the ICEDS project because its intuitive structure is easier to replicate in other environments and contexts, without particular experience of spatial database management. The data-sets served are all held in a regular gridded geographic (lat,lon) format.

The format and the dimension of the files stored in the different directories is very important when they have to be accessed by the map server. There are several factors conditioning the performance of a map server and some of them are indeed relevant to the structure adopted in the tiling and hierarchy of the constituent files. The dimension of the files may increase when the web server has a more powerful processor or higher RAM – here, dimension can be taken either to be image size in pixel dimensions, or simply storage space in RAM. It should be noted that some formats offer space advantages on disk through compression, for example JPEG, but may require as much memory in RAM in a map server if the server holds the data in a decompressed form. Other physical factors that can slow down the process of publishing and accessing a geospatial dataset on the Internet are the capacity of the network connecting the web server with the storage disks and the number of requests performed contemporaneously to the map-server.

SETTING THE MAPSERVER

Raster data files are frequently large in size. In many cases, only a small subset of the area at full spatial resolution is requested by the client for display by the map server. In this situation, there is no need to load the entire image into the map server's memory. Given that only a subset of the area may be requested, it makes sense to store data in smaller tiles forming one 'logical' dataset. It is also very desirable to avoid re-sampling large volumes of full resolution data on the fly to cover large areas at low resolution for display – an expensive operation in terms of computational resources. The solution is the creation of different versions of the same data at lower resolutions. This operation is usually referred to as pyramiding. In this case, the SRTM dataset is already tiled, so one only needs to create sub-sampled versions of that same data and merge those same sub-sampled versions together until a certain optimised size is achieved.

During the first phase of the project, several prototypal versions of ICEDS were assembled. The two first demonstration servers were based on Cadcorp's "SisIsapi.dll" simple Web Map Server and IONIC's RedSpider Web software, both commercial packages. The last two generations of the prototype were implemented using open source software: the third was built using the Deegree map server and the fourth using the University of Minnesota MapServer. The ICEDS team settled on the

UMMS as the final server software due to its stable and more complete support of WMS and WCS compared with the versions of Deegree at the time of development (summer 2004). ICEDS is locally serving the already mentioned two main global spatial datasets, made freely available from different sources and agencies: the SRTM DEM for Africa, Europe and India and the Landsat 5 imagery data for Africa. Another data set was also used as reference: the MODIS Blue Marble mosaic at 1 km resolution.

The two services mentioned above have the purpose of providing geospatial information from a server into a client via the Internet. On the server side, both of them can share data; the main difference amongst those services resides on the client side. While the WMS delivers simple pictorial data to the client for visualisation purposes, the WCS provides the client with a true replication of the same data stored on the server. An analogy can be made between this latter service and an FTP pull service, for both are able of duplicating data from a server into a client. The combination of WMS and WCS allows GIS users to browse data on servers and obtain the data from servers in the form that exactly matches their needs (Di et al., 2001).

The current implementation consists of a web portal with a user friendly interface allowing the discovery of multiple data layers, provided by different sources according to OGC's Web Map Service specification. A Web Coverage Service (WCS) serving raw African Landsat5 imagery and SRTM unedited DEM data is also available, as mentioned before. To demonstrate the WCS capabilities and connectivity, a client was designed, which main functions are the establishment of an on-line connection to the ICEDS WCS server and SRTM DEM data retrieval after a geographic extent has been defined by the user. This data is then portrayed as a 3D colourised by height hill-shaded DEM.

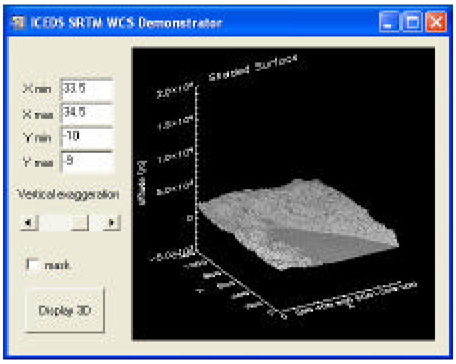

Figure 1: The ICEDS WCS client demonstrator

In order to assist those agencies in deploying their own map-server without expensive costs for software licenses, a guidelines document describing the technical processes involved in publishing large geospatial datasets over the Internet and a package of scripts were also made available for free re-distribution.

WEB CLIENT IMPLEMENTATION

The current version of the ICDES portal prototype includes different data layers, coming from the local server and from the cascaded WMS services. The snapshot below gives a picture of the website. The interface, derived from a template provided by IONIC, consists mainly of a viewer with zoom/pan tools and a layer visibility control in the right-hand frame.

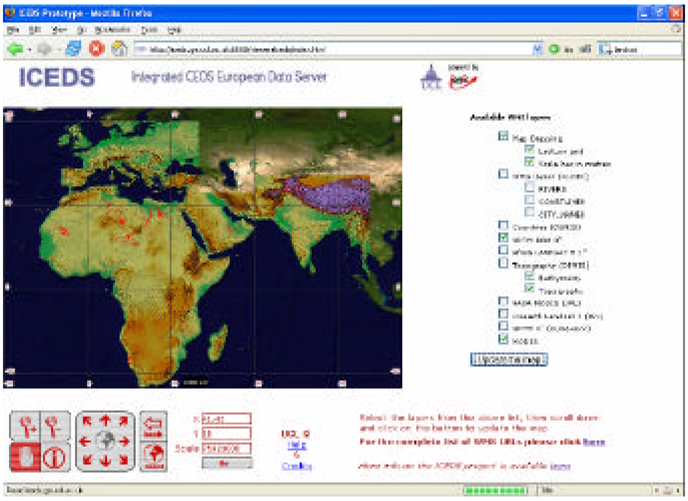

Figure 2: The ICEDS prototype portal interface

In the lower frame there is a basic description of the website contents and some links to other pages containing additional information and some help on the command tools. The complete list of the layers is available as a link from the viewer and contains additional links to the “Capabilities” XML files and a sample “GetMap” request for each layer. In addition to the hill-shaded SRTM and Landsat 5 mosaic, the portal cascades Landsat7 WMS mosaics from the NASA OnEarth server; topography and bathymetry from the DEMIS[2] website; and other general vector layers like water bodies and country borders from the GLOBE[3] WMS server. Functionality has also been added to provide a cursor-based readout of latitude and longitude position. The website is accessible directly at the following URL:

http://iceds.ge.ucl.ac.uk:8080/viewer/iceds/index.html

and runs on the ICEDS RAID server (running Mandrake Linux, and Apache as the Web server). The portal usability is high and allows non expert GIS users to manage and visualize the various sets of data. The possibility of turning the listed layers on and off, allows the creation of composite and personalized maps that can be saved as images. The zoom and pan tools give enough capacity to discover the datasets and make useful visual analysis in a very short time, considering the amount of data accessed and considering that all the data-access is available through a web-service available everywhere and to everybody for free.

For those expert technicians interested in connecting their OGC compliant clients to this data sources, there are few simple steps to access them:

1. Open the layer list html webpage (the link given above)
2. Open the service GetCapabilities link (“xml” link)

---

[2] www.demis.com

[3] http://www.globe.gov - a joint project managed by UCAR/CSU with support from NASA, NSF, the US Dept. of State, and other cooperating organizations.

3. Find the "online resource" tag in the XML file
4. Add the service URL in your client or viewer

Some WMS compliant viewers are available online and allow advanced processes. Others are integrated into desktop applications like ArcGIS 9, MapInfo 7 or Cadcorp SIS 6. Future development of the portal could include the addition of advanced online tools, to manage the layer list (add/remove layers), to control the transparency, to compute distances and other geo-analysis tools.

CONCLUSIONS

A principal factor that has determined the direction and rate of progress in the ICEDS project has been the newness of the WCS OGC specification. Although many Web GIS packages have supported WMS for some time, WCS implementations are new and generally still developing. This was true of all the packages tested (IONIC RedSpiderWeb, Deegree and the University of Minnesota MapServer). Within the time span of this project, MapServer has proved to be the most advanced and flexible of these packages and hence has been adopted. However it should be noted that the other two packages listed above and others are developing quickly and readers may well find capabilities to recommend other map server software. This is a fast moving area – at the time of this document's creation (December 2004), discussions are underway in OGC for a new and improved revision of the WCS specifications and this will also have an impact on the server packages.

The power of the OGC methods used to create the ICEDS server lies perhaps less in the obvious Web portal. A number of such portals, allowing users to view large spatial datasets online, are becoming available, the JPL OnEarth service being a good example. Where there is in fact most potential is the WCS interface. This allows live, online access to data (as opposed to maps) and can form the start of an online processing chain. OGC interoperability forms the glue that allows online program components to share and chain information – this is particularly useful, for example, in the new web services paradigm.

Future developments for the ICEDS project will include the implementation of an OGC Web Terrain Server specification and the development of the WCS client in order to allow Landsat imagery to be displayed in 3D using the elevation information from the SRTM DEM data. A Landsat 7 global mosaic, made available by NASA including all the band products will be added to the prototype (WCS and WMS). This dataset in natural colour format (combination of bands 3, 2 and 1), is also being served by the ICEDS WMS service, cascaded from the NASA OnEarth WMS server. It is proposed that in future level 2 (swath and frame) data representing geocoded imagery will also be added so that space agencies around the world can create their own online browse and display of their own satellite data holdings.

BIBLIOGRAPHY

Open Geospatial Consortium (OGC), Inc., 2004 Web Map Service (WMS),Version 1.3.0. Available at: http://portal.opengeospatial.org/files/index.php?artifact_id=5316

Open Geospatial Consortium (OGC), Inc., 2003 Web Coverage Service (WCS) Version 1.0.0. Available at: http://www.opengeospatial.org/docs/03-065r6.pdf

Di L, Yang W, Deng M and Deng D, 2001 The Prototypical NASA HDF-EOS Web GIS Software Suite (NWGISS). In Earth Science Technology Conference 2001 proceedings.

Groat C and Asrar G, 1999 Management Plan For the Landsat Program. USGS Technical Information in Landsat Project