THE ESTABLISHMENT OF DIGITAL HIGH RESOLUTION GEODATABASES FOR WEBGIS: FROM DIGITAL CAMPUS TO DIGITAL NATIONAL PARK

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ABSTRACT:

In 1999 right after Al Gore brought the idea of the Digital Earth, aiming to promote the Digital Earth concept Chinese Culture University (CCU) in Taiwan established the Digital Earth Research Center (DERC) and start building Digital Campus, Digital Hua-Gang project. In the mean time nations and organizations around the world have promoted and involved activities in the fields of global sustainability such as global society dialogue, information networking, and delivering services to citizens. Taipei city government, along with Taiwan government, started establishing GIS database infrastructure work in early 90's and merging into development stream of E-government, E-Taipei project. To establish a geodatabase for a digital community, we faced several problems. This was quite different experience trying to implement the digital community since the different sizes, user needs, query functions and information resolutions from different community. This study compared the components of different community from size of large national park to small campus. To bring E-government idea down to digital community faces the problems of various requirement, mass information distribution and quick data communication response from citizens. The Digital Hua-Gang faces the problem focus on the propagation of the digital earth concept and on its application aspects in ecological, economical, technological, cultural and social studied. We found that to implement digital community, all different communities should focus on converting the mass information into geodatabase and with the help of Geoinformatics techniques we can reach the goal of providing better accurate, 3D visualized geo-information and more real-time communication services to the public. Applications of Geographic Information System (GIS) on environmental monitoring and natural hazard management have been carried out around the surrounding area of Yangmingshan (YMS) National Park and have proved very successful in providing protection to rare animals and plants. Located in the north of Taiwan, Yangmingshan is also a very important place for studying environmental conservation, hazard prevention and sustainable development of natural resources. High resolution digital aerial images and Lidar images are recently available in Taiwan, and Taiwan's remote sensing satellite Formosat-2 also efficiently provides two-meter high-resolution imagery. In order to implement the idea of Digital Earth and to reach the goal of substantial development of natural resources, the aim of this study is to establish a high resolution geodatabase for YMS National Park by using all the available geo-information. Using such massive high resolution images to merge into a geodatabase creates all kinds of problems, such as mass data storage, large image server, and the need for more efficient computer operation functions. In order to handle such mass information and expand future new applications, we have introduced a high performance computing system and used it to establish a high resolution digital national park database. With this new computer system we expect the new applications with high resolution images will fulfil the future application needs.

1. INTRODUCTION

Since US former Vice President Al Gore brought up the concept of Digital Earth during his 1998 speech at California Science Center, a lot of studies around the world have focused on the issues of digitizing national geographical and environmental information. The major components of Digital Earth are: collecting all kinds of information from different resources, especial from satellites, to build a mass geodatabase; sharing and communicating this information via the global internet infrastructure; and presenting data with 3D virtual reality simulation for scientific study and application in order to reach the sustainable management and development of the earth's natural resources.

The implementation of Digital Earth has become more realistic due to recent technical developments such as high resolution satellites, the availability of Google Earth, and high performance computing systems. In Taiwan, many projects, such as National Land Information System, have become enthusiastically involved in the developing of spatial information technology for both government and civilian use. There are seven national parks on this small island, all of which have different characteristics. Yangmingshan National Park, located in the north Taiwan, has much volcanic activity and abundant biological diversity, and is also an important environmental conservation area. In order to implement the idea of Digital Earth and to reach the goal of sustainable development of natural resources, the aim of this study is to establish a high resolution geodatabase for Yangmingshan National Park by using all the available geo-information.

It was quite a challenge trying to implement the digital community owing to the different sizes, user needs, query functions and information resolutions from different communities. This study compared the components of communities varying in size from a small university campus to a large national park. To establish digital national park we face the problems raised by various differing requirements, mass

information distribution and demands for quick data communication response from citizens.

The Chinese Culture University located right on the border of Yangmingshan National Park. Digital Campus faces the problem focusing on the propagation of the Digital Earth concept and on its application to aspects of ecological, economical, technological, cultural, and social studies. We found that to implement a digital community, both different sized communities should focus on converting the mass information into a geodatabase, and with the help of Geoinformatics techniques we can reach the goal of providing better accurate, 3D visualized geo-information and more real-time communication services to the public.

2. METHODOLOGY

Recently, even though the prototype model of Google Earth has shown us the accomplishments of Digital Earth in presenting a 3D 'scientific reality' earth with all kinds of spatial information built into one super-large geodatabase, the concept of Digital Earth is still questioned by most people. To further realize the concept of Digital Earth we can start building smaller geodatabase for smaller communities and then, step by step, build up digital communities on different levels and scales. Objectives in establishing a Digital Community
There are several concerns in the implementation of a digital community. The Hwa-Gang community includes the campus of the Chinese Culture University and surrounding area. Although Hwa-Gang community is small in size, there are 3S spatial information techniques, 3D visualization presentations, and 3G wireless WebGIS environments involved. To complete the Digital Community project the assistance and cooperation of the whole society of the Hwa-Gang community is required. Interactive communication is necessary between members of the whole community.

The geodatabase and WebGIS query system for Digital Hwa-Gang project should fulfil all the quick response needs for the university faculty and students' research work, and should include all the spatial information and scientific study data of earth science, climate, geology, humanities and social science. A campus virtual tour in the form of a 3D visualization display should also be provided.

The Hwa-Gang study area includes the area adjacent to the university campus, and all the economic and cultural activities of the surrounding college town are also included. The digital Hwa-Gang project focuses on contents of educational resources for 3S technology and internet online services of geoinformatics techniques such as GIS. All the maps are first digitized and then with geo-coded imagery converted into TM 2° Transverse Mercado Projection on TWD67 Taiwan Datum for later GIS overlapping applications. The three major projects are the Spatial Information Query WebGIS System, the Digital Hwa-Gang Address Query System and Hwa-Gang Campus 3D Visualization Simulation. The Spatial Information Query System is designed so that faculty and students can use the spatial information in the Digital Hwa-Gang geodatabase by operating the WebGIS on the campus internet. The Digital Hwa-Gang Address Query System is designed to locate buildings and shops on and around the campus and can be a very helpful resource for students and visitors. The Hwa-Gang Campus Visualization Simulation shows a 3D virtual tour of the campus and 3D 'scientific reality' visualization provides a dynamic view of the campus from another angle.

Located on the edge of Yangmingshan National Park, we have for years collected various different kinds of maps and digital images of the national park from satellite and aerial photo images. However, there is no data-sharing function or information communication platform between different departments. The information is in different formats or scales, and there is no efficient way to share information. Therefore, we collected and preprocessed all the information relating to the national park using 3S spatial technique to establish a geodatabase for the convenient use of all Remote Sensing and GIS users. Figure 1 shows the high performance computing system and EVA storage system of CCU. Figure 2 shows the steps of establishing geodatabase and WebGIS.

Figure 1. CCU high performance computing system and EVA storage system

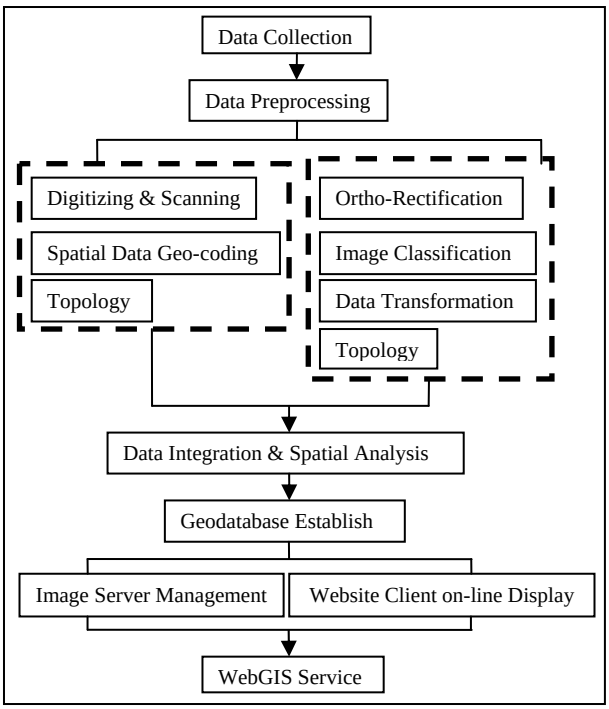

Figure 2.The flow chart of establishing geodatabase WebGIS

2.1 Data Collection

The data from many published maps, results from research, and academic articles from government and civilian sources are

collected from Yangmingshan National Park and adjacent areas, and are catalogued into four categories: natural resources; land use; ecology conservation; and hazard prevention, in GIS vector and raster format for the following data preprocessing. The collected data from different resolutions, type sensors and spectrums for the establishment of the geodatabase includes digital aerial photos; conventional scanned photos; satellite images of Landsat; SPOT; topographic maps; digital maps; and thematic vector maps etc. We are especially interested in high resolution satellite images, such as IKONOS, QuickBird and Formosat-2 satellite images (the latter launched on May 2004 from Taiwan, See Figure 3) and Lidar images which provide high resolution DEM and DSM, generated by using digital Photogrammetric techniques (See Figure 4; the orange colour represents the points on the ground). The thematic maps are based on object-oriented classification from both high resolution satellite and aerial images.

Figure 3. 2m- resolution Formosat-2 satellite image of YMS

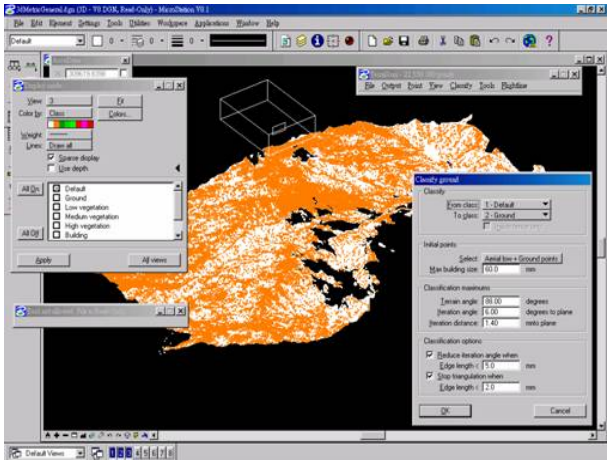

Figure 4. Filtered Lidar images of YMS National Park

2.2 Data Preprocessing

Before storing in the geodatabase, all the collected map data is geo-coded into geo-coordinate systems with high accuracy, in order to be more efficient in GIS overlapping operations and to match the requirement of high resolution images. Since higher resolution images provide more detailed information from image pixels (in other words, one object can be composed of several image pixels) the unit for using classification changes from pixel size to object unit. The image classification method for using high resolution satellite or digital images therefore uses image object classification to retrieve image features and create high resolution thematic maps, consequently providing more accurate and detailed classification features for interpretation of information.

Other than performing image rectification to create orthophoto images for GIS data acquisition, we also use digital stereo pair digital images and the Digital Photogrammetry method to create high resolution DEM which can create one- to five-meter grid intervals for 3D GIS or 3D virtual reality fly through simulation. Other work involves using Lidar images to create DSM and DTM for the national park. There is a lot of work involved other than preparing orthophotomaps and DEM. The statistic and attribute information must be rearranged into the geodatabase files. The attribute data transformation from different files into a unique organized geodatabase format is especially labour-intensive as well. For the implementation of the Digital Earth concept of data sharing, we need to modify the GIS geodatabase in order to make it suitable for WebGIS use.

3. IMPLEMENTATION

3.1 Establish Geodatabase

The data created for the geodatabase should consider the accuracy of geo-coding coordinates, fulfil the requirements of topology and be stored in layers for GIS in order for use in spatial analysis. For the convenient management of the database and integration of different types of information, the items of Yangmingshan National Park geodatabase category are listed in Table 1. The Items of Yangmingshan Geodatabase divided into four major groups which are Base Map of Land Use, Natural Resources, Ecologic Conservation and Hazard Prevention. Each item consist several layers and each layer composes many types of GIS information which consists of points, lines or polygons.

Class	Layer	Content
Base Map of Land Use	Administration Boundary	City Boundary, County Boundary, National Park Boundary, etc.
	Traffic	Road, Highway, Trail, Sidewalk, etc.
	Cadastre	Buildings, Land Use, Zoning, etc.
	Landmark	Station, Bus Stop, Police Station, School, Gas Station, Hospital, Visitor Center, etc.
Natural Resources	Topology	Geology Map, Soil Map, DTM, Slope, etc.
	Hydrology	River Name, River Grading, Watershed, Precipitation Station, Hydrometric Station, Qater Quality Monitoring Station, etc.
Ecologic Conservation	Land Cover	Forest, Orchard, Farm.
	Rare Plants	Taiwan Isoetes, Silver Grass, Arrow Bamboo.
	Rare Animals	Formosan Macaque, Parantica Sica Butterfly.
Hazard Prevention	Environmental Sensitive Areas	Geologically Sensitive Areas, Natural Landscape Sensitive Areas, Ecologically Sensitive Areas.
	Landslide hazard	Landslides, Debris flow.

Table 1. The Items of Yangmingshan Geodatabase

3.2 Establish Metadata

Aside from establishing the attribute data of the geodatabase, the establishment of metadata is also labour-intensive work. This metadata information is also a very important reference for users. In order to reach the goal of data sharing, the input of metadata information will follow the specifications announced by the Information Center of Taiwan's Department of Interior which include: information identity name; data quality; spatial information structure; spatial reference information; entity and attribute information; data offered resource; quoted information; data time; contact information; and others. Furthermore, a function is required for updating the standard specifications, contents and format in order to meet the data-sharing aims of the National Land Information System project in Taiwan.

3.3 3D Fly-Through Simulation

One of the key elements to implementing the Digital Earth concept is to use the virtual reality technique to present the spatial information results in a dynamic and 3D stereo view. A 3D volcano fly-through simulation scenario of Yangmingshan National Park is available for public viewing on the website of Digital Yangmingshan National Park. This 'scientific reality' 3D fly-through scenario model provides a better understanding scenario for public presentation and education.
Another challenge is to establish the high resolution digital national park geodatabase in the high performance computing system at the Chinese Culture University by using high resolution digital images and DEMs.

3.4 WebGIS Query System

The primary work in this project is to build up a geodatabase for the national park. The major parts of the project focus on the design of the website and on converting all the data for the WebGIS applications. One of the goals of this project is also to provide all the available GIS information for scientific study needs: for instance, the study of landslide sensitive areas in the national park, the correlation between geology data and geographic data, and the application of land use/land cover. All the information from different times and dates is provided by the national park geodatabase and can also be operated by WebGIS.

The convenience and accuracy of data for users is a major concern. The time frequency of image data provided should also be considered in order to reach the goal of providing near real-time data and increase the automation process of the spatial data analysis operation. The design of WebGIS for the national park geodatabase provides an interactive platform for the different spatial information users.

The digital image data updating of the national park geodatabase is arranged in sequence by date and time during the data acquisition. Multi-layers, multi-resolution, multi-spectrum, multi-elevation, and multi-scale concepts are involved in the design of the geodatabase for studies such as the change detections of the image object correspond to the fast changing reality of Mother Nature.

4. APPLICATION SCENARIOS

4.1 Digital Campus

The Digital Hwa-Gang project incorporates three query systems: the Spatial Information Query WebGIS System, the Digital Hwa-Gang Address Query System, and Hwa-Gang Campus 3D visualization simulation. Figure 5 shows the procedure for establishing the Digital Hwa-Gang project.

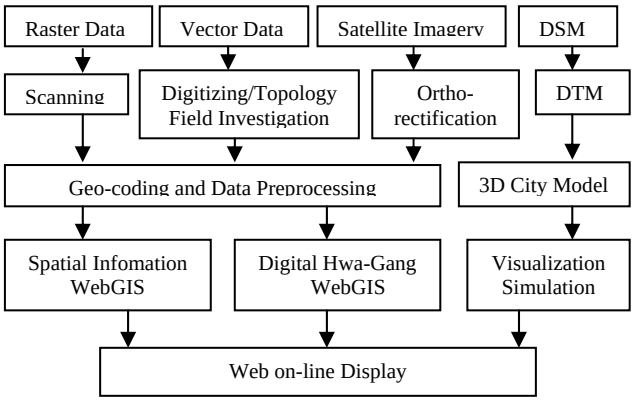

Figure 5. Procedure for Establishing Digital Hwa-Gang

4.1.1 WebGIS Spatial Information Query System

The Spatial Information Query System is designed for faculty and students to access spatial information in the Digital Hwa-Gang Geodatabase by operating the WebGIS on the campus internet network. Therefore, the system integrates vector maps and raster imagery and can represent all the available spatial information owned by the school, including digital maps, scanned aerial photos, digital images, satellite images (LandSat, SPOT, Ikonos, QuickBird, Formosat-2), DTM, DSM from

Lidar, etc. The system allows information to be queried either from text data or from spatial data and can present the required image online with all geo-coded coordinates and metadata. Figure 6 shows the result of querying the attribute data from images. The result shows a frame of SPOT satellite images with image ID, type, date, time, coordinate system, store place and index attribute information.

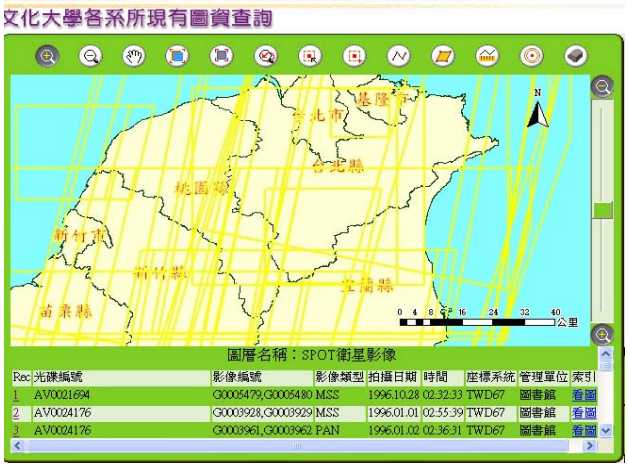

Figure 6. The result of querying the attribute data from images

4.1.2 Digital Hwa-Gang Address Query System

The Digital Hwa-Gang Address Query System is designed to locate buildings and shops in the area and can be very helpful for students and visitors. Besides GIS format data with topology, the attribute data has additional columns for commonly requested information such as restaurants and shops. Multimedia information is also linked to the system. The WebGIS software used in the project is the Taiwanese developed Super-GIS.

The base map used in the Digital Hwa-Gang Address Query System is 2005 high resolution QuickBird satellite imagery with GIS map layers of the campus buildings, road, shops, etc. Each building has its own address complete with related information such as shop name, type, etc. Figure 7 shows the attribute information result from WebGIS. The selected building (colour yellow in the image) and corresponding attribute data can be found on the lower right side, with shop name, type, address and telephone number.

Figure 7. WebGIS Query attribute information from internet

4.1.3 3D Visualization Simulation

The Hwa-Gang Campus Visualization Simulation gives a 3D virtual tour of the campus and a 3D 'scientific reality' visualization providing a dynamic view of the area from another angle. The 3D fly-through simulation software used in the project is the PCI or ERDAS Imagine Virtual GIS model and 3D city model software for 3D building modelling. The surface of the terrain uses DEM created from digital photogrammetric stereo images and the 3D buildings are created by using 'photo-real' technique to 'pave' the surface of the building. Figure 8 shows the Hwa-Gang campus 3D Visualization Simulation.

Figure 8. Hwa-Gang Campus 3D Visualization Simulation

4.2 Digital National Park

Some application scenarios for the Digital High Resolution Yangmingshan National Park are as follows: The geology layers and the soil thickness layers of natural resource samples in the raster format for Yangmingshan National Park geodatabase are shown as Figures 9 and 10.

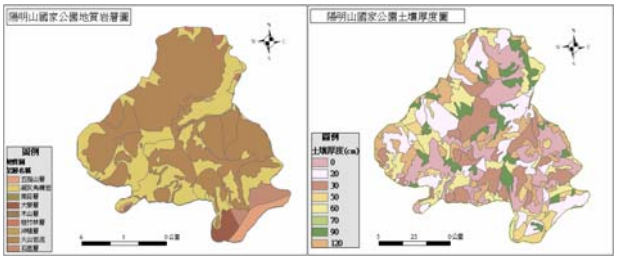

Figure 9. Geology Layers Figure 10. Soil Thickness Layers

Some project final output layer maps are obtained by the GIS spatial analysis operation process from overlapping geology, soil, and slope layers and are very useful for future research usage. The landslide sensitive area layers of hazard prevention samples in the raster format for Yangmingshan National Park geodatabase are shown as Figure 11.

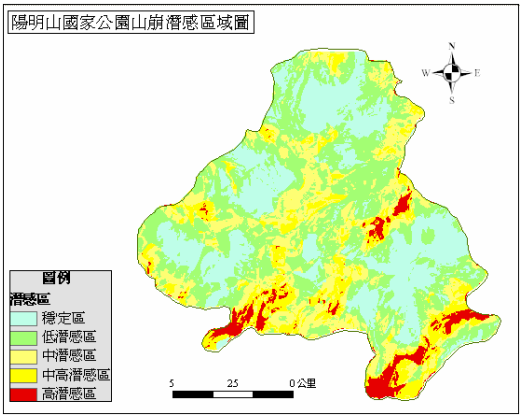

Figure 11. YMS National Park GIS Landslide Sensitive Layer

The website of Digital YMS National Park geodatabase includes all the related research information and descriptions and online WebGIS operation procedure. The website of Digital YMS National Park geodatabase is shown as Figure12. An example of a geological data query taken from the WebGIS Query System webpage for Digital YMS National Park geodatabase is shown as Figure13.

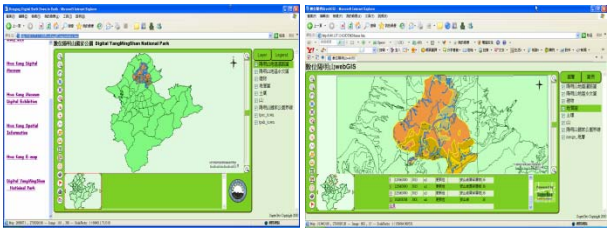

Figure 12. Geodatabase Website Figure 13. WebGIS Query

The 3D Fly simulation for YMS National Park is shown as Figure 14.

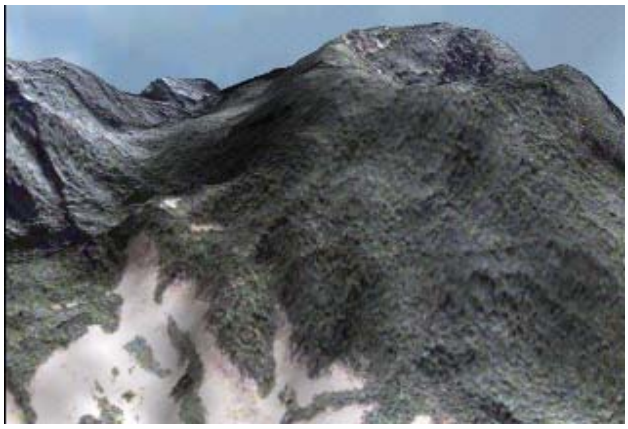

Figure14. YMS National Park 3D Fly Simulation

5. SUMMERY

This study focuses on a smaller size campus community. To finish the Digital Hwa-Gang project we face the problems of various different requirements, mass information distribution and demands for quick data communication response from Hwa-Gang residents. The Digital Hwa-Gang project faces problems focusing on aspects of ecological, economical, technological, cultural and social studies. We found that to implement the digital community, we must deal with problems converting the mass information into geodatabase and creating the functions for the WebGIS. The smaller Hwa-Gang area is suitable for using high resolution digital images and DEM to present more detailed information. To improve the digital community the project needs more time and manpower. Some suggestions can be made for future work: The database for the Digital Hwa-Gang Spatial Information Query WebGIS System should be continuously updated and added to, especially in building a satellite image database from Taiwan's Formosat-2 satellite images. The items and functions in the Hwa-Gang Address Query WebGIS System should be increased in order to meet the needs of Hwa-Gang community members. Higher resolution DEM modified from Lidar generated DSM data and high resolution digital aerial images will be available for the Digital Hwa-Gang 3D Visualization Display project in the future. It remains a challenge to gain better results in the 3D modelling of buildings.

As high resolution digital aerial images and Lidar images are available in Taiwan, Taiwan's remote sensing satellite Formosat-2 also efficiently provides two-meter high-resolution imagery. There are more needs and applications in using new material. Therefore, in this study we explore the possibility of establishing a high resolution geodatabase for Yangmingshan National Park by using all the available Geo-information.

This project merges massive high resolution images into a geodatabase, creating problems in mass data storage, large image server, and the need for more efficient computer operation functions. In order to handle such mass information and expand new applications, the established digital high resolution geodatabase has been introduced into CCU's high performance computing system. With the new computer system we face the fresh challenge of new applications.
The high resolution geodatabase with interactive WebGIS operations should lead to an increase in new demands for near real-time images from users. The geodatabase preprocessing and attribute information updating work will have to be more intensive in the future. We will continue maintaining the established digital geodatabase and try to provide new updated information for the studies of environmental conservation, hazard prevention and sustainable development of natural resources.

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