ASSESSMENT OF HIGH SPEED INTERNET FOR REMOTE SENSING DATA ACQUISITION AND EXCHANGE IN COLOMBIA AND LATIN AMERICA

Carlos Meneses, Glenn Hyman, Johan Munoz, Tania Jordan, Claudia Perea

Centro Internacional de Agricultura Tropical (CIAT)
Email: c.meneses@cgiar.org, g.hyman@cgiar.org, j.munoz@cgiar.org; t.jordan@cgiar.org; c.perea@cgiar.org
Teléfono: (57-1) 2 4450-000 Cali- Colombia

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Abstract

New remote sensing platforms and data programs have dramatically increased the availability of satellite image data for analysis of climate, agriculture, environment and society. Particularly important new sensor systems include the USA's MODIS system, Brazil and China's CBER platform, and India's IRS satellite. These and other systems have created considerable benefits to the international community of remote sensing analysts. Today, we have more data with greater options regarding spatial, radiometric and temporal resolution.

While having these greater options is a positive development, substantial problems remain in acquiring and managing large data volumes. Data providers and consumers must support significant costs in copying remote sensing data to tapes and disks. Internet transfer of satellite imagery is only possible on broadband networks. Even then, download times can be considerable. Downloads may be interrupted if the Internet connections are unstable.

How can we improve the acquisition of large volumes of remote sensing data for environmental analysis? What alternatives are available to remote sensing researchers to acquire near-real time satellite imagery for research use?

This paper assesses the potential of high-speed Internet as a medium for transferring large satellite imagery data sets between the United States and Colombia, between Colombia and other Latin American countries and within Colombia. Academic and research networks have led developments in high-speed Internet. Many countries throughout the world are installing the infrastructure needed to develop these networks. In the United States this system is referred to as Internet 2. Latin American countries are developing a system called RedCLARA (Cooperación Latinoamericana de Redes Avanzadas). In January 2006, Colombia launched the National Advanced Academic and Technology Network (RENATA). Our analysis examines the potential of this network for utilizing satellite imagery for research purposes. We assess download times for transferring data. We compare the efficiency of high speed networks to normal broadband and to other forms of transferring satellite data

transfer. Our analysis also considers how high speed networks can facilitate image browsing before users decide to download the data.
Our analysis suggests that Colombia and Latin America's recent development of high speed Internet for universities and advanced research institutes has great potential for improving the efficiency of use of remotely sensed imagery.

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Introduction

Capacities to carry out remote sensing science and technology have increased substantially over the last decade due to the combined influence of many factors. The availability of data has perhaps been the most important reason for this improved capacity (Chen, 2005). New data programs from non-traditional providers like China and Brazil are adding to globally available content. Data sets at finer resolutions have also helped to increase capacities to conduct analyses. Improvements in computing – improved software, faster processors, larger storage mechanisms, more efficient networks – have also helped to increase the capacity to use remote sensing for science and technology applications.

Despite these improvements, substantial gaps remain in access to remote sensing technology and data, especially in the developing countries. While satellite programs in Brazil, China and India have improved capacities in those countries, a great many nations do not have this type of access. One difficulty is that often property rights or commercial interests prove to be an obstacle to disseminating data (USDA, 2003). However much of the problem for developing countries is simply the logistics of acquiring data. Poor public postal systems in many countries hamper dissemination of tapes, CDs and DVDs. Commercial courier service can be expensive. Much of the problem is the international transfer of remote sensing imagery. The Internet will likely be the solution to data transfer problems. But current data transfer speeds on the Internet are insufficient for transferring large file sizes that are typical of remote sensing imagery. This paper addresses the question of how this Internet bottleneck could be resolved.

Our proposal is to increase capacity in remote sensing science and technology by taking advantage of high speed internet for non-commercial use by universities and research institutes in Colombia and throughout Latin America. The initiative would build on recent efforts to build high speed Internet connections among the academic and research communities of the region. Government data providers could participate when their data dissemination policies are goals are in line with supporting public research in the region. Some initial connectivity tests were made between research institutes and data providers in Colombia, Peru, Mexico, Guatemala and the United States. Data transfer speed was as much as four times greater than conventional Internet. A ten-fold increase in data transfer speed can be obtained once the full bandwidth capabilities of the high speed Internet system are implemented.

Data Access Problems

Several difficulties create obstacles to accessing remote sensing data. Acquiring data through government postal service is not an attractive option in most cases. In many countries the postal service is unreliable. Courier service is an option, but can be expensive. The logistics of making payments for shipping tapes, CDs and DVDs can be difficult to arrange for the data user due to different financial transfer processes between the country of the data provider and that of the user. The Internet would seem to be the ideal solution. But data transfer velocities for the Internet are often too slow. Acquiring more than a few image scenes could potentially take from a half day

to several days to weeks to download. In many parts of the world, Internet connections fail. With long download times, this is even more likely.

Our experience with a vegetation analysis of Latin America illustrates the difficulties of acquiring satellite imagery. CIAT and partners are conducting a continental analysis of vegetation change using MODIS (or Moderate Resolution Imaging Spectroradiometer) imagery. The research requires 250 m resolution image products captured every 16 days for the entire mainland of the continent. The products include spectral bands, vegetation indices (EVI and NDVI), quality data and metadata, all provided by the United States Geological Survey's (USGS) Eros Data Center (EDC) in Sioux Falls, South Dakota, USA. The combined imagery corresponds to more than 2 terabytes of data. Obviously we could not download such a huge volume of data. EDC rejected our offer to send a hard drive to Sioux Falls for copying the data, a solution that conflicts with their data processing policies. The solution was for EDC to burn 500 DVDs, shipping them by commercial courier to CIAT headquarters in Cali, Colombia. It should be noted that this solution was worked out in the context of a visiting scientist program between CIAT and EDC. Acquiring these images would have been difficult without the close collaboration that the two institutions had build up over the years.

The solution had several drawbacks. One problem is the time that it takes EDC to download the images to DVDs. When the data arrived at CIAT, a technician was employed to upload the DVDs to our servers. Since the project will continue into the future, new images will be needed every 16 days. The costs of mail shipments would be prohibitive.

New opportunities to access data

Recent developments in networking infrastructure could solve many remote sensing data access problems for Latin America. At the regional level, universities and advanced research institutes have developed the project "Cooperation in Advanced Networks in Latin America" (CLARA, 2006: Figure 1).

The project is equivalent to Internet 2 in the United States. 18 Latin American countries in the region participate. The Latin American group has also forged high speed Internet links with Europe and the United States.

Colombia's high speed Internet network is called RENATA (Red Nacional Académica de Tecnología Avanzada) and comprises six subnational networks: (Figure 2).

Figure 1: CLARA Network

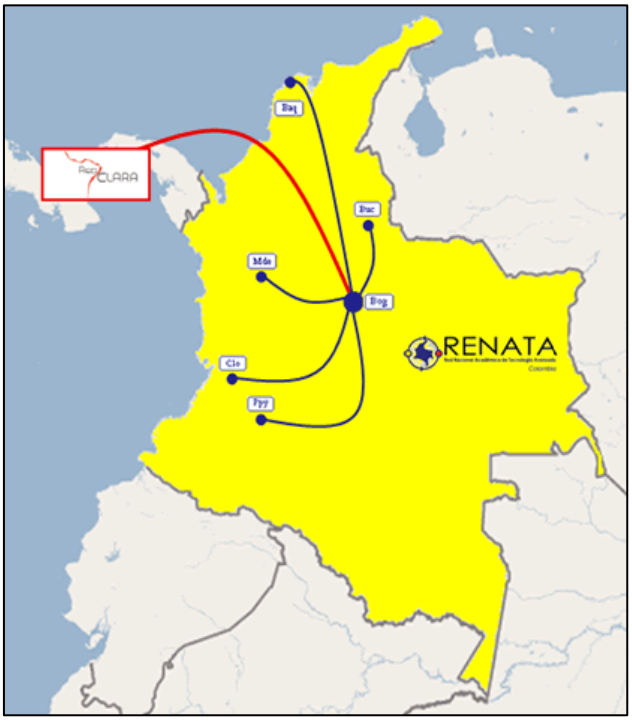

Figure 2: RENATA Network (Colombia's high-speed network)

These sub-networks are centered around the cities of Barranquila, Bucumaranga, Bogota, Medellin, Cali and Popayan. The network consists of 47 nodes, mostly universities, but also including some advanced research institutes.

The Latin American and Colombian high speed Internet networks are still in the initial stages of development. In Colombia, connectivity problems are being addressed to make the system run more smoothly. Developers of the system are working on applications in grid computing, videoconferencing, interactive distance learning, virtual laboratories and other applications. The system is made efficient by excluding SPAM, commercial Web sites, peer to peer programs and all other non-scientific content. The initiative seems to be well suited to applications in geographic information systems (GIS) and remote sensing, fields that deal with very large files. Since much of this technology is for non-commercial use, researchers in universities and advanced research institutes could take advantage of high speed Internet to build capacities.

How such a system might work

Data providers must participate in any effort to launch high speed networks for remote sensing research in Latin America. Most satellite imagery providers have some kind of mandate to support partner countries in the use of remote sensing technology. For example, the United States' remote sensing policy mentions the need to share data as part of overall diplomatic efforts (USDA, 2003). Other countries like Brazil, China and India will make special arrangements to provide data for non-commercial use.

The developers of high speed Internet must also be willing to provide the infrastructure support for using the network to support remote sensing science and technology. In principle, this kind of support is a key objective of groups like CLARA, RENATA and Internet2. For example, CLARA and Internet2 signed a memorandum of understanding with the objective of supporting non-commercial research and development between Latin America and the United States (CLARA 2003).

CIAT and partners recently tested high speed Internet connections to assess the viability of transferring satellite imagery (Table 1). Tests were made between CIAT headquarters and our partners in Peru, Mexico, Guatemala and the United States. The connection with the USGS Eros Data Center is particularly important since they are one of the world's leading satellite image data providers. At present, making these connections is not simple or straightforward. A considerable amount of electronic mail correspondence was necessary to set all the connections up.

Our tests included satellite image files from the MODIS platform. The MODIS files were 150 M bytes in size. Data transfer speeds from our tests showed improvements on the order of two to four faster than convention Internet (Figure 3).

Table 1. Institutions participating in connectivity tests.

Name of Institution	Acronym	Purpose	Location
International Center for Tropical Agriculture	CIAT	Agricultural research and development for the tropics	Cali, Colombia
Eros Data Center	USGS-EDC	Study landscape, natural resources and natural hazards	Sufalls, South Dakota
International Potato Center	CIP	Root crops research for small farmers.	Lima, Peru
Universidad Mariano Galvez	UMG	University	Guatemala
International Wheat and Maize Improvement Center	CIMMYT	Research in Wheat and Maize improvement	Texcoco, Mexico
Institucion Universitario Politécnico GranColombiano	POLIGRAN	University	Bogota, Colombia

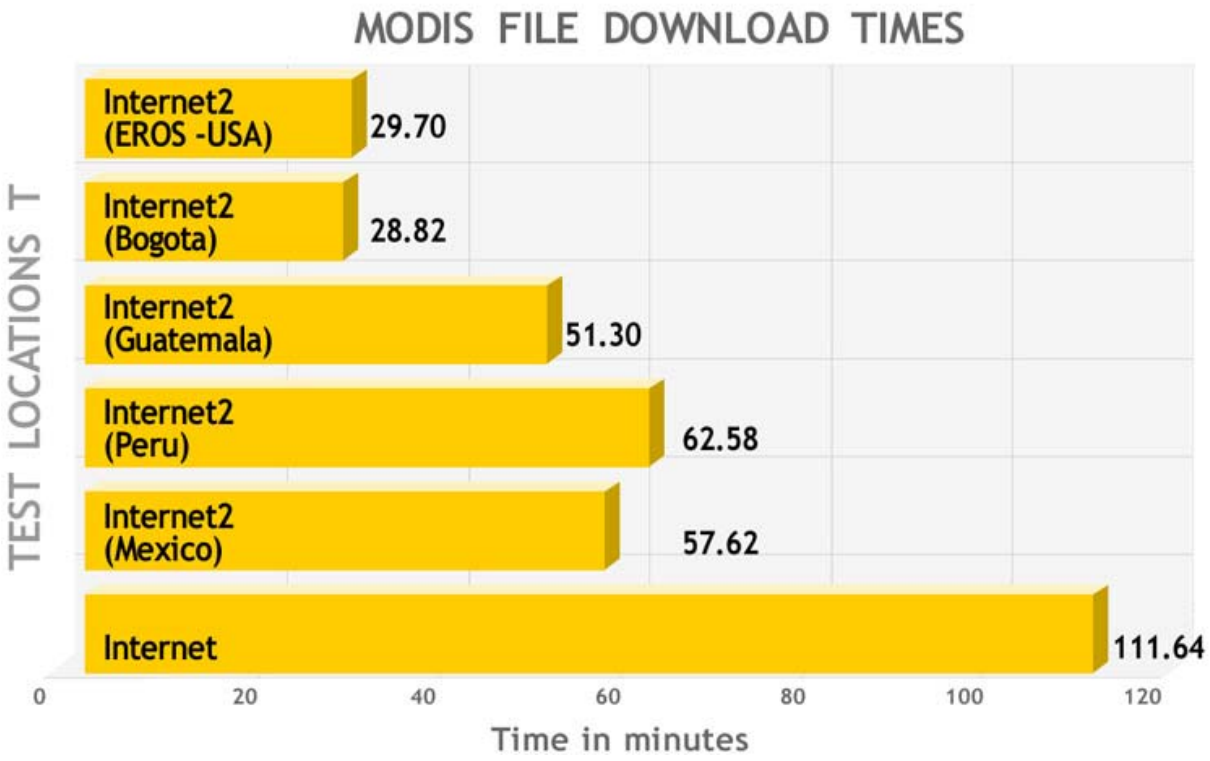

Figure 3

Data transfers from Cali, Colombia to Mexico and Peru were twice as fast. Connections between the United States and Bogota were 4 times as fast. Download times could improve to a ten-fold or greater increase over conventional Internet when the Colombian and Latin American networks are fully implemented.

The download times shown in Figure 3 are partly due to the bandwidth designed for the initial stages of development. Current bandwidth is 10 M bytes shared amongst all the universities in Colombia. Future increases in bandwidth will depend on the quantity and type of applications that will use the network. Increasing the bandwidth is not a technical limitation. Currently, it's possible to increase the link up to 155M bytes, but this depends on user requirements and funding resources.

Remote sensing applications in Colombia and Latin America

While high speed Internet could solve imagery access issues, there are many other applications for remote sensing and geographic information science and technology. For example, the system could decentralize data, models and processing throughout the region. Decentralization would be in line with larger trends in computing and networking. Another application is grid computing. Computing-intensive digital image processing could take advantage of a grid computing network over high speed Internet. Processes that take days and weeks to run could be conducted in a few hours or less. High speed Internet also opens up possibilities to collaborate with colleagues in different institutions. Groupware and collaborative tools are becoming increasingly popular, and would run particularly well on high speed networks. For example, interactive maps are notoriously difficult to use on conventional Internet. Drawing graphics and accessing data needs high velocity computing that RENATA, CLARA and Internet2 are providing.

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