

SATELLITE IMAGERY AND INFORMATION NETWORKS FOR MONITORING CLIMATE AND VEGETATION IN COLOMBIA

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ABSTRACT

Remote sensing and monitoring of vegetation and climate on time scales of the growing season and shorter can provide important information for agricultural and food security planning. Projects such as the United States Department of Agriculture's (USDA) CropExplorer and the well-known Famine Early Warning System Network (FEWSNET) are prominent examples of how to bring remotely sensed information to decision-makers in agriculture and food security.

These systems have some shortcomings that limit their utility, especially by researchers that need remote sensing imagery before processing. Another shortcoming with these systems is that the original remote sensing data for the assessments is not widely available to a broad range of researchers in a given country. Remote sensing data is often difficult to acquire in countries that do not have the satellite systems which provide the data.

How might some of these limitations be overcome? How could we facilitate increased use of remote sensing data for monitoring climate and vegetation in Colombia?

We propose to develop a network of specialists in Colombia applying remote sensing and other technologies to monitoring vegetation and climate for agriculture. The network would take advantage of the availability of remote sensing data and the high speed Internet networks under development in Colombia.

The network would feature organizational and technological components that would support greater use of information in Colombian universities and advanced research institutes. A key technology for the network is NASA's MODIS satellites, which provide information on vegetation condition, land cover and surface temperature. The network would develop processes that facilitate the use of MODIS data by Colombian researchers. Since there are large volumes of data available, Colombia's high speed Internet network – RENATA – will be employed as a medium to transfer imagery.

The partners would include all Colombian universities with remote sensing and computer networking capacities. The network would build a strong alliance with the Eros Data Center (EDC) of the United States Geological Survey (USGS) in Sioux Falls, South Dakota, USA. EDC provides several different types of imagery for use in vegetation and climate monitoring. EDC provides MODIS data shortly after image acquisition. The network would also forge strong links with researchers that manage ground weather stations and capability for field verification of satellite imagery. Organizations who use assessments of vegetation and climate would be another natural partner for the proposed network. We have prototyped some components of the proposed network. The proposed system could have considerable impact on research and decision making related to monitoring weather and climate in Colombia.

INTRODUCTION

This paper describes a proposal for establishing a network of researchers and analysts for monitoring weather and vegetation for Colombian agriculture. Opportunities for using satellite images and other data products are evaluated. The paper suggests how such a network could be put together. Some preliminary pilot studies have been conducted to assess the feasibility of the proposed project.

Weather and vegetation monitoring for agriculture and food security

Agricultural and environmental scientists, market analysts, farmers and others monitor weather and vegetation change throughout the growing season. The information can be used by the Ministry of Agriculture to plan extension activities. Market analysts use the data to estimate shortfalls in production or likely effects on prices of the coming harvest. Researchers use weather and vegetation information to better understand how climate affects crop growth and yield, and other factors related to agroecosystem health.

Scientists and professionals in developed countries have made great progress in developing weather and vegetation monitoring systems for agriculture. Some of the demand for these systems has come from market analysts who want to know how reduced or increased harvest might affect farm and food prices in different parts of a country or the world. One example of such a system is the United States Department of Agriculture's Crop Explorer, which provides data for users throughout the world (Foreign Agricultural Service, 2006). Other uses of weather and vegetation data are food security professionals. The Famine Early Warning System developed for Africa and Central America provides information from satellites for countries to plan their food aid programs in the context of expected harvests due to weather conditions (FEWSNET, 2006).

Weather and vegetation monitoring for Colombia

As with many countries, networks of weather stations cannot cover the full range of agricultural environments throughout the country. A satellite-based weather and vegetation monitoring system that could provide data for places without ground stations would be of great benefit to agricultural areas that lack monitoring infrastructure.

Food security monitoring systems such as FEWSNET are not yet available for Colombia. Although it is possible that Colombia could become a partner in FEWSNET in the future, it is unlikely to happen soon. Colombia is of lower priority for food security monitoring since the country has relatively less drought than other countries. Some information from Crop Explorer is available for Colombia, but often researchers need access to the raw data. Another problem for Colombia is the lack of use of satellite imagery by the research and development community. Sometimes raw data is inaccessible to people outside of the country in which it was produced. Shipping data by Internet or mail courier may present additional problems to acquiring satellite data. Language barriers, lack of training and other factors may also contribute to less use of satellite imagery.

How might some of these limitations be overcome? How could we facilitate increased use of remote sensing data for monitoring climate and vegetation in Colombia?

A proposal for a climate and vegetation monitoring network for Colombia

We propose to develop a network that would improve decision-making for Colombian farmers by providing researchers and analysts with useful near-real time satellite data on weather and

vegetation. The project would support the larger goal of providing information that supports increased productivity and food security in Colombian agriculture.

Data for monitoring vegetation and weather

Governments and data providers are increasing the number of satellites and imagery products that are available to users of this data throughout the world. Countries with a long history of satellite imagery programs, like the United States, Russia and France, are making more of their products available to users. More recently countries such as China, Brazil and India have made new imagery products available. The availability of these data are creating new opportunities for monitoring weather and vegetation.

Two data products for monitoring weather and vegetation would be appropriate for Colombia. MODIS imagery and the Tropical Rainfall Measuring Mission (TRMM) data sets provide data on vegetation vigor and rainfall respectively. Vegetation indices can be developed from the MODIS imagery to estimate the vigor or moisture of plants. The MODIS images are available at 250, 500 and 1000 meter spatial resolutions. Other variables available from MODIS include reflectance, temperature, aerosols and others. Imagery for a given scene is taken every 16 days. The TRMM data is available every 3 hours from the NASA web site (NASA, 2006). Rainfall is reported in millimeters for 3-hour or greater time periods for the entire globe. One advantage of this data set is for areas where no ground rain gages are available. TRMM is a viable alternative for countries that have poor coverage of weather stations or have otherwise been unable to maintain stations.

The MODIS and TRMM data have been processed for Colombia as a pilot study at the International Center for Tropical Agriculture (CIAT). With the assistance of the United States Geological Survey (USGS), we were able to fully process vegetation indices from MODIS images. Processing requires selecting high quality imagery, stitching together image tiles, re-projecting the data to a standard Colombian coordinate system and converting the images to formats appropriate for digital image processing and geographic information systems software. Figure 1a and 1b shows January 2004 images of the enhanced vegetation index (EVI) and the normalized difference vegetation index (NDVI) for Colombia. Many of the processing algorithms are provided by the USGS. Without the assistance of USGS scientists it would have been very difficult for us to put together these images. But with better-documented programs, the processing algorithms could be applied by a wide range of potential users. One difficulty in developing these images is in acquiring the raw data itself. We acquired these data by special arrangement with Eros Data Center. They were sent to Colombia by international mail courier on DVDs. Standard download times are too slow to acquire the images over the Internet. We discuss potential solutions to acquiring the data more efficiently later in this document.

We have also acquired TRMM data for Colombia and the surrounding regions (Figure 2). These data sets were developed by colleagues at the United States Geological Survey. Each digital map shows the 10-day rainfall accumulation in millimeters. Pixels are 0.25 degrees of longitude and latitude. The rainfall maps have adequate temporal and spatial resolution for vegetation and climate monitoring.

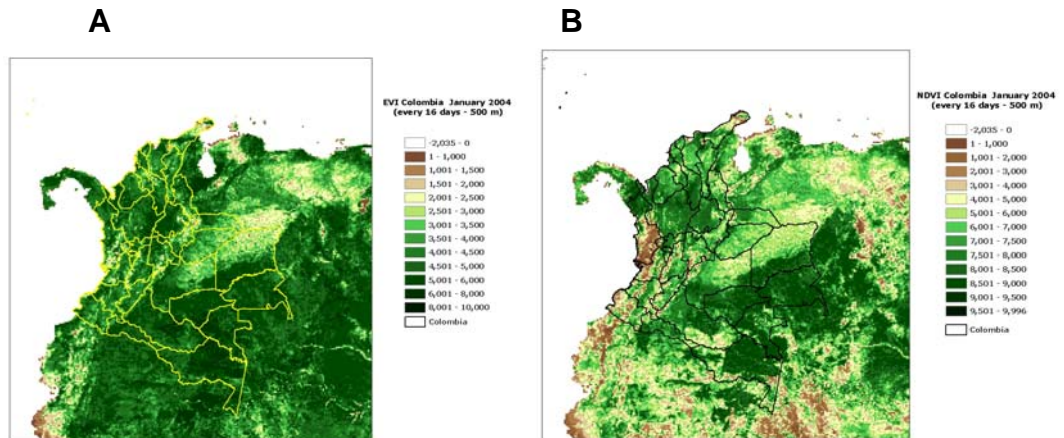


Figure 1. Vegetation indices from January 2004 of Colombia. (A) shows the enhanced vegetation index (EVI). (B) is the normalized difference vegetation index (NDVI).

Necessary elements of any satellite monitoring program are ground data to calibrate and validate information from imagery. Some measures could be direct comparisons. TRMM data can be compared against any weather station that maintains suitable records. Vegetation indices can be compared with different measures collected in the field, such as soil moisture and field spectrometer data. An inventory of available ground data would need to be developed. Most of this data would likely come from government agencies such as the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) or the Ministry of Agriculture. Some of the information could come from farmer organizations and their research institutes, such as the Coffee Federation and

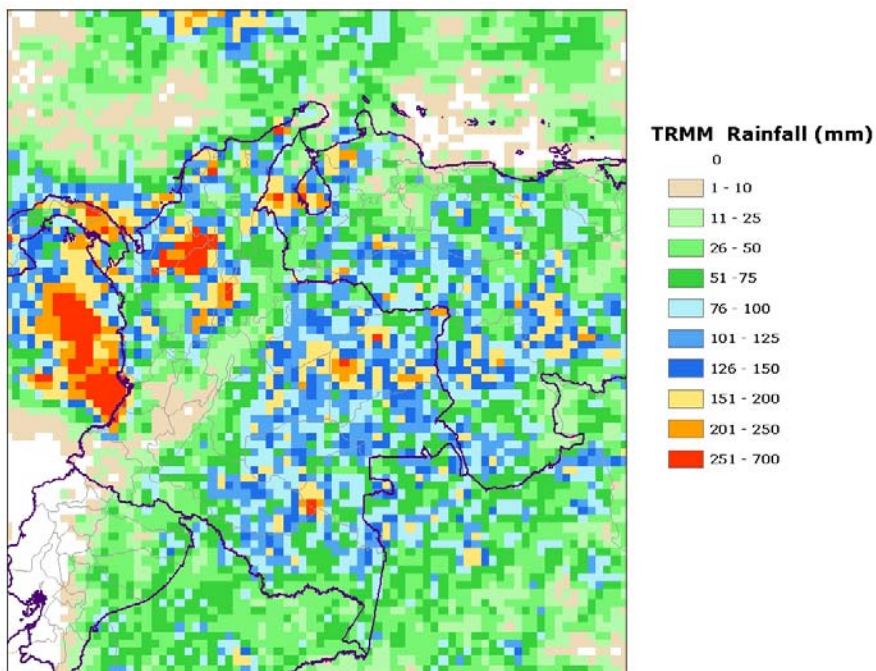


Figure 2. Accumulated rainfall between June 10th and 20th of 2005 from the TRMM satellite. Data set courtesy of Diego Pedreros, USGS.

the association of sugar cane growers. An important source of ground data will be universities and advanced research institutes. The next sections discusses how satellite-derived data products, ground station data and the people that work with this information can be integrated into a functioning network.

High speed Internet networks for data exchange

Columbian users of remote sensing data have traditionally found difficulties in acquiring satellite imagery for environmental analysis. In the past the cost of the data product itself has been prohibitive. But that is changing with new policies from countries providing data. The cost of sending the data from the producer to the end user is also a substantial obstacle. Some data providers may not send data overseas or it may be too expensive. In a project on vegetation change for South America, CIAT requested MODIS imagery for all of South America. Due to policies of the USGS and lack of other options, the imagery was copied onto 500 DVD's. The costs included the price of the DVD's, the time for technicians to upload the data to the DVD's and download it once it arrived at its destination, as well as the shipping fees. Downloading images on the Internet could work in cases where the images are small. But current bandwidth conditions prevent this option in most cases.

We are proposing to utilize high speed Internet connections for downloading imagery. Colombia recently joined international efforts to develop high speed Internet. The system is called Internet II in the United States. Colombia's network is called the National Academic Network of Advanced Technology or RENATA for its Spanish acronym (RENATA, 2006). The network connects 25 universities and advanced research institutes by high-bandwidth communication lines. The network has nodes in 6 regions centered on the cities of Bogota, Barranquilla, Bucamaranga, Cali, Medellin and Popayan. Other regions are expected to join the network in later phases. Table 1 shows how the characteristics of high speed Internet fit well with a research and development project that uses enormous and difficult to manage remote sensing data sets for monitoring vegetation and climate.

	Internet	High speed Internet
Use	general	academic, research
Technologies	proven, common	proven, common, advanced
Quality of service	variable	advanced
Connection type	personal, ISP	1 connection per country (RENATA)
Connection speed	normal	very fast
Content	any	non-commercial, academic, research, educational

Table 1. Characteristics of normal Internet and high speed Internet

Since the Eros Data Center in Sioux Falls, SD is an Internet II node, the Colombian network can be connected to the main data provider of MODIS imagery. Eros Data Center provides other potentially useful image products from United States satellite programs. We have yet to test the speed of the connection between Colombia and Eros Data Center. But we have been able to establish the connection. The next step is to benchmark download times and further evaluate the possibility that

Colombia and the United States could set up a project to provide MODIS and other imagery for vegetation and weather monitoring. A Colombian high speed Internet network for remote sensing specialists could open up new opportunities in addition to those described above. Distributed data storage and maintenance, dynamic mapping and grid computing are three applications that seem to be well suited to our proposed network.

Groupware for information exchange

A climate and vegetation monitoring network for Colombia will need a mechanism to share information among researchers and analysts throughout the country. We propose the development of software for image storage and inventory, sharing technical information, participation in ground verification and validation activities and other forms of collaboration among the remote sensing community of Colombia. Figure 3 shows a prototype Web site that could serve as the communication mechanism for the project (<http://198.93.225.109/valle/tiki-index.php>). This prototype was developed using open source Tiki Wiki software.

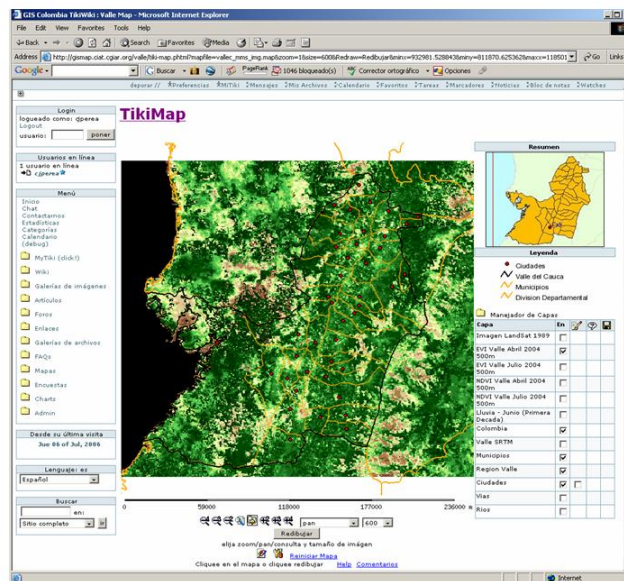


Figure 3. Prototype Web site for weather and vegetation monitoring

The site includes capacities for file transfer, image viewing and collaboration in groups. Partners can download images using the file transfer protocol (FTP). An interactive map interface permits users to view “quick look” images in order to assess cloud cover or other image characteristics before downloading. Vector GIS files of roads, towns and other reference layers can be overlaid on these “quick look” images. The site includes file galleries where partners in the network can share technical information, data and any other digital files related to vegetation and weather monitoring in Colombia. The site includes other groupware tools such as forums, surveys, calendars and many others. The groupware tools would be used to integrate data, methods, hardware, software and people into a functioning network for monitoring vegetation and climate in Colombia.

CONCLUSION

This paper described a proposal for setting up a Colombian network to monitor vegetation and weather during the growing season from satellite and ground data. The network would provide

MODIS, TRMM and other satellite image products to Colombian researchers and analysts. Ground data would be shared for calibrating and validating the images. The network would take advantage of Colombia's high speed Internet for exchanging image files. The community of researchers and analysts will use groupware for exchanging information, data, imagery and results from the project.

The concept and methods of the proposed project could be replicated in other developing countries. Almost all the mainland Latin American countries are developing high speed Internet networks. Recent trends in information and communication technologies suggest that this type of network would receive broad support from governments, universities and advanced research institutes. The next step is to gauge the interest of potential partners and seek funding for future development.

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