USE OF OPERATIONAL SATELLITE DATA IN CENTRAL AMERICA TO SUPPORT DISASTER MANAGEMENT

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ABSTRACT

In order for Central American countries to respond to weather related disasters, they need to have strong meteorological forecasting capabilities, knowledge of the current state of the land and water resources, and emergency plans of action. In response to the devastating effects of Hurricane Mitch (October 1998), the United States Agency for International Development funded a project through the National Oceanic and Atmospheric Administration (NOAA), the National Environmental Satellite, Data, and Information Service (NESDIS), and the Cooperative Institute for Research in the Atmosphere to improve the forecasting capabilities in Central American countries. The project included upgrading the geostationary satellite receive capabilities and installing a data server at the Instituto Meteorológico Nacional (IMN) in San José, Costa Rica to serve digital satellite data to the surrounding countries through the Internet. Project plans included the installation of Personal Computers loaded with McIDAS/RAMSDIS software in Costa Rica and the surrounding six countries (Belize, El Salvador, Guatemala, Honduras, Nicaragua, and Panama). Training sessions were scheduled on the use of the RAMSDIS systems and satellite imagery interpretation. In addition, a visiting scientist from IMN was selected to work with the NOAA/NESDIS Hydrology Team in Camp Springs, Maryland to adapt the satellite based rainfall techniques for Central America to be used by the forecasters and for input to hydrologic models. This project was successful in part due to prior cooperative efforts in the region. This article chronicles events both prior to and during the project and presents ongoing efforts in the region.

INTRODUCTION

One of the components necessary to responding to weather related disasters is the ability to forecast and monitor the weather as it happens. Other components include knowledge of the status of the hydrologic, geologic and natural resources of the region, and integration of the information to produce plans of action. Here the focus is on the weather. In many Central American countries resources are limited for monitoring the weather. There are few daily soundings, no radar facilities, and a dearth of rainfall monitoring stations. Remote sensing resources are available, but in the past, many Central American countries received GOES satellite imagery in picture format at infrequent time intervals. In many countries, the forecasters receive Class II meteorological training – the minimal as suggested by the World Meteorological Organization. There are few forecasters who have a college degree, and

even fewer who have training at the Masters level or beyond. In addition, many governments give minimal financial support to their forecast offices. In order to strengthen the forecasting capabilities in Central American Countries tools and training must be a component.

In response to the devastating effects of Hurricane Mitch in 1998, the United States Agency for International Development funded one of its many projects through the National Oceanic and Atmospheric Administration (NOAA), the National Environmental Satellite, Data, and Information Service (NESDIS), and the Cooperative Institute for Research in the Atmosphere to improve the forecasting capabilities in Central American Countries. This past July, Global Imaging Inc., under contract with NOAA/NESDIS, installed a Geostationary Operational Environmental Satellite (GOES) receive ground station and server at the Instituto Meteorológico Nacional (IMN) in San José, Costa Rica. The server has made GOES-8 imagery and products available to the surrounding six Central American Countries (Belize, El Salvador, Guatemala, Honduras, Nicaragua, and Panama). In addition, Personal Computers (PCs) loaded with the Man computer Interactive Data and Analysis System (McIDAS) software (Lazzara et al., 1999) and the Regional and Mesoscale Meteorology Advanced Meteorological Satellite Demonstration and Interpretation System (RAMSDIS) interface (Molenar et al., 2000) were installed in Costa Rica and the surrounding six countries to ingest and display the satellite imagery. The key collaborators in Central America were: the World Meteorological Organization's (WMO) Regional Meteorological Training Center (RMTC) located at the University of Costa Rica (UCR), the National Meteorological Services in Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panamá, the USAID Missions, and the Comité Regional de Recursos Hidráulicos.

Background

The NOAA/NESDIS/CIRA interaction with Central American and Caribbean Countries began before Hurricane Mitch. In 1996, the 45th session of the World Meteorological Organization (WMO) executive council recommended that "each satellite operator ... cooperate with at least one of the specialized satellite applications training centres ("centres of excellence") strategically located around the globe with regard to the satellite programme, facilities and expertise required" (Purdom, 1997). Under this activity, NOAA/NESDIS/ CIRA partnered with NOAA's Cooperative Institute for Meteorological Satellite Studies (CIMSS) and the Regional Meteorological Training Centers (RMTCs) in Costa Rica and Barbados.

The RMTC in Costa Rica is closely associated with the Universidad de Costa Rica (UCR), and Dr. Vilma Castro Leon has been the driving force behind their activities. The RMTC in Barbados is closely associated with the Caribbean Institute for Meteorology and Hydrology and Mr. Selvin Burton and his brother Horace have been leading the efforts in the Caribbean. Dr. Bernadette Connell acted as the focal point for the RMTCs to interact with CIRA. The original project was designed around the concept of the virtual laboratory, which focuses on using PCs with the McIDAS/RAMSDIS software, case study data sets, and Internet connections to demonstrate the invaluable use of digital satellite imagery. When used as a data ingest system, the RAMSDIS workstation is capable of pulling in and displaying real time loops of visible, infrared, and water vapor imagery at various scales for analysis by meteorologists. Imagery loops and analysis programs can be easily accessed through the Graphic User Interface buttons at the bottom of the image screen.

Activities and Prior Training

Since the inception of the program, many sets of retrospective digital satellite imagery have been provided to both Costa Rica and Barbados. These case studies include heavy rain events associated with hurricanes at different stages of development and heavy rains associated with tropical waves. Other case studies focused on cycles of convective development over land and water, strong wind events, fire detection, and volcanic ash detection. The case studies have been used for training on the use of single and multi-channel imagery in detecting fog, water and ice cloud, and on the use of applications such as image averaging and determining cloud motion winds.

In addition to these case data sets, a major effort was initiated in Costa Rica in November 1996 and in Barbados in February of 1998 towards developing localized satellite climatology archives. Both RMTC's have utilized the satellite imagery in offerings of new satellite courses and by requiring students to use the RAMSDIS systems and digital data for class assignments and graduation theses.

In October of 1998, the WMO sponsored a two-week satellite meteorology training event in Barbados. Researchers from NOAA/NESDIS/CIRA worked closely with the RMTC in Barbados to develop the training schedule and prepare and deliver lectures and hands-on laboratories. Prior to the training, discussions had begun on upgrading satellite imagery receive capabilities in Central America, the Caribbean, and South America. With adequate Internet connections, the RAMSDIS system, which was successful in National Weather Service offices in the United States prior to the deployment of the Advanced Weather Interactive Processing System, was the perfect

candidate for distribution. In the meantime, Hurricane Mitch developed near the end of October 1998, and had devastating effects on many Central American countries. The focus of PC deployment at this point quickly changed to reconstruction efforts for the Central American countries.

HURRICANE MITCH RECOVERY EFFORTS

The initial NOAA/NESDIS/CIRA reconstruction efforts included the installation of a ground receive station in one of 5 Central American countries affected by Hurricane Mitch (Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua) and serving the data through the Internet to the other countries. Officials from CIRA, CIMSS, and NOAA/NESDIS traveled to the countries in October of 1999 to determine the most suitable location for the ground station. The RMTC and a regional organization, Comité Regional de Recursos Hidráulicos (CRRH), recommended that the ground station go to IMN in Costa Rica. IMN had an existing antenna with a ground station that displayed the imagery in TIFF format and it also had the best infrastructure to support the project. Both the RMTC and CRRH also recommended that Belize and Panamá be included in the project. Belize and Panamá were included with additional support from NOAA's National Weather Service Interagency Activities.

Installation of Equipment

As mentioned in the introduction, Global Imaging Inc., under contract with NOAA/NESDIS, installed a GOES receive ground station and server at IMN in San José, Costa Rica during the last week of July 2001. From July through October 2001, the PCs loaded with the McIDAS/RAMSDIS software were shipped to the various countries and installed. NOAA's NESDIS Office of International Affairs was instrumental in drawing up memorandums of agreement for transfer of property and responsibility for maintenance of equipment to each of the countries. They also aided in the shipment of the PCs by making contacts with the local USAID Missions in each country. Personnel from CIRA and UCR traveled to each of the countries for two days to set up the systems and give on-site technical and meteorological training.

Satellite Precipitation Estimates

One aspect of the Mitch Recovery effort was directed towards adaptation of satellite techniques to better identify and quantify heavy rain events. A CIRA visiting scientist, Rosario Alfaro, from the IMN in Costa Rica, was selected to work with the NOAA/NESDIS Hydrology Team in Camp Springs, Maryland to adapt the satellite based rainfall techniques, primarily the Autoestimator (Vicente and Scofield, 1998), for Central America. As part of her work, daily estimates of rainfall for Hurricane Keith, which made landfall in Belize in October 2000, were compared with rain gauge data. Comparisons of satellite rainfall estimates were also made with rain gauge data during the Central American rainy season of 2001. An example of the Autoestimator product for Hurricane Keith is presented in Figure 1. Rosario worked in Maryland from August 2000 through January 2002, when she returned to the IMN in Costa Rica to implement the satellite rainfall techniques.

Training

In December of 1999, a WMO sponsored two-week satellite meteorology training event was held at UCR in Costa Rica. As with the previous training in Barbados, researchers from NOAA/NESDIS/CIRA worked closely with the RMTC in Costa Rica to develop the training schedule and prepare and deliver lectures and hands-on laboratories. The Mitch Project took advantage of the opportunity and sponsored participants from four Central American countries (El Salvador, Guatemala, Honduras, and Nicaragua). In this and subsequent trainings, CRRH arranged the travel and lodging for the Mitch Project participants.

The first intensive one-week training was held at UCR in Costa Rica during the last week in April 2001 (Figure 2). In order to build on the information learned in the previous training, each country was asked to send the participants that attended the previous December 1999 training. The highlights of the training included a review of the GOES Imager channels and their applications, the Autoestimator and its results for Hurricane Keith (2000), the detection of fires and volcanic ash using satellite imagery, and hydrological applications. Since each of the attending countries were scheduled to receive RAMSDIS systems in the coming months, the laboratories used PC systems loaded with the McIDAS/RAMSDIS software to analyze case studies using retrospective digital data.

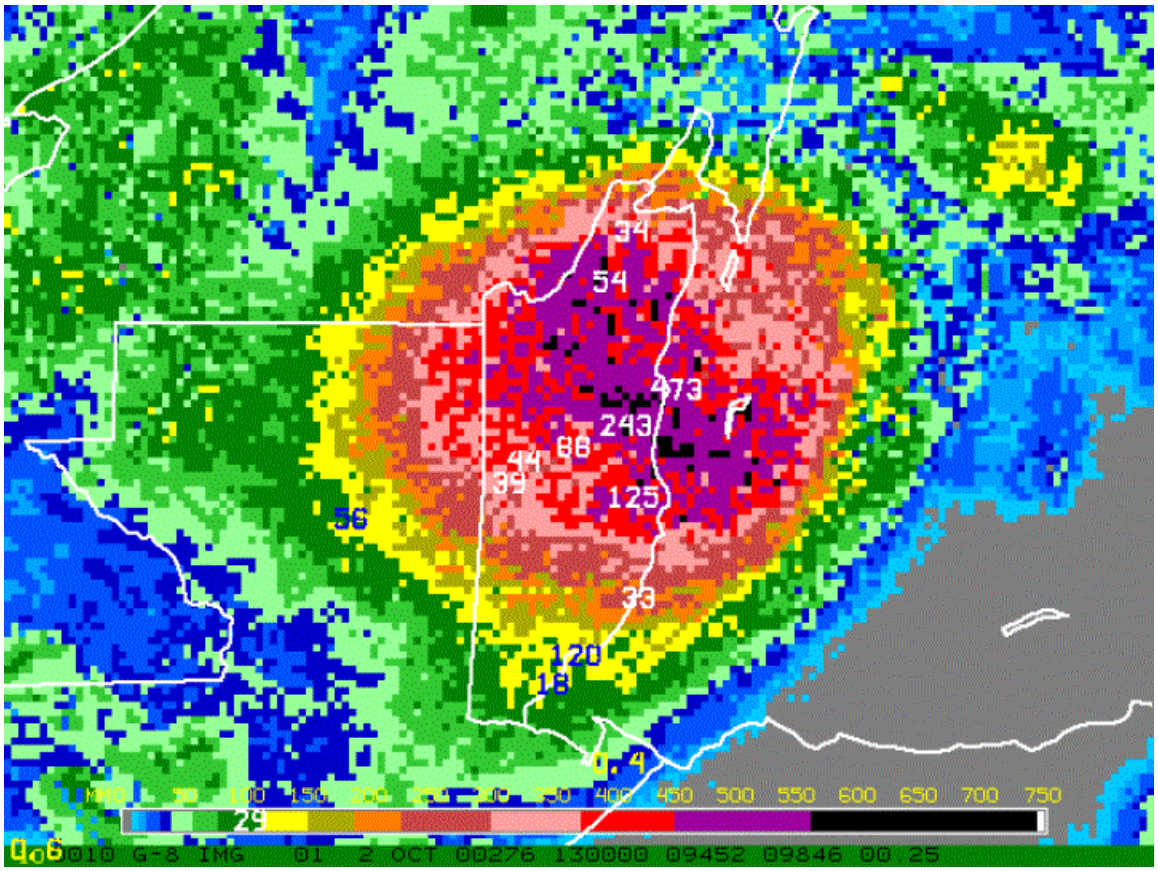

Figure 1. Satellite estimated rainfall (mm) from the Autoestimator for a 24-hour period (Oct. 1, 2000:1300 UTC - Oct. 2, 2000:1300 UTC) when Hurricane Keith made landfall over Belize. Values labeled on the image are precipitation measured at surface rain gauges (mm).

Figure 2. Participants and instructors for the one-week training held in April 2000 in Costa Rica.

The second intensive Mitch training was held December 4-7, 2001. It included a review of satellite image interpretation, rainfall estimation techniques and hydrological applications. Since the countries have their own RAMSDIS systems, the training also focused heavily on maintenance and troubleshooting.

Other Activities

One area of concern for disaster management not mentioned in this paper so far is the occurrence of fires in the region during the dry season. This can be of concern during a particularly dry year such as 1998. In separate funding through the Central America Integration System (SICA), a web page was developed to display the satellite rainfall estimates and fire detection products for Central America. (http://www.cira.colostate.edu/ramm/sica/main.html).

A project help desk was set up through UCR and includes a users email list. Questions on system functionality can be asked and answered and interesting weather features can be pointed out. Even though the USAID funding ran out at the end of December 2001, the help desk will continue operating through most of 2002.

Current Usage

The RAMSDIS systems are currently in use in each of the 7 Central American countries. They gained immediate acceptance in the forecast offices because of their ease of use. Besides providing the "typical" visible, infrared, and water vapor imagery at various scales every half hour, the satellite rainfall estimate product is being produced on the data server in Costa Rica. This product is available for analysis on the RAMSDIS system and is also being made available for input to hydrologic models. Both the rainfall products and the fire products are also being displayed on the web page mentioned in the previous section. We know the information is getting used because we get email when the systems go down.

LESSONS LEARNED

The completion of the project in a timely manner would not have been possible without the cooperation of persons from the many organizations involved and without the establishment of prior relations with the RMTC in Costa Rica. The RMTC was instrumental in facilitating the communication with the National Meteorological Services in each of the countries and in providing the training and help desk activities. Language could have been a barrier, but translation of agreements and training materials was extremely useful. The assistance of CRRH, a local organization, was helpful in making arrangements for the participants to attend the training in Costa Rica. The Spanish-speaking contractor, Global Imaging, that installed the GOES receive ground station in Costa Rica was also essential.

In terms of getting the equipment to the proper destination, it was extremely helpful to have the insight from individuals who have dealt with the same sort of issues previously – the NOAA/NESDIS International Affairs Office. It was very helpful to pay attention to shipping details and have an awareness of local Customs regulations and other important details. The help of the USAID Missions in each of the countries was essential. Following the chain of command was important in setting and meeting deadlines. On another note, technical and Internet capabilities are highly variable among the countries. Training and patience are helpful in overcoming technical difficulties; persistence is more helpful in overcoming Internet problems.

FUTURE INTERNATIONAL TRAINING GOALS

A meeting of an International Satellite Data Utilization and Training Focus Group was held at the European Meteorological Satellite (EUMETSAT) Agency in Darmstadt, Germany, 16-18 May, 2001. This meeting was organized by the World Meteorological Organization, and included representatives from NOAA/NESDIS, the RMTCs, and the international satellite community. A decision was made at this meeting to establish a Virtual Laboratory (VL) to foster the international exchange of satellite data and training material. For this purpose, web servers are being established at EUMETSAT, the Bureau of Meteorology (BOM) in Melbourne, Australia and at CIRA in Fort Collins, CO.

The focus includes the development of a library of resources for training and the establishment of centrally located sites to provide easy access to real-time satellite imagery. The web page under development at CIRA can be viewed at: http://www.cira.colostate.edu/ramm/wmovl/main.html

NOAA/NESDIS/CIRA will continue to collaborate with the RMTC's in Central America and the Caribbean, particularly in new endeavors with WMO's international virtual laboratory.

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