Hydrology and climatology of the River Amazon: GOES telemetry network

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ABSTRACT The UNPD/WMO/SUDAM project "Hydrology and Climatology of Brazilian Amazon Basin" has as one of its main activities the establishment of a pilot network of telemetering stations in order to obtain hydrometeorological data using the GOES data collection system (DCS) facilities. During the second half of 1982 ten field stations were installed in the River Tocantins basin to measure water level, rainfall, humidity, temperature, atmospheric pressure and station battery voltage. A receiving site was installed at the headquarters of the Brazilian Institute of Space Research. This paper reports on the characteristics of this network, the problems during installation and initial operation, the experience gained using the GOES DCS, and comments on the future of this methodology in the Amazon basin. Recommendations are given on special support instrumentation used and on some important aspects of the GOES DCS that future users must not overlook.

Hydrologie et climatologie de l'Amazonie: le réseau téléémétrique de GOES

RESUME Le projet PNUD/WMO/SUDAM "Hydrologie et Climatologie de l'Amazonie Brésilienne" compte parmi ses activités principales, l'établissement d'un réseau pilote des stations téléémétriques afin d'obtenir des données hydrométéorologiques utilisant le système de collection de données (DCP) GOES. Pendant la seconde moitié de 1982 dix stations ont été installées dans le bassin de la rivière Tocantins pour mesurer: le niveau d'eau, les précipitations, l'humidité, la température, la pression atmosphérique et la tension de la batterie de la station. Une station de réception a été installée également dans le quartier général de l'Institut Brésilien de Recherche spatiale. L'objectif de cet exposé est de présenter les caractéristiques de ce réseau, les problèmes rencontrés pendant l'installation et l'exploitation initiale, les expériences acquises pendant l'utilisation du GOES DCS, et de commenter l'utilisation future de cette méthodologie dans le bassin de l'Amazonie. Des recommendations ont été formulées à propos de certains aspects importants du GOES DCS qui ne devraient pas être négligés par les utilisateurs futurs.
INTRODUCTION

Since 1977 the United Nations Development Programme (UNDP) and the World Meteorological Organization (WMO) have been cooperating with the government of Brazil on the project "Hydrology and Climatology of Brazilian Amazon River Basin" (Projecto de Hidrologia e Climatologia da Amazonia - PHCA) (Dengo, 1982).

Because of the extremely large size of this basin and the prevailing natural conditions, the network of existing meteorological and hydrological stations has been considered as inadequate despite the efforts of local institutions towards the improvement of the data collection system.

Under the above-mentioned project, several studies have been developed regarding different ways for improving the network of stations. Among the various alternatives, one which has been considered as mandatory is the establishment of a system of automated data transmitting stations. The main reasons for this are:

(a) the distances from the data collection points to the main population centres.
(b) the difficulties of access to the data collection sites; and
(c) the severe natural conditions of the entire region.

Among the existing methods for this type of data collection, three were closely examined, namely:

(a) telemetry via UHF/VHF radio transmission;
(b) telemetry via meteor burst; and
(c) satellite telemetry (using either a polar orbiting spacecraft or a geostationary one).

Based on technical, cost and management considerations, (Halliday, 1978), it was decided that the self-timed option of the GOES data collection system (DCS) would be used. Through WMO contacts with the US National Oceanic and Atmospheric Administration's National Environmental Satellite, Data and Information Service (NOAA/NESDIS) were established. An inter-institutional committee was formed by INPE (Brazilian Institute of Space Research), DNAEE (Brazilian Hydrological Agency), ELETRONORTE (Northern Brazil Power Authority) and SUDAM (Government Regional Development Agency for Amazonia) where the project "Hydrology and Climatology of River Amazon" has its headquarters.

The Tocantins river basin, with an area of approximately 750 000 km², was selected for the installation of the first 10 stations comprising the pilot network. The annual flood problems of Marabá and other riverine cities, the construction by ELETRONORTE of a giant 8000 MW hydropower station at Tucurui, the relative ease of access to different points in the basin because of the Belem-Brasilian Highway and the Trans-Amazon Road were the factors which influenced the choosing of this area for the establishment of the first network of stations.

The tasks were divided as follows:

(a) PHCA/SUDAM would buy via WMO all the necessary equipment (sensors, data collection platforms and data receiving station) and would also provide the required training for national personnel.
(b) ELETRONORTE would construct the physical bases for the field stations and would be in charge of their final installation and maintenance.
(c) INPE would be in charge of installation and operation of the receiving site and would provide the antenna to receive the signals from the satellite. As operators of the receiving station they would also be in charge of the distribution of the information to the other members of the committee.

(d) DNAEE, as the national agency for hydrology, would coordinate site selection, would watch closely all installation and operation activities, and would receive all data as input to the Sistema de Informacoes Hidrometeorologicas.

EQUIPMENT ACQUIRED

The acquisition of equipment was done through WMO headquarters. The contract, including equipment and training, was granted to Sierra Misco of Berkeley, California, who presented an integrated system consisting of:

(a) 10 sets of five sensors: river level, rainfall, relative humidity, temperature and atmospheric pressure (all made by Sierra Misco) plus one battery voltage sensor for each station in order to check the energy supply;

(b) 12 data collection platform (DCP) radio sets, 10 active plus two spares, made by La Barge;

(c) two La Barge DCP programming "Test Sets";

(d) 10 sensor to platform interfaces and 10 solar panels by Sierra Misco; and

(e) one ground receiving station made by SUTRON Corporation.

FIELD INSTALLATION

Actual field installation was possible in the second half of 1982, one year after the arrival of all of the equipment in Brazil. The one year delay was due to the difficulties encountered in developing the "Memorandum of Agreement" for using the satellite which was satisfactory to both the Brazilian Government and NESDIS.

The ground station located in Sao Jose dos Campos, was the first component of the system to be installed. This receiving system uses the antenna already existing at INPE and consists of a fully redundant station in order to offer back-up in case of a component failure. The equipment supplied by PHCA and assembled by INPE's technical staff consists of: one satellite synchronized clock, two pre-amplifiers, two downconverters, two receivers, two demodulation units, two PDP 11/03 microprocessors and one Data General Micro Nova 4X minicomputer (128 KB and magnetic tape unit) for "after reception" data processing and data distribution to users of the system.

ELETRONORTE, being responsible for the installation and maintenance of the field stations, contracted the services of Hidrologia S/A to carry out this task.

Table 1 gives the names of the selected locations of stations in the basins of the rivers Araguaia and Tocantins. Figure 1 shows the drainage basin of these rivers and the approximate location of the telemetering stations.

After successful tests of the ground-receiving station were
completed on 25-26 August 1982, the first of the field data collection sites was installed at Tucurui Dam on 29 August 1982.

FIG.1 Location of field stations.
Carolina was the next station to be put on the air. All other installations were carried in sequence as the field crew started in Brasilia and continued installing stations along the Belem-Brasilia road all the way to Marabá. Tucurui was selected as the first site to be activated because of the logistical support existing there. As ELETRONORTE is constructing a hydroelectric power plant at the same location, there are all sorts of facilities: airport, telephones, electricity, mechanical and electrical workshops, etc. This all proved to be very important, especially the communication lines. The direct link with the ground station is of extreme importance in order to know whether the installation has been successful or not.

The deployment of the other DCPs and sensors continued without any serious problems; the main worry of the field crew was to always obtain a communication link with the ground station to verify that satellite communication had been successful. Some places offered radio-linkages, others radio to telephone interconnections, while in some cases it was impossible to have any contact with the receiving station at the time of installation. Only after returning to a point where there were telecommunication facilities available was it possible to check whether everything was correct. This source of uncertainty is an annoying factor, considering the difficulties overcome in order to reach the station site and the expense of the operation as a whole.

Following recommendations of NESDIS a new piece of equipment was bought by PHCA in order to supply information in the field indicating whether the station has correctly transmitted. This instrument is a modification of the satellite synchronized clock of the ground receiving station. The equipment is made by True Time Instruments and permits users of the GOES DCS to take advantage of the Data Acquisition and Monitoring Subsystem, known as "DAMS", while deploying or repairing platforms in the field. It is a self-contained totally portable unit which allows the field team to obtain special information emitted by the GOES DCS, known as "DAMS health messages", regarding the quality of the transmission of the DCP being installed. This equipment was field tested early in 1983 on a routine visit to the stations, and the results were most satisfactory. The confidence of knowing what is occurring, no matter how far the field crew is from a communications link with the ground station, is worth the extra investment. This allows for timely DCP adjustments and corrections before leaving the site, thus assuring a correct installation.

MODE OF OPERATION

The platforms collect data from the sensors every half hour and transmit to the satellite every 3 h (at 1 minute intervals from one another) all the information collected in the time elapsed between two consecutive transmissions. In addition, the DCP message also contains the data set corresponding to the previous interval. This is a back-up feature that allows the recovery of valuable data whenever a transmission is lost. Once the transmission is relayed from GOES-East to Sao Jose dos Campos, it is translated into engineering units and stored in a computer equipped with a Telex
interface. System users dial-up this line and obtain the information on their regular Telex terminals.

The National Department of Water and Electricity of the Brazilian Ministry of Mines and Energy has acquired an equivalent unit for its computer so that the telemetered data flow directly into the Hydro-meteorological Information System files. Other users enter the received data manually into their data processing equipment. It is important to realize that this mode of operation is only possible because the system is small, and the amount of information presently produced allows manual handling. It must be acknowledged that upon expansion of the data collecting network, there will have to be an upgrading of the present data dissemination scheme.

During the period of initial operation, two types of visits to the field stations were planned: bi-monthly control visits during the first 6 months, in order to check all of the instruments installed; and emergency visits in the event of failures. The time between control visits will be extended to once every 6 months when the system is considered to be running smoothly.

The above plan has worked fine so far. It has only been necessary to visit two of the stations on an emergency basis, because of battery problems in one case and because of a DCP loss of timing in the other case.

INITIAL OPERATION RESULTS

The initial operation phase of the project has been characterized by: (a) a series of minor specific problems at both the transmission and reception sides of the system; and (b) the satisfactory behaviour of the system as a whole.

The ground receiving station had some adjustment problems mainly regarding the receivers, which had difficulties in locking the assigned frequency for GOES channel 61, which is the channel designated by NESDIS for operation of the River Tocantins System. These problems were finally solved during a visit from the manufacturers to the receiving station at Sao Jose dos Campos. This control visit was part of the contract with Sierra Misco and proved to be necessary.

The difficulties on the transmission side have been mainly due to battery failures. The batteries being used are the rechargeable gel/cell type, 12 V 23 amphours, and it is believed that the one year storage period before installation might have affected most of them as they lost the ability to maintain the charge supplied by the solar panels. Regular car batteries have been temporarily substituted in order to keep the system on the air until a definite solution is found. New gel/cell batteries should put an end to the problem. For a time it was thought that the solar panel could be draining the battery during the night. After control checks were carried out, this possibility was discarded.

There have been some problems with the platforms themselves. Two of them have been returned to the manufacturer, under warranty, because they did not accept programming. Another has had timing problems, the cause of which, at the moment of writing this paper, has not been clearly defined; La Barge technicians are going to
Brazil, under their contract with PHCA, to fix the equipment.

There have also been some problems with the sensors. The humidity and temperature sensors were out of calibration, and there were also signs of need for adjustment in some of the rainfall and river level sensors. The barometric pressure units have also caused some trouble and they are being checked in order to make them operational.

One piece of equipment that proved to be very valuable during this period, has been the receiver of the DAMS's "health" messages. It allows the field technician to be certain of the good operation of the station before leaving the site. It is also a good support tool for planning maintenance trips, as well as for general monitoring of a particular network, as it can be used from the office in order to find out how the different stations are operating. This last feature is of special importance for those users who do not have a direct down link from the satellite.

The system as a whole can be considered as having had a successful period of initial operation. It is producing results which are helping to improve the system itself by feedback, and results which are being operationally used by PHCA on river forecasting activities. It is also showing that the choice of the satellite data collection technique was the right choice, and that this is the most promising method for obtaining hydrometeorological and other environmental information in this particular area of the world.

There are many parties involved in the day-to-day operation of the system, and as in any pilot scheme, everyone is learning a great deal every day both about technicalities of the system itself, and about coordination of activities among all of the participating organizations. The support from manufacturers and suppliers has been very good and the relationship with NESDIS has been excellent.

CONCLUSION

The River Tocantins telemetry network has complied with the main objectives of the development plan originally established. It is a totally operational pilot network, with a trained national personnel which has acquired the desired experience to further the application of the methodology. It has been demonstrated that this is the most feasible and technically effective way of harnessing hydrometeorological data in the difficult conditions of the River Amazon basin.

This experience has made evident a series of factors that should be considered when planning a GOES based environmental data collection network. First of all, the GOES DCS user-to-be must be aware of the fact that the system not only consists of a signal relay satellite, but also entails being a member of a complex computerized system with strict access and operational procedures (NESDIS, 1982). These procedures must be mastered by the user's technical staff in order to reap the full benefits of the system. It is only through this aggregated conception of the GOES DCS that the user can actually develop his plans in such a way that they are optimal in using the DCS resources, as well as in fulfilling his specific data collection requirements.

The future user must prepare personnel to install, service and
operate the system; it is very convenient to develop a certain degree of in-house "self-sufficiency" for the whole scheme. Electronics and telecommunications technicians, data processing and communications staff are desirable personnel to be considered when staffing to meet the needs of the telemetry project.

Even for those users who are planning the installation of a receiving station, it is very important to consider a back-up link with the satellite in case of a serious failure. The most logical, and probably most cost efficient, option would be to use one of the direct "dial-up" lines that connect with NESDIS computers, where information could be temporarily stored during an emergency situation. Today's microcomputers and semi-intelligent terminals, as well as the telephone facilities available, make this option a very attractive alternative. Needless to say, whatever plans are made they should be fully discussed with NESDIS well in advance of their implementation, in order to ascertain their actual feasibility and to obtain due approval.

REFERENCES

