Telemetric monitoring system for meteorological and limnological data acquisition

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Introduction

The rupture of a natural processes system resulting from river dam building needs to be assessed quantitatively and qualitatively. This assessment is essential for mathematically modelling the interactions among system variables to develop forecasting tools. The comparative study of modified and preserved systems is one of the most promising approaches in environmental research. This approach allows the evaluation of both the size and intensity of natural system variable reactions to human impact and their accommodation time lags so as to identify stability critical limits at different spatial and temporal scales (TUNDISI 1999). Moreover, the research involves the evaluation of natural and antropic systems. The pulses are defined as any type of fast alteration suffered by the system variables. They can be natural or induced for antropic activity, frequent, seasonal or intermittent, with variable magnitude and both direct and indirect effect (TUNDISI 1999). Studies performed in different parts of the world and Brazil have stressed the effect of greenhouse gas emissions by hydroelectric reservoirs surfaces (LIMA et al. 2000, DUCHEMIN et al. 1995, RUDD et al. 1993).

Long term environmental time series of continuously collected data are fundamental to performing the identification and classification of pulses and determining its role in aquatic systems (particularly in the variability of greenhouse gas emissions), as well as comparing different aquatic systems. Boundary condition variables for the functioning of aquatic systems (TUNDISI 1999) are: climatic (e.g. temperature and wind), hydrological (e.g. outflow) and limnological (e.g. turbidity, pH, chlorophyll). Thus, this work presents the potential and constraints of the placement an automatic station for monitoring environmental variables in Brazil, including a brief description of the system concept and technology used in the Integrated System of Environmental Monitoring (SIMA) and preliminary data collected by SIMA in an Amazonian lake and hydroelectric reservoirs, located in both Brazilian savannah (Cerrado) and tropical forest regions.

Key words: , ,

Materials and methods

Integrated System for Environmental Monitoring – SIMA

SIMA, developed in partnership between the Vale do Paraíba University and the National Institute of Space Research, is a set of hardware and software designed for data acquisition and real time monitoring of hydrological systems (STEVENSON et al. 1993). It is composed of an independent system formed by an anchored buoy, in which sensors, data storage systems, battery and the transmission antenna are fixed (Fig. 1). The data are collected in preprogrammed time intervals and are transmitted by satellite in qua-

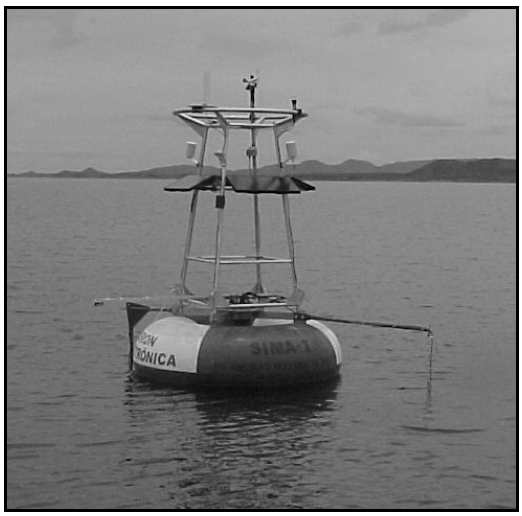

Fig. 1. Photo of the SIMA installed at Serra da Mesa reservoir.

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Table 1. Environmental Parameters Monitored by SIMA.

Environmental Parameters		
Chlorophyll-*a*	Nitrate	Air Temperature
pH	Ammonia	Wind Direction and Intensity
Turbidity	Water Temperature	Incoming Solar Radiation
Dissolved O_2 Concentration	Atmospheric Pressure	Reflected Solar Radiation
Electric Conductivity	Relative Humidity	Water Flow Direction and Intensity

si-real time for any user in a range of 2500 km from the acquisition point.

The selection of the environmental parameters measured by SIMA took into account aspects such as: relevance as an environmental index (i.e. the variables that respond consistently to alterations in the functioning of the aquatic system); importance in the greenhouse gases emission process in aquatic systems; and technical suitability for data acquisition and transmission from automatic platforms (Table 1).

Study area

The study area corresponded to the Brazilian North and Center-West geographic region (Fig. 2). Three stations were placed in hydroelectric reservoirs: Tucuruí and Serra da Mesa in the Araguaia-Tocantins basin (region of tropical forest and savanna, respectively), and APM-Manso in north of Paraguai basin (region of transition between savanna and tropical forest). These stations serve as models of environments modified by antropic action and subject to pressures of public development polices. The last one was installed in Lake Curuai, located in the low Amazon River floodplain (tropical forest) and represents an almost pristine area were human activities exert low environmental impact. This lake has dimensions compatible with the remaining reservoirs and can be assumed as a base line for comparative experiments.

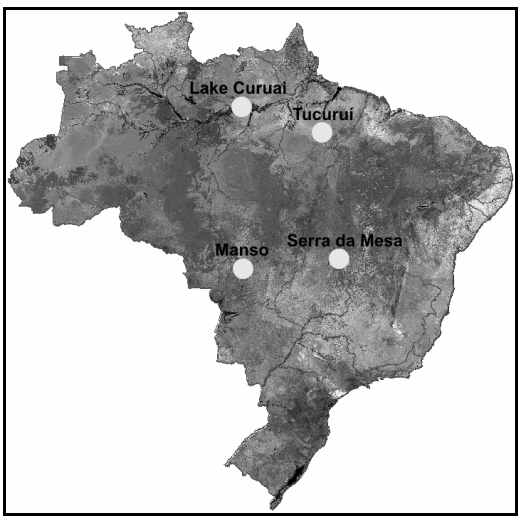

Fig. 2. Localization of Curuai Lake, and Serra da Mesa, Manso and Tucuruí reservoirs.

Results

The data acquired operationally by the SIMA stations have been continuously transmitted to the National Institute of Space Research, where they are continuously submitted to quality control and storage in a numerical database. The system has been in operation since January 2004 in the reservoirs of Serra da Mesa and Manso and April 2004 in the reservoir Tucuruí and Curuai Lake.

Parameter time series collected by the SIMA stations (Fig. 3) present hourly values of water temperature at 2-m depth, dissolved oxygen concentration, and pH measured in Manso reservoir from 19 January to 23 March 2004. Despite the parameters being observed at a single point, which is a drawback for spatial application, the continuous data acquisition generates an excellent temporal accompaniment of the phenomena acting in the environment. The hourly monitoring allows monitoring of the synoptic scales process (around one week), such as diurnal variations (high frequency observed in the graphs; Fig. 3). This approach is particularly useful for detecting events occurring in short times periods, scales lower than daily, but with low recurrence frequency.

A summary (mean and standard deviation) of the parameters monitored by SIMA in the four water bodies (Table 2) shows a significant variability in the data, and particularly in the limnological parameters, even when using integrated

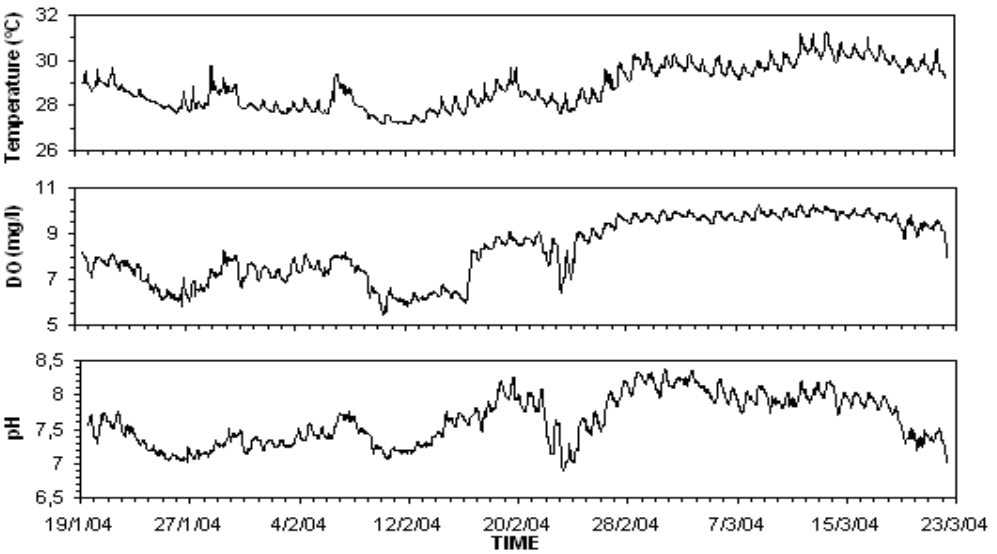

Fig. 3. Environmental parameters collected from SIMA at Manso reservoir, Brazil: (top) water temperature at 2-m depth; (middle) dissolved oxygen concentration; (bottom) pH factor.

Table 2. Basic statistics of the environmental parameters monitored by SIMA at Brazil.

Variable / Unit	S. Mesa reservoir		Manso reservoir		Tucuruí reservoir		Lake Curuai	
	Mean	*Stdev*	*Mean*	*Stdev*	*Mean*	*Stdev*	*Mean*	*Stdev*
Chlorophyll-*a* (µg/l)*	3.9	6.4	1.9	4.2	4.0	0.7	17.7	1.0
pH*	8.0	0.2	7.6	0.4	7.7	0.7	7.3	0.2
Turbidity (NTU)*	2.0	1.8	1.8	1.4	7.5	1.5	8.0	2.0
DO (mg/l)*	6.9	2.8	8.3	1.3	6.5	2.0	7.0	2.1
Conductivity (µS/cm)*	100.0	10.0	40.0	5.0	51.8	3.5	48.9	0.9
Water Temperature (°C)*	27.7	0.4	28.9	1.0	30.5	0.7	30.2	0.4
Atmospheric Pressure (hPa)	979.7	3.1	963.1	2.3	1003.8	1.9	1011.5	2.1
Relative Humidity (%)	78.4	12.3	76.8	14.0	76.7	9.3	79.8	7.5
Air Temperature (°C)	25.2	3.3	25.0	2.6	27.6	1.8	27.6	1.4
Wind Direction (°NV)	166.9	80.7	152.2	100.1	125.7	106.7	138.0	61.3
Wind Intensity (m/s)	2.6	1.7	1.7	1.3	2.4	1.6	3.0	1.8

* Limnological parameters collected at 2-m depth.

values. Each aquatic system exhibits peculiar behavior (Fig. 3).

Conclusion

This work presented a robust system designed to transmit via satellite link both meteorological and water quality data, offering state-of-the-art technology to access a large variety of environmental parameters for bodies of water such as reservoirs, lakes, rivers, oceanic and coastal waters. This capacity for reception of data on remote regions promises to be a powerful tool in the management of ecohydrological resources in the environmental protection and policies statements of development and construction of new hydroelectric dams.

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