SIMA

AN INTEGRATED ENVIRONMENTAL MONITORING SYSTEM

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Abstract. During the past decade there has been a sharply increasing interest and need in obtaining environmental information related to the aquatic domain. The ability to receive serial information about current or recent weather, hydrological or environmental (quality) conditions, in a timely and reliable fashion is now recognized as the basis for any modern environmental monitoring system, whether the data are used for the protection of the environment, or to minimize the negative impact of extreme environmental conditions on the day-to-day safety of communities. Because the reliability of receiving such data via conventional telephone lines is often affected by the same adverse weather or environmental conditions being reported by the system, a moderm system based on telemetry via satellite, that is, a system where the envirомment is remotely sensed, should be considered among the most reliable and desirable systems. This report presents the development of Project SIMA, an integrated system for monitoring the aquatic environment. Because SIMA is based on the ARGOS system aboard the polar orbiting NOAA satellites, SIMA has no global limits for its 19+ million km^2 regional coverage. The objective of this project is to design and develop a prototype system that can be used to monitor conditions in a coastal region where the possibility of oil spills exists, or in inland waters such as reservoirs and lakes, where the system can monitor changes in environmental parameters that may indicate the onset of floods, pollutants entering a reservoir, and so forth. The

SIMA consists of the following parts: a subsystem for the collection and transmission of data (SCTD)- one or more instrumented, anchored buoys; a subsystem for the reception of the data (SRD)- a compact VHF satellite receiver station located within a 2,500 km radius of the most distant buoy used; a subsystem for the processing of data (SPD)- a PC microcomputer with specially developed software to obtain important statistical characteristics and tendencies from the environmental data; and a subsystem for mathematical modelling (SMM)- a sophisticated numerical model supported by a 486 PC microcomputer and adapted for a particular coastal region or reservoir, that uses the quasi real-time environmental data to make its diagnostics. Details of how SIMA functions, as well as its capabilities, are presented within this report. Project SIMA, located on the UniVap campus, is an example of a university sponsored project for the transfer of technology to the community, made in partnership with a small group of researchers, engineers and technicians.

INTRODUCTION

During the past decade there has been a sharply increasing interest and need in obtaining environmental information related to the aquatic domain. The ability to receive serial information about current or recent weather, hydrological or environmental (quality) conditions, in a timely and reliable fashion is now recognized as the basis for any modern environmental monitoring system, whether the data are used for the protection of the environment, or to minimize the negative impact of extreme environmental conditions on the day-to-day safety of communities. Because the reliability of receiving such data via conventional telephone lines is often affected by the same adverse weather or environmental conditions being reported by the system, a moderm system based on telemetry via satellite, that is, a system where the environment is remotely sensed, should be considered among the most reliable and desirable systems.

This report presents the development of Project SIMA, an integrated system for monitoring the aquatic environment. Because SIMA is based on the ARGOS system aboard the polar orbiting NOAA satellites, SIMA has no global limits for its 19+ million km^2 regional coverage. The objective of this project is to design and develop a prototype system that can be used to monitor environmental conditions in a coastal region where the possibility of oil spills exists, or in inland waters such as reservoirs and lakes, where the system can monitor changes in environmental parameters that may indicate the onset of floods, pollutants entering a reservoir, and so forth.

COMPOSITION OF SIMA

As an integrated system, SIMA consists of the following parts:

SCTD- A subsystem for the collection and transmission of data. In practice, this part consists of one or more instrumented toroidal buoys (Figure 1), weighing approximately 750kg and 2.3m in diameter, anchored in coastal waters or in an inland reservoir or lake. The environmental data are transmitted via UHF, to either of two NOAA operational satellites passing over the horizon of the buoy, using a DCP (Data Collection Platform). A microprocessor, together with associated electronic circuitry, allows the sensors to be sampled at hourly intervals, the data to be stored in successive data bins in the memory and then transmitted in sequence during the normal operation of the SIMA;

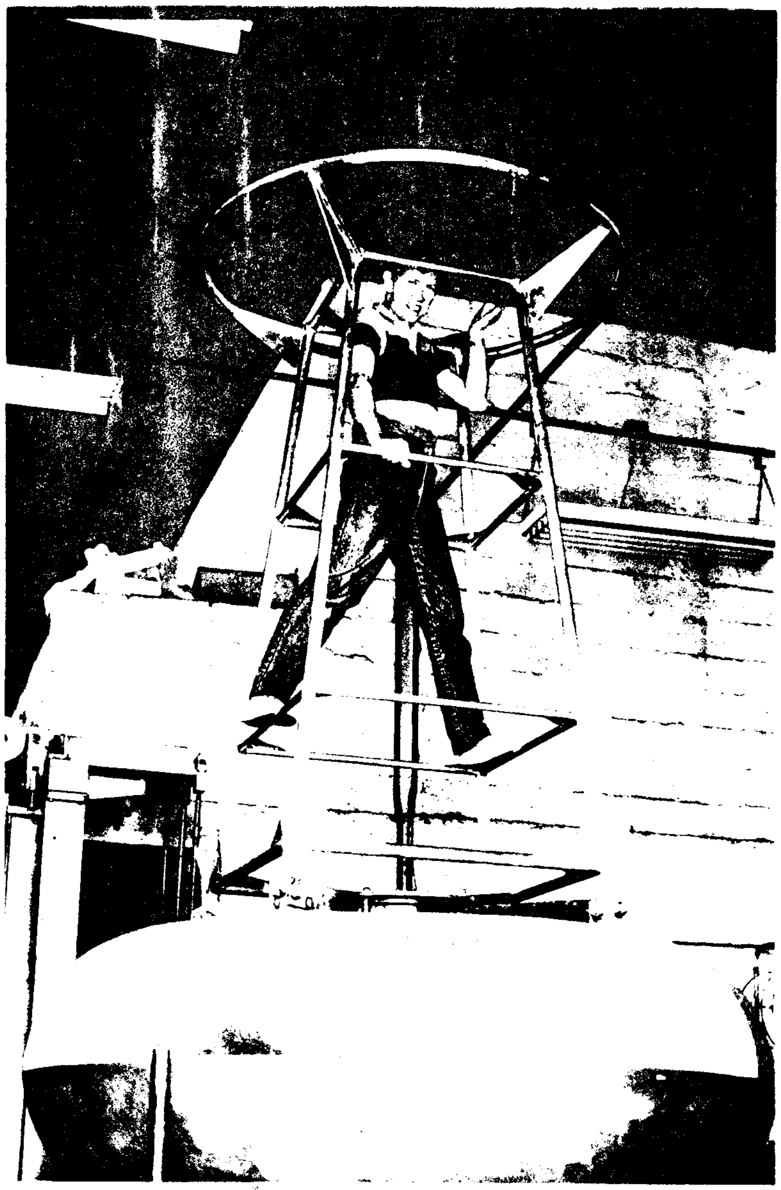

Figure 1. View of prototype SCTD buoy and its tower.

The principal physical components of SIMA are shown in Figure 2.

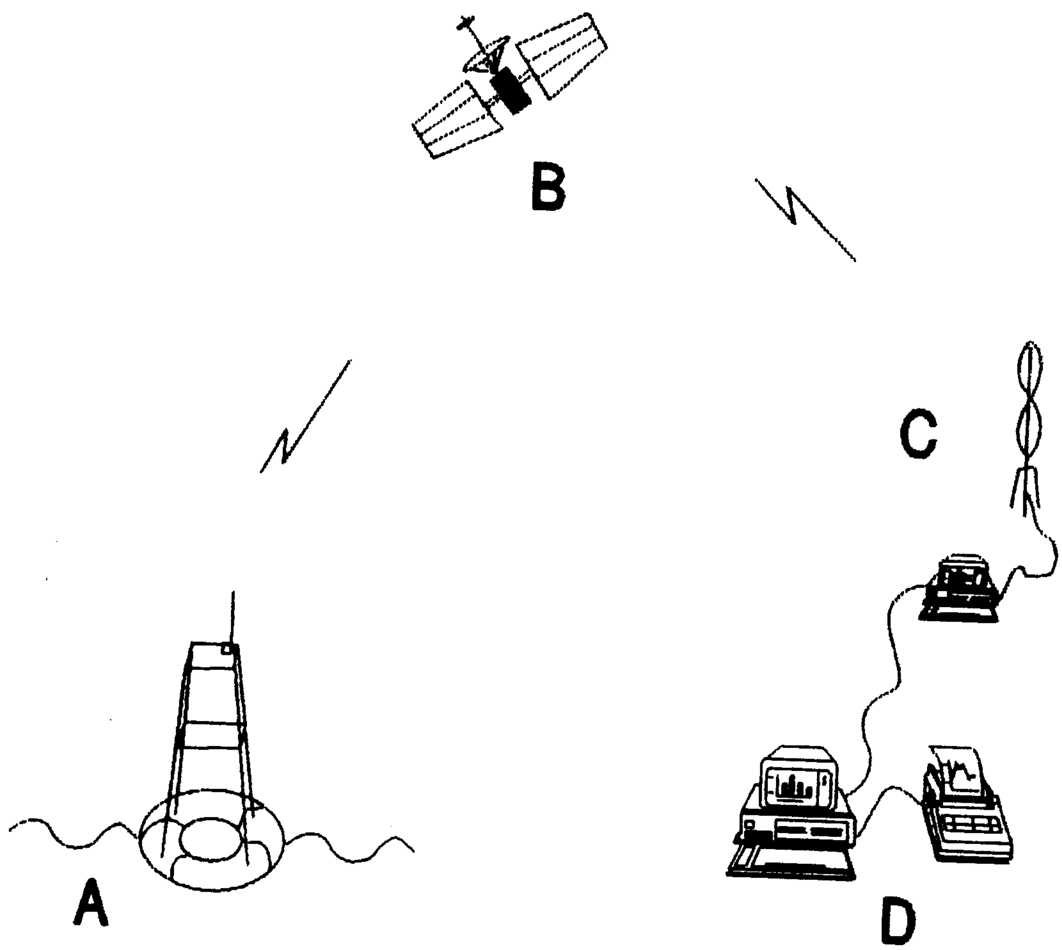

Figure 2. Schematic of physical components of SIMA. A) SCTD, B) NOAA satellite, C) SRD, D)SPD and SMM.

SRD- A subsystem for the reception of the data. After the environmental data have been received by the ARGOS DCLS (Data Collection and Location System) aboard the two NOAA satellites, these data are then retransmitted in real-time back to earth via VHF. These data transmissions are then captured using a compact VHF satellite receiver station (developed and fabricated by INPE/Natal), located within a 2,500 km radius of the most distant buoy used. A PC microcomputer interfaced to the receiver receives and stores these data;

SPD- A subsystem for the processing of data. A 486 PC microcomputer is used with specially developed software to obtain important statistical characteristics and tendencies from the environmental data; and

SMM- A subsystem for mathematical modelling. A sophisticated numerical model supported by the 486 PC microcomputer and adapted for a particular coastal region or reservoir, that uses the quasi real-time environmental data to make its diagnostics.

Environmental Sensors

SIMA is able to support various environmental sensors, including those shown in Table I.

TABLE I.

Typical environmental parameters that can be measured by SIMA

Variable	Typical Dynamic Range	Precision
Air temperature*	10-40^{o}C	0.12^{o}C
Relative humidity*	0-100%	0.39%
Water temperature*	15-30^{o}C	0.06^{o}C
Wind speed*	0-50ms^{-1}	0.20ms^{-1}
Wind direction*	0-360^{o}	1.4^{o}
Solar (incident) radiation*	0-10wm^{-2}	0.04wm^{-2}
Solar (reflect.) radiation*	0-10wm^{-2}	0.04wm^{-2}
Water level	0-300cm	1.2cm
Current speed	0-250cms^{-1}	1.0-cms^{-1}
Current direction	0-360^{o}	1.4^{o}
Water turbidity	0-200ppm	0.8ppm
Water pH	0-14	0.05
Dissolved oxygen	0-10mll^{-1}	0.04mll^{-1}
Chlorophyll concentration	0-10mgm^{-3}	0.04mgm^{-3}

* Variables to be measured by the prototype SIMA.

SIMA IN OPERATION

The operation of SIMA is seen in the form of flow diagrams in Figures 3, 4, 5 and 6.

SCTD SUBSYSTEM

(INSTRUMENTED BUOY)

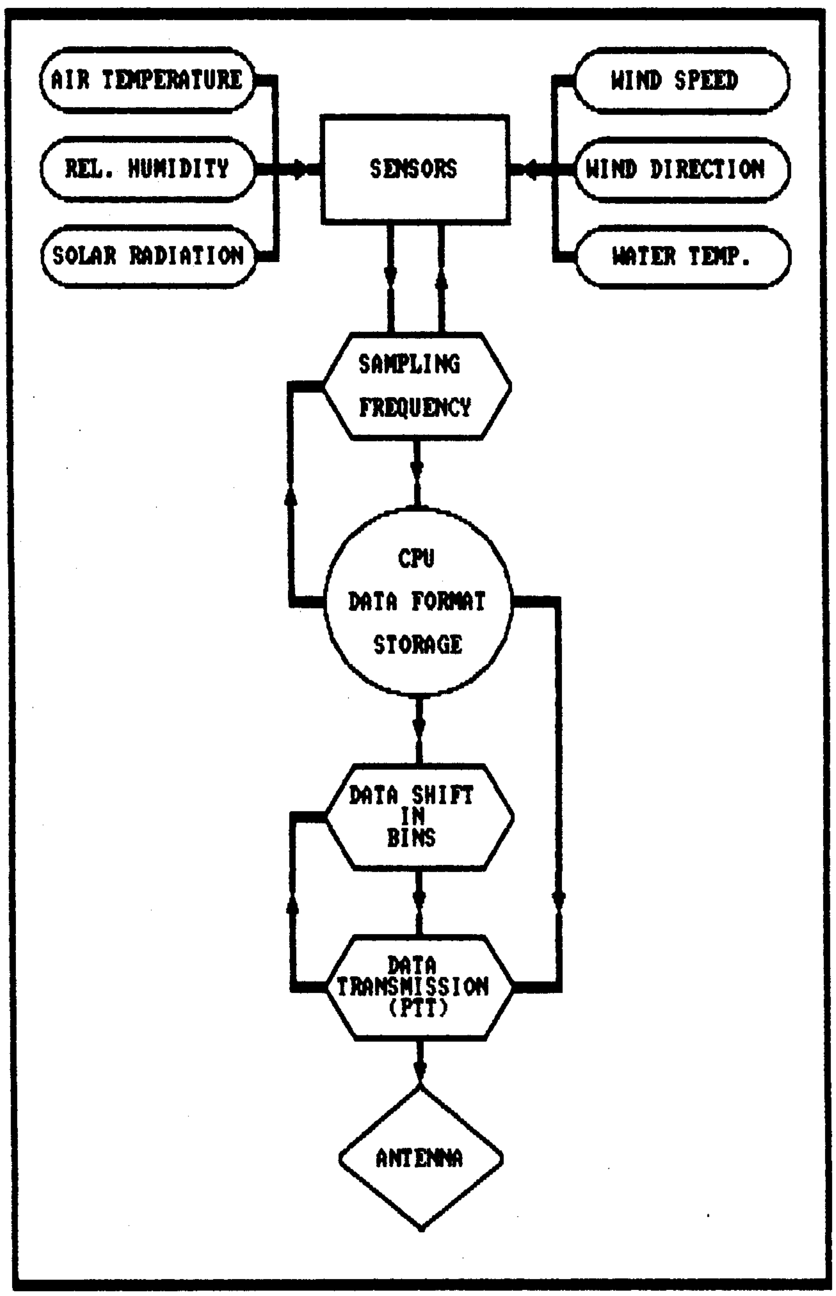

Figure 3. Flow diagram for operation of the SCTD.

As seen in Figure 3, the sampling frequency for the different sensors is controlled by the CPU inside the payload container, within the well of the toroid. The frequency is normally set at one observation per hour per sensor. Each data set is associated with its time of collection and is stored in memory in "data bins". To provide a high degree of efficiency, there are 7 data bins, corresponding to a series of data sets collected over a period of 7 hours. With the passage of each hour, the data sets in the 7 bins are shifted one bin position (corresponding to one hour in time) to the next higher bin. The oldest data set is then lost from bin 7, while the new data set enters bin 1.

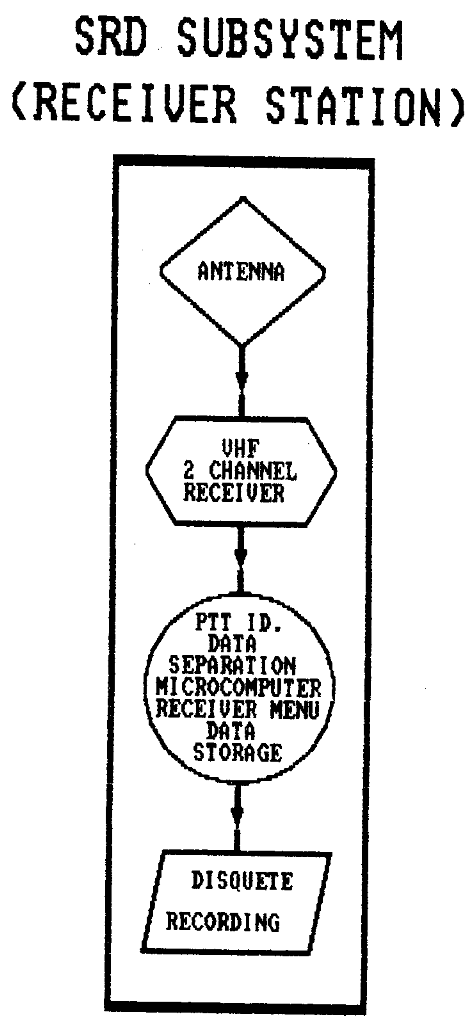

Figure 4. Flow diagram for operation of the SRD.

The PTT transmits the data at 100 second intervals, starting with bin number one. After each 100 second interval, the next bin is transmitted, until the 8th time interval when bin 1, with newly acquired data, is transmitted again.

Once a transmission of data from the buoy has been received by the DCLS aboard one of the two operational NOAA satellites, the same data are retransmitted on VHF. If the satellite is above both the buoy's and receiver station's horizon (buoy within 2500 km of the receiver station), the retransmitted data can be received by the station (Figure 4).

Note in Figure 4 that the VHF receiver is designed to receive on two channels. This is necessary because the transmissions from the two satellites must not interfere with each other. When in operation, the receiver alternately listens to each channel. When a satellite appears above the horizon, the receiver station begins to record the data being retransmitted by the satellite. The software, developed by INPE/Natal, for the receiver station and its PC microcomputer, has the ability to selectively record prespecified PTT identification numbers. These data can then be transferred to a disquete for processing by the SPD (Subsystem for Processing Data).

Environmental data may be processed by the SIMA by entering data disquetes into the 486 PC microcomputer (Figure 5). The data are first quality controlled, by scanning each time series for missing data and interpolating those values where needed. Individual values that are erroneous need to be corrected and this step is automatically done by a special routine prepared for this purpose. Once the data are considered "clean", specially prepared software is used to determine statistical characteristics (maximum and minimum values, mean, standard deviation, etc.) and tendencies such as persistance. The operator of the PC can then generate hardcopy output as desired.

Once recently acquired data have been processed, the SIMA user can see how the actual wind field may affect the circulation within the defined region (coastal region, lake or reservoir) by using the Subsystem for Mathematical Modelling- SMM (Figure 6).

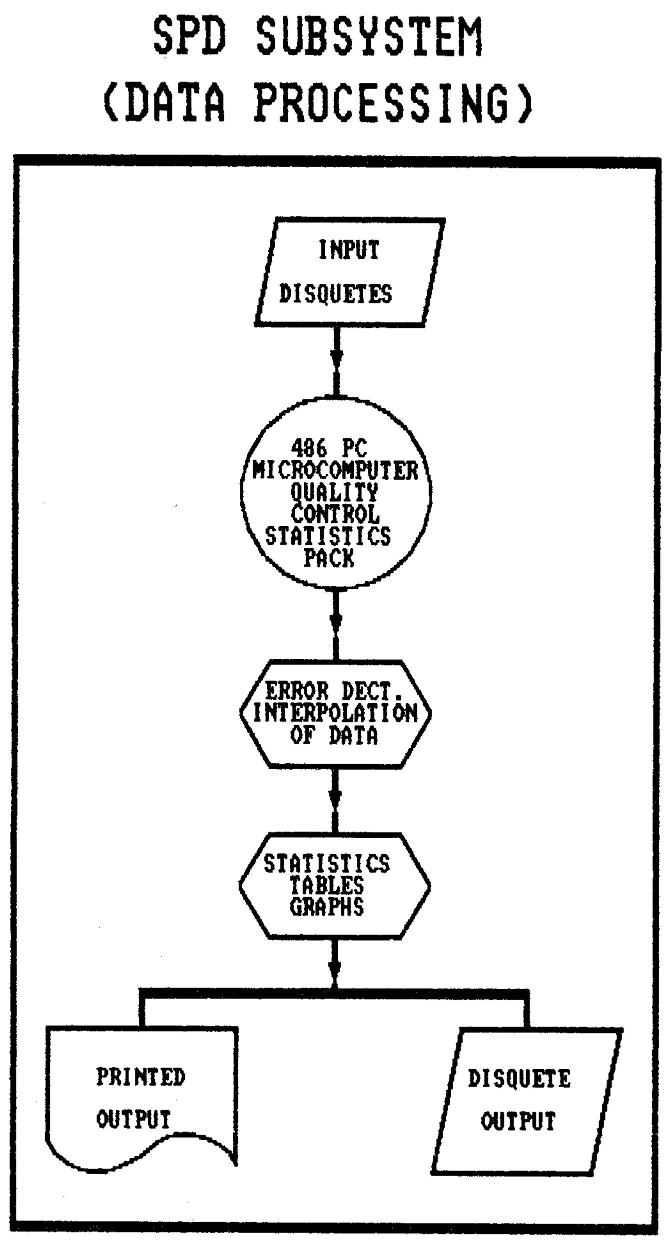

Figure 5. Flow diagram for operation of the SPD.

The finite element, numerical diagnostic model can be run using one of two options (Figure 6): the user may specify a specific date and hour and the model will run until the resulting circulation field is ready for display on the monitor; or the user may specify interest in seeing the circulation for a given time interval.

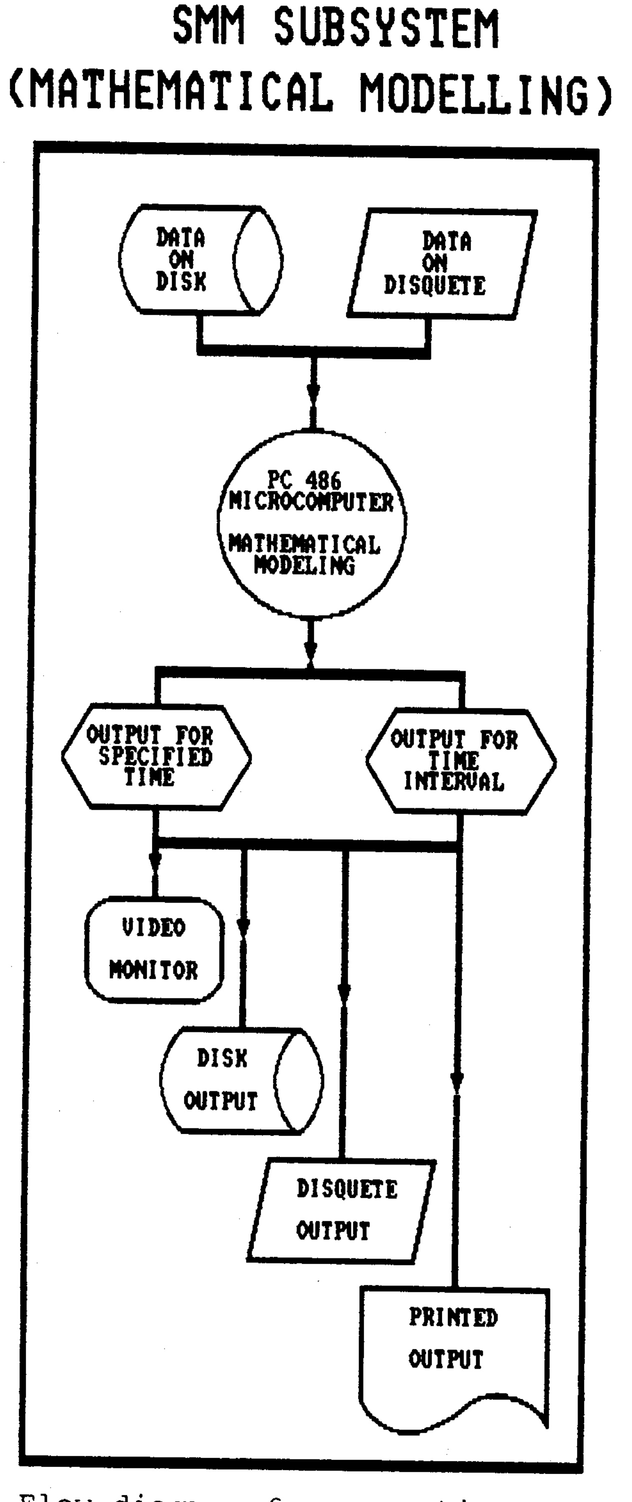

Figure 6. Flow diagram for operation of the SMM.

In the first case one final circulation field is available; in the second case several circulation fields, corresponding to the time interval are available. As desired, the user may generate a printed output or save the circulation map on hard disk or floppy disquete.

PERSPECTIVES FOR SIMA

As seen from the previous description of the system, SIMA is an extremely powerful and flexible integrated system. The buoy can be instrumented with various sensors, depending on the general objectives of its use. Due to the different subsystems, there is normally no need for additional equipment or software in order to use the system. Technical aspects of the numerical model are modified to fit different field applications.

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