Hydrological data collection and transmission in Sweden

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ABSTRACT Systems for automatic data collection are currently being developed in a variety of fields. At SMHI there is a data collection system comprising stations which collect data on mountain and coastal weather, water levels and temperatures in seas and rivers, and water quality, waves and currents in the sea. The data are transmitted via the telephone network or satellite. Satellite transmission means that automatic field stations can be set up where access to electricity or the telephone network is lacking. With this technique stations can easily be moved. The transmission systems result in new demands and new possibilities for sensor equipment. New remote sensing methods will also be available for monitoring waters.

INTRODUCTION

At SMHI some projects are at hand, which aim at improving the runoff forecasts to reservoirs and hydropower plants. Some of them concern measurements of hydrological and meteorological data, snow cover, precipitation and air temperature while others concern development of hydrological models and forecasting routines. Regarding measurements, new manually operated stations have been established. In the
Swedish mountains, however, it can be extremely difficult to find people to carry out observations, and therefore automatically operated stations are often the only way to extend the network of hydrometeorological stations in these areas. As a result, some stations, from which data are collected and transmitted automatically to SMHI, have been established.

Remote sensing methods are used to complement other measurements. Snow mapping by airborne gamma-ray spectrometry is used in mountainous areas. Weather satellites are used to study, for example, the surface temperature conditions throughout the Baltic (Wennerberg, 1980) and Landsat MSS data have been used in turbidity mapping (Wennerberg, 1981).

AUTOMATIC DATA COLLECTION AND DATA TRANSMISSION

Systems of communication have been used as far back as the Inca Empire. Theirs was made up of a system of roads and "running" messengers. A message could be carried 200 km a day. Today, however, we have other demands.

In 1968, SMHI started work on a network of automatic weather stations. The network now consists of a fully computerized system for automatic data collection. Transmission of the data is via the telephone network. The original idea behind the system was to make available to meteorologists data from places where no observers were stationed. The stations have been sited on lighthouses and in the mountains to supplement the meteorological data collected by SMHI observers. The stations installed on lighthouses have been supplemented by sensors placed in the water to measure current, temperature, salinity, tides and waves. At the request of the hydrologists, inland stations have been equipped with sensors which transmit data on water level, water quality and precipitation. Apart from the meteorologists, other current users of the data include hydrologists, power stations, mountain-rescue services, shipping and researchers.

The SMHI data collection system is based at Norrköping in Sweden. This acquisition centre automatically calls up the stations and then receives the measurements recorded by them. At present, transmission is via the public telephone network. The system is being developed, so that it will be possible to use both the telephone network and special public data transmission lines. The central station is linked by computer to the SMHI computer centre. The system permits rapid access to the data and can trigger an alarm in the event of a malfunction or a critical reading being detected. Automatic checking of the data is also possible, and the data are stored and processed at the SMHI computer centre. External users can also be linked to the data collection system via computer screen or telex.

Field measurements are collected by means of terminals, to which various types of sensors are connected. Microcomputers in the terminals enable checking, data reduction and a certain amount of data processing to be performed at the field station. Energy spectra, mean periods and significant wave heights are calculated to measure waves. For other readings, such as wind, water levels and current, mean values are calculated for 10-minute periods, and
maximum and minimum values every hour. A terminal of this type can also be used in controlling the liming of acid lakes and rivers. SMHI has a team of microcomputer programmers and can offer users tailor-made software for local data collection functions (Hovberg, 1978).

It was, however, quite evident that this transmission could not fulfil the demands of hydrologists for information from mountain areas, since it is almost impossible to install telephone equipment or radio links in such areas. The Swedish telephone network is extremely good, but it doesn't include this sparsely populated area. Thus SMHI has conducted promising tests with the transmission of data via satellite. Automatic recording of precipitation and air temperatures has been in progress at a mountain station since 1978. The data are transmitted via the Argos system. The first Swedish experimental station was set up by SMHI and the Swedish Space Corporation and has functioned very well. Later another station, which also measures water level, was installed. With microcomputers in the station, mean values, e.g. temperature, water level and 24-h (0700-0700) precipitation can now be stored until they are transmitted to the satellite.

The Argos satellite transmission system is suitable for the collection of hydrological and climatic data, when real time transmission, i.e. transmission exactly at the time the reading is made, is not necessary. At present, our data are received via Toulouse, France. Data from the stations are also received in Norway. Within a year, SMHI will have acquired its own receiving station for data transmitted via satellites which will enable receiving the data when the satellite is passing directly overhead. At that time, a new data acquisition central at SMHI will be able to receive, control, store and distribute data transmitted via the telephone network and satellite telemetered data received by the antenna on the roof of the Institute (Wennerberg, 1982).

The experience of transmission via the telephone network and satellite is extremely good.

SYSTEMS FOR LOCAL DATA COLLECTION

In many cases it is not necessary, or not possible, to transmit data directly to a central receiving station. For occasional measurements, or measurements which are not required immediately, the data can be stored on magnetic tape or on plotter printouts for subsequent collection and analysis. Readings of currents and temperatures in lakes or along the coast, for example, are recorded on magnetic tape. Battery-driven instruments are suspended from a system of buoys, and the tapes and batteries are replaced at monthly or other intervals. If a large amount of data needs to be stored, the use of a minicomputer is recommended.

Simple plotters are still the most common type of equipment used to measure isolated factors, such as the water level and air temperature. In the near future, new types of memory, such as bubble memories and low-power semi-conductor memories, will enhance the prospects of this form of data collection.
NEW SENSORS FOR DATA ACQUISITION

We have noticed, however, that the use of automatic data collection systems often results in over-confidence in the validity of the collected data. The problem is not the data acquisition, as this is shown to be very reliable. The results depend mainly on the sensor at the other end of the system. Generally, the development of sensors has not followed that of the transmission systems. These new systems result in not only new demands but also in new possibilities for sensors.

At stations in mountain areas, we have to choose sensors with a low consumption of energy, as the stations are battery driven. Since a stilling well cannot be kept free from ice in northern Sweden without access to electricity or any other adequate power supply, we have chosen to put a pressure sensor at the bottom of the lake to measure the water level at the new Argos station. The sensor is a Digiquartz from Paroscientific, USA. This sensor makes it possible to measure water levels with an accuracy of 1 cm even at stations where the water level varies very much. The sensor is an oscillating quartz crystal, the frequency of which depends on the pressure. As we have to compensate for air pressure variations, these must be measured. The air pressure sensor is of the same kind.

Temperature measurements are mainly performed with Pt-100 sensors. Zener diodes are also used. This makes it possible to read increments of 0.1 °C. When better accuracy is required, we hope to be able to use quartz temperature sensors in the near future. As low power consumption is mandatory, the precipitation gauge used at our stations is a collecting bucket, which is weighed.

As to the oceanographical sensors, a new Swedish Doppler profiling current meter has just been designed, and is going to be tested this year.

As for other sensors, there is a need for solid sensors for the measurement of water quality. The sensors must be able to work under various conditions to make an extension of satellite data collection into the environmental sector possible.

FUTURE SYSTEMS

The rapid advances that have taken place in computer technology in recent years are likely to continue. This applies equally to checking and control components and to memories. Computer prices have also fallen appreciably in recent times. Consequently, it is now viable to check, reduce and process data in the field. Furthermore, storage capacity has increased substantially; semiconductors and bubble memories have made it possible to get away from printers with mechanical parts and have also facilitated further processing of the data. New data-storing media with even greater capacities will be produced. In contrast, work on the development of sensors has not advanced as fast. We can foresee, for example, the development over the next few years of new methods for measuring currents using ultrasonic and doppler techniques.

For data transmission we expect to utilize both the telephone network and the national data transmission network. The new data-
collection centre at SMHI will now increase the capacity and enhance the prospects of linking a variety of stations. In future data input manually via simple terminals will be collected in the same way. This would enable data, for instance, from the manned precipitation stations, to be fed into the system without delay. It is probable that satellite telemetering stations will play a major part in the collection of data from mountain areas, sea-based stations and temporary field stations. It is planned that these data too will be transmitted via the satellite receiving station to the data-collection centre in order that they can be processed in the same way as the other data collected automatically. It is likely that conventional communication satellites will make an essential contribution to data transmission. This applies not only to the collection of data from the field stations but also to the transmission of large quantities of data from one regional centre to another.

Another technique of great interest is the meteor-burst technique, in which the reflecting properties of meteors are used for data transmission. The advantage of this system is the independence from satellites.

Radio links will also be used in the future. Fibre optics seem to be of great importance in linking systems for rather short distances.

Just now a new Swedish low energy consumption, automatic terminal, is being designed. This will be a relatively inexpensive terminal and will be of great importance in the modernization and automatization of the network for water level and discharge in Sweden. A mobile station for discharge measurements is being designed as well.

Regarding remote sensing techniques, significant results are to be expected from the development work. For monitoring water pollution, satellite-borne monitoring systems with higher resolution and more suitable spectral channels will be launched. In addition laser systems are being developed and tested for use in studying oil and other pollutants in water. These should be ready for use in the near future.

It is estimated that within about 10 years radar equipment on various platforms will be able to provide data about wave spectra, wave forms, wind conditions and water levels. Most of the development work here concerns the data processing side.

Furthermore, SMHI is planning to install a system primarily for meteorological information. This will incorporate the data from automatic stations, weather satellites and radar stations. This combination should provide better information about the amounts and intensity of precipitation and, by the end of the 1980's, information about the areal distribution of precipitation (Bodin, 1982).

REFERENCES


water surface temperature. *SMHI, HB Report 41.*
