5 Information service

5-1 Ionospheric observation and observation information processing system

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The CRL has been making ionospheric observations for about 70 years. Recently, we have updated the ionospheric sounder and have expanded the observation information processing system. The new ionospheric sounder gathers various observational data by automatic control / remote control. The new observation information processing system ensures the reliability / safety of data. The system also provides the data service quickly and conveniently to users.

Keywords
Ionosphere, Ionogram, Data service

1 Introduction

For approximately 70 years, the CRL (including the Radio Research Laboratory of the former Ministry of Posts and Telecommunications and the Radio Physics Laboratory of the former Ministry of Education) has carried out ionospheric observations in which a variety of ionospheric data has been acquired and analyzed. Made available to researchers, this data has been used as an important source of information for HF radio communication and also as basic data useful in monitoring long-range variations of the global environment. Over the years, there have been many changes in the methods of ionospheric observation and the ways in which the observation data is treated[1]; and the current system, which began in fiscal 2001, is the natural successor to these past methods[2][3], responding to current trends in information communication technology and attempting to answer the needs of diverse groups. This paper will give an outline of the system configurations and the main methods of treating ionospheric observation data.

2 Outline of Systems

An outline of the hardware configuration is shown in Fig.1.

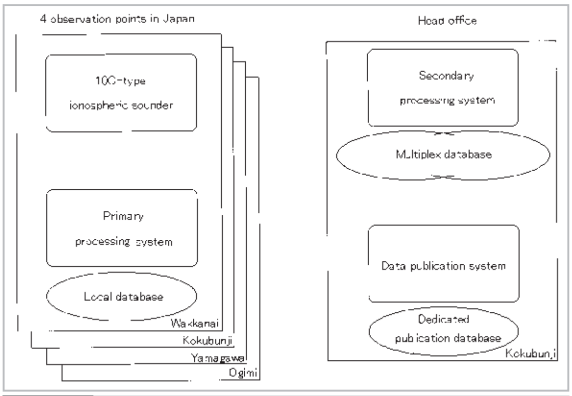

Fig.1 *Outline of system hardware configuration*

A newly developed 10C-type ionospheric sounder (hereinafter referred to as the "10C") and a primary processing system (primary system) are arranged at each of the four observation points (Wakkanai, Kokubunji, Yamagawa, and Ogimi) set up in Japan to enhance operational functions, improve classification of observation data, and allow for better load distribution in terms of processing. Moreover, a secondary processing system (secondary system) with a duplicate database and a data-publication system with an exclusive database have been established at the head office (Kokubunji) to manage safe, quick services while ensuring the reliability of data. In addition, all facilities are connected via TCP/IP communication, allowing them to function as a whole.

3 10C-type Ionospheric Sounder

The outline of a hardware configuration for the 10C ionospheric sounder is shown in Fig.2.

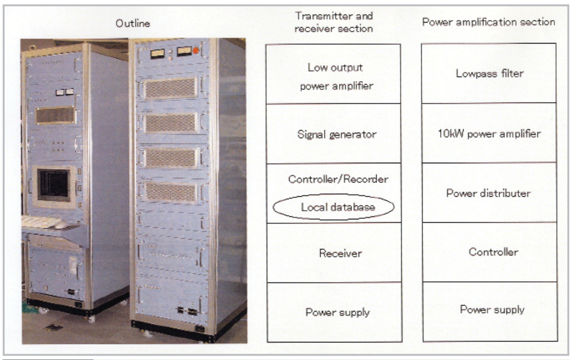

Fig.2 *10C-type ionospheric sounder*

The 10C is equipped with the basic functions of a conventional ionospheric sounder, is capable of acquiring a wide variety of observation data, and is highly accessible, highly functional, and easy to use, without the need for an attendant operator. The main new functions of the 10C are described below.

3.1 Observations Including Intensity Information

Conventional ionospheric sounders output observation data that was essentially made up a black-and-white (2-level gradation) ionograms, in which received intensity information was digitized relative to a certain threshold. However, in view of the current cost performance of external computer storage, improved reliability, and advances in network environments, we have decided that observation data output from the 10C should consist of color (256-level gradation) ionograms with 8-bit intensity information.

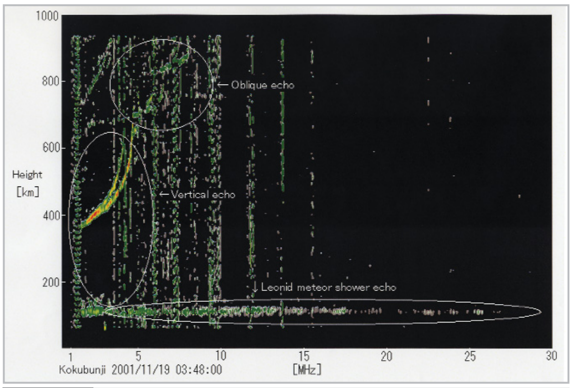

Fig.3 *Example of a color ionogram*

Observations that include intensity information allow for the recording of faint echoes. Prior to the Leonid meteor shower in November 2001, the ionospheric sounder recorded a great number of sudden faint echoes, which were considered to be related to this event. It is hoped that in the future the new ionospheric sounder will enable us to investigate phenomena that might previously have gone unnoticed.

3.2 Polarization Split Observation

In normal operation, the 10C acquires ionograms in which an ordinary wave and an extraordinary wave are intermixed on a one-sheet-per-observation basis; in addition, two built-in receivers (featuring the same performance) enable research observations in which the ordinary wave and the extraordinary wave are received separately, through polarization split observaion. Through ionograms obtained using polarization split observation on a two-sheet-per-observation basis, automatic reading and processing of factor values and the like becomes relatively easy; it is thus hoped that more accurate values may be obtained.

Moreover, since one of the two receivers is always on stands-by during normal operation, this configuration improves reliability.

3.3 Oblique Incidence Observation

The 10C is configured to be capable of

oblique incidence observation on its own, supplanting the now-obsolete dedicated sounder for oblique incidence. The vertical-observation transmission waves of all stations are observed by each of the 10Cs at the four observation points, all of which have clocks calibrated to high precision using GPS. By performing conversion processing of the observed data into a pseudo vertical ionogram that takes propagation distance into account, six pseudo vertical observation points may be added. Moreover, the sounder is provided with a function for observing the error rate of digital communication (at a fixed frequency) at the time of the propagation of oblique incidence.

3.4 Programmable Automatic Observation

The signal-processing component is modified to allow for DSP (Digital Signal Processing), thus enabling reduced dependence on hardware relative to its predecessor, and is also configured so that almost all observation setup information (date and time, classification, detailed parameters for each classification, etc.) can be input into the application program. By setting basic observation information and variable information beforehand, including such items as observation-point data and data on seasonal variation, the new sounder allows for automatic observations that do not require human labor in normal operation.

3.5 Unattended Operation

The operating state of each circuitry block of the hardware constituting the 10C is regulated through multipoint monitoring, while auxiliary information collected at the time of observation (such as various electric power values and self-diagnostic values) enables faults to be located at the earliest stages. Through the automatic evaluation of such auxiliary information, early detection of problems and the issuance of corresponding alerts become possible. Moreover, the new sounder is prepared for emergencies, with a remote shutdown function in the event of power failure as well as an automatic recovery function upon restoration of power.

3.6 Networking Capability

By making the 10C's control computer capable of networking, nearly complete remote control and remote monitoring via network are realized, making it possible to transmit observation data in real time and enabling quick response to a variety of unexpected events. In addition, the new sounder is configured to allow for remote maintenance, including upgrading the firmware/application software of the 10C itself, leading to improved ease of maintenance and greater modularity.

In addition, the 10C is provided with a local database for storing observed raw data for a certain period, which is useful, for example, in the event of a failure halting operations in the primary, or any other following system including the secondary system.

4 Primary System

The main data streams of the primary system are shown in Fig.4.

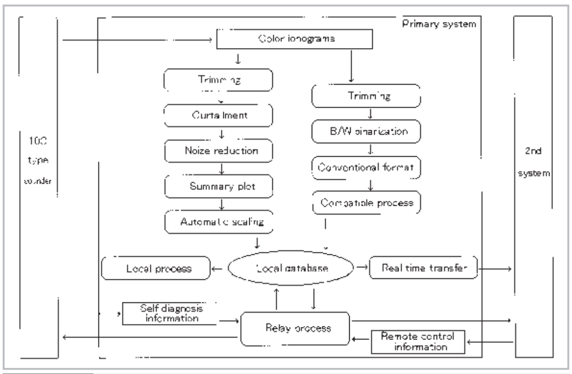

Fig.4 *Main data streams of primary system*

The primary system, deployed at each observation point, performs, for each observatory, distributed processing of the data obtained from the 10C and manages relay processing of control-system information between the 10C and the head office, as well as a variety of local processing tasks. The main functions of the primary system are described below.

4.1 Vertical-Observation Color Ionogram Data

A vertical observation color ionogram obtained from the 10C is subjected to trimming, reduction, noise removal, summary plot formation, automatic reading, etc., and the output thus obtained is stored in the local database. This data is used for a variety of local processing tasks and is transferred to the secondary system as well, so that the sequential real-time nature of the data is preserved. Moreover, the data is subject to the processing required for color ionogram noise removal, summary plot formation, and the like, to improve overall data quality.

4.2 Conventional Database Compatibility

In order to maintain compatibility with existing conventional databases, the vertical-observation color ionogram obtained from the 10C is subject to trimming, black-and-white binarization, and conventional format processing. Subsequently, the processed data is subject to compatibility processing (equivalent to the processing of observation data obtained from the earlier ionospheric sounder), thereby ensuring continuity and consistency with past data.

4.3 Control-system information relay

The auxiliary information obtained from the 10C at the time of observation (including various electric power values, self-diagnostic values, remote-control information from the system at the head office, etc.) is relayed in real time within the CRL system, allowing the primary system to perform both collective remote monitoring and collective remote control. Moreover, the primary system enables operational and control details from the local station's ionospheric sounder to be confirmed with reference to past data, and provides a basis for evaluation of the transition between the different operational modes of the 10C, together with evaluation of the observation data itself.

In addition, by performing distributed processing of the relatively large load presented by observed raw data (involving conversion of the oblique incidence observation data to a pseudo vertical ionogram, for example), load is prevented from concentrating in the secondary system. Moreover, the storage of main data for a certain period in a local database enables not only response to a network or secondary-system failure that halts operations but also recovery of lost data through re-transmission thereof.

5 Secondary System

The main data streams of the secondary system are shown in Fig.5.

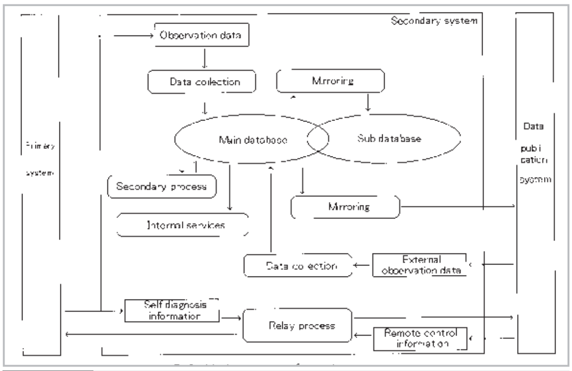

Fig.5 *Main data streams of secondary system*

The secondary system, established in the head office, collects and manages the data obtained from the primary system at each observation point and from the data-publication system, and also functions as a data server and a server for various internal functions. Moreover, the secondary system handles database multiplexing. The main functions of the secondary system are described below.

5.1 Observation Data Collection and Management

The secondary system collects and manages observation data obtained from both the primary system (at each observation point) and from the data-publication system, and also performs sequential storage of the data in corresponding locations on the main database. In terms of this data storage, user convenience is enhanced through connection processing for each observatory, secondary conversion processing for each period, and so on; at the same time, storage and data-access efficiency are improved through archive processing for each data classification.

5.2 Various Internal Services

Various internal services, such as display output and printouts (including publication of the Ionospheric Data in Japan) and data-file output for specified data classifications for selected periods, are enriched, thereby offering greater user convenience.

5.3 Data Multiplexing

Various files on the main database and their contents are automatically evaluated by mirror processing, and complete duplication of the data is implemented through sequential replication in the sub database, resulting in improved reliability of both the system and the data it holds. Moreover, all data that must be externally accessible is subjected to mirror processing in an exclusive database within the data-publication system, to ensure independent multiplexing, thus ensuring system safety and integrity of data.

5.4 Control-System Information Relay

The auxiliary information obtained from the primary system at each observation point at the time of observation (such as various electric power values and self-diagnostic values) is collected for all observation points and is relayed to the data-publication system in real time, and remote control information and the like obtained from the data-publication system is distributed to the primary systems at the various observation points in real time.

Since the primary system relieves the secondary system from the relatively large load required to process observed raw data, and since the secondary system is also protected from the load resulting from general public access to the external services of the data-publication system, the secondary system can concentrate on data management and internal services; therefore it will be capable of expanding in response to the larger anticipated processing loads of the future, without the need for local enlargement of the system.

6 Data-publication system

The main data streams of a data-publication system are shown in Fig.6.

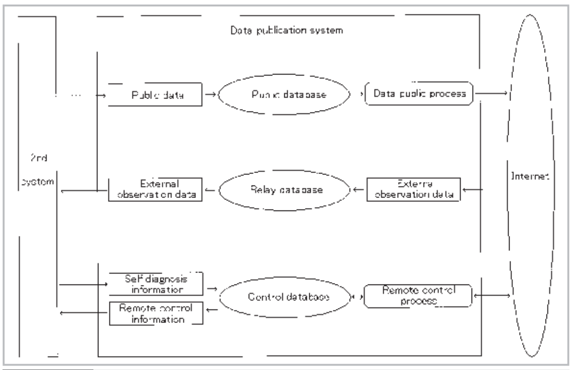

Fig.6 *Main data streams in a data-publication system*

The data-publication system, established in the head office, performs data publication services for outside users (mainly via the Internet), and manages collection and relay of data received from outside of the system. The main functions of the data-publication system are described below.

6.1 Dedicated Publication Database; External Data Publication

Data for publication that is transferred to the data-publication system by mirror processing in the secondary system is sequentially stored in a corresponding location on the dedicated publication database for each classification. The data stored in the database exclusive for publication immediately becomes available for various services intended for external use. As a result, although available data is limited by physical storage size, popular services nearly equivalent to the various internal services are available through the worldwide web, thus offering greater overall user convenience.

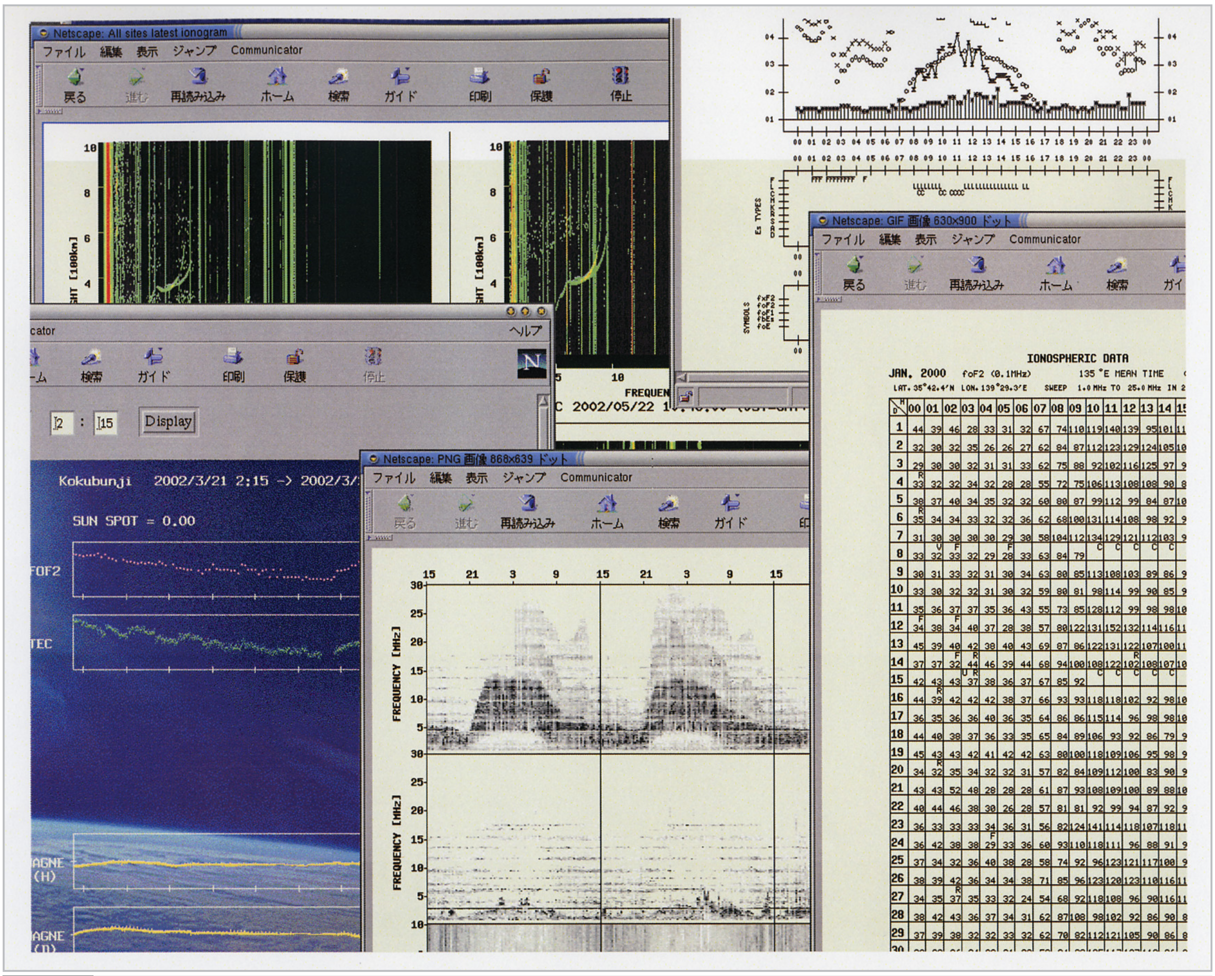

Fig.7 External data publication through the worldwide web

6.2 External Observation Data Collection and Relay

Observation data obtained from observation points other than those of the CRL is sequentially stored in the relay database in locations corresponding to each classification. The data stored in the relay database is sequentially collected within the secondary system, thus preserving the sequential real-time characteristics of the data.

6.3 Collective Remote Monitoring and Control

Information obtained from the 10C at each observation point (such as various electric power values and self-diagnostic values) is collected and managed within the data-publication system and may be reviewed via the worldwide web. Moreover, control information for the 10C at each observation point is also controlled collectively within the data-publication system and may be operated through the worldwide web.

This configuration has allowed for collective remote monitoring and for the collective remote control of 10Cs at all observation points, from anywhere, subject only to sustained Internet connection.

In addition, we have implemented home processing of manual scaling operations by developing a Windows-version manual scaling system and installing an exclusive interface for the data-publication system.

Moreover, rapid and safe services are possible through the provision of a data-publication system with an exclusive database and configuring it independently; further, outside users can still use the services even when operation of the secondary system is halted. In addition, a special firewall is installed for

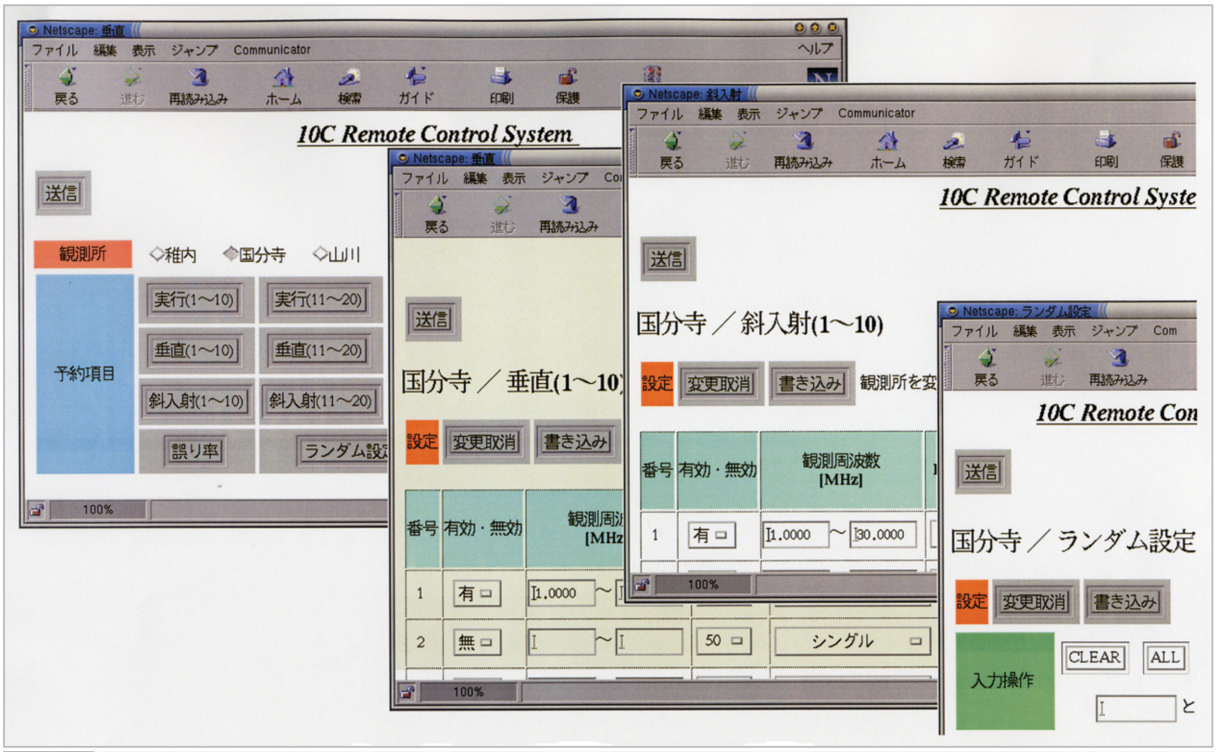

Fig.8 Remote control of 10C through the worldwide web

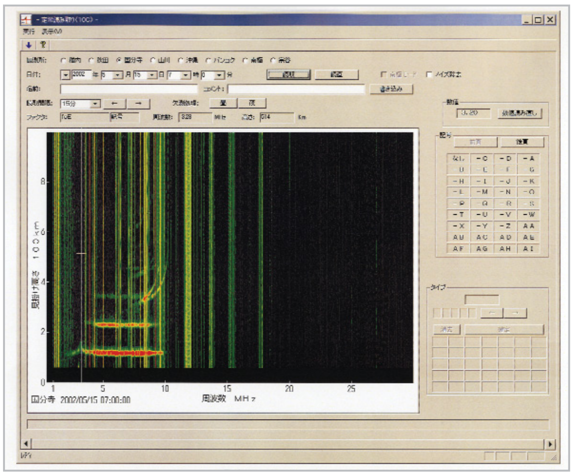

Fig.9 Manual scaling system

the data-publication system to block out unnecessary logical communication ports, thereby further ensuring the safety of the system.

7 Conclusions

This system has been constructed to require virtually no attendant intervention with respect to basic operations, from data acquisition to the distribution and use thereof. Moreover, this system has the following advantages compared with its predecessor.

(1) This system has paved the way for the transition to color ionograms featuring intensity information, offering the possibility of the investigation of previously unobservable phenomena.

(2) The ability to perform polarization split observation allows for unprecedented high precision in calculations.

(3) With oblique incidence observation performed among all four observation points, we will see an increase in the number of pseudo vertical observation points.

(4) Enriched programmable automatic observation, remote monitoring, and remote control all support unattended operation of the sounder and also enable quick response in the event of unexpected events.

(5) Data reliability has been improved by providing a storage buffer on each data path and by multiplexing the respective databases.

(6) Quick and safe external services have

been realized by making the data-publication system independent.

(7) Expansion is possible to accommodate future load increases.

The focus of this paper is on the main handling of ionospheric observation data. The system in question operates as a comprehensive ionospheric information system and deals simultaneously with multiple items of ionospheric observation data. We hope that with the effective use of this system, ionospheric phenomena will be grasped more precisely; accordingly, we intend to investigate the ways in which analytical values having higher precision may be automatically acquired, and to pursue service techniques that will meet the needs of future data users.

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