Real-time observation monitoring and analysis network

Haihe LIANG[1], Chunhui ZHANG[2] ,Zhaolin MENG[1]

[1]Meteorological Observation Centre of China Meteorological Administration,

No.46, Zhongguancun South Street, BEIJING 100081, China

TEL:+86-10-68406999, FAX: +86-10-68400936, E-mail:lhhaoc@cma.gov.cn

[2]The 28th research institute of China electronics technology group corporation, Nanjing 210007, China

ABSTRACT:

The Real-time Observation Monitoring and Analysis Network of China (ROMANC) has been developed to provide real-time meteorological observation data and instrument parameters to meteorologists and equipment managers who deal with malfunction. ROMANC is a web-based system designed to provide access to weather observations quality management from a large number of networks across China. The system collects, processes and displays Doppler Radar, Sounding Radar and Weather Automatic Station observation data and metadata in fast-loading formats tailored to Chinese Meteorological Administration (CMA) users for quality evaluation and equipment failure analysis. The interface is intuitive, interactive, and dynamic. The software is designed to be accessible to the wide range of professionals requiring observational data, from the top-level managers using high speed networks to the instrument behaviour analysts in the field using a slow dial-up connection.

ROMANC has been under development since April 2006 and tested during 2006 and 2007 . During the short time when ROMANC was in operation, it got to be used more and more. Meteorological Instrument behavior analysts, observation quality analysts, managers, and meteorologists began to use ROMANC to monitor observation system performance for strategic and tactical decision making as well as to determine material and personnel resources.

1. Introduction

World Meteorological Organization (WMO) considers that the quality guarantee of meteorological observation needs to establish effective management system. A good management system should run through all phases of the whole observation system, besides its performance it also includes equipment installation, operation, compatibility, sitting and exposure, performance monitoring, test and calibration, maintenance, metadata, real-

time quality control and some other factors. In China, there is a great observation network used in weather, climate and professional meteorology observation services. With the requirement of natural disaster prevention and climate change response, and quickly developing of the observing equipment, the operational guarantee of meteorological observation has become a key point of the whole observation system. Chinese equipment maintenance and data quality management are being underway, it is an exigent and important mission to quicken the construction of developing operation system.

The basic principle of operation monitoring system is to take watching status parameters, managing the maintenance information and the data quality surveillance, then to develop the observations analysis and maintenance supporting for enhancing the reliability and level of the observation network. Since the beginning of 2006, China has been designing and developing the monitoring system of meteorology observation network, and during the flood season of the year the operation monitoring experiment of Doppler weather radar was finished, collecting very good effect. In 2007, the development of data quality monitoring and maintenance information management of the automatic weather station, sounding system and Doppler weather radar got completed, then the operational experiment was done in 2007 and 2008. Based on it, Meteorological Observation Centre, CMA (MOC, CMA) established daily monitoring and analysis system, began to monitor the observation network on real-time developed the analysis of the observation products, improved the operation quality and achieved notable benefits.

2. The design principle

ROMANC integrated the status monitoring of equipment operation, information managing of meteorological technology maintenance, and monitoring of data quality into one platform. Based on RAMANC, a complete set of meteorology monitoring and analyzing operation will be established step by step, which can enhance the capability of observation quality and monitoring service. ROMANC includes operation status monitoring, data quality monitoring and information management of technology maintenance.

(1) By the technological ways, such as status monitoring, parameter monitoring, data checking and technology supporting, the status of meteorological observation system can be analyzed and evaluated, at the same time the technology supporting can also be offered to the equipment managers and decision-makers. Status monitoring is to inspect the status of equipment, which forms a closed cycle from status information collecting, processing, data statistic and feedback. By receiving the information of status parameter and failure alarm from the stations, a database composed of equipment categories, substation points, time and frequency of monitoring the equipment performance, and failure-alarming has been set up, conducting statistic analysis on the availability, failure ratio, and validity of data, analyzing and evaluating the general performance and development situation of the network.

(2) By the analysis methods, such as real-time monitoring of the data quality, the space-time distribution consistency, stations and environment changes, products of monitoring, analyzing and evaluating data quality have been produced, which can enhance the service level of observation. Data quality monitoring system takes the charge of information display, data quality check and analysis, and data continuity, space-time consistency and reliability, and guide the maintenance technicians to find failure in time, thus, periodical analysis and evaluation report can come into being and offer evidences for decision-makers.

(3) By automatic information management of equipment maintenance, calibration logistic management and license, the continuing, reliable operation of the observation system can be ensured. Information management takes the charge of collecting maintenance information, supervising equipment and instrument, online searching for some regulations, criterions, standards, rules and software of the meteorological equipment and also monitoring the equipment supply and demand, at the same time putting out the information of equipment and instrument providing and storage, offering information platform for the equipment license to monitor the equipment and all kinds of components completely.

The operation monitor is based on national and provincial arrangement, as for the national class, which offers synthetic situation, operation quality and benefit analysis to the top-level decision-makers, simultaneously, offers some evidences for the development and revolution of observation technology and maintenance operation. While for the provincial class, it emphasizes operation management and application service, which offers operation situation, storage/requirement/consumption of spare parts, maintaining and testing, stocking plan to the operation manager. Moreover, it can also offer real-time operation status for the maintenance technicians so that they can successfully carry through maintaining, calibrating, providing spare parts, technology supporting and some other operational activities, and providing metadata and quality analysis for the users in the meteorology field.

3. Software structure

1) The top structure

The system structure has been designed as “2-level services and 3-level users”, which means that there is a 2-level system, national and provincial system, offering application service to levels of station, provincial and national. Among them, the application function of station level is offered by provincial service centre.

National system accepts the status data, products, operational data from provincial system, then analyzes and evaluates them synthetically, and provide statistics products for the national users in time. Meanwhile it can instruct, supervise, and manage the maintenance operation for its branches. The provincial system is responsible for collecting operational status data, observation products, operational information from stations, providing monitoring products and service function for provincial users and also reporting operational monitoring

information to the national system. The national and provincial systems have the function to carry out the real-time data exchange.

2) Software structure

Based on the designing method of the object, the system is divided into two parts, to data processing and to service for user. Data processing system adopts multi-task way to run, mainly focuses on data processing, including data collecting, data resolving, data analyzing, products and storage function. System of service for user adopts modularized design and takes on the external service mainly, offering monitoring products to users, accepting answers from users and responding to the web by all kinds of technologies (such as GIS). This system includes monitoring, maintenance, logistics, calibration, license, data surveillance and operational efficiency index modules. They become an organic system, so the inner relations were considered emphatically when the system was designed.

The software system adopts the way of combining C/S with B/S. C/S structure is taken to data processing system, and B/S structure for service system. Data processing system uses VC++ and ORACLE technologies to establish C/S pattern to realize data collecting, resolving, processing and evaluating. System of service for user adopts J2EE technology combined with WEBGIS and ORACLE technologies to establish multi-layer B/S/S pattern, and also to realize operation monitoring, product issuing and some other functions. J2EE system has better technological framework for retractility, opening and credibility.

3) Application based on WEBGIS

Meteorological observation equipments, such as weather radar, AWS, upper-air sounding system, have evident spatial characteristics. When technicians watch the operation status, they need to know the spatial location and the local weather conditions. Furthermore, stations and equipments based on the GIS can directly show the distribution of each equipment and the network and some information about the network programming. Therefore, GIS is one of key technologies for this system.

WEBGIS is the product of the internet technology applying to GIS. Using internet technology to issue geography information in the Web, makes it easy to browse from an arbitrary point in WWW, do all kinds of searching and processing, and offer practical technology for the opening and sharing of monitoring information to meet the different demands of national, provincial and station users.

4. Main system functions

(1) Function engine and interface

A method based on the platform or module is to divide some function modules with commonness and internal relation, according to the commonness, which establishes a uniform model and realized extended function by clear interface. According to this method, the user interface of this system is designed into 3 function regions: system engine, function operation and information display. Among of them, system engine is divided into monitoring and maintenance, which is a top function area. Function operation area is a functional menu for monitoring and maintenance. Information display area is a displaying interface for GIS, data form, statistical figure, image and text, which provides users for searching and analyzing. The function of system engine can be layered, classified and positioned, providing favourable interface for users.

Fig 1. System interface figure. Left is engine area, top bar is function area and the middle is displaying area.

(2) Monitoring

Monitoring engine area has equipment and data monitoring function including equipment types and positions. Take equipment types tree and area tree as mainly searching engine, then it is convenient for users to quickly position some region or all equipment layers. At the same time, the operational information and data content will be displayed. At present, the equipment types include weather radar, AWS, upper-air sounding system, and region types are divided into 3 classes, that is national, provincial (31 provinces) and prefectural.

1) Equipment monitoring.

Based on parameters and certain model, equipment monitoring can show some indexes by processing and judging operational status, such as normal, failure and alarming in many ways. Equipment monitoring is composed of processing and analyzing, parameter checking, real-time monitoring and displaying, historical

monitoring and displaying and station synthetical displaying modules. Parameter checking takes the charge of checking operational parameter of radars, picturing its change during some period and showing suggestive information for super-values. Real-time monitoring can directly respond the equipment status by overlapping on the Chinese electrical map with some special flags. Historical monitoring figures show the equipment operational status in any time or any period with time series. Station synthetical displaying can gather figures, parameters and alarm information, which is beneficial for analyzing both equipment status and products quality (Fig. 2).

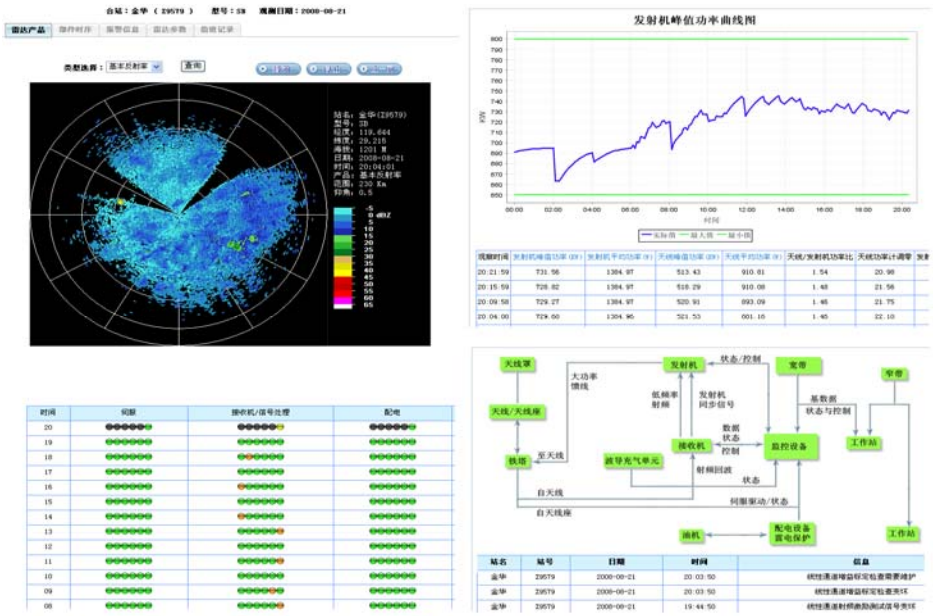

Fig. 2. Station synthetical displaying figure of radar. (Top left is echo intensity, bottom left is time-series figure of operational status, top right is power curve and data, and bottom right is alarm or failure position)

2) Data monitoring.

Data monitoring adopts extremum check, internal consistency check, spatial consistency check and time continuity check for the elements of AWS and upper-air sounding system, offering real-time results of the normal, doubtful, abnormal and error. Data monitoring includes data records monitoring, data quality checking and products displaying modules. Among them, data records monitoring module is majored in monitoring and analyzing the validity of data file format and contents, consequently, find some problems in data unit. Products display module includes dynamic radar image, AWS and sounding figure.

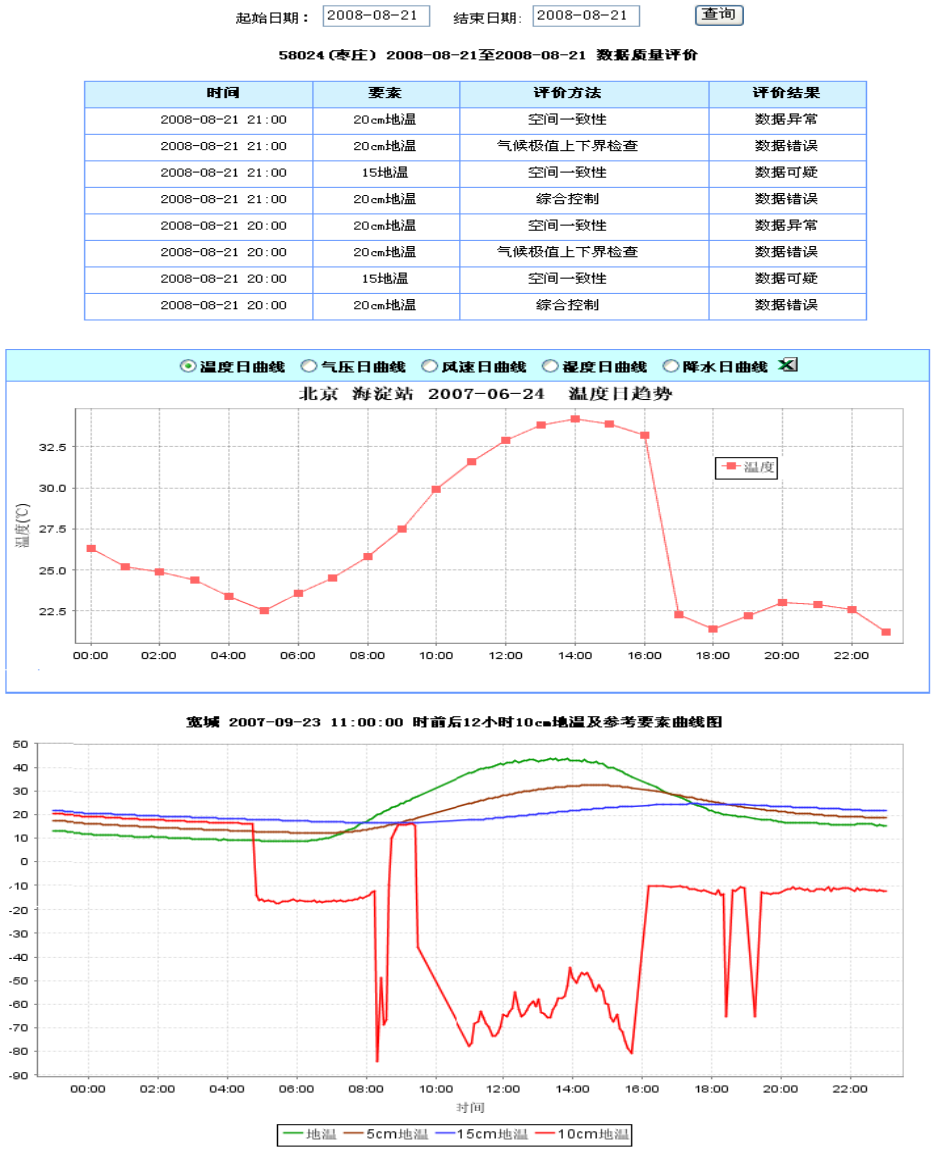

Fig. 3. Threshold displaying of AWS (Top is data quality evaluating result, middle is elements displaying and the bottom is error data)

(3) Equipment maintenance

Maintenance function design takes the equipment as the core and only takes the equipment ID as function chain, then develops the system function and module design. It can realize the life-circle management and monitoring of the equipment, offer supporting platform to improve maintenance level by archiving the life time of the equipment from registration. Maintenance function includes maintenance management and transaction management.

1) Equipment maintenance management

In China, nation, province and station take the charge of meteorological equipment maintenance, which adopts event triggering and response mechanism, that is, different department can take a start up based on responsibility and criterion, whose section and technicians will give response until this event close forms a closed

process. Equipment maintenance includes restoration, calibration, logistics and license modules. Restoration management module is some kind of information monitoring management including failure report, maintaining response, remote supporting and expert diagnosis, meanwhile, combined with alarm function to realize automatic report and response in time (Fig. 4). Calibration module establishes a database for supervising instrument calibration valid periods, which has alarm, and statistics function. Logistics management has realized plan, stock, supply and storage in the internet. On the basis of operation and consumption, it can form stock plan and submit report by corresponding approval procedure then carry out stock in the internet and issue storage status at the same time. License module has realized declaration, experimentation, approval and search information management and has standardized management flow. Technology rules, regulations, criterions, database and information searching platform were established.

The system has some functions such as editing, modifying, inputting, maintaining, including some basic information about stations, equipment types, numbers, observation items and update information about the sensors. Furthermore, there are some other relative parameters, such as communication, IP address, transmission velocity and some information about operation and technicians.

Data is collected on the basis of different levels (national, provincial and station), and issued in daily, weekly, monthly, seasonal and annual way, therefore form statistical tables such as equipment consumption and spare parts storage. According to that, the operational department compiles evaluation reports and then reports to functional department of CMA.

Fig. 4 The programme interface of maintenance (Left is function engine area, and right is displaying and editing area)

2) Affairs management

Affairs management is composed of operational report, log book and monitoring report modules. Operational report includes bulletin, asking for instructions, notice, collecting various information and monitoring issue function. When operational staff find some problems during monitoring they will send information to the technicians or branch in different level in time. For example, the information of weather radar can be transmitted from monitoring centre to radar technology department of MOC (Meteorology Observation Centre, CMA). The technicians in provincial level report vital events to national system, such as checking out, daily maintenance, etc. Log book offers records on duty, telephone record, technology support service and shift record. Monitoring report is some kind of analysis report issued by MOC in weekly, monthly, seasonal and annual way.

(4) Other functions

It mainly includes station environment monitoring, station basic information management and so on. Environment monitoring includes real-time video monitoring and automatic displaying function. Basic information mainly offers some information about system maintenance, such as basic information of surface stations, radars, upper-air sounding.

5. Application effect.

On the support of monitoring platform, MOC has established monitoring maintenance operation step by step and can know about the operation status. Therefore, passive situation of the maintenance has been changed. The observation quality has been improved by evaluation, which offers powerful technology support for efficient management.

(1) In order to evaluate radars operation status objectively and quantificationally, 3 indexes have been designed, that is reliability, availability and failure rate. Here, T stands for radars working time, T1 for normal time, T2 for valid time (If there is alarm, observation will not be influenced), T3 for needing maintenance but radar is on operating and T4 for failure but radar is power off.

Reliability (R) = T1/T,

Availability (A) = （T1＋T2）/T

Failure (F)= (T3+T4)/T

Since radar efficiency was evaluated, radar technician and manager have adopted effective measures, which greatly improved it. The statistical results show that the reliability, availability and failure rate of radar from June to August in 2006 is 87.21%, 89.49% and 9.35% respectively, while it is 94.23%, 95.68% and 1.64% in 2007,respectively.

2) Based on the monitoring platform, the maintenance idea has been changed from passivity to initiative, that is if severe weather occurs, it can take the initiative to check equipment performance, do material and personnel deployment according to monitoring and analysis results, which is helpful to equipment maintenance in important and crucial period.

Fig. 6 (left) is Yangjiang radar power figure before typhoon “Pearl” landing. It can be seen that transmission power is unstable and 130 KW below normal level. When this phenomenon was found out, the technicians immediately debugged the radar. Fig. 6 (right) is failure power curve. After checking, we found klystron was aging then MOC has changed it in time.

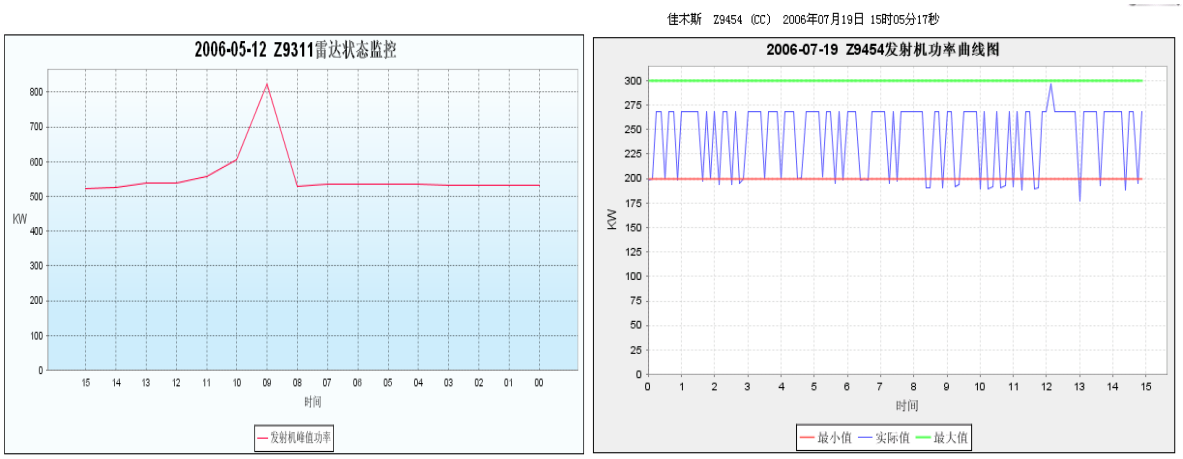

Fig. 6 Parameter curves of equipment operation.

(3) For AWS, under the development of monitoring, the data format errors have become less and less, from hundreds of records during flood season in 2007 to very few now. Data error or doubtful numbers have also decreased and the quality has been improved by time consistency, spatial consistency and extreme value checking. While for upper-air sounding system, data quality checking has also been developed and the system malfunction can be found, for example, the upper-air sounding data in Kunming was abnormal in Oct, 2007. After checking, the antenna became flexible and the technicians took measures, then the data was in normal. Moreover, it is convenient for real-time data analysis and operation quality by statistical analysis of sounding balloon altitude.

6. Conclusion

After two years of designing and development, ROMANC has got great progresses and established a new operation-monitoring and analysis. Its capability is improving step by step. But it is different from some other tool software, which includes operational flow, scientific method and operation content. So, it is difficult to design and develop. In addtion, many of the existing functions need to be improved, especially the data checking arithmetic needs to be focused. This platform is just one step of data quality management ,and there is a lot to do in the system, including a new concept to strengthen the equipment manufacture in function designs.

References:

1. WMO Guide to Meteorological Instruments and Methods of Observation,WMO No. 8, sixth edition 1996, seventh edition in English to be published in 2006.

2. Atkins, M. A., 1984: Quality control, selection and processing of observations in the Meteorological Office's operational forecast system. In ECMWF Workshop proceedings 'The use and quality control of meteorological observations'.
3. Lars Andresen, Halldór Björnsson, Ulf Fredriksson, etc. Manual Quality Control of Meteorological Observations Recommendations for a common Nordic HQC System, CLIMATE REPORT， NORWEGIAN METEOROLOGICAL INSTITUTE，BOX 43 BLINDERN , N - 0313 OSLO, NORWAY
4. Flemming Vejen, Caje Jacobsson, Ulf Fredriksson, etc. Quality Control of Meteorological Observations Automatic Methods Used in the Nordic Countries, CLIMATE REPORT ， NORWEGIAN METEOROLOGICAL INSTITUTE，BOX 43 BLINDERN , N - 0313 OSLO, NORWAY
5. World Meteorological Organization. CBS/OPAG-IOS/ET AWS-3/Doc.4(1).Guidelines on Quality Control Procedures for Data from Automatic Weather Stations. 2004.