Design and Implementation of the Informatization Management System for the Meteorological Station Network Basic Data

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Abstract. The basic data of the meteorological station network has such problems as inaccuracy, untimely review and inconsistency among operational systems. Aiming to solve these problems, we design an informatization management system for the meteorological station network through the WeChat enterprise. It employs the area verification and the altitude validation based on the digital elevation model, and it performs a regular comparison with the data from the China Integrated Meteorological Information Sharing System. This system realizes the dynamic management for the filling, submitting and reviewing of the station network basic data. It has functions such as intelligent verification of the input data of the station network, efficient and convenient data review, timely reminder message and flexible data service interface. Therefore, the system effectively improves the accuracy of the station network basic data and the review efficiency.

Keywords: Station network basic data, WeChat enterprise, informatization, intelligent verification.

1. Introduction
The basic data of the meteorological station network is a set of information describing the distribution of the stations, including the station name, station number, longitude, latitude, altitude, observation elements, personnel information, equipment information and environmental condition [1,2]. It is the basic information of the meteorological operation, which plays important roles in various fields such as integrated meteorological observation, forecast and prediction and meteorological service [3, 4]. Improving the accuracy of the station network basic data will help to promote the meteorological observation operation.

Recently, with the advancement of meteorological modernization, the scale of the integrated meteorological observation network has been expanding, and its layout has been continuously optimized. Meanwhile, the basic data of the station network has also changed in some degree [5,6]. However, the station network basic data is still filed and reviewed with Excel and Word and transferred through the document management system. Thus, the problems such as data inaccuracy, untimely review and data inconsistence among operational systems exist. By simplifying the alteration process of the basic date of the meteorological station network and applying the intelligent verification method and the mobile Internet technology, the system realizes the dynamic management for the collecting, submitting and
reviewing of the basic data. It provides technical support to effectively improve the integration and informatization of the basic data management of integrated meteorological observation operations.

2. Design idea

The system covers the basic data of new-generation weather radar, upper-air sounding system, national automatic weather stations, regional automatic weather stations, automatic soil moisture stations, lightning monitoring stations, Global Positioning System Meteorology water vapor observation and atmospheric composition monitoring stations. At present, when the basic data of the meteorological station network is changed due to the construction, relocation and cancellation of meteorological stations, the alteration application is initiated by the station staff, and sequentially approved by the municipal and provincial operational managers. After approval, the alteration information is issued to all levels of operational management and data application departments. This workflow of basic data management is quite complicated. The system designed in this paper can simplify the workflow of the basic data alteration. The review function for the station network basic data is established on the mobile terminal, so users can receive reminder messages timely and perform editing and reviewing operations. Therefore, the review efficiency of the station network basic data is significantly improved. Besides, the system checks the data validity and correctness as it is input to help users avoid input errors. In addition, the system is designed to automatically check and compare the station network basic data regularly, and the comparison results are automatically fed back through WeChat to further improve the accuracy of the basic data.

3. System design

The system consists of two parts: The Web-based application and the WeChat-based platform. The Web-based application displays the station distribution on the home page in real-time with the Geographic Information System map and shows the alteration status of station in different colors. The data maintenance module tracks and manages the whole process of the basic data alteration, mainly including the operations of editing, modifying, submitting and reviewing. The module carries out verification for the latitude, longitude and altitude and validity check for other data, thus effectively avoiding the human input errors in the traditional management method. The comparison and analysis module automatically obtains the station basic data in various real-time meteorological observation documents and compares them with the existing data in the system to form the false alarm information. The data service module allows flexible customization for the data type and the sharing method, so that the basic data can be applied to other operational systems.

For the WeChat-based platform [7], users can scan the two-dimensional code and follow the public account of the system, and then they can view the station alteration within the jurisdiction in the past week, month, half-year and year in WeChat. Besides, users can receive reminder messages anytime and anywhere throughout the whole approval process of the basic data alteration, and edit or review the data through the personal to-do module.

3.1. Validation method for basic data

The latitude, longitude and altitude are widely used station network data, and their accuracy directly impacts the application quality of the meteorological observation data [8]. However, in the traditional management of the meteorological station network basic data, errors occur frequently in the station latitude, longitude and altitude. The system in this paper employs the area verification and the altitude validation based on the digital elevation model (DEM) to check the input accuracy of the latitude, longitude and altitude. If the verification fails, the data will not be submitted and reminder messages will be displayed.

3.1.1. Area verification. The management of meteorological stations is based on administrative divisions of province, city and county, and the effective latitude and longitude range of the station can be determined according to the latitude and longitude of the county (banner) where the station is located.
The system obtains the boundary latitudes and longitudes of each banner and county in Inner Mongolia from the application programming interface of Baidu Map [9], and saves the boundary data to the database. When users save the created or modified station network basic data, the system automatically checks whether the station's latitude and longitude are within the corresponding county (banner) boundary. If yes, the input is identified to be correct; otherwise, it is identified to be incorrect.

The system derives the extreme altitude range of each banner and county in Inner Mongolia based on the Shuttle Radar Topographic Mission DEM data with a spatial resolution of 90 m×90 m published on the website of Geospatial Data Cloud [10]. The station altitude is denoted by alt, and the minimum altitude and maximum altitude of the county (banner) where the station is located are represented by minalt and maxalt, respectively. If minalt ≤ alt ≤ maxalt is not satisfied, the altitude data of the station is identified to be incorrect.

3.1.2. Altitude validation based on the digital elevation model. Due to the influences of various factors, such as the interpolation algorithm and the measurement accuracy, the DEM data and the station altitude cannot be matched precisely. Therefore, the statistics of maximum, minimum, average and standard deviation of the DEM data within a specific reference area around the station are adopted to validate the accuracy of the station altitude. The representative grid point of the DEM is determined with interpolation based on the station latitude and longitude. Then, a reference area is determined with the representative grid point as the center and a specified length as the radius. The validation parameters are derived based on the altitudes of all the grid points in the reference area. The correctness indicator D is shown in Eq. 1. If |D| > 5.5×σdem alt, the altitude is identified to be wrong. D>0 and D<0 indicate overestimated and underestimated altitude, respectively.

\[
D = \begin{cases} 
0, & \text{min}_{demalt} \leq alt \leq \text{max}_{demalt} \\
alt - \text{max}_{demalt}, & alt > \text{max}_{demalt} \\
alt - \text{min}_{demalt}, & alt < \text{min}_{demalt}
\end{cases}
\]

Where misdealt, mindemalt, avgdemalt and σdemalt present the maximum, minimum, average and standard deviation of the DEM altitude in the specific reference area around the station, respectively. In this method, the validation parameters of DEM data are closely related to the radius of the selected reference area. The absolute bias between the station altitude and the DEM data is expressed by |alt - avgdemalt|. The standard deviation of the absolute biases is the smallest when the radius of the reference area is 13 km, indicating stable biases of the validation parameters within the reference area. Thus, the radius of the reference area is taken as 13 km.

3.2. Workflow of basic data alteration

The station network basic data is edited based on the operations of construction, migration, cancellation and upgrade of the meteorological stations. The system automatically verifies the correctness and validity of the submitted basic data when it is saved. The data is submitted to the municipal department for approval if it passes the verification, and a reminder message for review is pushed to the municipal users. After the municipal approval, a reminder message for review is pushed to the provincial users, and the station users will receive a message about the approval. A message of successful data alteration is sent to both the municipal and station users after the provincial approval. Otherwise, the data is directly returned to the station users, and a rejection message is pushed to the municipal users.

3.3. Regular comparison-feedback mechanism

The China Integrated Meteorological Information Sharing System (CIMISS) is the support environment for the provincial observation data, which collects and stores various real-time meteorological observations [11]. The informatization management system links to the MUSIC interface of CIMISS.
[12] to obtain the information of various real-time meteorological observation data, such as station name, station number, latitude, longitude and altitude. First, the system automatically extracts the information in the observations at the current moment according to the set comparison period. Then, the longitude, latitude and altitude of the corresponding station are automatically searched for comparison. Finally, the alarm message of suspected error obtained through the comparison is automatically pushed to the relevant user's WeChat, reminding the user for verification and processing.

4. System implementation and applications
The system is developed with the popular framework of SpringMVC+MyBatis+Apache Shiro+Jquery+Bootstrap+Ehcache+Redis+Ztree and the open source MySql database [13, 14]. The PC application adopts the B/S architecture, and the mobile platform is based on the WeChat enterprise. The system is deployed on the provincial server and available for provincial, municipal and county (banner) users. The Information Table of Integrated Meteorological Observation Quality Assessment issued by the provincial management department in Inner Mongolia on March 1, 2018 is initialized in the system. It is compared with the station longitude, latitude and altitude in the observation data reported at 0000 UTC on March 10, 2018 to remove the stations with alteration during March 1 to March 10, 2018. After the 1-year trial operation, the existing station network basic data is compared with the station longitude, latitude and altitude in the observation at 0000 UTC on March 10, 2019. The results show that the consistency between the existing basic data in the system and that in the real-time meteorological observation has been significantly improved for various meteorological stations in Inner Mongolia, especially the regional automatic meteorological stations with frequent operational changes.

5. Conclusions
The station network basic data in the present integrated meteorological observation operation has such problems as inaccuracy, untimely review and inconsistency among operational systems. An informatization management system for the station network basic data is designed to solve these problems. The system performs automatic calibration for latitude, longitude and altitude with the area verification and the DEM validation. In addition, it allows online review, pushes reminder messages intelligently with WeChat and regularly compares the station information with the CIMISS data. The system realizes the informatization and mobile management of the station network basic data, effectively improving the data accuracy and the review efficiency. Therefore, it helps to realize the standardized management and application of the station network basic data. Furthermore, the system can be popularized in all the provincial meteorological bureaus across China.

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