Application Design of Provincial Meteorological Service System Based on National Unified Meteorological Data Environment

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Abstract. A unified data environment is established in China Integrated Meteorological Information Sharing System (CIMISS) or the national meteorological service. The paper discusses the establishment of provincial meteorological service system application flow and scheme based on unified data environment. It creates a seamless integration between local system and China Integrated Meteorological Information Sharing System without changing business processes and system architecture of existing meteorological service system. In the design scheme, the meteorological data is obtained by the multiple services based on unified data environment and data interface. According to different data structures, analytical methods of discrete data, gridded data and raster data are discussed. Finally, efficient and rapid visualization of meteorological data is realized. The result shows that the application flow and scheme that China Integrated Meteorological Information Sharing System used in provincial meteorological service system are effective and feasible. It is hoped that the studies of this paper can provide a reference for accessing unified national meteorological data environment for meteorological service system.

Keywords: Application design of provincial meteorological operational system · Data interface · Analytical methods of data · Visualization methods of data · Application flow and scheme

1 Introduction

The National Integrated Meteorological Information Sharing Platform is a set of integrated meteorological information business platform which integrates data collection, processing, storage management, sharing services and business monitoring [1]. The system stores 14 kinds of meteorological data, including real-time observation data, product generation data and historical compilation data [2]. It provides integrated meteorological observation data and meteorological products sharing services for meteorological services and users of related industries, and meets the needs of modern meteorological business, scientific research and services for meteorological information. The accuracy

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of data is difficult to guarantee is difficult to guarantee, for the data entry of each business system is not uniform and the algorithm is different. Some systems have the problem of data redundancy. These factors lead to the inconsistency of product data generated by meteorological operational systems at present [3–6]. The popularization and application of CIMISS system provides a unified meteorological data supporting platform for meteorological business application at provincial, municipal and county levels, realizes data reduction and integrated management, and ensures the accuracy of data [7].

The purpose of this paper is to discuss the effective process and scheme of CIMISS application in provincial meteorological operational system. The seamless connection between localization system and CIMISS system is realized on the basis of maintaining the existing overall business process and system architecture of provincial meteorological operational system. In this way, we can further improve the service ability and access efficiency of meteorological data, and provide some reference for other meteorological operational systems to access CIMISS data environment.

2 Function Design of System

2.1 Architecture of Platform

As shown in in Fig. 1, the system architecture consists of four layers: data access layer, component layer, business logic layer and presentation layer. The data access layer is responsible for the data access scheduling. The component layer is mainly the internal component design of the system. The business layer deals with the business logic of the system. The presentation layer is responsible for the terminal display of the system and provides the user with an interactive interface.

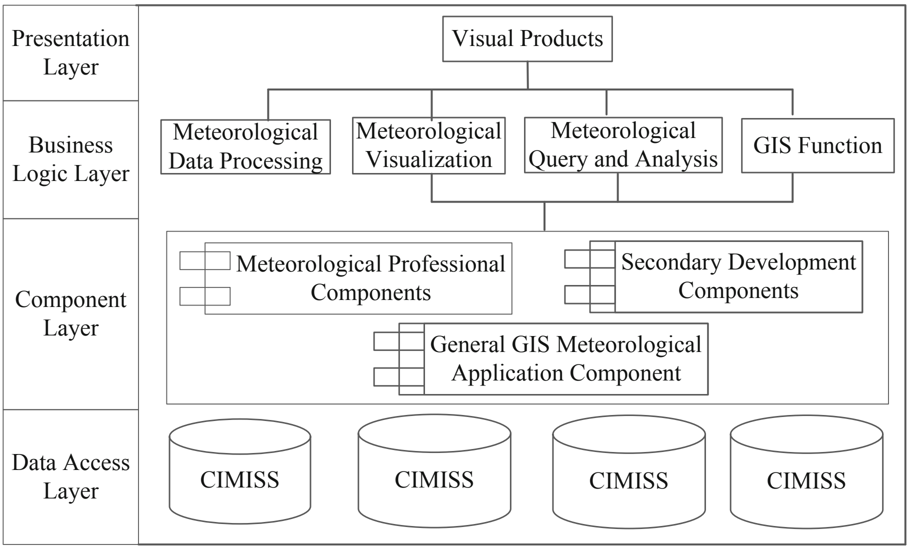

Fig. 1. System architecture

2.2 Functional Design

According to the particularity of meteorological business and function, the platform mainly includes the following parts:

First level, meteorological data processing: Support the analysis of discrete, grid and raster structure type meteorological data, and output meteorological data into various formats, including ShapeFile, Json, Kml, Image, etc. as required. Supported meteorological data products include meteorological station data, grid data, radar products and satellite cloud image products.

Second level, meteorological visualization and caching: Visualization provides the rendering of meteorological data points, lines, surfaces and volumes, and provides users with various forms of visualization effects. It also supports the rapid access of massive meteorological data by using memory database technology and static caching technology.

Third level, meteorological query and analysis: support the retrieval of meteorological elements and download of data files; support the sampling, interpolation, isoline or isosurface generation, smoothing processing of meteorological data and other functions [8].

Fourth level, geographic Information System (GIS) functions: support the management of map layers and the query and operation of geographical data; support the spatial query and analysis based on GIS, including the extraction and analysis of meteorological data, visual analysis; support the production of maps, graphic display and so on.

2.3 Data Access Design

Meteorological data is the core of meteorological operational system. It has many characteristics, such as many kinds of elements, wide coverage and strong timeliness. The meteorological data processed by provincial meteorological operational system are uniformly obtained from CIMISS meteorological data service interface.

At present, most of the meteorological operational system data are obtained from the local meteorological data center by reading the original files, accessing the database, calling the local interface to read the data and so on. At the same time, the meteorological operational system will also write the generated product data back to the local meteorological data center. By developing localized business applications around CIMISS system, the data processing flow is optimized and a unified data service interface is established. After the establishment of CIMISS data environment, business system data is directly obtained through CIMISS data service interface, and the generated product data is transmitted back to CIMISS data environment through CIMISS data service interface. The data access design diagram of meteorological operation system accessing CIMISS data environment is shown in Fig. 2.

3 Research on Technical Method

3.1 Meteorological Data Access Based on CIMISS Environment

Designing Configuration File. XML configuration scheme is designed in this paper by the configuration of XML for meteorological products. By editing the parameters

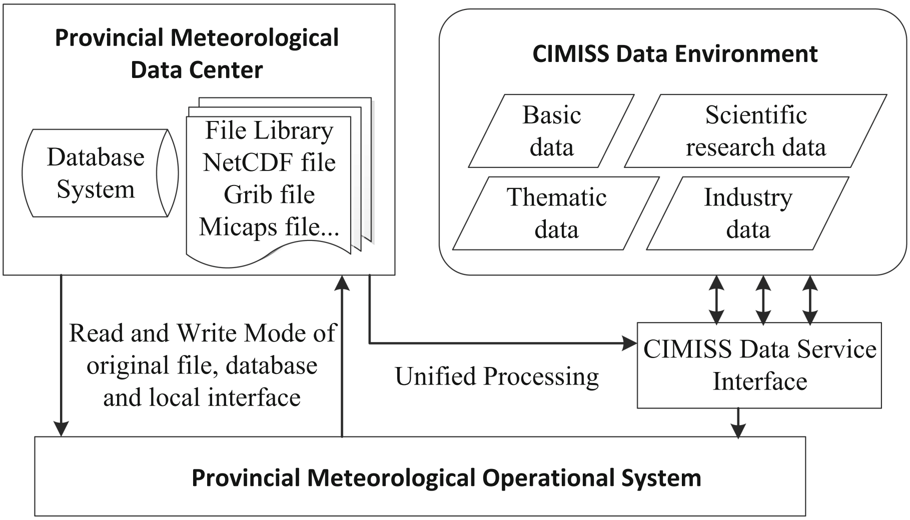

Fig. 2. Data access design

in the XML configuration file, it can add and delete meteorological products, modify the operation, obtain different types of meteorological data, and return the types after acquiring the data. Configuration file makes configuration parameters flexible, makes content and structure independent, and effectively improves the scalability of software [9]. After the system accesses the CIMISS data environment, XML files need to be configured according to the actual requirements of system development.

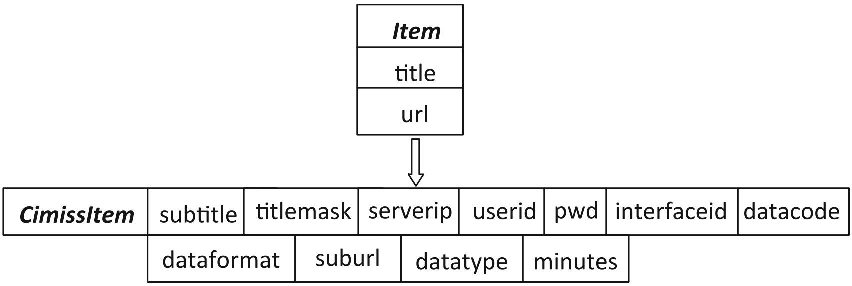

Fig. 3. XML profile diagram of business system accessing CIMISS data environment

The upper part of arrow in Fig. 3 is the configuration of the data product part before the system accesses the CIMISS data environment. The title node represents the product name. The *url* node contains the product's sub-configuration file information, file path, file format and file aging. The lower part of arrow in Fig. 3 is the configuration of the data product part after the system accesses CIMISS data environment. The subtitle represents the product name. The *titlemask* represents the title. The *serverip* represents the IP address of the data obtained through the interface. The userid represents the user name of the access. The *pwd* represents the password of the access. The *interfaceid* represents the interfaceid of the access. The *datacode* represents the data format. The *dataformat* returned after data acquisition. The configuration of *suburl* varies according to the type of data acquired: the configuration of lattice data includes product configuration file, product timeliness, latitude and longitude range, elements to be queried and wildcard of file name, the configuration of site data includes product configuration file, product query condition and wildcard product timeliness of file name. The *datatype* denotes the type of query data (including grid lattice data and station site data). The minute denotes the minute-level timeliness of the product.

Meteorological Data Retrieval Based on CIMISS Interface. CIMISS meteorological data service interface is based on CIMISS data environment, facing meteorological business and scientific research, providing unified, standard, rich data access services and application programming interface (API) [10]. CIMISS establishes a separate access interface for different meteorological data. Each data interface provides multiple functional interfaces and each functional interface has different retrieval parameters. It can retrieve different parameters according to time point, latitude and longitude range, statistical period and so on. Meteorological data and products are obtained by calling the data retrieval interface provided by CIMISS API through input parameters, including station information query, site information query, statistics, grid data retrieval, analysis and tailoring, document products (radar products, satellite clouds, numerical forecast products) retrieval, download and so on. The specific invocation method is shown in Table 1.

Table 1. The methods of the CIMISS interface.

Call method	Call method name	Format of returned data	Applicable information
Call API_to_serializedStr	Gets a serialized string	String (serialized)	Site information, lattice information (point/area), document products (document URL, etc.)
Call API_to_array	Get a two-dimensional string	Array (no descriptive information)	Site data, grid data (point/surface), document products (radar, satellite, numerical prediction)

Structured data are retrieved through API, including site element data, element values of single or multiple points in lattice data, data of a single field in lattice data, station metadata information, attribute information of data field, etc. Retrieving file list information interface and getting picture files encapsulated in Base64 format through API.

The data obtained by the call *API_to_serializedStr* method is returned as a serialized string (xml/json/html/text), and the data obtained by the call *API_to_array* method is returned as a binary array.

3.2 Organization and Analysis of Meteorological Data

According to the difference of data structure, meteorological data can be divided into discrete data, grid data and raster data. Meteorological data need to be analyzed before visualization. At present, most meteorological business systems mainly parse the data of Micaps class format files. The business system directly parses the data acquired in CIMISS after accessing the CIMISS data environment. Data in the form of discrete data include real-time and historical data of various meteorological elements observed automatically (including rainfall, temperature, pressure, relative humidity, visibility, wind, etc.) and site data of external door units such as water conservancy, environmental protection and ocean. The grid products of various meteorological elements (including rainfall, temperature, air pressure, etc.) need to be transformed into grid data first. Satellite cloud map, radar products and numerical model forecasting products need to be converted into raster-type data first.

The process of discrete data processing is to parse text files and assign values to visual sites. Call the CIMISS interface to get the two-dimensional site data and assign the information to the object. Objects include the site area station number, the address of the automatic station, provinces, cities, counties, towns or streets, longitude, latitude, height, numerical value and other attributes.

In the process of Gridding Data processing, CIMISS interface can be invoked to obtain grid field data. According to the latitude and longitude range of grid data and grid size, the latitude and longitude network data covering the research area can be generated. It can also call CIMISS interface to obtain two-dimensional site data, convert the data into grid data, and use interpolation in the process of grid processing of site data. In view of the limited number of meteorological stations and the discreteness of spatial distribution, the data of unknown points are estimated by interpolation based on the data of known samples. The data of discrete points are interpolated into continuous surface data through one or more interpolations, and then the contours or color patches are formed and displayed [11].

In the process of raster data processing, data is pre-mapped and the mapped data is divided into tile data according to a certain scale [12], and these tile data are stored in the file system in the form of picture files. The number of tile data after pre-processing is quite large. These files are organized through a specific file index directory structure, and a large number of tile data are managed and dispatched efficiently to adapt to the rapid transmission of the network and facilitate WebGIS to provide efficient services to the outside world.

3.3 Visualization Method of Meteorological Data

WebGIS Technology based on Silverlight. Data visualization uses Microsoft Silverlight plug-in technology, combined with ArcGIS Server meteorological data service to realize the query, analysis and display of meteorological data based on geospatial discretization, grid, raster and so on. For different data types, different data visualization methods are used. The visualization of discrete data is loaded into map vector layer rendering through the properties of longitude, latitude and numerical value of discrete data. In meteorology, grid data are mainly contours and grid points, which are overlapped on the map. The visualization of grid data is mainly in the form of pictures, which are displayed in the slice layer of the map.

In the process of data visualization, we use Microsoft Silverlight plug-in technology and ArcGIS Server application platform to construct meteorological business system to realize meteorological data visualization and query and analysis of meteorological data based on geographic space. ArcGIS API for Silverlight is used in the meteorological operation system to realize the operation, analysis, simulation and display of meteorological data, cartographic analysis, geographic information processing, spatial analysis, editing and other functions.

WebGIS based on Silverlight plug-in can fuse and render meteorological data including discrete, grid, raster and other data structures, so as to enhance the expressive ability of meteorological data. For the representation of discrete data, the longitude and latitude of each point in the discrete point data set are loaded into the object of geographical graphic layer to display in real time, and different rendering styles are used according to the fields of the data set; for the expression of gridding data, the gridding data obtained after parsing are plotted graphically to generate isoline or isosurface graphics, and the visualization product is generated by superimposing and displaying with geographical information. For the expression of raster data, the Silverlight client obtains the images in jpg, PNG format returned by the server, displays them by slice layer, and then superimposes them on the map base according to coordinate position [13].

Memory Database Technology. Before the meteorological operation system was connected to CIMISS system, the response speed of the system was relatively fast because most of the documents read by the system were localized files. After access to CIMISS system, the response speed of business system becomes slower when displaying meteorological data gridding products. In order to meet the needs of rapid response of the system, the business system introduced memory database technology when displaying meteorological data products after access to CIMISS system. The data in the database is resident in memory, which saves the time of disk I/O and improves the query performance of data [14]. In memory database query processing, cache performance is optimized, data is partitioned into cache to improve cache hit rate, and hash index is used to improve cache performance. In order to reduce the cost of memory access, data is compressed proportionally [15–17].

Static Caching Technology. When the air service system is connected to CIMISS system, the corresponding speed of displaying relatively large data such as raster data (radar, cloud image) is slow. In order to improve the efficiency of interactive response with users, static cache technology is used in the visualization of raster data. The vector data is pre-mapped by the GIS server statically, and the mapped data is divided into slice files, which are organized by a specific file index directory structure for direct invocation by the WebGIS client. Static caching technology effectively improves the product performance, guarantees the efficient browsing of data on the client side and the rapid release of data on the server side.

4 Application Examples

Zhejiang Meteorological Display Platform is one of the successful cases of Zhejiang Meteorological Business System accessing CIMISS system. The data acquired by CIMISS interface greatly meets the requirements of Zhejiang Meteorological Digital Display Platform for wide coverage and high real-time of meteorological data such as station network observation, numerical model and so on. It also provides stable underlying data support for ground, high altitude and numerical model modules in the platform. At the same time, CIMISS interface reduces the maintenance intensity of the platform system, avoids the repeated construction of data sources, and improves the consistency and authority of data. Figure 4 is a comparison of Zhejiang Meteorological Digital Display Platform before and after access to CIMISS data environment.

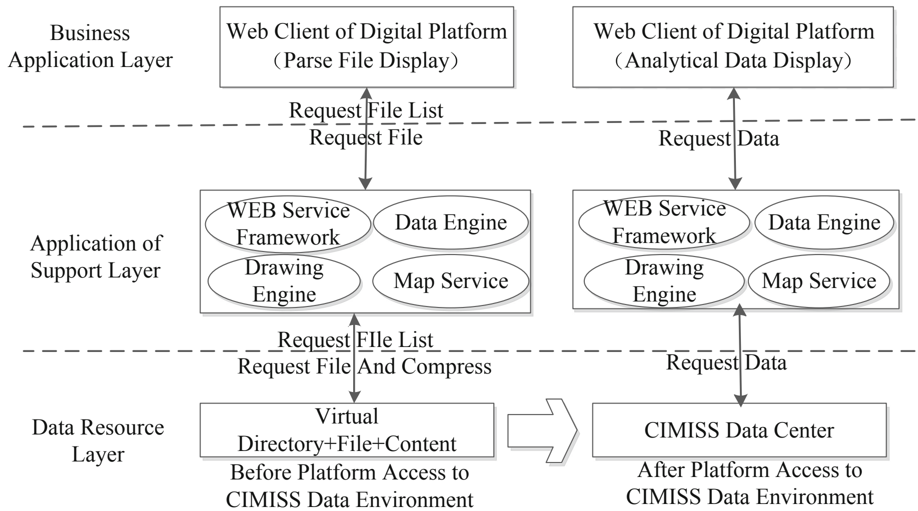

Fig. 4. Contrast chart of Zhejiang Meteorological Digital Display Platform before and after accessing CIMISS data environment

Zhejiang Meteorological Digital Platform based on CIMISS environment only needs to transform the data layer, while the business logic layer and the presentation layer remain basically unchanged. The data source is provided by multiple file servers, instead of the virtual directory on the Web server of the digital platform, it is provided by CIMISS data center, which reduces the construction process of the file server and virtual directory. Data transmission mode changed from file mode to CIMISS data stream mode, which reduced the process of obtaining file list and compressing file decompression. In data parsing mode, the original parsing file content display of the client of the data platform is changed to directly parsing CIMISS data, which reduces the process of parsing files. Figure 5 shows the Zhejiang Meteorological Digital Display Platform after it is connected to CIMISS data environment. Figure 5(a) shows the effect of grid data acquired through CIMISS environment on WebGIS after interpolation. Figure 5(b) shows the effect of raster data acquired through cimiss environment on WebGIS after pre-mapping.

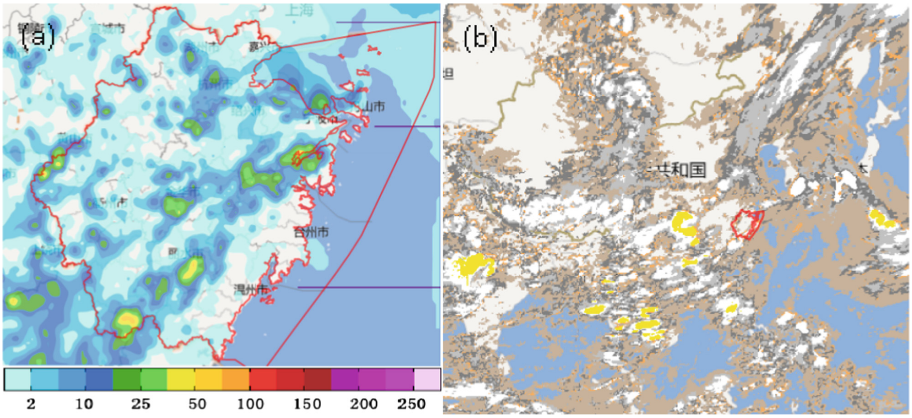

Fig. 5. Effect of Zhejiang Meteorological Digital Display Platform accessing CIMISS data environment (a) Distribution map of precipitation discrete data in Zhejiang province for nearly 24 h at 00:10 on 9 July 2016 (in millimeters) (b) Distribution map of raster data of Fengyun 2E cloud classification (CLC) products at 16:15 on July 12, 2016.

5 Concluding Terminology

In order to meet the needs of meteorological business system, we realize seamless connection between localization system and CIMISS system without changing the business process and system architecture of existing business system. The method proposed in the paper improves the service ability and access efficiency of meteorological data.

(1) In the part of data access business system, the extensibility and portability of the software are improved by designing the structure of XML configuration file. Using CIMISS data interface to obtain meteorological data.
(2) According to the different data structures, the analytical methods of three types of meteorological data, discrete data, grid data and raster data, are discussed respectively.
(3) In the process of meteorological data visualization, Zhejiang meteorological operational system is constructed by using Silverlight plug-in technology and ArcGIS Server application platform to realize meteorological data visualization and meteorological data query and analysis based on geographical space. In order to ensure the rapid release of meteorological data products on the server side and efficient browsing on the client side, memory database technology and static caching technology are adopted.

In summary, the application of CIMISS in Zhejiang Meteorological Operational System is feasible and effective. The application process and scheme provide a good idea for the promotion of CIMISS in National Meteorological services.

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