Development of dual-polarization weather radar products display platform

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Abstract: Dual-polarization weather radar is more advanced than doppler weather radar, with higher observation accuracy and more products. Using PHP and Dreamweaver to develop dual-polarization weather radar products display platform. The dual-polarization weather radar products display platform can display ZDR, CC, KDP, HCl, QPE and other dual polarization radar products in real time, and has the function of playing back 30 times products in the past three hours of a single product. Using this platform, forecasters can compare and analyze doppler radar products with dual-polarization radar products to grasp the real-time conditions of short-term strong convective weather better, to improve the accuracy of short-term forecasts, especially disastrous weather forecasts, so as to further exert the advancement and superiority of dual-polarization weather radar. After applications, it shows that the dual-polarization radar products display platform is reliable and stable operation.

1. Introduction
Since the idea of dual-polarization radar was put forward [1], the United States, Japan, Europe and other developed countries have developed dual-polarization radar for meteorological observation [2-4]. Entering the 21st century, China has started the construction of doppler weather radar network. By the end of 2016, 233 doppler weather radars of C-band and S-band have been completed. With the improvement of the technology, China has formulated a development plan for the dual-polarization upgrading of existing doppler radars and increasing 33 dual-polarization radars as shown in Figure 1. By 2020, there are nearly 40 S-band dual-polarization weather radars in China [5]. In addition to the doppler function, the dual-polarization weather radar is more advanced with higher observation accuracy and more products. And it is very important to short-term nowcasting, especially strong convection and disastrous weather.
According to the needs of forecasters, we developed the dual-polarization radar products display platform based on the diversity and advanced nature of dual polarized weather radar products, so that forecasters can compare and analyze single-polarization products and dual-polarization products more intuitively, so as to better grasp the real-time situation of short-term strong convection and disastrous weather. This paper introduces the development process and functions of the dual-polarization radar products display platform.

2. Brief introduction of dual polarization weather radar

Dual-polarization weather radar is a high-tech radar equipment at the forefront of the world [6]. The transmitter can transmit horizontal and vertical polarized electromagnetic waves through a power splitter. The dual-channel receiver and digital intermediate frequency process the data in parallel. The radar system consists of the following three parts:

- **RDA**: Radar data acquisition subsystem which forms radar base data through digital processing.
- **RPG**: Radar product generation subsystem which processes basic data and generates various products, and transmits the products to users.
- **PUP**: The main user terminal subsystem, the main function is to obtain, store and display products.

Compared with single polarization radar, dual-polarization radar has the following advantages:

2.1 Products quality improvement

By upgrading and improving the calibration system and signal processing and software subsystems, the dual-polarization radar improves the calibration level and data quality of the system, is compatible with the existing business functions and products of the single polarization radar, has better attenuation correction, and improves the product quality.

2.2 Radar clutter recognition

The dual-polarization radar data can provide phase information of particles, describe the size and shape of particles better, distinguish meteorological echoes from non meteorological echoes, and filter out non meteorological waves such as abnormal propagation, surface features and sea clutter.

2.3 Radar products advantages

The dual-polarization radar can identify weather processes and precipitation types, detect and warn hail and storm areas, identify melting layers more accurately, and estimate precipitation more accurately by secondary products.
3. Layout of doppler and dual-polarization weather radar in Shandong Province

![Figure 2. Layout of doppler and dual-polarization radar sites in Shandong Province.](image)

Shandong Province is a coastal province in East China, with a total area of 157,900 square kilometers and 16 cities under its jurisdiction. At present, there are 8 S-band radars (4 of which are dual-polarization radars) and 1 C-band dual-polarization radar (Taishan Station) and 1 S-band dual-polarization radar (Liaocheng Station) is under construction in Shandong Province. According to the special plan for the development of weather radars, all doppler weather radars will be upgraded to dual-polarization radars. By then, it will form a "9+1" dual-polarization weather radars distribution pattern in Shandong Province. In Figure 2, the S-band weather radar stations built in red, Liaocheng S-band weather radar station under construction in blue, and Taishan radar station in yellow.

3. Development of dual polarization radar products display platform

3.1 Development significance
With the application and popularization of dual-polarization weather radar, how to make use of the advancement and superiority of new technologies and new products of dual-polarization weather radar and improve short-term forecasting and early warning of disastrous weather is critical. Since each RPG host can only connect to a maximum of 8 PUPs, it is far from meeting the forecast business needs. In addition, the standard for dual-polarization radar products has not been officially announced, so it is impossible to realize real-time transmission of dual-polarization radar products in the whole province. Therefore, the development of dual-polarization weather radar products display platform (shorter form: the display platform) which can real-time display of dual-polarization radar products in the form of web pages has become an effective way to solve this problem. By using the display platform, forecasters can compare and analyze single-polarization radar products and dual-polarization radar products more intuitively, so as to grasp the real-time conditions of short-term strong convection and disastrous weather better, and improve the accuracy of short-term and nowcasting forecasts.

3.2 Development Tools
The dual-polarization radar products display platform runs in the form of web pages, and the development tools are Macromedia Dreamweaver (shorter form: DW) and PHP. We used DW to build the display platform framework and PHP to write background code.
3.3 Platform development

3.3.1 Web Design. First, we made a preliminary idea of the layout of the dual-polarization radar products display platform interface, and drew the original diagram. The display platform is divided into three areas, including the interface name area, URL link area, and products display area as shown in Figure 3. The interface name area displays "Dual-Polarization Radar Products Display Platform"; the URL link area includes three websites in common use, including Shandong Meteorological Service Integration Platform (http://10.76.10.166/), Severe Weather Monitoring and Warning Platform (http://172.18.200.217/) and Atmospheric Observing System Operation And Monitoring (http://10.76.10.39:8080/PASOM/); the products display area is set with 12 independent display areas, 6 products in common use, such as DBZ, ZDR, CC, KDP, HCl and QPE are selected according to the needs of forecasters. Among them, DBZ, ZDR, CC and KDP are selected with 0.5° and 1.45° elevation angles products, and HCl with 0.5°, 1.45° and 2.4° elevation angles products.

3.3.2 Build server environment. The display platform runs in the form of web pages. Since the core program of the platform is developed by PHP, a PHP web server environment needs to be built. There are many options for setting up a server environment, such as IIS, Apache, phpstudy, etc. The display platform uses Apache. After the Apache Web application server is successfully installed, an icon will display in the lower right corner of the computer, indicating that the Apache server has been started. If it is displayed , it means that it has not been started [7].

3.3.3 Products generate and transfer. Products can be generated by algorithms with radar base data. Using algorithms to generate product data on the display platform will take up a lot of computer resources and reduce the response time and running efficiency of the display platform badly.

The Linux version of PUP has the function of generating and transferring PNG or JPG products in real time. After configuring the storage device, PUP can generate picture format products and transfer the latest products to the designated directory of the display platform host in real time by ftp mode. The display platform can directly obtain the required products from the path and display them directly, without reducing operating efficiency.

3.3.4 Web pages programming. According to the design layout drawing, DW is used to build the display platform framework and the interface layout of the web page. PHP is used to write background codes which realize the function of identifying and displaying the latest products in the specified position of the web pages as shown in Figure 4. When any of the products is selected and clicked, it can be displayed in a separate web page which has the function of playing back 30 times of products in the past three hours as shown in Figure 5. So that the forecasters can understand the movement and
development trend of the weather system better.

Figure 4. Shows the platform interface.

Figure 5. Single product display interface.

A part of the program code is as follows:

```php
<?php
$type = $_GET["type"];
$array_file = array();
if ($handle = opendir('data')) {
    while (false !== ($file = readdir($handle))) {
        if(strpos($file, $type))
            array_push($array_file, $file);
    }
} arsort($array_file);
$array_file = array_slice($array_file, 0, 60);
sort($array_file);
```
3.3.5 Function. The dual-polarization weather radar products display platform can display ZDR, CC, KDP, HCl, QPE and other dual polarization radar products in real time, and has the function of playing back 30 times products in the past three hours of a single product, which can display the evolution process of radar echo more intuitively. The display platform refreshes every three minutes to display the latest time products automatically. And the display platform links three websites in common use, including Shandong Meteorological Service Integration Platform, Severe Weather Monitoring and Warning Platform and Atmospheric Observing System Operation and Monitoring.

3.3.6 Intensive application. The Severe Weather Monitoring and Warning Platform is one of the main business application software developed by the Shandong Meteorological Observatory, and has been widely used in Shandong province. In order to achieve intensive use of resources, the dual-polarization weather radar products display platform has been incorporated into the Severe Weather Monitoring and Warning Platform. The display platform has been modified accordingly to maintain the overall style consistency as shown in Figure 6 and Figure 7. In order to ensure the stability of the system, the previous radar products were deleted on time to prevent performance degradation due to insufficient system space.

![Figure 6. Shows the platform interface.](image-url)
Figure 7. Shows the platform interface of a single product.

4. Conclusion
The dual-polarization weather radar products display platform can display Zdr, CC, KDP, HCL, QPE and other dual-polarization radar products in real time in the form of web pages, and has the function of replaying a total of 30 times products in the past three hours of a single product, which can show the evolution process of radar echo more intuitively.

Using the dual-polarization weather radar product display platform, forecasters can grasp the real-time conditions of short-term strong convective weather and predict the development trend of the weather system better, so as to improve the accuracy of short-term forecasts, especially the disastrous weather forecasts. And it will further play the advancement and superiority of new technologies and products of dual-polarization weather radar.

After applications, it shows that the dual-polarization weather radar product display platform has high stability, good real-time performance, and easy to promote extremely. It is only necessary to modify the relevant configuration file to realize the products display of other dual polarization weather radars.

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