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GNSS/MET Equipment Maintenance, Data Processing and Products Application

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Abstract

Based on the use of Global Navigation Satellite System (GNSS) for meteorological detection in the world, we used the GNSS/MET detection equipment in the meteorological departments of Liaoning Province of China and its data to study and summarize the maintenance methods of GNSS/MET (Global Navigation Satellite System Meteorology) detection equipment and the application of water vapor products in operational systems. The results show that: 1) For GNSS/MET failures, specific inspections and classifications can be performed according to different phenomena; 2) The GNSS water vapor measurement station samples every 30 seconds, forming one set of GNSS data every hour, and can detonate the atmospheric precipitation by solving the original data; 3) Using the "Navigation Satellite Remote Sensing Water Vapor Application Management System", the GNSS/MET water vapor products can be directly displayed. We can get the conclusion that GNSS/MET has far-reaching significance for studying the law of atmospheric water vapor changes and enhancing the ability to monitor severe weather such as heavy rain and strong convection.

Keywords

Atmospheric Detection, GNSS/MET Detection Equipment, Equipment Maintenance, Product Application

1. Introduction

Global Navigation Satellite System (GNSS) is a satellite navigation system for timing and ranging spatial intersections, including the US's GPS and China's Beidou. It can provide continuous, real-time, high-precision 3D position, 3D speed and time information to users around the world. Its high-precision, real-time and all-weather characteristics have far-reaching significance for studying the law of atmospheric water vapor changes and enhancing the ability to monitor severe weather such as heavy rain and strong convection.

As the system matures, its application field is also wider (Taoufiq et al., 2018; Titouni et al., 2017; Andrianarison et al., 2017). GNSS meteorology is the latest application of GNSS technology in the detection of atmospheric atmosphere by using GNSS theory and technology to remotely measure the Earth's atmosphere to determine atmospheric temperature and water vapor content, and to monitor climate change. Meteorological detection using GNSS has been widely used around the world. GNSS detection includes space-based detection and ground-based detection (Abbasy et al., 2017; Wang & He, 2017; Yao et al., 2018). At present, the GNSS of the station is mainly ground-based detection, and the detection products mainly have vertical integrated water vapor content. Most of the above studies involve the latest theoretical and technological advances, however, research on GNSS/MET equipment maintenance, data processing and display applications for local meteorological stations in China is rare, making it difficult for Chinese meteorological departments staff to operate and maintain equipment, and process and use data.

In this paper, we will study the fault diagnosis and maintenance of GNSS/MET equipment, the data processing flow and the display and application of water vapor products, and give the research results and analysis.

2. Methodology

2.1. GNSS/MET Detection Equipment

The GNSS/MET detection device consists of a receiver and an antenna. GNSS detection stations include pier GNSS antennas, antenna cables, lightning protection surge protectors, UPS, GNSS receivers, network equipment, business computers, etc., as shown in **Figure 1**.

2.2. Routine Maintenance

GNSS/MET detection equipment is divided into indoor equipment and outdoor equipment. For outdoor equipment, the piers and GNSS antennas of the general stations are installed in the observation field. Due to the wide field of view around the site, the zenith range of the elevation angle of 10˚ or more is unobstructed (Liu & Chen, 2006; Wei & Zhao, 2006). Therefore, maintenance personnel should always pay attention to the environmental changes around the site, but also pay attention to cleaning the dust and debris on the radome. Always check whether the radome is intact and ensure that the antenna receives satellite signals normally.

For indoor equipment, the antenna device receives the satellite signal, and it is easy to be struck by lightning during thunderstorms. Therefore, to ensure that the lightning protection surge connection is normal, the distribution box and

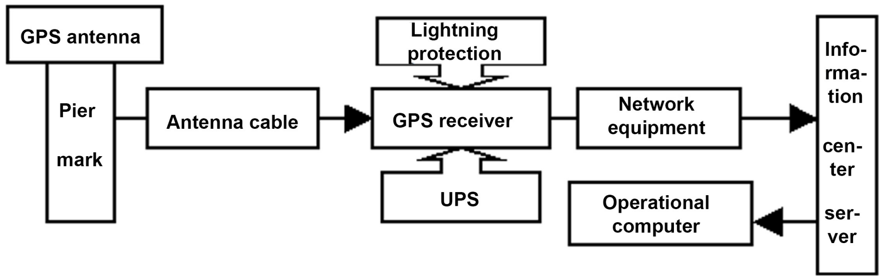

Figure 1. GNSS/MET detection equipment system topology.

network should also be equipped with lightning protection. When the power indicator of the receiver panel is flashing, it indicates that the UPS power supply voltage is low. It should be charged in time to ensure that the receiving system is powered normally without mains. Generally, the GNSS receiver has the ability to work normally in an environment of −40 to +85˚C, humidity less than 95%, and voltage of 200 to 240 V AC (straight) current. Pay more attention to the environment of the equipment room, especially the humidity in the spring is large. The instrument is rusty. The antenna cable is an important part of connecting outdoor and indoor equipment, but this part is buried underground and generally does not require maintenance (Wang et al., 2009; Zhou et al., 2008).

3. Results and Analysis

3.1. Fault Diagnosis and Maintenance of GNSS/MET Equipment

Figure 2 is the description of the rear panel of the GNSS receiver, and Figure 3 shows the front panel description of the GNSS receiver. Before the GNSS/MET system is turned on, check the whole machine. After connecting the hardware, turn on the power and press the GNSS receiver power switch. The faults of GNSS/MET can be divided into the following categories, and specific inspections and treatments are carried out according to different phenomena in Table 1.

3.2. Data Processing of GNSS/MET Equipment

The GNSS water vapor measurement station is sampled every 30 s, forming one set of GNSS data per hour, including GNSS navigation data and observation data. After solving the original data, the final atmospheric precipitation can be reversed (Cao et al., 2006; Li et al., 2008). The data processing flow is shown in Figure 4.

GNSS raw data includes navigation files, observation files, and weather files. The files are in RINEX format. See the RINEX 2.10 format specification for the detailed format.

The GNSS raw data file should be compressed into a single compressed package file using the zip format and then uploaded.

The original data files include GPS navigation files, GPS observation files and GPS weather files, which are named by short file name. The file name format is ssssdddHmm.yyx.

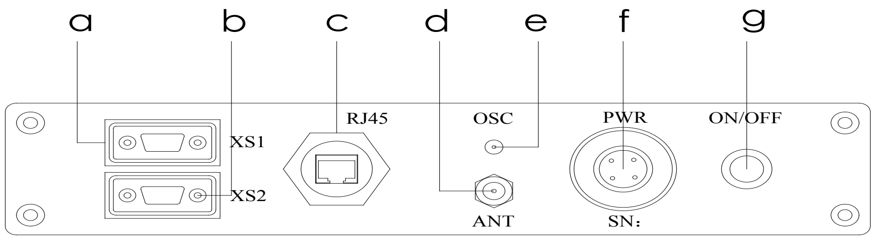

Figure 2. GNSS receiver rear panel (a and b denote to connect the meteorological instrument cable interface with 9-pin serial ports, c denotes network interface, d denotes GNSS antenna cable interface, e denotes external frequency interface, f denotes aviation socket 9 v - 36 v DC power supply, g denotes a switch).

Figure 3. GNSS receiver front panel (a denotes a power indicator which lights up during normal operation, and b denotes a receiver status indicator which lights up during normal operation).

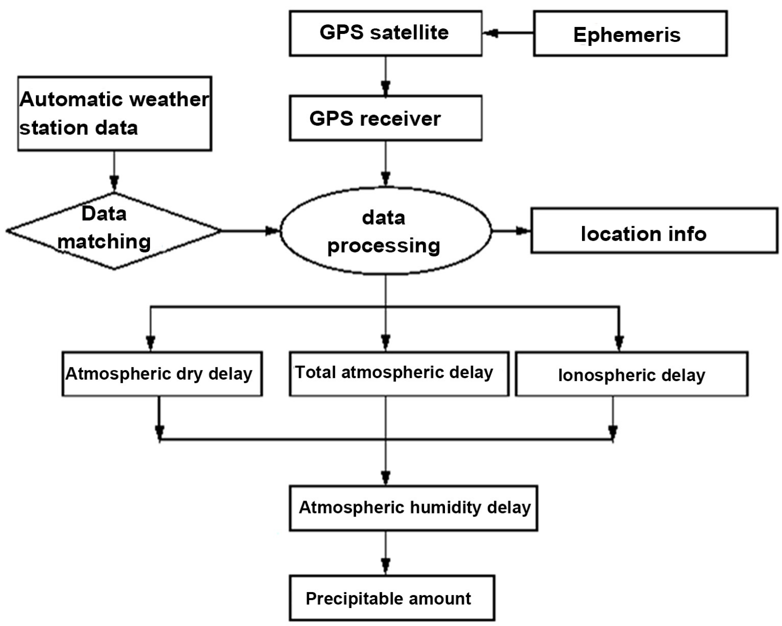

Figure 4. Data processing flow.

ssss: Four station names consisting of letters and numbers are named by the construction unit when the station is built. For stations built by the meteorological department, it is recommended to name them according to the following rules: the first two are the province's pinyin abbreviation, and the provincial letters are abbreviated with reference to China. The last two digits of the CCCC

Table 1. GNSS/MET equipment failure phenomena and inspection, diagnosis and treatment methods.

Fault Phenomenon	Inspection Method	Diagnosis and Treatment
Receiver power indicator is not lit	Whether the mains supply is normal. Use a multimeter to measure the output voltage.	The power supply is normal, check the power adapter. The adapter output voltage is abnormal and the adapter is replaced. The normal voltage is that the receiver is bad and is reported to the manufacturer for repair.
The receiver did not receive the satellite	Replace the original cable with a test cable, connecting the antenna to the receiver. Or change to a receiver.	No satellite, it is a receiver problem.
Cable problem	Short the signal line and shield line at the end of the cable and test with a universal meter.	There are satellites that are cable problems.
Cable head problem	Whether the cable head is in good construction and the cable head tape is sealed.	The satellite reception is normal and the original receiver has a problem; otherwise it is a cable problem.
Cable break	Pull out the cable check.	The resistance file is tested and the cable is good.
The receiver did not receive the satellite	Check that the receiver settings have changed without checking the cable.	The resistance file cannot be measured and it is determined that there is a problem with the cable.
The number of satellites received by the receiver has dropped	Check for interference from other sources.	The cable head structure is not good, and the cable head is replaced.
Communication problem	Check the communication network.	There is a data file on the receiver indicating a problem with the communication line.
FTP server problem	Check the FTP server and network.	After using other PCs to connect to the machine, the data files are taken, and the data files are not obtained, indicating that the receiver communication module is bad and sent to the manufacturer for repair.

code of the provincial and municipal governments of the Meteorological Administration, the latter two are the abbreviation of the first two words of the name of the station, and the provinces can be appropriately modified when the last two codes have a duplicate name. Named stations prior to this rule can use the previous name.

ddd: The calendar year, the serial number of the date within one year, automatically generated by the instrument.

H: The hour of the first recorded data, with the letter of one of the 24 letters a - x, representing an hour of the 24 hours a day, a for 00, b for 01, in this order to x for 23 , with 0 for data containing one day, automatically generated by the instrument.

mm: indicates the time (minutes) to start observation, which is 00 - 59 minutes, automatically generated by the instrument.

yy: The last two digits of the year, automatically generated by the instrument.

x: Data category code, automatically generated by the instrument. Correspond to the following:

m: weather file,

o: Observation files,

n: ephemeris file.

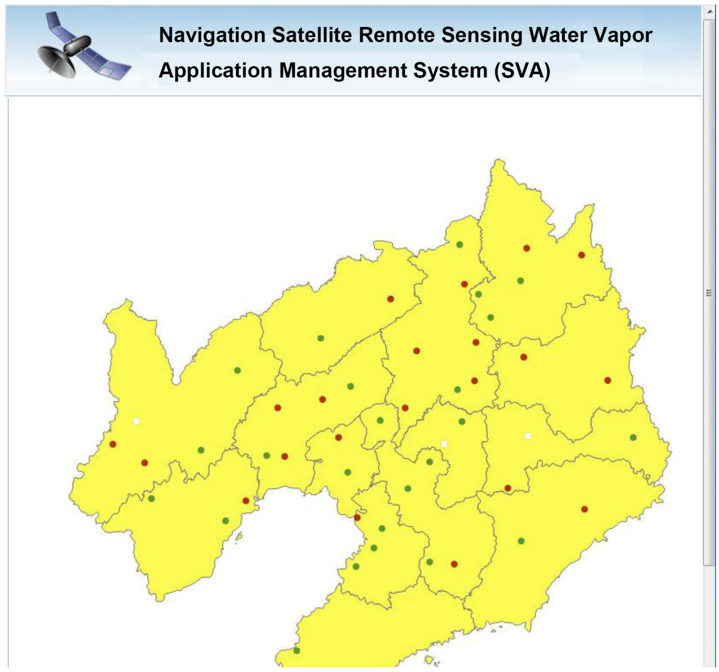

Figure 5. GNSS/MET transmission monitoring module display (Red points denote "time out" and green points denote "normal").

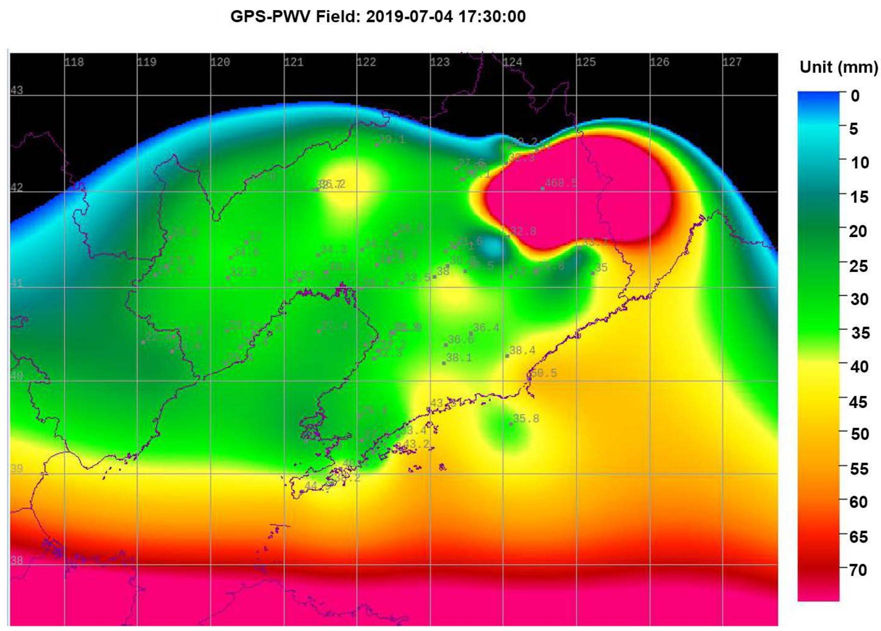

Figure 6. GNSS/MET transmission monitoring module display.

All of the above time uses UTC (World Time).

The GPS compressed file package is named by long file name, and the format is as follows:

Z_UPAR_I_IIiii_yyyymmddhhMMss_O_GPS2.rnx.zip

Z is a fixed code, indicating domestic exchange data; UPAR is a fixed code, indicating a large class of code for high-altitude observation; I: is a fixed code, is

Navigation Satellite Remote Sensing Water Vapor Application Management System (SVA)

Time	(%)	MP1	MP2	SNR1	SNR2	CSR
2019-07-04 00:00:00	100	0.23	0.18	47.42	42.86	0.00
2019-07-04 01:00:00	100	0.20	0.15	48.24	44.08	0.00
2019-07-04 02:00:00	100	0.23	0.20	47.64	43.33	2.00
2019-07-04 03:00:00	100	0.22	0.18	48.08	43.87	0.00
2019-07-04 04:00:00	100	0.21	0.17	47.82	43.06	0.00
2019-07-04 05:00:00	100	0.23	0.22	47.13	42.14	3.00
2019-07-04 06:00:00	100	0.21	0.18	47.96	43.58	1.00
2019-07-04 07:00:00	100	0.20	0.16	48.47	43.45	0.00
2019-07-04 08:00:00	100	0.27	0.23	46.84	41.51	0.00
2019-07-04 09:00:00	100	0.19	0.21	48.17	43.72	0.00
2019-07-04 10:00:00	100	0.19	0.16	48.16	44.33	1.00
2019-07-04 11:00:00	100	0.20	0.16	48.35	43.74	0.00
2019-07-04 12:00:00	100	0.21	0.15	47.89	43.42	0.00
2019-07-04 13:00:00	100	0.18	0.14	48.21	43.96	2.00
2019-07-04 14:00:00	100	0.25	0.19	46.68	42.18	5.00
2019-07-04 15:00:00	100	0.22	0.16	47.86	43.52	0.00
2019-07-04 16:00:00	100	0.18	0.15	48.20	43.09	0.00
2019-07-04 17:00:00	100	0.22	0.21	46.70	41.47	0.00
2019-07-04 18:00:00	100	0.24	0.18	47.17	41.85	1.00
2019-07-04 19:00:00	100	0.19	0.20	48.20	43.13	1.00
2019-07-04 20:00:00	100	0.33	0.22	47.47	42.65	2.00
2019-07-04 21:00:00	100	0.21	0.17	48.26	43.62	1.00
2019-07-04 22:00:00	100	0.17	0.15	48.87	44.78	1.00
2019-07-04 23:00:00	100	0.22	0.17	47.91	43.42	3.00

Figure 7. Quality check display of GNSS/MET data.

the observation site code IIiii indicator code; IIiii indicates the station number of the observation site, such as the Beijing Observatory 54511; yyyymmddhhMMss indicates the time at which the observation data file starts recording (UTC, year, month, day, hour, minute, and second), taken from the observation time in the first line of the o file in the observation file.

3.3. Application and Display of GNSS/MET Water Vapor Products

The navigation satellite remote sensing water vapor application management system is a direct application display for GNSS/MET water vapor products. It includes six functional modules: transmission monitoring, upload statistics, water products, equipment status, quality inspection, and site information. Transmission monitoring is the real-time monitoring of the status of the GNSS/MET equipment (Figure 5). The water vapor product module (Figure 6) is the application display of the GNSS/MET water vapor product, including the precipitation schedule, the Zenith total delay timing diagram, and the day. The top wet delay timing diagram, the water distribution regional heat map, the water vapor data text display, and the water vapor data value increment timing diagram, and Figure 7 show the detailed data display of the GNSS/MET data quality data.

4. Conclusion

For GNSS/MET failures, specific inspections and classifications can be performed according to different phenomena. In the routine maintenance of

GNSS/MET equipment, attention should be paid to the cleaning and protection of the radome. Indoors should always check the UPS, network and lightning protection conditions to prevent damage caused by lightning or power failure. After the instrument fails, it is necessary to check in the order of the above steps to prevent the fault from being misjudged, resulting in failure to repair in time.

The GNSS water vapor measurement station samples every 30 seconds, forming one set of GNSS data every hour, and can detonate the atmospheric precipitation by solving the original data. Using the "Navigation Satellite Remote Sensing Water Vapor Application Management System", the GNSS/MET water vapor products can be directly displayed. We can get the conclusion that GNSS/MET has far-reaching significance for studying the law of atmospheric water vapor changes and enhancing the ability to monitor severe weather such as heavy rain and strong convection.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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