JLCORS Observation Data Quality Checking and Assessment

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Abstract-To adopt teqc software to carry out comprehensive checking and assessment on 49 continuous running observation stations from the JLCORS network system, including data integrity, ionospheric delay and variability, multipath effect etc. Besides, data sampling rate adopts 30 seconds and the satellite cut-off angle is 10 degrees. The result reveals that 95% observation station sampling efficiency is between 0.9 and 1 and 80% CSR value is between 0.0 and 0.35; the RMS of the MP1, MP2 is between 0.15 and 0.45m and the maximum value of MP1 and MP2 is 0.45m of SLAN station and 0.42m of DEFN station. The operating condition of receiving set is good and detection environment as well as data are in accordance with the requirements of Technical specification for Crustal Movement Observation Network of China and are better than the standard of international IGS station. In addition, we carry out statistical analysis on the time interval with serious delays in terms of ionosphere as well as unhealthy satellite so as to provide reliable foundation for GNSS post-processing.

Keywords-GNSS;CORS;TEQC;Multipath effect;Earth movement

I. INTRODUCTION

GNSS continuously operating reference system (CORS for short) provides a dazzling array of high-accurate, dynamic and all-day convenient services in terms of real time positioning, navigation and time service. What is worth paying attention to is that its emergence can be beckoned as a milestone for spatial measurement modern development. At present, it is widely used in land surveying and mapping, urban construction and planning, land administration, deformation monitoring of building, traffic monitoring, environment monitoring, earthquake prevention etc. A dazzling array of countries has established their own CORS network. For example, in America, NGS is responsible to establish 160 CORS network composed by more than 160 stations; in England, the CPGRS network is a CPRS network composed by more than 60 GNSS stations; and in Germany, Japan,and India, there are large scale CORS network. In China, the first CORS network is established in Shenzhen and there are CORS systems with comprehensive functions in Jiangsu[1],Sichuan and Shanghai.

Different applications have different requirement on the accuracy of GNSS and general navigation time does not need a high level of accuracy yet researches on deformation monitoring or plate motion requires sub-millimeter accuracy[2, 3]. What's more, site selection, environment observation and data quality are highly demanded because it is necessary to test the CORS indicators as well as the comprehensive quality[4]. This paper carries out a full test and evaluation on the observation quality based on calculating various indicators of all stations of JLCORS.

II. INTRODUCTION OF JILIN CONTINUOUSLY OPERATING REFERENCE SYSTEM

Jilin Continuously Operating Reference System JLCORS is jointly established by the mapping Bureau of Jilin province,Jilin Meteorological Bureau Jilin Seismological Bureau with 57 stations and the average distance is 60km which can cover 90% areas of Jilin.It is a provincial level GNSS system which establishes an eternal references system via internet to construct a new earth measurement system. Besides, it comprehensively adopts the GNSS technology in terms of earth measurement, engineering measurement, meteorological monitoring, ground settlement monitoring and city geographic information system which organically integrates satellite navigation positioning technology, surveying and mapping, meteorology, and modern communication technology etc. In December 2012, 49 stations were put into use and the station distribution can be seen in figure 1. The controlling center of CORS acquires GNSS data and carries out unified calculation to get the correction value of systematic errors in the network so as to establish a error correcting model covering the whole network and send the correct values to users. While users receiving these correct data, they are able to obtain a high precision positioning result in real time of after[5].

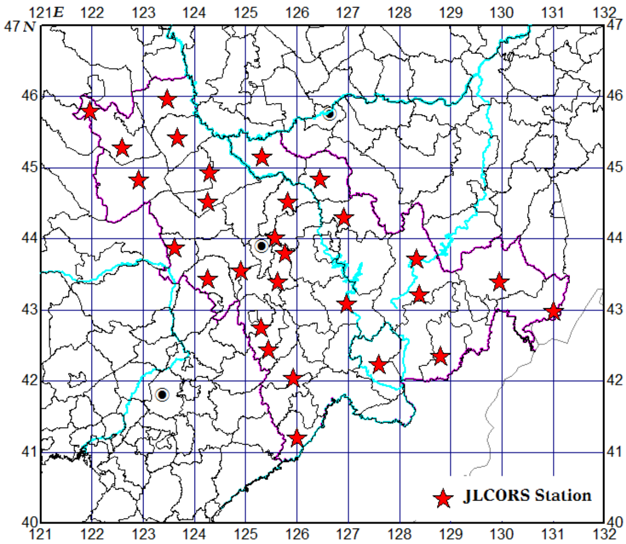

Figure 1. JLCORS reference station

III. TEQC SOFTWARE INTRODUCTION

Teqc (Translation, Editing and Quality Checking) is a powerful preprocessing software for GNSS, which is developed by UNAVCO and completed by C language, which can be adopted in dos and linux. Its main functions include standardization of observation data for various GNSS receivers (binary to the RINEX format), data editing and data quality assessment. In terms of earth movement, and deformation monitoring GNSS requires sub-millimeter accuracy, which ask higher requirement in terms of station establishment and observation environment selecting. Observation quality evaluation includes the proportion of comprehensive observation data to total observation, total epoch to cycle slips, the signal-noise ratio of receivers, multipath of L1 and L2, among which the calculation formula for multipath shows in the following:

$$MP_1 = \rho_1 - \left(\frac{\alpha+1}{\alpha-1}\right)\varphi_1 + \left(\frac{2}{\alpha-1}\right)\varphi_2 \qquad (1)$$

$$MP_2 = \rho_2 - \left(\frac{2\alpha}{\alpha-1}\right)\varphi_1 + \left(\frac{\alpha+1}{\alpha-1}\right)\varphi_2 \qquad (2)$$

In the formula, ρ_1 and ρ_2 are Pseudo-range observation data for L1 and L2 while φ_1 and φ_2 are phase observation data and α is the frequency ratio which is a constant.

IV. PREPARE YOUR PAPER BEFORE STYLING

It adopts 24-hour continuous observation data on 1st January 2014, and all data sample rate is 30 seconds. What's more, it adopts teqc to carry out various indicator calculation, including supposing data (#expt), real data (#have) and data utilization ratio, L1 multipath effect (MP1), L2 multipath effect (MP2), observation data and cycle slip ratio (o/slps), IOD(10°) and parts of the station results show in table 1.

A. *Analysis on the data integrity*

Sampling efficiency refers to the ratio of maximum collecting epoch to theoretical epoch during a certain period which can be beckoned as the comprehensive reflection of the surrounding station environment[6, 7]. CSR is the ratio of cycle slip to the maximum collecting epoch and in reality, it should be multiplied by 1000 for readability and the formula is shown as follows:

$$CSR = 1000 \times \frac{slps}{o} \qquad (3)$$

In the formula, *slps* refers to cycle slip and o refers to the maximum collecting epoch. The rest result of JLCORS (tab.1 and fig.2) reveals that the sampling efficiency of 95% observation station is between 0.9 and 1, 0.95 and 1.0 for 33 stations, the comprehensive observation environment is good. The CSRT value of 80% stations is between 0.00 and 0.35 while the maximum is 1.66 of BAIC station, the CSR standard of international IGS is less than 10. Therefore, we can see that the data integrity of JLCORS is in accordance with the basic requirement and the overall indicator is superior to international IGS station.

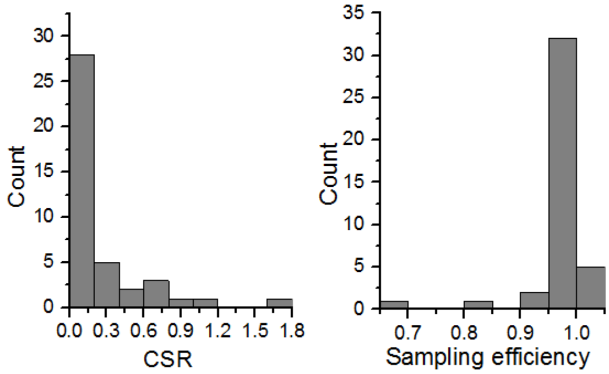

Figure 2. CSR and sampling efficiency histogram from JLCORS reference stations

TABLE 1 TEQC TESTING RESULT

Station name	Observation length（hrs）	Supposing collecting Data （#expt）	Real collecting data （#have）	Data efficiency （%）	MP1	MP2	0/slps
ANTU	24	24976	24971	100	0.26	0.28	24971
BAIC	24	24883	24669	99	0.28	0.29	602
BAIS	24	24958	24576	98	0.33	0.34	4915
CBAI	24	25000	24393	98	0.34	0.36	24393
CHAC	24	24893	24816	100	0.25	0.23	1460
CHYA	24	24895	24895	100	0.15	0.18	24895
DAAN	24	24818	24818	100	0.30	0.36	24818
DEFN	24	24929	24929	100	0.26	0.42	24929
DGAN	24	24985	24982	100	0.32	0.33	24982
DHUA	24	24960	24945	100	0.26	0.28	12473
DHUI	24	24960	24945	100	0.26	0.28	12473
EDAO	24	24987	24718	99	0.34	0.40	3090
FJTN	24	24892	24755	99	0.21	0.19	917
FUYU	24	24882	24845	100	0.17	0.17	24845
GJZI	24	24862	24846	100	0.28	0.31	24862
GZLN	24	24886	24860	100	0.35	0.39	24886
HCUN	24	15279	12668	83	0.37	0.25	12668
HDAN	24	24951	24925	100	0.38	0.37	6231
JIAN	24	24961	24699	99	0.15	0.19	6175
JIUT	24	24904	24875	100	0.21	0.26	12438

B. Analysis on the multipath

Multipath is an important source of error in GNSS testing and its emergence is caused by the GNSS signal reflection of surrounding architectures, water surface or other smooth surfaces. Besides, the unwanted signal of the receiver is weak yet greatly affected the calculation of pseudo-range and the positioning error can reach 30m[6, 8]. In order to avoid or weaken the path effect, the location of GNSS station should be away from large reservoirs, buildings, and mountains so as to avoid the condition that the reflection shall affect the signals. However, because of limitations of station construction conditions, we cannot always have ideal locations which requires us to carry out multipath efficiency. After data-processing, we can add the receiving cut-off angle or shield the satellite during a certain period so as to improve the positioning accuracy.

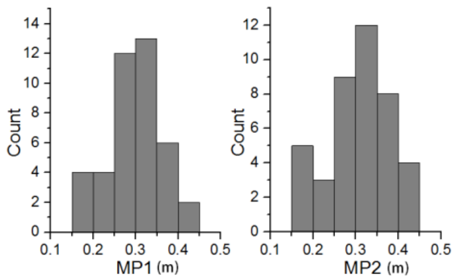

Figure 3. MP1 and Mp2 histogram from JLCORS reference stations

IGS has once calculated the multipath for the fixed stations and the average MP1 of 2/3 observation stations is less than than 0.5 m, and the average MP2 is less than 0.75m. We design the multipath based on this result, namely, MP1<=0.5 m, MP2<=0.5 m. According to Chinese standard, MP1<=0.5 m, MP2<=0.5 m means that the smaller the data the poorer effect of the multipath. The MP2 multipath of JLCORS result (table 1 and figure 3) shows that two indicators of all stations are between 0.15 and 0.45 and the value of 80% stations is between 0.25 and 0.35m, and the maximum value of MP1 and MP2 is 0.45m of SLAN and 0.42m of DEFN. All of the multipath efficiency should be in accordance with the requirement of *Technical Specification for Crustal Movement Observation Network of China* and be superior to global IGS station.

C. Analysis on the Ionospheric delay and change rate

The ionospheric delay is the main error source of GNSS observation which cannot be avoided so we have to combine the L1 and L2 so as to eliminate the errors. The signal transmission path of ionospheric delay can be shown in the following integral formula:

$$d_{ion} = -C\frac{40.28}{f^2}\int_{s'} N_e ds \qquad (4)$$

In the formula, N_e refers to ionospheric intensity, and the unit is electronic number/m^3; f refers to signal frequency and the unit is Hz; C refers to the speed of light in vacuum and the unit is m/s; s' refers to the GNSS signal transmission path.

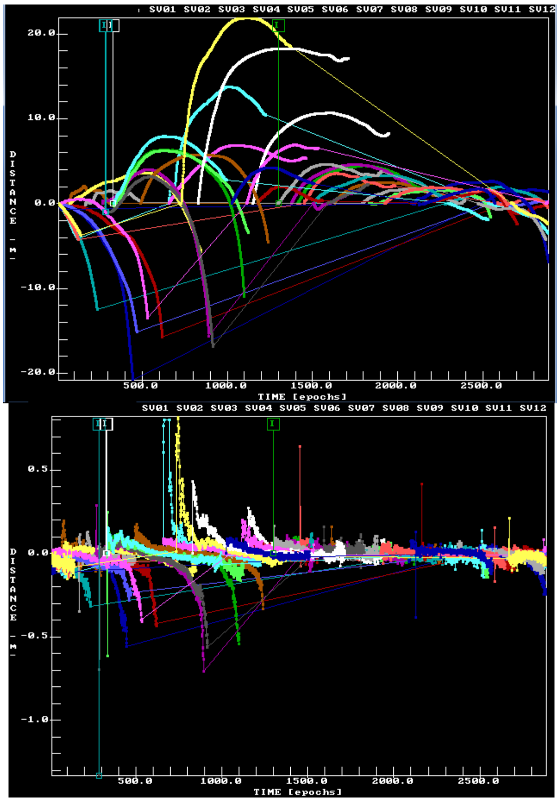

Figure 4. Ionospheric delay and its change rate in ANTU station

Teqc adopts the comparison expression to have the ionospheric delay and change rate and the output document is *.ion and *.iod. This paper deals with 49 stations and acquires observation materials during the period with ionospheric delay and drastic change which can provide references for selecting time and healthy satellite of base line post-processing[9]. The part error will bring 30m to 100m error so it is a key sector for choosing proper observation time and getting rid of unhealthy satellite so as to have accurate GNSS calculation[10]. Fig. 4 shows the ionospheric delay and change rate curve of 2880 epochs of ANTU station. In the figure, between epoch 700 and 2000, the ionospheric delay of four satellite reach 20m. After observation, we can know that the four satellites are SV04, SV09, SV16 and SV 26. Therefore, in post-processing, we have to shield the observation data of these four satellites.

V. CONCLUSIONS

By carrying out comprehensive observation on various indicators of JCCORS, we hold the idea that the observation environment is in accordance with the requirement of GNSS and various indicators are in accordance with the standards of *Technical Specification for Crustal Movement Observation Network of China* which are obviously superior to international IGS station. Concerning the error source of positioning accuracy, the multipath efficiency, the JLCORS station effect is poorer than IGS standard. Concerning some large observation stations, we can improve the environment or add the anti-diameter so as to weaken the effect. To conclude, the receivers of various observation stations operate well with relatively good observation quality.

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