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IONOSPHERE STUDY USING BEACON SATELLITES IN CRIRP

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Summary: In this paper, we summarize the ionospheric study by using beacon satellites in China Research Institute of Radiowave Propagation (CRIRP), including the ionosphere observations, the TEC characteristics and modeling the ionospheric scintillation characteristics and modeling, the study of tomography algorithms and methods, the research of ionospheric effects on transionopheric systems and the new observation technologies study.

1 INTRODUCTION

In China, study on ionosphere and radio propagation was developing since 1930's and it is already an important subject now. China Research Institute of Radiowave Propagation (CRIRP) is the only professional institute engaging in the studies of propagation properties of radio wave through different media and their applications. By using satellite beacon, some achievements on ionosphere have been acquired, including the ionosphere observations, the TEC characteristics and modeling, the ionospheric scintillation characteristics and modeling, the study of tomography algorithms and methods, the research of ionospheric effects on transionopheric systems and the new observation technologies study.

2 IONOSPHERE OBSERVATIONS

For collecting the ionospheric observations, some equipment has been developed independently by CRIRP, including the satellite beacons, GPS-TEC receiver, multi-frequency (UHF/L/S/C) scintillation monitors, Doppler receiver and etc[1,2,3]. And, up to now, a monitoring network covering the most area of China has been set up. Also, through international cooperation, they have set up the GPS monitors in Singapore and Chile.

Moreover, in order to study the polar ionosphere, the GPS monitors were installed at Antarctica Zhongshan and Great-wall stations in 1990's and in Norway and Finland in 2004 by CRIRP[4]. A tri-receiver observation system for studying the ionospheric irregularis has been set up at Yellow River station in Arctic. Now, all the observation data can be transmitted to the network centre in CRIRP.

3 TEC CHARACTERISTICS AND MODELING

TEC is an important ionospheric parameter and can be extracted by using beacon satellites. In 1980's, CRIRP starts to implement the ionospheric TEC observation using ETS-II satellite beacon at Xinxiang China. And based on the observations, Long et al.[5] compared the diurnal variations of ionospheric TEC in high and low year of solar activity with statistical method. Wu et al.[6,7] analyzed the ionospheric TEC characteristics and studied the slab thickness model and the topside ionospheric profile deducing method by using TEC and ionosonde data. Since 1990s, CRIRP is engaging at the ionospheric TEC observation and study based on the dual-frequency GPS signal. A trial monitoring network was set up in 1996, which comprises three GPS observation sites including Xinxiang, Qingdao and Haikou. And then, the monitoring network was extended to more than 15 sites in 2005, which covers the mainland of China. We obtained the statistical characteristics of ionospheric TEC at Qingdao area using the GPS observation during 1999-2006. Furthermore, based on the characteristics of ionospheric TEC of China region, we develop the ionospheric delay correction algorithm/model, the TEC mapping technique and the TEC short-term forecasting methods.

4 IONOSPHERIC SCINTILLATION CHARACTERISTICS AND MODELING

Ionospheric scintillation effects on satellite signals and ultimately on satellite navigation and communication is a growing concern. In 1980's, CRIRP starts to study the scintillation using ETS-II satellite beacon. They studied the ionospheric scintillation characteristics in VHF and L bands in the low latitude and mid-latitude region8,9. In recent years, they used the GPS signals to study scintillation[10,11,12]. Feng et al.10 used the L-band ionospheric scintillation data from Aug.2003 to May. 2007, studied the character of L-band ionospheric scintillations over low-latitude area. Using the UHF-band and L-band ionospheric scintillation data in 2005, Zhen et al.11 studied the characteristics of UHF-band and L-band ionospheric scintillations over Hainan region. And, the relativity for UHF-band and L-band ionospheric scintillations has been studied. Zhen et al.12 studied the ionospheric irregularities in low-latitude area of China by using multi-station GPS multi-link signals. The ionospheric

scintillation in polar region was also studied in CRIRP. Using the GPS data at Zhongshan station of Antarctic, Zhen et al. have studied the ionoshperic scintillation in Antarctic region4. Based on the observation of ionospheric scintillation in arctic region, Zhen et al. have studied the ionoshperic scintillation in arctic region13. Some theoretical and empirical models were developed base on the above results. A model on ionospheric scintillation was studied at CRIRP that could be used to now-casting and short-term forecasting in China sub-continent[14].

5 STUDY OF TOMOGRAPHY ALGORITHMS AND METHODS

Computerized ionospheric tomography (CIT) is the new application of computerize tomography to ionosphere monitoring. This technique aims to investigate the ionosphere by delaminating mode. It not only overcomes the limitation of those single-layer ionospheric models, but also suits to monitor large-scale spatial distribution and the perturbation of the ionosphere. OuMing et al.[15] suggested a method of estimation of electron density combining single site's ground GPS data with ionosonde, tomography algorithms plays a important role in this method. They also analysed the response of low-and-mid latitude ionosphere to the magnetic storm of November, 2004 using GPS observations of 6 stations along 115ºE meridian. Their results demonstrate that CIT with ground-based GPS network can be used to monitor large-scale ionospheric structures under disturbed conditions.

6 RESEARCH OF IONOSPHERIC EFFECTS ON TRANSIONOSPHERIC SYSTEMS

Radiowaves at frequencies at VHF and above are capable of penetrating the ionosphere, and therefore provide transionospheric communications. So, the radio systems working in these frequencies, including the satellite navigation system, the satellite communication system and the radar system, will suffer the effects of ionosphere. The ionosperhic effects on transionopheric systems are also studied in CRIRP. Zhen et al.[16] analysed the effects of ionosphere on GPS positioning. Zhen and Feng[17] studied the effect of ionospheric scintillation on the earth-space communication system.

There has been a considerable interest in the use of lower frequency (VHF/UHF, P band) space-based synthetic aperture radar (SAR) for realizing the foliage and ground penetration. The phase perturbation, signal distortion and imaging resolution degradation by the ionosphere will be particularly severe; however the model is not yet well established. On the basis of improvements for the model proposed by Ishimaru and others, potential ionospheric effects on SAR imaging are evaluated by Xu et al.[18] using ionospheric turbulence spectrums and TEC inferred from the IRI and ETS-II satellite beacon observations.

7 NEW OBSERVATION TECHNOLOGIES STUDY

The new observation technologies have been studied in CRIRP. First, we are now developing the tri-band beacon and ground receiver independently. Besides the study of TEC and multi-frequency scintillation, we want to study the seismo-ionospheric coupling using tri-band beacon. Second, as we know, the TEC which is the integrated electron density between a ground beacon and a satellite is a by-product of the International DORIS Service (IDS) used for precise orbit determination of altimetry satellites. Studies of TEC variations observed by the DORIS station also carried out in CRIRP.

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