Introduction

Global Navigation Satellite System (GNSS) have become a key technology leading to significant advances in ionospheric sounding with high spatial and temporal resolution. In addition to the legacy global positioning system (GPS) and GLONASS, users now can benefit from BeiDou for ionospheric total electron content (TEC) modeling and monitoring in view of the increasing visible satellite numbers and the unique placement of BeiDou GEO and IGSO satellites.

In spite of the 3 in-orbit-validation (IOV) satellites launched in 2015, the current BeiDou constellation compromises a total of 13 active satellites: 5 GEOs (C01, C02, C03, C04 and C05), 5 IGSOs (C06, C07, C08, C09 and C10) and 3 MEOs (C11, C12 and C14). In this presentation, the ionospheric monitoring activities based on BeiDou observations at the Institute of Geodesy and Geophysics (IGG) are introduced.

a) Characteristics of BeiDou satellite and receiver differential code biases (DCBs). BeiDou DCBs are determined by IGDCB method based on observations collected by the IGS network of the international GNSS services (IGS). 

b) Regional ionospheric grids for BeiDou Wide Area Augmentation System (WAAS). An adjusted spherical ionospheric single layer at a height of 350 km on August 23, 2012 for precisely modeling the ionospheric delay is developed for BeiDou WAAS.

c) Observation of the ionospheric irregularities over the mid- and low-latitudes of China.

Characteristics of BeiDou DCBs

BeiDou satellite and receiver DCBs are determined by IGDCB method based on observations collected by the IGS network of the IGS. In the approach of IGDCB, local ionospheric modeling is employed for the combined estimation of DCBs and ionospheric activities at each individual station, instead of global ionospheric modeling or using a priori ionospheric information like global ionospheric maps (GIMs). BeiDou satellite and receiver DCB estimates for a full span of three years (2013-2015) are shown in Fig.1 and Fig.2, respectively.

The monthly stability of BeiDou satellite DCBs of DLR and IGG is illustrated in Fig.3 for the example of C2I-C7I bias. The stability of the IGS solutions in 2014 is more stable than that in 2013 (0.19 ns vs. 0.26 ns on average). Considering individual types of BeiDou satellites, the stability indices also confirm an improved performance of IGSO satellite DCBs as compared to that of GEO and MEO satellites.

Observation of the ionospheric irregularities over China

The IGS Ionosphere Working Group has recommended to start a new TEC fluctuation product over North Pole to study the dynamic of oval irregularities since 2012. Similarly, the low-latitudes of China are also confronted with serious ionospheric irregularities, and GNSS observations from CMONOC network provide an opportunity for ionospheric space weather monitoring over China low-latitude regions.

a) IGACAS provides BeiDou (also GPS, GLONASS and Galileo) satellite and receiver DCB products to MGEX since mid-October 2015 routinely. Good agreement of BeiDou satellite DCBs with that of DLR is obtained (0.33ns and 0.39ns for BeiDou C2I-C7I and C2I-C6I, respectively).

b) The correction accuracy of BeiDou-based ionospheric grids performs at the level of 0.5m over China region, including 0.33ns and 0.39ns for BeiDou C2I-C7I and C2I-C6I, respectively.

c) dTEC: detrended TEC;          d) Dif1Rot: first difference of ROT;    

Further reading