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ORIGINAL ARTICLE

Evaluating the effect of the global ionospheric map on aiding retrieval of radio occultation electron density profiles

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Abstract Radio occultation (RO) has been proven to be a powerful technique for ionospheric electron density profile (EDP) retrieval. The Abel inversion currently used in RO EDP retrieval has degraded performance in regions with large horizontal gradients because of an assumption of spherical symmetry as indicated by many studies. Some alternative methods have been proposed in the past; the global ionospheric map (GIM)-aided Abel inversion is most frequently studied. Since the number of RO observations will likely increase rapidly in the near future, it is worthwhile to continue to improve retrieval method. In this study, both the simulations and the real data test have been done to evaluate the GIM-aided Abel inversion method. It is found that the GIM-aided Abel inversion can significantly improve upon the standard Abel inversion in either the F or the E region if an accurate GIM is available. However, the current IGS GIM does not appear accurate enough to improve retrieval results significantly, because of the spherical symmetry assumption and sparse global navigation satellite system (GNSS) stations used in its creation. Generating accurate GIM based on dense GNSS network to aid the Abel inversion might be an alternative method.

Keywords Radio occultation · Abel · GNSS · GIM · Ionosphere · FORMOSAT-3/COSMIC

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Introduction

The global navigation satellite system (GNSS)-based radio occultation (RO) has been proven to be a powerful technique for remotely sensing the earth's troposphere, stratosphere, and ionosphere in the past decade (Anthes 2011). In the ionosphere, the important scientific RO data product is the retrieved electron density profile along the tangent points during an occultation event. Currently, the Abel inversion is the most frequently used method to retrieve electron density from RO measurements by different groups with minor differences in the plasmasphere calibration and top boundary derivation. As indicated by Schreiner et al. (2007) based on the closely collocated occultations during the initial stage of the Formosa Satellite 3/Constellation Observing System for Meteorology Ionosphere and Climate (F-3/C), the precision of the Abel inversion on electron density is about 10^3 cm^{-3}. Many other kinds of ionospheric electron density observations such as those from ionosonde, the incoherent scatter radar (ISR), and satellite in situ measurements have been used to evaluate the Abel retrieved electron densities (Jakowski et al. 2002; Jakowski 2005; Liu et al. 2010a; Yue et al. 2011a). In addition, the Abel inversion error has been systematically evaluated by a series of simulation studies (Liu et al. 2010b; Straus 2007; Yue et al. 2010, 2012a). Generally, the Abel inversion shows good quality around F_2 peak region with less than about 20 % accuracy (Hajj and Romans 1998; Krankowski et al. 2011). However, the Abel inversion is based on several assumptions, with the spherical symmetry assumption being one of the most significant error sources (Schreiner et al. 1999). The electron density is assumed to vary only with the altitude under the spherical symmetry assumption. The retrieved electron density should be precisely the true value of the tangent