JAST, Vol. 6, No. 3, pp 139–149
© Iranian Aerospace Society, Summer 2009

JAST Journal of Aerospace Science and Technology

Tomographic Reconstruction of the Ionospheric Electron Density in term of Wavelets

Y. Amerian[1], M. M. Hossainali[2], B. Voosoghi[3], M.R. Ghaffari[4]

Ionospheric tomography is a method to investigate the ionospheric electron density in two or three dimensions. In this study, the function-based tomographic technique has been used for regional reconstruction of a 3D tomographic model of the ionospheric electron density using the GPS measurements of the Iranian Permanent GPS Network. Two-dimensional Haar wavelets and empirical orthogonal functions are used as base functions to model the horizontal and the vertical structure of the electron density, respectively. Sparseness of data and data gaps make ionospheric tomography an ill-posed inverse problem. The truncated singular value decomposition (TSVD) method is used to come up with solution. The data analysis results show that the latitudinal sections of the electron density in ionosphere obtained from the tomographic technique supports the expected time and height variations in the electron density. Moreover, these findings show that the height of maximum electron density is changed during the day. This confirms the efficiency of the developed multilayer model in comparison to the traditional single-layer ones. The relative error between the reconstructed electron density and the electron density obtained from ionosonde data varies between 5 to 35 percent. The difference between the reconstructed electron density (as well as the corresponding estimations of the IRI-2001 model) and the direct estimates of this quantity increases when the electron density reaches to its maximum value. Assuming that the ionosonde station in Tehran produces reliable results, this proves that the reconstructed image as well as the IRI-2001 model does not efficiently constraint the electron density during this period of time.

INTRODUCTION

During the last decade, GPS has become a common tool for analyzing the Earth's atmosphere. The ionosphere is that part of the atmosphere in which the number of free electrons is so high that it significantly affects the propagation of radiowaves. Radio signals are delayed by the ionosphere proportional to the inverse of their squared signal frequency. The fact that GPS and other GNSS systems broadcast signals on two or more frequencies can be used to measure the integrated ionospheric electron density TEC (Total Electron Content, electron density integrated along signal path from satellite to receiver on ground). The International GNSS Service (IGS) uses its dense global GNSS ground stations network to compute global ionospheric TEC maps on a routine basis (*e.g.* Hernandez-Pajares *et.al.*, 2009).With the development of regional and local permanent GPS networks, the spatial and temporal resolution of such studies has been considerably increased as compared to the traditional meteorological techniques. Determining TEC or electron density in this layer of atmosphere presents valuable information about ionosphere and its activities.

In the customary two dimensional modeling techniques, ionosphere is approximated by a thin spherical shell of free electrons located 250 to 450 Km above the

1. *PhD Candidate, Faculty of Geodesy and Geomatics Eng., K.N. Toosi Univ. of Tech., Tehran, Iran, Email: amerian@dena.kntu.ac.ir.*
2. *Assitant Professor, Faculty of Geodesy and Geomatics Eng., K.N. Toosi Univ. of Tech., Tehran, Iran.*
3. *Associate Professor, Faculty of Geodesy and Geomatics Eng., K.N. Toosi Univ. of Tech., Tehran, Iran.*
4. *Formerly MSc Student, Faculty of Geodesy and Geomatics Eng., K.N. Toosi Univ. of Tech., Tehran, Iran.*