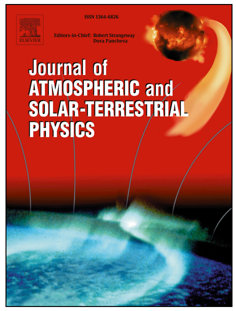

Three dimensional ray tracing technique for tropospheric water vapor tomography using GPS measurements

Saeid Haji Aghajany, Yazdan Amerian

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Three dimensional ray tracing technique for tropospheric water vapor tomography using GPS measurements

Saeid Haji Aghajany, Yazdan Amerian*

Faculty of Geodesy and Geomatics Engineering, K. N. Toosi University of Technology, Tehran, Iran

s_h_aghajany@mail.kntu.ac.ir, *amerian@kntu.ac.ir

Abstract

Tropospheric water vapor has a key role in tropospheric processes and it is an important parameter in meteorology studies. Because of its non-uniform spatiotemporal distribution, modeling the spatiotemporal variations of water vapor is a challenging subject in meteorology. The GNSS tomography of the troposphere is a promising method to assess the spatiotemporal distribution of water vapor parameter in this layer. The tomography method efficiency is dependent on the ray tracing technique and GPS derived tropospheric slant wet delays. Implementing constraints and regularization methods are necessary in order to achieve the regularized solution in troposphere tomography. In this paper, the three dimensional (3D) ray tracing technique based on Eikonal equations and ERA-I data are used to perform the reconstruction the signal path, Iranian Permanent GPS Network (IPGN) measurements are used to calculate slant wet delays and the LSQR regularization technique is used to obtain a regularized tomographic solution for tropospheric water vapor. The modeled water vapor profiles are validated using radiosonde observations.

Keywords: Troposphere tomography, Water vapor, Ray tracing, GPS, Radiosonde

1. Introduction

The tropospheric path delay is one the errors in GNSS observations and reduces the accuracy of GNSS positioning. It is strongly correlated with vertical component of coordinates. Accurate estimation of tropospheric path delay in GNSS signals is necessary for meteorological applications (Rocken et al., 1997; Cucurull et al., 2004). The tropospheric delay is divided into the dry and wet parts. The dry tropospheric delay depends on the pressure variations between satellite and Earth's surface (Baby et al., 1988) and can be determined accurately using the Saastamoinen and Hopfield models (Saastamoinen, 1973; Hopfield, 1971). The wet delay can be determined by subtracting the dry delay from the total GPS derived delay. The precipitable water vapor (PWV) can be computed using the tropospheric wet delay. Due to the high spatiotemporal variation of water vapor, modeling this parameter is a challenging subject in meteorology (Bevis et al., 1992; Emardson et al., 1998). The high spatiotemporal resolution computing, all-weather and day and night functioning of GNSS made it an interesting tool for tropospheric water vapor determination. GNSS tomography is a well-known method for high spatiotemporal resolution modeling of tropospheric water vapor, which ability has been demonstrated in numerous investigations using slant wet delays (Rohm and Bosy, 2011).

Tomography models have been investigated by Flores in 2000. He divided the model space into horizontal and vertical voxels and other researchers have utilized this method using different inverse solutions (Flores et al., 2000; Hirahara, 2000; Bi et al., 2006). The main issues in troposphere tomography problems concern three areas: the model resolution, ray tracing method and inversion of the equations system (Nilsson and Gradinarsky, 2006).