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Formulating the regional reconstruction of ionospheric electron density and wet refractivity fields using Slepian and empirical orthogonal base-functions

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In this study, an innovative reconstruction technique (recently published as Farzaneh and Forootan, 2017, Surveys in Geophysics, doi:10.1007/s10712-017-9446-y) is presented, which can be used to estimate electron density and wet refractivity fields using in-situ GPS measurements. The most common approach for ionospheric/atmospheric tomography is the voxel-based formulation, in which: (i) the ionosphere/atmosphere is divided into voxels, (ii) the slant total electron content /refractivity is then measured along (many) satellite signal paths, and finally (iii) an inversion procedure is applied to reconstruct the electron density/refractivity distribution in the ionosphere/atmosphere. In this study, a computationally efficient approach is introduced, which improves the inversion procedure in step (iii). Our proposed method combines the empirical orthogonal function (EOF) decomposition method and the spherical Slepian base-functions to describe the vertical and horizontal distribution of electron density/atmospheric refractivity, respectively. Thus, the proposed method can be applied on regional and global case studies. Numerical application is demonstrated using the ground-based GPS data over the west and south part of the USA. Using the proposed approach, we find that using 30 GPS measurements in the this area, one can achieve comparable accuracy with those from COSMIC data, Global Ionosphere Maps (GIM), and radiosonde that use considerably more observations and require more computational efforts.
Keywords: Computerized Tomography, spherical Slepian base function, Empirical Orthogonal Function (EOF), Slant Total Electron Content (STEC), Wet refractivity