LOCALIZED THREE-DIMENSIONAL IONOSPHERIC TOMOGRAPHY WITH GPS GROUND RECEIVERS

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Abstract Submission Form

2006 National Radio Science Meeting

Abstract: lee27648

Date Received: September 26, 2005

This paper evaluates the performance of two different reconstruction techniques for localized 3D tomographic imaging of the ionosphere with high spatial resolution. The total electron content (TEC) values are derived from dual-frequency measurements obtained from GPS satellites by ground-based receivers. Ionosonde observation data is used to construct *a priori* vertical profiles modelled using Chapman functions. The altitude range of interest is 100km to 800km, with voxel sizes at most about 30 km in altitude.

Two regularization algorithms are used for tomographic image reconstruction: Tikhonov and Total Variations (TV). The methods have different norm minimizations of the penalty constraint: quadratic and l_1. The TV method is used because it generally better preserves jump discontinuities in the image and is more resistant to noise. By contrast, Tikhonov or quadratic regularization tends to oversmooth image structures. However, a closed-form solution of the TV method does not exist, and so performance depends heavily on numerical optimization techniques, which is non-trivial to implement because the inverse problem is both ill-posed and ill-conditioned.

The algorithms are demonstrated using real and simulated GPS TEC measurements from actual observation geometry centered in Southern California. We demonstrate the successes and limitations of these techniques under quiet mid-latitude conditions. The resulting reconstructions reasonably determine the shape of the ionospheric profile. The limitations, such as artifacts near voxels with no ray path information, are directly related to the sparseness and nonuniform distribution of the GPS ray paths. Some methods addressing this are discussed. We also apply regularization parameter-selection methods to demonstrate their applicability in our study.

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2. G - Ionospheric Radio and Propagation
3. (a) S-G3
4. C - Contributed Paper
5. No special instructions