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Solving the non-linear model of the electron density of the ionosphere

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Precise and high precision ionosphere models are important for modern satellite navigation and positioning systems. In most cases, the ionosphere models are based on pure mathematical approaches, e.g. by applying spherical harmonic expansions for the vertical total electron content. In order to achieve a deeper understanding of the complex phenomena within the ionosphere, physical conditions have to be considered and introduced.

The physics-motivated Chapman function is very efficient for describing the vertical structure of the electron density. Introducing the Chapman function and a plasmasphere layer, the vertical distribution of the electron density can be described by five parameters altogether, namely (1) the F2 peak electron density (NmF2), (2) the peak height (hmF2), (3) the topside scale height (H_{F2}), (4) the plasmasphere basic density (N_P) and (5) the scale height (H_P). In our approach, each of these parameters is decomposed into an initial part, derived from a given ionosphere model or other initial assumptions, and an unknown correction term. Exploiting the localizing property of B-spline base functions, the latter is modeled as a series expansion in terms of tensor products of three one-dimensional endpoint-interpolating B-splines depending on latitude, longitude and time, respectively. Considering the necessary linearization of the exponential terms of the Chapman and the plasmaspheric layer, the unknown model coefficients are solved by an appropriate parameter estimation procedure using an iterative algorithm. In this contribution we focus on the numerical solution of the linearized model. This includes a closer view on the iterative method, the regularization scheme and the convergence analysis. Due to complexity of the problem, the topside scale height H_{F2} is expanded in a first step to test the adjustment approach. Data gaps are artificially created to investigate inhomogeneous data availability. In this case proper prior information and regularization are needed to ensure the convergence of the system.