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Comparative Analysis of 1D Var Ionospheric Electron Density Retrieval Method using GNSS RO Data

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GNSS-RO delivers observations that are pivotal in precisely constraining parameters such as bending angle, refractivity, temperature, pressure, humidity, and other geophysical variables within NWP models, crucial for accurate terrestrial weather forecasts. This requires accurately estimating the impacts of both the ionosphere and lower atmosphere on GNSS-RO signals. EUMETSAT's ROM SAF partnership provides the ROPP code which allows these estimations to be made operationally. ROPP employs various methodologies for these estimations, among which is the 1DVar method. This method assumes a one-dimensional ionospheric structure extending vertically, ignoring horizontal gradients, and uses a variational approach to estimate the vertical electron density distribution.

This study benchmarks the performance of the existing ionospheric 1DVar inversion code within ROPP, which is used for estimating ionospheric electron density profiles and in turn the forward modelled bending angles as the GNSS-RO signal traverses the ionosphere. The 1DVar code has undergone previous testing on the MetOp GRAS extension period (when observations were extended up to ~600 km heights), revealing various 'bad' retrievals. However, those evaluations were conducted for a single day. This study extends the analysis to a longer month-long period in Jul and Aug 2020, comprising ~24,000 occultations. The primary goal is to present the performance of the retrievals in terms of plots of bending angles and retrieved ionospheric electron density profiles and to segregate the 'good' and 'bad' retrievals based on the metadata values. Furthermore, a statistical analysis of metadata will be conducted to recognize the factors contributing to these 'bad' occultations, potentially arising from large convergence costs, a high number of iterations required for minimization, quality control check, and/or the presence of missing data. Spatial and temporal analyses will also be performed to enhance the understanding of these ionospheric profiles, accompanied by a comparison with geomagnetic and solar activity indicators Kp and F10.7.

This approach aims to provide insights into the underlying causes of different retrieval outcomes and lead to a benchmark for future work, looking to improve the existing 1D Var method using additional parameters, like extra Vary-Chap layers, parameters which vary spatially/with solar or geomagnetic drivers, and possibly integrating other GNSS-RO sources.