Utilizing 4D-var technique to image South African regional ionosphere

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In an endeavor to characterize and model a time-space variant ionosphere through which trans-ionospheric signals propagate, we have developed a strong constraint four dimensional variational data assimilation (4D-var) technique, and used the same to more accurately estimate the South African regional ionosphere (bound latitude 20deg S - 35deg S, longitude 20deg E - 40deg E and altitude 100 -1336 km). The altitude was capped to the JASON-1 satellite orbital altitude for the purpose of eliminating the plasmasphere contribution hence reducing the computation expense. Background densities were obtained from an empirical internationally recognized ionosphere model (IRI-2016), and propagated in time using a Gauss-Markov filter. Ingested data were STECs (slant total electron content) obtained from the South African GNSS (Global Navigation Satellite System) receiver network (TrigNet). The vertically integrated electron content was validated using GIMs (Global ionosphere Maps) and JASON-3 data over the continent and ocean areas, respectively. Further, vertical profiles after assimilation were compared with data from a network of ground based regional ionosondes (Hermanus (34.25S, 19.13E), Grahamstown (33.3S, 26.5E), Louisvale (21.2S, 28.5E) and Madimbo (22.4S, 30.9E). Results show that assimilation of STEC data has a profound improvement on the estimation of both the horizontal and vertical structure during quiet and storm periods. Accuracy of the horizontal structure decreases from the continent towards the ocean area where GPS receivers are less abundant. Superiority of assimilating STEC is best pronounced during day time especially when estimating maximum electron density of the F2 layer (NmF2), with a 60% RMSE improvement over the background values.