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Application of thin plate splines for accurate regional ionosphere modeling with multi-GNSS data

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GNSS-derived regional ionosphere models are widely used in both precise positioning, ionosphere and space weather studies. However, their accuracy is often not sufficient to support precise positioning, RTK in particular. In this paper, we presented new approach that uses solely carrier phase multi-GNSS observables and thin plate splines (TPS) for accurate ionospheric TEC modeling. TPS is a closed solution of a variational problem minimizing both the sum of squared second derivatives of a smoothing function and the deviation between data points and this function. This approach is used in UWM-rt1 regional ionosphere model developed at UWM in Olsztyn. The model allows for providing ionospheric TEC maps with high spatial and temporal resolutions - 0.2x0.2 degrees and 2.5 minutes, respectively. For TEC estimation, EPN and EUPOS reference station data is used. The maps are available with delay of 15-60 minutes.

In this paper we compare the performance of UWM-rt1 model with IGS global and CODE regional ionosphere maps during ionospheric storm that took place on March 17th, 2015. During this storm, the TEC level over Europe doubled comparing to earlier quiet days. The performance of the UWM-rt1 model was validated by (a) comparison to reference double-differenced ionospheric corrections over selected baselines, and (b) analysis of post-fit residuals to calibrated carrier phase geometry-free observational arcs at selected test stations. The results show a very good performance of UWM-rt1 model. The obtained post-fit residuals in case of UWM maps are lower by one order of magnitude comparing to IGS maps. The accuracy of UWM-rt1 -derived TEC maps is estimated at 0.5 TECU. This may be directly translated to the user positioning domain.