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Concepts for modeling VTEC as multi-scale representation

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A multi-scale representation means basically the approximation of a signal under different resolution levels. Thus, we decompose the target function, i.e. In this contribution the vertical total electron content of the ionosphere into a system of detail signals each related to a specific geographical region and a specific frequency band. Whereas the modeling of coarse structures needs generally only a small number of input data, finer structures, however, require a considerably larger number of observations. Consequently, the computation of the detail signals depends on the data distribution.

In this contribution we present a multi-scale ionosphere model calculated from the combination of measurements from various space-geodetic observation techniques. The approach consists of a given background model such as the International Reference Ionosphere (IRI) or the IGS VTEC maps and an additional unknown term represented by a series expansion in terms of multi-dimensional B-spline (scaling) functions. Since different kinds of B-splines - namely trigonometric and endpoint-interpolating B-splines - are selectable, our approach can be applied to both global and regional data sets.
The series coefficients of the chosen B-spline expansion can be calculated from space-geodetic observation techniques by parameter estimation. To take advantage of the different characteristics of the various techniques a combined adjustment of terrestrial GNSS measurements, GNSS observations from LEO satellites, observations from VLBI, and measurements from dual-frequency altimetry missions is performed. The weights of the different techniques including the reference model IRI may be estimated by variance component estimation. This more classical approach means an evaluation of all input data in one step. However, since the input data are heterogeneously sampled in space and time due to the specific orbit and instrumental characteristics, finer structures of VTEC can be modeled just in regions with a sufficient number of observation sites. But within the MSR this problem can be solved, since it allows the estimation of the target function at different resolution levels, e.g. GNSS data can be used to estimate VTEC at a much higher level than altimetry allows. This alternative approach provides a successive level-to-level parameter estimation, in which the connections between the different levels are provided by a mathematical tool, namely the pyramid algorithm. In this contribution we provide first results on this procedure for a regional application.