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Uncertainty of crustal models from geostatistical analysis of USGS Global Seismic Crustal Structure Database

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Over the last decades an extensive amount of active-source seismic measurements of the seismic velocity structure of the Earth's crust have been made. Many of these measurements have been compiled into a database that indicates the crustal thickness and P-wave velocity distribution. Based on this database, global crustal models such as Crust5.1 and Crust1.0 have been derived using geologically guided interpolation techniques. However, it is not clear how accurate such global models are, in a quantitative sense. Uncertainty of crustal models mainly results from interpolation between seismic profiles, especially in sparsely surveyed regions. In addition, the individual seismic results might be inaccurate, particularly if the data were acquired before the 1980s when many sesmic surveys were only sparsely recorded due to a lack of portable seismographs.

We demonstrate how geostatistical analysis and kriging can be used to estimate the numerical accuracy of a crustal model. Due to the global scale, our analysis has to account for non-stationarity and spherical geometry. We apply our approach to the USGS Global Seismic Catalogue (database), which was also used in the construction of Crust1.0.

We find that in well-surveyed areas the estimated uncertainty of crustal thickness is less than 4 km, whereas sparsely-surveyed parts of South America and Africa have uncertainties of up to 10 km. The average P-wave velocity of the crystalline crust has uncertainties of up to 0.2 km/s, but is almost negligible in well-studied areas.

Crustal models can be used to calculate residual topography by 'stripping' from the observed topography the crustal isostatic contribution. Thus, the uncertainties in the crustal properties (thickness and density as estimated from Vp) propagate to the residual topography. We discuss the importance of the uncertainty of the assumed crustal model in light of the on-going controversy regarding the mismatch of residual and dynamic topography.