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Comparison of uncertainty quantification methods on the example of soil organic carbon stock mapping in Hungary

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Digital soil mapping (DSM) aims to provide spatial soil information for a wide range of studies (e.g. agro-environmental management, nature conservation, rural development, water and food security etc.). For this purpose, advanced statistical methods are in use for inferring the spatial variations of soil. Nowadays, there is a heap of evidences that researchers and stakeholders are not just interested in the maps of soil properties, functions and/or services but in their uncertainties as well. This is indispensable to support decision making process. In DSM various uncertainty quantification methods are in use, however, only a few studies have addressed the issue of comparing them. In this study, we compared the suitability of several commonly applied digital soil mapping methods to quantify uncertainty with regard to a survey of soil organic carbon stock in Hungary. To fairly represent the wide range of DSM methods, the followings were selected: universal kriging (UK), sequential Gaussian simulation (SGS), random forest plus kriging (RFK) and quantile regression forest (QRF). For RFK two uncertainty quantification methods were adopted based on kriging variance (RFK-1) and bootstrapping (RFK-2). We used a control dataset consisting of 200 independent SOC stock observations for validating not just the spatial predictions but their uncertainty quantifications as well. For validating the uncertainty quantifications we applied accuracy plots (a.k.a. prediction interval coverage probability plots) and a modified version of G-statistics. According to our results, QRF and SGS provided the best quantifications of uncertainty. UK and RFK-2 overestimated whereas RFK-1 underestimated the uncertainty. Based on our results we could draw a conclusion that there is a need to validate the uncertainty quantifications before using them for decision making. Furthermore, special attention should be paid to the assumptions made in uncertainty quantification.

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