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Detailed soil mapping for large areas in Berne – putting well researched knowledge into practice

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Spatial information on soil is crucial for many applications such as spatial planning, erosion reduction, climate mitigation and forest or natural hazard management. Many countries (e. g. Switzerland, France, Germany, Albania) still use conventional soil mapping approaches which are often very time consuming and costly. Methods to gain soil maps with geostatistics and supported with other digital technologies have reached a high level of maturity some time ago. Each single method has been well studied and transfer to practice took place in some countries. Nevertheless, we are not aware of a large soil mapping endeavor that sampled a considerable amount of new soil data by a practical and geostatistically sound sampling design and by integrating digital field tools, centralized soil data management, soil spectroscopy, digital soil mapping and subsequent soil function assessment all followed by quality assurance measures.

In Switzerland, political pressure has recently risen to improve the basis for soil related decision making. The administration of the Swiss Canton of Berne aims to map agricultural and forest soils of the lowlands (210000 hectares) with high resolution to allow for decisions relevant to landownership. In the mountainous areas (240000 hectares) at least maps with medium detail are necessary, especially for natural hazard management. Currently, the project is in the phase of efficiency testing of each methodological element and establishing of interfaces between them. We present a concept that combines available state-of-the-art technologies and should allow to create the required detailed soil maps within the next 15 years. Only few legacy soil data are available, hence we planned for 5200 newly sampled profile pits and about 360000 auger holes. This large sampling effort is hierarchically structured with field observations based on classical pedological descriptions supported with laboratory and field spectroscopy. Iterative sampling is driven by the uncertainty of the maps up to the point where the required accuracy is reached. Intermediate and final soil maps are created with machine learning based digital soil mapping techniques. From the finally mapped soil properties soil functions and application products are derived by digital soil assessment approaches driven by the needs of the end users.

Within this phase of the project we exploited the legacy soil maps available for the surroundings of some villages. As soil augerings were not recorded during map production, we generated “virtual soil samples” from the maps and used a machine learning based model averaging approach to predict soil properties for the nearby areas. Class width and multiple assignments of legend units per soil map polygon were considered by a non-parametric bootstrap approach to create predictive distributions and map the uncertainty. To avoid extrapolation into areas with different soil forming factors we have carefully chosen the target area for prediction based on a similarity analysis. The predictions have been successfully validated with legacy soil profiles and new field observations.