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Fingerprinting: Modelling and mapping physical top soil properties with the Mole

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The Mole is a passive gamma ray soil sensor system. It is designed for the mobile collection of radioactive energy stemming from soil. As the system is passive, it only measures energy that reaches the surface of soil. In general, this energy comes from upto 30 to 40 cm deep, which can be considered topsoil. The gathered energy spectra are logged every second, are processed with the method of Full Spectrum Analysis. This method uses all available spectral data and processes it with a Chi square optimalisation using a set of standard spectra into individual nuclide point data. A standard spectrum is the measured full spectrum of a specific detector derived when exposed to 1 Bq/kg of a nuclide. With this method the outcome of the surveys become quantitative.The outcome of a field survey with the Mole results in a data file containing point information of position, Total Counts and the decay products of 232Th, 238U, 40K and 137Cs. Five elements are therefor available for the modelling of soil properties.

There are several ways for the modelling of soil properties with sensor derived gamma ray data. The Mole generates ratio scale output. For modelling a quantitative deterministic approach is used based on sample locations. This process is called fingerprinting. Fingerprinting is a comparison of the concentration of the radioactive trace elements and the lab results (pH, clay content, etc.) by regression analysis. This results in a mathematical formula describing the relationship between a dependent and independent property. The results of the sensor readings are interpolated into a nuclide map with GIS software. With the derived formula a soil property map is composed.

The principle of fingerprinting can be applied on large geographical areas for physical soil properties such as clay, loam or sand (50 micron), grain size and organic matter. Collected sample data of previous field surveys within the same region can be used for the prediction of soil properties elsewhere when adding a relatively small number of new calibration samples. For this purpose stratification of data is necessary.

All radioactive trace elements play a part in the fingerprinting process for the mapping of physical soil properties. Clay content is best predicted with 232Th. It has a general R2 of 0.75 up to 0,9. The correlation is positive and basically linear. The variation of loam (or sand) content is very well described by 232Th or the combination of 232Th and 238U. It has a comparable R2 to clay. Grain size can be well modelled with 40K, probably due to the fact that this nuclide is positively correlated with matter. 40K is therefor negatively correlated to grain size. The R2 is good: 0,7 to 0,8 on average. The combination of 40K and 137Cs is generally applied for modelling organic matter content with a quality comparable with that of grain size models. Finally, Total Counts turns out to be a very useful parameter for the identification of different types of parent material and of unnatural or non-parent material.

Passive gamma ray soil sensors as the Mole are very suitable for high resolution mapping of physical soil properties. The FSA method has the advantage that data from previous surveys becomes applicable in the fingerprinting procedure of new fields. Being able to model the physical soil properties with gamma ray sensors opens the possibility to run pedotransfer function models for a particular survey.