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A homage to soils and scales

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Deciding on the topic for this lecture was far from trivial. In my research, I used knowledge obtained from formal training in applied mathematics and from informal training in soil science, and worked with data and scientists from 40 countries. Topics that I tackled present quite a hodgepodge. To select the motif for this lecture, I asked myself if there was some idea that often lead to the satisfactory research outcomes, and found that it was the notion of scale and scaling.

I will start with scales in soils defined via hierarchy of levels of organization, and will use large-scale projects – irrigation in steppe region, interregional water transfer, landscape reorganization to combat droughts, relationship between soil quality and public health, and regional crop simulations - to illustrate important differences between research approaches and outcomes at different scales. Specifically, I intend to demonstrate how moving from finer to coarser scales changes (a) role of modeling, purpose of modeling, and selection of modeling approach, (b) type of the soil information, number of variables, type of variables used, as well as the temporal, scale, and (c) interaction with other disciplines, relevance of research results to policies, and public perception of proposed changes in soil management. I will address pitfalls of estimating parameters of coarse scale models using properties measured at fine scales.

At any hierarchical scale, we discover patterns that emerge due to the processes operating at the finer scales and are affected by environmental variables coming from yet coarser scales. I will invoke the Philippe Duchaufour's formula of pedogenesis to illustrate the relationship between pattern and scales. I will also use examples of actively studied patterns, i. e. temporal stability of soil variables and fluxes, relation between information content and complexity metrics in soils, and better survival of pathogenic microorganisms in soils undergoing eutrophication.

I will briefly comment on patterns often found when scales in soils are defined based on measurement metrics of support, spacing, and extent such as power law scaling in soil properties and scale effects on relationships between soil and environmental variables.

I will conclude with discussing several grand challenges in the field. Currently we are encountering Increasingly large volumes of available data, often not having a clear physical interpretation. We need to be able to aggregate such data within our data processing algorithms and use the data aggregates for further interpretation and forecasts. Discovering, quantifying and understanding "scale – pattern" relationships is the major direction to advancing upscaling and downscaling.

I will also use the opportunity to acknowledge my colleagues and friends who worked with me and supported me in many ways through the career path, as well as scientists who affected my studies the most.