Regional spatial modeling of topsoil geochemistry

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Abstract

Geographic information about the levels of toxics in environmental media is commonly used in regional environmental health studies when direct measurements of personal exposure is limited or unavailable. In this paper, we propose a statistical framework for analyzing the spatial distribution of topsoil geochemical properties, including the concentrations of various toxicants. Due to the small scale heterogeneity of most geochemical topsoil processes, direct measurements of the processes themselves only provide highly localized information; it is thus nancially prohibitive to study the spatial patterns of these processes across a large region using traditional geostatistical analyses of point-referenced topsoil data. Instead, it is standard practice to assess geochemical patterns at a regional scale using point-referenced measurements collected in stream sediment since, unlike topsoil data, individual stream sediment geochemical measurements are representative of the surrounding area. We propose a multiscale soils (MSS) model that formally synthesizes data collected in topsoil and stream sediment and allows the richer stream sediment information to inform about the topsoil process, which in environmental health studies is typically more relevant. Our model accommodates the small scale heterogeneity of topsoil geochemical processes by modeling spatial dependence at an aggregate resolution corresponding to hydrologically-similar regions known as watersheds. We present an analysis of the levels of arsenic, a toxic heavy metal, in topsoil across the midwestern U.S. using the MSS model and show that this model has better predictive abilities than alternative approaches using more conventional statistical models for point-referenced spatial data.