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Spatial statistics for multi-scale study of subsurface systems and processes.

Murray Lark

Rothamsted Research, Biomathematics and Bioinformatics Department, Harpenden, United Kingdom
(murray.lark@bbsrc.ac.uk)

When we use statistical methods to study processes in the geosciences we treat variables as realizations of random processes with particular, mathematically convenient, properties. This option is commonly taken because of the complexity of the processes of interest, and the inherent difficulties of attempting to predict their behaviour mechanistically.

In this session we are asked to look towards joint interdisciplinary visions for how progress might be made in the study of subsurface geosciences. On the face of it it might seem that statistical processes close down such a joint vision because they use random functions to model variables that we know arise from mechanisms. Is a statistical approach compatible with process understanding?

In this paper I shall review the scope for synergy between statistical approaches and process-based approaches to the study of multiscale variation in soil systems. How can sampling and statistical analysis be structured so as to yield insight into processes over multiple orders of scale, and so contribute to the modelling enterprise? At the same time, can understanding of processes allow us to select appropriate spatial statistical models whose parameters and structure are linked directly to processes, and so, when estimated, provide process information and not merely convenient statistical descriptors? In addressing these general questions I shall provide examples of how understanding of the soil system has been enhanced by statistical analyses which:

- provide efficient sampling to permit analysis of the variation or covariation of soil properties over strongly contrasting spatial scales,
- allow spatial analysis over different scales without unrealistic statistical assumptions about the stationarity (uniformity) of soil variation in space, and
- avoid assumptions about the statistical distribution underlying soil variables, and so permit more realistic spatial models, particularly for hydrological processes.