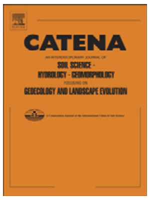
Catena 77 (2009) 28–38

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena



Accounting for extensive topographic and pedologic secondary information to improve soil mapping

Annamaria Castrignanò [a,*], Edoardo A.C. Costantini [b], Roberto Barbetti [b], Donato Sollitto [a]

[a] C.R.A.-SCA, Via Celsio Ulpiani n.4, 70125 Bari, Italy
[b] C.R.A.-ABP, P.zza Massimo D'Azeglio n. 30, 50121 Firenze, Italy

ARTICLE INFO

Article history:
Received 28 March 2008
Received in revised form 11 November 2008
Accepted 9 December 2008

Keywords:
Soil mapping
Pedology
Topography
Auxiliary information
Gaussian anamorphosis
Multicollocated cokriging

ABSTRACT

Soils generally vary in a quite complex way. To assess and model spatial variability, several variables can be sampled in addition to the target used to quantify and describe the main phenomenon under study. One of the major advantages of geostatistics over simpler spatialization methods is that sparsely observations of the primary attribute can be complemented by secondary attributes that are more densely sampled. Two methods were applied to incorporate dense secondary information: multicollocated cokriging, which restricts the neighbourhood to the only secondary data collocated with the available data of the primary variable and simple cokriging with varying local means related to crisp classes. The objective of this paper was to find the method that best improves the estimation of primary attributes through dense secondary information for the study area, which was the province of Siena in central Italy, an area of about 3820 km^2. Soil samples were taken at 742 locations and depth, sand and clay contents and available water capacity were determined.

A multivariate geostatistical analysis was performed using the four soil properties and elevation from a digital elevation model of 20×20 m resolution as auxiliary variable. The variables were interpolated using three different approaches: cokriging, multicollocated cokriging, multicollocated simple kriging with local mean, estimated by averaging over the soil unit occurring at each node of the interpolation grid.

These methods were compared in terms of precision, through cross-validation, and of accuracy, through a validation test, using an independent data set of 170 soil depth measurements. The results did not show clear differences among the methods.

1. Introduction

Soils are natural bodies which generally vary over space and time across landscape in a quite complex way. To assess and model spatial variability, most times, several variables are sampled in addition to the one used to quantify and describe the main property under study.

There are two main approaches to describe spatial variation: one is the geostatistical approach, that considers soil as a “continuum” and quantitatively describes the variation of continuous variables on the land (Matheron, 1962); the other one is the approach that considers the soil as a “discontinuum” and partitions the soil cover into a number of discrete classes, called taxa (Soil Survey Division Staff, 1993). Both approaches are based on specific assumptions of the real world. Fundamental to geostatistics is that a regionalized variable is considered a realization of a random function and any quantitative spatial attribute, defined on the spatial domain of interest, can be expressed as the sum of a deterministic variable (mean) and a random variable (error) being the latter generally spatially auto-correlated. This simple model of spatial variation does not produce any subdivision of the domain or region of interest. Soil mapping was first relied merely on the experience of soil surveyors to read a soil landscape (Grunwald, 2005). Soil factor equation was introduced by Jenny (1941) and his model describes soil as a function of climate, biological activities, topography, parent material and time. This approach produces a subdivision of the land into classes of finite extension, delineated by sharp boundaries so to maximise between-unit variance and minimise within-unit variance. Both geostatistics and mapping-unit approach have their advantages and disadvantages and no approach can be considered fully satisfactory, as both abrupt and gradual variation are very often present in the same region at all scales, that is, at all levels of generalization of the studied variables.

After the first enthusiastic acceptance of kriging in the in the late nineteen eighties, which led to identifying pedometricians as a group with common interest, they realised that abandoning deterministic approach was not the best solution, but merging the discrete and continuous models of spatial variation was much more reasonable. To bridge the gap between the two approaches, numerous solutions were proposed. Rogowski and Wolf (1994) used an unweighted average of the

---

* Corresponding author. Fax: +39 080 5475023.
E-mail address: annamaria.castrignano@entecra.it (A. Castrignanò).

0341-8162/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.catena.2008.12.004

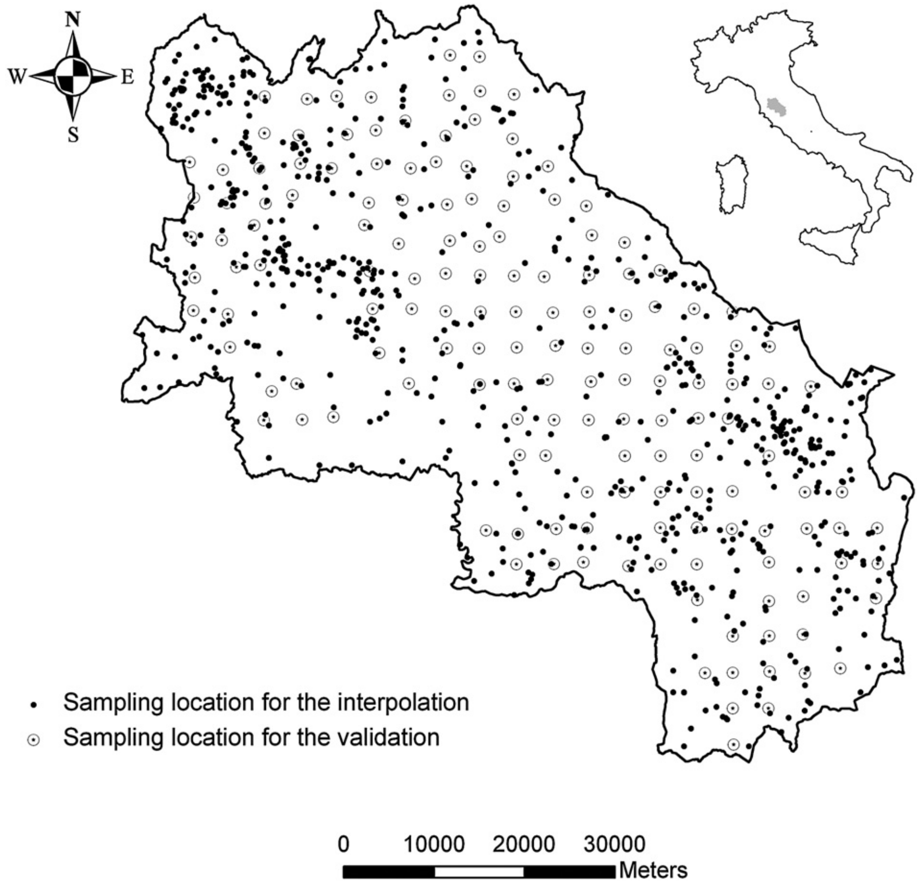


Fig. 1. Location of the 742 sample points in the study area.

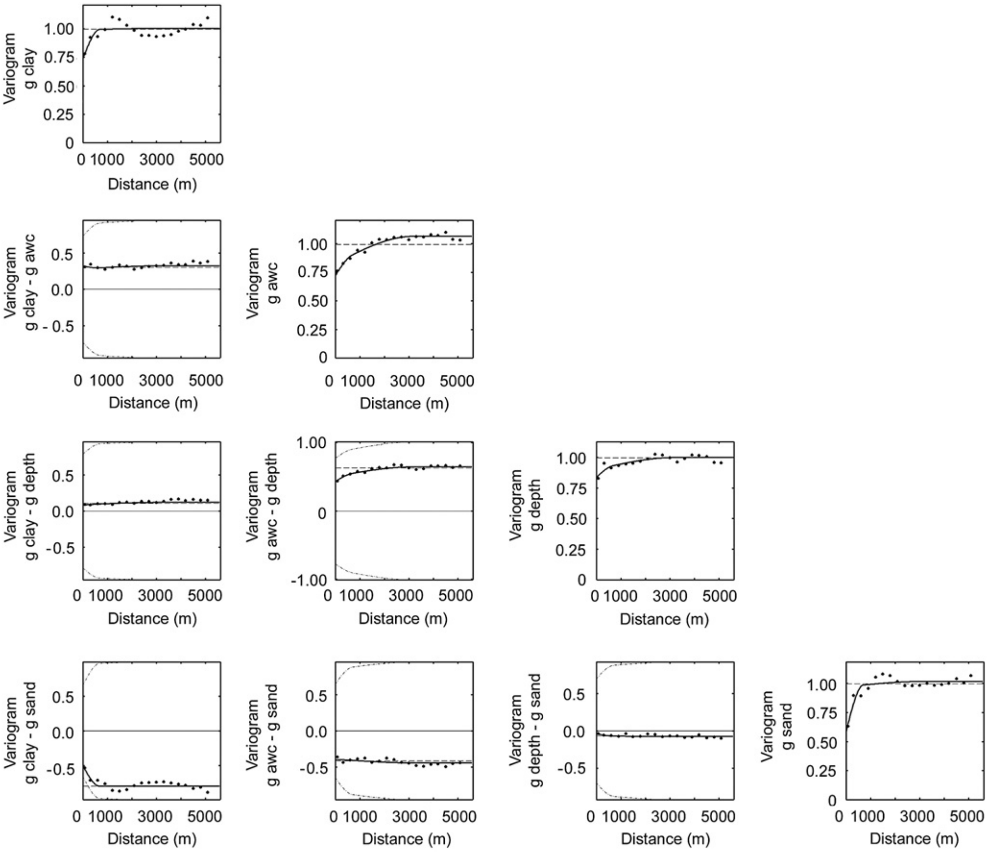


Fig. 2. Matrix of the experimental (dots) and model (line) variograms of the variables (depth, clay, sand and AWC), with cross-variogram of the hull of perfect correlation (dot-line).