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Stochastic analysis of field-scale hydraulic behaviour sensitivity to measured and estimated hydraulic properties

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Soil hydrological behavior controls soil water processes in the vadose zone at a wide range of scales. At local scale, flux and storage of water in the unsaturated zone is adequately described by the classical nonlinear Richards equation. Extrapolating the theory for the nonlinear unsaturated flow process to a larger-scale system is ordinary practice (scale-invariant equation) but its application in modeling field-scale water flow set two major and strictly related problems; namely (i) the characterization and parameterization of soil hydraulic properties and (ii) their inherent variability at the field scale.

In order to address (i) the characterization and parameterization issue, the soil hydraulic properties are typically derived either through expensive laboratory and/or field experiments or with alternative approaches like pedotranfer functions in order to increase cost effectiveness.

On the other side (ii) the variability of soil hydraulic properties at the field scale can be treated by a simple, feasible approach, considering soils in the field as an ensemble of parallel and statistically independent tubes, assuming only vertical flow. Each stream tube defines local flow properties that are assumed to vary randomly between the different stream tubes. We used the Monte Carlo technique, which treats any uncertain parameter as a random variable that obeys a given probabilistic distribution,

for analyzing soil hydraulic properties probabilistic uncertainty.

The goals of this work, placed at the core of the issues (i) and (ii), are the following:

- recognize the sensitivity of a Richard-based model to the measured variability of θ(h) and k(θ) parameters;
- establish the predictive capability of PTF in term of a simple comparison with measured data taking into account the results of point (i);
- establish the effectiveness of using PTF by using as data quality control an independent and spatially distributed information (NDVI).

The study area is located in the Po plain (Lodi) in Northern Italy and it has an extension of approximately 2000 hectares; most of the area has corn land use.

A considerable number (about 100) of top soil sample sites, throughout the whole study site, were identified for hydropedological analysis.

All samples were analyzed for texture, bulk density, organic matter content and other chemical properties, and for about 60 samples water retention curves and saturated hydraulic conductivities were determined and parameterized following the Mualem-van Genuchten functional relationships.

Several pedotransfer functions were tested; then the PTF proposed by Vereecken was applied to derive hydraulic properties of the entire soil database. A site was also settled, within the area, for continuous monitoring of soil water variables for model calibration and validation.

The model was applied and the Monte Carlo approach was used to analyse modelling sensitivity in relation to two measured input parameters: the slope of water retention curve (n) and the saturated hydraulic conductivity (*Ks*). The analysis has shown that the "n" parameter affects the variability of the process simulated to an extent significantly higher than the Ks parameter, although the former is much less variable.

The experimental analysis of the data, obtained through application of the PTFs, showed a smoothing effect, even though they had been previously validated on a set of measured data. These results, also in view of the data obtained through the sensitivity analysis of the applied model, underline the absolute need for a correct assessment of the parameters.

Interesting positive and significant correlations were found between the "n'' hydraulic parameter, both from measured and estimated water retention curves, and the NDVI

(Normalized Difference Vegetation Index) using high resolution remotely sensed data on maize cultivation. This study requires further investigations, but it emphasise the feasibility of alternative low costly approaches for the estimation of data quality at the scale of landscape.

Keywords: simulation model, PTF, Monte Carlo, NDVI.