A new approach to modelling soil structure dynamics and a preliminary application to structure recovery after heavy compaction due to earthworm bioturbation

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The pore structure of soil is known to be dynamics at time scales ranging from seconds (e.g. compaction) to seasons (e.g. root growth, macro-faunal activity) and even decades to centuries (e.g. changes in organic matter content). Nevertheless, soil physical and hydraulic functions are generally treated as static properties in most soil-crop models. Some models account for seasonal variations in soil properties (e.g. bulk density) due to tillage loosening and post-tillage consolidation or soil sealing, but none can account for longer-term changes in soil structure due to biological agents and processes. Here, we present a new concept for modelling soil structure evolution impacted by biological processes such as root growth and earthworm activity. In this preliminary test of the model, we compare simulations against field observations made at the Soil Structure Observatory (SSO) in Zürich, Switzerland, that was designed to provide information on soil structure recovery following a severe compaction event. In this simple application, we modelled changes in the pore size distribution in a bare soil treatment resulting from soil ingestion and egestion by earthworms and the loosening of compacted soil by casting at the soil surface. Following calibration, the model was able to reproduce the observed temporal development of total porosity, soil bulk density and pore size distribution during a four-year period following severe traffic compaction. The modelling approach presented here appears promising and could help support the development of cost-efficient strategies for sustainable soil management and the restoration of degraded soils.

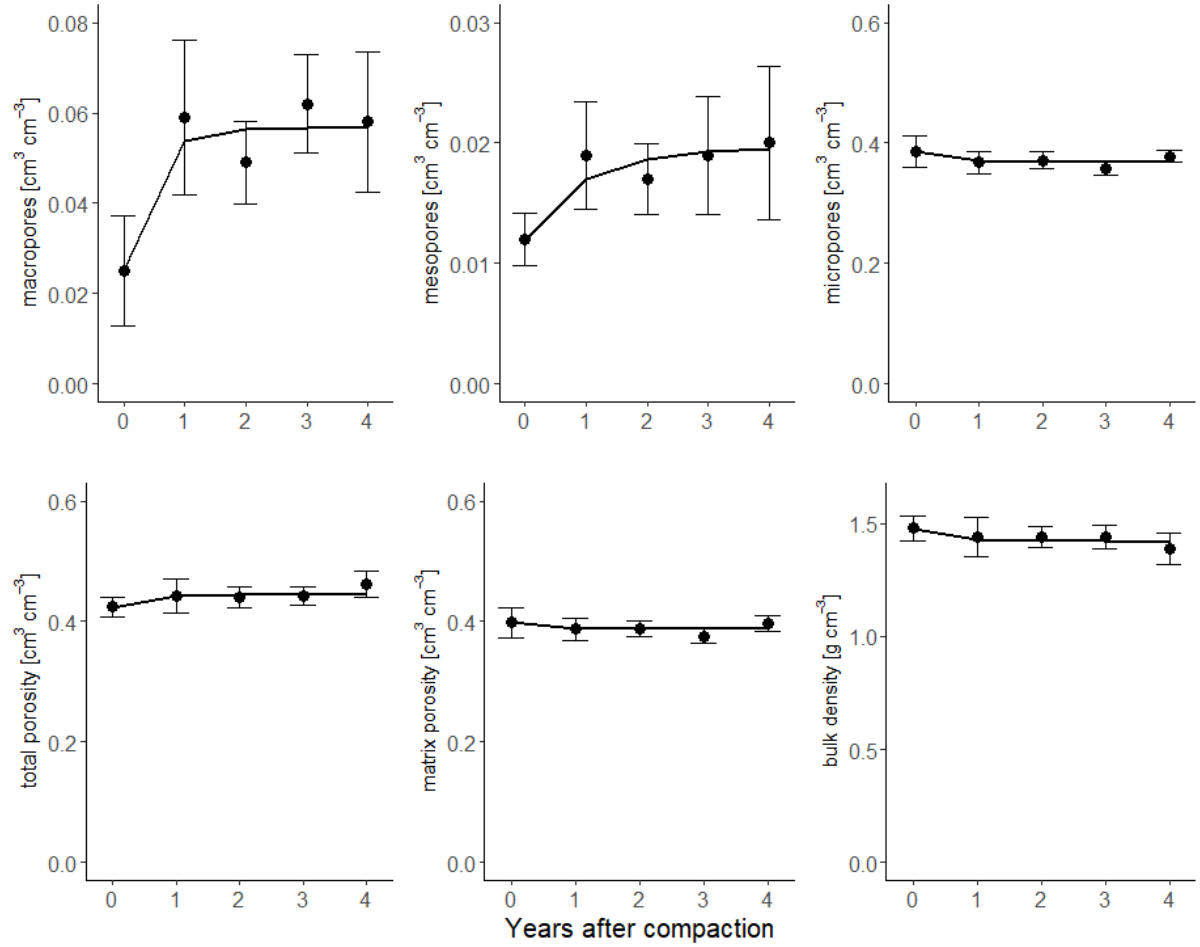

Figure 1. Comparison of model simulations (lines) with observed soil physical properties on bare soil plots at the compaction recovery experiment (Keller et al., 2017, VZJ 16(4); bars are standard deviations). To minimize the effects of seasonal variations and to reveal trends related to compaction recovery, the measured data on the compacted plots has been scaled making use of the measurements made on uncompacted control plots (the data were multiplied by the ratio of the initial value to the current value on the control plots).