Geoderma xxx (xxxx) xxx

Contents lists available at ScienceDirect

Geoderma

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

Preface

On the Geoderma special issue "Digital soil mapping for a sustainable future"☆

Digital Soil Mapping (DSM) is a valuable tool to enhance our understanding of spatial soil variability at a feasible cost and with reproducibility (McBratney et al., 2003). By employing numerical models, DSM generates accurate maps of soil properties across scales, from field to global. Although DSM has transitioned from an academic exercise to an operational practice, it remains a vibrant area of research, with scientific advancements continually unfolding.

This special issue on DSM originated at the "Soil Mapping for a Sustainable Future" conference held in Orléans, France, in February 2023 (Richer-de-Forges et al., 2023). This conference, attended by approximately 150 participants, was organized by the International Union of Soil Sciences (IUSS) Digital Soil Mapping and GlobalSoilMap Working Groups, under the auspices of Commission 1.5 "Pedometrics" of Division 1 "Soils in Space and Time" of the IUSS.

This virtual special issue (VSI) compiles research papers presented at this conference alongside additional studies on related topics. The VSI highlights cutting-edge advancements and the latest developments in digital soil spatiotemporal assessment.

1. Content

This VSI comprises 16 articles contributed by over 100 authors from organizations, research institutes, and universities across 23 countries, including numerous European and African nations, as well as Brazil, the United States, Japan, and Australia (Fig. 1).

Some authors conducted research outside their countries of origin, and some articles provide continental reviews, e.g., DSM in Africa (Nenkam et al., 2024), Soil Monitoring Networks in Europe (Froger et al., 2024). Additional studies included in this SI cover 17 more countries across Africa and Saudi Arabia. Consequently, this SI encompasses studies from 41 countries, along with pan-continental approaches (European Union, Africa) and global-scale DSM perspectives (Fig. 2).

The geographical coverage of this SI is unbalanced as studies in Middle-East, Asia, Latin-America and Caribbean countries are rare. Nevertheless, this SI covers a wide range of objectives, target attributes, scales and methods.

2. Target soil attributes

The most studied target attribute is, as expected, soil organic carbon (SOC), either static SOC content or SOC stock maps, or the capacity and condition to store SOC. Other studies focused, in decreasing order, on pH, various particle-size distributions (mainly clay) and soil texture, CEC, the capacity to fix or release some nutrients (N, P, K) and other major elements (Fe, Al) and soil salinity. Several studies address soil thickness. Some studies focused on qualitative attributes, among which soil groups (peats, acid sulfate soil), classes of water table depth and the occurrence of a diagnostic horizon (fragipan). One study explicitly deals with soil erosion and another one is focused on assessing seven soil ecosystem services.

3. Sampling and support issues

Three studies address sampling issues, either with the aim of optimizing the cost of sampling under constraints or aiming at comparing various sampling designs and densities among different countries and at continental level. The spatial resolution of DSM products ranges from 5 to 500 m, with most studies having spatial resolutions ranging between 30 and 100 m. Both EU and Africa scale reviews are focused on the state-of-the-art of data collection and raise similar issues about harmonization

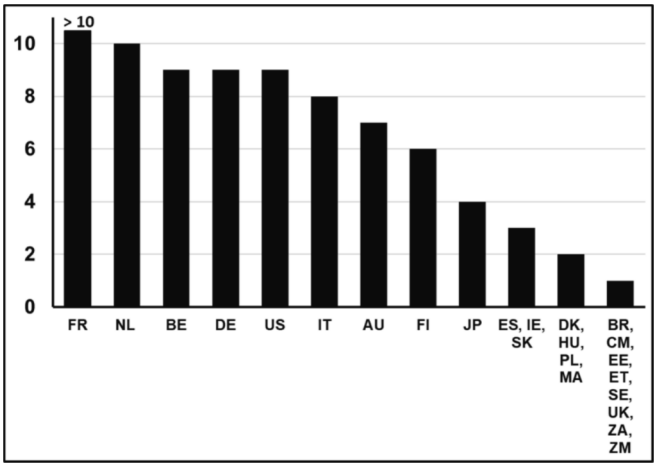

Fig. 1. Country of origin of the authors involved the Geoderma Special Issue "*Digital Soil Mapping for a Sustainable Future", 2024.* AU: Australia; BE: Belgium; BR: Brazil; CM: Cameroon; DE: Germany; DK: Denmark; EE: Estonia; ES: Spain; ET: Ethiopia; FI: Finland; FR: France; HU: Hungary IE: Ireland; IT: Italy; JP: Japan; MA: Morocco; NL: The Netherlands; PL: Poland; SE: Sweden; SK: Slovakia; UK: United Kingdom; US: United States of America; ZA: South Africa; ZM: Zambia.

☆ This article is part of a special issue entitled: Digital Soil Mapping for Sustainable Future published in Geoderma.

https://doi.org/10.1016/j.geoderma.2024.117122

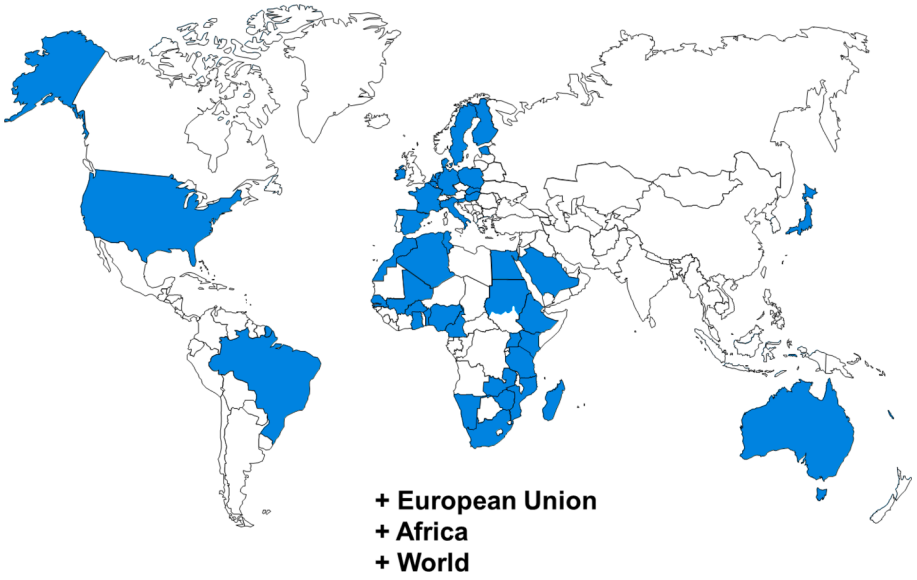

Fig. 2. Countries where the studies of the Geoderma Special Issue "*Digital Soil Mapping for a Sustainable Future*", are located.

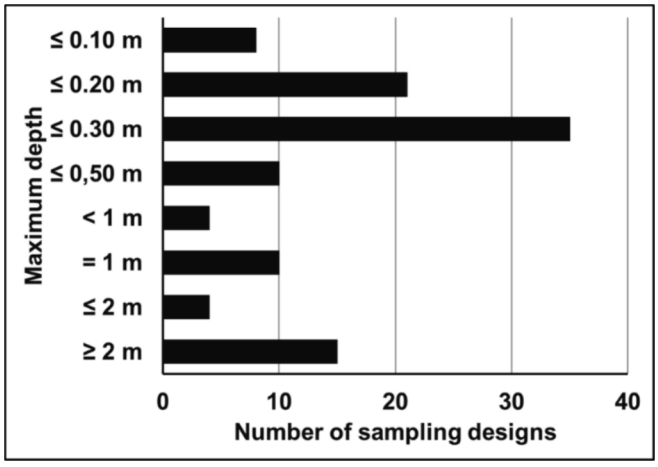

Fig. 3. Maximum depth to which soil properties or functions were assessed.

at a continental level.

The depth to which soil properties and functions are assessed varies greatly among studies (Fig. 3). Two main strategies are observed, i.e. focusing on topsoil where larger changes and human impact are expected or considering deeper layers or the whole soil thickness. Indeed, several studies indicate that the assessment is conducted for the whole soil profile (not included in Fig. 3). This tendency to increase soil thickness is consistent with the objectives of global soil DSM approaches such as SoilGrids (Hengl et al., 2017; Poggio et al., 2021) and GlobalSoilMap (Arrouays et al., 2014). Besides, it is most relevant if the aim is to map and assess a wider range of soil properties and functions, the dimensions of soil security (Arrouays et al., 2021) and soil ecosystem services (Adhikari and Hartemink, 2016).

4. Modelling

Most studies employ machine learning models that relate soil observations with covariates. Two studies (Baert et al., 2024; Owens et al., 2024) used process-based models to simulate water flow and erosion. They demonstrate that soil processes are useful to characterise the spatial patterns of soil.

5. Conclusion

This SI brings together scientists in the field of DSM and end-users of their products to address challenges and implementations for a sustainable future and soil health management. It also demonstrates the ongoing transition from mapping soil properties to soil functions and ecosystem services.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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