Comment on https://doi.org/10.5194/essd-2025-336 “OpenLandMap-soildb: global soil information at 30 m spatial resolution for 2000–2022+ based on spatiotemporal Machine Learning and harmonized legacy soil samples and observations”. Validation of soil organic carbon and bulk density predictions at the national scale of Mexico.

Carlos Arroyo, Viviana Varon, and Mario Guevara

Geosciences Institute, National Autonomous University of Mexico, Campus Juriquilla, Queretaro, Mexico.

The authors present an interesting spatial and temporal digital soil mapping effort to predict soil key variables at the global scale. Among other variables, soil organic carbon and bulk density are critical to understand soil responses to environmental change and land use. The authors increase the global availability of these variables with unprecedented spatial resolution for its use by multiple users across a large diversity of applications. There is a high scientific merit behind this effort and we hope to see the final version published soon.

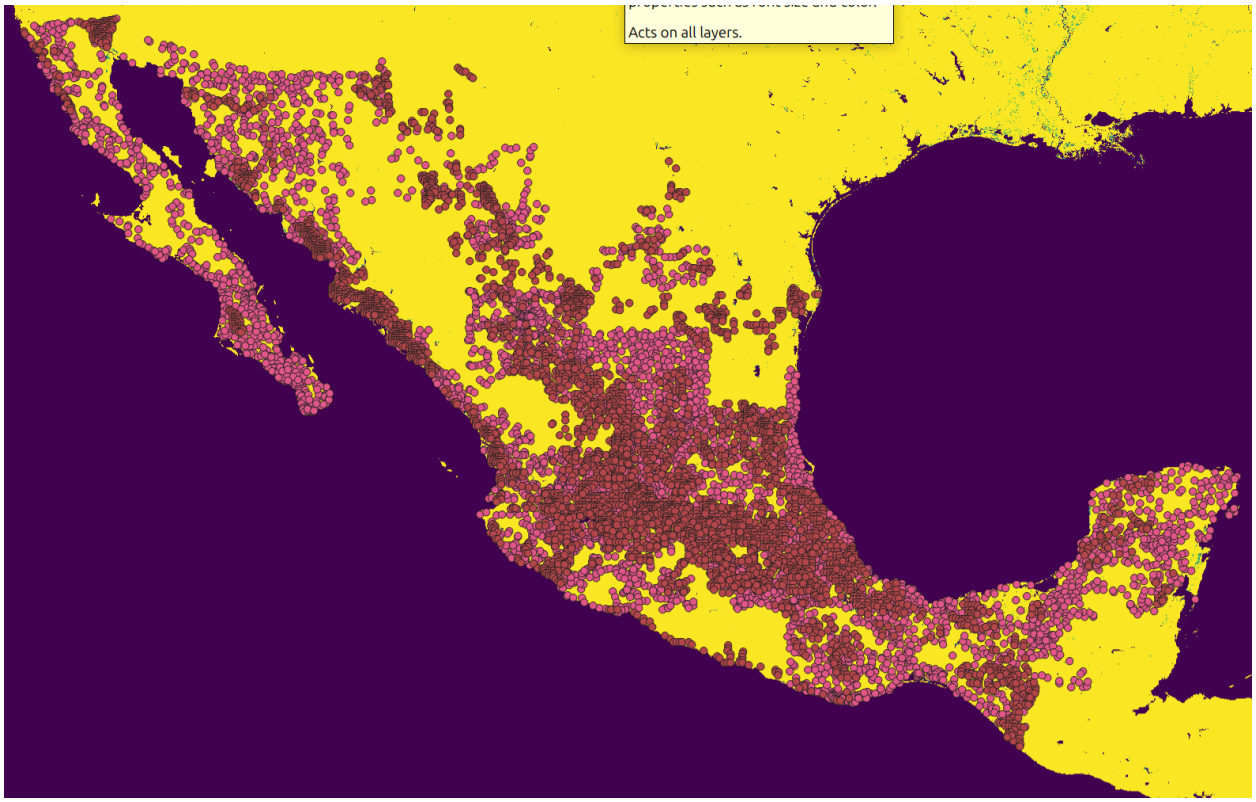
However, important implications exist in the misuse of model derived products, because they are not error free and they include intrinsic and multisource uncertainty. In a revised version, the narrative could better prevent the misuse of soil model derived products across high uncertainty dominated areas. While the authors report relatively high accuracy in model predictions from cross validation, we hypothesize that such accuracy will drop-down significantly when compared with fully independent datasets, e.g., leave one dataset out cross validation, because each dataset is collected for a different purpose. Our overarching goal is to increase interoperability of digital soil mapping efforts from the plot, to the global scale. Therefore the objectives of this comment are a) to highlight the existence of fully independent national databases in Mexico that can be used to improve model accuracy of global soil predictions, or to calibrate country specific estimates, and b), to compare country-specific values of soil organic carbon and bulk density from fully independent datasets, with values derived from the new global soil variability models across 30m grids.

RE: We thank our Mexican colleagues for submitting this short evaluation and for critically evaluating the global data we have produced. Indeed, it is difficult to validate global models and predictions given the costs / technical challenges of organizing eventual new global soil sampling campaigns, hence we only try to emulate how true stress-tests look by spatial blocking of existing training points. Using national data sets produced by probability sampling can fill that gap.

We use two fully independent datasets to validate global soil predictions at the national scale in Mexico. The first dataset was collected and analyzed by our National Institute of Geostatistics and Geography-INEGI in the year 2008 to assess soil erosion at the national scale, considering multiple land covers (INEGI, 2014). The second database was collected and analyzed by the former Ministry of Agriculture (now SADER) with support from FAO in 2012, considering only agricultural land (Arroyo et al, 2025). While the dataset from INEGI is representative of the topsoil, from the mineral surface to a maximum of 30 to 40 cm of soil depth, the agriculture soil

dataset is representative of the first 30cm of soil depth. The INEGI dataset is available here: https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=702825004223 and the SADER dataset is described and available here: https://bsssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70116. Note that INEGI metadata is available in Spanish only (please let us know of any required assistance). We first download the soil datasets and model predictions from OpenLandMap-soildb, and then we compute the R2 between soil carbon and bulk density values from global predictions and the datasets. Because the agriculture dataset reports organic matter values rather than organic carbon, we use the conventional 0.58 factor as explained by (Van Bemmelen, 1897).

RE: If our colleagues could possibly share their code (steps) we could try to reproduce their results to try to detect possible issues from our and their sides. We have downloaded the 5,292 point data set from INEGI "Conjunto de Datos de Erosión del Suelo" and the SADER data set (4029 points). Because INEGI data set has a date of observation (temporal reference) and enough metadata we can translate to English and import and add to the next round of predictions. We will try to add both data sets to https://soildb.openlandmap.org/025-import_chemical_data.html and then also use them to update predictions. We will keep the colleagues in loop so that they can also double check that our use of their data is correct. This is very valuable feedback and exactly the type of critical feedback we were looking for.



We observe, as expected, relatively low correlation compared to that reported in the paper, when comparing predictions against fully independent datasets (Fig. 1). Comparing global models with fully independent datasets is appealing to identify the main drivers of soil research

across countries and identify the capacity of a global model to reproduce nationwide information.

RE: We value your effort and we understand possible disappointment with OpenLandMap-soildb. Before we can understand why the match between your ground in-situ data is limited, what would help us if you could share your spatial overlay and derivation steps; see for example: https://github.com/openlandmap/soildb/blob/main/OpenLandMap_soildb_tutorial.ipynb.

Comparing all land uses, the correlation between the Openlandmap derived soil carbon values and the INEGI 2008 dataset increases significantly from R2 0.06 to R2 0.34 when transforming their values to a natural log scale. The Openlandmap soil carbon predictions and the soil carbon values in the dataset described in Arroyo et al, (2025) from 2012 across agricultural land only shows an R2 value of 0.23 that, interestingly, was not sensitive to the logarithmic transformation. Bulk density in the Mexican datasets is also different from that reported in the Openlandmap products (Fig. 1).

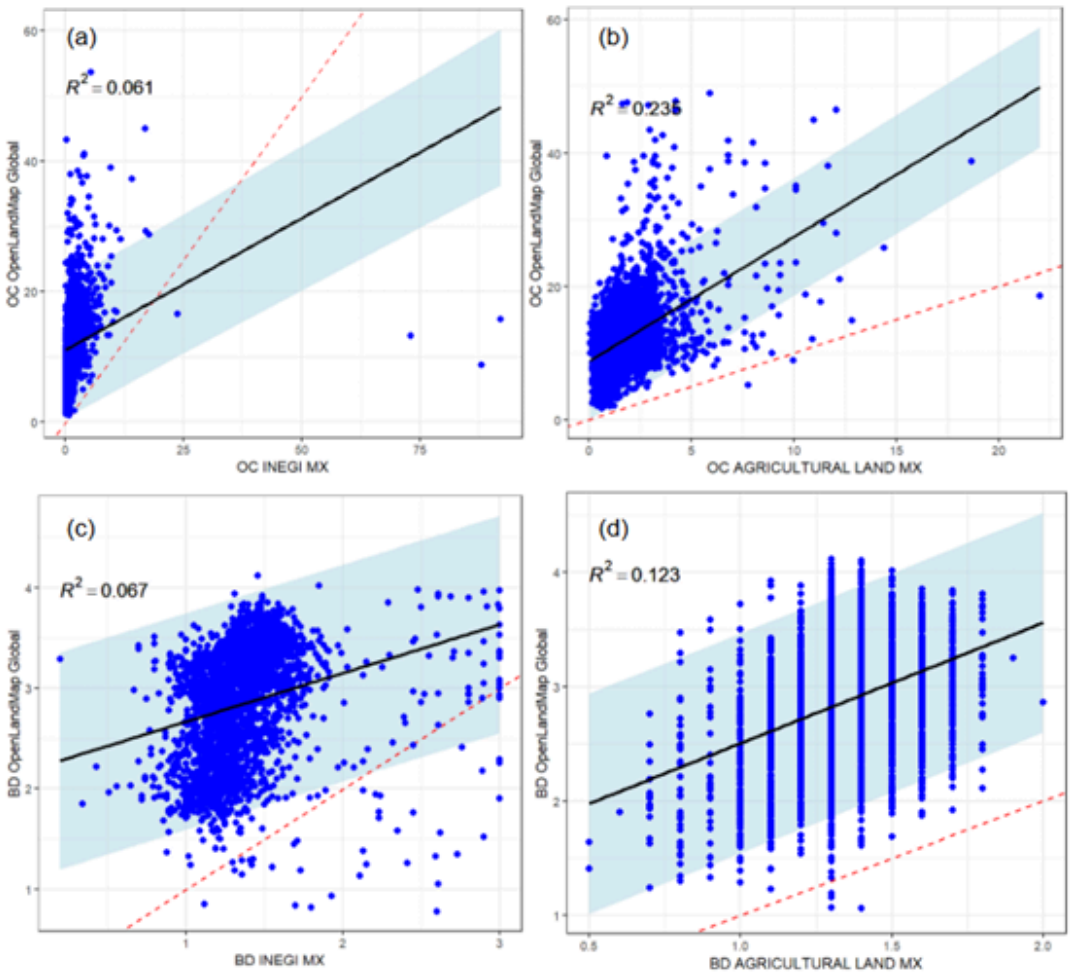


Figure 1

Fig 1 Scatterplots of soil organic carbon and bulk density values from the Openlandmap project compared with independent soil datasets across Mexico. Soil organic carbon carbon across all land uses considering a national dataset representing the year 2008 show a lowest correlation against the Openlandmap product (a). Considering a national dataset collected in 2012, only agricultural land, the correlation is slightly higher (b). Bulk density across all land uses (c) and across agricultural land (d) show even lower correlation values.

RE: We see that our colleagues have used, in the example above, the BD which as the log-transformed value (i.e. maps we registered in the S3 in the first version of submission were in error; as documented also in https://github.com/openlandmap/soildb/issues/1) which means that this variable of course does not match the laboratory data from Mexico. In the meantime, we have resolved this issue, so our colleagues can double check the numbers one more time; for OC (g/kg) it seems that your values were not translated to permilles (you used dg/kg or % and we use g/kg). This is a minor technical item but can lead to values being completely off. In any case, it is excellent that you are testing our data and discovering issues. Our objective remains to produce the most usable (at lowest possible costs) and such exercises help us resolve issues, improve data and produce better maps for the research community.

It is clear that, based on R2 metrics and an independent dataset, the validation at the national scale is different from that reported in Openlandmap products. Due to this kind of global soil map being commonly used in governmental institutions for decision making, overall in countries with a lack of soil information. Therefore we propose that it would be interesting to report a country-based validation; for example, leaving- one-country-out validation. Maps of R2 variation across the world help users (i.e., public institutions, universities) to understand the specific limitations of global products in their countries.

RE: We completely agree and we are documenting in the most transparent way any limitation we discover. Our Disclaimer (https://github.com/openlandmap/soildb?tab=readme-ov-file#disclaimer) is hopefully also unequivocally clearly indicating that the initial maps we made are for testing purposes only and we complete the review process (methodology) we might eventually recommend using the maps for operational work.

The authors present an unprecedented opportunity to increase soil data quantity, quality and accessibility by combining local to national datasets into global soil variability models. The synergy between regional to global soil variability models brings positive implications towards more robust soil estimates (Zhang et al., 2025). We hope that the authors find the highlighted datasets useful for their global soil mapping efforts towards an increased interoperability among national to global soil mapping groups. We believe that highlighting all possible sources of uncertainty and clarifying the scope of the new information would help to promote the responsible use of global soil variability models. In conclusion, our comment enriches the ongoing discussion around global soil mapping by grounding it in real-world national data and offering constructive pathways for improvement. It's the kind of feedback that can elevate both the scientific robustness and practical relevance of large-scale environmental models.

RE: Yes your comments and especially you sending us links and information about additional 10,000 legacy points is fantastic / much appreciated. We will attribute your contributions and add respective citations. We will also work on removing any such issues you discovered.

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