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Predicting global soil organic carbon dynamics in tidal marshes

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Tidal marshes are known for their capacity to store large amounts of carbon in their water-logged soils; however, this coastal ecosystem is threatened by land conversion, climate change, and habitat degradation. Therefore to support conservation efforts, it is important to accurately quantify and map the benefits of this ecosystem such as their current soil organic carbon (SOC) stocks. Based on the newly developed tidal marsh extent map by Worthington et al. (2023), we produced the first global spatially-explicit map of SOC storage in tidal marshes at 30 m resolution, as well as presenting the uncertainty and limitations around the predictions

To produce our predictions, we used training data from the recently published global tidal marsh soil organic carbon (MarSOC) dataset, supplemented by data from the Coastal Carbon Research Coordination Network database. We modelled SOC in relation to potential landscape-level environmental drivers, including vegetation indices, elevation, tidal amplitude, and climatic variables. Finally, we trained a random forest model using the dataset and the environmental covariates, taking into account the spatial nature of the data in the cross validation. We applied a new area of applicability method from Meyer & Pebesma (2021) to avoid predicting SOC values into unknown space, and estimated pixel-level uncertainty using the predicted model error.

Globally the model predicts on average 83.09 Mg SOC ha^{-1} (average predicted error 44.77 Mg ha^{-1}) is held in the 0-30 cm layer and 185.27 Mg ha^{-1} (average predicted error 105.71 Mg ha^{-1}) in the 30-100 cm layer. However due to the current sparsity of data in places, the area of applicability of the model for the 0-30 cm layer represents 58.0% of mapped marshes and this drops to 46.2% for the 30-100 cm layer. Considering the total tidal marsh extent, we estimate tidal marshes to hold 1.44 Petagrams of SOC to 1 m globally. Regionally, higher predicted stocks per unit area are found in the Arctic; however, this is confounded by high uncertainty. The Temperate Northern Atlantic is estimated to hold the highest amount of carbon due to the large tidal marsh extent in this region.

Due to the lack of training soil carbon data we were unable to provide accurate predictions in several areas, therefore our approach also highlights the need for further sampling efforts in specific geographies. It also highlights the needs for the development of additional global covariate layers, to improve our estimates on SOC stocks in tidal marshes. Notwithstanding, our

model and map will be valuable to support conservation efforts, aiding the implementation of blue carbon actions in Nationally Determined Contributions.

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