Exploring the Relation Between Soil Salinity on Soil Organic Carbon Dynamics in Global Terrestrial Ecosystems

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Context

- Soil Organic Carbon (SOC) is integral to terrestrial ecosystems, influencing climate regulation, nutrient cycling, and soil health
- Soil salinity, measured by soluble salts concentration, can occur naturally or due to anthropogenic activities, adversely affecting soil fertility and ecosystem productivity
- Understanding the relationship between soil salinity and SOC is crucial for carbon sequestration and climate change mitigation, though it varies widely across geographical scales.
- High salinity levels can slow OM decomposition, leading to SOC accumulation, while salinity-induced plant stress and soil degradation can reduce SOC content, highlighting the complex interplay between these factors
- It is known that soil salinity impacts SOC content, yet the specific direction and magnitude of SOC variability of in relation to soil salinity remain poorly understood[1,2]

Methods

- Soil profile data, including SOC (< 150 g kg^{-1}) and soil salinity measurements since 1992, were gathered from soil databases alongside a stack of relevant environmental and soil physio-chemical properties
- Significant parameters from the dataset were selected as inputs for developing General Additive Models (GAMs)
- We first ranked covariates based on their minimum redundancy and maximum relevance to SOC using Minimum Redundancy Maximum Relevance (MRMR) algorithm
- GAMs enabled the identification of specific correlations between soil salinity and SOC content while considering the role of other environmental and physio-chemical factors
- We analyzed a dataset comprising 43,459 soil samples
- We separated the analysis into croplands (n = 25,634) and non-croplands (n = 17,825)

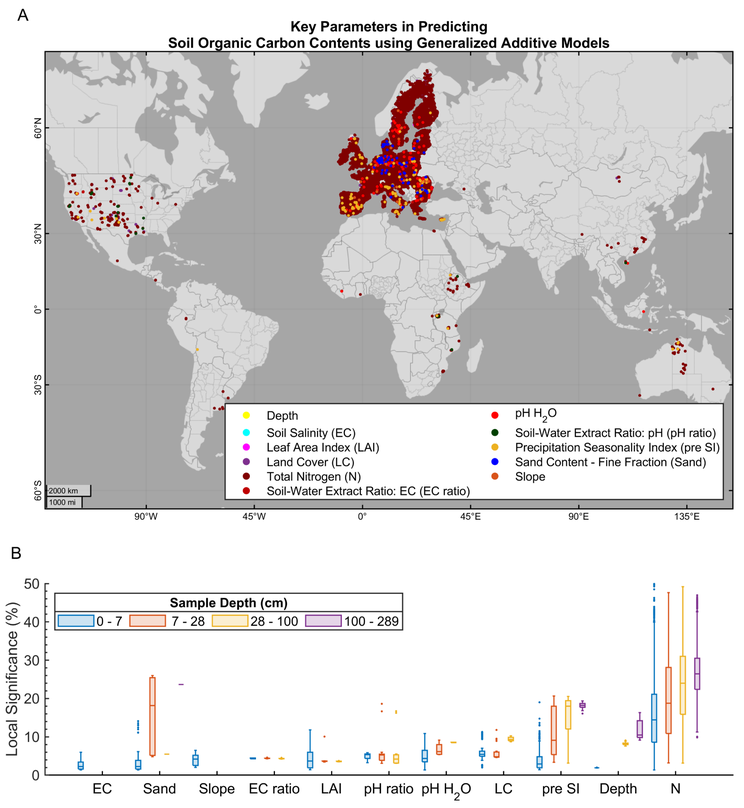


Figure 1. *Covariates with the highest local significance in predicting Soil Organic Carbon (SOC) content using the General Additive Models.*

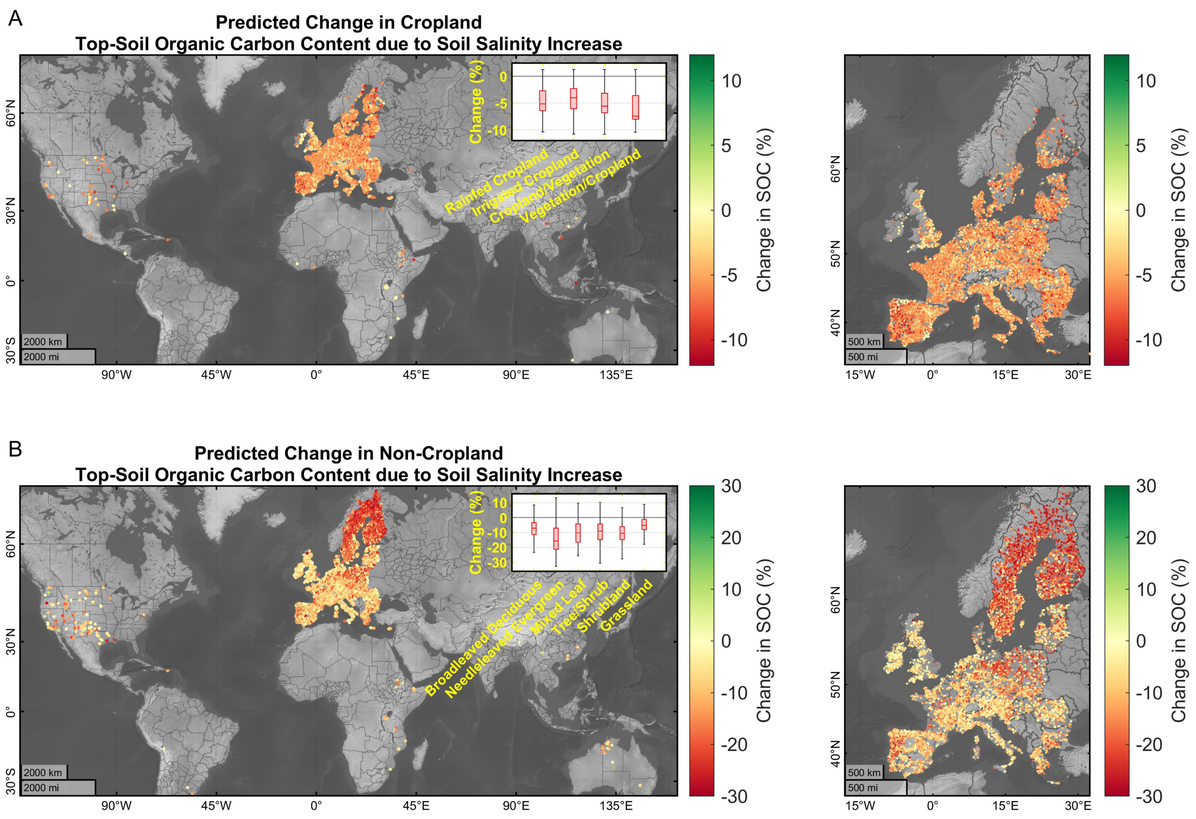


Figure 2. *Impact of one standard deviation increase in soil salinity on topsoil (0 - 7 cm) Soil Organic Carbon (SOC) content at the location of soil profiles/samples.*

Relation Between Soil Salinity and SOC

- For croplands, ALEs are quantified by the equation ALE = 0.34 + -0.21EC + 0.01EC2 while for non-croplands, ALE = -7.42 + 11.43exp(-0.31EC)
- ALE represents the deviation of SOC from the mean predicted SOC, 18.47 and 35.96 g kg^{-1} for croplands and non-croplands, respectively, and EC is the soil salinity measured in dS m^{-1}
- This implies that higher soil salinity is associated with reduced SOC content

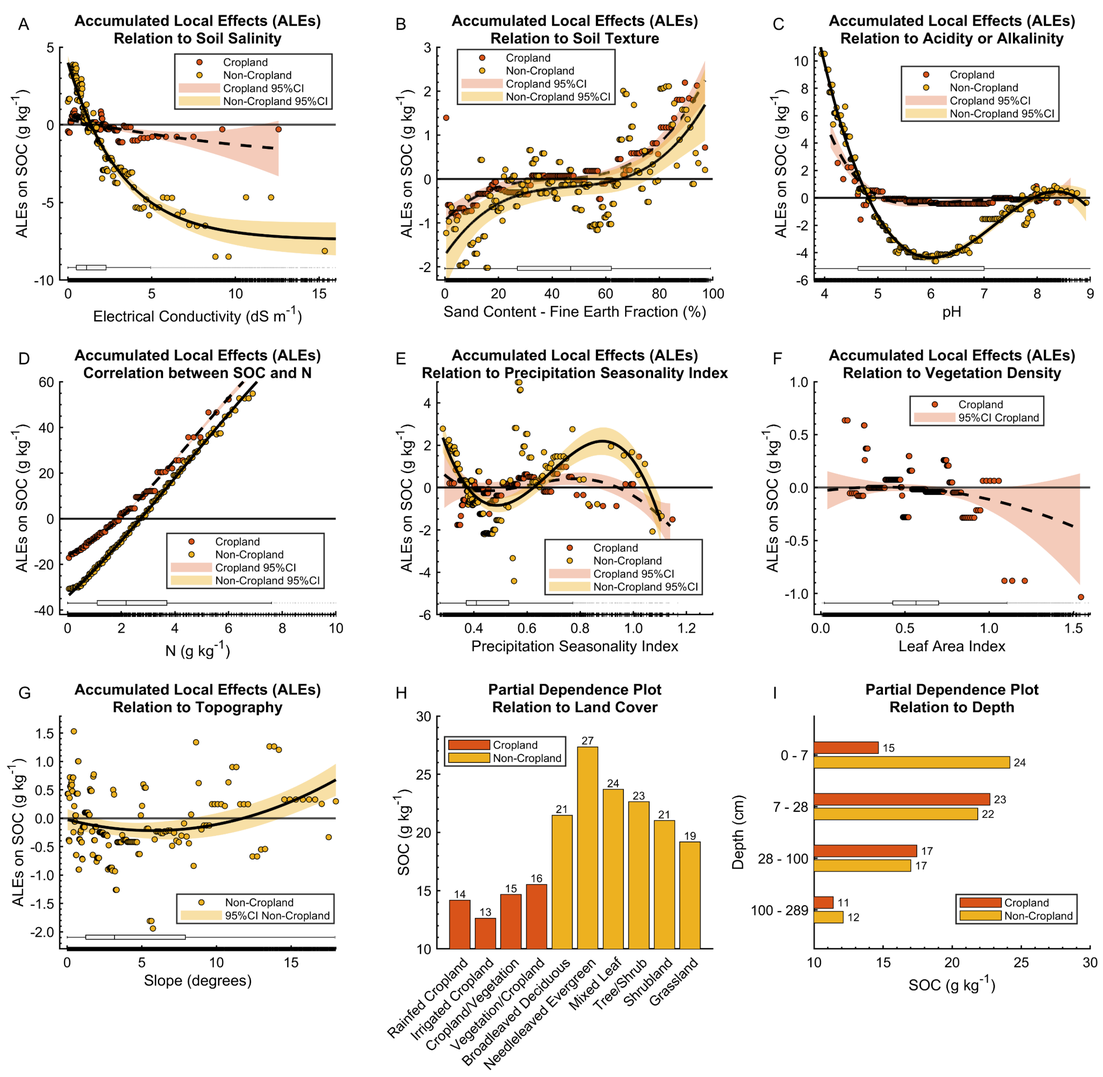
Topsoil SOC Response to Increased Salinity

- For croplands, the one standard deviation increase in soil salinity corresponds to an approximately 263.2% increase in the median salinity (relative to original median = 4.32 dS m^{-1})
- For non-croplands, it represents a nearly 245.24% increase in the median (original median = 3.83 dS m^{-1})
- Results also indicated the variability in the relationship between soil salinity and SOC at different land covers

Significance of Soil Salinity

- The local significance of soil salinity in prediction of SOC contents ranged from 0% to ~6% across different soil-water extracts
- On average, the salinity's mean significance in prediction of SOC content was ~1.13% (std = ~0.94%)
- N, land cover, and precipitation Seasonality Index, and pH among main factors highly correlated with SOC content
- For a total of 30,216 observations, soil N emerged as the most significant covariate, with a mean importance of ~15.35% (std = ~8.51%)

Figure 3. *Accumulated Local Effects (ALEs) of covariates on predicted Soil Organic Carbon (SOC) content using the fitted General Additive Models. The Y-axis represents the deviation of General Additive Models' predictions from the mean predicted SOC (18.47 and 35.96 g kg^{-1} for croplands and non-croplands, respectively) as the covariate varies from its lowest to highest values.*



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References

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2. Z. Haj-Amor *et al.*, Soil salinity and its associated effects on soil microorganisms, greenhouse gas emissions, crop yield, biodiversity and desertification: A review. *Science of the Total Environment* **843**, 156946 (2022).

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