Spatial Variability of Soil Nitrogen, GPP and Biomass Relationships in the Conterminous United States

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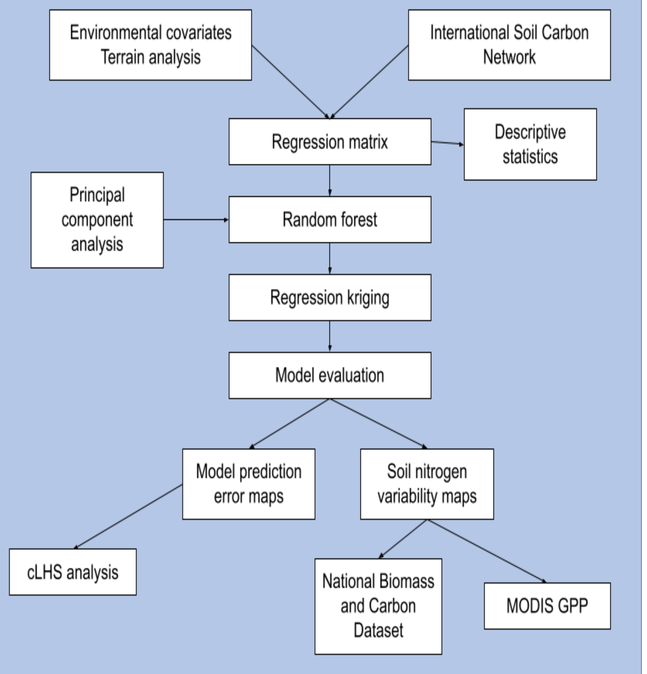
Introduction

Nitrogen (N) is a primary macronutrient needed for plant growth. Thus, it requires proper management and understanding to prevent mismanagement that could lead to environmental and economic issues.

In recent years, anthropogenic activities such as the burning of fossil fuels have altered the nitrogen cycle more than any other basic chemical cycle and humans continue to add more reactive nitrogen to the system (Fields 2004). As the human population continues to grow and utilize more resources it is important to understand the spatial variability of nitrogen in the soil for agricultural and environmental management.

Thus, this research seeks to provide a quantitative understanding of the spatial distribution of soil nitrogen concentration across the conterminous US, as well as its variation across depths, and relationship to gross primary productivity (GPP) and biomass using a digital soil mapping framework.

Methods



Results

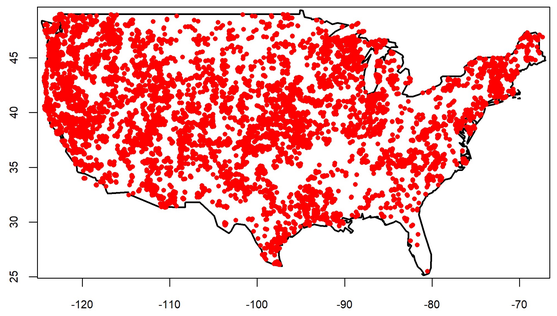


Figure 1. International Soil Carbon Network sample points

Depth (cm)	RMSE	Nugget Sill Ratio	Explained Variance (%)
0 – 5	0.1326	< 0.25	38.90
5 – 15	0.138	< 0.25	40.50
15 – 30	0.1348	< 0.25	41.30
30 – 60	0.1323	< 0.25	40.50
60 –100	0.1358	< 0.25	42.20
100-200	0.1327	< 0.25	40.10

Table 1. Results of 10-fold cross validation of model

Depth (cm)	Soil Nitrogen (%)		Prediction Error	
	Mean	Standard Deviation	Mean	Standard Deviation
0-5	0.133	0.082	0.032	0.008
5-15	0.130	0.081	0.029	0.008
15-30	0.125	0.077	0.027	0.008
30-60	0.155	0.072	0.026	0.008
60-100	0.105	0.069	0.031	0.008
100-200	0.096	0.067	0.051	0.014

Table 2. Descriptive statistics of soil N and prediction error across CONUS

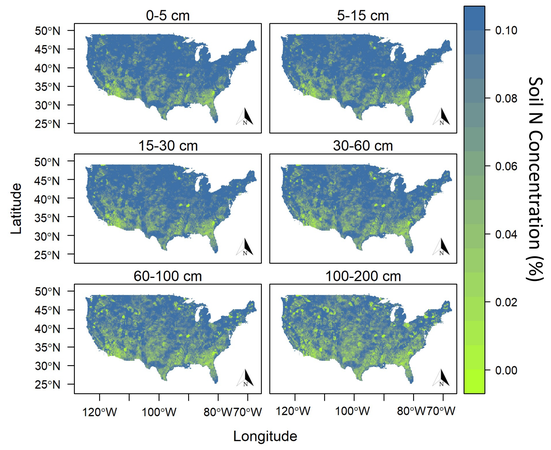


Figure 4. Spatial variability of soil nitrogen in CONUS (percent by weight of nitrogen (organic and inorganic) in an oven-dried sample)

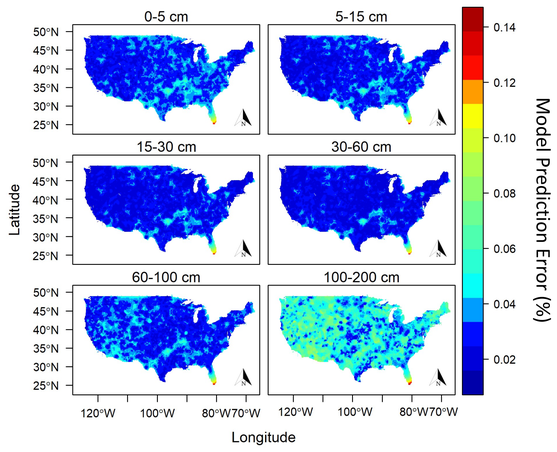


Figure 5. Model prediction error produced by kriging the model residuals

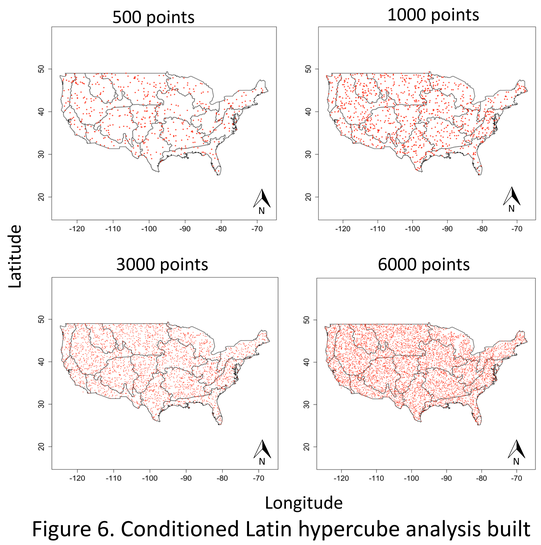


Figure 6. Conditioned Latin hypercube analysis built on uncertainty estimates

Soil Depth	Biomass (kg m^{-2})	GPP (g C year-1)
0-5 cm	0.53*	0.09
5-15 cm	0.52*	0.1
15-30 cm	0.50*	0.12
30-60 cm	0.45*	0.15
60-100 cm	0.40*	0.2
100-200 cm	n.s.	n.s.

Table 3. Linear regression analysis and r^2 values for soil N and biomass, and GPP at all depths across CONUS. *Denotes significant p value at $p \leq 0.05$; n.s. means not significant.

Conclusion

- The spatial distribution of soil N became more variable with depth and differs across NEON domains
- Soil N tends to decrease with depth, but model prediction uncertainty increases with depth.
- Climatic and biological soil forming factors are more relevant closer to the surface (0-60 cm).
- Topographic and hydrological related sources of information are more relevant at deeper depths (60-100 cm).
- The expected relationship between soil N, biomass, and GPP could be influenced by soil depth.
  - Our results support the expected relationship between soil N and biomass.
  - We did not find a significant relationship between soil N and GPP across CONUS.
- The probability distributions of the optimized locations are independent of the sample size of the hypothetical survey.

Acknowledgements

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