PO052

The Central African Soil Spectral Library: A new soil infrared repository and a geographical prediction analysis

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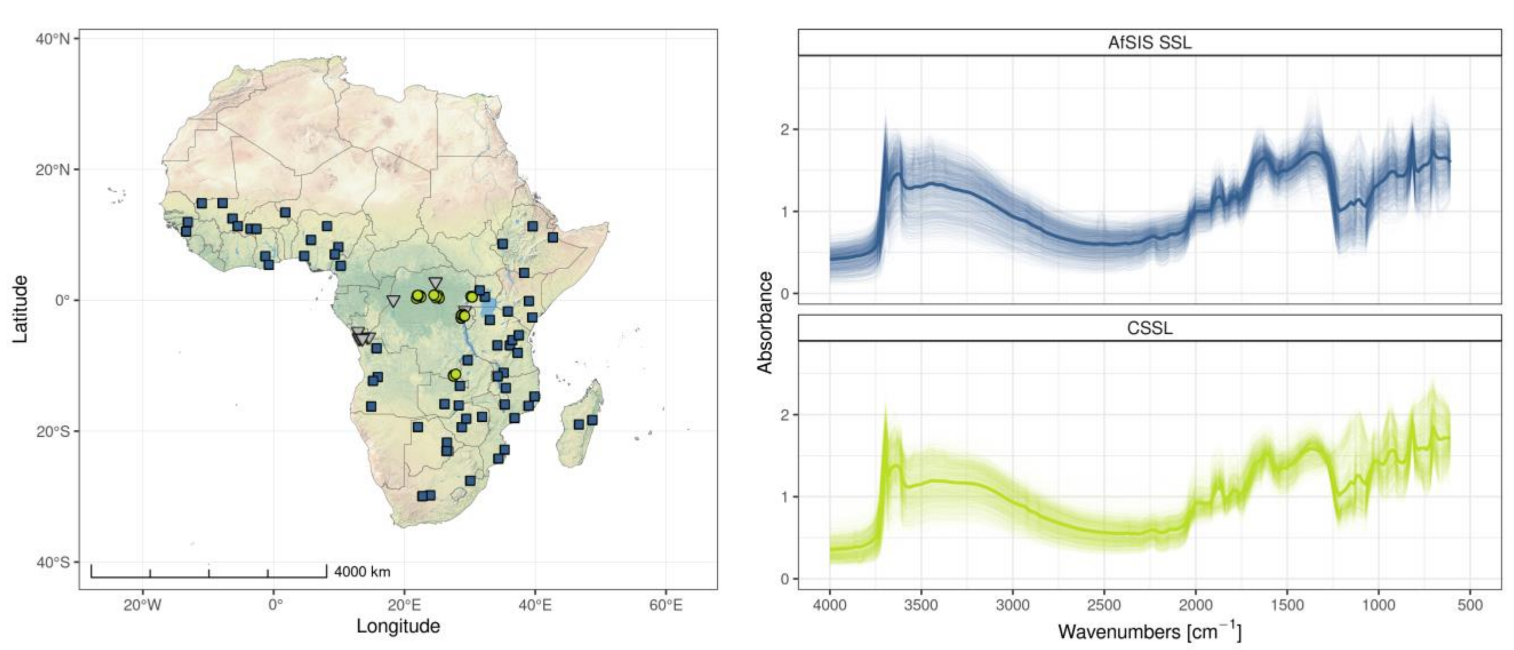
Need for soil data in the African humid tropics

- Soil health is required to maintain soil ecosystem services such as plant nutrition, agricultural production, food security, erosion prevention, and climate change mitigation
- The humid tropics of Africa are a frontline of global change due to deforestation and agricultural land-use conversion which are expected to increase with population growth in the coming decades.
- Soil data for this area is scarce.
- Spatially explicit soil data is urgently needed to maintain soil services to allow sustainable agricultural production, improve climate mitigation possibilities and reduce deforestation.



Locations and resampled spectra of our central African SSL and the continental AfSIS SSL

Soil infrared spectroscopy

- Soil mid-infrared and near-infrared spectroscopy have gained attention as cost effective and rapid methods for soil analyses.
- Due to distinct absorption features of functional groups of organic matter and minerals in the infrared region of the electromagnetic spectrum, the quantity of carbon, nitrogen, and crop nutrients can be derived by modelling the relationships.
- Large-scale soil spectral libraries (SSLs) have been created to cover large areas with the aim to further minimize traditional wet chemistry analyses for future soil samples.
- Many SSLs span vast areas covering very heterogeneous soil types and climates. For example, memory-based learning has shown promising results using a similarity based approach for predicting new soil samples with SSLs.
- Spiking SSLs with samples from the target sites have shown to improve prediction accuracy.

Aim

- Propose three strategies that leverage the use of a large SSL to accurately predict total carbon and total nitrogen in regions for which coverage is poor.
- Examine the effect of spiking together with a memory-based learning approach.
- Fill a gap of a continental SSL with a new central African SSL and therefore improve predictions for these soils.

Methods

Data

- Six selected regions of the central African SSL (CSSL, n = 1578) and an existing continental SSL (AfSIS SSL, n = 1902), both with TC and TN data (dry combustion) and mid-infrared spectra (FT-IR spectrometer).
- The six regional sets were split up into a validation and spiking sets (n = 20)

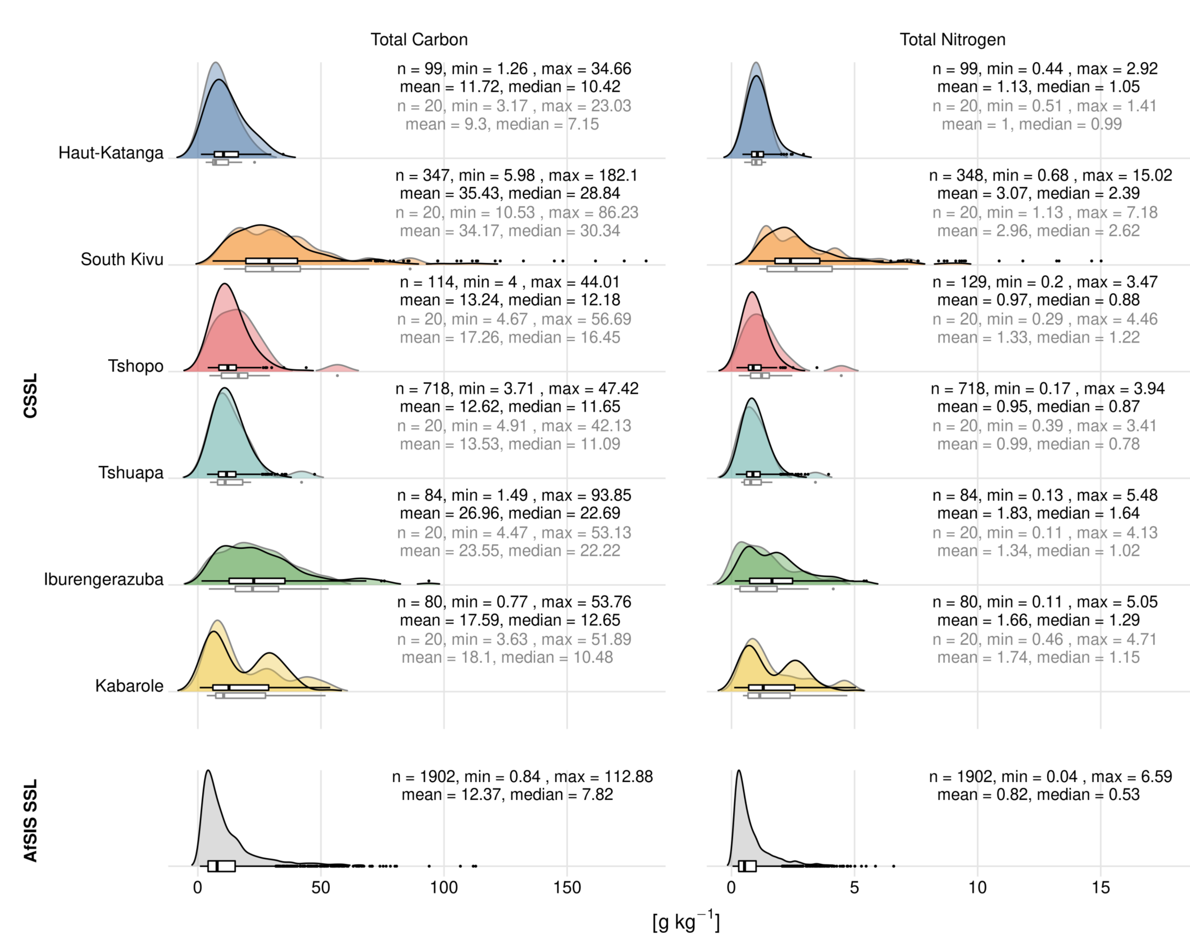
Modeling and predictions

After spectral resampling and pre-processing each central African region was predicted by:

- Strategy 1: the AfSIS SSL
- Strategy 2: the five remaining regional validation sets and the AfSIS SSL
- Strategy 3: the 20 spiking samples, the five remaining regional validation sets, and the AfSIS SSL

After a similarity-based neighbor search using MBL, a weighed Partial Least Squares regression was trained.

TC and TN contents for the two libraries



Total carbon and total nitrogen contents for the soil samples of the central African SSL and the continental AfSIS SSL

Prediction accuracies

Strategy	Region	Total carbon [g kg^{-1}]					Total nitrogen [g kg^{-1}]				
		n_{pred}	$RMSE_{pred}$	R^2_{pred}	ME_{pred}	$RPIQ_{pred}$	n_{pred}	$RMSE_{pred}$	R^2_{pred}	ME_{pred}	$RPIQ_{pred}$
Strategy 1	Haut-Katanga	99	5.99	0.79	4.99	1.62	99	0.81	0.31	0.70	0.59
	South Kivu	347	8.61	0.94	3.50	2.43	348	1.66	0.85	1.32	1.10
	Tshopo	114	7.34	0.47	2.61	0.96	129	0.55	0.52	0.34	0.93
	Tshuapa	718	3.85	0.71	2.06	1.84	718	0.40	0.68	0.29	1.37
	Iburengerazuba	84	8.73	0.84	4.46	2.60	84	0.82	0.81	0.60	2.13
	Kabarole	80	5.73	0.86	1.10	3.95	80	0.65	0.84	0.47	2.86
Strategy 2	Haut-Katanga	99	4.22	0.72	1.84	2.30	99	0.32	0.59	0.02	1.50
	South Kivu	347	8.88	0.95	4.72	2.36	348	1.17	0.89	0.72	1.55
	Tshopo	114	5.38	0.64	0.30	1.31	129	0.34	0.72	0.07	1.49
	Tshuapa	718	4.12	0.78	2.21	1.71	718	0.29	0.77	0.12	1.88
	Iburengerazuba	84	7.96	0.86	2.69	2.84	84	0.54	0.82	0.02	3.21
	Kabarole	80	8.56	0.83	4.29	2.65	80	0.64	0.86	0.40	2.90
Strategy 3	Haut-Katanga	99	3.57	0.80	1.35	2.72	99	0.26	0.71	0.06	1.87
	South Kivu	347	7.32	0.95	1.53	2.86	348	0.89	0.89	0.32	2.05
	Tshopo	114	4.93	0.69	0.11	1.43	129	0.31	0.75	0.03	1.62
	Tshuapa	718	3.19	0.80	0.90	2.22	718	0.24	0.79	0.03	2.25
	Iburengerazuba	84	6.34	0.91	1.14	3.57	84	0.39	0.91	0.03	4.45
	Kabarole	80	4.13	0.94	1.72	5.48	80	0.44	0.91	0.23	4.27

Conclusion

- The predictions with all strategies were encouraging and reasonably accurate.
- There was a trend toward more accurate predictions with less geographical extrapolation (strategy 1 to strategy 3).
- The CSSL fills an appreciable gap of the continental library and contributes to cover an important range of soil variability.
- Our study highlights the wider utility of spectral libraries, since they are not necessarily limited to their geographical domain.
- More soil properties and more soil samples are still needed to improve the predictive performance. Our SSL, also with other soil properties, is openly available on our GitHub repository *ssl-central-Africa (https://doi.org/10.5281/zenodo.4351254).*

Summerauer et al. (2021) *SOIL Discussions.*
https://soil.copernicus.org/preprints/soil-2020-99/

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