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Spatial pedocomplexity in old-growth temperate forest driven by tree-uprooting: its formation and role in forest dynamics

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Introduction

Soil formation →

Topography
Biota
Bedrock
Climate
Time

Interactions between soil properties, water dynamics, plant growth and disturbances

↓

No well quatified yet

↓

Better understanding of these interactions and the resulting patterns

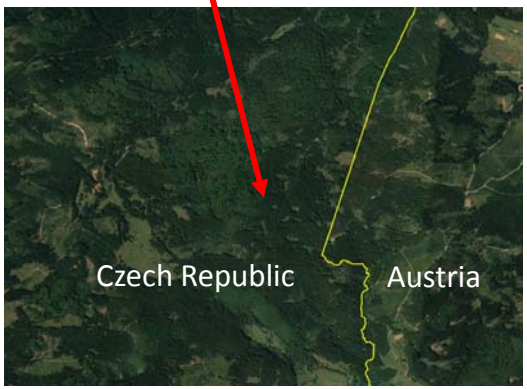
Objectives

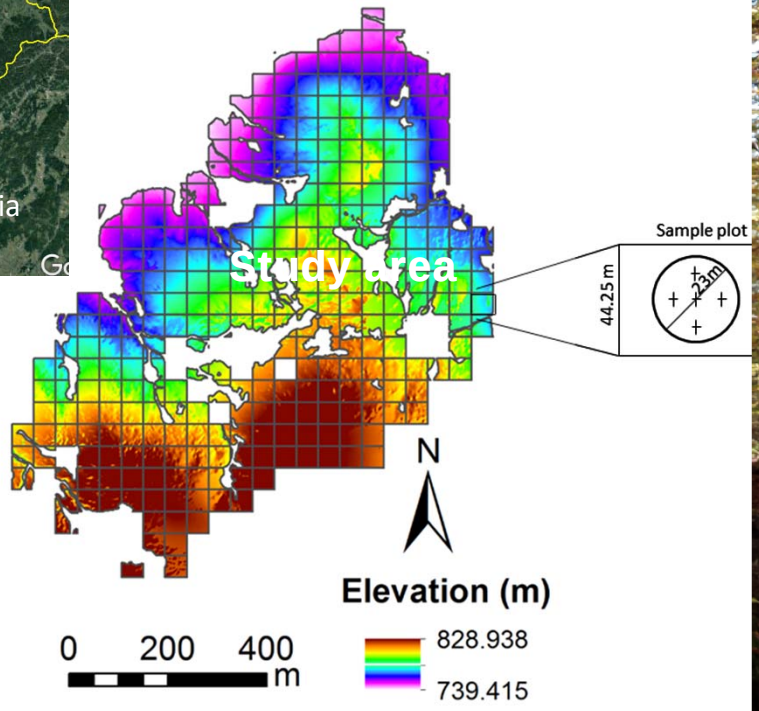
1- To reveal spatial pattern of soil chemical properties

2- To explain differences in spatial pedocomplexity formation in A and B soil horizons

3- Factors controlling the spatial variation of soil chemical properties

Study area





Methods

- Soil chemical properties

1. Linear correlation

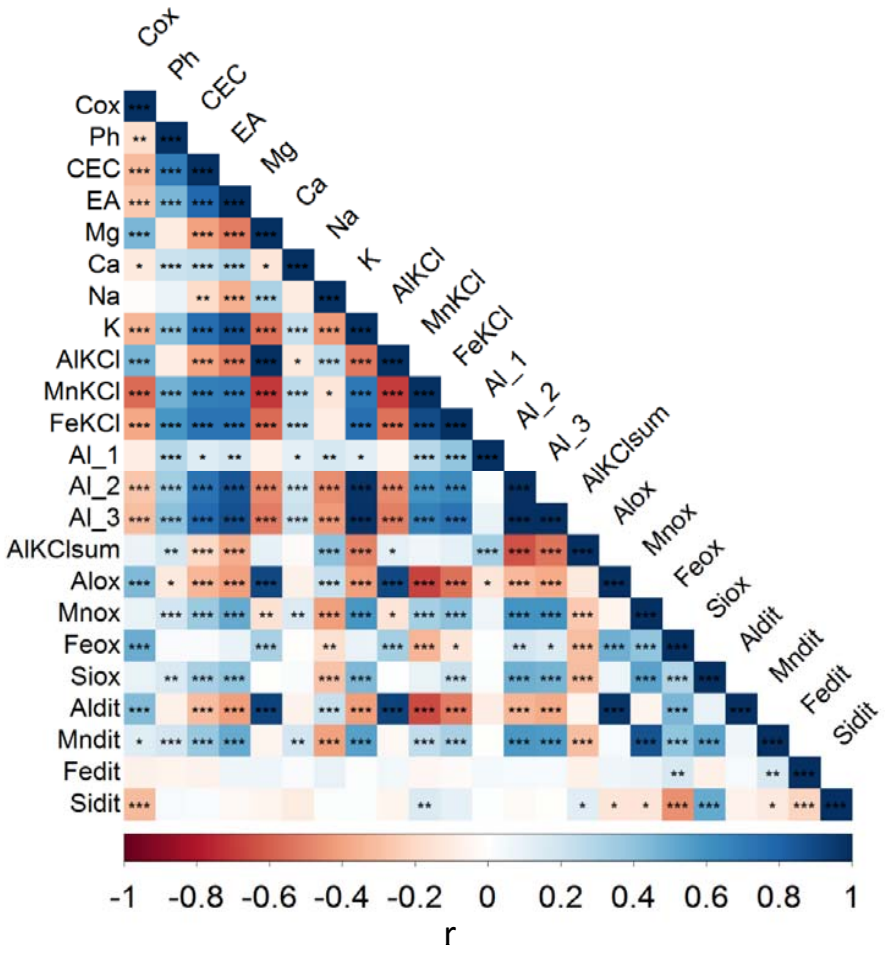
2. Geostatistical analysis
   - *Omnidirectional variograms*
   - *Directional variograms*

3. Spatial correlation
   - *Linear correlation*
   - *Random forest model*

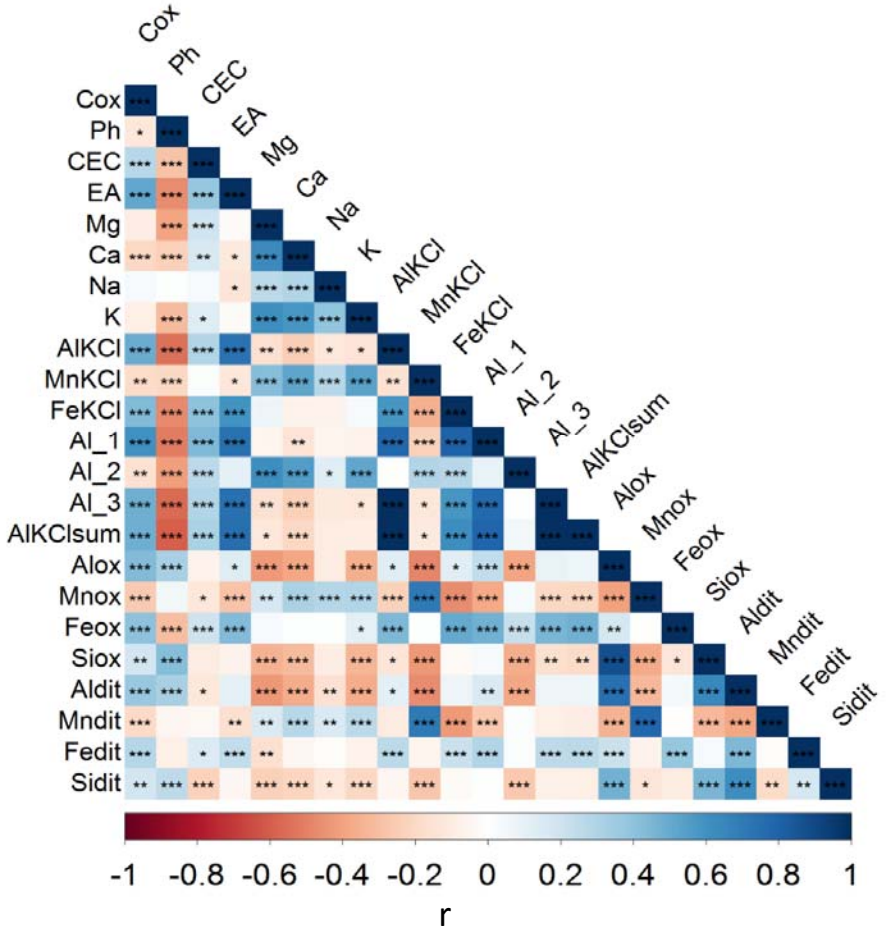
Results

1. Linear correlation

Horizon A



Horizon B



Results

2. Geostatistical analysis

Omnidirectional variograms

-Range hz A> Range hz B

-Disturbance in hz A > hz B→Tree uprooting

-Rejuvenation of hz A faster than hz B

Spatial autocorrelation hzA > hzB

	Horizon A Effective range	Horizon B Effective range
Cox ^{log}	51.633	80.566
Ph ^{log}	59.252	165.304
CEC	40.840	192.552
EA	39.854	63.189
Mg ^{log}	191.334	53.591
Ca ^{sqrt}	132.053	159.064
Na ^{log}	217.554	55.236
K	102.115	62.557
AlKCl	61.713	53.454
MnKCl ^{log}	102.857	95.368
FeKCl	149.192	98.367
Al^{+1}	210.973	128.797
Al^{+2}	47.512	71.268
Al^{+3}	92.302	46.096
AlKClsum	161.707	51.819
Al_ox ^{log}	59.529	92.902
Mn_ox ^{log}	102.253	72.376
Fe_ox	210.911	96.017
Si_ox	72.989	75.436
Aldit	55.637	52.640
Mndit ^{log}	112.760	48.421
Fedit	57.467	78.612
Sidit ^{sqrt}	31.732	73.782

Biogenic properties

Geogenic properties

Results

Paired difference test between horizon A and B

→ Range Hz A and B are different in Group 1 and 2

→ Sill Hz A and B are different in Group 2

→ Sill Hz A and B are not different in Group 1

→ Nugget Hz A and B are not different in Group 1 and 2

Group 1- ***Range in horizon A< Range in horizon B*** *(Cox, Ph, CEC, EA, Al+1, Al+2, Al+3, Siox, Sidit)*

Group 2- ***Range in horizon A> Range in horizon B*** *(Mg, Ca, Na, K, AlKCl, MnKCl, FeKCl, AlKClsum, Alox, Mnox, Feox, Aldit, Mndit, Fedit)*

Directional variograms

→ Only depending on the ***elevation*** the horizon A

Results

3. Spatial correlation

Predictor variables

Abbreviation	Data description	Units	Mean	Median	Stdev	Min	Max
Elevation	*Elevation above mean sea level*	m	780.343528	779.5	20.7152717	743.54	826.08
Aspect	*Local hillslope aspect*		201.832524	272.75	133.636667	0.44	359.95
Curvature	*Local hillslope curvature*	m	-0.49278317	0.08	4.61576435	-32.92	21.34
Slope	*Local slope gradient*	$m\ m^{-1}$	15.2585113	14.98	6.01581037	1.29	30.86
Insolation	*Potential incoming solar radiation*	10^6 W h m^{-2}	1075307.23	1079718.88	52761.9283	929089.75	1217742
TPI	*Topographic position index (Guisan et al., 1999)*	-	-0.0029394	0.000915	0.03404555	-0.165344	0.133178
TWI	*Topographic wetness index (Beven and Kirkby 1979)*	-	4.78097087	4.65	1.82540541	1.3	14.6
TRI	*Topographic Ruggedness Index (Riley et al., 1999)*	-	0.50255663	0.5	0.05154371	0.35	0.7

Linear correlation

→ Factors controlling soil chemical variables:

Horizon A: Elevation, aspect, slope and insolation

Horizon B: Elevation, aspect, slope and insolation

Results

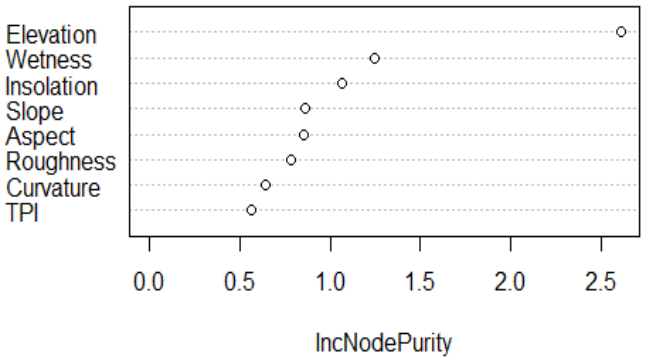
Random forest model

→ Explain 10-23% validation dataset horizon A

→ Explain 0.1-12% validation dataset horizon B

→The relative importance based on the average Gini impurity index

Ca- HzA



→ Factors controlling soil chemical variables:

Horizon A: Elevation, topographic wetness index, aspect and insolation

Horizon B: Aspect, insolation and elevation

→ The Gini impurity index is higher in horizon A than B indicating more importance of factors controlling the soil chemical properties

Conclusions

- The range on horizon A is higher than on horizon B

- The neoformation of horizon A after a pedoturbation as tree uprooting is faster than in horizon B

-The range in both horizons are independent, indicating that the driving factors for disturbance in horizon A and B are different

-The factors controlling the soil chemical variables are elevation, aspect, slope and insolation

-The Random Forest model confirms the factors controlling the soil chemical variables from the simple linear correlation analysis

Future work

1- To integrate the role of vegetation in the soil spatial complexity

2- To develope a soil formation model integrating the biogenic and geogenic pedoturbation and factors controlling soil properties

Questions?

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Thanks !

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