Utilization of VNIR diffuse reflectance spectroscopy to map soil erosion

Czech University of Life Sciences Prague
Department of Soil Science and Soil Protection – Spectroscopy Lab

Lukáš Brodský, Tereza Zádorová, Aleš Klement, Ondřej Jakšik, Luboš Borůvka
brodsky@af.czu.cz

Erosion mapping

Needs:

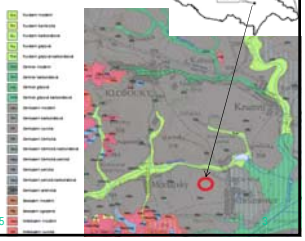
- Rapid spatial delineation of erosion / deposition areas
  [extensive field work is required to make a successful spatial delineation]
- 'Need of cheap and technically simple methods of erosion assessment at the field scale' *(Boardman 2006: 'Soil erosion science: Reflection on the limitation of current approaches')*

Objectives:

- Develop generic framework for soil erosion mapping
- Utilize VNIR spectroscopy (develop & validate model, provide SOC prediction, transfer the model to other field)
- Apply quantitative methods to other erosion areas

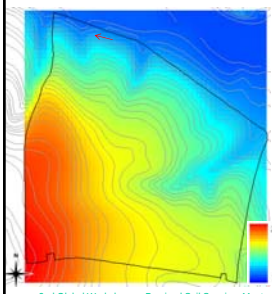
Study area

- Southern Moravia (~100 ha field)
  - *Haplic Chernozem (dominant soil unit)*
  - *steepest slopes Haplic Regosols*
  - *Colluvic Chernozems and Colluvial soils*
    A horizon depth varies from 0.25 m to 3 m in the accumulation positions

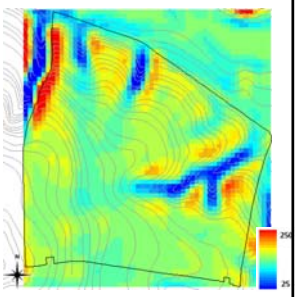


Study area

Elevation (DEM 20 m)

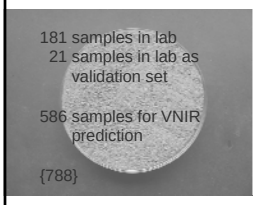


MEANC



Materials

Field sampling



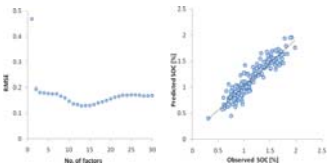
Methods

- VNIR Spectroscopy instrumentation
  FieldSpec-3 (350 – 2500 nm)
- Model
  Partial-Least Square Regression – PLSR (ParLeS)
- DEM analysis (derivatives)
- Geostatistics: Orinary (Universal) Kriging

Results

- VNIR spectroscopy: [A] Brumovice field – model training

PLSR cross-validation

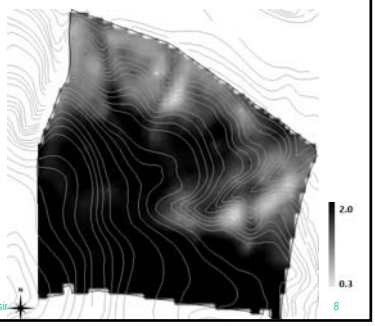


A/ Brumovice field	
Cross-validation	*#181*
R^2	0.88
RMSE	0.13
RPD	2.66
No. factors	14
Independent validation	*#21*
R^2	0.89
RMSE	0.14
ME	0.03

- Soil samples prediction (#586)

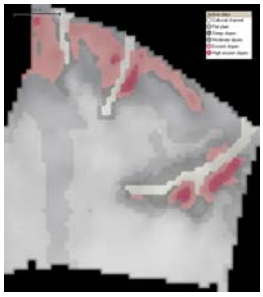
Results

- Soil organic carbon [%] distribution at Brumovice field



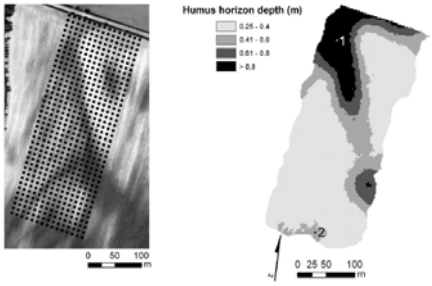
Results

- Classification together with DEM

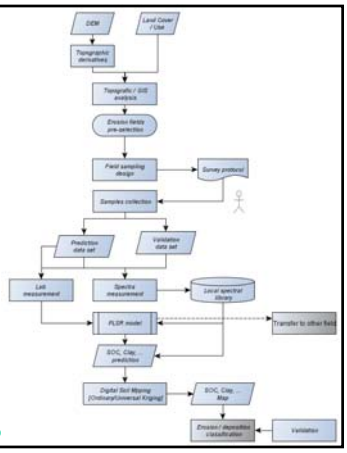


Results

- Validation (Zadorova et al., 2011)

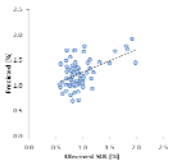


Workflow



Results

- VNIR spectroscopy: [A-B] A model transfered to (B) Chrastany field (~ 7 ha) , B samples - independent validation



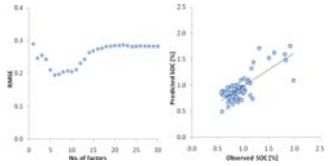
PLSR model (A)	*#181*
R^2	0.88
RMSE	0.13
RPD	2.66
No. factors	14
Independent validation (B)	*#65*
R^2	0.32
RMSE	0.41
ME	0.29

Results

- VNIR spectroscopy: [B] Chrastany field – model training

- loess, loess loam and paleozoic complex of Cesky Brod (schist, claystone, conglomerate, chert)

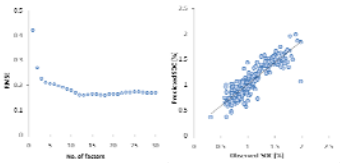
PLSR cross-validation



	B/ Chrastany field
Cross-validation	*#65*
R^2	0.58
RMSE	0.19
RPD	1.55
No. factors	6
Independent validation	*#10*
R^2	0.60
RMSE	0.18
ME	-0.04

Results

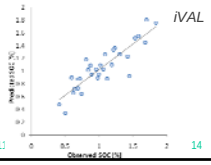
- VNIR spectroscopy: [A-B] merged-> model, validation
  Smp: 181+75; 21+10



PLSR cross-validation

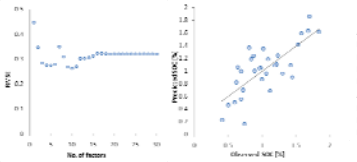
PLSR model (A+B)	*#181 + 75*
R^2	0.78
RMSE	0.16
RPD	2.14
No. factors	18
Independent validation (A+B)	*#21 + 10*
R^2	0.78
RMSE	0.17
ME	0.02

iVAL



Results

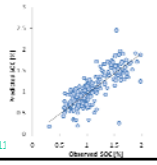
- VNIR spectroscopy: [A-B] A-B model, A-B validation
  Smp: 21+10; 181+75



PLSR cross-validation

PLSR model (A+B)	*#21 + 10*
R^2	0.57
RMSE	0.27
RPD	1.40
No. factors	11
Independent validation (A+B)	*#181 + 75*
R^2	0.67
RMSE	0.24
ME	-0.05

iVAL



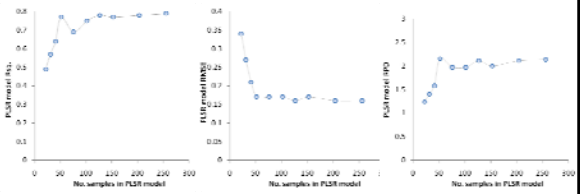
Results

How many samples is needed
for model calibration?

Results

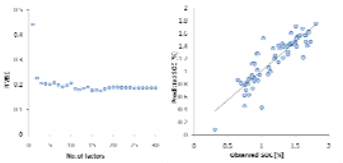
VNIR spectroscopy:

- [A-B] model with changing number of observed samples



Results

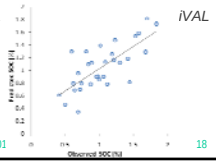
- VNIR spectroscopy: [A-B] A-B model, A-B validation
  Smp: 50+10; 21+10



PLSR cross-validation

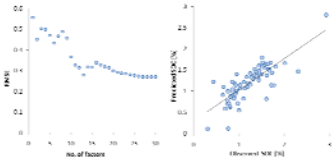
PLSR model (A+B)	*#50 + 10*
R^2	0.77
RMSE	0.17
RPD	1.97
No. factors	17
Independent validation (A+B)	*#21 + 10*
R^2	0.54
RMSE	0.26
ME	0.01

iVAL



Results

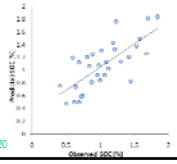
- VNIR spectroscopy: [A-B-C] A-B-C model (C = 10 different fields of research stations across CZ) Smp: 50+10+10



PLSR cross-validation

PLSR model (A+B)		*#50 + 10 +10*
R^2	0.64	
RMSE	0.27	
RPD	1.63	
No. factors	30	
Independent validation (A+B)		*#21 + 10*
R^2	0.54	
RMSE	0.27	
ME	0.04	

iVAL



Findings

- VNIR spectroscopy supports well the concept of field-scale (status) erosion mapping
- combining training data sets from different fields is possible; Where are the limits?
  (from local to regional spectral library / model)
- "*every*" new field to be mapped needs samples with laboratory analysis for model calibration (re-calibration)
- How many new samples? ~ 10
- 50 samples for model calibration gives already reasonable results

Acknowledgment

Authors acknowledge the financial support of the Grant Agency of the Czech Republic grant No. 526/09/1762.

Thank you for your attention!