„The soil map paradigm: the production of verifiable digital landscape projections versus complex-coded expert views“

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Contributions

- Jan Willer, Ulrich Schuler (BGR, eSOTER)
- Federal States, Gerhard Milbert (NRW), Enrico Pickert (Saxony)
- Michael Bock, Rüdiger Köthe (Scilands): eSOTER, geomorphographic mapping
- Dietmar Zirlewagen (upscaling GEMAS/ICP Forests Level 1),
- GS Soil partners: Harri Lilja (Finland), Jozef Kozak (CZ), Stanislav Bialousz (PL), Rastislav Skalsky (SK), Günther Aust (AT)

Demand in high-resolution continent-wide data about the condition of soils

Objectives

- **Find common denominator between existing data sets, its re-use, the planning of effort into harmonization, and landscape-scale prediction methods using GIS, remote sensing etc.**
- **To optimize and efficiently target new data campaigns: gap filling, integration of data from various sources and domains**

Existing soil maps

Frame conditions in Europe

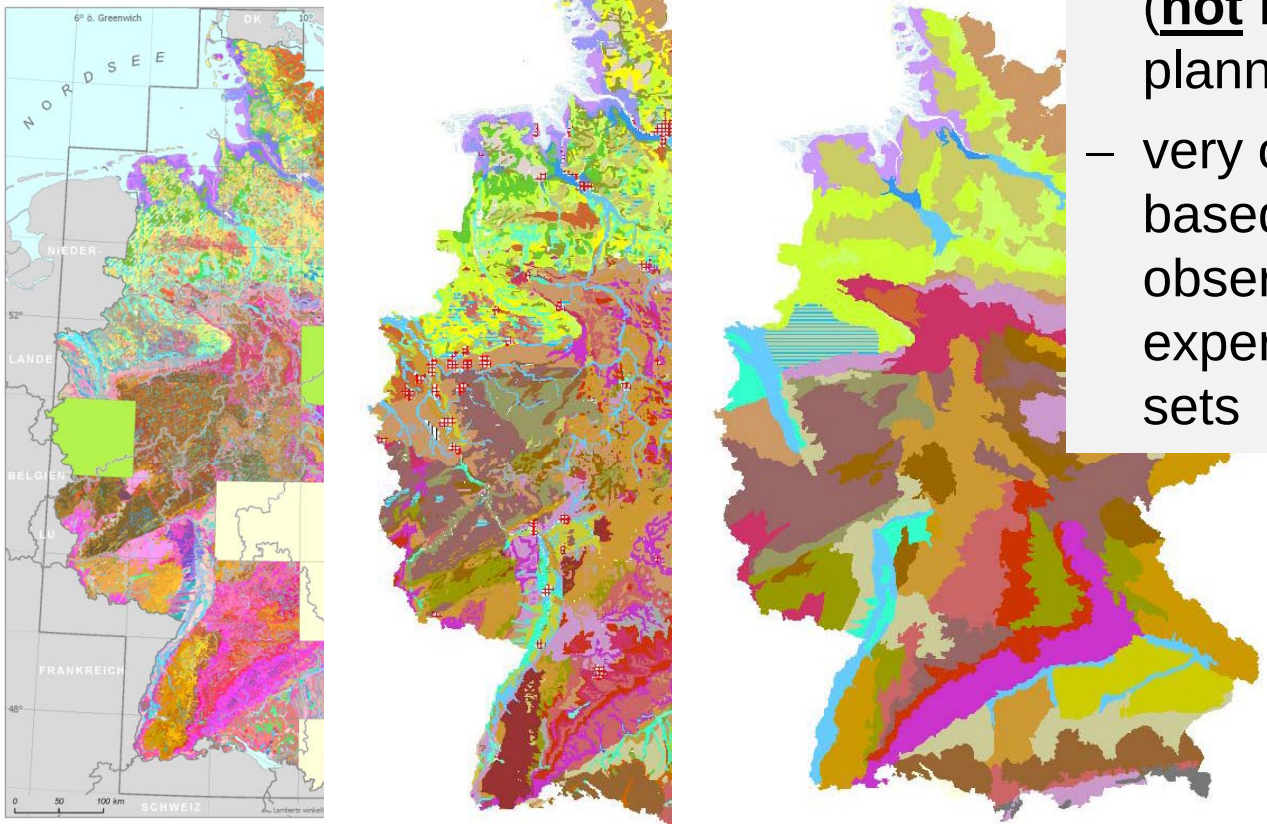
⇒ **Large amount of soil maps available in digital format** (Baritz et al. at Eurosoil 2008)

From EUROSOIL 2008 to 2012:

- Various FP7 „mapping projects“, e.g. eSOTER
- Soil data harmonization: GS Soil (econtentPlus)
- Diverse national DSM projects
- Discussions in
  - Pedometrics/
  - GlobalSoilMap.net/
  - GEO Global Soil Data

Frame conditions in Europe

⇒ **Whole countries are usually covered by small-scale maps** (ca. < 200,000)



- Purpose: overview about soil associations in the landcscape; policy support (**not** for land owners, regional planning);
- very often „top down“, not based on aggregated field observations; „derived“ by experts and ancillary data sets

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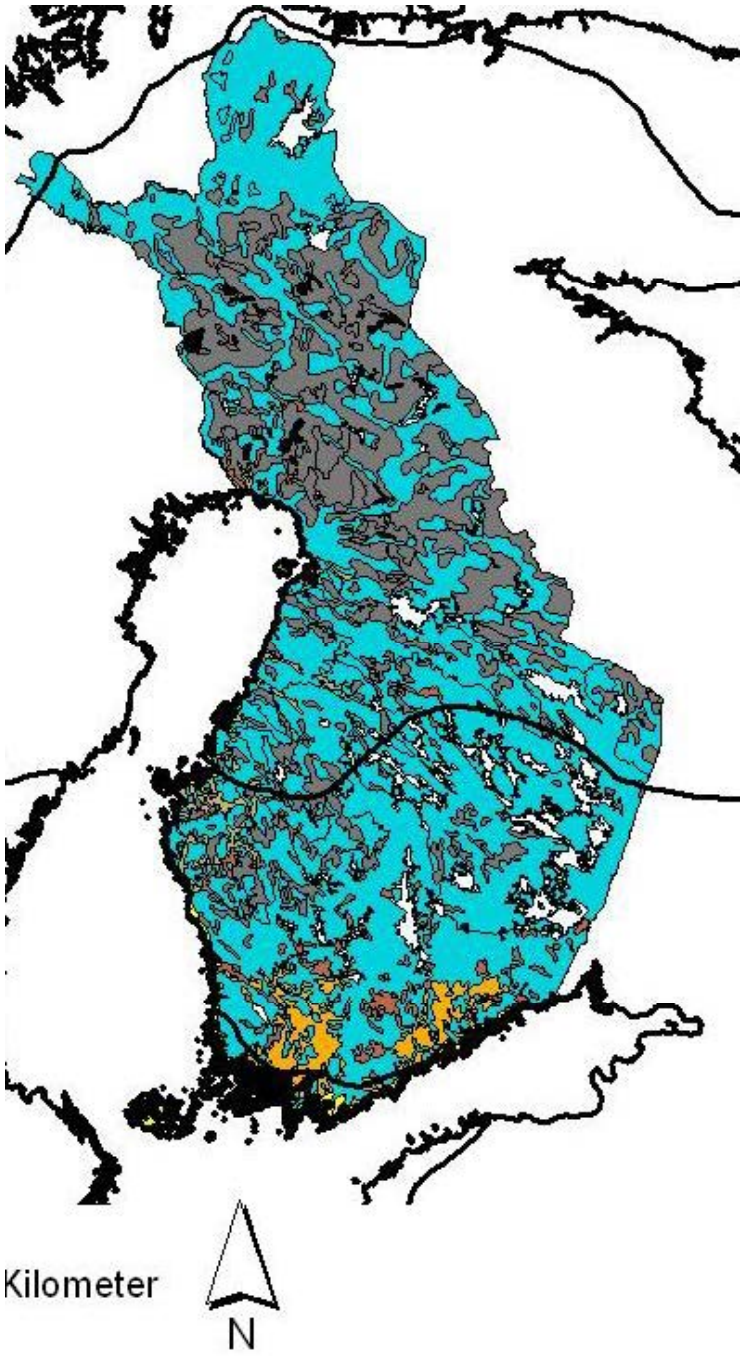
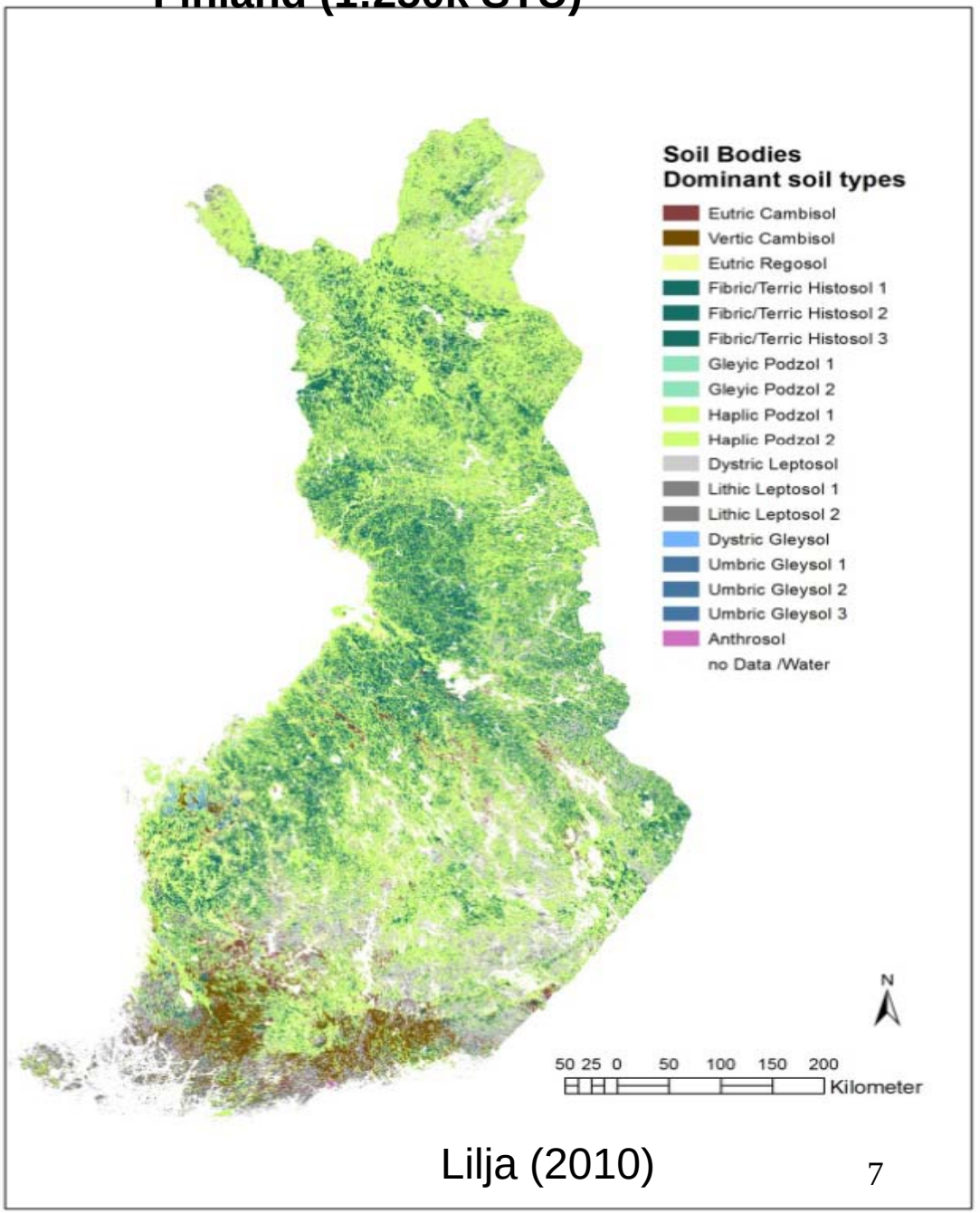
Finland (1:1 Mio SGDBE)



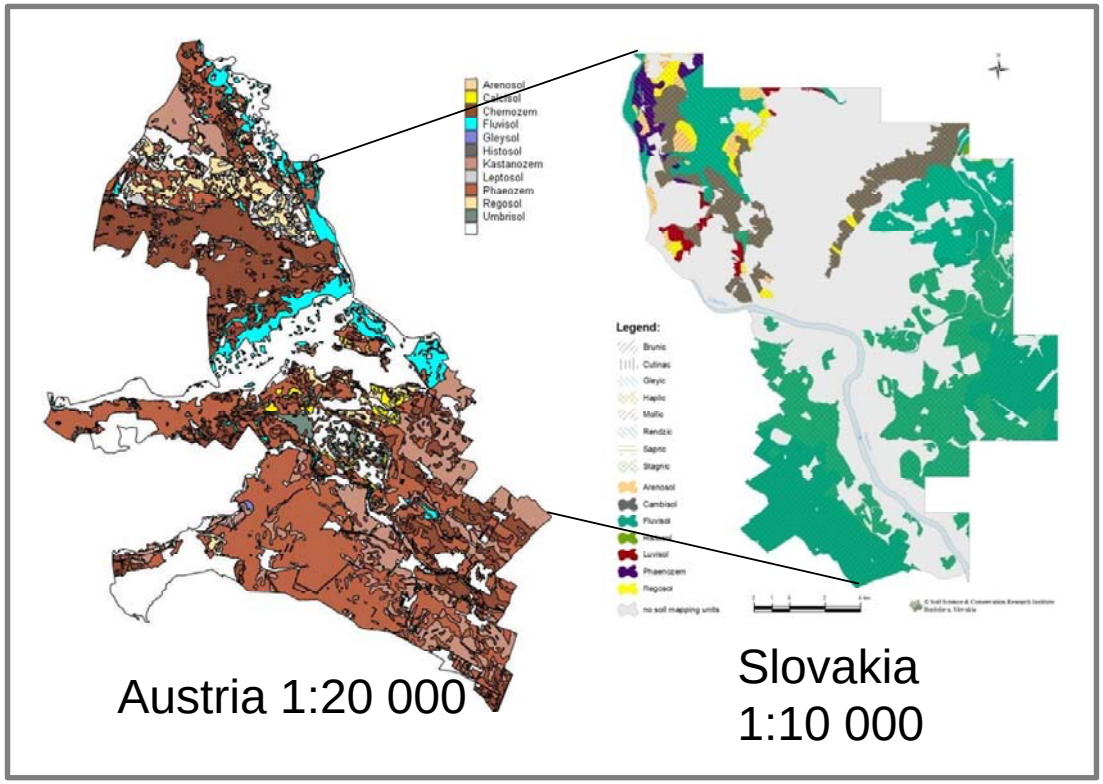
Finland (1:250k STU)

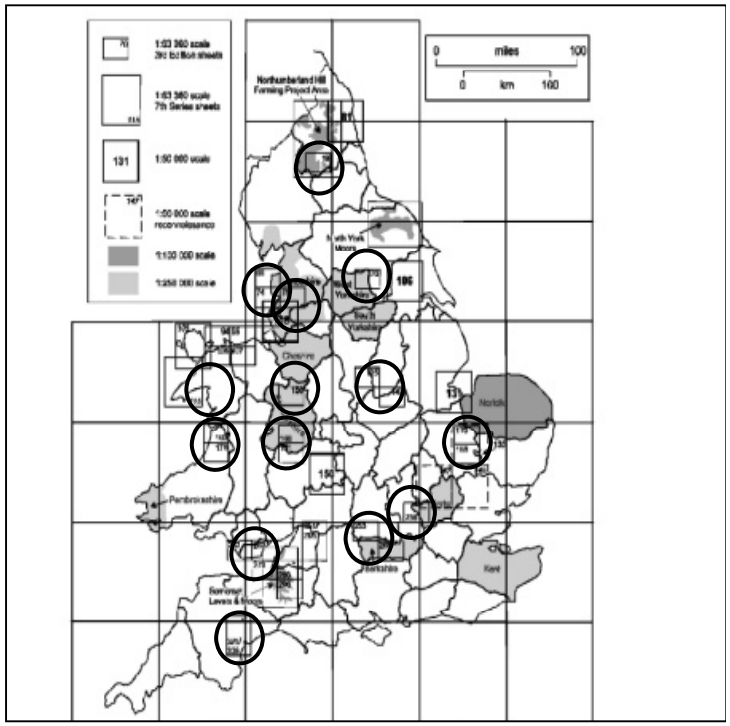


Lilja (2010)

Frame conditions in Europe

⇒ **High-resolution large-scale maps in larger countries often still have gaps** (especially southern Europe), or are not nationally harmonized





GS Soil test case 2012

England/Wales 1:10k – 1:63k
Cranfield Univ.©

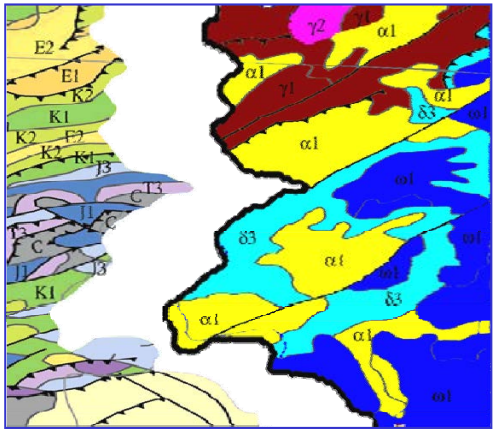
Frame conditions in Europe

⇒ **What happens when this information is harmonized: translated into FAO/WRB on the basis of derived profiles, then aggregated, then generalized?**

- Diverse methodologies (not documented)
- Diverse simplifications due to data gaps (WRB!)
- Deviations between authors are substantial (comparablity is thus limited, e.g. along country borders or mapping districts)

Harmonization of maps

- different formats
- different content



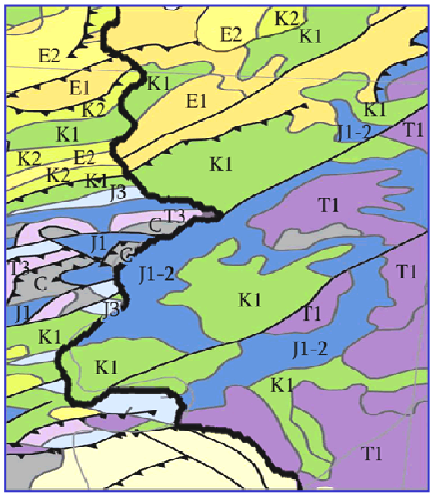
Figures:
Asch and Troppenhagen (2004)

standardized domain-specific exchange formats: e.g. GeoSciML, SoilML

Translation procedures

Agreements on content descriptions and semantic harmonization

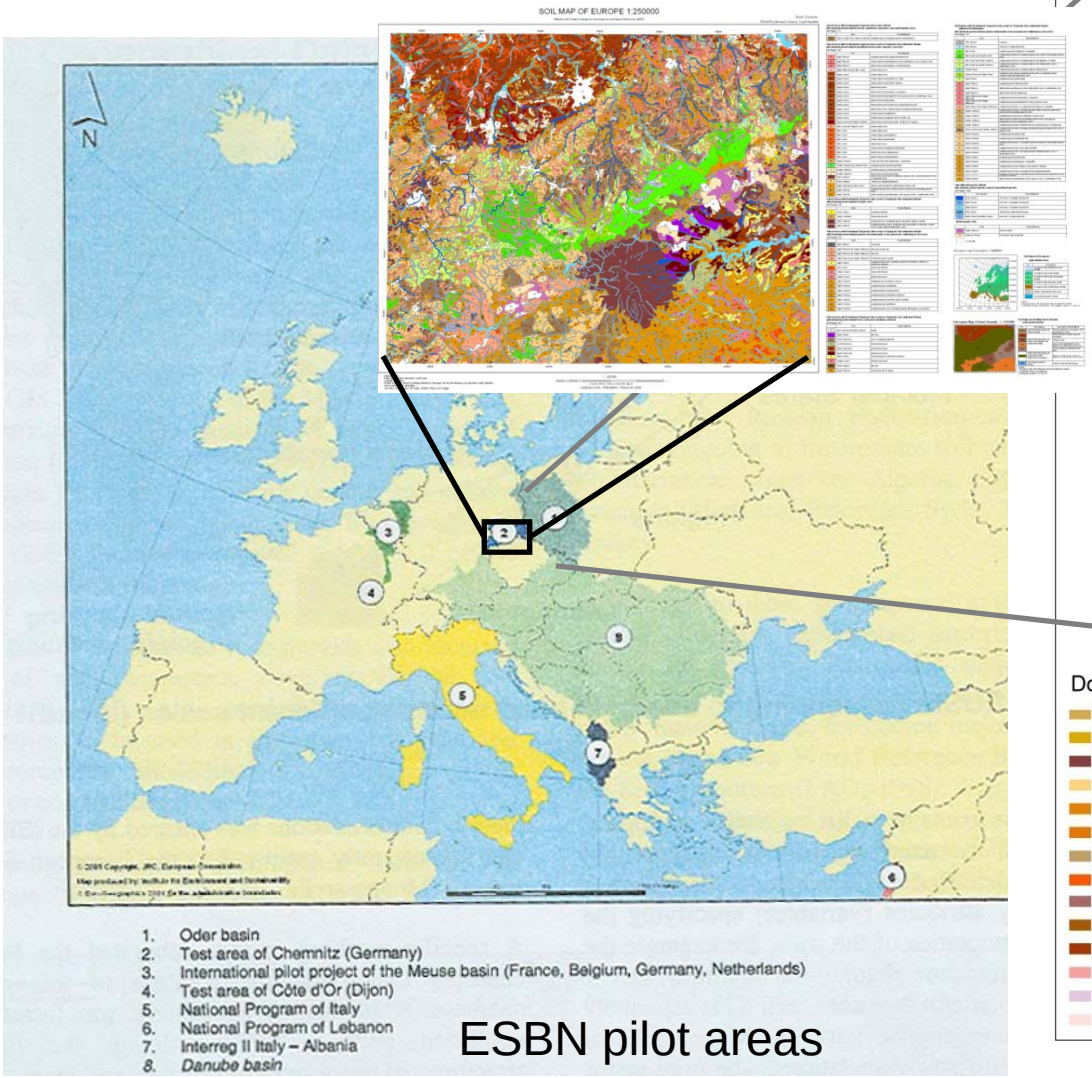
- comparable content and format



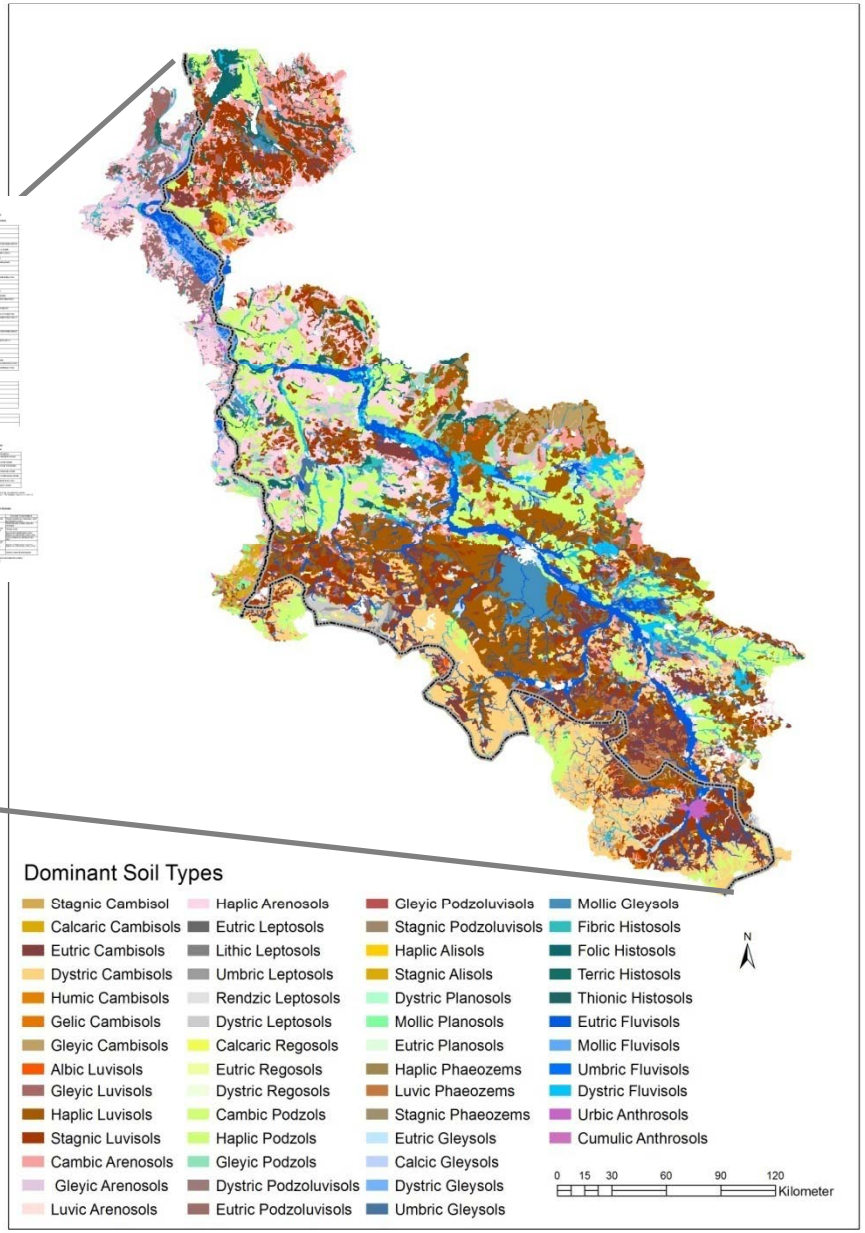
Delineation?

Harmonization of maps

⇒ **Harmonized mapping acc. to manual**



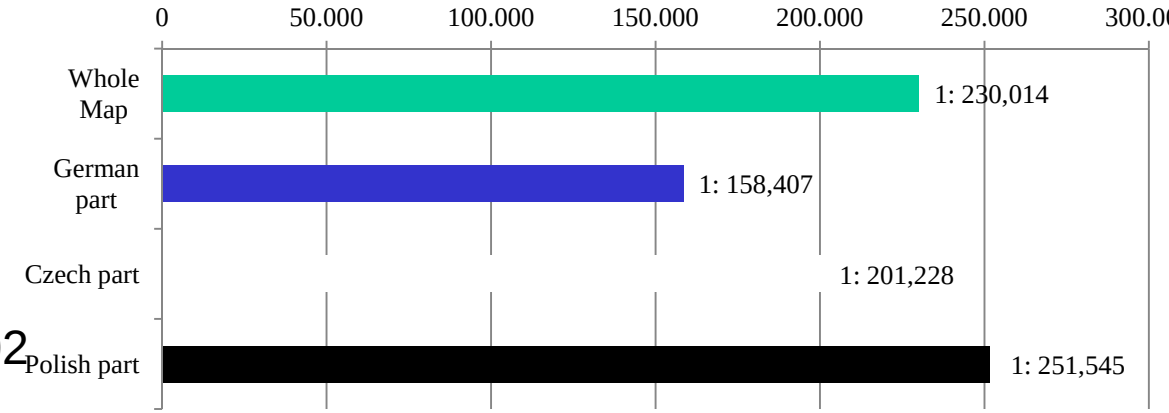
ESBN pilot areas



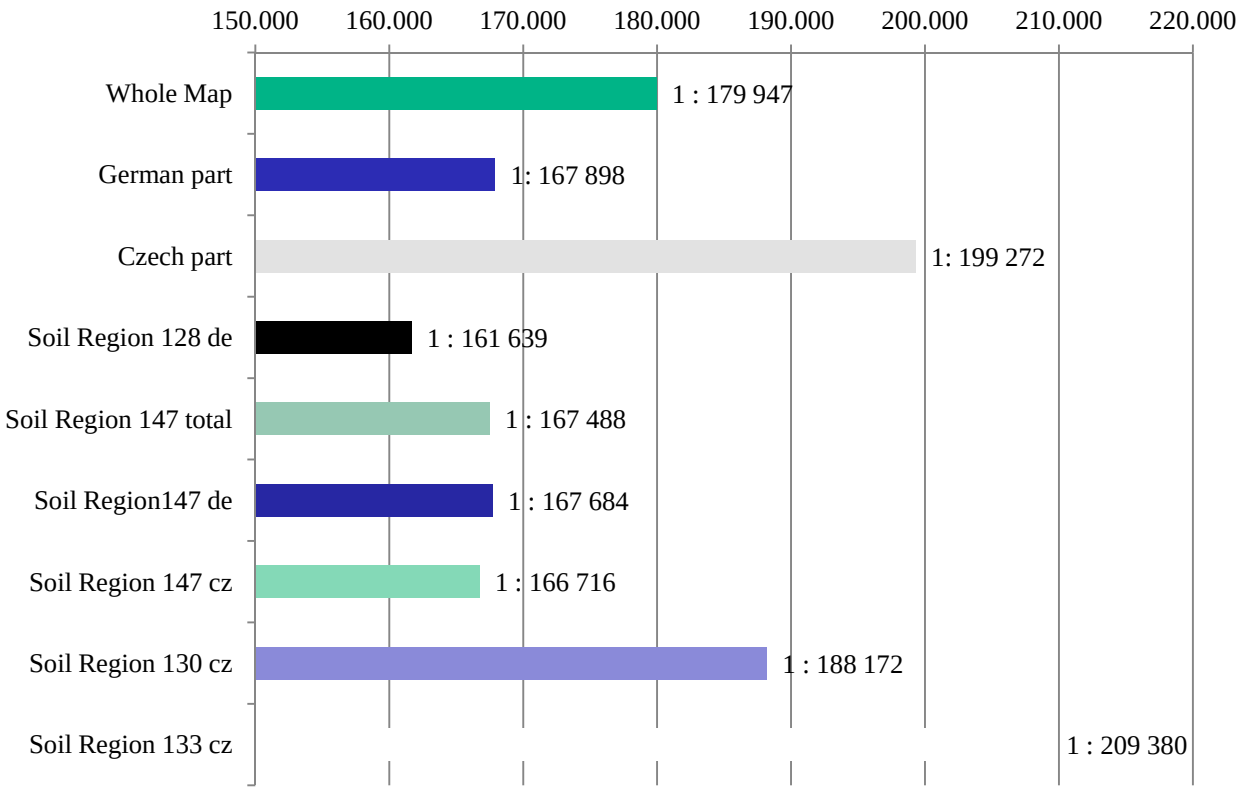
Harmonization of maps

⇒ **Nominal scale vs. „Optimal“ scale**

Statistic acc. to Fuchs 2002

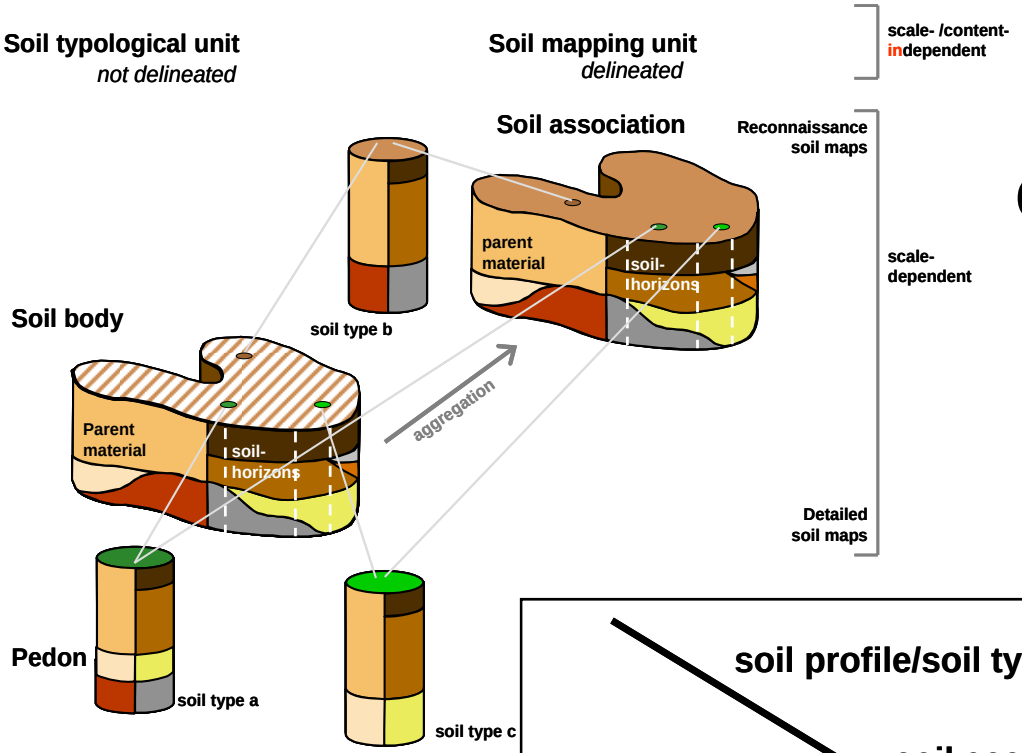


Odre Basin 1:250k

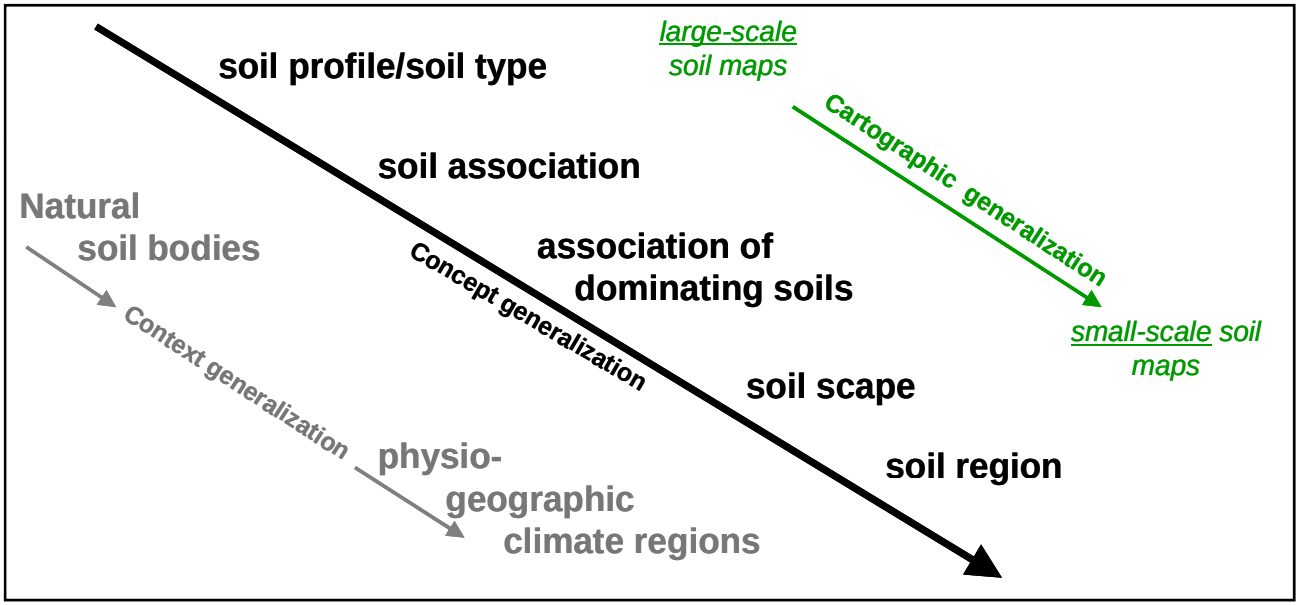


Sheet Chemnitz 1:250k

Harmonization of maps

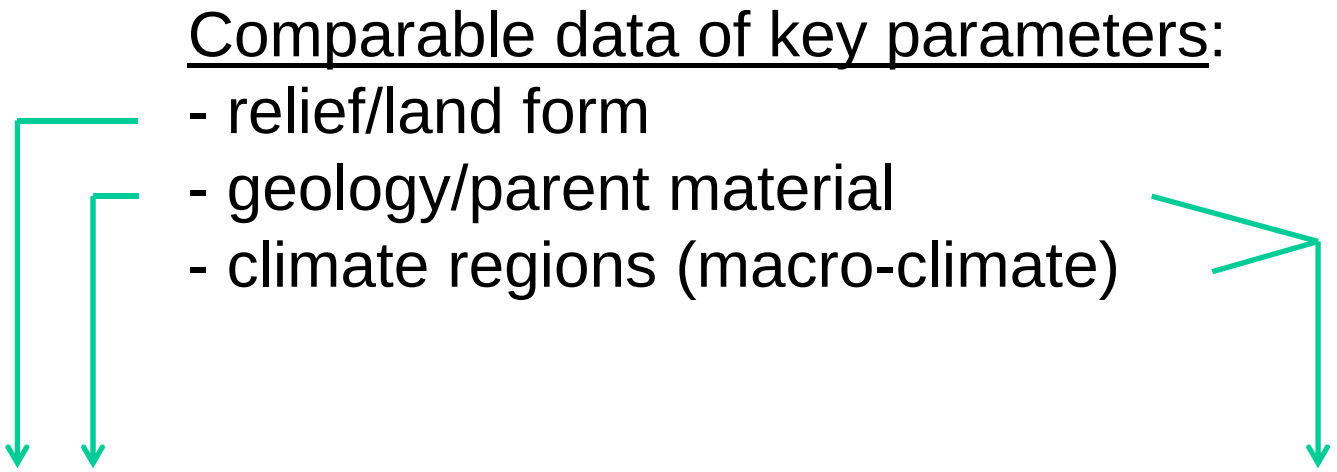


Concept, rules, content definitions for the semantic map content



Harmonization of maps

⇒ **What supports harmonization with regard to geometries?**



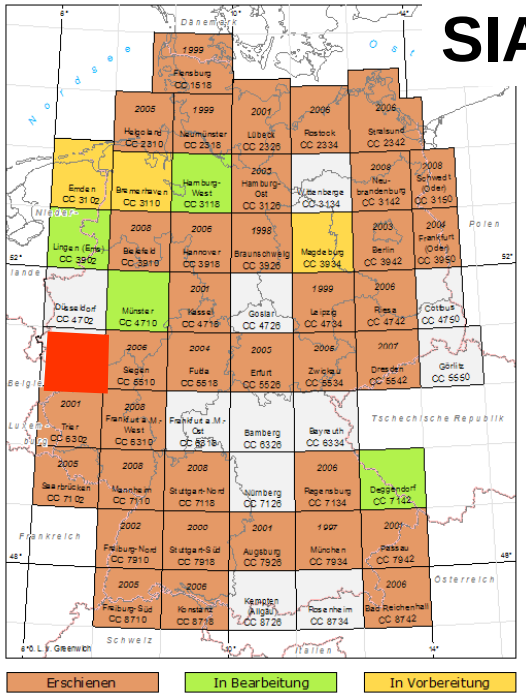
⇒ **Re-draw all maps?**

Digital soil mapping

I. Prognoses of soil typological units (soil types, associations of soils)
II. Prognoses of soil properties (upscaling of measured data from sampling locations (site, plot)

I. Prognosis of soil typological units

SIAM project Sheet Cologne (BGR, Willer et al.)

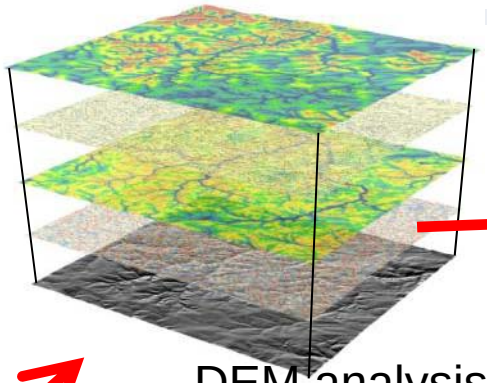


7,647 km²

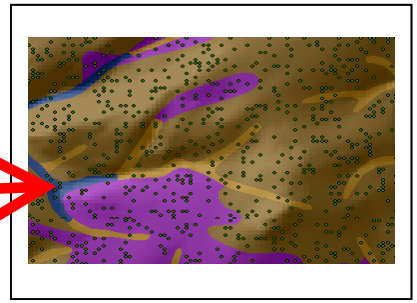
8 soil macro scapes

Training area

Validation area

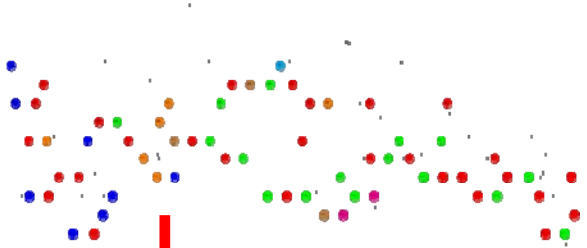


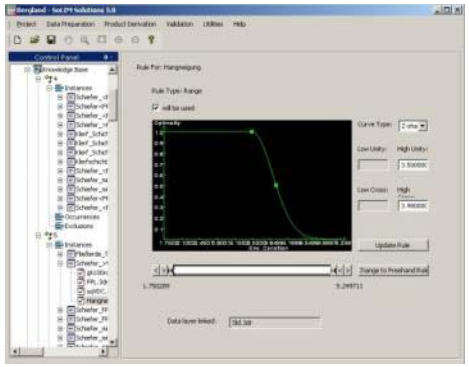
DEM analysis
Geology



100,000 arbitrary plots

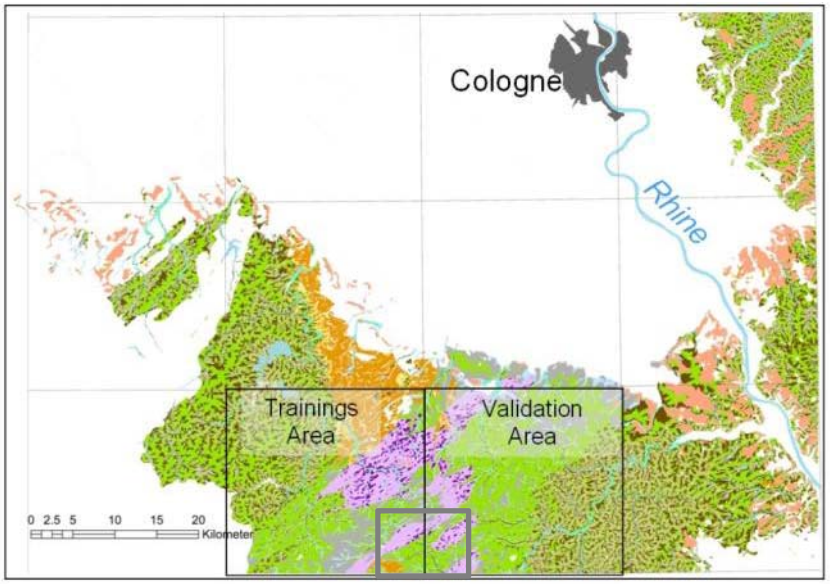
Classification tree for each stratum





SOLIM

Predictive mapping



Simplified Legend
(dominant Soiltyps)

- Fluvisols
- Haplic Fluvisols

Soil Landscape 11.1

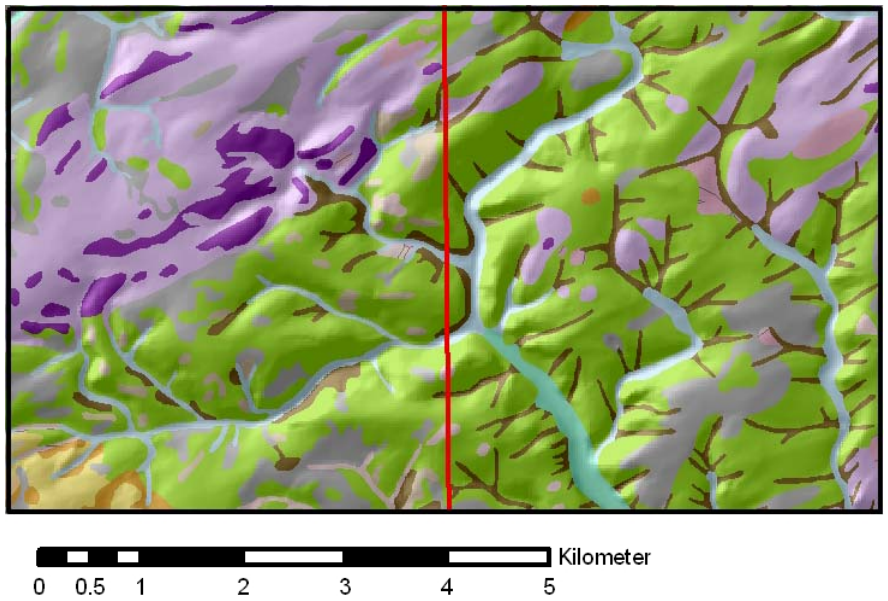
- Eutri leptic Cambisols
- Eutric Cambisols
- Leptic Cambisol and Leptosols
- Haplic Cambisols
- Colluvic Cambisols
- Planosols

Soil Landscape 7.2

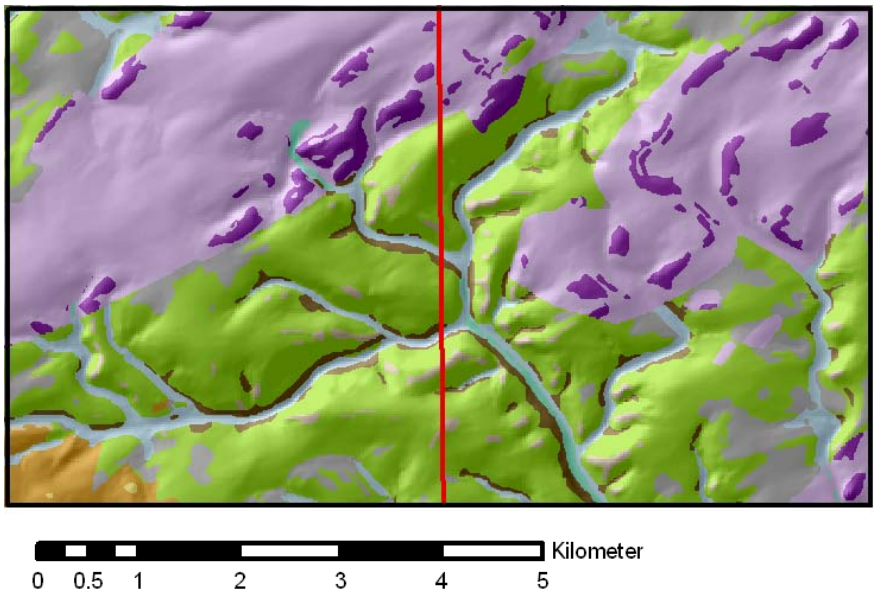
- Dystric arenic Cambisols
- Stagnic Cambisols
- Arenic Cambisols
- Podzols
- Planosols and stagnic Cambisols
- Haplic Luvisols

1:50k mapped

Blatt L5504 Blatt L5506



Predicted, free of edge effects



⇒ Quality of training area is crucial

II. Prognosis of soil properties

Example: regionalization of continent-wide soil inventrories

(regression krigin)

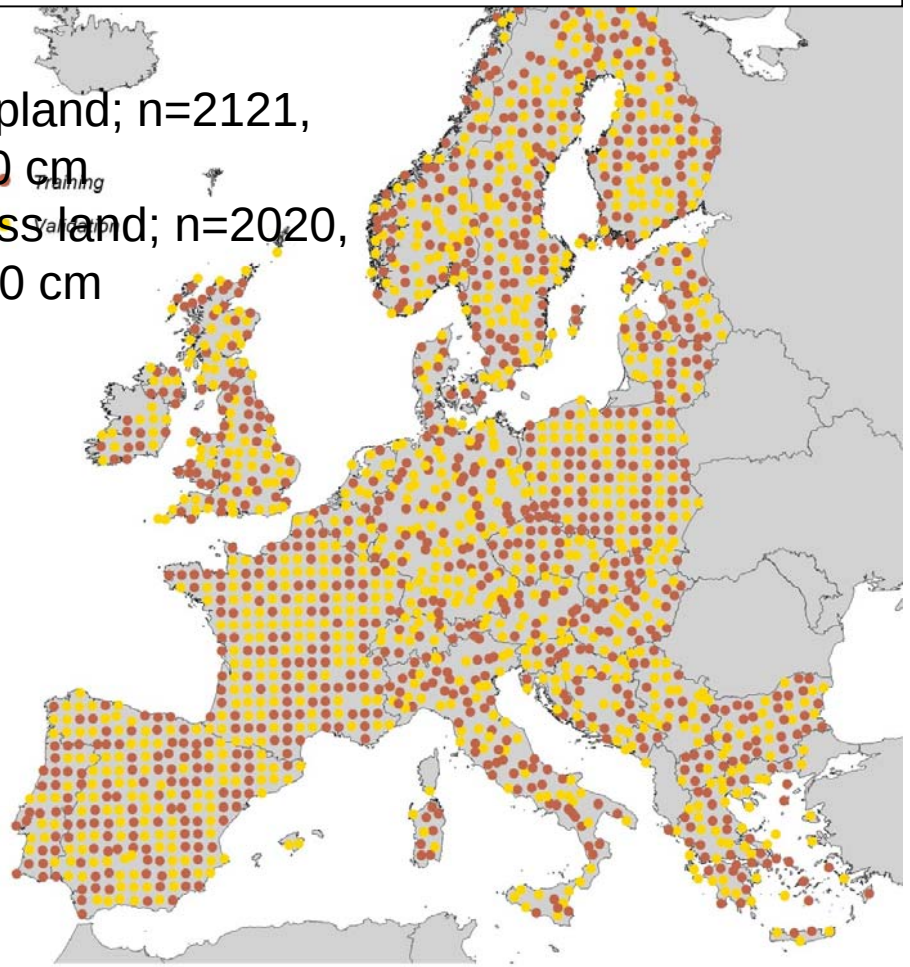
EU/ICP Forests Level I
1990-1995

EuroGeoSurveys Geochemical mapping of agricultural and grazing land soil of Europe (GEMAS)

O-layer

mineral soil (0-20 cm)

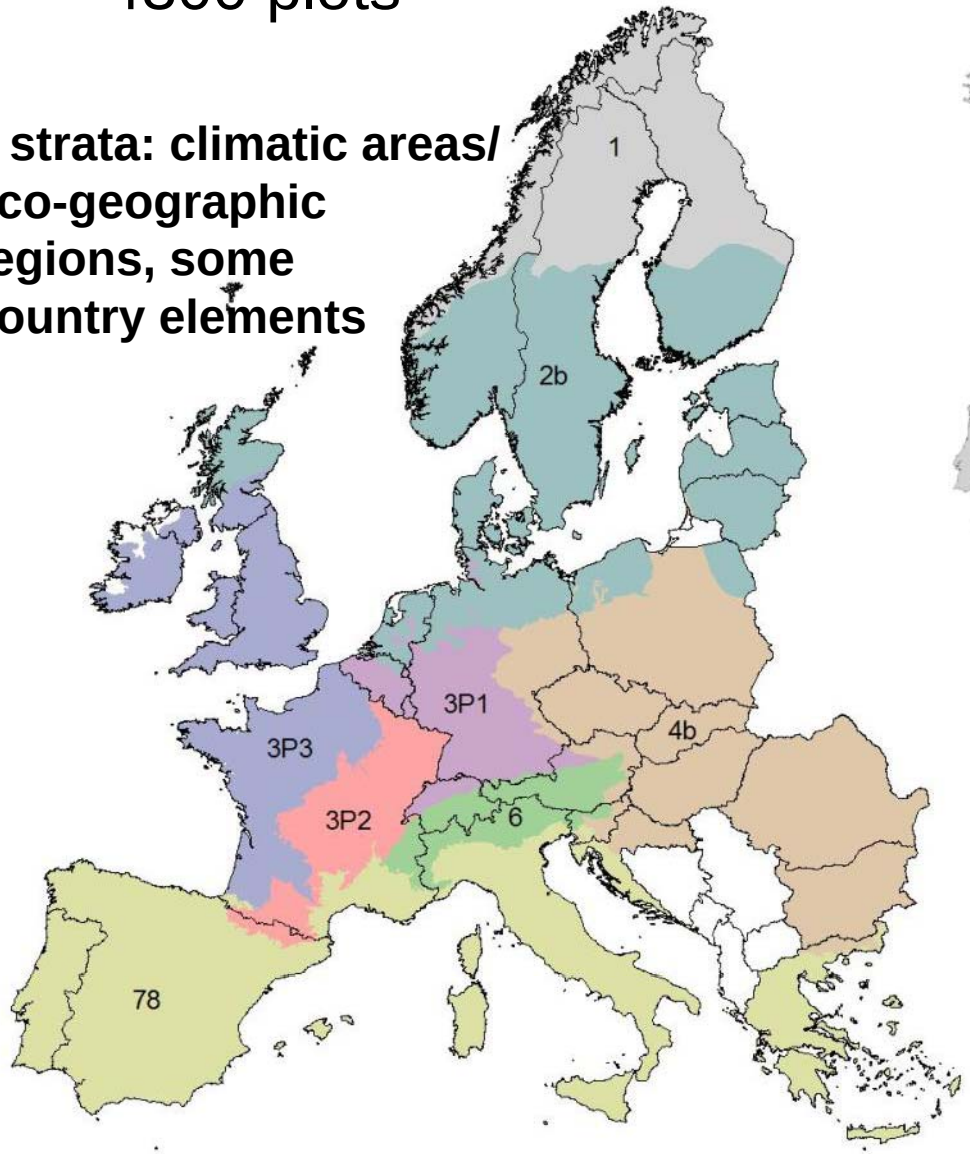
Cropland; n=2121,
0-20 cm
Grass land; n=2020,
0-10 cm



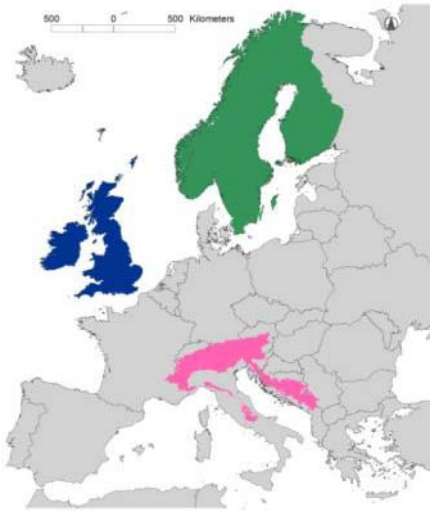
Stratification Europe:

Forest SOC
4300 plots

8 strata: climatic areas/ eco-geographic regions, some country elements



Agricultural land
2300 plots

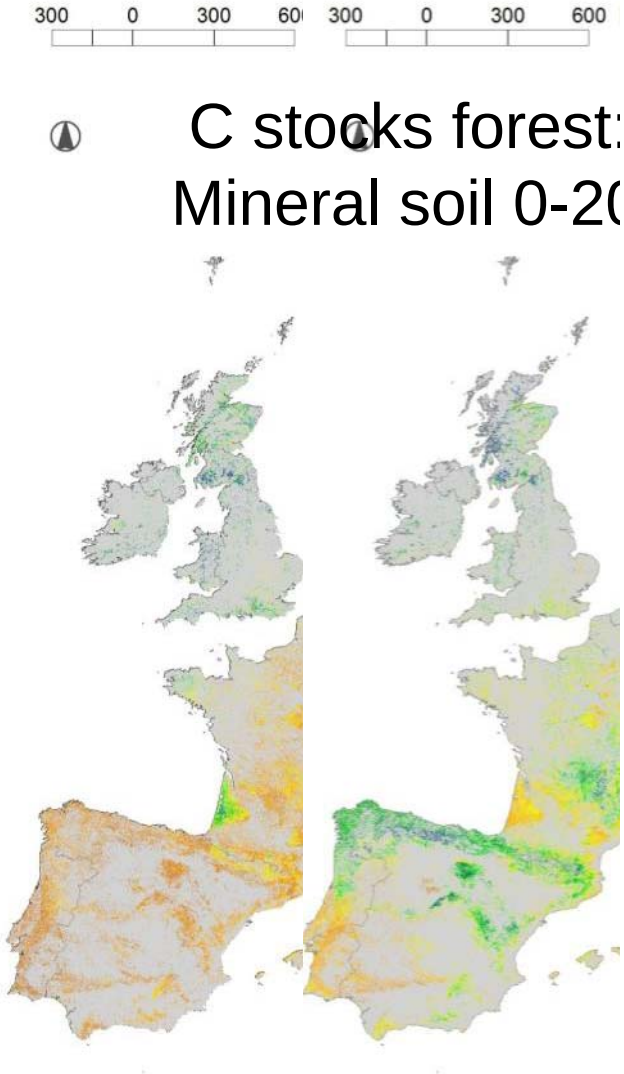


SOC

pH

Thematic maps in 1k resolution

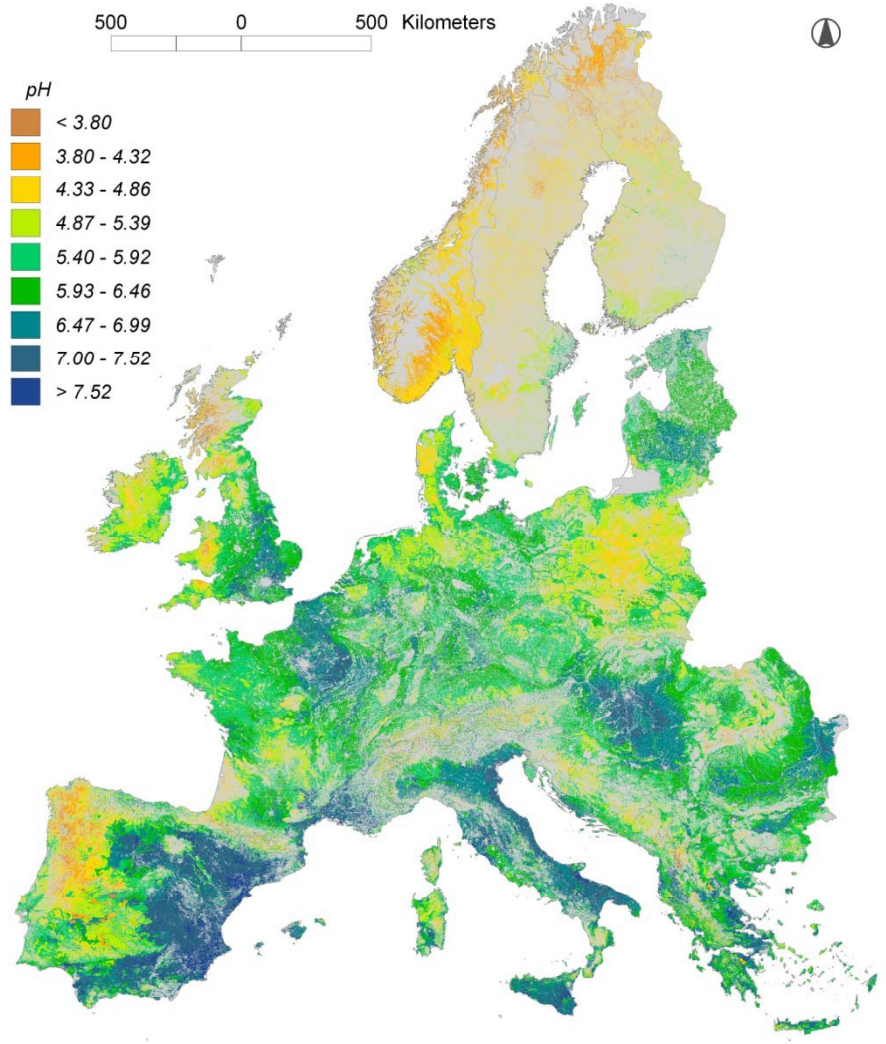
C stocks forest:
O-layer



C stocks forest:
Mineral soil 0-20

TOC agicultural land

pH



Europe (0-20 cm depth)

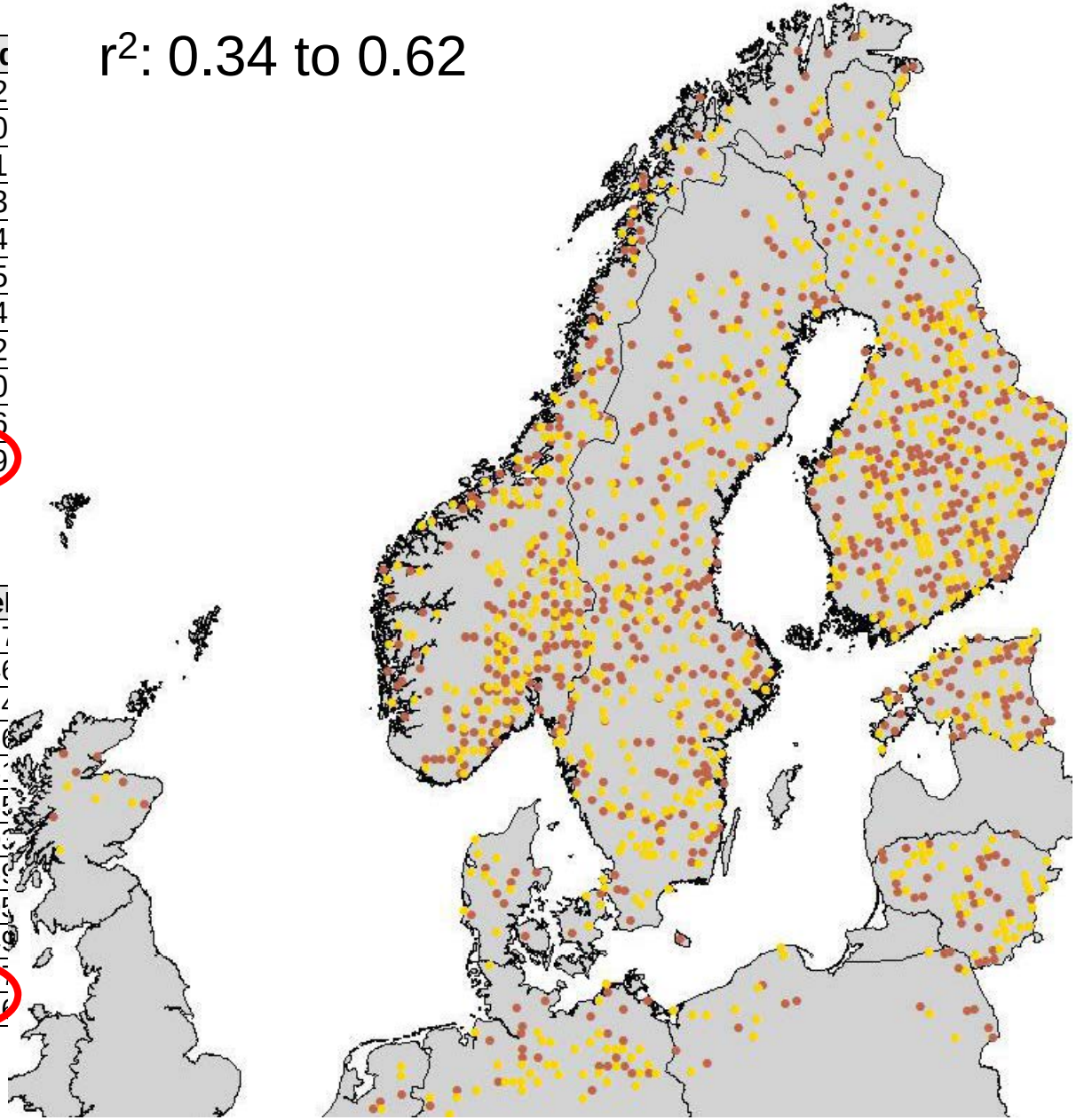
Boreal

Step	Variable	Partial R^2	Mod
1	p_Histosol	0.4027	0.402
2	BIOCLIM_3	0.0974	0.500
3	DEM	0.0211	0.521
4	TMIN8	0.0321	0.553
5	p_Cambisol	0.0115	0.564
6	WR3	0.0106	0.575
7	p_Regosol	0.0088	0.584
8	p_Podzol	0.0181	0.602
9	BIOCLIM_15	0.0079	0.610
10	PICEA	0.0060	0.616
11	PREC8	0.0036	0.619

Subboreal/Baltic

Step	Variable	Partial R^2	Model
1	p_Histosol	0.3617	0.361
2	TMAX2	0.0729	0.434
3	p_pinus	0.0538	0.488
4	p_Regosol	0.0282	0.516
5	SlopeDegr_kl5	0.0185	0.535
6	Ecocode_46	0.0204	0.555
7	Ecocode_86	0.0048	0.560
8	PREC7	0.0056	0.565
9	p_Luvisol	0.0046	0.570
10	p_Cambisol	0.0044	0.574
11	DICONVG	0.0038	0.578
12	TPI1000	0.0070	0.585

r^2: 0.34 to 0.62



Summary: soil types which appear as predictors in the landscape-SOC models

Main predictors

Temperature

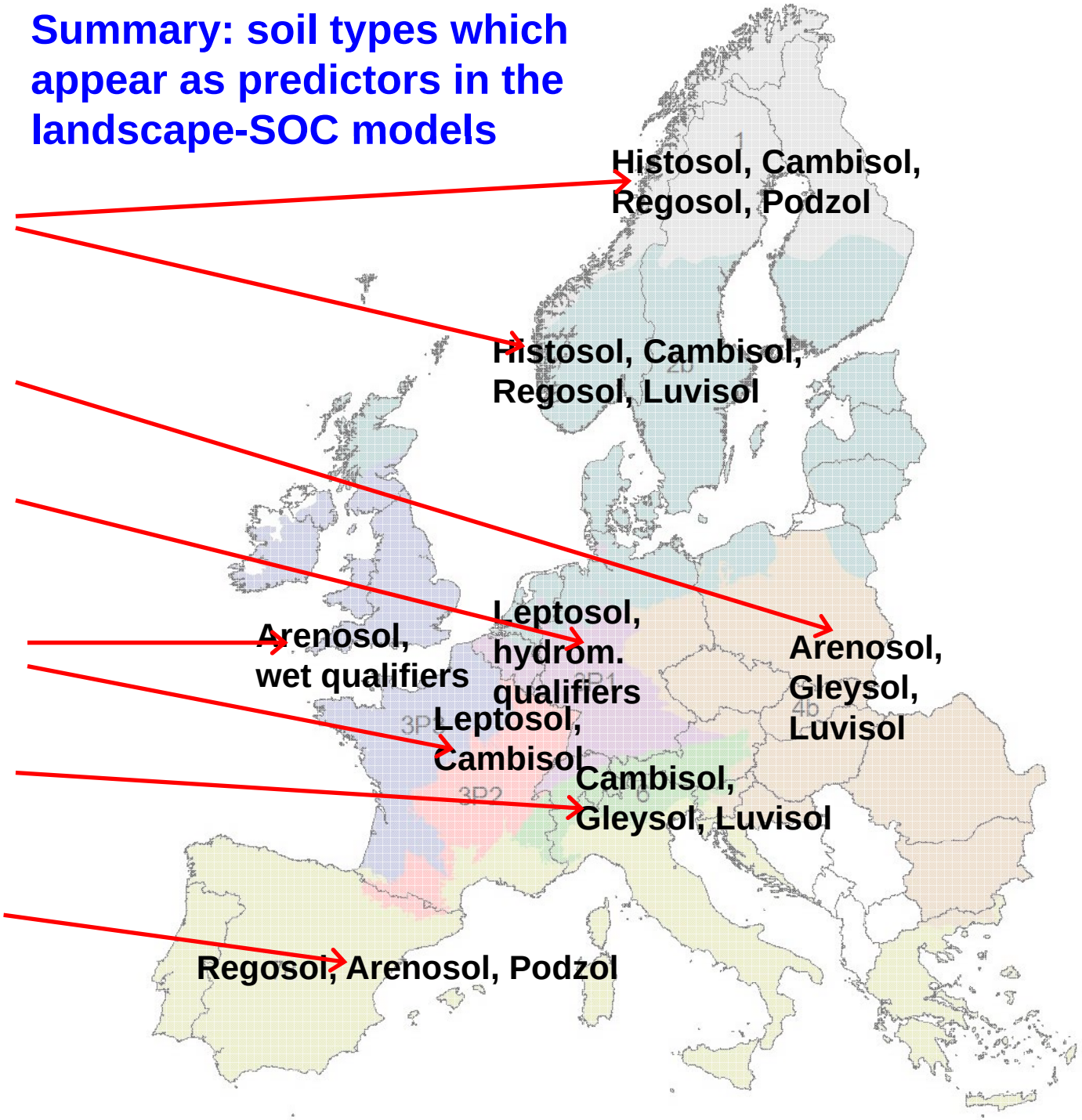
Climate

Climate, relief and parent material

Climate and Relief

Relief

Climate

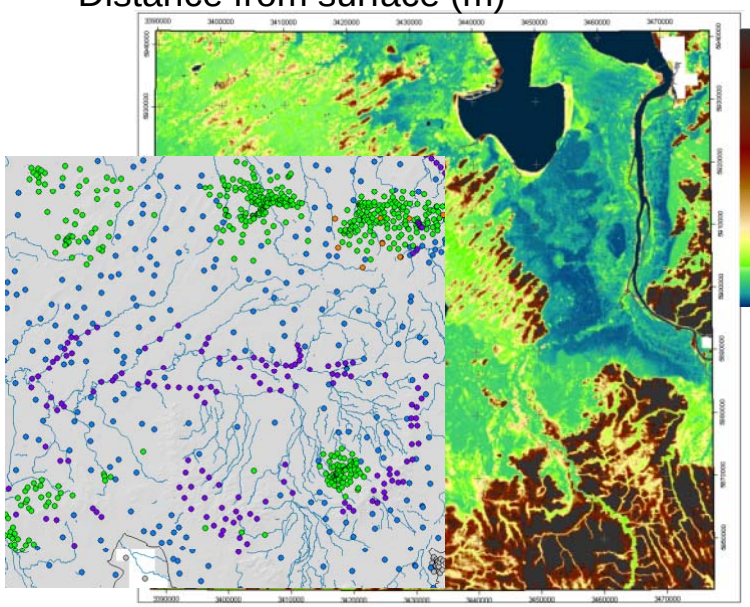


Regionalization of ground water levels

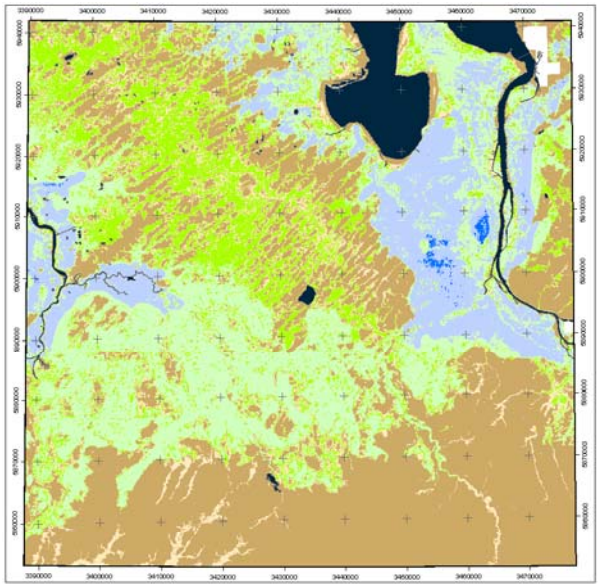
multiple (stepwise) regression

3 models for hydrogeological subregions

Distance from surface (m)

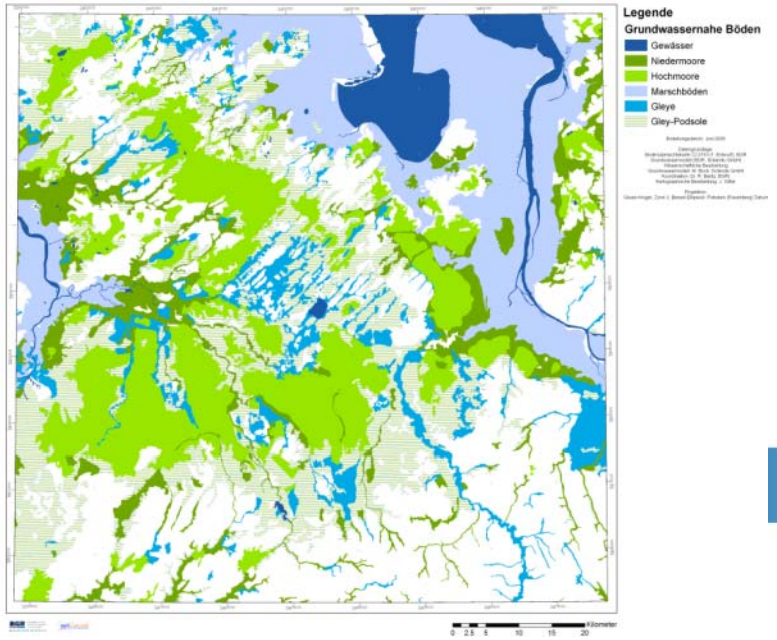


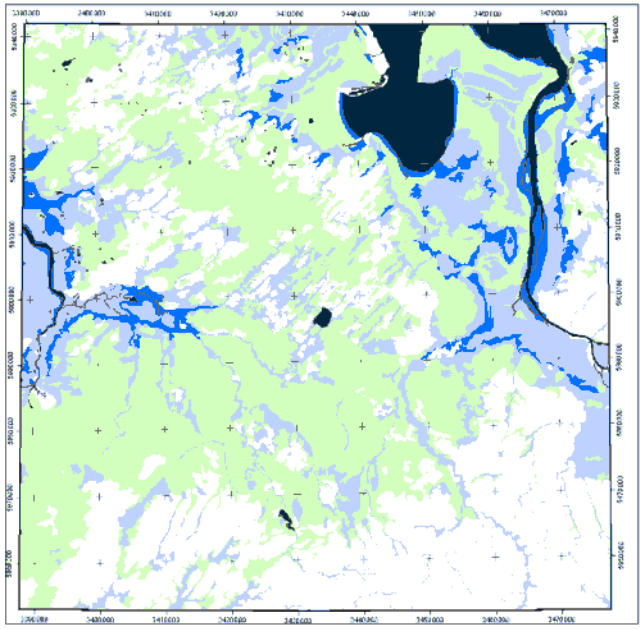
Blatt Bremerhaven (CC 3110)



Grundwassernahe Böden

Blatt Bremerhaven (CC 3110)





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Current developments

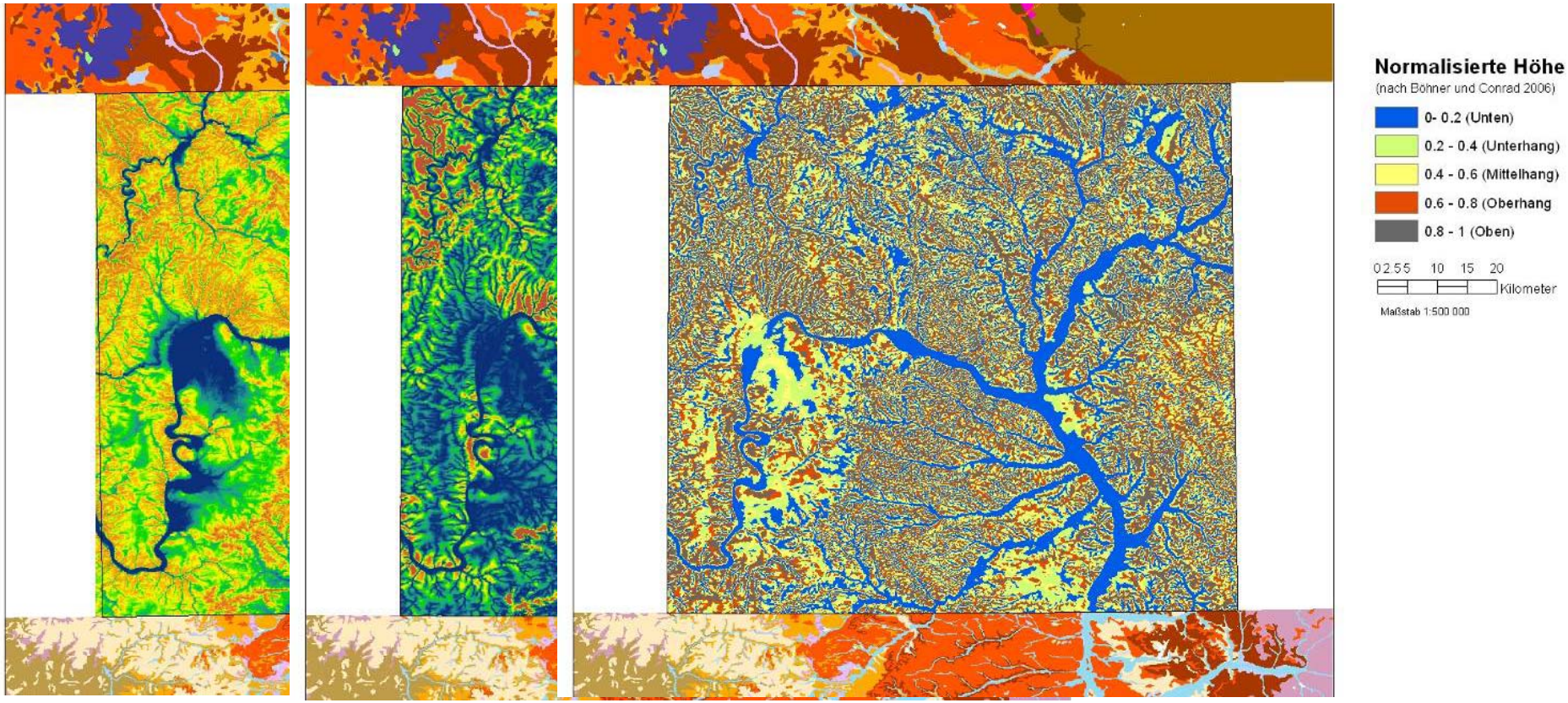
New developments in geomorphographic DEM analysis

- Enhanced morphometric terrain parameters play an important role for the prediction of soil properties

„Elevation above channel line“

SAGA Wetness Index

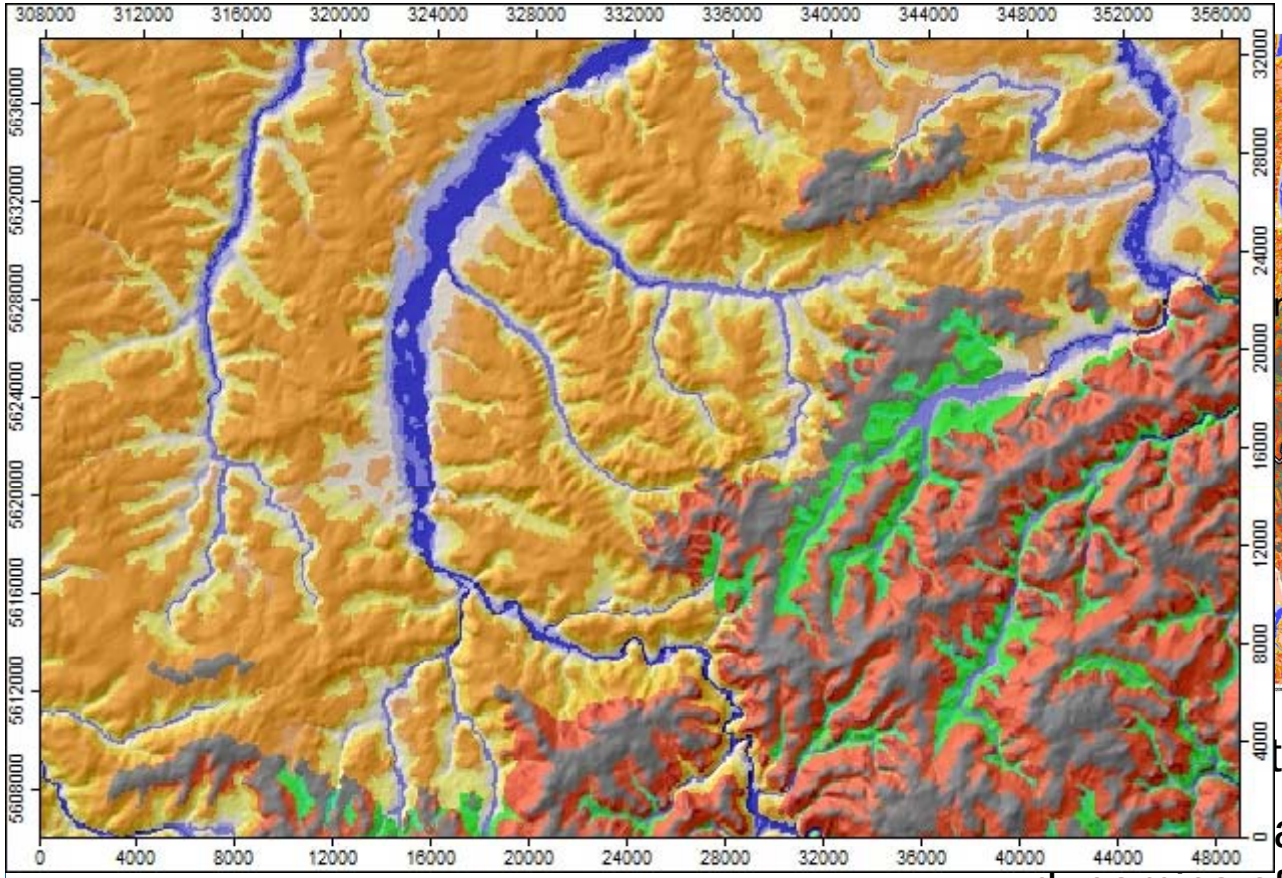
Normalised elevation



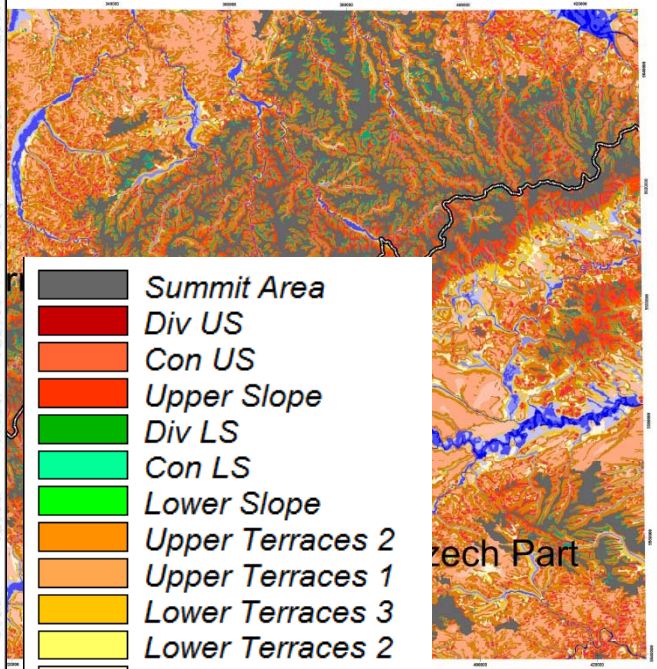
Willer 2012 (case study sheet Bamberg)

New developments in geomorphographic DEM analysis

- Developments in geomorphographic analysis identify landscape-level process units rather than projections of pre-classified land form units



zoomed in 1/6th of total pilot



012

and

breaks):

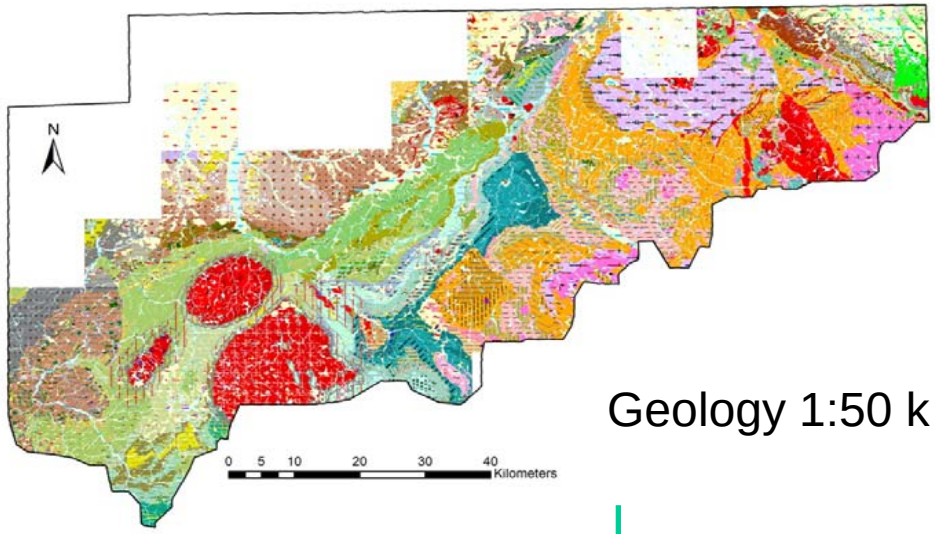
dynamics of

Terrain classification index for lowlands (TCI_low)

New developments: parent material

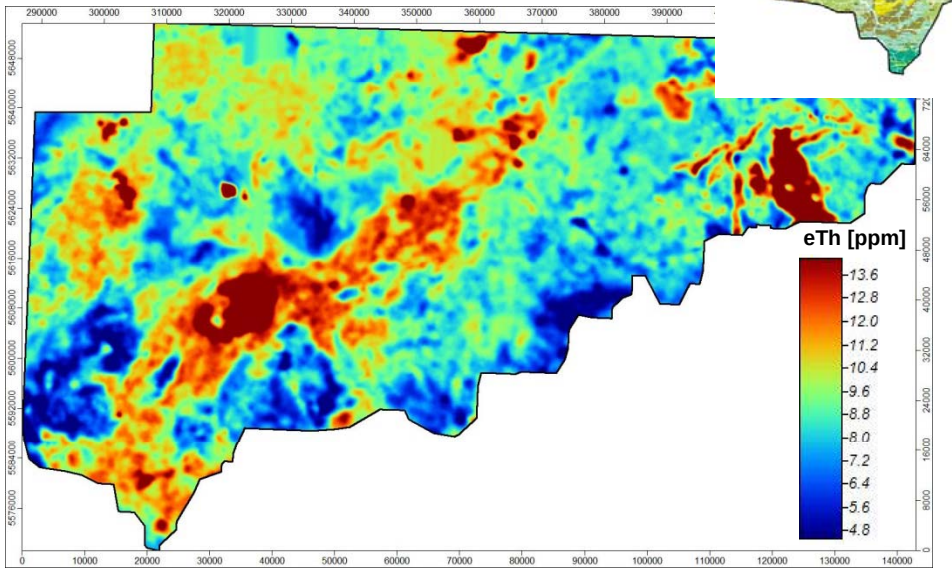
- Parent material

German part Sheet Chemnitz
acc. to Schuler et al. (eSOTER)



Geology 1:50 k

Gamma ray



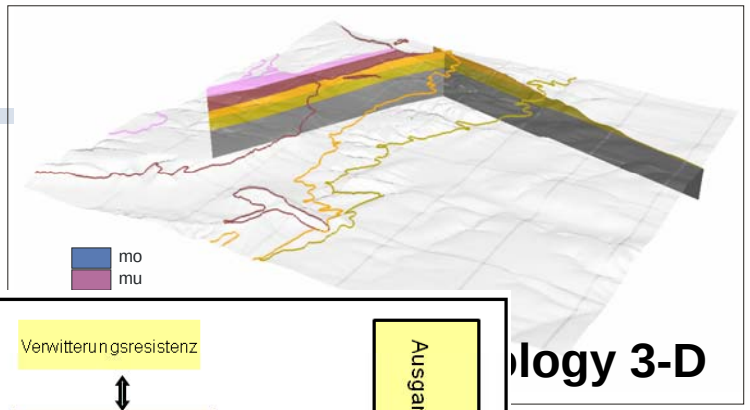
Thorium

predict top soil substrates
- derive properties

predict soil types

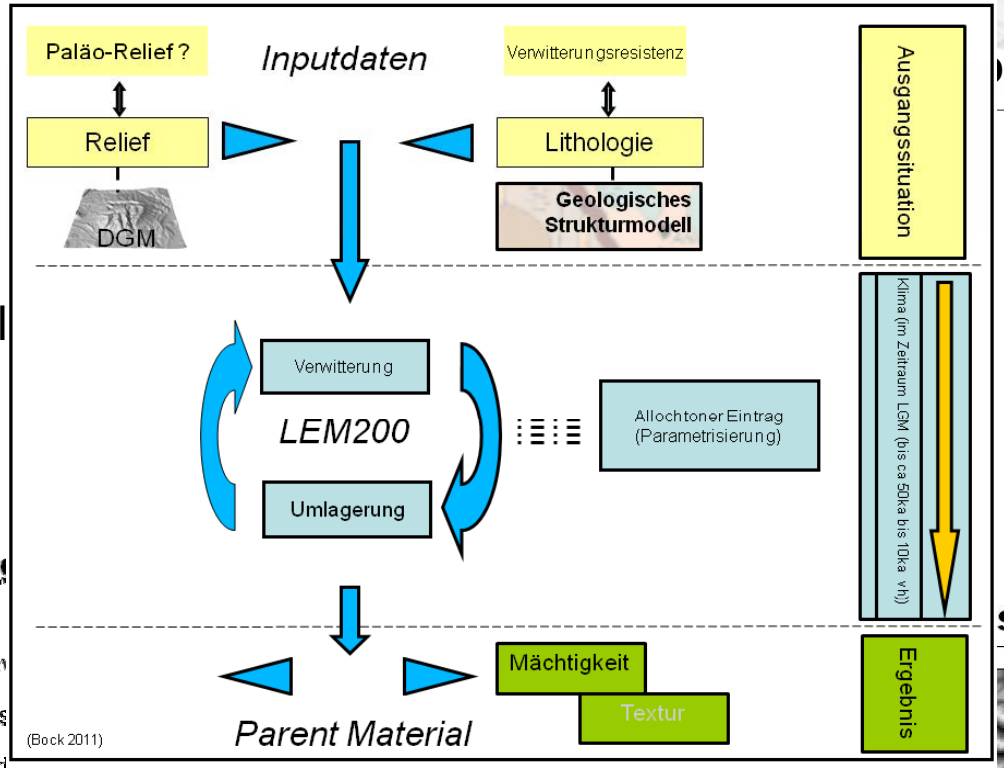
Landscape evolution modelling

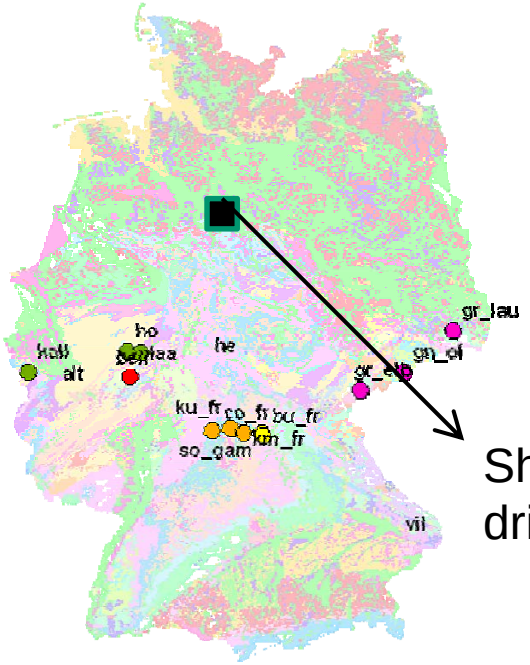
- Predict regolith properties (all project phases in development)



Weathering index

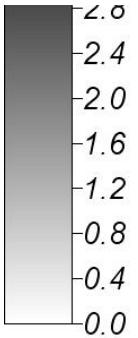
Geochemical and mineralogical analysis of rocks in different weathering phases and depths

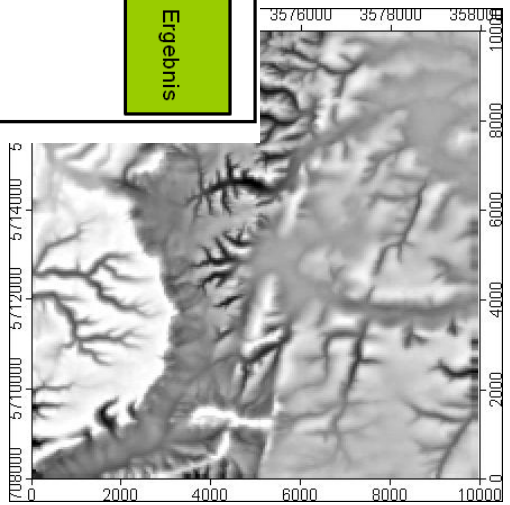




pmloc_
LITHO
Trias Sandsteine
Trias Tonsteine

Sheet Ebergötzen as pilot for drilling (for LEM validation)





Conclusions

„Pro“ soil typological maps

- **Soil typological units in „DSM_properties“ are of limited value**: high resolution climate data, DEM_derivates and land cover often more important (e.g. for predicting soil carbon)
- Nevertheless, depending on the quality and density of the soil plot and map data, it provides crucial delineations for specific **azonal/extrazonal soils**: Leptosols (shallow soils), Histosols, stagnic soils, podzolic soils
- **Representative soil profiles** in soil maps reflect the **vertical gradient** of soil properties; meaningful **stratification of landscapes/**representativity, valuable orientation for designing any kind of soil study;
- Many soil functions depend on the **interaction of key properties**; seperately upscaled parameters are difficult to combine

„Pro“ DSM properties

- **high resolution climate and DEM_derivates** (partly also parent material) are becoming more and more **available**, have high predictive power for soil properties (e.g. soil carbon)
- **process zonation of the landscape**; new definition of representativity; effects on soil sampling strategies
- Information from **different themes** can be more accurately **connected** (climate-relief-land use)

„Pro“ DSM + soil maps

- **In combination, both approaches together allow the harmonized mapping, aggregation and gap filling in one step towards truely harmonized data sets.**
- **Intelligent stratification and sampling allows for high-resolution coverage of soil components in the landscape (eSOTER) . This approach is suitable for the intermediate scales utilizing (and aggregating) existing mapping data.**

Thank you for your attention!

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