Automated classification of the German soil map (BUEK 200) into FOOTPRINT Soil Types and parameterization in MACRO

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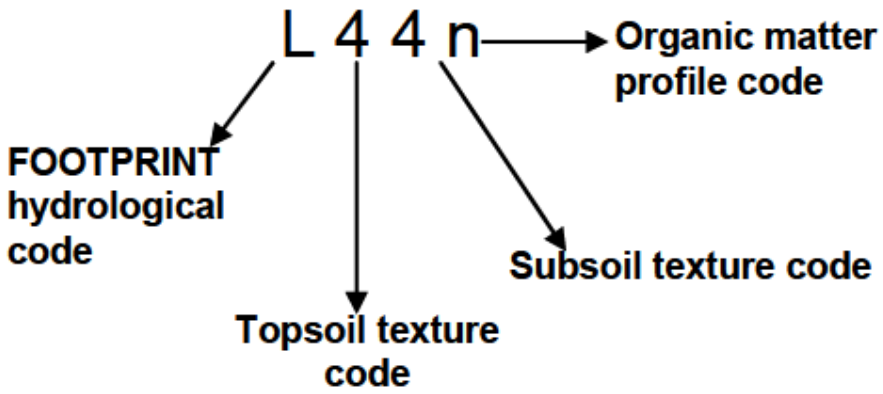
Summary

- The **FOOTPRINT Soil Type (FST) system** derived during the FOOTPRINT project (2006-2009) enables the soil classification and parametrization at EU scale

- We explored the FST´s potential to classify the 1:200,000 German soil map (BUEK200) to facilitate the application of computationally intensive environmental fate models on large scale

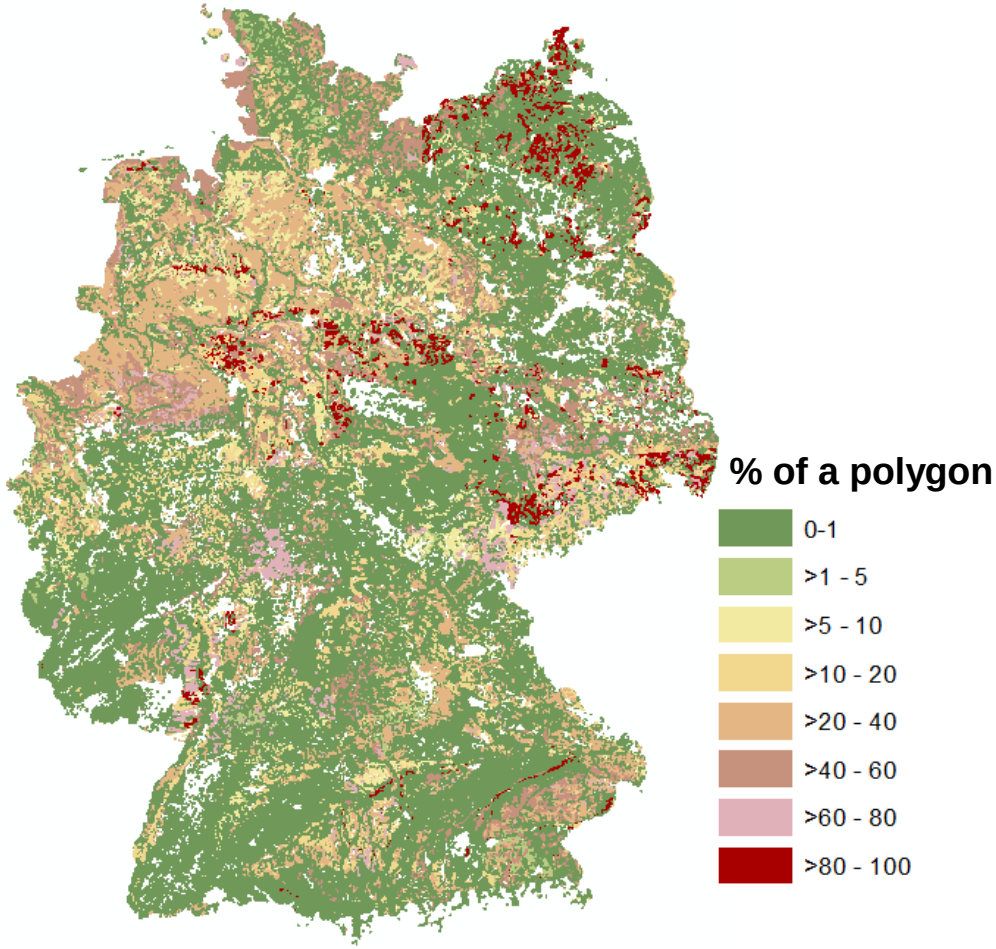
  - The **3648** arable soil typological units are classified into **226** FSTs
  - A representative soil profile is created for each FST
  - Each FST is parameterized for the model MACRO
  - The routine is automated

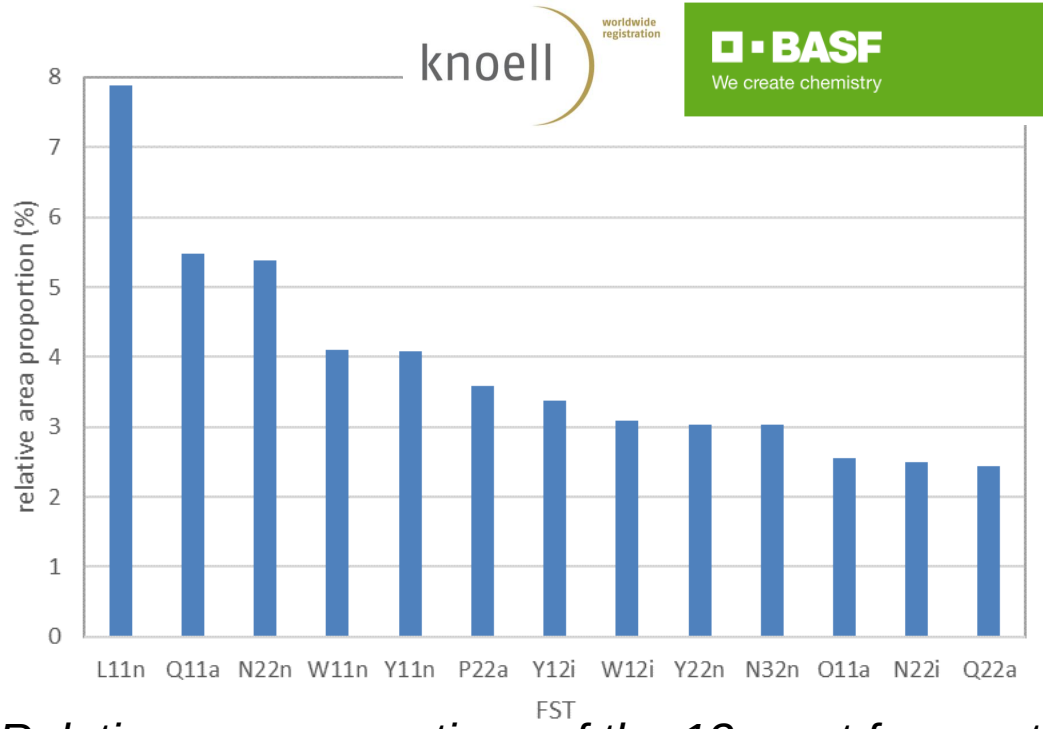


Example of a FST code

Summary

- *Drained area percentages for BUEK200 polygons for the agricultural landuse*





- *Relative area proportions of the 13 most frequent soils*

- The 13 most frequent soils already cover 50 % of the arable land area
- 87 FSTs are defined by their hydrological group as artificially drained to facilitate arable land use, covering 40.7 % of the arable land area in Germany
- Map of drained area percentages shows realistic spatial pattern

Table of Content

Background

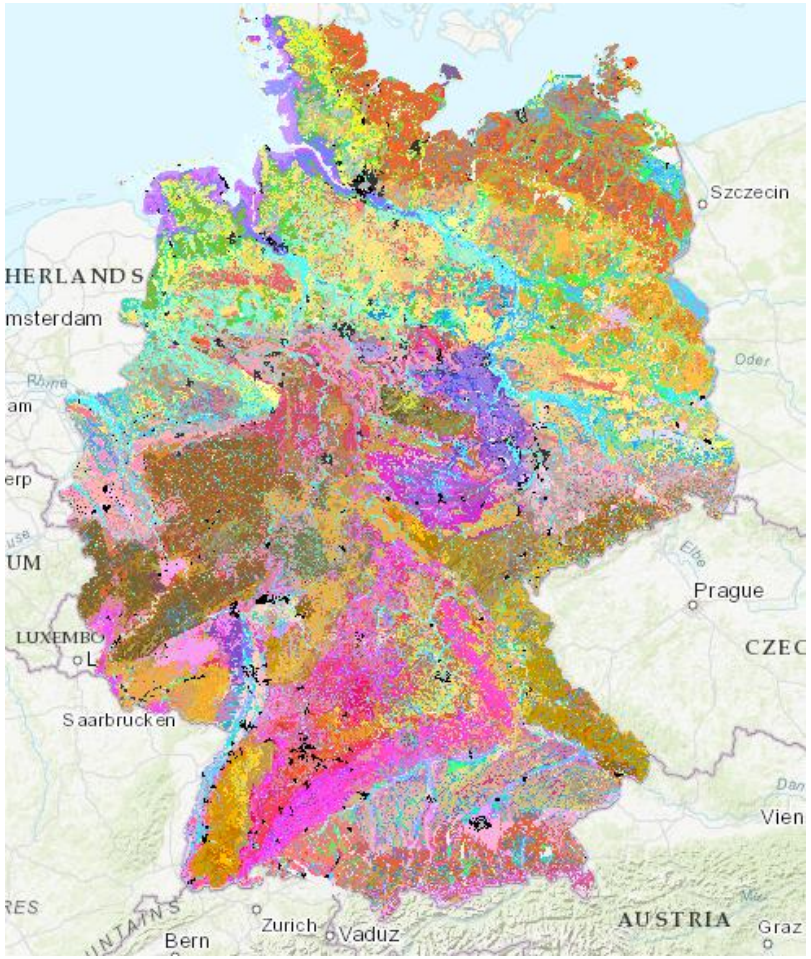
The **FOOTPRINT Soil Type (FST)** system has been derived during the FOOTPRINT project (2006-2009) to facilitate spatially distributed pesticide fate modelling at national or EU scale. The system

- classifies the soil typological units (STUs) of a national or European soil database into limited number of soil types
- reduces the number of unique soil-climate combinations
- is model-independent, but complete parameterization methodologies for pesticide fate models (e.g. MACRO) have been established

The potential of the FST approach to facilitate the application of numerically expensive simulations for large scale has triggered this study to adapt it to classify the soil types for Germany.

Objectives

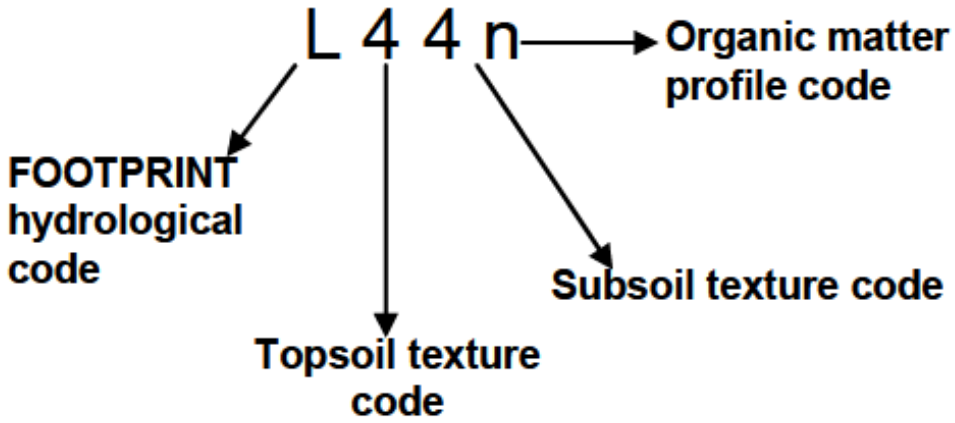
- To translate the latest version of the 1:200,000 German soil map (BUEK200, BGR 2018) into FOOTPRINT Soil Types
- To derive representative profiles for each FOOTPRINT Soil Type for agricultural land use
- To parameterize the representative profiles for the model MACRO



BUEK200 soil types overview
BGR Geoportal - Geoviewer

Soil classification scheme – the FSTs

- The BUEK200 consists of:
  - 9245 distinct soil typological units (STUs), 3648 have arable land uses
  - 4385 distinct soil mapping units
  - Each mapping unit has one to multiple STUs, identified by their area percentages
- Each STU is assigned with a FST code, consists of:
  - A hydrological class
    - FOOTPRINT Hydrological Group (FHG), L-Y
  - A topsoil texture code and a subsoil texture code
    - 1-6: from sandy to very fine clay (5); peat (6) ; hard rock (0: only for subsoil)
  - An organic matter profile (1-3 suffixes)
    - Organic matter content to denote sorption potential



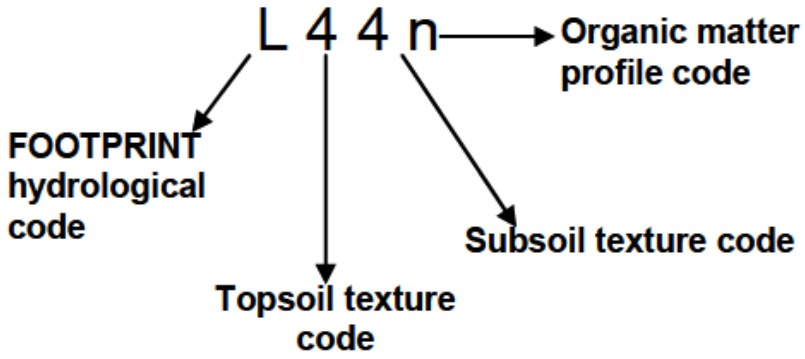
Example of a FST code

Soil classification scheme – FOOTPRINT Hydrologic Groups (FHG)

- Fundamental types of site hydrology
  - Soils L, M, N: free draining (better: free percolation)
  - Soils O, P, Q: groundwater in the profile
  - Soils R, S, T, U, V: impermeable substrate
    - R, S, T: deep/intermediate/shallow soil over hard substrate
    - U, V: deep soil over soft substrate
  - Soils W, X, Y: slowly permeable substrate (leading to perched water tables)
  - Soils Z: undrained peat (not modelled)
- Implications for modelling
  - Q, U, V, Y soils are assumed as **artificially drained** (if not, unsuitable for agriculture)
  - O, P, R, S, T, W, X soils have **lateral subsurface flow**
  - L, M, N soils have neither of them
  - Artificial drains and lateral subsurface flow are technically modelled in the same way in MACRO. However, parameterization and interpretation are different.

Soil classification scheme – Classification of the BUEK200

- The FST classification flowchart was already established during FOOTPRINT, but it has to be translated into rules specific to each soil database
- Follow the classification rules used in the GERDA project (Bach et al., 2017) for BUEK1000 (1:1,000,000 German soil map, BGR)
- The considered soil parameters for all soil horizons from the BUEK200 including but not limited to:
  - Soil substrate, texture, hydromophical status, organic matter content
- Adapt rules where necessary:
  - Account for update of soil survey guideline to KA5 (AG Boden, 2005)
  - Account for greater detail in BUEK200



Example of a FST code

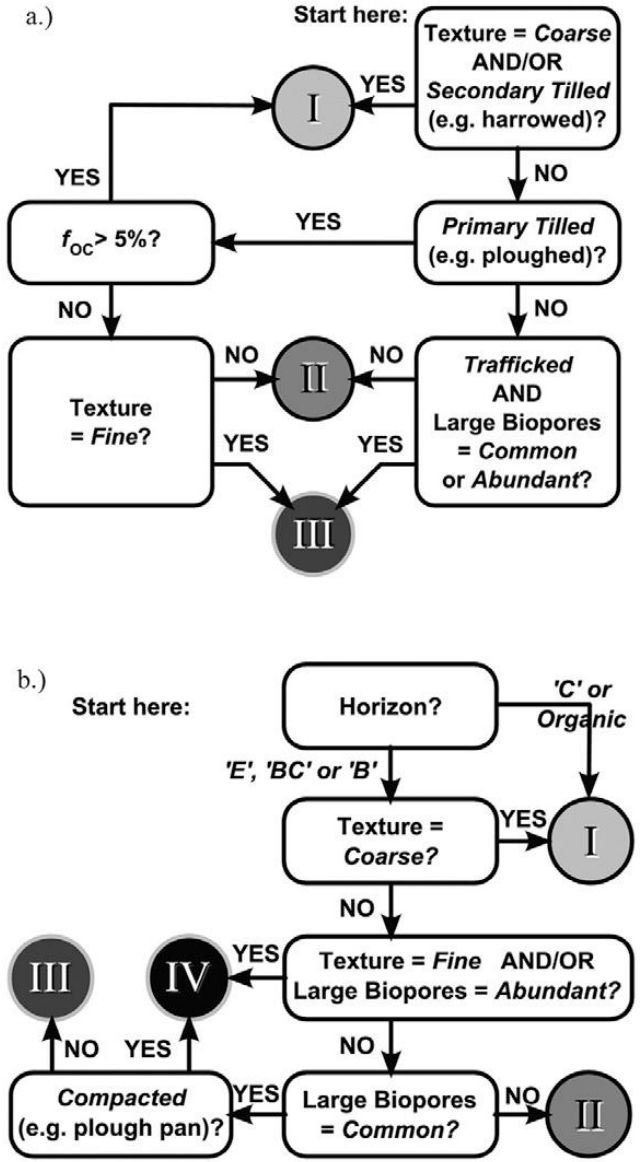
Representative soil profile creation

- A representative soil profile was established for every FOOTPRINT Soil Type (FST) :
  - Depth-weighted average was implemented for the soil profiles classified to the identical FST on the horizon level
    - Only arable soil profiles were considered
    - Soil horizons were selected within the depth interval of 0-30-40-60-70-80-100-120-150-200 cm
  - The averaged soil properties include
    - Clay, silt, sand content, bulk density, organic matter content, volumetric stone content, and stone porosity and pH ($CaCl_2$)
    - Additional parameters include depth to hard rock, depth to differen, hydromorphy levels, thickness of peat layer, depth to limiting factor for earthworms
  - Special care was taken to ensure that mineral soil layers were not mixed with peat or hard rock layers

MACRO parameterization

- MACRO parameterization
  - Implemented in an R package
  - Following method developed in FOOTPRINT (Dubus et al., 2010; Jarvis et al., 2009)

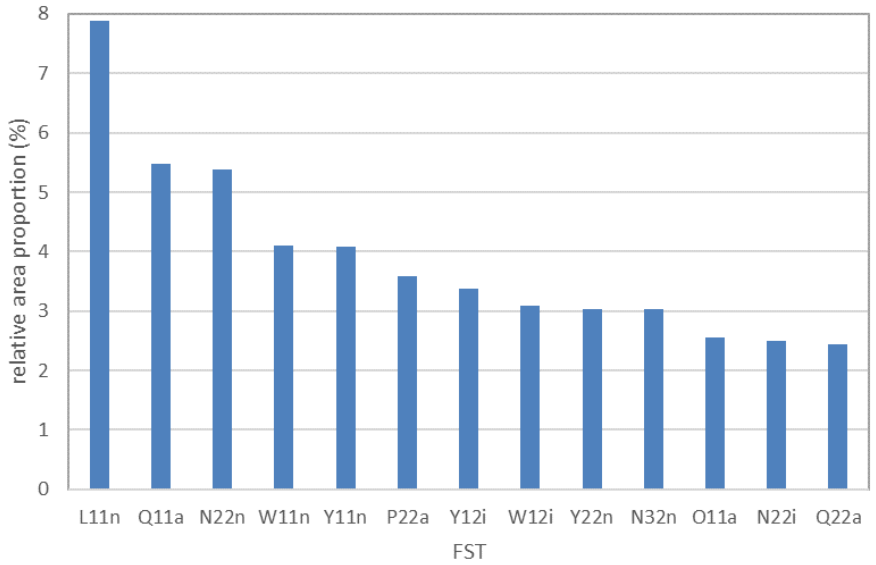
- The parameterized FST profiles could potentially be used for MACRO water balance simulations for diverse soil/climate combinations to enable model´s large-scale application



Soil structure flowchart to determine macropore flow class (Jarvis et al., 2009).

Results – The derived soil classes

- The 3648 STUs with arable land use in the BUEK200 yielded 226 FSTs.
- Area proportions covered by the different FSTs are highly skewed:
  - The 13 most frequent soils already cover 50 % of the arable land area.
  - To cover 90 % of the arable land area one needs to simulate already 64 FSTs



Relative area proportions of the 13 most frequent soils for arable land use after clip with CLC 2018 class 2

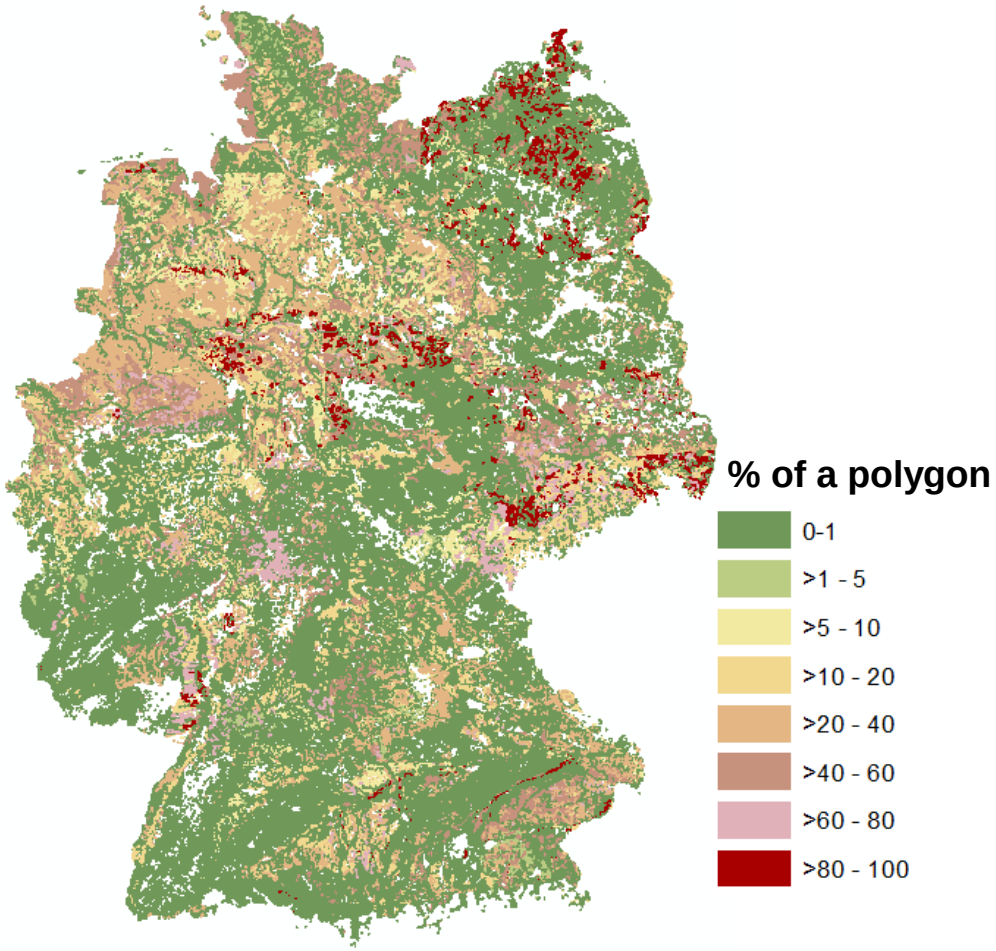
Number of simulated FSTs and the associated percentage of arable land in Germany covered

Area average (%)	Num. of FSTs
50	13
75	32
90	64
95	94
99	162
100	226

Results – the drainage map

- The FST code already contains the information whether the soil needs to be artificially drained to allow arable land use, which facilitated the creation of a map of potentially drained areas in Germany.
  - Assumptions regarding drainage of Soil Typological Units (STUs)
    - Only STUs with land uses of arable land or fallow are considered
    - Only FOOTPRINT Hydrological Group Q, U, V, Y are assumed as artificially drained (otherwise unsuitable for arable land use)
  - Calculation
    - The Corine Land Cover 2018 is applied to extract the agricultural areas for BUEK200
    - For every spatial unit of BUEK200, the arable soil types are rescaled to 100%
    - The drained area is derived **as a percentage of each polygon**

Results – the drainage map



Drained area percentages for BUEK200 clipped with CORINE Land Cover 2018 (EEA, 2020) Class 2, based on the FST classification

- 87 FSTs belong to FOOTPRINT Hydrologic Group Q, U, V or Y and are defined as artificially drained to facilitate arable land use
- They cover 40.7 % of the arable land area in Germany
- The general spatial pattern is realistic, with increased drained area percentages predicted for:
  - River floodplains
  - Areas with glacial till
  - Areas with impermeable rocks
  - Coastal areas with former salt marshes
  - Peatlands
  - Loess areas
- A comparison with other sources of drained area derived:
  - Our research: 2.78 x 10^6 ha
  - Watergap dataset (Feick S, et al, 2005): 2.66 x 10^6 ha

Conclusion and outlook

- The BUEK200 has been classified into FOOTPRINT Soil Types (FST)
- Representative profiles have been derived for all 226 FSTs with arable land use and parameterized for MACRO
- All calculations have been done in an automated way
- A map of potentially drained areas has been produced based on the FST classification
- The present case study for the BUEK200 soil database demonstrates the potential of the FST system for spatially distributed fate modelling at large scale based on national soil databases

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