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Resources Optimization by Homogenization of Agricultural Fields

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JOANNEUM RESEARCH POLICIES

Current Agricultural Situation

- Optimization of resources due to constantly growing population, sustainability and environmental protection
- Management: soil conditions within the fields are not taken into account

  → over-fertilization or undersupply
- Sowing seeds: at proper distances and depth, but selected quantity uniformly for the entire field

  → affect plant development and yield
- Soil samples: taken at 25 different field points, obtained information is averaged and standardized for the entire field

  → high loss of information

Aims and Objectives

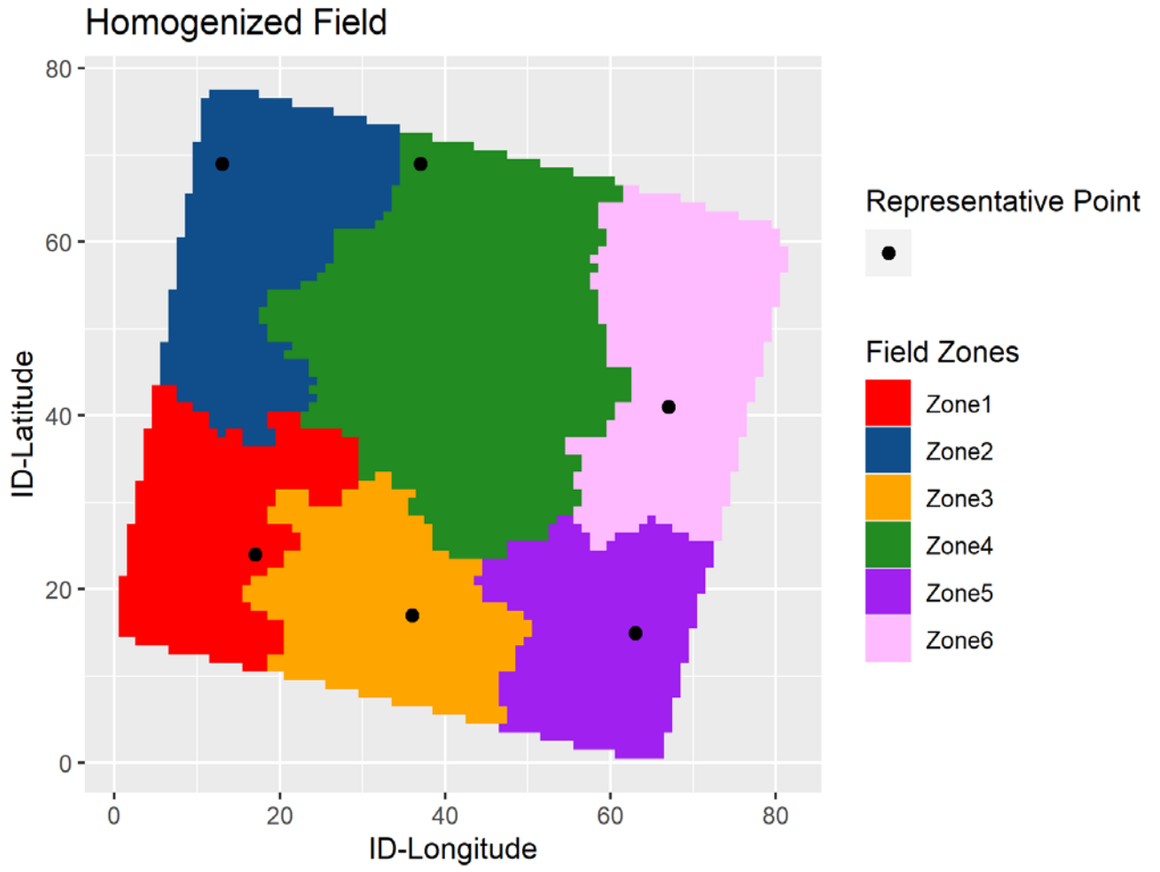
- **Optimization of resources**
  - Exact knowledge of the soil characteristics needed
  - Differences between and within fields have to be identified
- **Characterization of soil differences**
  - Identification of homogeneous field areas (clusters) based on georeferenced soil sensor data
- **Identification of representative points**
  - Basis for additional soil samples

    → analysis in labor

Diverse Soil Types

How to Split a Field Into Homogeneous Areas?

?



Prerequisites for Zoning

- Extensive data base
  - Georeferenced data matrix, point related to geografical location (longitude, latitude, altitude)
- Collection of divers soil parameters
  - Data should describe soil characteristics
- Technologies for data generation
  - Diverse sensor technologies
  - Satellite information
  - Results from chemical analysis of soil data
  - Drone-collected data
- Statistical methods to extract relevant information from recorded data

Soil sensor generates thousands of georeferenced data records per field

Data Recording by Veris Soil Sensor

RTK GPS
permanent measurements

electrical conductivity
- 0 – 30 cm
- 0 – 90 cm
permanent measurement

pH measurements
every 20m

Infrared and red-radiation
every second measurement

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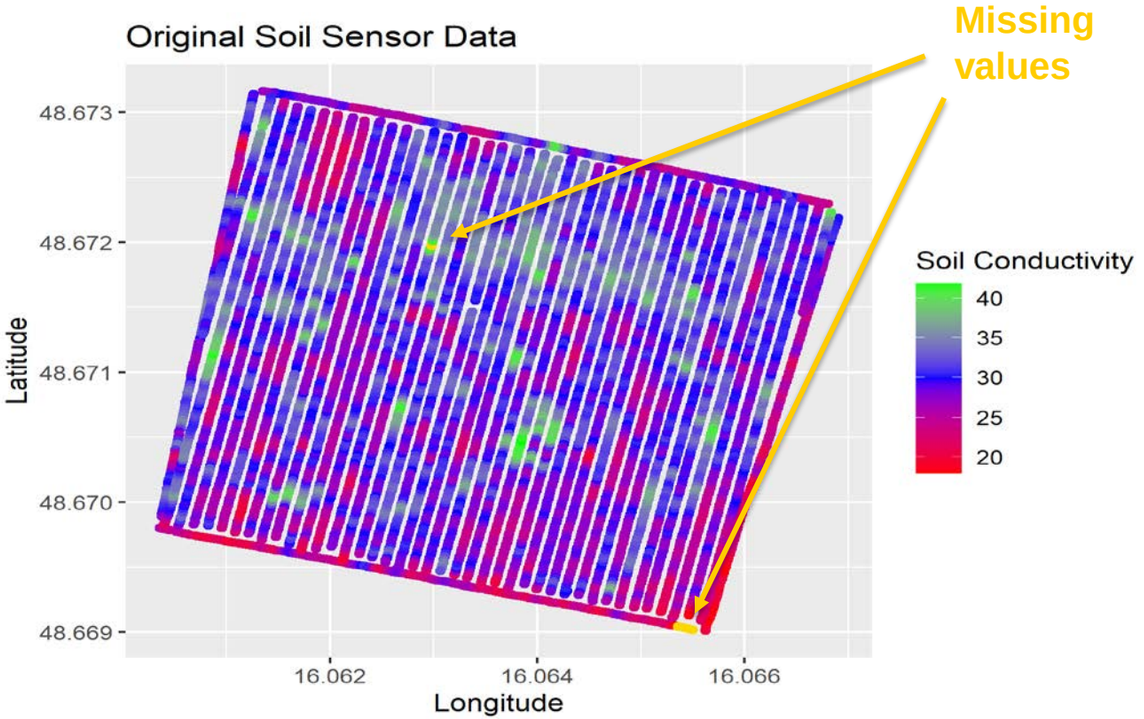
Data Recording on a Field

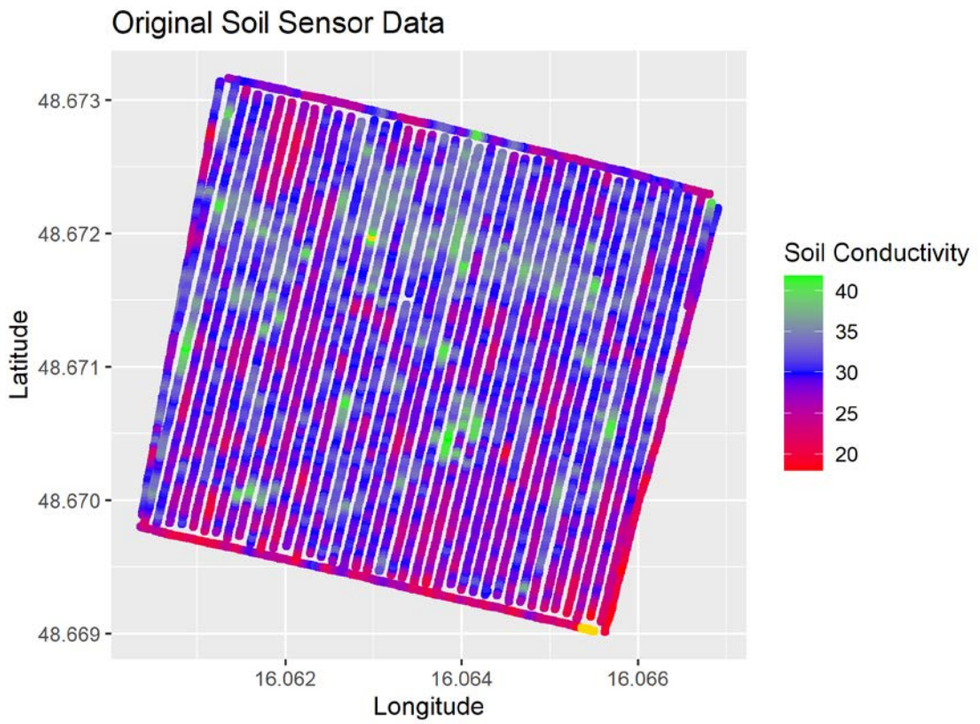
Step 1: drive along the edge of the field

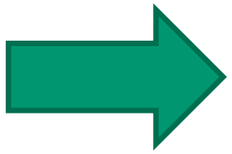
Step 2: drive inside the field, distances between two tracks constant

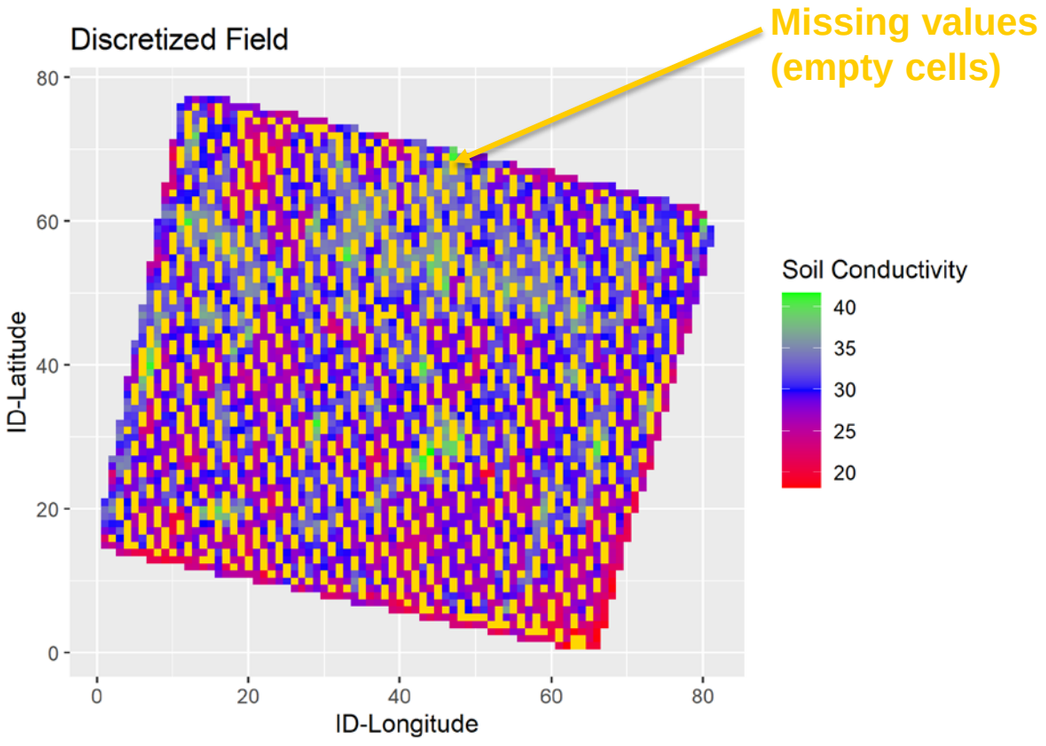


Data Preparation

- 1. Plausibility check to eliminate non-positive values and outliers
- 2. Data discretization on 6mx6m grid to ensure data completeness
- 3. Data aggregation (by mean calculation) in order to get one value per cell

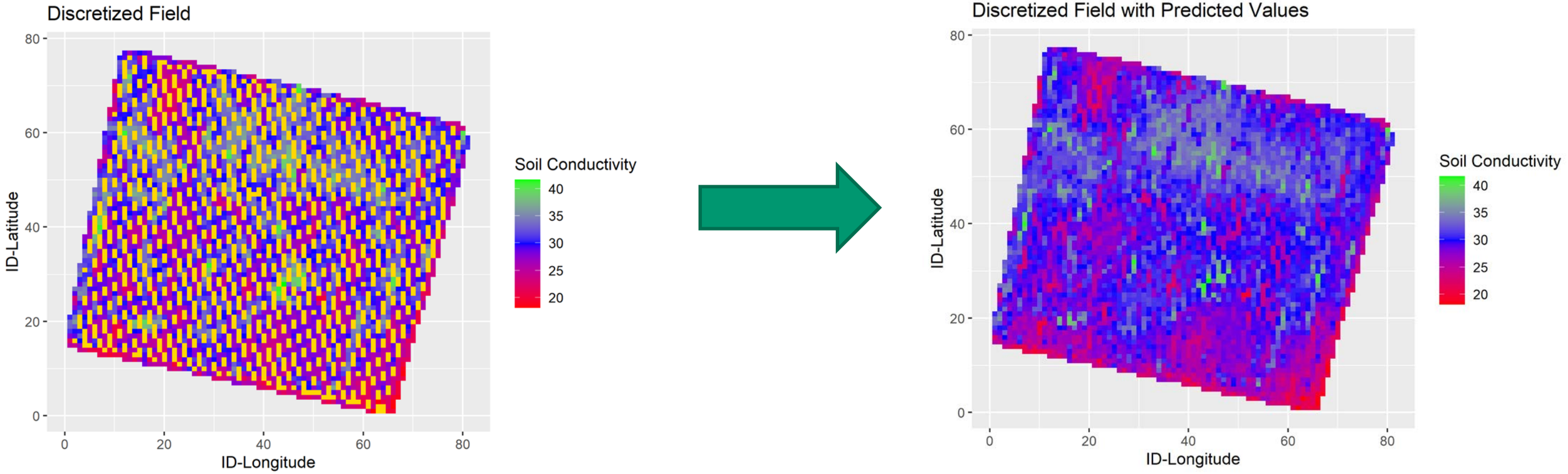






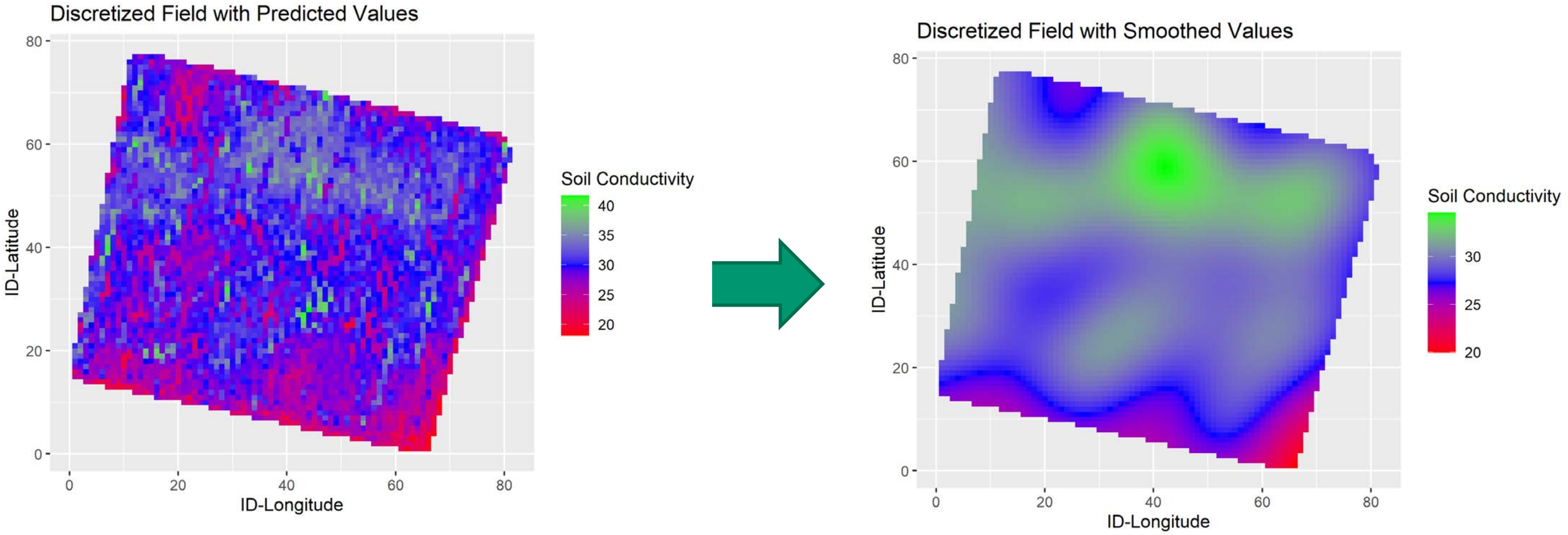
Spatial Interpolation

- Prerequisite for identification of homogeneous areas
  - Prediction of missing values (empty cells) in order to get complete data
    - **Model of choice: Generalized Additive Model (GAM)**



Data Smoothing

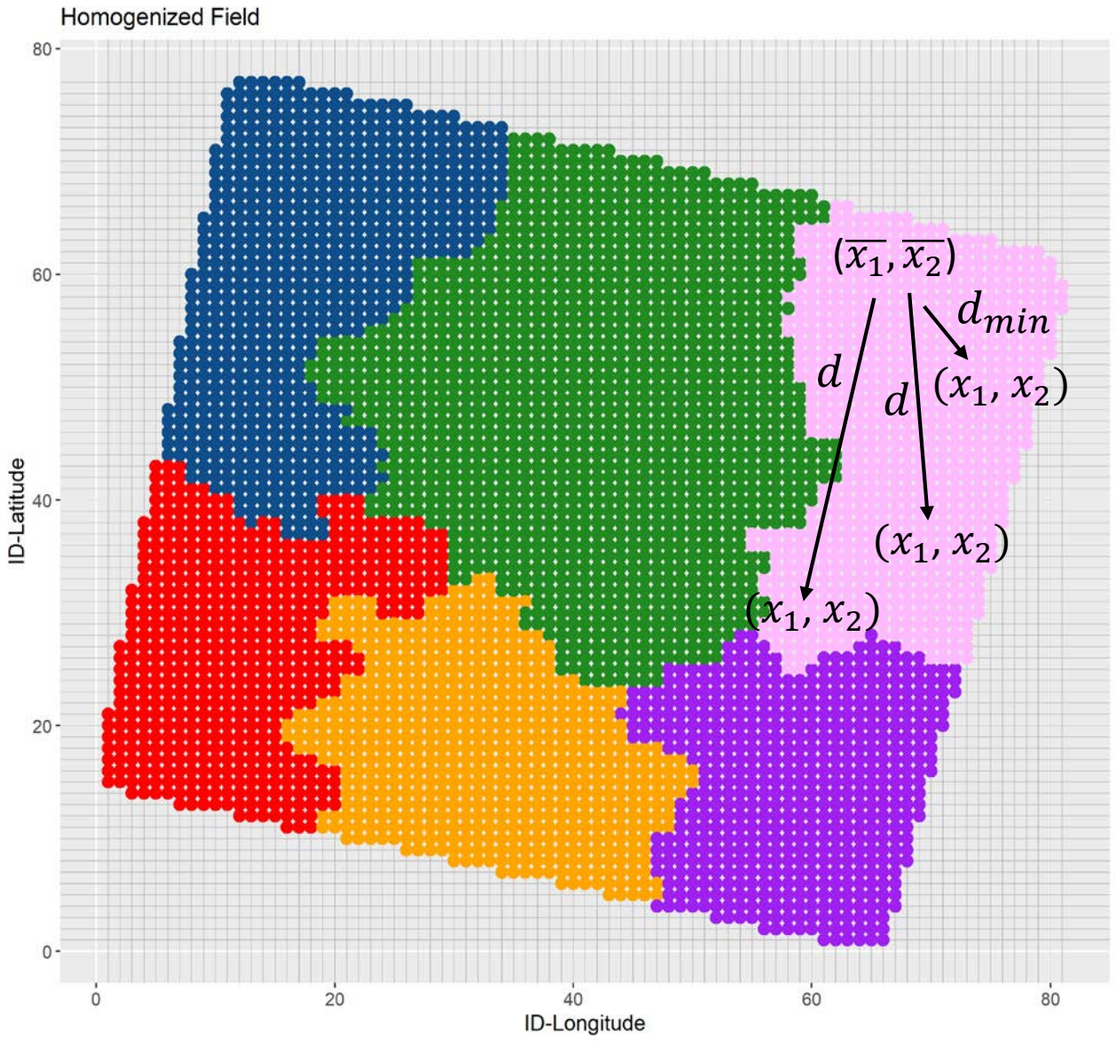
- Smoothing of all values by GAM proved to be more beneficial



Identification of Homogeneous Field Areas

- Application of cluster analysis
  - Approach that groups a set of objects similar to each other in the same clusters
  - Objects within the same cluster are dissimilar to the objects in other clusters
  - Number of clusters n must be specified in advance
- Hierarchical clustering performed in statistical software R
  - $\mathrm{hclust}(d, \mathrm{method})$, where d denotes the Euclidean distance (dissimilarity measure)
- Cluster analysis is based on m explanatory variables
  - Our case ($m = 2$): soil conductivity parameters (in 30cm and 90cm depth)

Identification of Representative Points



- 1. Determination of overall-mean for each explanatory variable and cluster

  → for m=2, n=6: Zone1$(\bar{x}_1, \bar{x}_2)$,…, Zone6$(\bar{x}_1, \bar{x}_2)$

- 2. Computation of the Euclidian distance between overall-mean and cell values (x_1,x_2) of the respective cluster

$$d_l = \sqrt{(\bar{x}_1 - x_1)^2 + (\bar{x}_2 - x_2)^2} \text{ for } l = 1, \dots, 6$$

- 3. For each cluster the selection of the cell with minimum d_l

→ Representative point

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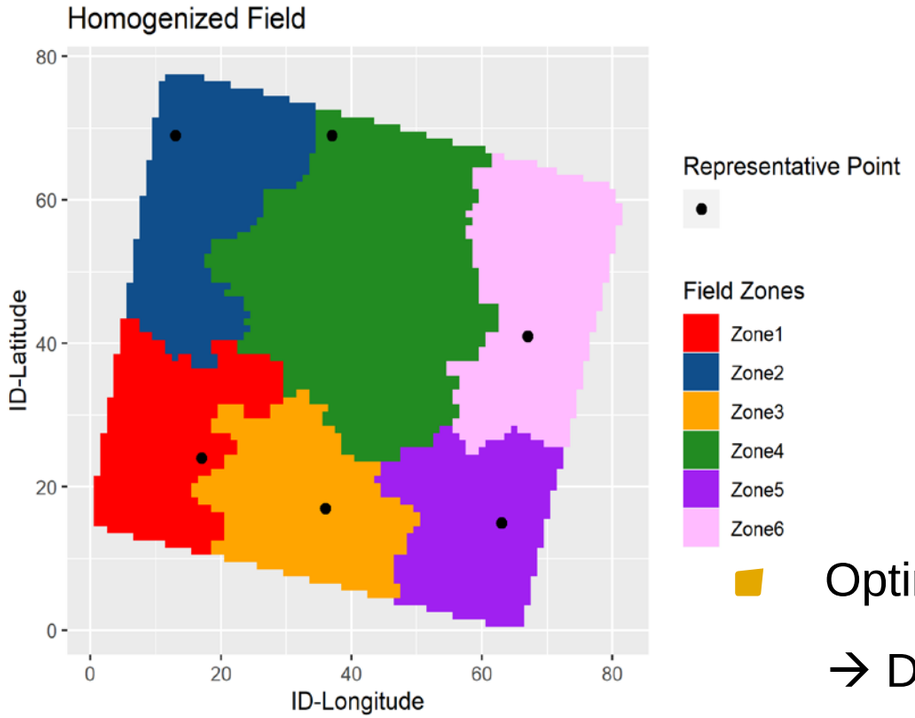
Methodology Advantages

- Obtained zone information basis for determination of sowing quantities and application maps

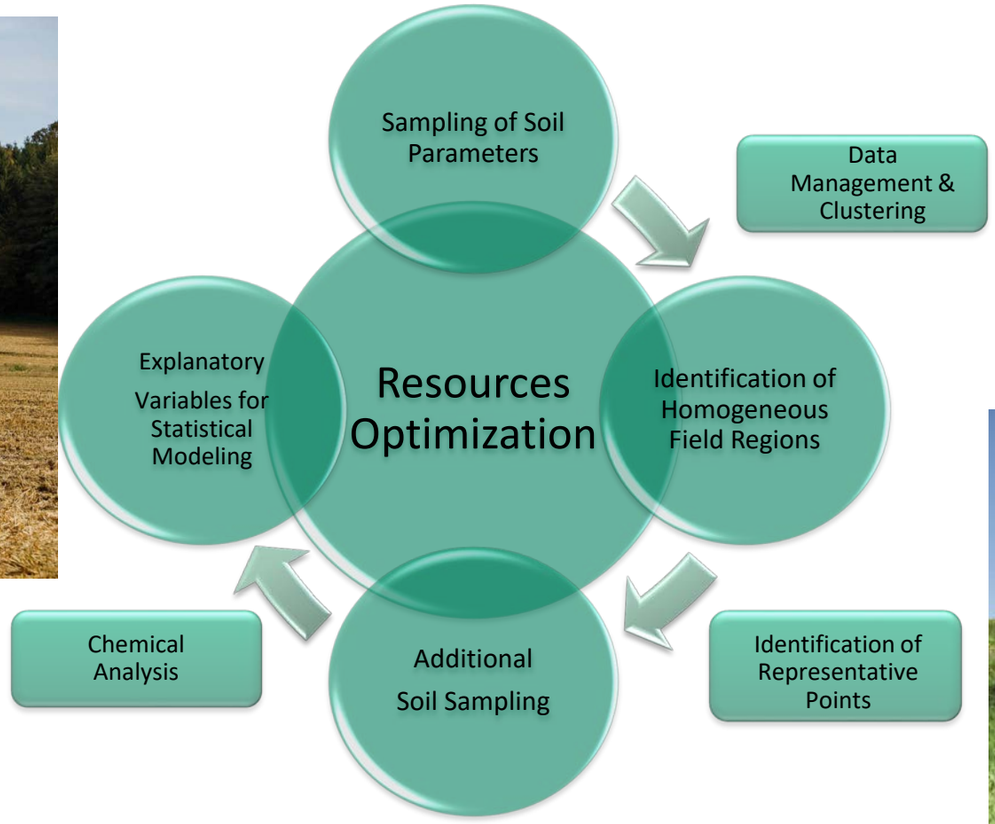


- Optimal points for additional soil data collection and analysis in labor

  → Data are characteristic for the entire zone, not only one point

- Zone information and results from chemical analysis basis for statistical modeling of crop, manuring and irrigation
- Applicability does not depend on the farm size and shape of a field

Resources Optimization Diagram



Future Work

- Data fusion: Inclusion of remote sensing data into the existing database
  - Diverse vegetation indices as further explanatory variables
  - To what extent the zoning of homogeneous areas with similar growth conditions can be improved
- Consideration of seasonal and year-specific effects
- Consideration of weather conditions

Thank You For Your Attention!

Fotocredit: Maschinenring Steiermark

Partners

Data Recording & Sampling on Representive Points by

Maschinenring Steiermark Nährstoffmanagement

aGRAR-ZT

Statistical Analysis, Database Building and Development of a Shiny-App by

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