Creation of high resolution soil parameter data by use of artificial neural network technologies (advangeo®)

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GeoFARMatics 2010 INTERNATIONAL CONFERENCE

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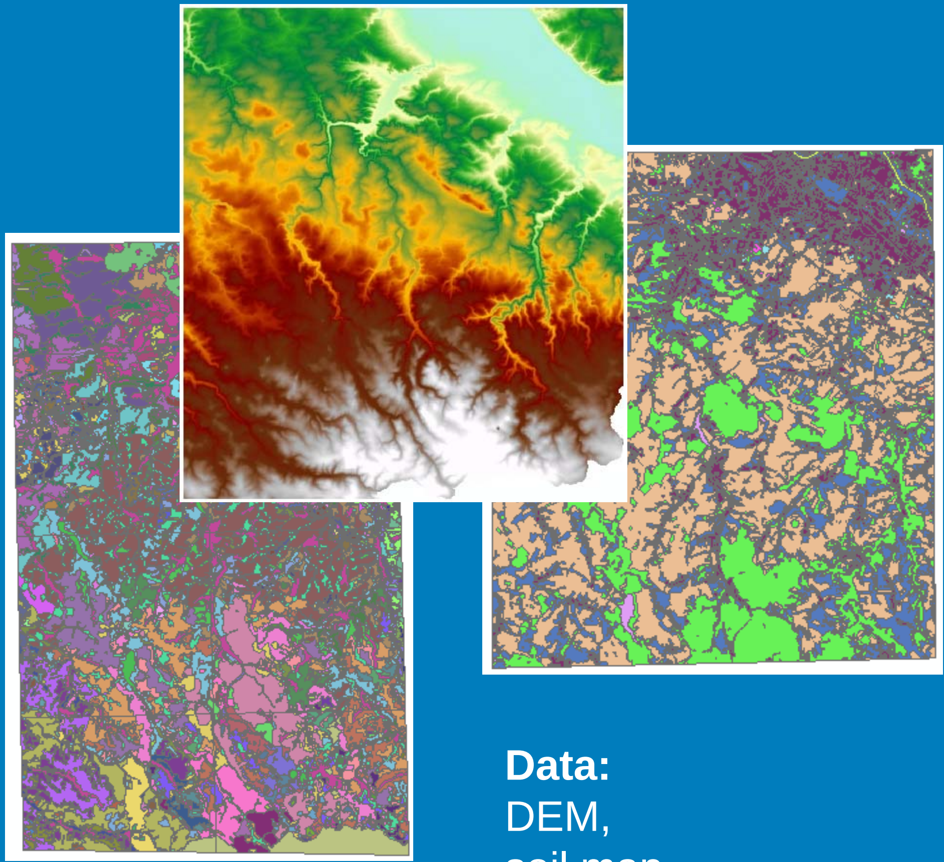
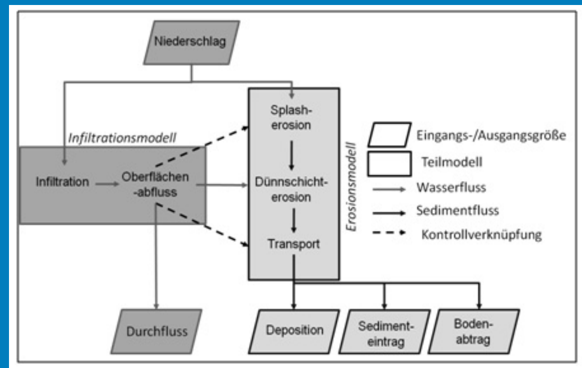
Available Data and Knowledge



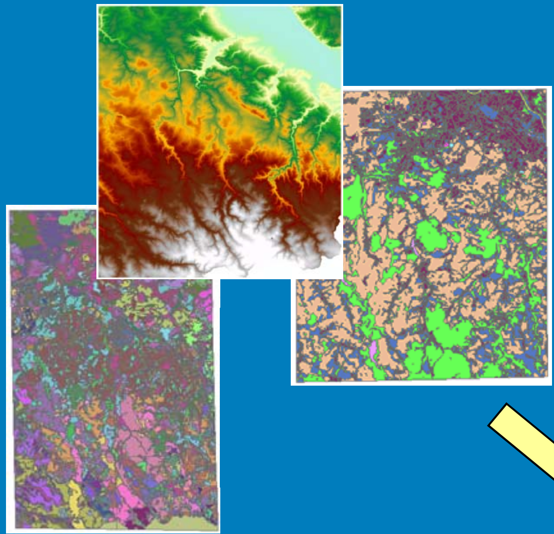
Data:
DEM,
soil map,
land use,
yield map

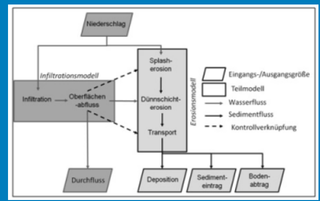
Training Data: Aerial Images, Field Observations



Knowledge: Natural Processes

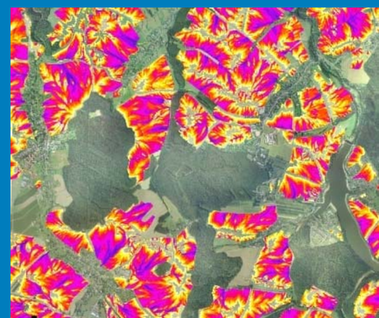
Traditional Approach



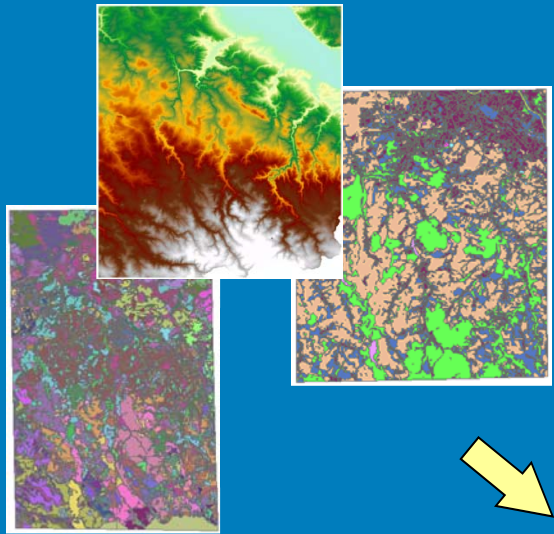


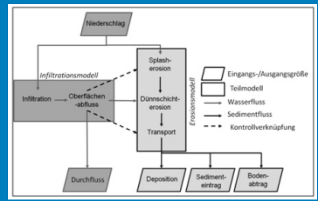
Traditional prediction methods are based mainly on the expert´s knowledge / experience supported by modern information technology

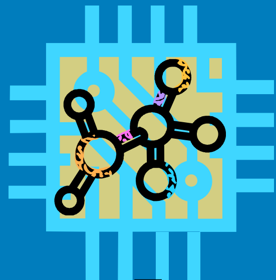
Data Analysis and Interpretation



Modern Approach Using Artificial Intelligence

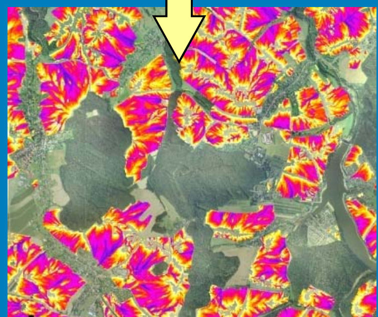






Pre-Processing

The artificial neuronal network “replaces” the experts empirical data analysis



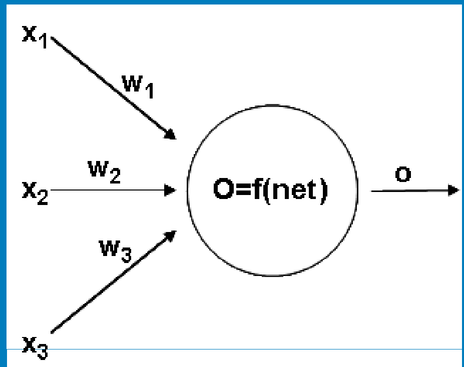
Validation

Model: Neuron Cell

- Functionality as a biological neural system
- Consists of artificial neuron cells
- Simulation of biological processes of neurons by use of suitable mathematical operations
- In most cases layer-like configuration of the neurons

The Neuron Cell as a Processor

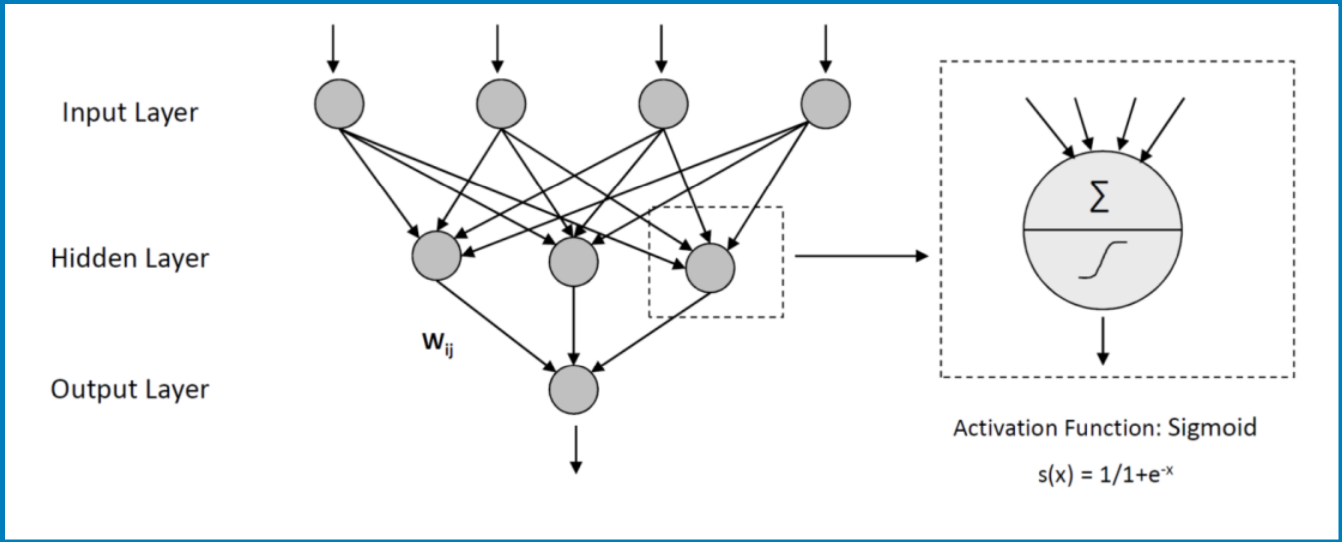
- **Connection between the neurons by weights w**
  - Enforce or reduce the level of the input information
  - Are directed, can be trained
- **Input signals**
  - Re-computed to a single input information: the propagation function
- **Output signals**
  - Activation function computes the output status of a neuron (often used: Sigmoid function)



Principle Setup of Artificial Neural Networks

Network Topology: MLP (Multi Layer Perceptron)

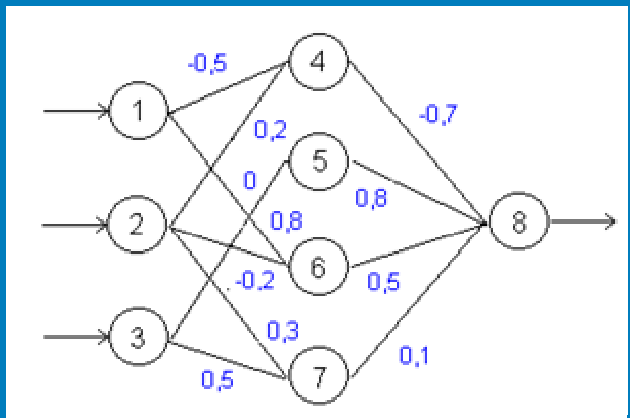
- Set-up of neurons in layers
- Direction and degree of connections
- Amount of hidden layers and neurons

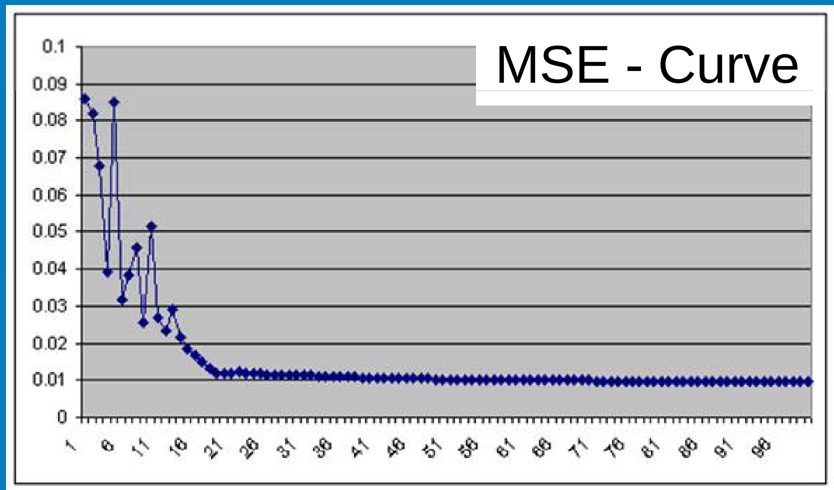


Training of Artificial Neural Networks

Learning Algorithm: Back-Propagation

- Repeated input of training data
- Modification of weights w
- Reduces error between expected and actual output of the network





Advantages / Disadvantages of Artificial Neural Networks

Advantages:

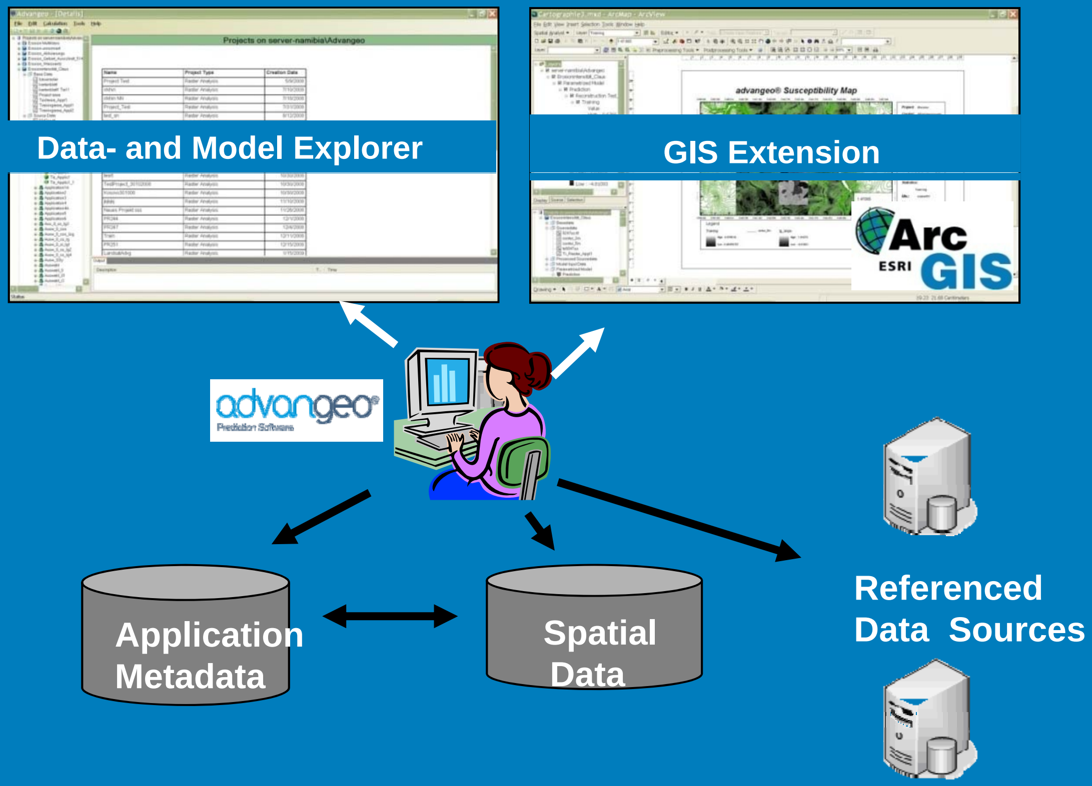
- ***learnable***: learning from examples
- ***generalization***: able to solve similar problems that have not been trained yet
- ***universal***: prediction, classification, pattern recognition
- able to analyze complex, non-linear relationships
- f***ault-tolerant*** against noisy data (e.g. face recognition)
- ***quickness***

Additional characteristics:

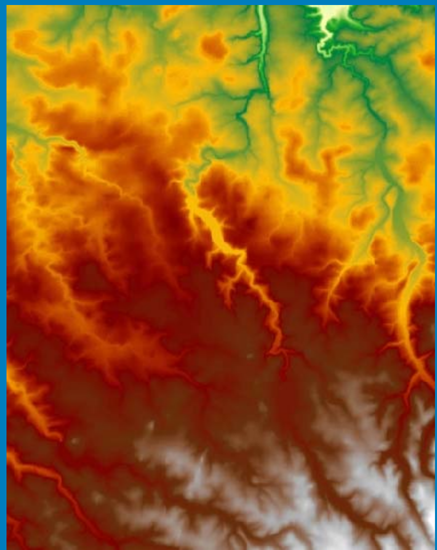
- choice of ***topology*** and ***training algorithm***
- ***black box system***: evaluation of weight of parameters

Software: advangeo® Prediction Software

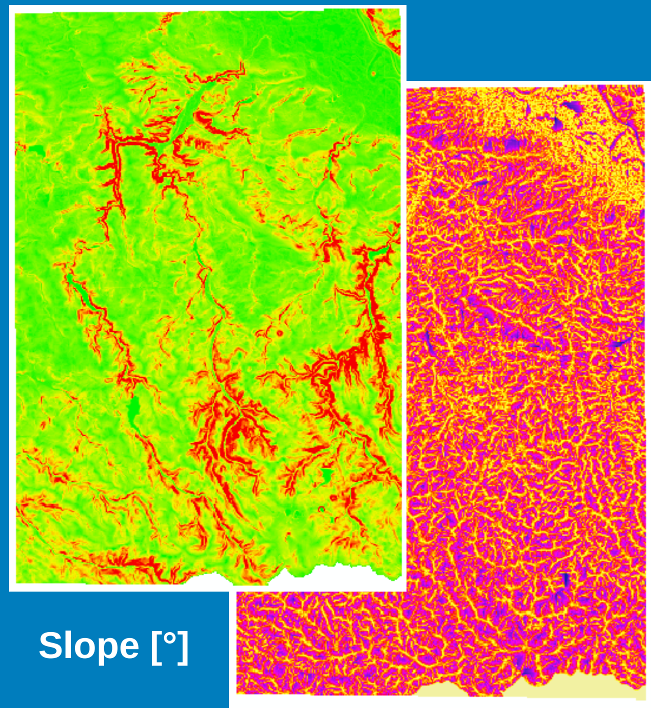
- Easy Access to Methods of Artificial Intelligence for Spatial Prediction
- Documentation of Working Steps
- Capture and Management of Metadata for Geodata
- Tools for Data Pre-Processing, Post-Processing and Cartographic Presentation
- Integration into Standard ESRI ArcGIS-Software



Input Data: Derivate of the Digital Elevation Model
→ Slope



DEM Saxony 5m RESAMPLED

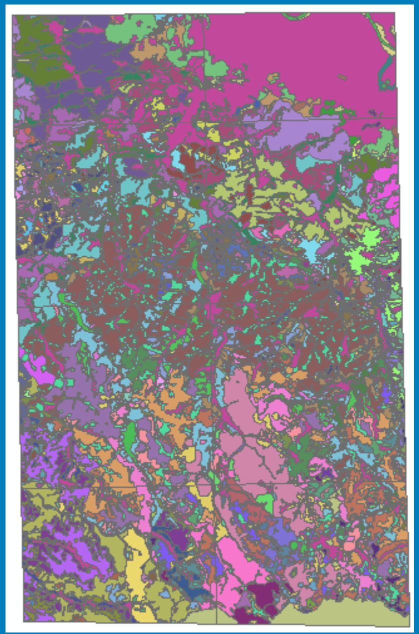


Slope [°]

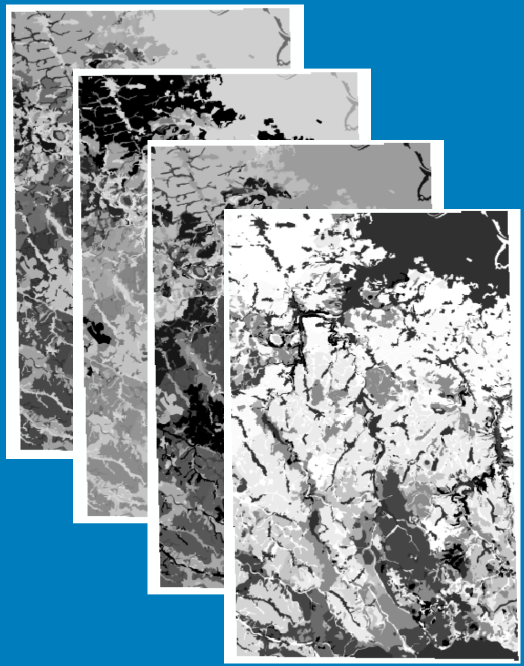
Log Flow Accumulation

Case Study 1: Extensive Soil Erosion

Input Data: Soil Map
→ Fine Soil (Clay, Silt, Sand), Skeleton Soil



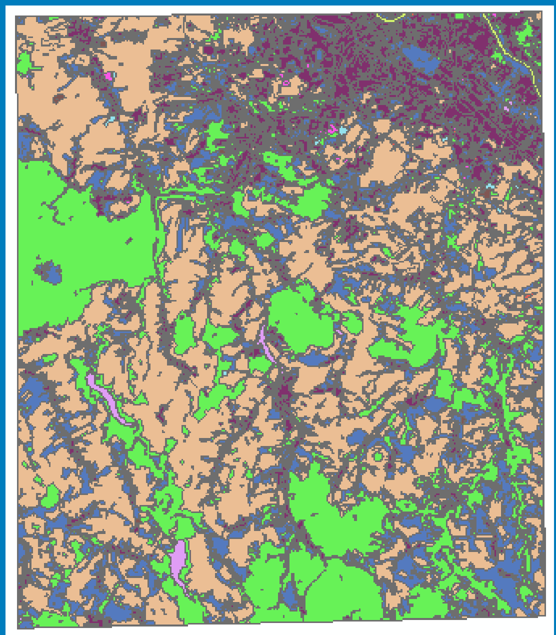
Soil Map



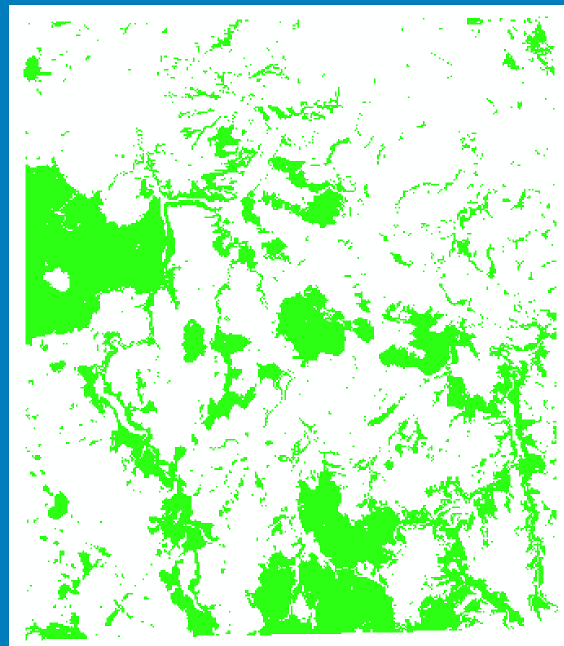
Fine Soil
(Clay, Silt, Sand), Skeleton Soil

Case Study 1: Extensive Soil Erosion

Input Data: Land use (ATKIS, Biotope Type Mapping)
→ Forest, arable land, pastures, wetland, etc.



Land use (ATKIS, Biotope Types)



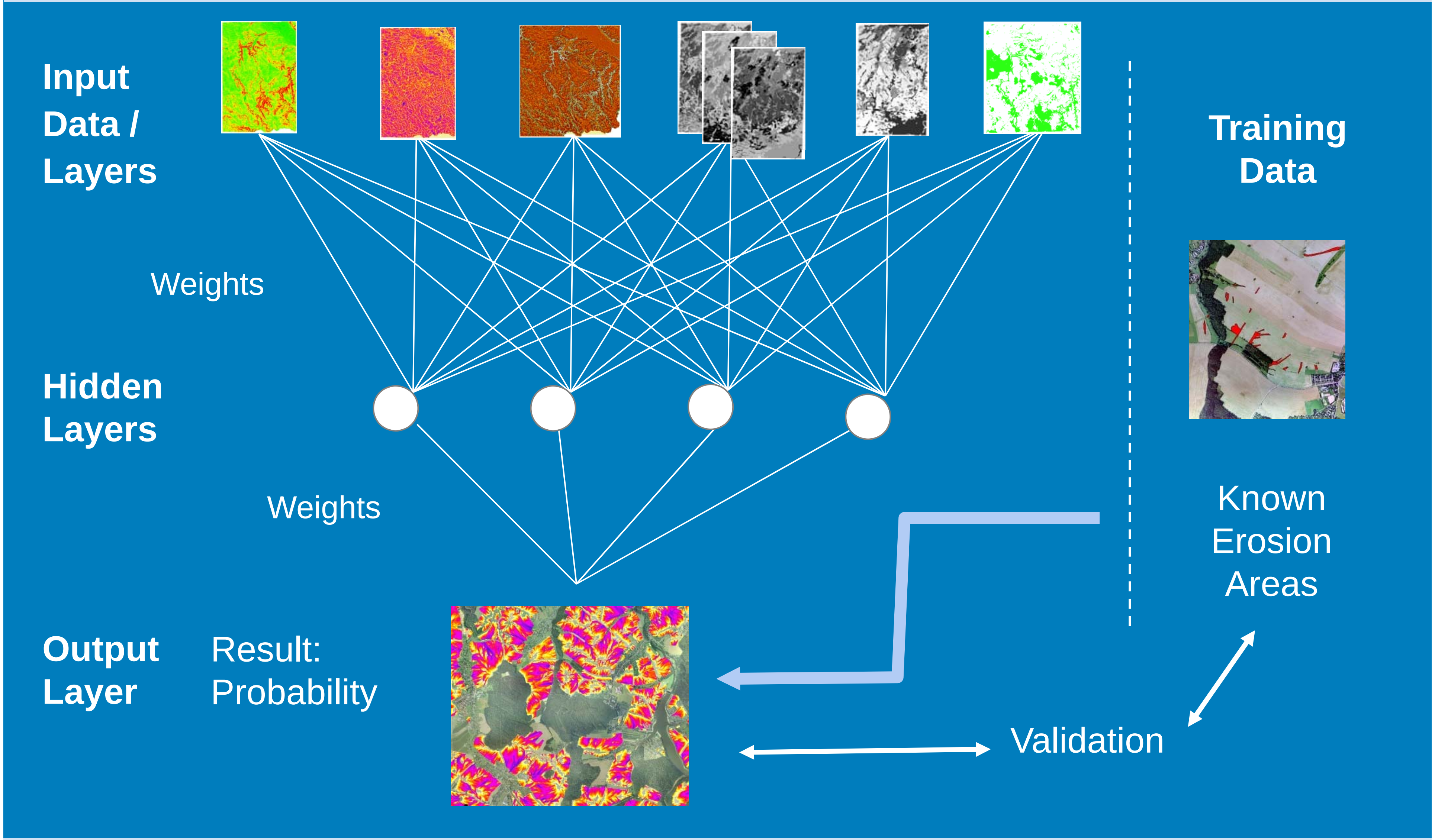
Single raster for each land use class (Forest, arable land, pastures, wetland., etc.)

Training Data: Based on Aerial Images
→ Mapping of Erosion Areas

Aerial Images – intense rainfall/flood 2002

Mapped Erosion Areas

Case Study 1: Extensive Soil Erosion

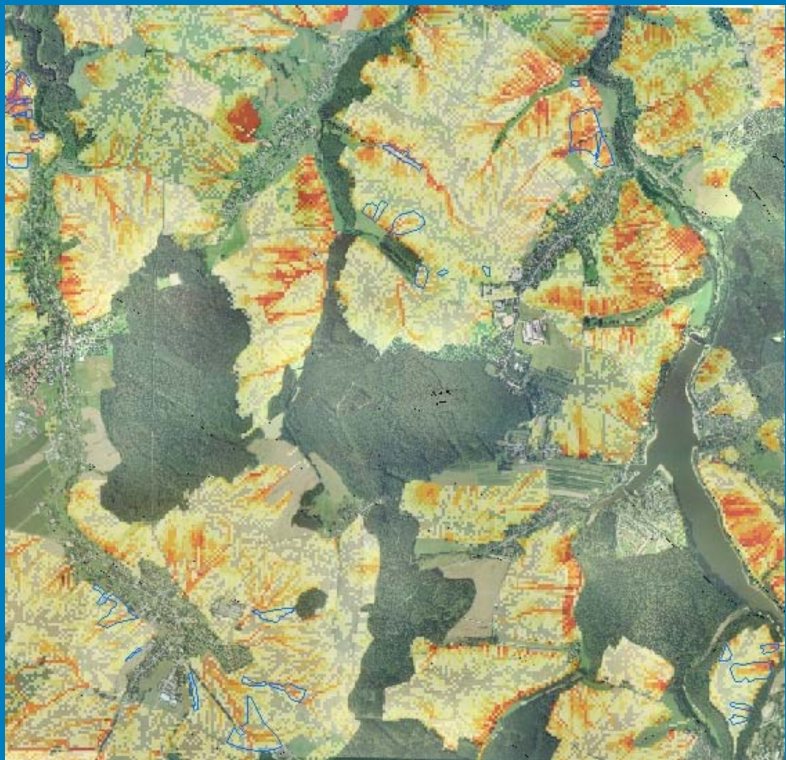


Case Study 1: Extensive Soil Erosion

Input Data:

Slope, Silt, Clay, Sand, Landuse, Flow Accumulation

+ Horizontal curvature



Re-Modeled Erosion Areas:

Training Areas

ca. 80 % of known erosion areas with p>75%

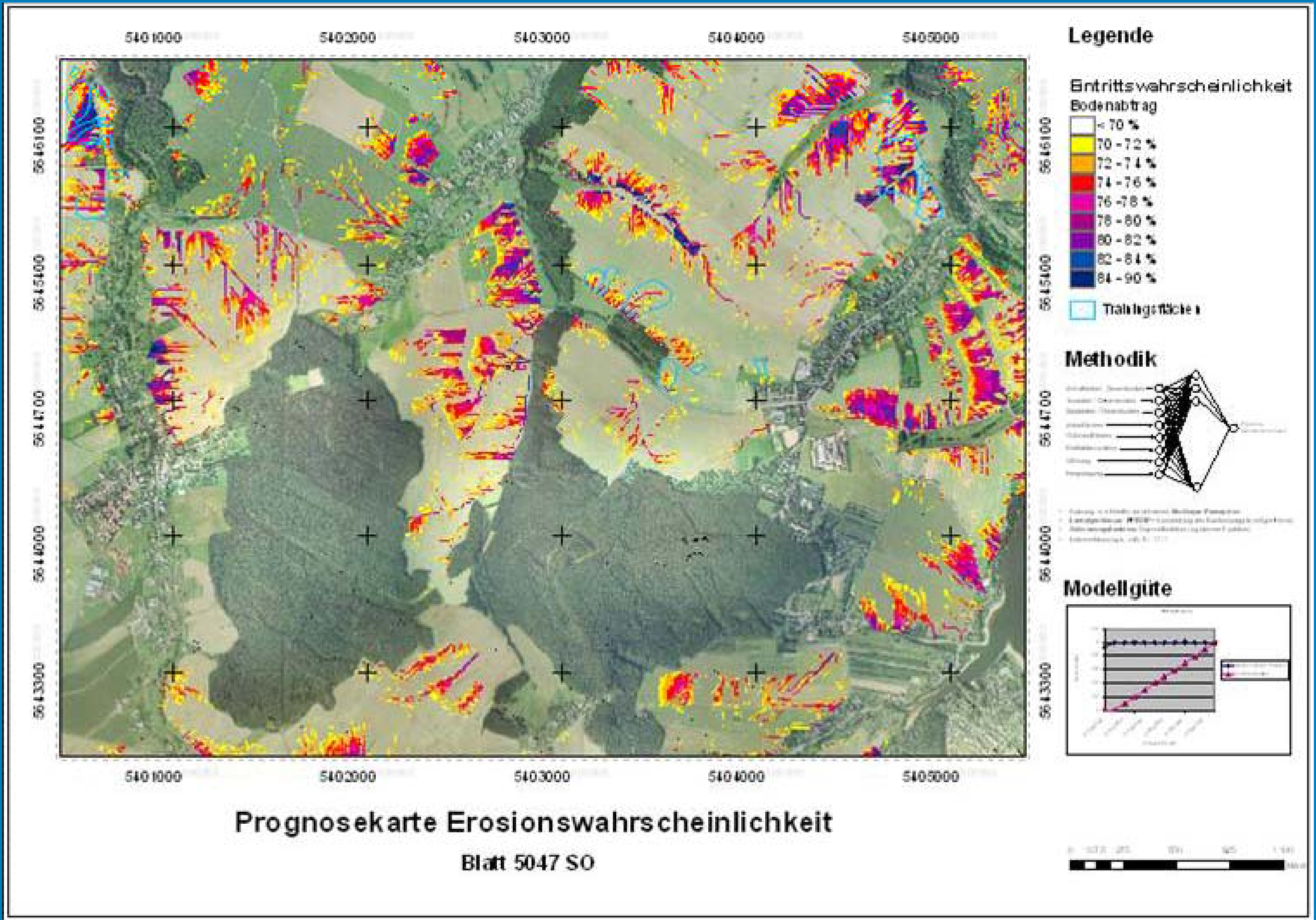
Test Area:

ca. 90 % of known erosion areas with p>75%

Probability:

- 0.5 - 0.55
- 0.55 - 0.6
- 0.6 - 0.65
- 0.65 - 0.7
- 0.7 - 0.75
- 0.75 - 0.8
- 0.8 - 0.85
- 0.85 - 0.9
- 0.9 - 1

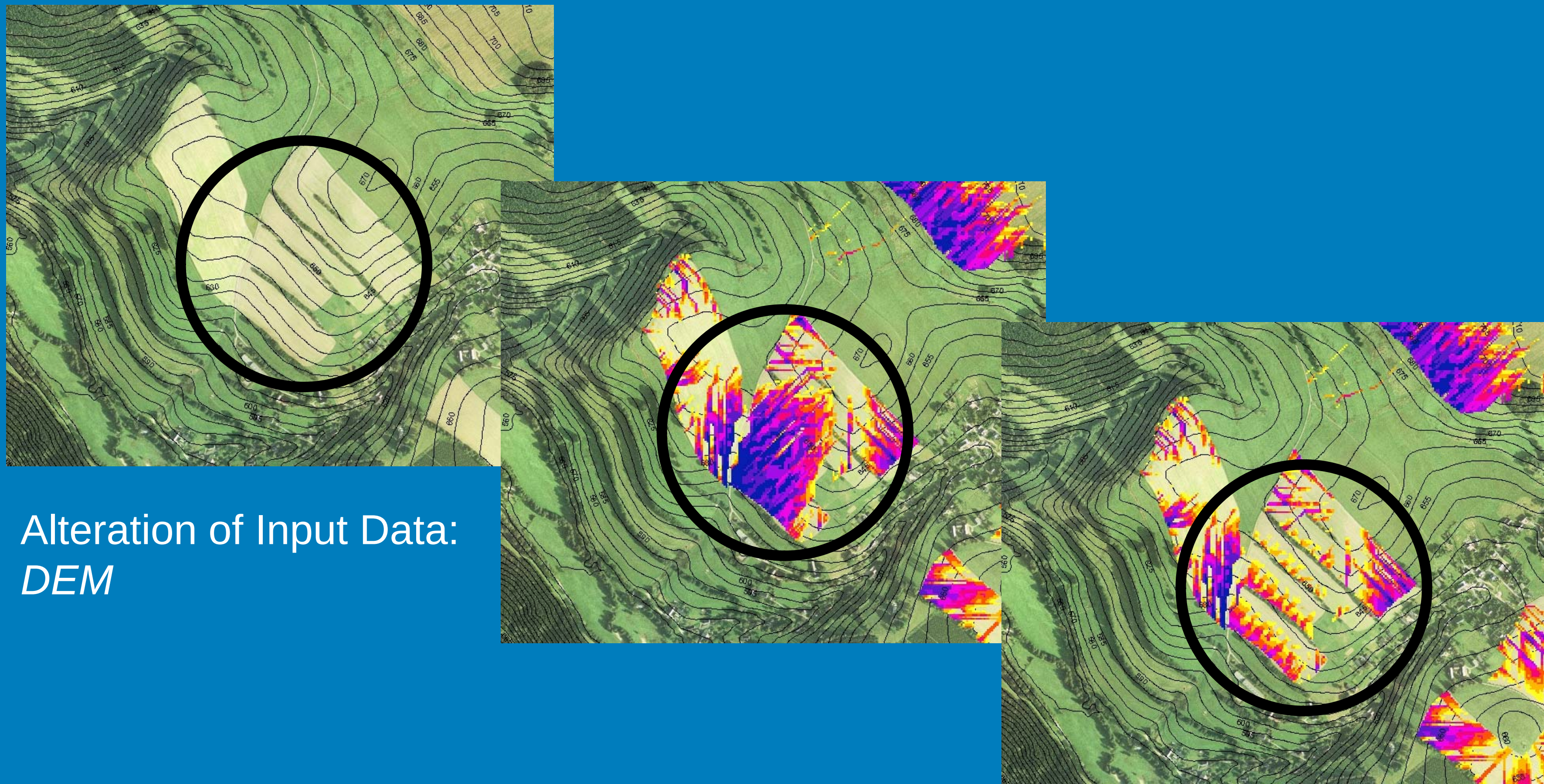
Case Study 1: Extensive Soil Erosion



Case Study 1: Extensive Soil Erosion

Validation of Prediction Results in the Field

Optimization of Protection Measures

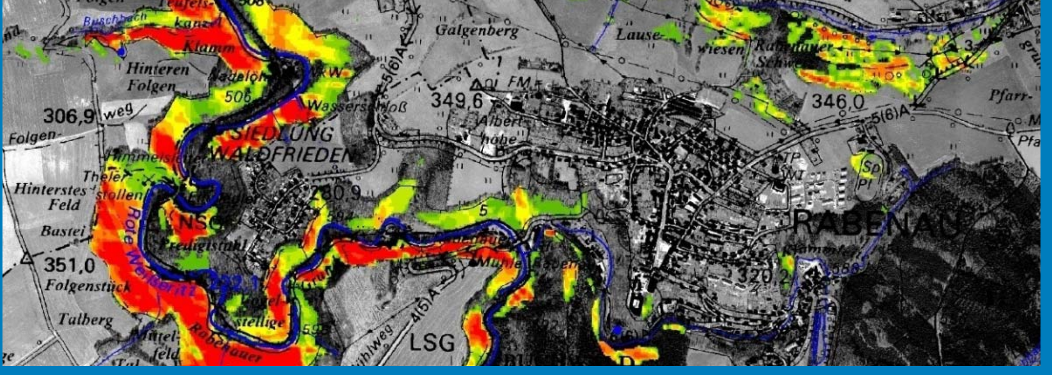


Alteration of Input Data:
DEM

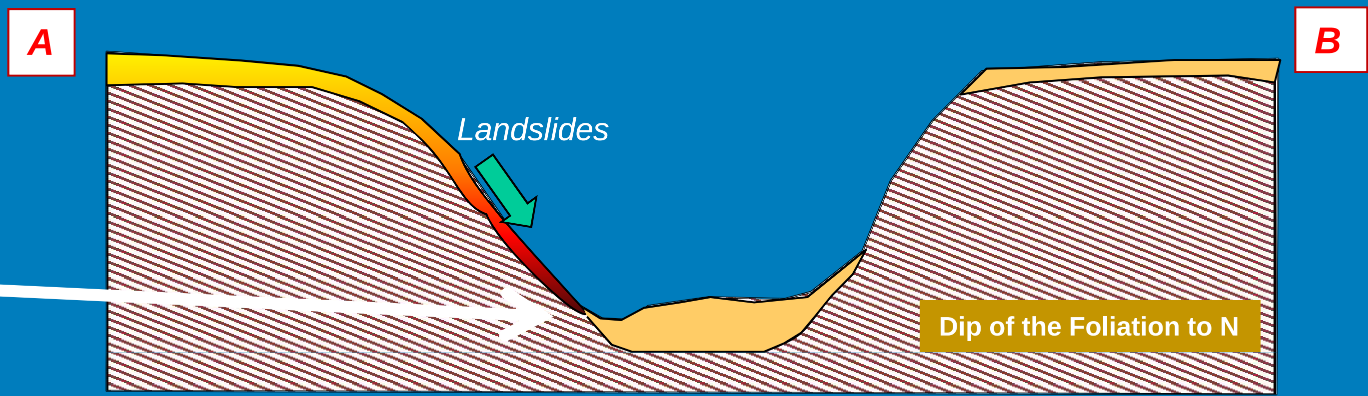
Case Study 2: Soil Creeping

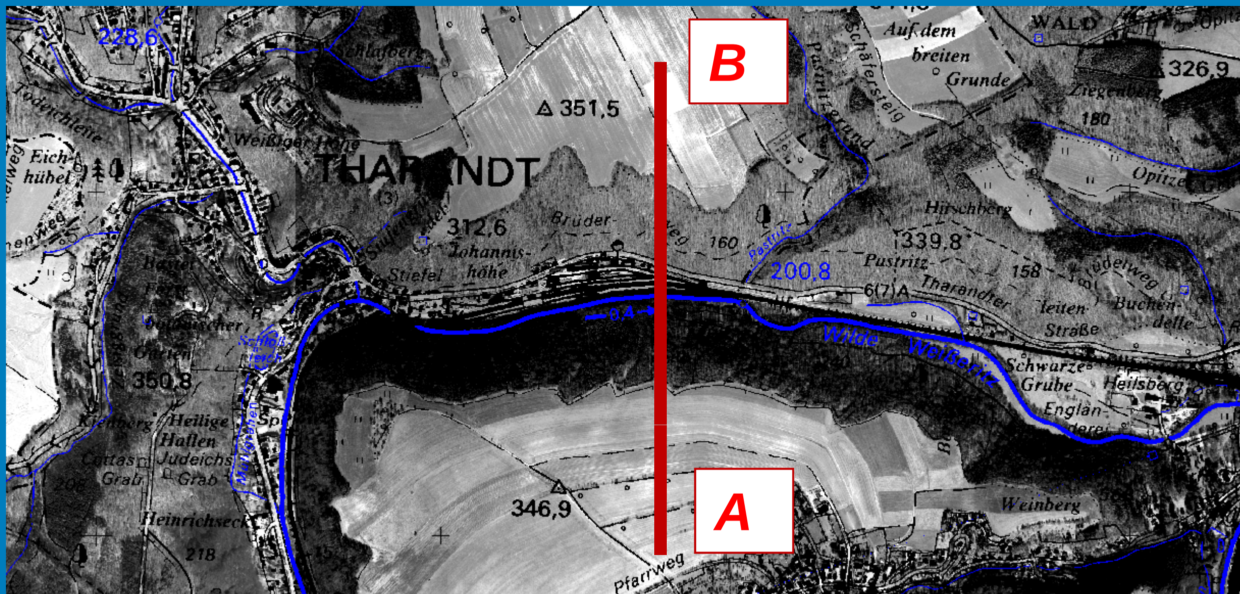
Input Data
Elevation Model and its Derivates
Geology: Lithology, Foliation
Landuse
Soil Types

Training Data
Known Areas with
Sliding / Creeping



Case Study 2: Soil Creeping

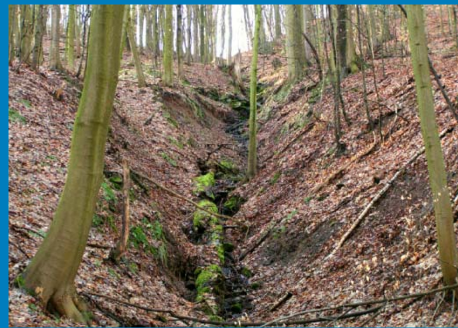




Case Study 3: Erosion Gullies

Input Data
Elevation Model and its Derivates
Geology: Lithology, Foliation
Landuse
Soil Types

Training Data
Known Areas with
Gullies



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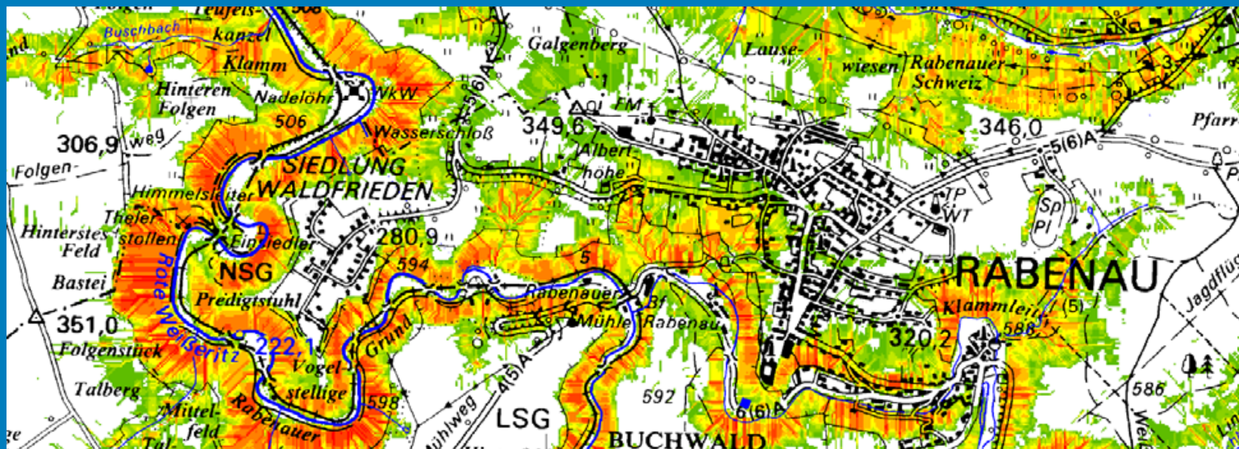
Prediction Software



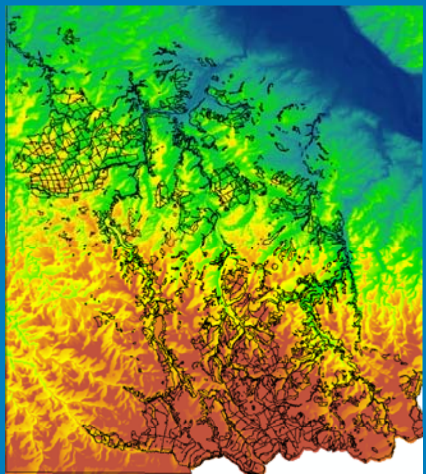
Case Study 4: Spread of Forest Pests

Input Data:
Elevation Model and its Derivates,
Soil Map,
Forest Inventory Data

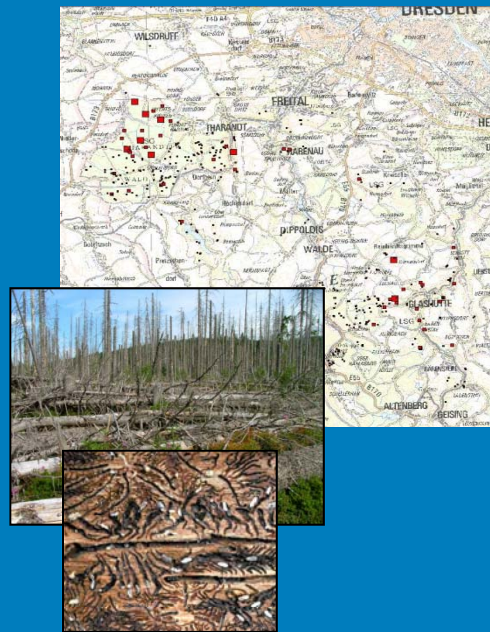
STAATSBETRIEB SACHSENFORST | Freistaat SACHSEN

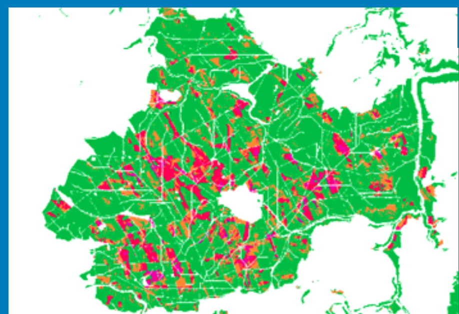
Sachsenforst

Training Data:
Qualitative/
Quantitative
Infection Data



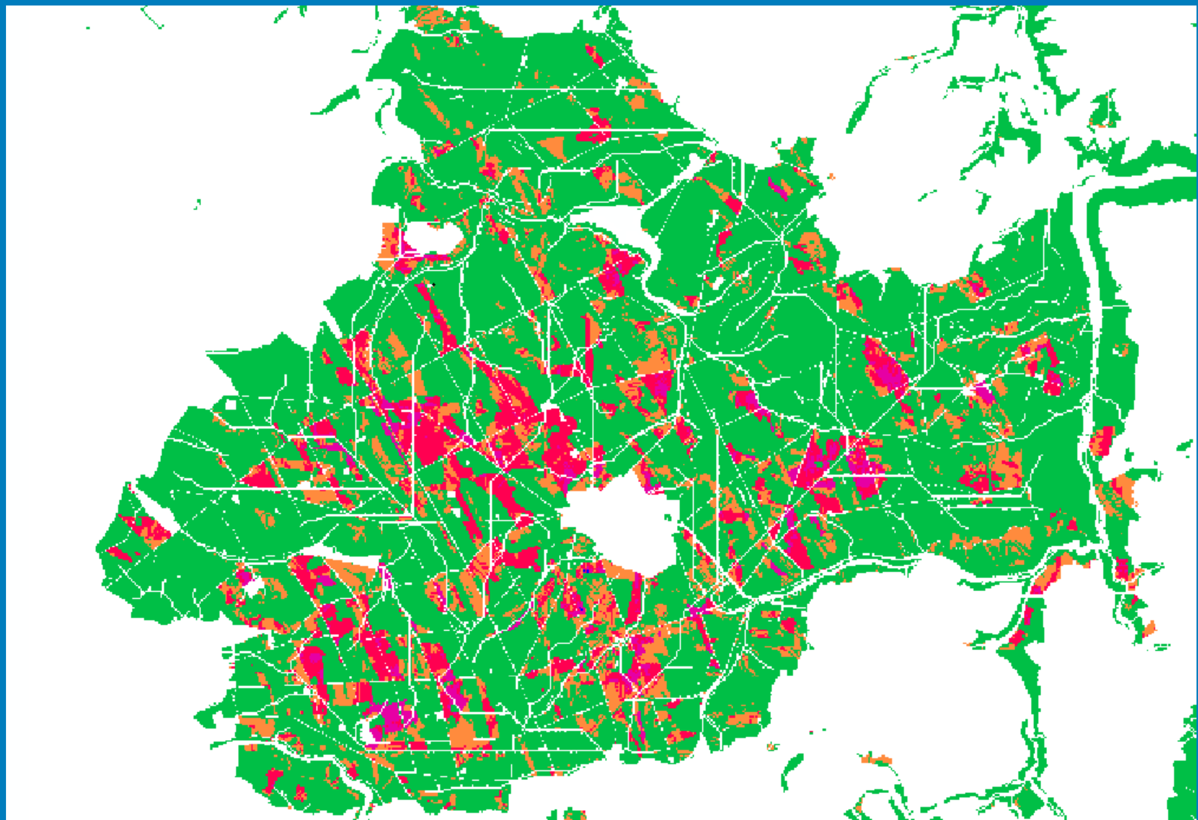
advangeo®
Prediction Software





Investigation Area:
Forests in Eastern Erzgebirge,
Tharandter Wald

Average Result from a Total of 15 Different Models with Different Input Data

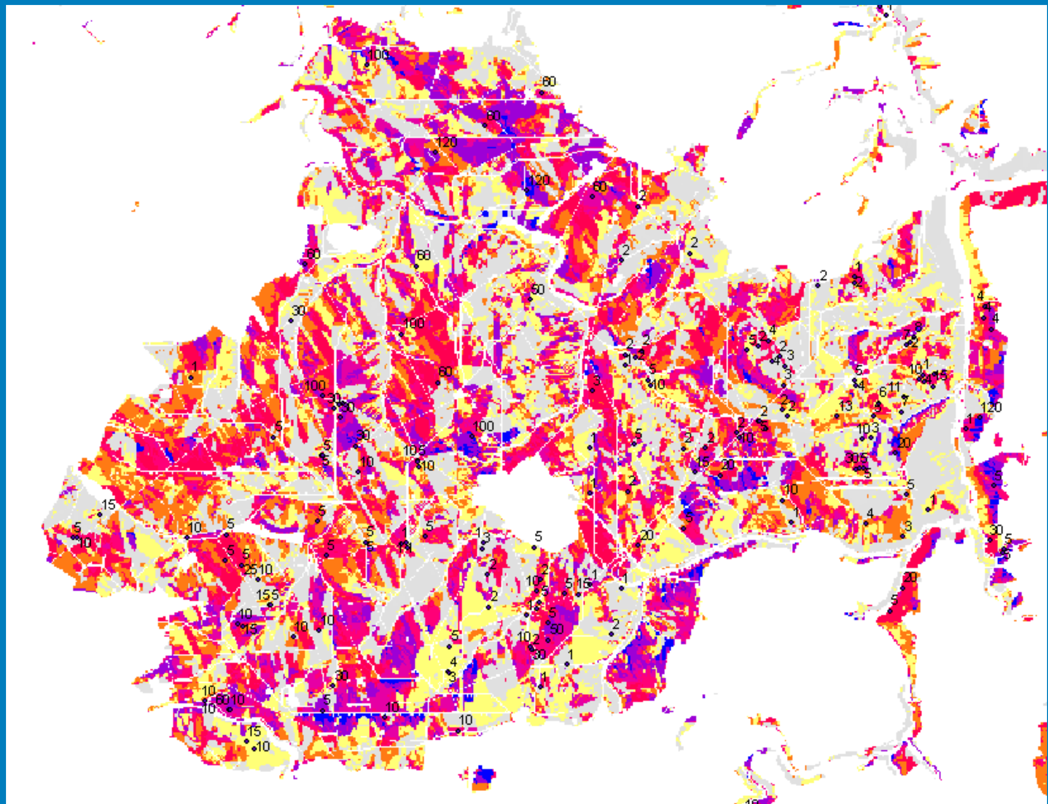


Training Data:
Infection Data 2008
Coded as:
Infected = 1
Rest= 0

- No Endangerment
- Low Endangerment
- Medium Endangerment
- High Endangerment
- Very High Endangerment

Case Study 4: Spread of Forest Pests

Average Result from a Total of 15 Different Models with Different Input Data



Training Data:
Infection Data 2008
Coded as:
Infection Rate

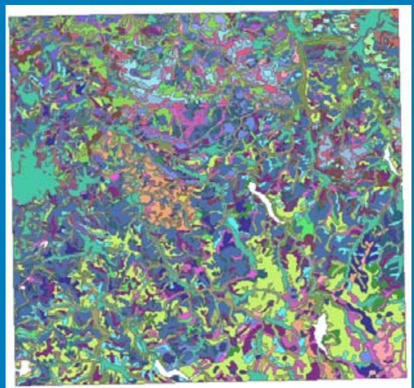
Infection Rate (m³/Infection Area)

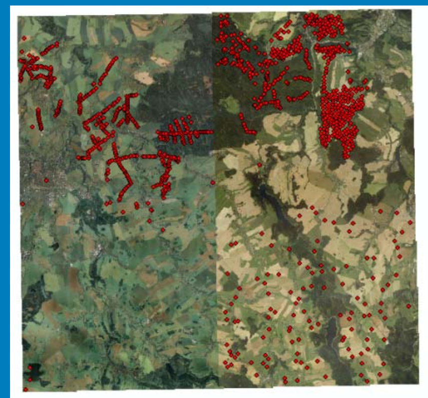
- bis 1
- 1 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 30
- 30 - 50
- 50 - 100
- 100- 140

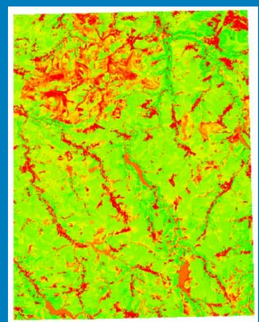
Case Study 5: Regionalization of Soil Parameters: ***Humidity Level***

Input Data:
Elevation Model and its Derivates
Soil Map
Climate Data
Landuse

Training Data:
Sounding Rods /
Auger
(1252 Points)



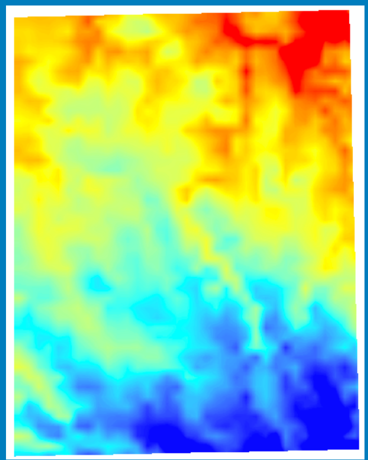




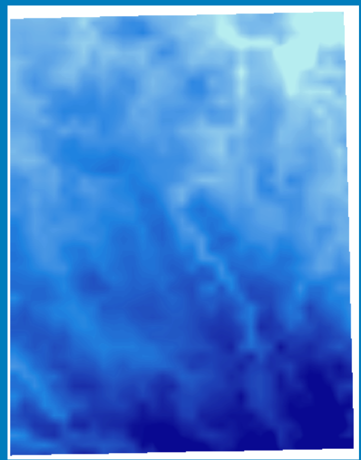
→ feu1 – feu6

TK 5046, 5047, 5146, 5147

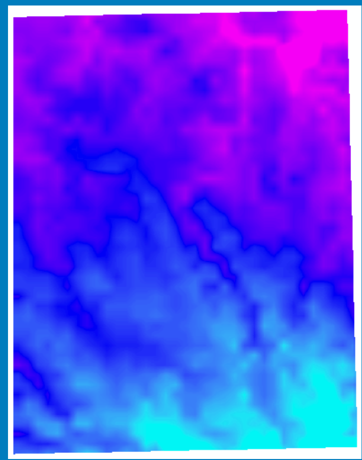
Additional Input Data: Climate Data
→ Evaporation, Rainfall, Relative Humidity



Evaporation [mm]



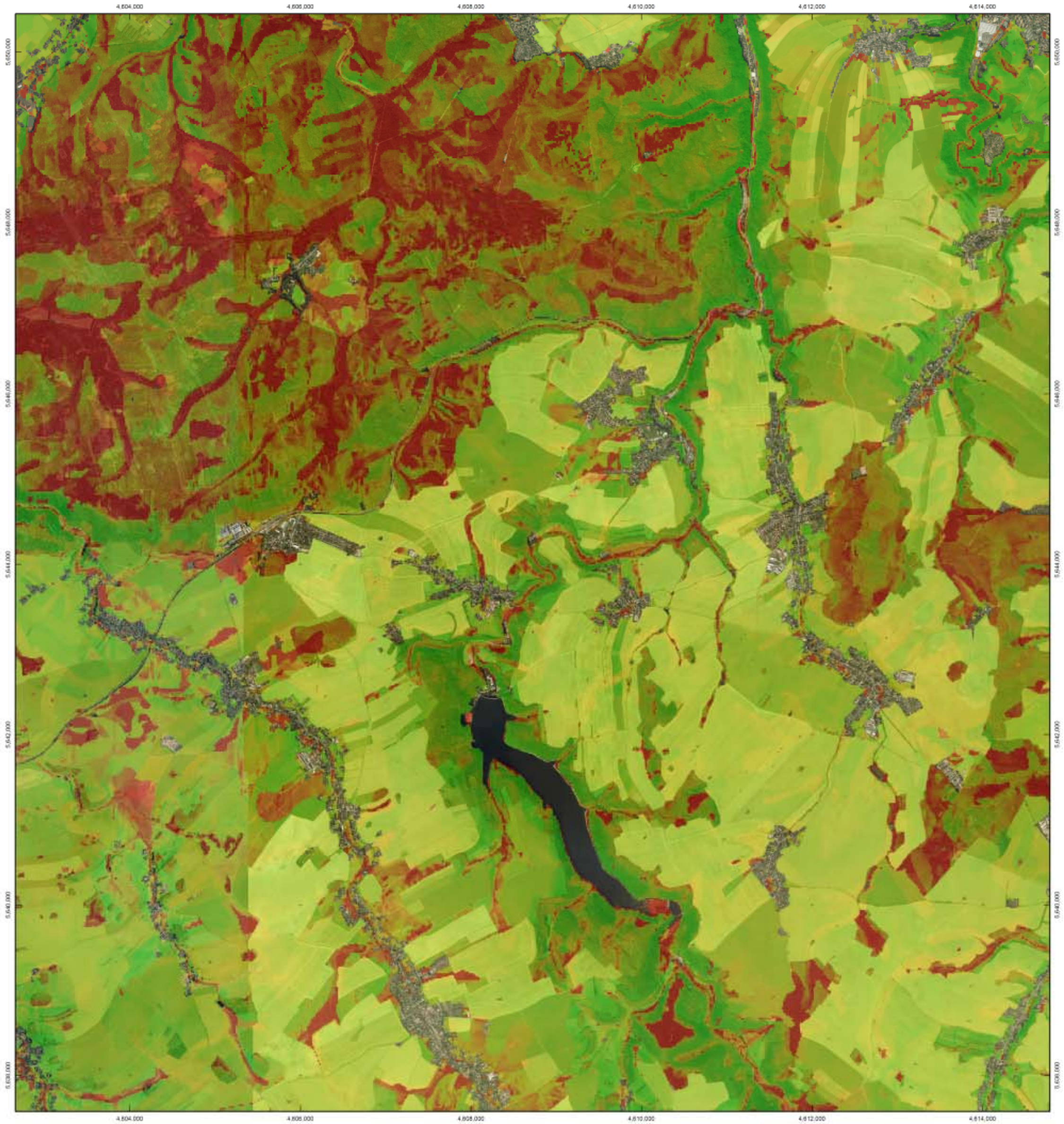
Rainfall [mm]



Relative Humidity [%]

Training Data: 1252 Sounding Rods / Auger with Humidity Level
→ feu1 – feu6

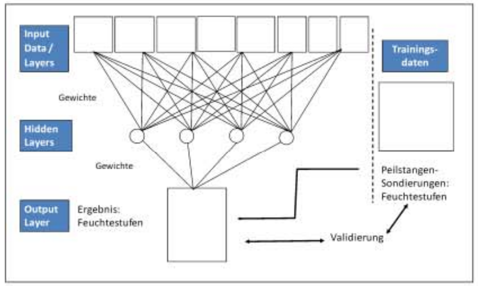
Case Study 5: Regionalization of Soil Parameters: ***Humidity Level***



Bodenmonitoring Sachsen

Prognosekarte

-Bodenfeuchtestufe-



Projekt: Bodenmonitoring Sachsen
Bearbeitung: A. Knobloch, M. K. Zeidler
Datum: 30.09.2010

Legende

Max: Stufe 6

Min: Stufe 1

0 625 1.250 2.500
m

Scale: 1:25000

Layout:
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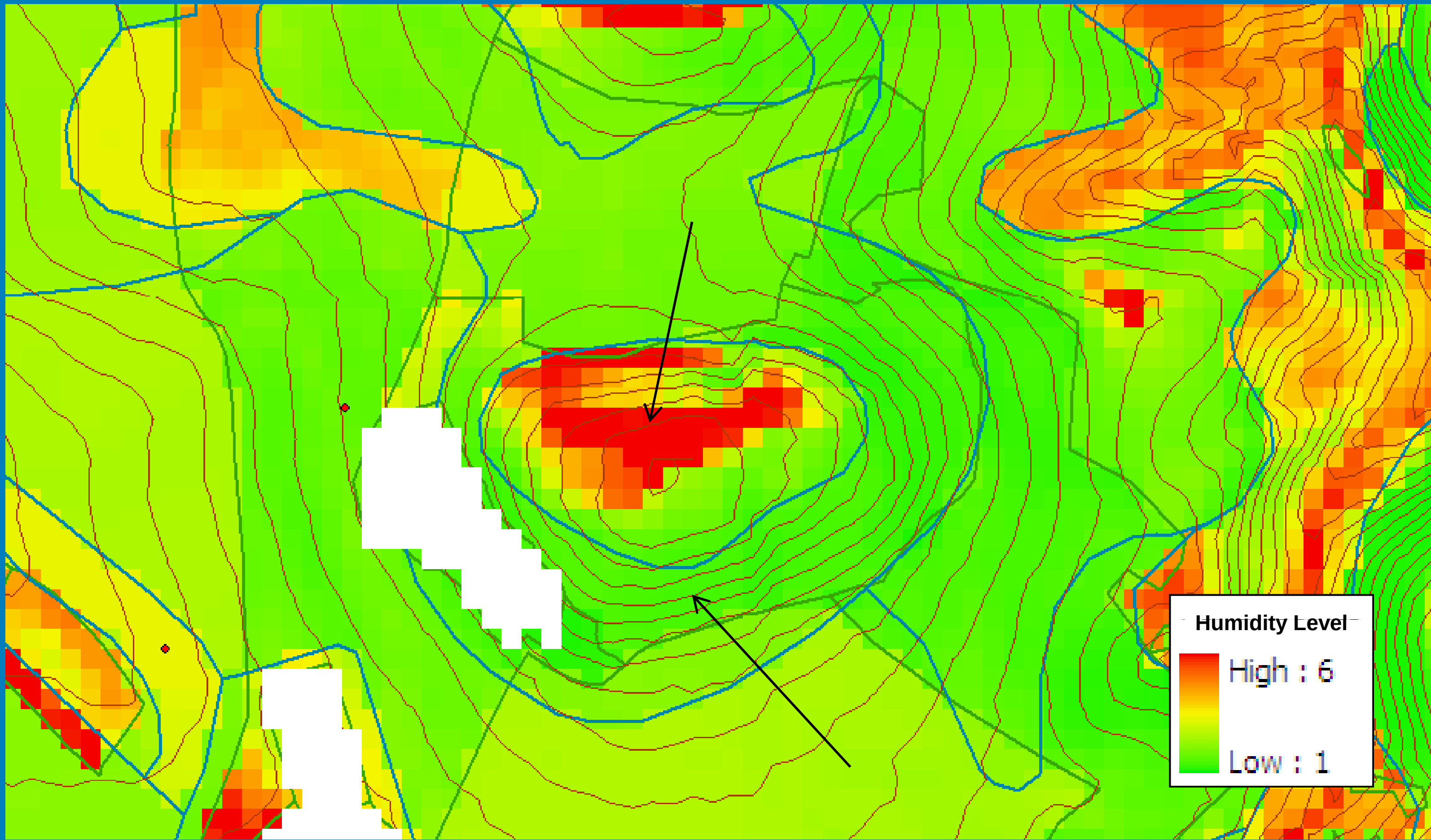
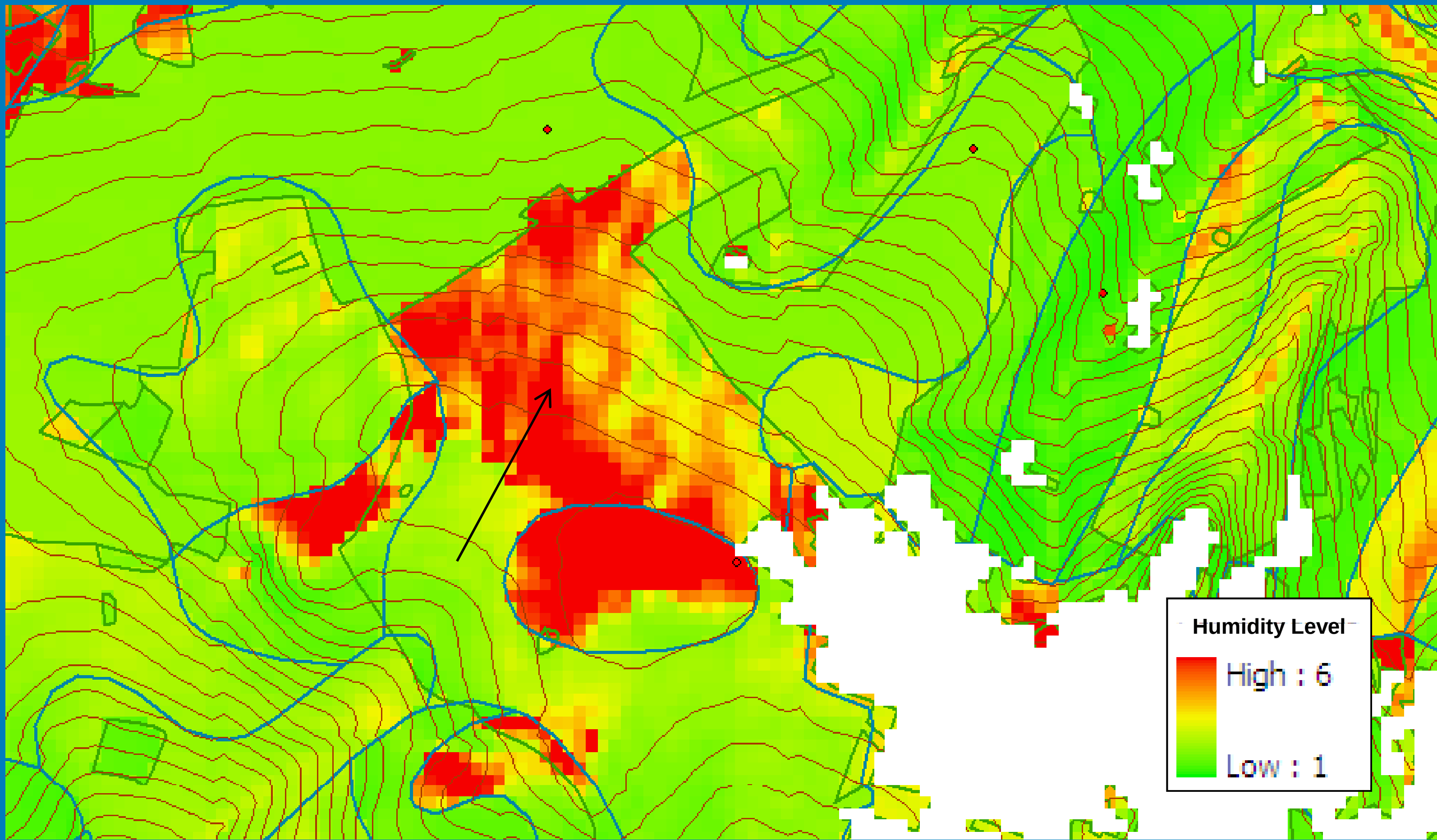
09599 Freiberg
GERMANY

Case Study 5: Regionalization of Soil Parameters: ***Humidity Level***



Influence of Exposition (here: N-Hillside) and Climate (Rainfall Distribution)

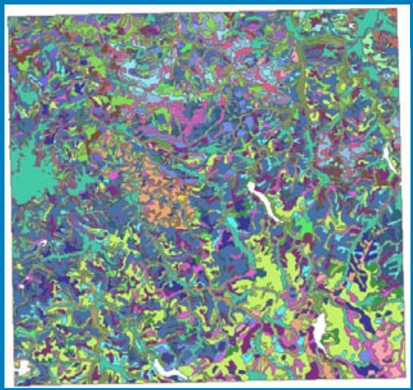
Case Study 5: Regionalization of Soil Parameters: ***Humidity Level***



Visible Gradient of Humidity Level within Biotope Types (here: Grassland)

Case Study 6: Regionalization of Soil Parameters: ***Humus Level***

Input Data:
Elevation Model and its Derivates
Soil Map
Climate Data
Landuse



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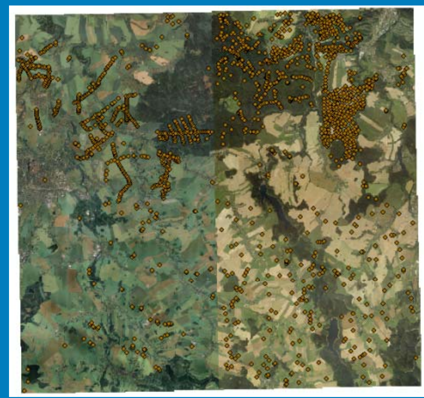
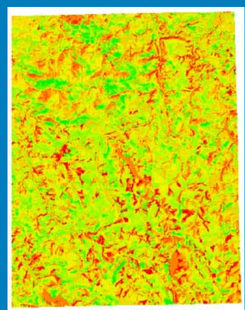
Prediction Software

Training Data:
Sounding Rods / Auger
(1725 Points)

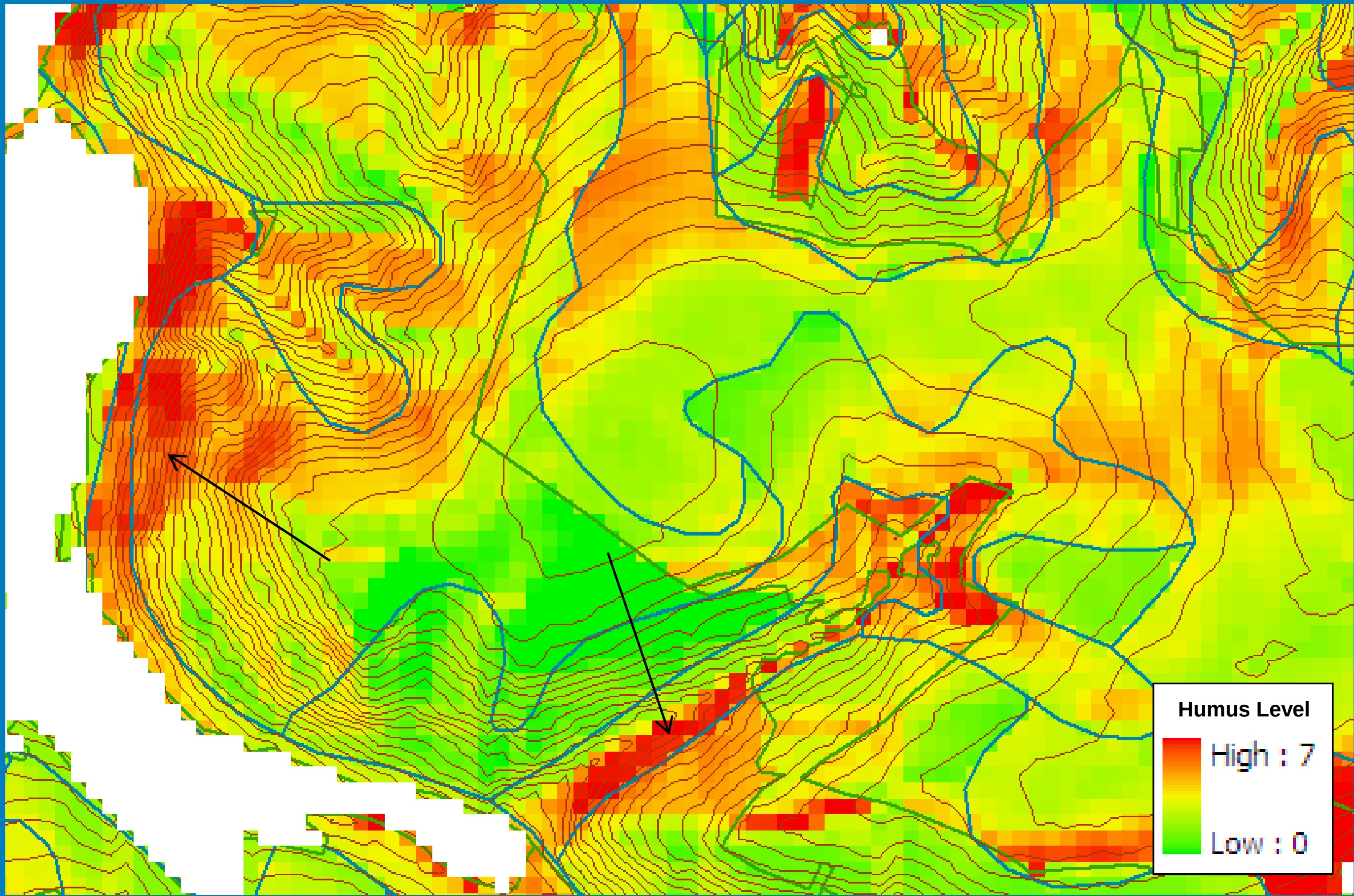




→ h0 – h7

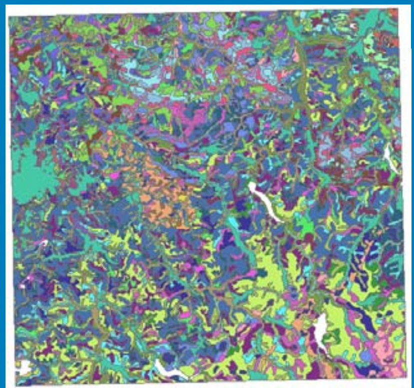
TK 5046, 5047, 5146, 5147

Case Study 6: Regionalization of Soil Parameters: ***Humus Level***

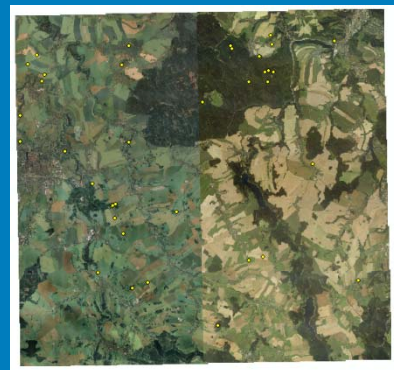


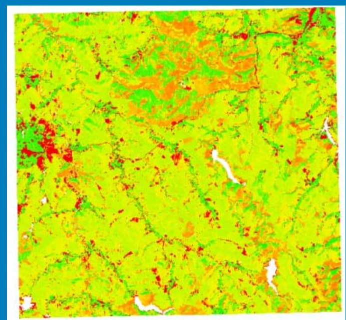
Case Study 7: Regionalization of Soil Parameters: ***TOC [%]***

Input Data
Elevation Model and its Derivates
Soil Map
Landuse



Training Data:
Exploratory Soil Excavation
(38 Points)

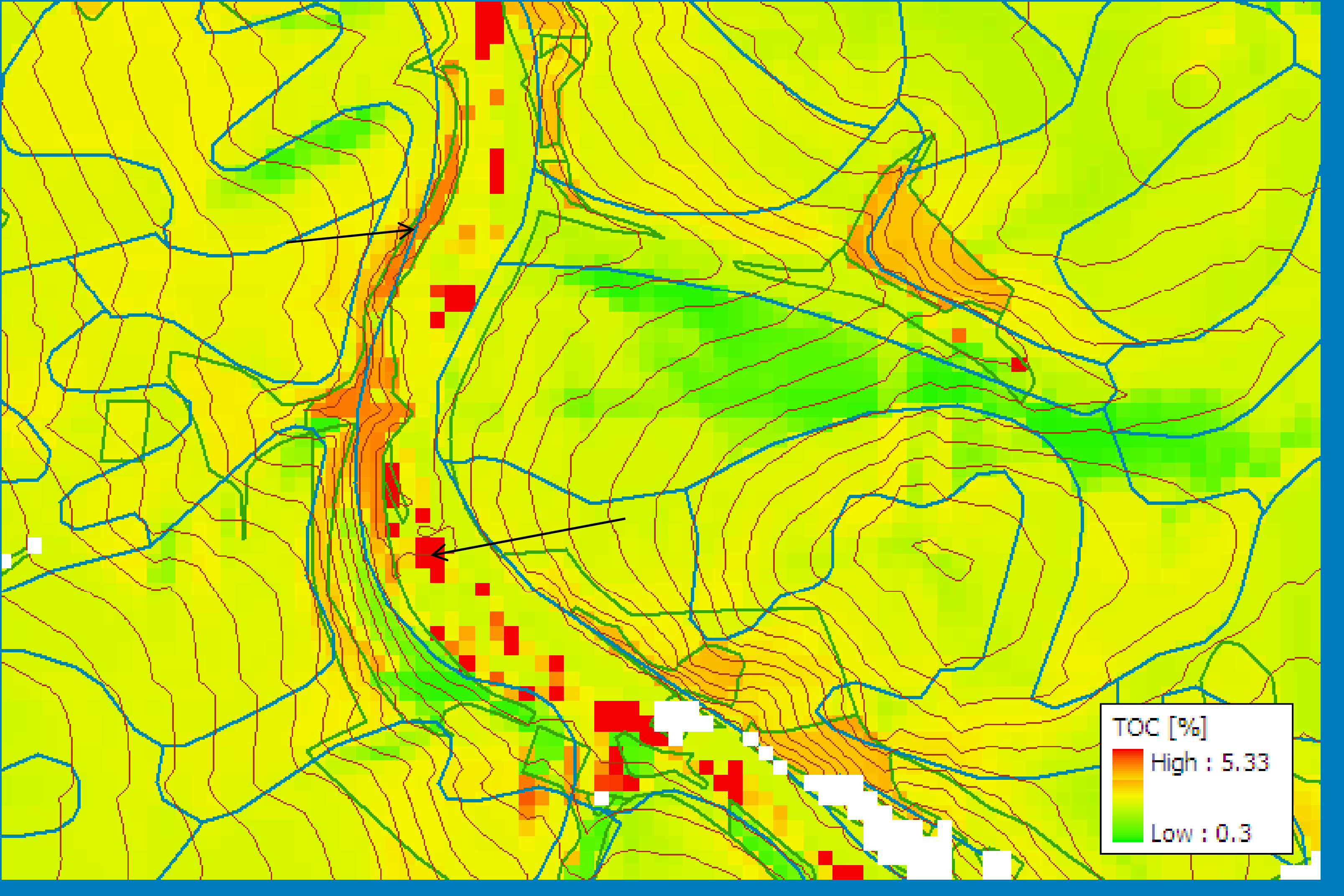




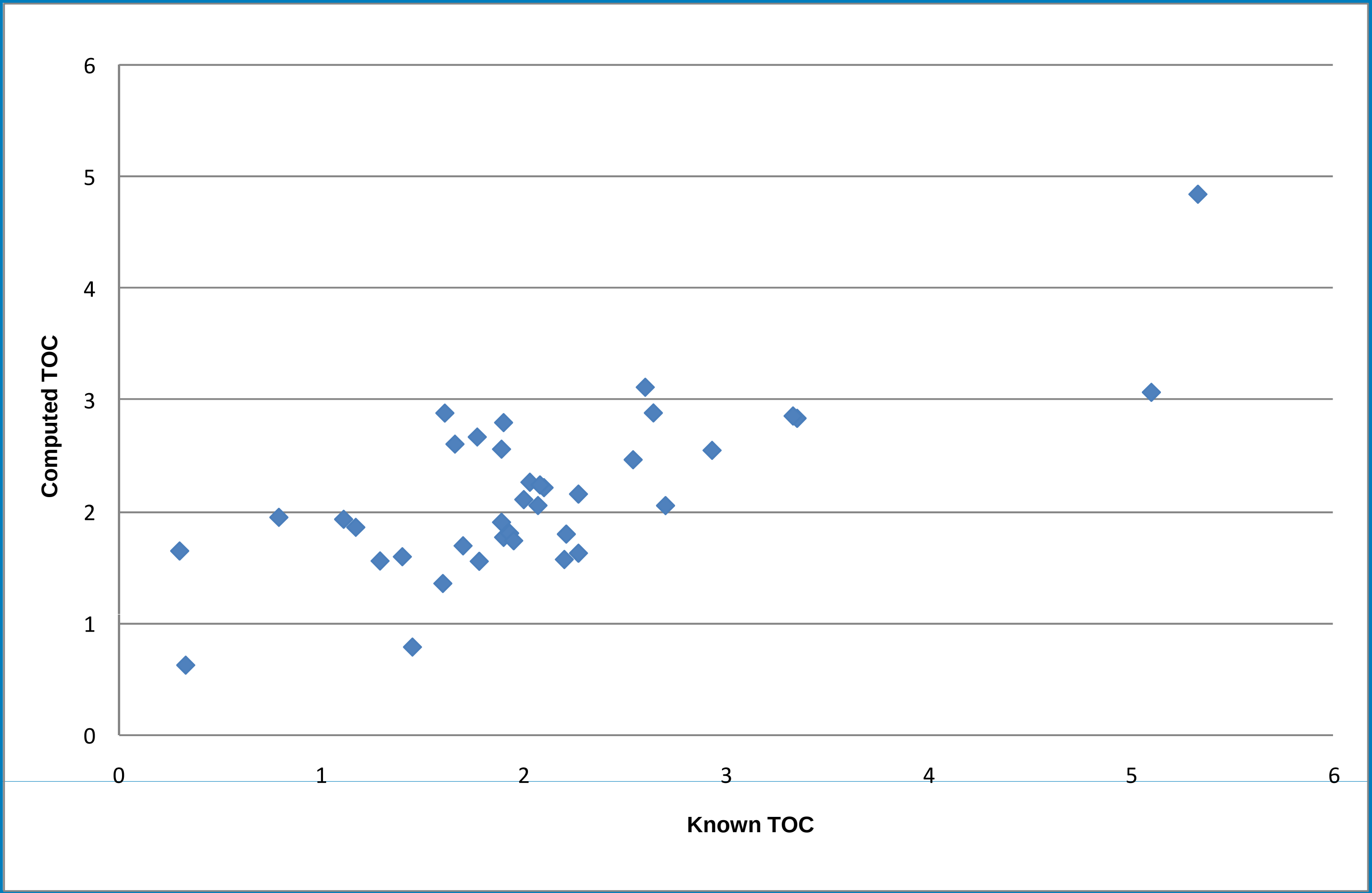
→ **TOC [%]**

TK 5046, 5047, 5146, 5147

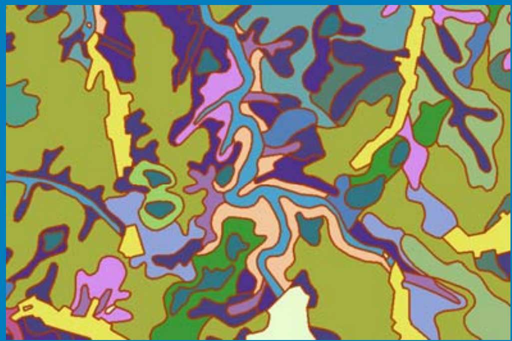
Case Study 7: Regionalization of Soil Parameters: ***TOC [%]***

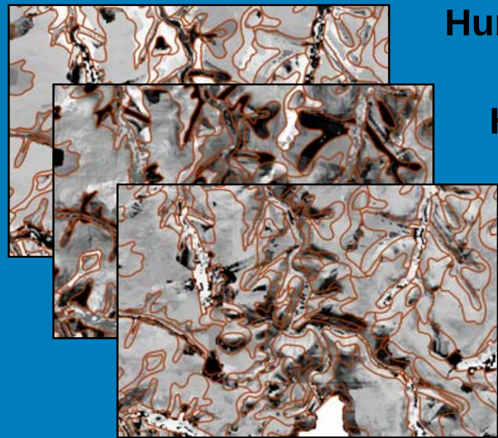


Case Study 7: Regionalization of Soil Parameters: ***TOC [%]***



Outlook: Vision of a „Rasterised Soilmap“





Humus

Humidity

TOC

Fine Soil
(Clay, Silt, Sand)
Fine Skeleton Soil
Coarse Skeleton Soil

CURRENT:

Vector Soil map
with defined polygon boundaries
with the same parameters inside
a polygon (without gradient)

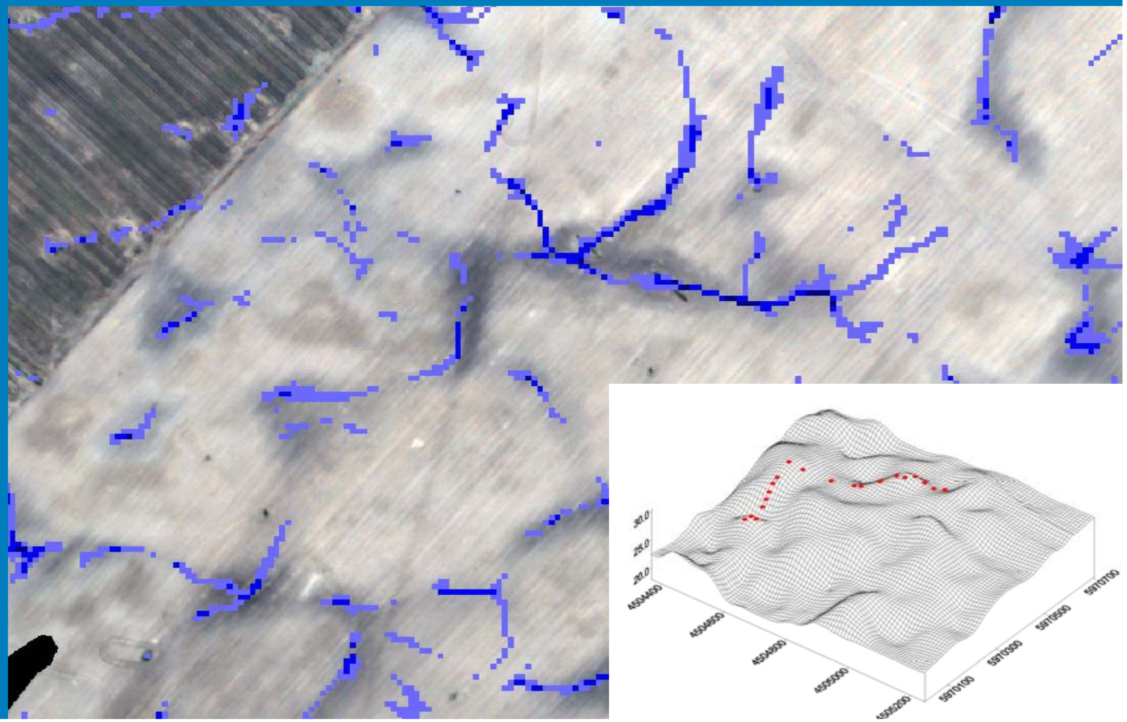
VISION:

Raster Soil map
with separate raster layers for
each parameter and gradient
inside the original polygon

Outlook: Application of Artificial Neural Networks in Precision Farming

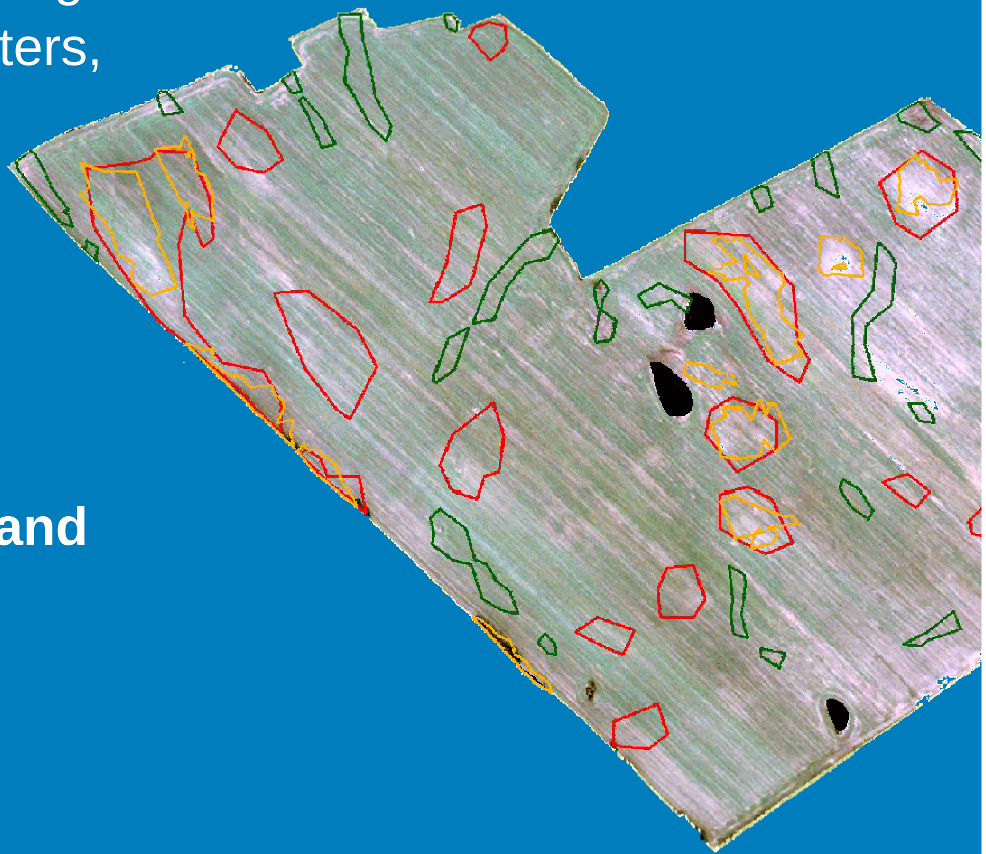
- **Input Data:**
  - **Various soil data**
  - **Water balance data**
  - **DEM and derivations**
  - **Phenomena mapped from aerial images**
  - **ECa maps**
  - **Yield maps**

- **Possible Results**
  - **Enhanced raster soil maps**
  - **Prediction of pests**
  - **All other spatial phenomena that are based on various controlling (spatial) factors**



Summary: Application of Artificial Neural Netwroks

- Various applications are possible, e.g.:
  - Regionalization of soil parameters,
  - Time series analysis,
  - "Raster soil map“,
  - Analysis of influencing factors



→ **We are looking forward to your comments, knowledge sharing and collaboration!**

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