advangeo® Prediction Software Erosion

Die neue Fachschale zur Prognose erosionsinduzierter Georisiken

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17. Firmenkolloquium
Beak Consultants GmbH
Freiberg, 06.05.2011

Agenda

- **Theoretischer Hintergrund des Verfahrens: Künstliche Intelligenz / Künstliche Neuronale Netze**
- **Kurzdarstellung der Software *advangeo®* und der entwickelten Erweiterung / Fachschale *advangeo® Erosion***
- **Beschreibung der Arbeitsmethodik am Beispiel:**
  - Fallstudie: Risikoanalyse im Einzugsgebiet des HRB Glashütte
    - *Flächenhafter Bodenabtrag*
    - *Erosionsrinnen*
    - *Hangprozesse*
- **Weitere Anwendungsbeispiele**
- **Zusammenfassung**
- **Webseite**

Motivation

Where are the deposits located ?

Where do forest pests spread ?

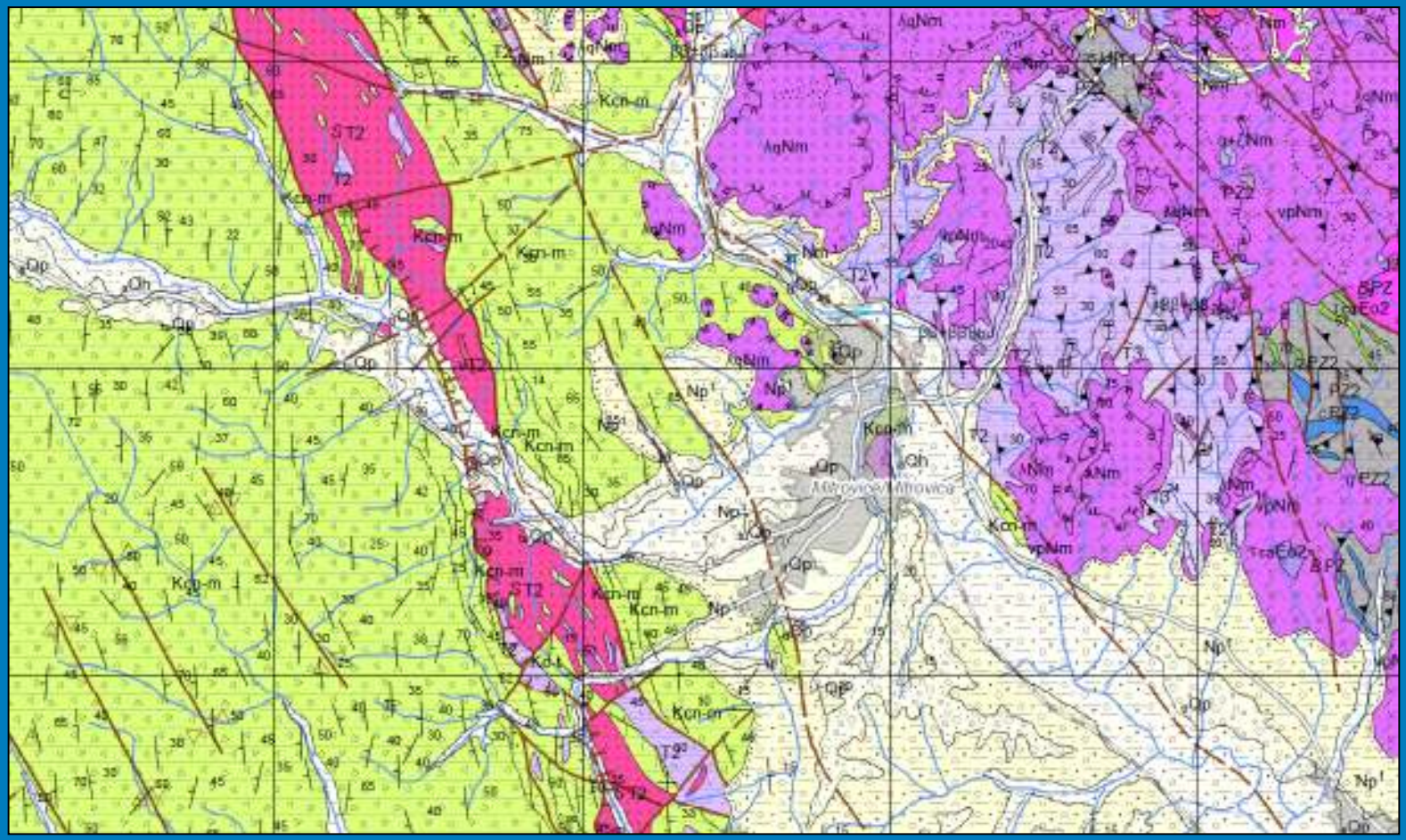
Motivation

Where does coal burn ?

Where are karst caves located ?

Motivation

Where is a geological / pedological boundary?



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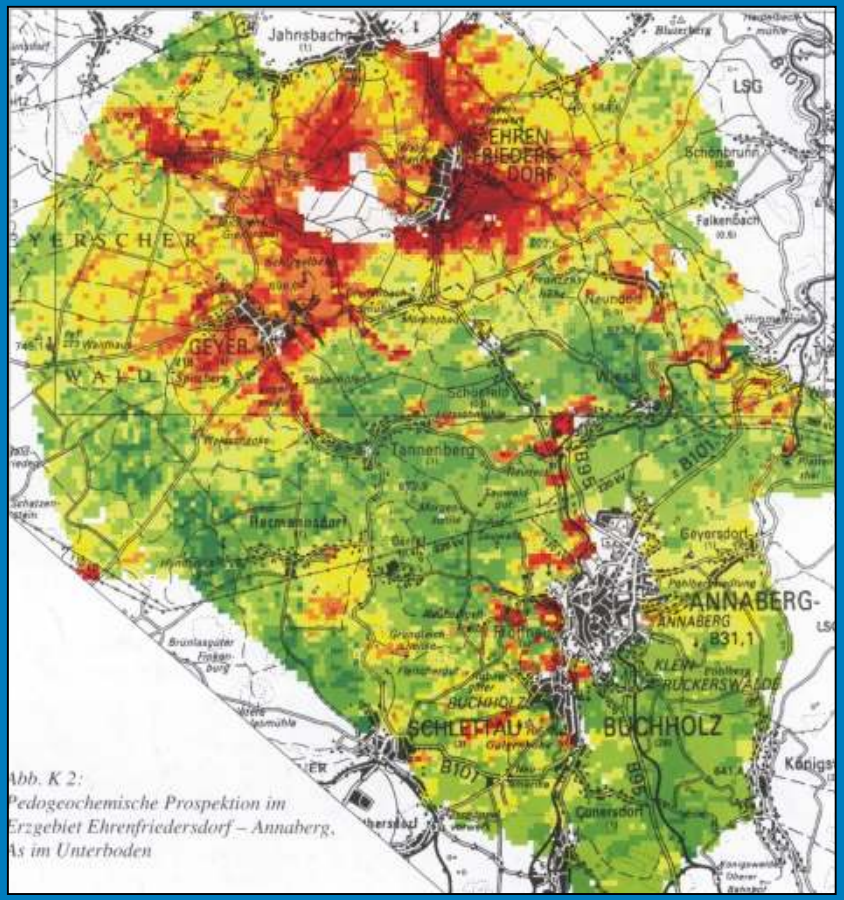
Motivation

Where is soil contaminated ?



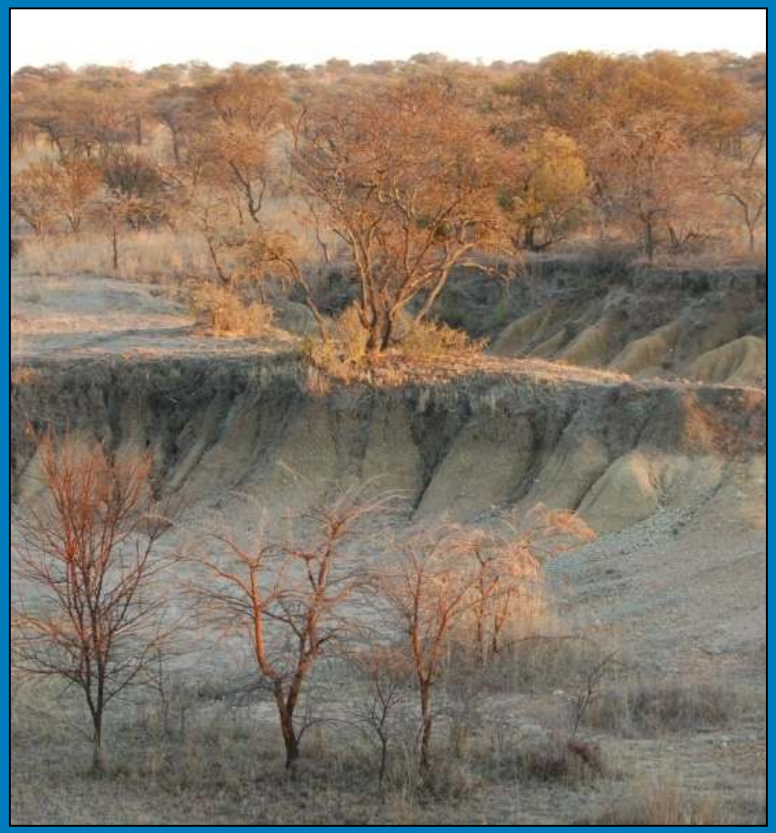
Quelle: LfULG Sachsen

Motivation

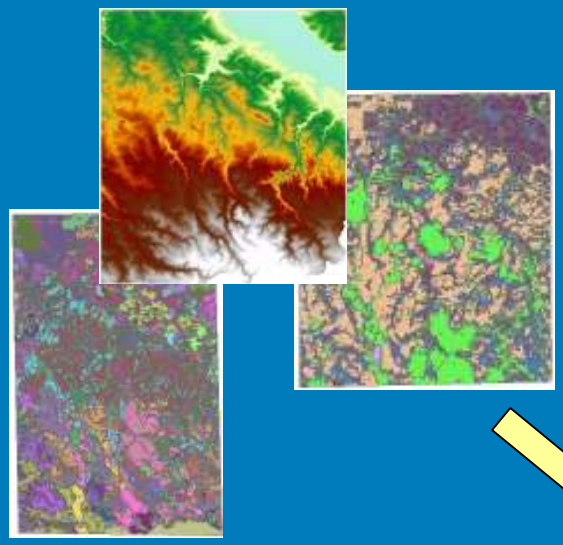
Where do hillside slides occur?

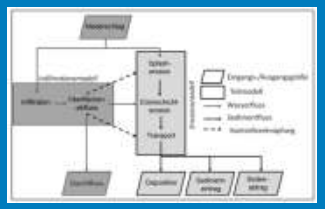
Motivation

Where do erosion gullies form?



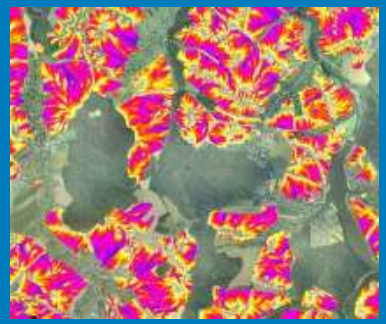
Predictive Mapping: Traditional Approach



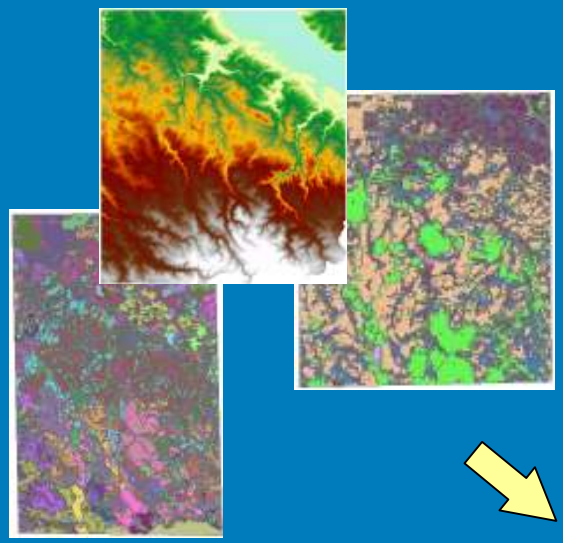


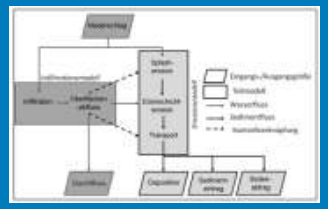
Traditional prediction methods are based mainly on the expert´s knowledge / experience supported by modern information technology

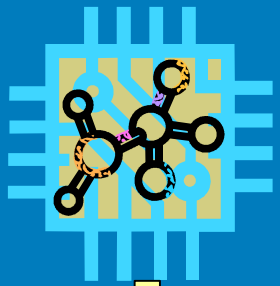
Data Analysis and Interpretation

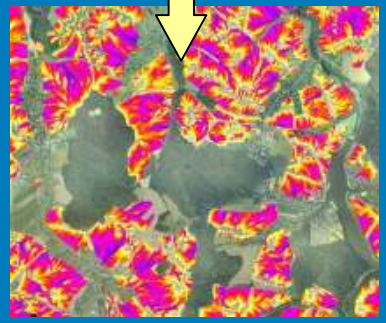


Predictive Mapping: Modern Approach Using Artificial Intelligence







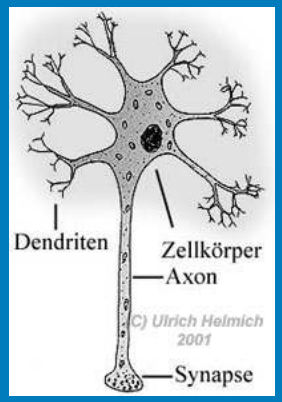


The artificial neuronal network “replaces” the experts empirical data analysis

Pre-Processing

Validation

Definition: Artificial Neural Networks

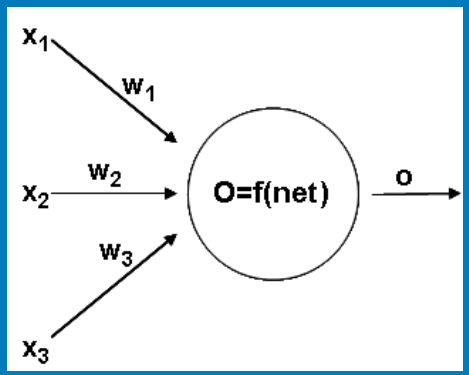


Modell: Neuron Cell

- 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

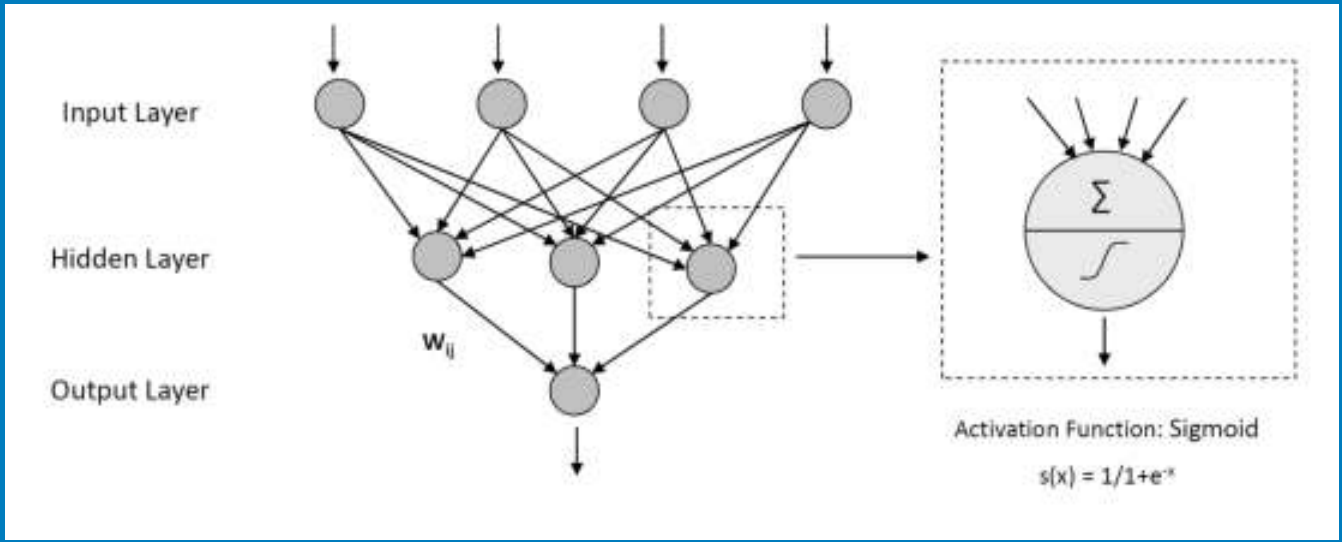
- **Connection between the neurons by weights w**
  - Enforce or reduce the level of the input information
  - Are directed, can be trained
- **Input signals**
  - Re-computed to a single input information: the propagation function
- **Output signals**
  - Activation function computes the output status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



Principle Setup of Artificial Neural Networks

Network Topology: MLP (Multi Layer Perceptron)

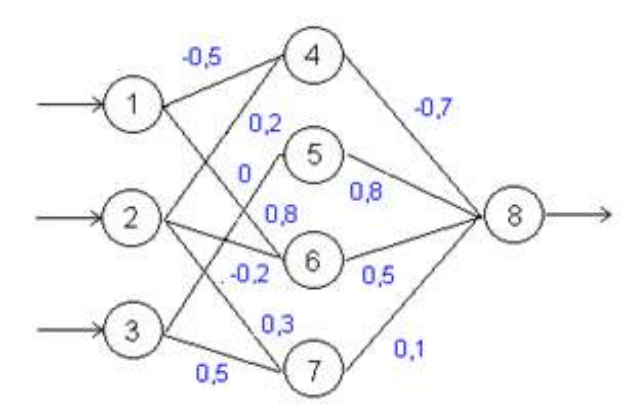
- Set-up of neurons in layers
- Direction and degree of connections
- Amount of hidden layers and neurons

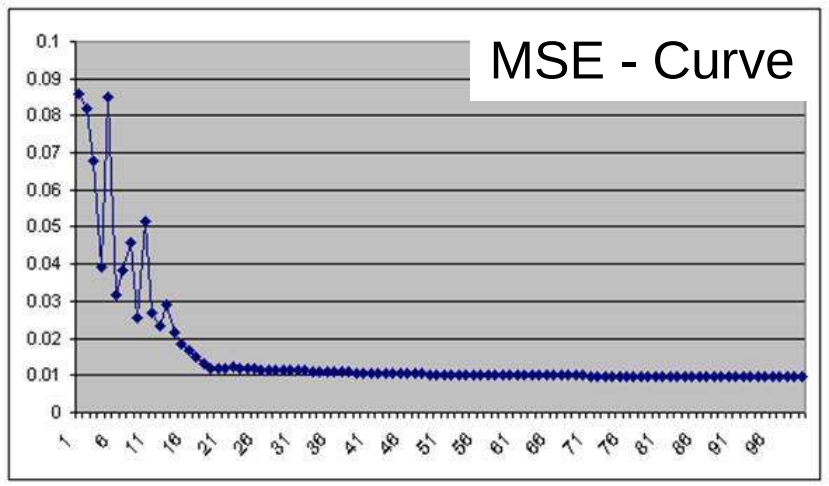


Training of Artificial Neural Networks

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:

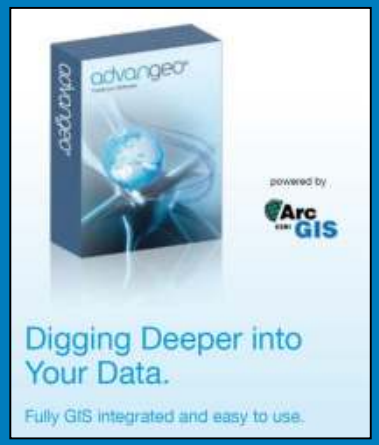
- ***learnable***: learning from examples
- ***generalization***: able to solve similar problems that have not been trained yet
- ***universal***: prediction, classification, pattern recognition
- able to analyze complex, ***non-linear*** relationships
- ***fault-tolerant*** against noisy data (e.g.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

Additional characteristics:

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

Software: advangeo

- **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



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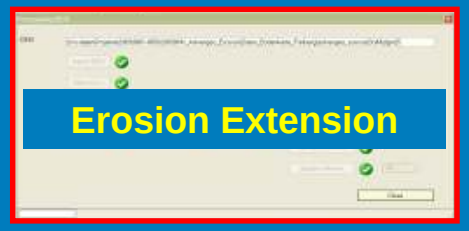
Prediction Software

Software Components



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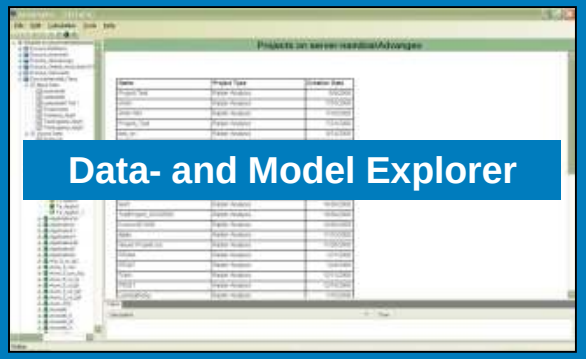
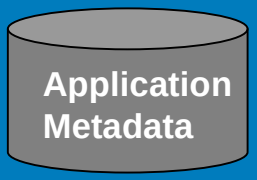
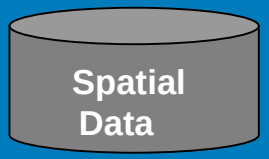




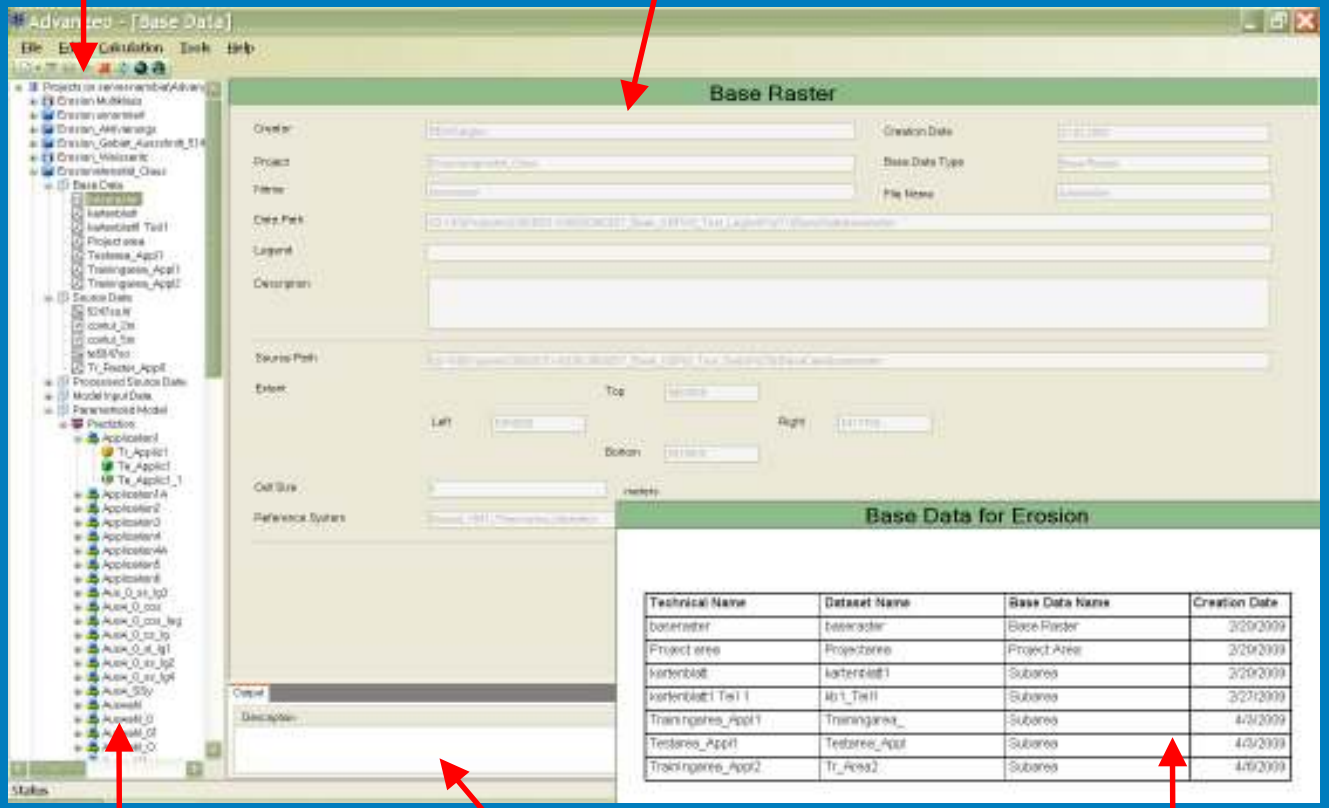


Referenced
Data Sources

advangeo: Data and Model Explorer

Menu & Toolbar
With Tools and Functionality

Form for Collection, Processing and Display of Data Objects and Models

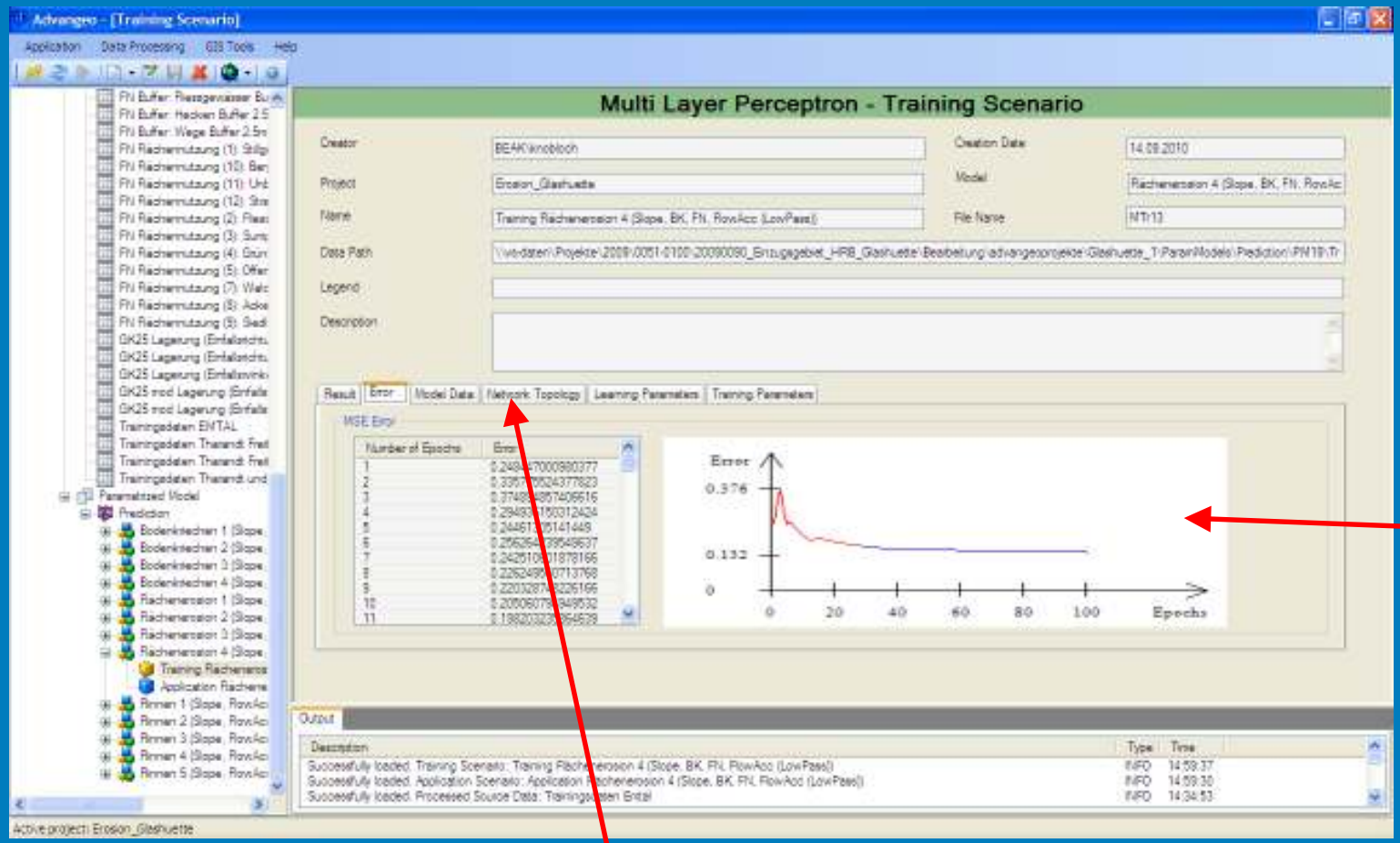


Explorer for Project Navigation with Context Functionality

Message Box with Information of Status, Warnings, Errors

Overview of Data Objects & Models

advangeo: Prediction Modeling



Training Curve

Selection of Model Input Data, Network Topology, Learning Parameter, Training Parameter

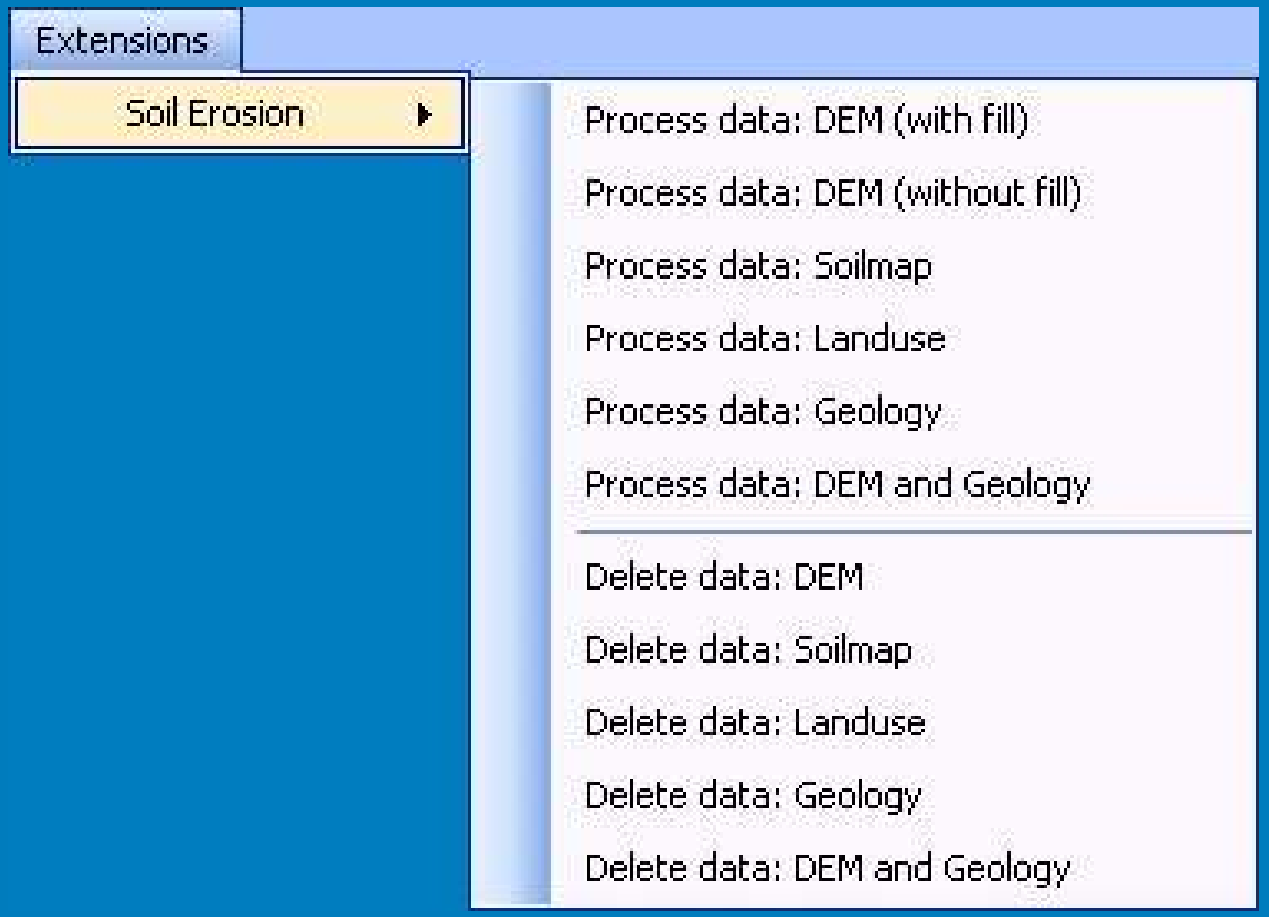
advangeo: Work Flow / Methodology

Working Steps:

1. **Task description**
2. **Definition of working area borders**
3. **Collection of primary source data**
4. **Processing of model input data**
5. **Statistical pre-processing**
   (unit transformation, data recoding, reduction of dimensions, …)
6. **Modeling of training and application scenarios**
7. **Statistical post-processing**
   (appraisal of repeatability, robustness, …)
8. **Presentation of prediction results**

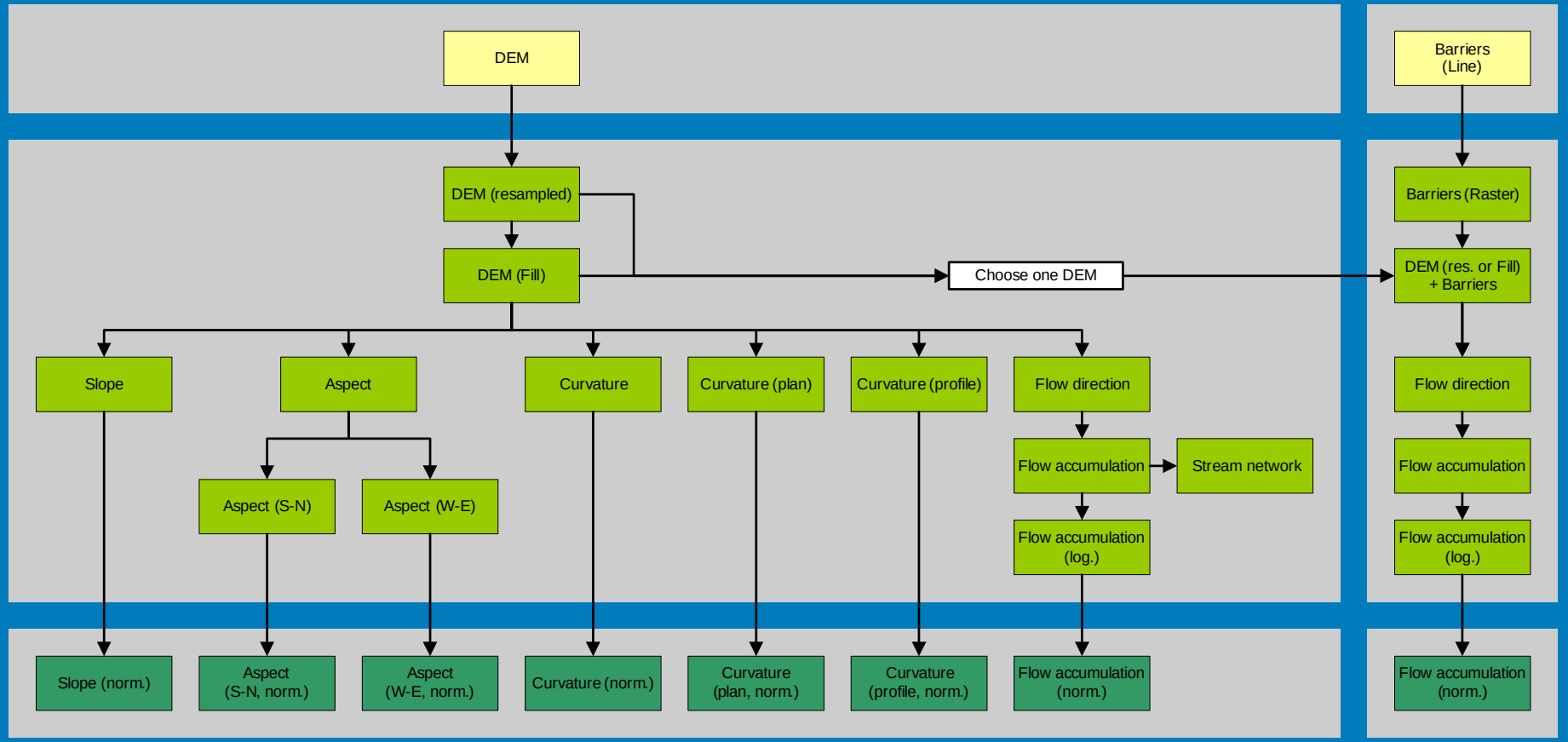
advangeo: Erosion Extension with Pre-Processing Tools

- **Soil Erosion Toolbar:** Overview



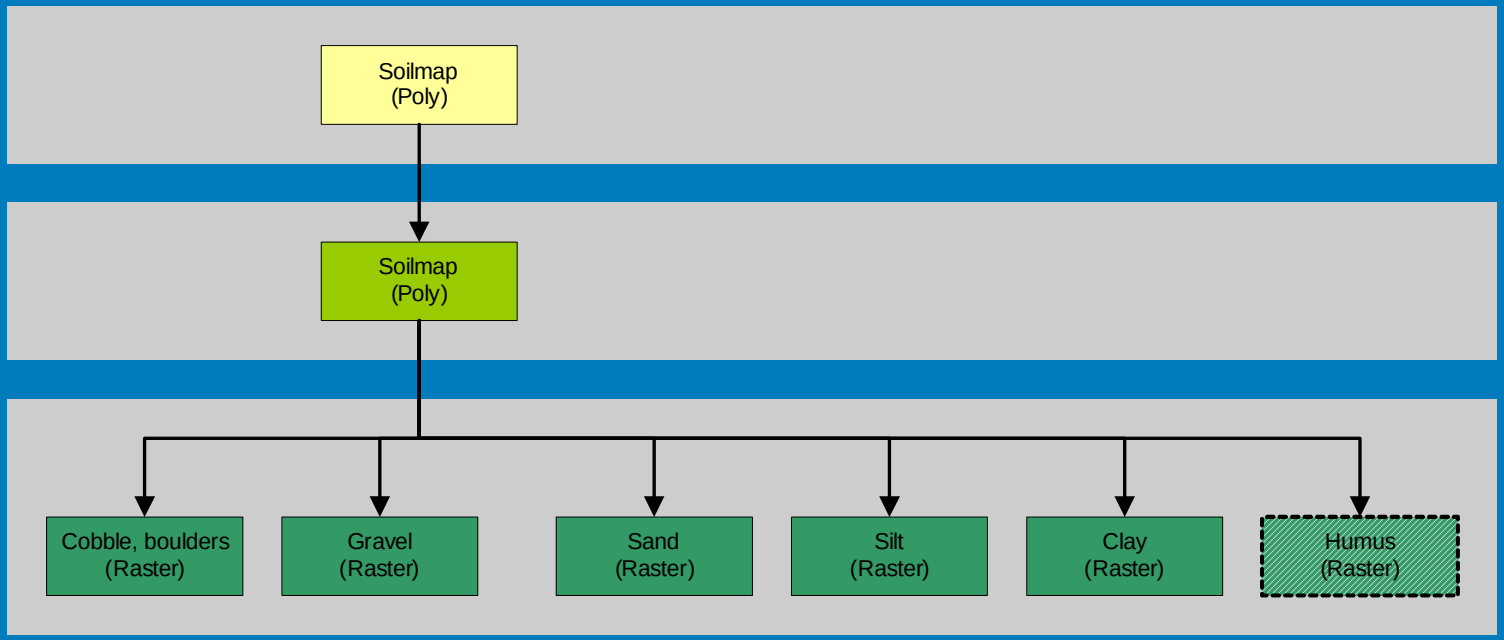
advangeo: Erosion Extension with Pre-Processing Tools

- **Data Processing Workflow:** DEM



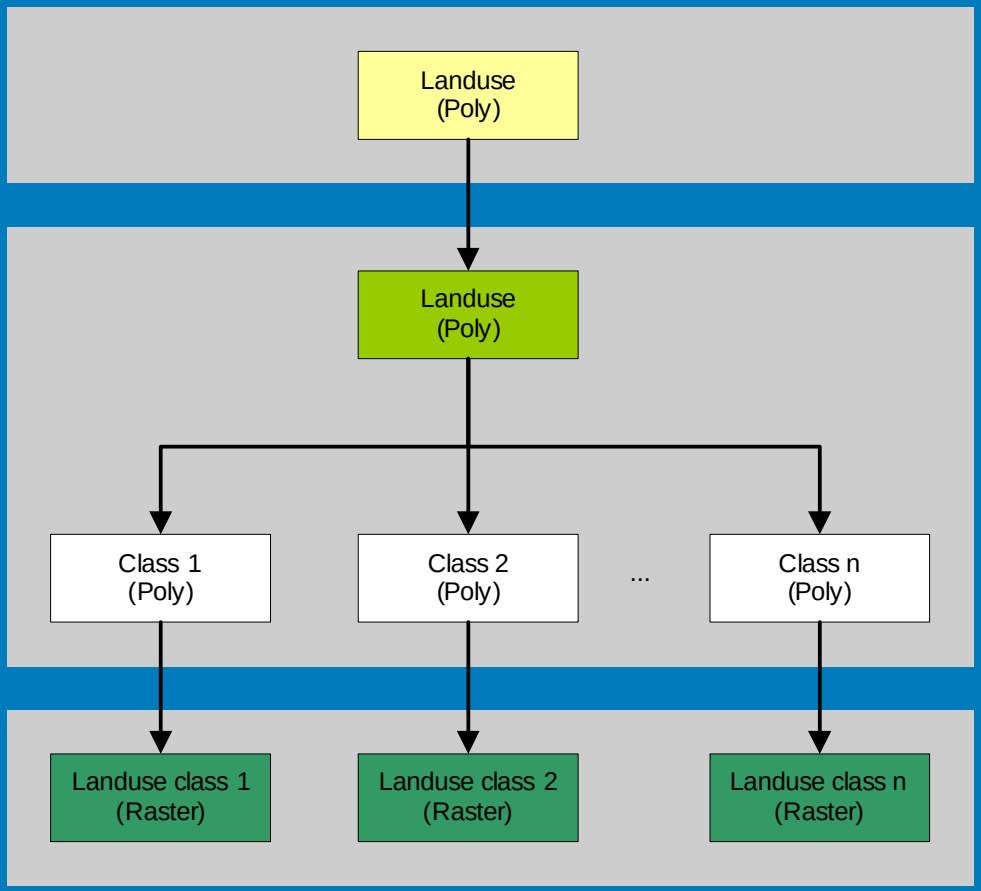
advangeo: Erosion Extension with Pre-Processing Tools

- **Data Processing Workflow:** Soil



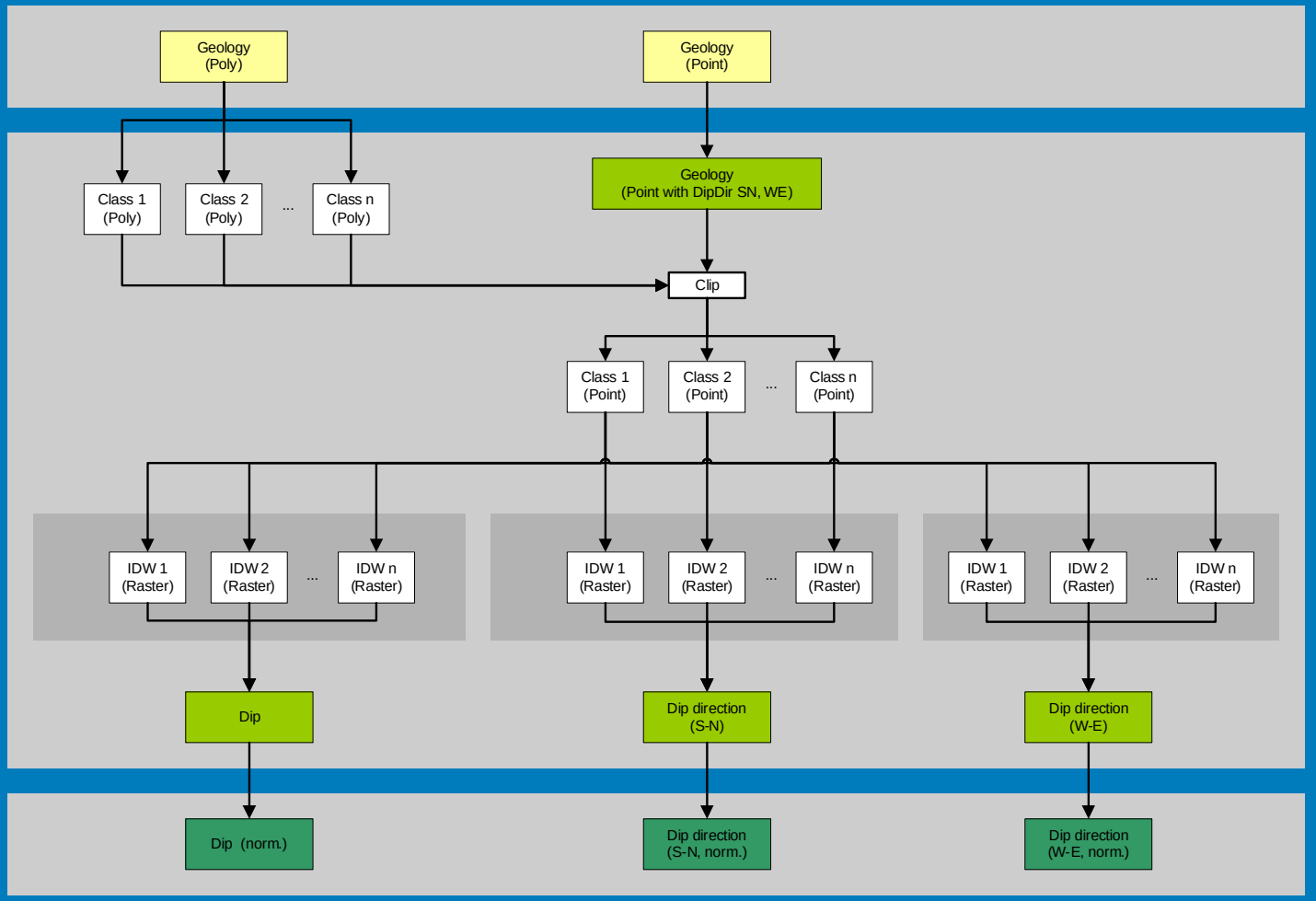
advangeo: Erosion Extension with Pre-Processing Tools

- **Data Processing Workflow:** Landuse



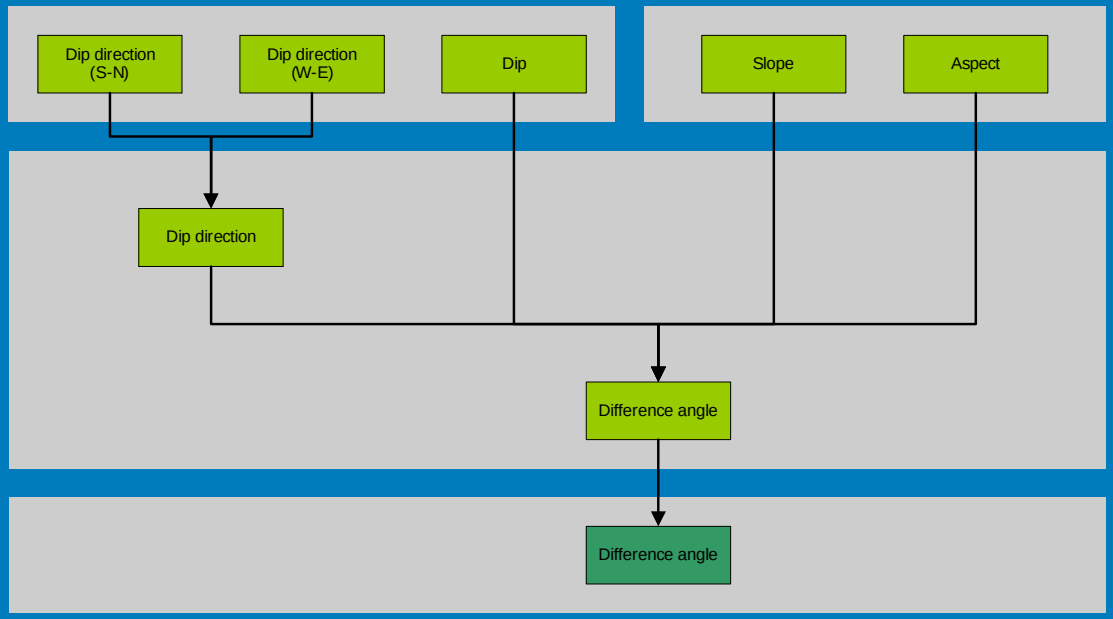
advangeo: Erosion Extension with Pre-Processing Tools

- **Data Processing Workflow:** Geology

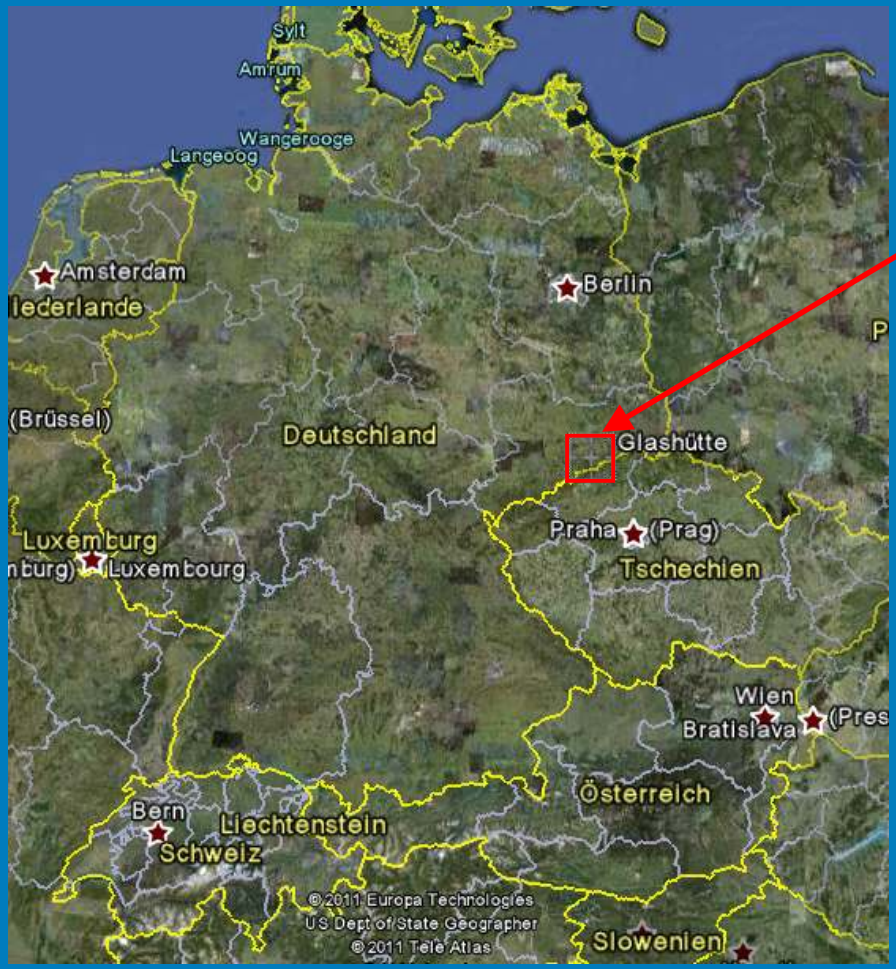


advangeo: Erosion Extension with Pre-Processing Tools

- **Data Processing Workflow:** DEM and Geology



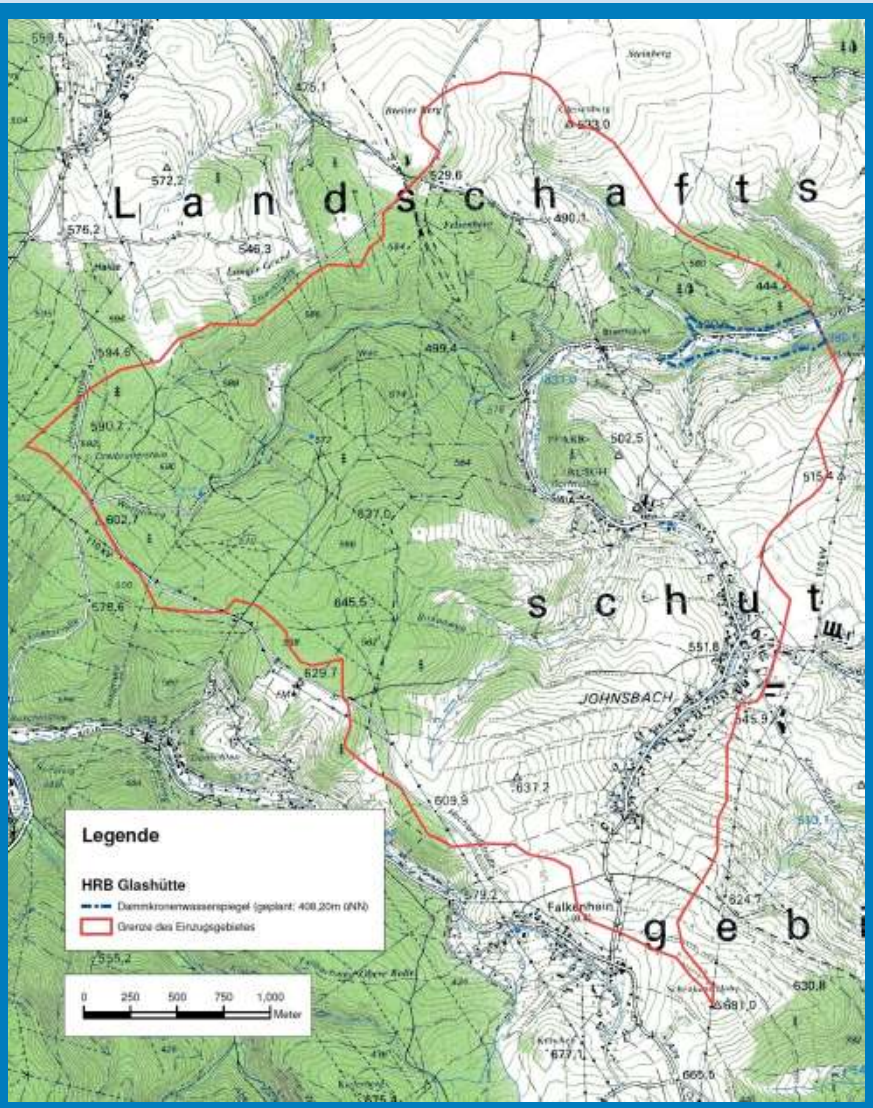
Case Study : Glashütte Flood Control Reservoir Catchment Area



Glashütte
Flood Control Reservoir
Catchment Area

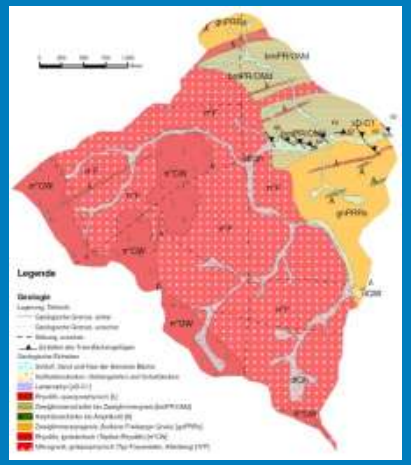
LANDESTALSPERREN VERWALTUNG
des Freistaates Sachsen

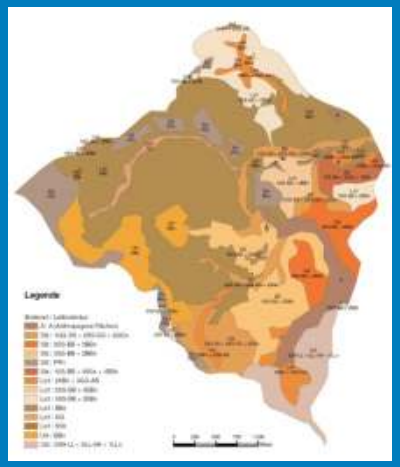
Case Study : Glashütte Flood Control Reservoir Catchment Area

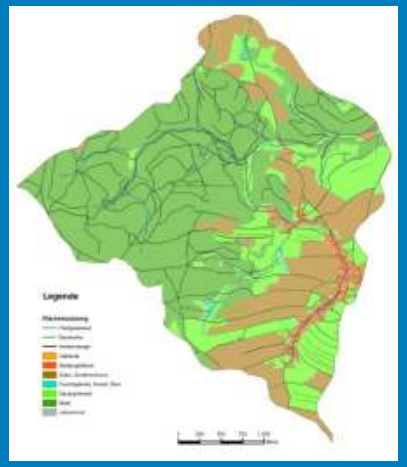


Case Study : Glashütte Flood Control Reservoir Catchment Area

Available Knowledge and Input Data

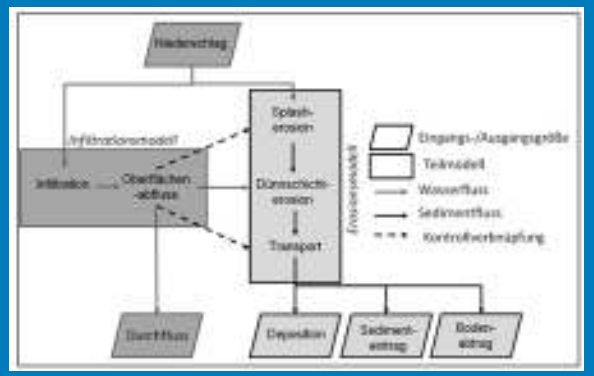






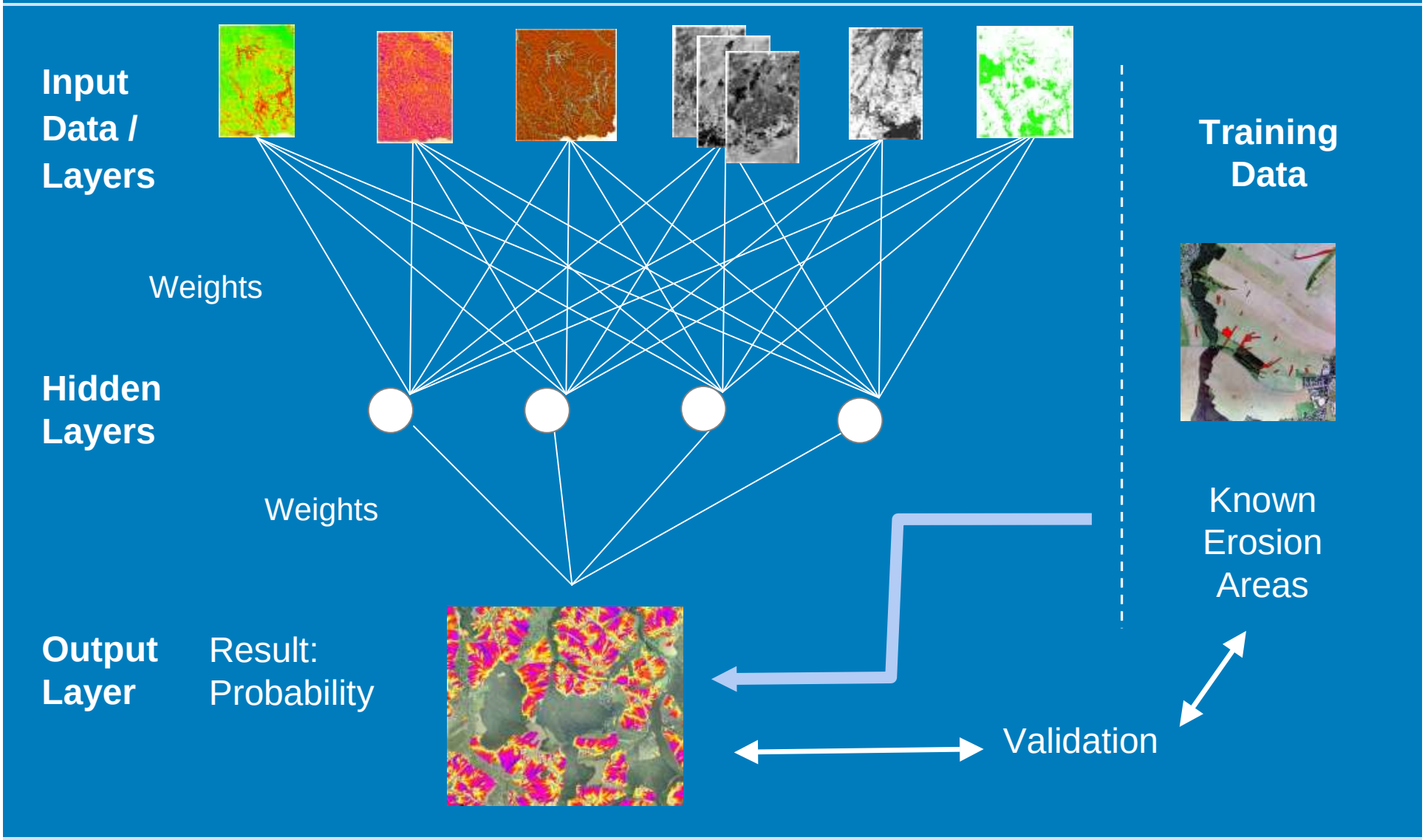
Data:
DEM,
Soil Map,
Landuse,
Geology

Knowledge: Aerial Images,
Field Observations



Knowledge: Analytical Models

Case Study : Glashütte Flood Control Reservoir Catchment Area



Probability Modelling Workflow 1: Extensive Soil Erosion

Input Data

Elevation Model and its Derivates:
- *Slope*
- *Flow accumulation*

Soil:
- *Clay*
- *Silt*
- *Sand*
- *Fine skeleton*
- *Coarse skeleton*

Landuse
- *Grassland*
- *Open area without vegetation*
- *Cropland*
- *Urban / industrial areas*

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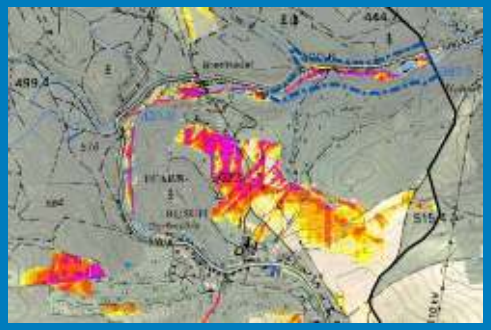
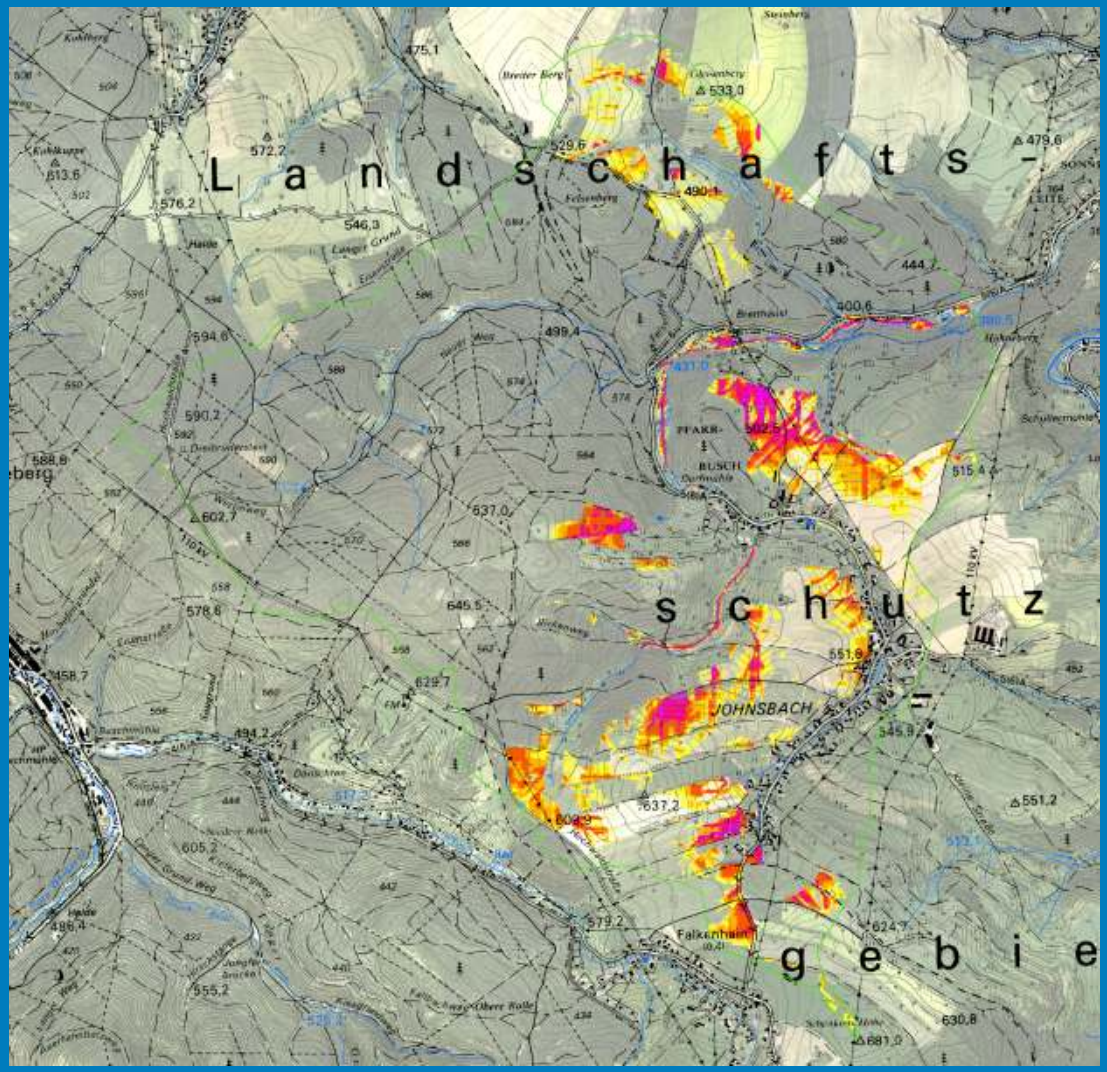


Training Data
Known Areas with
Extensive Soil Erosion

Probability Modelling Results 1: Extensive Soil Erosion



Legende

Arbeitsgebiet

Einzugsgebiet HRB Glashütte

HRB Glashütte

Dammkronenwasserspiegel (geplant: 408,20m üNN)

Gefährdung durch flächenhaften Bodenabtrag

Eintrittswahrscheinlichkeit

- < 55 %
- 55 - 60 %
- 60 - 65 %
- 65 - 70 %
- 70 - 75 %
- 75 - 80 %
- 80 - 85 %
- 85 - 90 %
- 90 - 95 %
- 95 - 100 %

Probability Modelling Workflow 2: Erosion Gullies

Input Data

Elevation Model and its Derivates:

- *Slope*
- *Flow accumulation*

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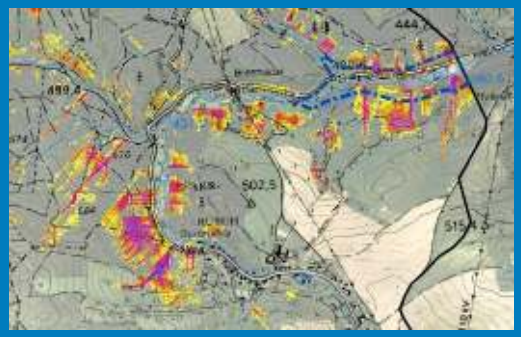

Training Data

Known Areas with Erosion Gullies

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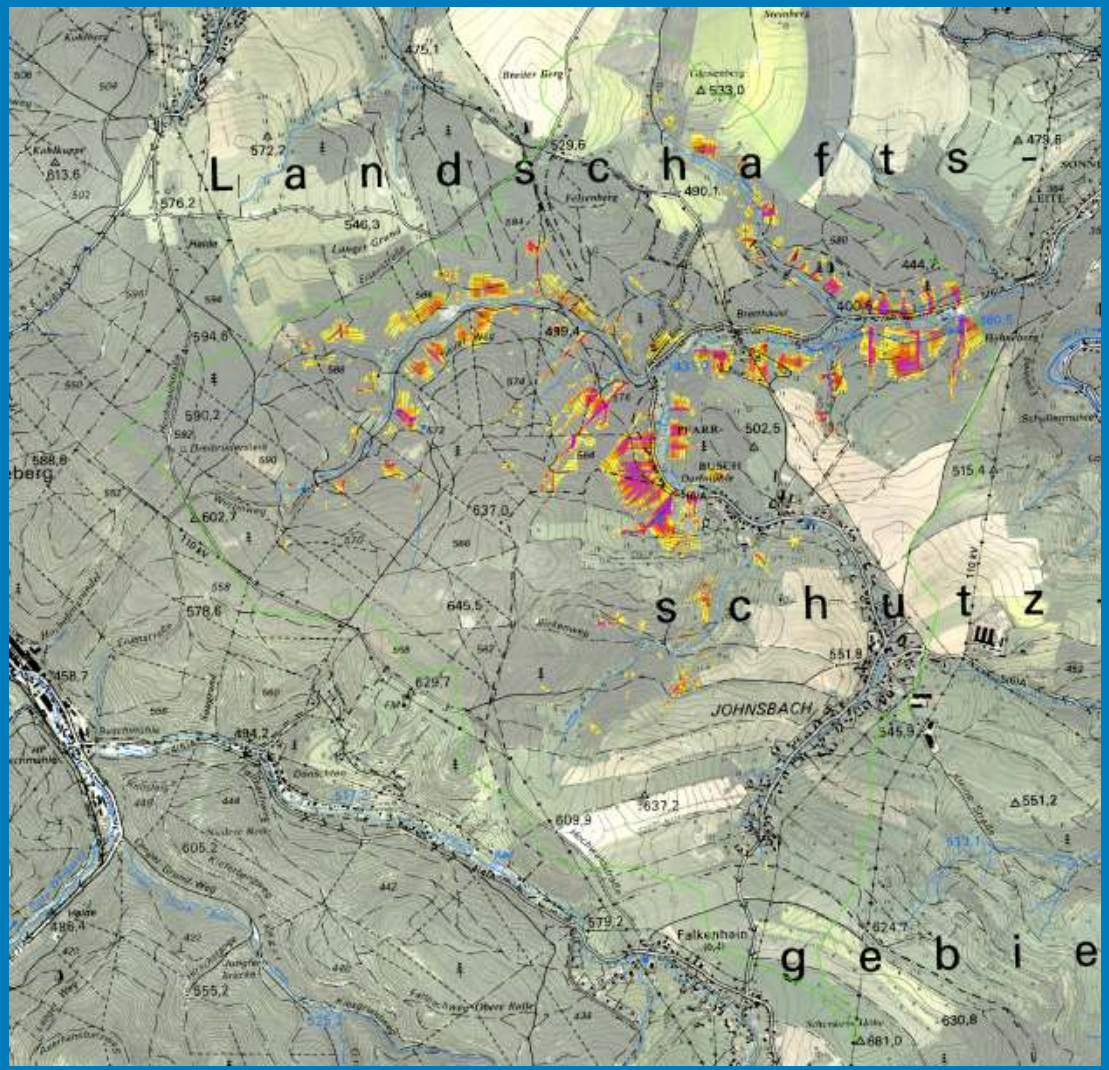
Probability Modelling Results 2: Erosion Gullies



Legende

Arbeitsgebiet

Einzugsgebiet HRB Glashütte

HRB Glashütte

Dammkronenwasserspiegel (geplant: 408,20m üNN)

Gefährdung durch Erosionsrinnen / -schluchten

Eintrittswahrscheinlichkeit

- < 55 %
- 55 - 60 %
- 60 - 65 %
- 65 - 70 %
- 70 - 75 %
- 75 - 80 %
- 80 - 85 %
- 85 - 90 %
- 90 - 95 %
- 95 - 100 %

Probability Modelling Workflow 3: Soil Sliding / Creeping

Input Data

Elevation Model and its Derivates:
- *Slope*
- *Exposition N/S*
- *Exposition W/E*

Geology:
- *Dip angle*
- *Dip direction N/S*
- *Dip direction W/E*

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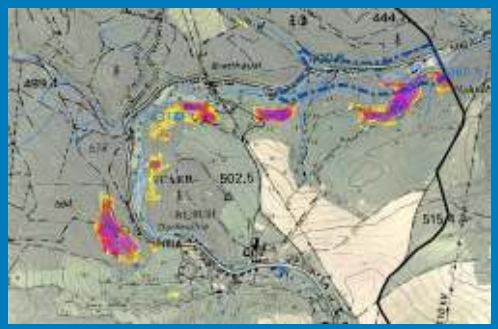
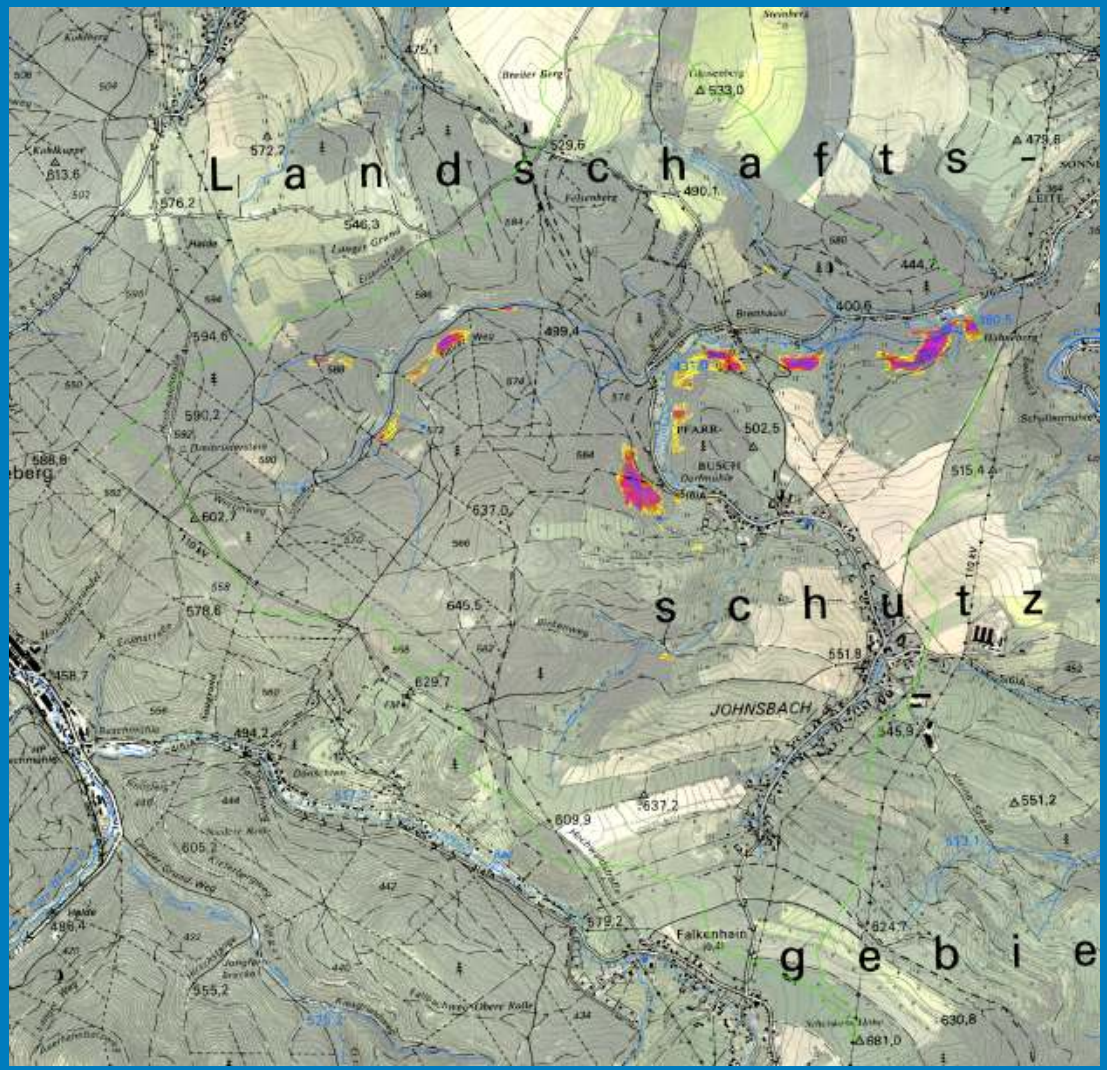


Training Data
Known Areas with Soil Creeping

Probability Modelling Results 3: Soil Sliding / Creeping



Legende

Arbeitsgebiet

Einzugsgebiet HRB Glashütte

HRB Glashütte

Dammkronenwasserspiegel (geplant: 408,20m üNN)

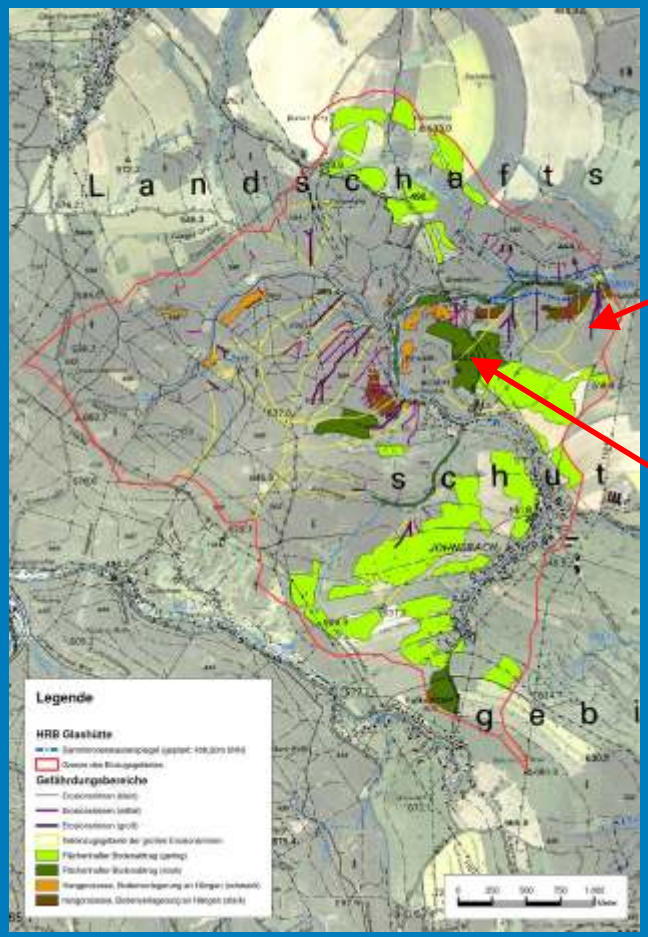
Gefährdung durch Hangprozesse / Bodenverlagerung an Hängen

Eintrittswahrscheinlichkeit

- < 55 %
- 55 - 60 %
- 60 - 65 %
- 65 - 70 %
- 70 - 75 %
- 75 - 80 %
- 80 - 85 %
- 85 - 90 %
- 90 - 95 %
- 95 - 100 %

Case Study : Glashütte Flood Control Reservoir Catchment Area

Delineation of Endangered Areas and Recommendation of Prevention Measures

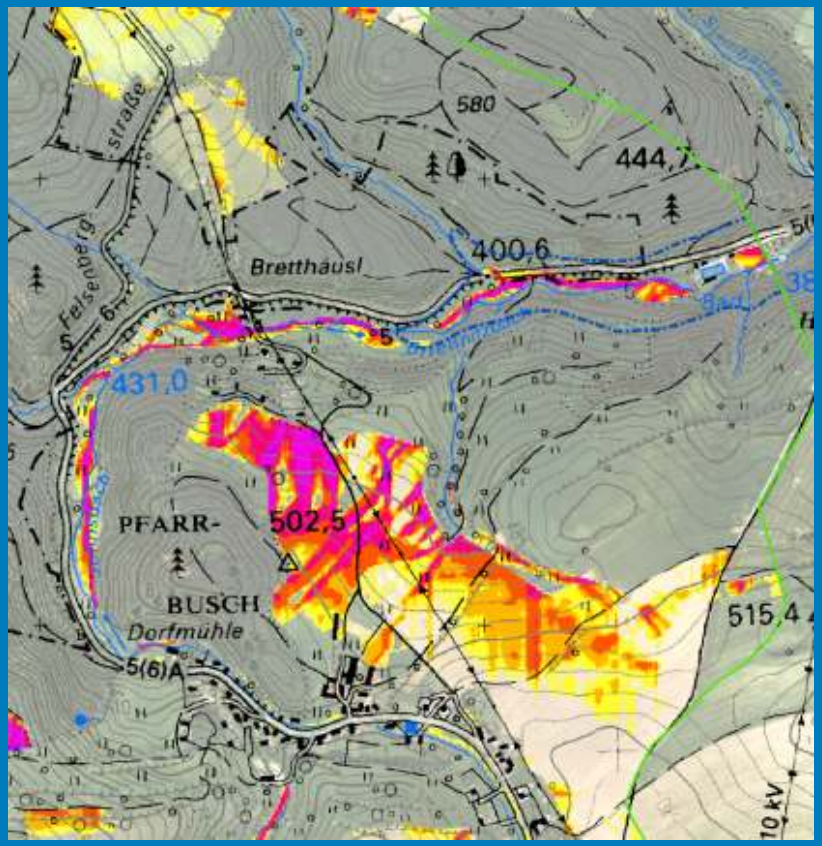


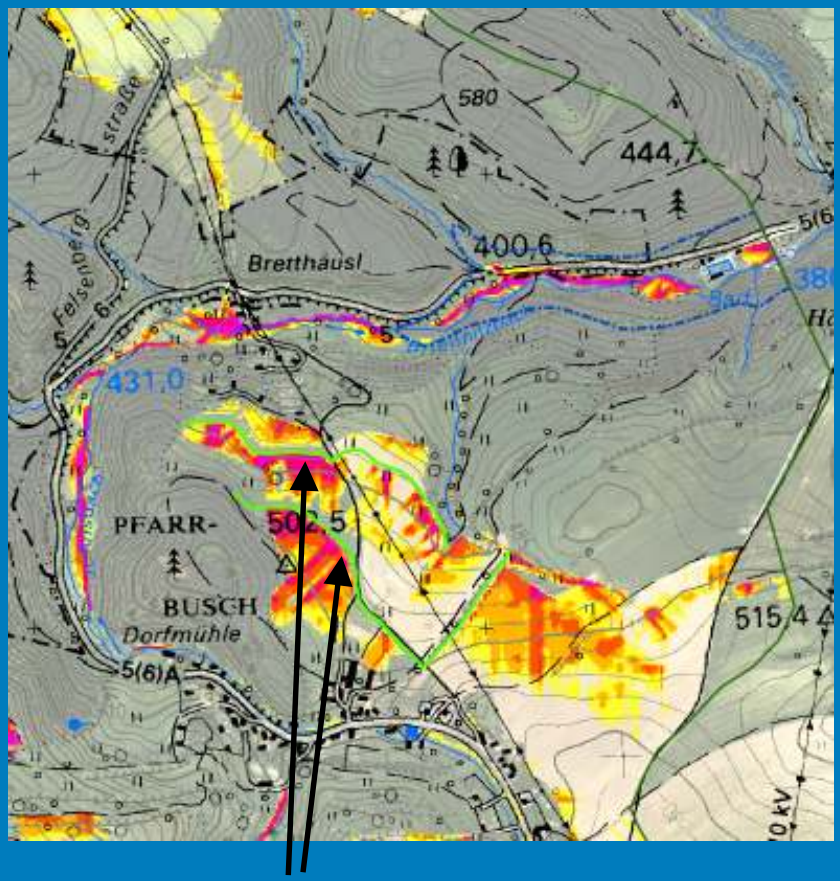
Bolder barriers against erosion gullies

Stone ridges against extensive soil erosion

Case Study : Glashütte Flood Control Reservoir Catchment Area

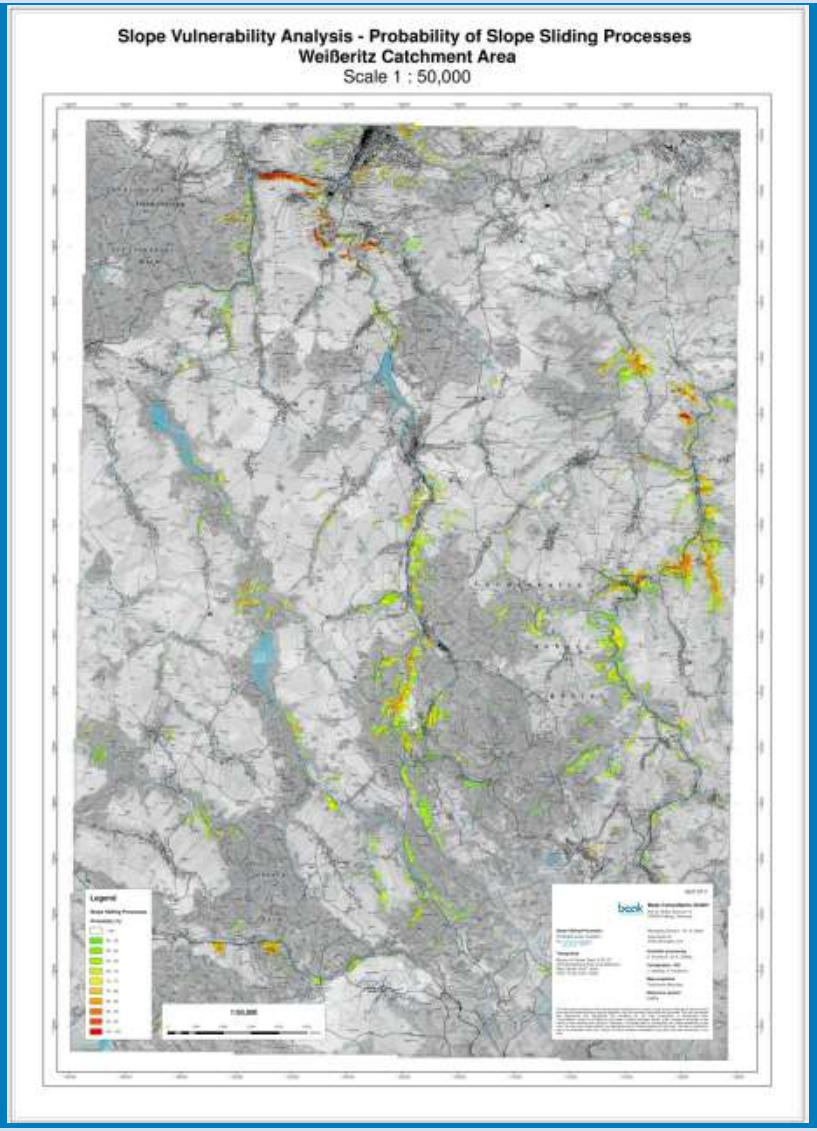
Modeling of Recommended Prevention Measures





Stone ridges against extensive soil erosion

Model Application: Weißeritz Catchment Area



Further Case Studies

- **Soil Creeping, Formation of Erosion Gullies**: Freital / Germany (2009)
- **Extensive Soil Erosion**: Weißeritz Catchment (2008)
- **Erosion Gullies**: Limpopo Area / South Africa (2009)

- **Coal Fires**: China (TUBAF, 2010)
- **Manganese Nodules Coverage Density**: Clarion-Clipperton Zone / Pacific Ocean (BGR, 2010)
- **Mineral Deposits / Occurrences - Pb/Zn, Au, Cr**: Kosovo (ICMM, 2003 – 2009)
- **Regolith Classification**: Burkina Faso (Vaclav Metelka, 2010)
- **Soil Contaminations in Urban Areas**: Marienberg / Germany (LfULG, 2010)
- **Spread of Forest Pests**: Tharandter Wald / Germany (Sachsenforst, 2009)

Summary: Application of Artificial Neural Netwroks

- Multiple applications of the developed methodology using artificial neural networks and GIS for the **prediction of geo-hazard**

- **Currently in development:**
  - Soil Parameter Regionalisation Model
  - Mineral Deposit Prediction Model

→ **We look forward to your questions, suggestions and comments and hope for future knowledge sharing and collaboration!**

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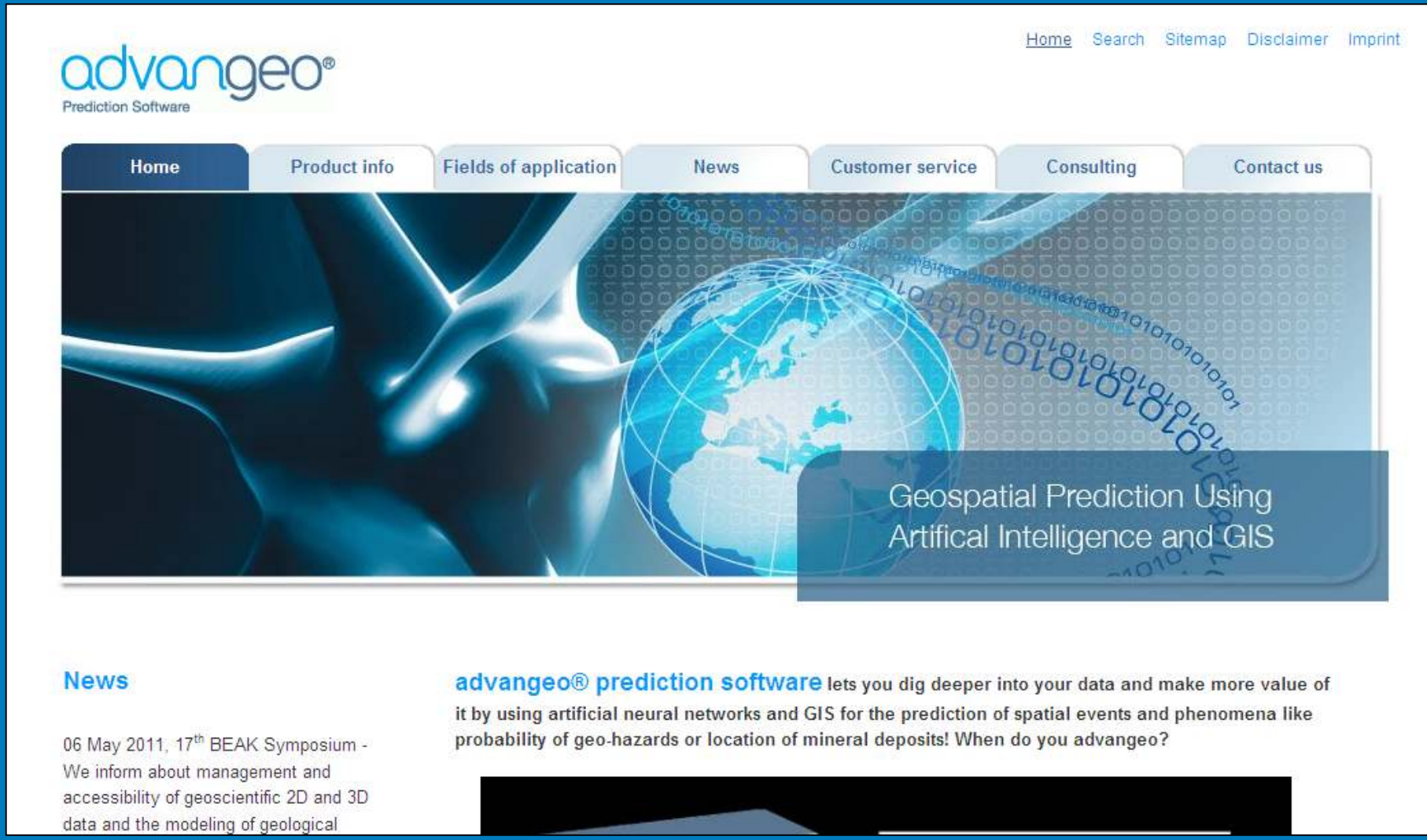
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