IMPROVING ANN-MLP AS EFFECTIVE SPATIAL MODELING METHOD FOR COPPER AND LEAD DISTRIBUTION IN MINING AFFECTED AREAS

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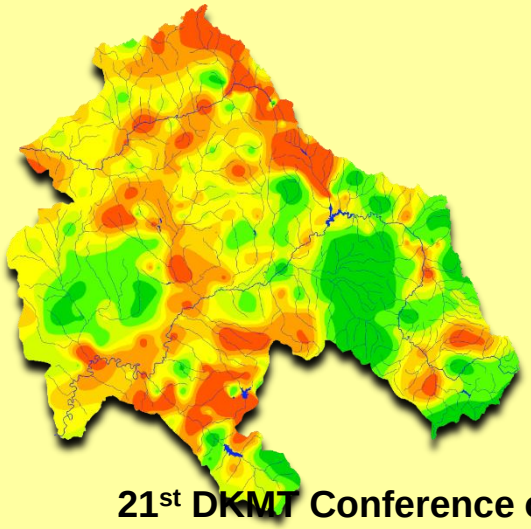

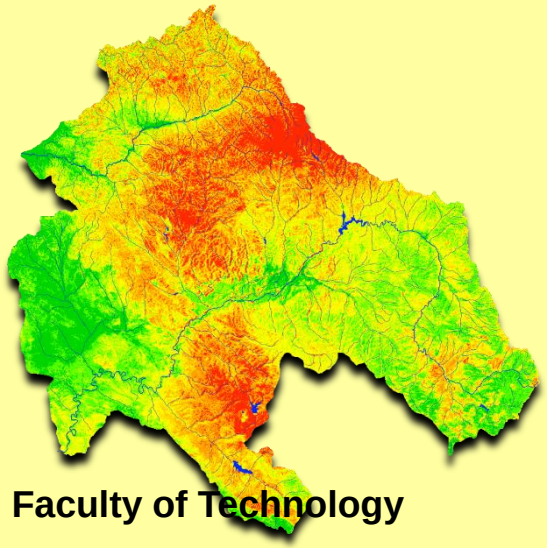

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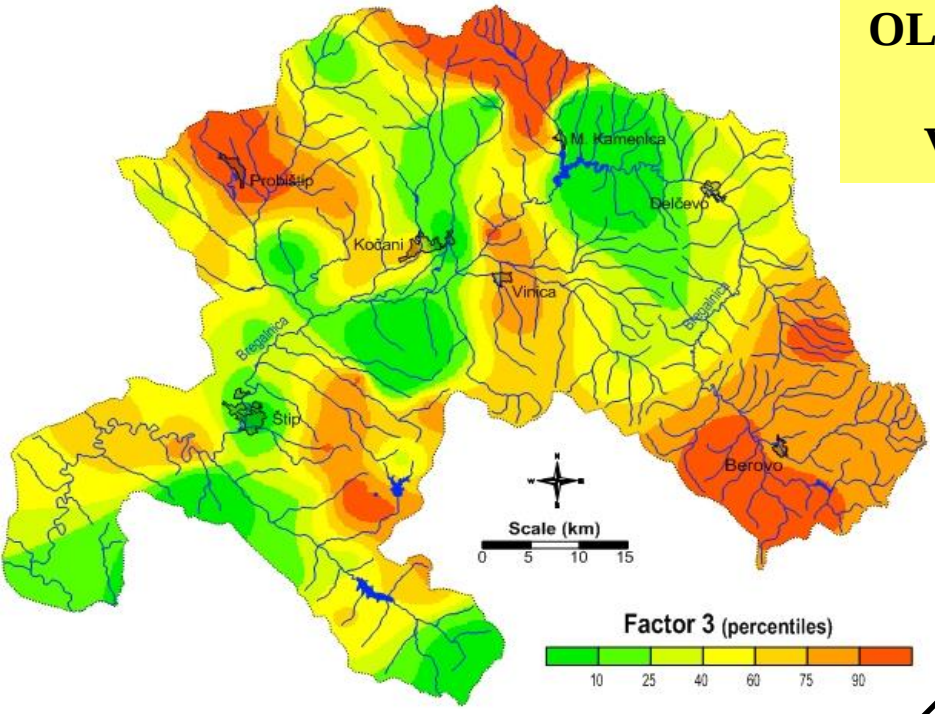
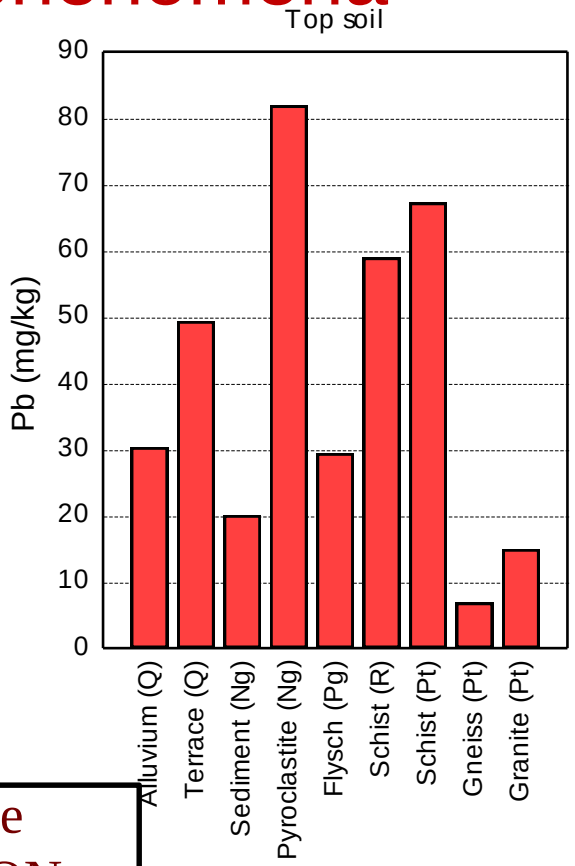
Lithogenic *vs.* Anthropogenic phenomena



OLIGOCENE AND NEOGENE VOLCANISM

Occurrence in area with dominance of



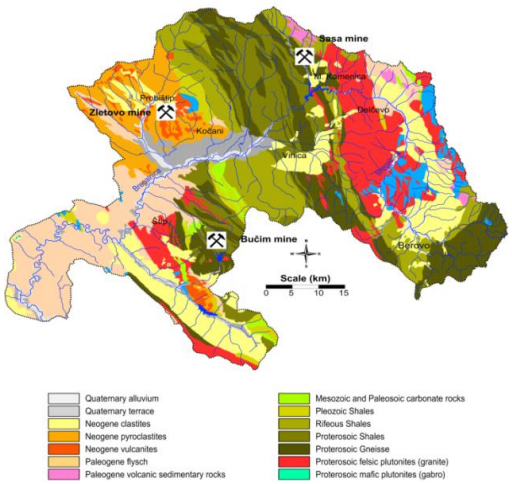
(Ag-Bi-Cd-Cu-In-Mn-Pb-Sb-Te-W-Zn)

Multivariate EXTRACTION

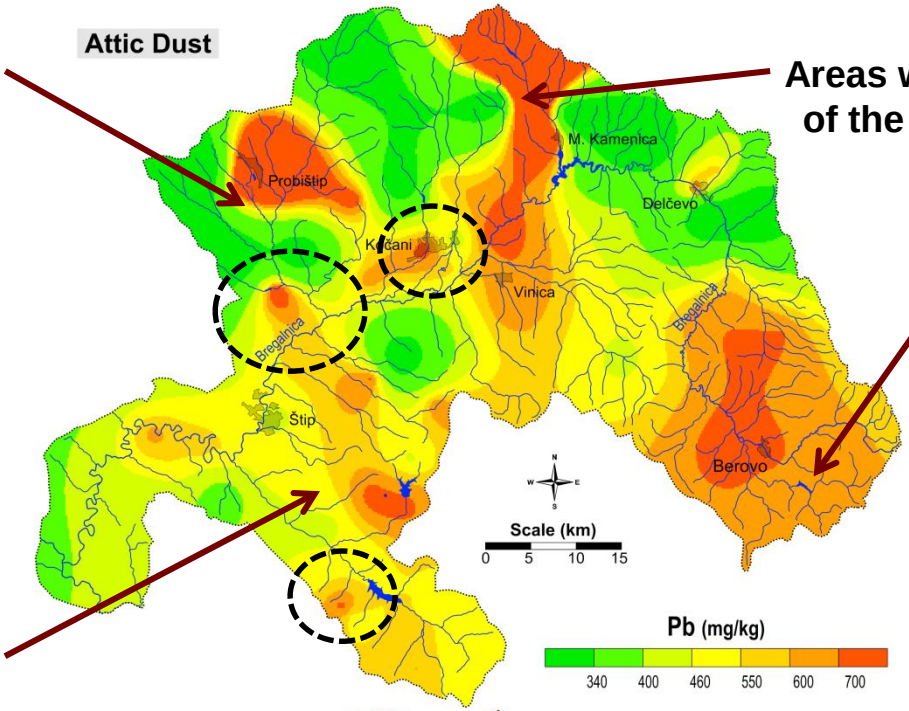
ANTHROPOGENIC ANOMALIES!!!

Balabanova et al. (2019) Journal of Environmental Science and Health, Part A.
Balabanova et al. (2017) Archives of Environmental Contamination and Toxicology.
Balabanovaet al. (2017) Journal of Environmental Science and Health, Part A.
Balabanova et al. (2016) Environmental Science and Pollution Research.
Balabanova et al. (2016) Macedonian Journal of Chemistry and Chemical Engineering.
Balabanova et al. (2016) Journal of Environmental Science and Health, Part A.
Balabanova et al. (2015) Journal of Environmental Health Science & Engineering.
Balabanova et al. (2015) Macedonian Journal of Chemistry and Chemical Engineering.

Total 69 elements: Ag, As, Al, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, I, In,Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Os, P,Pb, Pd, Pr, Pt, Rb, Re, Rh, Ru, Sb, Sc, Se, Sm, Sn, Sr, Ta, Tb, Te, Ti, Th, Tl, Tm, V, W, Y, Yb, Zn and Zr

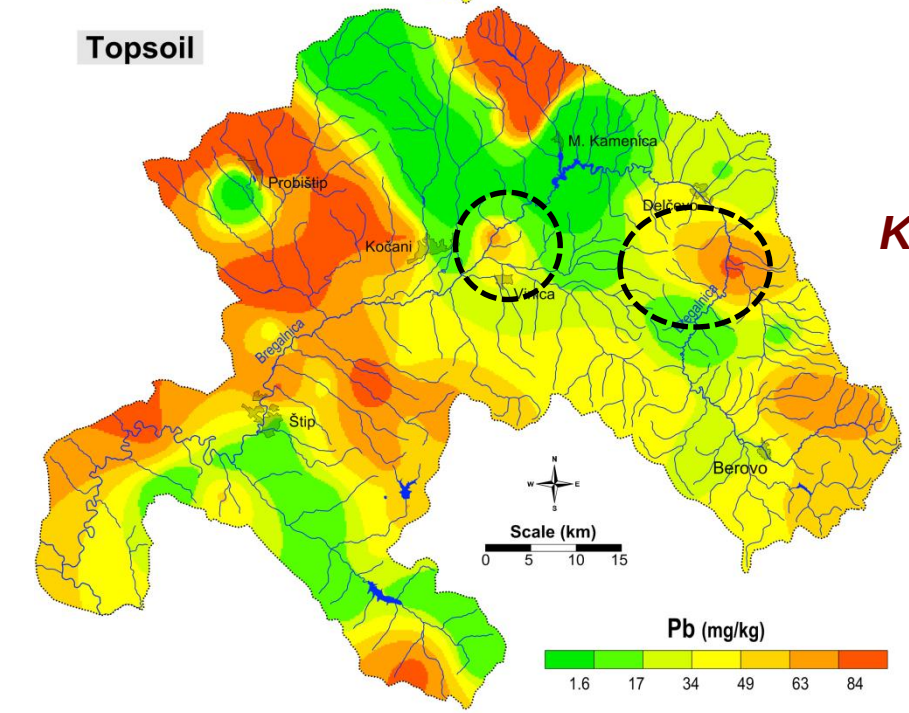


Attic Dust



Areas with dominantly presence of the Oligocene and Neogene volcanism

Topsoil



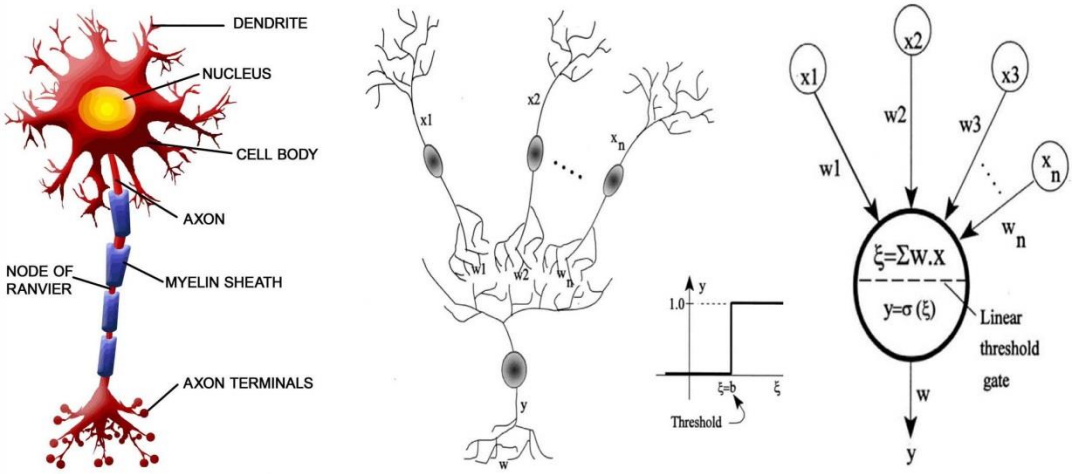
***Kriging* anomaly?**

Spotting effect!!!!

Bull's eye effect

Artificial neural networks

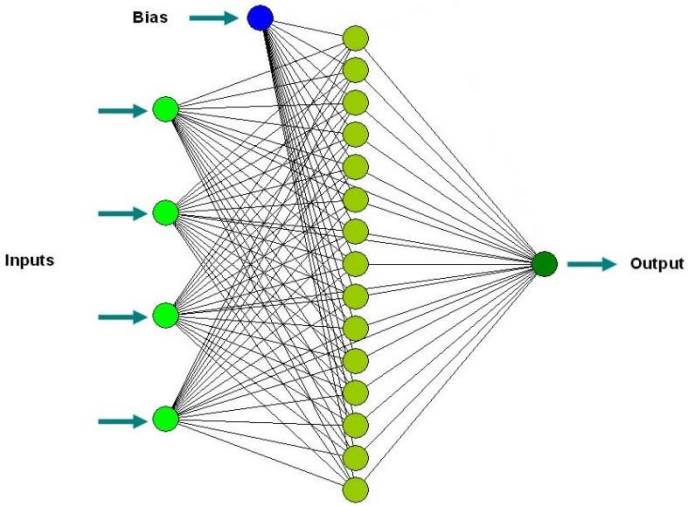
Artificial Neural Network - A computer simulation of human neurons. A system (implemented in software or hardware) that is intended to emulate the computing structure of neurons in the human brain. The main challenge is to actually produce a modelling system that can handle a large number of input and output parameters.



Biological neuron and mathematical model of McCulloch and Pitts neuron

A neuron is a processing unit in a neural network. It is a node that processes all fan-in from other nodes and generates an output according to a transfer function called the activation function. The activation function represents a liner or nonlinear mapping from the input to the output. A neuron is linked to other neurons by variable synapses (weights). Simple neuron model have been proposed by McCulloch and Pitts.

Multilayer Perceptron



Multilayer perceptron architecture

REASONS FOR APPLICATION

They can model extremely complex systems, which cannot be modeled by methods based on linear algebra.

No problems with the dimensionality - it can be arbitrary.

Due to well developed learning algorithms they are easy to use.

Input data - secondary attributes sourced from the DEM, land use, and remote sensing in combination with sparse and expensive soil measurements

Due to high cost and time consuming nature of soil sampling, research in developing methods for the creation of soil maps based in various prediction methods is becoming increasingly important. Each aforementioned applied modelling technique by itself helped us in reconstruction simultaneously different processes that influenced the entire study area.

Techniques used in modelling

a) THE BASIC DESCRIPTIVE PARAMETERS:

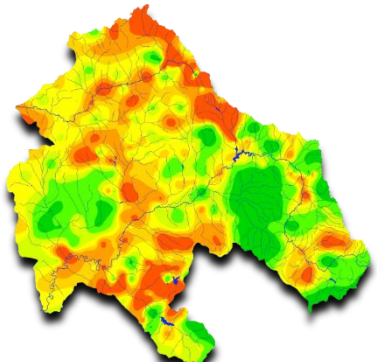
- Identification number
- Sample label,
- Sampling material

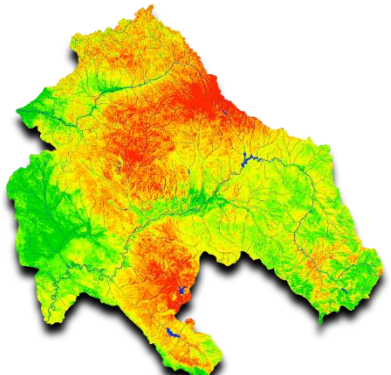
b) ANALYTICAL DATA; → DATA TRANSFORMATION

c) GEOSPATIAL DATA:

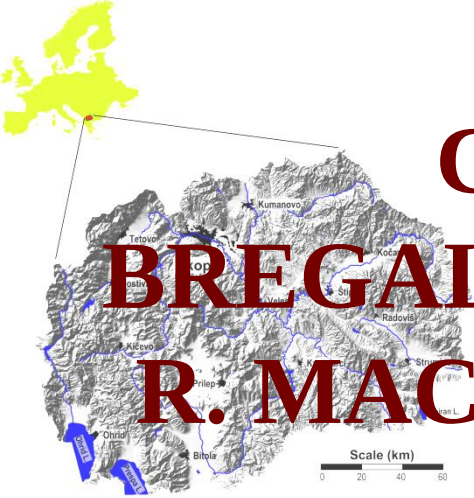
- Landuse unit,
- Lithological unit,
- Defined zones,
- Latitude,
- Longitude,
- Absolute distance from mines,
- Elliptical distance from mines,
- Distance from the rivers,
- Altitude,
- Altitude above the bottom of valley,
- Terrain Slope,
- Aspect,
- Plan Curvature,
- Profile Curvature,
- Tangent Curvature,
- Landsat spectral bands

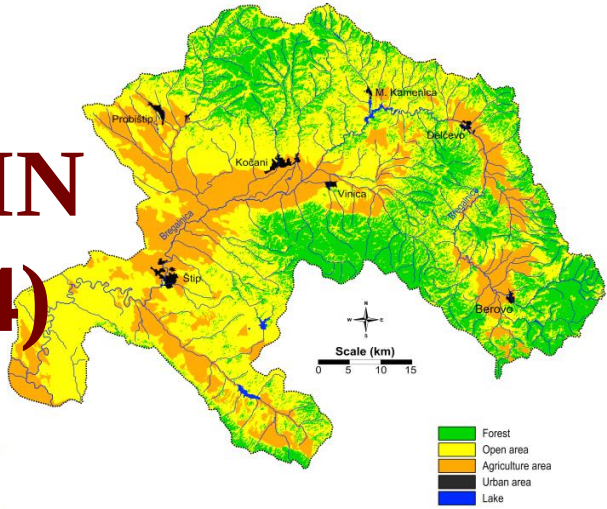
Performing the same mathematical operation on each piece of the original data





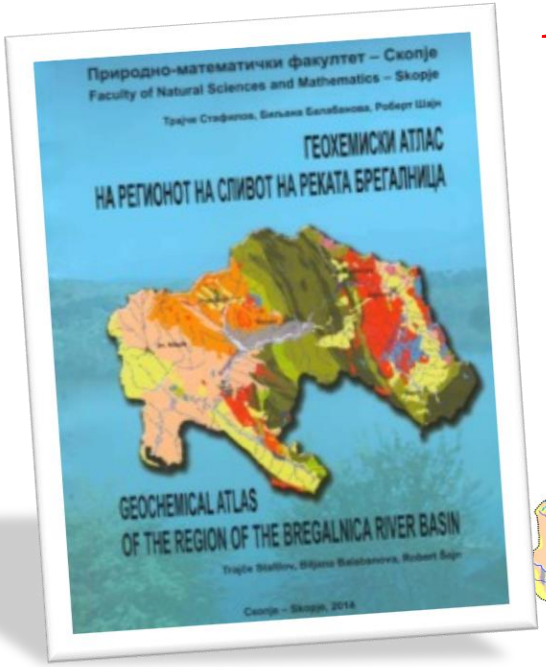
CASE STUDY:
BREGALNICA RIVER BASIN
R. MACEDONIA (2012-2014)

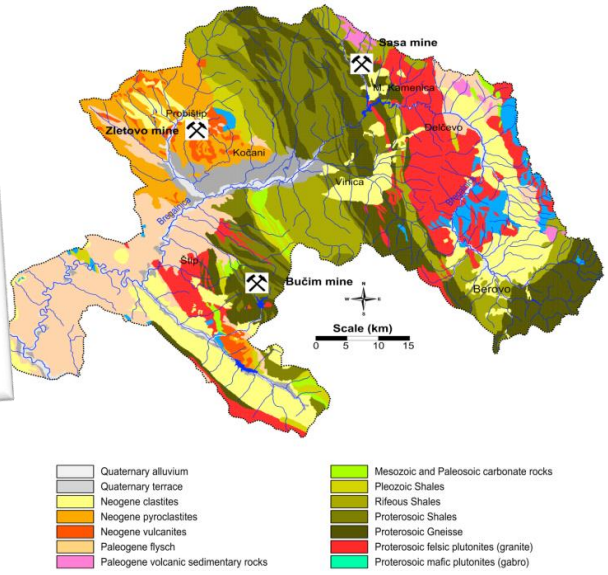


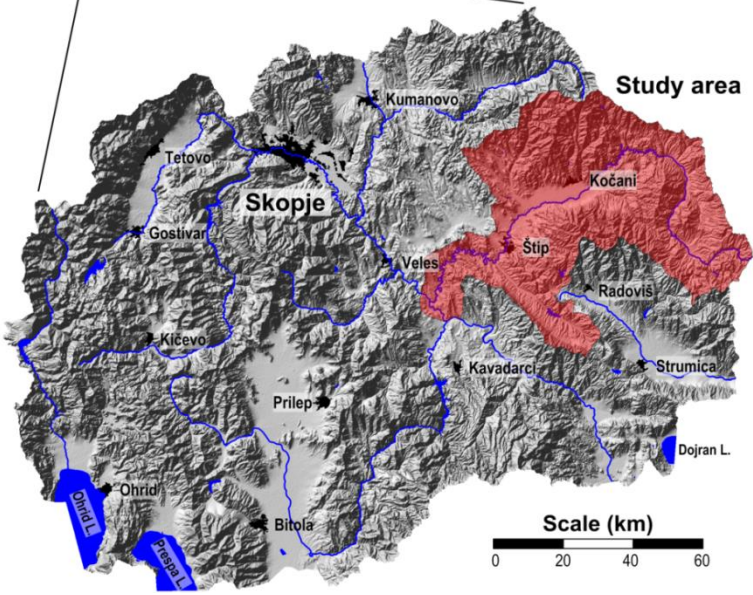


Bregalnica River basin

N: 41°27'-42°09'
E: 22°55'-23°01'

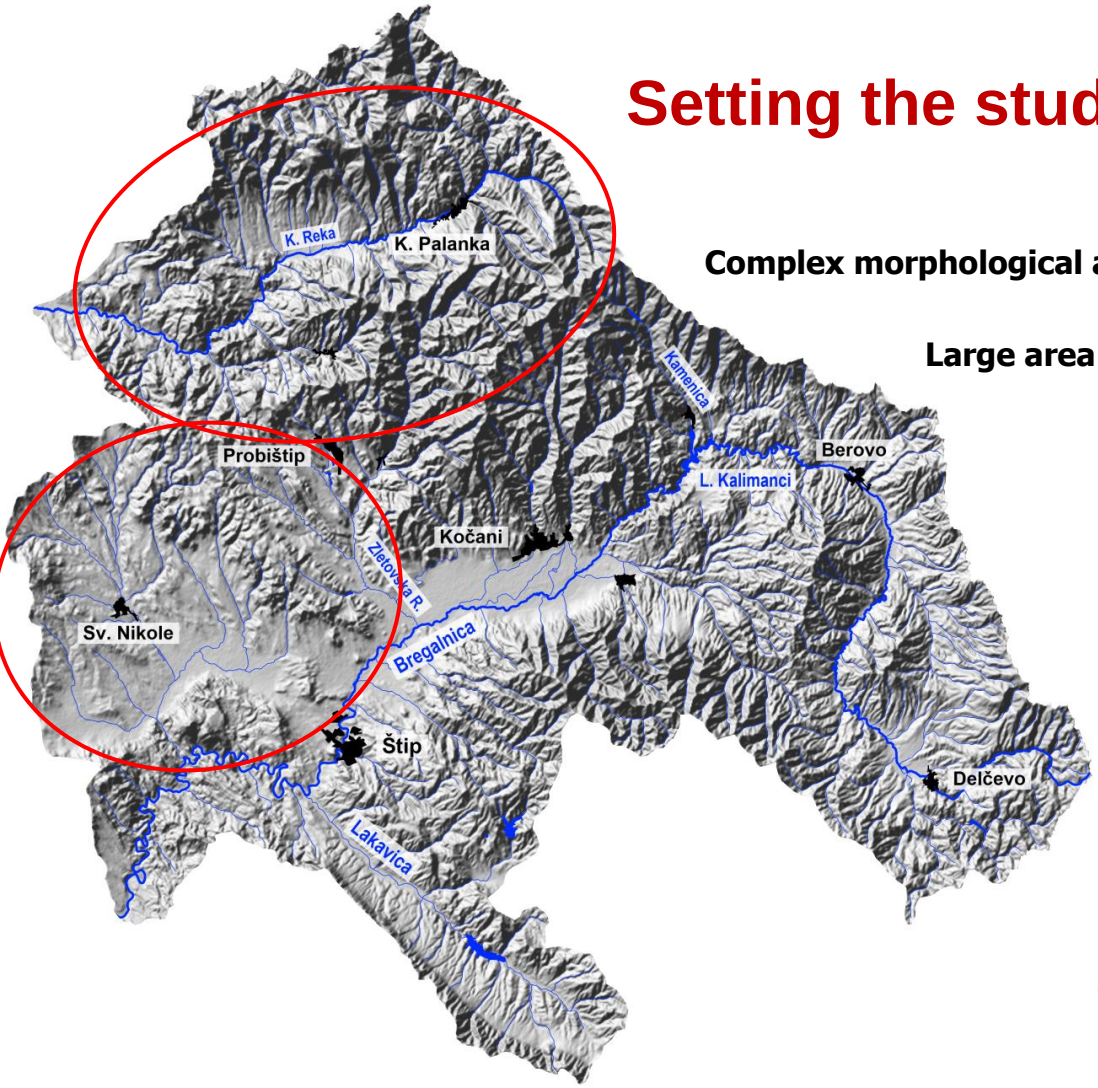






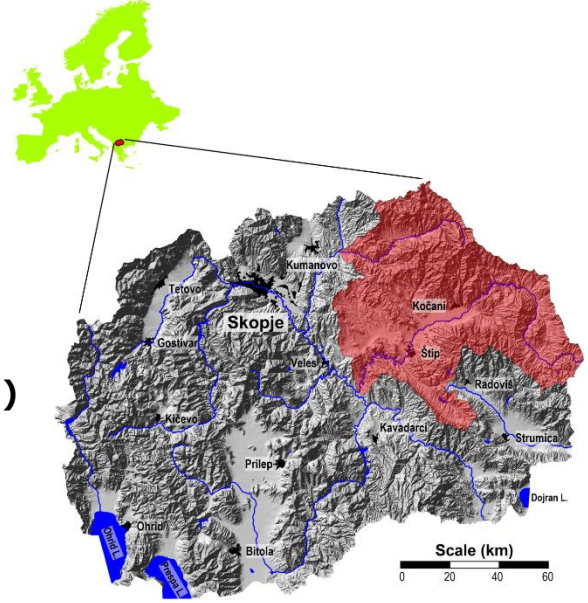
Stafilov T., Balabanova B., Sajn R. (2014) *Geochemical atlas of the region of the Bregalnica river basin.* Faculty of Natural Sciences and Mathematics – Skopje.

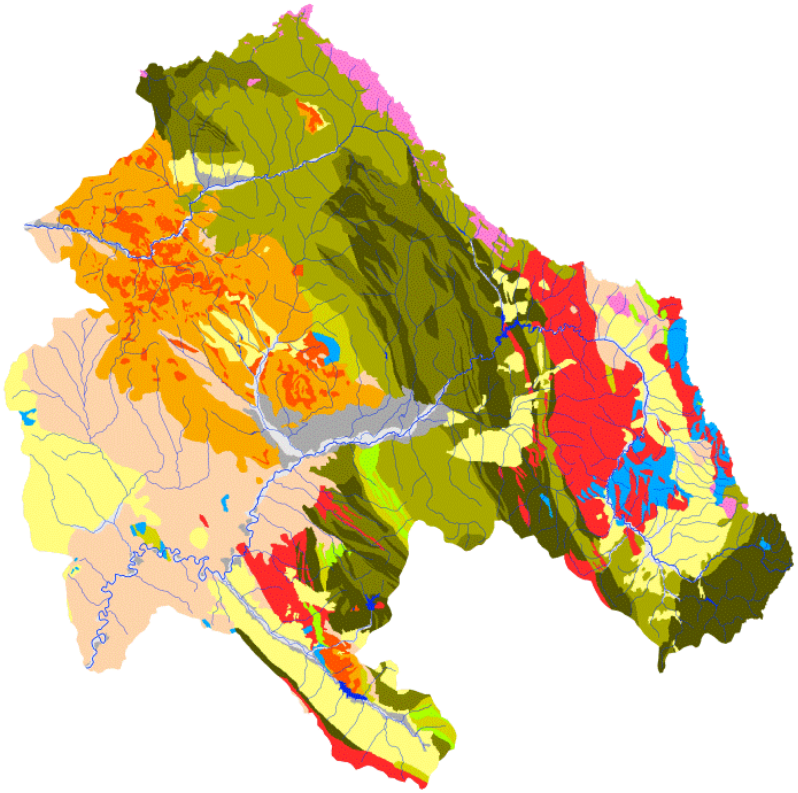
Setting the study area



Complex morphological area

Large area (c. 5400 km^2)





Geological background -
many different lithological units (Pt-Q)

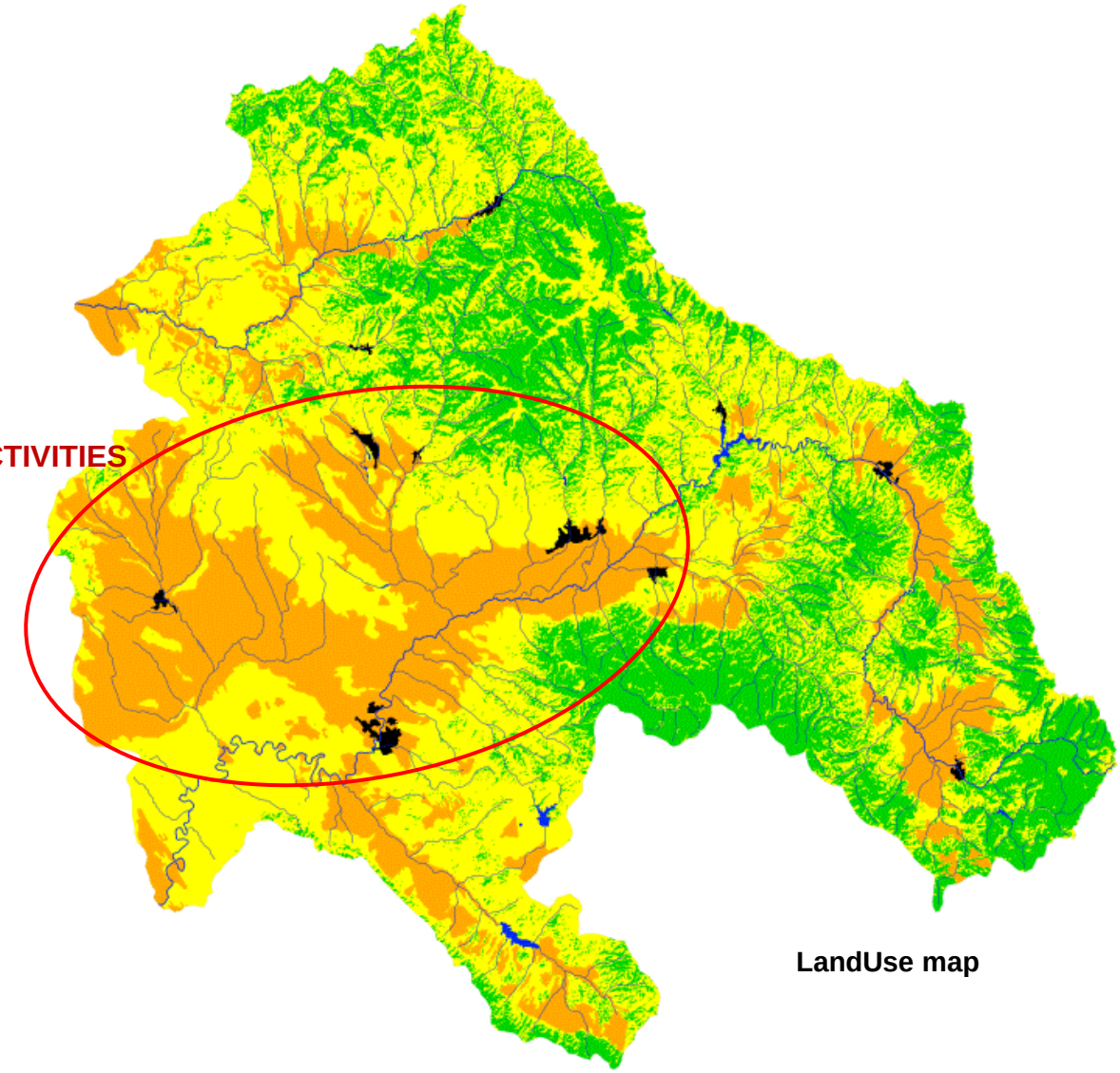
Setting the study area

Large area (c. 5400 km^2)

Complex morphological area

Geological background
many different lithological units (Pt-Q)

AREA OF IMPORTANT AGRICULTURAL ACTIVITIES



LandUse map

Case study NE part of the Republic of North Macedonia

Large area (c. 5400 km^2)

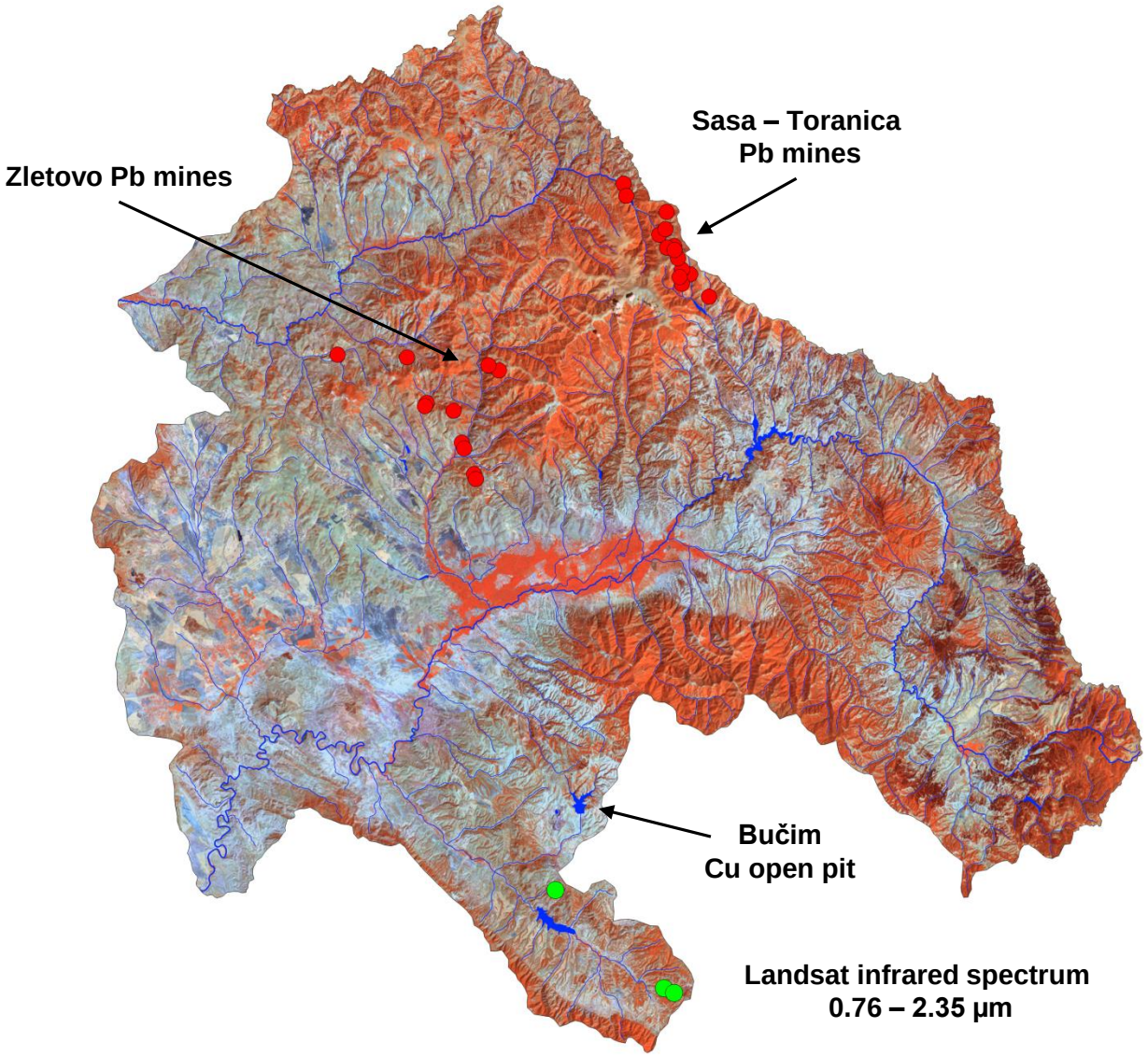
Complex morphological area

Geological background -
many different lithological units (Pt-Q)

Area of important agricultural activities

Intensive mining activities
Pb mines Sasa, Toranica, Zletovo
Cu open pit Bučim
Pb-Zn-Cu mineralisation outcrops

Presence of natural enrichment and complex anthopogenic impact in various directions



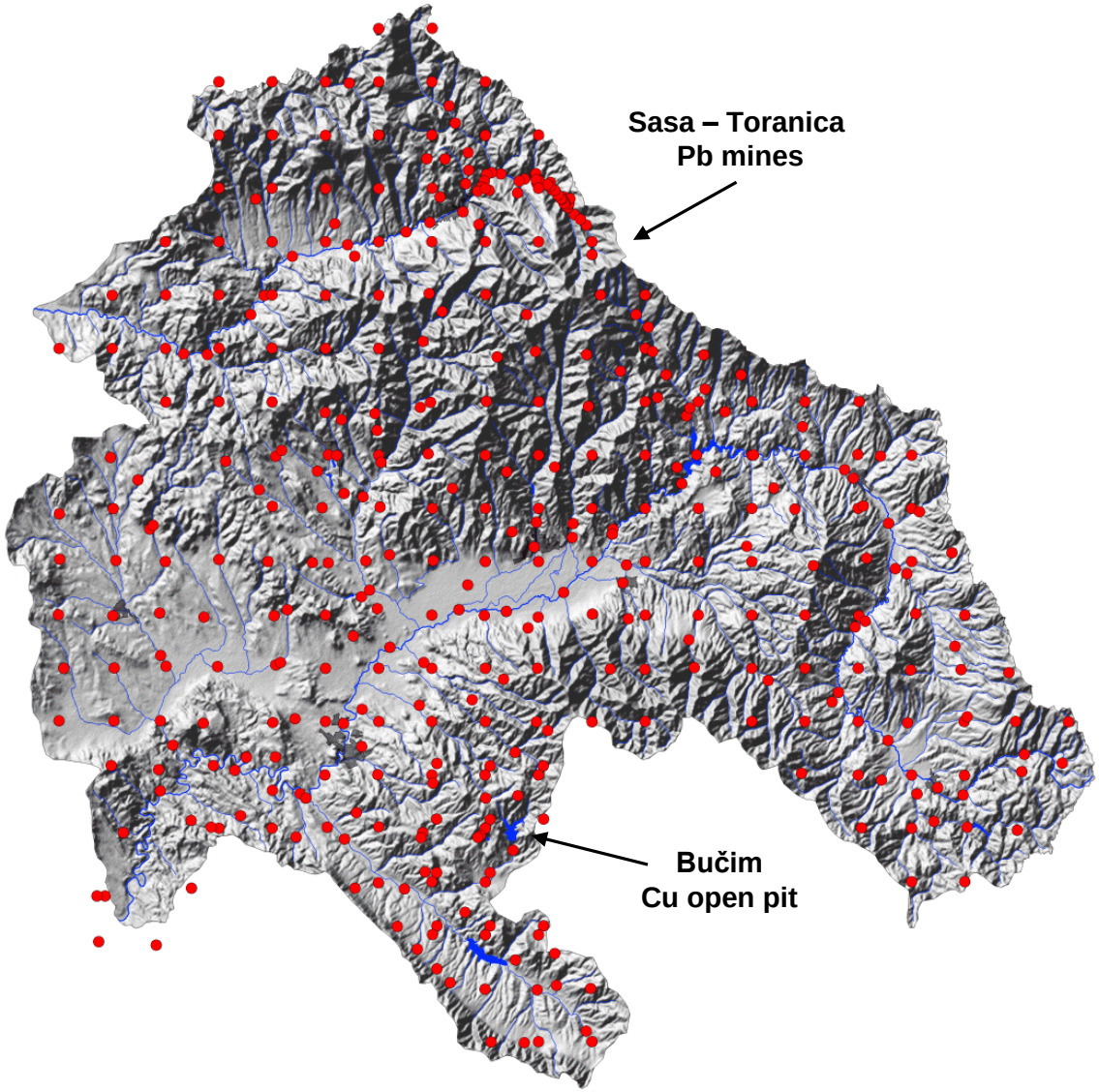
ANN-MP input data (topsoil)

409 sampling points (learning data)

218 – regular grid 5 x 5 km
(geochemical map of Macedonia)

126 – other investigation
(mainly around mines)

65 – alluvial soil investigation

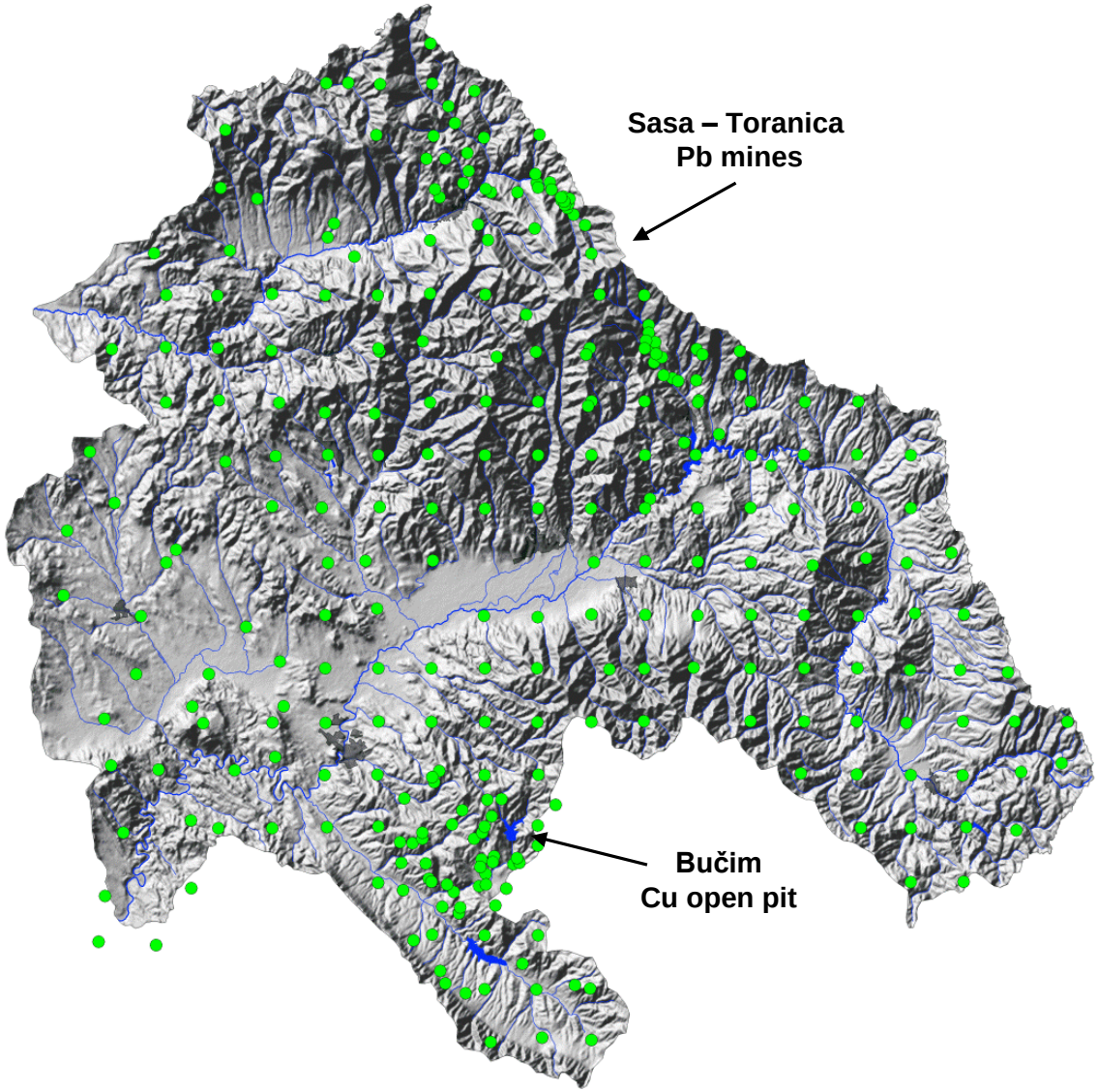


ANN-MP input data (Moss)

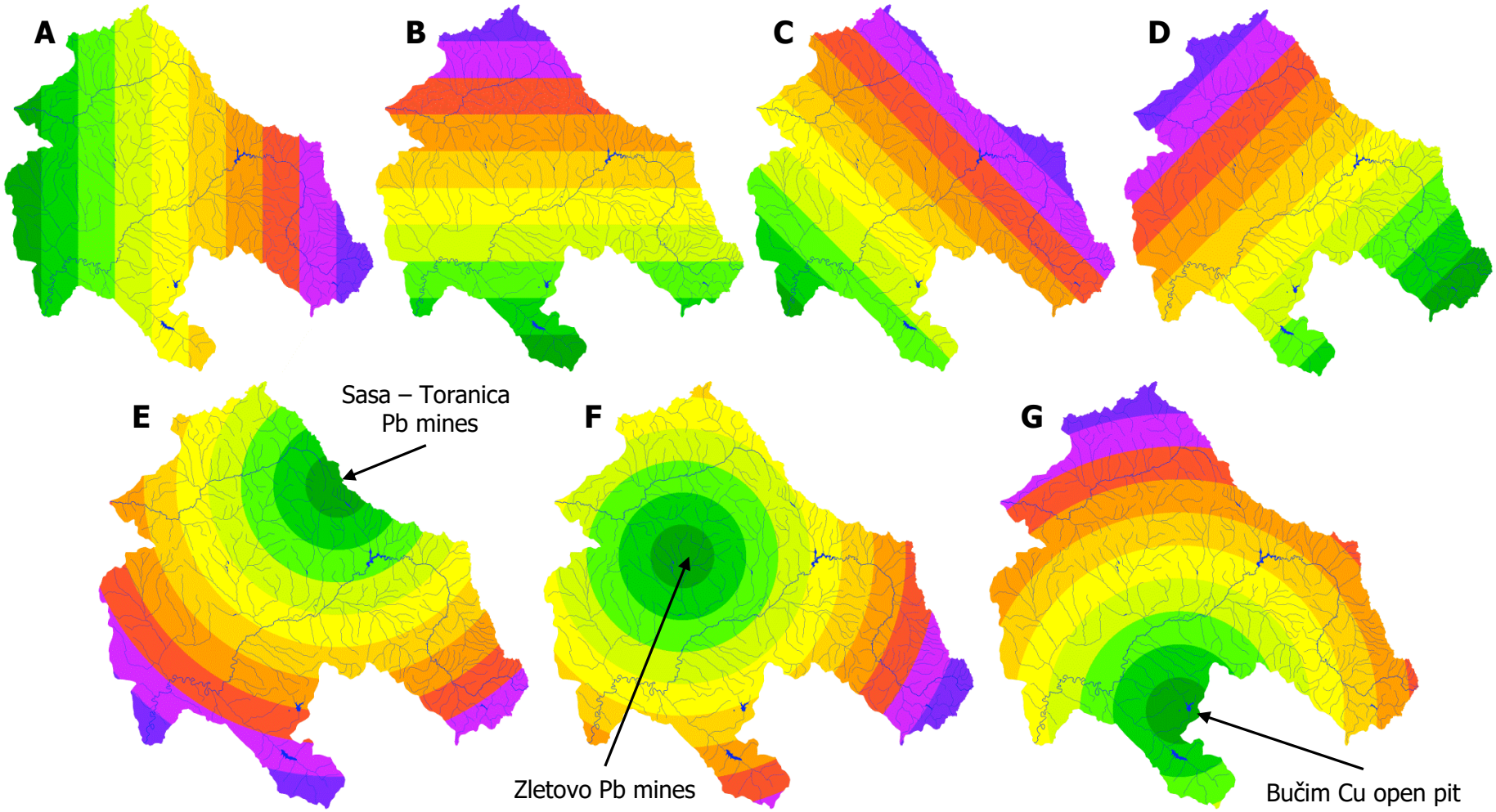
286 sampling points (learning data)

195 - regular grid 5 x 5 km
(geochemical map of Macedonia)

91 – other investigation
(mainly around mines)



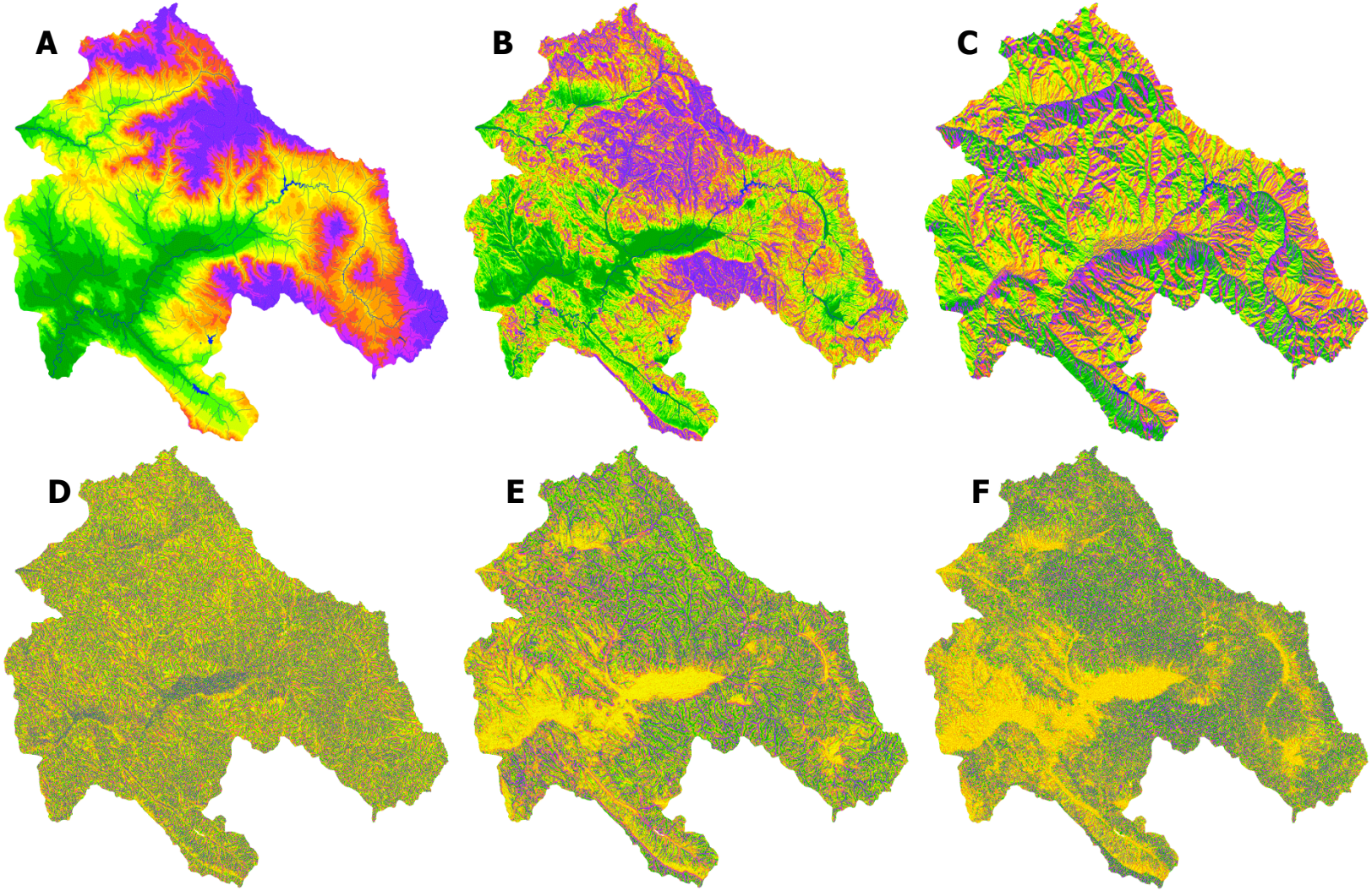
ANN-MP input data (distances)



A – Distance in W-E direction
B – Distance in S-N direction
C – Distance in SW-NE direction
D – Distance in SE-NW direction

D – Distance from the area of Sasa – Toranica Pb mines
E – Distance from the area of Kratovo Pb mines
F – Distance distance from the Bučim Cu open pit

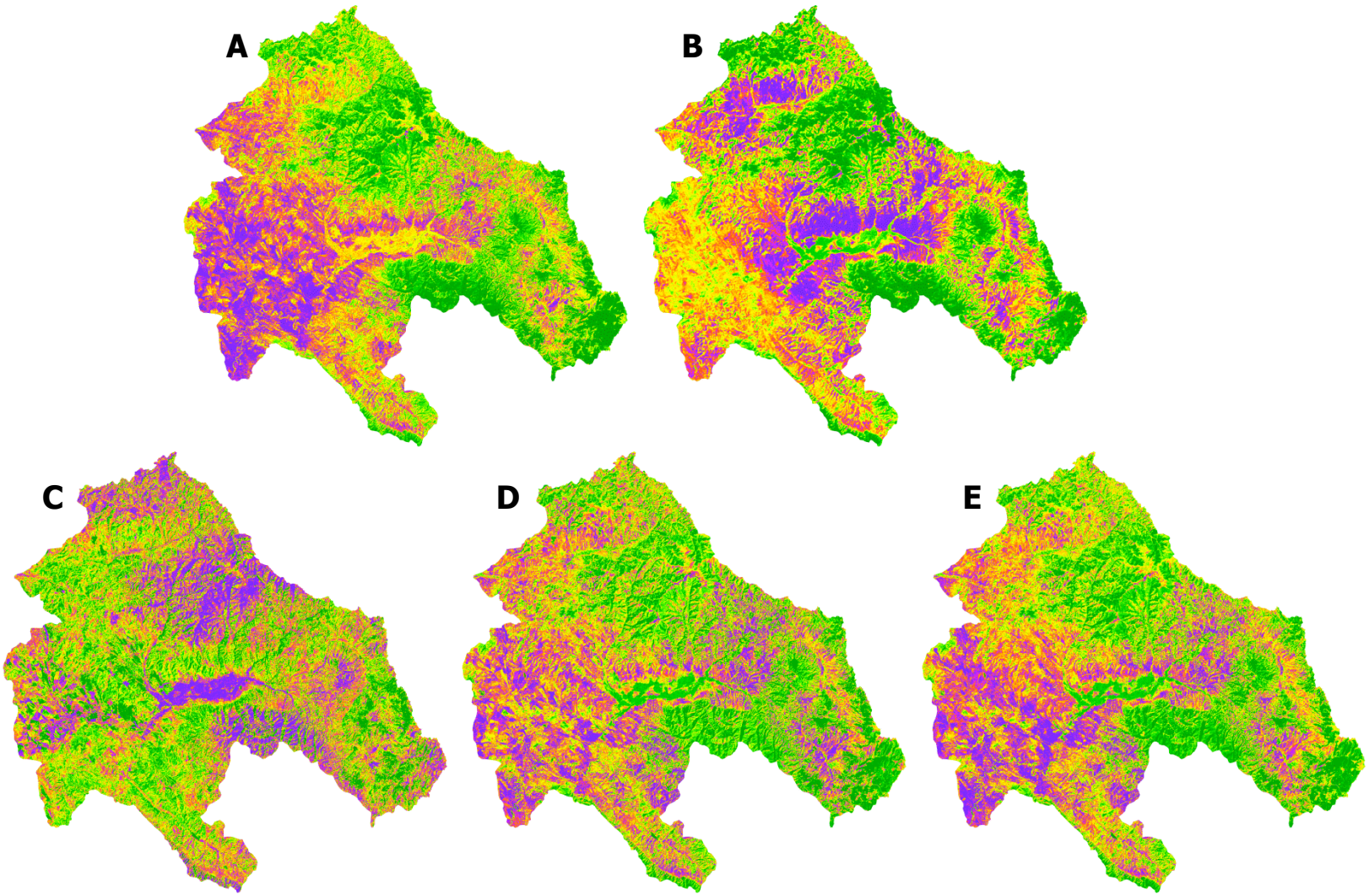
ANN-MP input data (DEM)



A – Altitude above the see level (absolute)
B – Terrain slope
C – Aspect (insolation)

D – Plan terrain curvature
E – Profile terrain curvature
F – Tangent terrain curvature

ANN-MP input data (LandSat)



A – Join visible spectrum, 0.45 – 0.69 μm (B10-B20-B30)
B – Thermal radiation spectrum, 10.4 - 12.5 μm (B60)

C – Infrared spectrum, 0.76 – 0.90 μm (B40)
D – Infrared spectrum, 1.55–1.75 μm (B50)
E – Infrared spectrum, 2.08–2.35 μm (B70)

ANN calculation summary

Categorical input data

Geological map
Landuse map

Numerical input data

Distances
Digital elevation model and its derivates
LandSat satelit images (B10-B70)

Learning and recall

Learning data: 409 sampling points (Topsoil)
Learning data: 286 sampling points (Moss)
Recall data: 540 497 locations (Grid 100 X 100 m)

ANN Training

Multilayer perceptron - Hidden units - 120

Train networks - 25 (the final model representing an average of 5 most logical solution)

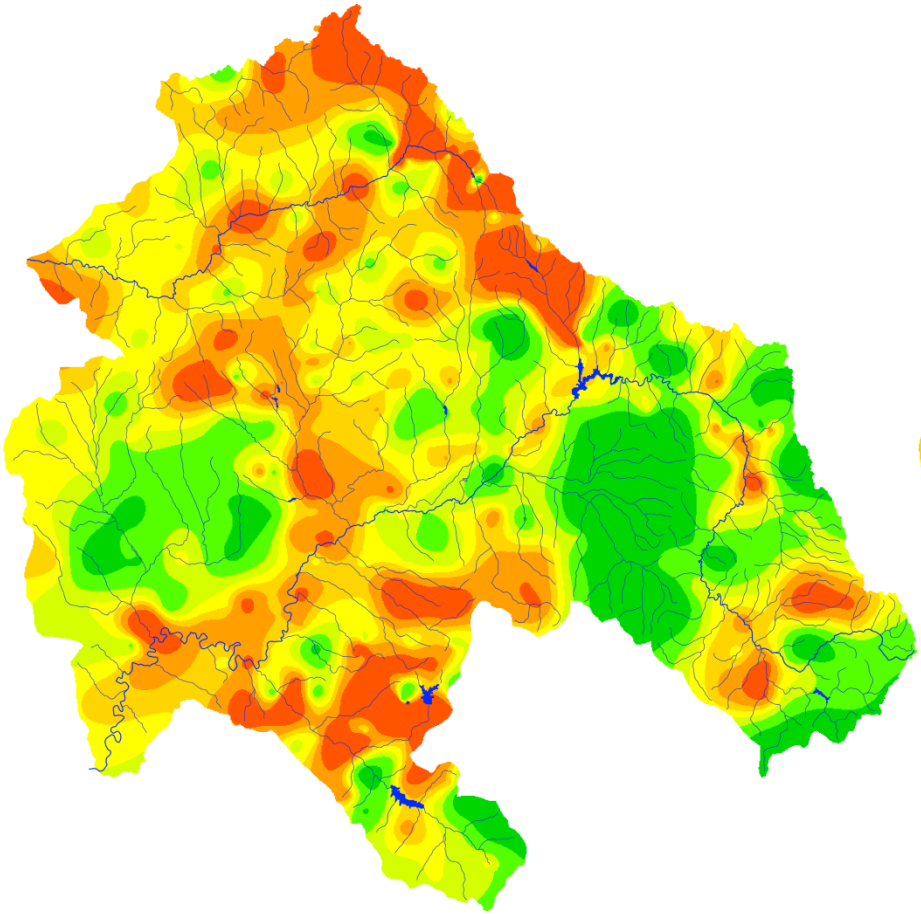
Each training model contain: Training perfection, Test perfection, Validation perfection, All perfection, Training error, Test error, Validation error, Training algorithm, Hidden activation, and Output activation.

Next step (improvement of model)

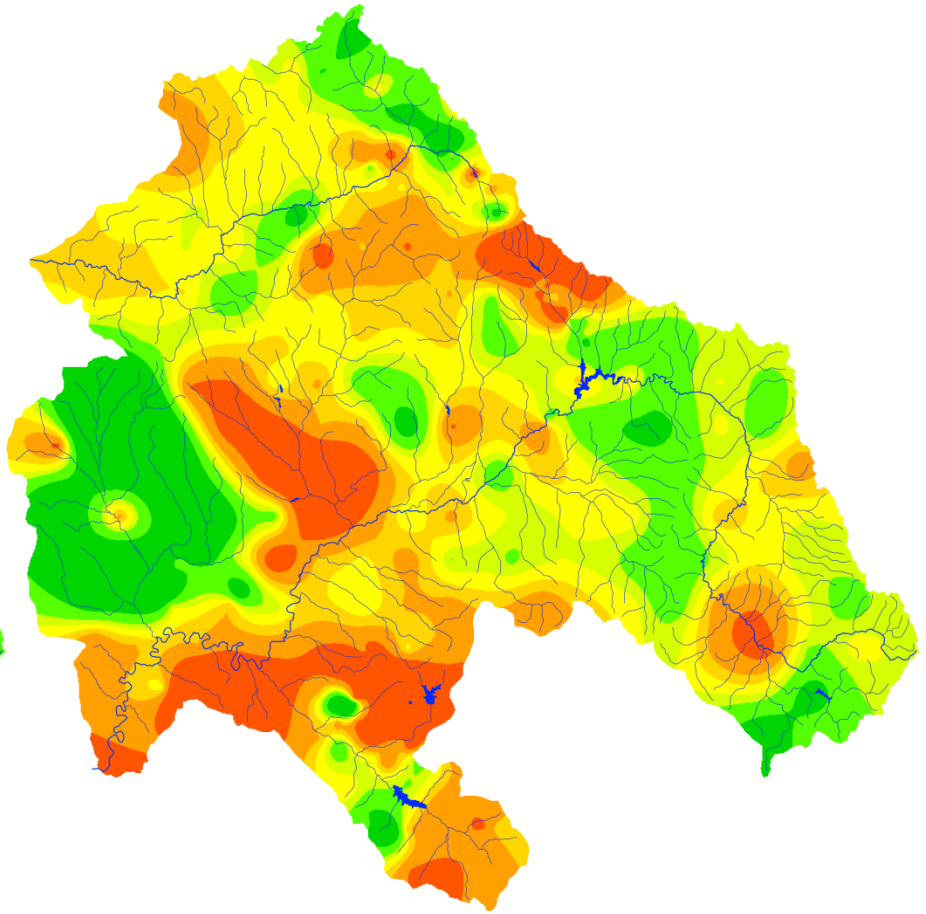
CORINE Landuse map (categorical data)
Pedological map (categorical data)
Mean annual precipitation map (numeric data)
Mean annual temperature map (numeric data)
Mean annual wind magnitude (speed) map (numeric data)
Mean annual wind vector (direction) map (numeric data)

Distribution of copper (Universal Kriging)

Topsoil



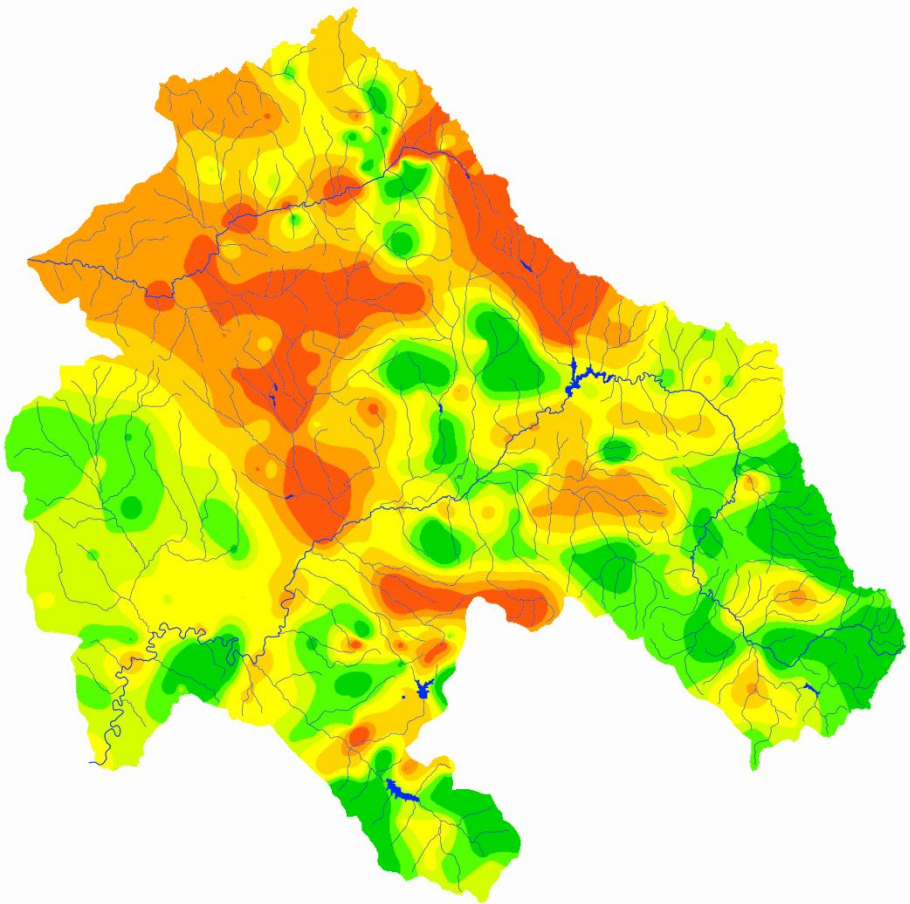
Moss



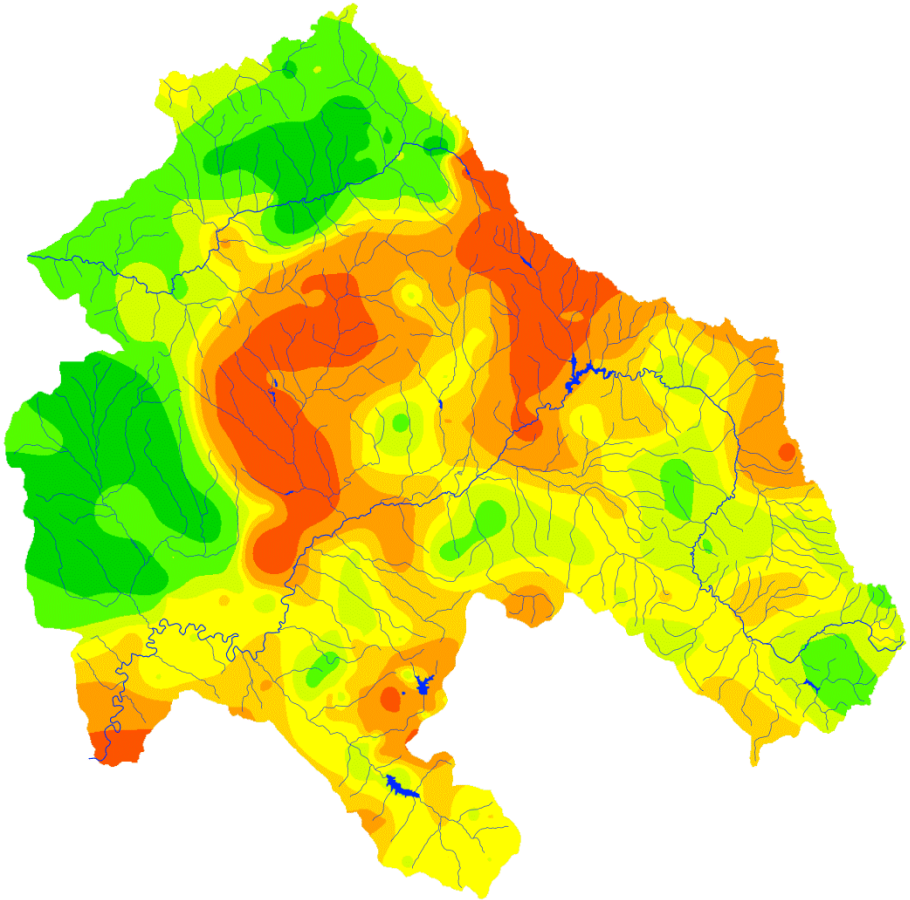
The results are difficult to interpret in both sampling materials due to typical anomalies of linear interpolations – Bull's-eye effect.

Distribution of lead (Universal Kriging)

Topsoil

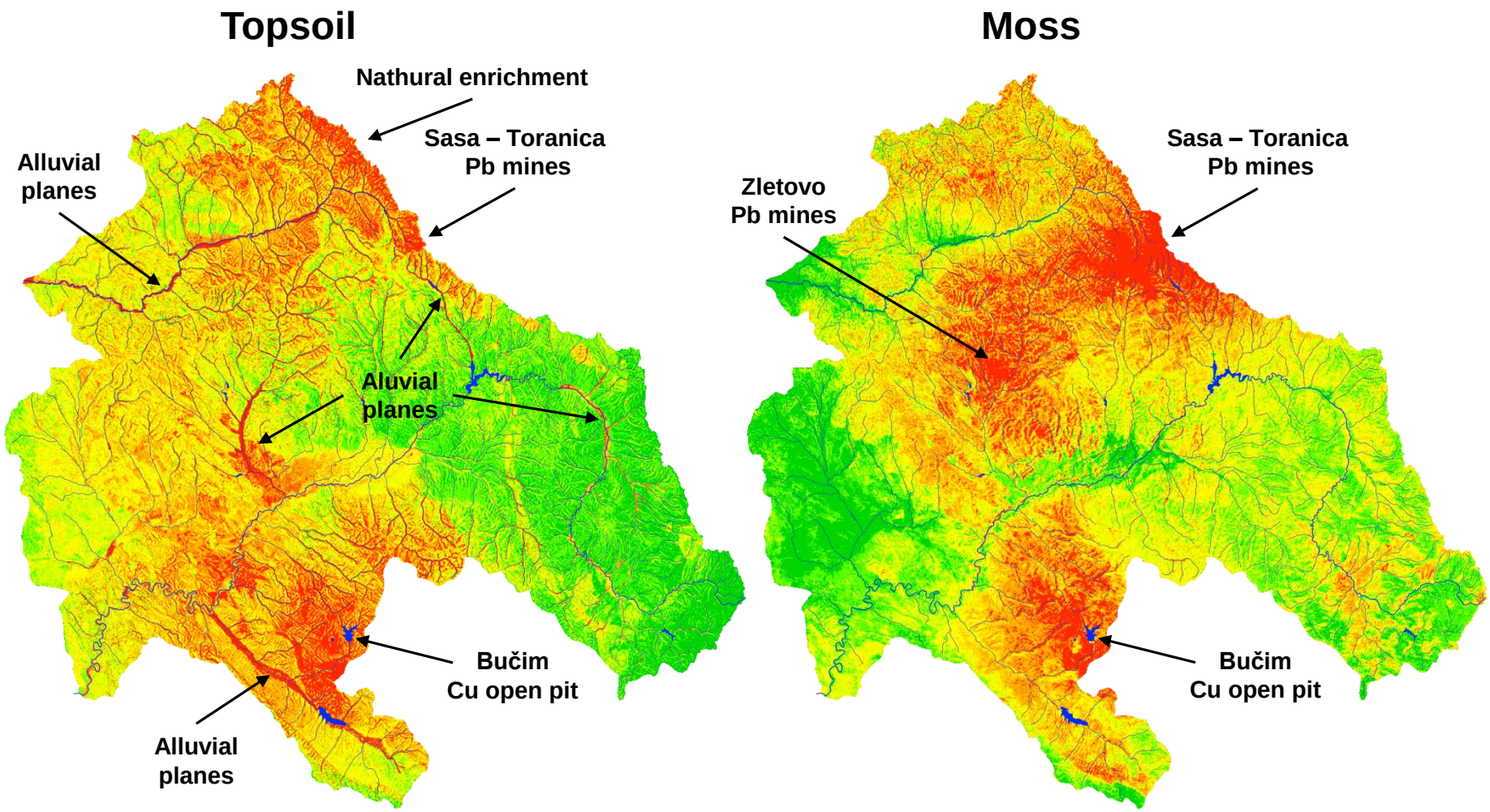


Moss



Spatial distributions of Lead are more logical than the previous one. The high concentrations are connected to the natural enrichment on particular lithological units or Pb mining areas .

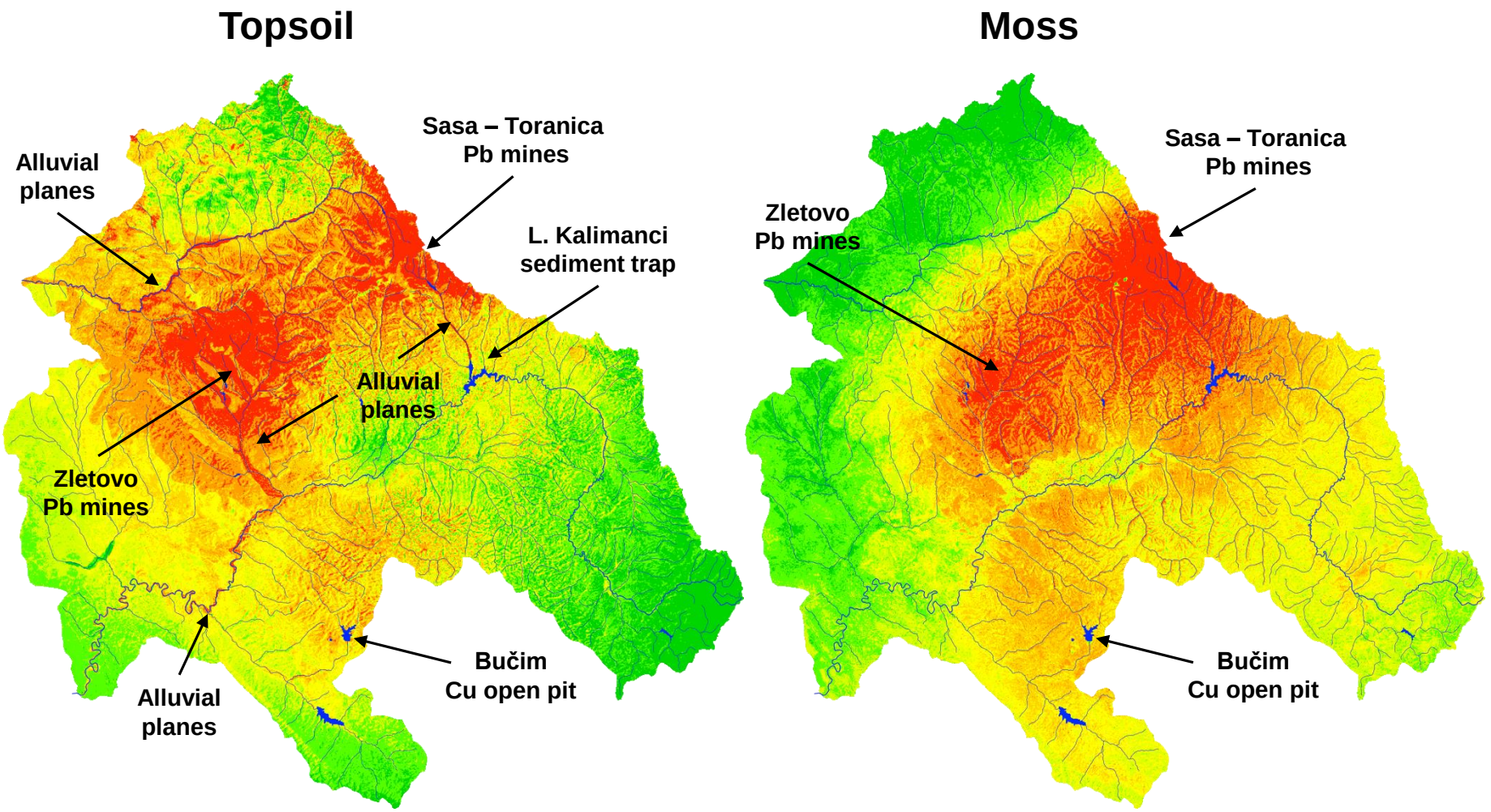
Distribution of copper (ANN-MLP)



Model obtained by ANN is significant and logical. Cu enrichment is connected to the Cu open pit and some lithological units and along the rivers (alluvial planes) – what indicate presence of river transport.

Areal distribution is more significant for the moss. Atmospheric enrichment is connected to the mining areas. The high concentrations are not connected to the lithological units.

Distribution of lead (ANN-MLP)



Pb enrichment is connected only to lithological units and along the rivers (alluvial planes). At the middle flow of the river Bregalnica the ANN didn't isolated the high concentrations. This means that the sediments are trapped in the lake Kalimanci and polluted sediments accumulate in the lake.

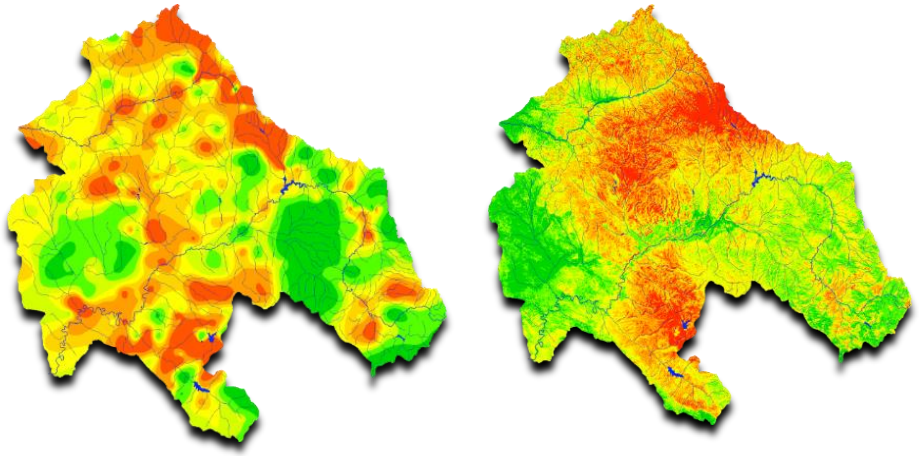
Atmospheric enrichment is connected to the mining areas. The high concentrations are not connected to the lithological units.

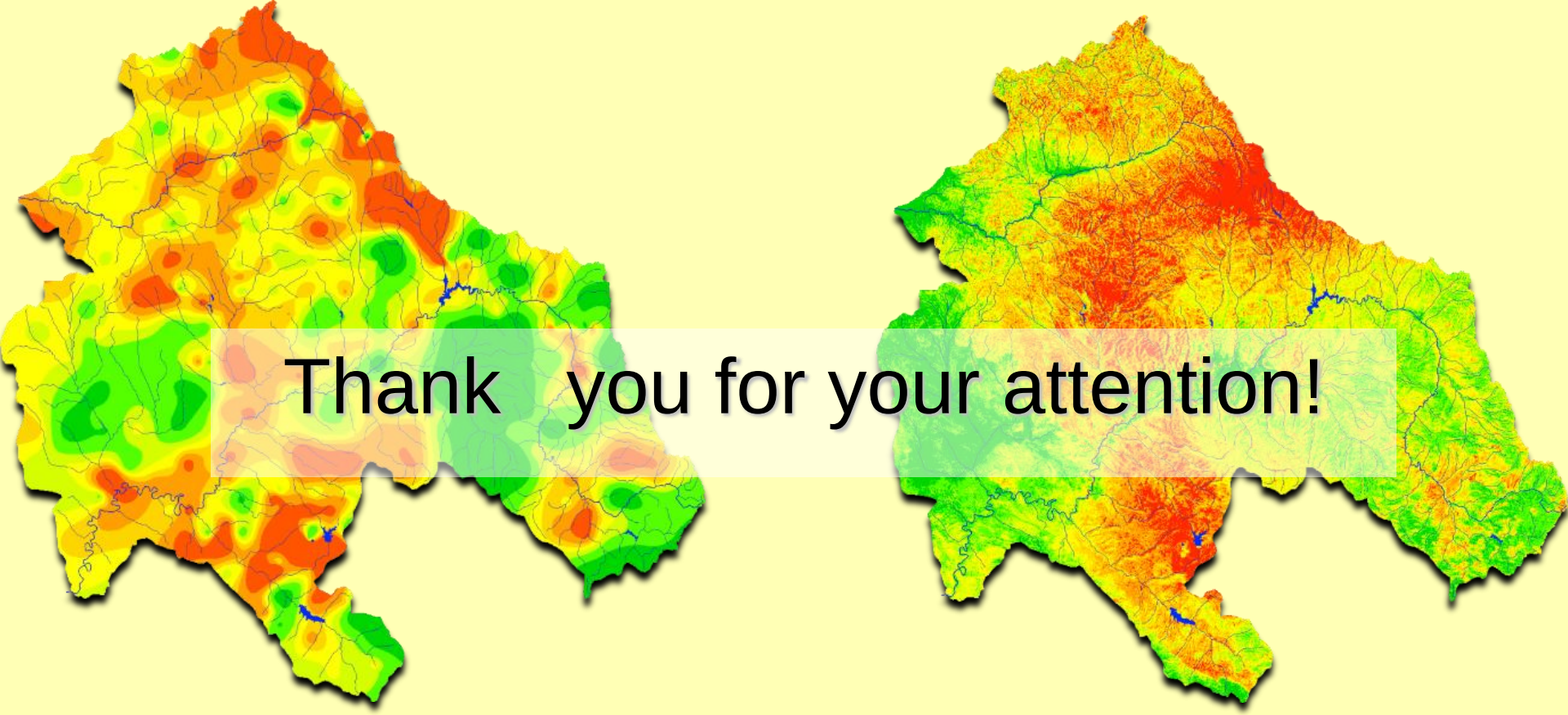
Conclusions

(ANN-MLP)

- HELP us in reconstruction different processes that influenced small and large area.

- ISOLATION OF HOTSPOTS with highest concentrations but simultaneously they DISTINGUISH the distribution pathways!





Thank you for your attention!