Transboundary contamination risk assessment and modelling in the Drava River floodplain

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Geological Survey of Slovenia

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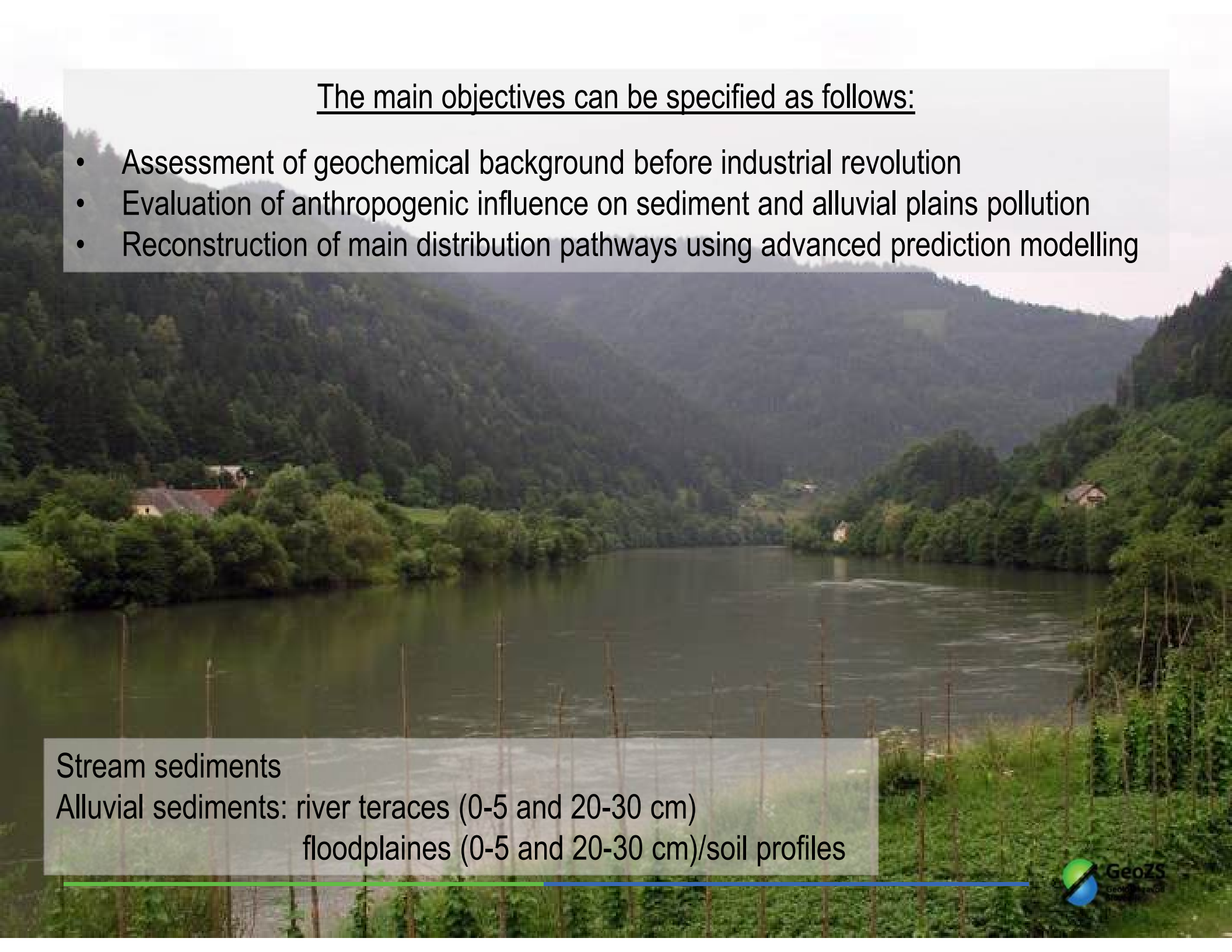


The main objectives can be specified as follows:

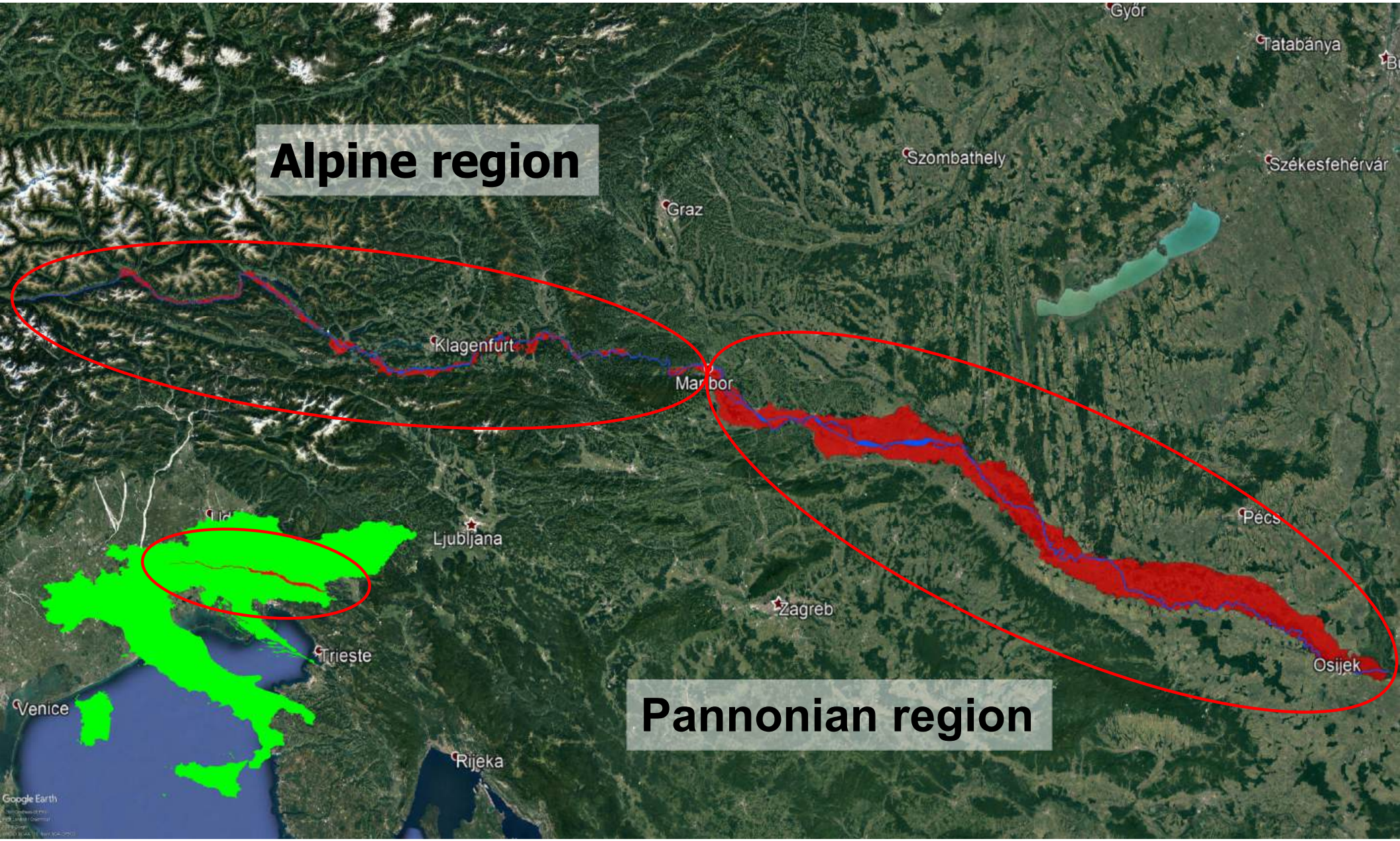
- Assessment of geochemical background before industrial revolution
- Evaluation of anthropogenic influence on sediment and alluvial plains pollution
- Reconstruction of main distribution pathways using advanced prediction modelling

Stream sediments
Alluvial sediments: river teraces (0-5 and 20-30 cm)
floodplaines (0-5 and 20-30 cm)/soil profiles

- Length: 725 km
- Catchment area: 42.240 km^2
- River terraces: 2.480 km^2
- Alluvial plains: 720 km^2
- Swamp and Marsh: 340 km^2

- Typical fluvioglacial river (highest flows in spring and autumn)
- Connection between Alpine and Pannonian biogeographical diversity
- Large hydropotential - 21 hydroelectric power plans

Numerous mines and smelters such as Bleiberg-Kreuth in Austria, Cave del Predil in Italy and Mežica in Slovenia have left great consequences on chemical composition of the Drava alluvial sediments



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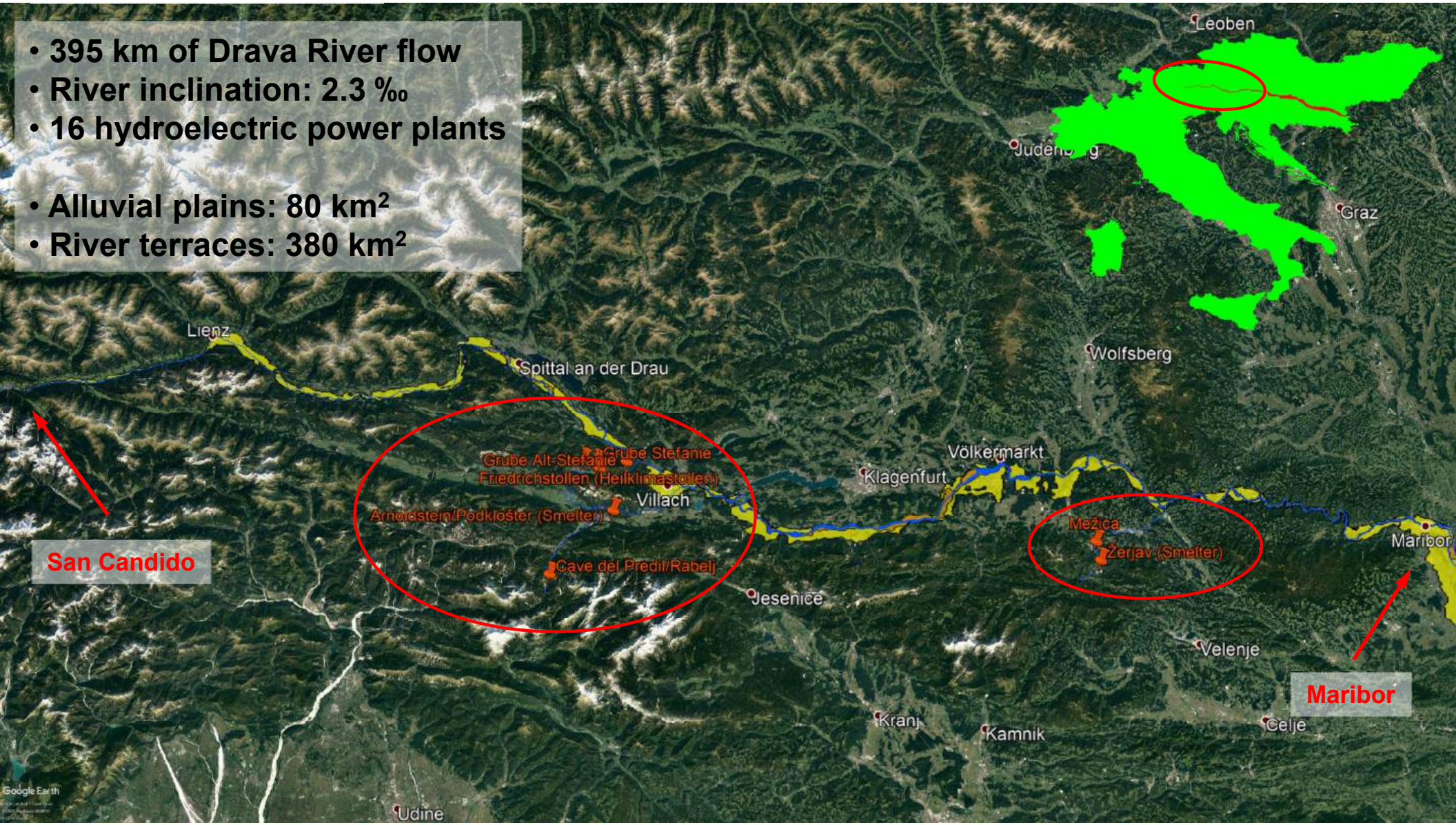
Alpine region

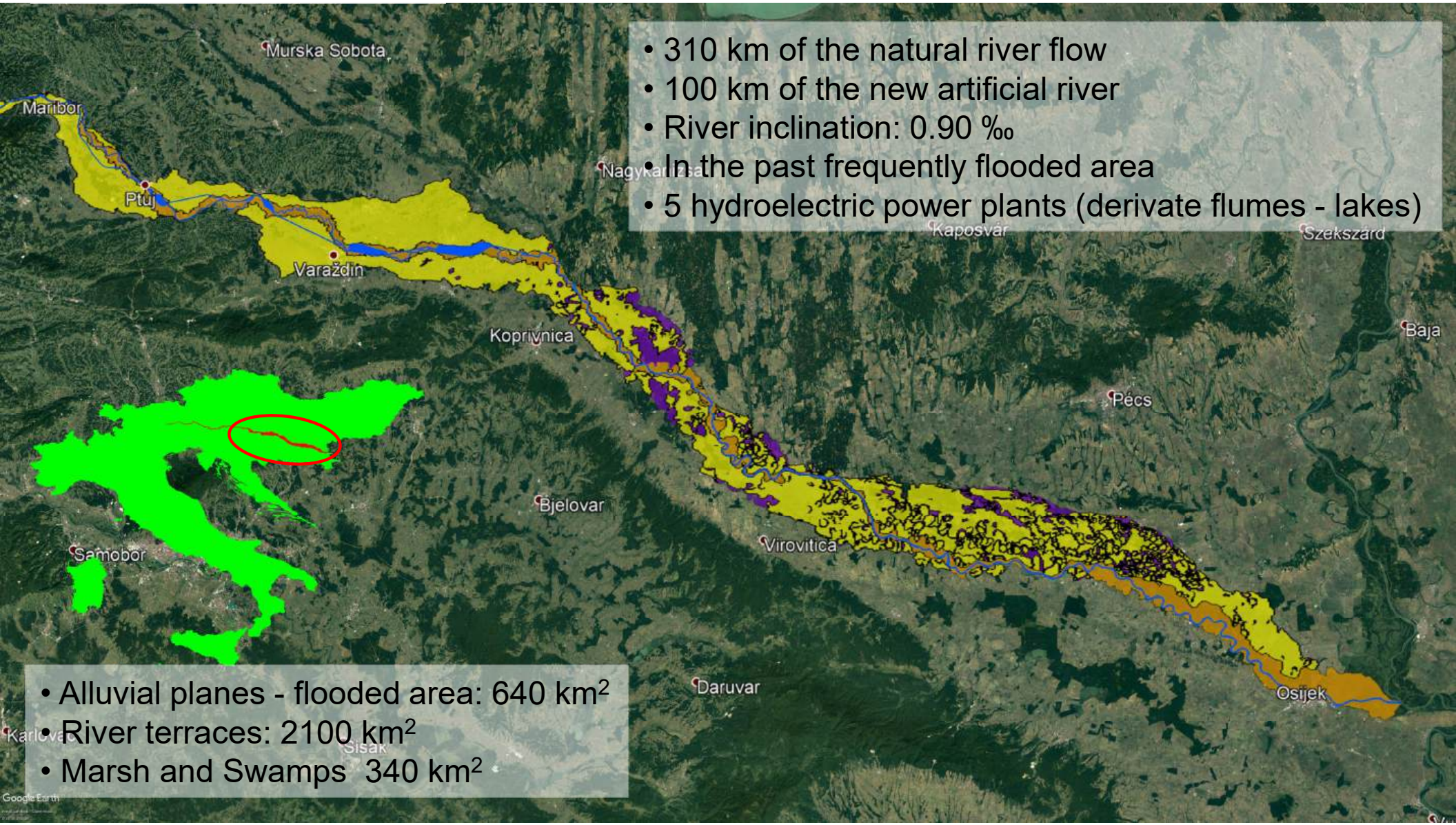


Alpine region – Natural river Flow

Alpine region – Hydroelectric power plant

Alpine region – man made lake

Panonian region



- 310 km of the natural river flow
- 100 km of the new artificial river
- River inclination: 0.90 ‰
- In the past frequently flooded area
- 5 hydroelectric power plants (derivate flumes - lakes)

- Alluvial planes - flooded area: 640 km^2
- River terraces: 2100 km^2
- Marsh and Swamps 340 km^2

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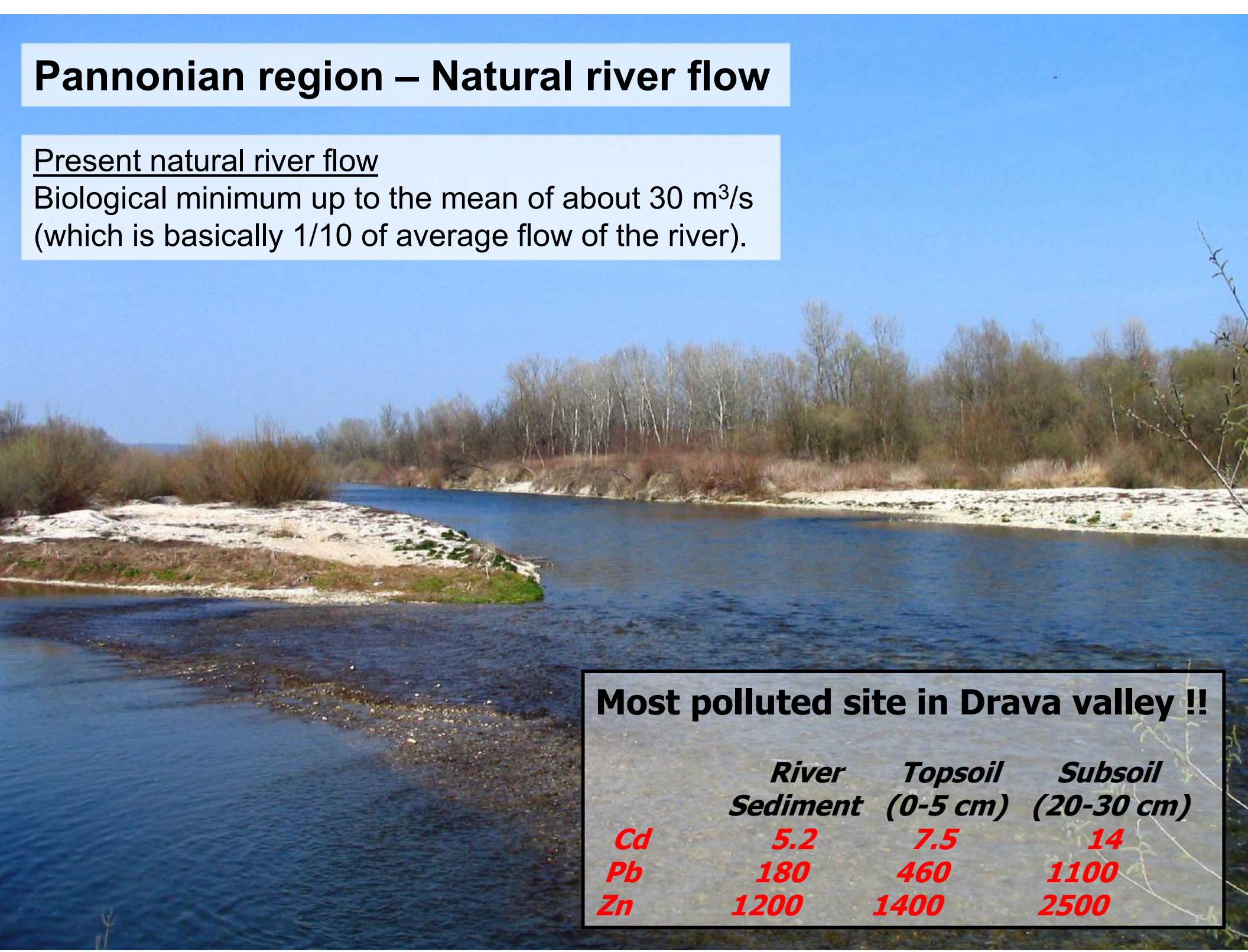
Pannonian region – Natural river flow

Present natural river flow

Biological minimum up to the mean of about 30 m^3/s (which is basically 1/10 of average flow of the river).



Most polluted site in Drava valley !!

	River Sediment	*Topsoil (0-5 cm)*	*Subsoil (20-30 cm)*
Cd	*5.2*	*7.5*	*14*
Pb	*180*	*460*	*1100*
Zn	*1200*	*1400*	*2500*

Pannonian region – Regulated

Pannonian region – Hydroelectric power plants

New artificial river

Construction of the hydroelectric power plants with new banks created an actual border in the area where land surfaces for agriculture and other anthropogenic activities were separated from the natural biotope.

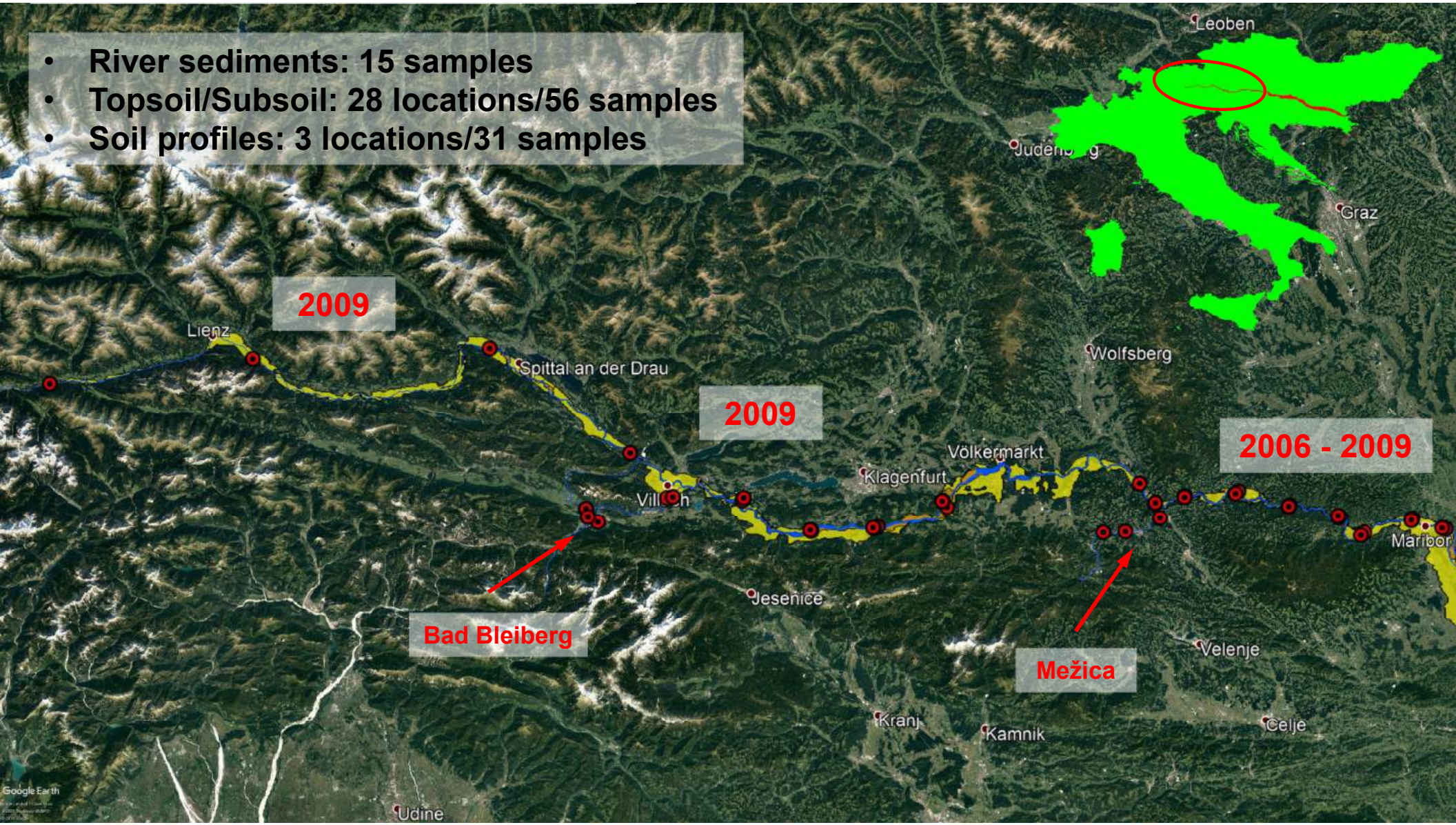
After the construction of the hydroelectric power plants, transport of the river suspended material is interrupted.

Pannonian region – Flooded area

Pannonian region – Flooded area


OPASNOST
MINE/MINES
hcr

Sampling - Alpine region



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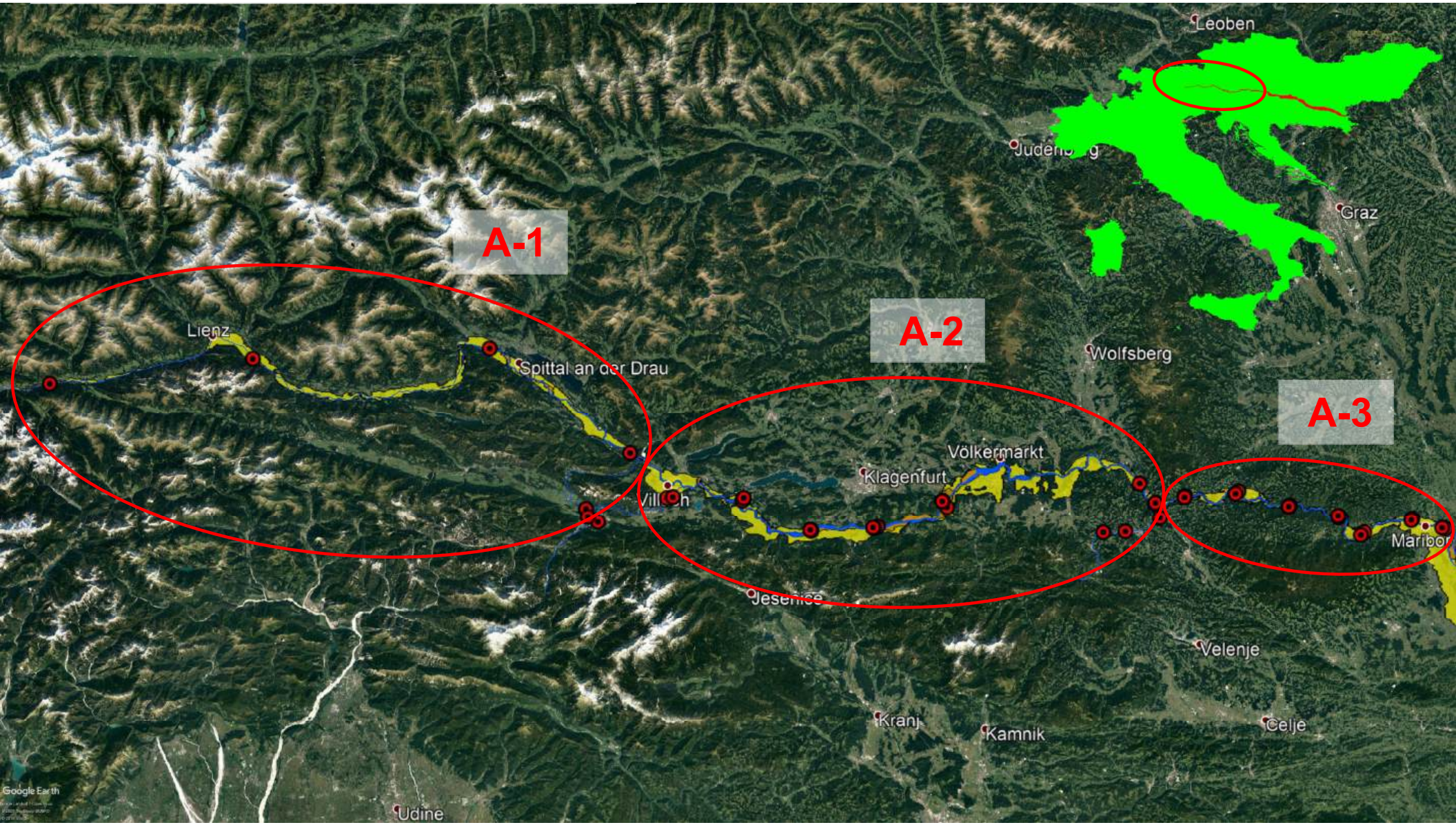
Sampling - Apine region



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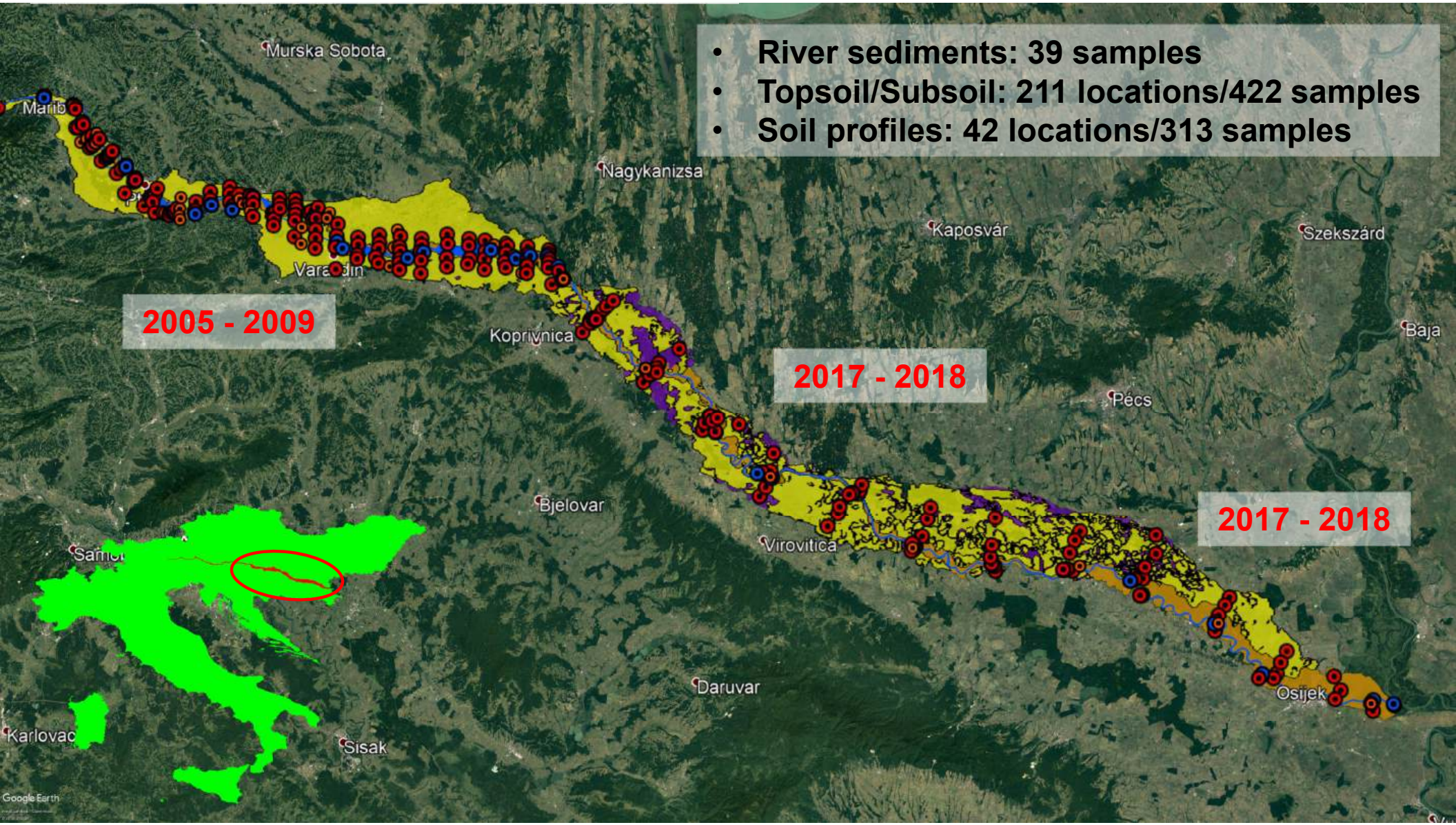
Sampling - Pannonian region



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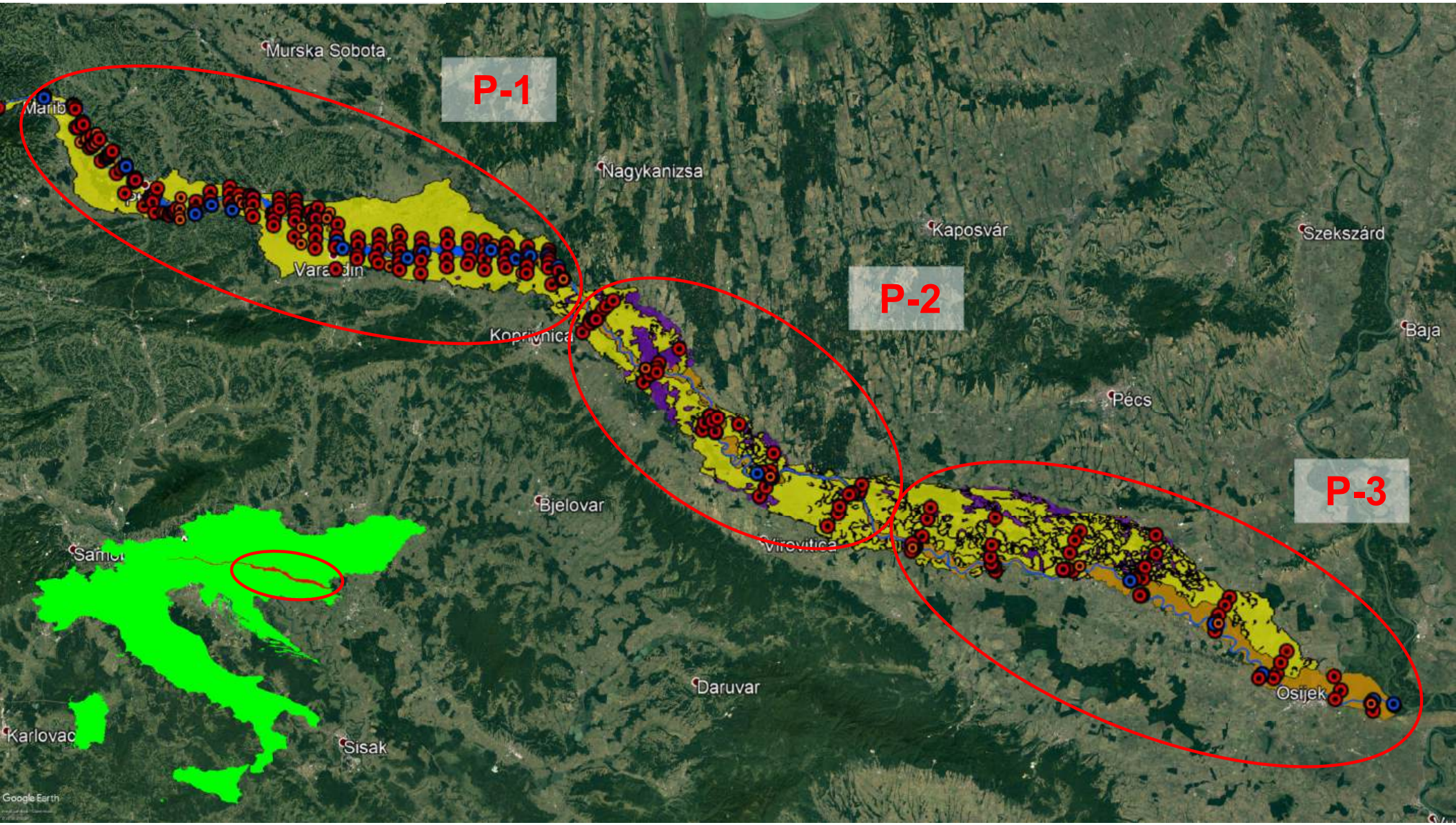
Panonian region



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Sample Preparation

- Soil samples: fraction smaller than 2 mm was pulverized
- River sediments: fraction smaller than 0.125 mm was prepared by sieving

Analytics

- MS-ICP after total 4-acid digestion
- Analysis of 41 chemical elements (Al, Ca, Fe, K, Mg, Na, P, S, Ti, Ag, As, Au, Ba, Be, Bi, Cd, Ce Co, Cr, Cu, Hf, La, Li, Mn, Mo, Nb,Ni, Pb, Rb, Sb, Sc, Sn, Sr, Ta,Th, U, V, W, Y, Zn and Zr)

Statistical analysis

- Distribution of 36 chemical elements in 552 samples of topsoil (0-5 cm), subsoil (20-30 cm) and 54 samples of river sediments
- Basic statistics parameters
- R mode factor analysis - association between elements (27 elements)

Prediction of distribution

- Artificial neural networks – Multilayer perceptron
- Seven classes of the percentile values (0-10, 10-25, 24-40, 40-60, 60-75, 75-90 and 90-100)

Three geogenic and one anthropogenic geochemical associations were established on the basis of visually indicated similarity of distribution of elemental patterns along the Drava River; similarity of spatial distribution; comparisons of basic statistics and results of factor analysis.

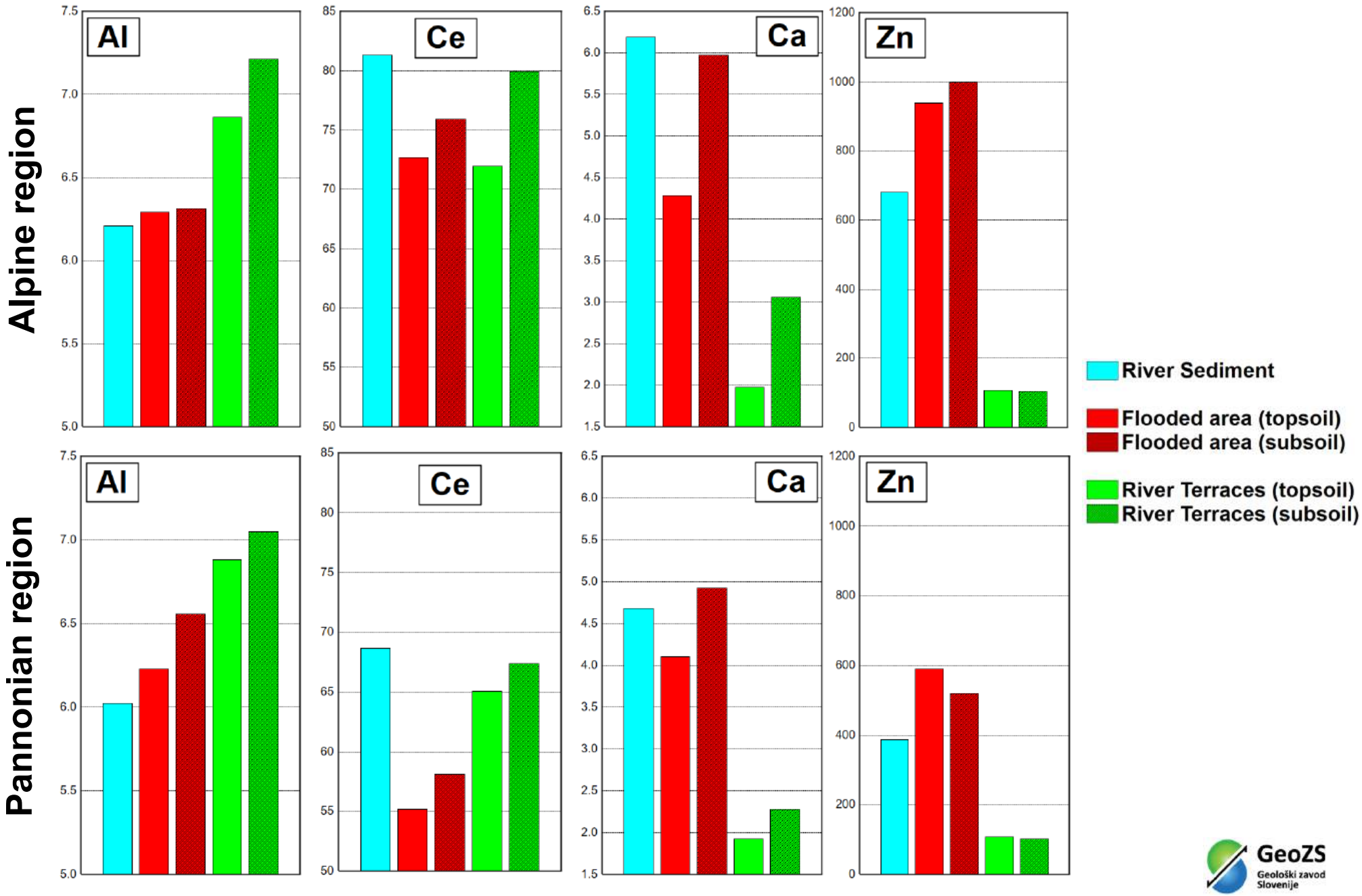
Geochemical association typical for silty and clay fraction (Al, Co, Cr, Cu, Fe, K, Li, Ni, Rb, Sc and V)

Geochemical association typical for sandy fraction (Ce, La, Th and U)

Geochemical association typical for carbonate rocks weathering (Ca, Mg and Sr)

Geochemical dispersion halo caused by the natural weathering ore deposits and by historical mining and smelting activities (As, Ba, Cd, Mo, Pb, Sb and Zn)

Distribution of Aluminum, Cerium, Calcium and Zinc regard to sampled material and location



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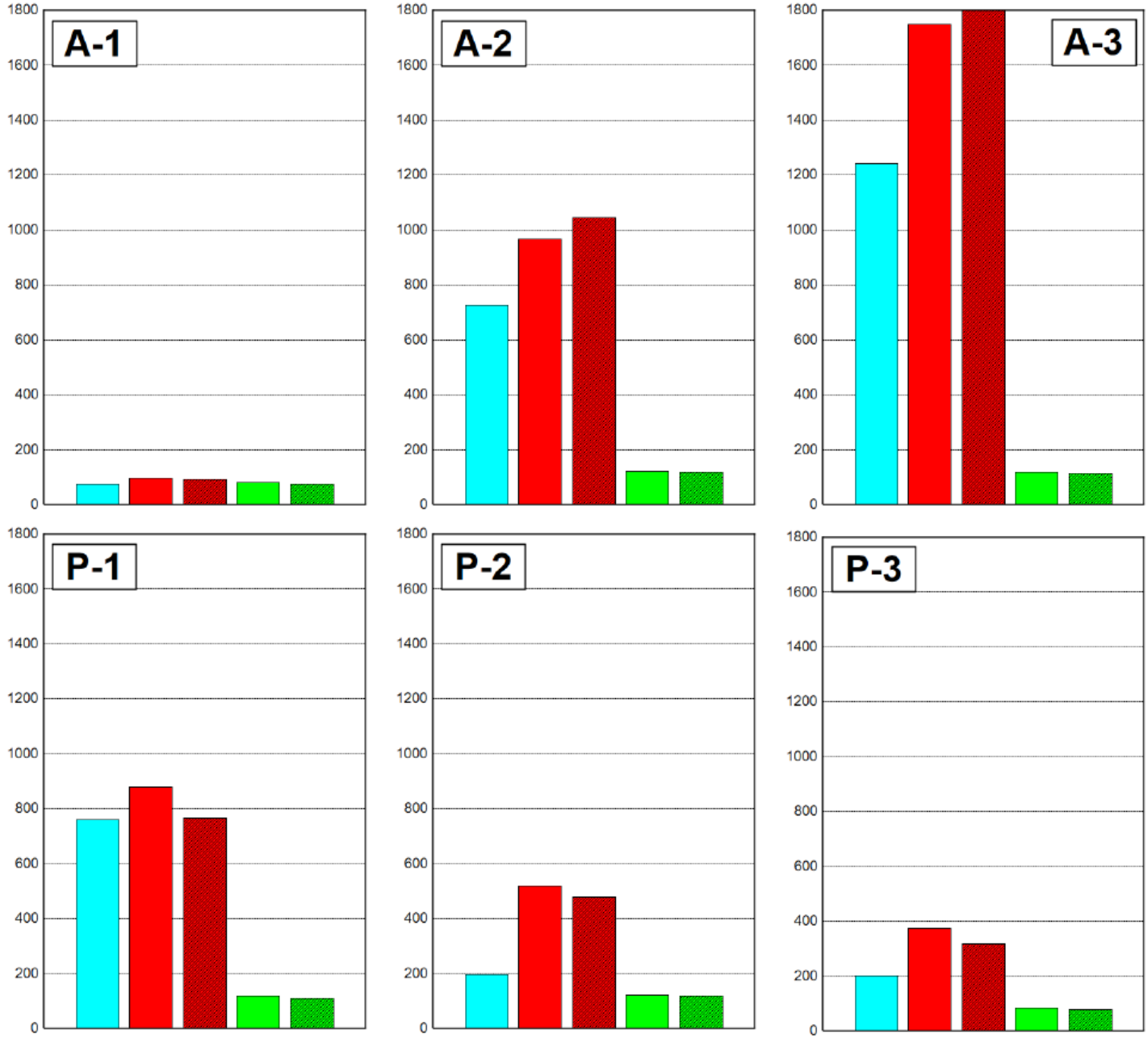
Distribution of Zinc concentrations regard to sampled material and location of sampling

Alpine region

Pannonian region



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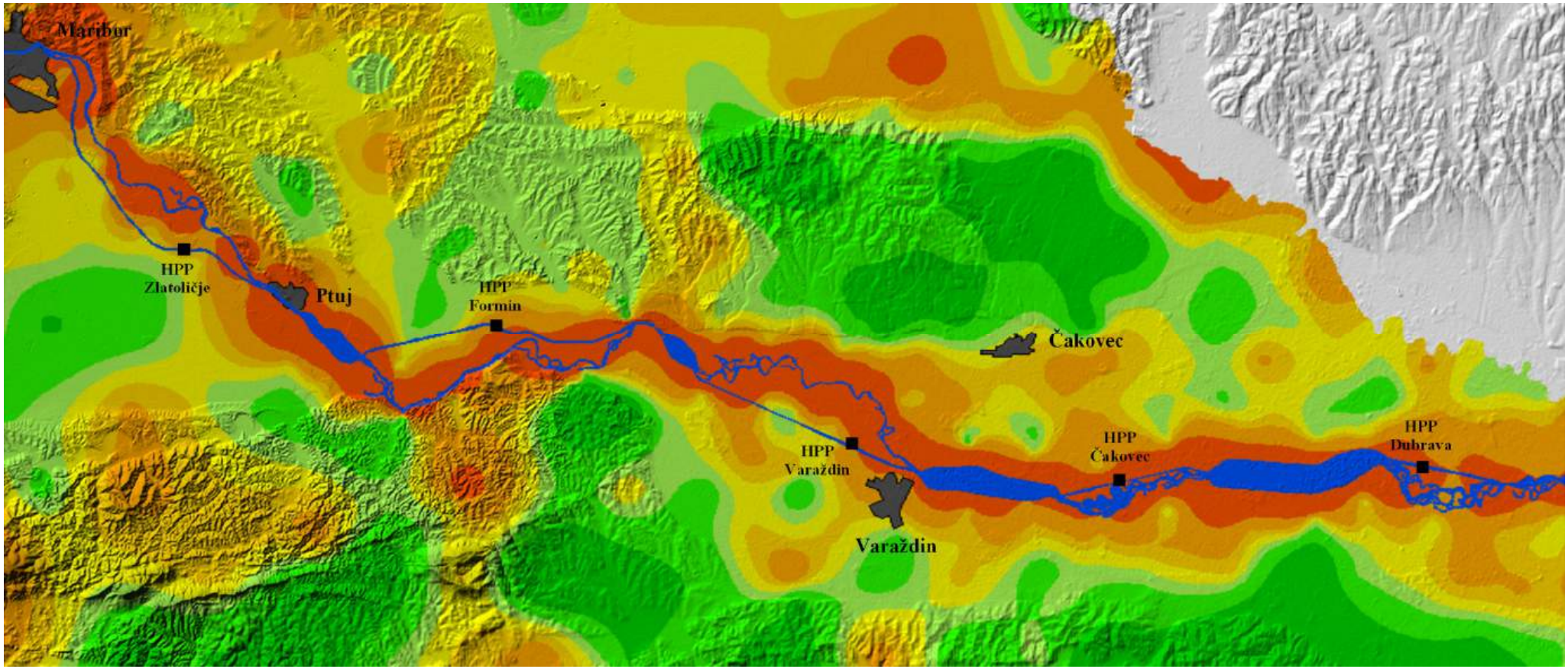
Spatial distribution of Calcium in the Drava valley (Pannonian area) – Universal Kriging

River terraces
Range: 0.44 – 6.4 %
Median: 2.3 %

Flooded area
Range: 5.0 – 9.2 %
Median: 6.7 %



Ca (%)

0.44 0.58 0.74 1.0 1.5 2.9

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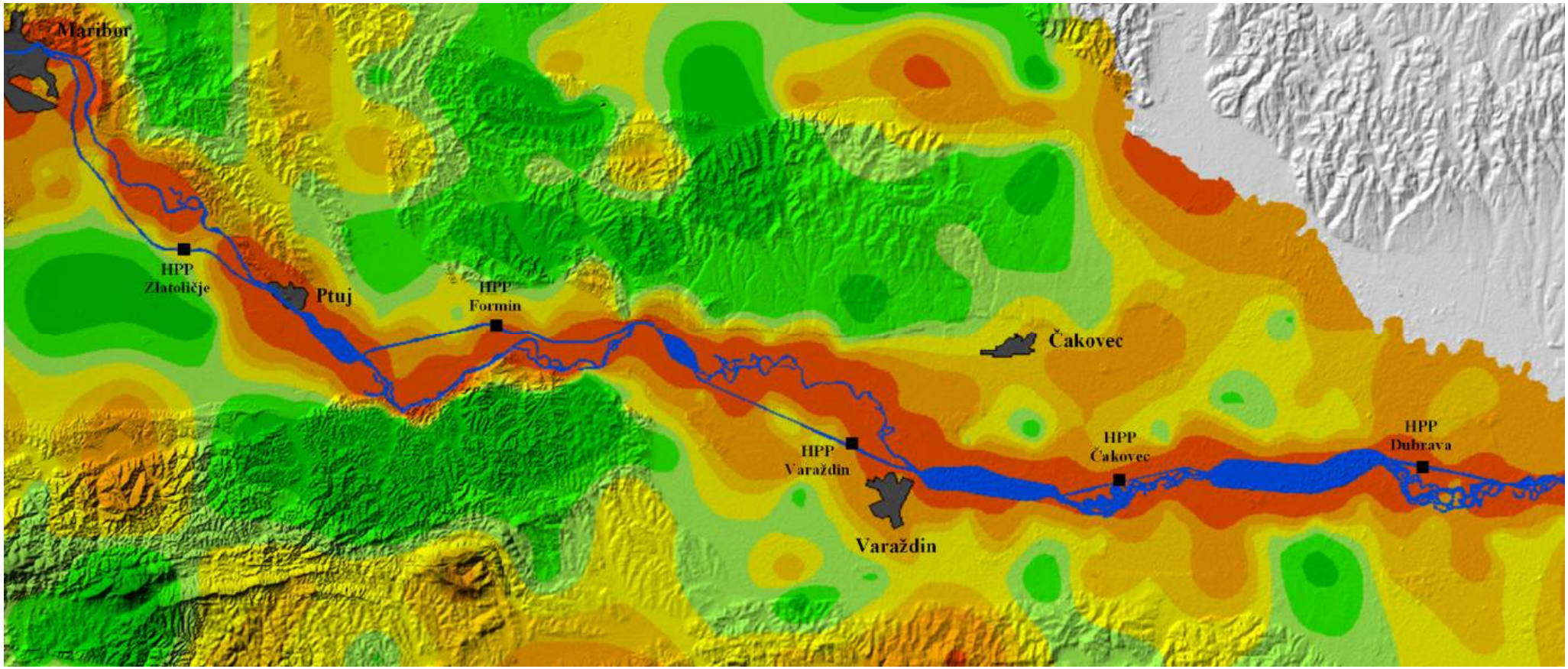
Spatial distribution of Zinc in the Drava valley (Pannonian area) – Universal Kriging

River terraces
Range: 57 – 210 mg/kg
Median: 110 mg/kg

Flooded area
Range: 360 - 2500 mg/kg
Median: 1300 mg/kg

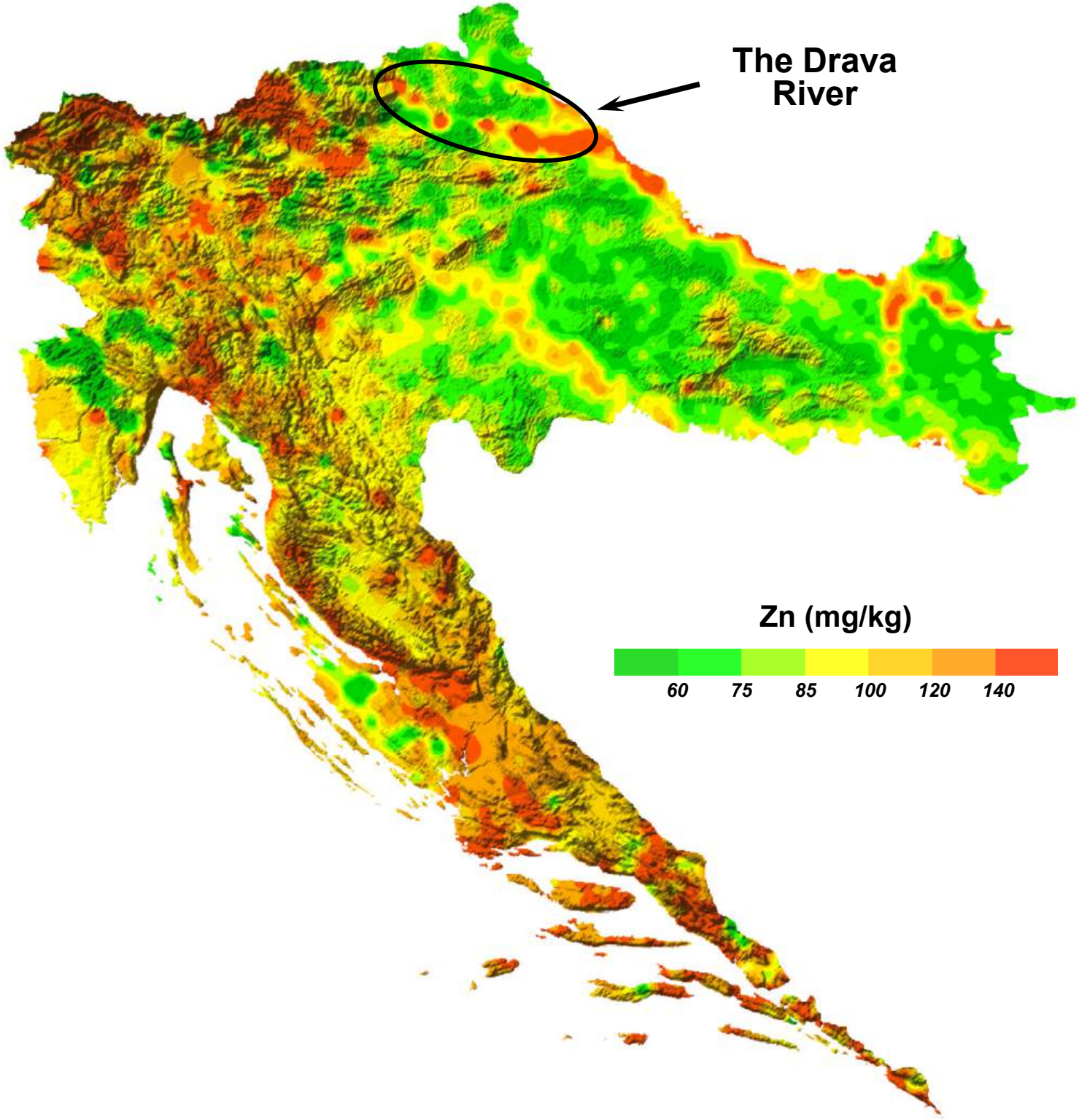


Zn (mg/kg)

66 80 88 100 120 180

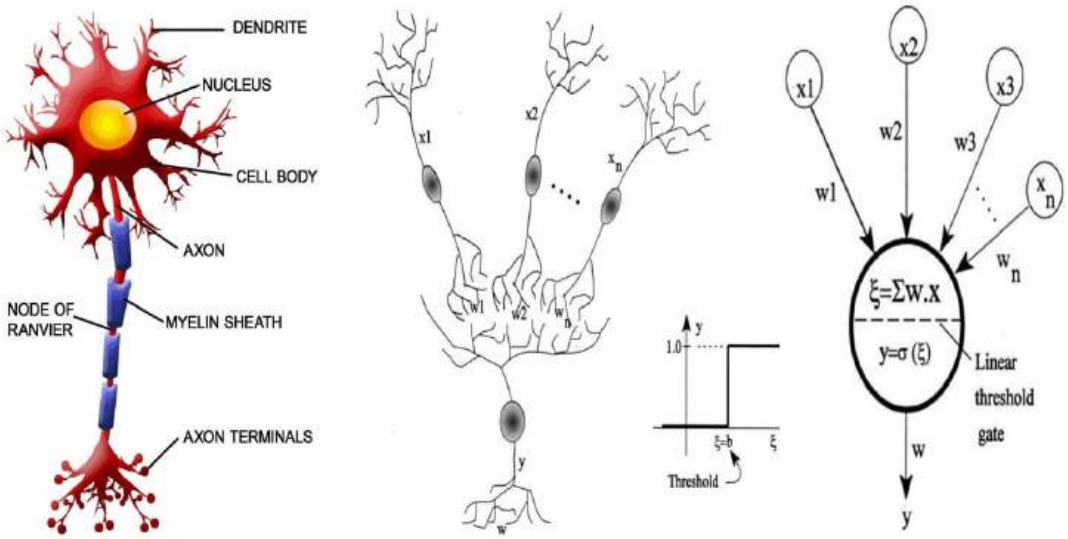
Spatial distribution of Zinc

(Experimental geochemical map of Croatia and Slovenia)

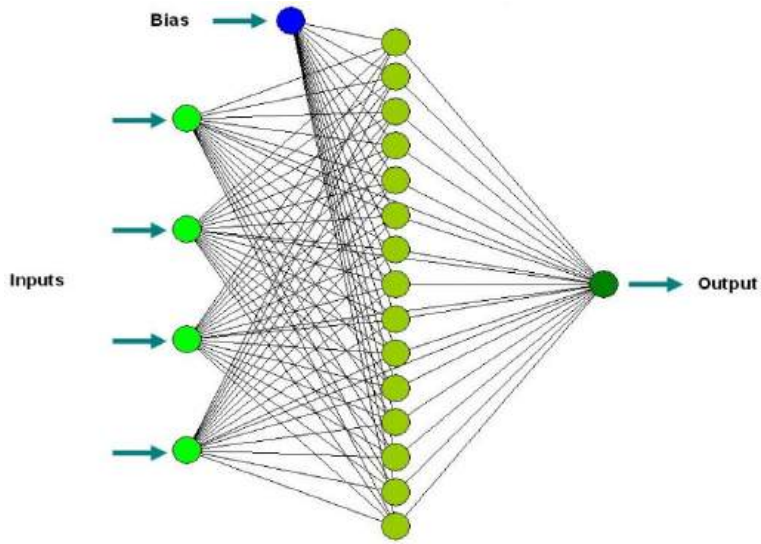


Artificial neural networks

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.

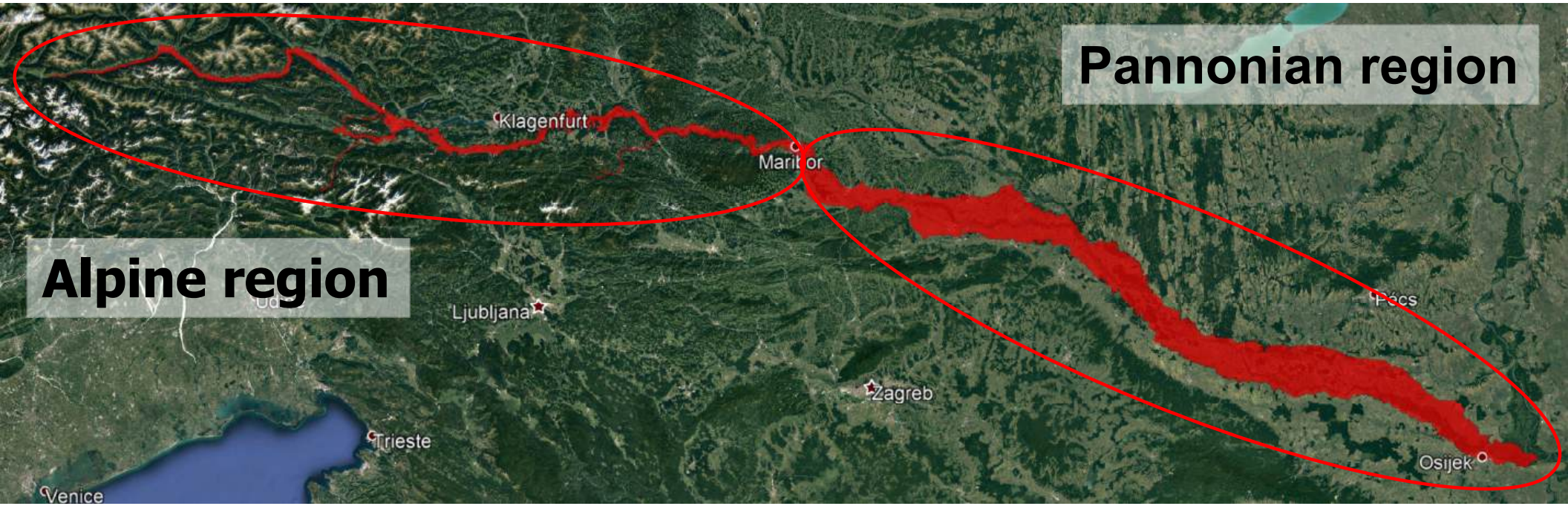


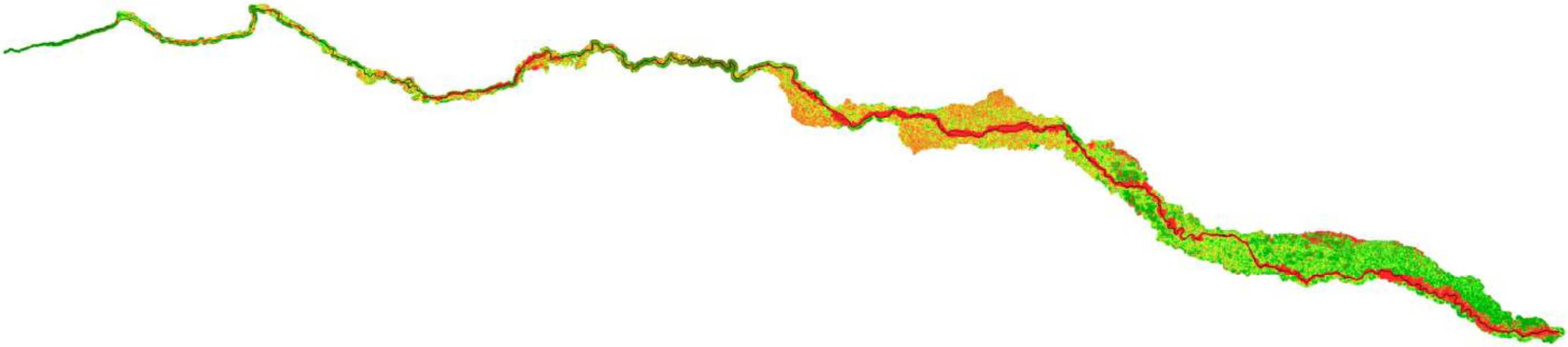
Biological neuron and mathematical model of McCulloch and Pitts neuron



Multilayer perceptron architecture

Prediction of Zinc distribution





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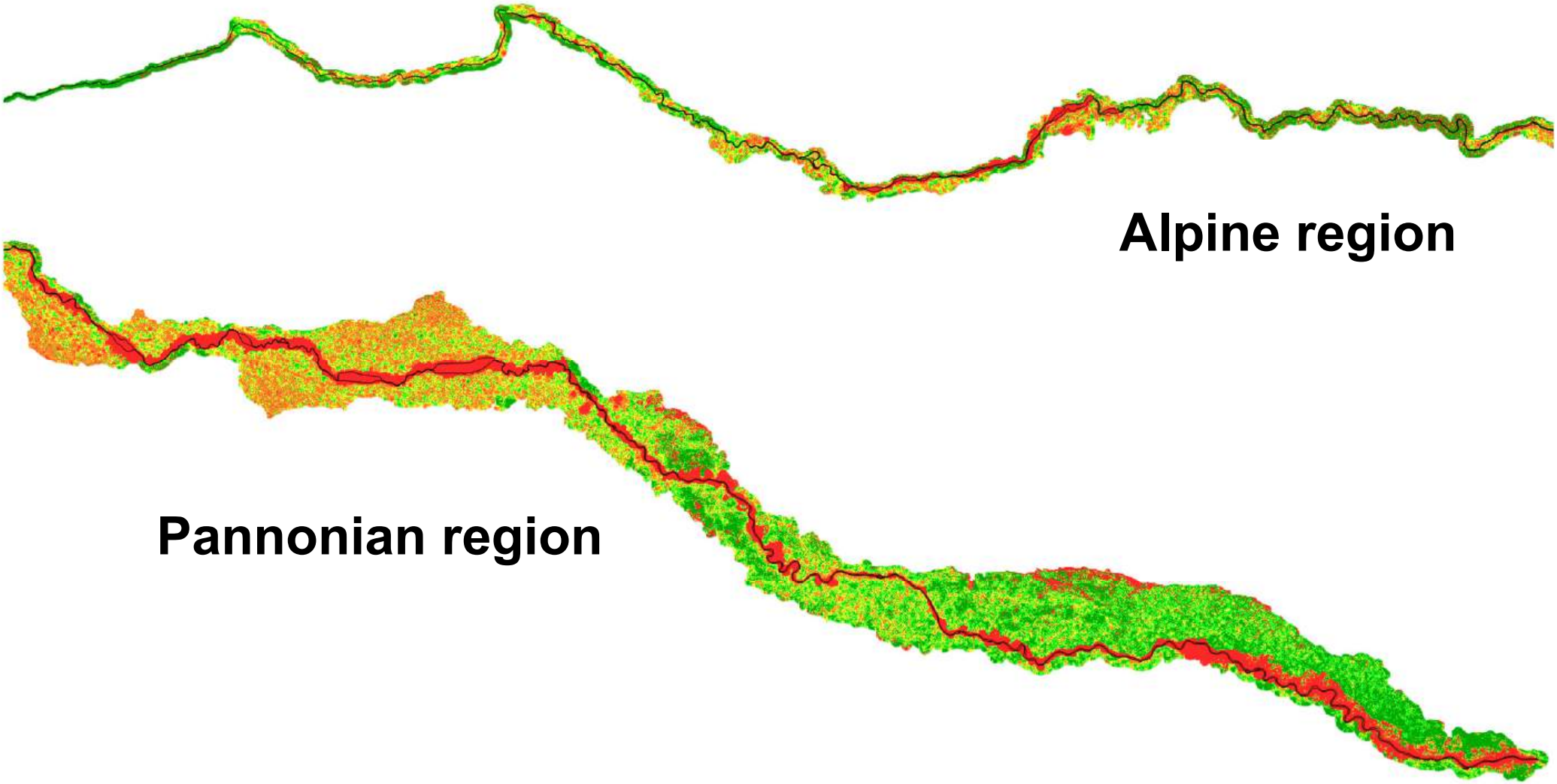
Prediction of Zinc distribution



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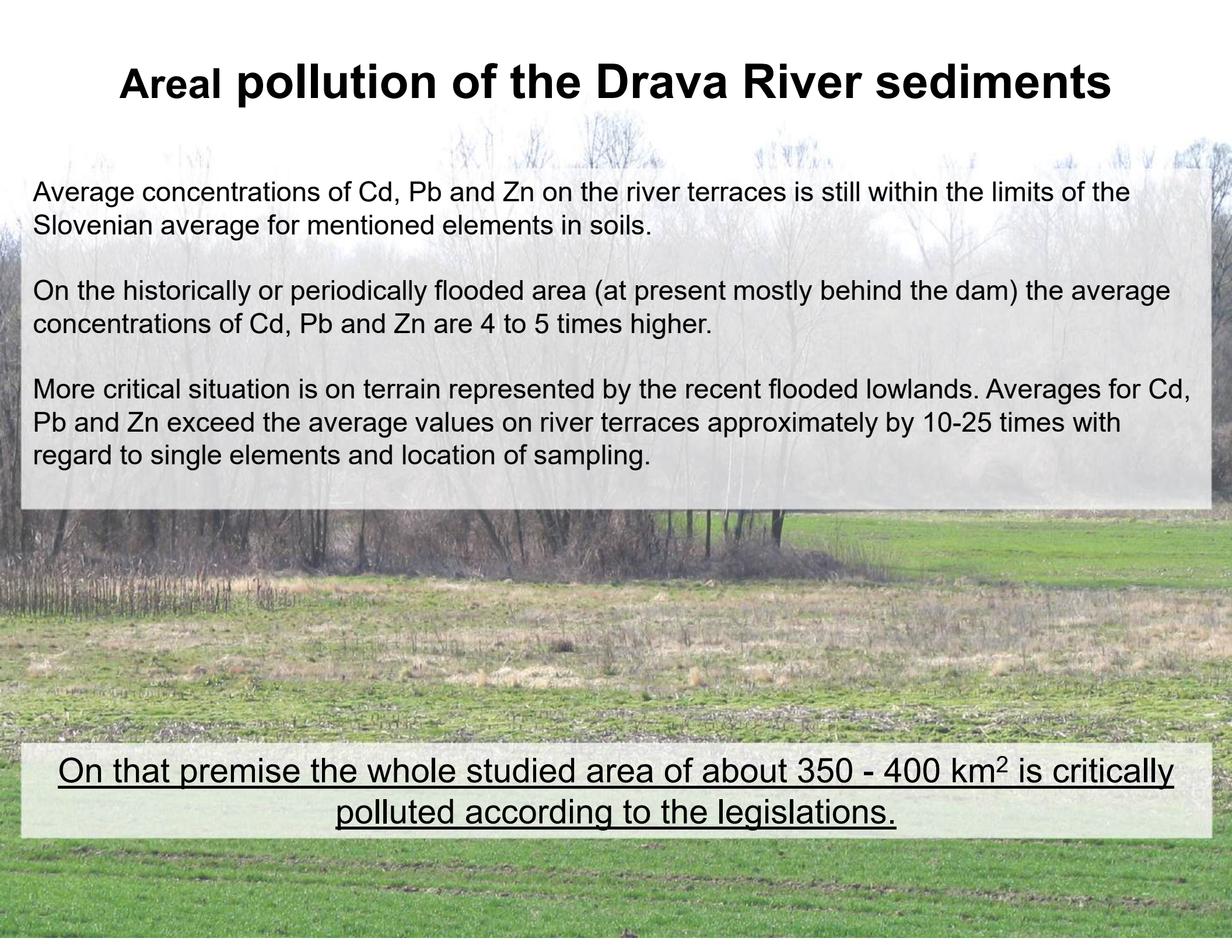
Areal pollution of the Drava River sediments

Average concentrations of Cd, Pb and Zn on the river terraces is still within the limits of the Slovenian average for mentioned elements in soils.

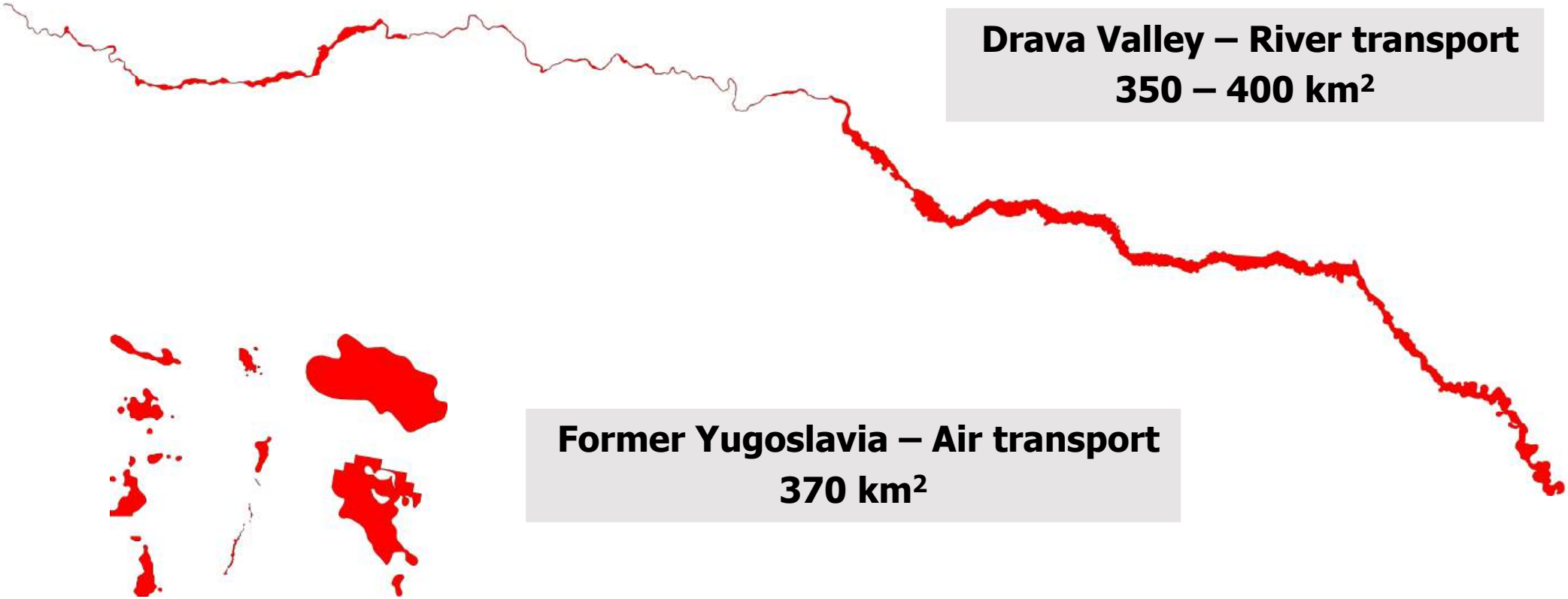
On the historically or periodically flooded area (at present mostly behind the dam) the average concentrations of Cd, Pb and Zn are 4 to 5 times higher.

More critical situation is on terrain represented by the recent flooded lowlands. Averages for Cd, Pb and Zn exceed the average values on river terraces approximately by 10-25 times with regard to single elements and location of sampling.



On that premise the whole studied area of about 350 - 400 km^2 is critically polluted according to the legislations.

Polluted areas (river transport vs. air transport)



Drava Valley – River transport
350 – 400 km²

Former Yugoslavia – Air transport
370 km²

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Thank you!