

# Objektová klasifikácia mestskej zelene na príklade šiestich stredoeurópskych miest

Hana Bobáľová, Alexandra Benová, Miroslav Kožuch

Ciel' – vyvinúť metodiku mapovania mestskej zelene, ktorá:

A) využíva voľne dostupné satelitné údaje Sentinel-2

B) je ľahko prenositeľná na iné územie bez potreby zberu tréningových vzoriek

C) dosahuje porovnateľnú presnosť s *machine learning* metódami

Územie – šesť stredoeurópskych miest s mierne odlišnými klimatickými charakteristikami:

*Bratislava, Nitra*

*Žilina, Zakopane*

*Kaposvár, Orosháza*

Údaje – šesť snímok Sentinel-2 z konca augusta 2016



# Segmentácia a klasifikácia

Hierarchická objektová klasifikácia založená na pravidlách

Úroveň L1

Úroveň L2

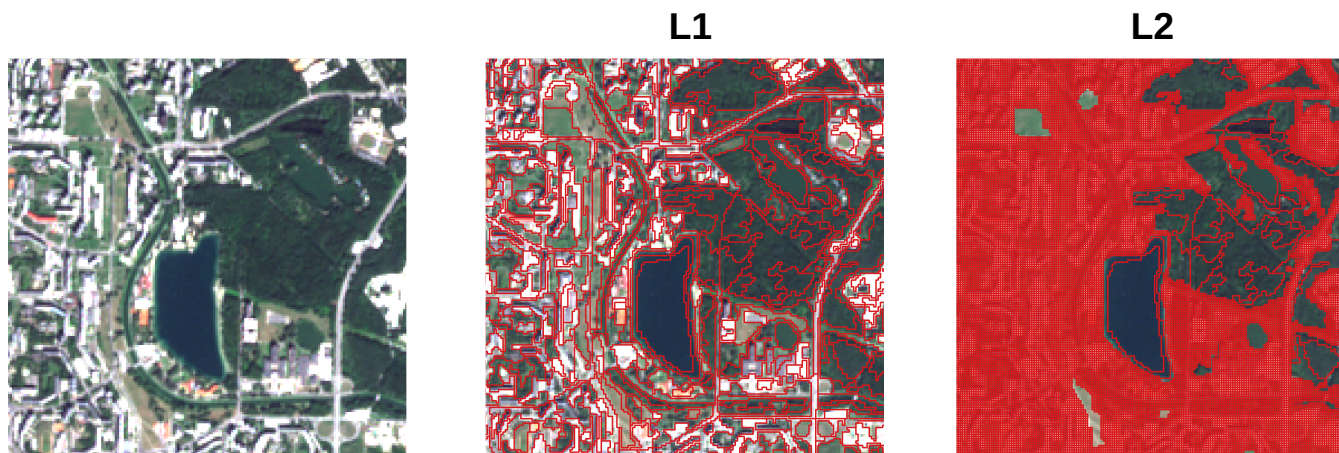


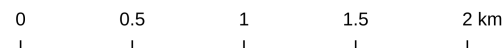
 image objects

**L1 classes**

-  Forest
-  Scattered trees
-  Shrubland
-  Grassland
-  Cropland
-  Urban fabric
-  Water

**L2 classes**

-  Forest
-  Trees/shrubs
-  Green grass
-  Dry grass
-  Cropland
-  Non-vegetation
-  Water
-  Shadow



# Klasifikačné pravidlá L1

L1

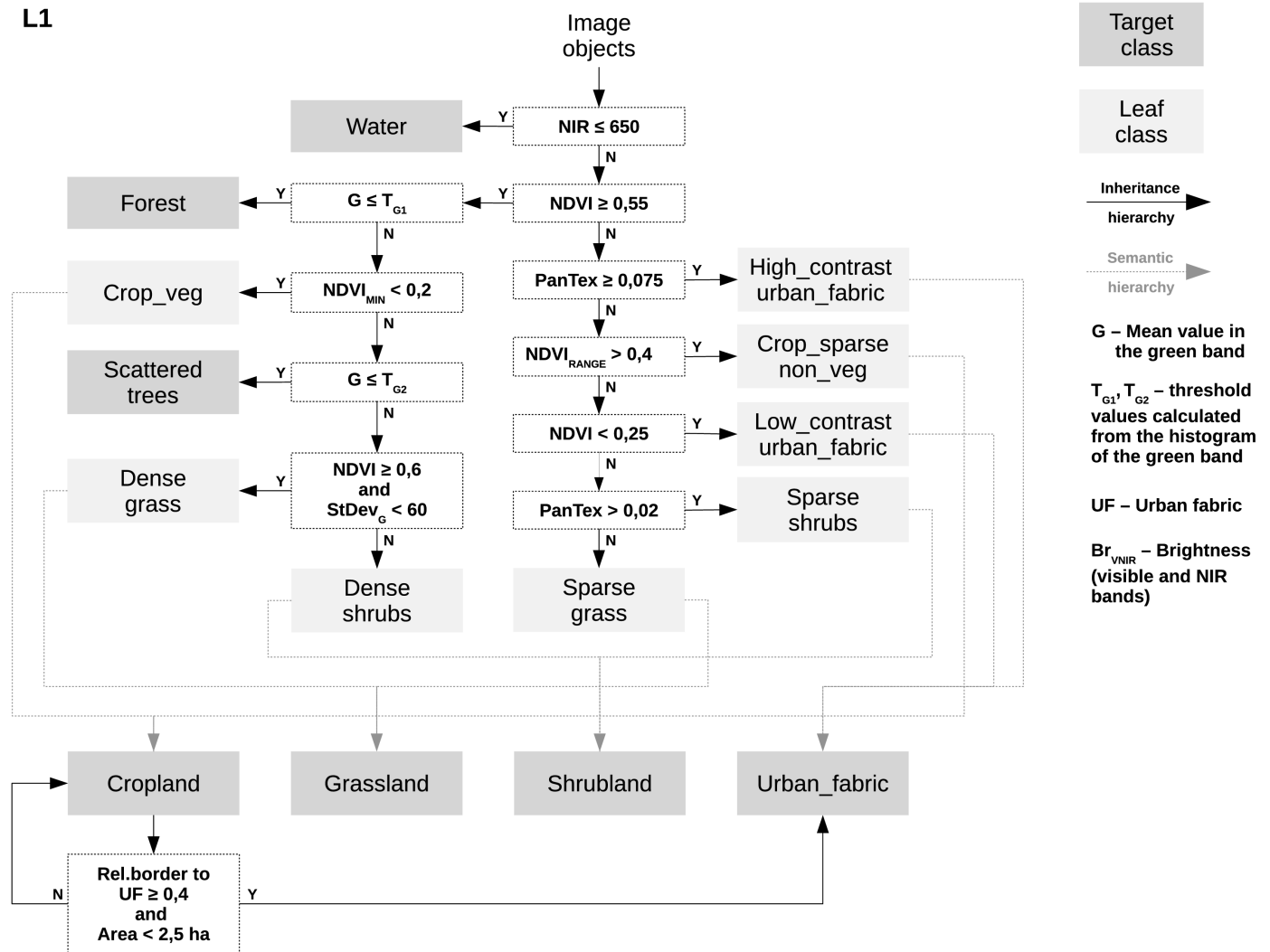
NDVI

PanTex

G pásmo

NDVI<sub>RANGE</sub>

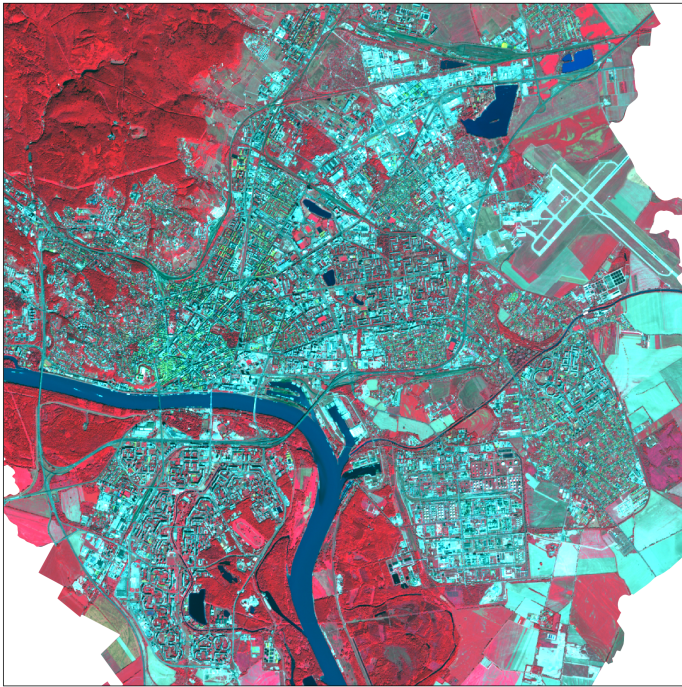
NDVI<sub>MIN</sub>



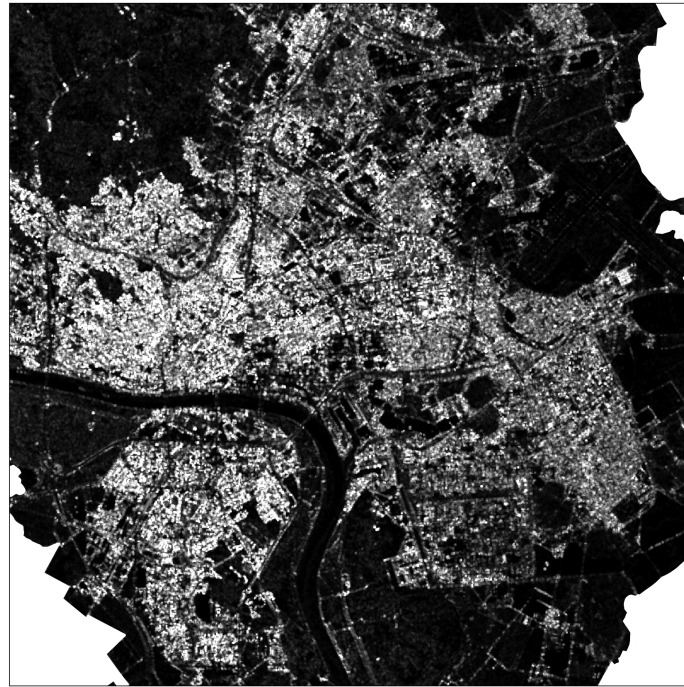
# Textúrny index

**PanTex** (Pesaresi et al. 2008) – klasifikácia zástavby, sídiel

- založený na Grey Level Co-Occurrence Matrix a meraniach kontrastu



NIR - R - G



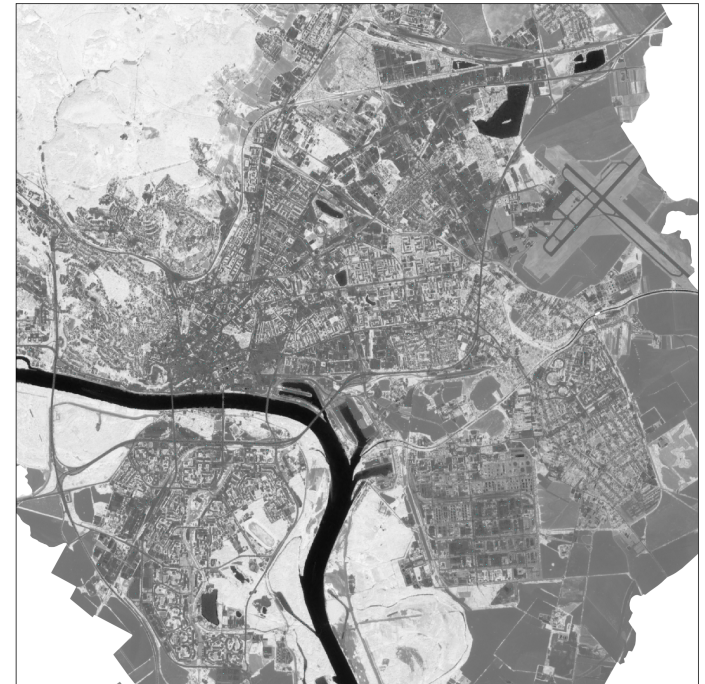
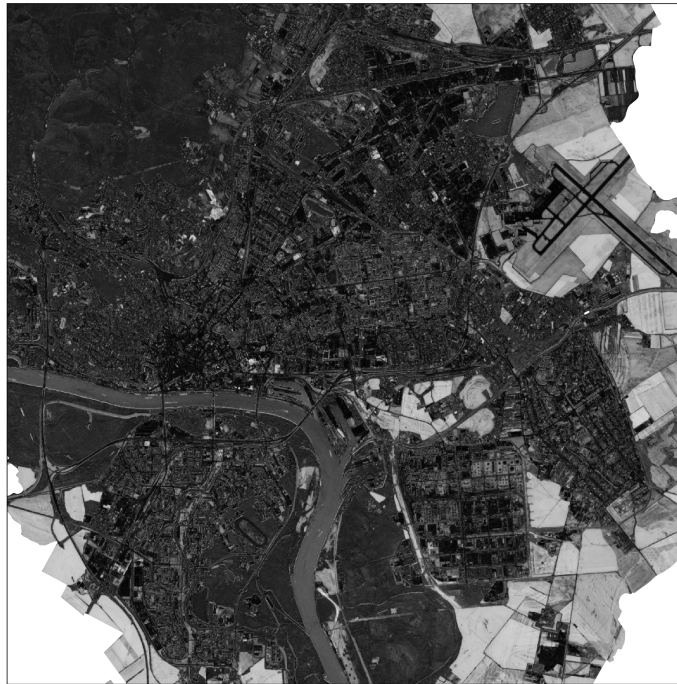
PanTex intensity



# Variácie NDVI

$NDVI_{RANGE}$ ,  $NDVI_{MIN}$  – klasifikácia ornej pôdy

Google Earth Engine – časové série NDVI z letných mesiacov



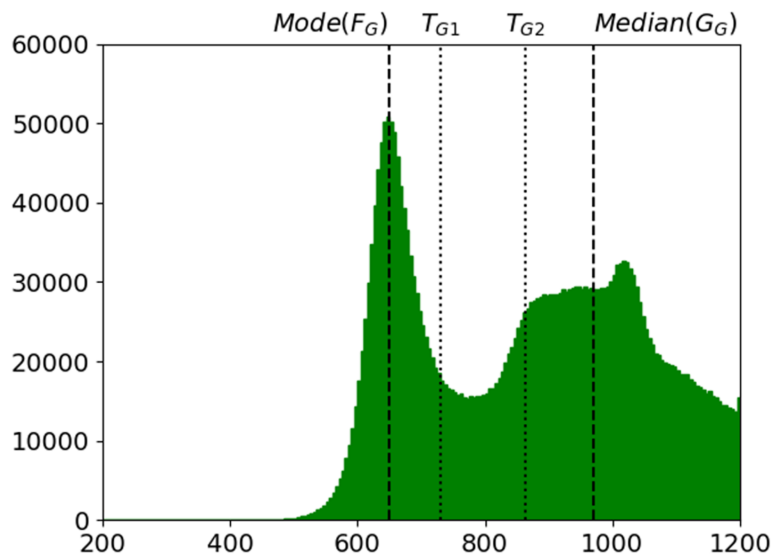
# Zelená vegetácia

**G pásma** – odlíšenie stromovej a trávinatej vegetácie

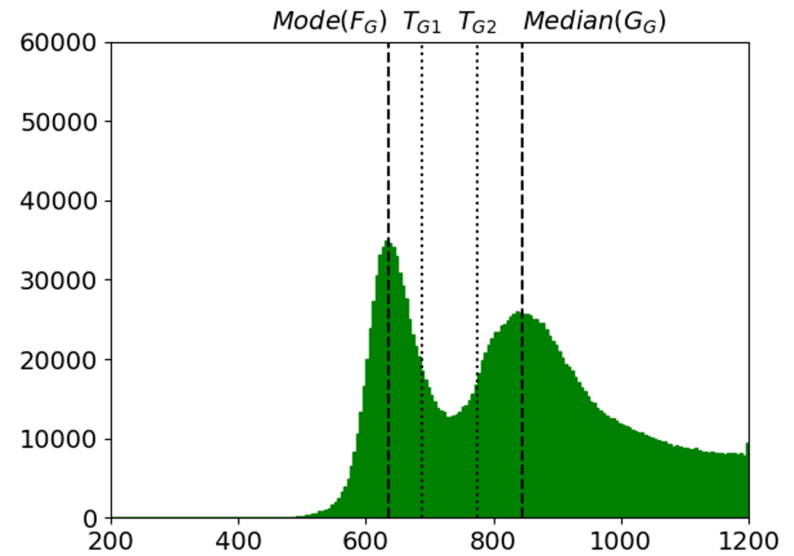
$T_{G1}$  – threshold *dense forest* – *scattered trees/shrubs*

$T_{G2}$  – threshold *scattered trees/shrubs* - *grassland*

Bratislava



Kaposvár



$$T_{G1} = \text{mode}(F_G) + d/4$$

$$d = \text{median}(G_G) - \text{mode}(F_G)$$

$$T_{G2} = \text{mode}(F_G) + 2d/3$$

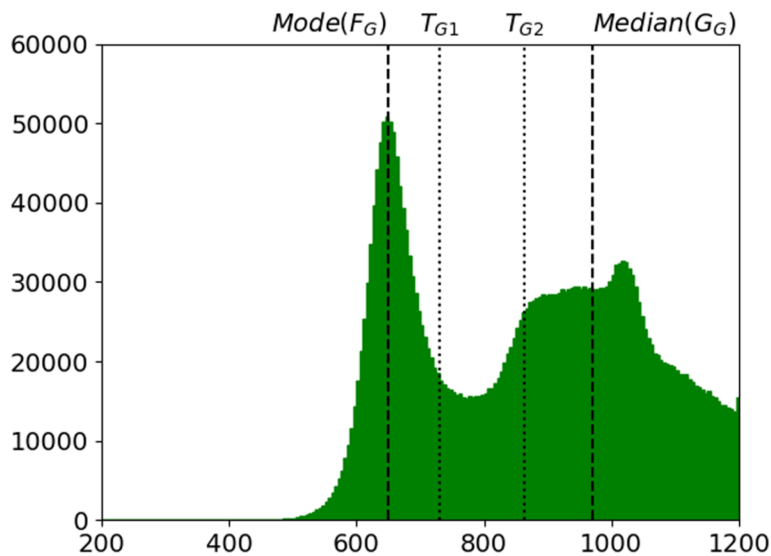
# Zelená vegetácia

**G pásmo** – odlíšenie stromovej a trávinatej vegetácie

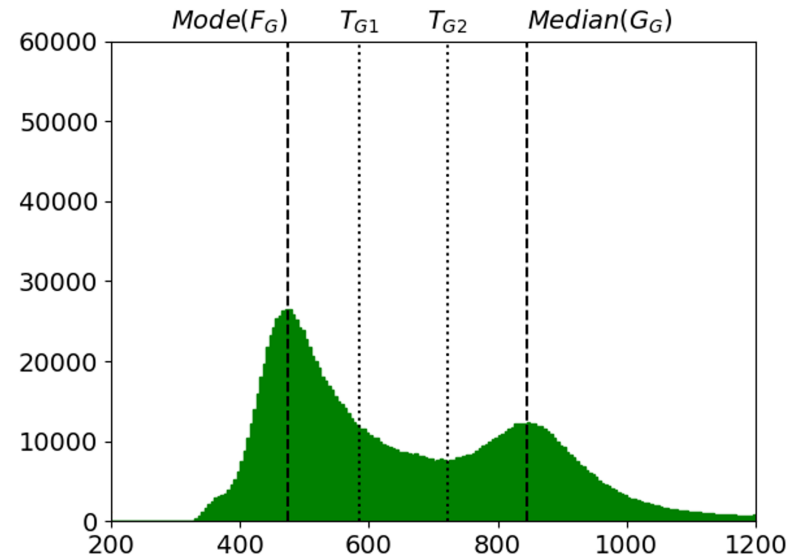
$T_{G1}$  – threshold *dense forest* – *scattered trees/shrubs*

$T_{G2}$  – threshold *scattered trees/shrubs* - *grassland*

Bratislava



Zakopane



$$T_{G1} = \text{mode}(F_G) + d/4$$

$$d = \text{median}(G_G) - \text{mode}(F_G)$$

$$T_{G2} = \text{mode}(F_G) + 2d/3$$

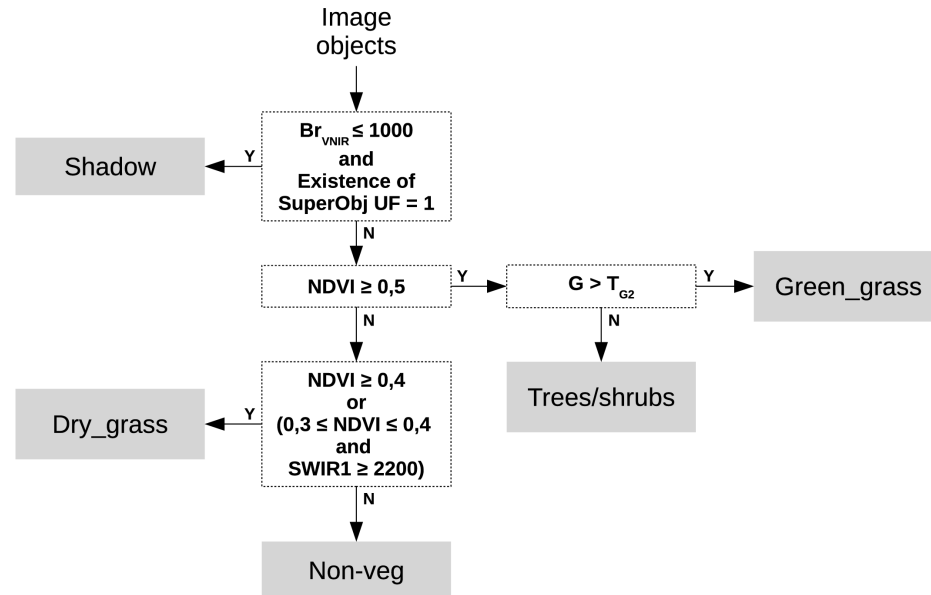


# Klasifikačné pravidlá L2

NDVI

G pásma

L2



## Hodnotenie správnosti:

L1 – testovacie objekty (149 až 472 podľa veľkosti územia)

L2 – testovacie body (210 až 636 podľa veľkosti územia)

# Hodnotenie správnosti klasifikácie

| L1 rule-based |    | Bratislava | Nitra | Žilina | Zakopane | Kaposvár | Orosháza |
|---------------|----|------------|-------|--------|----------|----------|----------|
|               | OA | 86.7       | 77.9  | 89.8   | 77.9     | 90.3     | 85.6     |
|               | F  | 0.85       | 0.77  | 0.90   | 0.80     | 0.90     | 0.83     |
| L2 rule-based |    | Bratislava | Nitra | Žilina | Zakopane | Kaposvár | Orosháza |
|               | OA | 88.7       | 83.2  | 83.7   | 75.7     | 81.7     | 84.3     |
|               | F  | 0.87       | 0.83  | 0.85   | 0.78     | 0.83     | 0.82     |

OA – Overall Accuracy

F – F-score

# Správnosť klasifikácie tried

| L1 | Forest |      | Scattered trees |      | Shrubland   |      | Grassland |      | Cropland |      | Urban fabric   |      | Water |       |        |      |
|----|--------|------|-----------------|------|-------------|------|-----------|------|----------|------|----------------|------|-------|-------|--------|------|
|    | PA     | UA   | PA              | UA   | PA          | UA   | PA        | UA   | PA       | UA   | PA             | UA   | PA    | UA    |        |      |
|    | 91.0   | 94.5 | 88.9            | 81.4 | 74.2        | 79.9 | 75.7      | 71.8 | 88.3     | 82.3 | 93.9           | 84.3 | 75.2  | 100.0 |        |      |
| L2 | Forest |      | Trees & shrubs  |      | Green grass |      | Dry grass |      | Cropland |      | Non-vegetation |      | Water |       | Shadow |      |
|    | PA     | UA   | PA              | UA   | PA          | UA   | PA        | UA   | PA       | UA   | PA             | UA   | PA    | UA    | PA     | UA   |
|    | 92.7   | 95.2 | 82.5            | 87.0 | 90.5        | 80.0 | 75.6      | 65.7 | 88.9     | 77.5 | 73.8           | 89.8 | 64.9  | 96.6  | 93.0   | 72.7 |

PA – Producer’s Accuracy

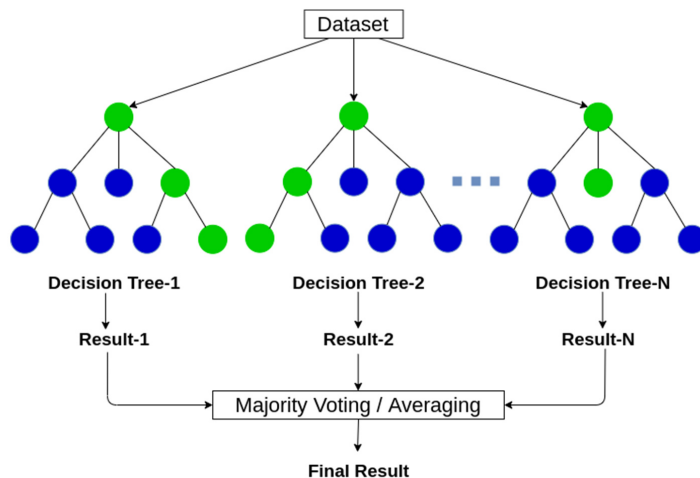
UA – User’s Accuracy

# Random Forest klasifikácia

Na úrovni L2 – tréningové vzorky z územia Bratislava (444 bodov)

**RF1** – vlastnosti ako pri rule-based klasifikácii (vrátane PanTex,  $NDVI_{RANGE}$  a  $NDVI_{MIN}$ )

**RF2** – 10 vlastností vybraných nástrojom Feature Space Optimization



# Hodnotenie správnosti klasifikácie

| L2 rule-based |    | Bratislava | Nitra | Žilina | Zakopane | Kaposvár | Orosháza |
|---------------|----|------------|-------|--------|----------|----------|----------|
|               | OA | 88.7       | 83.2  | 83.7   | 75.7     | 81.7     | 84.3     |
|               | F  | 0.87       | 0.83  | 0.85   | 0.78     | 0.83     | 0.82     |
| L2 RF1        |    | Bratislava | Nitra | Žilina | Zakopane | Kaposvár | Orosháza |
|               | OA | 85.8       | 78.4  | 55.8   | 41.0     | 71.6     | 65.0     |
|               | F  | 0.84       | 0.79  | 0.59   | 0.42     | 0.85     | 0.74     |
| L2 RF2        |    | Bratislava | Nitra | Žilina | Zakopane | Kaposvár | Orosháza |
|               | OA | 75.6       | 67.2  | 42.8   | 28.6     | 44.2     | 33.5     |
|               | F  | 0.75       | 0.69  | 0.41   | 0.29     | 0.57     | 0.52     |

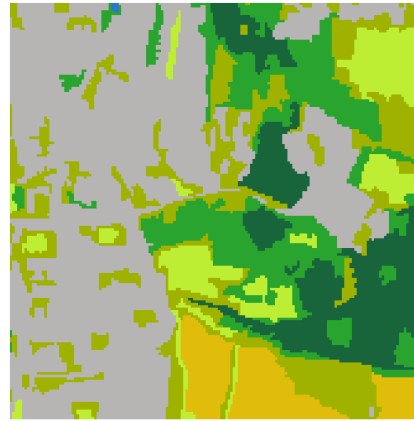
OA – Overall Accuracy

F – F-score

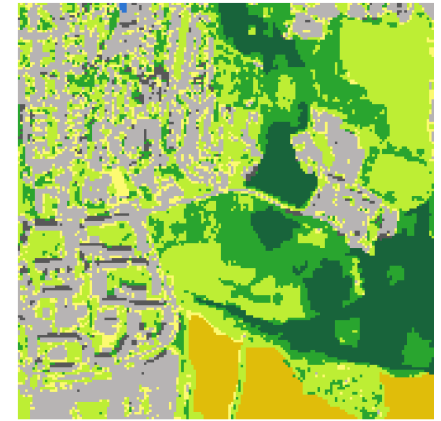
Žilina



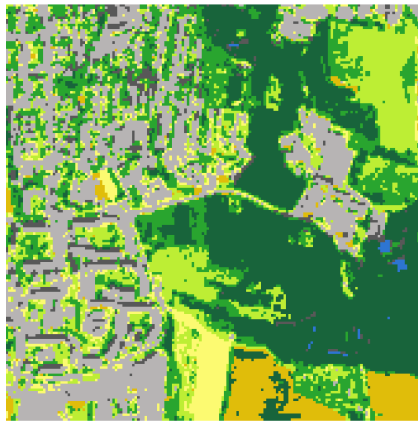
L1 rule-based



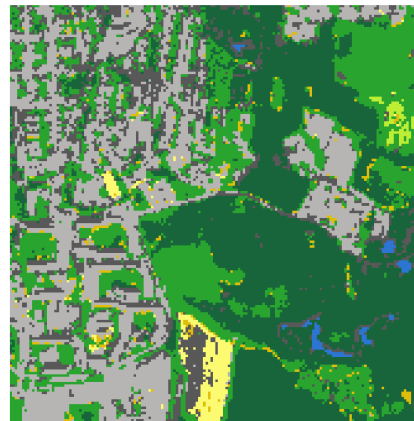
L2 rule-based



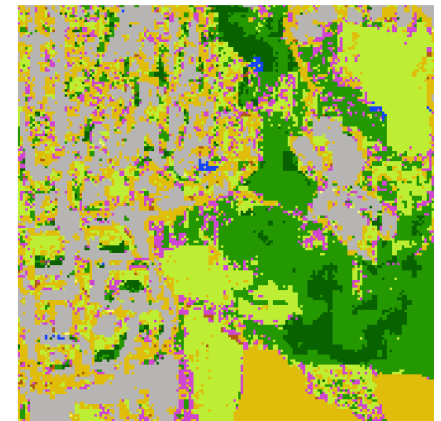
L2 RF1



L2 RF2



S2GLC



**L1 classes**

- Forest
- Scattered trees
- Shrubland
- Grassland
- Cropland
- Urban fabric
- Water

**L2 classes**

- Forest
- Trees/shrubs
- Green grass
- Dry grass
- Cropland
- Non-vegetation
- Water
- Shadow

**S2GLC**

- Coniferous tree cover
- Broadleaf tree cover
- Vineyards
- Herbaceous vegetation
- Cultivated areas
- Artificial surfaces
- Water bodies
- Marshes



# Ďakujem za pozornosť.

hana.bobalova@uniba.sk

Bobáľová, H., Benová, A. & Kožuch, M. (2021) Hierarchical Object-Based Mapping of Urban Land Cover Using Sentinel-2 Data: A Case Study of Six Cities in Central Europe. *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 89, 15–31 (2021). <https://doi.org/10.1007/s41064-020-00135-8>