

Can a Hierarchical Classification of Sentinel-2 Data Improve the Land Cover Mapping?

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07.06.2021

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The project InCoNaDa “Enhancing the user uptake of Land Cover / Land Use information derived from the integration of Copernicus services and national databases” is funded by the Norway Grants via the National Centre for Research and Development’.

The aims of the project:

- improve the user uptake of land cover and land use information derived from the integration of Copernicus Land Monitoring Services (CLMS) and national databases,
- to address the request for more detailed information on LCLU and its changes (in respect to spatial, temporal and thematic content),
- to assessment of usefulness of enhanced LCLU database and CLMS products for decision makers, reporting obligations in natural resources monitoring, urban and spatial planning, agricultural management and reporting greenhouse gases emissions and removals from LULUCF in Poland and Norway.

One of the objectives is:

To develop methodology for land cover classification using the advance non-parametric machine learning algorithms, based on a time series of Sentinel-2 imagery.

Project website: <https://inconada.eu/>

Land cover classes and study area

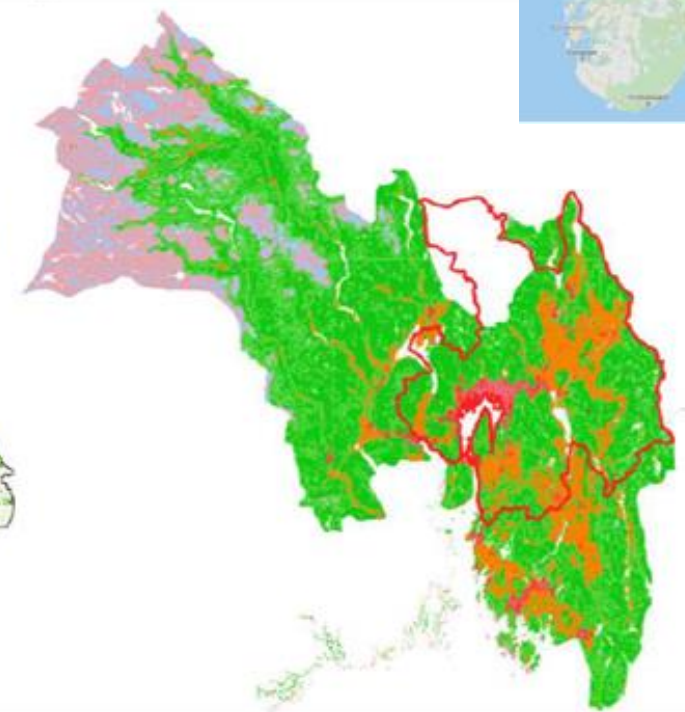
The subsequent land cover classes are mapped:

sealed surfaces,
woodland broadleaved,
woodland coniferous,
shrubs,
permanent herbaceous (i.e. grassy areas),
periodically herbaceous (i.e. arable land),
wetlands and mosses,
non-vegetated,
water bodies ,
snow and ice (in Norway)

Study area

Poland, Łódź province

Norway, Viken county



Data

- Time series of Sentinel-2, from early March to late September 2020

Resampling 20 m spatial resolution bands to 10 m

Layer stacking all selected Sentinel-2 images, in total 8 images

Reference samples

- Points were created randomly on reference data:
 - BDOT10k - topographic database (scale 1:10 000),
 - Land cover classes from Agency for Restructuring and Modernisation of Agriculture (ARMA),
 - BDL – Forest Data Bank.
- Analysis of spectral histograms
- Reference samples: 60% training and 40% testing samples

Random Forest (RF) classifications were carried out in the Python environment.

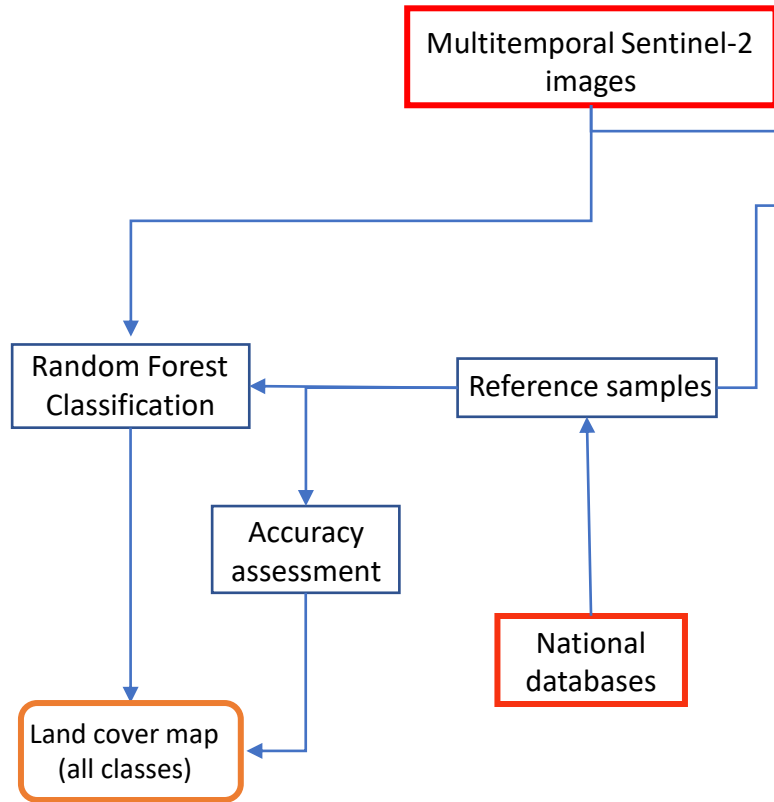
- RF parameters:
 - n_estimators = 100
 - criterion = 'entropy'
 - random_state = 42

Classification was iteratively repeated 100 times

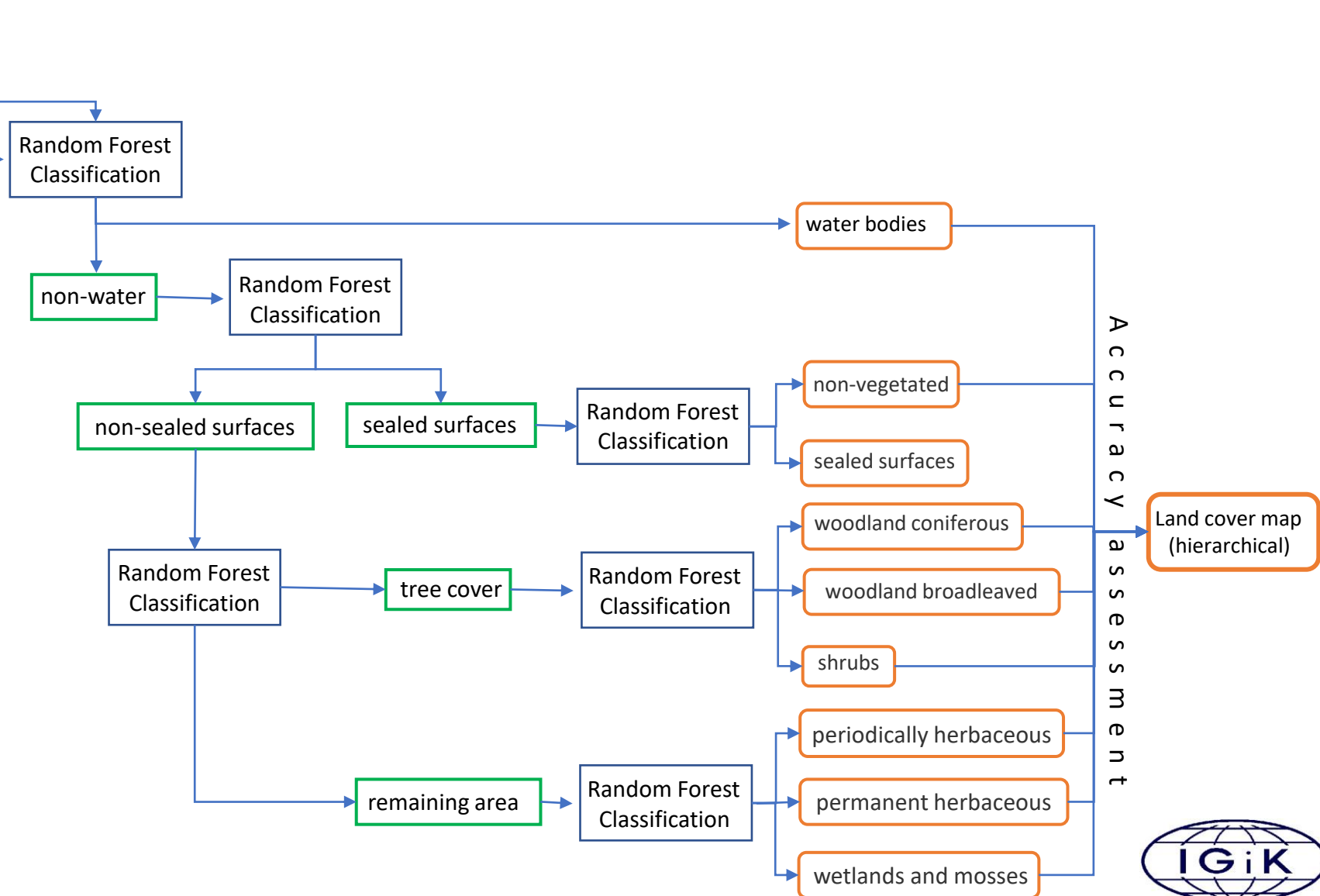
Filtering the final map using Region Group and Nibble tools in ArcGIS Pro.

Classification scheme

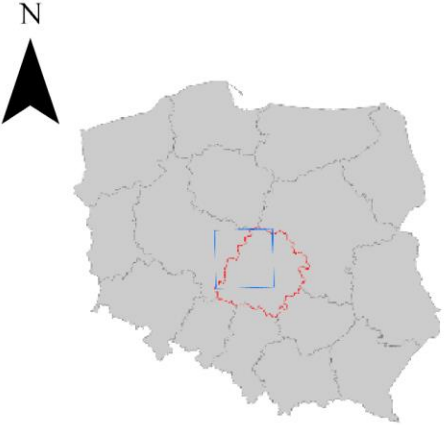
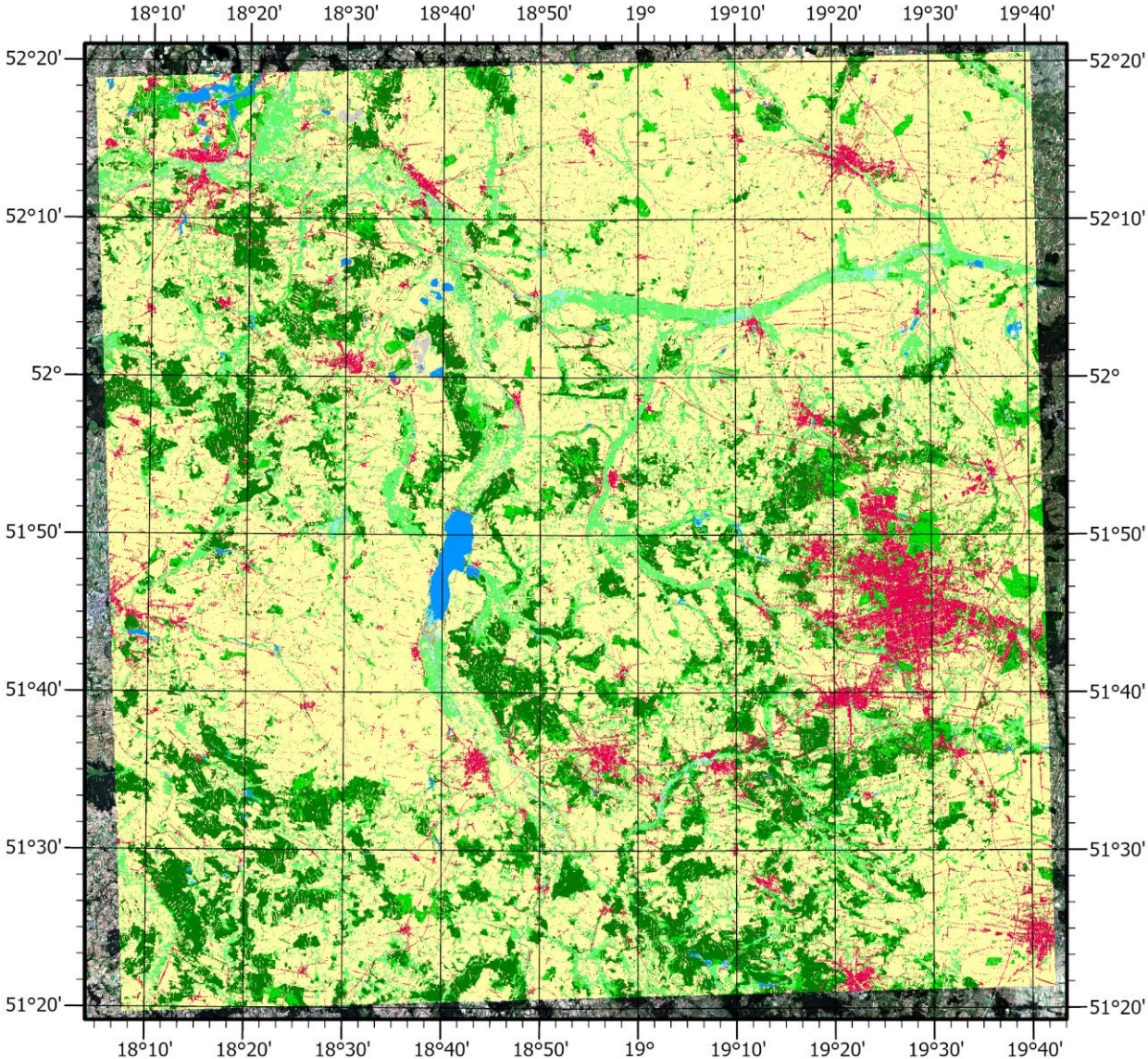
Flat Classification



Hierarchical Classification (HCL)



Hierarchical classification, land cover map



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- woodland coniferous
- shrubs
- permanent herbaceous
- periodically herbaceous
- wetlands and mosses
- non-vegetated
- water bodies

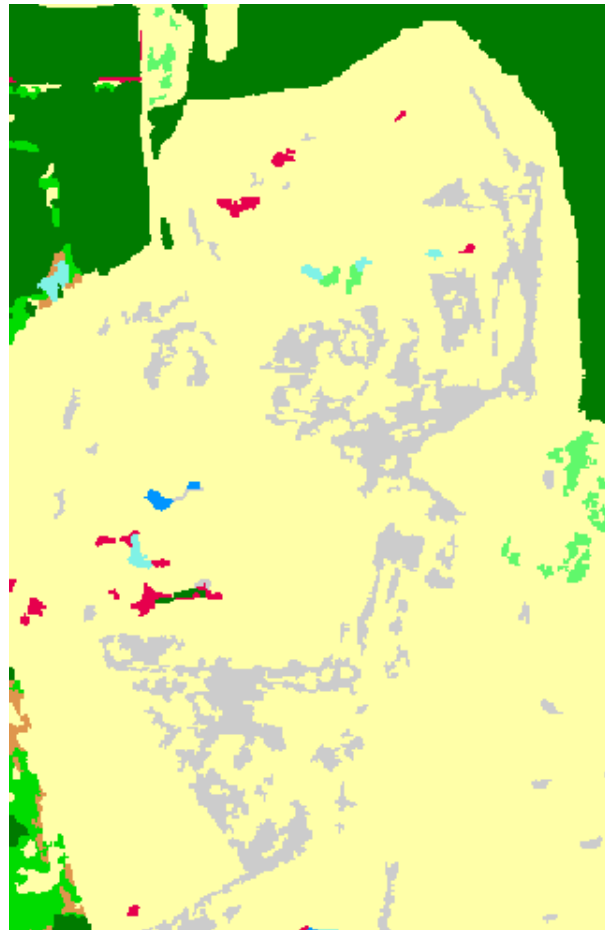


Hierarchical and flat classification comparison

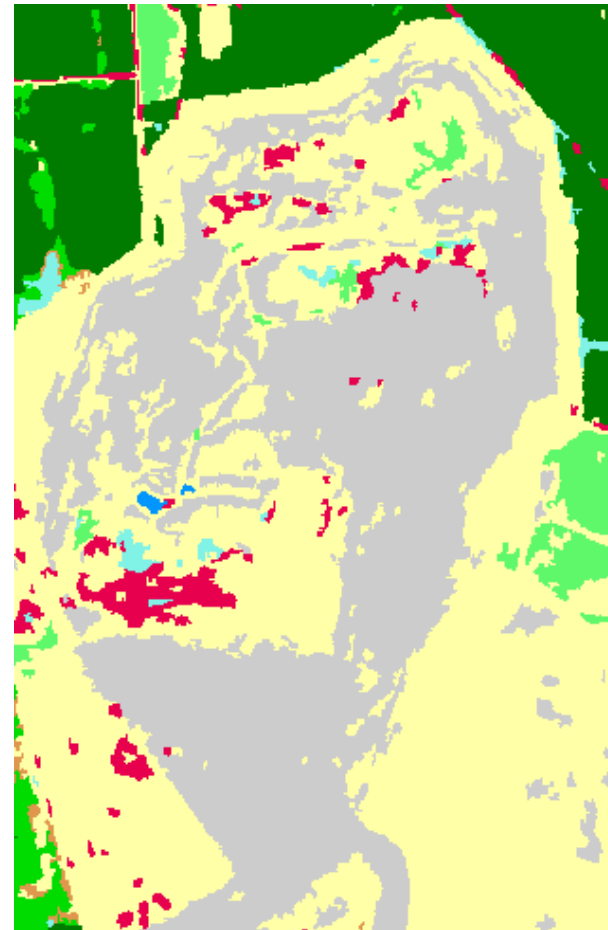
RGB



Flat



HCL



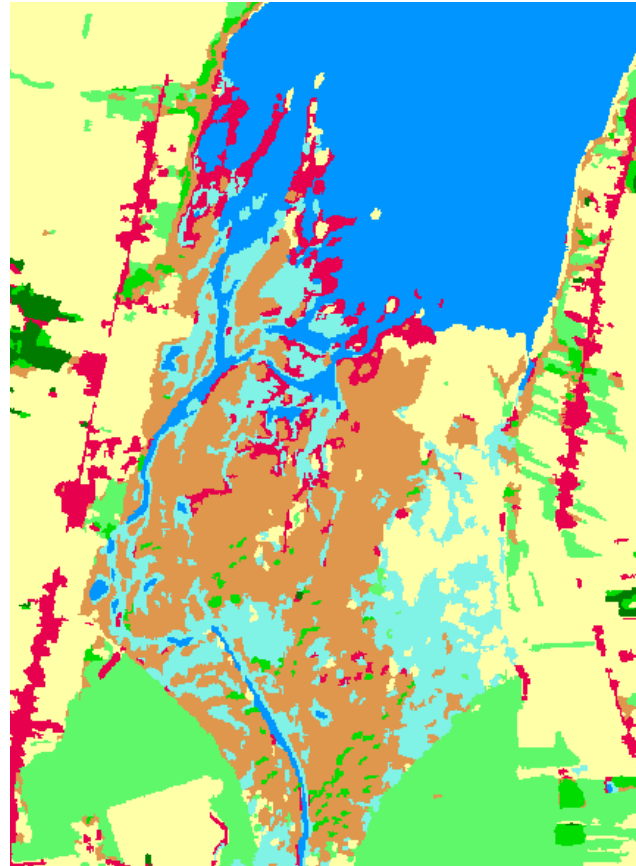
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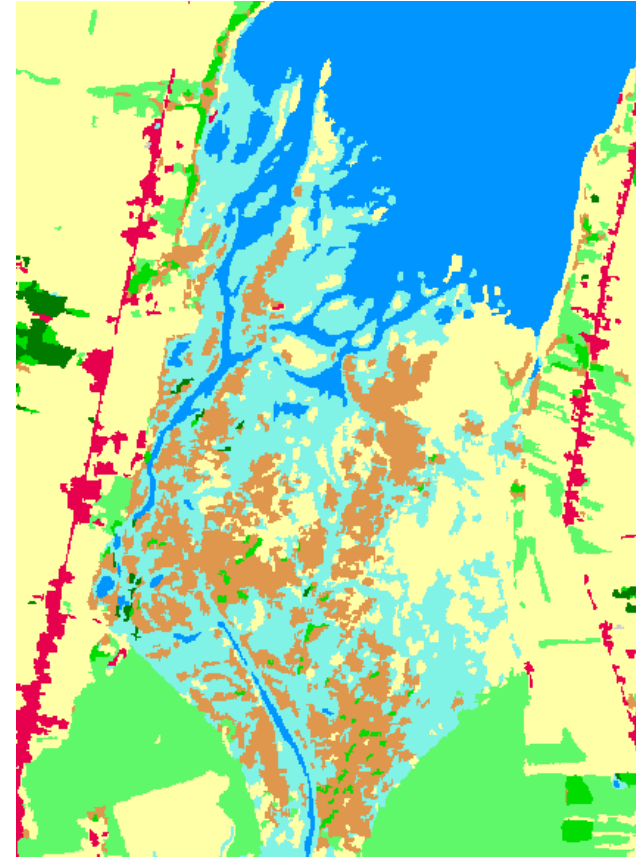
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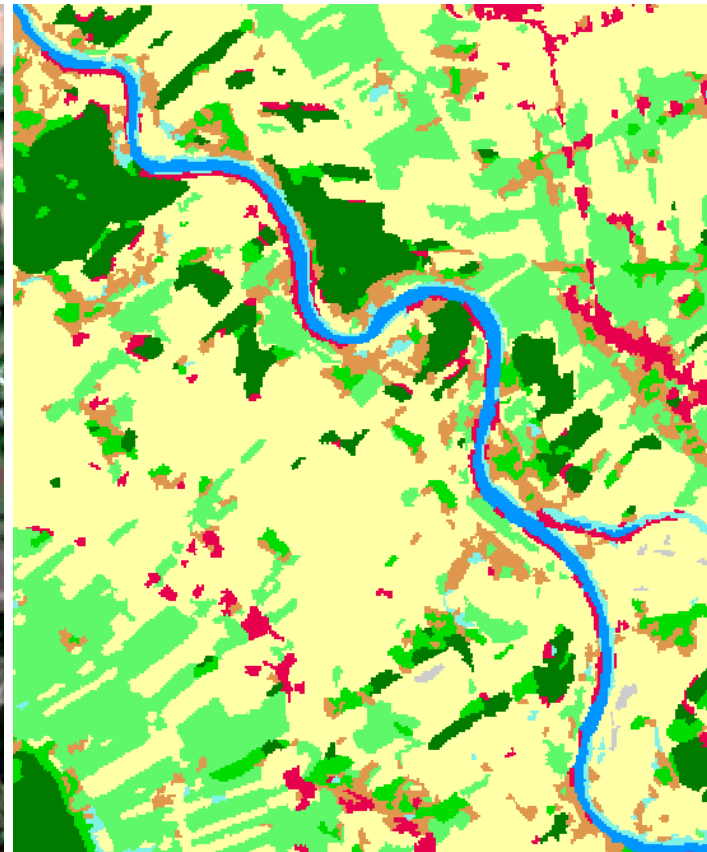
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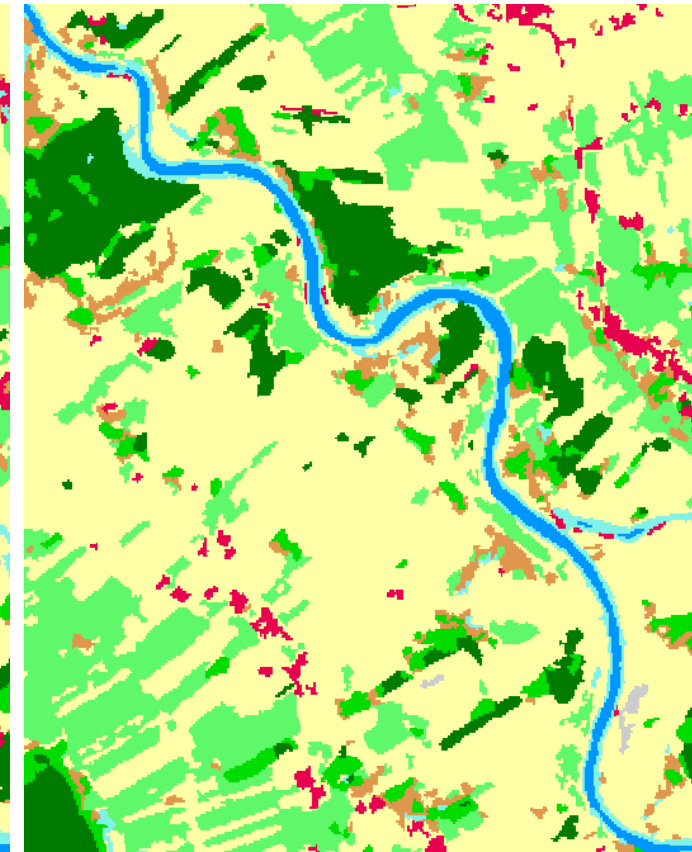
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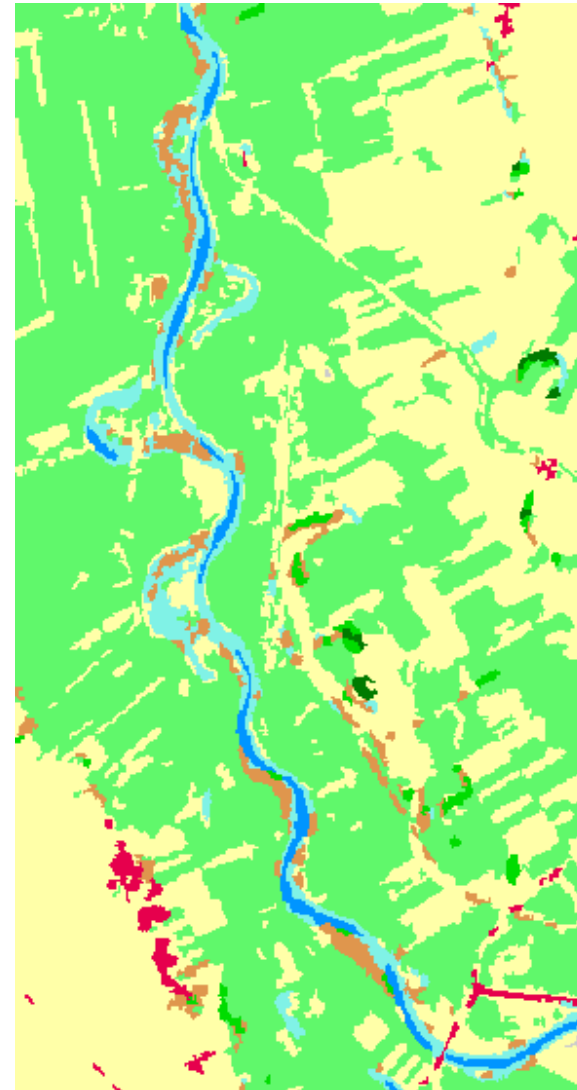
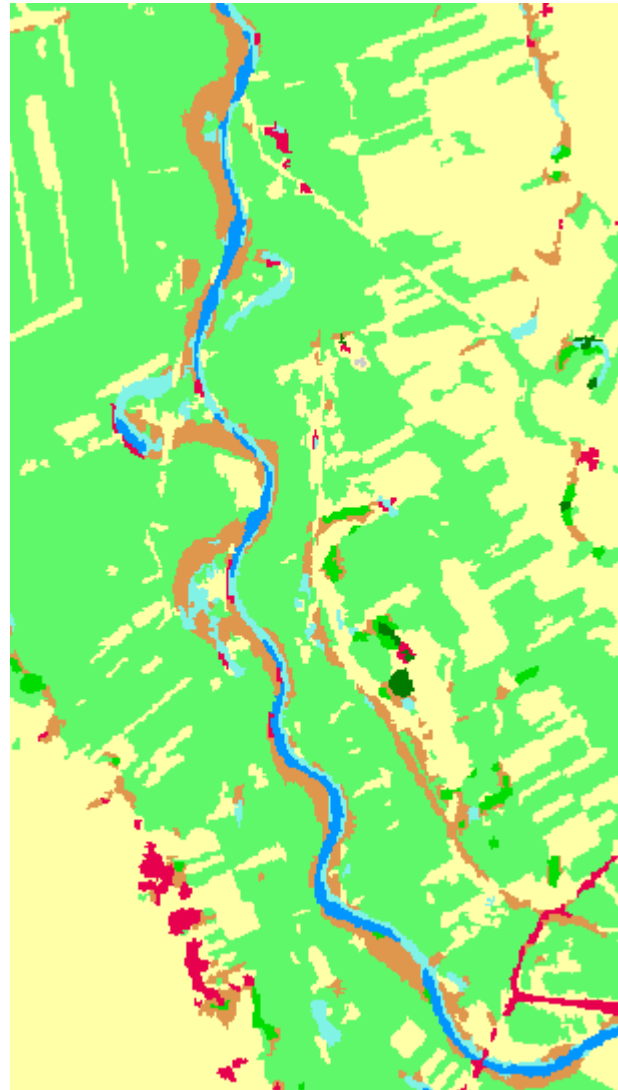
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Hierarchical and flat classification comparison

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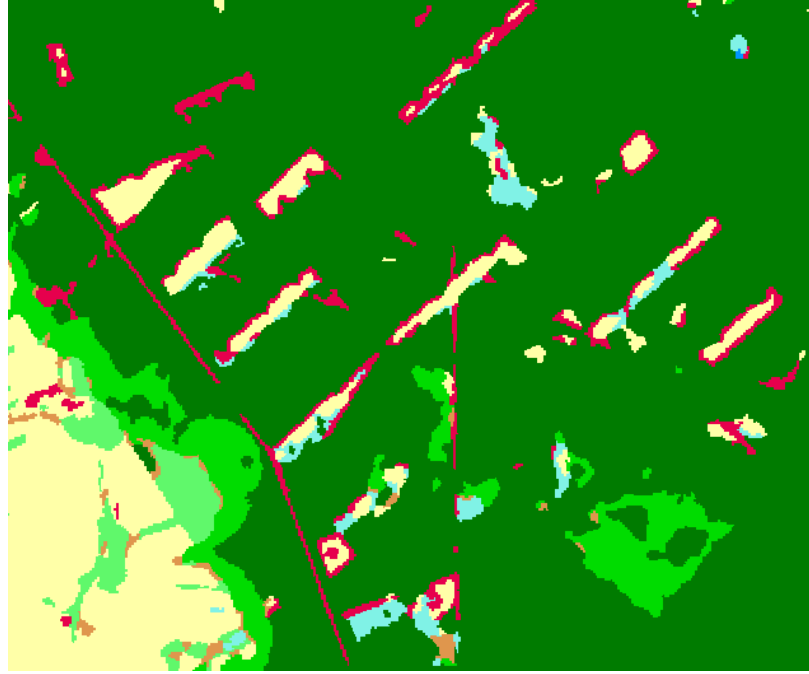
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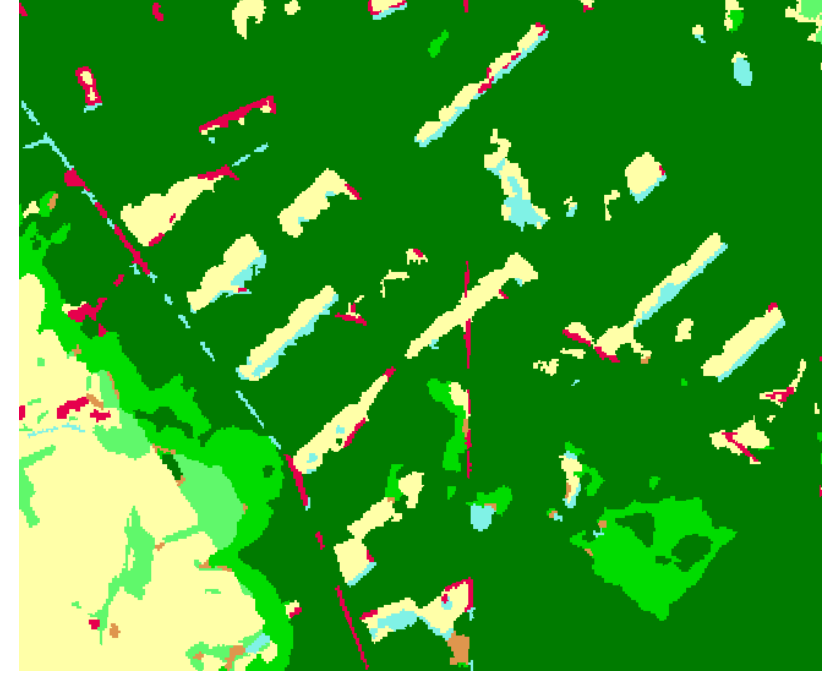
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Flat



HCL

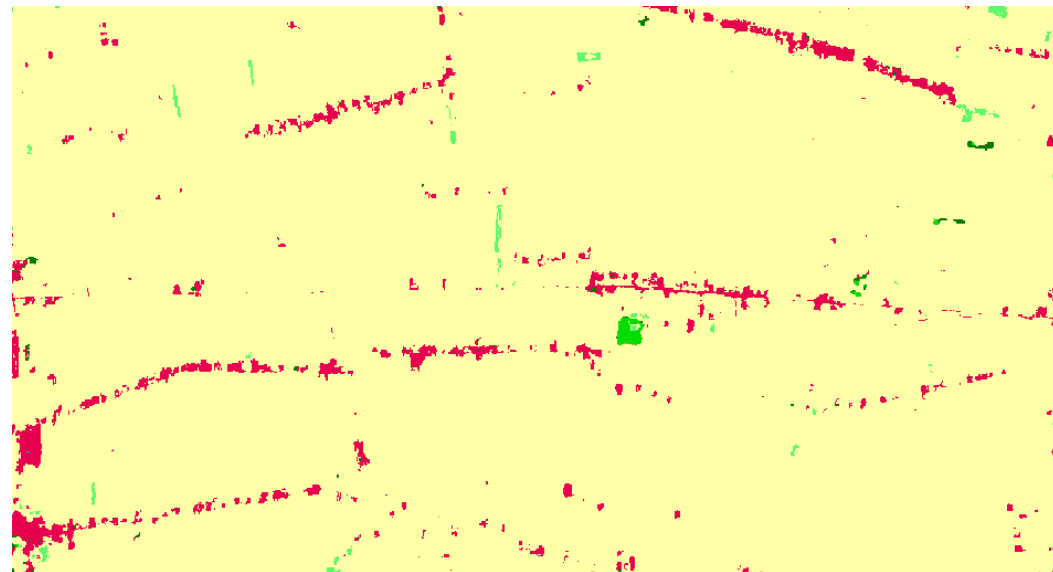


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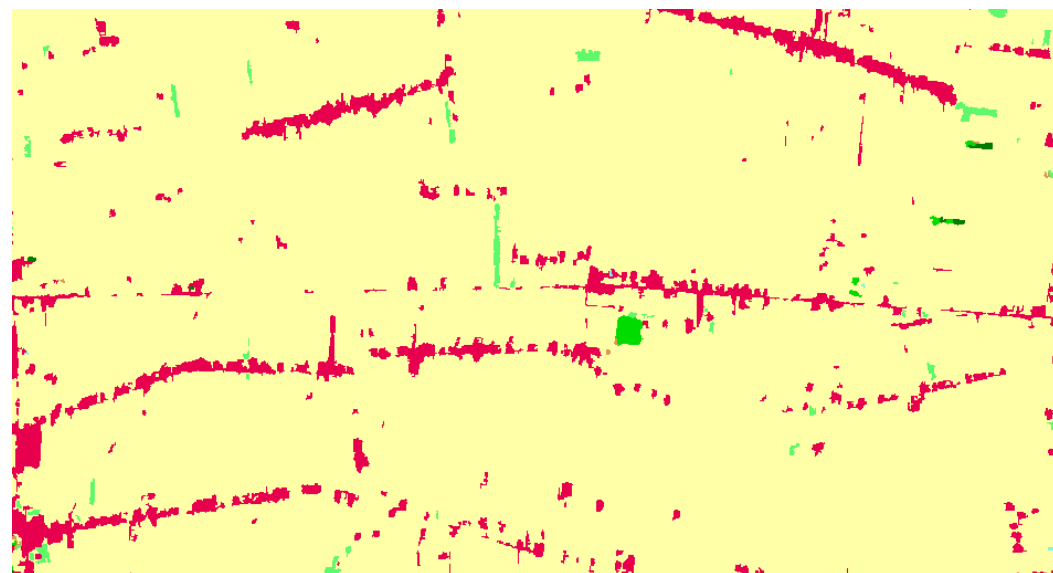
Flat



RGB



HCL



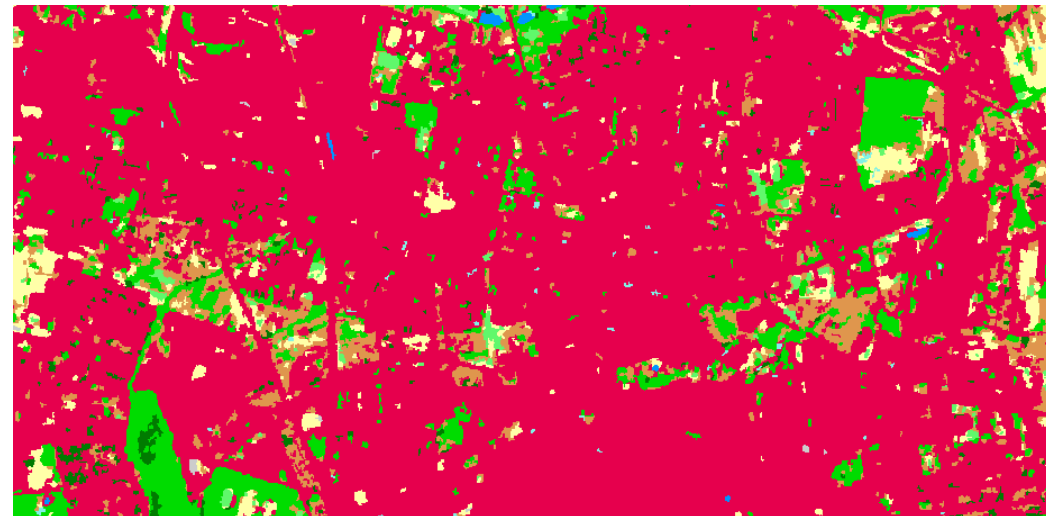
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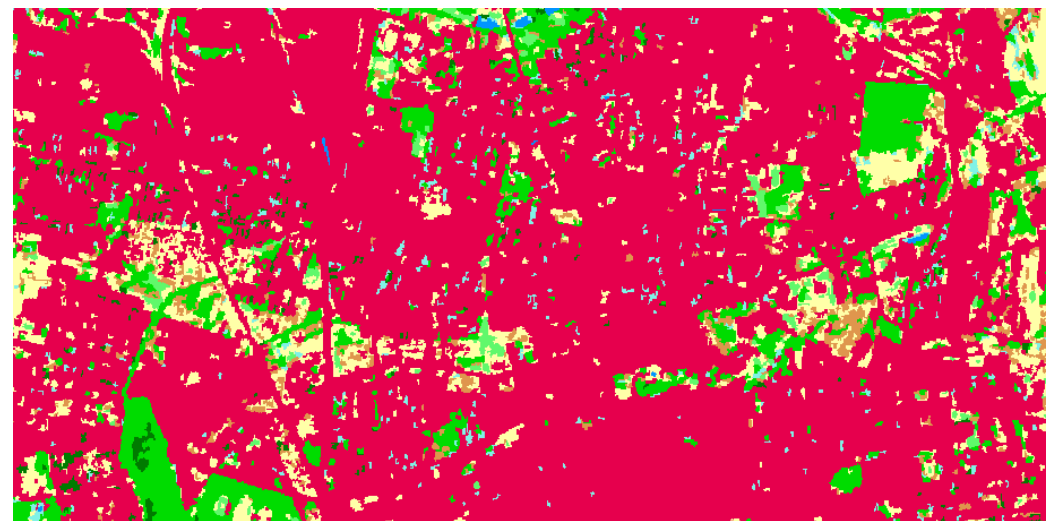
RGB



Flat



HCL



Flat classification error matrix

	sealed surfaces	woodland broadleaved	woodland coniferous	shrubs	permanent herbaceous	periodically herbaceous	wetlands and mosses	non-vegetated	water bodies	UA (%)
sealed surfaces	281	3	6	6	2	73	0	1	0	75,5
woodland broadleaved	3	159	5	1	0	1	1	0	0	93,5
woodland coniferous	1	8	280	0	0	0	0	0	0	96,9
shrubs	7	12	3	60	22	83	3	0	0	31,6
permanent herbaceous	1	1	0	4	564	124	1	0	0	81,2
periodically herbaceous	21	3	4	6	89	3868	4	4	1	96,7
Wetlands and mosses	4	1	1	4	6	12	50	0	4	61,0
non-vegetated	3	0	0	1	1	46	0	34	2	39,1
water bodies	1	0	0	0	0	1	3	0	265	98,1
PA (%)	87,3	85,0	93,6	73,2	82,5	91,9	80,6	87,2	97,4	

Flat and hierarchical classification accuracy

	Flat classification	Hierarchical Classification			
		Water bodies / non-water	sealed surfaces / non-sealed surfaces	Tree cover	Remaining area
OA	89-90%	99%	96-97%	97%	93 – 95%
Kappa	0,80 -0,82	0,96 – 0,98	0,72 - 0,78	0,81 - 0,86	0,78 - 0,81
F1	0,76 - 0,79	0,98 – 0,99	0,86 - 0,89	0,91 – 0,92	0,84 - 0,88

	FLAT		HCL	
	UA (%)	PA (%)	UA (%)	PA (%)
sealed surfaces	75,5	87,3	98,1	94,8
woodland broadleaved	93,5	85,0	91,2	92,3
woodland coniferous	96,9	93,6	97,6	95,9
shrubs	31,6	73,2	73,2	87,7
permanent herbaceous	81,2	82,5	79,5	84,7
periodically herbaceous	96,7	91,9	97,4	96,1
wetlands and mosses	61,0	80,6	73,2	87,0
non-vegetated	39,1	87,2	77,0	90,5
water bodies	98,1	97,4	98,1	95,7

- **water bodies / non-water**

- + band 8(NIR), band 8a (Narrow NIR), band 11 (SWIR)

- band 2 (blue), band 3 (green), band 4 (red)

- **sealed surfaces / non-sealed surfaces**

- + band 2 (blue), band 4 (red), band 12 (SWIR)

- band 3 (green), band 5 (Vegetation red edge), band 6 (Vegetation red edge)

- **tree cover**

- + band 3 (green), band 5 (Vegetation red edge), band 4 (red)

- band 8a (Narrow NIR), band 12 (SWIR), band 11 (SWIR)

- **remaining area**

- + band 11 (SWIR), band 8 (NIR), band 1 (blue)

- band 3 (green), band 5 (Vegetation red edge), band 4 (red)

Hierarchical classification gives better visual results and higher accuracy than flat classification for the most problematic classes:

- the largest increase of UA were noticed for shrubs and non-vegetated classes, around 40 percentage points,
- UA and PA for wetlands and mosses increase from 61% and 80% to 73% and 87% respectively.

In hierarchical classification, over the densely built-up areas the building's shadows are misclassified as wetlands and mosses

In flat classification, the sealed surfaces were generally underestimated, the overestimated were visible in forest shadows and along the rivers.

Hierarchical classification is more time consuming and more laborious.

Obtaining satisfying results requires repeating the processes and experimenting with parameters.

- Independent verification of final land cover maps using Random Sampling method
- Classification the other granules which cover Łódz province
- Testing other mashine learning alghoritms
- Publication
- Land cover classification for the Norwegian study area

Thank you!

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