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Comparison of hierarchical and flat land cover classification of Sentinel-2 data

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ABSTRACT

Monitoring of land cover plays an important role in effective urban planning, sustainable development environmental management and protection. Despite a considerable number of approaches towards land cover classification based on satellite data, there is still a challenge to clearly separate complex land cover classes, for example grasslands, arable land and wetlands. The aim of this study is to examine, whether a hierarchal classification of Sentinel-2 data can improve the accuracy of land cover mapping and delineation of complex land cover classes. Classification is performer for the year 2020, using Random Forest algorithm. Classification is carried out following two approaches: **1)** all land cover classes are classified together (flat classification), and **2)** applying hierarchical approach by separating classes into groups and classifying then in different levels of detail.

InCoNaDa PROJECT

"**Enhancing the user uptake of Land Cover / Land Use information derived from the integration of Copernicus services and national databases - InCoNaDa**" is funded by the Norway Grants via the Polish National Centre for Research and Development', programme 'Applied Research', the POLNOR 2019 Call.

The main aim of InCoNaDa is to improve the user uptake of Land Cover / Land Use (LCLU) information derived from the integration of Copernicus Land Monitoring Service (CLMS) and national databases.

Project objectives:

- to determine the most accurate land cover and land cover chage map based on a time series of Sentinel-2 data for Łódź province (Poland) and Viken county (Norway) using machine learning approaches;
- to design and develop web-based application enabling to query the enhanced LCLU database;
- to proof if and how enhanced LCLU database and CLMS can be used in spatial planning, agricultural management, environmental monitoring;
- to demonstrate the usefulness of the enhanced LCLU database and CLMS for reporting GHG emissions and removals from LULUCF.

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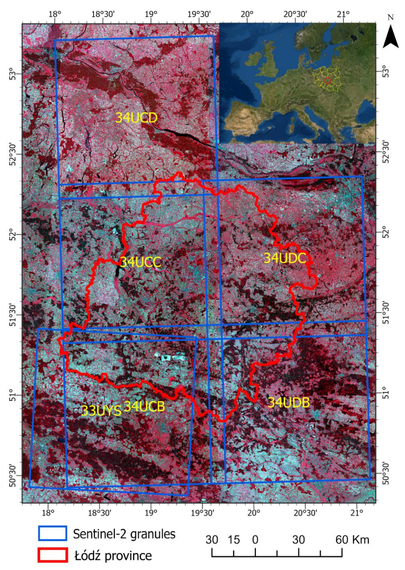
More about InCoNaDa

STUDY AREA

The study area is located in central Poland, with the Łódź province in the middle. The study area is delineated by the extent of the six Sentinel-2 granules (100 by 100 km each).



Data:

- Sentinel-2 images

Reference Dataset :

- National Topographic Database BDOT-10k
- Forest Data Bank - FDB
- Land Parcel Identification System (LPIS) managed by the Agency for Restructuring and Modernization of Agriculture - ARiMR

Land cover classes:

- sealed surfaces,
- woodland broadleaved,
- woodland coniferous,
- shrubs,
- permanent herbaceous,
- periodically herbaceous,
- mosses,
- non-vegetated,
- water bodies.

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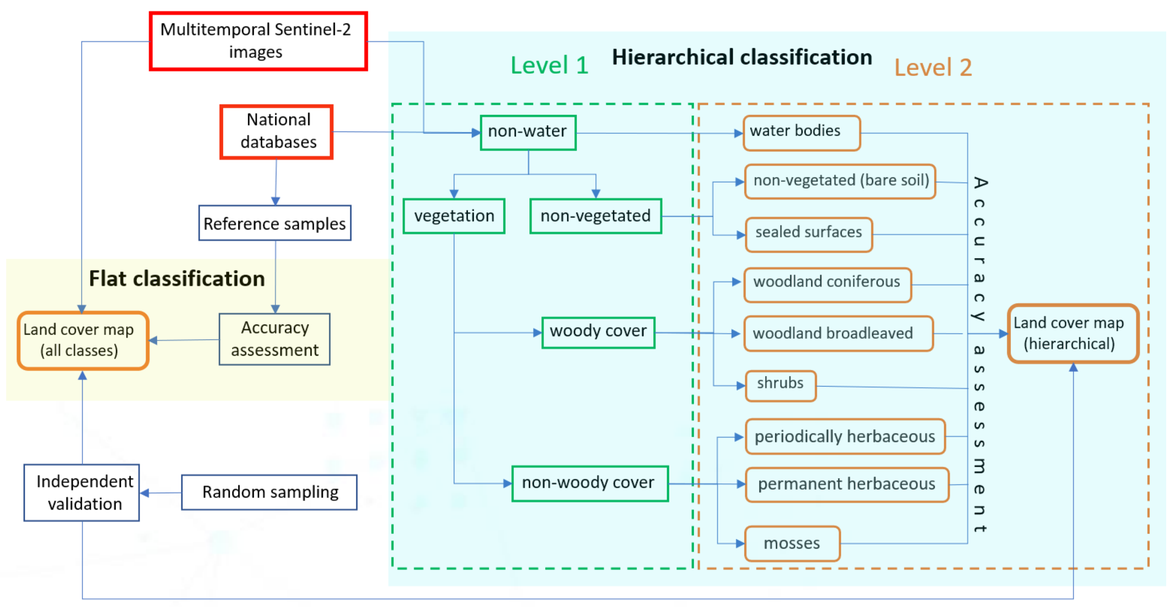
Article

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

Adam Waśniewski [1,2,*], Agata Hościło [1] and Milena Chmielewska [1]

METHODOLOGY

Algorithm – Random Forest.
Training – 60% reference sampling.
Validation – 40% reference sampling.
Independence verification – 50 verification polygons per each land cover class.



RESULTS

ACCURACY ASSESMENT

The accuracy assessment of the classification results was carried out for each granule using the validation sampling plots. The classification accuracy was expressed as overall accuracy (OA), F1 score, Kappa coefficient and user's (UA) and producer's (PA) accuracy. For the hierarchical classification, the accuracy assessment was carried out individually for each classification at each level.

HIERARCHICAL CLASSIFICATION ACCURACY

HIERARCHICAL CLASSIFICATION		Overall accuracy	Kappa coefficient	F1 score
level 1	non-water/water bodies	0.99 - 1.00	0.93 - 0.99	0.96 - 1.00
	vegetation/non-vegetation	0.97 - 0.98	0.70 - 0.79	0.85 - 0.90
	woody cover/non-woody cover	0.95 - 0.99	0.86 - 0.97	0.92 - 0.99
level 2	sealed surfaces ,non-vegetated (bare soil)	0.92 - 0.97	0.56 - 0.85	0.78 - 0.92
	woodland broadleaved, woodland coniferous, shrubs	0.94 - 0.99	0.86 - 0.97	0.88 - 0.99
	permanent herbaceous, periodically herbaceous, mosses	0.93 - 0.99	0.68 - 0.79	0.77 - 0.87
FLAT classification		0.89 - 0.93	0.82 - 0.89	0.74 - 0.81

FLAT CLASSIFICATION ACCURACY

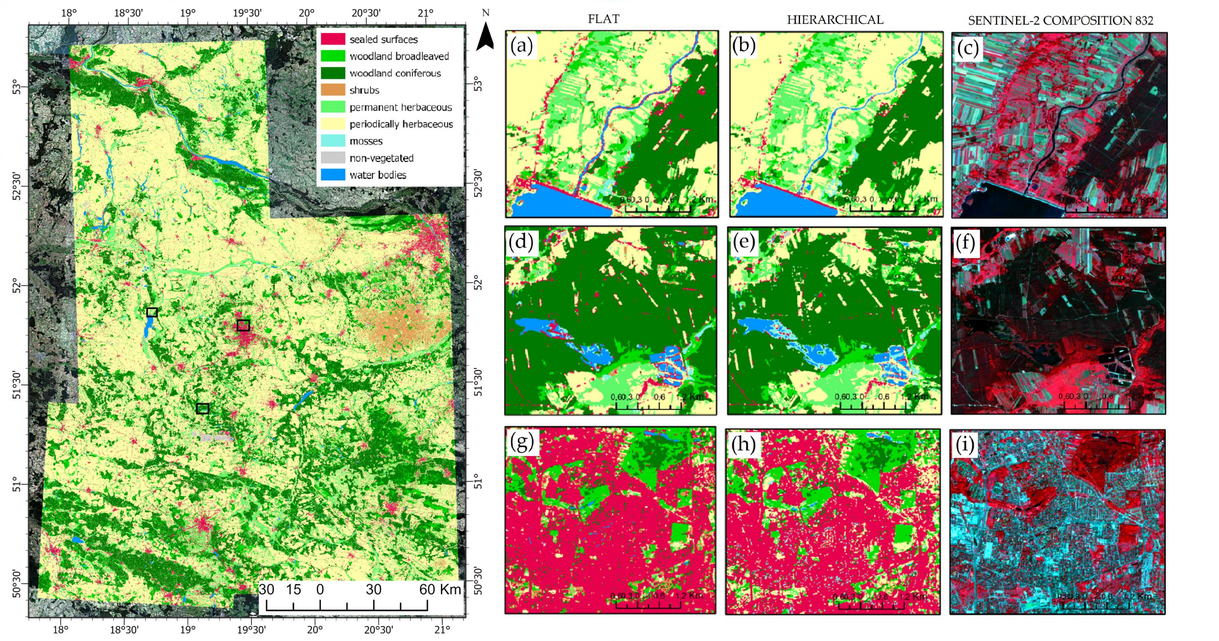
Land Cover Classes	UA	PA	F1 score
Sealed surfaces	0.63 - 0.82	0.79 - 0.82	0.72 - 0.83
Woodland broadleaved	0.77 - 0.89	0.76 - 0.83	0.77 - 0.84
Woodland coniferous	0.94 - 0.99	0.92 - 0.98	0.94 - 0.98
Shrubs	0.15 - 0.74	0.38 - 0.77	0.25 - 0.76
Permanent herbaceous	0.65 - 0.80	0.73 - 0.81	0.69 - 0.80
Periodically herbaceous	0.94 - 0.96	0.90 - 0.94	0.92 - 0.95
Mosses	0.32 - 0.67	0.55 - 0.79	0.40 - 0.73
Non-vegetated (bare soil)	0.18 - 0.76	0.50 - 0.89	0.26 - 0.80
Water bodies	0.90 - 0.99	0.92 -0.99	0.92 - 0.99

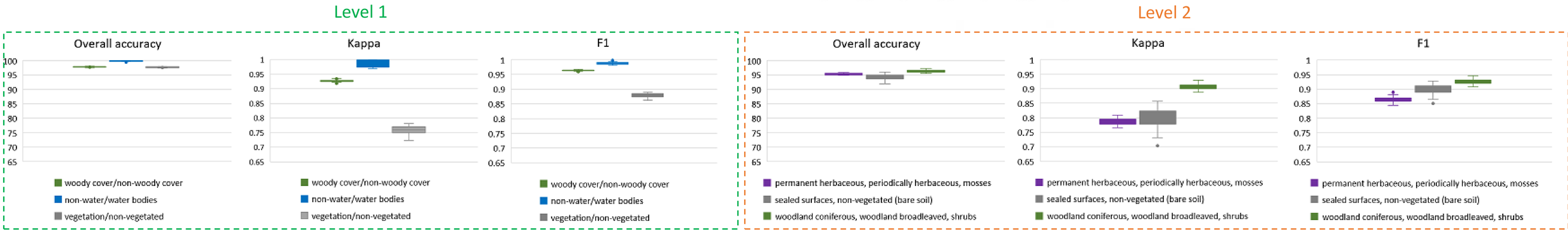
INDEPENDENT RANDOM SAMPLING VERIFICATION

	FLAT		HIERARCHICAL	
	UA	PA	UA	PA
Sealed surfaces	0.79	0.74	0.77	0.92
Woodland broadleaved	0.80	0.74	0.71	0.88
Woodland coniferous	0.76	0.88	0.91	1.00
Shrubs	0.65	0.70	0.71	0.78
Permanent herbaceous	0.66	0.92	0.84	0.84
Periodically herbaceous	0.78	0.80	0.81	0.70
Mosses	0.82	0.64	1.00	0.74
Non-vegetated (bare soil)	0.97	0.66	0.92	0.68
Water bodies	0.96	0.98	0.96	0.98

Visual comparison of the classification results versus the Sentinel-2 data and aerial orthophotos.

- Misclassification of areas along the river or water bodies (a, b, c).
- Overestimation of sealed surfaces along the edges of ponds and forest clearcuts, especially on the forest edges (d, e, f).
- Misclassification of densely built-up areas with high buildings and shadows (g, h, i).





CONCLUSIONS

- The hierarchical classification approach produced more accurate and reliable land cover classification results than the standard flat method
- The overall accuracy of the land cover classification increased by three to seven percentage points by applying the hierarchical approach.
- The hierarchical approach gave better visual results, which are closer to reality than the flat classification.
- Hierarchical approach produces the additional products as a result of level 1 classifications that can be used for various purposes.
- The biggest disadvantage of the hierarchic approach is the complexity of the classification process, which makes it time-consuming.

ACKNOWLEDGEMENTS

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