

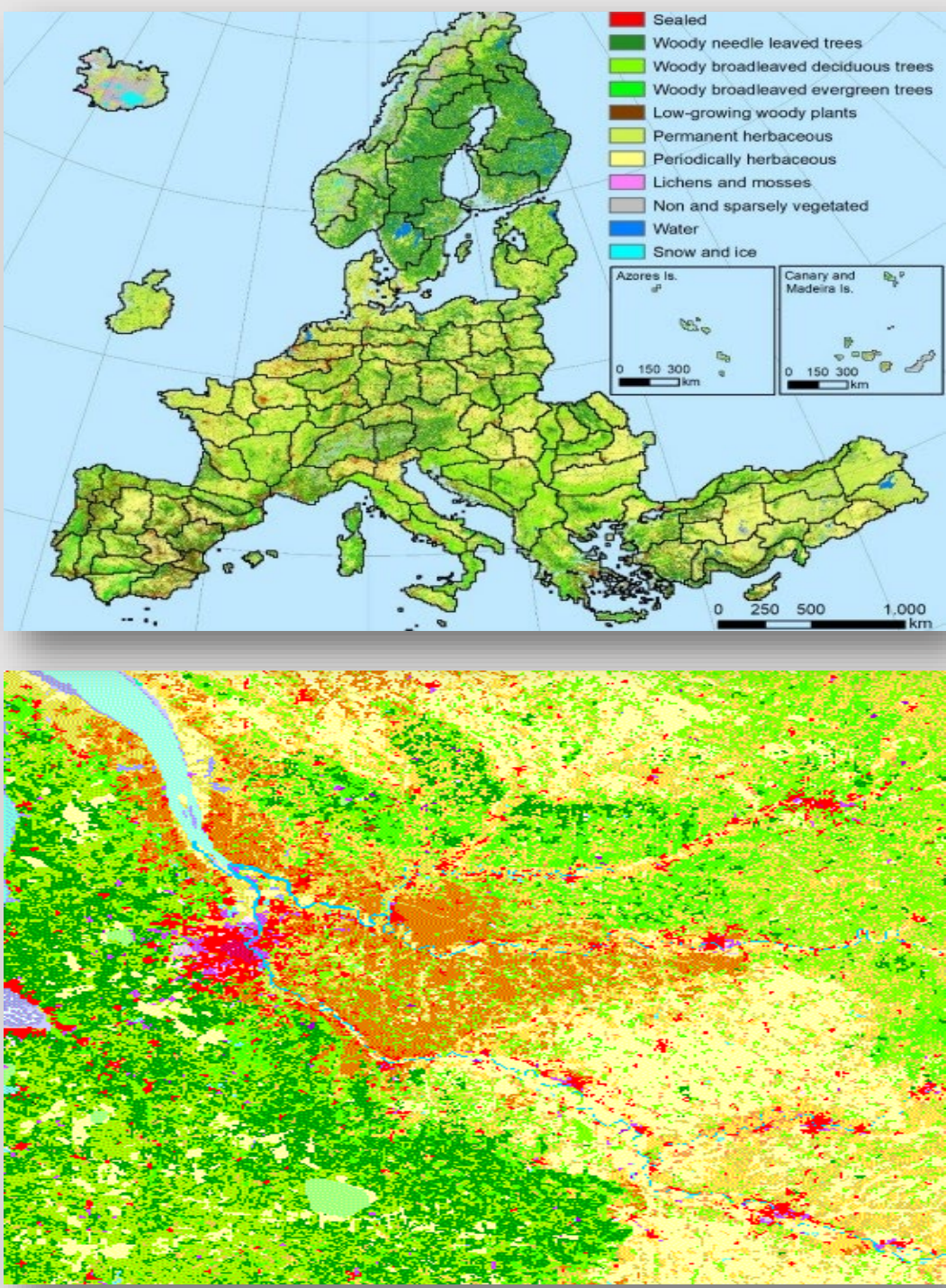
Validation of Copernicus CLC+ and Global Land Cover maps: A case study in Northern Greece

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INTRODUCTION

Advancements in remote sensing technology, combined with the increasing availability of high-resolution satellite imagery, have significantly improved land cover mapping capabilities. Modern machine learning algorithms and cloud computing platforms have enabled the systematic generation of high resolution **Global and Regional Land Cover (LC) Products**, based on Sentinel-1/2 10 m imagery.



OBJECTIVES

Independent and/or comparative **validation** studies of modern LC maps are essential for assessing their reliability and guiding users in selecting the most appropriate product for various applications.

This work aims to assess the accuracy of three High-Resolution LC products, consisting of two **global** maps, **ESA WorldCover** and **ESRI LULC**, and one **regional**, the Copernicus **CLCplus Backbone**, over a large region in Northern Greece. An independent reference dataset was used for comparison for year 2021.

- What are the differences in spatial mapping of land cover types among the products?
- What is the overall and class-specific accuracies of the LC products?

DATASETS AND METHODS

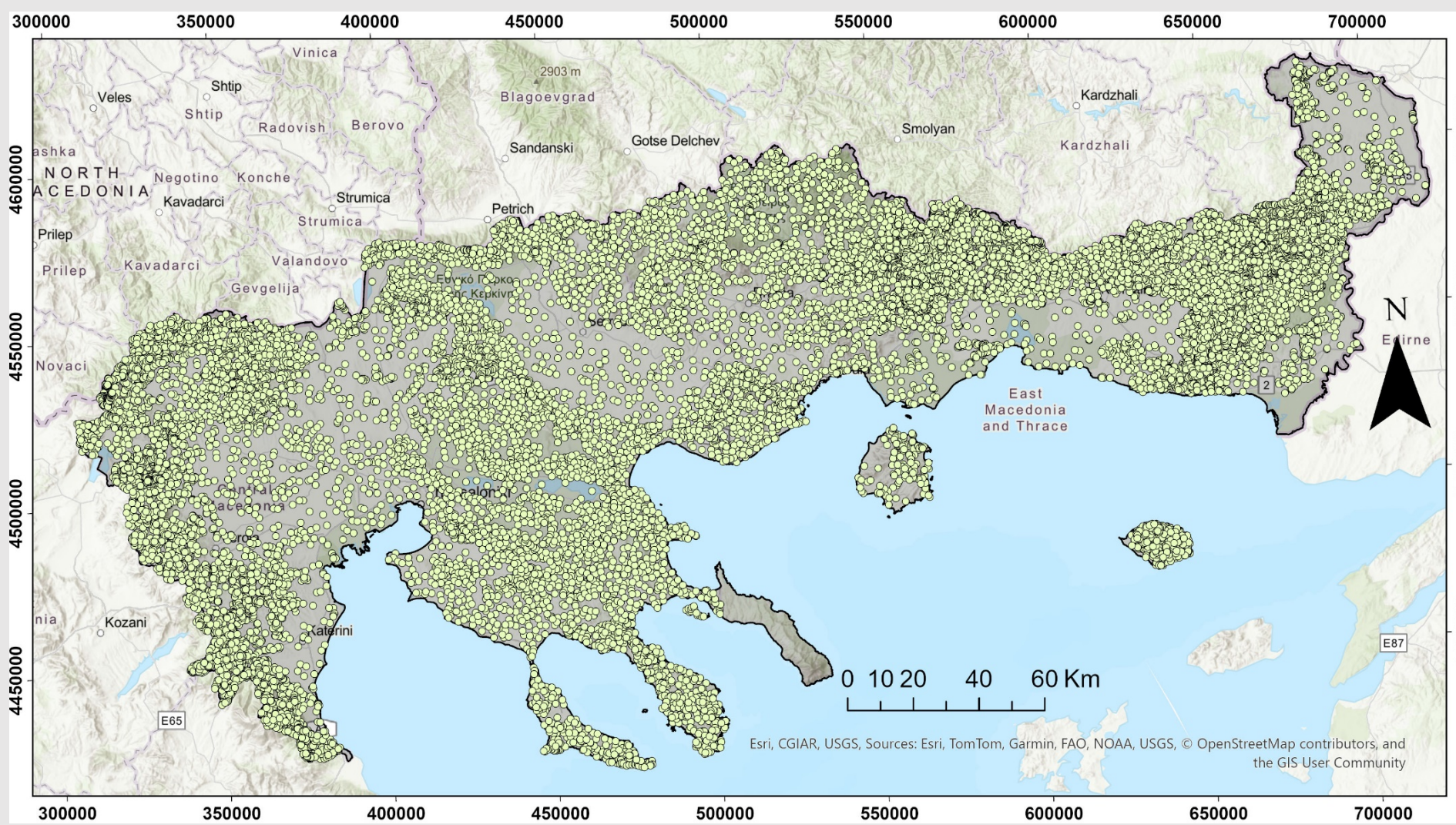


Fig. 1. The study area (33,000 km²) in Northern Greece with the reference dataset sample points superimposed

- Step 1**
Downloading and pre-processing of LC raster maps
- Step 2**
Harmonization of LC class typology
- Step 3**
Accuracy assessment against the reference dataset

- Random sampling validation was performed for the **year 2021** against an independent dataset consisting of **19588** point samples.
- Confusion matrices were generated for each product assessment and Overall Accuracy (OA), Producer’s Accuracy (PA), User’s Accuracy (UA) and F1-score metrics were computed.

Table 1. Original and harmonized land cover classes with the number of reference samples per class

ESA World Cover	ESRI Land Cover	CLC+	New Label	Samples
Tree Cover	Trees	Woody: Conifers, Broadleaved Trees	Tree Cover	11149
Shrubland Grassland/ Herbaceous Wetlands	Rangelands Flooded Vegetation	Low-Growing Woody Plants Permanent Herbaceous	Shrubs/Grass	5086
Croplands	Crops	Periodically Herbaceous	Crops	1638
Bare/Sparse Vegetation	Bare Ground	Non and Sparse- Vegetated	Bare/Sparse	973
Built-up Area	Built Area	Sealed	Built-up	675
Water Bodies	Water	Water	Water	67

CONCLUSIONS

- All maps achieved comparable, consistent overall accuracies, with CLC+ performing marginally better (74.75%).
- Discrepancies were observed in class-specific accuracies, especially in the heterogeneous semi-natural areas including grasslands, shrubs and sparse vegetation.
- The regional CLC+ product achieved the most balanced performance between omissions and commission errors in most classes.
- These new 10 m products are promising for various applications, however users should be aware of specific land cover biases but also of the spatial detail of each map.
- More assessments are required at national and regional level for investigating the consistency of fine resolution satellite LC products.

RESULTS AND DISCUSSION

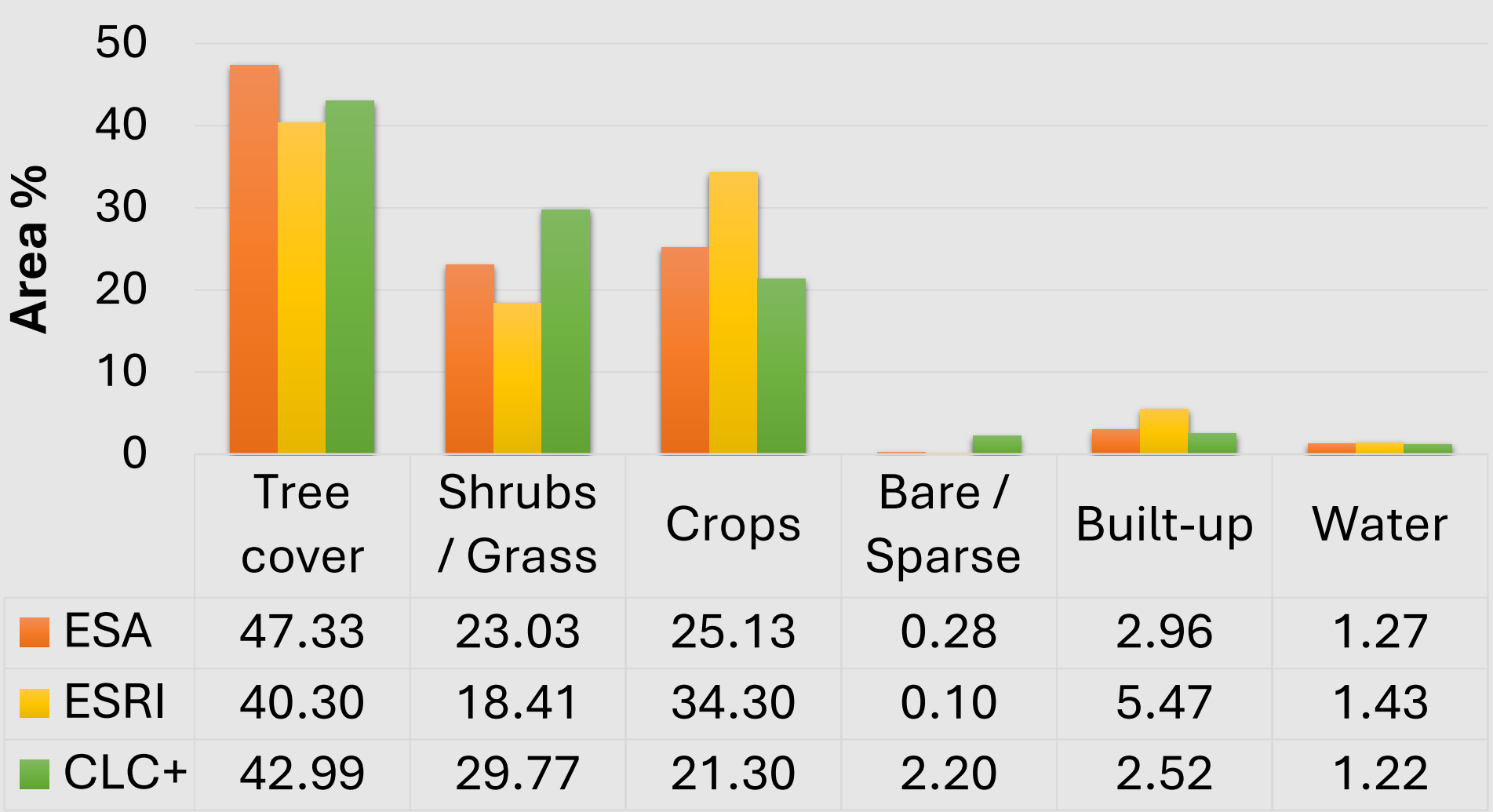


Fig. 2. Area percentage of the classes mapped by each LC product

Table 2. Accuracy results for the three LC maps. The highest scores are highlighted in bold

Class	ESRI LC			ESA WC			CLC+		
	PA (%)	UA (%)	F1 (%)	PA (%)	UA (%)	F1 (%)	PA (%)	UA (%)	F1 (%)
Tree cover	90.65	77.18	83.38	98.12	75.24	85.17	97.60	77.78	86.57
Shrubs/Grass	39.56	55.84	46.31	37.59	63.40	47.20	40.62	62.34	49.19
Crops	84.49	83.32	83.90	51.40	93.35	66.30	44.14	93.90	60.05
Bare/Sparse	13.17	88.89	22.94	22.40	86.51	35.59	48.30	59.42	53.29
Built-up	91.56	61.13	73.31	74.81	62.12	67.88	65.04	66.82	65.92
Water	91.04	84.72	87.77	94.03	94.03	94.03	95.52	96.97	96.24
OA (%)	73.92			73.06			74.75		

- Tree cover is mapped with high accuracies. Very high PAs are recorded across all products (90–98%). Crops were more accurately mapped by ESRI.
- A significant proportion of shrubs/grass lands was erroneously classified as trees by all products, while considerable confusion occurred with crops and sparse vegetation.

Table 3. Accuracy metrics estimated after considering shrublands and grasslands as separate classes

Class	ESA WC			CLC+		
	PA (%)	UA (%)	F1 (%)	PA (%)	UA (%)	F1 (%)
Shrubs	11.84	78.32	20.57	19.98	77.67	31.79
Grassland	85.11	27.11	41.12	87.50	29.92	44.60
OA (%)	70.00			72.00		

- Additional assessment was performed by discriminating grasslands from shrublands. For ESRI LC this was not possible since it does not distinguish between the two classes.
- Both (ESA and CLC+) products exhibit large omission errors for shrubs and large commission errors for grasslands (Table 3).

Acknowledgments

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