Empowering Accuracy Assessment Procedures for Global Land Cover Maps with Spatial Association Analysis

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Background & Objectives

The availability of **Global Land Cover** (GLC) products has increased over the last few years driven by the modern Earth Observation (EO) platforms capabilities (frequent pass | **high-resolution** | global coverage). However, the accuracy of GLC maps not always meets the users' requirements making the use of regional land cover maps often preferred. The **accuracy assessment** of GLC maps still represents a pivotal task in order to promote the use of **GLC map for local applications**.

- The study focuses on the validation of the GlobeLand30 (GL30) map at a regional scale by empowering traditional accuracy assessment procedures with spatial association statistics and error patterns mapping

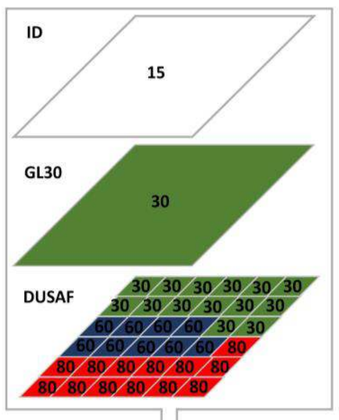
Case Study & Data Collection

The **Lombardy Region** (Northern Italy | ~ 23870 km²) is chosen as study area. The study makes use of the following datasets:

- **GL30**: the most frequently updated (2000, 2010, and 2015 announced) high-resolution (30m) GLC multiple-class map currently available, employed as target map for the accuracy assessment
- **DUSAF**: the official land cover (vector) maps of Lombardy Region at a scale 1:10000, employed as reference map for the classification accuracy

Location of Lombardy Region in Northern Italy

Data Processing



ID	GL30	DUSAF									
		10	20	30	40	50	60	70	80	90	100
15	30	0	0	14	0	0	9	0	13	0	0

ID	GL30	DUSAF									
		10	20	30	40	50	60	70	80	90	100
15	30	0%	0%	39%	0%	0%	25%	0%	36%	0%	0%

Schematic of the data overlay procedure to compute sub-pixel error on a sample target map pixel

The DUSAF vector map is rasterized using a 5m pixel to take into account the minimum mapping unit declared by the producer. The dataset is then harmonized with the GL30 in terms of classification legend, coordinate reference system and projection.

To enable the investigation of error spatial patterns, an overlay procedure for sub-pixel errors detection between the target and the reference map was designed and implemented by means of GRASS GIS. This allows preserving both the original resolution of the reference map and the spatial reference (ID) of the target map pixels, by producing a single table including pixel-wise disagreement counts (i.e. errors) for each map class.

The table is processed by means of the DASK Python library that provides support for multithreading computation allowing manipulation and analysis of larger-than-memory datasets - such as the errors table of the case study (> 10 GB) - on a standard desktop machine .

GL30 class code	Class
10	Cultivated Land
20	Forest
30	Grassland
40	Shrubland
50	Water bodies
60	Wetland
70	Tundra
80	Artificial surfaces
90	Bareland
100	Permanent snow and ice

GlobeLand30 classification legend

DASK GRASS GIS

Preliminary Results

1. Traditional Accuracy Assessment

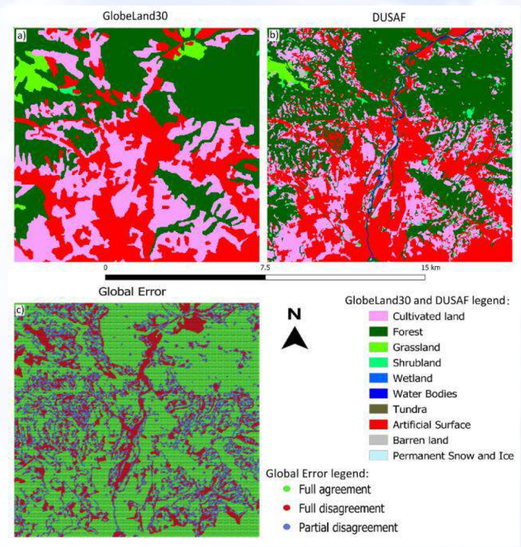
From the errors table, the confusion matrix is extracted. The computed Overall Accuracy of the GL30 map is 79% for the Lombardy Region. The agreement (diagonal values) of class 40 is the lowest, and that the highest confusion (extra-diagonal values) is between class 40 and class 20.

Class		GlobeLand30								
		10	20	30	40	50	60	80	90	100
DUSAF	10	90	11	1	20	35	9	30	1	0
	20	5	79	13	42	16	3	2	7	0
	30	1	3	51	13	4	0	1	7	0
	40	0	3	10	14	0	0	0	5	0
	50	0	0	0	0	35	1	0	0	0
	60	0	0	0	0	8	83	0	0	0
	80	3	2	0	2	1	2	66	0	0
	90	0	1	24	8	1	1	0	79	19
	100	0	0	0	0	0	0	0	0	81

Normalized confusion matrix [%]

2. Error Spatial Patterns Investigation

Maps are derived from the errors table to provide visual insight into the spatial patterns of global, inter-class, or intra-class errors. To quantify these patterns in terms of spatial association, the global Moran's I index is computed. The index computed for the global error map is 0.80 confirms the marked positive spatial association that can be also visually detected on the global error map. Additional tests on the error spatial patterns can be performed starting from the proposed errors table.



Example of global error pattern maps

Example of inter-class error pattern maps

E.g.: Focusing on the highest and the lowest confusions for class 40, i.e. class 20 and class 80, the resulting Moran's I for these inter-class errors is respectively 0.82 and 0.62 thus providing evidence of an underlying connection between errors from the confusion matrix and the spatial association characterizing their patterns.

Conclusions & Acknowledgements

The traditional accuracy assessment provides robust indicators to describe the global accuracy of land cover maps but no insights into the errors spatial distribution. The proposed errors table provides a comprehensive input dataset to detailed accuracy assessments facilitating both visual and statistical analysis of error spatial patterns, thus - in turn – potentially improving the GLC maps accuracy evaluation at a local or regional scale.

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