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Detection and identification of archaeological features using aerial LIDAR data in a forested environment (Châtillon-sur-Seine, Côte-d'Or, France).

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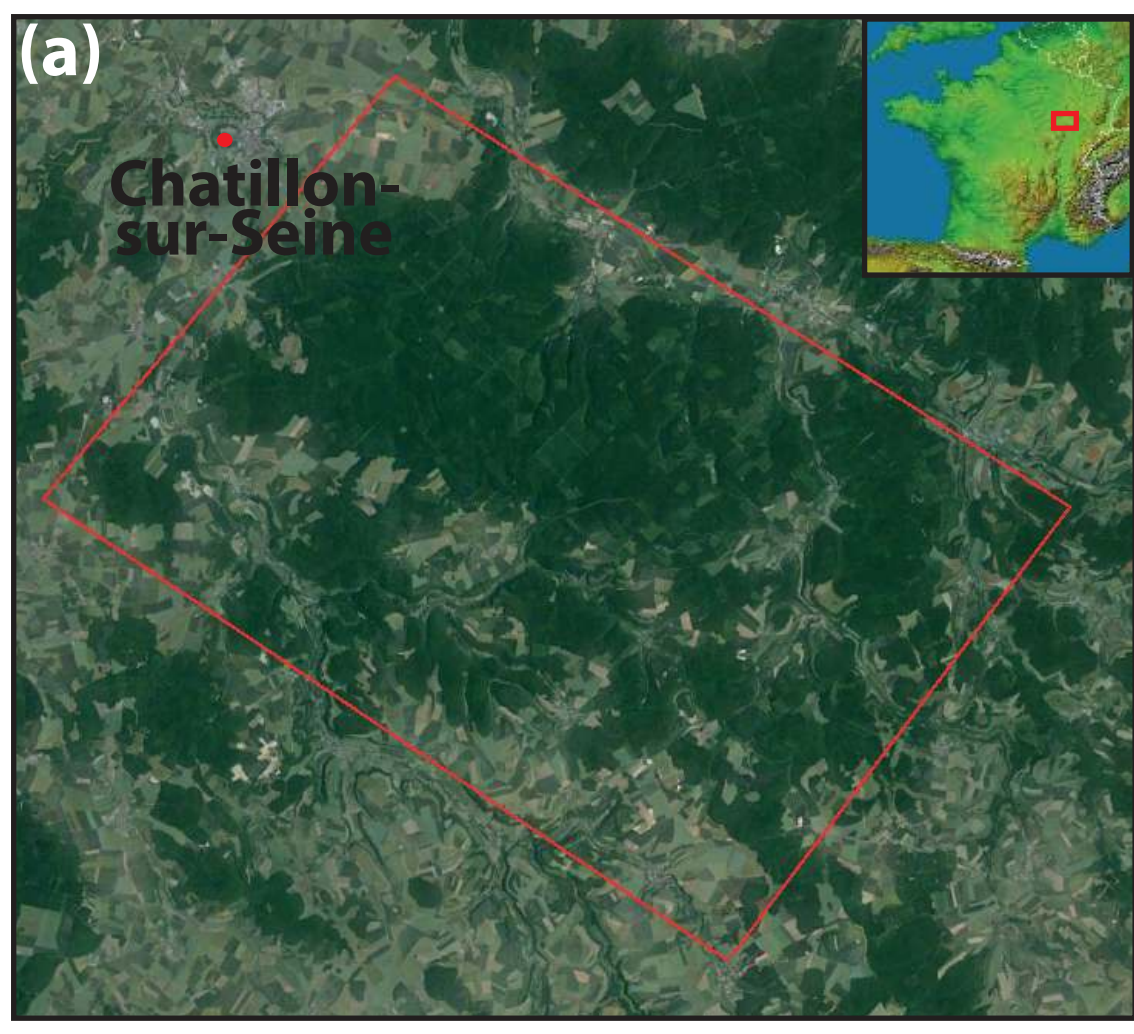
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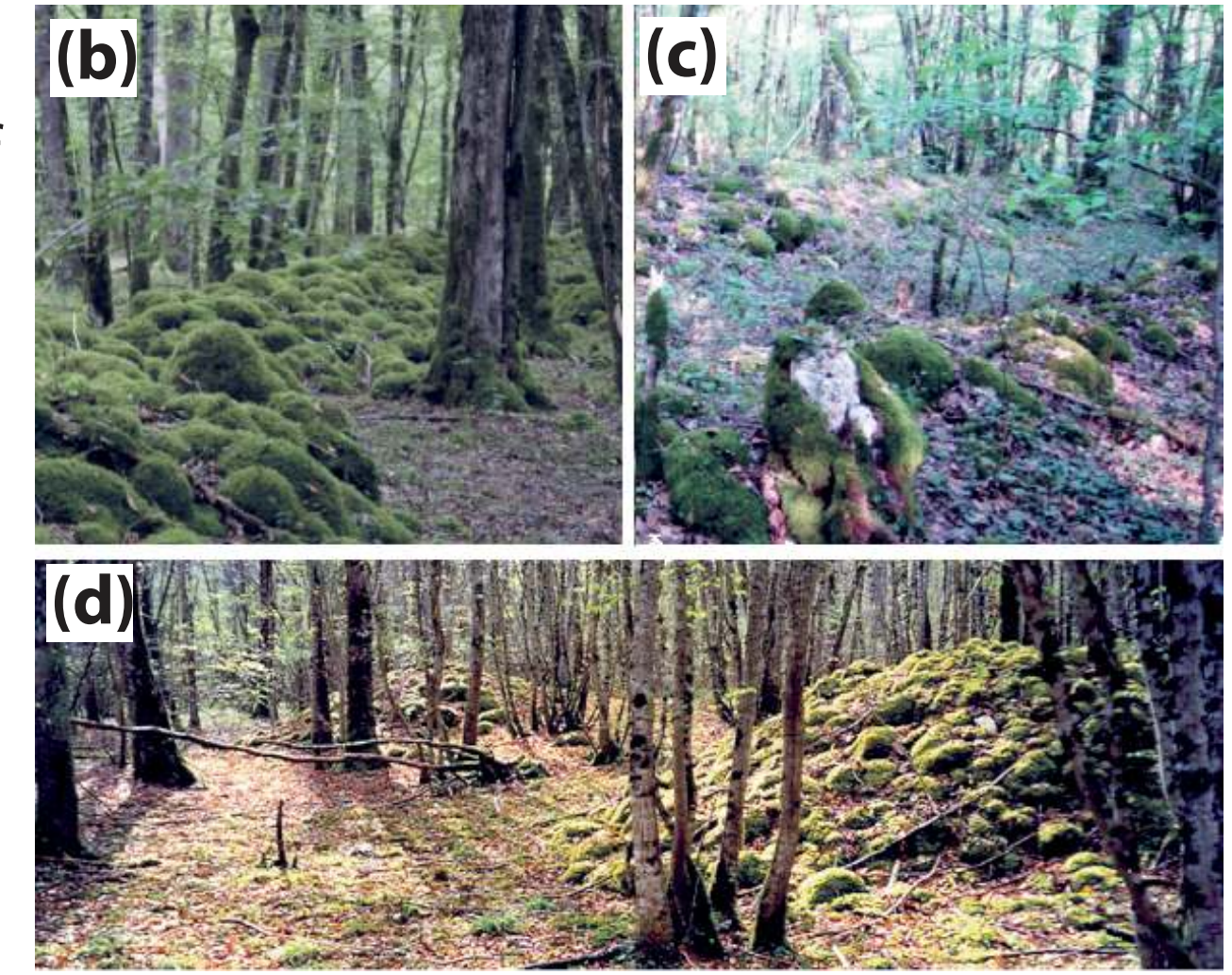
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The study area is located in the northern part of the Côte-d'Or (Burgundy, France) in the state forest of Châtillon-sur-Seine (a). The place is covered by sets of protohistoric to medieval dry-stone structures were GPS prospection investigations were performed during 10 years (Vix Program). To complement this prospection, LiDAR data were acquired by PNF (Parcs Nationaux de France) in 2012, on a 400 km² area.

The objective of this work is to identify feature types defined for GPS prospection from LiDAR data indices. To evaluate the recognition of feature type with LiDAR data, we used two indices calculated on the LiDAR DEM (50 cm resolution). The local slope map highlights morphological variations of each feature, leading to define feature type. As some features present the same appearance on slope map, the topographic positive openness was calculated to determine the negative or positive elevation of features. For openness index, we used 8 directions on a 20 pixels radius distance (10 m diameter).



GPS typology VS LiDAR data

	GPS Typology	Definition	2D representation	Local slope	Positive openness	Key factors of recognition
Linear forms	Murée (b)	Dry-stone wall; plot limits				low slope in centerline = top of the wall; medium slope with the same footprint around centerline = two sides of the wall
	Murée sur épaulement	Dry-stone wall located on a naturel or anthropogenic embankment; plot limits				low slope in centerline = top of the wall; medium slope with wide footprint = embankment and wall side; medium slope with small footprint = wall side
	Epaulement	Naturel or anthropogenic embankment; plot limits				medium slope with wide footprint = embankment
	Fossé	Ditch; plot limits				low slope in centerline = ditch bottom ; medium slope with the same footprint around centerline = two sides of the ditch
	Chemin/Voie (c)	Path/Roman road; communication road				low slope in center area (3 to 10 m width) = path/road footprint; two parallel lines with medium slope around center area = two edges of the path or two dry-stone walls
Point forms	Tertre (d)	Dry-stone mound; sree or plot limit (aligned) or tumulus				Circular to ovoid forms (rarely quadrangular); low slope in center = top of the mound, medium slope surrounding center = mound sides
	Excavation (minière ou lavière)	Excavation; mining or quarry				Circular form; low slope in center = bottom of the excavation , medium slope surrounding center = excavation sides
	Place à feux	Charcoal burning, charcoal place production				Circular form; low slope in center area = fire place, two medium slope surrounding center area with crescent shaped = one is dug border and the other is backfilled border
Surface forms	Tertre surfacique	Surficial dry-stone mound, more than 10 m diameter; probably tumulus				Circular to ovoid forms higher than 10 m diameter; low to medium slope in center = top of the mound, medium to high slope surrounding center = mound sides
	Four à chaux	Lime kiln; lime place production				Circular form higher than 10 m diameter; high slope in the center = excavation ; low slope around center = top of the mound ; medium slope outside = side of the mound ; access area to center feature
	Carrière	Quarry, place of stone extraction				No particular form; high slope with small footprint = quarry face , low slope = extracted area

Application and validation

This method was applied on a 2,5 km² area, where:

- 106 line, 192 point and 12 surface features were recorded by GPS
- 164 line, 398 point and surface features were recorded by LiDAR

Feature types recognized by LiDAR were compared to GPS records.

- **70 %** of **linear** features observed with LiDAR were great classified
 - => 1 % forgotten
 - => 5 % misclassified «Murée <=> Epaulement»
 - => 10 % misclassified «Epaulement <=> Murée sur épaulement»
 - => 14 % misclassified «Murée <=> Murée sur épaulement»

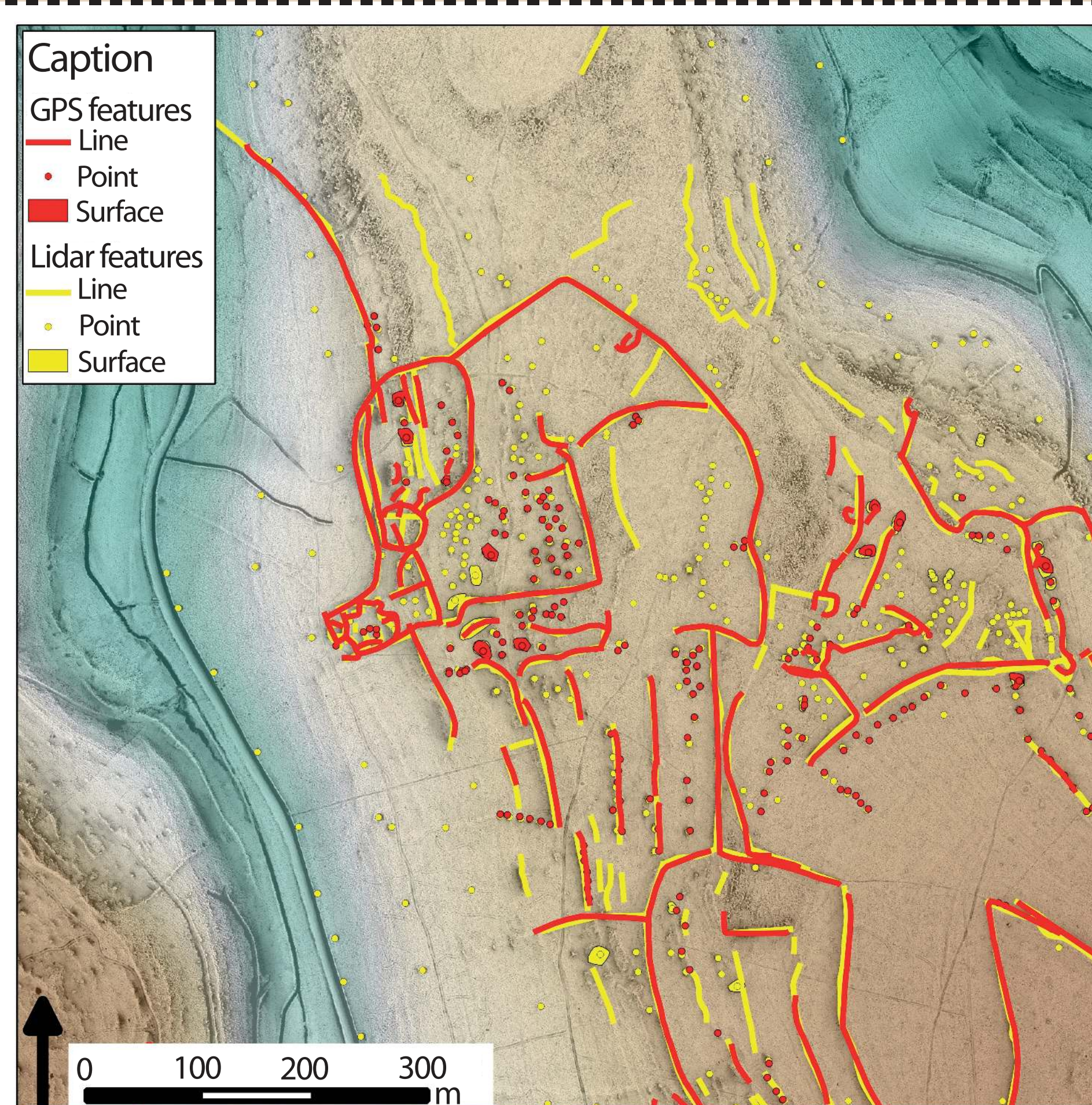
- **81 %** of **point** features from LiDAR were great classified
 - => 5 % forgotten
 - => 5 % not visible
 - => 3 % double GPS acquisition on the field
 - => 6 % misclassified (elongated mound were classified as small embankment)

- **84 %** of **surface** features from LiDAR were great classified
 - => 8 % classified as multi features
 - => 8 % misclassified with GPS (lower than 10 m diameter)

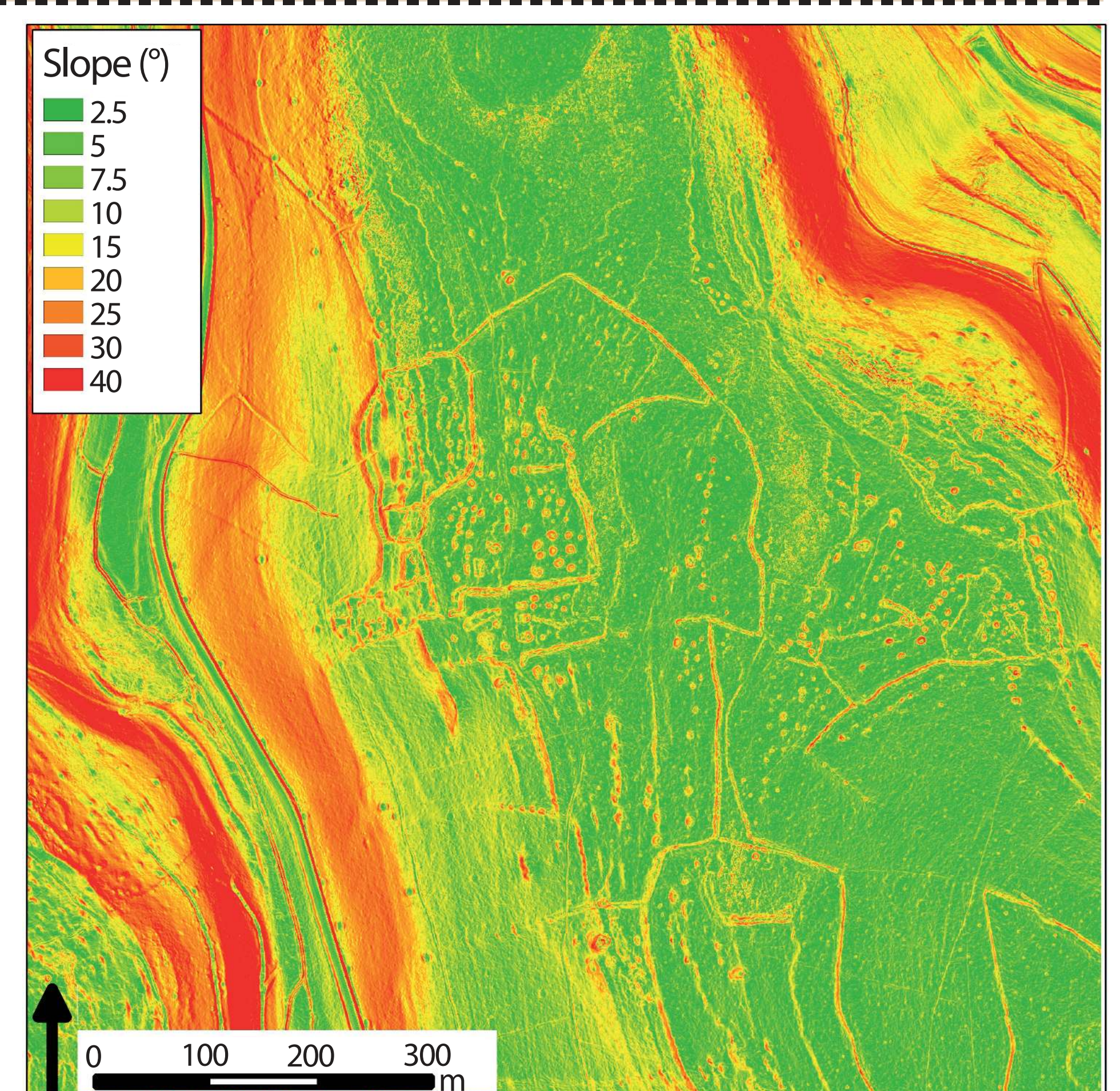
To evaluate GPS and LiDAR classification availability, 2D cross-sections were performed on the LiDAR DEM for all misclassification areas. The results show that LiDAR data recognition is conform to 2D topographical profil.

The misclassification of features observed on GPS data may be due to:

- a bad estimation of low topographical variations on the field
- a «continuous» record on the field, which do not take into account all morphological changes (observable on LiDAR) on a linear structure



Archaeological features recorded from GPS (red) and LiDAR data (yellow) (GPS data, ENVIX BD, 2012)



Slope map highlighting different types of archaeological features

Discussion

This work shows that local variations of slope values combined with topographic positive openness facilitate the detection of new structures and their assignments to one of the typology defined by the GPS prospection. The high altimetric resolution of LiDAR data allows to observed low topographical changes, with decimetric variations. However, the location of these features is not easy to be assessed, and the determination of feature types is almost impossible. Therefore, a return to the field is needed to validate the assumptions from LiDAR data.