USING AERIAL IMAGE ANALYSIS AS A TOOL FOR TOPSOIL, SOIL AND SUBSTRATE MAPPING IN VINEYARDS (BURGUNDY, FRANCE)

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L' ANALYSE D'IMAGES : UN OUTIL DE CARTOGRAPHIE DE L'ETAT DE SURFACE DU SOL, DU SOL ET DU SOUS-SOL EN CONTEXTE VITICOLE (BOURGOGNE, FRANCE)

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Introduction

The Burgundy vineyards display a high diversity of terroirs, resulting from complex interactions between natural and anthropogenic factors. Combination of all these factors defines wine typicity. Studying vineyard soils leads to a better understanding of the diversity of terroirs. This work aims at improving our understanding of terroir from the mapping of soil surface characteristics. We attempted to combine Very High Spatial Resolution (VHSR) images analysis permitting soil surface heterogeneities identification at a centimetre spatial scale [1, 2] and local soil sampling. For each soil surface class (SSC) mapped at the hillslope scale, several auger holes were performed, allowing soil type identification. These surface soil characterizations were combined with Electrical Resistivity Tomography (ERT) surveys to delineate the geological substrates distribution on the hillslope.

Methods

1 Geological substrate investigation

Electrical Resistivity Tomography (ERT) was used to obtain images of subsurface from substrate electrical resistivity measurement. This method highlights changes in lithology and may indicate a fault occurrence [4].

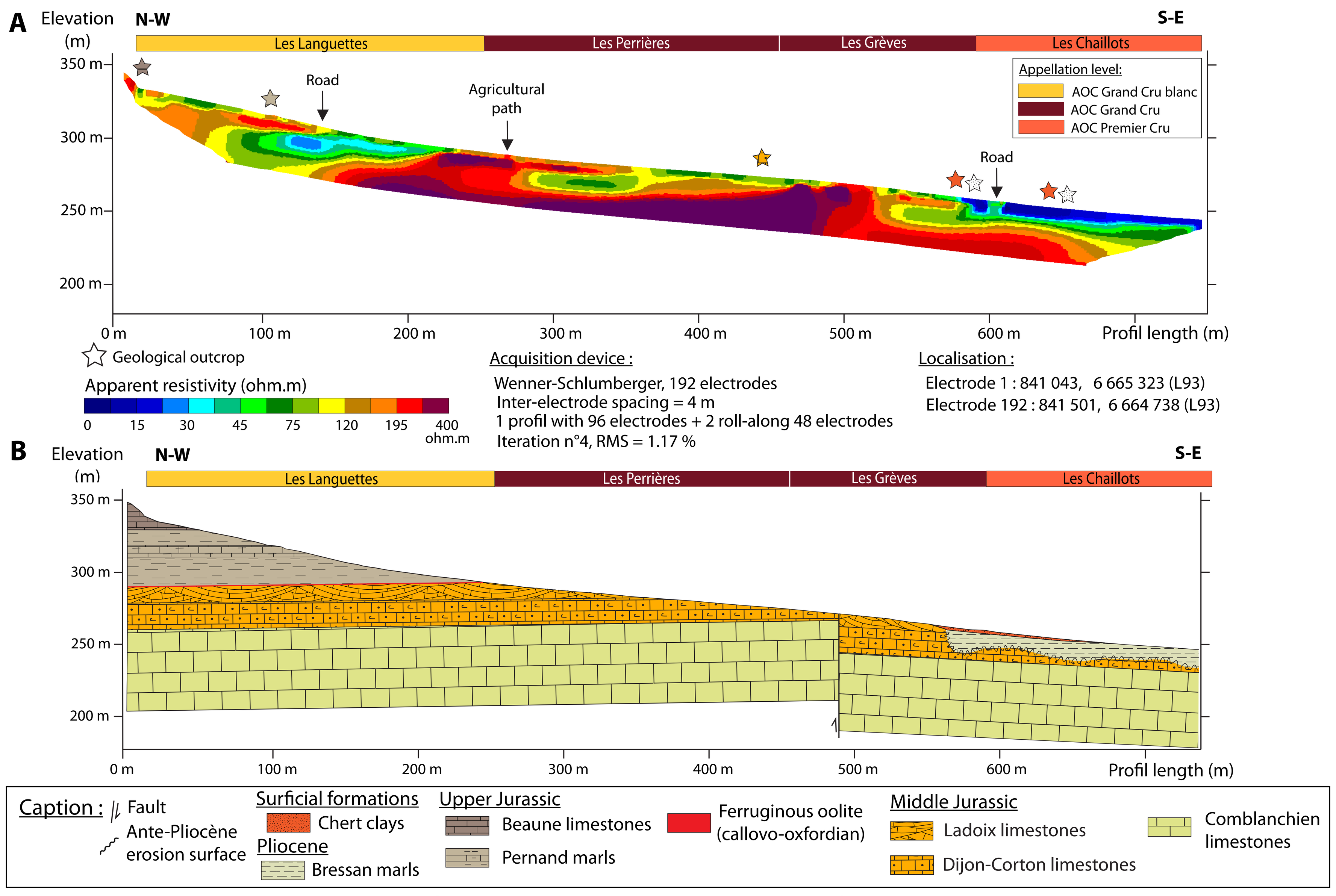
2 Topsoil characterisation and soil typology

Topsoil sampling (surface of 0.25 m^2 on a 10 cm depth) and **auger holes** (dug near topsoil samples) were performed according to image analysis results to characterise SSC and determine soil typology.
On these samples, **physical** (stoniness, grain size distribution, matrix colour) and **chemical** (total calcium carbonate, organic carbon, nitrogen and free iron contents) **parameters** were analyzed in laboratory.
All data were integrated into a **GIS** to evaluate **links** between **imagery** and **topsoil/soil parameters**.

3 Imagery

VHSR images acquisition using an unmanned helicopter DRELIO [3] equipped with a digital camera (Nikon D700) allowing a **centimetric spatial resolution** in the visible domain.
After **image pretreatments** (mosaicking, masking, and georefrencing), **image analysis** (Unsupervised classification «ISODATA») were performed to classify and map SSCs according to reflectance values.

Results - Geological substrate investigation

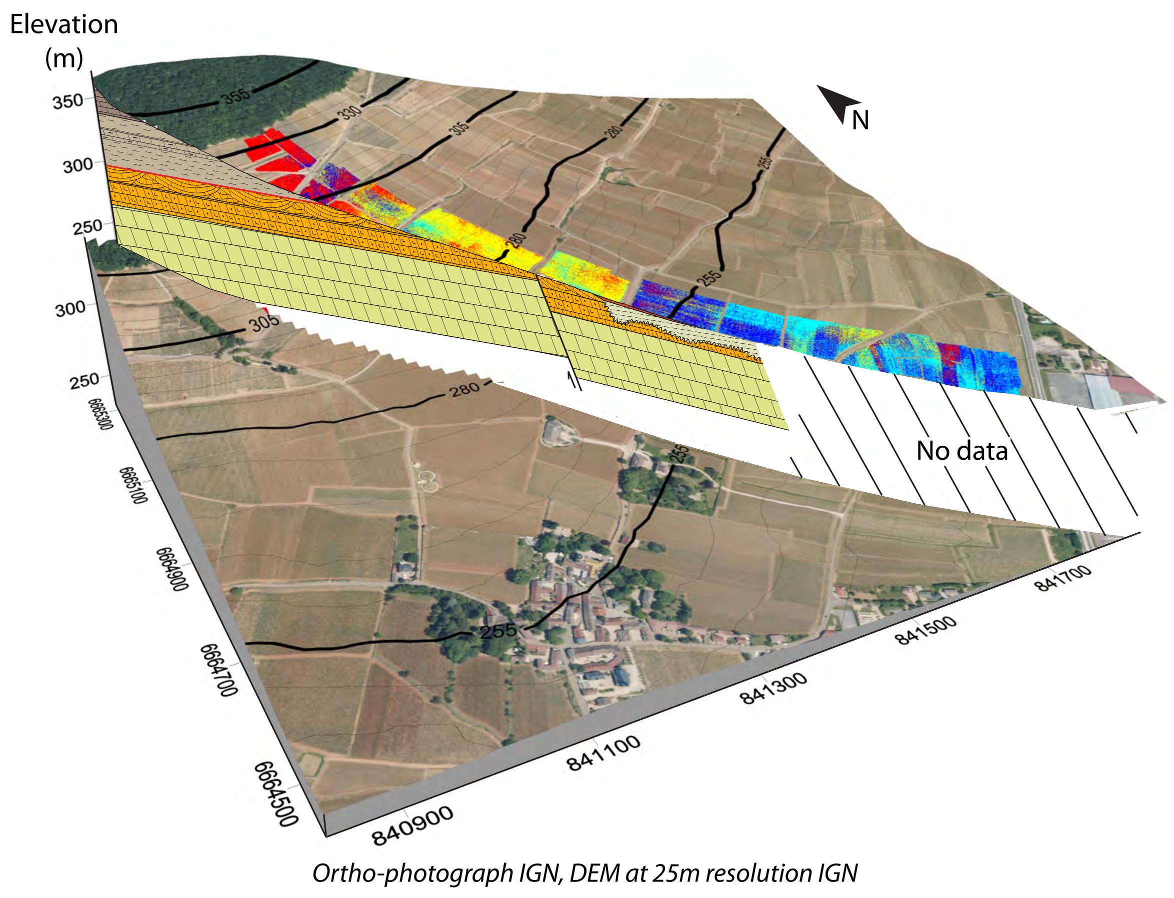


Electrical apparent resistivity profile and geological interpretation performed on the Aloxe-Corton hillslope
Profil de résistivité apparente et coupe géologique interprétative réalisés sur le versant d'Aloxe-Corton

Apparent resistivity profile highlights variations of lithology along the hillslope:
- marly-limestone alternations from Upper jurassic upslope
- hard limestones from Upper and Middle Jurassic at mid slope
- chert clays spreading and tertiary marls downslope

=> **lithology varies according topography**

Discussion



3D representation of Aloxe-Corton hillslope combining topographical, geological data and SSC map
Bloc 3D du versant d'Aloxe-Corton combinant les données topographiques, géologiques et la cartes des états de surface.

Combination of the different datasets shows that:

- **lithological variations** controlled **topographical profile**, Upper Jurassic marls are on steep slope area, limestones are on moderate slope, and tertiary marls are on gentle slope area

- limits between **SSCs** were **progressives** (SSC1/SSC2) when controlled by lithological variations, or **sharp** (SSC2/SSC3 & SSC3/SSC4) when controlled by anthropogenic features (road) or agricultural management practices

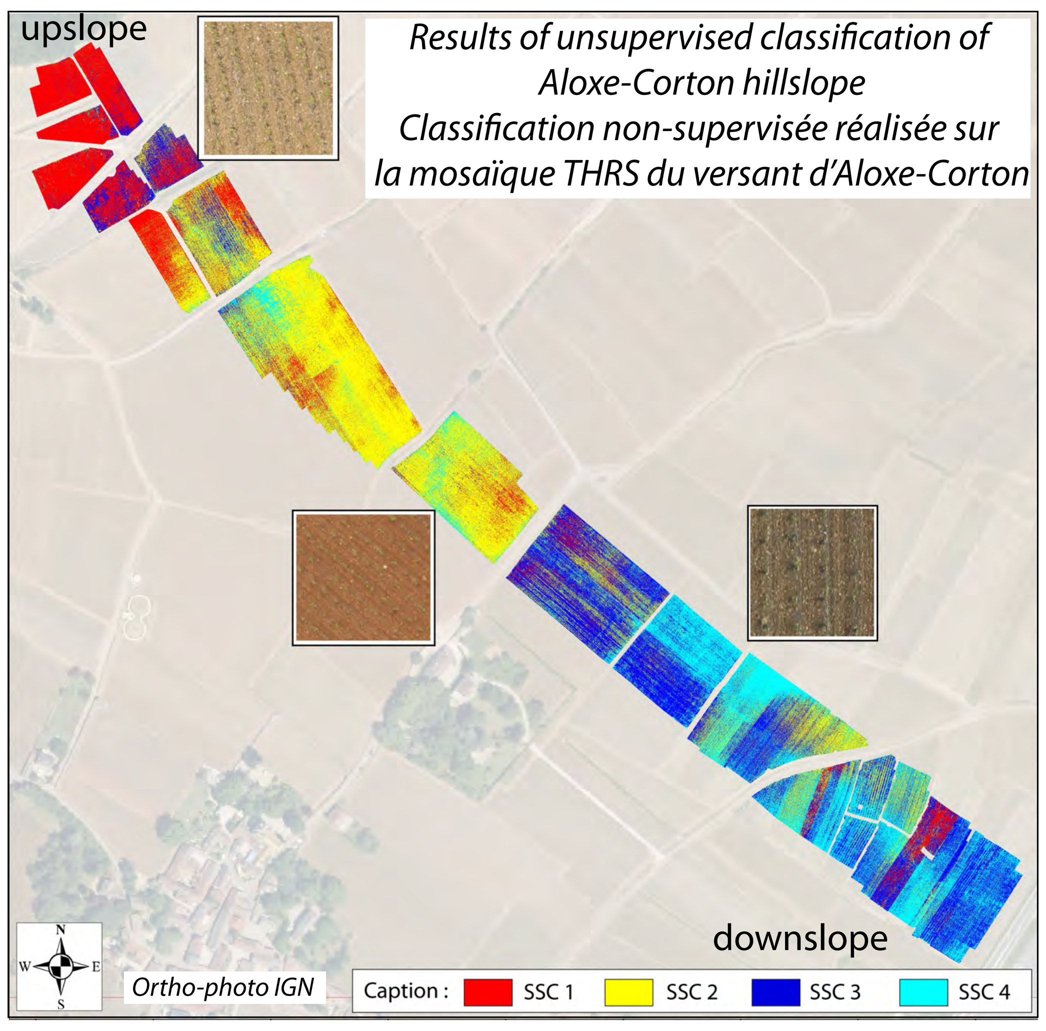
- changes of topsoil classes and soil type are correlated to **lithological variations** according to the model of "topolithoséquence" proposed by Mériaux [5]

Results - Topsoil and soil mapping

➤ Topsoil mapping

Unsupervised classification shows that:

- 4 topsoil classes (SSC) are identified
- SSC spatial distribution evolves from upslope to downslope
- SSC1 and SSC2 are controlled by topography
- SSC3 and SSC4 highlight the use of several agricultural management practices in the downslope



Results of unsupervised classification of Aloxe-Corton hillslope
Classification non-supervisée réalisée sur la mosaïque THRS du versant d'Aloxe-Corton

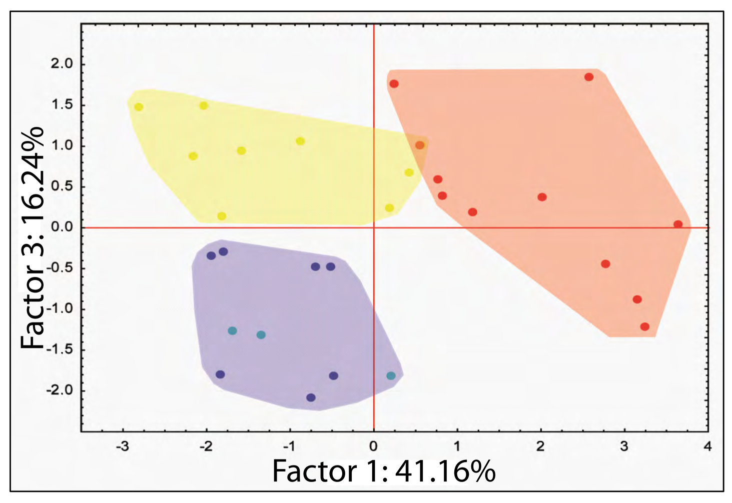
PCA performed on topsoil physicochemical parameters shows that:

- 3 groups were identified
- classes recognized by imagery presented their own physicochemical parameters
- SSC3 and SSC4 belong to the same group

	Number of samples	Gravel ø > 2cm	Fine gravel 2 cm to 2mm	Texture	Colour			
					L	a	b	Munsell
SSC1	5	15 (4)	19 (5)	Silty clay	53 (3)	11 (2)	26 (3)	Brown
SSC2	6	18 (3)	11 (2)	Clay	46 (5)	15 (2)	30 (2)	Reddish-brown
SSC3	4	23 (12)	8 (5)	Silty clay	45 (2)	11 (2)	27 (2)	Strong brown
SSC4	3	22 (5)	5 (3)	Silty clay	45 (3)	9 (0)	26 (1)	Strong brown

	$CaCO_3$ (%)	C org (%)	N (%)	C/N	pH	Free iron (%)
SSC1	35 (8)	2.5 (0.6)	0.12 (0.03)	22 (4)	8.1 (0.1)	1.5 (0.1)
SSC2	10 (7)	1.9 (0.4)	0.10 (0.02)	18 (2)	8.0 (0.1)	3.5 (0.8)
SSC3	1 (0)	1.7 (0.3)	0.12 (0.01)	15 (1)	7.9 (0.2)	2.3 (0.3)
SSC4	0 (0)	1.6 (0.2)	0.11 (0.01)	15 (1)	7.7 (0.1)	2.2 (0.2)

Physicochemical parameters of SSCs
Paramètres physico-chimiques des états de surface



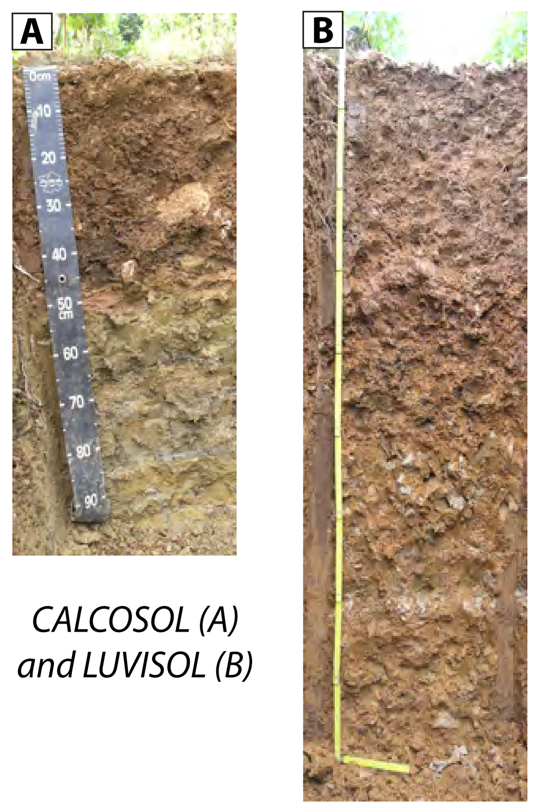
PCA performed on SSC physicochemical parameters
ACP réalisée sur l'ensemble des paramètres physico-chimiques des états de surface

=> **topsoil surface evolves from upslope to downslope**
=> **in downslope part topsoil surface distribution seems to be complex, it highlights the use of several agricultural management practices**

➤ Soil typology and distribution

According to topsoil map, several auger holes performed for each topsoil class show that:

- **SSC1** was characterised by brown silty clay CALCOSOL with variable depth (50-150 cm) developped on marly-limestone formation (5 auger holes)
- **SSC2** was characterised by reddish-brown clayey deep CALCOSOL developped on hard limestone (3 auger holes)
- **SSC3** and **SSC4** occurred indiscriminately on two soil types
- the upper part of SSC 3-4 area, was characterised very deep silty clay LUVISOL (>160 cm) developped on chert clays formation (3 auger holes)
- the downslope part of SSC 3-4 area, was characterised by very deep silty-clay CALCOSOL developped on tertiary marls (2 auger holes)
- However, these two SSCs differed by agricultural practices



CALCOSOL (A) and LUVISOL (B)

=> **topsoil surface can inform on soil typology**
=> **for colluviums areas or for area presenting high agricultural management practices diversity, it is difficult to linked SSC with soil type**

Conclusion and perspectives

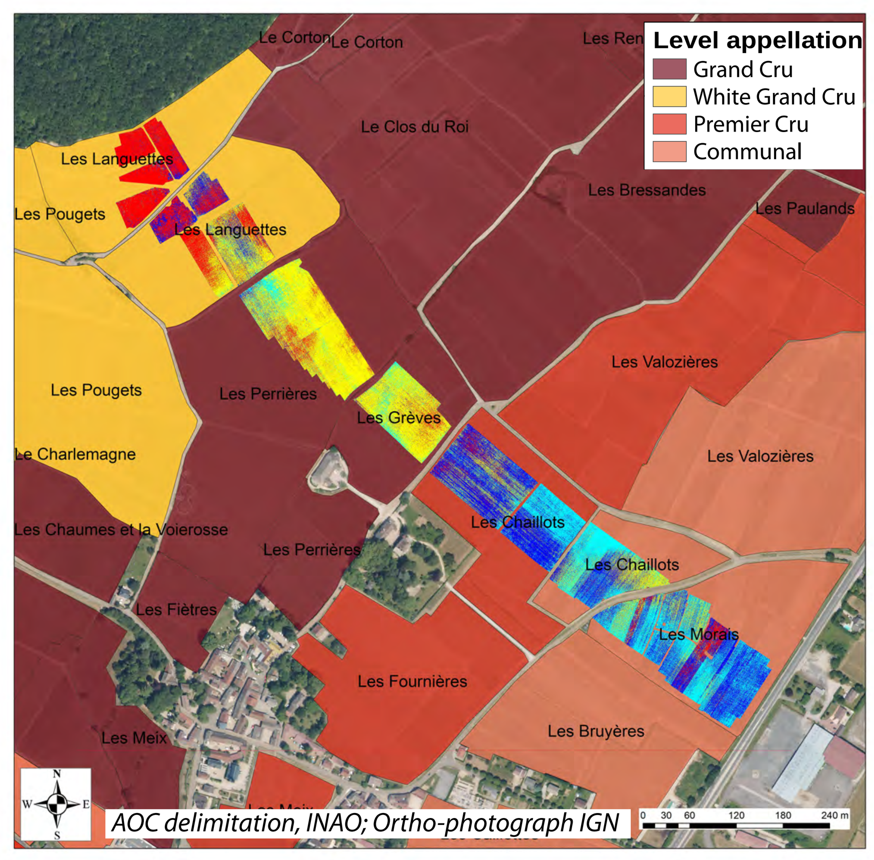
VHSR aerial images processing allow to establish a precise mapping of topsoil spatial distribution

SSCs can inform on soil type and lithology when not hidden by agricultural management practices

Soil diversity plays an important role on terroir, on Aloxe-Corton hillslope, changes of soil type are correlated to changes of level appellation

To improve soil and lithology identification, it would be interesting to mask plots with agricultural practices which hinder topsoil detection.

Moreover, using other proxies with higher spectral resolution (VISNIR, thermical infrared) would allow better discriminate of topsoil classes.



SSC map draped on the AOC delimitaion
Carte des états de surface drapée sur les limites AOC

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