Contribution of Fenix high-resolution hyperspectral airborne images to the socio-morphological characterisation of Toulouse

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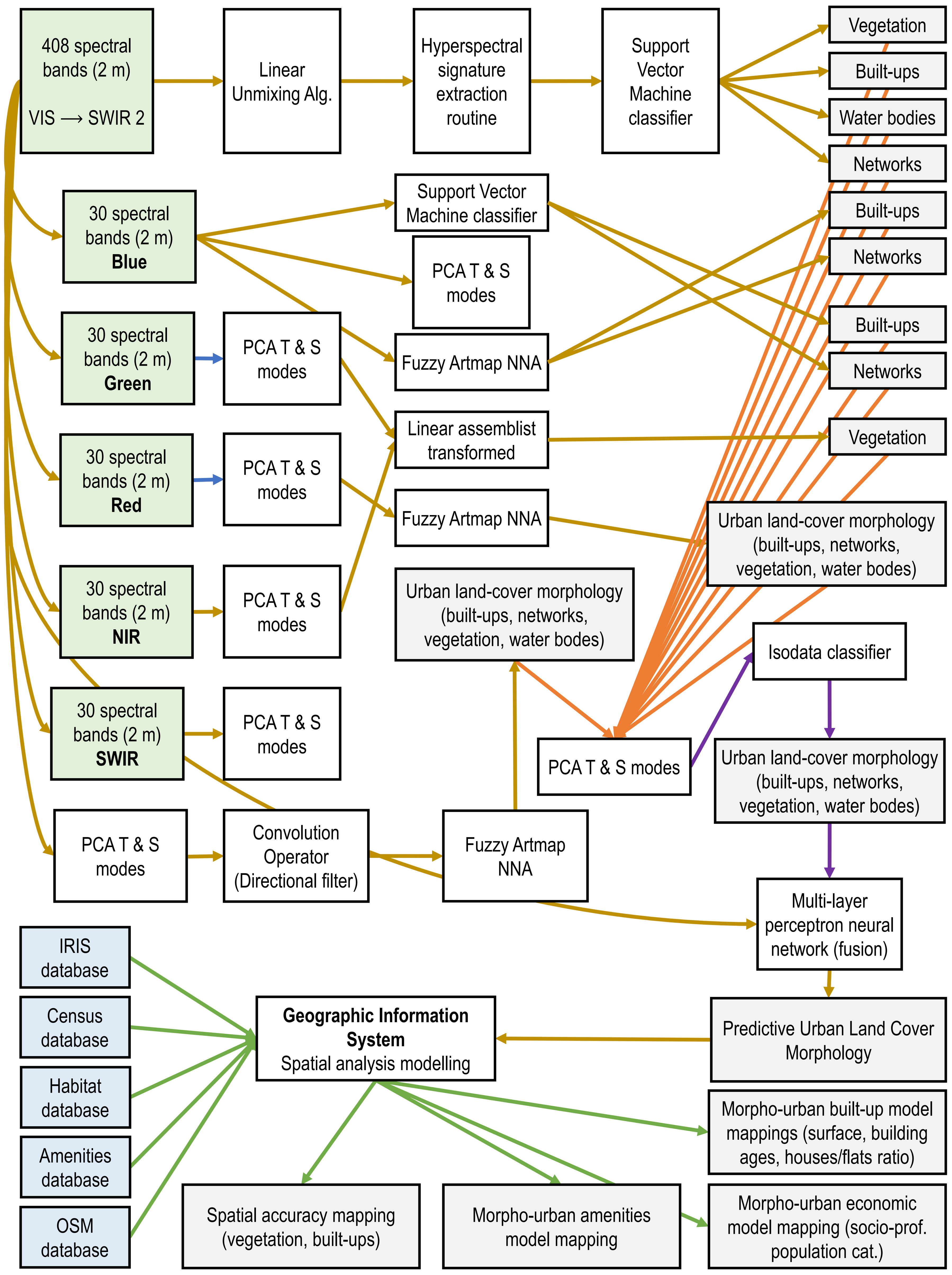
INTRODUCTION

In this presentation, the contributions of high metric resolution hyperspectral images from the FENIX sensor (2 m) from the CAMCATT airborne campaign (ONERA) covered in June 2021 in Toulouse will be presented to characterise urban generate morpho-social pattern indicators. These indicators are essential in urban planning to understand the relationships between urban forms, functions, populations, and uses. The construction of this type of morpho-social (and morpho-economic) indicators is usually made by integrating socio-economic and demographic databases with high resolution remote sensing images. Hyperspectral images make a significant contribution compared with multispectral images, thanks to their ability to discriminate between urban geographical objects: soils, vegetation, types of materials, etc.

METHODOLOGY



The methodological approach, which was exploratory and involved testing several approaches, focused on the individual identification of urban components (spectral analysis and machine learning extraction) and urban structures/forms: morphologies and deep learning object recognition, data classification and urban-object data fusion.

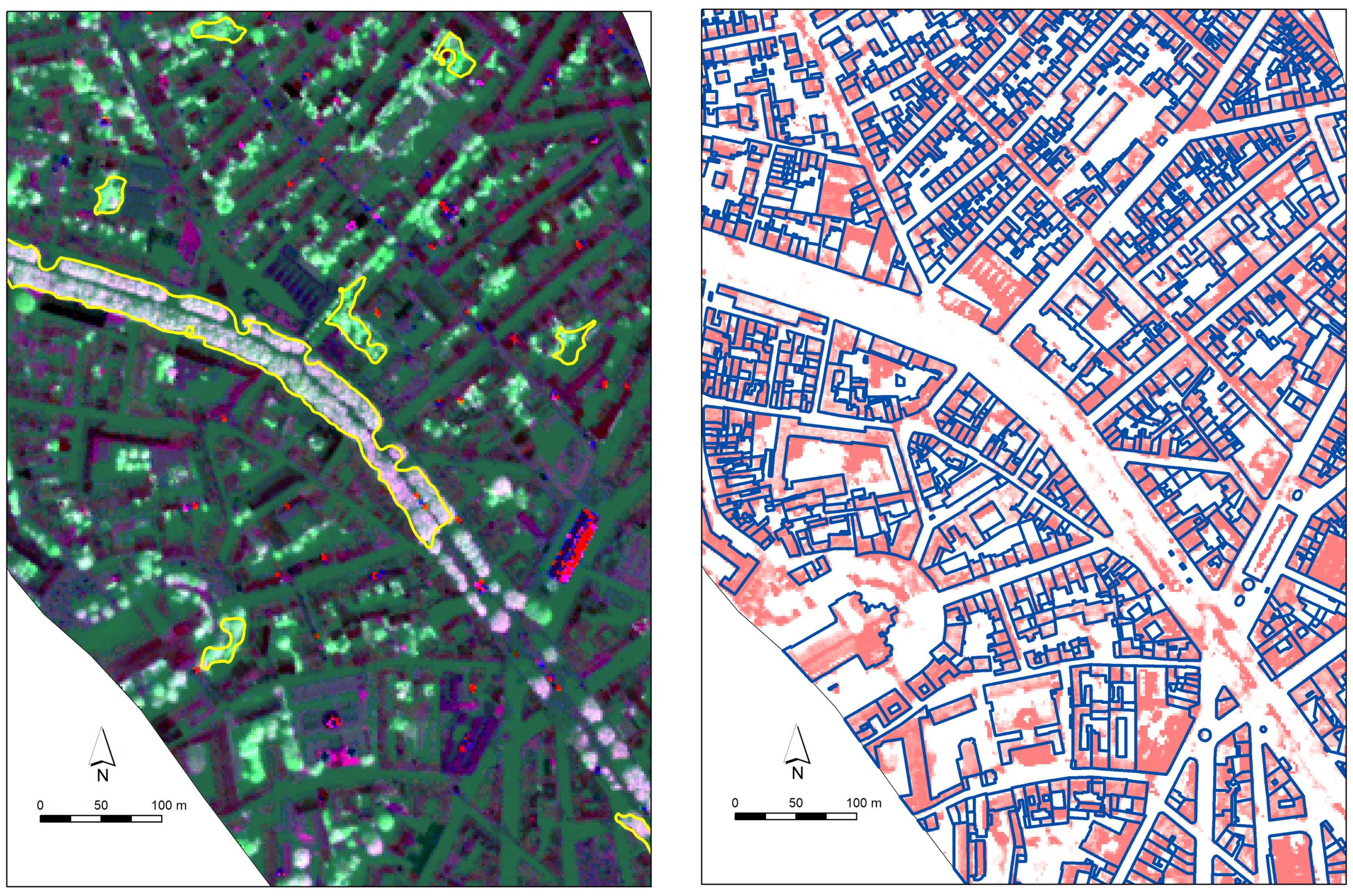


Fig. 1 – Overall accuracy of urban land cover mapping with vegetation (left) and built-ups (right) objects.
The level of mapping accuracy is better than that of reference data such as Street Tree Layer (yellow linear) for vegetation or Open Street Map (blue linear) for built-ups.

RESULTS

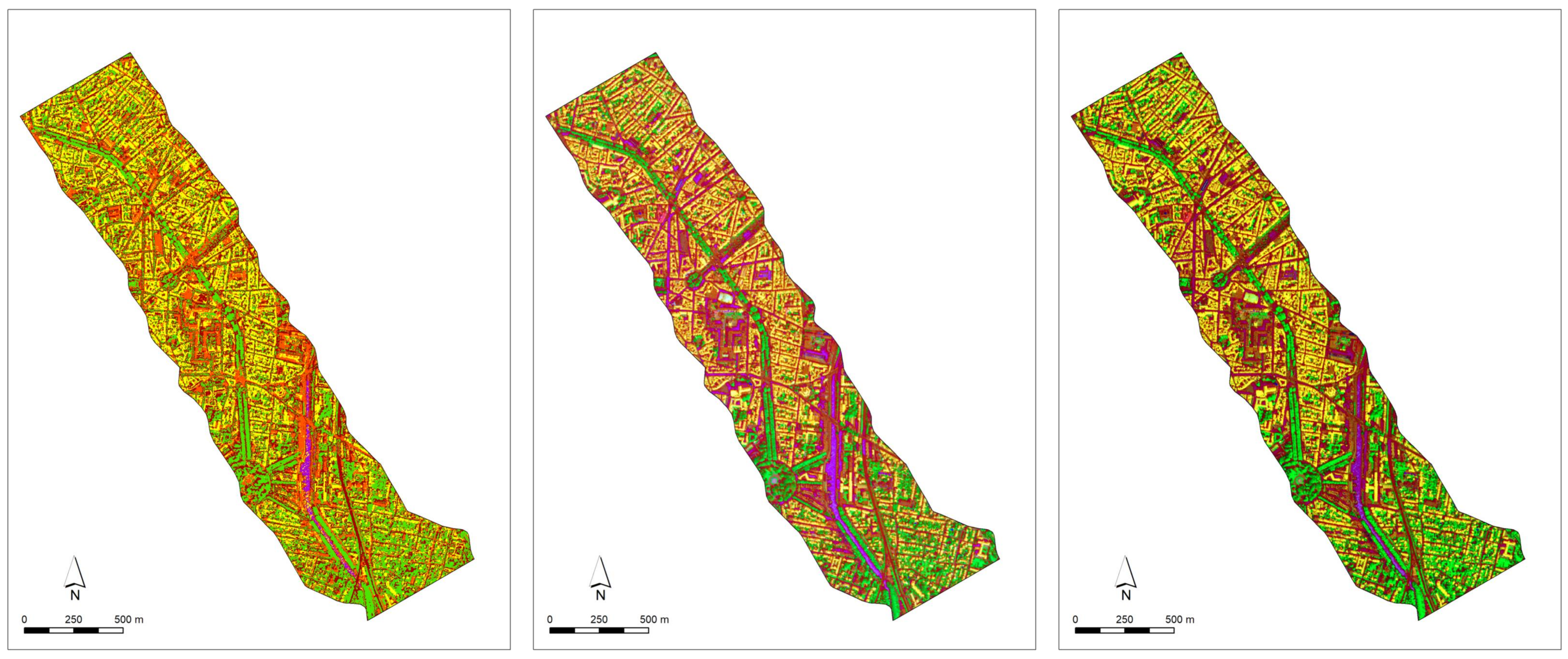


Fig. 2 – Urban Land Cover Morphology of Toulouse
Results of processing with the predictive deep-learning model using the Multi-Layer Perceptron algorithm (left) and principal component analyses in T-mode (centre) and S-mode eigenvector (right).

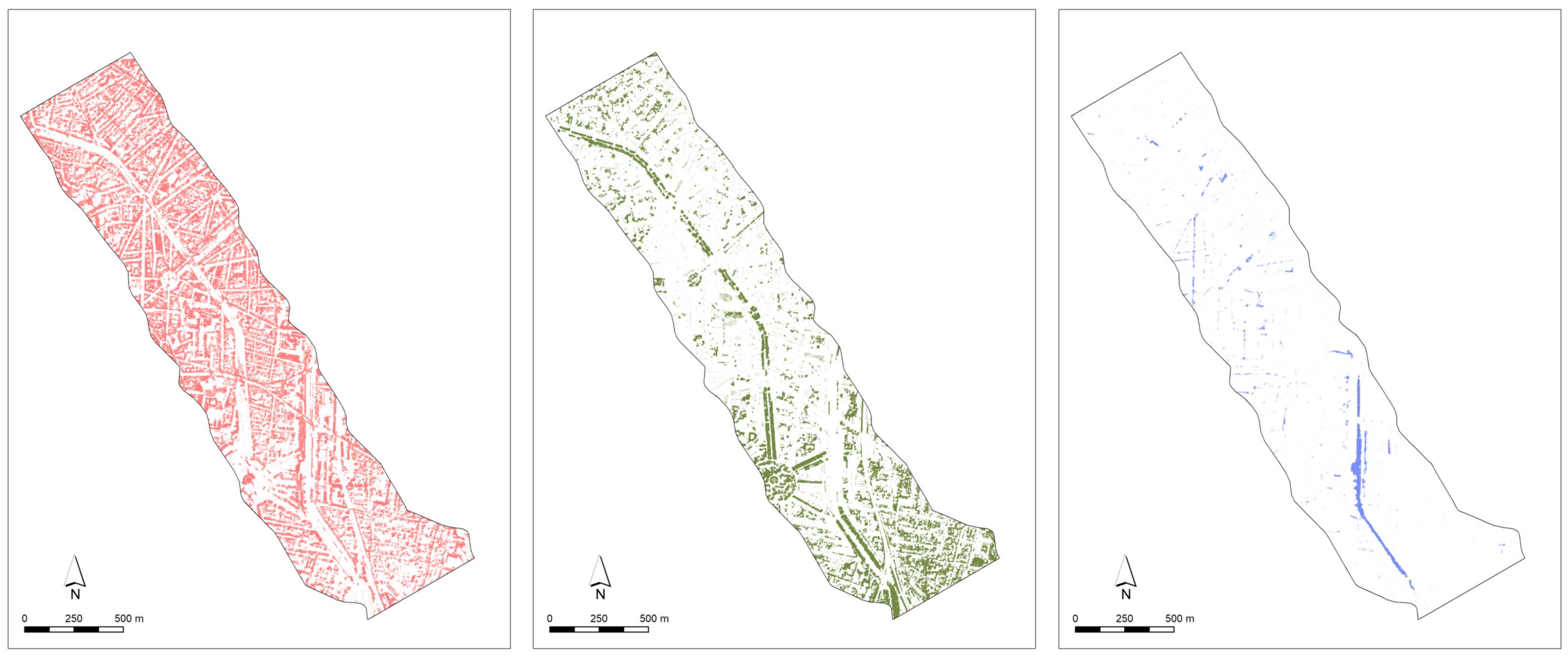
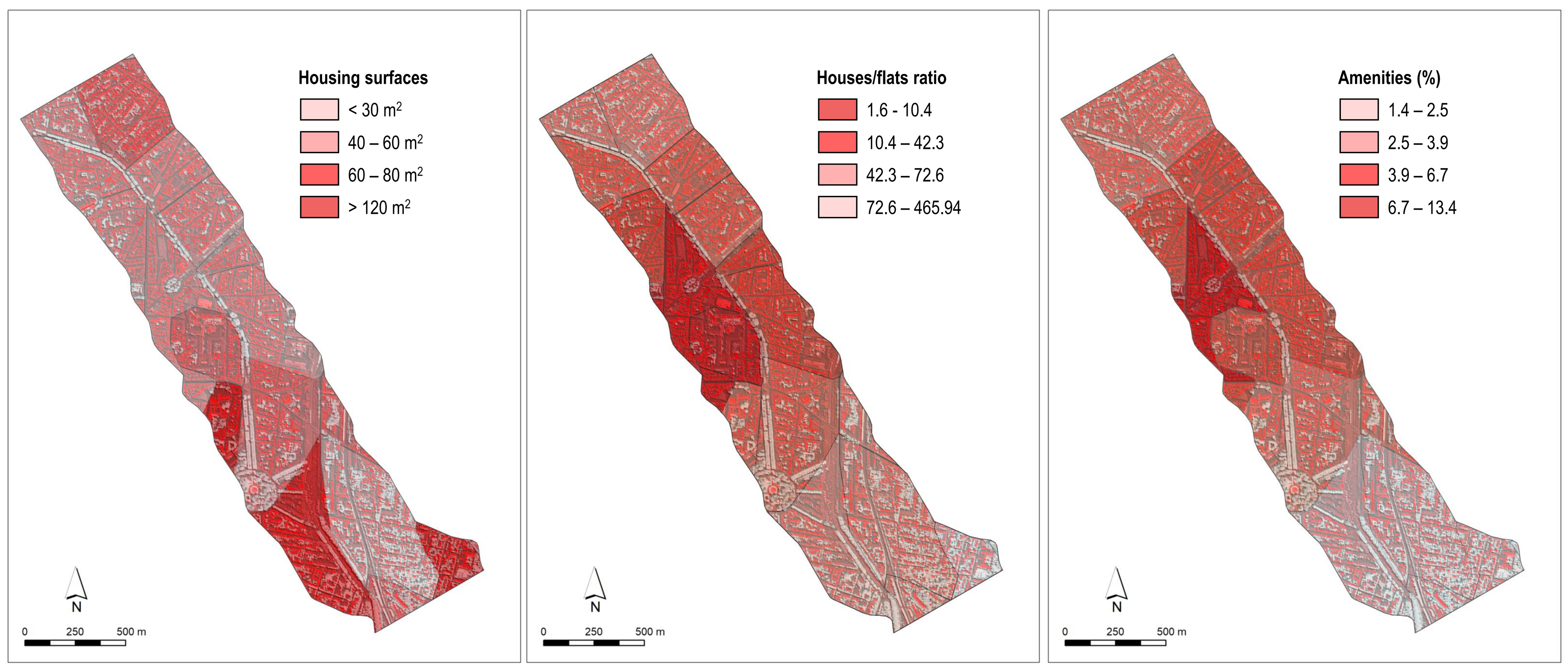


Fig. 3 – Extraction of geographic objects in dense urban environments
Identification of the built-up structure (left), water surfaces and humidity (right) using a Support Vector Machine classifier, and vegetation (centre) using a Linear Assemblist Transformed into Principal Component Analyses of the green and infrared bands.



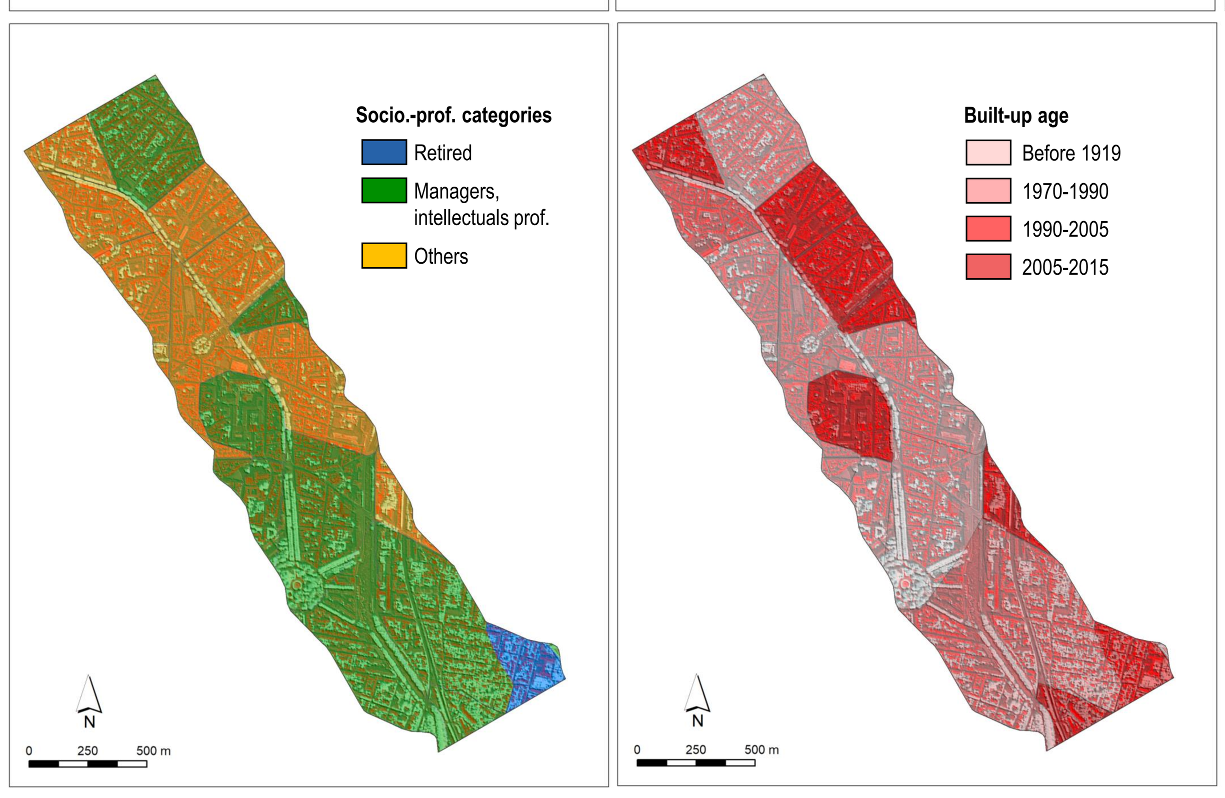


Fig. 4 – Morpho-urban and socio-demographic/economic model

The area with the highest concentration of buildings coincides with a high number of small flats, most of which were built before the war, and a strong presence of amenities (stores, services, etc.). Socioeconomic structures are interrelated with urban morphologies and fabrics.

Areas with a lower ratio of flats to houses are those with more vegetation and larger, newer buildings, inhabited mainly by pensioners or managers and intellectual workers.

CONCLUSIONS

- Metric hyperspectral images can be used to better identify the geographical objects that make up the urban fabric in dense built-up areas. They make it possible to identify urban objects and environmental indices (trees, buildings, materials, water features, humidity, etc.) that are absent from geographic databases and more precise spatially.
- The urban morphologies, socio-demographic and economic structures identified are perfectly spatially correlated.
- The exploratory methodologies show a strong correlation between the results and the spectral sensitivity of the images. Certain algorithms, whatever the spectral domain and spatial resolution (2 and 4 meters), such as ACP Tmode and Fuzzy Artmap NNA, are remarkably consistent in their ability to recognise urban objects and morphologies.