Use of photogrammetry for the study of riparian vegetation dynamics

Utilisation de la photogrammétrie pour l'étude de la végétation riveraine

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RÉSUMÉ

Cette étude présente les résultats de tests méthodologiques réalisés en photogrammétrie aérienne avec pour objectif le suivi diachronique de la végétation riveraine dans ses trois dimensions, c'est-à-dire sa distribution spatiale et sa hauteur. L'étude est menée à deux échelles d'analyse. La première échelle est celle d'un tronçon longitudinal de 10 km de la plaine alluviale de la rivière Allier. À cette échelle de travail, un avion a été utilisé pour les prises de vue aérienne. La deuxième échelle d'analyse est celle d'un banc boisé, localisé dans la zone de 10 km. À cette échelle, la couverture photographique a été faite à l'aide d'un drone. Pour les deux objets d'étude des modèles de hauteur du couvert végétal (MHC) sont produits. La précision des MHC est ensuite vérifiée à partir de la mesure de la hauteur d'arbres sur le terrain. Les résultats révèlent une très bonne précision des modèles pour les deux approches, de l'ordre du mètre à l'échelle du tronçon de 10 km et de quelques centimètres à l'échelle du banc. Cette inégalité s'explique surtout par des résolutions photographiques différentes pour les deux missions. Il ressort de ce travail que les deux approches sont complémentaires. La première permet de cartographier la structure de la végétation à l'échelle de la plaine alluviale, la deuxième permet une cartographie de la végétation à plus haute résolution mais seulement à une échelle plus réduite.

ABSTRACT

This study presents the results of methodological tests in aerial photogrammetry with the objective of a diachronic survey of riparian vegetation in three dimensions, i.e. its spatial distribution and height. The study is undertaken at two complementary scales. The first one corresponds to a 10 km reach of the Allier river floodplain. At this scale, aerial photographs were taken from a small airplane. The second level of analysis corresponds to a wooded point bar located within the 10 km reach. At this scale, the photographs were taken from an unmanned aerial vehicle (UAV). Canopy height models (CHM) are produced at two scales of analysis. The accuracy of the CHMs is then analysed by comparison with vegetation height measurements collected during a filed campaign. The results show significant agreement for the models derived from two approaches, with an error of one meter at the floodplain scale and few centimetres at the bar scale. This variation in error is mainly due to different photographic resolutions. The two approaches appeared to be complementary. The first one is adequate for mapping vegetation structure at the floodplain scale, the second for mapping vegetation in smaller areas but at a higher resolution.

KEYWORDS

Aerial photographs, photogrammetry, riparian vegetation, UAV, vegetation height model

1 BACKGROUND AND OBJECTIVES

Riparian vegetation responds to hydrogeomorphic disturbances and also controls sediment erosion and deposition. However, there are still gaps on understanding and quantifying reciprocal biogeomorphic processes within river systems. Many studies based on aerial photographs have been realized to better understand two dimensional spatiotemporal variation in riparian vegetation cover within fluvial corridors. Photogrammetry can currently be used to derive vegetation height models which allows the quantification of vegetation vertical growth rates. These growth rates are a fundamental component to be considered when studying feedbacks between fluvial landform construction and vegetation establishment and succession. Photogrammetry leads to the development of a useful 3D approach. However, the heterogeneity of riparian vegetation height and spatial distribution including isolated trees within fluvial corridors represents a difficulty for building 3D models. That is one of the reasons why vegetation height models were initially applied for the study of homogeneous forests. The recent development of computers' performances as well as of new algorithms now offers improved possibilities for 3D modelling. Moreover, recent developments in data acquisition tools, like unmanned aerial vehicles (UAV), also provide new opportunities to study riparian vegetation structure through the production of high resolution images at the appropriate time, for example after a flood.

Here we tested these new photogrammetric tools and the application of UAV photographs to study riparian vegetation structure. The aim is to build 3D photogrammetric models of riparian vegetation height based on aerial photographs at two complementary scales. Aerial photographs were produced with (i) a small airplane for a large area of the floodplain and (ii) a UAV for a small area. We evaluated the quality of the models by measuring vegetation height in the field during the same period. The objective is to test the two methods as a complementary approach for the study of riparian vegetation dynamics.

2 METHODS

2.1 Study site

The study reach is located on the Allier river, France. It is a dynamic wandering river characterised by lateral erosion in the outer bends of meanders and gravel point bar formation in the inner bends. This river section is also characterised by a complex landscape mosaic with a heterogeneous spatial distribution of vegetation patches of different sizes and ages. This landscape structure provides a good opportunity for testing the construction of vegetation height models based on photogrammetry.

2.2 Acquisition of aerial photographs and photogrammetrical methods

Two different series of photographs were taken in August 2014. The first was taken with a UAV Falcon-8 (Asctec GmbH, Krailing, Germany) at the scale of the point bar (18 ha) and the second by an airplane (Cessna172) at the scale of the floodplain over a 10 km section. A Sony NEX-5n (16 megapixel) camera was used for the UAV flight at an altitude of 80 m. This enabled us to produce a series of photographs of very good quality with a resolution of 25 mm/pixel. A higher flight altitude (400 m) was chosen for the airplane flight in order to cover a larger area (2300 ha) with a resolution of 10 cm/pixel.

For both scales, a digital terrain model (DTM) and a digital surface model (DSM) were produced using photogrammetry in order to deduce canopy height models (CHM). We applied two different methods to derive the photogrammetric models: (i) multi-image photogrammetry and (ii) stereophotogrammerty. Photoscan and Erdas LPS software were used for the procedures.

2.3 Field data collection for model relevance verification

Isolated trees and larger vegetation patches may influence differently the quality and the precision of the construction of 3D vegetation height models. In order to obtain non-biased field data, two different methods of vegetation height measurements were applied. First, we selected isolated or nearly isolated trees and shrubs and measured the highest point of the plant. A 5 m measuring rod and a laser telemeter were used to measure nearly 80 individuals with contrasting heights. We made measurements from three different angles with the laser telemeter. The second method was applied for the measurement of the dominant vegetation height in a given area. Within eleven circular plots with a radius of 5 m we measured the five highest points of the dense vegetation patch. We repeated the measurements twice for all circular plots from two different angles.

3 EXPECTED RESULTS

In a preliminary study we tested the method of stereophotogrammerty on aerial photographs of IGN (National Institute of Geographic and Forestry Information). A precision of approximately 1 m of the vegetation height models was obtained. The representation of young vegetation (one or two years old) was not possible due to the lower resolution of these photographs. Furthermore, the acquisition dates of these photographs are determined by IGN and thus no interannual vegetation monitoring could be carried out (Hortobagyi et al., 2014).

The precision of the 3D models we will build based on our UAV photographs and on our aerial photographs will certainly differ. In the first case, a centimeter accuracy is expected, whereas in the second case a lower resolution with the loss of details is anticipated. Both types of 3D models should enable us to represent adult woody vegetation, but only the high resolution UAV photographs will probably ensure the representation of young stages of vegetation growth. We expect that the different spatial scales and resolutions covered by the two methods will complement each other for the study of riparian vegetation dynamics.

LIST OF REFERENCES

Hortobagyi, B., Vautier, F., Corenblit, D. and Steiger, J. (2014). Stereophotogrammetry in studies of riparian vegetation dynamics. In: *Geophysical Research Abstracts*, Vol. 16, EGU2014-4175, 2014.