Chapter 16
Accuracy of UAV-Based Digital Elevation Models:
A Case Study in Colombia

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ABSTRACT

UAV photogrammetry has simplified the measurement of the terrain's surface; however, the accuracy of the method is still a matter of research as it depends on multiple factors such as the UAV employed and the decisions made by the user during information acquisition and processing. This chapter analyses the accuracy of 27 digital elevation models (DEMs) built from the data acquired with a DJI Phantom 3 drone, which was flown at different heights and trajectories in a case study in the Colombian Department of Antioquia. The statistical analysis confirmed that the use of ground control points (GCPs) is fundamental to increase the accuracy of the map products. It also showed that accuracy, understood as the comparison between the coordinates of points measured in the field (CPs) with their corresponding values estimated in the orthophotomosaics, depends on the number of CPs and their location. An insufficient number of CPs or an inadequate distribution, for instance all or most of them located in a single land cover, will cause the accuracy to be overestimated.

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INTRODUCTION

The reliability of a measurement depends on its proximity to a reference value, which is commonly referred to as accuracy. However, it is recognized that, although all the known or suspected sources of error have been evaluated and the appropriate corrections have been applied, a certain level of uncertainty about the correctness of the declared result still exists. Therefore, the Joint Committee for Guides in Metrology defined the uncertainty of measurement as the dispersion of the values that could reasonably be attributed to the measurand (Joint Committee for Guides in Metrology [JCGM], 2008).

The sources of error from measurements made with unmanned aerial vehicles (UAVs) have been widely examined in the scientific literature; among the best-known are flight altitude, image overlap, weather, and the number and distribution of ground control points (GCPs), which are marked targets on the ground of known location used to georeference UAV imagery (Rock et al., 2011; Leitao et al., 2016; Seifert et al., 2019; Barba et al., 2019). Different studies assess DEM quality for specific case studies; examples are viticulture in the Mediterranean (Pichon et al., 2016), surface mining in Slovakia (Kršák et al., 2016) and DEM generation for Sahitler hill in Turkey (Uysal et al., 2015).

The accuracy of map products, namely digital elevation models (DEMs) and orthomosaics, is determined by comparing the planimetric coordinates and elevations of well-defined points with information of the same points from an independent source of higher accuracy (Federal Geographic Data Committee of the United States of America [FGDC], 1998). The results are usually compared with standards developed for traditional procedures, such as ground-based total station surveys and manned aircraft photogrammetry, as most of the countries do not have consistent and appropriate accuracy standards that apply specifically to the new technologies for digital data (American Society for Photogrammetry and Remote Sensing [ASPRS], 2015).

The American Society for Photogrammetry and Remote Sensing proposed the Positional Accuracy Standards for Digital Geospatial Data (ASPRS, 2015), which are based on the United States of America standards for maps and spatial data, such as the National Map Accuracy Standard (NMAS) of 1947, the National Standard for Spatial Data Accuracy (NSSDA) of 1998, and the NDEP Guidelines for Digital Elevation Data of 2004. The ASPRS horizontal accuracy standard is divided into accuracy classes using root-mean-square-error (RMSE) statistics. The vertical accuracy standard uses RMSE statistics in non-vegetated terrain and 95^{th} percentile statistics in vegetated land.

There are no quality standards for UAV-based measurements in Colombia. During 2018, as part of the research presented in this chapter, an online survey was

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