

ORTHORECTIFICATION OF QUICKBIRD BASIC AND STANDARD ORTHOREADY DATA

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ABSTRACT:

For a proper exploitation of satellite data, geometrical processing is a key issue. Several techniques can be applied for this purpose. DigitalGlobe, which operates the QuickBird satellite, within its products integrates the image data with additional information that can be handled by image processing software packages for a proper orthorectification of the data. In this paper, focus is on the geometrical processing of the Basic and Standard OrthoReady QuickBird products using commercial image processing software. For a set of four frames, both products were collected and processed with the same sets of Control and Check Points by applying the RPC approach (for both products) and the rigorous approach (for the Basic imagery). The results show that better accuracy can be obtained with Basic images, and that the rigorous approach supplies slightly better results compared to the RPC-based processing.

1. INTRODUCTION

Image providers, to satisfy the widest user needs, often offer in their catalogues several products starting from the same imagery. Products can differ in band combination, geometrical resolution or radiometric and geometric processing. Therefore, the selection of the proper source data, driven by the use that must be made of it, is a very important step that often is not well considered by many users, with a negative impact on the quality of the products extracted from the imagery. When dealing with QuickBird data, that at the moment offers the best available geometric resolution from a commercial satellite, several products are offered by DigitalGlobe, the satellite operator. Very often, one key requirement is a good positioning accuracy of the imagery within a geographic reference system. This calls for proper geometrical processing of the starting product, that can provide very different results depending on the selected product and the geometrical processing approach followed. This paper evaluates the accuracy results that can be obtained starting from the two products, Basic and Standard OrthoReady, that are the most suitable for geometrical processing.

2. QUICKBIRD PRODUCTS

Several products are available from DigitalGlobe. The main difference between the products is the different level of geometrical processing applied.

2.1 Basic Imagery

Available at the moment only on a whole-frame basis, this is the least processed of the QuickBird imagery products from a geometrical point of view, and has been designed for users having advanced technical capabilities, who can process the data with an approach very similar to the one used for the processing of aerial photos. Basic imagery is supplied with Image Support Data files containing:

- *general image metadata*: information related to acquisition and processing, image quality, cloud cover, corner coordinates, collection angle, pixel size, etc.

- *attitude parameters*: sampled mean and covariance estimates of the attitude of the spacecraft, often computed each 0.020 seconds, starting at least four second before image collection, and ending at least four seconds after image collection.
- *ephemeris parameters*: sampled mean and covariance estimates of the position of the spacecraft, often computed each 0.020 seconds, starting at least four second before image collection, and ending at least four seconds after image collection
- *camera model information*: standard photogrammetric parameters of a virtual camera modelling the imaging and optical system. This camera models the system as a moving camera with a single continuous linear detector array on the focal plane for each spectral band.

The information contained in these files allows the application of a rigorous sensor model for Basic data processing, since DigitalGlobe has released the sensor model of the satellite to the main image processing software vendors, and several software packages (for example Socet Set or Erdas Imagine) allow rigorous geometrical processing of the Basic frame.

In the Basic product packaging there is also an *RPC file*, containing the values of the rational polynomial coefficients for the imagery, that can also permit powerful geometric processing of the imagery.

2.2 Standard OrthoReady imagery

Standard OrthoReady imagery can be considered as an intermediate product for users who require good geometric processing and have basic processing capabilities. The original satellite data has undergone the same radiometric and sensor corrections as the Basic product, but has also been geometrically processed and mapped to a cartographic projection. Geometrical processing applied by DigitalGlobe is fully based on spacecraft detected parameters, and uses a constant value DEM, expressing the average height of the scene as measured on the GTOPO30 30 arcseconds DEM. The Standard Ortho Ready Product is available on a full or part-

frame basis, and is supplied with an RPC file for further geometrical processing.

2.3 Standard imagery

Standard imagery is a plug-and-play product that has been geometrically processed and mapped to a cartographic projection by using orbit information and the coarse GTOPO30 DEM to take into account topographic relief. The declared geolocation accuracy of this product is 23-meters CE90%, excluding any topographic displacement. This product is the least suitable for geometrical processing, since it has been designed for users that don't want to deal with geometrical processing, and are not requiring very accurate positioning but a product that can be directly ingested within, for example, a GIS system.

3. TEST DESCRIPTION

3.1 Overview

According to the technical features of QuickBird products, the best choice when dealing with an accurate orthorectification is to start from the Basic or Standard OrthoReady products. The test described in the following paragraphs, was designed to have a first evaluation of, on the same frame, the orthorectification accuracy results that can be obtained in a processing environment with commercial software, with three different approaches:

- rigorous model from Basic product
- RPC approach from Basic product
- RPC approach from Standard Ortho Ready product

The test was carried out on four QuickBird frames, collected on a hilly area in the centre of Italy. For each frame, the imagery was produced both as Basic and Standard OrthoReady products. In the area covered by each image, the area height differences are in the range 600 to 800 meters; the collection angle range from 6 to 22 degrees.

For each frame 12 ground control points were selected, and specific attention was paid to their spatial arrangement. Four of them were located as near as possible to the corners of the frame, four in the central area and the other four in the remaining area. The ground control points have 30-centimeters declared planar accuracy, and the height was derived from a DEM with 3-meters z-accuracy. The same DEM was used for orthorectification. Some of the points were used as Ground Control Points, the remaining as Check Points (CPs). The processing was carried out by using the LPS (Leica Photogrammetric Suite) software package. When using the rigorous model, all available fine settings were left at the default values. When using the RPCs, a refinement with a first order polynomial was applied.

The same points were collected both on the Basic and the Standard OrthoReady images, to allow the comparison of the results using exactly the same reference data.

3.2 Input images

In Table 1 the collection angles along and across track for each of the four considered images are reported. In the Basic imagery, which has not been geometrical processed and therefore retains the original collection geometry, different

collection angles involve different pixel sizes in x and y directions. In addition, with increasing angle the geometric resolution decreases from the nadiral 61-centimeters up to 70-centimeters of the scene named 657 in the across-track direction. With the Standard OrthoReady products, however, images were projected in UTM/WGS84, and resampled with a squared 60-centimeter pixel size.

The overall quality of the images can be considered very good, and all ground control points were clearly recognized.

SCENE	COLLECTION ANGLE	
	Along	Across
649	-0.6	-5.9
655	1.4	-8.3
658	-9.2	-19.6
657	-10.2	-20.1

Table 1. Collection angles of selected frames

4. RESULTS

Several tests were carried out by considering different numbers of GCPs. For each fixed number of GCPs, at least three different combinations of GCPs were used, supplying at least three different datasets of results; for each number of GCPs, the average value of the results (Rmse tot, Rmse x, Rmse y, etc.) was considered. In all the tests, the same GCPs and CPs were used for each of the three studied orthorectification approaches (Basic with rigorous or RPC, Standard OrthoReady with RPC).

4.1 Results with a variable number of GCPs

The first test was the comparison of the Rmse computed on the Check Points when using from 4 (8 Check Points) to 10 (2 Check Points) Ground Control Points.

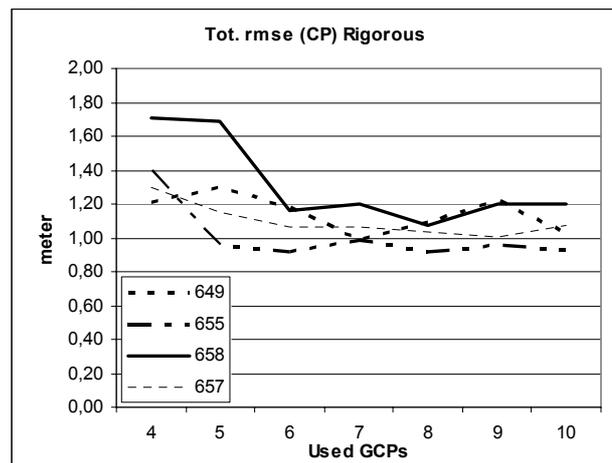


Figure 1. Rmse computed on CP for different numbers of GCPs, - Basic imagery, Rigorous

Figure 1 shows the results obtained on the four Basic images when using the rigorous model. The results, starting from 6 GCPs, show Rmse values in the range 1.0 – 1.2 meters. No strong differences can be seen between the results on the four images.

In figure 2 the results when using the RPC approach on the Basic imagery are shown.

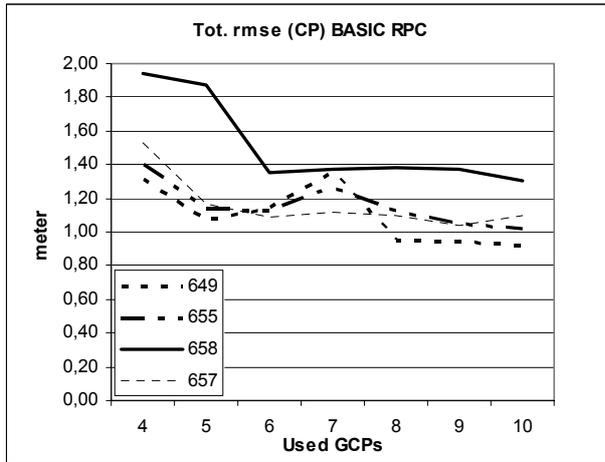


Figure 2. Rmse computed on CP for different numbers of GCPs – Basic imagery, RPC

In this case the results are in the range 1.0 – 1.4 meters, showing a slight accuracy decrease

The values obtained on the four images were averaged in order to obtain a single line for each of the two tests. The results are reported in figure 3, where the line obtained from the averaging of the four images results when applying RPC on the Standard OrthoReady images is also shown.

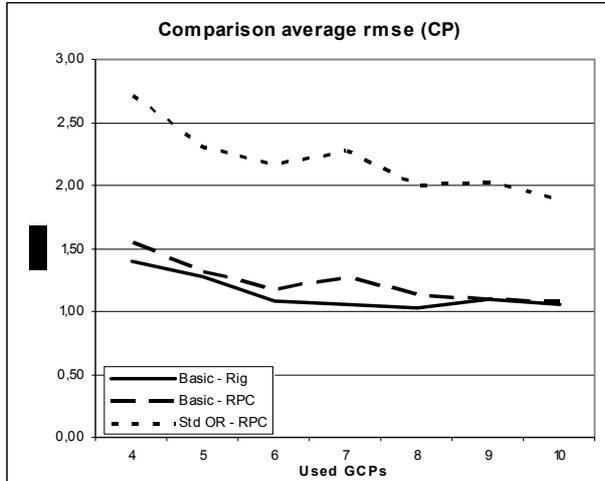


Figure 3. Average Rmse on four images computed on CP for different numbers of GCPs – Comparison of Basic (Rigorous and RPC) and Standard OrthoReady (RPC)

It appears clear that results with the Basic imagery are better than those achieved with the Standard OrthoReady. Results with the rigorous model are slightly better in the range between 4 and 8 GCPs. With the rigorous model, the average Rmse on CPs is around 1.10-meters when using at least 6 GCPs; when considering the average Rmse on all the points (GCPs + CPs), this value is close to 0.90 meters both for the rigorous and the RPC.

The maximum error measured on CPs is well below 2-meters both with the rigorous and RPC approach.

4.2 Results with 5 GCPs

All the points that were used in the test were surveyed in-situ. Field measurements can often have a strong impact on budgets, especially in places that are not easy to reach. Therefore, using a limited number of GCPs can be often a constraint more than a choice. A test using only 5 GCPs, was carried out on the four images. Four points were located near the corners, the remaining one in the center. The results in terms of Rmse on 7 Check Points are reported in figure 4.

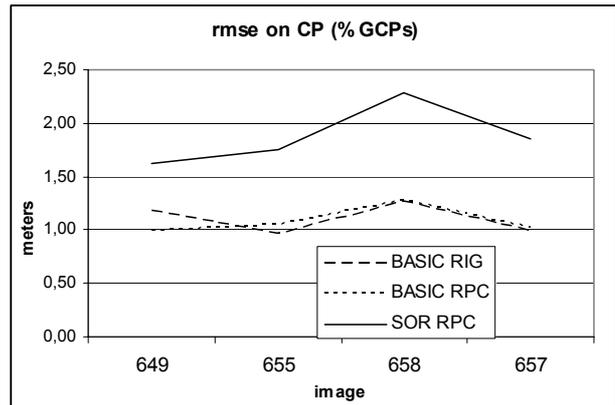


Figure 4. Rmse computed on CP for 5 well located GCPs

Operating with the rigorous model supplies slightly better results for three images, with Rmse in the range 0.96 – 1.26 meter

5. CONCLUSIONS

The described test was designed to have a first comparative evaluation between three different approaches in the processing of a QuickBird scene using commercial software. In the evaluation of the results, several issues must be taken into consideration:

- The area over which the tests were carried out has a quite severe morphology. Similar tests carried out in flat areas could provide slightly better results
- The points were well spread over the images, therefore the obtained values are expected to describe quite well the expected accuracy all over the image
- The Digital elevation model used was quite accurate. This means that the transformation from image pixels to projected coordinates was obtained relying on accurate GCPs in x, y and z. In any case, when applying the transformation to the whole image, the position of each pixel in the final rectified imagery is dependent on the elevation data. Due to the non-nadir viewing geometry, the higher the collection angle, the higher the influence of a not accurate DEM on the results. Therefore, less accurate results are expected when using less accurate DEMs
- Several image collection angles were involved in the dataset, therefore involving, for a quite homogenous hilly morphology, a large range of possible collection angles.

- When accuracy is a key issue, off-nadir collection angle exceeding 15° are not recommended, since the influence of DEM quality on final accuracy can be very high

The best results can be obtained starting from Basic imagery, as expected. The processing of the imagery with the rigorous model as implemented within Leica-Geosystems LPS software package supplied slightly better results in comparison with those obtained with the RPC, especially for a limited number of Ground Control Point.

From a quantitative point of view, considering an accuracy expressed as Rmse measured on CPs, on all processed images values well below 1.5-meter were obtained both with rigorous and RPC-based geometrical processing, even when using only 5 GCPs.

The test has shown the robustness of the RPC approach, even over a large area –close to 300 km² – covered by a Basic frame. If in the future images with a larger number of rows become available, processing with the rigorous model should probably show a more appreciable advantage with RPCs.

Additional work is anyway required for a deeper knowledge of how the implementation of the rigorous model within LPS software works, and how it can be tuned to provide the best results.

References from websites:

DigitalGlobe Product Guide <http://www.digitalglobe.com>
(accessed 14 Apr. 2005)