GEOMETRIC CORRECTION OF THE QUICKBIRD HIGH RESOLUTION PANCHROMATIC IMAGES

Aguilar, M. A., Aguilar, F. J., Sánchez, J. A., Carvajal, F. and Agüera, F.

Departamento de Ingeniería Rural, Universidad de Almería (Spain). Email: maguilar@ual.es

ABSTRACT

The new very high space resolution satellite images, such as QuickBird and IKONOS, open new possibilities in cartographic applications. This work has as its main aim the assessment of a methodology to achieve the best geometric accuracy in orthorectified imagery products obtained from QuickBird Basic Imagery. Root Mean Square Error (RMSE), mean error or bias and maximum error in 79 independent check points are computed and utilized as accuracy indicators.

The ancillary data were generated by high accuracy methods: (1) Check and control points were measured with a differential global positioning system (DGPS) and, (2) a dense digital elevation model (DEM) with grid spacing of 2 m generated from a photogrammetric aerial flight at an approximate scale of 1/5000 ($RMSE_z$<0.32 m) was used for image orthorectification.

Two 3D geometric correction methods were used to correct the satellite data (3D rational function refined by the user, and the 3D Toutin physical model). The number of control points by orthorectified imagery (9, 18, 27, 36 and 45 control points) was studied as well. The best results ($RMSE_{1D}$ of between 0.48 m and 0.61 m) were obtained when the dense MDE was used for the image orthorectification by 3D physical model. A larger number of GCPs (more than nine) does not improve the results.

1. INTRODUCTION

Since the successful launch in the recent past of very high resolution sensors, especially IKONOS-II with 1 m Ground Sample Distance (GSD) and QuickBird with 0.61 GSD, many researchers have considered them as possible substitutes of the classical aerial images used for cartographic purposes at large scales (Fraser, 2002; Kay et al., 2003; Chmiel et al., 2004; Pecci et al., 2004). The cost of acquiring such mapping products (IKONOS Pro and QuickBird Orthorectified Imagery) is quite considerable, however, there are methods available for users with photogrammetric capability to generate high accuracy mapping at the lowest cost (Ikonos Geo and QuickBird Basic Imagery).

To obtain orthorectified images of very high resolution imagery, whatever the raw data format, it is necessary to follow the steps of the process: (1) acquisition of image(s) and metadata, (2) acquisition of the coordinates *X*, *Y*, *Z* of ground points, ground control points (GCPs) and independent check points (ICPs), (3) to obtain the image coordinates of these points, (4) computation of the unknown parameters of the 3D geometric correction model used, and (5) image(s) orthorectification using a digital elevation model (DEM).

When high accuracy is required in the orthorectification process, the ancillary data (GCPs, DEM) must be of high quality as well. With GCPs measured by differential global positioning system (DGPS), the predominant error came from image pointing, therefore, the selection of points that are very well-defined in the image is very important. A good distribution of GCPs can improve accuracy (Zhou and Li, 2000) and it should be spread over full image in planimetry and also in the elevation range (Toutin, 2004a).

The main aim of this paper is the methodology assessment to achieve the best geometric accuracy in orthorectified imagery products obtained from panchromatic QuickBird Basic Imagery. A high number of well-defined and accurate IPCs and GCPs were measured with DGPS. In order to address some aspects of orthorectification of very high spatial resolution satellite imagery, the following variation sources have been studied:

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a) Two 3D geometric correction models have been used to correct the satellite data using PCI Geomatica OrthoEngine software from PCI Geomatics: (1) refined image vendor coefficients of 3D rational functions using GCPs (RF), and (2) 3D physical model developed by Dr. Toutin at the Canada Centre for Remote Sensing (CCRS).
b) Number of GCPs used to computed the 3D geometric correction models (9, 18, 27, 36 and 45).
c) Accuracy of the digital elevation model employed in imagery orthorectification: (1) a grid spacing of 2 m generated from a photogrammetric aerial flight at an approximate scale of 1/5000 using digital photogrammetric workstations, and (2) a grid spacing of 20 m devised by the Council for the Environment of the Andalusia Government.

2. STUDY SITE AND DATA SET

2.1 Study site

The study site is an area situated to the north-east of Almería City, Spain, specifically in the region of Campo de Níjar. The area has an elevation range of between 50 m to 850 m above sea level, and can be considered like slightly hilly. Figure 1 shows the DEM of the study area on the European Datum ED50 with the International Ellipsoid from Hayford and projection to the UTM 30 N.

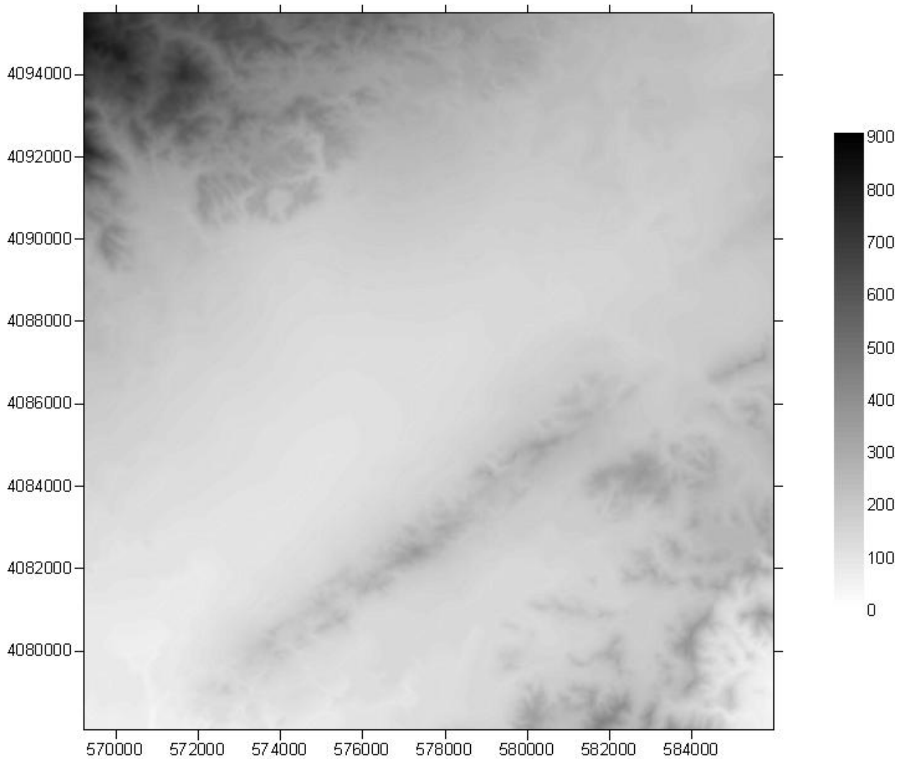

Figure 1: Digital elevation model of the study area on the European Datum ED50 with the International Ellipsoid from Hayford and projection to the UTM 30 N (elevations in meters).

2.2 QuickBird panchromatic basic imagery

On December 19, 2004 a QuickBird panchromatic basic imagery by DigitalGlobe™ was acquired. The basic scene was centred on the coordinates WGS84 (lattitude and longitude) of N 36.93045 º and W 2.12685 º. Other characteristics of the basic image are shown in table 1.

Table 1. Characteristics of the QuickBird Basic Imagery acquired at the study site. GSD (Ground Sample Distance).

Product	Acquisition Date	Off Nadir Angle	Cloud Cover (%)	Image (km)	GSD (m)
QuickBird Basic Imagery Panchromatic	December 19, 2004	8º	6	16.5×16.5	0.61×0.61

Basic Imagery products are radiometrically corrected and sensor corrected, but not geometrically corrected or mapped to a cartographic projection and ellipsoid. Image resolution varies between 0.61 m (at nadir) to 0.72 m (25º off-nadir look angle) for panchromatic products. Basic imagery comes accompanied by information relating to satellite attitude, ephemeris and camera model information.

2.3 Ground Control Points collection

A color photogrammetric flight at an approximate scale of 1/5000 with 60% and 25% longitudinal and transversal overlap respectively was commissioned by the State-owned Company for the Agrarian and Fishing Development of Andalusia (D.a.p.) and carried out on 15 May 2001, covering a surface of around 160 km^2 in Almería, Spain. The photographs were scanned using a Vexcel UltraScan 5000 photogrammetric scanner at a geometric resolution of 20 µm per pixel. From this flight, digital cartography at a scale of 1/1000 and a DEM with a grid spacing of 2 m were generated using four digital photogrammetric workstations (two SOCET SET from LH Systems™, and two ImageStation SSK Z/I Imaging from Intergraph™).

The coordinates of the control and check points measured for the ground control of this flight were referred to the ED 50 European Datum (Hayford international ellipsoid), using the UTM projection. The vertical Datum will take the geoid as reference surface, adopting as null orthometric height point the medium level in the calm seas of Alicante (Spain). In the first place, a network of bases was constructed supported by the Spanish Geodesic Network (Lower Order Network) with the idea of increasing its density by triangulation, which allows the verification, compensation and adjustment of the network.

First of all, 29 bases network were obtained. They were supported by three survey points belonging to the National Geodesic Network obtained using Spatial Techniques, such as Castillico, Morron and Cuesta Colorada, the coordinates of which are known in the WGS84 system.

The observations of the bases were done in static mode by four Trimble Navigation™ GPS receivers, of which two were 4700 models and two 4800 models. The 4800 models and one 4700 were installed on the Castillico, Morron and Cuesta Colorada survey points, whereas the other 4700 model was placed on each of the bases (10 minutes observation minimum), obtaining the baselines that constituted three triangles for each point.

Once the static measurement data had been processed using the GPSurvey WAVE module, a network was obtained as observed in system WGS84. That is to say, a set of redundant observations of the location of the bases, which requires the introduction of an adjustment and compensation process in the network. This process was carried out with the GPSurvey TRIMNET module.

Using this procedure, and once the good fit of the adjustment of the network in the WGS84 system had been verified, we proceeded to transform the coordinates of the bases into the ED 50 local system by means of a 3D Helmert transformation of 7 parameters. In order to determine the transformation parameters we needed to know at least the coordinates of three points in both systems (global and local). In our case we had WGS 84 and ED 50 coordinates with 5 points: Castillico, Ramayo, Yeguas, Morron and Cuesta Colorada. The computing of the transformation parameters was carried out with the GPSurvey GPTRANS module.

The obtention of photogrammetric ground points was done using a total station DGPS 4800 Trimble™ working in RTK mode. All the 29 RTK radiations carried out were supported in at least three bases, the coordinates of which were determined during the adjustment and compensation of the statically observed network. In this way, it was possible to orientate each figure radiated in RTK and correct it planimetrically and altimetrically. Later on, we proceeded to do a planimetric and altimetric compensation of the adjustment errors between the points of the coordinates known for each radiation. The correction calculations of each RTK radiation and the errors obtained were done with the software Trimble Survey Office. As a final result of the methodology described the UTM ED 50 coordinates were obtained as well as the orthometric levels with 254 photogrammetric ground control points and 80 check points.

For the orthorectification of QuickBird basic imagery, 45 uniformly distributed GCPs were used. Thus, the QuickBird scene was divided into nine equal sub-areas, inside each of which five control points were placed (Fig. 2). To control the errors in the processes of 3D geometric correction model and orthorectification, 79 ICPs were placed. These ICPs were inside the area of which digital cartography at a scale of 1/1000 and dense digital elevation model was available (green line in Fig. 2). The selection of the 124 points (ICPs + GCPs) used in this study, was based on well-defined points on the QuickBird image. Because of this, a high percentage of the points measured in the ground control of the flight carried out in 2001 was rejected for this study.

On February, 2005 a new topographic campaign was took place to obtain coordinates of new points well defined in QuickBird scene. Thus, a good final distribution of the 45 GCPs was ensured, spread over full image of QuickBird and of the 79 ICPs inside the area with digital cartography. On this occasion, a total Trimble™ DGPS 5700 station was used working in RTK mode. The methodology followed was the same as that reported above. The goal was a reliable measurement of 124 points with an accuracy better than a decimetre.

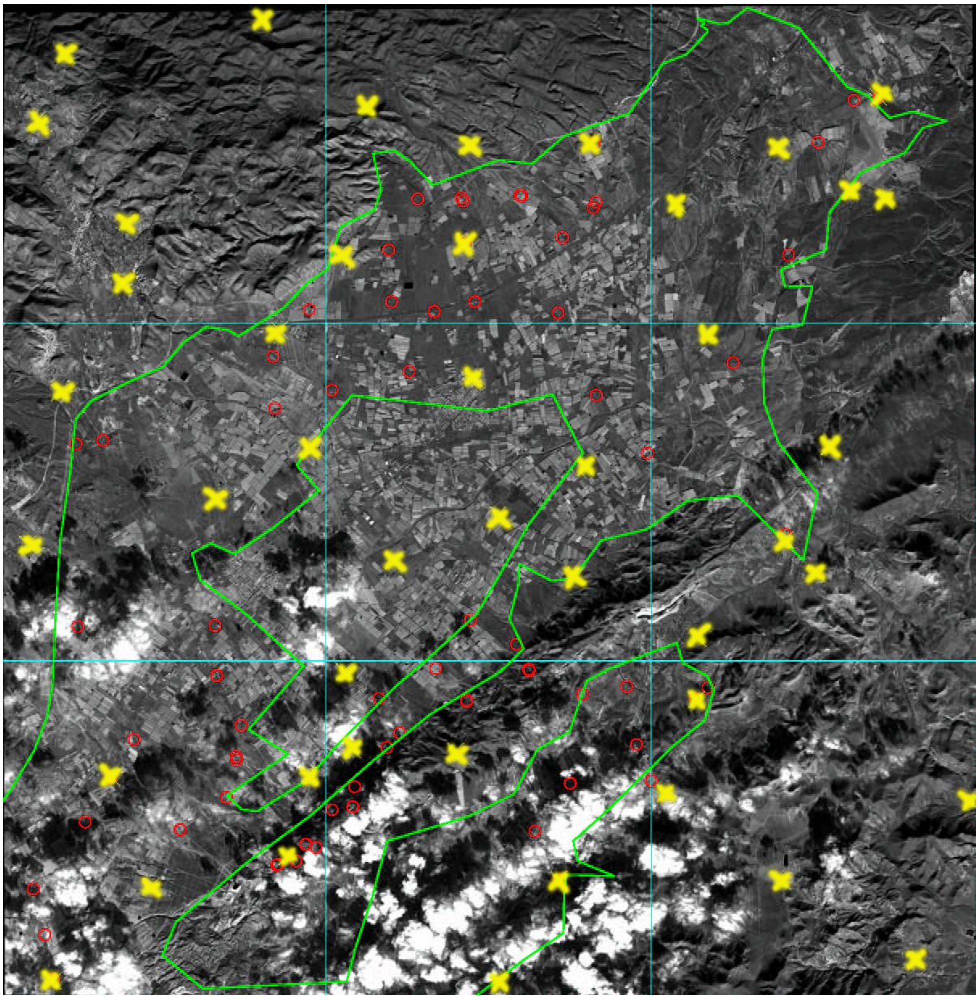

Figure 2: Distribution of GCPs (yellow crosses) and ICPs (red circles) overlaid on the QuickBird Panchromatic Basic Imagery Orthorectified. The grid shows the partitioning of the scene into equal sized areas to ensure a good distribution of GCPs chosen in every test. The green line encloses the area of which digital cartography at scale of 1/1000 and dense digital elevation model was available.

2.4 Digital Elevation Models

For the generation of QuickBird panchromatic orthoimage, two DEMs were used:

- A coarse DEM with a grid spacing of 20 m created by the Council for the Environment of the Andalusia Government from topographic information with a contour interval of 20 m, of the 1/50000 technical cartography.
- A dense DEM with a grid spacing of 2 m generated from a photogrammetric aerial flight at an approximate scale of 1/5000 using digital photogrammetric workstations. This DEM was available only in the zone where digital cartography was carried out in 2001 (Fig. 2).

The statistics of the differences of the 50 known DGPS coordinates, placed on the natural terrain, minus the DEM interpolated ones (using Radial Basis Function) were, for the dense DEM: mean error=0.13 m, $RMSE_z$=0.31 m, maximum error=0.65 m, and for the coarse DEM: mean error=1.71 m, $RMSE_z$=5.82 m, maximum error=-14.53 m.

3. ORTHORECTIFICATION AND GEOMETRIC QUALITY ASSESSMENT

3.1 Geometric correction models of QuickBird imagery

Several geometric modelling of distortions can be used to correct a satellite imagery: 2D Polynomial functions, 3D Polynomial functions, 3D rational functions and 2D/3D physical models (Toutin, 2004a).

However, for the 3D geometric correction of very high resolution satellite images, usually three methods can be used:

(1) 3D rational functions with the coefficients computed by the user.
(2) Terrain-independent or refined image vendor coefficients of 3D rational functions using GCPs.
(3) 3D physical models.

The 3D rational function mathematical models built a correlation between the pixels (2D image space) and their ground locations (3D object space). This correlation is based on a ratio of two cubic polynomial functions. In the first method the unknown rational polynomial coefficients can be computed by the user by means of GCPs. A minimum of 7, 19 and 39 GCPs are required to resolve the first, second and third order rational polynomial function, respectively. This method is not stable enough in operational environments. The accuracy depends on the number, location, and accuracy of GCPs (Toutin and Cheng, 2002).

In the second method, rational polynomial coefficients can be derived using physical sensor/camera model at the ground station. Usually, these coefficients are distributed by image vendor in very high resolution sensors (IKONOS-II, QuickBird). This method can be applied without GCPs (called terrain-independent), although the accuracy obtained is not very good. Results published showed root mean square errors in one dimension ($RMSE_{1D}$) between 2.4 and 13.0 m with this method (Cheng et al., 2003). A very interesting possibility of this second method is that users can improve the accuracy of the rational function model, refining the image vendor coefficients by a few GCPs. Several researchers have used the refined rational function (RF) with quite good results (Cheng et al, 2003; Kay et al., 2003; Robertson, 2003; Chmiel et al., 2004)

Physical models, also named rigorous or deterministic, fully reflect the geometry of viewing. For this purpose, it is necessary to include in the model camera timing, alignment and focal plane layout information, and a full set of satellite attitude and ephemeris information. Basic Imagery provides a complete set of image acquisition metadata. This method provides the most accurate and complete geolocation data (Robertson, 2003) and has a great robustness over the full image with the use of only a few GCPs (Cheng et al. 2003).

Of all the previously exposed possibilities, the refined RF and physical model represent a reasonable and cost effective choice where high accuracy of final product is intended (Chmiel et al., 2004).

3.2 Methodology Geometric correction models of QuickBird imagery

To process the Basic Imagery product the PCI Geomatica OrthoEngine software v. 9.1, developed by PCI Geomatics was used. It supports, among others, the use of refined RF model and a physical model developed by Dr. Toutin at the Canada Centre for Remote Sensing (Toutin and Cheng, 2002). This physical model, initially developed for medium-resolution sensors in the visible and infra-red as well as in the microwave (Toutin, 1995), was later adapted for QuickBird data (Toutin, 2004b). The refined RF model needs at least one GCPs and the Toutin physical model (CCRS) requires a theoretical minimum of six GCPs for Basic imagery. These two computation models are compared in this work.

Of 45 measured GCPs using DGPS (see 2.3), combinations of n GCPs (9, 18, 27, 36 and 45) were generated.

The combination of nine GCPs was obtained choosing at random a point of the five ones located inside each of the sub-areas in which the QuickBird scene was divided. For the combination of 18 GCPs two points per sector were chosen, for the one with 27 GCPs, three points by sector, and so on. The five combinations of GCPs remained constant in all the tests carried out.

Five GCPs's combinations and two 3D models were tested, thus, a total of ten 3D geometric correction models was generated (RF 1, RF 2, RF 3, RF, 4, RF 5, CCRS 1, CCRS 2, CCRS 3, CCRS 4 and CCRS 5). Once generated the 3D geometric correction models, root mean square errors in one dimension ($RMSE_{1D}$), maximum errors and mean errors were computed in X and Y coordinates on 79 ICPs. Root mean square errors in two dimension ($RMSE_{2D}$) (equation 1) also was calculated. These errors statistics report the goodness of the 3D geometric correction model used (RF or CCRS), depending on the number of GCPs.

$$RMSE_{2D} = \sqrt{RMSE_x^{\ 2} + RMSE_y^{\ 2}} \quad (1)$$

Later on, ten 3D geometric correction models previously computed were used to generate orthorectified images. For this purpose, two available DEMs (dense and coarse DEM) were used. $RMSE_{1D}$, $RMSE_{2D}$, maximum errors and mean errors were computed again for the 79 ICPs on each of the 20 orthorectified images generated. A descriptive diagram of the methodology used in this work is showed in Figure 3.

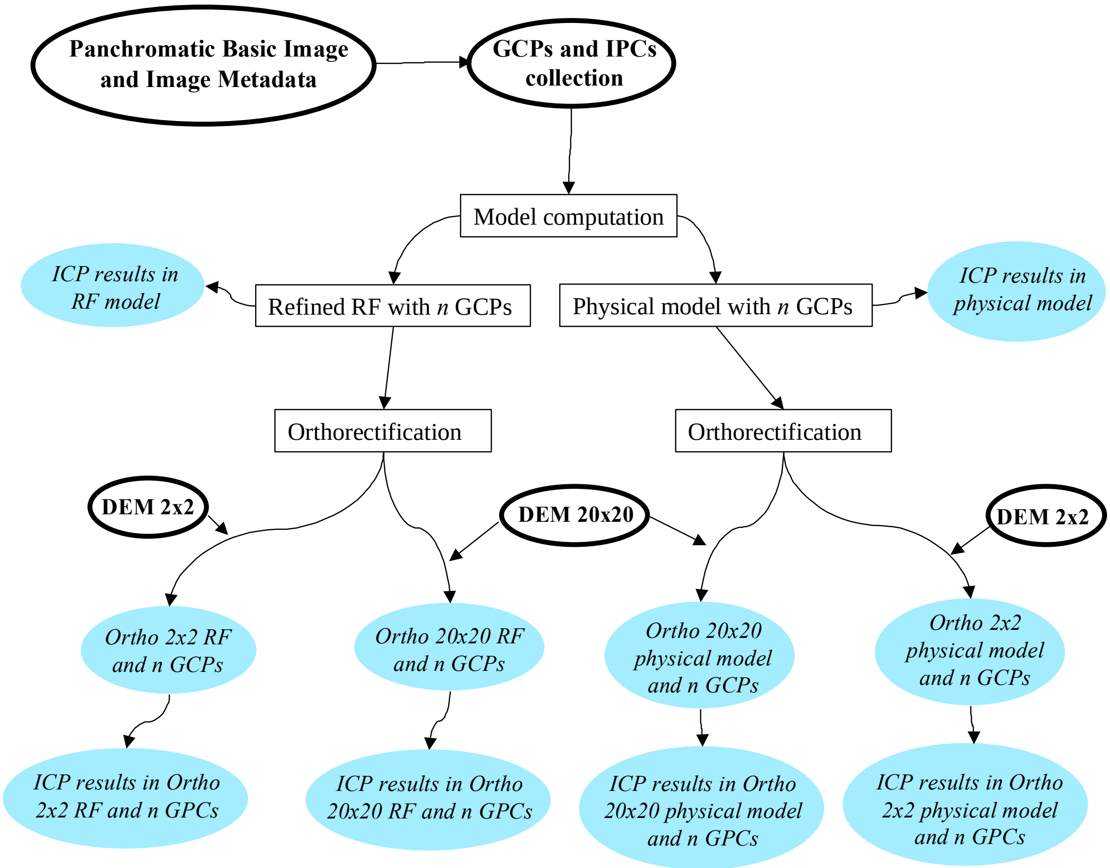

Figure 3: Descriptive diagram of the methodology used. The ellipses with edge symbols are input data, ellipses without edge symbols are output data and the box symbols are processes.

The digital orthophotos created have a GSD of 0.6 m. In the process of orthorectification, the radiometric operation uses a resampling kernel applied to original image cells. The best results are obtained with the sinusoidal resampling kernel (sin(x)/x with 16×16 windows) (Toutin, 2004a). This one was the resampling method used in 20 orthorectified images generated in this work.

3. RESULTS AND DISCUSSION

Errors made in the generation phase of the 3D geometric correction models in 79 ICPs and with different combinations of GCPs are shown in table 2. ICPs $RMSE_{1D}$ reflect the restitution accuracy, which includes feature extraction error and are, therefore, a good estimation of the final positioning accuracy of planimetric features (Toutin, 2004c). $RMSE_{1D}$ changes of between 0.58 m and 1.11 m when RF models were used. On the other hand, with the CCRS model, values for $RMSE_{1D}$ of between 0.39 m and 0.52 m (around $0.75 \times$ GSD) were obtained. Also, maximum and mean errors were high when the RFs were used.

Besides, with the RF models, inherent positional biases were detected in Y axis that arise from systematic errors in the sensor exterior orientation. These biases are well known and several strategies have been devised to remove their effects on ground point determination (Fraser et al., 2002; Robertson, 2003).

Both methods used to generate 3D geometric correction models were independent from the number of used GCPs. Therefore, nine well-defined and accurate GCPs seem a sufficient number for the generation of 3D geometric correction models in QuickBird Basic imagery of, both for the CCRS model and for the RF one. $RMSE_{2D}$ generated in the computation of the 3D models by number of GCPs are presented in Figure 4. $RMSE_{2D}$ generated with RF are almost twice the number of those obtained with CCRS.

In previous researches, when CCRS was used, $RMSE_{1D}$ between 0.5 m and 0.8 m were reported in the generation phase of the 3D geometric models on ICPs (Cheng et al., 2003; Cheng et al., 2003; Toutin and Chénier, 2004), although the GCPs used in some of these research works had a worse accuracy than the GCPs used in our work.

Table 2. $RMSE_{1D}$, maximum error and mean error, in the ICPs using a different number of GCPs and two 3D geometric correction models: Refined Rational Function (RF) and 3D multisensor physical geometric model developed at the Canada Centre for Remote Sensing (CCRS).

Model	GCPs	ICPs	ICPs $RMSE_{1D}$ (m)		Maximum Error (m)		Mean Error (m)	
			X	Y	X	Y	X	Y
RF 1	9	79	0.65	1.11	-1.73	-3.37	-0.30	-0.48
RF 2	18	79	0.61	1.08	-1.63	-3.30	-0.20	-0.41
RF 3	27	79	0.58	1.09	1.76	-3.32	0.04	-0.43
RF 4	36	79	0.58	1.08	1.70	-3.29	-0.03	-0.40
RF 5	45	79	0.58	1.11	1.77	-3.36	0.04	-0.47
CCRS 1	9	79	0.45	0.47	1.40	-1.49	0.10	-0.04
CCRS 2	18	79	0.45	0.48	-1.16	1.55	-0.03	0.02
CCRS 3	27	79	0.41	0.53	-1.08	-1.33	0.10	-0.12
CCRS 4	36	79	0.40	0.52	-1.17	-1.34	0.04	-0.11
CCRS 5	45	79	0.39	0.52	-1.19	1.35	0.06	-0.08

Table 3 shows the errors in 79 IPCs on the orthorectified images when coarse DEM are used. It shows as the $RMSE_{1D}$ added to the presented one in the table 2, due to the process of orthorectification with the coarse DEM, is lower in FR that in CCRS. Nevertheless, the increases in the produced errors were higher in axis *X* in both cases. This was the only time one when mean errors clearly different from zero were produced when CCRS was used.

Table 3. $RMSE_{1D}$, maximum error and mean error, in ICPs measured in the orthorectified imagery using a coarse DEM of 20×20 m.

Model	GCPs	ICPs	ICPs $RMSE_{1D}$ (m)		Maximum Error (m)		Mean Error (m)	
			X	Y	X	Y	X	Y
RF 1	9	79	0.85	1.23	2.33	-4.08	-0.09	-0.69
RF 2	18	79	0.86	1.20	2.72	-3.84	0.01	-0.65
RF 3	27	79	0.87	1.18	2.64	-3.92	0.24	-0.64
RF 4	36	79	0.88	1.21	2.61	-4.11	0.19	-0.65
RF 5	45	79	0.88	1.23	2.69	-4.10	0.26	-0.70
CCRS 1	9	79	1.03	0.79	2.28	-2.22	0.32	-0.31
CCRS 2	18	79	0.90	0.89	2.22	2.01	0.16	-0.22
CCRS 3	27	79	0.92	0.76	2.46	-1.97	0.33	-0.30
CCRS 4	36	79	0.90	0.74	2.29	-1.92	0.29	-0.34
CCRS 5	45	79	0.93	0.81	-2.32	-2.01	0.30	-0.37

Table 4 shows the total of errors in 79 IPCs on the orthorectified images when dense DEM are used. In this case, the highest increases of $RMSE_{1D}$ are produced when RF are used. The increases in the produced errors were higher in axis *X* for RF again, whereas the dense DEM did not produce biases when CCRS was used. When the dense MDE was used for the image orthorectification by CCRS model, $RMSE_{1D}$ of between 0.48 m and 0.61 m were obtained (only about 0.074 m more than $RMSE_{1D}$ of 3D geometric models computation). The maximum $RMSE_{1D}$ recommended by ASPRS draft (ASPRS, 1989) are 0.625 m, 1.25 m and 2.50 m for 1/2500, 1/5000 and 1/10000 scale Class 1 product respectively

Kay et al. (2003) reported $RMSE_{1D}$ on the QuickBird basic orthorectified images in 28 ICPs around 1.15 m and $RMSE_{2D}$ of 1.62 m when they used refined rational functions with only three or four DGPS GCPs and a DEM with $RMSE_z$<5 m. $RMSE_{2D}$ measured in orthorectified image by number of GCPs are shown in Figure 5, for two 3D correction models an two DEMs used in this work. It is possible to observe that the lines that join the different series are almost parallel, as it happened in Figure 4.

Table 4. $RMSE_{1D}$, maximum error and mean error, in the independent check points (ICPs) measured in the orthorectified imagery using a dense digital elevation model (DEM) of 2×2 m.

Model	GCPs	ICPs	ICPs $RMSE_{1D}$ (m)		Maximum Error (m)		Mean Error (m)	
			X	Y	X	Y	X	Y
RF 1	9	79	0.80	1.11	-2.28	-3.64	-0.45	-0.42
RF 2	18	79	0.76	1.13	-2.10	-3.59	-0.35	-0.35
RF 3	27	79	0.67	1.09	-1.88	-3.65	-0.11	-0.38
RF 4	36	79	0.70	1.08	-1.94	-3.53	-0.18	-0.36
RF 5	45	79	0.68	1.09	-1.92	-3.69	-0.12	-0.40
CCRS 1	9	79	0.50	0.55	-1.52	-1.82	-0.06	0.01
CCRS 2	18	79	0.51	0.57	-1.53	1.77	-0.12	0.06
CCRS 3	27	79	0.48	0.61	-1.47	-1.56	-0.04	-0.09
CCRS 4	36	79	0.50	0.58	-1.44	-1.56	-0.13	-0.09
CCRS 5	45	79	0.48	0.58	-1.54	1.52	-0.10	-0.05

The importance of the quality of the ancillary data (DEM, GCPs) with regard to the accuracy of the final products when very high resolution sensors were used, that had already been reported by some researchers (Lingua and Borgogno, 2003; Chmiel et al., 2004; Toutin and Chénier, 2004), has again been confirmed in this study. One must bear in mind that the possibility of having a dense DEM for image orthorectification is not very common. In this respect, the guidelines adopted by the European Commission for best practice in the orthorectification of very high resolution imagery (European Commission, 2003), DEM with <5 m $RMSE_z$ height accuracy is required for off nadir angles <15º and <2 m $RMSE_z$ for off nadir angles >15º.

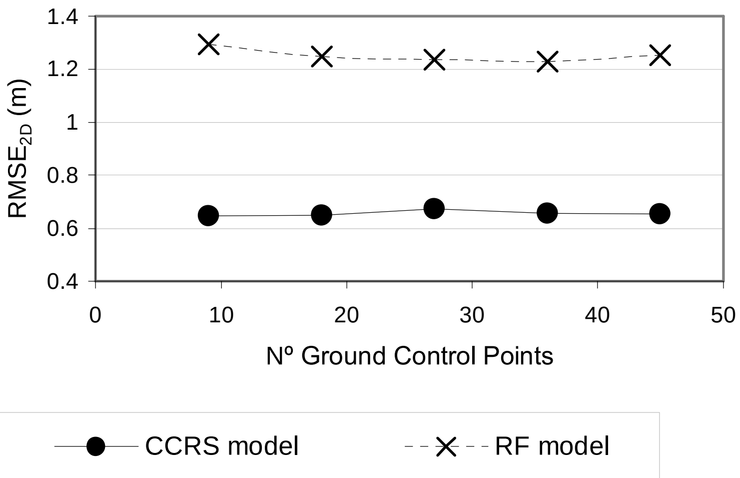

Figure 4: Planimetric Root Mean Square Error ($RMSE_{2D}$) obtained in 79 ICPs by number GCPs using both 3D geometric correction models: Refined Rational Function (RF) and 3D multisensor physical geometric model developed at the Canada Centre for Remote Sensing (CCRS).

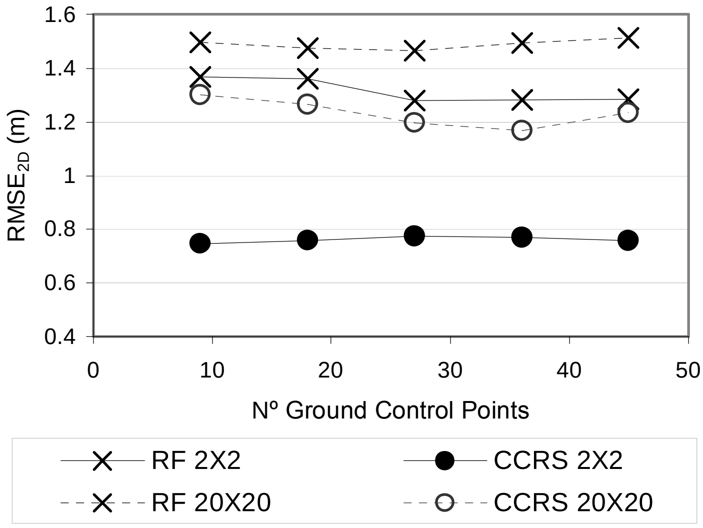

Figure 5: Planimetric Root Mean Square Error ($RMSE_{2D}$) obtained in 79 ICPs by number of GCPs, measured in the orthorectified images using two DEMs, dense of 2×2 m one and another coarse of 20×20 m.

4. CONCLUSIONS

The best accuracy results in the orthorectified images are obtained using CCRS model, although good results are also produced with the RF model. In addition, the results generated in the orthorectified images created with the CCRS model are very robust at complete scene and do not present biases due to the 3D geometric correction model. Thus, the CCRS model is more sensitive to the quality of the DEM used for orthorectification processes.

The best results for any of the two tested models are produced when nine well-defined, uniformly distributed (one in each cell of a 3x3 grid dividing the image) and accurate GCPs (DGPS measured) are used for the generation of the 3D geometric correction model. A larger number of GCPs does not improve the results and the cost of collecting them increases.

The study confirmed the high importance of the quality of ancillary data (DEM, GCPs) on the accuracy of the final products. When the dense MDE was used for the image orthorectification by CCRS model, $RMSE_{1D}$ of between 0.48 m and 0.61 m were obtained. These values correspond to approximately 0.8 or 1 pixel.

5. ACKNOWLEDGEMENTS

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Biography of the presenting author.

Manuel Ángel Aguilar Torres was born in La Carlota, Córdoba, Spain on January 4, 1972. After obtaining a degree in Rural Engineering from Córdoba University (Spain), in 1996, he was employed by the private sector for some years, carrying out work related to rural development. In 2001, he attained a Ph.D. in Rural Engineering from the University of Córdoba. Up until this moment his research is centred on the application of organic residues in olive groves in the Mediterranean area, working specifically with compost from sewage sludge.

In 2000 he begins to work as Associate Professor in the area of Graphical Expression in the Engineering Department at the University of Almería (Spain). Since then, he has taken part, together with his group of investigation "Tecnología de la Producción Agraria en Zonas Semiáridas" [http://www.ual.es/GruposInv/AGR-199], in several projects on the generation of digital cartography at large scales using digital photogrammetric workstations. He has also developed works related to agriculture, using close-range and low-cost photogrammetry (modelling equipment of tillage and obtaining micro-topography of agricultural soils). In the last few years, he has worked on the analysis and modelization of digital elevation models accuracy.

Recently, he has started developing a research project subsidized by the Andalusia Government on cartography at large scales update using QuickBird basic images for applications to rural development.