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GEOLOCATION EVALUATION OF RAPIDEYE 3A AND 1B ORTHORECTIFIED: CASE STUDY IN SÃO SEBASTIÃO/SP/BRAZIL

Avaliação da Exatidão da Geolocalização de Ortoimagens RapidEye 3A e 1B: Estudo de Caso em São Sebastião/SP/Brasil

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ABSTRACT

This study aims to present the results obtained in the geometric evaluation of two RapidEye scenes, acquired in two levels of processing: 1B and 3A. To evaluate the RapidEye 1B data, the parties were considered the two scenes that make up the 3A cut. Both 1B orthorectified scenes were considering two scenarios: using only the RPCs and also using nine-point control in the field (GCPs), and the MDE SRTM, using PCI Geomatic OrthoEngine 2013. The determination of the accuracy was made using 30 evaluation points. All points (control and evaluation) were collected in the field by making use of GNSS receivers of two frequencies through static relative positioning. For the assessment of accuracy was made comparing the coordinates of the evaluation points with their counterparts in orthoimagery (either 3A or that have been generated from 1B scenes). The 3A product has CE90 = 7.76 meters and standard deviation = 2.52 meters. When considering orthoimagery derived from the data 1B with GCPs, we have CE90 = 8.04 meters and standard deviation = 2.48 meters for February 2013 scene, and CE90 = 6.28 meters and standard deviation = 2.57 meters to the scene May 2013. For orthoimagery corrected without GCPs met CE90 = 6.8 m and standard deviation = 2.38 meters for the scene, 2013 and CE90 = 7.64 meters and standard deviation = 2.76 meters for the scene February 2013. Considering the PEC (Cartographic Accuracy Standards), the values obtained allow saying that the observed accuracies are compatible with the specified product to up the scale 1: 10,000, class B (orthoimage, 2013) and class C (orthoimagery February 2013 and 3A product). Making use of statistical inferences proposed by Vieira & Genro (2013), which estimate the accuracy for the population of the errors and the trend in the data, the results were not so good: all orthoimagery (3A, February and May 2013) would accuracy compatible with the specified product to scale 1: 25,000, class B. As the approach statistical inferences is more robust than specified in the PEC, the authors believe that the geolocation of RapidEye images evaluated in this study should be considered compatible with products in scale 1: 25,000, class B. The authors emphasize, though, that only the planimetric accuracy or the geolocation was evaluated. Products must undergo assessment of thematic accuracy to have a full assessment of your application, which is in progress.

Keywords: Positional Accuracy, Remote Sensing, Cartography.

RESUMO

Este trabalho se propõe a apresentar os resultados obtidos na avaliação geométrica de duas cenas RapidEye, adquiridas em dois níveis de processamento: 1B e 3A. Para avaliação dos dados RapidEye 1B, foram analisadas partes das duas cenas que compõem o recorte 3A. As duas cenas 1B foram ortorretificadas considerando-se dois cenários: usando-se apenas os RPCs e utilizando-se também nove pontos de controle no terreno (GCPs), além do MDE SRTM, fazendo uso do PCI Geomatica OrthoEngine 2013. A determinação da exatidão foi feita usando-se 30 pontos de avaliação. Todos os pontos (de controle e de avaliação) foram levantados em campo fazendo-se uso de receptores GNSS de duas frequências, através de posicionamento relativo estático. Para a avaliação da exatidão foi feita a comparação das coordenadas dos pontos de avaliação com seus homólogos nas ortoimagens (seja a 3A ou as que foram geradas a partir das cenas 1B). O produto 3A apresentou CE90 = 7,76 metros e desvio padrão = 2,52 metros. Ao se considerar as ortoimagens oriundas do dado 1B com GCPs, tem-se CE90 = 8,04 metros e desvio padrão = 2,48 metros para a cena de fevereiro de 2013, e CE90 = 6,28 metros e desvio padrão = 2,57 metros para a cena de maio de 2013. Para as ortoimagens corrigidas sem GCPs encontrou-se CE90 = 6,8 metros e desvio padrão = 2,38 metros para a cena de maio de 2013 e CE90 = 7,64 metros e desvio padrão = 2,76 metros para a cena de fevereiro de 2013. Considerando-se o PEC (Padrão de Exatidão Cartográfica), os valores obtidos permitiriam dizer que as exatidões observadas são compatíveis com o especificado para produtos até a escala 1:10.000, classe B (ortoimagem de maio de 2013) e classe C (ortoimagens de fevereiro de 2013 e produto 3A). Fazendo uso das inferências estatísticas propostas por Vieira & Genro (2013), que estimam a exatidão para a população dos erros e a tendência observada nos dados, os resultados não foram tão bons: todas as ortoimagens (3ª e 1B de fevereiro e maio de 2013) teriam exatidão compatível com o especificado para produtos na escala 1:25.000, classe B. Como a abordagem por inferências estatísticas é mais robusta do que o especificado no PEC, os autores consideram que a geolocalização das imagens RapidEye avaliadas neste estudo deve ser considerada compatível com produtos na escala 1:25.000, classe B. Os autores enfatizam, ainda, que apenas a exatidão planimétrica ou da geolocalização foi avaliada. Os produtos devem passar por avaliação da exatidão temática para se ter uma avaliação completa de sua aplicação, o que se encontra em andamento.

Palavras chaves: Acurária Posicional, Sensoriamento Remoto, Cartografia.

1. INTRODUCTION

Today we are witnessing a reality marked by a strong technological development, due to the increased computing in various areas of activity, which, despite the advantages offered, has sharply causing different impacts due mainly to the speed with which it installs. Since the last decade of the twentieth century, we can see a rapid growth in the use of remote sensing products with higher spatial resolution, allowing you to work more and more, with products that meet the more detailed scales.

With regard to remote sensing, it can be said that today is a powerful source of environmental data. Not long ago, the separation of products from remote sensing in orbital and air level covered clearly distinct market niches. Today, however, the situation is a little different and some demands that were covered exclusively by aerial photography can now be served by orbital products.

It is true that the consideration of the possible level of information to be obtained in orbital images is becoming more variable and dependent on a number of situations, but the main one is found tied to the resolutions related to the capture of data, directly related to the type of used sensor (Cruz, 2000). Considering the diversity of today's existing sensors and a number of others who are about to become available, it is necessary to investigate, with some urgency, which demands can be met.

The technical and scientific point of view, remote sensing images from orbital bases, are already serving as a data source for studies and geomorphological surveys, geological, agricultural, mapping, forestry, epidemiological, urban, oceanographic, among others. That not only weigh meet the demands related to these areas of knowledge, but also the fact of being formed a critical base of users familiar with these products. In an integrated, rational design, many organs are already public acquiring images, which in some cases could serve more of a demand, a cost reduction that actually experienced by our country may be relevant. One of the greatest examples of this is the purchase of RapidEye images by the Federal Government, through the Ministry of Environment, in law model of use that allows other public agencies can make use of such data without charge.

The national mapping presents serious problems related to updating and availability of bases at appropriate scales to various studies (Cruz, 2000), especially in scales greater detail the systematic mapping. On the other hand, the development of remote sensing in an orbital base may contribute to this task, sensors constructed as a higher order geometric accuracy may in some ratios, replacing the photo areas for a much lower cost. This is the case, for example, the RapidEye satellite sensors whose characteristics enable the generation of maps or update existing maps in accordance planimetric possibly contributing to a scale of 1: 25,000 to 1: 100,000.

Given the new technological reality in the data collection area and mapping in general, the investigation of the possibility of its use for activities related to national mapping is required. On the other hand, proposals for changes in mapping methods traditionally used in the production, in general, are much resistance. Not doing them is a very great cost to the country over the last few decades, has seen his cartography present a very small production because of a large set of difficulties encountered in most Brazilian public agencies, such as lack of funds, personnel structure.

In this sense we need to stay up to date on the new products, assess their potential, know your limitations to provide a basis for an evaluation grounded cost-effective. Thus, depending on the results, one can make a proposal to include some of these new technologies in cartographic production line in order to meet the demand of users who require updated mappings and whose quality can be known and trusted (Barros, 2006) .

Outside of the systematic mapping universe, this kind products can have a range of broader applications, supporting studies aimed at large areas as is quite common in a country like Brazil. Surely, as well as issues related to accuracy, in thematic cartography there is great weight given to the availability, simplicity in handling, cost, scope. And these aspects the RapidEye data can contribute a lot.

1.1 Objectives

The objective of this study is to analyze the planimetric accuracy observed in two RapidEye scenes, acquired in two processing levels (1B and 3A), the 1B orthorectified image in PCI Geomatic with RPC (Rational Polynomial Coefficients), GCP (Control points Land) and MDE (Digital Elevation Model) and SRTM 3A image automatically orthorectified by the supplier.

2. CHARACTERIZATION OF AREA

The study area is located in São Sebastião, São Paulo (Figure 1), with land area of approximately 400 square kilometers, and resident population in 2010 of 73,942 people (IBGE, 2010). During the high season of tourism, the local population increases significantly. The city is approximately 215 km from São Paulo and 260 kilometers from Rio de Janeiro and is composed of two districts: São Sebastião and Maresias. To the north, São Sebastião borders on Caraguatatuba, southwest and northwest with Bertioga, already on the plateau, with the municipality of Salesópolis. In the eastern part lies the island of São Sebastião, where is located the municipality of Ilha Bela.

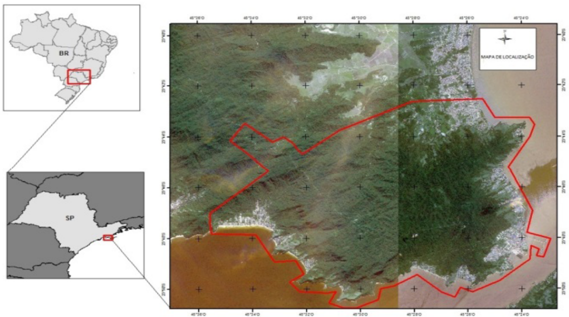

Fig. 1 – Location of the study area.

Besides the beaches, the city is also characterized by tectonic escarpment of the Serra do Mar, whose height can reach about 1,000 meters. In several places, the slope approaches the coastline, limiting the expansion of certain economic activities and of the urban area. The area's most extensive plains are located in the municipalities of Caraguatatuba and Bertioga.

In the mountainous area observed the presence of the cover of the Atlantic Forest, in which predominates the tropical rain forest. In the coastal area, however, they can be highlighted also other important ecosystems, such as some areas of mangroves and salt marshes.

The city's economy started to grow from the 1930s, when it established the road connecting São Sebastião with the Vale do Paraíba (Paraíba Valley). From there the old port was reactivated, giving flow to products coming from the state (IBGE, 2010).

Another influential factor in the local economy was the installation in São Sebastião channel, the terminal of PETROBRAS, through which much of the oil destined for refineries located on the plateau.

Thus, the port activity and tourism to São Sebastião represent the main sources of employment and income for the population. No wonder that its urban space is consolidated in the vicinity of the public port of São Sebastião, the ferry terminal PETROBRAS and its storage areas.

3. MATERIALS AND METHODS

The following items present the main materials and methods used in this study.

3.1 Images

The RapidEye images are acquired by sensors called REIS, which are equal and are aboard a constellation of five satellites RapidEye called. The nominal spatial resolution is 6.5 meters. Images can be acquired at different levels of processing, with emphasis on the 3A level, which is the "shelf product," ie, the most common and which was acquired by the Brazilian Government to the Ministry of Environment. This product has radiometric and orthorectification corrections made automatically by the supplier, using MDE SRTM and is distributed in cuts (tiles) with a length of 25 x 25 kilometers, with pixel resampled to 5 meters. There is also the 1B level, where the images have radiometric corrections and positioning applied from the ephemeris data and attitude of satellites. At this level the product is distributed in the PRC. The images in this level of processing are distributed with pixel showing the dimensions of the nominal spatial resolution: 6.5 meters.

Were analyzed 2 RapidEye scenes acquired on different days and bought from different processing levels. The first product was analyzed the clipping regarding the priority area for study. This cut is made up of parts of two scenes: an acquired on February 25, 2013 (ID 2328113) by REIS sensor 5 and another on May 3, 2013 (ID 2328112), acquired by REIS sensor 1. The second product were analyzed scenes for the previous crop bought, but at 1B processing level.

As shown in Figure 1, which shows the area by study of the scenes forming the cut, it appears radiometric difference between them. In some cases this leads to difficulties in homogenizing a study area covered by various factors.

For orthorectification the scenes 1B was used MDE SRTM 90m version 4 and checkpoints on the ground, collected in the field specifically for this purpose.

3.2 Field Survey for Processing and Evaluation of RapidEye products of São Sebastião

We selected 39 points for determination of coordinates in the field, 30 points reserved for the evaluation of planimetric accuracy and 9 points for use in the orthorectification of the two scenes level 1B comprising the clipping level 3A.

Each point assessment was planned so that was well identifiable in the picture and could be occupied in the ground surface. The vast majority of checkpoints and evaluation refers to cross roads or paths. It sought to ensure that the control points and the evaluation were distributed throughout the analyzed area, although the presence of Serra do Mar prevent that obtain a homogeneous distribution. Endeavored to carry out the survey points in duct servitude area and in some stretches where road approaches or crosses the duct. Figure 2 shows the location of the evaluation points. The field survey was conducted in July 2014, on the plains and in the mountain region, in the surroundings of São Sebastião.

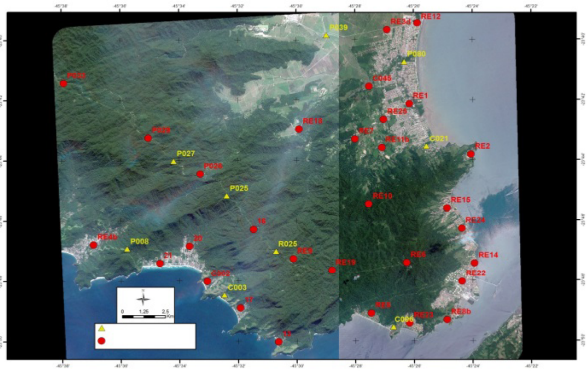

Fig. 2 – Distribution of points of control and evaluation on the image RapidEye 3A.

To determine the coordinates of the selected during the planning of field points were used trackers GNSS (Global Navigation Satellite System) dual frequency Trimble R6 model by relative static positioning method. The field team was composed of a cartographic engineer, a surveyor and two geographers.

To facilitate the field survey, a transport from the base of SAT 91606 point, located in Ilha Bela (SP) was done for a landmark installed in a hostel located in São Sebastião within 10 km of the SAT point. This transport is done with two-day screening for four hours each day, with the same two frequencies trackers. The points determined from the new base away to a maximum of 22 kilometers and have always been traced for at least 20 minutes with 5 seconds of screening rate. The antenna height was standardized at 2 meters. During the screenings, sketches were made illustrating the survey point, as well as a photo record so that each point were photographed in different perspectives, in order to assist in phase identification on images.

In case the data were processed using the TBC software, Trimble, with accuracy specification of up to 5 centimeters in planimetry and 10 centimeters in altimetry. All points were below those limits.

4. ACCURACY PLANIMETRIC EVALUATION OF RAPIDEYE PRODUCTS ACCORDING TO THE PEC

To perform planimetric evaluation of RapidEye products were used as input images in levels 1B (floor), the PCI orthorectified and OrthoEngine 3A (orthorectified by the supplier). This review considered the PEC (Cartographic Accuracy Standards) as a reference, i.e 90% of the tested points should have smaller errors than specified for the scale and target class, and standard deviation of the entire set of samples should be less than the amount also indicated in the same scale and class.

4.1 Evaluation of Images RapidEye 1B

Regarding images with 1B processing level, it performed the process of orthorectification on the raw images of the two dates (February and May), by using the software *OrthoEngine* PCI Geomatic version in 2013, which presents the specific correction parameters for the sensor RapidEye in addition to using the RPC files (*Rational Polynomial Coeficient*) made available in conjunction with the images on this processing level.

In order to assess the advantage of using control points (GCP) were considered two scenarios in orthorectification both using MDE SRTM:

Scenario 1 - The use of only RPC without the use of GCP;

Scenario 2 - Using RPC with the adjustment using 9 GCPs.

In the first scenario tested using *Rational Function* model, was not selected for any GCP orthorectification 1B of product images, that is, correction was made only using the parameters defined in the RPC files accompanying the images and the MDE SRTM.

Analyzing the image 1B, may 2013, orthorectified with RPC and without GCP in PCI OrthoEngine 2013, it was found that the error observed in 90% of the 30 evaluation points (CE90) was 6.80 meters (CE90) and standard deviation 2.38 meters. Thus it is possible to say that their planimetric accuracy is consistent with what is specified for the product in scale 1: 10,000, class B. Figure 3 shows the location of points and their errors.

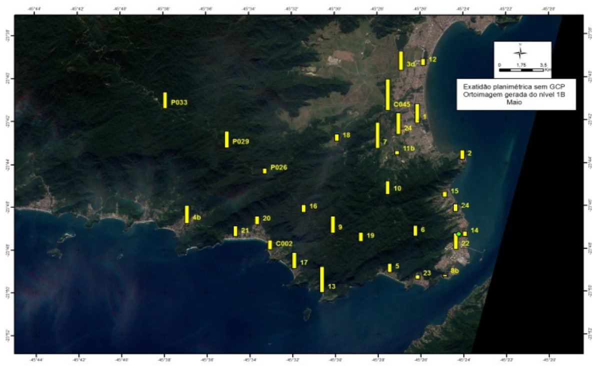

Fig. 3 – Distribution of errors observed in RapidEye 1B image acquired in May 2013 orthorectified with RPCs and without GCPs.

In relation to the image of February, it was found that the error observed in 90% of the 30 evaluation points (CE90) was 7.64 meters (CE90) and standard deviation of 2.76 meters. Thus it is possible to say that their planimetric accuracy is consistent with what is specified for the product in scale 1: 10,000, class B. Figure 4 illustrates the distribution of errors.

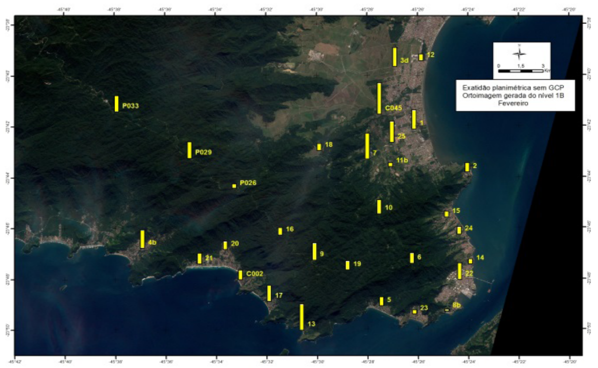

Fig. 4 – Distribution of errors observed in RapidEye 1B image acquired in February 2013 orthorectified with RPCs and without GCPs.

In the second scenario tested, using *Rational Function* Model, 9 GCPs were selected for modeling of two scenes that made the 3A Cut. The modeling for image orthorectification, level 1B of February generated a total of 0.80 pixel RMS (5.2m).

For orthorectification and the definition of the GCPs, you must use the digital elevation model to minimize the deformations due to relief. Thus, we used the same reference MDE defined by suppliers in their technical documentation: MDE SRTM version 4 (BLACKBRIDGE, 2013).

From this model, the image orthorectification was performed RapidEye, of February 2013. The error observed in 90% of the 30 evaluation points (CE90) was 8.04 meters and standard deviation of 2.48 meters. These values allow saying that this product is compatible with planimetric accuracy specified for products in the scale 1: 10,000, class C. The smallest and the largest error value observed in this scene of February was 1.01 and 9.99 meters respectively. Figure 5 illustrates the location of points and their corresponding errors.

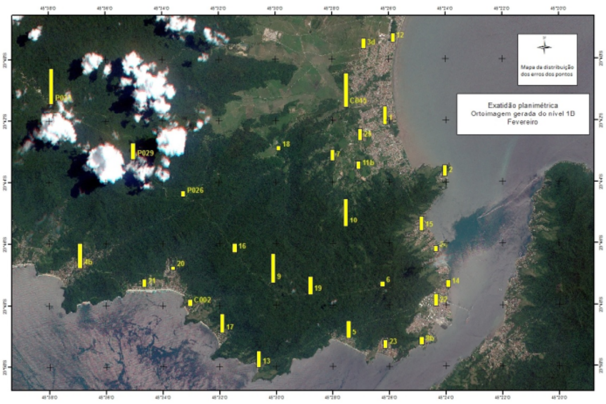

Fig. 5 – Distribution of errors observed in RapidEye 1B image acquired in February 2013 orthorectified with RPCs and GCPs.

Modeling for orthorectification image 1B level of May 2013 generated a total of 0.88 pixel RMS (5.72 meters). From this model, the RapidEye image orthorectification was held May 2013. The error observed in 90% of 30 evaluation points (CE90) was 6.28 meters and standard deviation of 2.57 meters. These values allow saying that this product is compatible with planimetric accuracy specified for the scale 1: 10,000, classing B. The smallest and the largest error value observed this scene of February was 0.30 and 10.76 meters, respectively. Figure 6 illustrates the location of points and the respective errors.

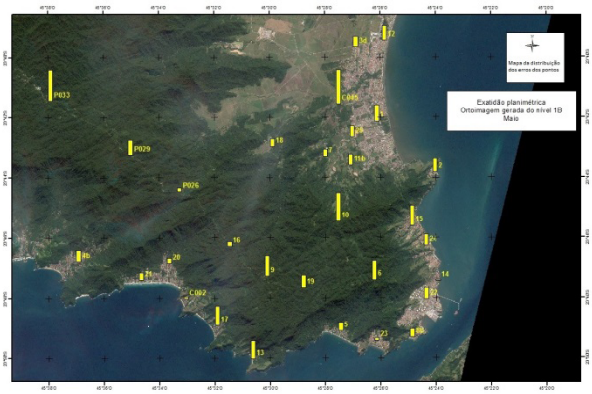

Fig. 6 – Distribution of errors observed in RapidEye 1B image acquired in May 2013, orthorectified with RPCs and GCPs.

4.2 Picture Rating RapidEye 3A

The suppliers usually sell to their customers orthorectified image (3A) through the delimitation of their area of interest. The client provides a file outlining your area, with a minimum area of 500 km². Upon receiving the data, the project team has found that the image 3A provided consisted of two pieces of images acquired at two different dates, as shown in Figure 7. Although there was a technical impediment to this, this can generate an evaluation with different results for each part of the image. The image is located west of May 2013, while the image is located in the eastern part of February 2013.

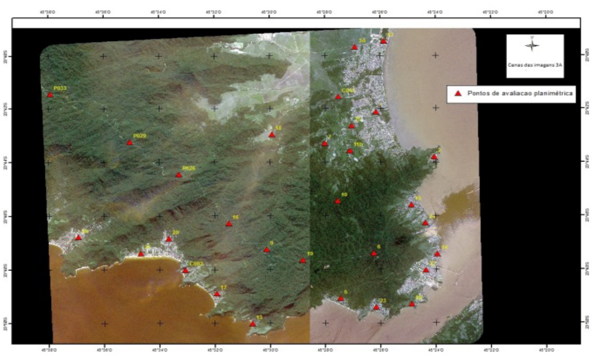

Fig. 7 – RapidEye Cut, level 3A.

The error observed in 90% of the 30 evaluation points (CE90) was 7.76 m and standard deviation of 2.52 meters. These values allow RapidEye to say that this cut, with 3A processing level, presents planimetric accuracy compatible with the specified product to scale 1: 10,000, class B. The smallest and the largest error value observed this scene of February was 0, 30 and 9.95 meters, respectively. Figure 8 illustrates the location of points and the respective erros.

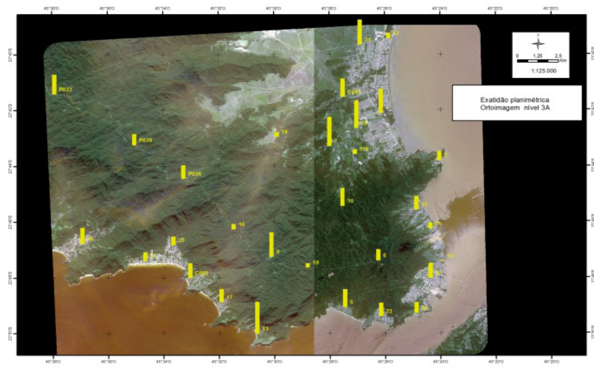

Fig. 8 – Distribution of errors observed in the image RapidEye, level 3A.

5. EVALUATION PLANIMETRIC USING STATISTICS INFERENCES, ACCORDING TO VIEIRA & GENRO (2013)

The evaluation map products using only the PEC may be considered incomplete or at least outdated. PEC is present in the decree 89817, June 1984 and specify references related to the analog cartography, appropriate for another time and technological level. It is important to update it, but these attempts have been lackluster or restricted, making the PEC still, 30 years after its publication, the only official reference and used nationally. The proposed Vieira & Genro (2013), presented here, using the most robust statistical inferences, it helps to complement this analysis.

Vieira & Genro (2011) have proposed a statistical approach to planialtimetrics reviews of cartographic products, referencing Merchant (1982) and Galo (1994). In 2013, the same Vieira & Genro refine its proposal in order to indicate a way to estimate the accuracy regardless of the existence of relevant trend, based on an adaptation of Congalton & Green (2009), summing up the frame accuracy standards predefined in the probable maximum error in relation to confidence intervals.

The applied statistical foundations are based on the Cartographic Accuracy Standard (PEC), considering 90% probability for different classes and as statistical inference, the t-Student distribution, emphasizing that the accuracy values depend, primarily, on the method of sampling. It is worth noting, according to Vieira & Genro (2013), this method applies to larger samples of 20 points.

The estimated positional accuracy standard is performed in this way, through the *t-Student* distribution at a confidence interval of 90% (0.1), with corresponding central value to the root mean square errors (RMSE) obtained from samples. For planimetry it can be applied to both the resulting (as laid down in legislation) and for the X and Y components (in this case, Easting and North), so as to allow the diagnosis of various problems (VIEIRA & GENRO 2013).

Tables 1, 2 and 3 show the calculations made for the generation of RMSE of components and planimetric resulting for the 30 sampling points collected in the field. Table 1 refers to the inferences regarding the planimetric RapidEye image evaluation 3A level (orthorectified by the supplier), while Tables 2 and 3 deal with the calculations for the orthorectified images 1B level from the use of RPCs and adjust with 9 GCPs and MDE SRTM for the months of February and May, respectively.

Based on these values were calculated standard deviations of error population (SRMSE), which are shown in the table along with the root mean square error estimates of the population (RMSE).

The values observed in Table 1, the RapidEye 3A image evaluated meets, in terms of planimetric accuracy, the specified products to scale 1:25,000, class B. It can be seen that there is a slight tendency in this coordinates (E).

The values observed in Table 2, the image RapidEye 1B of May also meets, in terms of planimetric accuracy, the specified products to scale 1:25,000, class B. There is no trend in this case.

The values observed in Table 3, the image RapidEye 1B of February also meets, in terms of planimetric accuracy, the specified for the scale 1:25,000, class B. In this image there is very little trend in North direction (N).

Table 1: Statistical inference for accuracy calculation and tendency to Rapideye image, level 3a

ESTIMATION OF MEAN SQUARED ERROR OF ERROR POPULATION				
$RMSE_{\Delta x} = \sqrt{\frac{(\sum_{i=1}^{N} \Delta X_i^2)}{N}}$	$RMSE_{\Delta N}$	$RMSE_{\Delta E}$	$RMSE_{\Delta H}$	
	4,05 m	3,07 m	-	
$RMSE_{\Delta P} = \sqrt{RMSE_{\Delta E}^2 + RMSE_{\Delta N}^2}$	$RMSE_{\Delta P}$ 5,08 m			
Estimation of standard deviation of error population				
$S_{RMSE_{\Delta X}} = \sqrt{\left[\frac{\sum_{i=1}^{N}(\lvert\Delta X\rvert_i - RMSE_{\Delta x})^2}{N-1}\right]}$	$S_{RMSE_{\Delta N}}$	2,61m		
	$S_{RMSE_{\Delta E}}$	1,98 m		
	$S_{RMSE_{\Delta H}}$	-		
$S_{RMSE_{\Delta P}}^2 = \left(\frac{RMSE_{\Delta N}}{\sqrt{RMSE_{\Delta N}^2 + RMSE_{\Delta E}^2}}\right)^2 . S_{RMSE_{\Delta N}}^2 + \left(\frac{RMSE_{\Delta N}}{\sqrt{RMSE_{\Delta N}^2 + RMSE_{\Delta E}^2}}\right)^2 . S_{RMSE_{\Delta E}}^2$	$S_{RMSE_{\Delta P}}$ 2,40 m			
Confidence intervals of estimated accuracy of the error population				
$t_{90\%,N-1}$ (bicaudal)	1,6991			
$RMSE_{\Delta x} \pm t_{90\%,N-1}(S_{RMSE_{\Delta X}})$	Planimetry	Altimetry		
	5,08 $\pm$ 4,08m	-		
Estimated accuracy of the population from the probable maximum error (Analogy to PEC)				
$t_{90\%,N-1}^{\theta}$ (acumulada)	1,3114			
$RMSE_{\Delta x} + t_{90\%,N-1}^{\theta}(S_{RMSE_{\Delta X}})$	Planimetry	Altimetry		
	15,99 m	-		
TREND ASSESSMENT				
Estimatation of standard deviation of waste population				
$S_{\Delta \bar{X}} = \sqrt{\frac{\sum_{i=1}^{N}(\Delta X_i - \Delta \bar{X})^2}{N-1}}$	$S_{\Delta \bar{P}}$	$S_{\Delta \bar{N}}$	$S_{\Delta \bar{E}}$	$S_{\Delta \bar{H}}$
	2,53m	4,10m	2,88m	-
Mean estimate of waste population				
$\Delta \bar{X} = \frac{(\sum_{i=1}^{N} \Delta X)}{N}$	$\Delta \bar{P}$	$\Delta \bar{N}$	$\Delta \bar{E}$	$\Delta \bar{H}$
	4,43 m	-0,33m	1,17m	-
Statistics				
$t_{90\%,N-1}$ (bicaudal)	1,6991			
$t_{amostral} = (\Delta \bar{X}/S)\sqrt{N}$	N	E	H	
	-0,4503	**2,2666**	-	

The statistical inferences were applied only to the RapidEye 3A level scene - which is the typical product for this sensor - and the two scenes RapidEye level 1B image (February and May) orthorectified with use of RPC and adjust with 9 GCP.

Table 2: Statistical inference for accuracy calculation and tendency to orthorectified image from the Rapideye (1b) of may with the use of rpcs and adjust using gcps.

ESTIMATION OF MEAN SQUARED ERROR OF ERROR POPULATION			
$RMSE_{\Delta x} = \sqrt{\frac{(\sum_{i=1}^{N} \Delta X_i^2)}{N}}$	$RMSE_{\Delta N}$	$RMSE_{\Delta E}$	$RMSE_{\Delta H}$
	3,34 m	3,38 m	-
$RMSE_{\Delta P} = \sqrt{RMSE_{\Delta E}^2 + RMSE_{\Delta N}^2}$	$RMSE_{\Delta P}$ 4,75 m		
Estimation of standard deviation of error population			
$S_{RMSE_{\Delta X}} = \sqrt{\left[\frac{\sum_{i=1}^{N}(\lvert\Delta X\rvert_i - RMSE_{\Delta x})^2}{N-1}\right]}$	$S_{RMSE_{\Delta N}}$	2,15 m	
	$S_{RMSE_{\Delta E}}$	2,45m	
	$S_{RMSE_{\Delta H}}$	-	
$S_{RMSE_{\Delta P}}^2 = \left(\frac{RMSE_{\Delta N}}{\sqrt{RMSE_{\Delta N}^2 + RMSE_{\Delta E}^2}}\right)^2 . S_{RMSE_{\Delta N}}^2 + \left(\frac{RMSE_{\Delta N}}{\sqrt{RMSE_{\Delta N}^2 + RMSE_{\Delta E}^2}}\right)^2 . S_{RMSE_{\Delta E}}^2$	$S_{RMSE_{\Delta P}}$ 2,31 m		
Confidence intervals of estimated accuracy of the error population			
$t_{90\%,N-1}$ (bicaudal)	1,6991		
$RMSE_{\Delta x} \pm t_{90\%,N-1}(S_{RMSE_{\Delta X}})$	Planimetry 4,75 ± 3,92m	Altimetry -	
Estimated accuracy of the population from the probable maximum error (Analogy to PEC)			
$t_{90\%,N-1}^{\theta}$ (acumulada)	1,3114		
$RMSE_{\Delta x} + t_{90\%,N-1}^{\theta}(S_{RMSE_{\Delta X}})$	Planimetry **14,37 m**	Altimetry -	
TREND ASSESSMENT			
Estimatation of standard deviation of waste population			

	$S_{\Delta\bar{P}}$	$S_{\Delta\bar{N}}$	$S_{\Delta\bar{E}}$	$S_{\Delta\bar{H}}$
$S_{\Delta\bar{X}} = \sqrt{\frac{\sum_{i=1}^{N}(\Delta X_i - \Delta\bar{X})^2}{N-1}}$	2,61m	3,38m	3,41m	-
Mean estimate of waste population	$\Delta\bar{P}$	$\Delta\bar{N}$	$\Delta\bar{E}$	$\Delta\bar{H}$
$\Delta\bar{X} = \frac{(\sum_{i=1}^{N} \Delta X)}{N}$	4,00 m	0,26m	0,43m	-
Statistics				
$t_{90\%,N-1}$ (bicaudal)	1,6991			
$t_{amostral} = (\Delta\bar{X}/S)\sqrt{N}$		N	E	H
		0,4236	**0,6864**	-

Table 3: Statistical inference for accuracy calculation and tendency to orthorectified image from the Rapideye (1b) of february with the use of rpcs and adjust using gcps.

ESTIMATION OF MEAN SQUARED ERROR OF ERROR POPULATION			
$RMSE_{\Delta x} = \sqrt{\frac{(\sum_{i=1}^{N} \Delta X_i^2)}{N}}$	$RMSE_{\Delta N}$	$RMSE_{\Delta E}$	$RMSE_{\Delta H}$
	3,59 m	2,93 m	-
$RMSE_{\Delta P} = \sqrt{RMSE_{\Delta E}^2 + RMSE_{\Delta N}^2}$	$RMSE_{\Delta P}$ 4,64 m		
Estimation of standard deviation of error population			
$S_{RMSE_{\Delta X}} = \sqrt{\left[\frac{\sum_{i=1}^{N}(\lvert\Delta X\rvert_i - RMSE_{\Delta x})^2}{N-1}\right]}$	$S_{RMSE_{\Delta N}}$	2,28 m	
	$S_{RMSE_{\Delta E}}$	1,96 m	
	$S_{RMSE_{\Delta H}}$	-	
$S_{RMSE_{\Delta P}}^2 = \left(\frac{RMSE_{\Delta N}}{\sqrt{RMSE_{\Delta N}^2 + RMSE_{\Delta E}^2}}\right)^2 . S_{RMSE_{\Delta N}}^2 + \left(\frac{RMSE_{\Delta N}}{\sqrt{RMSE_{\Delta N}^2 + RMSE_{\Delta E}^2}}\right)^2 . S_{RMSE_{\Delta E}}^2$	$S_{RMSE_{\Delta P}}$ 2,16 m		
Confidence intervals of estimated accuracy of the error population			
$t_{90\%,N-1}$ (bicaudal)	1,6991		
$RMSE_{\Delta x} \pm t_{90\%,N-1}(S_{RMSE_{\Delta X}})$	Planimetry 4,64 ± 3,66m	Altimetry -	
Estimated accuracy of the population from the probable maximum error (Analogy to PEC)			
$t_{90\%,N-1}^{\theta}$ (acumulada)	1,3114		
$RMSE_{\Delta x} + t_{90\%,N-1}^{\theta}(S_{RMSE_{\Delta X}})$	Planimetry **13,12 m**	Altimetry -	
TREND ASSESSMENT			
Estimatation of standard deviation of waste population			

	$S_{\Delta\bar{P}}$	$S_{\Delta\bar{N}}$	$S_{\Delta\bar{E}}$	$S_{\Delta\bar{H}}$
$S_{\Delta\bar{X}} = \sqrt{\frac{\sum_{i=1}^{N}(\Delta X_i - \Delta\bar{X})^2}{N-1}}$	2,48m	3,49m	2,99m	-
Mean estimate of waste population	$\Delta\bar{P}$	$\Delta\bar{N}$	$\Delta\bar{E}$	$\Delta\bar{H}$
$\Delta\bar{X} = \frac{(\sum_{i=1}^{N} \Delta X)}{N}$	3,95 m	-1,08m	-0,09m	-
Statistics				
$t_{90\%,N-1}$ (bicaudal)	1,6991			
$t_{amostral} = (\Delta\bar{X}/S)\sqrt{N}$	N	E	H	
	-1,7206	-0,1597	-	

6. FINAL CONSIDERATIONS

The results of the RapidEye orthoimagery, level 3A and orthoimages generated from the 1B level showed values even better than expected. Even considering the characteristics of the local relief, which presents significant altimetric gaps, there is no major mistakes trend in higher areas.

The results observed in this case study, we cannot say if the product 1B orthorectified presents the best results of geometric correction with respect to 3A product. While 3A showed better image values (CE 90 = 7.76m) of the February image 1B (CE 90 = 8.04m), the May image 1B had a better evaluation (CE 90 = 6.28m) than 3A. Added to this, the observed differences are very small compared with the spatial resolution of the RapidEye images (6.5 and 5.0 meters). I.e, much smaller differences than the pixel size can be explained by normal variations in identifying the image of the point raised in the field.

It was also observed that the evaluations according to the methodology proposed by Vieira & Genro (2013) have always been more critical, leading to a classification of products at smaller scales than those indicated in the evaluations under the PEC. It should be emphasized that the PEC, although outdated, is still the official Brazilian standard for assessment of cartographic products.

What is considered more relevant in the results obtained is that, within the same valuation approach, the products showed very similar results and always according to the supplier's specification: even considering the assessment proposed by Vieira & Genro (2013), the products meet the specified for the scale 1:25,000, as the supplier does not indicate the mapping class.

Due to the robustness of the approach by statistical inferences of Vieira & Genro (2013), the authors understand that evaluated orthoimages feature planimetric accuracy compatible with the specified for the scale 1: 25,000, class B.

Considering the cost-benefit ratio and considering only the data used in ratings reported here, the use of "shelf" RapidEye product, ie, the 3A level image is the most suitable for purchase, since attended the same specification scale that 1B orthorectified images by the user, at least in this case study.

It is emphasized that this article presents only the results for the evaluation of the planimetric accuracy (or geometric or positional) of data. That is, even having been pointed out that the RapidEye images evaluated have submitted planimetric accuracy compatible with the specified for the scale 1:25,000 does not mean that these same images are appropriate for extracting data for products in the scale of 1:25,000. They cannot provide sufficient detail for cartographic products in this range, although its geometry is compatible with it.

Although they are important inputs for cartographic production, data obtained by remote sensors have limitations of the equipment, which may preclude satisfactory classification of images. But how to identified the characteristics of an ideal sensor to meet certain applications? How to set the best sensor that meets a certain cartographic scale in geometric terms and interpretation? Images from a sensor can meet the positional accuracy requirements, but are not suitable for extraction of features that check the accuracy thematic map. The answers to these questions necessarily go through the assessment measures the positional quality and also for assessing the expected quality theme for a particular sensor.

Congalton & Green (2009) point out that, unlike the positional accuracy, there are no official standards established to assess the thematic accuracy. This fact is explained by the complexity of the matter, moreover, studies of thematic accuracy only intensified from the development of remote sensing techniques in recent years.

Studies are being developed to propose an image Interpretability Index, which would be an indicator for the thematic accuracy that can be expected from products extracted from images of a sensor data.

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