CO-191

GEOLOCATION ACCURACY EVALUATION OF GEOEYE-1 ORTOIMAGES

BARROS R., CRUZ C., BARBOSA S., CARDOSO P., SANTOS R., ROSáRIO L.
UFRJ, RIO DE JANEIRO, BRAZIL

1. INTRODUCTION

The brazilian cartography has serious problems related to the update of bases and the availability of maps at scales appropriate to a variety of studies. This situation is worse for larger scales of detail, very important in municipal applications. In this sense, the use of images of high spatial resolution has been very important to the generation of large-scale maps, especially for countries with continental dimensions like Brazil.

For nearly a decade, high resolution sensors are constituting themselves into some very interesting options for mapping. Today there are various options available and considering one of the latest satellites, GeoEye has been the object of this study.

The GeoEye-1, launched in September 6, 2008 from Vandenburg Air Force Base in California (Geoeye, 2010), is one of the satellites responsible for generating images with high spatial resolution for civil uses nowadays. Its geometric accuracy specification suggests it is useful for applications in large scales, if high cost of high resolution images is compatible with the desired application.

The Geoeye-1 provides panchromatic and/or multispectral bands (blue, green, red and near infrared) with spatial resolution of 0.41 and 1.65 meter, respectively, with 15.2 kilometers swath width. Its radiometric resolution is 11 bits and range of up to 3 days revisit (Spaceimaging of Brazil, 2010). This newly developed sensor is optimized for large projects, as it can collect over 350,000 square kilometers of pan-sharpened multispectral satellite imagery every day.

In this sense, this work seeks to present the results of an assessment of the Geoeye-1 scene geolocation accuracy. This scene was acquired over a flat area, and it was orthorectified using control points. The evaluation included, also, the influence of the use of Digital Elevation Models (DEM) with different resolutions and accuracies.

Objectives

This work aims to evaluate the geolocation accuracy of a Geoeye-1 scene orthorectified using ground control points (GCPs), considering Brazilian standard specifications (Brasil, 1984) for classification of cartographic bases. It will also be evaluated the influence of DEM used in orthorectification. To do this, DEMs were generated using different inputs, like: from a cartographic base in scale 1: 2,000; by photogrammetry, scale 1: 25,000; ASTER GDEM; and SRTM version 2.

Study area

Study area corresponds to the University City, an island within Guanabara Bay, in Rio de Janeiro, Brazil (Figure 1), where the main campus of the Federal University of Rio de Janeiro is located in. The island is predominantly flat, with altitudes near sea level (generally between 0 and 20 meters), presenting area of 4.7 square kilometers, approximately.

2. METHODOLOGY

The GeoEye-1 scene, acquired in July 2010, with RPCs, was orthorectified in OrthoEngine, PCI Geomatica, version 10.2. It was tested the use of 1 to 5 GCPs in order to verify the stability of the model and the minimum number of points needed to achieve the best results. All points were established in the field with a GPS of one frequency (L1), through static and relative positioning with a minimum of 1,500 epochs, for a vector less than 10 km to the base. GPS data were post processed in Ashtech Solution software, considering accuracy of 5 centimeters in planimetry and 10 centimeters for altimetry.

Source: Cartographic base – IBGE and Image – Google Earth

Figure 1: Ilha do Fundão, State of Rio de Janeiro, Brazil

After the determination of the best set of GCPs, orthorectification was repeated four times – one for each of the four DEMs used, always using the same GCPs, previously identified in the image. GCPs were used consist linear feature crossings. The orthoimages generated were evaluated by comparing the position of checkpoints (not used in the process of orthorectification) with their counterparts in orthoimage. This process was repeated for the four orthoimages generated with four DEMs.

3. RESULTS

It was observed, through the RMS indicated in the control points identification stage, that the use of up to 3 GCPs did not stabilize the model for the orthorectification, and RMS always indicated a value above 1 pixel. After the identification of the 4th GCP, the model presented stability, achieving RMS below 1 pixel. Due to a very small improvement by adding a 5th GCP it was decided to use 4 GCPs in the orthorectification process.

When DEM generated from contours and quoted points from 1:2,000 cartographic base was used it was obtained an orthoimage with an average displacement of 0.32 meter, with standard deviation of 0.22 meter. The maximum displacement observed was 0.76 meter.

Using DEM generated from correlation of aerial photographs, processed in photogrametry stations, for 1: 25,000 scale mapping, average displacement observed was 0.50 meter, with standard deviation of 0.40 meter. The maximum displacement observed was 1,64 meter.

Orthoimage generated using ASTER GDEM presented a result quite lower than it was expected: average displacement was 3.66 meters and standard deviation was 1.46 meter. The maximum displacement observed was 6.61 meters.

SRTM DEM version 2, with its 3 arc second pixel, allowed a good orthorectification, presenting an average displacement of 1.60 meters, with standard deviation of 0.88 meter and maximum displacement of 3.41 meters.

4. CONCLUSIONS AND FINAL CONSIDERATIONS

According to the results for the amount of GCPs required for orthorectification, it was observed that, although it is possible to orthorectify Geoeye-1 scenes with only one control point – or even without any GCP –, it is necessary to use 4 GCPs in order to achieve a RMS less than 1 pixel (0.5 meter). This number seems to be quite reasonable if the purpose is to reach accuracy better or equal to 1 pixel.

Results showed that, even in a flat area and next to the sea level (less than 20 meters), using DEMs with different details and accuracy (with different resolutions) really interfere in the product quality. Not surprisingly, the best result – and the only one in which displacement was less than 1 pixel (0.5 meter) – was obtained with the use of DEM generated from 1:2,000 cartographic base, whose pixel was 1 meter. With this DEM, orthoimage presented accuracy according to class A of 1:2,000 scale. It is necessary to comment that this orthoimage presented deformation on the edge of the island, nearby with the waterline. Since this orthoimage was the only one which showed this problem, the origin of it may be the DEM used.

Orthoimage generated using Photogrammetric DEM (1: 25,000) kept the average displacement within 1 pixel. However some of the checkpoints used in the evaluation presented displacements around one meter. Because of this, this orthoimage meets accuracy specified to class B of 1:2,000 scale. On the other hand, as the State of Rio de Janeiro is completely covered by this DEM it is important to consider its usage because of convenience. The DEM 1: 2,000 is available only in a few localities in Brazil. Considering the availability of 1:25,000 DEM, accuracy difference between these orthoimages may be considered are too small.

The ASTER GDEM is a very interesting product because of its global coverage and resolution of 1 arc second. However, it seems to have been the responsible for the bad performance of orthoimage in which it was used. This orthoimage reached specifications for class B of 1:10,000 scale, what is not acceptable for a product like the Geoeye-1 scenes. ASTER GDEM probably presents problems in this area, which deserves an investigation.

The 3 arc seconds SRTM DEM surprises again due to the good result observed: orthoimage generated making use of it had a good performance, achieving the specified for class A of 1: 5,000 scale. It may be commented that orthoimage presented artifacts in 2 locations, close to the coastline of the island, and should be investigated, since version 2 of SRTM DEM may present some problems, possibly demanding some editing.

Geoeye-1 scenes orthorectification, using ground control points and appropriate DEMs, may reach geolocation accuracy values specified for large scales such as 1:2,000. In fact, it almost reach the specification of class B of 1:1,000 scale, according to the Brazilian standards (Brasil, 1984). It is important to emphasize that the assessment was made in a scene acquired over a flat area, close to sea level, where favorable conditions for the geometric correction are usually found (Barros, 2006, Correia, 2007).

Results achieved suggest the possibility of the use of Geoeye orthoimages into high details studies and/or mapping in which high accuracy is necessary. It may be usefull for most of municipalities in Brazil.

It is necessary the continuity of this study, including expansion of the number of checkpoints and with research on a stereoscopic pair to DEM generation from correlation between images. It is also necessary repeating the tests over areas with different topography.

ACKNOWLEDGEMENT

Thanks to Spaceimaging of Brazil for providing, free of costs, this Geoeye-1 scene for this evaluation and to Pereira Passos Institute, from the municipality of Rio de Janeiro for providing, free of costs the DEM 1: 2,000.

BIBLIOGRAPHY

BRASIL. Decreto nº 89.817, de 20 de junho de 1984. Normas Técnicas da Cartografia Nacional. Diário Oficial da União, Brasília, DF, 22 jun. 1984. Disponível em: http://www.planalto.gov.br/ccivil_03/decreto/1980-1989/D89817.htm. Acesso: 25 maio de 2009.

BARROS, R. S. Avaliação da Altimetria de Modelos Digitais de Elevação Obtidos a Partir de Sensores Orbitais. 2007. Instituto de Geociências. UFRJ. Tese de Doutorado.

BARROS, R. S., CRUZ, C. B. M., SILVA, N. C. C.; REIS, R. B.; SEABRA, V. S. (2005a). Avaliação da Qualidade Vertical de DEMs do SRTM. In: XXII Congresso Brasileiro de Cartografia. Macaé – RJ.

CORREIA, J. D. A Contribuição dos Sensores Orbitais Terrestres de Alta Resolução Espacial no Mapeamento Geomorfológico de Coberturas Sedimentares Cenozóicas. 2007. Instituto de Geociências. UFRJ.Tese de Doutorado.

CUARTERO, A.; FELICISIMO, A. M.; ARIZA, F.J. (2004). Accuracy of DEM generation from TERRA-ASTER stereo data. In: ISPRS, Vol. 35, Parte B2, Comissão 2, pp. 559-563. Istambul – Turquia.

GEOEYE (2006). Stereo Technical Overview. www.spaceimaging.com/products/ikonos/stereo_technicaloverview.html. Último acesso: 22/05/2006.

GEOEYE. GeoEye-1 Fact Sheet. 2010. Site: http://www.geoeye.com/CorpSite/resource/marketing-brochures.aspx. Access: October, 4th, 2010.

KAY, S.; SPRUYT, P.; ZIELINSKI, R. (2005). Quality checking of DEM derived from satellite data (SPOT and SRTM). 25th EARSeL Symposium Global Developments in Environmental Earth Observation from Space. Porto, Portugal.

NASA (2006b). SRTM V1 & V2. Site: ftp://e0srp01u.ecs.nasa.gov/srtm/. Último acesso: 26/05/2006.

NASA (2006c). SRTM Data Editing Rules. Site: ftp://e0srp01u.ecs.nasa.gov/srtm/version2/Documentation/. Último Acesso: 25/06/2006.

RODRIGUEZ, E.; MORRIS, C.S.; BELZ, J.E.; CHAPIN, E.C.; MARTIN, J.M.; DAFFER, W.; HENSLEY, S. 2005, An assessment of the SRTM topographic products. Technical Report JPL D-31639, Jet Propulsion Laboratory, Pasadena, California, 143 pp.

SPACEIMAGEING DO BRASIL. Geoeye-1 - Especificações do Satélite. 2010. Site: http://www.spaceimaging.com.br/novo_sitemai09/geoeye.htm. Acess: September, 13th, 2010.

TOUTIN, T. (1995). Generating DEM from Stereo Images with Photogrammetric Approach: Examples with VIR and SAR Data. EARSel journal "Advances in Remote Sensing", Vol. 4, No. 2, pp. 110 – 117.

TOUTIN, T. (2001a). DEM Generation from New VIR Sensors: IKONOS, ASTER and Landsat-7. IEEE-IGARSS.

VALERIANO, M. M. (2005). Modelo Digital de Variáveis Morfométricas com Dados SRTM para o Território Nacional: O Projeto TOPODATA. In: XII Simpósio Brasileiro de Sensoriamento Remoto. Goiânia – GO. Pp. 3959-3602.