Proceeding of the 10th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences
Florianopolis-SC, Brazil, July 10-13, 2012.

Study of the positional quality obtained by the method Precise Point Positioning, PPP, for use in georeferencing of rural properties

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Abstract

The Brazilian Institute of Geography and Statistics - IBGE offers the service of Precise Point Positioning - PPP, which are used the precise ephemeris and clock corrections of satellite data with the carrier wave, so static or kinematic. Established itself as the choice of statistical test every Monday, from 28/02/2005 to 22/11/2010 totaling 296 days of raw GNSS data files of twenty four hours. The observation files tablets were sent individually to the IBGE-PPP to make the post-processing. The PPP has been converted into geodetic coordinates in UTM coordinate plane. Comparisons made by subtraction of coordinates of the Brazilian Network for Continuous Monitoring -RBMC SMAR, coordinates Officers SIRGAS 2000, the date of survey coordinates and coordinates of two, four and 24 hours. The latter resulted in a comparison between the different screening times. The results are satisfactory as to the positional accuracy required by INCRA. Which remained throughout the six years studied. Observing small variations in the position of the coordinates, including shortening the time of screening, two hours. Therefore, the PPP technique proved a modern, safe and easy to use in providing precision geodetic surveys**.**

Keywords: GPS, PPP, Precise Point Positioning.

1. Introduction

Proceedings Global Navigation Satellite Systems - GNSS is a navigation system that has three segments: space (satellites), Control (monitoring stations) and User (GPS), allowing the geodetic positioning from any point on Earth's surface. However, when employed the precise ephemeris and clock corrections of the satellite, with the data of the carrier wave, has been called Precise Point Positioning - PPP.

The Brazilian Institute of Geography and Statistics - IBGE, PPP provides for free, the Geocentric Reference System for the Americas (SIRGAS2000) and ITRF. Process data only tracked after February 25, 2005. Its official launch was on April 2, 2009 (Matsuoka, *et al*., 2009; Monico, 2008). The PPP still does not replace other services that require high degree of accuracy, achieved only with vec-

tors and adjustment of the network with statistical control of processes that require high computational activity (Pereira, 2007).

The PPP is the evolution of point positioning, their main goal is the precision and accuracy, which can reach the level of centimeters, using a single GPS receiver. The differential is the post-processing of data, will be employed where the precise ephemeris and clock corrections of the satellite, with the data of the carrier wave. It can be used to process data collected in a fixed location (static) or along a trajectory in the kinematic, or a mixture of both - "stop and go" (Matsuoka, *et al.* , 2009).

The International GPS Service - IGS and its monitoring network around the world, along with the centers, produce three types of ephemeris and clock correction for the satellite: the IGS resulting from the combination of the orbits produced by its analysis centers and is available with a latency of about 13 days, the IGR resulting from the combination of the orbits generated by rapid analysis centers and is available with a latency of about 17 hours and the GUI that is ultra-rapid orbits.

International Terrestrial Reference Frame - ITRF reference frame is adopted in the ephemeris accurate, made by GSI at the time for which the orbits were calculated.The IGS uses the current ITRF currently IGS05, a realization of ITRF2005. As the IGS orbits are available daily, the time of the ITRF coordinates calculated by the PPP are referred to the date of the data collected, ie, the date of the GPS survey (Alves *et. al*., 2010).

The observable most commonly used in the PPP are the data from the receivers of two frequencies (L1 and L2), the set of equations of pseudorange and phase in the two carriers are combined to produce the observed ion-free pseudorange (Monico, 2008).

With the advent of IGS, the accuracy of GPS products become available, the carrier phase information from the position of a turning point for a decimetre (for some applications) to a technique millimeter, more recent description of PPP. Geodetic Survey Division of Natural Resources of Canada - NRCan's Canadian Spatial Reference System CSRS-PPP is designed to provide users the benefits of accurate observations of the accuracy of carrier phase and the convenient access provided by the Internet (Mireault *et. al.,* 2008).

Some agencies cited by (Alves *et al*., 2010) is available free of charge, data processing services online as PPP. For the coordinates are given in SIRGAS2000, the station should be located in South America Area covered by the SEE model - Model Speeds used to transport or reduce the coordinates calculated on the date on which the data were collected for 2000.4 epoch, time of SIRGAS2000 (IBGE,2009).

The model charge ocean FES2004 PPP is used by the processing of GPS observations. These corrections will be used for ocean freight to the station to be processed is up to 10 km away from a station in RBMC. For the transformation of geometric altitude (referenced to the GRS80 ellipsoid - SIRGAS2000) in orthometric heights (referred to the geoid), PPP uses the Model Geoid Undulation MAPGEO2010.

The INCRA has adopted in its technical standard for the georeferencing of rural properties using the IBGE-PPP, in order to determine the points of support. Defining the term is associated with the precision level of adhesion of a group of measurements obtained under the same conditions, the average value thereof when calculated on the value of a deviation or a sigma (1σ), the result is expressed resulting from the horizontal components σE and σN, the confidence level of 1σ (INCRA, 2010). The indicator of positional accuracy for each pair of coordi-

nates for each vertex defining the boundary of the property shall not exceed the value of 0.50 m.

Objective is to verify the quality of service provided by IBGE-PPP, the pattern of positional accuracy required by the National Institute of Colonization and Agrarian Reform - INCRA, the vertices of basic support, immediate, and limit with precision less than or equal to ten inches (≤ 0.10 m), comparing the coordinates of the base RBMC official of Santa Maria - RS with the coordinates obtained by the PPP.

2. Methodology

The study was conducted at the station RBMC GNSS SMAR, in Santa Maria, Rio Grande do Sul belongs to the densification of the IGS Network, has a plate fastened to the south face where the international code consists of the station No. 92013, in a concrete column equipped with a forced centering device located on the slab of the Building Center of Rural Sciences - CCR, Federal University of Santa Maria. The receiver is of double frequency. On page after the user account IBGE, there were downloads from the station RBMC RMAS report with details, including the antenna height, accurate coordinates, plus the data files compressed observation and navigation.

To compare the official data from the station RBMC SMAR, with the data obtained by the methodology of IBGE-PPP, established itself as the choice of statistical test every Monday, from 28/02/2005 to 22/11/2010, totaling 296 days of observations of GNSS data, and in seven days the data were unavailable and were not part of the study. The data files of 24 hours, static processing mode are stored in folders divided into years, months and days.

The compressed RINEX observation files were sent individually to the IBGE-PPP to do post-processing of data, where the height and design of the antenna were adjusted. The result of processing the data were obtained on the page itself IBGE-PPP, in the compressed file in ZIP format and stored with the raw file data on the same day, then unzipped the file.

The IBGE report provides RBMC stations in geodetic coordinates, and Cartesian plane (UTM), since the report of the PPP PDF file extension is provided only in geodetic coordinates, with two coordinates: the Official SIRGAS 2000.4 and the date of survey .For better visualization of differences in the coordinate system is the best metric, the geodesic coordinates were converted, the IBGE PROGRID flat UTM coordinates entered in the spreadsheet and Microsoft Office Excel 2007.

Three spreadsheets were assembled with the following title: Official Coordinates SIRGAS 2000; Coordinates Coordinates and Survey Data from two, four and 24. The latter resulted in a comparison between the different screening times. The comparison of the three sheets were always with the Coordinated Official Station RBMC SMAR

3. Results and discussion

The data collected are the date of the coordinates of the day they were collected, therefore, should not be used for georeferencing. Its main feature is the constantly shifting over time, in six years there has been a shift in this component in Component I of 0.035 North 0.075 m, compared to the first PPP undertaken in 2005. If we compare the station with RBMC 19/07/2010 will coordinate a positional accuracy of 0.11 m ≥ 0.10 m. Results not accepted by INCRA to be greater than

ten centimeters. We observed the direction of the vector displacement, to the northwest of the point of origin.

Table 1 presents the differences of station coordinates RBMC SMAR coordinated with the date of lifting of the PPP, through the mean, standard deviation variation in the components of the East, North and Height Positional Accuracy and PP. It is observed that from 2005 to 2010 was at 0.023 m ≤ 0.10 m.

Even with the lower result than required by the entity can not be accepted because they appear hours later to the north and south of the base RBMC, the first uses the coordinate data of the survey, while the second reduction of coordinates for SIRGAS 2000. So be careful to note that the information extracted from the PDF file of the PPP, if we use the coordinate of the date of survey positional accuracy is good, but will be coordinated out of the correct positioning.

Table 1. PPP from the date of survey, data from 24 SMAR station, Santa Maria-RS, Brazil.

Ano	Média ÄE (m)	Média ÄN (m)	Média ÄH (m)	Desv. Pad. ÄE (m)	Desv. Pad. ÄN (m)	Desv. Pad. ÄH (m)	PP Precisão (m)
2005	0,015	-0,043	0,007	0,007	0,005	0,011	0,008
2006	0,021	-0,053	0,003	0,009	0,007	0,011	0,011
2007	0,024	-0,069	-0,005	0,009	0,006	0,012	0,011
2008	0,022	-0,082	-0,004	0,005	0,004	0,009	0,006
2009	0,026	-0,093	-0,005	0,004	0,005	0,010	0,007
2010	0,036	-0,101	-0,002	0,006	0,004	0,013	0,007
2005 a 2010	0,024	-0,074	-0,001	0,009	0,021	0,012	0,023

The displacement of the coordinates is progressive, due to displacement of the tectonic plates of Earth's crust. Being able to measure this shift and make projections for the future. The greatest variation is coordinated in North, which indicates a strong trend away from the point of origin. Also notes the coordinates This deviate more slowly. Height remains with some variations.

A period of six years on the horizontal components with a range from 0.03 m to the east and north, on the other hand was the best day in the component vertical, which equaled the season SMAR. Therefore the positional accuracy of 0.045 m was ≤ 0.10 m, higher than the average for the years 2005 to 2010 is 0.01 which results accepted by INCRA for the vertices of C1. For the time trace 24.

According to the results in Table 2 the difference positional accuracy of the observations for 24 hours to four hours was an inch and a difference of a millimeter between the result of two and four hours, and larger standard deviation at the time of two hours. Search result in enhanced (Perdigão, et al., 2010) at the station RBMC VICO, positional accuracy was obtained within two hours, 0.016 m likewise changes from the horizontal components of the two hours have become less and significant degree of difference between them quite softened.

Analyzing two hours vertical component varies more than the other 24 hours and four hours, because it requires more time altimeter which stabilize planimetry. The time is critical for improving the accuracy of the elevation and planimetry, with always more variation in the observations of two hours followed

by four hours. The spread data 24 are closer to, but data from four to two hours are dispersed. Because of this, occasionally the largest discrepancy was found in the coordinates of two hours, producing the following range: 0.042 m to the East, 0.026 m to the North and 0.08 m in Height.

Table 2. Comparative time trace PPP OFFICIAL IN SIRGAS 2000, years 2005 to 2010 SMAR station, Santa Maria-RS, Brazil.

Time	average ÄE (m)	average ÄN (m)	average ÄH (m)	Desv. Pad. ÄE (m)	Desv. Pad. ÄN (m)	Desv. Pad. ÄH (m)	Accuracy PP Posicional
24 h	0,010	0,018	-0,002	0,010	0,007	0,014	0,012
4h	0,000	0,020	-0,002	0,02	0,007	0,023	0,022
2h	0,003	0,019	0,013	0,018	0,011	0,034	0,021

4. Conclusion

The findings of the study are satisfactory as to the positional accuracy, according to the standards demanded by INCRA. Staying over the six years studied where one observes small variations in the position of the coordinates, including shortening the time of screening, in the case two hours.

The free service provided by IBGE-PPP is the easy way of obtaining coordinates of post-processed with high accuracy using a single receptor but must be dual frequency without need to adjust network. Still has a disadvantage in the latency of data item, only after 13 days of the survey.

The PPP broke the monopoly exercised by the relative positioning, showing that it is another option for professionals in the measurement in jobs that require high precision. Each method of positioning with its uniqueness. The precise formulation of the PPP-IBGE shows similarity to the result of GPS relative positioning. That is, the accuracy depends only on the duration of the observation session. The longer, the better and more approximate relative positioning.

For better convenience of users of the system PPP, IBGE report could provide the PDF from the point along with the geodetic coordinates to Cartesian coordinates and UTM coordinates plane. Likewise providing data from RBMC stations. Would further diminish the errors that can be made by the user in the coordinate transformations.

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