

## Assessment of geodetic coordinates processed using different baselines

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### Abstract

*The relative kinematic methods of GNSS positioning are characterized by the movement of a rover station, tracking simultaneously at least one fixed base station, for trajectory coordinate solution. The purpose of this work is to evaluate the accuracy of geodetic coordinates from kinematic surveying, processed using different baselines. The relative kinematic surveying was made with a GPS receiver along a sand spur located in Ilha do Mel in Paraná State, Brazil. Use was made of 4 base stations for data processing, where 3 stations belonged to the Brazilian network called Rede Brasileira de Monitoramento Contínuo (RBMC): NEIA; UFPR, and IMBT. A fourth station called CASA was a static base station near the survey. After data processing, these stations generated baselines with lengths averaging around 0.7km, 70km, 90km and 300km for vectors generated by CASA, NEIA, UFPR and IMBT, respectively. The vectors were classified according to the ambiguities solution. The survey precision limit was fixed to 0.1m + 1 ppm for horizontal and vertical coordinates. The tridimensional standard deviations in meters obtained in processing were 0.044; 0.321; 2.522; 7.00. The deviations values obtained, represent the degradation of generated coordinates, where their values increase depending on the increase of baseline.*

**Keywords:** GNSS, geodetic coordinates, baseline processing, coastal application

### 1. Introduction

The GNSS (Global Navigation Satellite System) positioning application has served several types of users around the world. With its source in NAVSTAR – GPS (Navigation System with Time and Ranging – Global Positioning System), developed by United States since 1973, the system started to contribute for Geodetic Sciences since 1983 (Seeber, 2003).

The surveying of surface features using GPS is a mapping technique used in cartographic and geodetic applications. If the mapped features are tracks (streets,

roads, rivers, etc), one of the most suitable methods for this purpose is the relative kinematic positioning. In this kind of positioning, each point from mapped track is processed according to a vector that joins a fixed base station to the point, this vector is called a baseline.

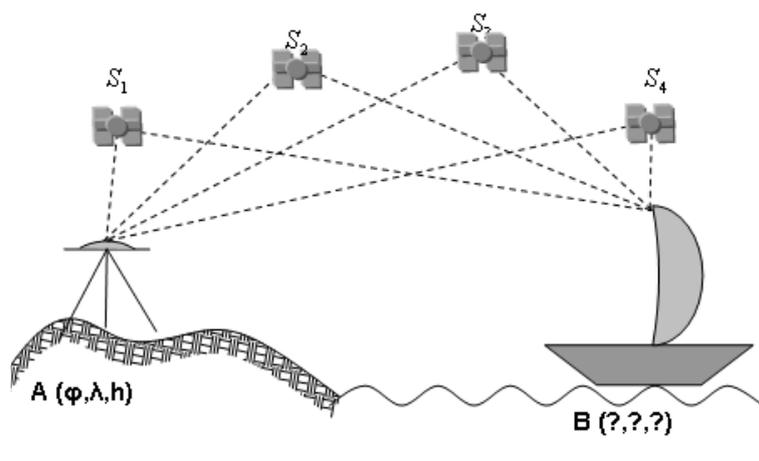
### 1.1.GNSS Positioning Methods

There are several classifications in literature about GNSS positioning. Generally, they can be classified into three groups: absolute, relative and differential (Monico, 2008) as shown in Table 1.

**Table 1:** Classification of GNSS positioning methods.

Positioning Methods		
Absolut	Relative	Differential
Static	Static	DGPS
Kinematic	Rapid Static	RTK
	Stop and go	PDGPS
	Kinematic	WADGPS
	Pseudokinematic	

In this study, the relative positioning method was used. It is characterized by simultaneously acquisition of data by two receivers. One receiver is installed in a station with known coordinates, called base. The second receiver is put in a place(s) of unknown coordinates, it is called rover station. The kinematic relative positioning (Figure 1) is defined by movement of GNSS receiver/antenna for a track determination. One of its advantages is the high productivity, because a great quantity of points can be recorded in a short period of time interval. The precision level of this method with post-processing is 10 cm, but it can obtain few centimeters if there are favorable conditions (satellite coverage, absence of multipath, etc) (Seeber, 2003).



**Figure 2:** The Kinematic Relative Positioning.

## 1.2. Study Area

The geodetic surveyings were made in an island called *Ilha do Mel* in Paraná State, Brazil. The *Ilha do Mel* is located around 4 km from *Pontal do Paraná* city, and 24 km from *Paranaguá* city. The access to Island can be made by road BR 277 to *Paranaguá* or *Pontal do Paraná* (Roads PR 407 and 412), in these places the boats leave to island. The travel time is around 30 minutes from *Pontal do Paraná* and 1 hour and a half from *Paranaguá* (Figure 2).

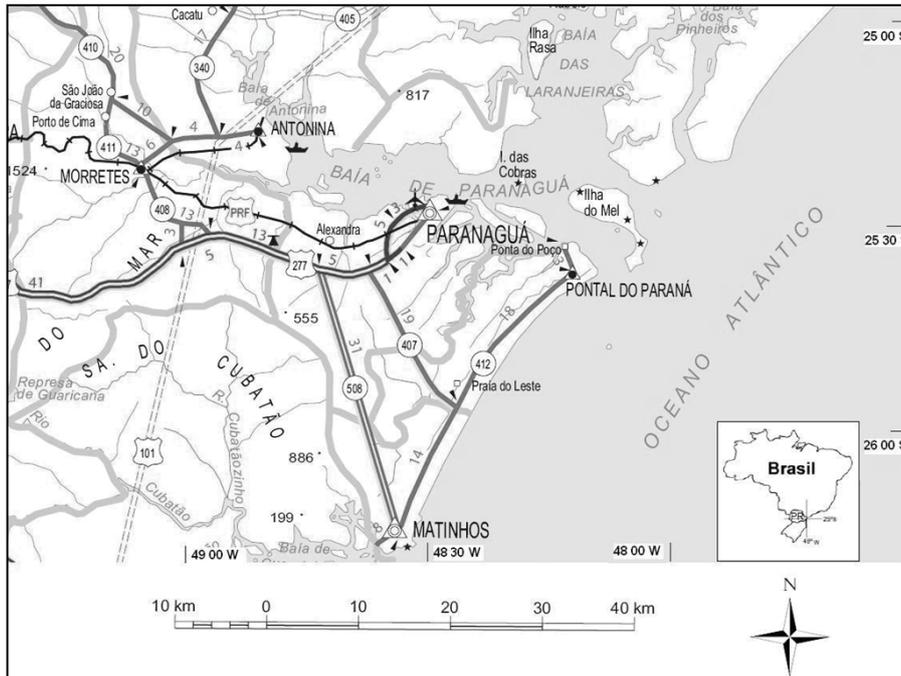


Figure 2: Localization of Island (DNIT, 2002).

## 2. Materials and Methods

The relative kinematic surveying was made using a GPS L1 receiver in December of 2007, along a sand spur located on island. All the edges of the sand spur were mapped using the rover station recording data at 15 seconds interval over sections spaced approximately homogeneous (Figure 3).



**Figure 3:** Surveying illustration along the sand spur.

Four base stations were used for data processing, where 3 stations belonged to Brazilian network called *Rede Brasileira de Monitoramento Contínuo (RBMC)*: NEIA, located in *Cananéia-SP*; UFPR, located in *Curitiba-PR* and IMBT, situated in *Imbituba-SC*. A fourth station called CASA was a static base station near the survey. Table 2 shows some information about these stations.

**Table 2:** Localization and baselines length of stations.

Base	Localization	Baseline length
		(Average)≈km
CASA	Ilha do Mel	0.7
NEIA	Cananéia - SP	70
UFPR	Curitiba - PR	94
IMBT	Imbituba - SC	300

The data collected by rover station generates 318 points on spur. The raw GPS data were processed and the vectors classified according to the ambiguities solution. The solution are referred to as Fixed when the ambiguities are solve in totality; Partial, above 50% are solve, and Float when less than 50% of ambiguities are solve. The survey precision limit was fixed to 0.1m + 1 ppm for horizontal and vertical coordinates, the row data were processed with precise ephemerides from IGS (International GNSS Service).

### 3. Results and discussions

The processed solutions of 318 vectors generated using the CASA base station was Fixed. The others (NEIA, IMBT and UFPR) had their solutions as partials and floats according to Table 3.

**Table 3:** Numbers of vector listed according to their ambiguities

	CASA	NEIA	UFPR	IMBT
Fixed	317	-	-	-
Partial	-	215	218	209
Float	1	103	100	109
<b>Total</b>	<b>318</b>	<b>318</b>	<b>318</b>	<b>318</b>

After that processing, the geodetic coordinates ( $\phi$  = Latitude,  $\lambda$  = Longitude,  $h$  = Ellipsoidal height) were analyzed. The obtained results are assessed using the standard deviations and the degradation levels of positioning characterized according to each executed solution. Table 4 shows the maximum, minimum and average values of standard deviation of the generated coordinates calculated using the tridimensional deviation according to Equation (1):

$$\sigma_{3D} = \sqrt{\sigma_{\phi}^2 + \sigma_{\lambda}^2 + \sigma_h^2} \quad (1)$$

Where:

- $\sigma_{3D}$ : Tridimensional deviation;
- $\sigma_{\phi}$ : Latitude standard deviation;
- $\sigma_{\lambda}$ : Longitude standard deviation;
- $\sigma_h$ : Ellipsoidal height standard deviation.

**Table 4:** Maximum, Minimum and Average of standard deviation values

Generates Coordinates												
	$\sigma_{\phi}$			$\sigma_{\lambda}$			$\sigma_h$			$\sigma_{3D}$		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
<b>CASA</b>	3.159	0.006	0.024	0.051	0.007	0.011	1.591	0.016	0.032	3.537	0.02	0.044
<b>NEIA</b>	0.217	0.058	0.134	0.220	0.081	0.130	0.432	0.156	0.255	0.492	0.222	0.321
<b>UFPR</b>	23.926	0.100	1.912	23.728	0.065	0.540	23.768	0.204	1.291	41.236	0.259	2.522
<b>IMBT</b>	23.833	0.168	3.395	23.833	0.150	3.041	23.839	0.395	5.146	41.283	0.657	7.002

The average values of tridimensional deviations ( $\sigma_{3D}$ ), as shown on Table 3, correspond to the degradation of the generated coordinates, where their values increase with the increase of baseline. However, when we look at the tridimensional deviations on Table 3, the disparity of its value in IMBT solution (7.002 m) when compared to another values can be seen. It is justifiable, because that particular baseline was around 300 km in length, i.e., about 3 times longer than NEIA, UFPR, and 300 times longer than CASA.

When the tridimensional deviations of NEIA and UFPR are compared between themselves, the discrepancies between their values are 0.321 m and 2.522 m, respectively. In this case, the lengths of baseline are in the same magnitude of order (70 km and 90 km, respectively).

The geodetic coordinates in a relative kinematic positioning are degraded with the increasing baselines, therefore, the degradation of vertical component in this work was similar when compared to horizontal positioning.

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