COMPARING INPE AND ARGOS GEOLOCATION ACCURACIES USING ARGOS SYSTEM REAL DATA

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ABSTRACT

The main goal of this work is to compare the accuracies of transmitters' geolocation results obtained by Argos system [1] and by INPE´s system, using the algorithm for geographic location of transmitters developed in [2]. Data (time and Doppler shift measurements) were supplied by Argos Control Center staff, except for the satellites ephemeris. This comparison was performed using NOAA satellites, in order to verify the robustness of the INPE location procedure compared to the supplied ARGOS results. The ARGOS control center uses precise orbitography transmitters data for precise orbit determination of the NOAA satellites, besides having the full Doppler curve data available for geolocation. On the other hand, INPE has developed a simple scheme for processing the sparse Doppler data obtained through the Brazilian network of DCPs (Data Collecting Plataforms). In INPE's geolocation scheme, the satellite ephemeris (two-line elements) is recovered via Internet, the orbit is computed by the SGP4 model [4], and the Doppler data is modeled and processed using a robust Householder orthogonalization for the least squares processing procedure [5]. The results using such data and either Internet based two-line orbit elements or refined orbit elements are compared in terms of precision with results of Argos system.

1. INTRODUCTION

The comparison of accuracies between INPE and Argos geolocation systems [1-2] was accomplished using location data (time and Doppler shift) and corresponding location results (latitude and longitude) provided kindly by the Argos system staff; and two fixed and known reference transmitter platforms. The geographic location of transmitting platforms were computed as shown in [6] and five NOAA satellites (NOAA 11,12,14,15,16) were used.

There are two classes of location results: a) using satellite passes containing at least one measurement with elevation higher than 11º; b) the same passes but using only a subset of such measurements with elevation higher than 4º, to attenuate atmospheric refraction effects.

2. INPE AND ARGOS SYSTEMS LOCATION DESCRIPTION

Both INPE and Argos system determine a geographic location measuring the Doppler shift of the transmitted frequency due to the relative velocity between the satellite and the transmitter [1-2, 6]. This velocity in vacuum conditions, denoted by $\dot{r}$, is given by the Doppler effect equation [3] $\dot{r} = (f_r - f_t)c/f_t$ where f_r is the frequency value as received by the satellite; f_t is the reference frequency sent by the transmitter; $(f_r - f_t)$ is the Doppler shift due to the relative velocity satellite-transmitter; and c is the speed of light. A characteristic Doppler curve is shown in Fig. 1 where b_o and b_1 are constants associated with each Doppler curve [7].

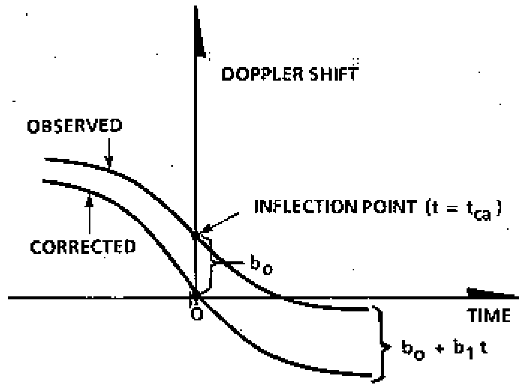

Figure 1 - Doppler curve

In Argos system all UHF signals from the transmitters are received on board the satellite, which measures the Doppler shift and records its arrival time reproducing then the full Doppler curve. Those recorded measurements are played back to the ARGOS ground reception stations where the data are processed after some time delay (some hours) [1]. In INPE´s system, the received frequency signals are relayed in real time to the ground reception stations and processed right after the satellite pass [2]. Thus, some data are lost, resulting in a broken Doppler curve, but gaining in location fastness.

3. COMPARING RESULTS BETWEEN INPE AND ARGOS

For the purpose of accuracy comparison between both systems, two DCPs (Data Collecting Platforms) located in French Guiana and in Peru were considered: DCP 109 at 5.17137^o N, 307.31388^o W, altitude 0.007m; and DCP 113 at 12.09003^o S, 282.96146^o W, altitude 0.134m; both transmitting signals every 30s. All data were taken during November 2001.

3.1 Statistical Analysis

In Tables 1 and 2 we gathered the location mean error considering the five NOAA satellites, the fixed DCPs, orbit ephemeris (two-line elements) obtained via Internet (www.celestrak.com), and the two location systems (Argos and INPE).

TABLE 1 - Synthesis of the results for Transmitter DCP #109

Comparing Argos/INPE - DCP 109				
Satellite	Satellite Passes	Mean Location Error (km)		
		Argos	INPE	INPE: h>4º
NOAA 11	16	0.56±0.5	1.17±0.6	1.47±1.1
NOAA 12	23	0.31±0.2	1.23±0.9	1.20±0.8
NOAA 14	27	0.25±0.2	0.95±0.5	0.92±0.5
NOAA 15	23	0.51±0.5	1.48±0.7	1.49±0.8
NOAA 16	20	0.38±0.3	1.62±1.1	1.49±1.1
Mean		**0.40±0.34**	**1.29±0.76**	**1.3±0.8**

TABLE 2 - Synthesis of the results for Transmitter - DCP #113

Comparing Argos/INPE - DCP 113				
Satellite	Satellite Passes	Mean Location Error (km)		
		Argos	INPE	INPE: h>4º
NOAA 11	38	0.46±0.3	1.23±0.5	1.30±0.9
NOAA 12	40	0.41±0.4	1.12±1.3	0.92±0.4
NOAA 14	35	0.46±0.3	1.13±1.3	1.06±1.3
NOAA 15	35	0.61±0.4	1.34±0.9	1.20±0.7
NOAA 16	32	0.44±0.2	0.83±0.3	0.84±0.3
Mean		**0.48±0.32**	**1.13±0.92**	**1.06±0.7**

From Table 1 we can see that the mean location error of DCP 109 is 0.40±0.34km for Argos system, and 1.29±0.76km and 1.30±0.80km (when minimum elevation h is higher than 4º) for INPE´s system. This implies that the (1-σ) errors mostly range between 0.08km and 0.74km for Argos and 0.5km to 2.1km for INPE. From Table 2 the location error of DCP 113 is very similar to results of Table 1.

3.2 Analysis of Ephemeris Accuracy

Here, we investigate the error in location caused by the orbit ephemeris error. In standard mode INPE gets the two-lines ephemeris through well known Internet sites. For this test we performed orbit determination at INPE's control center to refine the orbit ephemeris. Tables 3 and 4 show location errors using satellite NOAA 15, where the orbit ephemeris used are identified by either Internet or INPE (refined) respectively.

TABLE 3 - Synthesis of results for Transmitter - DCP #109 - NOAA-15

		Location Error (km)			
Day	Hour	Internet h>4º	INPE	INPE h>4º	Argos
19	11	1.53	0.82	0.86	0.14
19	22	2.67	1.11	0.88	2.97
20	11	1.39	0.78	0.78	0.34
20	22	1.1	1.06	1.01	0.11
21	10	1.53	1.12	1.12	0.58
Mean		**1.64**	**0.98**	**0.93±0.13**	**0.83±1.2**

TABLE 4 - Synthesis of results for Transmitter - DCP #113 - NOAA-15

		Location Error (km)			
Day	Hour	Internet h>4º	INPE	INPE h>4º	Argos
19	00	1.08	0.86	0.86	0.72
19	11	1.71	1.09	1.09	0.34
20	00	4.29	2.89	1.86	2.53
20	13	0.67	0.39	0.37	0.19
21	00	1.49	0.93	0.93	0.77
21	01	0.93	1.26	0.71	0.71
21	11	1.78	1.03	1.03	0.19
21	12	1.58	0.82	0.23	0.40
21	23	1.53	2.05	1.64	0.71
Mean		**1.67**	**1.26**	**0.97±0.53**	**0.73±0.7**

The Tables 3-4 show that the location errors using orbit ephemeris from Internet are larger than using INPE's refined orbit ephemeris. It indicates the inacuraccy of orbit ephemeris (two-line elements) provided by Internet. On the other hand, using refined ephemeris the location error comes closer to that of Argos system. Therefore most of the discrepancy between INPE and Argos results is probably due to orbit ephemeris inaccuracy.

4. CONCLUSIONS

The results show that the developed INPE's geolocation system attains, in standard mode, a precision around 1.2km, using orbit ephemeris from Internet. An investigation, after refining the orbit ephemeris, showed that INPE's location accuracy approaches the Argos one.

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