ASTROMETRY AND GEOESTATIONARY SATELLITES IN VENEZUELA

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ABSTRACT

We present the current status and first results of the astrometric project CIDA-ABAE for tracking geostationary satellites. This project aims to determine preliminary orbits for the Venezuelan satellite VENESAT-1, using astrometric positions obtained from an optical telescope. The results presented here are based on observations from the Luepa space tracking ground station in Venezuela, which were processed using astrometric procedures.

1. OBSERVING SITE

The relative motion of a geostationary satellite can be observed by telescopes of medium diameters (Montojo, 2011).

In a reference system attached to the Earth, such satellite appears as a fixed point with a magnitude between 6 and 12, in the visual band, depending on the phase angle with the Sun.

Figure 1. Luepa pace tracking ground station where the telescope is installed.

Figure 2. Researchers and engineers from CIDA and Agencia Espacial para Actividades Espaciales (ABAE) during the observatory's installation (Otero, 2013).

2. ASTROMETRIC REDUCTIONS

By adding exposures is possible to see the satellite motion over the CCD. Astronomical coordinates must be extracted from the exposure reduction (Abad, 2004). The telescope shows a strong distortion problem (Fig. 4). Using the overlap method (Stock, 1981) applied to the data corrected by non-linear terms (Abad, 1993), it is possible to find the field distortion (Fig. 5) and correct it, getting final errors better than those obtained by telemetry.

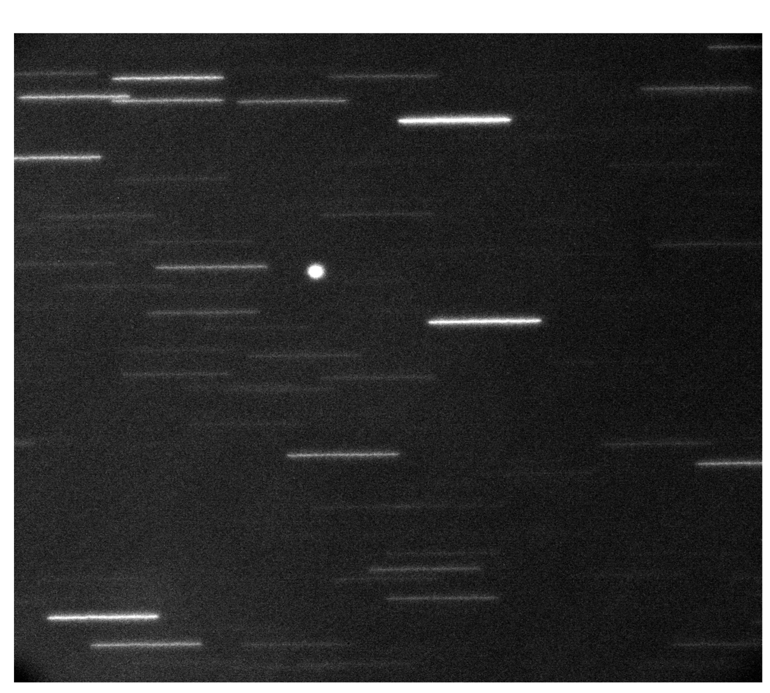

Figure 3. Because the telescope is attached to the Earth, therefore rotating as well, the satellite is a point over the CCD and stars show as traces proportional to the time of exposure.

Figure 4. Distortion is clearly visible when we observe 2 stars placed on the corners of the CCD.

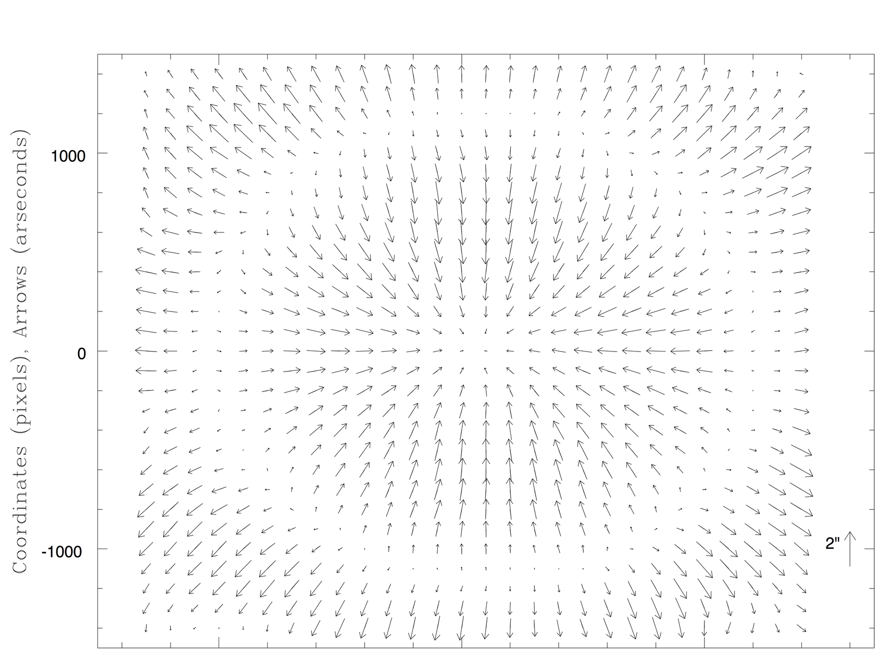

Figure 5. A representation vectorial of the distortion introduced by the telescope.

Table 1 shows final errors by coordinate for common stars down to 12 magnitude of the UCAC4 catalog.

Link with the catalog : 18382

Link between observations : 30922

Magnitude (m_v)	Error α_* (^{s})	Error δ_* ($''$)	# Stars
5	0.088	0.31	2
6	0.089	0.27	4
8	0.026	0.15	154
9	0.026	0.16	1747
10	0.030	0.17	4331
11	0.035	0.18	7072
12	0.045	0.21	3536

Table 1. Final errors by coordinate using only overlap stars are $(0.^s024, 0.''14)$.

The relative motion of the satellite from March 23rd to 30th, 2013 is shown in Fig. 6 and Fig. 7. Black points represent the telemetric tracking measurements and red points represent the optical tracking. The plot of Azimuth vs Universal Time (UT) and Elevations vs UT are seen in Fig. 6 and Fig. 7, respectively. We can see that each topocentric coordinate contains a sinusoidal libration of the period, that lasts one sidereal day, since the orbital period of this satellite is equivalent to the period of rotation of the Earth (Soop, 1994).

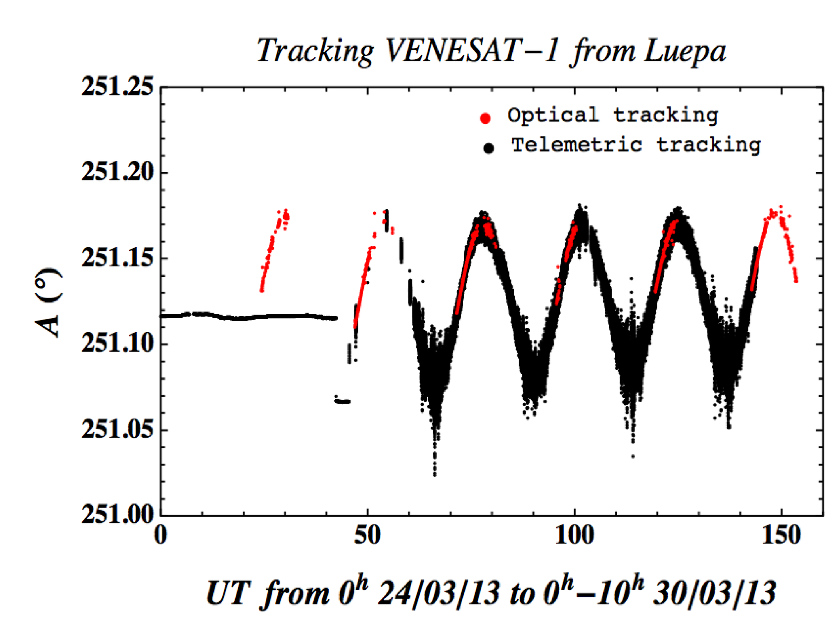

Figure 6. Azimuth, in degrees, versus Universal Time, in hours, relative to the ground station.

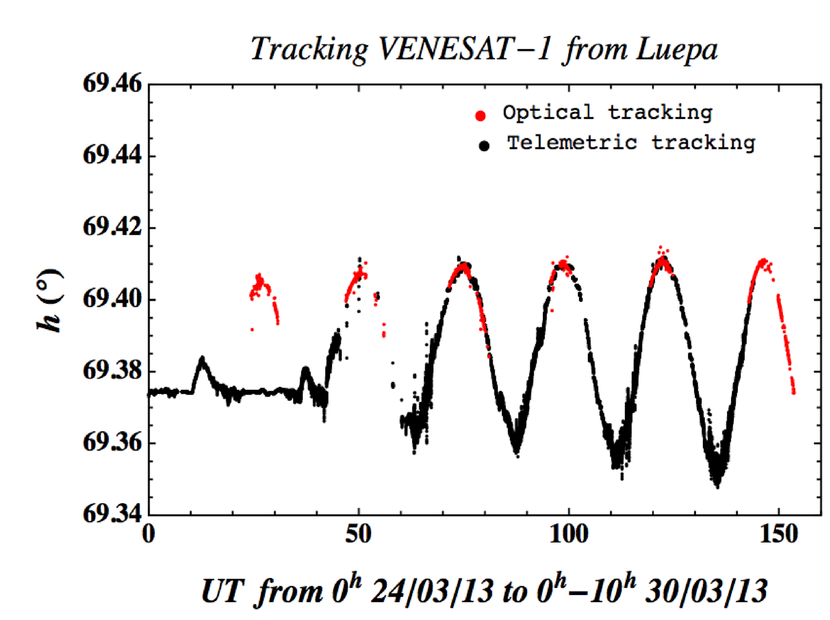

Figure 7. Elevation, in degrees, versus Universal Time, in hours, relative to the ground station.

3. RELATIVE ORBITS

The combined influence of conservative and not conservative forces make the satellite position changes with time. This becomes evident in the non-stationary relative orbital motion, as shown in Fig. 8 and Fig. 9. Relative orbital motion of the VENESAT-1 satellite is shown in Fig. 8. Black points correspond to measurements performed by telemetric tracking on March 28th, 2013.

The orange curve represents the linearized motion of the satellite obtained from telemetric data as a first approximation for the geostationary orbit determination. Likewise, we obtain the linearized motion from optical tracking on March 27th and 28th, 2013 as show in Fig. 9 (blue curve) over CCD.

This movement is constrained to an area $0.^\circ 037 \times 0.^\circ 046$.

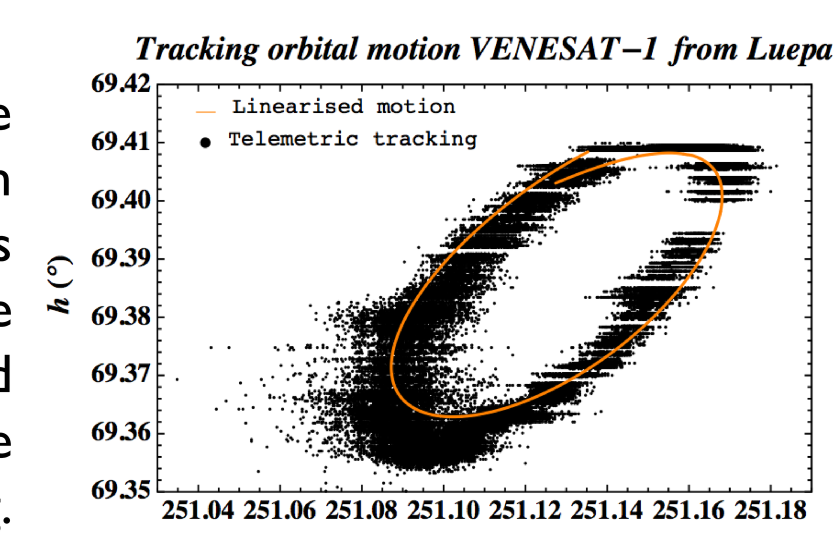

Figure 8. Orbital motion during a sidereal day projected on the local topocentric coordinates.

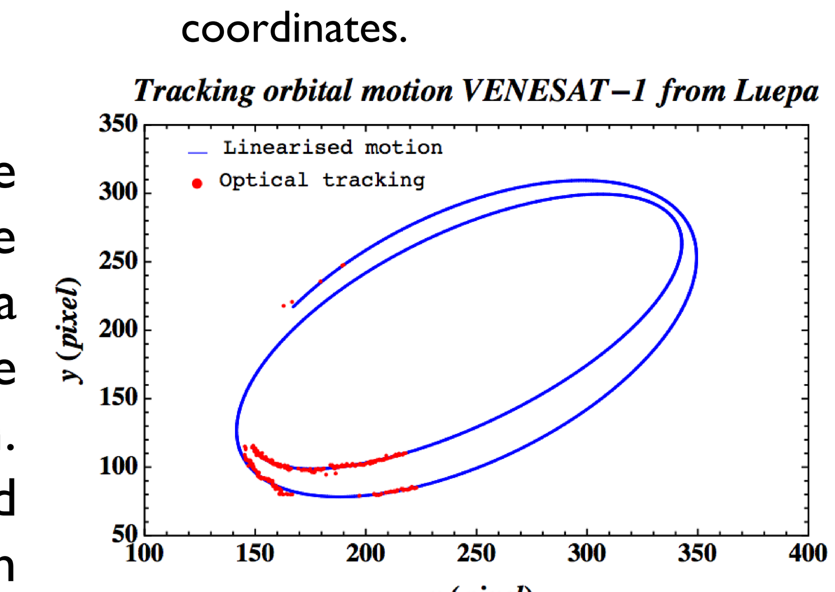

Figure 9. Orbital motion on the sky. The vertical and horizontal axes correspond to Elevation and Azimuth, respectively, where $1\ pixel \approx 0.''67$.

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