Trying to understand what is happening in Madrid IGS station

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1. Introduction

Madrid is an IGS station and it was one of the fixed sites used by IGS for its products, since the starting of its official activity in 1994, until August 18,1998, when the station was definitively removed from the list of the IGS fiducial site, as analyses of EUREF and JPL suggested (according to IGS Mail n.1991). Madrid time series coordinates show several jumps and long periods of high noise in the estimations, not depending on the analyses centers processing.

2. History of the site

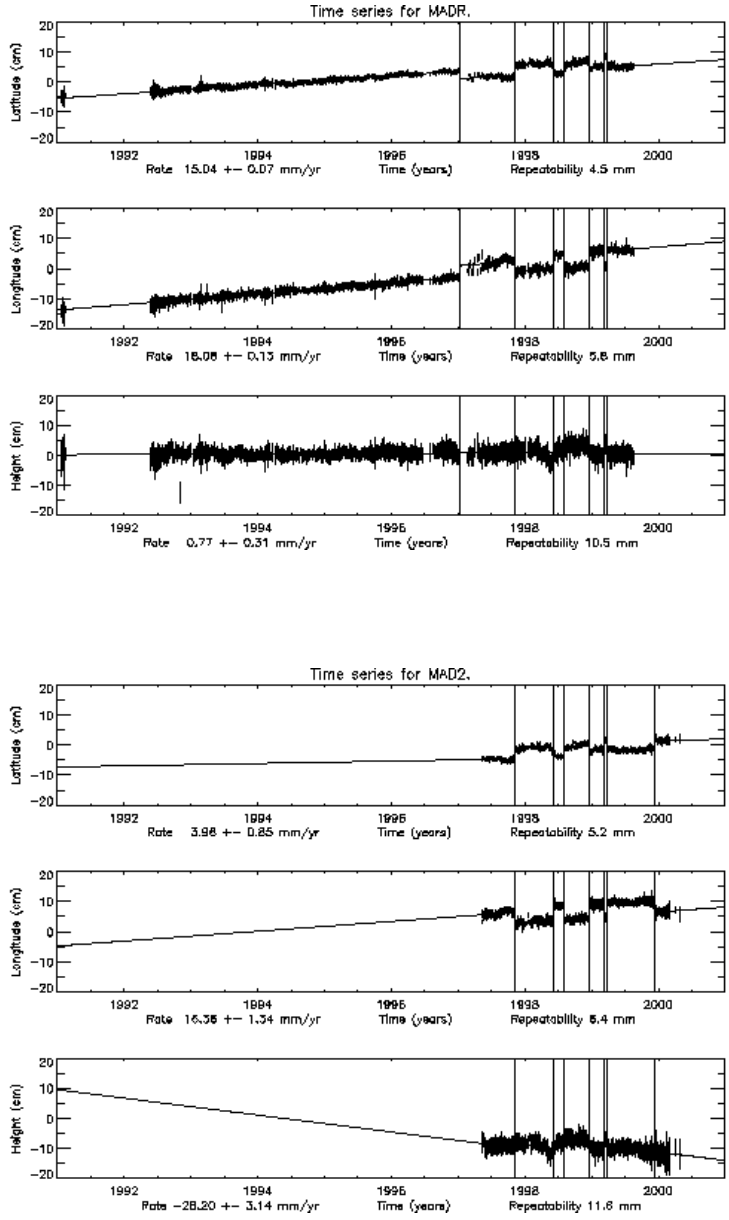
The first permanent GPS receiver at the site was installed on December, 15, 1989. With the IGS mail n. 2428, sent on August 19,1999, JPL officially announced the shutdown of that receiver (a Rogue SNR-8). Madrid site, known as MADR, suffered some important changes in the hardware configuration (receiver / antenna). On September 25, 1996 a Dorne Margolin T antenna took the place of a Dorne Margolin R. This change probably due to the high noise in the data. Contemporary, a new receiver, a Turborogue, was also be tracking on the site. Both the receivers, the Rogue and the Turborogue, were connected to the same antenna, but data from the new receiver were made available only one year later, (October 1997), when the site-log of MAD2 was officially pubblished through an IGS Mail by JPL (IGS Mail n. 1718). Soon after, starting from January, 4, 1998, EUREF community switched on MAD2 data, due to the unreliable behaviour of the old Rogue receiver (EUREF Mail n.0084).

3. Madrid in EUREF solutions

Looking at EUREF solutions since the beginning of the IGS Pilot project for regional densification with GPS (GPS week 0860, June 30,1996), we see that MADR was one of the fiducial sites to align the free solutions with the suitable terrestrial reference frame. Starting from GPS week 0898 (March 23, 1997), Madrid was removed from EUREF solutions, because it has been behaving very anomalous since the starting of 1997. Contemporary, it stopped to be one of the EUREF fiducial sites. It has been including again in EUREF solutions in GPS week 0909 (June 08, 1997) until week 0930 (November 02, 1997). Soon after, in GPS week 0931, Madrid showed a jump in the horizontal componets of the coordinates of about 30 millimeters, so that it was removed again from EUREF solution until GPS week 0939 (January 04,1998), when EUREF switched to new receiver (ROGUE SNR-12 RM) called MAD2, connected to the same antenna as the older ROGUE SNR-8. According to a decision taken within EUREF community (EurefMail n. 0084), the station name and domes number of Madrid remained unchanged in EUREF SINEX files. Unfortunately, also the new receiver data showed anomalous behavior, causing jumps in N and E components of few centemeters. According to EUREF weekly report, these jumps were due to the change of equipment and EUREF officially stopped processing this site in GPS week 0970 (August 08, 1998) (cf. IGS MAIL n.1991).

4. Madrid in JPL solutions

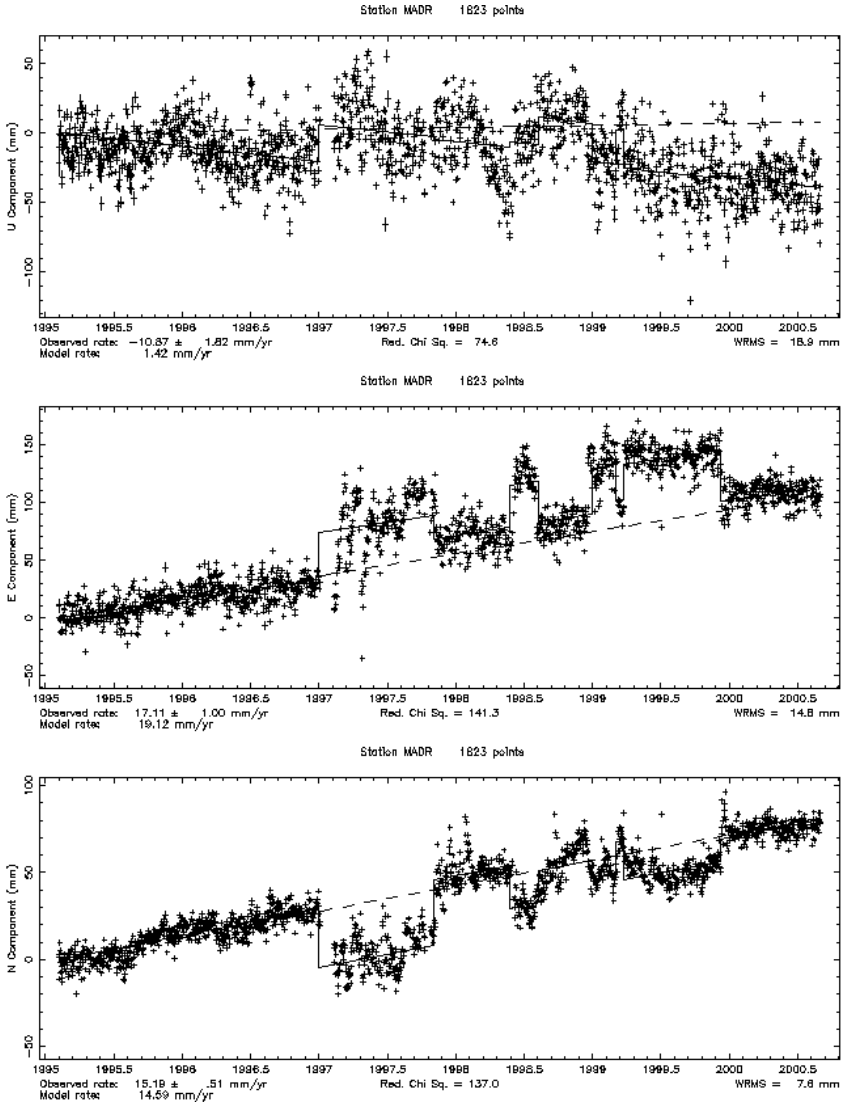
Analysing the last update of JPL coordinates time series of Madrid (M. Heflin, JPL, June 12, 2000 IGS Mail n.2883), several jumps of few centemeters in horizontal and height components are clear. The time series cover the entire period of acquisition of both MADR and MAD2 (SNR-8 and SNR-12 RM): for MADR from 1991 to August 1999, while for MAD2 from October 1997 since now. As a consequence, velocity estimation based on these time series are unreliable. This is largely true for MAD2, which bases the entire acquisition over the unlucky period started at the beginning of 1997. On the other hand, MADR velocity could be more reasonable due to the good time series covering more than 4 years (1992.5-1996.9).



JPL Madrid time series

5. Madrid in ASI/CGS solutions

ASI started processing Madrid GPS station since the beginning of 1995. Data from MADR were analysed until MAD2 data became available (October, 1997). No gap must be expected between the two time series, because the same antenna was collecting data for both the receivers.
Looking at the time series of some parameters we usually look at to have a feel about the quality of the stations, obtained with QC vs.3 (which are: data collected percentage, number of cicle-slip, value of multipath on L1 and L2), it is clear that this station had never acquired under excellent conditions. As the author of QC suggest, what is interesting in parameters checked by it, are the eventual jumps, discontinuities or whatever could be related to some changes in the value, rather than the value itself. The introduction of MAD2 has dramatically lowered the multipath level both on L1 and L2 and cycle-slip have been reduced too (beginning of 1998). Unfortunately, it cannot be found a direct correlation between bad quality parameters and bad data analyses or jumps.



ASI-CGS Madrid time series

Generally speaking, six big (some centemeters) jumps are present on time series of horizontal components of coordinates; these jumps are less evident in the up component, which, on the contrary, shows a high (unrealistic) lowering rate (more than 10.0 mm/yr). Both ASI and JPL time series show jumps at the same epochs; this is encouraging because it means that the jumps aren't 'analist-depending' and are surely site-depending.

Now, we try to find correlations between jumps and known events occured to the station.

The first jump in the coordinates time series appears at the beginning of 1997. Changes were made at MADR antenna in October 1996: the old Dorne Margolin R was replaced by a new Dorne Margolin T, but the receiver remained unchanged (old Rogue). The new receiver became operative only one year later (October, 1997), when the site-log of the site was pubblished by JPL.

ASI results covering the first ten months of 1997 are drammatically noisy: WRMS of the linear fit for horizontal components, which usually is within 10 mm or less, reachs 22.5 mm in the E component; moreover, the jump in N component is about of 3.5 cm and the E component is about of 4.0 cm. The results for that period seem to be unrealistic. The shape of the JPL time series of the coordinates seems to be as scattering as ours over the same period. In November 1997 ASI switched on MAD2 and an opposite jump took the estimations on reasonable values. Apart from a little cluster of points, the period from November 1997 to June 1998 shows values compatible with the expected ones (according to ITRF97 predictions and the trend extrapolated from the first two years of analysis), both for mean value of the fit and WRMS, which is within the expected values (max 10.0 mm per horizontal component).

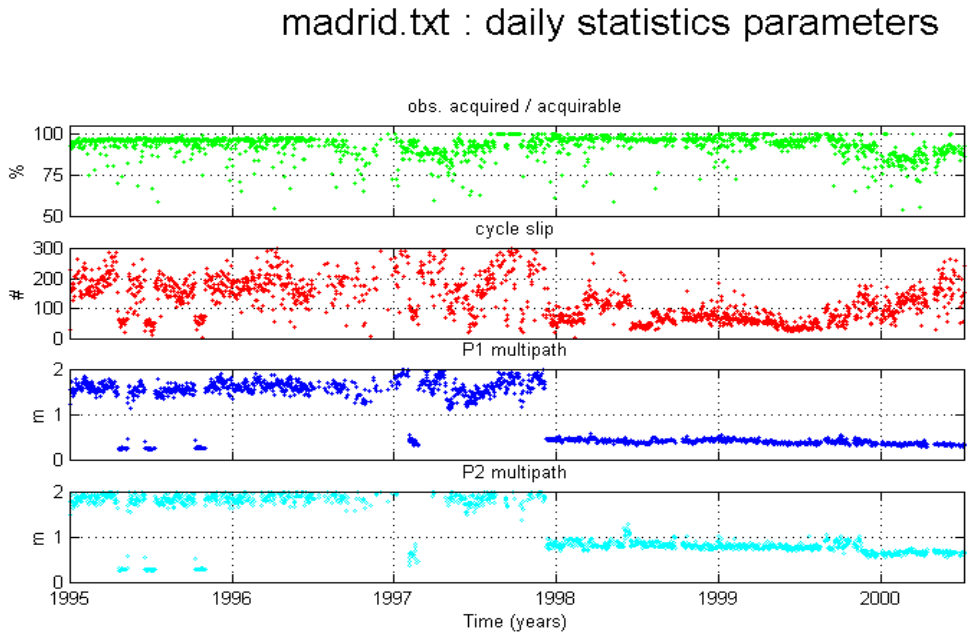
A new jump in horizontal components appears in June 1998. In June 1998, (IGS Mail 1927) JPL announced the replacement of receiver at MAD2 site with a new one of the same kind. The replacement was compelled by calibration problem at the site. The jump could be related to this change. The jump is of about 2.5 centemeters in N and 3.4 centemeters in E. This jump was 'cancelled' by an opposite one appeared in August of the same year. No IGS mail about Madrid site was found for that period, even if a suspect update of the site log without any updating information inside was made in August 1998.

The next and last important jumps in time series are at the beginning and at the end of 1999. Jumps are of about 1.0 cm for N and about 4.0 cm for E. No explanation has been found for these jumps.

During the last nine months horizontal values are again reasonable: fitting 1995, 1996 and the last 10 months Madrid velocity become realistic in horizontal components (14.2 mm/yr N, 21.1 mm/yr E); problems still remain on the up component (-6.0 mm/yr).

	Value (mm)			**Possible cause**
Epoch	N	E	U	
01-01-1997	- 33.6±0.9	41.9±1.7	26.8±3.1	*To be investigated*
05-11-1997	37.6±0.8	- 20.3±1.5	- 1.1±2.7	Switch on MAD2
25-05-1998	-24.5±1.0	36.4±1.8	4.1±3.2	Calibration problem: change of rec.
10-08-1998	18.6±1.0	- 34.8±1.9	19.8±3.4	None: site-log updating without news
01-01-1999	-10.1±1.0	39.5±2.2	-27.9±3.7	*To be investigated*
05-03-1999	17.5±2.1	- 30.9±3.6	25.2±6.6	Minor jump
25-03-1999	-22.5±2.0	30.9±3.2	-27.1±6.1	Minor jump
10-12-1999	12.5±0.7	- 44.0±1.4	1.8±2.6	*To be investigated*
wmean	-5.0±1.2	10.0±2.2		

Table of the jumps



6. Conclusions

First quality analyses of the signal at Madrid site don't let to find clear correlation between noisest period with worst results in terms of coordinates. Only the jump at the end of 1997 (the switch to the new receiver MAD2) seems to be correlated to a lowering of the multipath level both on L1 and L2. Generally, also the cycle-slip level seems to be lower than before that change. No relationship can be found between the other jumps and changes in the quality parameters we have looked at.

Looking at the time series, what is interesting to notice is that the jumps are always equal (at 3 sigma level) and opposite in sign for the North component, two by two; this is partially true also for the East component (apart from the second jump).

When jump occurs, its sign is always opposite for the two horizontal components.

The range of variability of the jumps' size is larger for the North component (10.0 mm up to 37.6 mm) than for the East one (20 mm up to 44.0 mm).

The Up component seems do not benefit at all by the introduction of jumps in time series.

Erasing completely the period from 01-01-1997 to 01-01-2000, horizontal velocities become very similar to the ITRF97 expected values (est.: 14.2 N, 21.1 E; Mod.:14.6 N, 19.12 E). This is not true for the Up component which remains around an unbelievable -6.0 mm/yr.

Is it possible that Madrid is again ok or must we expect to introduce soon another jump?