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New Directions in Seismic Hazard Assessment through Focused Earth Observation in the Marmara Supersite

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[Long-term monitoring experiment in geologically active regions of Europe prone to natural hazards: the Supersite concept]

D3.1

GPS Time Series and Velocity Maps

Project Start Date	1 November 2012
Project Duration	36 months
Project Coordinator /Organization	Nurcan Meral Özel / KOERI
Work Package Number	3
Deliverable Name/ Number	GPS Time Series and Velocity Maps /3.1
Due Date Of Deliverable	
Actual Submission Date	
Organization/Author (s)	TUBITAK / Rahsan CAKMAK KOSMA

Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission)	
RE	Restricted to a group specified by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	

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1 INTRODUCTION

The deliverable D3.1 is the one of the main outputs of WP3 "Long-term Continuous Geodetic Monitoring of Crustal Deformation" in which long-term continuous monitoring of the crustal deformation will be investigated by using the existing geodetic crustal deformation monitoring systems.

The objective of this deliverable is to share the results of geodetic process in WP3-Task 1 named as "Land-based continuous monitoring of crustal deformation".

GPS time series and velocity field, in this report, are needed to calibrate the results of SAR studies and the crustal models, which are developed within data related WPs of MARSite.

Task 1 contains the active studies of TUBITAK. TUBITAK has been started to distribute the GPS-related outputs via project ftp server from the beginning of the project. This report summarizes the details of the process in Task 1 and introduces the results.

2 MARMARA CONTINUOUS GPS NETWORK (MAGNET)

MAGNET is the Continuous GPS Network in Marmara Region. The establishment of the network was started in 1998 and now it reaches 22 continuous GPS stations (**Hata! Başvuru kaynağı bulunamadı.** and **Hata! Başvuru kaynağı bulunamadı.**). Besides MAGNET, complementary GPS surveys have been carried out since 1998 (**Hata! Başvuru kaynağı bulunamadı.**).

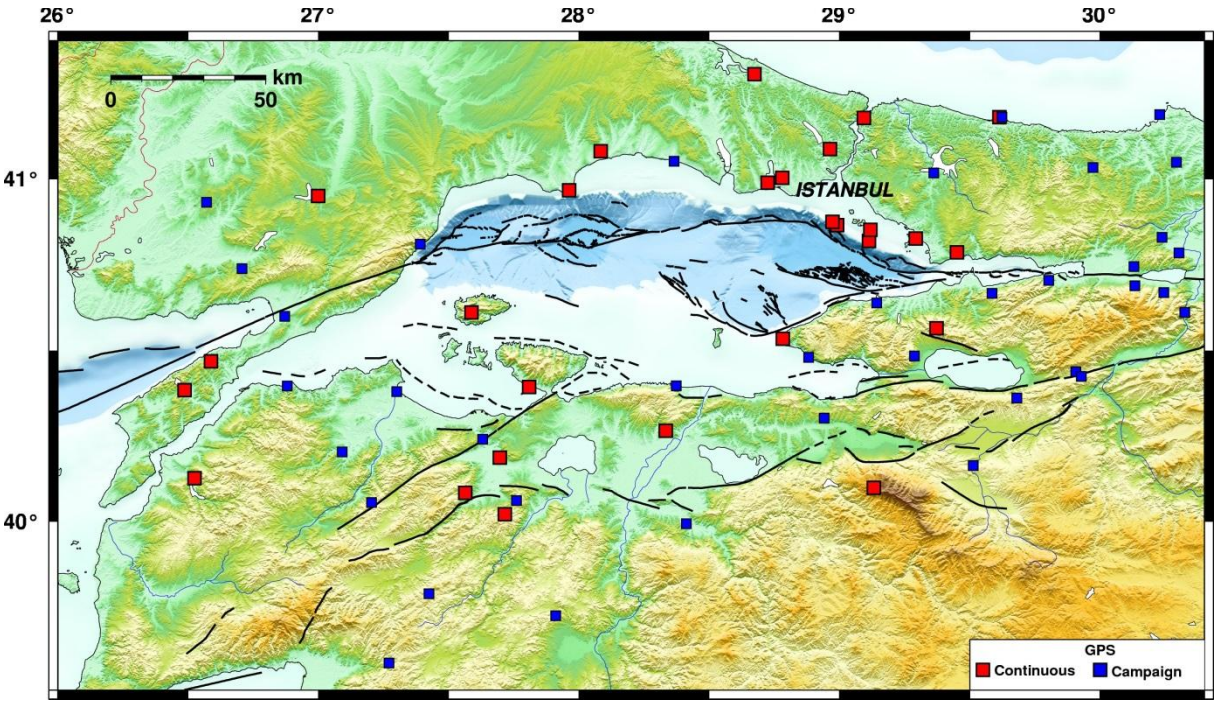

Figure 1. Continuous GPS stations (MAGNET) (red) and campaign survey GPS sites (blue) in the Marmara Region.

Table 1. Continuous GPS stations of MAGNET

Station ID	Station Name	Location	Coordinate (WGS84)		
			Long °	Lat °	Up (m)
TYF1	Tayfur	Çanakkale Gelibolu	26.48567790	40.38407251	200.5213
ATHT	Atikhisar	Çanakkale	26.52361322	40.12569083	106.5721
YENT	Yeniköy	Çanakkale Gelibolu	26.58727012	40.46833405	302.9550
KRDT	Karaiğdemir	Tekirdağ Malkara	26.99850520	40.95072905	180.0202
ATCT	Atıcıoba	Balıkesir Gönen	27.56330556	40.08302355	327.1198
MADT	Marmara Adası	Balıkesir	27.58694299	40.61135232	749.1330
ALAT	Alaattin	Balıkesir Gönen	27.69579844	40.18643674	104.4632
CHMT	Çobanhamidiye	Balıkesir Gönen	27.71496430	40.01985331	496.4170
ERDT	Erdek	Balıkesir	27.80794911	40.39322336	92.1755
MER1	Marmara Ereğlisi	Tekirdağ	27.96174890	40.96693379	91.7447
KART	Karacabey	Bursa	28.33256626	40.26525876	485.6161
AVCT	Avcılar	İstanbul	28.72386047	40.98866667	122.3623
BOZT	Bozburun	Yalova	28.78203580	40.53438555	115.5547
SVRT	Sivriada	İstanbul P. Islands	28.97351098	40.87471369	57.4326
YSST	Yassıada	İstanbul P. Islands	28.99086717	40.86577765	75.3325
KANT	Kandilli	İstanbul Üsküdar	29.06143119	41.06080795	155.0009
YANT	Yandros	İstanbul P. Islands	29.11271904	40.81972387	63.9704
BAD1	Büyükada	İstanbul P. Islands	29.11789697	40.85211710	239.1318
ULUT	Uludağ	Bursa	29.13144549	40.09754875	2088.8951
DUM2	Dumanlı	Bursa Orhangazi	29.37189633	40.56552512	930.3721
TUBI	TUBITAK	Kocaeli Gebze	29.45068361	40.78672512	221.6744
UCG2	Üçgaziler	Kocaeli	29.96240059	40.84551416	397.4312

3 DATA PROCESS

GAMIT / GLOBK software developed by the Massachusetts Institute of Technology Department of Atmospheric and Planetary Sciences (EAPs MIT, USA) was used for processing of data mentioned in the previous section. First of all, in data processing, continuous and survey GPS measurements have been converted into RINEX format and required information for evaluation are prepared (such as receiver and antenna types, antenna height and type of height measurement). The precise orbit information produced by International GPS Service (IGS) in SP3 (Standard Product 3) format is taken from SOPAC (Scrips Orbit and Permanent Array Center). Earth rotation parameters (ERP) taken from usno_bull_b (United States Naval Observatory_bulletin_b) values were used. 10-15 stations from IGS global monitoring network were included to the evaluation. To define the reference frame, ITRF2005 coordinate system was used. For Radiation-pressure effects, Berne 9 parameterized model (standard of the SOPAC) was used. For ocean loading effect, Scherneck model (IERS standards, 1992) was studied with. The zenith delays were calculated with the 2-hour intervals based on Saastamoinen precursor standard tropospheric model. In the evaluation, LC (L3), independent linear combination of the ionosphere of L1 and L2 carrier phases is used. For antenna phase center, the model depending

on the height is used. Daily loosely constrained solutions from GAMIT were identified by transformation with 7 parameters (3 translations, 3 rotations and 1 scale factor) taking advantage of 15 IGS stations in ITRF2005 reference frame. Daily precise coordinates and repeated measurements at each period were joined by Kalman analysis and time series containing position variations of these points are obtained. Also, with the help of the Kalman filtering using trend analysis from the time series velocities for sites are determined.

4 TIME SERIES AND VELOCITY FIELD

As mentioned in the previous section, time series of the stations and the velocity field respect to Eurasia (Figure 2) are produced for 2002-2013 time period. The velocities of the stations are also given in Table 2. In Annex, the time series of all GPS stations are shown.

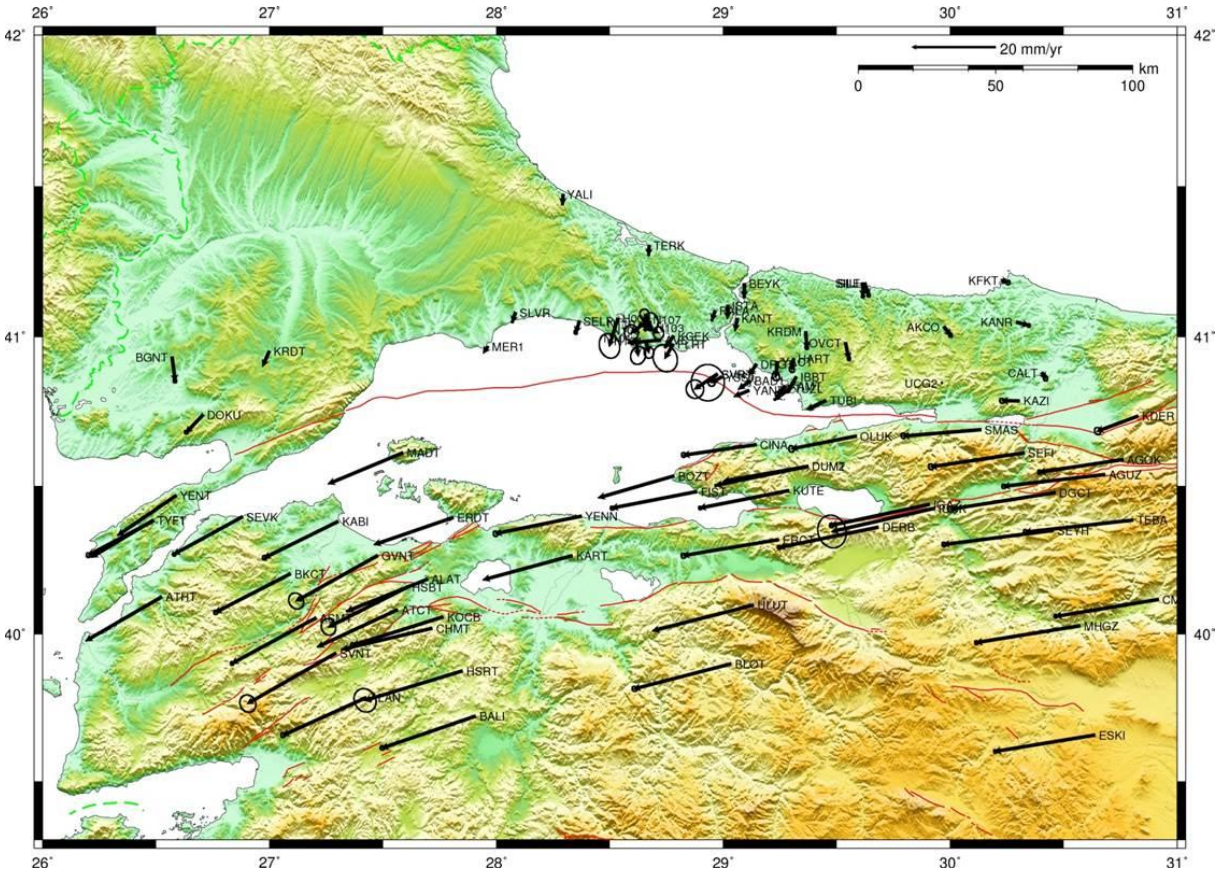

Figure 2. Velocity field for Marmara Region (respect to Eurasia and with %95 confidence ellipses) (2002-2013)

Table 2. Velocity field for Marmara Region (2002-2013)

Station ID	Long°	Lat°	Velocity (mm/yr)		Sig (mm/yr)		RHO
			East	North	East	North	
CMLN	30.91635	40.11795	-24.38	-4.02	0.15	0.18	-0.099
KDER	30.82663	40.73478	-9.57	-3.57	0.29	0.36	-0.175
TEBA	30.80449	40.38572	-25.55	-2.85	0.19	0.23	-0.111
AGOK	30.76109	40.58886	-19.84	-2.97	0.18	0.21	-0.074
AGUZ	30.68037	40.53834	-24.00	-2.78	0.18	0.22	-0.099
ESKI	30.63704	40.65758	-23.69	-3.89	0.15	0.17	-0.098
MHGZ	30.57041	40.02786	-24.60	-3.99	0.16	0.19	-0.103
DGCT	30.46175	40.47786	-24.89	-3.91	0.24	0.29	-0.087
SEYH	30.45336	40.35061	-25.99	-3.36	0.18	0.22	-0.134
CALT	30.40452	40.88000	0.85	-1.32	0.18	0.21	-0.078
SEFI	30.32520	40.61163	-22.16	-3.32	0.24	0.28	-0.135
KAZI	30.30341	40.78522	-4.06	0.05	0.22	0.25	-0.122
KANR	30.29356	41.04825	2.83	-0.72	0.15	0.18	-0.076
KFKT	30.22937	41.18680	1.39	-0.41	0.19	0.22	-0.053
SMAS	30.13402	40.68972	-18.39	-1.50	0.21	0.26	-0.086
AKCO	29.97311	41.03354	1.53	-2.02	0.16	0.19	-0.072
UCG2	29.96240	40.84551	0.13	0.07	0.02	0.02	-0.045
IUCK	29.92893	40.42473	-24.29	-5.49	1.38	1.59	-0.108
IGAZ	29.90799	40.43800	-23.31	-4.98	0.18	0.22	-0.078
DERB	29.68137	40.36165	-23.49	-4.82	0.17	0.19	-0.086
SILE	29.62324	41.17945	0.89	-2.90	0.16	0.18	-0.076
SILI	29.61332	41.17900	0.13	-3.08	0.14	0.16	-0.013
OLUK	29.58524	40.66713	-15.38	-3.02	0.26	0.31	-0.096
OVCT	29.53923	40.97974	0.76	-3.73	0.16	0.19	-0.080
TUBI	29.45068	40.78672	-4.34	-2.07	0.02	0.02	-0.047
DUMT	29.37189	40.56552	-21.82	-4.49	0.09	0.10	-0.047
DUM2	29.37189	40.56552	-20.82	-3.49	0.03	0.03	-0.041
KRDM	29.36246	41.01709	0.30	-3.77	0.16	0.19	-0.074
IBBT	29.32081	40.86602	-1.90	-3.23	0.16	0.19	-0.041
HART	29.31021	40.92680	-0.44	-2.55	0.25	0.29	-0.123
TUZL	29.29245	40.82650	-3.54	-2.55	0.07	0.08	-0.023
KUTE	29.28794	40.48473	-21.08	-4.14	0.15	0.16	-0.087
KAMT	29.27328	40.83435	-1.86	-1.88	0.21	0.25	-0.053
ERCT	29.24320	40.31874	-22.63	-3.77	0.22	0.25	-0.073
YACT	29.23786	40.91670	-0.33	-3.52	0.35	0.41	-0.141
DRGT	29.14526	40.90880	-1.56	-2.43	0.03	0.04	-0.053
CINA	29.14313	40.63947	-17.17	-2.49	0.20	0.23	-0.058
ULUT	29.13144	40.09755	-23.80	-6.07	0.02	0.02	-0.052
BAD1	29.11790	40.85212	-2.71	-1.90	0.02	0.02	-0.049
YANT	29.11272	40.81972	-3.36	-1.36	0.03	0.03	-0.045
BEYK	29.09352	41.17672	-0.09	-3.09	0.09	0.10	-0.005
KANT	29.06143	41.06081	-0.53	-2.76	0.02	0.02	-0.053
BLOT	29.03304	39.89917	-22.93	-5.93	0.23	0.25	-0.055
ISTA	29.01934	41.10445	-0.09	-2.94	0.02	0.02	-0.050
YSST	28.99087	40.86578	-2.29	-1.34	0.33	0.35	-0.017
SVRT	28.97351	40.87471	-5.32	-3.53	0.85	0.89	-0.013
SVR1	28.97351	40.87471	-2.26	-1.98	1.61	1.77	-0.004
PALA	28.96320	41.08632	-0.70	-2.15	0.08	0.08	-0.010
FIST	28.88184	40.48057	-20.08	-3.90	0.17	0.20	-0.081
BOZT	28.78203	40.53438	-17.81	-5.15	0.02	0.02	-0.047
KCEK	28.77975	41.00275	-1.85	-2.60	0.09	0.09	-0.005
FLRT	28.77893	40.97483	-1.90	-3.30	1.19	1.33	-0.142

AVCT	28.72386	40.98867	-7.69	-0.70	0.02	0.02	-0.048
N103	28.68388	41.03013	-1.68	3.16	0.46	0.52	-0.038
TERK	28.67358	41.30307	-0.13	-2.10	0.09	0.09	-0.010
N107	28.67184	41.05651	-4.16	-3.15	0.65	0.80	-0.024
N104	28.65969	40.98540	0.67	-2.69	0.47	0.56	-0.032
N108	28.65249	41.02162	1.50	2.04	0.71	0.88	-0.029
N110	28.63109	41.04333	4.52	-2.20	0.51	0.61	-0.013
N101	28.61528	40.99572	0.51	-4.13	0.73	0.87	-0.120
H009	28.53579	41.06188	-2.02	-6.56	1.00	1.20	-0.144
YENN	28.37327	40.39790	-20.36	-4.13	0.23	0.26	-0.107
SELP	28.36533	41.05183	-0.83	-2.63	0.16	0.18	-0.093
KART	28.33257	40.26526	-20.99	-5.69	0.02	0.02	-0.048
YALI	28.29320	41.47335	-0.12	-2.27	0.09	0.09	-0.006
SLVR	28.08340	41.08022	-0.70	-2.15	0.08	0.08	-0.016
MER1	27.96175	40.96693	-0.95	-1.38	0.02	0.02	-0.049
BALI	27.90643	39.72167	-22.14	-7.57	0.20	0.21	-0.047
HSRT	27.84810	39.87523	-23.06	-6.99	1.07	1.14	-0.143
ERDT	27.80795	40.39322	-18.60	-6.39	0.02	0.02	-0.046
KOCB	27.76345	40.05858	-21.43	-6.74	0.19	0.22	-0.054
CHMT	27.71496	40.01985	-21.29	-5.01	0.06	0.06	-0.026
ALAT	27.69580	40.18644	-19.14	-7.59	0.05	0.06	-0.020
HSBT	27.60821	40.15944	-18.78	-9.50	0.71	0.80	-0.118
MADT	27.58694	40.61135	-17.59	-7.34	0.02	0.02	-0.043
ATCT	27.56330	40.08302	-18.87	-8.77	0.05	0.05	-0.025
GVNT	27.47554	40.26550	-19.32	-10.78	0.73	0.78	-0.146
ALAN	27.42449	39.78469	-19.73	-8.93	0.21	0.23	-0.070
KABI	27.30123	40.38099	-17.46	-8.63	0.19	0.21	-0.073
SVNT	27.29249	39.93513	-20.94	-11.95	0.78	0.84	-0.119
ASMT	27.20352	40.05448	-19.89	-10.79	0.16	0.18	-0.063
BKCT	27.09140	40.20343	-17.76	-9.15	0.18	0.20	-0.116
KRDT	26.99851	40.95073	-1.52	-3.44	0.02	0.02	-0.043
SEVK	26.87973	40.39580	-16.20	-8.86	0.16	0.18	-0.068
DOKU	26.70644	40.73927	-3.95	-4.16	0.16	0.18	-0.063
YENT	26.58727	40.46833	-13.77	-9.42	0.03	0.03	-0.032
BGNT	26.57014	40.93244	0.72	-5.66	0.17	0.19	-0.076
ATHT	26.52361	40.12569	-17.89	-10.39	0.02	0.02	-0.041
TYFT	26.48698	40.38310	-15.43	-8.16	0.20	0.22	-0.051
TYF1	26.48568	40.38407	-14.51	-8.68	0.02	0.02	-0.037

Annex I: Time Series

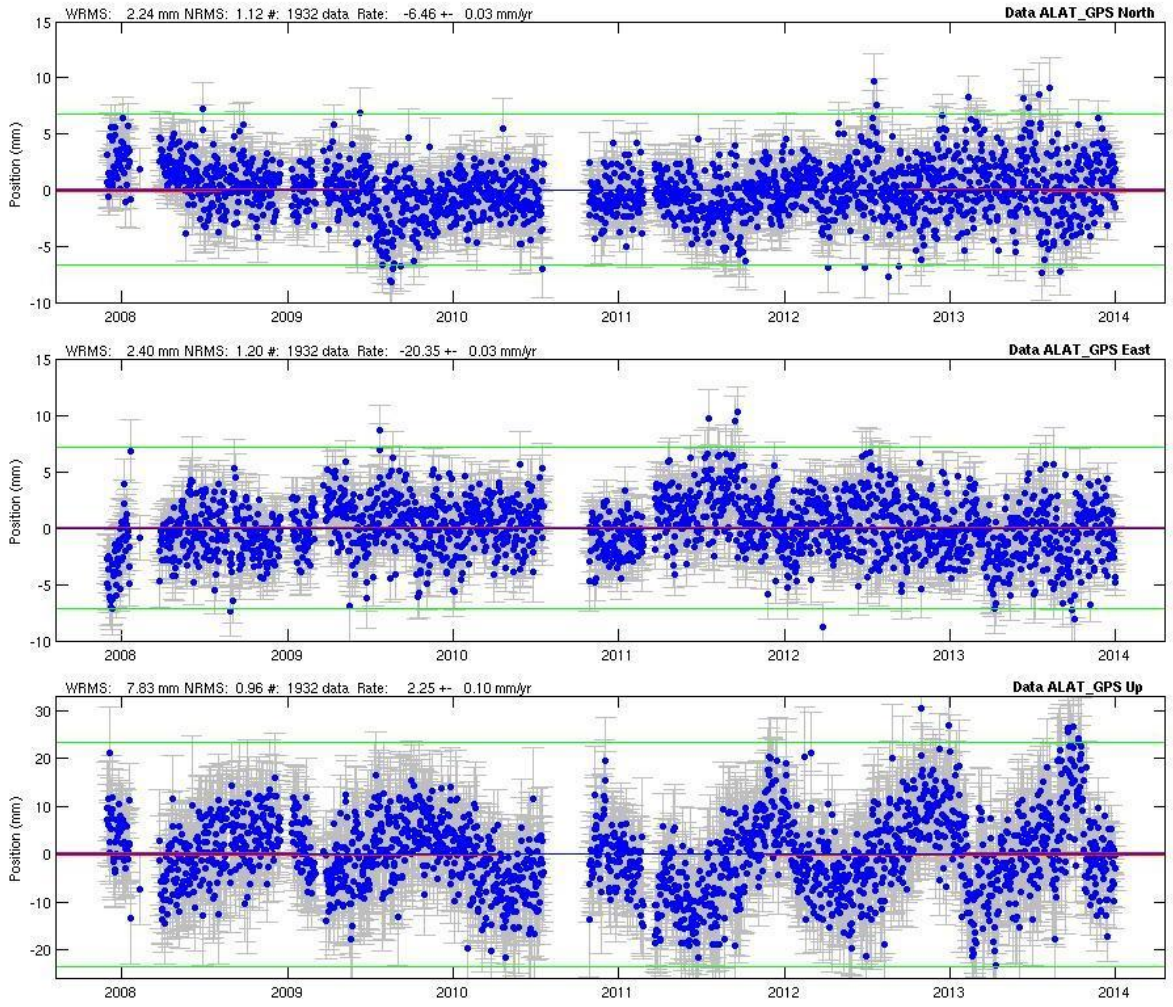

Figure 3. Time series for ALAT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

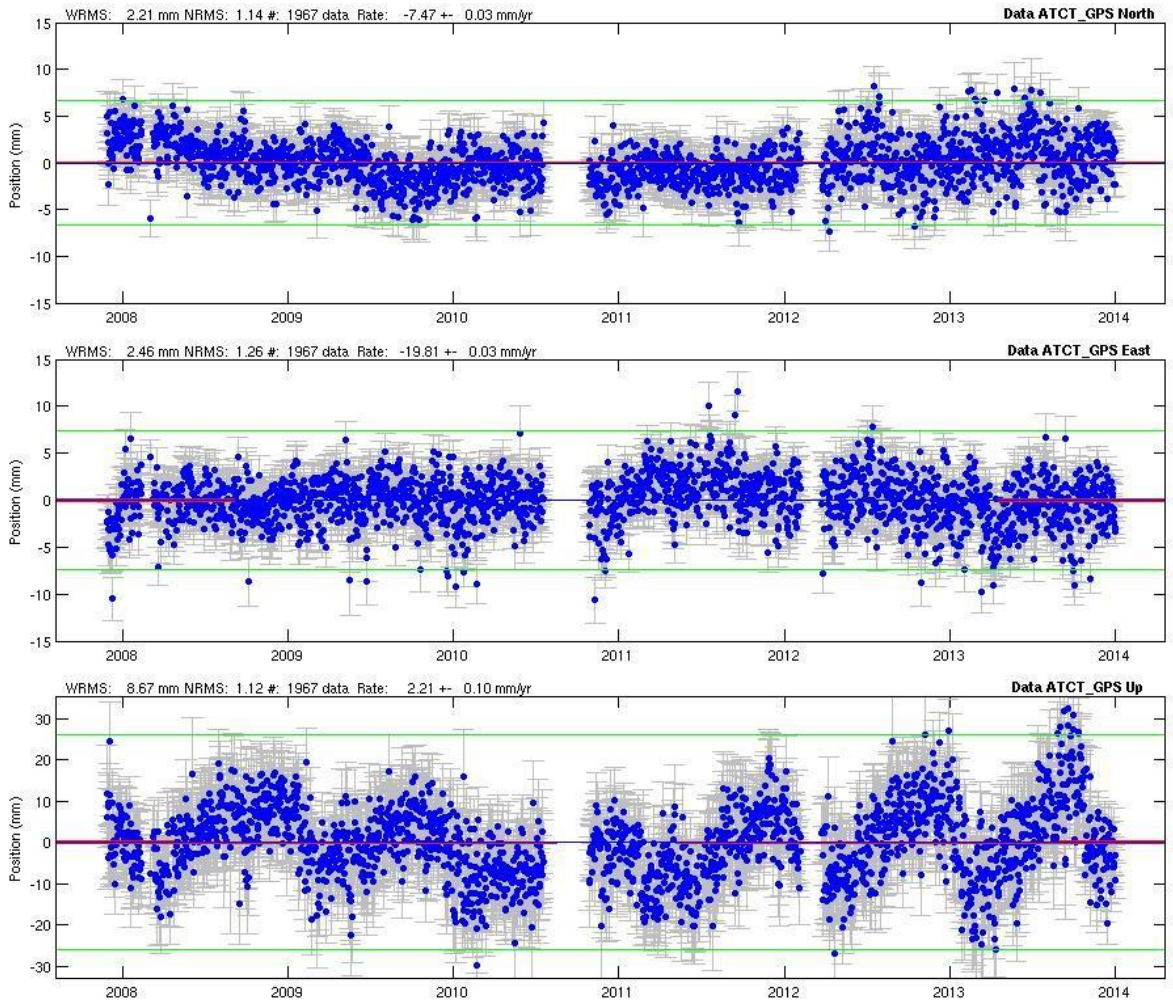

Figure 4. Time series for ATCT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

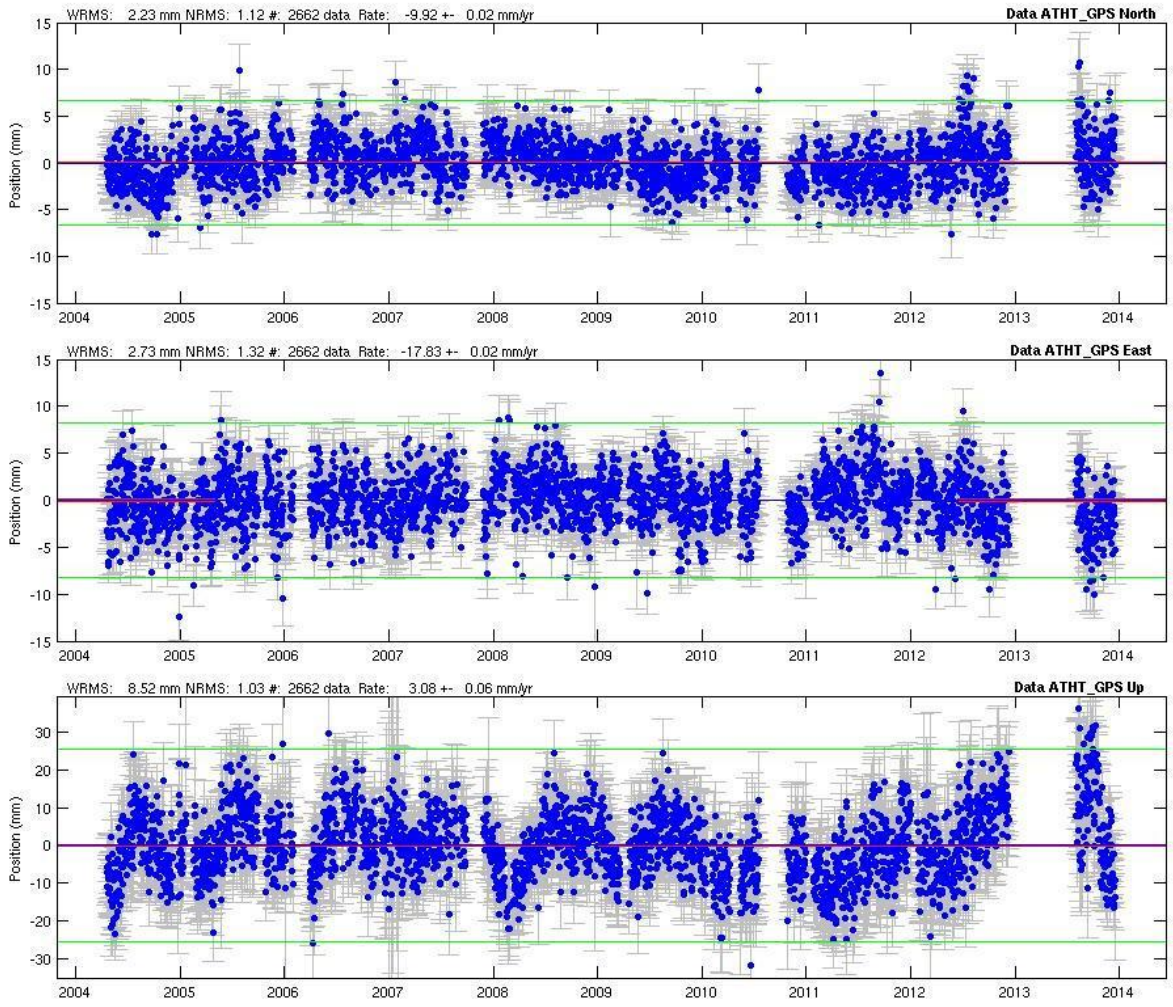

Figure 5. Time series for ATHT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

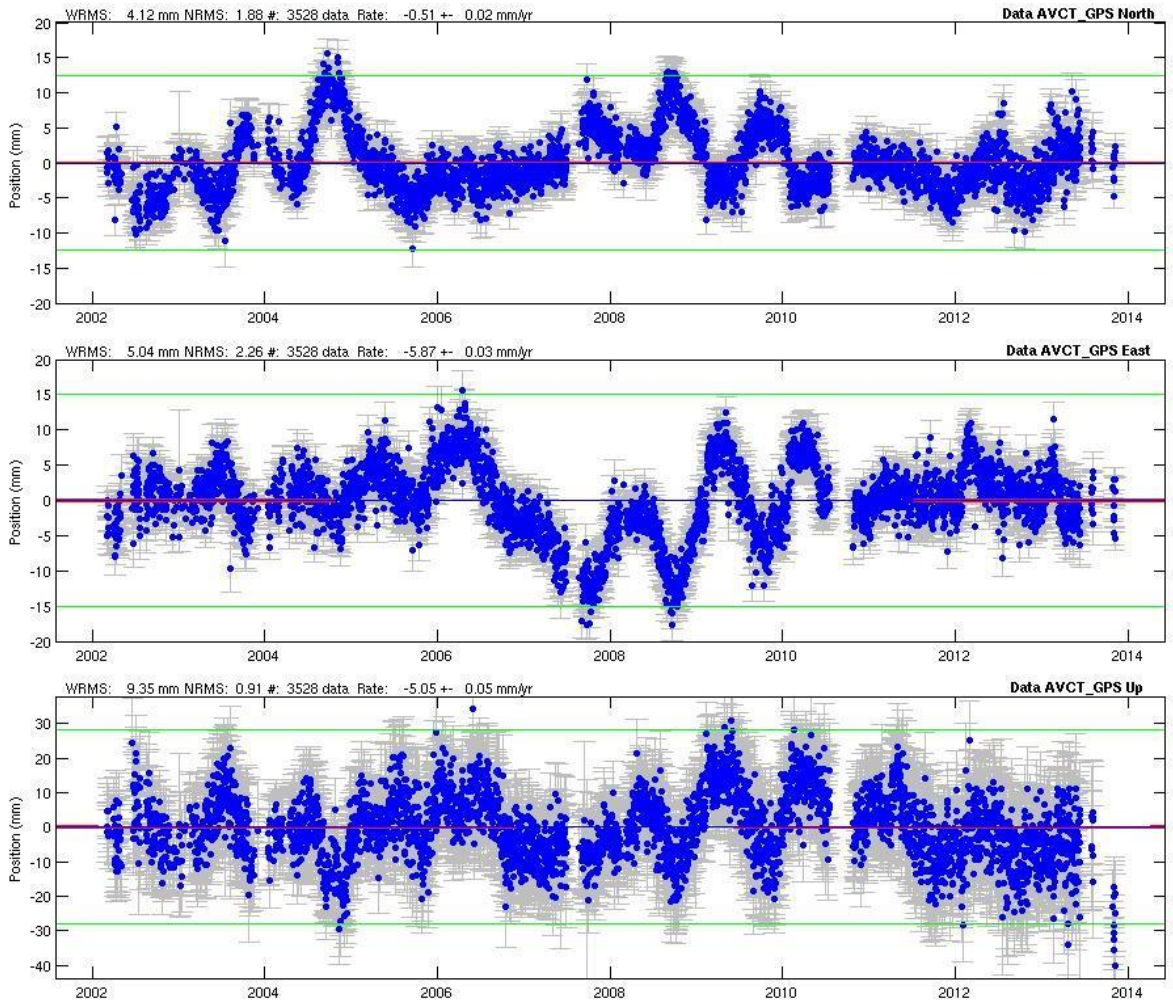

Figure 6. Time series for AVCT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

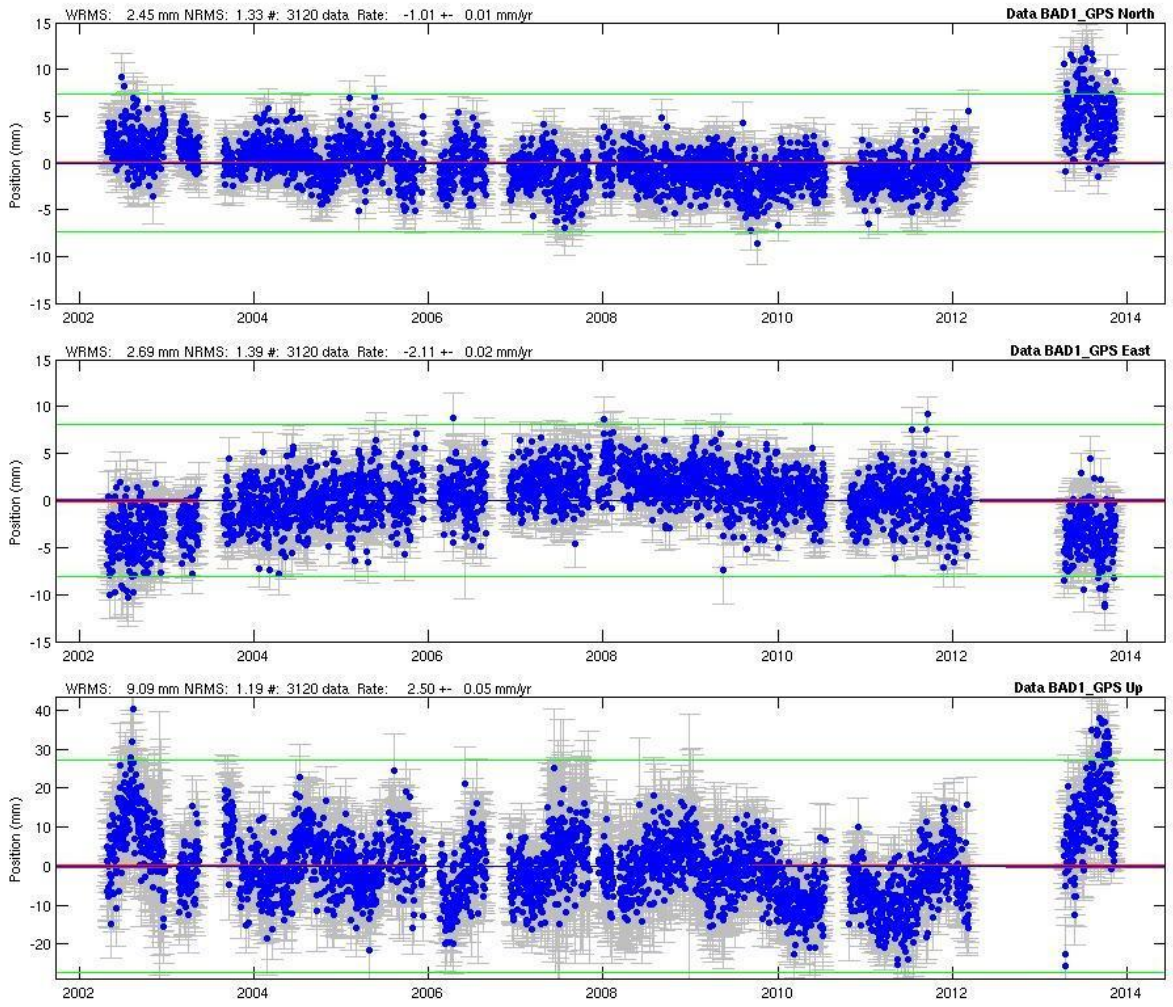

Figure 7. Time series for BAD1 (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

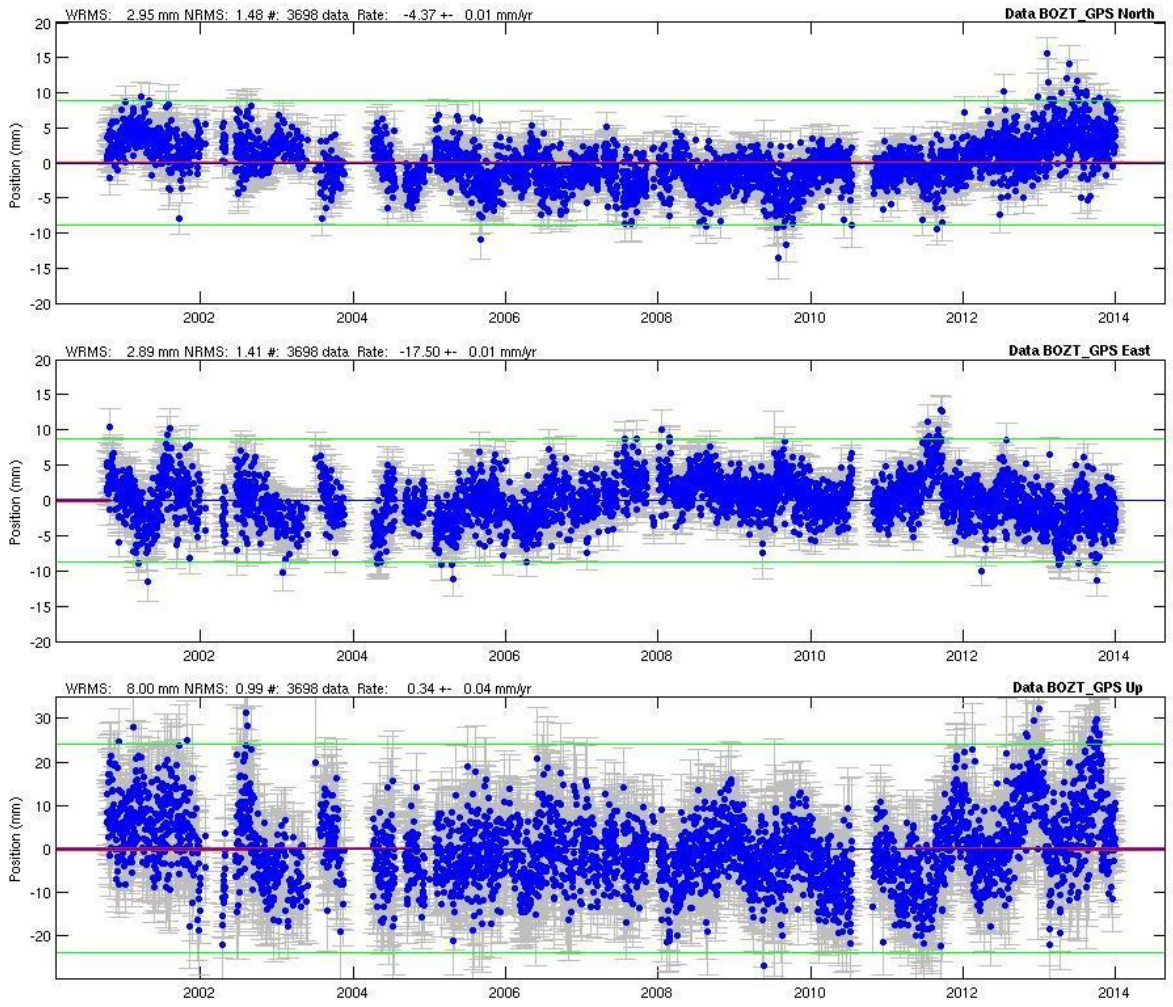

Figure 8. Time series for BOZT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

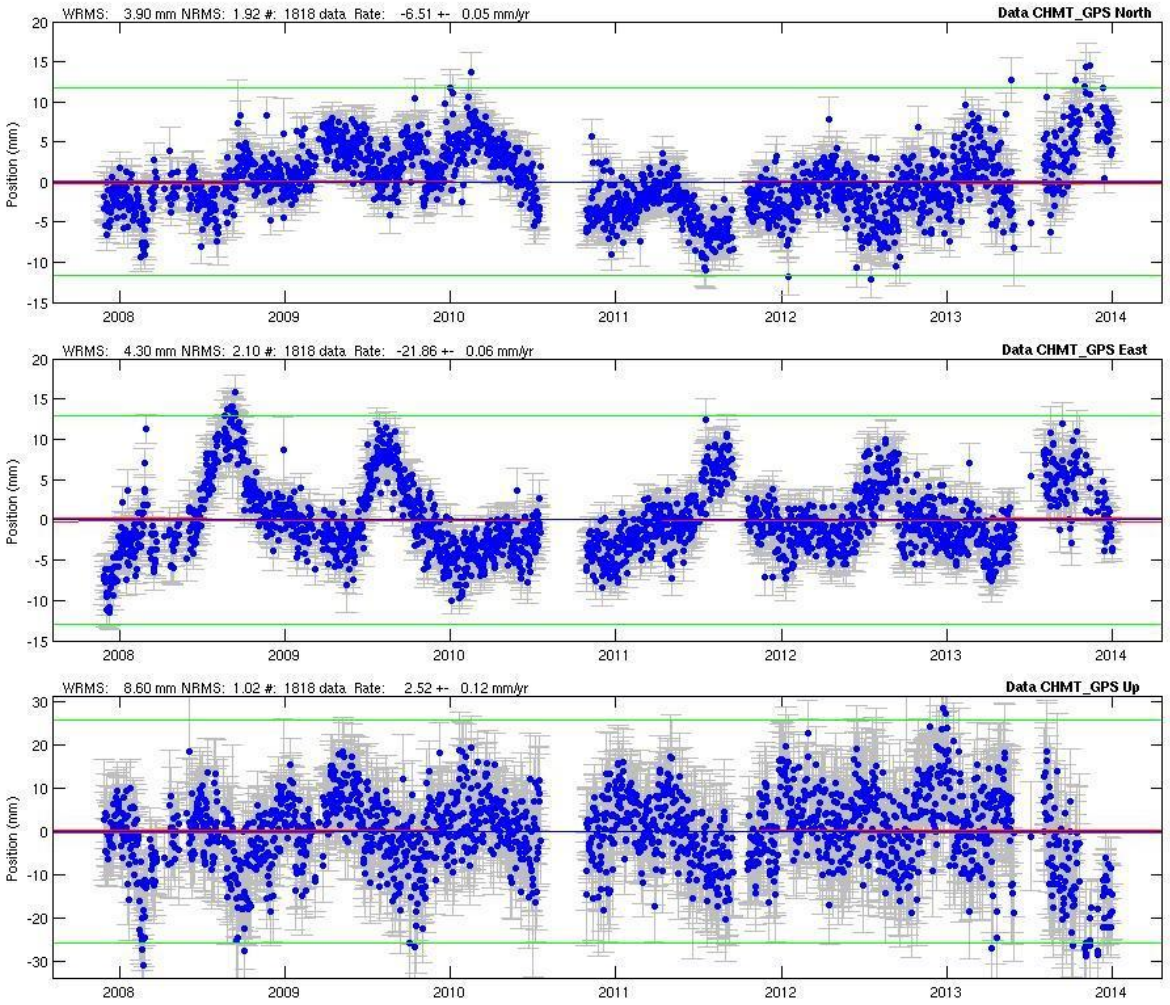

Figure 9. Time series for CHMT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

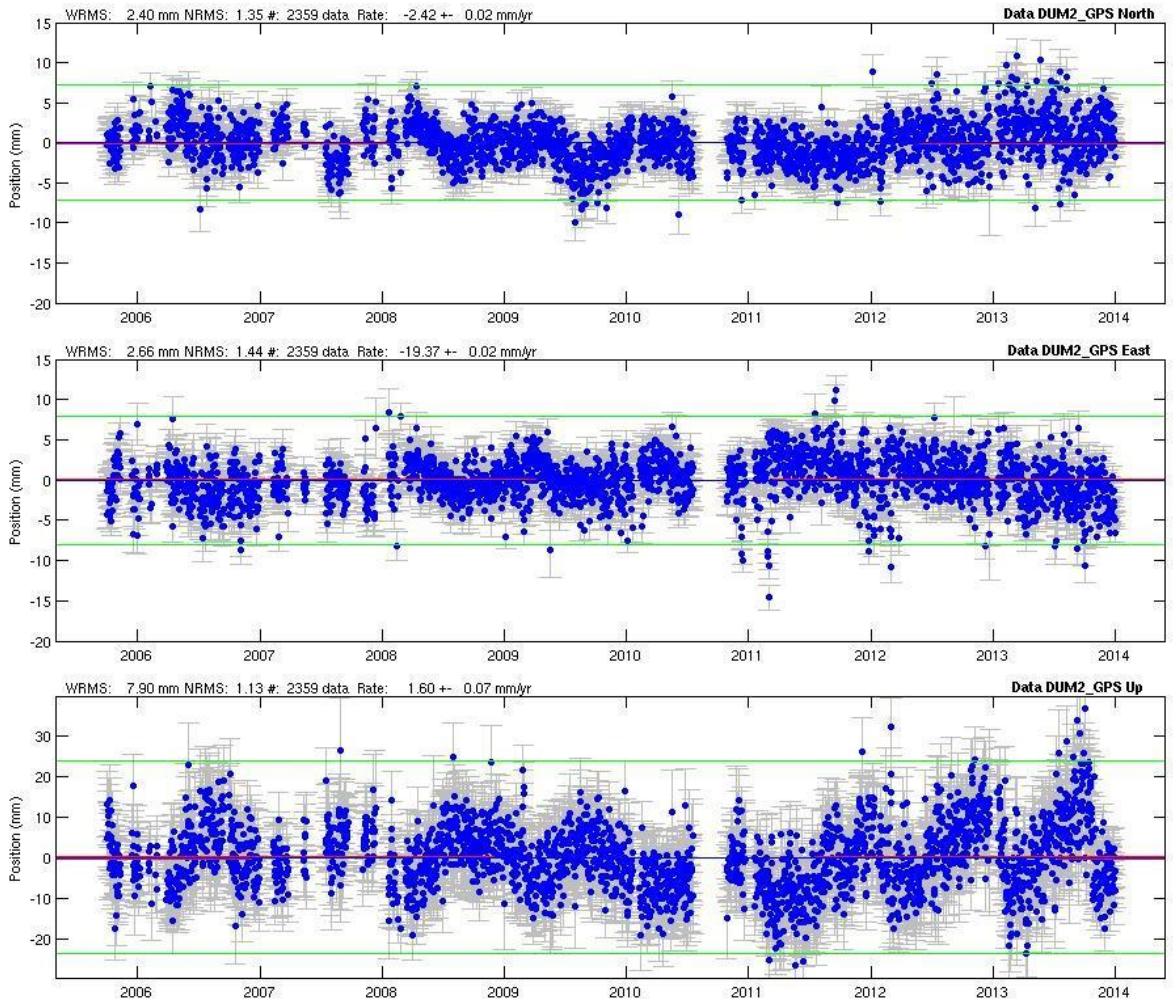

Figure 10. Time series for DUM2 (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

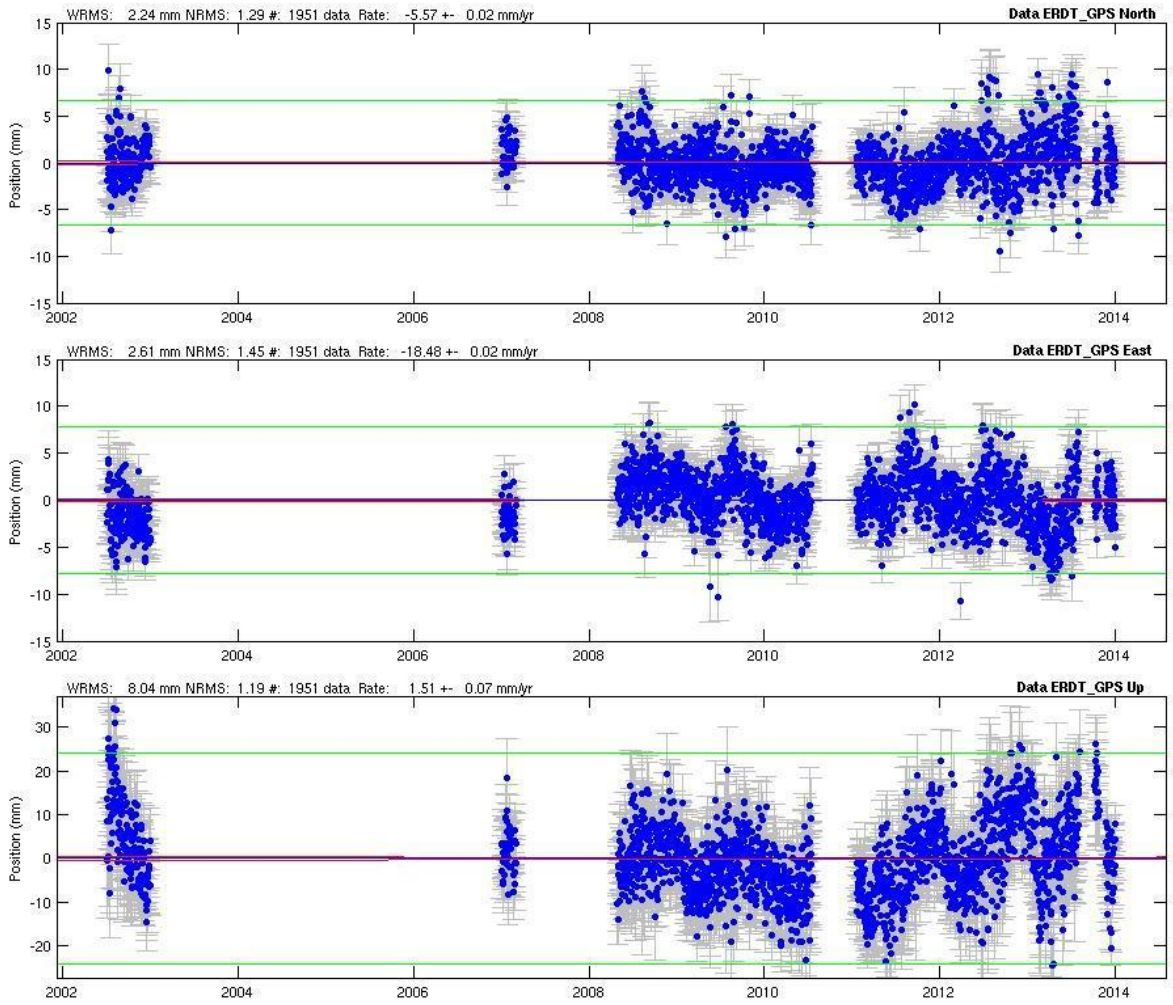

Figure 11. Time series for ERDT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

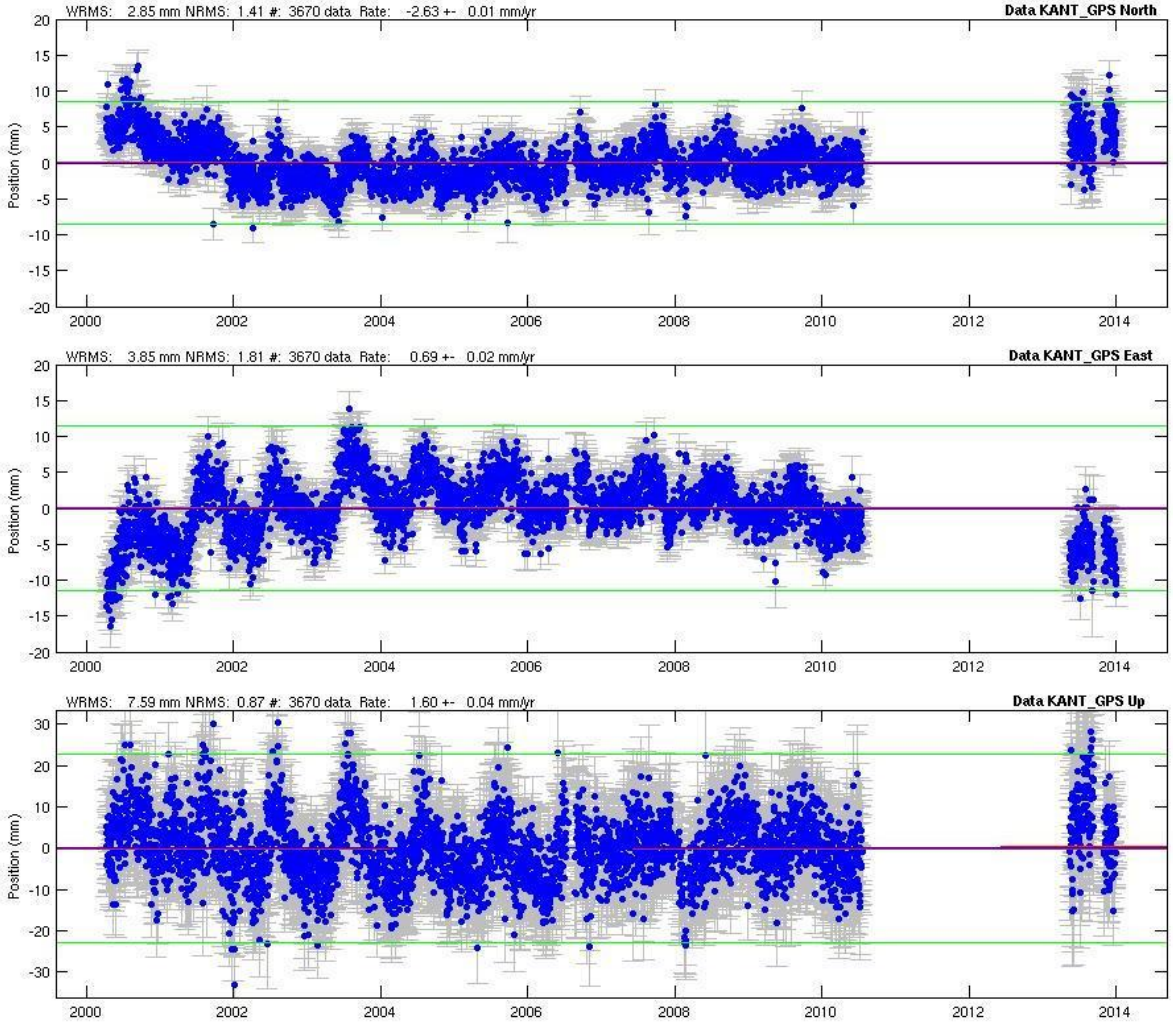

Figure 12. Time series for KANT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

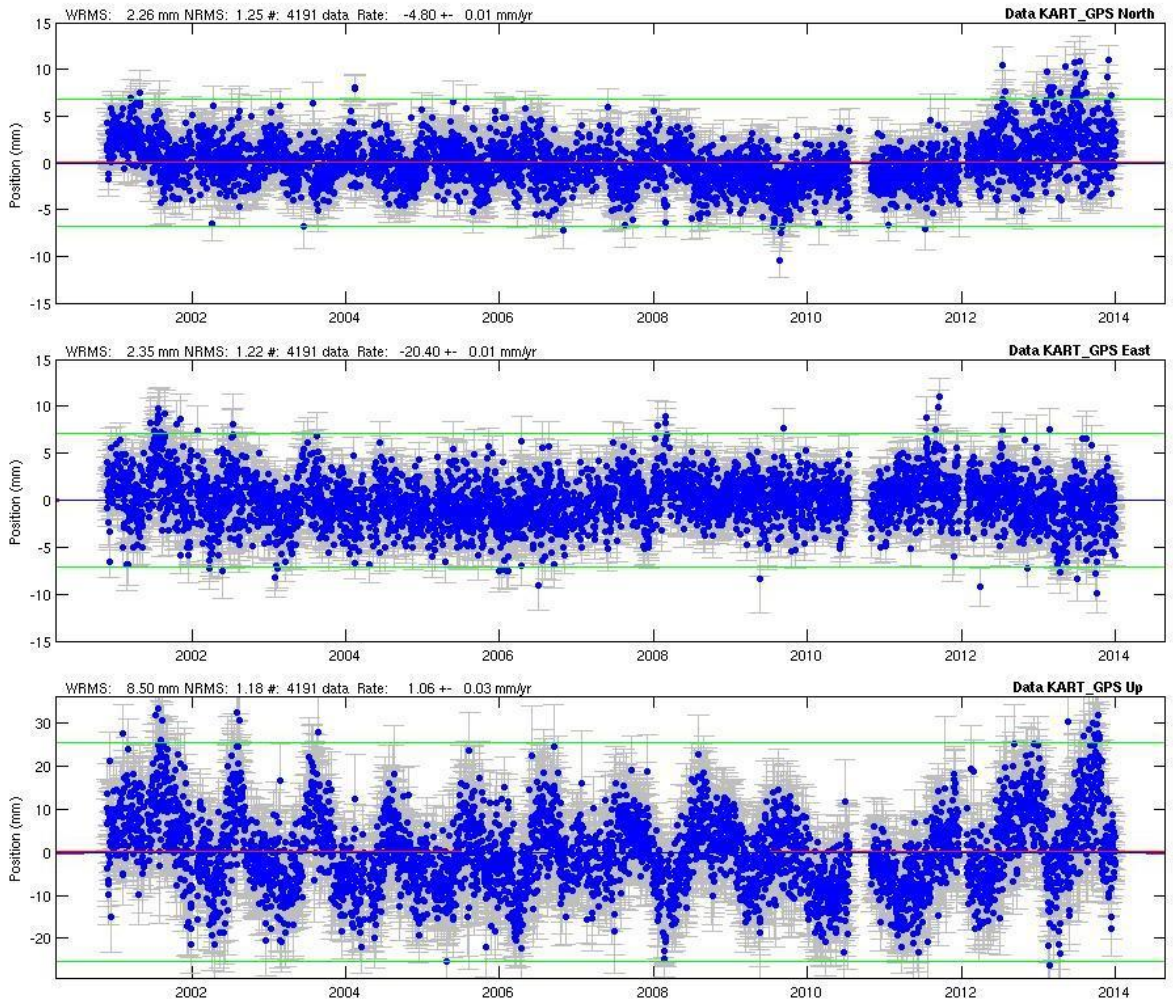

Figure 13. Time series for KART (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

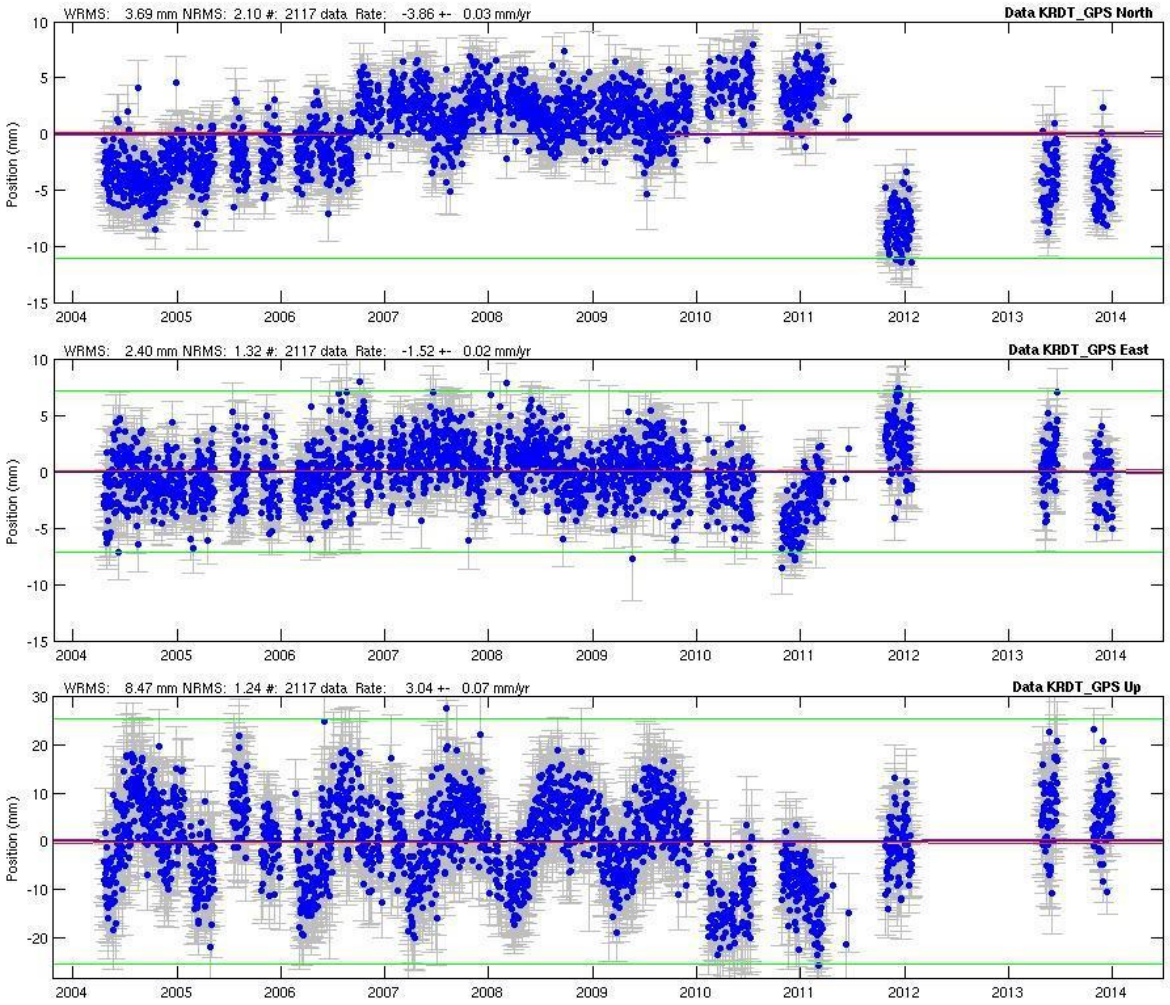

Figure 14. Time series for KRDT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

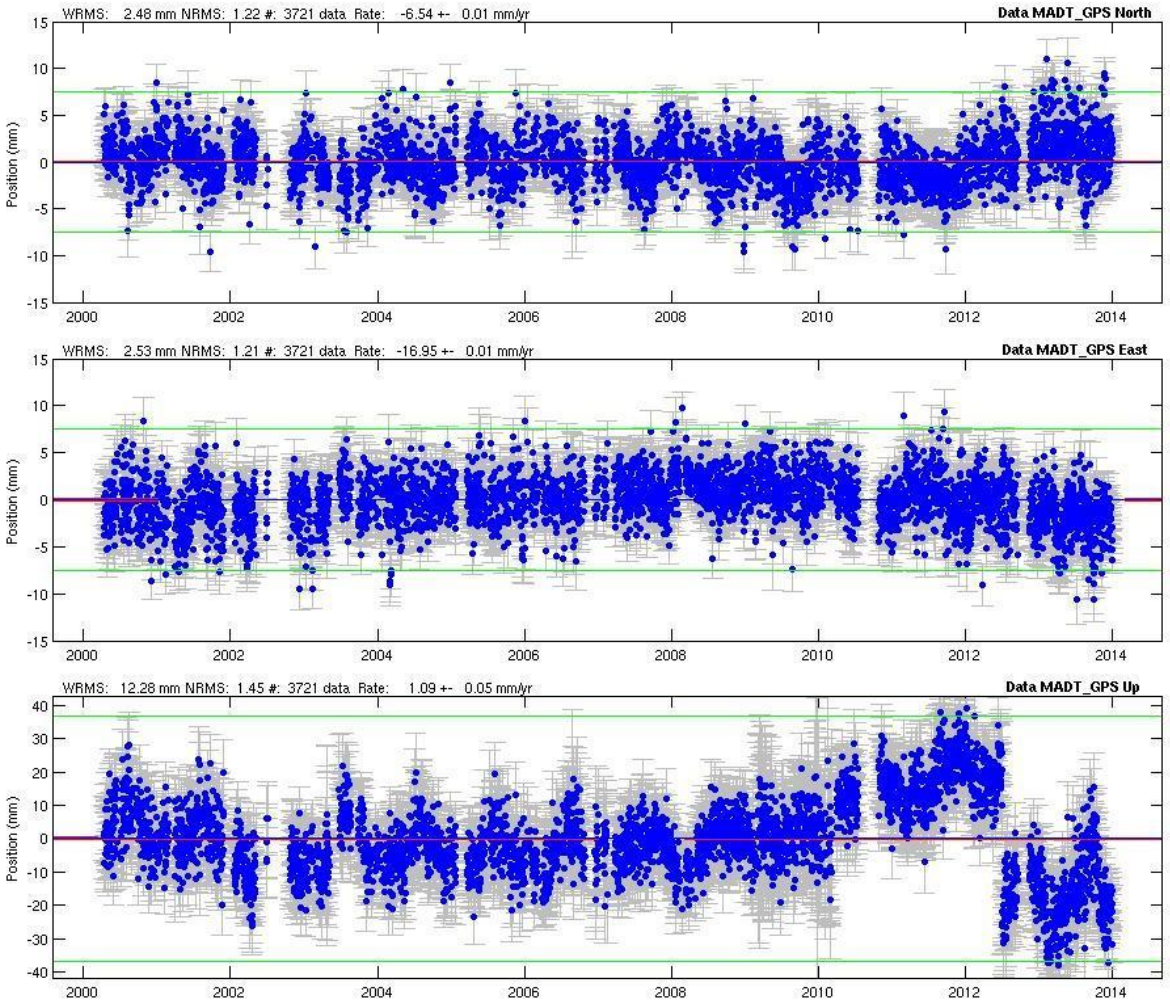

Figure 15. Time series for MADT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

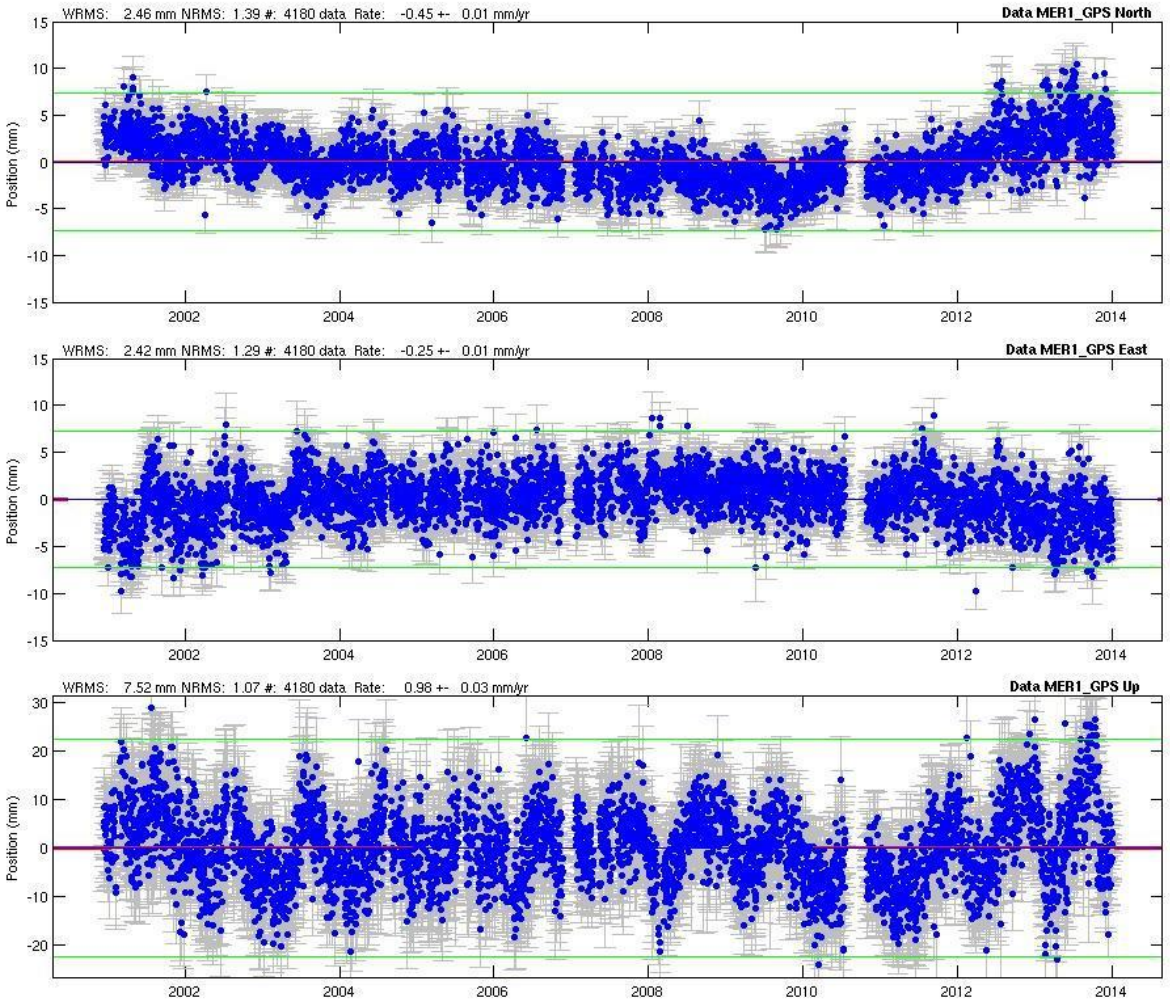

Figure 16. Time series for MER1 (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

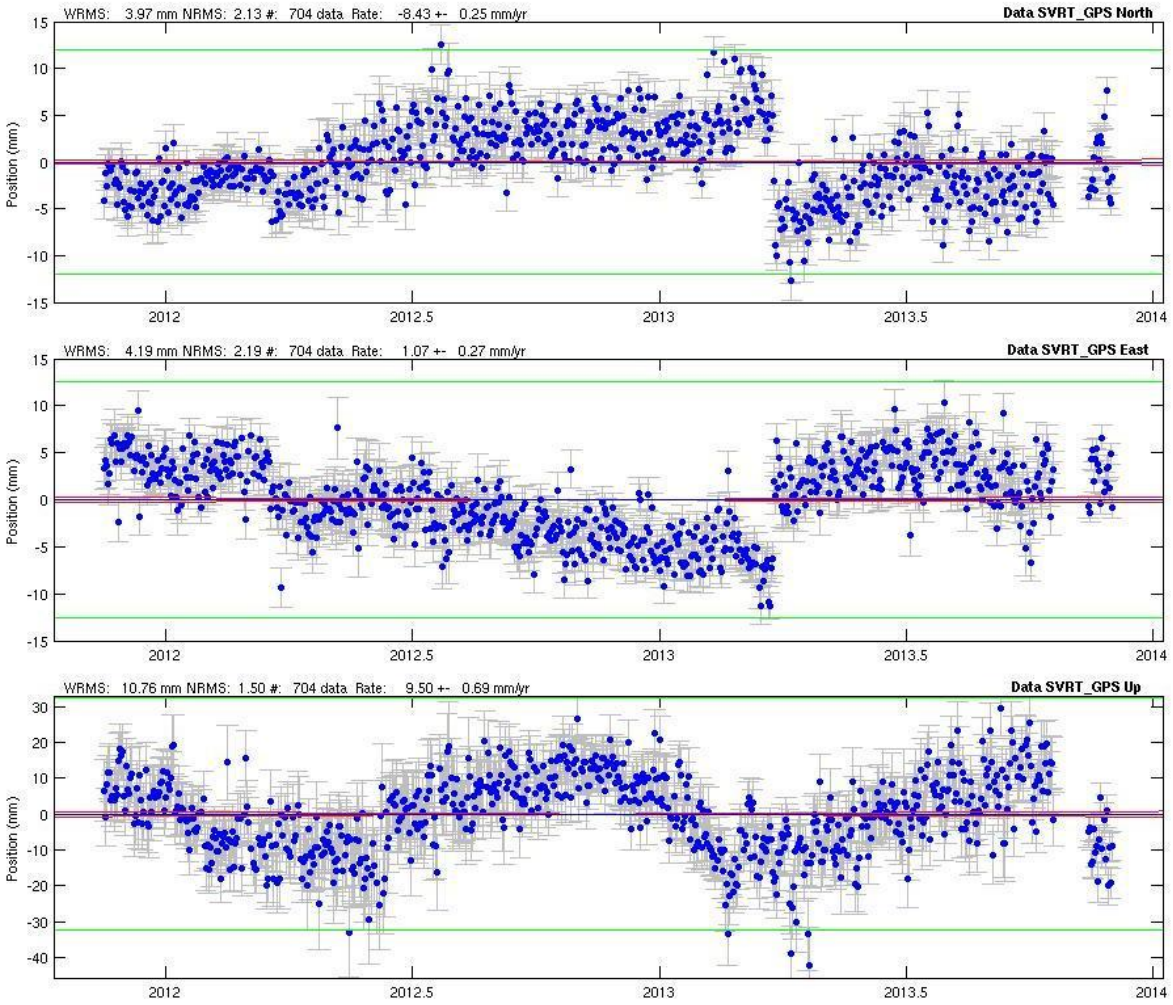

Figure 17. Time series for SVRT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

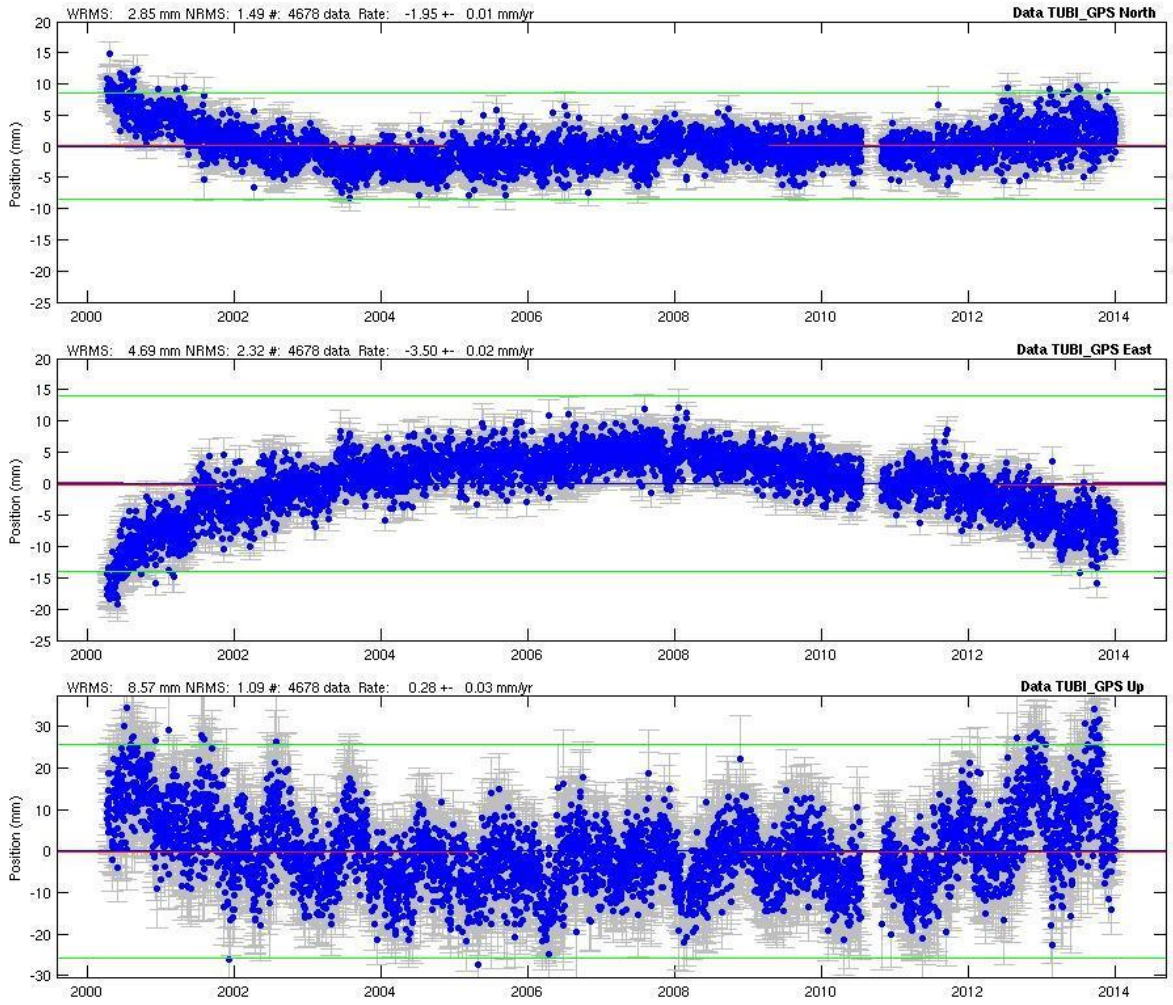

Figure 18. Time series for TUBI (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

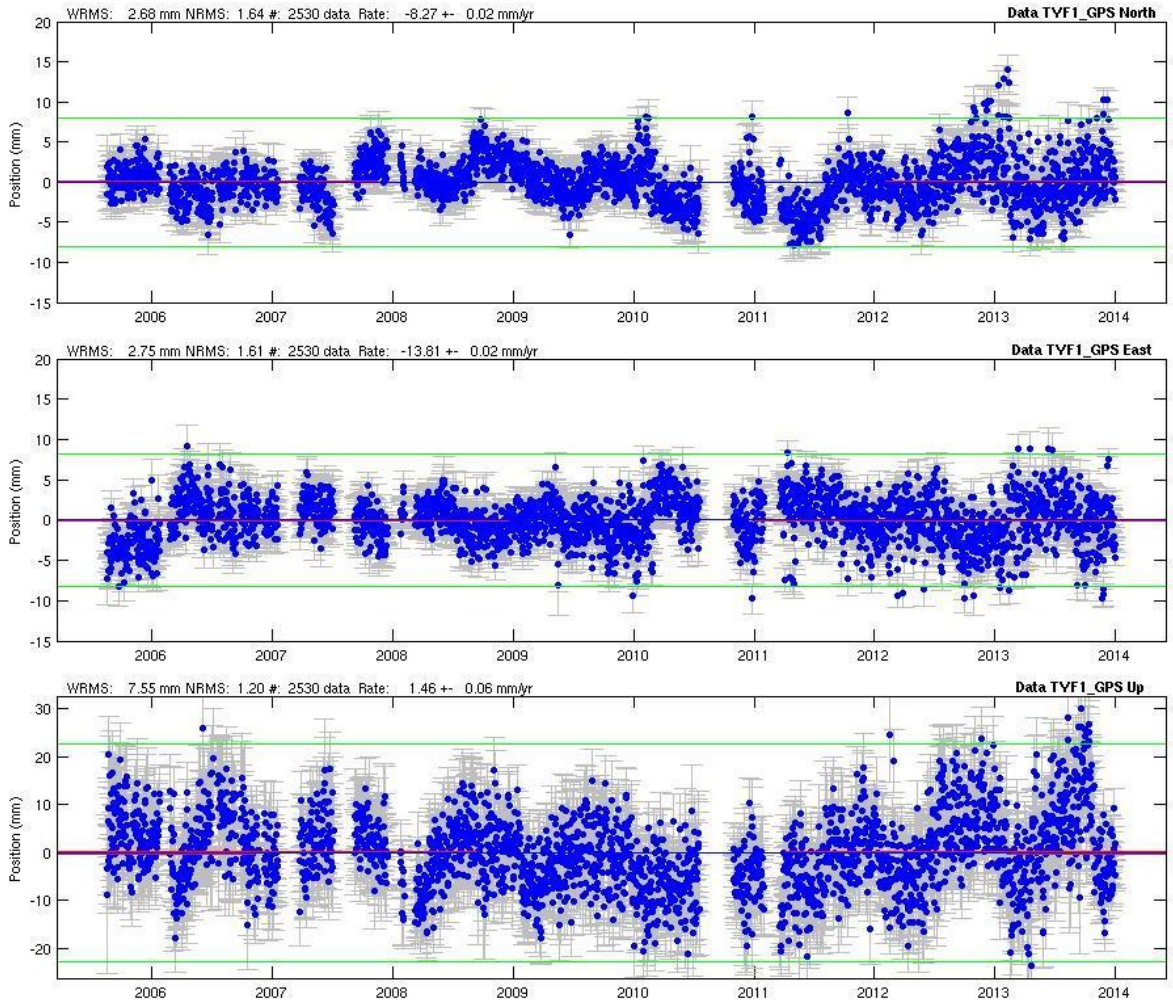

Figure 19. Time series for TYF1 (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

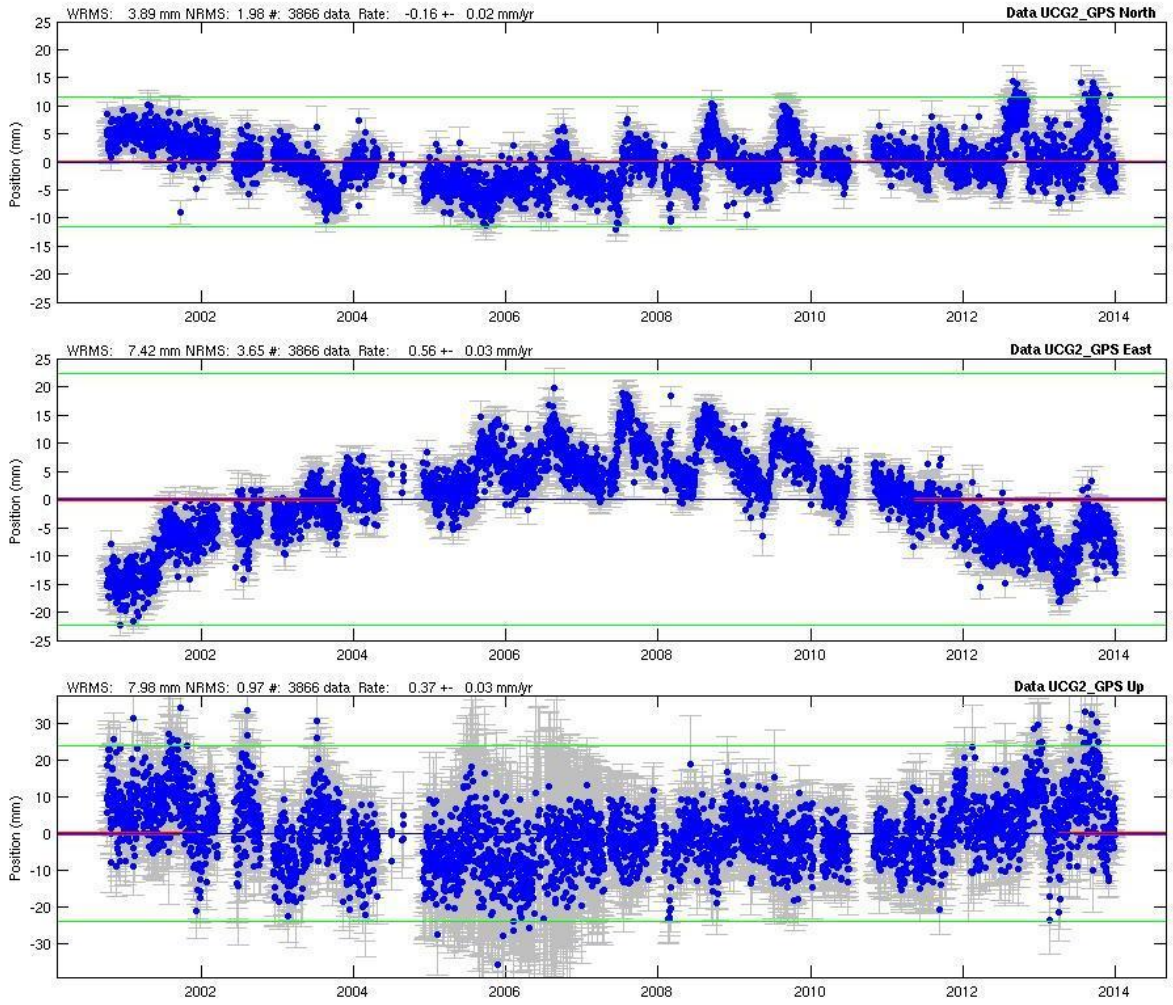

Figure 20. Time series for UCG2 (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

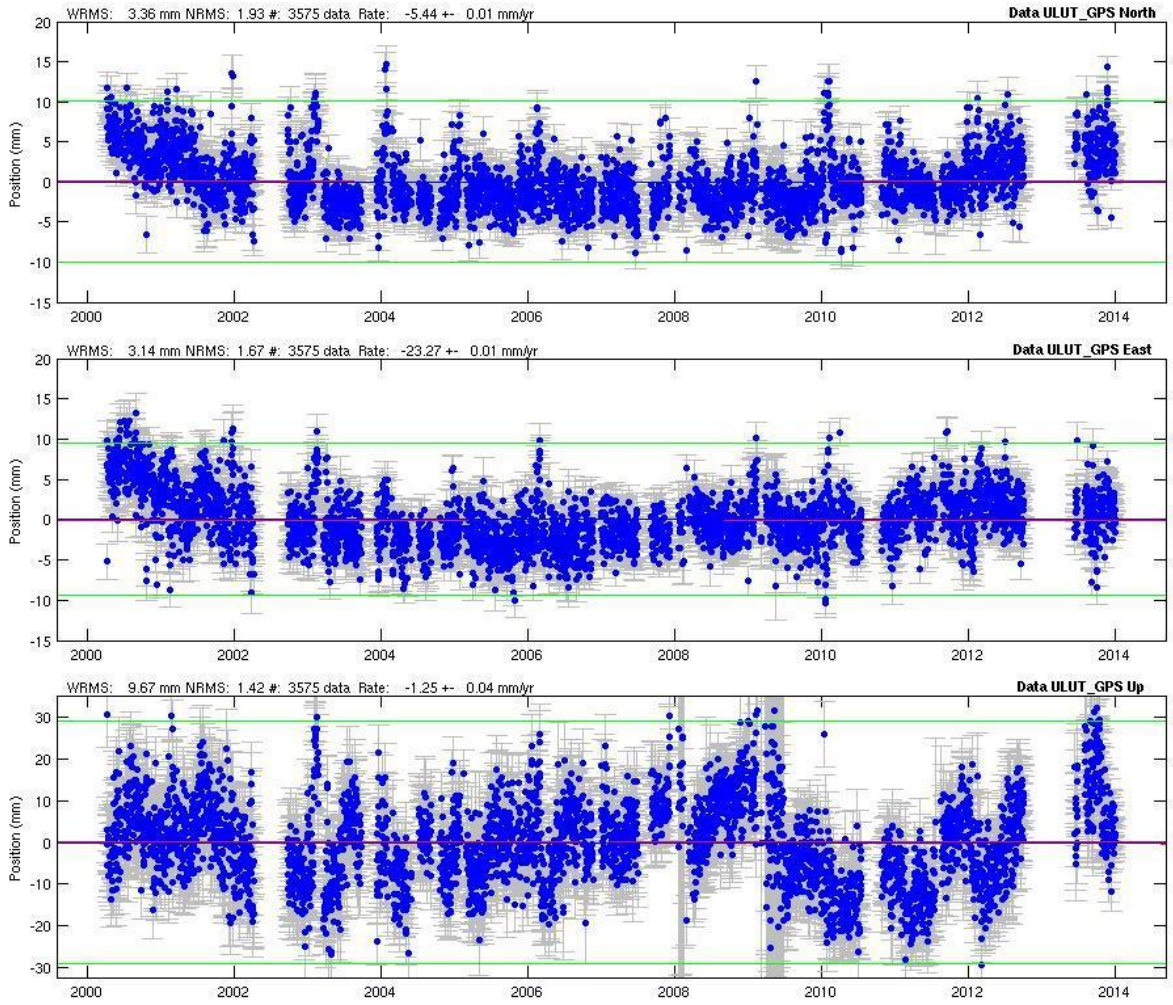

Figure 21. Time series for ULUT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

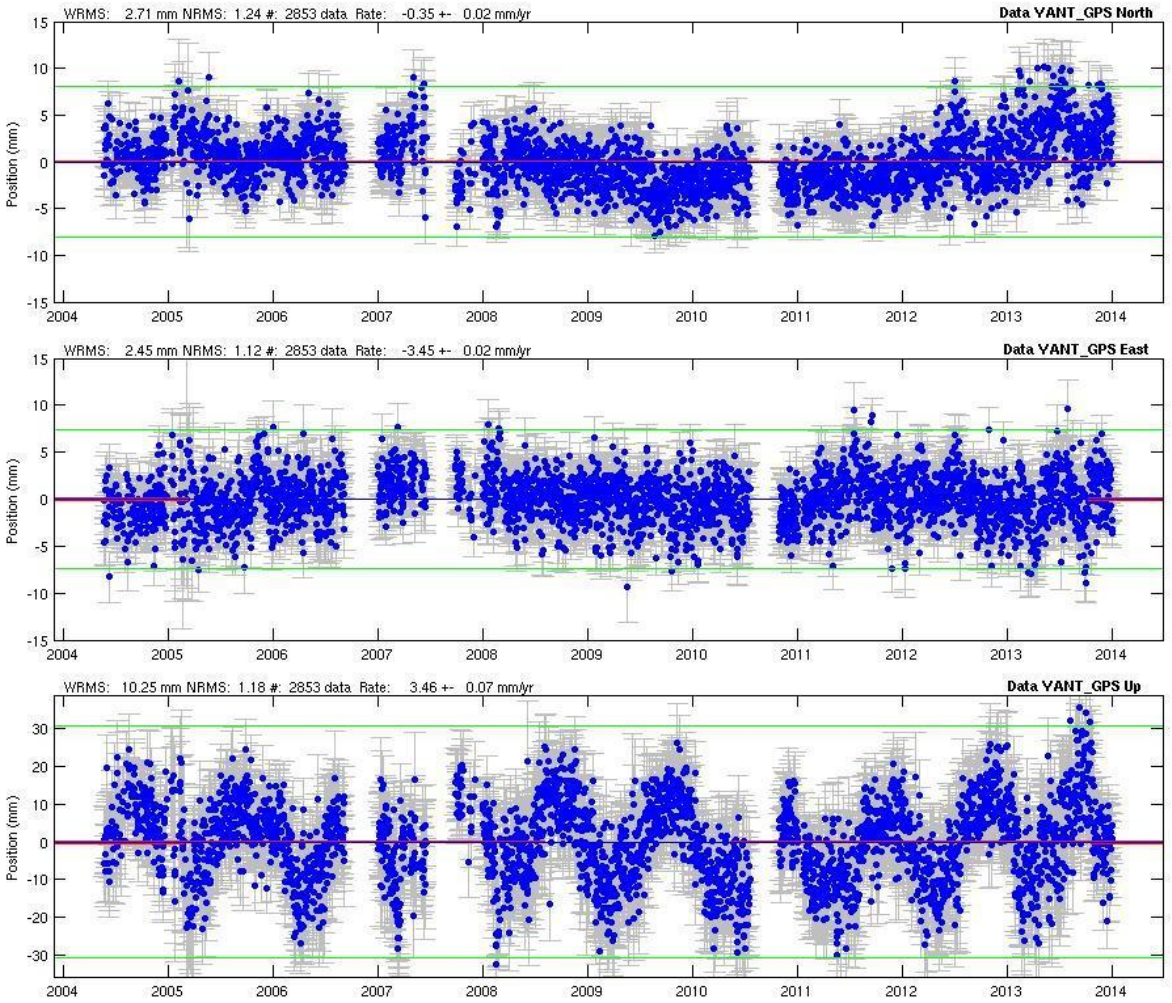

Figure 22. Time series for YANT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

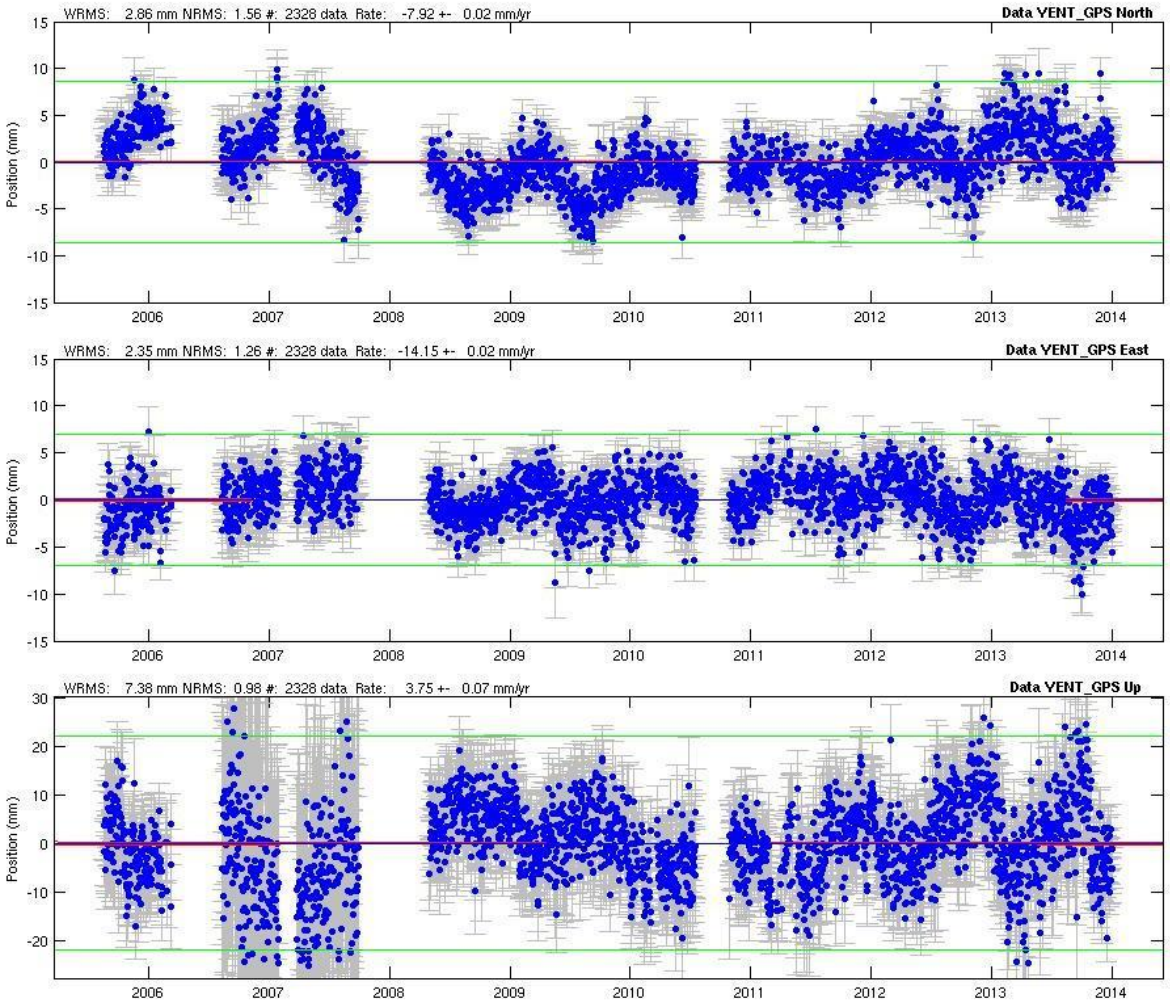

Figure 23. Time series for YENT (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.

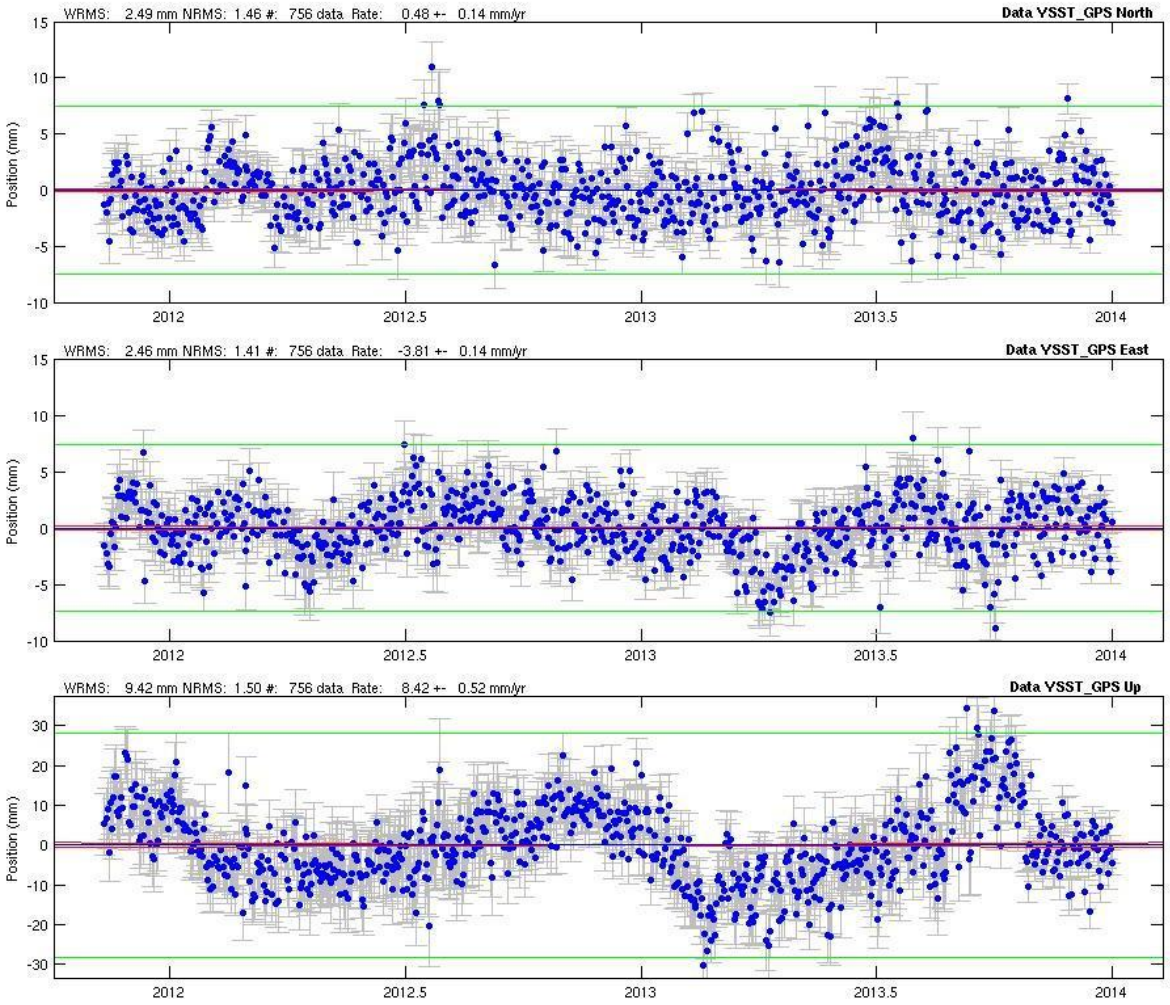

Figure 24. Time series for YSST (in the graph, north-south, east-west and elevation components are shown respectively). The horizontal axis represents the GPS day, the vertical axis is representing the changes in the respective component coordinates are in mm scale.