Research of Current Movements of the Earth's crust in the Territory of Almaty City

Zhumabek Zhantayev, Baurzhan Kurmanov, Assylkhan Bibossinov, Kairat Sadykov
Department of geophysical and geodynamic monitoring
LLP "Institute of Ionosphere"
Almaty, Kazakhstan
Emails: {Nckit@spaceres.kz, baur.kurman@gmail.com, bibossinov@yahoo.com, sadykovka@gmail.com}

***Abstract*—During the work carried out, measurements were taken by a local GPS network. It was the primary pre-processing and interpretation of the data network for the city of Almaty. The investigation had been carried to find the velocity field of modern movements of the Earth's surface according to the GNSS-service. All the GPS-data were processed by the software package GAMIT/GLOBK.**

Keywords-GNSS-network; IGS; SELE station; GNSS-measurements; velocity field; data interpretation.

I. INTRODUCTION

Deformation of the Earth's surface on the territories of large cities occurs very often. The main reason is the growing demand of high-rise buildings, the intensive development of underground space, hydro-mode system violations and finally vibration impacts. In some areas of Almaty, the level of impact on the geological structures is already approaching a critical point. This means that the number of destructions will increase dramatically due to any deformations of the Earth's surface.

Organization of a geodesic effective monitoring system of major cities is possible with high precision satellite methods. This allows almost continuous monitoring in a variety of geographical conditions to observe a certain strain down to millimeter level accuracy [1-4]. These studies were conducted for the first time in the territory of Almaty city.

II. GOALS AND OBJECTIVES

The goal of this work is to study the velocity of modern movements of the Earth's surface by GNSS-measurements data for the region of Almaty.

On the basis of the known geological conditions, taking into account the differences, a priori data was compiled which preliminary was used for observing the network for the Almaty region. Research showed that it is the stochastic network with distribution points which is the most appropriate solution for this region. We have relied on the size of the foundation block structures that may have a major impact on the surface deformation processes in case of their mutual relative movements during strong earthquakes.

There are several kilometers between large faults when we consider the Earth's crust depth is about 3 km.

The network is split over the Almaty region with insignificant deviations beyond its limits (Figure 1) and consists of 14 observation points (Table I). The expected results are maps of modern movements in the territory of Almaty city.

TABLE I. THE LOCAL GPS NETWORK

№	Points name	Id	Coordinates		
			X	***Y***	***H***
1	Base	Baza	$43^0$10'37.1850	$76^0$57'4.0122	1209
2	Astrophysics	Act2	$43^0$10'35.7349	$76^0$57'58.5639	1316
3	Koktobe	Kokt	$43^0$13'40.7683	$76^0$59'06.7640	925
4	Airport	Aers	$43^0$19'38.9931	$77^0$0'46.2605	639
5	Sairan	Sair	$43^0$14'17.5640	$76^0$51'54.7307	757
6	Kiziltu-4	Kzt4	$43^0$22'13.5082	$77^0$5'5.0653	634
7	Kapchagai highway	Kpch	$43^0$22'30.8869	$76^0$57'20.5690	614
8	Baiserke	Bser	$43^0$27'8.1595	$77^0$2'46.2691	573
9	Boraldai	Borl	$43^0$18'56.6571	$76^0$48'56.5204	727
10	Pervomaysky pond	Trpp	$43^0$23'46.1461	$76^0$54'32.1729	620
11	Hippodrome	Ipdr	$43^0$18'27.0849	$76^0$55'42.3869	668
12	12th city hospital	Gorb	$43^0$13'54.3048	$76^0$54'36.2963	791
13	Kazakhfilm	Kazf	$43^0$14'50.4854	$76^0$54'15.9350	927
14	Central Park	Cprk	$43^0$15'47.3451	$76^0$58'12.4722	743

III. METHOD

Not being able to organize a network of GPS-synchronized observations in the city, there were a restricted series of successive observations using one receiving station. Measurements are held periodically by each of the points using a Leica GRX 1200 GG Pro receiver, twice a year. The duration of recording satellite signals at one point is 48 hours in a continuous mode with intervals of 30 seconds which was adopted by regulations. Per one session, each point worked about 48 hours and produced 5720 independent acts of registration. This gives an opportunity for further processing

 ISBN: 978-1-61208-264-6

to increase the ratio of signal/random noise in the square root of this number (about 76 times).

GPS - measurements was conducted since 2010 to the present time. GAMIT / GLOBK software package is used for pre-processing GPS data [7].

During calculations of a priori coordinates and velocities of points, a priori data of the Earth's rotation and orbital data generate a single integrated set that must be internally consistent. Imposition of severe restrictions on any of these parameters for a regional solution can deform the system. In order to prevent such action restriction, a priori coordinate, the speed, the parameters of orbit satellite and the Earth's rotation in the solution should not be rigid. However, that decision could shift or collapse the entire system of points and/or their velocactionity vectors. Stabilization allowing to define reference system by minimizing the deviation of the resulting solution which was obtained as the result of a decision using the a priori coordinates and velocities for a set of well-defined stations. The iterative scheme of stabilization automatically excludes measurements points, for which coordinates have large deviations. The velocity fields of the region are shown in Figs. 2 and 3. The rest of the time points are not very accurately measured [4-6].

The permanent station SELE, part of the global network IGS, has an error about 0.1 mm / year. The rest of the time points are not very accurate measurements. This shows that is necessary to conduct special works to reduce the errors in the city network stations to the order of 1-2 mm/year.

IV. CONCLUSIONS

For the study of modern movements of the Earth's crust of Almaty, was built a local network and data collection from 2011 to 2012.

The first study which was conducted in the city of Almaty showed that within urbanized areas such work is possible and necessary. The main advantage of working with such a system is the possibility of rate parameters simultaneously in three mutually orthogonal components, characterized by significant variations during the year.

The errors of international IGS stations in the pre-processing were about- 0.5-2 mm/year, and the local points showing the error of 5-20 mm/year.

Errors are likely due to the small number of independent observations in temporary settlements, due to the inability to organize continuous monitoring because of the absence in receiver numbers and transportation problems.

During two years of follow up in urban areas, set features significant movement of surface points about 3- 25 mm/year. The conclusion shows that it is necessary to observe simultaneous points, then moving receivers to other items with overlapping observation systems.

To ensure the high quality of the primary data monitoring it is necessary to choose points of global network stations (IGS) with following control of the data quality.

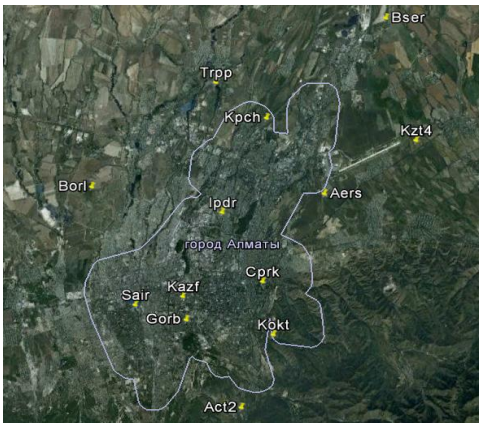

Figure 1. Local area network in the territory of Almaty city.

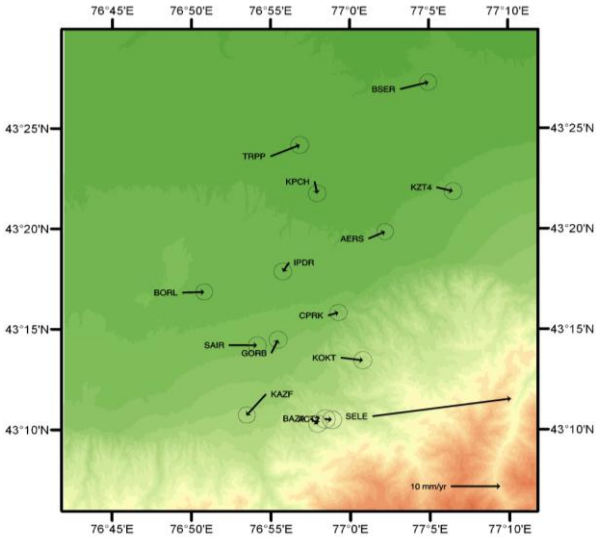

Figure 2. Velocity field relative to the Eurasian continent.

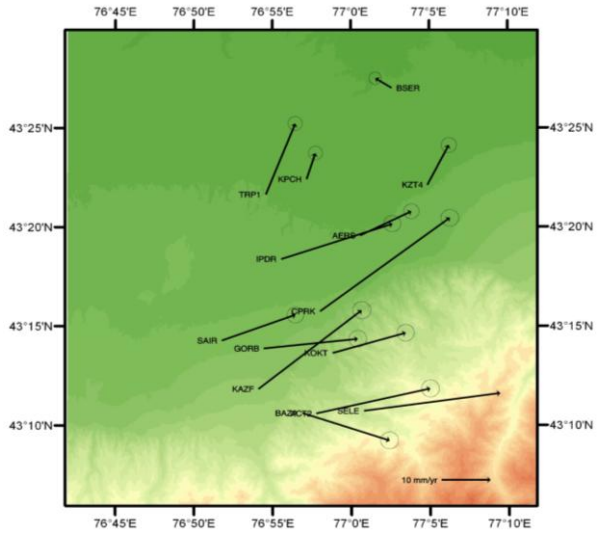

Figure 3. Velocity field relative to the center of the Earth.

 ISBN: 978-1-61208-264-6

REFERENCES

[1] Zubovich A.V., X.-q. Wang, Y.G. Scherba, G.G. Schelochkov, R. Reilinger, C. Reigber, O.I. Mosienko, P. Molnar, W. Michajljow, V.I. Makarov, J. Li, S.I. Kuzikov, T.A. Herring, M.W. Hamburger, B.H. Hager, Y.-m. Dang, V.D. Bragin and R.T. Beisenbaev; GPS velocity field for the Tien Shan and surrounding regions. Tectonics, 2010, Vol. 29, TC6014, doi:10.1029/2010TC002772.

[2] Zhantayev ZH.SH., Namvar R.A-A., Aketaev Zh.E. Shcherba Y.G.; The effectiveness of modern satellite GPS-monitoring technologies geodynamic state of the lithosphere in Kazakhstan. Almaty: Nauka, 2009. pp. 2-3. [Rus].

[3] Gabrielov A.I., Keylich-Borok V.I., Levshina T.A., Shaposhnikov V.A.; The block model of the lithosphere dynamics. Mathematical methods in seismology and geodynamics. Pergamon Press, 1986, pp. 168-178. [Rus]

[4] Garagash I.A., Patalaha E.I.; When the fracture collapse (shear flow) and folding / / Geotectonics, № 6, 1990, pp. 23-31. [Rus]

[5] Steinberg V.V., et al. Assessment methods of seismic effects. / / Problems of Engineering Seismology, Vol. 34, 1993, pp. 5-94. [Rus]

[6] Shebalin N.V. The estimation of seismic intensity. Seismic scale and methods of measurement of seismic intensity. Moscow: Nauka, 1975. pp. 87 - 109. [Rus]

[7] Http://www-gpsg.mit.edu/~simon/gtgk/ [retrieved: July 2009]

 ISBN: 978-1-61208-264-6