National Research Institute of Astronomy and Geophysics
NRIAG Journal of Astronomy and Geophysics
www.elsevier.com/locate/nrjag

Monitoring of global geodynamic processes using satellite observations

S.K. Tatevian [a], **G.F. Attia** [b], **N. Abou-Aly** [b], **R. Ghoneim** [b,*], **M. Hegazy** [b]

[a] *Institute of Astronomy of Russian Academy of Sciences, (INASAN), Moscow, Russia*
[b] *National Research Institute of Astronomy and Geophysics, (NRIAG), Cairo, Egypt*

Received 24 February 2014; accepted 30 March 2014

KEYWORDS
GPS;
Aswan;
Earthquake;
Deformation parameters

Abstract To study mechanisms of destructive geodynamic phenomena including determination of places of possible severe earthquakes, volcano eruptions and some other natural hazards, it is important to have means to evolve areas where maximum changes of the displacement velocities and the terrestrial crust vertical movements are possible. The previous experience has shown that the satellite geodesy techniques including global navigation systems and satellite laser ranging are the most effective for research activities in this field. Permanent control of secular movement of GPS-stations of the international geodynamic network, located in Russia, has allowed improving the reference coordinate frame for North Eurasia since Russian network stations provide representative covering of the largest stable areas (the Siberian and the East European) of the Eurasian plate. Along its southern border, there is a zone consisting of a great number of microplates surrounding the South-Eurasian stable plate. Interaction of these small plates and blocks influences distribution of seismic stresses in internal parts of the continent that is confirmed by the highest seismic activity of the triangle bordered by thrusts of the Himalayas and faults of the Pamirs, the Tien-Shan, the Baikal and the North-Eastern China.

One of the active tectonic zones of Egypt located in Aswan, is characterized by regional basement rock uplift and regional faulting. In 1997, the African Regional Geodynamic Network was developed around the northern part of Lake Nasser, consists of 11 points, on both sides of the Lake. Its main goal is to study the geodynamical behavior around the northern part of the lake. The collected data were processed using the Bernese software version 5.0. From the velocity results, including also the African plate motion, it can be noticed that all stations of this network are moved to the northeast direction and it is typically the direction of the African plate motion.

* Corresponding author. Tel.: +20 1222525944.
E-mail address: rmfg66@hotmail.com (R. Ghoneim).
Peer review under responsibility of National Research Institute of Astronomy and Geophysics.

ELSEVIER Production and hosting by Elsevier

1. Introduction

Plenty of new information about the Earth and the near-Earth environment has been obtained by indirect way (as distinct from direct measurements from a satellite's board) as a result of processing of data of systematic earth-based observations

2090-9977 © 2014 Production and hosting by Elsevier B.V. on behalf of National Research Institute of Astronomy and Geophysics.
http://dx.doi.org/10.1016/j.nrjag.2014.03.001

allowing to record changes of satellites' orbits. Since an artificial satellite circles the Earth and is in its gravitational and magnetic fields, then all results of detailed explorations of its orbital motion have very direct relation to understand physical and dynamical properties of the near-Earth environment and the planet itself. An important advantage of this new space branch in the field of Earth's sciences is its global nature in particular. The space geodesy allows connecting islands with continents, combining geodetic networks of the continents through oceans and seas, and measuring the Earth's planetary parameters. Theoretical fundamentals and engineering equipment of the space geodesy have been developing very dynamically for the last 50 years. The considerable increasing of satellite laser ranging accuracy in the space geodesy and fast development of radio satellite navigation systems such as GPS (USA) and GLONASS (Russia) have fully changed the approach to problems of determination of dynamic and physical properties of the Earth, as a planet (Tatevian, 2010).

The relative coordinates of the ground-based points of the global reference network of the IERS (Fig. 1) and the base lengths at distances of hundreds or thousands kilometers are determined with errors of few mm horizontally and less than 1.0 cm vertically.

An important problem, being solved currently only by means of satellite observations and very long baseline radio interferometers (VLBI), is registration and monitoring of short-period variations of the Earth's rotation speed and its orientation in the space, since these parameters determine the Universal Time and are required to connect the inertial (celestial) frame with geocentric (terrestrial) frame. The International Earth Rotation and Reference Systems Service (IERS) Altamimi et al., 2002 regularly determines and publishes information about the Earth's orientation parameters to within 0.1–0.2 ms of the arc (1 cm) in the pole position and about 0.3 mc in time with resolution of 1 day and less (Table 1).

Coefficients of nutation (characterizing movement of the Earth's rotation axis in the inertial frame) have been determined to high precision that is necessary to study the Earth's internal structure and free nutation of its liquid external core.

Table 1 Precision of the earth rotation parameter estimation.

Years	σ(X) 0.001	σ(Y) – 0.001	σ(UT1) – 0.0001s	σ(ψδ) – 0.001	σ(εδ) – 0.001
1962–1967	30	30	20	–	–
1968–1971	25	25	17	–	–
1972–1979	11	11	10	–	–
1980–1983	2	2	3	2	1
1984–1989	.40	.40	.20	.5	.2
1990–2000	.20	.20	.20	.3	.1
2001–2005	.15	.15	.1	.3	.1

Interpretation of long-period fluctuations of the Earth's rotation velocity (day duration) and periodical movements of the Earth's center of masses must be probably connected with generation of perfect models of the planet internal structure. These researches go on as observed material is accumulated.

The Earth's gravitation field, before 1957, was known to be accurate within the third harmonic coefficient of the gravity potential model, i.e. accurate within the Earth's flattening (1/298). The new gravity models, developed with the use of satellite observations, contain more than 150 gravity potential harmonic coefficients. This means that the external form of our terrestrial globe has become known hundreds times better than before 1957 due to the satellite geodesy.

The recent detailed models of the gravity field, obtained with the use of space missions CHAMP, GRACE, GOCE, allow discovering fine peculiarities of the Earth's tectonic structure, which have not appeared before in global satellite models (Rummel and Foeldvary, 2006). These peculiarities are the consequence of various geophysical processes in active tectonic zones of subduction, collision and plate expansion such as, for instance, the Himalayan–Tibetan Region and the Middle-Atlantic Ridge. In so far existing geopotential models, the subduction zones have appeared only as spacious areas with high gravity anomalies due to mass volume increase when shift of the terrestrial crust strata under volcanic arches occurs. More

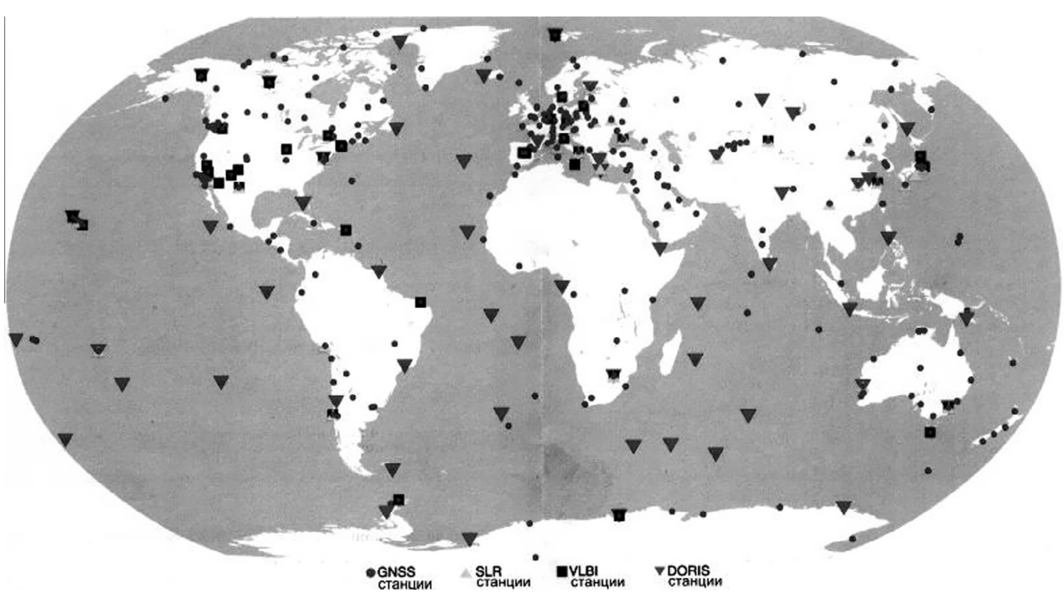

Fig. 1 Global network of observation sites of the International Earth Rotation and Reference System Service (ITRF).