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Static loading and vertical displacement at southern Siberia

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ABSTRACT

Seismic method is usually used for elastic parametric estimation. This is why this method presents dynamic parameters of Earth. Frequency seismic range changes greatly from geodynamic modelling time. Now we have opportunity to use geodesy result for some years for elastic parameters estimation. Static solution from elastic theory may be used for the interpretation of long term results. It presents static elastic parameter. The inverse problem for different types of vertical surface loading on one year period is calculated. Two cases of loading with maximal and minimal area are presented. Results are determined by space geodesy and leveling methods. Current relation between atmospheric pressure and vertical displacements was estimated at the center of Siberian Anti Cyclone with size varied from 2000 km to 3000 km. Pressure-displacement coefficients (PDC) can be achieved by three years observation (0.997 mm/mbar for NVSK GPS station). It is used for elastic module study of geology medium with maximum thickness up to 600 km. In the context of elastic model, the modulus of rigidity is estimated to be 113 GPa. Vast expanse of anti-cyclone may relate with rheology of crust and upper mantle. Smaller size of surface loading – local loading is seasonal variation of water reservoir. Annual vertical changes were obtained by leveling near the dam of the reservoir. PDC ratio was 1.15 mm/bar for these places. In elastic theory, the Young modulus $E = 80$ GPa (Poisson ratio = 0.25, the modulus of rigidity = 32 GPa) was calculated by sixteen years of leveling measurements. This result can effectively be represented for upper crust. Our results were checked by solution for coseismic displacement of Chyia-Altai earthquake (Sep. 27, 2003, $M = 7.3$). Coseismic results calculated by static modules agree with experimental coseismic GPS data at 10% level.

1. Introduction

Now we have opportunity to use geodesy result for study of static elastic parameters. Vertical motion of Earth surface may be caused by periodical loading. Static solution from elastic theory may be used for the interpretation of results. Maximal atmospheric pressure effect on the Earth observes at Siberia territory. We solved the inverse problem for maximal and minimal areas of vertical surface loading on one year period. We studied this effect at the south of Siberia. The classical approach of vertical motion study is the leveling method. The situation has improved significantly with development of new geodesy methods and it has been drastically changed with the application of geodetic space techniques such as VLBI and GPS method [1–5]. Using classical method and new technique opportunity for permanent measurement in the order of the millimeter appears to become possible in the last years. Observed seasonal displacement has spatial extensions between some kilometers (water reservoir of Hydro Electric Plant) and some thousand kilometers (Siberian anticyclone). We have examined the theoretical models are in accordance with geodetic data. Small load on large space have most effect on vertical displacement. Next step in frame of elastic theory is to obtain values of elastic modules for the earth crust and upper mantle. The goal of our project was estimation of elastic modules for crust and upper mantle used the modern geodesy results. These parameters are used for tectonic modeling

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and coseismic reconstruction with hypocenter situated at different depth (from 5 km to 600 km).

2. Datasets

Load's effects for maximal area and for minimal area are present at south Siberia territory. Eurasian central part is well-known for its maximal atmospheric loading on the Earth, which is a result of Siberian anticyclone, spreading for thousands of kilometers. Periodical vertical displacement at Siberian station (NVSK, Novosibirsk) is shown in Fig. 1. Station was introduced into international geodynamic net IGS since 2000 [6] with NVSK code (coordinates 54.84°N, 83.23°E) assigned number (DOMES 12319M001). Meteorology parameter has registered regularity from 2011 (Fig. 2). As a result, there is 40 mbar pressure annual variation correspondingly 40 mm vertical displacement.

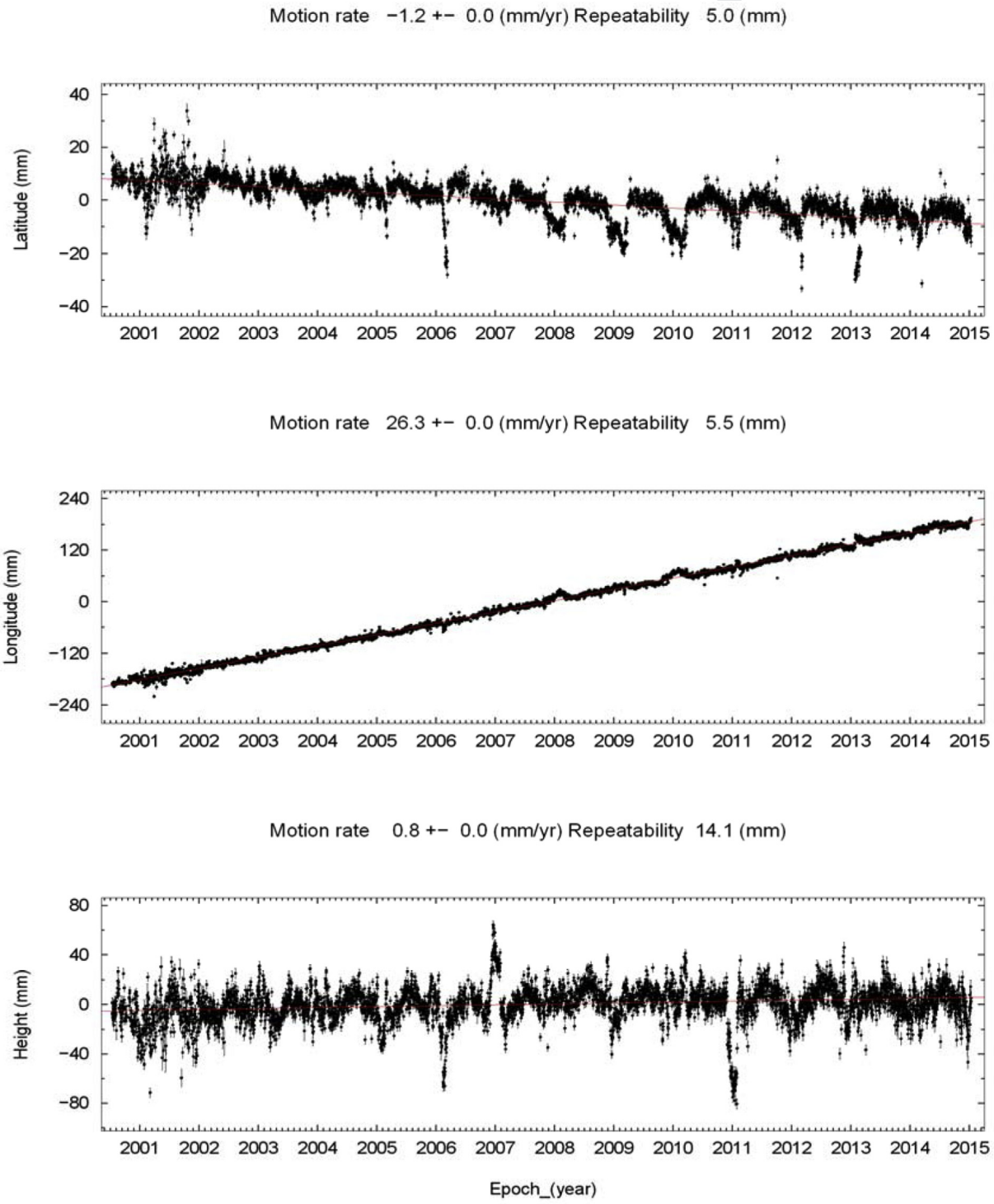

Fig. 1. Results of measurements at NVSK station for 2000–2015. Variation of vertical component is 40 mm.

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