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Gravity observation at continental borderlands (Russia, Primorie, Cape Shults)

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ABSTRACT

The paper is focused on different kinds of gravity results obtained in Shults Cape Observatory for 2010–2015. Gravity observation is interpreted together with GPS observation data which was obtained from 2012 to 2015 at the same station. The station is situated on Gamov peninsular (42.58° N, 131.15° E, Russia) at the coast of Japan Sea. This region constitutes the eastern boundary of Eurasia. This major continental tectonic feature is associated with a seismic activity, high heat flow and anomalous thickness of earth's crust. The goal of the observation was the investigation of gravity variation with time and seismicity situation monitoring. Gravity observation was developed at special basement by absolute gravimeter (GABL type) and by spring gravimeter (SCINREX CG-5and gPhone type). Tidal models were tested by results of observation with spring gravimeters. Reduction task was solved, as the experimental data received from different points of Shults Cape Observatory was used. Applied reduction coefficient is 203.3 μGal m^{-1}, and agrees with theoretical calculation. Next goal was studying structure of earth's crust by means of gravity models. Gravity anomaly varied from 30 mGal to 46 mGal, which also depend on difference reference system. Experimental results were used for testing of the structure of continental boundary, which also depends on the sea bottom flexion. Thickness of elastic layer was estimated from 12 km to 18 km by using different models.

1. Introduction

As a part of the integrated geophysical survey, the gravity measurements were organized at Marine Experimental Observatory Shults Cape of Il'ichev Oceanological Institute, Far East Branch of Russian Academy of Sciences at the South of Primorie. There is an obvious interest in setting up a complete station with a gravimeter and GPS receiver on the same site. The station is situated on Gamov peninsular (42.58° N, 131.15° E, Russia) on continental boundary with flexing sea bottom (Figs. 1 and 2). Regional tectonic feature is associated with a seismic activity and anomalous thickness of earth's crust [1,2]. In addition, heat flow densities increase to 70–90 mW m^{-2} there. This region has the real anomaly (more than 50 m) by map of quasigeoid heights in reference to the Krasovsky ellipsoid [3]. The map was compiled at TsNIGAiK on basis of astronomic-gravimetric leveling data (AGL) with allowance for general adjustment of astronomic-geodetic network (AGN) of the

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country. The AGL includes 2897 astronomic points. The astronomic coordinates of the points are determined with allowance for the necessary reductions and astronomic coordinates are referred to the OCI pole and the initial astronomic meridian established by International Earth Rotation and Reference Systems Service (IERS). The quasigeoid height of the initial point at Pulkovois assumed as 0 (zero). The root mean square (RMS) errors of the quasigeoid for the larger parts of the map do not exceed ± 1.0 m. For the regions farthest from Pulkovo (Kamchatka, Chukotka), the error increases up to ± 1.5 m.

On the other hand, new geoid height for points situated on the coast line at Shults Cape (GOCE − WGS84) is 24.3 m [4,5].

Regional map of bouguer anomaly [6] shows the values from +45 mGal to +50 mGal for Gamov peninsular (Pulkovo system). The surface is strongly deformed from the coast line to Japan Sea bottom and the curve of the lithosphere changes at 90 km distance, so the heights vary from +0.3 km to 0 km at the land and from 0 km to −3.5 km at the Japan Sea (at the profile from north to south).

Tidal gravity observations have been performed at Shults Cape Observatory since 2010 springtime. The post was placed onto a special pedestal in a cellar located far enough from microseismic disturbances. Former military underground bunker with special condition for passive temperature stabilization was used for different gravity measurements. The continuous gravity measurement is realized using SCINREX CG-5 40301 gravimeter, but first tidal analysis shown showed strange results. Tidal factors of main waves varied up to 5% during some months. The cause of this effect may be bad stability of scale coefficient. It is a reason for using other kind of instrument and for creation of second gravity point at different height level. Two level posts were used for equipment testing. The choice of second point determined exploitation condition and transport's possibility. Observation at sea coast point was carried out only at lower noise time. Absolute gravity observation started in Autumn 2010 with gravimeter GABL.

As we had a big problem with SCINREX CG-5 40301 gravimeter, we used other instrument. Relative gravity study with a gPhone 111 gravimeter and determination of the local net point position with the Trimble-4700 GPS receiver started in 2012. At this time, the second gravity point situated at Shults Cape Observatory on Japan Sea coast was constructed for testing of different gravimeter and for metrical control of scale parameters. Absolute gravimeter, spring gravimeter and GPS equipment are very complementary geodetic techniques and any monitoring station should include all of them. The first goal was to compare the observed variation with regional seismicity, and second goal was to compare the gravity variation with vertical motion. The description of Tohoku-Oki *M*w9.0 earthquake on 11 March 2011 is presented in many articles [6]. Preliminary gravity results at Primorie for Japan earthquake were discussed in our article [7]. Next goal was to study tidal model and reduction parameters for Shults Cape point, as measurement results will be used for gravity models testing at continental boundary.

2. Datasets: gravity measurement

Gravity measurement was carried out inside the special underground cellar with passive temperature stabilization. Tidal

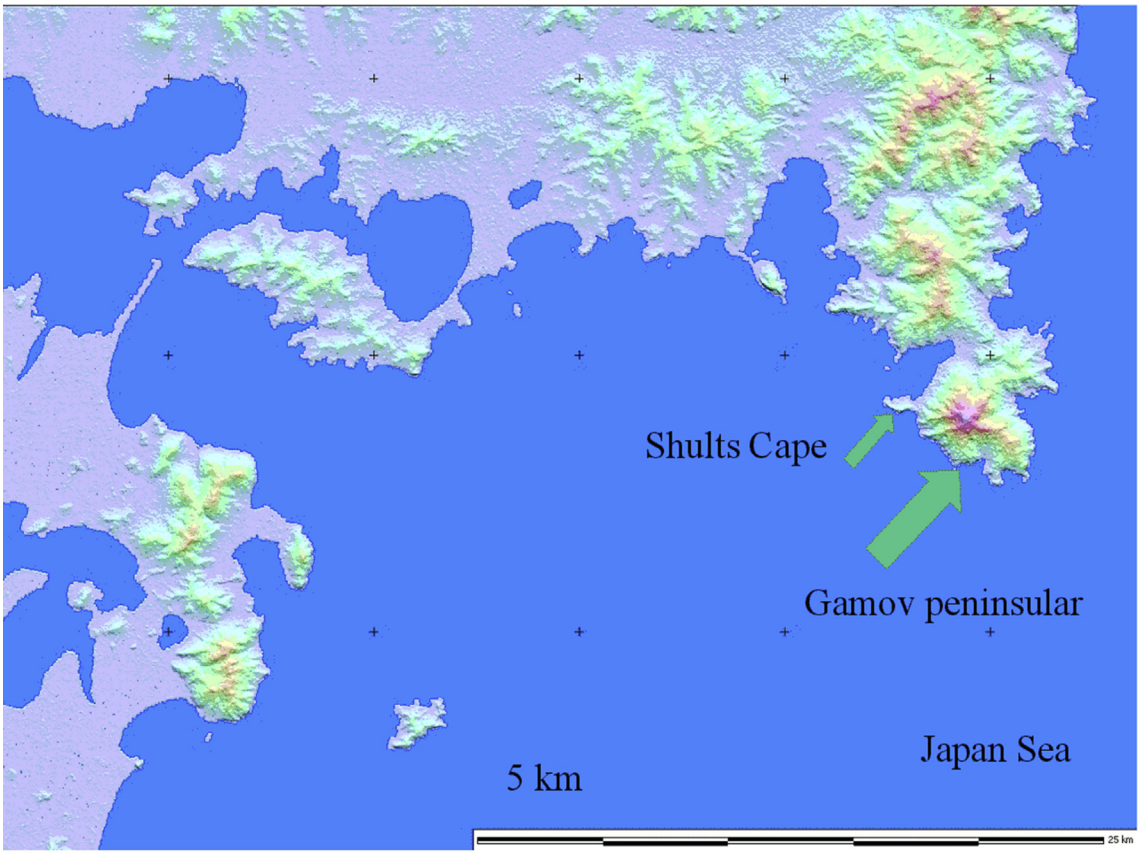

Fig. 1. Map of Shults Cape (42.58° N, 131.15° E) and Gamov peninsular at the south of Primorie (Russia).