ON THE QUESTION OF GLOBAL CHANGES IN GRAVITY WITH TIME

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Abstract

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ON THE QUESTION OF GLOBAL CHANGES IN GRAVITY WITH TIME

1. In paper ([1]) the drift of the eccentric dipole (the magnetic center of the Earth) is discussed. It is shown that the drift of this center takes place along an elliptical orbit. The semiaxes of the ellipse are $a \simeq 1150$ km, $b \simeq 700$ km. The period of revolution of the center is ~ 1200 years, if the angular velocity of this revolution is taken to be constant and equal to $\sim 0.3^\circ$ per year. The geometric center of the Earth is one of the foci of the ellipse. The major semiaxis intersects the Earth' s surface in the regions of the points with $\varphi = 30^\circ$, $\lambda = 60^\circ$ (minimum distance from the center to the solid shell ~ 1400 km) and $\varphi = -30^\circ$, $\lambda = 240^\circ$ (minimum distance to the geometric center of the Earth ~ 200 km). Fig. 1 shows the arc of a great circle along which the epicenter of the eccentric dipole moves; Table 1 gives the parameters of the dipole drift.

2. G. Barta ([2]) assumes that the magnetic center of the Earth coincides with the center of its eccentric solid inner core, i.e., that it is not only magnetic but also gravitating. If this is so, then the orbit of the motion, unbalanced in the Earth–Moon–Sun system, of the inner solid core floating in the liquid core is the ellipse indicated above. The latter should be noticeably reflected not only in geomagnetic, but also in certain other geophysical, as well as astronomical, phenomena. Such a drift of the inner solid core should bring about secular changes, of global character, in the force of gravity. The maximum changes, if they exist, should be observed near the epicenter of the dipole. At present it is located in the region of the Mariana Islands (for 1960 its coordinates are $\theta_0 = 75^\circ$; $\lambda_0 = 150^\circ$).

If the difference between the mean densities of the inner solid and outer liquid cores is taken as $\Delta\sigma \sim 2.4$ g/cm^3, then, for an inner-core radius $r_0 = 1250$ km and for its displacement in accordance with the data of Table 1, there should follow changes in the force of gravity at the epicenter of the dipole of ~ 4 mgal per year.

At a distance of 30° from the epicenter the change in the force of gravity should reach 2–2.5 mgal (the Japanese Islands, the regions of Vladivostok and southern Sakhalin), and at a distance of 45°, 1.5–2 mgal (the regions of Kamchatka and

Fig. 1. a –intersections of the ellipsoid axis with the Earth' s surface; b – projections of the eccentric dipole onto the Earth' s surface for different epochs

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Chita Oblast). At distances from the epicenter of up to 60° (the regions of Krasnoyarsk and Novosibirsk) the change in the force of gravity may reach 0.5-1.0 mgal per year, and at a distance of 90° (the regions of the Caucasus and the European territory of the USSR) the changes may reach 0.15-0.20 mgal per year. Of course, the values given are approximate and depend on changes in the initial data (excess density, radius of the inner solid core, etc.).

3. M. S. Abakeliya, in paper ([2]), gives the results of measurements of the force of gravity at 10 points in the Caucasus, carried out at different times during the period 1879-1931. The temporal changes in the force of gravity at the different points differ, with a mean annual change of 0.43 mgal. These results served as the basis for carrying out special work in 1936 ([3]). In the same article ([2]) results are given for measurements of the force of gravity at 4 points in India. The mean annual change reaches 0.97 mgal. According to estimates in accordance with the drift of the Earth' s core, the changes amount–

amounted to 0.5-1.0 mgal, i.e., the hypothetical and experimental data agree.

The problem of secular changes in gravity is considered in detail in the article by Yu. D. Boulanger [(3)]. In 1935-1936 work was carried out in the Caucasus to detect secular changes in gravity. It was established that the changes in gravity over an average of 25 years lie within the limits of the observational errors. At the same time, however, one circumstance gives grounds for reflection, namely: why, of the 14 points that were worked up, a decrease in gravity was noted in only 2 cases, whereas in all the others it increases.

Fig. 1. *a* –intersections of the ellipsoid axis with the Earth' s surface; *b* – projections of the eccentric dipole onto the Earth' s surface for different epochs

The mean value of its total change over 25 years is 4 mgal, i.e., 0.16 mgal per year. But according to the estimate we made, the drift of the core in the region of the Caucasus should produce changes in gravity of the order of 0.15-0.20 mgal per year, i.e., the observational results almost coincide with the quantities following from the hypothesis under discussion. Repeated measurements of gravity in 1951 and 1961 in Moscow, Kazan, Sverdlovsk, Omsk, and Novosibirsk apparently revealed no changes in gravity exceeding the observational errors (on average ±0.3 mgal) [(3)].

The same work gives the results of gravity measurements in Washington, carried out at different times from 1876 to 1959. From these materials it is evident that

fivefold repetitions of observations over the period from 1876 to 1928 give a total increase in gravity of 24 mgal, whereas, if the Earth' s inner core were drifting, a decrease should have occurred here. The author of the article [3] considers the observations from 1876 to 1928 unreliable, with the exception only of the observations of 1928, 1933, and 1959. During this period, according to the hypothesis under discussion, gravity should decrease at a rate of 0.16 mgal per year. The observed data either show no change in gravity, or, if the Vening Meinesz observations of 1928 are taken into account, show a decrease of the field at a rate of 0.06 mgal per year. In [3] the conclusion is drawn that at present we do not possess any reliable information on secular changes in gravity.

In our view, the observations in the Caucasus and in India speak in favor of the existence of secular changes, whereas the observations in Moscow, Kazan, Omsk, Sverdlovsk, and Novosibirsk apparently testify to the contrary—

by them. Contradictory results are also given by observations in Washington. The question under discussion requires further investigations.

Taking into account the present level of measuring technique and the above-cited magnitudes of annual changes in gravity by longitude, it seems highly desirable to organize special measurements of gravity increments along the routes most favorable for these purposes: Novosibirsk—Yuzhno-Sakhalinsk (or Vladivostok) or Moscow—Yuzhno-Sakhalinsk. Such observations will undoubtedly justify themselves even in the event that the proposed interpretation of the drift of the eccentric magnetic dipole is not confirmed.

Table 1

Epoch	θ_0	λ_0	R_0, km	γ	Angular velocity, ω
1829	96.0	185.0	250.0	17.9	0.312
1885	87.0	170.0	294.0	10.5	0.305
1922	81.5	160.0	350.0	7.0	0.300
1945	78.0	154.0	405.0	5.1	0.327
1960	75.0	150.0	445.0		

4. Let us note one further circumstance. If the geomagnetic center does indeed coincide with the gravitating one, then, in addition to the expected changes in gravity, the drift of the inner core should affect the rotation rate of the Earth. As a result of processing ancient astronomical observations, a decrease in the length of the day over the last 2000 years has been established ([4]). If these data are evaluated from the standpoint of the drift of the Earth' s inner core, then the situation should have been such that approximately 300 years ago there was a change in the sign of the change in the Earth' s rotation rate, since 300 years ago the core was at the shortest distance from the Earth' s center; moreover, as the core moved toward this approach, the Earth' s moment of inertia decreased,

which led to an acceleration of its rotation. Such a conclusion is in full agreement with the ancient data. In accordance with the hypothesis under consideration, for already ~ 300 years the Earth' s rotation should have been slowing down, which is confirmed by the data in the literature ([5]).

In recent years this deceleration has noticeably intensified: previously it occurred at a rate of 1 m/sec in 120 years, while in 1965 it reached 1.6 m/sec per year.

5. The interpretations set forth of the drift of the eccentric magnetic dipole and of the global changes in gravity associated with it are, undoubtedly, debatable. They require the continuation of searches and comparisons with various phenomena of geophysics and astronomy. However, the obvious importance of the conclusions already emerging and the necessity of a critical and comprehensive discussion of them impel us to publish these conclusions in their present form.

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Note: Figure translations are in progress. See original paper for figures.