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CELESTIAL GEODYNAMICS AND SOLUTION OF THE FUNDAMENTAL PROBLEMS OF GEODESY, GRAVIMETRY AND GEOPHYSICS

The motion of the planet consisting of an external shell (mantle) and a core (rigid bodies), connected by a viscous-elastic layer and mutually gravitationally interacting with each other and with external celestial body (considered as material point) is studied (Barkin, 2001; 2002; Barkin, Vilke, 2004). Relative motions of a core and a mantle are studied in the assumption that the centres of mass of a planet and an external perturbing body move on unperturbed Keplerian orbits around of the general centre of mass of the system. The core and mantle of a planet have an axial symmetry and have the different principal moments of inertia. Differential action of the external body on the core and mantle cause the periodic relative displacements of their centres of mass and their relative turns. Approximate solution of the problem was obtained on the basis of methods of linearization, averaging and small parameter method. The obtained analytical results are applied to the study of the possible relative displacements of the core and mantle of the Earth under gravitational action of the Moon. For suggested two-body Earth model and in the simple case of circular (model) orbit of the Moon a phenomenon of periodic oscillations of the core with the fortnightly period and with an amplitude 11.5 mm was observed. More remarkable phenomenon is a cyclic turn with same period (13.7 days) of the core relatively to the mantle with "big" amplitude 152 m (at core surface). In another model problem the deformations of elastic mantle due to relative displacements of the core are studied. The mantle we consider as elastic (homogeneous and isotropic) layer, and core as a rigid spherical body. In the undeformed state centers of mass of the mantle and core coincide and shells have concentric positions. We admit that mantle and core are subjected by differential action from the side of external celestial bodies. Due to this action shells undergo by the forced mutual mechanical interaction. The core pushes on the mantle and deforms its inner surface and all mantle layers. We give an analytical description of mentioned deformations of the mantle by the small displacements of the core. Here we consider restricted treatment of problem and believe that displacements of the core relatively of center of mass of the planet (by undeformed mantle) are given. Formally it means that here we do not take into consideration deformations of the mantle under attraction of the external celestial body. In accordance with linear theory of elasticity it can be studied separately. An analytical description of the possible geocenter displacements is given. Obtained results confirm a general Barkin's model (1999, 2002) that induced relative shell oscillations can control and dictate cyclic and secular processes of energization of planets and satellites in definite rhythms and in different time scales. The phenomena of inversion changes of the Earth figure, its tension states and deformation fields in opposite hemispheres, inversion of gravity in opposite hemispheres, the directed redistribution of the oceanic and atmospheric masses from one hemisphere to opposite hemisphere, density inverse changes in opposite hemispheres, inversion of variations of activity of the planetary processes (seismicity, volcanism, geyser activity) and others have been predicted and studied on the base of developed geodynamical model Barkin (1995-2007). The following fundamental problems of geodesy, astrometry, gravimetry and geophysics have been explained and solved: 1. secular drift and periodic motions of the geocenter and the core of the Earth; 2. directed mass redistribution of the Earth; 3. the Earth pole secular drift; 4. the Earth non-tidal diurnal acceleration; 5. lengthening (shortening) of parallels of the South (North) hemisphere; 6. contrast and asymmetric expansion and contraction of hemispheres; 7. non-tidal gravity variations due to the Earth core displacements; 8. height variations at the Earth surface; 9. inversion phenomena in activity of volcanism and seismicity of the Earth; 10. the sea level rise and sea surface changes in the last century; 11. the solution of the "attribution problem" about mechanisms of the secular sea level rise (SLR); 12. hour variations of natural processes and others.

Referenses

Barkin Yu.V. (2002) Explanation of endogenous activity of planets and satellites and its cyclicity, News of Russian Academy of Natural Sciences, Section of the Earth sciences. Issue 9, December 2002. pp. 45-97. In Russian.

Point model of the secular reorganization of the Earth

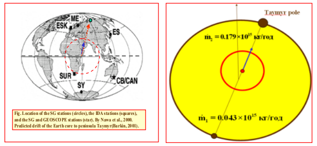
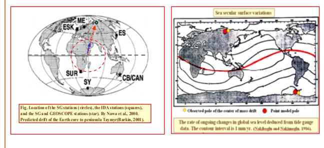


Fig. Location of the SG stations (circles), the IDA stations (squares), and the SG and GEOSCOPE stations (star). By Nawa et al., 2000. Predicted drift of the Earth core to peninsula Taymyr (Barkin, 2001).

Point model of the secular reorganization of the Earth Secular sea surface variations



To explanation of fundamental geodynamical phenomena:

Earth's axial acceleration;
Earth's pole secular drift;
Earth's center of mass drift;
Geopotential coefficients variations.

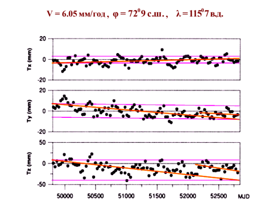
P	Model	Observ.	Authors, year
$\dot{\omega}/\omega$	6.17	6.7±1.7	Stephenson, Morrison, 1995
$\dot{p}/\omega$	387.7	394.5	Gross, Vondrak, 2001
$\dot{q}/\omega$	-1505.4	-1547.5	Gross, Vondrak, 2001
v_P/ω	1553.6	1597.0	Gross, Vondrak, 2001

P	Model	Observ.	Authors, yrears
$\dot{x}_C$ mm/yr	-0.57	- 0.77	Gajazov, 2003
$\dot{y}_C$ mm/yr	2.22	1.60	Gajazov, 2003
$\dot{z}_C$ mm/yr	6.28	5.78	Gajazov, 2003
v_C mm/yr	6.69	6.05	Gajazov, 2003
φ_C degrees	$70^0 0$	$72^0 9$	Gajazov, 2003
λ_C degrees	$104^0 3$	$115^0 7$	Gajazov, 2003

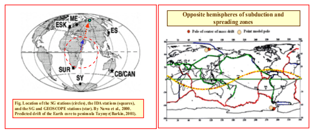
P	Model	Observ.	Authors,year
$\dot{J}_2$	-3.06	-3.07±0.4	Cheng, Shum, Tapley, 1997
$\dot{J}_3$	-1.51	-1.3±0.5	Cheng, Shum, Tapley, 1997
$\dot{J}_4$	-1.76	-1.4±1.0	Cheng, Shum, Tapley, 1997
$\dot{J}_6$	-0.27	0.3±0.7	Cheng, Shum, Tapley, 1997
$\dot{J}_8$	0.94	1.1±0.8	Cheng, Shum, Tapley, 1997
$\dot{C}_{21}$	-0.294	-0.337	IERS Conventions
$\dot{S}_{21}$	1.155	1.606	IERS Conventions
$\dot{C}_{22}$	-0.095	-0.095	Marchenko, Abrikosov, 2001
$\dot{S}_{22}$	-0.052	-0.052	Marchenko, Abrikosov, 2001

Point model: m2=0.179x10(15) kg/yr, m1=0.043x10(15) kg/yr; 1 unit= 10(-11)1/yr

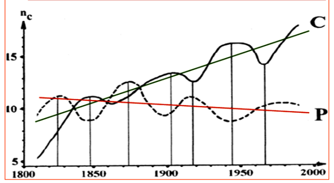
Secular geocenter drift on Gajazov (2003)



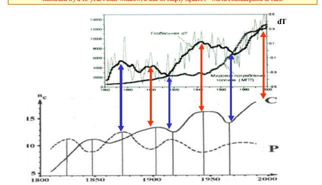
Point model of the secular reorganization of the Earth and opposite hemispheres of subduction and spreading zones



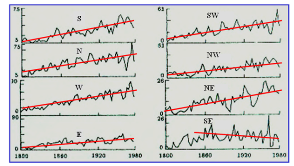
Inversion and trends of volcanism of subduction zones and spreading zones in period 1800-2000 (Khain et al., 2006)



Comparison of variations of global temperature anomaly dT and world consumption of fuel (mil.t of conditional fuel) with 1860 on 2000 with intensity of volcanism of zones of compression and extension with the filtered interannual variations. Thin dotted line - initial mid-annual values dT; a thick line - values of global dT, smoothed by a 13-years time window; a line of empty squares - world consumption of fuel.



Increasing of volcano activity in regions of Pacific



SECULAR GRAVITY TREND

Love numbers of the order $n=-2$: $h_{-2}=0.1419$ and $k_{-2}=-0.1423$.

$$h_{-2} = \left.\frac{u_r}{V_{-2}}\right|_{r=r_1} \cdot g, \quad V_{-2} = f\Delta m_c \frac{(\mathbf{r},\boldsymbol{\rho})}{r^3},$$

$$h_{-2}(\zeta) = \frac{m_E}{\Delta m_c}\left[(B_0+C_0)+(B_2+C_2)\zeta^2+(B_3+C_3)\zeta^3+(B_5+C_5)\zeta^5\right]\times\zeta^{-1}\Big|_{\zeta=1}$$

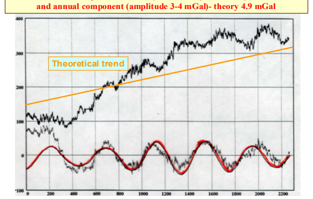
Secular gravity trend (Barkin, 2001)

$$\dot{g} = 2g\frac{\Delta m_c}{m_E}(1-h_{-2}-0.5k_{-2})\frac{\dot{\rho}}{r_1}\sin\varphi, \quad \Delta m_c = 0.1932 m_\oplus$$

$$\dot{g} = 2.6182\sin\varphi \ \mu\text{Gal}$$

Explanation of gravity variations at Potsdam (Neumayer, 2002):

trend component (2 mGal/year) –theory 2.5 mGal/year and annual component (amplitude 3-4 mGal)- theory 4.9 mGal



GRAVITY VARIATION AT ANTARCTIC SYUWA STATION

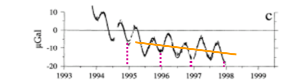
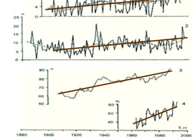


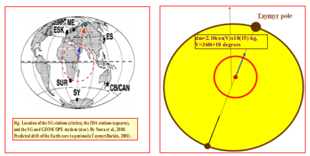
Рис. The secular trend of gravity variation at Syuwa Station 69.0 S in period 1995 -1998 is evaluated as -2.5 mGal/yr. Theory value is -2.38+/-0.55 mGal/yr.

Changes of regimes of functioning of atmosphere

1-fluctuations of the area of Aleutian depression; 2-occurrence of tropical storms in Northern Atlantic; 3-development of deep cyclones in Europe; 4-increase of tropical storm in the north of Pacific ocean



Point model of the annual mass change between southern and northern hemispheres of the Earth



Annual forced motion of the Earth pole

dp/w=44.1cos(V-246), dq/w=44.2cos(V-336)

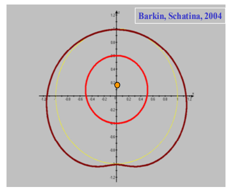
Astronomical observations

Автор	Период	v_1^c	v_1^s	v_2^c	v_2^s	F	φ_1	N	φ_2	λ
1. Астрономические наблюдения										
Уокер и Янг	1899–1954	−31,0	−34,4	33,9	−22,3	46,3	228	40,6	326	132
Джеффрис	1899–1967	−23,3	−37,2	33,7	−13,6	43,9	238	36,4	338	125
Рыхлова, ряд 1,	1891–1960	−14,5	−40,2	30,1	−12,1	42,7	250	32,4	338	116
ряд 2	1846–1915	−31,5	−20,8	29,6	−16,0	37,7	213	33,6	332	137
Гапошкин	1891–1970	−20,5	−38,6	27,9	−16,5	43,7	242	32,4	330	126
Корсунь, ряд 1	1846–1889	−48,2	−14,3	21,4	−25,0	50,2	197	32,2	310	156
Майор, ряд 2	1890–1956	−22,0	−38,2	28,1	−16,3	44,1	240	32,5	330	128
Яцкив, ряд 3	1957–1971	−15,3	−42,8	36,7	−18,4	45,5	250	41,1	333	113
Barkin						44.1	246	44.2	336	

Amplitudes in units= 10(-8) rad (Sidorenkov, 2002)

MECHANISM OF FORMATION OF THE PURE-FIGURE OF CELESTIAL BODIES AND PHENOMENA OF INCREASING OF MEAN RADIUS OF THE EARTH

Asymmetry of figure of the Earth change and increase of the mean radius of the Earth 0.22 - 0.23 mm/yr (Shuanggen Jin, 2005)



Polar asymmetry of decontamination in present epoch

(Marakushev, 1999)

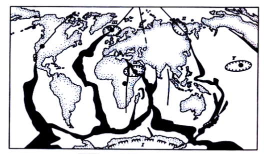


Fig. The world rifting system. The intensity of decontamination along spreading zones is reflected by their thinness. The centers of decontaminations of the Earth with ration of isotopes 3He/4He > 10(-5). Zones of distortion of ozone layer of the Earth (ozone holls): I- Antarctic, II- Indigirskaja, III- Islandskaja, IV- Krasnomorskaja, V- Hawaiskaja (Marakushev A.A., Syvorotkin D.L., 2002).