Perugia, Italy July 2-13, 2007

IUGG XXIV 2007 PERUGIA ITALY

EARTH: OUR CHANGING PLANET

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Session JGS002 Global sea-level change: Altimetry, GNSS and tide gauge measurements

MECHANISMS OF THE MEAN GLOBAL SEA LEVEL RISE AND SOLUTION OF "ATTRIBUTION PROBLEM"

The mechanism of perturbed relative small displacements (and rotations) of the Earth shells (the core, the mantle etc.) under of a differential gravitational attraction of external celestial bodies is responsible for formation of qualitatively new oceanic and atmospheric tides caused by a gravitational attraction of a displaced core and deformable mantle (Barkin, 2005). These tides are characterized by a wide spectrum of frequencies and various style of displays in opposite hemispheres of the Earth (in particular in northern and southern). The mentioned mechanism has allowed to explain divergences between the theory and the observations which have been found out by Blewitt et al. (2001) at studying of a style of global seasonal deformation of the Earth. The annual polar oscillation of the outer core and accompanying deformations of the mantle give the significant contribution to value of the observable load moment and to observable annual oscillation of the Earth centre of mass. On the other hand the gravitational attraction of displaced core substantially determines (and organizes) redistribution of atmospheric and oceanic masses between northern and southern hemispheres, i.e. determines process and cyclicity of formation of load on the Earth surface. From here it follows, that any other oscillations of the core (with other frequencies and form) and its linear trend will determine also the related phenomena of redistribution of oceanic and atmospheric masses, loading planetary deformations of the mantle, and also the appropriate variations of sea level. Here we obtain some upper evaluations of mean sea level rise on the base of value of velocity of linear trend of the Earth centre of mass in 6.69 mm/yr (Tatevian et al., 2004). The component of this drift caused by the polar trend of the core and by corresponding deformation of the mantle characterizes slow redistribution of water masses from a southern hemisphere in northern which leads to increasing of mean sea level with small velocity 0.33 mm/yr. The velocity of secular increasing of load on the mantle has been evaluated approximately on the known value of amplitude of the appropriate load moment making annual oscillation (for atmospheric and oceanic masses). It results in inversion of radial deformations of the mantle (similar and proportional to the annual mode), but increasing linearly in the time with velocity 1.81 mm/yr on South Pole and decreasing with the same velocity on North Pole. On equator radial displacements are equal to zero. The mentioned displacements of the Earth surface determine deformations of the ocean bottom and finally result in rise of mean sea level with velocity about 0.18 mm/yr. One more component in slow change of mean sea level is caused by the trend of the centre of mass, due to linearly increasing oceanic and atmospheric masses in northern hemisphere. By our evaluations it makes 0.40 mm/yr. Thus, the total effect results in rising of mean sea level with velocity consists about 0.91 mm/yr, that gives some additional positive arguments to solution of "attribution problem" about the unknown (lost) mechanism of increasing of mean sea level (Miller, Douglas, 2004).

SEA LEVEL RISE CAUSED BY CHANGE OF ITS BOTTOM

1. temperature change; 2. melting of continental ice; 3. ?

Mass and volume contributions to twentieth-century global sea level rise

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At the time of the second IPCC assessment in 1995[9], there seemed to be little controversy regarding global sea level rise (GSLR). Most gauge estimates fell in the range 1.5–2.0 mm yr^{-1}. Most of this rise was thought to result from ocean warming, with the rest due to melting of continental ice. However, by the third IPCC assessment in 2001[1], this consensus view had collapsed: new and better estimates of ocean warming had reduced the volume increase component to about 0.5 mm yr^{-1} (ref. 8), and the mass component was thought to be even smaller. This left a large unexplained gap between direct and indirect estimates of GSLR, now known as the 'attribution problem'.

Explanation of the Global Sea Level Rise
SOLUTION OF "ATTRIBUTION PROBLEM"

Bottom rising: $\dot{\zeta}_{Ocean} = 0.67 \pm 0.10$ mm/yr (Barkin, 2005)

Warm rising: $\dot{\zeta}_{Ocean} = 0.48 \pm 0.10$ mm/yr (Miller, Douglas, 2004)

Theory: $\dot{\zeta}_{Ocean} = 1.15 \pm 0.20$ mm/yr (Barkin, 2005)

Observation: $\dot{\zeta}_{Ocean} = 1.15 \pm 0.38$ mm/yr (Nakiboglu, Pointon, 1986)

"We find that gauge-determined of sea level rise, which encompass both mass and volume changes, are two to three times higher than the rates due to volume change derived from temperature and salinity data." (Miller, Douglas, 2004, p. 408).

Rotational annual tide

$$U_r = \frac{1}{2}\omega^2 r_\oplus^2 \sin^2\theta \qquad \zeta_O = \frac{\delta U_r}{g} = 0.09927 \cdot \sin^2\theta \cos(\oplus - 205^0)\,\mathrm{mm}$$

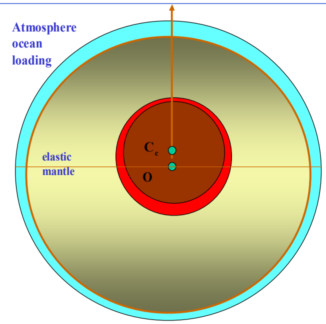
Polar annual tide

$$U_P = -\frac{1}{3}\omega r_\oplus^2 (p\cos\lambda + q\sin\lambda) P_{21} \qquad \delta U_P = -46.3\omega^2 r_\oplus^2 \cdot 10^{-8}\cos(\oplus + \lambda - 228^0)\sin\theta\cos\theta$$

$$\zeta_P = \frac{\delta U_P}{g} = -9.9915\sin\theta\cos\theta\cos(\oplus + \lambda - 228^0)\ \mathrm{mm}$$

Polar secular tide

$$\zeta_P = 0.3446\sin\theta\cos\theta\cos(\lambda - 104.3) \quad \mathrm{mm/yr}$$



Directed reorganization of Our Changing Planet

Luni-solar annual tides

$$U_P = \gamma m_\oplus m_P \frac{R^2}{r_P^3} P_2(z) = \left[\frac{3}{4}\frac{g r_\oplus^2}{a^3} m_P\right]\frac{4}{3g}\frac{a^3}{r_P^3} P_2(z) = \left\{G\frac{4}{3g}\right\}\frac{a^3}{r_P^3} P_2(z)$$

$$\frac{a^3}{r_P^3} P_2(\delta) = 3\sum_\nu B_\nu \cos\Theta_\nu \qquad B_\nu = -\frac{1}{6}(3\cos^2\rho - 1)A_\nu^{(0)} - \frac{1}{2}\sin(2\rho)A_\nu^{(1)} - \frac{1}{4}\sin^2\rho A_\nu^{(2)}$$

Moon tide annual

$$\zeta_P = 357.95\left(3\sin^2\varphi - 1\right)3B^{(0)}_{0.1.0.0.0}\cos l_\odot = 0.05602\left(3\sin^2\varphi - 1\right)\cos l_\odot \mathrm{mm}$$

Sun tide annual

$$\zeta_P = 164.16\left(3\sin^2\varphi - 1\right)\sum_\nu 3B_\nu^{(0)}\cos\Theta_\nu$$

$$\zeta_P = 3.1462\left(3\sin^2\theta - 2\right)\cos l_\odot \mathrm{mm} = (9.4385\sin^2\theta - 6.2924)\cos l_\odot \mathrm{mm}$$

Sea level annual variations

$$\delta h_O = \left(8.608\cos\theta + 9.4385\sin^2\theta - 5.6364\right)\cos V$$

Determination of amplitude of variation of the mean level of the sea 7.672 mm

$$\cos V \int_{\theta=0}^{\pi}\left(A\cos\theta + B\sin^2\theta + C\right)\sin\theta\,\Sigma_O^{(0)}(\theta)\,d\theta = 0$$

$$\delta h_O = \left(8.608\cos\theta + 9.4385\sin^2\theta - 5.6364\right)\cos V$$

Theory value: 7.672 mm

Altimetry data:(7.6+/-0.8) mm

References

Barkin Yu.V. (2005) Oscillations of the Earth core, new oceanic tides and dynamical consequences. Materials of XI International Scientific Conference "Structure, geodynamics and mineral genetic processes in lithosphere" (September, 20-22 2005, Syktyvkar, Russia), Publisher of Geology Institute of Komi SC of Ural Section of RAS, Syktyvkar, pp. 26-28. In Russian.

Blewitt G., Lavallee D., Clarke P., Nurutdinov K. (2001) New global mode of Earth deformation: seasonal cycle detected. Science, V. 294. pp. 2342-2345.

Miller L. and Douglas B. C. (2004) Mass and volume contributions to twentieth-century global sea level rise. Nature, v. 428, 25 March 2004, pp. 406-409.