How Does Earth Maintain the Stability of its Rotation Motion?: An Irreversible Thermodynamics Approach

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1. Aim

The last decades have seen a major improvement in the quantity and quality of available data for earth systems at both regional and planetary scales. This data has improved our knowledge of individual aspects of this system (e.g. tectonics, climate, vegetation), but very few studies have as yet looked at the dynamics of the entire planet. What is missing is a global model of Earth as a complex system describing the planet's evolution as a whole, together with all the negative and positive feedbacks, which determine the stability of the planet.

The main goal of this paper is that to provide a global model of the planet Earth using the framework of the irreversible thermodynamics. As a result a stability scheme for Earth rotation motion is developed.

2. Planet Earth as a self organizing system

The Earth structure is organized by several complexity levels each of them being individualized by its own time of change. These times are separated by several orders of magnitude. For example, between two consecutive changes of the Earth core, the biosphere passes through all possible states with the same probability (as stated by the ergodic theorem). According to irreversible thermodynamic laws (the Prigogine's theorem) the stability of the whole system is realized if the complexity level with the smallest time of change reaches its own stability.

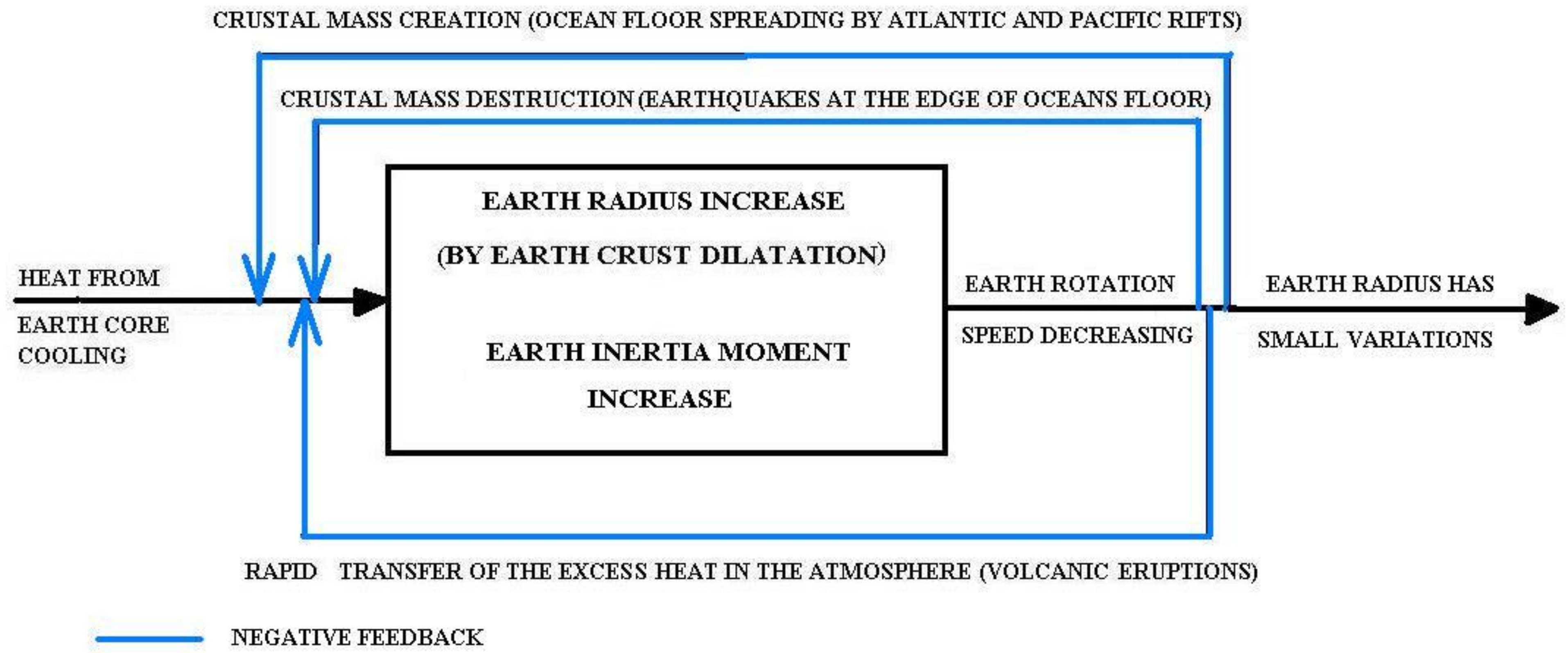
The biosphere is the Earth level of complexity which has the smallest time of change. The biosphere stability involves that the distribution of the solar radiation and the climatic conditions preserve their characteristics. These all occur only if the Earth rotation motion reach the near to equilibrium state.

The Earth rotation motion is perturbed by two phenomena.

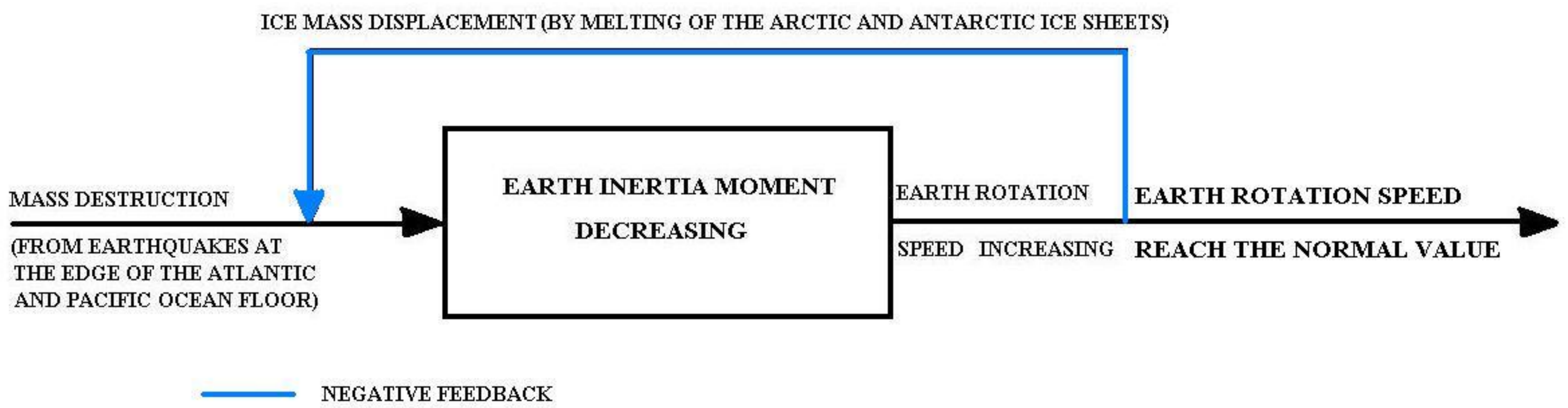
(1)The gravitational interactions. The perturbation are attenuated by the strong coupling Earth – Moon that generates the nutation and the vobler motions.

(2) The continuous cooling of the Earth core. The fluctuations of Earth radius and Earth inertia momentum are generated by the Earth crust dilatation so that the Earth rotation speed can be modified. The diminishing of these fluctuation are realised due to plate structure of the crust and with earthquakes and volcanic eruptions as negative and positive feedbacks.

THE CONTROL OF THE EARTH RADIUS VARIATIONS



THE CONTROL OF THE EARTH ROTATION SPEED



3. The stability scheme

THE CONTROL OF THE EARTH ROTATION STABILITY IS REALIZED BY THE MOMENTUM CONSERVATION LAW

$$L = I\omega$$

$$I = \sum_i m_i r_i^2$$

L – Earth momentum

I – Earth inertia momentum

m_i Earth's mass element

r_i – position vector

ω - Earth angular rotation speed

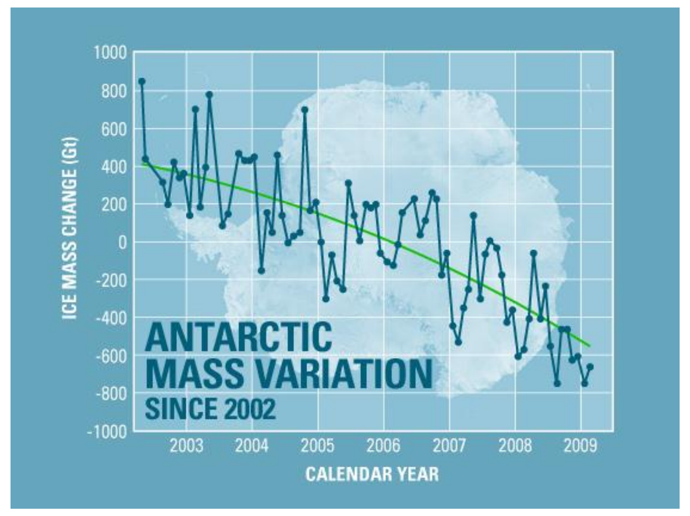
4. Experimental measurements and some preliminary estimations

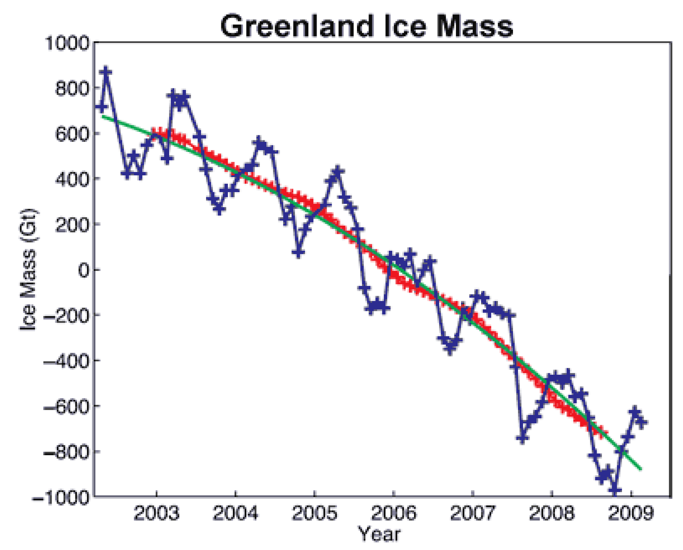
Decreasing the length of the day in response to major earthquakes

EARTHQUAKE LOCATION	LENGTH OF THE DAY DECREASE (μs)	EARTHQUAKE MAGNITUDE	NORTH POLE SHIFT (cm)	ENERGY RELEASE (J)	MASS DESTROYED (Gt)	Ref.
Alaska (1964)		**9.2**		**10^{18}**		**[1]**
Chile (2010)	**1.26**	**8.8**	**8**			**[2, 3]**
Sumatra (2004)	**6.8**	**9.1**	**7**	**1.1×10^{17}**	**1.35×10^3**	**[4, 6]**
Japan (2011)	**1.8**	**9**	**17**	**$1.9\pm0.5\times10^{17}$**		**[2, 5]**

Polar ice sheet melting

Time series of ice mass changes for the Antarctic ice sheet [7] (left) and the Greenland ice sheet estimated from GRACE monthly mass solutions for April 2002 to February 2009 [8] (right).





From ref. [6] for Sumatra 2004 Earthquake	
Mass destroyed at fault	1.35×10^3 Gt
Distance of failure	10 m
Moment of inertia involved	1.35×10^5 Gt m^2

From ref. [7] and [8] for ice sheet melting in 2005	
Mass melt from Greenland ice sheet/month	4 Gt
Mass melt from Antarctic ice sheet/month	4 Gt
Earth radius variation/hemisphere	100 m
Variation of inertia moment/month	0.8×10^5 Gt m^2

Then, the Earth rotation speed should reach the normal value after less than two months by ice sheets melting.

5. Conclusion

The earthquakes and the volcanic eruptions are positive and negative reactions in the process of reaching Earth rotation stability, being the essential phenomena for Earth stability.

The polar ice sheets melting is an essential phenomenon in order to reach the normal value of the Earth rotation speed.

[1] Press and Jackson Science Vol. 147 no. 3660 pp. 867-868 (1965)
[2] http://www.nasa.gov/topics/earth/features/japanquake/earth20110314.html
[3] http://earthquake.usgs.gov/earthquakes/eqinthenews/2010/us2010tfan/
[4] Richard S. Gross and Benjamin F. Chao "The rotational and gravitational signature of the December 26, 2004 Sumatran earthquake" Surv Geophys 27:615–632 (2006)
[5]http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usc0001xgp/neic_c0001xgp_e.php
[6] Giancarlo Scalera, "Geodynamics of the Wadati–Benioff zone earthquakes: The 2004 Sumatra earthquake and other great earthquakes", Geofis. Intl v.46 n.1 México ene./mar. (2007)
[7] Marco Tedesco and Andrew J. Monaghan, "An updated Antarctic melt record through 2009 and its linkages to high-latitude and tropical climate variability," Geophys. Res. Lett., 36, L18502 (2009)
([8] I. Velicogna "Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE", Geophys. Res. Lett., 36, L19503 (2009)