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Geophysics

Relaxation Processes in the Alterations of the Average Annual Temperature of the Earth

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(Presented by Academician T. Sanadze)

ABSTRACT. It is shown that alterations of the average-annual temperature of the Earth are characterized by relaxation oscillations with the period of 5-8 years. More low-frequency oscillations with the period about 60 years are also observed. Relaxation processes are connected with complex dependence of average annual temperature on changes of the Earth is albedo, quantity of the evaporated water, and also on the absorption of the solar radiation by green plants. Cycles of solar and human activity also influence the processes of temperature relaxation. Relaxation oscillations are caused by the negative feedback between parameters of the Earth and energy received by the Earth from the Sun. *© 2010 Bull. Georg. Natl. Acad. Sci.*

Key words: *relaxation oscillations, negative feedback, albedo.*

As calculations of the thermal balance of the Earth have shown [1], about half of the solar energy falling on the terrestrial surface is spent on the evaporation of water from the surfaces of oceans, seas and land, part of the energy is absorbed by green plants, but thermal energy emitted because of human activity is by four orders less than the energy received by the Earth from the Sun. Also it has been noted that increase in the concentration of CO_2 practically does not affect the value of average annual temperatures of the Earth and the infrared radiation of the terrestrial surface absorbed by CO_2 cannot evoke the greenhouse effect.

Nevertheless, oscillations connected with small changes in solar energy falling on the Earth are found by detailed study of the time dependence of average-annual temperature. It is highly significant that oscillations characteristic of transient processes are observed in the dependence of average annual temperature on time (Fig. 1). Faster oscillations have the period of 5-8 years (curve 1 in Fig. 1a). Temperature oscillations with a long period of about 60 years (curve 2 in Fig. 1a) are also well observed. Curve 2 is the result of averaging annual temperatures with a 5 year interval. Obviously, in nature there are temperature oscillations with much longer periods.

Relaxation oscillations of average annual temperature of the Earth with a 20-year interval around the years 1920(a), 1969 (b), and 2000 (c) and relaxation oscillations of the neodymium waveguide glass laser (d) [2] are shown in Fig. 2. It is necessary to note that the slightest changes of light pump intensity of the laser or efficiency of the optical resonator leads to disturbances of the regularity of relaxation oscillations of laser radiation (e) [2].

It is clear that fluctuations of such parameters as the power of solar stream, condition of atmosphere of the Earth, and other instabilities on the Earth hamper a more precise description of relaxation oscillations of temperature

The cause of fast average annual temperature oscillations lies in complex natural processes. Probably, the most significant of them is alteration of the albedo of the Earth due to changes of the cloudiness of the Earth. Rise in temperature evokes an increase of evaporation from the surface of oceans and seas, which increases

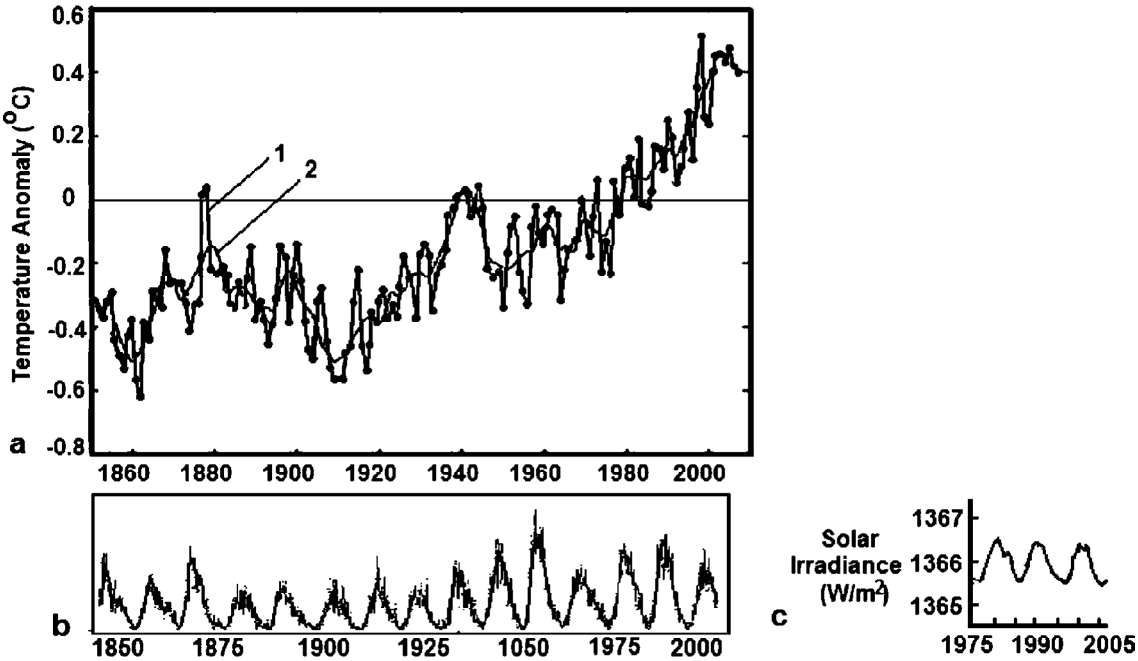

Fig. 1. a - temporary changes of average annual temperature (curve 1) and five years' averaging of size (curve 2); b - cycles of change of solar activity (Woolf's number); c - change of intensity of the sunlight.

the overcast of the whole planet and increases the Earth's albedo. It is clear that an increase of albedo reduces the stream of solar energy falling on the terrestrial surface and as a result decreases the evaporation of water. Owing to reduction of evaporation the cloudiness of our planet is reduced and as a consequence, the Earth's albedo decreases, which in turn increases the stream of solar radiation falling on the terrestrial surface with subsequent rise of temperature. This is the essence of a negative feedback for our planet.

It is necessary also to bear in mind that rise in temperature of the surface of oceans increases the number and energy of tornadoes, which in turn, taking away the thermal energy from the upper layers of oceans, transforms it into the kinetic energy of destructive hurricanes. Because of reduction of temperature of the surfaces of oceans (especially at sites of rise of powerful tornadoes) growth of number and energy of tornadoes, for example, in the Atlantic Ocean, can evoke some reduction of temperature of the Gulf Stream at the coast of England.

The full mathematical description of the global warming process is rather complex because of a great number of changing parameters. Nevertheless, it is possible to compose an equation of thermal balance for a simplified description of the kinetics of the process.

The full albedo of the Earth is determined both by reflection from the terrestrial surface and reflection and dispersion of light from clouds. Hence, the full albedo of the Earth consists of the factor of reflection from the terrestrial surface and the factor of reflection from clouds. Both these factors depend on time:

$$a = \eta S + \gamma m \quad (1)$$

where S is the area of a reflecting surface of the ground; m is the weight of clouds. Of course, the factor of reflection depends not only on the weight of clouds, but also on their volume and shape and also on their disposition in space and hence, formula (1) gives a fairly approximate description of the value of albedo. Certainly, an arrangement of clouds over the globe (to what extent do clouds block ice and green massive) has an influence on the value of the full Earth's albedo. Furthermore, evaporation of water and precipitations change the values of m and S in a very complex manner). Last measurements of the Earth's albedo by spacecraft have given the value near 40%.

The balance equation of thermal energy [1] as the basic equation for the kinetic process taking place on the Earth, so

$$\frac{dQ}{dt} = (1-\alpha)P + \rho N + Q_E / t -$$
$$-\kappa(Q + Q_E)/t - \lambda m_v / t - \sigma Q / t \quad (2)$$

where Q is the accumulated energy on the terrestrial surface and in the atmosphere, determining the average-annual temperature, a is the average factor of reflection from the terrestrial surface and from clouds (full albedo),

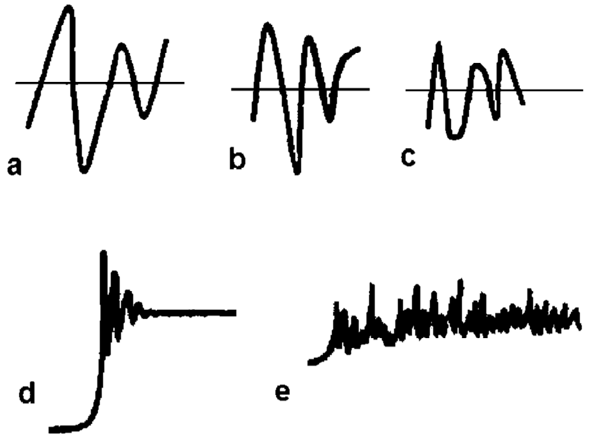

Fig. 2. Relaxation fluctuations of average annual temperature (a, b, c) and radiations of the Neodymium waveguide glass laser (d,e)

P is the stream of power from the Sun falling on our planet; ρN is an increase in heat in unit of time due to human activity; Q_E is the heat emitted from the bowels of the Earth; kQ is the ground cooling due to radiation in infrared area; λm_v is cooling of the Earth due to evaporation of water (m_v - weight of evaporated water), and σQ is the energy absorbed by green plants on the Earth. The process of evaporation transforms thermal energy in the potential energy of water (in clouds') and into kinetic energy of winds, and energy absorbed by plants due to photosynthesis produces oxygen from absorbed CO_2. All these values by themselves are complex functions of time that rather complicate more or less exact mathematical description of the whole process.

However, it is possible, though rather approximately, to describe the kinetics of changes of *a* by the equation:

$$\frac{d\alpha}{dt} = K(1-\alpha P)m_o - \Delta m/t\,, \qquad (3)$$

where m_0 is the weight of evaporated water for a unit of time, and $\Delta m/t$ is the reduction of the weight of clouds in a unit of time due to precipitation. The solution of a system of differential equations (2 and 3) is rather complex, but the presence of a negative feedback and similarity with the kinetic equations of generation of laser makes possible to assume the presence of transient processes with oscillations similar to radiation intensity oscillations of laser [2] (Fig.2) with obtaining the stationary value for temperature and Earth's albedo. Such, a cycle of oscillations could come to a constant value of the annual temperature if solar radiation were constant over time (with the constancy of the other parameters of the Earth), but even well-known cycles of solar activity (Fig 1b) showing changes of intensity of the sunlight in time, always lead to failure of the stationary value of average-annual temperature of the Earth.

It is clear that during the activity of the Sun the stream of power of the light radiation falling on the Earth (Fig.1c) increases too. In spite of the fact that these changes are small enough (about 0.07% of the power of solar radiation) they may be quite sufficient for the relaxation process to fail, especially in combination with fluctuations of the full albedo of the Earth.

Of course there are some more reasons leading both to the relaxation process alterations in mid-annual temperature (typhoons and tsunami, seasonal tropical downpours etc.) and to failure of the stationary regime of temperature, but the principal cause probably is periodic changes of the Earth's albedo.

In accordance with [1] the growth in average-annual temperature of the Earth in stationary regime is mainly compensated by radiation of the Earth in the infrared area of the spectrum and evaporation of water from terrestrial surface. Undoubtedly, in future increase of the stream of solar radiation will increase the mid-annual temperature of the planet. However, in spite of the growth of full albedo, it is possible to decrease average annual temperature artificially, for example, by the entering of thin reflecting surfaces in the circumterraneous orbit.

As we see, natural processes on the Earth are associated with each other by negative feedback, leading to stability of thermal processes on the planet. We have considered the negative feedback between the average-annual temperature and albedo of the Earth. An example of negative feedback may be the excessive increase of the Earth's population and related increase in further burning of hydrocarbons (at reduction of green plants) that can evoke an abrupt increase of the number of destructive tornadoes, tsunamis, earthquakes, landslips as well as droughts in some regions leading to reduction of agricultural production. These destructions by themselves can result in the reduction of population on the Earth and in turn lead to a decrease of heat emission connected with human activity and as a consequence - decrease of the average annual temperature of the Earth.

In conclusion, it is necessary to note that some warming, observed in definite regions, and related melting of glaciers, in general, due to the negative feedback between natural phenomena, will not result in essential and fatal changes of climate until the point when solar radiation increases substantially.

გეოფიზიკა

დედამიწის საშუალო წლიური ტემპერატურის ცვლილების რელაქსაციური პროცესები

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სტატიაში ნაჩვენებია, რომ დედამიწის საშუალო წლიური ტემპერატურის ცვლილებას ახასიათებს რელაქსაციური რხევები პერიოდით 5-8 წელიწადი. ასევე შეინიშნება ტემპერატურის დაბალი სიხშირის რელაქსაციური რხევები დაახლოებით 60-წლიანი პერიოდით. რელაქსაციური პროცესები დაკავშირებულია დედამიწის ალბედოს, აორთქლებული წყლის რაოდენობისა და, ასევე, მწვანე მცენარეების მიერ მზის ენერგიის შთანთქმის დროში ცვლილებებთან. ტემპერატურული რელაქსაციის პროცესებზე გარკვეულ გავლენას ახდენს მზის აქტივობის ციკლური ცვლილებები და ადამიანის ზემოქმედებით გამოწვეული ტემპერატურული ცვლილებები. რელაქსაციური პროცესები გამოწვეულია დედამიწის პარამეტრებსა და მზიდან დედამიწაზე დაცემულ ენერგიას შორის უარყოფითი უკუკავშირით.

REFERENCES

1. *M. Dzhibladze, A. Mikaberidze, Z. Razmadze* (2009), Bull. Georg. Natl. Acad. Sci., **3**, 2: 75-78.
2. *M.I. Djibladze* (1995), Laser Physics, **5**, 1: 1-15.

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