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Thermal analysis scheme aimed at better understanding of the Earth's climate changes due to the alternating irradiation

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Abstract Methodological scheme of thermal analysis is used for portraying the Earth environmental research and climate changes showing particularly the history, effect of atmosphere reflection (albedo) and absorption (so called greenhouse effect included). The net behavior of the Earth as a black body is reviewed. The most influential on climate changes is alteration of the geometry of the Earth trajectory and the irradiative power of the Sun (as a standard thermo-analytical pair of the sample and radiator). Thermodynamic basis of water vapor impacts is pointed out, the absorption spectra of atmosphere emphasized and temperature gradients indicated. The historical course of the Earth temperature and CO_2 concentration is put in analogy with the method of gas desorption analysis, which supports the view that the variation of CO_2 concentration recorded in the past may not be alone blamed for temperature changes.

Keywords Climate · Irradiation · Carbon dioxide · Greenhouse effect · Albedo · Temperature · Global warming · Atmosphere thermodynamics

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Introduction

From the outer space looks our livable world, the Earth, rather fragile. Despite its solid core it is covered by a relatively thin blanket of atmosphere underneath which is a very thin habitable layer capable to cradle the miracle of life. First, in the Earth's history, this layer contains self-reliant entity of mankind, which is becoming to exceedingly wear away its friendly surrounding by plentiful utilization of raw materials, over-burning fossils, abundant traffic and generation of superfluous wastes, which in fact destroys the living conditions on planet. Inherent biological network interacts with the ecosystem treated as a thermal structure which is no more a passive stage but has a character of a "living architecture" (often assimilated into the image of the Earth-goddess "Gaia"). The global treatment induces better understanding of the concept of global steadiness governing a distribution of local non-equilibriums.

We are living in an interglacial period but about 20,000 years ago massive glaciers were spread far away from poles [1]. Glaciers have come and gone many times but the footprints of climate may fluctuate even within a shorter phases. For example, in the period 1400–1800, the year-average temperature dropped by about 1.5 °C comparing today (even called as 'little ice age') [2] while within 1910–1940, the global warming (increase of the averaged temperature by ~0.5 °C [3]) appeared which was too big to be caused by 'greenhouse' effect alone. So, it is the question if our planet is under an unusual course of warming or is yet recovering from the little ice age, which may bring Greenland back its farming stage as it was 1000 years ago during the medieval climate optimum [4]. Looking to such historical records, we can make a thought ('gedanken') thermal analysis experiment and place the resulting figures to a certain correspondence with similar thought experiment, evolved gas analysis (desorption of greenhouse gases, especially of CO_2), etc. Understandably, we cannot cover herewith all the articles dealing with associated phenomena, so a certain profile is only offered. All politically motivated issues and reports, however, are avoided because they often reflect rather financial interests instead of the objective ecological aspects.

Earth irradiation treated in the frame of thermal analysis

Thermal analysis (TA) is traditionally exploited for a quantitative determination of thermal changes which occur in various samples under monitored heating/cooling, often within both mesoscopic and microscopic scale [5–7]. Instrumental arrangement makes thus available a suitable setting for controlled (and desirably homogeneous) sample heating provided by the surrounding furnace/thermostat. Temperature conditions are averaged by encircled heat convection, conduction and radiation. The sample temperature is, as a rule, measured either in a single place or, less commonly, is monitored spotty over various points of the sample [7, 8]. In some cases is the sample heated by directional light source and the equilibration of temperature is achieved by the sample rotation [9]. Sample has usually its own ambient atmosphere (sometimes decomposing), which is under the downward gravitation force and which motion and composition (air/O_2/N_2/H_2/He) helps to equalize the temperature gradients by inherent local heat fluxes [6, 7, 10]. The distance between the heater and the sample is usually kept constant, only in some special arrangements is the temperature program realized by the controlled movement of a sample along the stationary gradient of the furnace [7, 8, 10]. In some cases, a shielding reflector is inserted between the heater and sample in order to modify locally the radiation (and consequently the temperature gradients).

Apparently, the term "thermal analysis" can be synonymously used for describing the Earth's climate changes as the Sun–Earth system exhibits some analogous features of the shared furnace-sample assembly, which, certainly, must be imagined on much larger macroscopic scale. Directional heater, the Sun, and the one-way irradiated sample, the Earth, are in permanent interaction which controls the most important observable, Earth's temperature. The dynamical thermal equilibrium essentially due to the position and rotation of the Earth is modified by the presence of surrounding atmosphere with its varying composition, local motions and heat and mass fluxes (http://www.oism.org/pproject/s33p36.htm, http://www.fzu.cz/~sestak) [11–44]. Therefore, the irradiative input is complexly distributed vertically and horizontally including the advection, convection and diffusion in atmosphere. The warms is spread out within ocean with its long-standing convectional flows due to the changes of both temperature and salinity standing thus as a stock for climate inertia ('thermohaline oceanic heat exchanger and reservoir'). In order to study these effects, the temperature is measured at multiple points both on the Earth surface, marine and in the adjoining atmosphere and also includes the remote service of orbiting satellites. Similarly, the surface and atmosphere are scanned over various wavelength regions in the way traditionally known as 'thermography' [7].

The heat exchange near the Earth is realized through the adhering atmosphere layer, which is bound by the centripetal gravitational force, further surrounded by the near-vacuum space avoiding thus successive heat/mass transport by outward convection. On the interplanetary separation scale, the only mechanism remaining for the heat exchange is radiation which requires taking into account its reflection ("albedo") and absorption. These effects including also the popular "greenhouse effect" are extensively discussed in the literature [11–13].

Consequently, the weather has a regular component which is due to the diurnal and annual rotations of the Earth and a somewhat chaotic component due to the atmospheric circulation driven by the irradiative energy of the Sun. The climate is then understood as an integral of weather over the periods lasting more than 1 year. As we are convinced, the relevant method for theoretical description of such a complexity can be found, because of numerous analogies, in the theory of thermal analysis [6, 7, 14–30]. The experience with TA clearly reveals, namely, that the decisive effect on the sample (Earth) temperature should have the behavior of furnace (Sun) and their mutual position.

History of research into the Earth climate and atmosphere thermodynamics

The original concept of the so called "atmospheric greenhouse effect" can be traced back to the work of Jean B. J. Fourier (1768–1830) [31] who in the year 1822 realized that the Earth atmosphere is relatively transparent to solar radiation, but highly absorbent for the terrestrial radiation that results to a relative increase of the temperature of the Earth surface. Michael Faraday (1791–1867) [32] called attention to the atmospheric CO_2, which has a positive environmental effect on the growth of plants and animal population as well, helping to maintain their diversity. However, it was only Svante A. Arrhenius (1859–1927) [33] who in the year 1896 laid the formal foundation of the theory linking the variation of concentrations of atmospheric gases to the climate changes. His main goal, however, was the estimation of the surface temperature rise due to the increase in the content of carbon dioxide. It matured to a more detailed model of the radiation balance between the atmosphere and the surface and particularly led to the discovery of importance of water vapor which accordingly determines the sensitivity of climate toward the impact of greenhouse gases.

As the Earth catches warming, the saturation pressure (p_s) of water vapor would increase exponentially with temperature (T) according to the classical Clausius–Clapeyron relation [6, 7, 16, 21, 23, 25] $d \ln p_s/\mathrm{d}T = \Delta H/(RT^2)$ (ΔH being molar heat of evaporation). The increased saturation pressure would enhance the water-vapor concentration, further amplifying the greenhouse effect. On the other hand, over-saturation of water vapor would lead to the condensation and formation of clouds increasing the outside reflection ('albedo') and thus suppressing the internal greenhouse effect. The associated release of heat (ΔH) play an important role in the control of atmosphere temperature because it affects on macroscopic scale the balance of evaporation/condensation and the coexistence of liquid/gas phases. Moreover, for micro/nano-scale of condensing droplets the effect of surface tension (γ) and its curvature (radius r) become decisive. The actual saturated vapor pressure (p_{sr}) with respect to that over the flat surface (p_∞) is given by the Kelvin equation $RT \ln (p_{sr}/p_\infty) = 2\gamma V_m/r$, where V_m is the molar volume of water. It is clear that with decreasing of r the ratio p_{sr}/p_∞ increases, bestowing the instability of cloudy systems, where tiny droplets evaporate yielding then the vapor super-saturation and making the reestablishment of liquid water phase difficult. The condensation thus frequently needs an auxiliary (catalytic) stimulus of external (often heterogeneous) condensation cores, such as dust, aerosols (called CCN, clouds condensation nuclei), the occurrence of which additionally decreases the irradiative absorption. (This very often ignored Twomey's effect [34] is very likely responsible for most changes of rainfall activity [35]). There are some other dimension-dependent thermal effects [23, 36, 37], which detailed explanation falls beyond the frame of this contribution.

Early laboratory absorption measurements (accomplished by Tyndall [38] on the CO_2 and H_2O vapors) became important to see the foremost influence on the terrestrial rays and associated climate changes. It was followed by direct observations of an atmospheric transmission by Langley [39] who designed a high precision temperature detector, called bolometer, capable to record numerous data regarding the solar and even the lunar spectra. The birth of the quantum mechanical theory in the early twenties of twentieth century announced the beginning of theoretical spectroscopy, and expansion of relevant experiments led eventually to the availability of reliable spectroscopic data [40–44] as e.g. that by Goody [43] and supplemented by others [41, 44].

Natural cycles of atmospheric greenhouse gases and associated clouds have become a subject of many theoretical studies involving thermodynamic analysis [7, 14–25], which showed that the immediate Earth weather and long-lasting trends in global climate are very sensitive phenomena which are dependent on a plenty of variables having very often chaotic behavior [45, 46]. For example, recent estimates based solely on energy balance disturbances due to the changes of atmosphere composition (e.g., CO_2) have shown that in comparison with the variability of solar irradiation just this factor should dominate the climate.

Such an "energy argument", however, is greatly suspicious for highly nonlinear, extremely complex systems as is the coupled structure of atmosphere–ocean–cryosphere–biosphere and their power inputs and webs. It is well known that any multifaceted systems can behave bizarrely violently, i.e. can follow very different paths after the smallest change in initial or boundary conditions, or in response to the smallest perturbation. Chaos in climate (copious and meager years) and weather conditions is thus something "normal" revealing unpredictable fluctuations or drifts (see Fig. 1). In a firmly uneven makeup with large reservoirs of latent energy (such as the atmosphere-ocean-biosphere), global redistributions of energy can be triggered by unexpectedly small inputs, a process that depends far more on their spatial and temporal pattern than on their magnitude, and it is the question if the man-made (anthropogenic) effects are influential enough. Worth mentioning is the work by Lorenz [45] who stressed that only non-periodic systems are plagued by limited predictability. External periodic or quasi-periodic systems can positively impose their rhythm on the climate. This is not only the case of the periodic diurnal changes and of the Milankovič cycles (see later) which satisfy these conditions, but also of 11-year sunspot cycle in solar energy output playing no role in the practice of predictions.

For serious analysis of climate changes [47–49] are thus needed exact, extended and continuous measurements of atmospheric conditions. Such a data are, unfortunately, available only since about last century; for larger periods, we are dependent on historical records and on a somewhat fuzzy approach, which is based on the methodology of "computing" with words describing subjective sensations instead of with numbers [23].

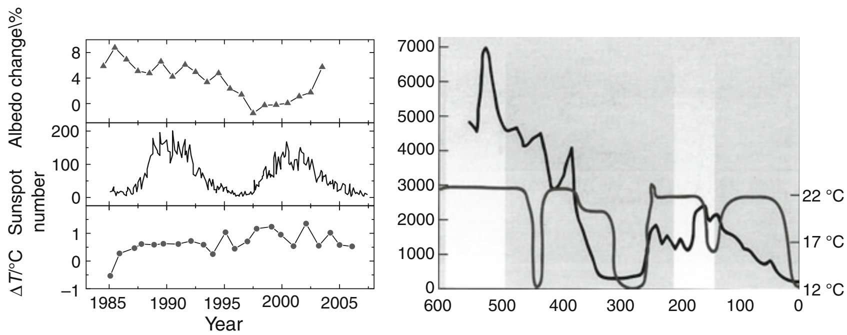

Fig. 1 *Left*: brief span records of major effects influencing the regional temperature changes (ΔT) due to the time-dependent irradiative power of Sun (affected by sunspots, *middle*) and the relative changes of the confined Earth albedo showing rather irresolvable upshot in long-lasting trends (composed on basis of various sources e.g. [26, 27, 56, 57). *Right*: The exploratory lifelong profiles of historical figures for the CO_2 concentration (in ppm—*upper blacker line* with the *left scale*) and associated temperatures (in °C—*lighter line* with the *right scale*) related to the assumed historical continuation in the past (in millions of—*bottom scale*) [48, 51, 71–74, 77–79]. Two lighter strips indicate the steady temperature period associated with the major geological periods of Cambrian and Jurassic and the 0-point on the right side shows the present day relatively low content of CO_2 ($\sim$370 ppm, close to the lower limit of the CO_2 content, $\sim$120 ppm, which may be even adjacent to the extinction of life). Note the era of global icing 300 million years ago, with markedly low temperatures close 10 °C. Remind that such a plot looks like that common for the procedure of evolved gas analysis and the figures are factually based on the chromatographic analysis of the bygone atmospheric content of ice-trapped micro-bubbles. Such examination toward climatologic history is often accompanied by isotopic testing of the ratio of heavy vs. normal ($^{18}O/^{16}O$) oxygen indicating thus the olden temperatures ('paleontological indicator') as well as by determination of the isotope ^{10}Be revealing in this fashion the intensity of cosmic radiation and thus also the amount of bygone sun energy

Influence of the sample position—geometrical anomalies of the Earth's orbit

Regarding the living conditions of mankind, the Earth's orbit is the most important attribute, which course, fortunately, is within an appropriate distance from the Sun and moves around it along the ellipse close to a circle (cf. Fig. 2, right). Under the gravitational force of the Sun combined with that of the distributed masses of the giant planets (Jupiter, Saturn) and nearest planets (Mars, Venus), the elliptical orbit revolves over the course of the year but its effect is too weak ($\approx$3 %) to cause the instant change of seasons (the full revolutions with respect to the stars takes about 112,000 year) but strong enough for to have a long-term impact. Now the Earth reaches perihelion (closest point towards the Sun) in early January, but this date does not remain fixed but slowly regresses. Tropical year is measured between two subsequent vernal equinoxes (being the base of our Gregorian calendar), while between two perihelia lies the anomalistic year (about 25 min longer), which moves completely through the tropical year in about 21 000 years, i.e. it advances by about one full day every 58 years. This effect is a combination of the above-mentioned orbit revolution, with the precession of the Earth's rotation axis i.e., a slight cyclic movement of the direction of the axis with a period of 26,000 years. Thanks to the gyroscopic effect of the Moon anomalies of the Earth revolution are well stabilized.

The eccentricity of the Earth's orbit varies complexly with resulting roughly periodic changes within the time scale of about 100,000 years (maximum distance Earth-Sun is 1.52×10^{11} m and minimum occurs at 1.47×10^{11} m), so that it can be significant for climate changes if modulated together with the 21,000 cycle of perihelion.

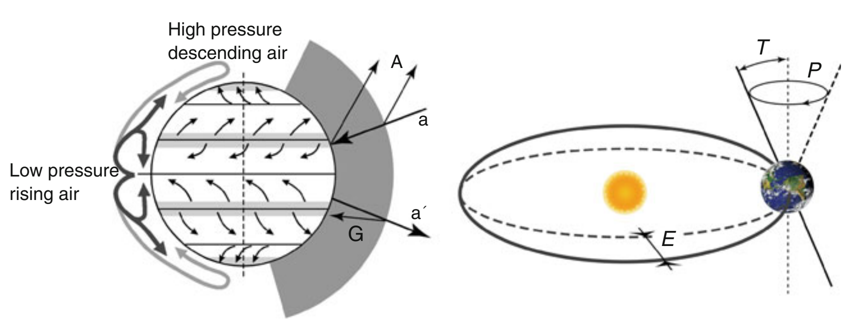

Fig. 2 *Right*: macroscopic arrangement of the sample (the Earth) and the furnace (the Sun) showing a schematic picture of the Earth orbital irregularity (eccentricity *E*, precession *P* and obliquity *O*). *Left*: Behavior of the sample—the Earth including the portrayal of its energetic balance accounting on albedo (*A*) and greenhouse effect (*G*) and showing the major stream of atmosphere, which are leveling uneven surface heating (this effect is on the micro-scale of standard TA samples unobservable)

Another 41 000-years variation is given by changes of the angle between Earth's axis and Earth's orbital plane (from 22.1° to 24.5°). These astronomical phases are often called the Milankovič cycles (after the theory of Serbian civil engineer Milutin Milankovič (1879–1958) [50]) but their true pattern [46] and impact on climate changes are not yet fully comprehensible [51] though they were forecasted by French mathematician Joseph Adhemar (1797–1862) and Scot James Croll (1821–1890) in that time, however, disbelieved (in light of obsolete 'quadricglacial hypothesis'). It is of no doubt, nevertheless, that the pronounced climatic changes during the past 2 millions years (glacial of about 100 000 years and interglacial of about 15 000 years each) emerged as a result of the simultaneous periodically repeating changes of the Earth orbit parameters (as shown in more details by Huybers [48]) accompanied at the same time with the variability of the Sun radiation [52, 53] (see below). However, it is not clear why these alterations did not show sooner (as at the turn of Tertiary and Quaternary) as they likely proceeded during the whole existence of our planet and could have puzzlingly amalgamated with the early shifts of planetary plates below continents or with other yet unidentified upshots.

Influence of the radiator—irregularities in the energy emission of the Sun

From various records in the current literature [52–59], we can deduce that the fluctuations of the heat source, Sun, plays a major role in natural secular climatic changes on the time scales of decades and centuries. The measurements from spacecrafts reveal the irradiation changes ranging from minutes do decades, including the pronounced cycle of roughly 11 years, often related to sunspots and other forms of solar activity. Besides, there are long-time averaged drifts of the total radiation produced by the Sun. However, this effect does not seem essential for variation of the Earth climate in present. For example, within the past 150 years, the mean global temperature at the Earth surface increased about 0.5 °C, and the amount of CO_2 measured at the Earth's atmosphere increased about 25% as a consequence of our enormous, continuously escalating and shabbiest burning of fossil fuels (instead their sparing for a more perspective future with further energy-sophisticated technologies). However, stellar and isotopic findings suggest an increase in solar total radiation of roughly 0.25 %. Let us note that the global mean temperature did not rise steadily as some statistics claim to show; the significant year-to-year and decade-to-decade variability, reaching $\sim$0.2 % from 1 month to the next one, are namely possibly consistent with the 27-day period of rotation of the Sun.

It becomes clear that the primary cause of the solar modulation of cosmic rays is not the level of the mentioned sunspot activity, but rather the variations of the strength of the solar wind [53–61]. This supersonic outflow of plasma originates in the very hot corona of the Sun and carries ionized particles together with the magnetic lines of force from the Sun. A steady stream of charged particles flowing continuously outward from the Sun impacts and deforms the Earth's extended magnetic field. The upper layers of the atmosphere (ozone layer and ionosphere) are strongly affected by the flow of high energetic solar particles and if strong enough, the particles penetrate further to atmosphere where provide the condensation nuclei enabling easier formation of rainy clouds changing the Earth's albedo.

Most important, however, are solar cycles which are without exception related to the Sun's fundamental oscillation about the center of mass of the whole solar system, into which the cycles of different length, but similar function, are integrated. In the simplest model, the dynamics of the magnetic sunspot cycle is driven by the Sun's rotation. Yet this theory only takes into account the Sun's spin momentum, related to its rotation about its axis, but not its orbital angular momentum, linked with irregular oscillations about the center of mass of the solar system as a whole, which is related also to the motion of giant planets (Jupiter and Saturn). The orbital momentum carries more than $\sim$99% of the angular momentum in the solar system (while the Sun's spin momentum is confined to a less than $\sim$1%). So, there is a high potential of angular momentum to be transferred from the outer planets to the revolving Sun and eventually to the spinning Sun. Recent considerations showed that such an effect in fact determines the length of the doubled period of sunspot activity (22.1-year magnetic cycle) and overall cycles called "big fingers" and "big hand" having a mean length of 35.8 and 178.8 years, respectively. Interestingly enough, varied climatic phenomena in different regions of the world show synchronized phases in a cycle of 33–37 years. The magnetic sunspot cycle of 22.1 years (often called the Hales cycle) is the true cycle of solar activity as groups of sunspots are usually composed of preceding and following spots with different magnetic polarity. With the commencement of a new cycle, the polarity reverses and the original polarity is only restored every second 11-year cycle. Some authors suspect that in Pleistocene, the impact of the Sun activity was physically more powerful than that of Milankovič cycles, which, however, dominated in warmer interglacial periods [48, 49, 51]. The Milankovič theory [50] in its modern form shows that the decrease in solar irradiation of $\sim$0.1%, effective during a very long interval, can release a real ice-age and that there may be some congruent modulation between eccentricities of the Sun and the Earth [48, 49, 53–62]. It may be thus expected that the Gleissberg cycle of sunspot activity having a characteristic time of 90–120 year and which super-modulates the intensity of the 11-year cycle, possesses a considerable potential to accumulate an effective surplus of irradiance, or, quite contrary, to induce a steadily decreasing of radiant flux density.

The Earth as a black body sample—heat and entropy fluxes

Income of irradiative energy on the Earth, $J_E(E)$, is about 1.2×10^{14} kW, which is a negligible fraction ($\sim 10^{-9}$) of the energy totally irradiated by the Sun ($J_S(E) \cong 10^{23}$ kW). Even though the total energy of the Earth remains constant, there is a definite change in the entropy flux, $J(S)$, because of the temperature disparity [20, 23, 28, 63, 64] in partial terms $J_{in}(S)$ and $J_{out}(S)$. It reads as $J(S) = J_{in}(S) - J_{out}(S) = 4/3 \quad (J_E(E)/T_S - J_E(E)/T_E) = 4/3 \ (1.2 \times 10^{14}) \ (1/5800 - 1/290) = -5.2{\times}10^{11}$ kW/K. The flux value of $J(S) = -5.2 \times 10^{11}$ kW/K can be related to 1 m^2 of the Earth, so that divided by $4\pi R_E^2$ yields the value of about 1 WK^{-1} m^{-2} . About 94% of entropy is produced during the absorption and re-emission of the radiant energy (the Earth serves as a transducer), and the rest can be attributed to material changes and motions of the atmosphere, oceans and Earth core ($\sim$0.07 WK^{-1} m^{-2}). Assuming that the whole mankind consumes roughly 10^{10} kW, i.e. produces entropy of about 3×10^7 kW/K being at about 0.1 % of the total production associated with material changes (photosynthesis, atmosphere circulation, phase changes of water, heating of the Earth surface, etc.).

Most important is an estimate of hypothetical balance of the Earth behavior assumed as a black body, in which we can take into account two decisive processes; the reflection (albedo, A) and the absorption (greenhouse effect, G) of radiation, see Fig. 2, left:

- *A* Incoming radiation from the Sun ($T \cong 5800$ K, $\lambda_{max} = 497$ nm)
- *a′* Outgoing radiation from the Earth ($T \cong 290$ K, λ_{max}= 9.9 µm)
- *A* Total albedo which is averaged over various angles and altitudes providing the recent value $\sim$35 %, strongly depending on the surface quality (e.g., wet surface considerably increases albedo)
- *G* Part of radiation which is returned back to the Earth surface due the interaction with atmosphere (dependent on its composition exhibiting the recent value $\sim$45 %)
- *T* Earth temperature $T = T_{bb}\{(1 - A)/(1 - G)\}^{1/4}$ (where T_{bb} is the temperature of black body equal to 278.6 K $\cong (S/4\sigma)^{1/4}$, S being the solar constant (density of the radiation power from the Sun at the distance of the Earth orbit) $\sim 1.365 \times 10^3$ W/m^2 and σ being the Stefan–Boltzmann constant $\sim 5.67 \times 10^{-8}$ W/m^2K^4)

From these data, we can calculate the following idealized conditions governing on the Earth surface, namely:

For $A = 0.35$, $G = 0.45 \Rightarrow T \cong 17$ °C (present state);
For $A = 0$, $G = 0 \Rightarrow T \cong 5.4$ °C (without any atmosphere);
For $A = 0.35$, $G = 0 \Rightarrow T \cong -23$ °C (without greenhouse effect);
For $A = 0$, $G = 0.45 \Rightarrow T \cong 50$ °C (without albedo).

These estimates illustrate very well the extraordinarily beneficial setting of the Earth in the space. Taking into account the parameters of orbits and atmosphere reflectivity G of the neighboring planets Mars (G is negligible) and Venus (G exceeds 0.70), we obtain much unfavorable figures. Relative thermal stability of the Earth together with reasonably small scatter of temperatures ($\Delta T \approx \pm 50$ °C) around the water freezing point at 0 °C (Notice, such a difference between maximal and minimal temperatures is insignificant in comparison with the usual extent of temperatures encountered in the Universe). Certainly, the actual temperature is not only the function of A and G, but is sensitively related to the Sun activity if the validity of Wien's law $T \cong 2.884 \times 10^{-3}$ K m/λ_{max} is assumed. Moreover, our evaluation shows that the Earth temperature is probably more sensitive to the changes of actual temperature of the Sun surface than the changes brought about by variations of coefficients A and G.

What more the Earth's temperature stability is curiously reinforced by the sudden change of the natural course of gradually falling temperature at tropopause ($\sim$15 km) to the positive gradient reversing again at stratopause ($\sim$50 km), see Fig. 3, which prevents the escape of the Earth atmosphere into the outer cosmic space and ensures the ultraviolet shielding, the ozonosphere.

Composition of the atmosphere, greenhouse effect and the recent views of climate changes

Let us recall that the water vapor is the major agent of the atmosphere absorption naturally controlling the Earth surface temperature, which is spontaneously fluctuating under the influence of other phenomena that are yet poorly understood [64, 66]. High temperature enhances evaporation and the enhanced amount of water vapor increases greenhouse effect and temperature of the Earth. Nevertheless, enhancement of water vapors in the atmosphere may have also a quite opposite effect. Saturated vapors in the presence of small disturbances tend, namely, to condensate and increase the albedo, which consequently

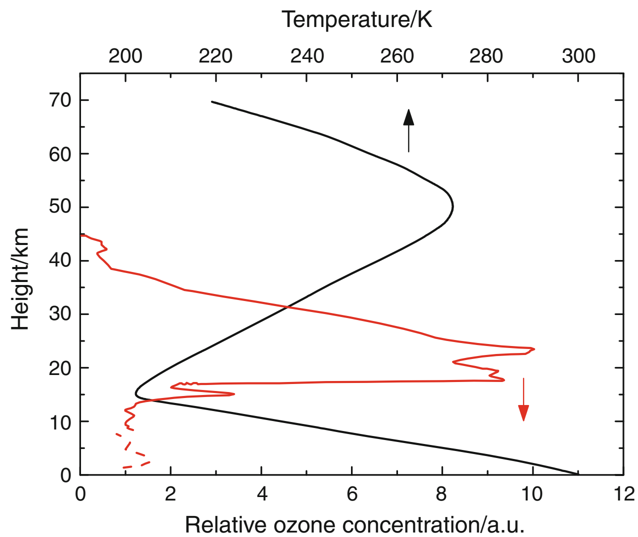

Fig. 3 Negative (troposphere) and positive (stratosphere) temperature gradients (*upper scale*) in the Earth atmospheric envelope (left) and associated distribution of ozone (*bottom*) as a far-reaching thermal measurement. Besides the gravitation this rare distribution assures the preservation of atmospheric layer onto the Earth surface

decreases the temperature and activates further vapor condensation releasing the latent heat and so on. The interplay of these antagonistic trends with random disturbances cannot converge to some equilibrium steady state but is rather a source of permanent chaos.

The dominating role of water vapors on greenhouse effect and allied processes in the atmosphere was confirmed by US satellite observations [67]. They revealed that the actual effect of individual gases on the degree of greenhouse effect may be estimated as follows (probable percentage of natural/ anthropogenic effect): H_2O as much as ≈99/0.10, CO_2— 0.12/0.01 and the rest, mainly CH_4—0.1/0.05 (cf. also Fig. 4).

The second most significant greenhouse gas is carbon dioxide. Let us make a balance estimate of the total human industrial production of CO_2, primarily from the use of fossil fuel, production of cement and automobile industry, which is about 8 Gt of carbon (C) per year while humans exhale mere 0.6 Gt C. Overall human CO_2 production is still negligible as compared to that residing in the ocean and biosphere [68–74]. Hence, the sources and absolute amounts of CO_2 in the atmosphere are likely of secondary importance and are thus rather insignificant to the hypothesis of human-caused global warming, because the overall rather weak absorption effect of CO_2 itself, seems to be overestimated with respect to that caused by H_2O. Nevertheless, historical records reveal that even insignificant narrow changes in the energy partaking (due to volcano eruption, meteorite collision or fire diminished forests) may cause the consequent far-reaching climate

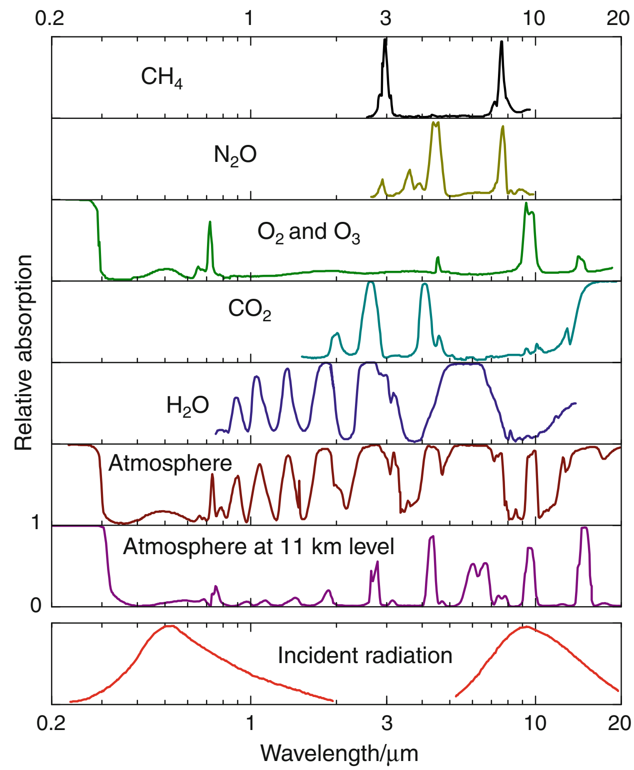

Fig. 4 Absorption bands of individual gases presented in the Earth atmosphere in various contents contributing thus the greenhouse effect (in comparison with the incoming (*left*) and outgoing (*right*) radiation shown bottom

modification and thus the impact of exponentially increasing mankind and their brutal Earth-exploration may turn out to become a yet unknown instigative mechanism worth of consideration in an unprecedented manner.

Based on the above given figures one can take for granted, however, that the recent effect of extra man-made exhalations of greenhouse gases alone, cannot be so significant as is believed, e.g., by protagonists of Greenpeace movement. This fact provides strong arguments for the opposition claiming that the greenhouse effect together with global warming is nothing but nonsense proclaimed by "eco-terrorists". Both these opinions are, however, fatally simplifying the real situation. Greenhouse effect, a physical effect par excellence stabilizing for millions years the conditions on the surface of the Earth, do exist. Global warming (till now of unknown origin) which is manifested in recent decades by fast disappearance of glaciers and unusual catastrophic behavior of weather also do exist. These effects must be properly accounted for and not only proclaimed or denied. Therefore, in conclusion, we would like to point out some important aspects which should by subjected to further research.

In order to separate anthropogenic and natural effects the influence of temporal changes of irradiation of the Earth by the Sun regardless of its origin (changes of the Earth's orbit or of activity of the Sun) should be eliminated first (very helpful may be here just TA approach). As the main greenhouse effect and albedo in the atmosphere of the Earth is very likely due to the water, the interactions resulting in phase transformations of the water changing dramatically absorption of radiation in atmosphere and its ion content has to be studied. Among the agents triggering the phase transitions of water belong heavy ions [75], nano-particle dust [35–37, 76], cosmic rays and chemically active gases (perhaps "greenhouse" ozone). The significance of these agents is due especially to the facts that they are efficient even in extraordinary small concentrations and some of them can be produced in appreciable amount by human activity. The attention should not thus be paid not only to increase of concentration of greenhouse gases but rather to other components of exhalations, to heavy ions and especially to nano-particles. It is evident that the combusting fabrication of CO_2 is always accompanied by the production of such nano-particles, the life of which is more steady (due to the Brownian motion, negligible sedimentation) than that of CO_2 which takes a part in the natural circulations (dissolution, precipitation). Very important become then the diurnal effects (rise of ions and charged nuclei and their dissipation) [75], which are reliant locally especially near the large agglomeration (cities, factories) where there is the greatest introduction of perilous nuclei into atmosphere (completing thus the natural cosmic background). It concerns the importance of (often neglected) values of the electric potential gradient at the Earth's surface, which for example, is remarkably low in fine weather (if the visibility is good lacking parasitic nuclei) while, on contrary, fog and dust produce high potential gradient not only harmful to human health but also affecting weather. Striking proof of such pollution was measured in a remote island (Samos) as early as in 1937 [75]) showing a marked difference in the diurnal variation of potential gradient (>50%, reaching up to 300 V/m) due to mere festival barbecue on holiday days; more crucial effects being detectable at the vicinity of great sources of man-made pollution. This subject matter is yet undervalued and can likely turn soon into the center of pollution policy to substitute the recently fashionable target of green house gases because we are still unable to discern how the world can shift beneath our feet.

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References

1. Clark PU, Dyke AS, Shakun JD, Carlson AE, Clark J, Wohlfarth B, Mitrovica JX, Hostetler SW, McCabe AM. The last glacial maximum. Science. 2009;325:710–4.
2. Moberg A, Sonechkin DM, Holmgren K, Datsenko NM, Karlén W. Highly variable Northern Hemisphere temperatures reconstructed from low- and high-resolution proxy data. Nature. 2005;433:613–7.
3. IPCC. 2007. Climate Change 2007: synthesis report. An assessment of the intergovernmental panel on climate change http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.
4. McGovern TH. Cows, harp seals, and churchbells: adaptation and extinction in Norse Greenland. Human Ecology. 1980;8:245–75.
5. Wendlandt WW. Thermal methods of analysis. New York: Wiley; 1962.
6. Šesták J. Thermophysical properties of solids. Amsterdam; Elsevier; 1984 (Russian version Teoreticheskij termicheskij analiz. Moscow: Mir; 1988).
7. Šesták J. Science of heat and thermophysical studies: a generalized approach to thermal analysis. Amsterdam: Elsevier; 2005.
8. Czarnecki JP, Koga N, Šestákova V, Šesták J. Factors affecting the experimentally resolved TA curves. J Thermal Anal Calorim. 1992;38:575–82.
9. Šatava V, Šesták J. Mechanism of thermal decomposition of sulphate hemihydrates by isothermal and nod isothermal thermogravimetry using light-aided heating. Anal Chem. 1973;45:154–9.
10. Šesták J. Thermal treatment and analysis. J Therm Anal Calorim. 1993;40:1293–1306.
11. Hartmann DL, Ramanathan V, Hunt GE. Earth radiation budget data and climate research. Rev Geophys. 1986;24:439–68.
12. Raval A, Ramanathan V. Observational determination of the greenhouse effect. Nature. 1989;342:758–61.
13. Wallace JM, Hobbs PV. Atmospheric science: an introductory survey. London: Academic Press; 1977.
14. Zemansky RW, Dittman RH. Heat and thermodynamics. New York: McGraw Hill; 1952.
15. Eskinazi S. Fluid mechanics and thermodynamics of our environment. New York: Academic Press; 1975.
16. Sertorio L. Thermodynamics of complex systems: an introduction to eco-physics. London: World Science; 1991.
17. Peixoto JP, Oort AH. Physics of climate. New York: The American Institute of Physics; 1992.
18. Odum HT. Environmental accounting: energy and decision making. New York: Wiley; 1996.
19. Bohren CF, Albrecht BA. Atmosphere thermodynamics. New York: Oxford University Press; 1998.
20. Maršík F, Dvořák I. Biotermodynamika (Biothermodynamics). Prague: Academia; 1998. (in Czech).
21. Curry JA, Webster PJ. Thermodynamics of atmosphere. New York: Academic; 1999.
22. Berdwell A, Hoden L. Weather and climate studies. New York: Prentice Hall; 2003.
23. Šesták J. editor. Society, science and ecology: progress against survival. In: Book heat, thermal analysis and society. Hradec Králové: Nucleus; 2004. p. 277.
24. Kiehl JT, Ramanathan V, editors. Frontiers of climate modeling. Cambridge: Cambridge University Press; 2006.
25. Day JA. The book of clouds. New York: Sterling; 2005.
26. Soon W, Baliunas SL, Robinson AB, Robinson ZW. Environmental effects of increased atmospheric CO_2. Clim Res. 1999;13:149–64.

27. Soon W, Baliunas S, Idso SB, Kondratyev KY, Posmentier ES. Modeling climatic effects of anthropogenic dioxide emissions: unknowns and uncertainties. Clim Res. 2001;18:259–75.
28. Šesták J. Úvaha nad ekonomicko-ekologickou knihou Václava Klause o oteplování naší planety a nevyčerpatelnosti energetických zdrojů (Consideration over the book by V. Klaus about the warming of our planet and inexhaustibility of planetary energetic sources). Chem Listy (Prague). 2007;101:832–9.
29. Šesták J. Jak je to s oteplováním naší planety Země a jaká je role skleníkových plynu. (How it is with the warming our planet Earth and what is the role of green house gases). Energetika (Prague). 2008;10:392–5 (in Czech).
30. Šesták J. On the availability, exploitability and sustainability of our energy resources. In: Knut E, Pliska V, Folkers G, editors. Promises of science. Zurich: Collegium Helveticum; 2006. p. 69.
31. Fourier JB. Theorie analytique de la chaleur. Paris: Gauthier-Villars; 1822.
32. Faraday M. Chemical history of candle. London: Royal Institution; 1860.
33. Arrhenius S. On the influence of carbonic acid in the air upon the temperature of the ground. Philos Mag. 1896;41:237–75.
34. Twomay S. Pollution and the planetary albedo. Atmos Environ. 1974;8:1251–6.
35. Teller A, Levin Z. The effects of aerosols on precipitation and dimensions of subtropical clouds: a sensitivity study using a numerical cloud model. Atmos Chem Phys. 2006;6:67–80.
36. Guisbiers G, Buchaillot L. Universal size/shape-dependent law for characteristic temperatures. Phys Lett A. 2009;374:305–8.
37. Vanithakumar SC, Nanda KK. Universal relation for the cohesive energy of nanoparticles. Phys Lett A. 2008;372:6930–4.
38. Tyndall J. On the absorbtion and radiation of heat by gases and vapors. Philos Mag. 1861;22:169–73.
39. Langley SP. Researches on solar heat and its absorption by the Earth atmosphere. Report of the Mt. Whitney Expedition. Washington: Governmental Printing; 1884.
40. Kaplan LD. Calculation of infrared fluxes. In: Bolin, B, editor. The atmosphere and the sea in motion. New York: Rockefeller Inst Press; 1959. p 170.
41. Poynting JH. Radiation in the solar system. Phil Trans A. 1904;202:525–52.
42. Tverskoy PN. Kurz metorologii: atmosfericheskaya fizika (Course on Meteorology: atmospheric physics). Leningrad: Hydrometeorological Izdatelstvo; 1951 (in Russian).
43. Goody RM. Atmospheric radiation: theoretical basis. New York: Clerandon; 1964.
44. Bednář J. Pozoruhodné jevy v atmosféře (Special phenomena in the Earth atmosphere). Prague: Academia; 1989 (in Czech).
45. Lorenz EN. Deterministic nonperiodic flow. J Atmos Sci. 1963;20:130–41.
46. Sussman GJ, Wisdom J. Chaotic evolution of the solar system. Science. 1992;257:56–62.
47. Strnad J. Chronologisches Verzeichniss der Naturbegebenheiten—Böhmen 633–1700. In: Studnička FJ, editor. Zábavy hvězdářské (Astronomical Amusements). Praha: Kolář; 1878. p. 104.
48. Huybers P. Glacial variability over the past two million years. Quat Sci Rev. 2007;26:37–55.
49. Oeschger H, Langway CC, editors. The environmental record in glaciers and ice sheet. New York: Wiley; 1989.
50. Milankovitch M. Theorie Methematique des Phenomenes Thermiques produits par la Radiation Solaire. Paris: Gauthier-Villars; 1920.
51. Kutilek M. Racionálně o globálním oteplování (Rationally about the global warming). Prague: Dokořán; 2008. (in Czech).
52. Clough HG. Synchronous variations in solar and terrestrial phenomena. Astrophys J. 1905;22:42–75.
53. Christensen EF, Lassen K. Length of the solar cycles as an indicator of solar activity closely associated with the Earth's climate. Science. 1991;254:698–700.
54. Christensen EF, Lassen K. Variability of the solar cycle length during the past five centuries and the apparent association with terrestrial climate. J Atmos Terr Phys. 1995;57:835–45.
55. Haigh JD. On the impact of solar variability on climate. Science. 1996;272:981–4.
56. NASA/Marshal Solar Physics: The sunspot cycle. 2010. http://solarscience.msfc.nasa.gov/SunspotCycle.shtml.
57. Hoyt DV, Schatten KH. The role of the Sun in climate changes. New York: Oxford University Press; 1997.
58. Svensmark H, Christensen EF. Variation of cosmic ray flux and global cloud coverage—a missing link in solar climate relationships. J Atm Sol Terr Phys. 1997;59:1225–32.
59. Svensmark H, Pedersen JOP, Marsh ND, Enghoff MB, Uggerhoj UI. Experimental evidence for the role of ions in particle nucleation under atmospheric conditions. Proc R Soc A. 2007;463:385–96.
60. Singer SF, Awery DT. Unstoppable global worming every 1500 years. Lanham: Rownan-Littefield; 2007.
61. Landscheidt T. Klimavorhersage mit astronomischen Mitteln? Fusion. 1997;18:58–75.
62. Arnold VI. Small denominators and problems of stability in classical and celestial mechanics. Russ Math Surv. 1963;18(6): 85–191. (in Russian).
63. Maršík F. Termodynamika kontinua (Thermodynamics of continuum). Prague: Academia; 1999. (in Czech).
64. Maršík F. Termodynamika a vznik tropických cyklonů (Thermodynamics and formation of tropical cyclones) Vesmír (Prague) 2001;80:83–86 (in Czech).
65. Pauluis OM. Water vapor and entropy production on the Earth's atmosphere. In: Kleidon A, Lorens RD, editors. Nonequilibrium thermodynamics and production of Entropy. Heidelberg: Springer 2005. pp. 107–119.
66. Adams DL, Renno NO. Thermodynamic efficiencies of an idealized global climate model. Clim Dyn. 2005;25:801–13.
67. Singer SF. Satellite observations of atmospheric gases. Wall Street Journal, Sept 10; 2001 (data from US Weather Satellite Service).
68. Ramanathan V. The role of ocean-atmosphere interaction in the CO_2 climate problem. J Atmos Sci. 1987;38:918–30.
69. Ramanathan V. The role of Earth radiation budget in climate and general circulation research'. J Geophys Res. 1987;92:4075–95.
70. Zámostný P, Kukula P, Young JS. Possible green house gases and global climate change. Chemické listy (Prague). 1999;93:238–42.
71. Houghton RA. Balancing the global carbon budget. Ann Rev Earth Planet Sci. 2007;35:313–47.
72. Romanova V, Lohmann G, Grosfel K. Effect of land albedo, CO_2, orography and ocean heat transport on extreme climate. Clim Past. 2006;2:31–42.
73. Rodhe H. A comparison of the contribution of various gases to greenhouse effect. Science. 1990;248:1217–19.
74. Burgmeister J. Missing carbon mystery: case solved? Nat Reports Clim Change. 2007;3:36–37.
75. Chalmers JA. Atmospheric electricity. London: Pergamon; 1957.
76. Buseck PR, Adachi K. Nanoparticles in the atmosphere. Elements. 2008;4:389–94.
77. Kuo C, Lindberg CR, Thorson DJ. Coherence established between the atmospheric CO_2 and global temperature. Nature. 1990;343:709–14.
78. Henderson GE. Caving in to new chronologies. Science. 2006;313:620–2.
79. Tison L, Werner M, Wolff EW. Orbital and millennial antarctic climate variability over the past 800, 000 years. A collective report. Science. 2007;317:793–7.