Climate Change in the XXIst Century: Mechanisms and Predictions

IGOR KHMELINSKII[a] and PETER STALLINGA[b]
[a]FCT, DQF and CIQA
Universidade do Algarve
Campus de Gambelas, Faro
PORTUGAL
ikhmelin@ualg.pt
[b]FCT, DEEI and CEOT
Universidade do Algarve
Campus de Gambelas, Faro
PORTUGAL
pjotr@ualg.pt

Abstract: Recent experimental works demonstrated that the Antropogenic Global Warming (AGW) hypothesis, embodied in a series of Intergovernmental Panel on Climate Change (IPCC) global climate models, is erroneous. These works prove that atmospheric carbon dioxide contributes only very moderately to the observed warming, and that there is no climatic catastrophe in the making, independent on whether or not carbon dioxide emissions will be reduced. In view of these developments, we discuss climate predictions for the XXIst century. Based on the solar activity tendencies, a new Little Ice Age is predicted by the middle of this century, with significantly lower global temperatures.

Key-Words: global warming, IPCC climate models, total solar irradiance, galactic cosmic rays, solar cycles, climate change, Little Ice Age

1 Introduction: IPCC climate scenarios are erroneous

The terrestrial climate system is quite complex. A complete theory needs to account for the phenomena taking place on the Sun, which provides the energy in the form of electromagnetic radiation that puts the climate engine in motion, and the atmosphere and the oceans, that redistribute the energy, with biosphere and humanity affecting the amount of solar energy circulating in the climate system. The energy is eventually re-emitted into outer space in the form of infrared (IR) radiation, maintaining the climate system in an approximate dynamic equilibrium. Surface temperature T is one of the most important climatic variables, which affects the distribution and the very existence of all of the diverse life forms on land, including human civilization, dependent for its existence on availability of potable water and agricultural productivity. The existence of amenable surface temperatures depends on the greenhouse effect, caused by gases present in the atmosphere. The most important greenhouse gas is water vapour (H_2O), followed by carbon dioxide (CO_2), methane (CH_4), ozone and halocarbons. These gases absorb IR radiation, that would otherwise immediately escape into space, reemitting part of it back towards the surface. Therefore, they provide some additional thermal insulation for the surface, resulting in the average surface temperature that is ca. 32 K (32 ºC) higher than it would be otherwise. Some 30 years ago, when the growth in atmospheric concentration of CO_2, which we shall denote as [CO_2], caused by increased human use of fossil fuels, has coincided with the growth in average global temperature (global warming), concerns were risen that the observed warming may be caused by CO_2, due to increased greenhouse effect, with possible adverse climatic consequences. These concerns led to the creation of the Intergovernmental Panel on Climate Change (IPCC), an entity under the UN, to evaluate risks of climate change caused by human activity. This entity produces reports, the latest of 2007, describing the current state of climate science as perceived by IPCC experts [1].

As it happens, the only evidence that ever indicated that global warming may be caused by growing atmospheric [CO_2] was that of the climate models. These are implemented in software, running on supercomputers, and first make use of real climate information to tune various parameters present in the models, attempting next to produce predictions/ projections on the future climate based on different scenarios of atmospheric [CO_2] evolution and other relevant human-generated perturbations, such as changes in land use. Climate models used by the

IPCC to asses the effect of atmospheric carbon dioxide on climate predict an average global warming of 3.5 K per doubled [CO_2]. Such doubling may happen by the end of this century if carbon dioxide emissions continue unabated at the same rate [1]. The consequences of such a temperature increase might be quite serious, as the temperature rise would be even more pronounced in the temperate and cold climatic zones, with some undesirable consequences for humanity.

However, any and every climate model belongs to the domain of theories; a theory remains valid while there is no experimental evidence that contradicts it. Now, recent experimental publications evaluated the dependence between the surface temperature anomaly and the anomaly in the long-wave (infrared) plus short-wave (ultraviolet and visible) radiation escaping from Earth to the outer space [2,3]. Here anomalies are defined as excursions from what is considered an equilibrium value. This dependence may be expressed by a linear relation, with the regression coefficient that we shall denote by α, which indicates the increase in escaping radiation for every degree of temperature rise. The authors of [2,3] place the experimental value of α, obtained from relevant satellite data, at between 4.5 and 8 $Wm^{-2}K^{-1}$. On the other hand, the IPCC models uniformly produce values that are negative, the average for the set of climate models considered being -2.3 $Wm^{-2}K^{-1}$ [2]. We note an obvious contradiction between the AGW hypothesis and the experiment, as regards the regression coefficient α, both in its numeric value and, even more importantly, its sign (positive *vs* negative).

We shall shortly demonstrate that the coefficient α is of critical importance in evaluating the effect of any perturbation on the terrestrial climate, be it caused by growing atmospheric CO_2 concentration, changes in the solar activity, presence of volcanic ash in the higher atmosphere, or any other factor. The reason is that without feedbacks it is fairly easy to evaluate the effect ΔT_0 on the average global temperature T of any perturbation Ω. This effect is obtained assuming that we isolated this perturbation Ω from any other phenomena taking place in the climate system. On the other hand, the practical outcome ΔT of a perturbation is determined by the product of ΔT_0 with the feedback parameter β, $\Delta T = \Delta T_0 \times \beta$, the latter uniquely dependent on the regression coefficient α. This climate feedback parameter β describes the entire complexity of the multiple interconnected phenomena defining the response of the climate system to a perturbation, and is therefore notoriously difficult to obtain theoretically, as evidenced by more than 20 years of the IPCC numerical modelling research.

Continuing, the values of the climate feedback coefficient, β, that exceed unity, as predicted by the IPCC climate models, correspond to amplification of perturbations by the climate system, with the value of $\beta = 2.7$ (corresponding to the model value of $\alpha = -2.3\ Wm^{-2}K^{-1}$) yielding a predicted temperature change for doubled [CO_2] of $\Delta T = 2.4$ K, instead of $\Delta T_0 = 0.9$ K for the no-feedback case [2]. The various model values of β, as obtained in each of the individual climate models, range from about 1.7 to 5.6 or more, and universally exceed unity, predicting an inherently unstable climate system that significantly amplifies every perturbation. Contrary to model predictions, the experimental values of $\beta = 0.3...0.6$ correspond to a reduction of perturbations by an inherently stable climate system that significantly reduces any perturbation, resisting the imposed changes. These experimental $\beta = 0.3...0.6$ yield ΔT values for doubled [CO_2] between 0.3 and 0.5 K [2,3]. These ΔT values, estimated from measurements performed on the real terrestrial climate system, are an order of magnitude below the predictions of the IPCC climate models, which range between 1.5 and 5 to 7 degrees of the average temperature increase for doubled [CO_2], with the most probable value of 3.5 K, as reported by IPCC in 2007 [1]. We therefore conclude that the Anthropogenic Global Warming (AGW) hypothesis, embodied in the IPCC climate models, has nothing in common with the real climate, as it fails to predict the value of the crucial parameter of the climate system, namely the climate feedback coefficient, β, which universally defines the response of the climate system to perturbations. Given this verdict, we must expressly disregard every and all of the other results and predictions/projections/scenarios of these models, and every and all of the recommendations based on the aforementioned results and projections/scenarios. Indeed, these models can't be trusted even for qualitative trends, as they miss the correct sense (model amplification, $\beta > 1$, *vs* experimental reduction of perturbations, $\beta < 1$) of the climate feedback coefficient. We also conclude that the terrestrial climate system is inherently stable, having the climate feedback coefficient β well below unity, contrary to IPCC predictions, and that, for this very reason, there is no imminent climatic catastrophe in the making, anthropogenic (man-made) or otherwise.

Having eliminated [CO_2] as the primary and defining driver of current climatic evolution, for complete lack of evidence, we will look at other factors affecting climate, in order to both explain the warming of the last century and provide a climate forecast for the future. Thus, carbon dioxide can only contribute to the climate change in this century with a very moderate warming, significantly lower than the 0.74 K recorded during the last century. Indeed, of these 0.74 K, knowing the [CO_2] increment during the XXth century, and the value of the climate feedback parameter, we can only attribute between 0.1 and 0.2 K to the antropogenic climate change caused by growth in the atmospheric carbon dioxide, product of fossil fuel combustion. Of these two estimates, the lower value of 0.1 K should be closer to the reality, corresponding to the more realistic higher value of α, as explained below. We The remaining warming has therefore been caused by other factors, which may include changes in land use, changes in concentrations of atmospheric aerosols, changes in solar activity, long-term periodicity in the atmospheric and oceanic circulation patterns, and others. Note that the first two of these additional factors have antropogenic contributions.

2 Results and discussion: climate in this century

2.1 Phenomenological approach

Looking at the global temperature record of the last 1.5 centuries, we readily note that warming has not been monotonous. As an example, consider the sea surface temperature data, shown in Fig. 1 and plotted using the Hadley Centre data [4]. Indeed, we note in the monthly global average sea surface temperature record that apart from a general warming trend (with the linear regression coefficient corresponding to a warming of only 0.48 K per century during the time period considered – this shows that continents warm faster than the oceans, the latter lagging behind) we observe a periodic contribution, with a period of about 60 years. The three maxima of this periodic contribution had occurred at about 1884, 1943 and 2004, whereas the two minima at about 1913 and 1973. In fact, newspapers in the seventies were full of predictions of imminent ice age global freezing and of a new ice age, issued by leading climate experts, including some of the present-day advocates of the AGW hypothesis, inspired by a distinct cooling tendency that has lasted for about 30 years, perfectly discernible in the sea, land and global surface temperatures. Note that similar periodic oscillations appear in other temperature records, global as well as regional. We shall not discuss their origin here, limiting ourselves to using them for prediction purposes.

Comparing the two warming periods between 1913-1943 and between 1973-2004, we note that the linear temperature trends are exactly the same. This constitutes yet another proof, if that were needed, that the AGW hypothesis is incorrect. Indeed, the fossil fuel consumption in the second half of the XXth century exceeded that of the first half by at least the factor of 5, with the anthropogenic contributions to atmospheric carbon dioxide equally increasing by a factor of 5 between the first and the second half of the XXth century [5]. Were the warming indeed caused by growth in atmospheric CO_2, as stipulated by the AGW hypothesis, the period of 1973-2004 would have produced at least 5 times as much warming than the 1913-1943 period, contrary to the experimental data shown in Fig. 1, where we see exactly the same amount of warming in these two time periods.

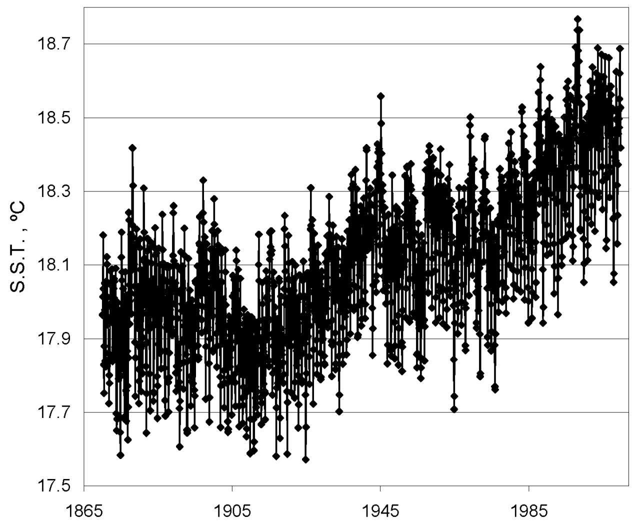

Figure 1. Global average sea surface temperatures from 1870 to 2009 [4].

Therefore, at present the climate system is in the cooling phase of the 60-year oscillation, which will predictably last till about 2034. The current cooling trend has caught the AGW climate modellers by surprise, as they are predicting continuous and ever accelerating warming, as long as atmospheric CO_2 is growing [1]. Obviously, no such thing is happening, demonstrating once again that the climate change is determined by factors other than atmospheric carbon dioxide. Following this phenomenological treatment, we predict global cooling until about 2034, after which the climate system will be warming once again. Considering the last 150 years of climate history, for which instrumental temperature record exists (see Fig. 1), we note no tendency of acceleration in the warming rates, therefore, using our phenomenological model, we predict that the Earth will warm during the XXIst century by the same amount as it has during the XXth century, that is, by about 0.7 K, in stark contrast to the catastrophic scenarios produced by IPCC/AGW modellers based on their erroneous models.

2.2 Solar Activity approach

As we already noted, all of the energy that gets the terrestrial climate machine moving comes from the Sun. This makes the Sun and the phenomena such as periodic changes in the elements of the Earth's orbit around the Sun potentially the most important contributors to the climate change. The solar activity has been monitored by astronomers for hundreds of years, in the simple form of counting sunspots. Figure 2 shows the yearly sunspot count record for the last 300 years.

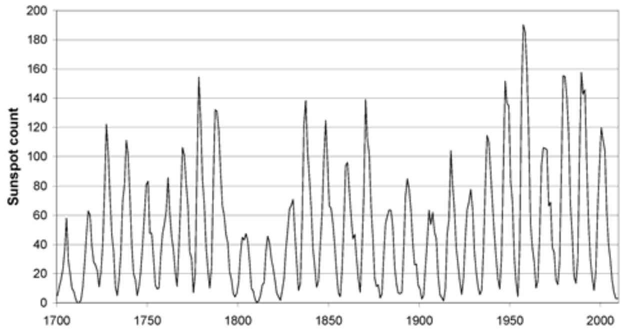

Figure 2. Sunspot count from 1700 to 2009 [6].

However, the total solar irradiance (TSI) variations corresponding to the 11-year sunspot cycle shown in Fig. 2 (Schwabe cycle) correspond to only about 0.1% of the TSI value, according to precise satellite measurements performed since 1980. This translates into ca. 1 Wm^{-2}, too little to account for the observed climate change [7]. Total solar irradiance was reconstructed for the entire period starting from 1610, taking into account astronomic data on solar-like stars. Such stars were found to emit measurably less in the state similar to the Maunder minimum (ca. 1645-1715), when the cycling switches off. This allowed to evaluate the slowly changing secular component of the total solar irradiance that could not be yet extracted from the TSI data directly [7]. The resulting reconstruction of the total solar irradiance, tracking the amplitude of the Schwabe cycle, is shown in Fig 3.

Addition of the slow-changing secular component provides a better although still insufficient match between total solar irradiance and climate change, as now the total irradiance change between the Maunder minimum and the contemporary maximum is about 0.24%, which translates into ca. 3 Wm^{-2} and explains at least 30% of the climate change that occurred since 1970, with a larger percentage explainable during preceding periods [7].

A much better correlation between total solar irradiance and climate change was found when irradiance reconstruction tracked the period length of the Schwabe cycle instead of its amplitude [9,10]. The relevance of the cycle period length as the main parameter determining total solar irradiance is supported by the fact that the Schwabe cycles close to Maunder and Dalton (1790 to 1830) minimums were significantly longer, thus, longer cycles correspond to lower TSI and colder climate. Some of the historic TSI reconstructions attribute almost the totality of the climate change of the XXth century to changes in solar irradiance, conditioned by the remaining uncertainty in the amplitude of secular changes of the solar irradiance, with estimates that vary from 2 to 7 Wm^{-2} [9-11].

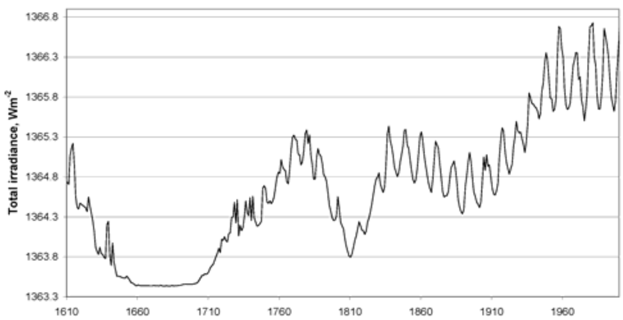

Figure 3. Total solar irradiance reconstruction since 1610 [8].

Still, there is at least one additional mechanism whereby the solar activity affects our climate system, which complements the total solar irradiance changes [12-14]. According to this mechanism, galactic cosmic rays (GCR) ionize the lower atmosphere, with the negative ions promoting nucleation of nanoparticles, facilitating the formation of water drops in the atmosphere, and therefore increasing the cloud cover. The intensity of GCR, as demonstrated by historic data on ^{14}C isotope abundance, increases in low solar activity periods, and decreases in high solar activity periods, when the GCR are swept away by solar wind and thus reach the Earth at lower intensities. As shown by direct measurements in 1978-1996, the low-altitude cloud cover directly follows the GCR variations. In its turn, GCR variations are anticorrelated to the solar activity as expressed by sunspot number. Thus, in periods of higher solar activity the GCR intensity and the cloud cover decrease, while the TSI increases, with the two

ISBN: 978-960-474-274-5

mechanisms acting in synchrony and causing warming [14].

In a separate development, satellite data yielded a 0.16 $Wm^{-2}year^{-1}$ trend in the total solar irradiance at the terrestrial surface from 1983 to 2001, with the total increment of 2.9 Wm^{-2} during the same period [15]. This increment was produced by reductions in the cloud cover (due to reduction of GCR in the period of high solar activity) and reductions in atmospheric aerosols (due to reductions in atmospheric pollution generated by developed countries), and is much larger than any changes in incoming TSI at the outer atmospheric boundary due to solar activity changes during the same period. Recalling the experimental range $\alpha = 4.5...8\ Wm^{-2}K^{-1}$, we deduce that the 2.9 $W\,m^{-2}$ increase in surface irradiance produced $\Delta T = 0.36...0.64$ K of global warming during the same period. This result shows that the more correct value of α should be close to the higher value of 8 $Wm^{-2}K^{-1}$, as otherwise the estimated warming is significantly larger than the 0.4 K in fact recorded during the last 20 years of the XXth century. Thus, we conclude once more that the climate change observed during the XXth century may be fully explained by changes in the solar irradiance reaching the terrestrial surface, whereas the role of carbon dioxide and other greenhouse gases has been almost negligible. Given the estimate of $\alpha = 8\ Wm^{-2}K^{-1}$, we estimate the warming contribution of carbon dioxide of 0.2 K for the current century, provided we don't restrict its emissions.

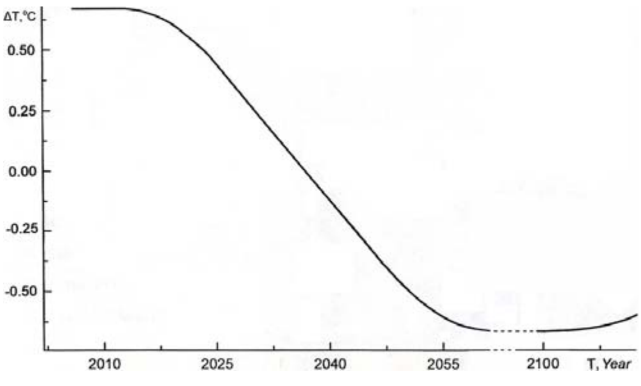

Figure 4. Climate scenario for the current century: the approaching Little Ice Age, taken from [16], with permission.

2.3 Climate change in this century

Based on the evolution of the duration of the Schwabe cycle and on the satellite measurements of the total solar irradiance during the last 30 years, astronomers predicted the amplitudes of the next three Schwabe cycles, of about 70, 50 and 35 sunspots at the maximum, as compared to 110 of the last complete cycle. This means that a new Little Ice Age will be developing during the XXIst century, with the lowest solar activity achieved around 2040 and the temperatures hitting the bottom at around 2055, at some 1.0 K below the present value for the global average temperatures. This is comparable to what occurred during the Maunder minimum, see Fig. 4 [16,17], being due to the existence of a bicentennial solar activity component, which produces changes in TSI that are significantly larger than those occurring during the Schwabe cycle, accompanied by increased intensity in GCR and cloud cover. This bicentennial component has produced notable climate differences, such as between the present solar maximum and the Maunder and Dalton minimums (Fig. 5), causing Little Ice Ages once in about every 200 years, as the historical record for the last 7500 years shows, with 18 of such cooling events documented [18].

Figure 5. "Windmill by a Frozen River" by Lodewijk Johannes Kleijn, evidencing weeks of freezing cold in Netherlands in the 19th century, after the lowest point of the Dalton minimum, which has been less intense than the Maunder minimum.

3 Conclusions

Anthropogenic Global Warming hypothesis and IPCC climate projections/scenarios have nothing in common with the terrestrial climate system and thus must be expressly ignored when considering climate change and its consequences.

Antropogenic carbon dioxide has contributed ca. 0.1 K to the climate change that occurred during the XXth century, and will contribute another 0.2 K in this century, provided its emissions continue unabated.

Simple phenomenological model, proposed by us and based on climate change patterns of the last 150 years, predicts a global cooling in the next 20 years.

Sun is the principal climate driver. The climate predicted for the XXIst century, based on the solar activity predictions, is equivalent to a new Little Ice Age, with the lowest temperatures in the middle of the century. Therefore, human society should prepare a response to deal with global cooling that will be occurring in the next decades. In this respect, an urgent review of building codes is needed. This will prepare a significant percentage of homes to cold, when it comes. In this context, any warming contribution of antropogenic carbon dioxide will be a welcome factor stabilizing the climate, therefore any measures targeting reductions of CO_2 emissions should be immediately suspended.

References:

[1] Intergovernmental Panel on Climate Change (2007), *Climate Change 2007: The Physical Science Basis*, report, 996 pp., Cambridge University Press, New York City, 2007.

[2] R. Lindzen, Y.-S. Choi, *Geophys. Res. Lett.* 36, 2009, pp. L16705. doi:10.1029/2009GL039628.

[3] R. W. Spencer, 2008. Satellite and Climate Model Evidence Against Substantial Manmade Climate Change, http://www.drroyspencer.com/research-articles/satellite-and-climate-model-evidence/. *Journal of Climate*, submitted.

[4] N. A. Rayner, D. E. Parker, E. B. Horton, C. K. Folland, L. V. Alexander, D. P. Rowell, E. C. Kent, A. Kaplan, Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century, *J. Geophys. Res.* Vol. 108, No. D14, 2003, p. 4407. doi:10.1029/2002JD002670.
Hadley Centre SST data set HadISST1. http://hadobs.metoffice.com/hadisst/data/download.html

[5] Wikipedia, Fossil Fuel. http://en.wikipedia.org/wiki/Fossil_fuel

[6] SIDC-team, World Data Center for the Sunspot Index, Royal Observatory of Belgium, Monthly Report on the International Sunspot Number, online catalogue of the sunspot index: http://www.sidc.be/sunspot-data/, yrs 1700-2009.

[7] J. Lean, J. Beer, R. Bradley, Reconstruction of solar irradiance since 1610: implications for climate change. *Geophysical Research Letters* 23: 1995, pp. 3195–3198.

[8] J. Lean, Solar Irradiance Reconstruction. IGBP PAGES/World Data Center for Paleoclimatology, Data Contribution Series # 2004-035. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA, 2004. ftp://ftp.ncdc.noaa.gov/pub/data/paleo/climate_forcing/solar_variability/lean2000_irradiance.txt

[9] E. Friis-Christensen, K. Lassen, Length of the solar cycle: an indicator of solar activity closely associated with climate, *Science*, 254, 1991, pp. 698-700.

[10] D. V. Hoyt, K. H. Schatten, A discussion of plausible solar irradiance variations, *J. Geophys. Res.*, 98, 1993, pp. 18895-18906.

[11] S. K. Solanki, M. Fligge, Solar Irradiance Since 1874 Revisited, *Geophysical Research Letters*, vol. 25, no. 3, 1998, pp. 341-344.

[12] H. Svensmark, Influence of Cosmic Rays on Earth's Climate, *Phys. Rev. Lett.* 81, 5027–5030 (1998).

[13] H. Svensmark, J. O. P. Pedersen, N. D. Marsh, M. B. Enghoff, U. I. Uggerhøj, Experimental evidence for the role of ions in particle nucleation under atmospheric conditions, *Proc. R. Soc. A* 463, 2007, pp. 385–396.

[14] H. Svensmark, Cosmic Rays And Earth's Climate, *Space Science Reviews* 93: 155–166, 2000.

[15] R. T. Pinker, B. Zhang, E. G. Dutton, Do Satellites Detect Trends in Surface Solar Radiation? *Science*, Vol. 308. no. 5723, 2005, pp. 850-854. doi: 10.1126/science.1103159.

[16] H. Abdussamatov, 2008, The Sun defines the Climate, http://www.gao.spb.ru/english/astrometr/abduss_nkj_2009.pdf, http://www.gao.spb.ru/english/astrometr/index1_eng.html

[17] Kh. I. Abdusamatov, Optimal Prediction of the Peak of the Next 11-Year Activity Cycle and of the Peaks of Several Succeeding Cycles on the Basis of Long-Term Variations in the Solar Radius or Solar Constant, *Kinematics and Physics of Celestial Bodies*, Vol. 23, No. 3, 2007, pp. 97–100.

[18] E. P. Borisenko, V. M. Pasetskii, Climate variations during the last millennium, Moscow, Mysl, 1988. http://www.pereplet.ru/gorm/dating/climat.htm