Is Aerosol Scattering in the Stratosphere a Safety Technology Preventing Global Warming?

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Received November 18, 2009

Abstract—In accordance with numerous investigations, global climate warming due to the increased greenhouse gas content in the atmosphere can significantly influence the environment already in the near decades. In order to mitigate or prevent possible adverse consequences of this warming the technologies on reducing greenhouse gas emissions as well as a deliberate interference with climate, including its control, are under consideration. Let us analyze the present investigations on the estimate of the influence of a simultaneous increase in the atmospheric CO₂ concentration and in the stratospheric aerosol on the global and regional climate, ozone layer, and World Ocean acidification. It is noted that the production and subsequent maintenance of the artificial aerosol layer in the stratosphere could, in principle, eliminate or retard climate warming, but it would be accompanied by a decrease in the global precipitation, especially in the tropical zone. Furthermore, the stratospheric aerosol screen does not solve the problem of the atmospheric CO₂ increase, which in turn results in the further World Ocean acidification, and thus has an adverse effect on the marine part of the biosphere. Political and ethic issues connected with the deliberate global man interference with the natural environment are also under considerations.

DOI: 10.3103/S1068373910070010

1. INTRODUCTION

The modern world community feels concern about an increase in the greenhouse gas emissions into the atmosphere and their possible adverse effect on climate and natural environment. A major part of these gases is represented by carbon dioxide (CO₂). The observational data show that the atmospheric CO₂ concentration increased by 38% compared to the pre-industrial period and amounted to 385 ppm in 2008. Such concentration has not been observed at least during the past 650 thousand years [14]. Out of the total volume of CO₂ emitted yearly into the Earth’s atmosphere (27 billion t) due to the economic activity 30% is taken up by the ocean, 13%, by the biosphere and soil of the continents, and 57% remains in the atmosphere. Because of a limited rate of the natural CO₂ uptake by the ocean and biosphere a substantial part of this gas will remain in the atmosphere for hundreds of years promoting further global warming. For example, out of one ton of CO₂ that entered the Earth’s atmosphere, about 50% will be taken up by the ocean and Earth’s biosphere for 30 years, other 30% will be removed from the atmosphere for several hundreds of years, and 20% will remain in the atmosphere for thousands of years [14].

The observational data show that the global surface air temperature rise over 100 years (1906–2005) amounted to 0.74 ± 0.18°C, while during the last 50 years the rate of its rise almost doubled (0.13 ± 0.03°C per 10 years) [14].

Global warming will continue throughout the 21st century under any known scenarios for anthropogenic emissions of greenhouse gases and aerosol. According to the estimates derived from the CMIP3 model ensemble1 for three scenarios on the greenhouse gas increase (B1, A1B, and A2), the global surface air temperature will increase by 1.5–1.9°C by the middle of the 21st century and by 2.1–3.5°C by its end [8].

In accordance with the recommendations made by international groups of experts of different levels, the global warming by 2°C is taken as a threshold value in respect to the pre-industrial period [18]. Warming

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1 CMIP3 is the third phase of the Coupled Model Intercomparison Project.
above 2°C can cause hazardous anthropogenic implications in natural ecosystems and will seriously harm the economy of several regions of the Earth. For example, 15–40% of ecosystem species can be endangered; water resources in the densely populated regions of the globe (Africa, the Mediterranean Sea region) will be reduced by 20–30%; agriculture crop yields will be reduced by 5–10% in some tropical regions; about 10 million people inhabiting coastal zones will yearly risk inundations; irreversible melting of the Greenland ice sheet will start and an accelerated ocean level rise will occur; the risk of significant changes in the atmosphere circulation and monsoon intensity will increase [37].

According to some estimates, to stabilize an increase in the atmospheric CO₂ concentration the emission of this gas should be reduced by, at least, 50% by 2050 compared to the 1990 level and still greater in the future [15, 19]. However, the efforts of the world community to reduce greenhouse gas emissions² have been unsuccessful so far. This promoted the increased interest to various technologies of the deliberate interference with the global climate as an alternative to reduction in anthropogenic emissions. Among others, global scattering of sulfate aerosols is mentioned as a means of the planetary albedo enhancement and, as a result, a global cooling effect in the lower atmosphere and on the Earth’s surface. M.I. Budyko was one of the first, who put forward such a proposal in the early 1970s. He stressed that the use of the method of interference with climate would be possible only after an accurate preliminary estimation of such impact on the atmospheric processes in all regions of the globe [1]. Scientists periodically returned to this problem during the last decades ([16, 35] et al.). A comprehensive analysis of different viewpoints on the expediency of the global climate control is given in several reviews [22, 32, 36].

The consideration of issues of anthropogenic climate warming at the Council-Seminar of the Russian Academy of Sciences is worth mentioning [2]. It was noted in its decisions that the fulfillment of the ultimate objective of the UN Framework Climate Change Conference (FCCC) aimed at the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system would demand huge material resources over a long-term period. Based on these and other conclusions of the Council-Seminar of the Russian Academy of Sciences, it was proposed in [4] to start developing a technology aimed at the stabilization of global warming by scattering aerosol in the stratosphere “without necessity to control greenhouse gases’ concentration in the atmosphere.” Further on, it is also said there that “the operational method proposed to restrain warming or climate control is not dangerous for the planet and all living beings inhabiting it.”

Abroad, the discussion in the scientific community about the global warming stabilization became more active in connection with paper [15] published, where it was noted that the use of deliberate aerosol scattering in the stratosphere was possible as an extremity in the case of catastrophic consequences of significant global climate warming (for example, by 5°C) in the 21st century. However, to the author’s mind, such measure to counteract the global warming should be thoroughly and comprehensively studied, and its inevitable negative consequences should be comprehended before certain actions can be taken. As a response to this statement, several known scientists expressed their concern over the idea itself concerning the deliberate interference with the natural environment, the more so, on the global scale [11, 13, 23, 25, 27, 33]. The conclusion made in these works is univocal: to solve the problem of global climate warming, first and foremost, the efforts should be directed at the elimination of causes of this warming rather than at the control of its symptoms.

In some Russian publications, a deliberate interference with the global climate is considered as the most effective and rather safety means for solving the problem of global warming [5, 6]. The main emphasis is placed on the low cost of the project, while many disputable points and negative consequences connected with the application of such technology are not discussed at all.

The purpose of this paper is to fill the gap in the treatment of this issue in the national scientific literature and provide a more comprehensive picture of the state of the problem based on the results of the modern investigations and considerations at different international forums.

² The term geoengineering used in the English literature is generally understood as a deliberate interference with climate or greenhouse gas concentration for reducing anthropogenic warming due to the increased content of these gases in the atmosphere.