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THE INFLUENCE OF VARIATIONS IN OZONE CONCENTRATION ON THE TEMPERATURE REGIME OF THE ATMOSPHERE

L. R. Rakipova

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16. Abstract

The article presents results of a study of the effects provided by changes in the concentration of atmospheric ozone on the mean temperatures of the troposphere and lower stratosphere. It concludes that ozone must be considered no less important in producing climatic changes than is CO_2.

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THE INFLUENCE OF VARIATIONS IN OZONE CONCENTRATION ON THE TEMPERATURE REGIME OF THE ATMOSPHERE

L. R. Rakipova

The effect of solar activity on the concentration of atmospheric ozone has for a long time been considered unclear. Now, however, we have at our disposal data which support the possibility of a connection between ozone and solar activity. /359

Observations of atmospheric ozone conducted at IZMIRAN since 1951 indicate a strong increase in the total content of ozone (to 200%) at the time of chromospheric flares [4]. Theoretical evaluations of the time of maximum perturbation in the ozone concentration, carried out by R. S. Steblova, likewise confirm that ozone can not be insensitive to flares of ultraviolet radiation on the sun [4].

Measurements of ultraviolet radiation in three spectral regions conducted by the satellite 1968-059A (OVI-15) have shown that the radiation responsible for the formation of atmospheric ozone (i.e. radiation in the 0.160-0.210 micron range) fluctuates by more than 60% depending upon the intensity of solar calcium flocculi (the Ca II index changed from 3 to 7 during the measuring period from June 16 to August 13, 1968). Such variations in ultraviolet radiation are insufficient to change the value of the solar constant (they amount to 0.02% of the solar constant), but they are quite sufficient to noticeably alter the ozone concentration. It thus follows that the connection between solar activity, ozone, and the atmosphere must be considered pressing.

The present communication briefly sets forth the results of a study of the effects produced by changes in the concentration of atmospheric ozone on the mean temperature of the troposphere and lower stratosphere. Only the effect of ozone on short-wave (solar) radiation is considered; the effect on long-wave (atmospheric) radiation can, according to Pleś and Oring, be ignored [2].

One of the most complete theories of atmospheric thermodynamics [3] was used in evaluating the thermal effects of variations in the ozone concentration. Computations were performed for a wide range of changes in concentration (from zero to five times the normal value). /360

Figure 1 shows the dependence of air temperature changes at the earth's surface on the relative changes in the ozone concentration C. An increase in the ozone concentration leads to a decrease in the flux of solar radiation

*Numbers in margin indicate pagination in original foreign text.

at altitudes of less than 20km and to a lowering of the air temperature at the earth's surface.

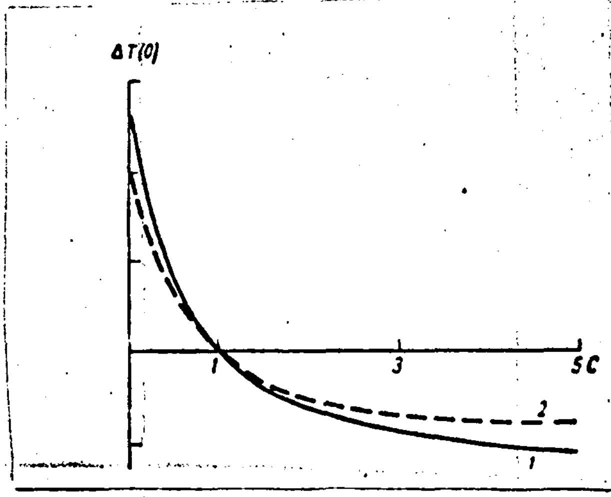

Fig. 1 - Dependence of ΔT(0) on C for a warm (1) and cold (2) half year

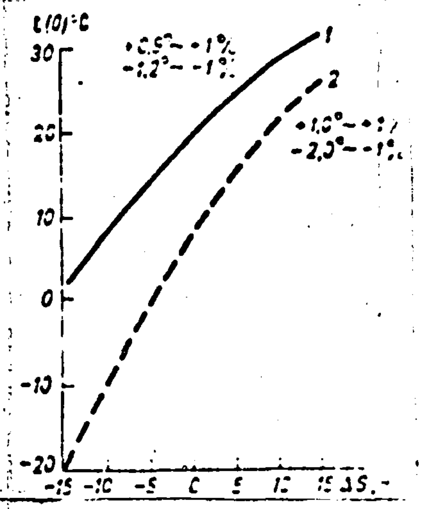

Fig. 2 - Dependence of the air temperature t(0) at the earth's surface on the variation of solar radiation ΔS(H) entering the earth – atmosphere system for warm (1) and cold (2) half years

The thermal effect of the normal concentration of ozone is 4.0K for a warm half year and 2.2K for a cold one. An increase in the ozone concentration to two times the normal value corresponds to ΔT = -0.9K for a warm half year and ΔT = -0.6K for a cold half year.

Are these changes small or large? According to modern conceptions, the earth's climate is very sensitive to small changes in the amount of radiation entering the atmosphere. In the opinion of M. I. Budyko, a long-term 1-1.5% decrease in radiation (corresponding to a temperature decrease of 1.5-2.0°C at the earth's surface) is sufficient to cause ice flows to move into the temperate latitudes, i.e. to initiate a new Ice Age [1].

This result was obtained by theoretical means. In confirmation one can cite the following example. In the years 1918 to 1947 the amount of direct solar radiation under a cloudless sky was 0.3% higher than it had been during the previous thirty years. Despite the fact that radiation changes over a /361
thirty year period are too short-lived to affect a thermally inert ocean, during the years from 1918 to 1947 there occurred a noticeable reduction in the surface area covered by the polar ices and likewise a certain retreat on the part of land glaciers [1].

At the present time, in light of these conceptions, the change in the concentration of atmospheric carbon dioxide is considered one of the fundamental factors in climactic change. However, evaluations of the thermal effects of ozone and CO_2 give comparable results (by the end of the current century the mean temperature of the atmosphere will rise 0.4K as a result of a predicted CO_2 concentration increase of 20%).

Consequently, ozone must be considered no less important in producing climactic changes than is CO_2. In addition, ozone gives greater latitude for explaining these changes, since changes both natural and artificial, as well as the climactic dependence on solar activity, can be linked to ozone.

The dependence of the solar constant on the Wolf sunspot number may be an additional cause behind the effect of solar activity on the climate. Figure 2 shows the changes in air temperature at the earth's surface as a function of variations in the solar constant. A 1% change in the solar constant could correspond, depending on its sign and the season, to temperature changes of from +1.0 to -2.0°C [3].

It follows that there may be several mechanisms by which solar activity influences the temperature of the atmosphere. Depending upon the level and character of solar activity, certain of these mechanisms may give rise to ambiguous relations. Thus the magnitude and sign of the sum thermal effect will also depend upon the level and character of solar activity. This shows that the ambiguity of the solar — atmospheric relations results from the very nature of these relations.

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