Various Ways of the Solar Energy Impact on the Earth's Climate and Weather

Makarova L.N.*, Shirochkov A.V., Frank- Kamenetsky A.V.

Arctic and Antarctic Research Institute, 38 Bering Street, Saint-Petersburg 199397 Russia

1. Introduction

The role and place of the solar wind energy in the whole spectra of the solar emissions which could influence the Earth's climate dynamic was investigated during the last years. Obtained results show that the Space originated energy could be considered as a factor capable to influence the Earth's climate dynamics together with the solar EUV radiation. As the first step of our investigation results of the atmosphere balloon sounding are compared with the solar wind energy which was expressed by different parameters of the solar wind (its density, velocity, dynamic pressure of the solar wind) as well as the interplanetary magnetic field and position of boundary of the Earth 's magnetosphere at subsolar point. Experimental data demonstrated a close connection between the atmospheric processes and the solar wind parameters. The best correlation ($r > 0.8$) between these data sets is observed at the height interval 20 -30 km. Reliable indicators of the direct coupling between the solar wind disturbances and short-term and long-term variations of the temperature in the high-latitude stratosphere are presented in [1, 2, 3, 4]. Additionally to these results which are based on the statistical studies, a reasonable physical mechanism capable to explain such connections is proposed.

2. Processes of transmission energy of the solar wind into the near-Earth Space

A new mechanism of the thermal heating of the atmosphere by the electric currents induced by the solar wind is proposed. This process is concentrated in the middle stratosphere (altitudes 20-30 km) where a permanent layer of heavy ion-clusters is produced by the galactic cosmic rays and by some other sporadically occurring sources.

Interaction of the solar wind energy with atmosphere in this scheme is as follows: under enhanced energy of the solar wind during changes of the structure of the Earth magnetosphere, excessive electric fields are generated. These fields induce electric current in the above-mentioned conducting layer of the middle atmosphere which could be considered as a part of the global electric circuit. The Joule heating produced by this current contributes to the warming of the stratosphere during disturbances in the solar wind. These effects are concentrated in the core of the layer with reasonable diminishing of them at both higher and lower altitudes. Numerical evaluation of the possible atmospheric heating rate due to this process shows that such heating could be equal to 1^{o}-2^{o} K per day. Existence of the conducting ion layer in the stratosphere at altitudes of the main ozone maximum seems to be important factor for atmosphere thermodynamics and electrodynamics.

The Joule heating rates in the stratosphere were parameterized on the base of the time series of the solar wind parameters and parameters of the interplanetary magnetic field taken from NASA satellite dataset (1973-2005). The results of the 10-year-long model run with the additional Joule source of heat are compared with the output of the 10-year-long control model run without it. These results are presented [5,6] and also in INTERNET file
http://www.pmodwrc.ch/eugene1560/sowa/input.phtml

We could conclude from the model simulations that the stratospheric circulation and ozone amount may be rather sensitive to the Joule heating induced by the solar wind energy and interplanetary magnetic field input into the stratosphere.

3. Experimental data

The experimental data used in this study were ground – based measurements of electric fields performed at Vostok Station (Antarctica) for several years [7] as well as simultaneous measurements of the surface temperature. The position of the magnetosphere in subsolar point was taken as a measure of the solar wind disturbance.
Figure 1 (left panel) shows temporal variations of the midday (03-07 UT) values of ground surface temperature (Ts), values of the electric field on ground surface (E) and energy of the solar wind expressed as a position of the magnetosphere in subsolar point (Re), where Re is radius of the Earth recorded at Vostok Station, Antarctica on 02 - 22 December 2007. Right panel of Figure 1 shows correlation between midday values of the ground surface temperature and values of electric field (a) as well as correlation between midday values of the ground surface temperature and position of boundary of magnetosphere Re (b) . Interval for 95 % confidence level is shown on Figure 1 by thin vertical lines. It seems that these systematic changes of degree of correlation between these parameters have a physical sense. The solar wind energy via induced electric fields and currents can influence ground surface temperature.
Experimental data demonstrated that impact of the solar wind energy on the thermal regime of stratosphere and troposphere could be different due to non - uniformity of electric conductivity of the ground surface as well as to different relations between conductivity of atmospheric layers and ground surface .

4. Role of conductivity of the ground surface.

Experimentally observed long – term trends in variations of the tropospheric and stratospheric temperatures could be related to some extent to variability of the solar activity. Temperature of stratosphere is decreasing during disturbances of the solar wind if conductivity of ground surface of the Earth is low above places covered by ice. On the contrary–temperature of stratosphere has positive correlation with energy of the solar wind if conductivity of the Earth ground surface is high [8].

5. Summary.

It was showed that enhanced solar wind energy caused changes of the stratosphere above both the Northern and Southern geographic poles.
So, transmission of energy of the solar wind into the Earth’s atmosphere will depend on this important parameter and will be different at different regions of the Earth, producing redistribution of temperature and pressure of the atmosphere.

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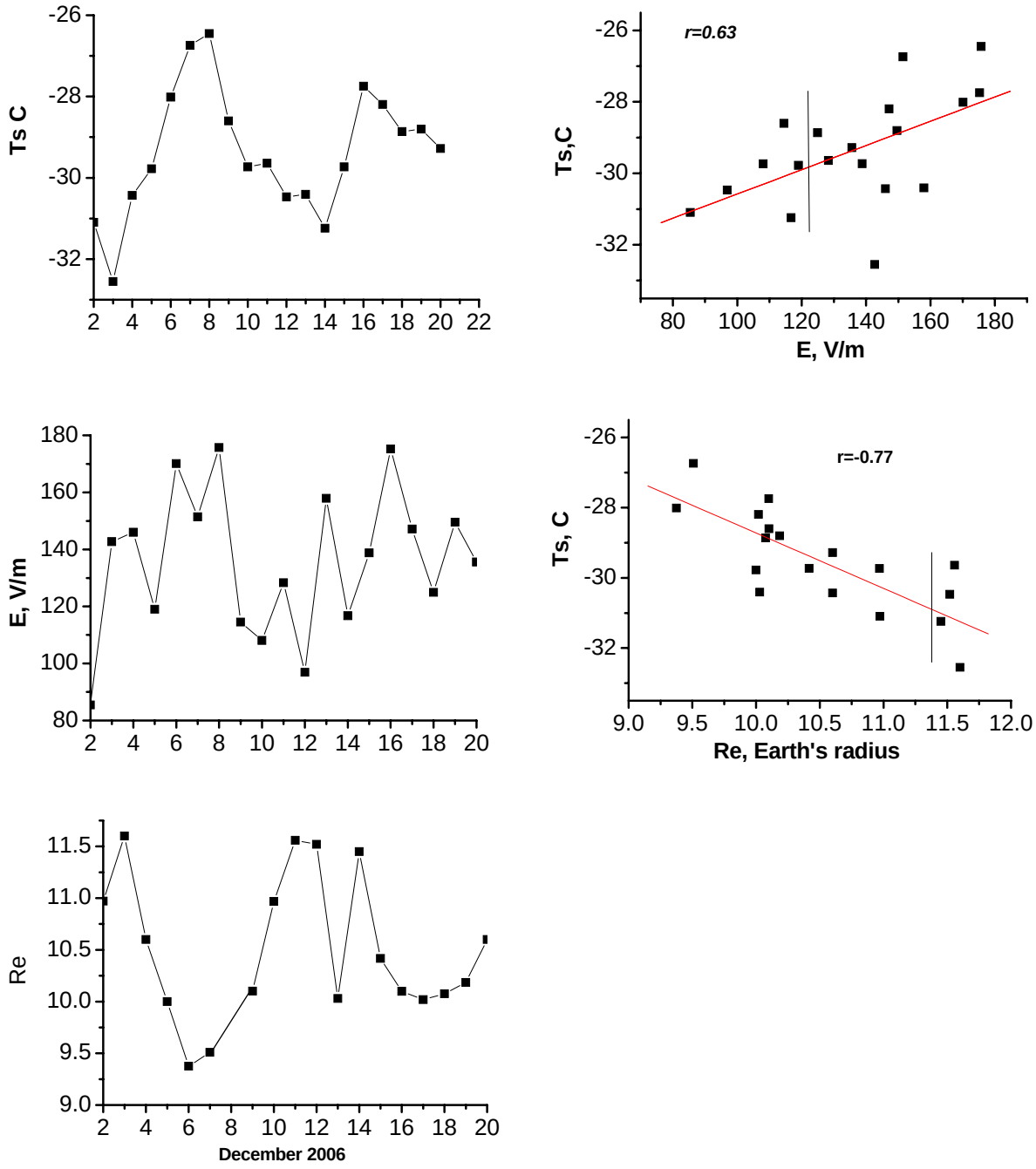

Figure 1

Temporal variations of the ground-based station and interplanetary data in December 2006 and their statistical relations. See the text for more details.

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