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Geomagnetic Activity Influence on Thermobaric Characteristics of the Atmosphere.

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Abstract. The main points of the model of the solar activity effect on the Earth climatic system are presented. The model is based on the physical mechanism of heliogeophysical factors' influence on climatic characteristics and atmospheric circulation in the high-latitude troposphere through the atmospheric electricity. In accordance with this mechanism, the atmospheric electricity parameters in the high latitudes depend on the solar activity; at the same time, they influence the altitude distribution of charged condensation nuclei in the troposphere, as well as the cloudiness formation and radiation balance. The mechanism is proved to operate more efficiently in the high latitudes resulting in additional cloudiness formation in areas with adequate vapour concentration. We present complex analysis results of response of temperature and tropospheric pressure fields to different heliogeophysical disturbances. It is detected that regular changes of the temperature and pressure field dynamic accompany these disturbances.

Keywords: Climate, troposphere, solar activity influence

Introduction

in recent years, there has been a marked resurgence of interest in the problem of solar activity (SA) influence on weather and climate. This is associated with the fact that firstly, the anthropogenic factor has appeared to be indecisive in the observable global warming that has been proved in a number of papers by analyzing experimental data with a special technique for detecting various changes in climate and a number of climatic indices [1–3]. Secondly, physical mechanisms and models have appeared of the relation between heliogeophysical characteristics and thermobaric and climatic parameters of the troposphere.

the earlier proposed physical mechanism and model of SA influence on weather-climatic characteristics of the high-latitude troposphere [5, 6] allowed us to develop a new concept of this effect.

A key concept of this model is the influence of heliogeophysical disturbances (HGD) on the Earth's climatic system parameters, which control the energy flux that goes form the Earth to space in the high-latitude regions.

solar wind and interplanetary magnetic field parameters that govern geomagnetic activity and influence changes in the electric field of the high-latitude atmosphere are the main solar-activity agents that act on weather-climatic characteristics of the troposphere. Besides, large fluxes of solar cosmic rays (SCR) generated during solar flares contribute to changes in the high-latitude troposphere electric field. Atmospheric electricity parameters in turn can have a pronounced effect on the radiation balance.

Changes in the electric field act on charged particles in the troposphere; i.e., lead to the height redistribution of aerosols, which may be atmospheric condensation nuclei, and hence influence cloud formation conditions. Cloudiness changes radiation balance, decreases radiation cooling, and changes the troposphere thermobaric field.

This manifestation can best be observed in high-latitude regions (in the auroral oval zone during magnetospheric disturbances and in the polar cap area with maximum at the geomagnetic pole during SCR invasion), where it produces additional cloudiness (in regions with sufficient concentration of water vapor).

using this model, one should expect the following features of the atmospheric response to the solar activity influence:

1. A maximal response should be expected in high-latitude regions, since there we can observe a considerable increase in the electric potential Earth–ionosphere during heliogeophysical disturbances.
2. The response will essentially depend on a height in the atmosphere. Opposite changes in temperature in the lower and upper troposphere should be expected.
3. The response is most pronounced in a local winter, when a short-wave flux is low or absent.

In this work, we made a complex analysis of the response of tropospheric thermobaric characteristics to some of heliogeophysical disturbances (HGD) (solar cosmic-ray fluxes and geomagnetic disturbances).

Analysis of the spatial-temporal distribution of response of tropospheric thermobaric characteristics to isolated heliogeophysical disturbances

Based on the NCEP/NCAR Reanalysis data archive, we studied space-time variations of the tropospheric temperature during invasions of anomalously large SCR fluxes, which usually occur during geomagnetic disturbances, from 1968 to 2005. For each HGD we drew daily maps of tropospheric average-temperature anomalies in the 925–450 hPa layer for the Nortern hemisphere for 31 days (15 days before and after the event). Using the created films, we analyzed changes in the pressure field and temperature for standard levels of the high-latitude troposphere during anomalous heliogeophysical disturbances. It has been found that HGDs change the typical zonal transfer bringing to a stop isolated moving structures. It has been found that it is precisely the stationary regions where a maximal tropospheric response to HGDs takes place. Fig. 1 presents temperature variations in standard isobaric levels for one of the stationary regions during the anomalous HGD.

Obviously HGDs cause an air temperature rise from the Earth surface to the level of 300 hPa and its fall above this level. A maximal air temperature rise in the stationary region can be observed in the layer of 400–700 hPa on the fourth day. The maximal temperature rise takes place in the 3rd–4th day (up to 15°).

Changes in tropospheric temperature distribution will occur with corresponding changes in tropospheric circulation. The analysis of maps of thermobaric fields during HGD actions shows that they lead to a zonal transfer breaking and a change of altitudinal frontal zone profile (Fig. 2).

Blocking processes that manifest themselves as

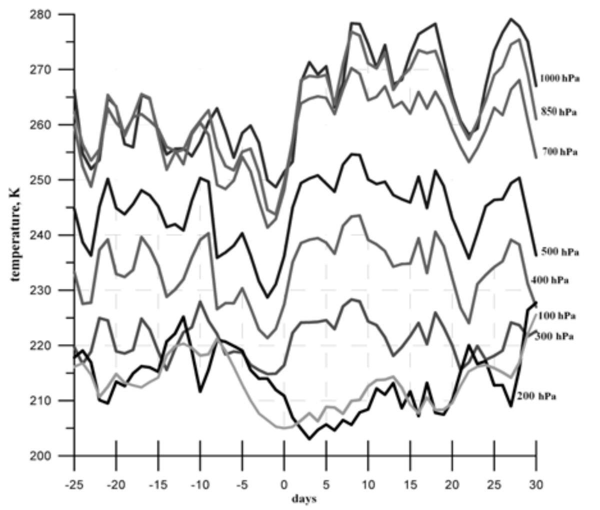

Fig. 1. Variations of average daily air temperature at standard isobaric levels of the atmosphere in the northern hemisphere in the region of 55-65°N, 205-215°E during the period from Jan 1 to Feb 28, 1982.

high tropospheric heat ridges are most pronounced in the northern part of the Pacific Ocean (Fig. 3). Besides, in this region HGD is succeeded by a decrease in the meridional temperature gradients (from 15–20° to 5° after the HGD) and in the geopotential in the latitude range 40–70° N. the blocking lasts as a whole

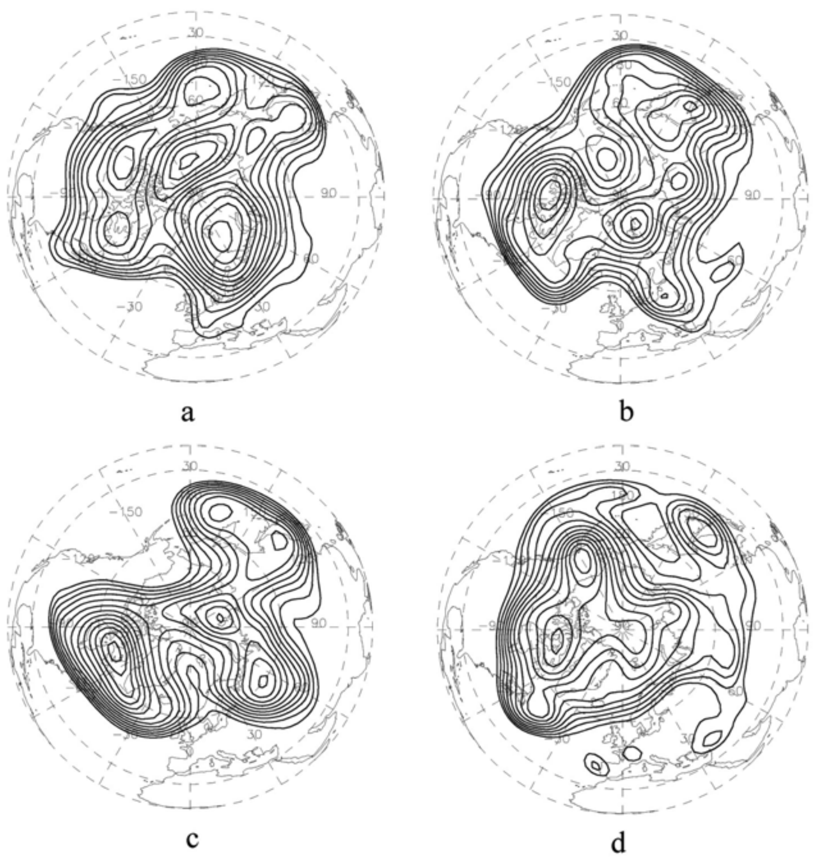

Fig. 2. Fig. 2 Change of structure of baric fields at the isobaric surfaces 500 hPa during the heliogeophysical disturbance on 31.01.1982: a) - 27.01.82 (on the day before the heliogeophysical disturbance); b) - 31.01.82 (the moment of the heliogeophysical disturbance); c) - 06.02.82 (the greatest changes in the structure of baric fields); d) - 14.02.82 (returning to initial structure).

from 3 to 5 days. Once the meridional exchange peaks, circulation types change, and zonal transfer is restored.

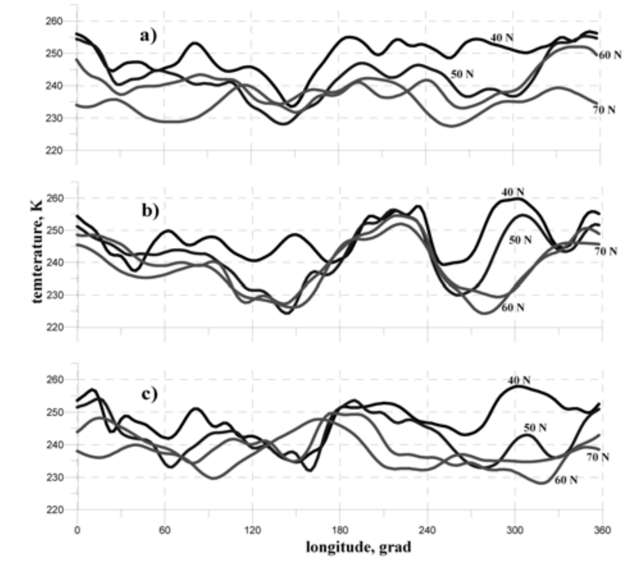

Fig.3 Distribution of air temperature at the isobaric surfaces 500 hPa:a) on the day before the heliogeophysical disturbance on 30.01.1982, b) on 04.02.1982, the fourth day after the heliogeophysical disturbance, c) on 10.02.1982, the tenth day after the heliogeophysical disturbance.

To estimate a contribution of some of HGDs to the change of climatic characteristics, we calculated changes (both local and zonally averaged in latitude 50–90° N) of the lower and middle troposphere heat content (Fig. 4). The analysis of the tropospheric heat content change revealed that HGDs causes an increase in the heat content that can run to several percent of the seasonal trend amplitude.

We should note that a real increase in the climatic system heat content will be more considerable, because we have not taken into account heat fluxes to the underlying surfaces as well as latent heat.

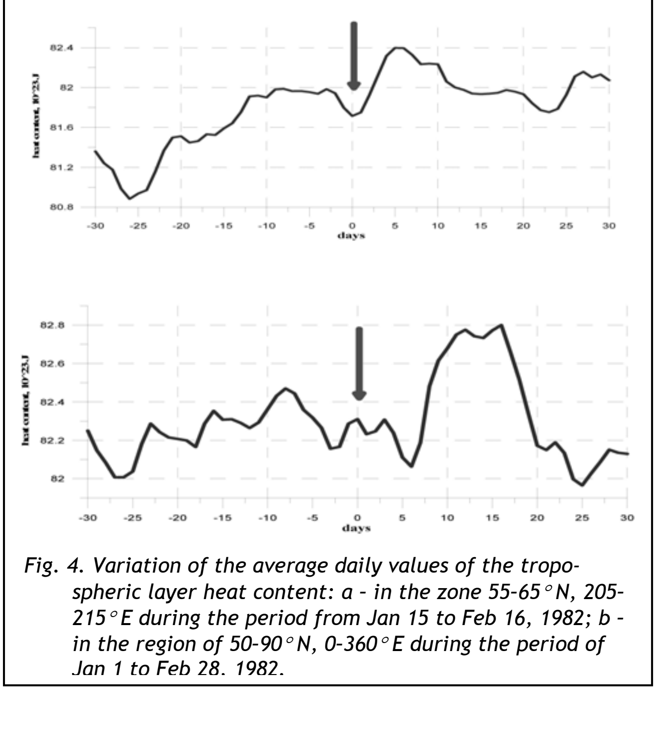

Fig. 4. Variation of the average daily values of the tropospheric layer heat content: a - in the zone 55-65°N, 205-215°E during the period from Jan 15 to Feb 16, 1982; b - in the region of 50-90°N, 0-360°E during the period of Jan 1 to Feb 28. 1982.

Main results

A complex analysis has been made of the response of tropospheric thermobaric characteristics to some of HGDs. It has been found that these disturbances occur with the regular change in the thermobaric field dynamics.

It has been established that after HGDs we can observe:

1. a change in the typical zonal transfer that manifests itself in "stationarity" of isolated moving structures;
2. temperature rise in the lower and middle troposphere in "stationary" regions (up to 15°), and its fall in the upper troposphere;
3. an increase in the atmospheric heat content in the 925–450 hPa layer in the "stationary" regions in latitude 50–90° N;
4. a change in the atmospheric circulation; namely, intensification of the meridian circulation and the altitudinal frontal zone.

Acknowledgements

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