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Impact of solar activity on structure components of the Earth.
I. Meteorological conditions

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Summary. — The mountain observations (Northern Caucasus) carried out during solar activity (SA) cycles 21, 22, and 23 testify to substantial SA impacts on radiative, optical, microphysical and meteorological parameters of the troposphere. Due to disturbances imposed on natural variations of meteorological parameters and changes of the microphysical state of the ensemble of water vapor molecules, distinct disturbances of the synoptic period lengths have been observed. Apparent responses of the atmosphere to activated processes on the Sun in October 1989, April 2002 and October 2003 confirm the existence of contributions to atmospheric perturbations of flare fluxes of protons (SCR) and fluxes of recently identified spiral-vortex radiation (SVR) outgoing via photospheric magnetic structures of various scales. With the 20 October 1989 event as an example, contributions of the flare flux of protons and the spiral-vortex radiation to dynamic processes in the lower troposphere have been illustrated. A conclusion has been drawn about similar level but different directions of their impacts on the degree of water vapour molecules association in the atmosphere. Destructive forcings of the focused SVR and its various manifestations on the dark side of the Earth (and, apparently, of the Moon) have been mentioned.

PACS `92.60.Vb` – Radiative processes, solar radiation.
PACS `92.60.Ta` – Electromagnetic wave propagation.

1. – Introduction

As far back as 1981, anomalous changes of tropospheric meteorological parameters due to solar activity were observed [1, 2] but only in 2003, analysing the whole volume of alpine observations of the impact of solar emissions on atmospheric parameters, manifestations of the impact of fluxes were identified as being not of electromagnetic or

(*) K. Ya. Kondratyev, for many years member of the Editorial Board of *Il Nuovo Cimento C*, died on May 1st, 2006.
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gravitational but of wave, spiral-vortex radiation from active regions (AR). The intensity of this specific radiation increases strongly with AR passing through the central part of the Sun's disk (the latitudinal belt $\pm 20°$ is considered). The SVR, as follows from the effects, affects mainly the dynamic and structural parameters of the environment, introducing (*e.g.*, in the Earth's atmosphere) an additional energy to air masses vorticity, imparting them a comparatively weak impulse and a substantial angular momentum, since the vortex field from a local photospheric source (*e.g.*, spots of a geometrically regular shape) can simultaneously, in different regions, locally and homogeneously "illuminate" areas of about 10^5 km^2. In further publications, with the specified applied model of the field of spiral radiation and processes of its interaction with other fields and substances, more adequate ideas will be given about the nature of the sources of spiral radiation, processes of interaction of this radiation with the Earth's media (hydrosphere, lithosphere, biosphere, ionosphere, magnetosphere, and technosphere) and, apparently, plasma of the stars.

The SVR impact on the atmosphere, as on other media, should apparently be considered separately for the sun-illuminated side of the Earth and its dark side, since SVR has a comparatively high penetrability and interacts specifically with the solid lithospheric shell, using it as a spherical lens. As calculations and natural features (*e.g.*, craters) show, the effect of focusing exceeds the losses by several orders of magnitude, when the SVR field quanta (spirones) move in the lithospheric spherical waveguide. In the focus located either on the surface of the Earth's spheroid, or near it on either side of the spheroid's boundary, a high-speed (supersonic) concentrated atmospheric vortex is created with the size of the focus spot 30–50 m and volume density of energy on the vortex periphery up to 14 Joule cm^{-3} (after focusing).

Without dwelling upon the effects taking place in the media mentioned above and manifesting themselves in most cases as catastrophic, note that the focused SVR is realized in the atmosphere as diverse anomalous atmospheric phenomena—ball lightning, geophysical meteors, sprites, and phenomena on the surface (craters, crop circles), or underground (geophysical solitons, earthquakes), etc. All the manifestations of interactions between the SVR field and features mentioned above are accurately kept within the developing model ideas about the characteristics of the SVR field. In which case during analysis of new SVR effects important circumstances have been found out, which make the SVR model more complete and reliable. These SVR manifestations will be considered in further publications.

Other widely known mechanisms of the impact of solar activity on the structure and composition of the atmosphere are connected with the above-mentioned wave electromagnetic and corpuscular solar radiation which largely controls concentrations of both charged and neutral components at different levels of the atmosphere and, besides, affects their phase state. On the other hand, it is well known that solar activity affects indirectly the fluxes of galactic cosmic rays (GCR) which, penetrating the upper troposphere, create conditions for ion clusterization of water vapor molecules. These aspects of the impact of solar activity have been noted [3, 4] in connection with the input to the atmosphere of energetic gamma-quanta and high-speed corpuscular fluxes emitted with proton flares on the Sun. When the Earth gets into these fluxes, the "meteorological solar constant" varies, that is, the climatic parameters of the surface-atmosphere system become directly affected. Much later, similar studies have been continued by Veretenenko and Pudovkin [5].

The present paper considers an indicative example of complex impacts of several mechanisms on meteorological and optical characteristics of the atmosphere observed under

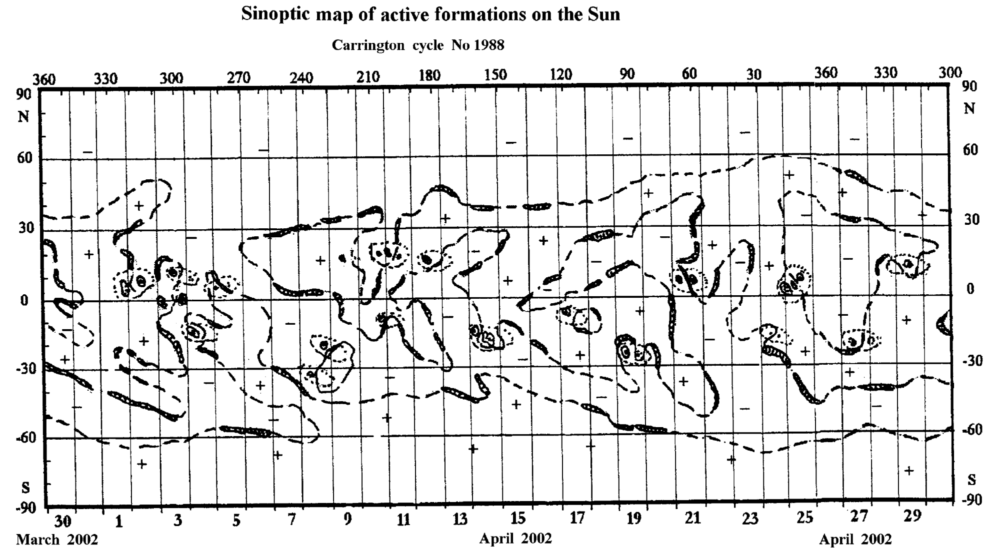

Fig. 1. – Synoptic map of active formations on the Sun for the period of Carrington cycle No. 1988. The location is shown of active regions contoured by small dotted lines and magnetic fields of different polarity contoured by bold dotted lines with bulges (filaments), in coordinates: latitude from 90°N to 90°S and the turning angle of the Sun (reverse scale). Most of the active areas are concentrated near the solar equator, especially the AR in the Northern Hemisphere, therefore they are more geoeffective with respect to their emissions.

conditions of the alpine laboratory "Solnechnaya-2" (Northern Caucasus, Russia)([1]).

2. – Solar activity and mountain observations in the spring of 2002

During regular field observations, in April 2002 and October 2003, the activity of processes on the visible surface (photosphere) of the Sun remained sufficiently high, despite the fact that almost half the decreasing phase of the 23rd cycle of solar activity has passed. Note that April and October were chosen for observations because the Earth passed the spatial-temporal sector of the orbit near the points of equinox (the Earth's axis inclination along the orbit) as well as in connection with the decreasing velocities of air masses motion in latitudinal and longitudinal directions.

The second spring month data are illustrated by a synoptic map of active formations on the Sun where active areas most closely located to the solar equator are surrounded with black points (fig. 1), and the heliographic map for 3 April (fig. 2). Near the center of the Sun's hemisphere (fig. 2) an individual spot is clearly seen with an oval shadow of the size exceeding the size of the Earth's diameter. It turns out that sunspots similar in size and location are potentially very dangerous for the Earth's ecosphere. In further

([1]) The mountain astronomic station "Solnechnaya" of the Main Astronomic Observatory of the RAS, the meteorological station "Shadzhatmas", the mountain base of the SPbSU Institute of Physics "Solnechnaya-2", and the Kislovodsk mountain scientific station (KMSS) of the RAS Institute of Atmospheric Physics are located on the Shadzhatmas plateau, spaced from 10 to 80 m.

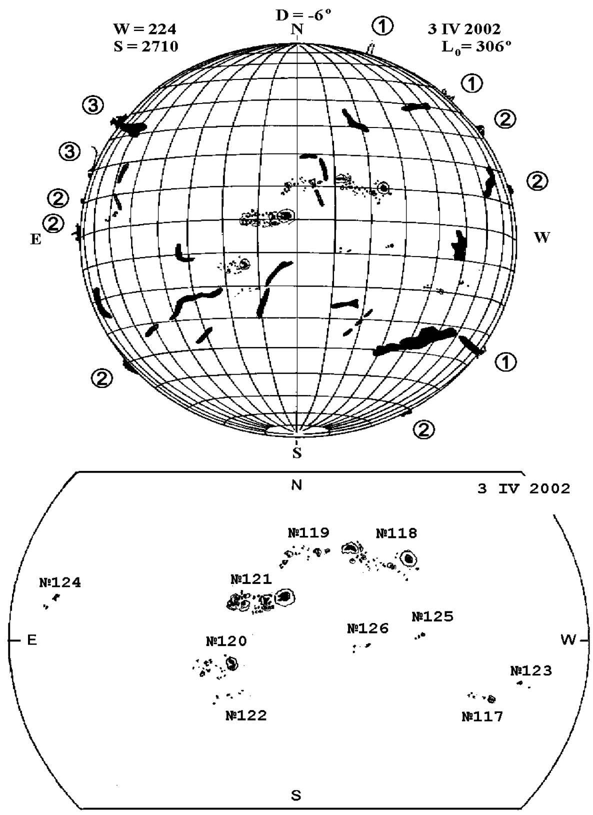

Fig. 2. – The heliographic map of magnetic fields and active regions of the Sun for 3 April 2002. Near the center (to the left and above) there is an oval dark nucleus of AR No. 121. Active regions are contoured by dotted lines. Dark oblong formations are relatively cold filaments. Below is given an enlarged central part of the disk with AR numbers. Wavy lines round the Sun show magnitudes of corona brightness (in relative units). To the left and above are given total parameters of sunspots: Wolf number $W = 224$ and spots' area $S = 2710$ mph. The area of AR No. 121 $S = 390$ mph was at a maximum on 3 April 2002 (mph— millionth parts of hemisphere).

analysis, an attempt will be undertaken to trace possible consequences of direct impacts of the vortex radiation emissions from such spots on natural and technogenic objects. However, there is also the background vortex radiation that is continuously emitted from numerous micro-scale (compared to the Sun) magnetic structures of the photosphere (with diameters < 200 km). On the illuminated side of the Earth, the density of the background vortex radiation flux exceed 10^4 erg cm^{-2} s^{-1}.

Now we consider the observational data that reveal a response of atmospheric parameters to a strong geoeffective factor such as SVR. Note that from variations of meteorological parameters obtained in April 2002 a direct connection has been established between simultaneous variations of surface pressure on the Shadzhatmas plateau and some other meteorological stations (Mineral Wody, Nalchik, Mozdok, Vladikavkaz, Makhachkala, Saratov, Ankara, etc.) and crossing the central meridian of the Sun's disk by AR Nos. 117, 118, 121, 125, 126, and 149 (see figs. 1 and 8 in this paper).

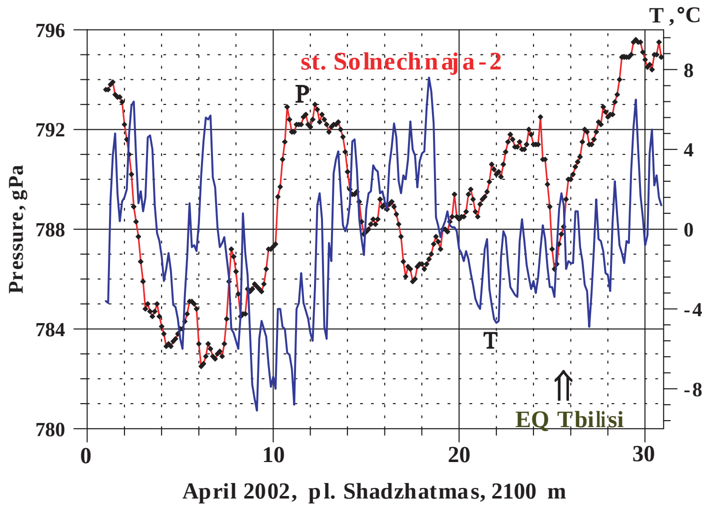

Fig. 3. – Variations of surface pressure and temperature from 3-hour data recorded at the meteorological station Shadzhatmas in April 2002. Variations of meteorological parameters in April were less regular than in October 2003. Apart from sudden temperature differences on the night from 4 to 5 April, on the night on 9 and 11 April, and at night on 27 April, there were pressure depressions on 2-4 and 24-25 April.

A consideration of these variations has shown the presence of apparently anomalous disturbances in a typical diurnal change of meteorological elements and/or in the course of their synoptical period appearing in the periods of an increased solar activity but not connected with an appearance of strong flares. Consider meteorological data on pressure and surface air temperature at the station "Solnechnaya-2" (Shadzhatmas) for April 2002 shown in fig. 3. The data at this station and at most of other Caucasian stations were obtained every 3 hours, which provided a detailed description of the diurnal course of meteorological parameters.

Analysing the behavior of meteorological parameters, it is necessary to take into account that on the abscissa axis the dates located under strokes indicate the beginning of day, that is, midnight. Now it is easy to determine that a minimum of temperature occurs during the second term, that is, at 3 a.m. UT, that is, almost before sunrise at the longitude of the station, and a maximum varies between 1 p.m. and 4 p.m., local time. The diurnal change of temperature reaches sometimes 7^oC. Note important moments in the change of surface pressure at observation locations (at an altitude of 2070 m the average pressure constitutes only 78% of the pressure above sea level). It is seen in fig. 3 that at the level of the station, the diurnal change of pressure (at lack of dynamic changes) is practically absent, but it is clearly expressed in temperature, and that in a series of 1-3-day periods, average variations of pressure and temperature have opposite trends, for instance, in April 6, April 17-18, April 20-22. These short periods refer to sectors, where the thermo-microphysical processes change "naturally", without interference of external (*e.g.*, dynamic) factors. It is natural to suppose that in the absence of the diurnal change of pressure a substantial diurnal change of temperature should be completely compensated with the opposite change of humidity, which does take place in fact. As following from comparisons with meteorological data at the station

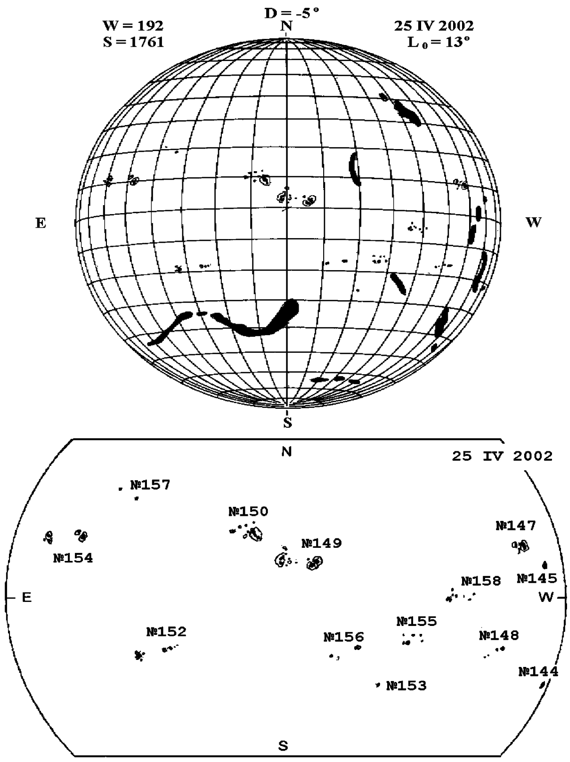

Fig. 4. – The heliographic map of magnetic fields and active regions of the Sun for 25 April 2002. Near the center (a little above and to the right) there is a dark nucleus of AR No. 149. Active regions are contoured by dotted lines. Dark oblong formations are relatively cold filaments. Below is given an enlarged central part of the disk with AR numbers. Wavy lines round the Sun show magnitudes of corona brightness (in relative units). To the left and above are given total parameters of sunspots: Wolf number $W = 192$ and spots' area $S = 1761$ mph. The area of AR No. 149 $S = 148$ mph was at a maximum on 24 April 2002. The area of AR No. 150 $S = 254$ mph was at a maximum on 25 April 2002.

Mineral Wody, such a complete compensation of the diurnal change of temperature and humidity is only characteristic of the atmospheric layer above 2000 m level.

Now consider the periods with the interference of some forcings. There are two apparent periods: April 2-4 and April 23-28. Consider at first the latter period as a clearer situation with some forcing factor (FF). The tendency of pressure change showing on 22-23 April ought to reach maximum values on 29 April, but it drops sharply on 24 April reaching a minimum at night on 25 April. Then a gradual going out of depression takes place, that is, a restoration of the state corresponding to a long synoptic process taking place during this decade.

The nature of FF that breaks the natural increase of pressure and reduces it by about 8 hPa, that is, by 1%, should be determined after an analysis of some other cases of forcing.

One can suppose, based on this example, that the forcing factor affecting the surface pressure has changed the mass of the air column over the observation region, in this case towards its decrease. However, since the atmosphere is a single system, the negative forcing pulse should be followed by a positive response of pressure smoothing (an advection). As seen in fig. 3, this response is slow. Therefore there is an additional reason to assert that the FF impact was not less than that of a middle-scale cyclone. Besides, the Great Caucasian Ridge could prevent the filling-in of the region of pressure deficit from the south. As will be seen below, this assertion has been substantiated.

An available experience during the analysis of the spatial-temporal features of synoptic processes variations points to a possibility of forcings in the first decade of April, too. A sharp decrease of pressure by ~ 7 hPa on 2 April continuing on 4 April was apparently caused by the same forcing factor. This is confirmed by figs. 1 and 2, which demonstrate powerful active regions in the central sector of the solar disk, especially for what concerns AR 121. Figure 3 demonstrates one feature more connected with the FF impact, namely, a substantial increase (22-29 April) of the magnitude of temperature diurnal variations. The complicated situation with the FF impact in the first decade can be understood from specific features of diurnal changes. Based on the amplitudes of diurnal changes of temperature and pressure as well as on the coincidence of temperature maxima with pressure minima by the meteorological terms, one can reliably determine the periods of the FF impact in the first decade. These periods are 1-5 April and 8-10 April. Now one can specify the period of the FF impact in the third decade of April. It is 22-29 April.

Now we can consider the Sun as the place of FF sources location and try to determine the kind of formation containing and reproducing the FF. Figure 2 shows the heliographic map of the Sun for the central key day of the first decade–3 April. In the center of the solar disk, that is, in the most geoeffective position, active regions Nos. 118, 119, 120, and 121 are located. The latter region moves along the Sun's equator, crossing the central meridian during the second half of 3 April. Apparently, the combination of these active regions determined the forcing on the lower atmosphere in the period from 1 April to 5 April, but the leading spot AR 121 should be considered the main source of forcing.

During the third decade of April the impacts of solar activity were connected with AR 149 and 150 that crossed the central sector of the solar disk. Figure 4 shows the first region crossing the central meridian of the Sun. There is no doubt that AR 149 was the main source of SVR on these days.

Note should be taken that half viewing angles ($\sim 60°$) of FF source (sunspot) has been estimated, which provides an illumination of the Earth during several days before the AR comes to the central sector.

3. – Solar activity and mountain observations in the fall of 2003

Figure 5 is the photo of the Sun obtained by the SOHO satellite on 23 October 2003 at 22:24 UT. As will be shown below, it is in this period that a maximum of the vortex energy flux reached the Earth surface, as if spots from the whole disk concentrated in the most geoeffective position favoring the global-scale and prolonged impact on our planet. It can be stated that analysis of active solar radiative forcings in 2003 will help to uncover the mechanism of direct forcing on all geospheres of the Earth. There is a possibility to start prognostic developments on the forecast and then warning about sudden destructive blows of vortex impulses.

Active region (AR) No. 249 (NOAA 10484) is a rare case of spots' concentration in the central sector of the Sun's disk. The total area of spots in this AR has increased with approaching the central meridian (CM) from 216 to 2190 millionth parts of the hemispheric area (mph). Such sizes of the areas are characteristic (in this period) of the

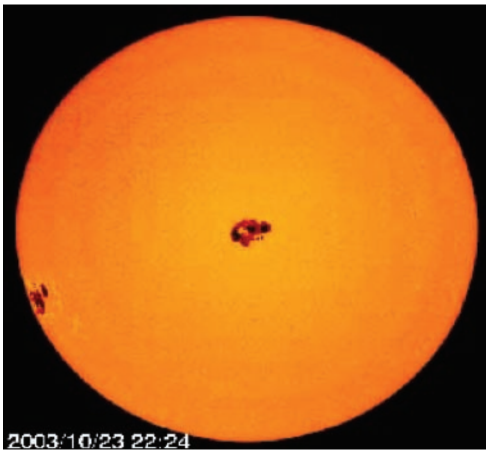

Fig. 5. – Photo of the Sun taken on 23 October 2003 at 22:24 UT from SOHO satellite. In the centre of the disk there is AR No. 249 where the area of spots reaches 2190 mph. The Wolf number of spots on this day was 82. Such a compact concentration of spots in the center of the disk occurs very seldom and is of real danger for the ozone layer and biosphere of the Earth, since there is a possibility of a powerful proton flare at this moment and covering the Earth with the flux of highly energetic particles.

sum of spots over the whole hemisphere of the Sun. The active area moved along the equator at latitude near 5°N. From behind the eastern edge of the disk, an AR appeared on 17 October and disappeared in the west on 29 October.

Note that a similar exclusive event took place between 20 and 23 March 1920 [6]. In that period an anomalously large group of spots crossed the CM responsible, apparently, for a decrease of solar activity to 1.8% (21 March 1920) and for its abrupt decrease to 5.5% on 23 March 1920 measured daily at the Calama station (Chili). The movement of this group along the solar equator from 16 to 26 March was accompanied by synchronous (with the solar constant change) decrease of atmospheric transparency to 3.3% and asynchronous change of the deposited water content with a sharp peak exceeding by 25% on 22 March 1920. Similar responses of meteorological parameters are also characteristic of events in October 2003 and on 12 October 1981 [2] when the impulse W (hour-long) reached 300%. This last case is explained by an extremely low initial level of $W \sim 0.2$ cm p.w. (precipitated water) reduced (in the process of modification of associative bonds of H_2O molecules) due to prolonged impacts on the atmosphere of high-speed fluxes of solar protons from the earlier series of flares.

From multi-year data, the average value of pressure for standard synoptic conditions of October at the station constitutes 795 hPa. In October 2003 the character of weather conditions during first 15 days completely corresponded in pressure and temperature variations (fig. 4) to mean-statistical characteristics, but by 17 October, shock waves of vortex fluxes appeared from a powerful active area coming from behind the edge of the disk. However, a more detailed analysis of the situation has shown that for the first time, the signs of the impact on the atmosphere appeared on 16 October (it should be borne in mind that the strokes on abscissa axis correspond to time moment 00:00 UT, that is, the beginning of Greenwich day denoted by numbers).

In October 2003 (fig. 6), of two cases of an apparent direct correlation between T and

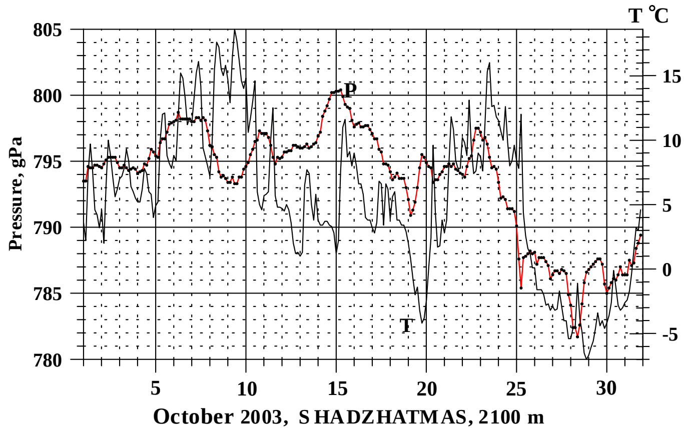

Fig. 6. – Variations of surface pressure and temperature from 3-hour data recorded at the station Shadzhatmas in October 2003. The "quiet" course of synoptic variations of pressure continuing during first two thirds of month was broken, apparently, by an external forcing factor, since not only the synoptic period changed but also natural thermobaric relationships turned out to be distorted. It can be supposed that during the last six days, the SVR-formed pressure hole got filled-in with cold and moist air moving down from the Great Caucasian ridge. The station is located 40 km from Elbrus on the plateau of GCR foothills convenient for air flowing.

P (15–18 and 25–30, on the whole), the latter case is seen as a "deep" and "prolonged" positive correlation. This phenomenon can be considered as evidence of a strong impact on the atmosphere which manifests itself in two main meteorological parameters: surface pressure and temperature, and hence, in relative humidity. The amplitude of temperature variations in October constituted 25°C, with an average temperature of +8°C, while at

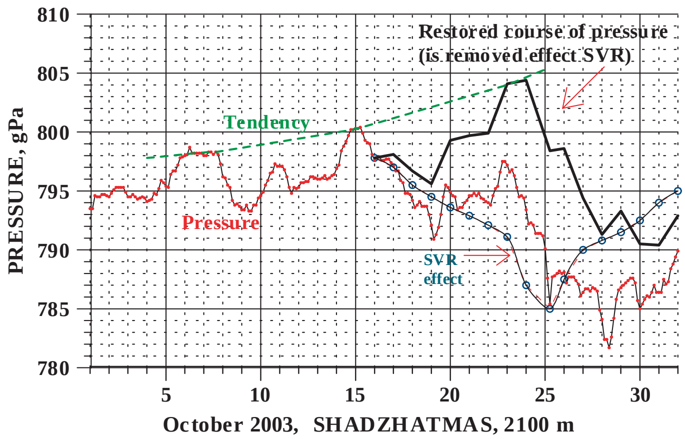

Fig. 7. – The scheme-model retrieval of the change of pressure for the case of lacking SVR impact. It was assumed in retrieving that the trend of pressure increase in the first half of month remained for the next ten days. A model presentation was accepted for the diagram (helmet-like) of SVR direction from a sunspot. Certain corrections into configuration of the SVR effect (after 25 October) were introduced with the effect of AR No. 252 taken into account.

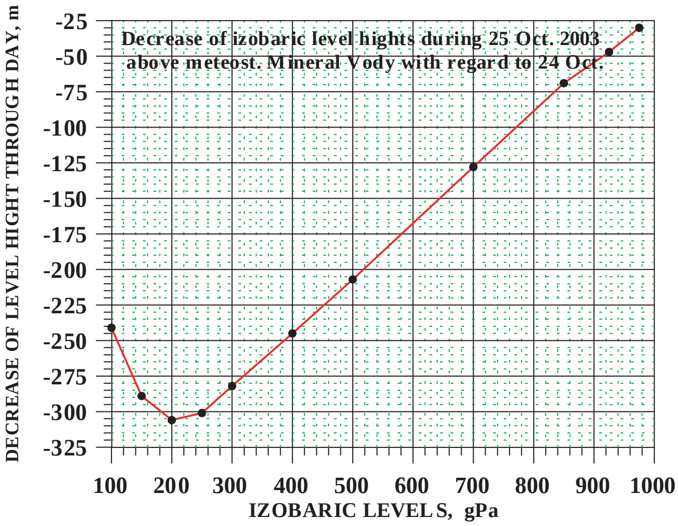

Fig. 8. – A decrease of isobaric levels from the data of radiowave sounding over the meteorological station Mineral Wody on 24-25 October 2003. Extrapolation of the decreasing trend above 100 hPa level indicates that even above 100 hPa level the decrease constituted not less than 150 m day^{-1}. The latter fact is an additional confirmation of uniformity of the increase in the air column over the region of sounding as a whole. Apparently, this could take place only under the influence of an external forcing factor.

a positive correlation, variations constituted 15°C, that is, 60% of monthly amplitude. With the SVR impact, to reduce pressure by 9 hPa at surface pressure 795 hPa, the energy with surface density 7×10^7 erg s^{-1} cm^{-2} is needed. The Sun-induced pressure decrease (to about 786 hPa) remained near this level at least during six days, from 24 to 30 October. On the assumption that the vortex field illuminated the area $400 \times 400 = 1.6 \times 10^5$ km^2 or 1.6×10^{15} cm^2, the energy coming to the atmosphere over this area during six days reached $\sim 6.5 \times 10^{21}$ Joule. Strange it may be, but the input of such a huge amount of energy (of vortex nature) led to a temperature decrease by $\sim$ 10°C. Further analysis of a large database obtained during the field observations makes it possible to understand a correlation between these perturbations in the values of meteorological elements and dynamic processes. It should be mentioned, however, that in our opinion, noticeable impact of SVR on the Earth began after the appearance of AR No. 249 from behind the eastern edge of the Sun's disk, that is, on 17 October. Figure 7 shows a schematic analysis of the SVR impact on pressure in the lower part of air column during the passage of this AR over the Sun's disk. The tendency of the synoptic situation development confirms the retrieved change of pressure during the passage of AR (22-23 October) across the CM of the Sun's disk (fig. 7). The first "deep" decrease of pressure took place on 25 October, the second on 28 October. Figure 8 demonstrates a decrease of the height of isobaric levels on 25 October over the meteorological station Mineral Wody in the troposphere and lower stratosphere. At levels above 800 hPa, in the late fall period, air masses in the region Kislovodsk-Mineral Wody are sufficiently homogeneous horizontally to propagate the transformation of levels on the region of the meteorological station Shadzhatmas where observations were made. Anomalous changes of pressure on 24-25 October in air column above 800 hPa level can be attributed to the impact of

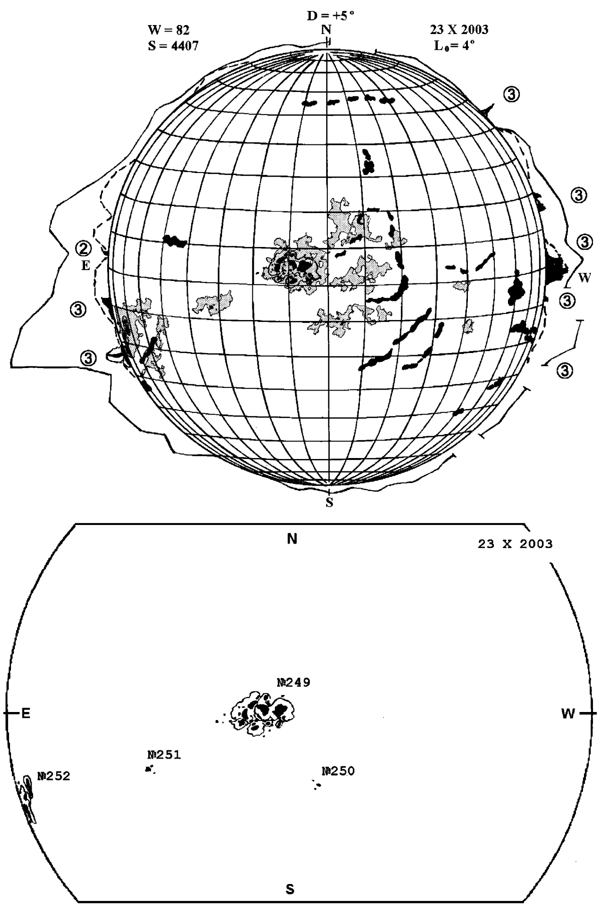

Fig. 9. – The heliographic map of magnetic fields and active regions of the Sun for 23 October 2003. Near the center (slightly to the left) is located powerful and compact AR No. 249. Dark oblong formations are relatively cold filaments. Below is shown an enlarged central part of the disk with AR numbers. Wavy lines round the Sun indicate equal magnitudes of corona brightness. To the left and above are shown total parameters of sunspots: Wolf number $W = 82$ and their area $S = 4407$ mph. The main spot in AR No. 249 has the area $S_1 = 2190$ mph was at a maximum on 23 October 2003.

SVR fluxes from AR No. 249 located geoefficiently on these days. Figure 9 shows a heliographic map of the Sun for 23 October 2003 with AR No. 249 (located near CM) whose area constituted 2240 mph at 5 h UT and the area of its leading spot was 2190 mph. Note that the area of spots for AR No. 121 reached 1040 mph, and the effect in pressure decrease constituted $\sim$ 8.5 hPa. It follows from these values that there cannot be any linear dependence between the spot's area and the magnitude of the effect, and on 3 April 2002 the effect was, apparently, suppressed by the synoptic component.

Of the total area of spots 4407 mph (see fig. 9), nearly half of it should be attributed to AR No. 252, containing a huge leading spot which on 27 October will take part in prolongation of manifestations of SVR effect. Note should be taken of numerous active formations located west (on the right) of AR No. 249 which are its vanguard constituting of several huge background magnetic fields and chains of dark fibres and having a trend of shifting to the southern hemisphere of the Sun.

There is independent statistical evidence [7] (for the meteorological station Shadzhatmas) of the presence in differential power spectra for daily mean data on pressure and temperature for the periods covering both maximum and minimum solar activity, of persistent maxima with periods of 13.5 and 27-28 days. These data indicate that AR is a source of effects in meteorological data.

4. – On energetics and physical mechanism of solar impacts

Studies accomplished in 2001-2003 have led to the conclusion [8] about the presence of a new, "effectively" functioning mechanism of the impact of solar activity on all components of the planet: its atmosphere, hydrosphere, lithosphere, biosphere, and technosphere. Effects of direct forcings of background and energetically powerful vortex impulse emissions from the AR and coronal holes of the Sun have been detected and identified. In April 2002 the alpine observations recorded, at least, two cases of impulse forcings on the atmosphere: surface pressure depressions constituted 9 and 6 hPa. The external forcing was responsible for 4.2×10^7 erg $s^{-1}\,cm^{-2}$ and 2.8×10^7 erg $s^{-1}\,cm^{-2}$, respectively.

An analysis of meteorological data at stations in the Northern Caucasus, European Territory of Russia, Central and Minor Asia has shown that in 2002 the external forcing manifested itself at the same level in all these regions. Hence, the spot of the Earth illumination covered $\sim 10^6\,km^2$, and the average flux of energy across this area constituted 3.5×10^{19} erg s^{-1}. This energy is close to the energy of explosion of a 1 Kt atom bomb, but even being distributed over the area of 1 mln km^2, it could induce synoptic disturbances to the general change of the atmospheric circulation in these regions. It is clear that the scale of impact on vorticity depends on the season, latitude, and type of surface.

To identify the nature of detected solar impulse emissions, it was necessary to consider the characteristic features of magnetic structures of AR of the Sun, and, of course, data of surface observations of extreme phenomena. The latter include, first of all, magnetic observations on 9 June 1984 during the passage of tornado near the Geophysical Observatory of United Institute of Physics of the Earth of the Russian Academy of Sciences "Borok" (the Volgo-Viatsky region) [9]. These observations have shown that the vortex structure of the tornado of a concrete size can emit electromagnetic waves with the central frequency about 2 Hz.

Calculations of the scientists of the Institute of Physics of St.-Petersburg State University have shown that the energy of the vortex structure of the tornado is comparable with energy characteristics of the focused spiral-vortex field that exhibits an impulse as well as powerful angular and orbital momentum. As an example, the linear velocity of the vortex motion of air particles has been calculated for typical values of the angular momentum, and the velocity constituted $410\,m\,s^{-1}$. The mass of molecules moving with a super-sound velocity in a circular volume localized on the periphery of the vortex column leads (due to collision processes) to ionization of air molecules with the accompanying optical emission in the UV and visible spectral regions as well as generation of low-frequency electromagnetic emission. The above emission with the central frequency 2 Hz should be emitted by a circular volume of tornado with an effective diameter ~ 60 m. The tornado formation is directly connected with the Sun. The consideration of the 9 June 1984 event is connected with its wide discussion in the periodical press, though the 12 April 1991 event ("Sasovo") has been more significant. Both these events and some others are reliably referenced to the moments of the AR appearance at geoeffective latitude and longitude in the central sector of the Sun.

The Conference "Ecology and Space" [8] stated the timeliness of organization in 2004 of a prognostic observational station. At present, the necessity of the organization of such a station raises no doubts. The main and supporting instruments at the station will be the precision gravimeter CG-5 "Autograv" and two original SVR sensors operating in coincidence. The data of observations (in the monitoring regime) of SVR and acceleration of gravity variations using these instruments are needed to resolve fundamental problems important for some relevant fields of physics (astrophysics, elementary-particle physics, etc.) appearing in the course of present studies. The development of a system of the spiral field realizing with its interaction with substance can be considered as one of the important results. For instance, the loss of SVR energy with its interaction with the substance is estimated at about 4×10^{-7} g^{-1}. With the entry to the Earth's atmosphere, the vortex field quantum exhibits an impulse of 1.5×10^{-21} g cm s^{-1}, with a great angular and orbital momentum.

5. – Other perspective directions of studies

A detection of the impacts of solar spectral radiation bursts on the magnitude of total input of solar radiant energy to the atmosphere and surface has shown that at a high solar activity the contribution of spectral bursts can reach several per cent [2]. But it turned out that an additional energy of bursts comes by short-term portions (during 1.5-2 hours) at once to the whole illuminated part of the Earth, with latitudinal variations that change depending on the season and phase of the SA cycle.

There is another mechanism of the SA impact on the lower troposphere, which is more effective and powerful compared with spectral bursts. The earlier (1980s) observations of transformations of the optical and microphysical parameters of the atmosphere over the alpine station "Solnechnaya2" (Shadzhatmas plateau, h =2070 m) have shown that the input of energetic solar protons to the lower troposphere (*e.g.*, 20 October 1989, after the flare 4B on 19 October 1989) results in substantial and rapid changes of atmospheric parameters (fig. 10), usually ending in the formation of an overcast local low-level cloudiness. It should be borne in mind, however, that the flare on 19 October 1989 is considered powerful and, hence, comparatively rare. Apart from changes in the water vapor content, invasions of solar protons are accompanied by changes of the height and temperature of pressure levels in the troposphere. The impact of a medium-force solar flare (2B) on the height and temperature of the levels 200 and 300 hPa [10] over the 20-hour period manifested itself through a decrease of 300 hPa level by 5 dkm and then (during three days) an increase by 14 dkm above the middle location of the level. A similar change is observed at 500 hPa level, but the oscillation amplitude turned out to be much shorter.

The impact of solar flares manifests itself also through a modulation (up to 30%) of the flux of galactic cosmic rays (GCR) continuously maintaining the condensation mechanism of water vapor transformation (via ionization of nitrogen and oxygen molecules) and formation of charged water clusters. The area of GCR maximum activity is the upper troposphere and the lower stratosphere. However, highly energetic particles of solar and galactic rays penetrate the middle and lower troposphere and cause weather changes in middle latitudes. Examples of functioning of condensation mechanisms given here and in [1] on different time scales testify to a broad spatial and temporal range of

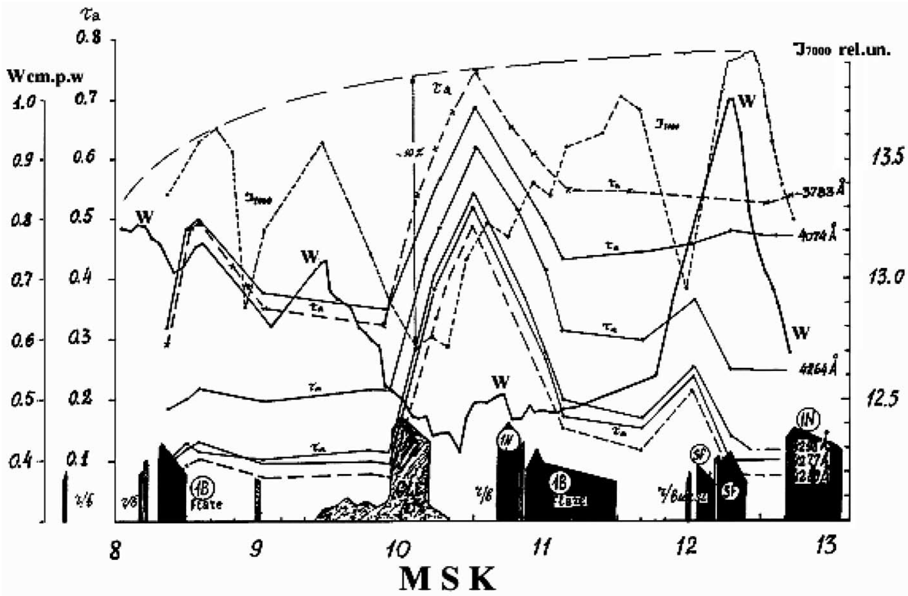

Fig. 10. – Variations of the solar spectral flux (I_{7000}) at wavelength 7000 Å (in relative units), spectral optical thickness ($\tau_{a\lambda}$), total water vapor content (W, cm p.w.) in the first half of the day on 20 October 1989. Above the abscissa axis are shown the moment of appearance on the Sun of flares, radio bursts, and the input to the lower atmosphere of a maximum flux of solar protons (and secondary neutrons—GLE).

functioning of this mechanism, its universal character and efficiency. However, the energetic significance of this mechanism for the lower troposphere is limited by comparatively rare powerful and geoeffective events on the Sun.

In the middle troposphere where the basic synoptic processes take place, geoeffective events on the Sun can play a marked role, especially when the atmosphere is jointly affected by heterogeneous forcing factors. Consider the results of complex observations on 20 October 1989. The data of the mountain astronomic station of Main Astronomic Observatory of the Russian Academy of Sciences for October 1989 show that on 20 October large active region No. 424 crossed the central meridian (CM) with the area of spots 1435 mph. Taking into account a time delay ($\sim$ 7 hours) due to non-relativistic velocity of the spiral radiation impulse from the corona up to 6000 km s^{-1} (estimated from thin structures of radio bursts), we obtain the time for reaching the Earth about 12 hours MSK. Note that Moscow time (MSK) is the local mean solar time for the station "Solnechnaya".

Considering the before-noon change of optical and meteorological parameters at the station "Solnechnaya2" shown in fig. 10, it can be seen that in this period the total content of water vapour (W) mesaured at 0.94 μm has twice suffered cardinal changes. From the initial value 0.78 cm of precipitable water recorded near 8 a.m., W started decreasing in spurts following the change of solar radiation intensity at the wavelength 7000 Å. To seek explanations, one should mark the GLE (ground-level event) impulse which indicates the input (9:30–10:10 a.m.) to the atmosphere of the main wave of the high-speed flux of highly energetic protons emitted during an extremely powerful flare (4B) at 16:00 MSK on 19 October 1989. From 9:30 a.m. the W acquired a clear decreasing trend. Apparently, one can reliably connect this decrease of W to 0.4 cm p.w. with the intrusion of solar protons to the middle troposphere, ceasing at 10:30 a.m. but still weakly affecting till 11:50 a.m. With the resulting rapid increase, the W almost doubled to 1 cm p.w. Apparently, in this time period the vortex radiation interacted with molecules of water clusters, changing the concentration and/or the degree of association of the latter and transforming the radiative and microphysical characteristics of pre-cloud layers.

Changes of the atmospheric optical thickness ($\tau_{a\lambda}$) in the wavelength region from 378 to 430 nm with the input of the main wave of protons were also rather abrupt, especially after a rapid decrease of W (at 9:55 a.m.) As we can see, with the input of the main mass of protons and decrease of W the optical thickness, $\tau_{a\lambda}$, increased 2-5 times, clearly connected with transformation of water vapor in the middle troposphere. The whole process of increase and decrease of $\tau_{a\lambda}$ took 1 hour and 10 minutes. Abrupt changes of solar radiation intensity in the 700 nm region (I_{7000}) also correlate with the change of the total water vapour content. The rapid growth of W and I_{7000} in the period 11:50 a.m.–12:15 p.m. turns out to be connected with the getting of the Earth into the SVR flux, the moment of the output of which from the corona was marked with a burst at 5:00 MSK (2:00 UT). The decrease of W and I_{7000} at 12:30 p.m. began due to the formation of surface fog and then the formation of a low-level local cloudiness (under anti-cyclonic conditions!). Similar impulse increases of W were observed in 1981 [2] and in the case of observations at the station Calama (by 26%) with the passage of an anomalous group of spots across the CM on 21-23 March 1920 [6]. These results testify to a comparability of the impacts of highly energetic protons from geoeffectively located flare (4B) and SVR flux from the geoeffective middle spot on the transition of phase state of H_2O molecules ensemble in the air column from the associated state to the free state and back.

6. – Conclusion

The above consideration of anomalous disturbances in a typical diurnal change of meteorological elements as well as in the course of their synoptic periods has led to a clarification of the causes of the appearance of the energetically capacitive disturbances in synoptic processes in the troposphere. Apparently, the main and comparable forcing factors of the impact of solar activity on the troposphere and lower stratosphere are directed spiral (vortex) radiation and fluxes of solar protons, however, only the former affects “effectively” all components without exception: the atmosphere, hydrosphere, magnetosphere, lithosphere, biosphere, and technosphere.

To forecast the destructive manifestations of SVR, it is necessary to carry out special surface and satellite monitoring of variations of SVR and solar radio bursts which are 6-7-h precursors of the arrival of SVR destructive impulses as well as to monitor the development of active formations on the Sun. An important step in understanding the impacts of SVR on cyclogenesis would be a complex monitoring of synchronous character of activation of cyclogenesis in the North-Atlantic center of action with the outcome from behind the disk of different-latitude active areas, with the SVR increase and variability of polarization characteristics of spectral solar microwave radiation monitored with the use of the Great radio-telescope at Pulkovo.

REFERENCES

[1] Kondratyev K. Ya. and Nikolsky G. A., *Studying the Earth from Space*, No. 5 (1995), 3 (in Russian).

[2] Kondratyev K. Ya. and Nikolsky G. A., *Studying the Earth from Space*, No. 6 (1995), 3 (in Russian).

[3] Kondratyev K. Ya. and Nikolsky G. A., *Stratospheric mechanism of solar and anthropogenic impact on climate*, in *Sun-Earth Connections, Weather and Climate* (Moscow, Mir Publ.) 1982, pp. 354-360 (in Russian).

[4] Kondratyev K. Ya. A and Nikolsky G. A., *Solar Physics*, **89** (1983) 215.

[5] Veretenenko S. V. and Pudovkin M. I., *J. Atmos. Solar-Terr. Phys.*, **61** (1999) 521.

[6] Abbot C. G., *Smith. Miscell. Coll.*, **110** (1948) 37

[7] Davydova E. I. and Davydov V. V., *Geomagn. Aeronom.*, **35** (1995) 163 (in Russian).

[8] Nikolsky G. A. and Shults E. O., *Sun-weather effects*, in *Proceedings Sci. Seminar "Ecology and Space": Problems of the Universe. Water ecology. 13 February 2004, St.-Petersburg* (SPbSU Publ.) 2004, pp. 36-43 (in Russian).

[9] Shchepetnov R. V., Troitskaya V. A. and Dovbnia B. V., *Dokl. Akad Nauk SSSR*, **363** (1986) 582 (in Russian).

[10] Krauklis V. L., Nikolsky G. A., Safronova M. M. and Shults E. O., *Opt. Atmos.*, **3** (1990) 227 (in Russian).