TRIGGER MECHANISM OF SOLAR-ATMOSPHERIC RELATIONSHIP AND THE CONTRIBUTION OF THE ANTHROPOGENIC IMPACT

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Abstract. A unified approach is suggested to the problem of impact of both space and several anthropogenic sources on the weather and climate changes. This impact is conducted by microwave ionospheric radiation with is generated both solar flares and by corpuscular precipitations from magnetosphere. Precipitations of electrons and proton fluxes from radiation belts take place during geomagnetic storms and also as result rocket launches, technological activity and at work of powerful radio transmitters.

We suggest three-stage radio-optical trigger mechanism for the influence of solar flares and geomagnetic storms on the weather characteristics. The first stage is an increase in generation of the microwave radiation which penetrates from the ionosphere to the earth surface. The second stage is a change in the proportion of water vapour to water clusters caused by increased microwave radiation. The third stage is a change of the atmosphere transparence in the absorption bands of water vapour and clusters. The atmosphere transparence determines the fluxes of solar irradiance coming down as well as flux of the thermal radiation coming out from the underlying surface. These fluxes form the basis of the thermal balance and affect the weather and climate characteristics of the lower atmosphere.

The maximum of secular cycles solar activity was observed in eighties last century. Since 1985 the total solar irradiance and ionizing fluxes have been decreasing but geomagnetic activity (aa - index) has been going up till 2003. Only during the last few years geomagnetic activity also started decreasing. This means that negative trends have come both for solar and geomagnetic activities. We suppose that according to our mechanism the natural global warming will go down to lower levels.

Introduction

The physical mechanism for natural global climate changes which happened during the last several 11-th solar cycles is considered. The mechanism explains how agents of solar and geomagnetic activities together affect low-atmospheric processes: with help the flux of microwaves from ionosphere, which are generated during solar flares and geomagnetic storms due to the excitation of Rydberg states of atoms and molecules in upper atmosphere by fast ionospheric electrons. It is here very important for climatic changes, that the maximum of seculars (near one hundred and near of two hundred years) cycle solar activity was observed in eighties last century.

In this paper are considered:

1) the novel radiooptical the three-stage trigger mechanism of the solar flare and geomagnetic storms influence at the weather and climate characteristics. [1].

2) forecasting of future climatic changes – a namely decrease of natural contribution of global warming, if take into account the sum of solar and geomagnetic activity together.

3) role of the new anthropogenic factor of the weather and climate – the experimentally registered precipitations of electrons from the radiation belts occurring during the period of work of power transmitters over the cyclotronic frequencies.

Microwave radiation from ionosphere during solar flares and geomagnetic storms as well as microwave bursts from the Sun are supposed to control the condensation processes in the low atmosphere and thus affect the weather. This physical mechanism is based on taking into account the excitation of Rydberg states of atoms and molecules in generation of the ionospheric microwave radiation and in realization of the dissociative recombination of cluster ions in troposphere [1].

Recently we can read [2]: “We show that over the past 20 years, all the trends in the Sun that could have had an influence on the Earth’s climate have been in the opposite direction to that required to explain the observed rise in global mean temperatures... Our results show that the observed rapid rise in global mean temperatures seen after 1985 cannot be ascribed to solar variability, whichever of the mechanisms is invoked and no matter how much the solar variation is amplified”. Indeed, since 1985 the total solar irradiance (this irradiance is the total solar energy flux received at the top of the Earth’s atmosphere) and EUV/X-ray ionizing fluxes have been decreasing. But geomagnetic activity (aa - index) has been going up till 2003 (+ 0.3 % / year), Fig. 1. Only during the last few years (on October 2007) geomagnetic activity also started decreasing (- 5.7 % / year). This means that negative trends after 2003 have come both for solar and geomagnetic activi-

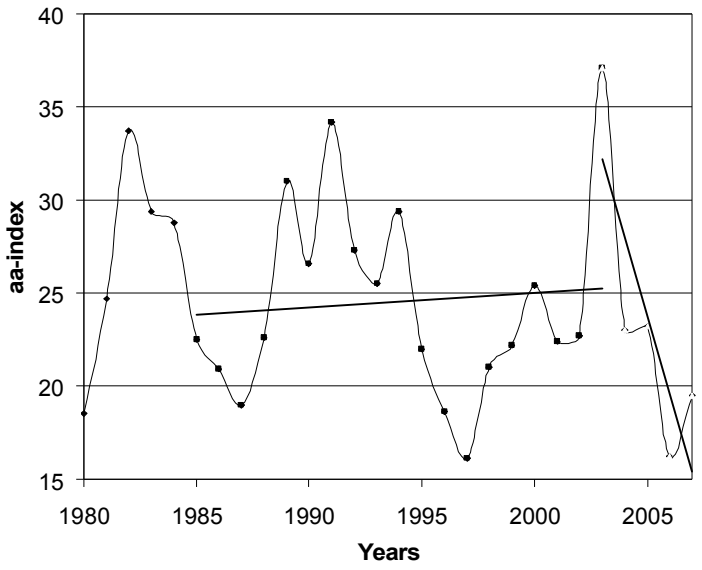

Fig. 1. Trends of the monthly aa-index of geomagnetic activity before and after 2003.

ties. We suppose that according to our mechanism the natural global climate changes will go down to lower levels.

There are also the change of sign for next trends of atmospheric parameters before and after 2000-2001:

- the Earth's albedo decreased during the period 1984 – 2000/1 and increase after the year 2000/1 [3],
- the content of water vapour increased in the atmospheric depth during the period 1980 – 2000 and decrease after the year 2001 (Kyrghyzstan, lake Issyk-kul station [4]),
- the total contents of ozone these decades, on the contrary, decreased, that has led to growth of a erythemal radiation in day time which also has started to decrease only with year 2000, then the content of ozone is increase [5].

Change of a sign on trend of total influence of solar and geomagnetic activity in generation of microwave radiation has actually occurred on 1-3 years earlier 2003, as was reflected in terms of change of signs in trends of the contents vapour of water, methane and ozone.

About the novel radiooptical trigger mechanism of solar-weather and climate links

In according to [6] it is necessary to propose the unknown trigger mechanism of ionospheric disturbance downward transfer into the troposphere under the action of the solar and geomagnetic activity factors (solar ionizing radiation and corpuscular fluxes from radiation belts) because the natural energy of weather–climate phenomena is very high. Avdyushin and Danilov [6] justified than such a necessity is related to the fact that the energy of the short waves (including the ionizing range) solar radiation, as well as that of corpuscles (electrons) from radiation belts and solar protons, cannot directly affect the troposphere because these fluxes do not reach the troposphere, being usually absorbed at much higher altitudes. Therefore, the effect of the solar ionizing radiation and corpuscular fluxes on the mesosphere and thermosphere should be somehow transferred downward, to the troposphere. Indeed, the mechanism of the effect of increasing solar activity on weather characteristics during geomagnetic disturbances due to the known Forbush decrease in the intensity of galactic cosmic rays was discovered (see [7] and references therein). However, these researchers repeatedly noted that solar flares, which lead a geomagnetic disturbance - magnetic storm - by approximately two days, also affect the weather characteristics, first of all, cloudiness. The effect of an increase in the UV (and X-ray) flux is registered several hours after a solar flare. This is directly related to the response of the degree of atmosphere transparency to the appearance of an enhanced flux of electromagnetic (UV) flare emission, when accompanying fluxes of the disturbed solar wind and SCRs have not yet reached the Earth's orbit [7].

During the last decades the influence of galactic cosmic rays (GCR) and solar cosmic rays (SCR) on the cloudness has been studies in detail. The factors of influence are Forbush decrease of GCR and sporadic increase of SCR. However these events are rare. For instance, geomagnetic storms (with Kp more than 5) occur 20-80 times per year and solar flares (class greater than M5) take place 50 times per year [8] whereas Forbush decrease of 3 % and more occurs only 2-4 times per year and solar proton events at energy than 100 MeV take place 5 times per year that is approximately ten times lesser.

We propose to solve this problem in a new way by introducing a "three-stage trigger." The first stage is transformation of the energy factors of solar (increased flux of ionizing radiation) and geomagnetic (precipitating corpuscles from radiation belts) activities in the ionosphere into the flux of microwaves, penetrating to the Earth's surface within the troposphere. This is a direct trigger (initiating triggering mechanism) since direct information relation between the upper atmosphere and the entire troposphere originates precisely during this stage, which was previously ignored in the solar–terrestrial coupling [9]. The second stage is regulation of the production and destruction rates of water cluster ions at altitudes where the condensation

mechanism operates and initiates the generation of cloud and aerosol layers in the lower atmosphere (at altitudes higher than 3–4 km; i.e., in the zone of influence of galactic cosmic rays) and stratosphere (in the zone of SCR absorption) [10]. In this stage taking into account Rydberg states excitation at the preliminary stages of association and dissociation of clusters (as well as ionized clusters) of water vapour and carbon dioxide. The rates of association and dissociation processes depend strongly on the magnitude of the Rydberg state orbital quantum number. An increase in the orbital quantum number by one results in a decrease of cross-sections of the dissociation processes by an order of magnitude. According to the developed theory [9]. this increase in the quantum number is caused by stimulated absorption of the ionospheric microwave radiation quanta as well as solar radiobursts radiation quanta during the periods of increased solar and geomagnetic activity (or anthropogenic precipitation impact).

The third stage consists in the evident role of formed clouds and aerosol layers in weather–climate phenomena via absorption and reflection of certain part of the solar radiant energy and thermal flux from the underlying surface by these formations [10]. There is various role cloudiness in global warming. According to [11], the net radiative properties of a cloud are mainly depend on its altitude and optical thickness. Optically-thin clouds at high and middle altitudes cause a net warming due to their relative transparency at short wavelengths but opacity in the IR region, whereas thick clouds produce a net cooling due to the dominance of the increased albedo of short-wave solar radiation, and according to [12], the role of high clouds in the radiation budget of the earth-atmosphere system depends on optical depths; high thin cloud acts to warm the atmosphere, while high thick cloud cools. Thus, the decrease in high clouds can reduce both the warming and cooling effect to the system. But it is clear that because of relatively low power of the ionospheric microwave radiation (in comparison with atmospheric energy) its influence on the clusterization leads to formation of optically-thin clouds at the high altitudes.

On the whole, the proposed three stage physical mechanism is an intensifying process since a low energy of cosmic factors regulates fluxes of incoming and outgoing radiation in the lower atmosphere owing to strong energy variability. According to numerous calculations [7, 10], even 6% weakening of the solar radiant energy flux due to reflection and absorption at altitudes of several kilometers can explain the observed contribution of solar and geomagnetic activities to weather phenomena. In addition, resonance absorption can participate in this process because the characteristic microwave emission of ionospheric nitrogen and oxygen molecules in Rydberg transitions in the lower atmosphere by Rydberg excited nitrogen and oxygen molecules participating (as an ambient gas) in collisional dissociative recombination of cluster ions from water vapor and carbonic acid molecules [13].

We emphasize that all stages of the proposed novel radiooptical mechanism are experimentally confirmed:

(i) the microwave ionospheric emission, which intensifies during solar and magnetic storms, was detected in [14, 15];

(ii) the regulation of humidity at altitude higher than 3 km by the solar microwave emission and flares was registered in [16, 17];

(iii) a direct influence of solar flares and magnetic storms on the total cloudiness is distinctly registered [18, 19, 20].

Our contribution consists in that we determined the mechanism of generation of the ionospheric microwave emission in transitions between highly excited (Rydberg) states and used the processes of dissociation and association of complex ions well known in physics of atomic collisions [13, 21, 22, 23] via intermediate Rydberg levels. In the case of association (i.e., formation of clusters), the process proceeds through the addition of proton to parent molecules owing to their high affinity to proton. Produced ions are neutralized when electron is trapped at a Rydberg orbital. The orbital moment, the value of which can change during absorption of quanta of the microwave emission from the ionosphere, is the main characteristic of Rydberg levels affecting the rate of the considered elementary processes.

Rydberg microwave emission of ionosphere during precipitation of electrons from the radiation belts caused by radio transmitters

Industrial greenhouse effect is usually suggested as a cause of global rise of the surface temperature over the last few decades. In this paper we propose to draw attention the new anthropogenic component – influence of powerful radio transmitters (navigation and communication) on the particles in radiation belts of the Earth. This anthropogenic factor affects mainly the electrons from inner and outer belts over the cyclotronic frequencies i.e. frequencies of the Larmor precession. These frequencies belong to very low frequency (VLF) range: from few to few tens kilo Hertz.

Surface transmitters with such frequency have power up to 1 Mw that cause precipitations and result in optical emission above the transmitter. Intensity of these emissions is of the same scale with the aurora of the class two or more in the international IBC II system. Thus, precipitations simulated by VLF transmitters we suggest to consider as anthropogenic analogue of the aurora caused by magnetic storm.

Let us estimate contribution of this phenomenon into microwave radiation of ionosphere, which according to experiment [1 16, 17] and its interpretation suggested in [1, 24] could control processes of condensation and cloud generation in the lower atmosphere. Previously, we considered global geomagnetic storms in the problem "Sun-weather" [24] and showed that during geomagnetic storms microwave radiation from Rydberg states, caused by ionospheric fast electrons (secondary electrons and Auger electrons), controls rate of cluster generation as well as during solar flares.

We take into account results [13] connected with influence of the orbital quantum number (l) of the Rydberg state on the rate of dissociative recombination of cluster ions. These results show that this rate decrease when high l levels are filled when strong fluxes of the microwave radiation appear [1, 24]. This could activate cyclonic activity [25]. Moreover generation of optically thin clouds of the upper layer might cause warming of the near surface air [11].

Thus we can make very important for the modern climatology conclusion that two important features of the modern climatic change: (a) global warming and (b) permanent increase in cyclone number (192 cyclones from 1970 to 1992 and 162 over the next 10 years [25, 26]) have the same nature – global increase of the number and power of VLF transmitters particularly near maritime coast regions where the cyclogenesis takes place. This conclusion is based on analysis on intensity of the stimulated electronic precipitations which are comparable with the precipitations during the global geomagnetic storms. Results of measurements performed by the satellite DEMETER [27, 28] confirm very high extent of disturbance of radiation belts and ionosphere during night above the zone of work of VLF transmitters both in Northern Hemisphere (transmitter NAA in USA with coordinates 44°39 N, 67°17 W), and in Southern Hemisphere (transmitter NWC in Australia with coordinates 21°47 S, 114°09 E). Areas of the stimulated electronic precipitations and areas of perturbed ionosphere are linked either with the magnetic force line at which the surface VHL transmitter is situated or with the magnetic line at which effect of radio wave on the pitch angle of electron, captured in radiation belt, takes place. In full agreement with the law of latitudinal drift in dipole magnetic field there is some expanding of the perturbed region eastward thus area of the stimulated perturbations reach a half of million of square kilometers [28]. Every time perturbation of less scale are observed in magnetic conjugate area. In accordance with our calculations [29] rate of the optical excitation of ionosphere in the conjugate point and hence, generation of microwave radiation from Rydberg states reaches 10 % of the effect in the point of the transmitter work. Intensity of precipitations corresponds to the main phase of geomagnetic storm. This conclusion is made by us after comparison of the data [27, 28] considering the scale [8], with the results of measurements of fluxes of electrons precipitating from radiation belts during global geomagnetic storms performed by satellites "Kosmos-348" [30] and "Kosmos-381" which had radiometric equipment made in State Optical Institute [31]. Actually, according to [31, 32] increases in electronic fluxes, precipitating to middle latitudes from radiation belts, occur during periods on 2-3 hours over the main and recovery phase with energies at least 300 times larger than 2.5 and 25 KeV. This regards also to latitudes more than 45° for both day and night conditions in both hemispheres. But just these increases of electron precipitation, stimulated by work of VFL transmitter are registered by DEMETER satellite [27] even over the lower latitudes. Experiment [27] showed also that stimulated precipitations correlate well with the level of geomagnetic perturbation. Fluxes, registered by DEMETER are few order of magnitude higher than levels measured by the satellite "Oreol-2" for the same energy of electrons in the work [33] for discrete forms of aurora.

Thus precipitation of electrons from radiation belts, registered over periods of VFL transmitters have fluxes close to that from the global magnetic storm. Such storm is accompanied by intensive emission of all the upper atmosphere [29] which is aurora. Hence, according to results of our investigation [1, 24, 9, 34] these simulated precipitations of electrons to ionosphere should cause excitation of Rydberg states with the corresponding emission of microwave radiation with intensity up to $10^{-12} – 10^{-11}$ W cm^{-2} [24]. It should be noted, however, that we have not enough information on the spectra of electrons precipitating due to influence of VLF transmitters [27, 28, 35, 36] that brings some limitations in energy estimations. High altitude experiments [1, 24] showed that microwave emission in 2-10 cm range might influence process of cluster generation in the lower atmosphere. According to our hypothesis [1, 24] that should reflect in changes of the weather and climate parameters. Since radio and VLF transmitters are both products of the industrial activity of 20th century probably it is necessary to take into account its geography and working regime when research solar-weather and solar-climate phenomena.

Conclusion

The new radiooptical mechanism of the action of solar and geomagnetic activity on the weather and the climate is substantiated. Suggest integral approach to the problem of the control of weather and climatic changes by both the natural - space sources and by some anthropogenic (technogenic) actions. In this case is examined the united agent of this control - microwave emission of the terrestrial ionosphere, which appears with atoms and molecules excitation of gases of the upper atmosphere by fast ionospheric electrons into the highly excited (Rydberg) states. Fast ionospheric electrons with the energies more than 10 - 15 eV are formed with the photoionization of the upper atmosphere under the effect of X-ray and extreme UV solar radiation, with the corpuscular precipitations both in the period of geomagnetic storms and under the anthropogenic influences. The latter (emission of powerful radio stations, electric power lines, starting space rockets, industrial activity) ensure the locality of precipitations (because the most of them induce VLF emissions) and, correspondingly, the local action of the microwave radiation of the ionosphere on the weather characteristics. Additionally locality they ensure coastal effect, and thunderstorms, is possible also connection with breakings of the earth's crusts, the centers of the preparation of earthquakes.

The negative trends after 2003 have come both for solar and geomagnetic activities. We suppose that according to our mechanism the natural global climate changes will go down to lower levels. Role of the new anthropogenic factor of weather and climate changes – the experimentally registered precipitations of electrons from the radiation belts occurring during periods of work of powerful transmitters over the cyclotronic frequencies – also is discussed.

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