GEODYNAMICS & TECTONOPHYSICS

PUBLISHED BY THE INSTITUTE OF THE EARTH'S CRUST
SIBERIAN BRANCH OF RUSSIAN ACADEMY OF SCIENCES

2019 VOLUME 10 ISSUE 3 PAGES 673–685 ISSN 2078-502X

https://doi.org/10.5800/GT-2019-10-3-0434

DYNAMICS FOR GEOMAGNETIC PULSATIONS, FIELD-ALIGNED CURRENTS, AND AIRGLOW AT MID-LATITUDES WITHIN SUBSTORM ACTIVATIONS DURING SUPERSTORMS

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Abstract: Within substorm activations during two superstorms (2000 and 2003) from the observations at mid-latitude geomagnetic observatories, we study short-period irregular geomagnetic pulsations and airglow in the 557.7 nm and 630.0 nm atomic oxygen emission lines, and in the 391.4 nm ionized nitrogen molecular band. Through the genuine magnetogram inversion technique, from the 1-minute data of the ground-based magnetometer global network, we investigate the distribution dynamics for field-aligned currents (FACs) in the ionosphere. The relation is shown between pulsation bursts and airglow disturbances in the post-midnight sector to precipitations of energetic electrons (~keV) and increase in the R2 upward FACs.

Key words: geomagnetic pulsations; storm; substorm; airglow; mid-latitude aurora

Recent Geodynamics

The article is published on the basis of the report made by the authors at the XII Russian-Mongolian International Conference "Solar-Terrestrial Relations and Geodynamics of the Baikal-Mongolia Region" (October 1–5, 2018, Irkutsk)

RESEARCH ARTICLE

Received: January 11, 2019
Revised: May 7, 2019
Accepted: May 23, 2019

For citation: *Klibanova Yu.Yu., Mishin V.V., Mikhalev A.V., Tsegmed B., Karavaev Yu.A., Kurikalova M.A.*, 2019. Dynamics for geomagnetic pulsations, field-aligned currents, and airglow at mid-latitudes within substorm activations during superstorms. *Geodynamics & Tectonophysics* 10 (3), 673–685. doi:10.5800/GT-2019-10-3-0434.

Динамика геомагнитных пульсаций, продольных токов и свечения ночной атмосферы на средних широтах во время суббуревых активизаций в ходе супербурь

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Аннотация: Во время суббуревых активизаций в ходе двух супербурь 2000 и 2003 гг. по данным наблюдений среднеширотных геомагнитных обсерваторий ИСЗФ СО РАН (Монды, Узур) и обсерватории Борок ИФЗ РАН исследуются короткопериодные иррегулярные геомагнитные пульсации, а также свечение ночной атмосферы в эмиссионных линиях кислорода 557.7, 630.0 нм и молекулярной полосе ионизованного азота 391.4 нм (по оптическим данным геофизической обсерватории ИСЗФ СО РАН Торы). С помощью оригинальной техники инверсии магнитограмм ИСЗФ по одноминутным данным мировой сети наземных магнитометров исследуется динамика распределения плотности продольных токов в ионосфере. Показана связь всплесков пульсаций и возмущений в свечении атмосферы в послеполуночном секторе с высыпанием энергичных электронов (~кэВ) и усилением вытекающих продольных токов зоны R2.

Ключевые слова: геомагнитные пульсации; буря; суббуря; свечения ночной атмосферы

1. Introduction

Studying geodynamics includes not only processes in the Earth crust, but also in the atmosphere and in the near – Earth space. Analyzing the features of variations in the Earth geomagnetic field is an important component of not only geodynamics, but also of space weather, a discipline of solar-terrestrial physics actively developed over the last years.

When studying the main objects of space weather and of geodynamics – magnetospheric substorms and storms – one observes geomagnetic pulsations of various types, as well as auroras with the intensity exceeding 100 kR. These events are accompanied by an increase in electric fields and currents in the ionosphere of the auroral zone that, during superstorms (sometimes observed strongest storms), can spread to the mid latitudes [*Troitskaya, Gul'elmi, 1967; Pudovkin et al., 1976; Tinsley et al., 1986; Brunelli, 1988; Rassoul et al., 1993; Kangas et al., 1998; Mikhalev et al., 2004; Zverev et al., 2012; Leonovich et al., 2013; Li, Wang, 2018*]. During the 2003 Nov 20 storm (one of the strongest), from the mid-latitude geophysical observatories located near Irkutsk (CGM: 47.3° Φ, 177° Λ) in the post-midnight MLT sector, there recorded short-period Pi1B/Pi1C pulsations, and disturbances of optical emissions in the 557.7 nm and 630.0 nm atomic oxygen [OI] lines, as well as in 391.4 nm ionized nitrogen molecular band, with record-breaking intensity values [*Mishin et al., 2018*]. The authors of the latter paper related the generation of these pulsations and an increase in the 557.7 nm and the 391.4 nm emissions to the precipitation of energetic electrons (~ keV) in the western electrojet head area. The model calculations of the ionosphere parameters showed that the total intensity of the 630.0 nm emission was caused by the process of collision between oxygen atoms and thermal electrons [*Mishin et al., 2018*].

To continue [*Mishin et al., 2018*], we analyze the behavior of short-period pulsations in greater detail here. In this analysis, we also included the 2000 Apr 6 superstorm, during which *Zolotukhina* [*2005*] from data of the Mondy (MND) Observatory investigated the irregular pulsations of the decay period (IPDP) and the Pc1,2 pulsations, but the author did not address the PiB pulsations, as well as the relation between the pulsations and field-aligned currents (FACs) and airglow. The pulsation noise bursts recorded during the superstorms may be attributed (by morphological signatures) to geomagnetic PiB pulsations that comprise a short-period part, Pi1B (T=0.5–40 s) and a long-period one, Pi2, Pi3 (T=40–600 s) [*Saito 1969, Kangas et al., 1998*]. We analyze the Pi1 short-period pulsations (T=0.5–40 s) of all types (Pi1B, Pi1C, IPDP) by using the observational data of the Borok (BOR) Observatory during the 2000 Apr 6 storm. All of them are usually observed at high latitudes, subauroral and auroral [*Kangas et al., 1998*].

2. Database

We use the geomagnetic data obtained at the MND (CGM: 47.5° Φ, 177.5° Λ) and Uzur (UZR, CGM: 48.5° Φ, 180.7° Λ) Observatories, both being the facilities at the Institute of Solar-Terrestrial Physics of Siberian Branch of Russian Academy of Sciences (hereinafter – ISTP SB RAS), and also at the BOR Geophysical Observatory (CGM: 53.9° Φ, 114° Λ), a branch of the Federal State Budgetary Institution of Science Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences. The data temporal resolution is 0.1 sec. We study airglow in the 557.7 nm and 630.0 nm oxygen emission lines, and in the 391.4 nm ionized nitrogen molecular band from optical observations at the ISTP SB RAS Tory (TOR) Geophysical Observatory (CGM: 47° Φ, 177° Λ) [*Afraimovich et al., 2002*]. Besides, we use the 1-min data of the global ground-based magnetometer network, including the Irkutsk Magnetic Observatory (IRT) data. From these data, by using a genuine magnetogram inversion technique (MIT-ISTP SB RAS) [*Bazarzhapov et al., 1979; Mishin, 1990*], we obtained time series of maps for FAC distribution in the ionosphere. On the maps, we defined the boundaries of the FAC regions by the classification from [*Iijima, Potemra, 1978*]. In this study, we also compare the behavior of the geomagnetic pulsation intensity and the airglow intensity with the position of the FAC low-latitude region southern boundary during the addressed events.

The description of the analyzed events from the ground-based and satellite geomagnetic and optical observations is presented in a number of papers [*Huttunen et al., 2002; Mishin et al., 2010; Mikhalev et al., 2004; Ebihara et al., 2005; Hairston et al., 2005; Hori et al., 2006; Mishin et al., 2007; Solovyev et al., 2008; Karavaev et al., 2009; Valladares et al., 2015; Mishin et al., 2016; Mishin, Karavaev, 2017; Mishin et al., 2018*].

3. Observational data of geomagnetic and optical disturbances during superstorms

3.1 The 2000 Apr 6-7 superstorm

The 2000 Apr 6 superstorm sudden commencement (SSC) was recorded at 16:40 UT, when the solar wind (SW) dynamic pressure (P_d) increased from 1 to 14 nPa. The D_{st} index reached its minimum (–287 nT) at about 23 UT [see the reference in *Mishin et al., 2013*]. Within the 2000 Apr 6 14:00 UT and Apr 7 00:20 UT, the MND and BOR recorded several types of geomagnetic pulsations: PiB bursts, irregular Pi1C, and IPDPs. Besides, within 14–21 UT (Apr 6) and 14–17 UT (Apr 7), mid-latitude auroras were observed at the TOR [*Afraimovich et al., 2002; Mikhalev, 2013*].

Fig. 1 presents the variations in: SW dynamic pressure (P_d), IMF (magnetic induction vector **B**), SYM–H, AE, AL, and AU – indices of geomagnetic activity from (http://omniweb.gsfc.nasa.gov), and the H-component of the geomagnetic field from the IRT (http://wdc.kugi.kyoto-u.ac.jp).

Let us analyze the behavior of geomagnetic pulsations within two time intervals: the 2000 Apr 6 14–20:40 UT, and the 2000 Apr 6 20:40 UT – 2000 Apr 7 00:20 UT. Recording the airglow was performed only within the first interval, when the TOR was in the region unlit with the Sun (Fig. 2). Figs. 3 and 4 present the dynamic spectra of geomagnetic pulsations within the periods (T=0.2–600 s) with indications of the intensity values (in arbitrary units). Within the first interval (14–20:40 UT), one observed several broadband PiB bursts simultaneously with airglow disturbances in the 557.7 nm and 630.0 nm oxygen, and in the 391.4 nm ionized nitrogen molecular band (Fig. 2, 3). From the MIT data, we obtained the FAC distribution maps for the analyzed intervals, which allowed us to define the boundaries of the FAC R0, R1, and R2 regions. Fig. 5 provides an example of such a map for 20:25 UT, when the MND and BOR were in the low-latitude R2 region of the auroral oval. The southern boundary of this region at the storm onset was north of Irkutsk and sank to the Irkutsk latitude within 19:00–20:30 UT. From the IRT 1-min data for the H-component, one can see manifestations for substorm activations in the form of two bays. Their onsets coincide with the AE–index growth and the AL sharp drop at ~16:40 UT and at ~20:00 UT (see Fig. 1). Herewith, the AE–index reaches high values: ~2500 nT and ~1250 nT, respectively. The first (noise) pulsation burst within a broad range of periods, that, by morphological signatures, may be attributed to PiB pulsations, was recorded at midnight at the MND and, in the dusk sector, at the BOR at~16:40 UT. From that time on, one observed a gradual increase in the intensities of the 557.7 nm (to 180 R), 630 nm (to ~250 R), and of the 391.4 nm ionized nitrogen molecular band emissions. At 17:10 UT, the MND recorded a PiB burst, when the SW dynamic pressure (P_d) reached the next maximum and the AE–index grew. Another PiB burst was recorded at both observatories during the next jump in the P_d and in the AE–index at 18:06 UT [*Mishin et al., 2010*] against gradual increase in the emission intensities of the 557.7 nm, 630.0 nm, and in the 391.4 nm. Dramatic variations in the 557.7 nm and 630.0 nm emissions were observed near 19:00 UT. A powerful PiB burst at ~20:00 UT was recorded both in the nightside sector (MND) and, with a higher amplitude value, in the pre-midnight sector (BOR). Herewith, one observed sufficiently dramatic increases in the

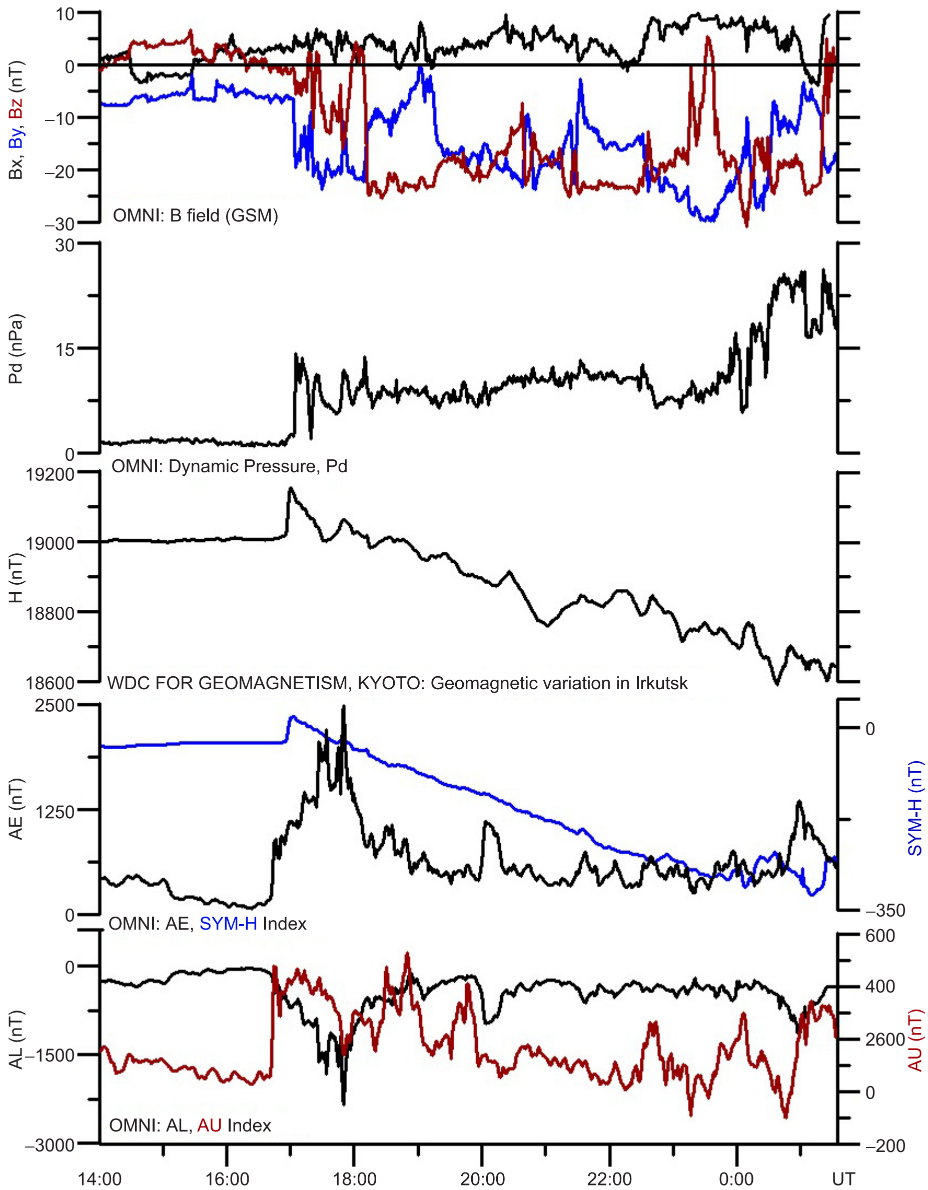

Fig. 1. The 2000 Apr 6–7 storm. Variations in IMF components, solar wind dynamic pressure (P_d), H-component of the geomagnetic field at the IRT, SYM-H ring current indices, and (auroral) geomagnetic activity AE, AL and AU.

Рис. 1. Буря 6–7 апреля 2000 г. Вариации компонент ММП, динамического давления солнечного ветра (Pd), H-компоненты геомагнитного поля в обс. Иркутск (IRK), индексов кольцевого тока SYM-H и (авроральной) геомагнитной активности AE, а также AL и AU.

intensities of, first of all, 630 nm (to 3000 R) and 557.7 nm (to 280 R) emissions.

Within the other interval (20:40–00:20 UT), the value of the SYM-H ring current index gradually drops and reaches its minimum (–340 nT). At the MND and BOR, one observed several kinds of pulsations: bursts of broad-band irregular PiB pulsations, continuous short-period noise Pi1C, and IPDPs (Fig. 3). The PiB burst at ~20:55 UT was recorded only at the BOR, when the latter appeared inside the R2 region, while the MND remained south of the R2 boundary.

The next PiB burst was observed at ~21:15 UT only at the MND, when the R2 southern boundary appeared near this observatory, and, on the contrary, departed north of the BOR. The PiB bursts were observed simultaneously at the MND and BOR at ~21:40 UT, ~22:15 UT, and ~22:40 UT, within substorm activations, i.e., increases in the AE- and AL-indices (see Fig. 1). At those instants, the R2 southern boundary reached the BOR and came close to the MND. The most powerful PiB burst was recorded at both observatories against a dramatic SW pressure increase at ~23:10 UT, when both observatories appeared inside the R2 region, which was accompanied by an increase in the AE– and AL–indices (see Fig. 1). Except the PiB bursts described above, both observatories recorded long-term series of

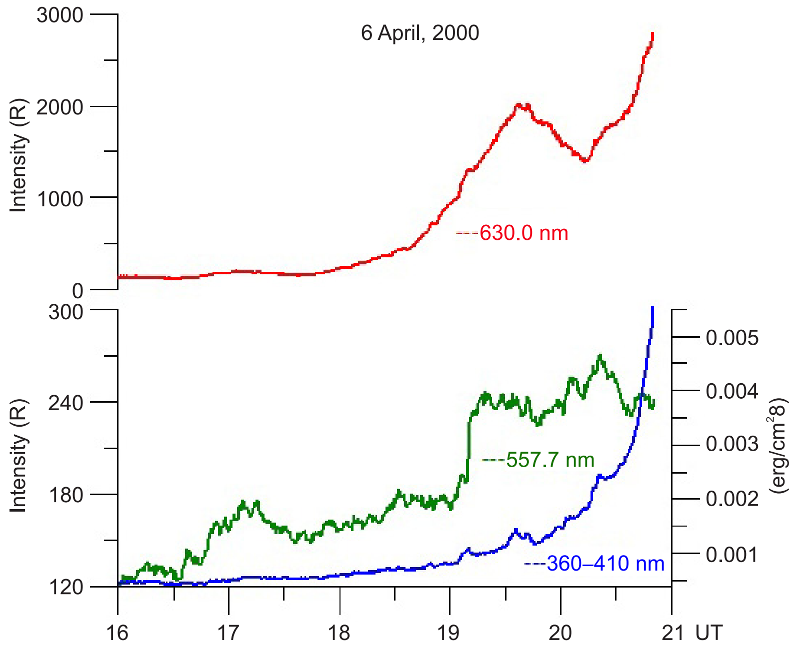

Fig. 2. Variations in the intensities of the 557.7 nm (green), 630 nm (red) emissions, and the 360–410 nm spectral range (blue) from the TOR data during the 2000 Apr 6 superstorm, within 16–21 UT.

Рис. 2. Вариации интенсивности эмиссий 557.7 нм (зеленая линия), 630 нм (красная линия) и спектральный диапазон 360–410 нм (синяя линия) по данным обс. Торы во время супербури 6 апреля 2000 г. в интервале времени 16–21 UT.

the Pi1C pulsations. Herewith, increases in amplitude for two types (Pi1C and IPDP) pulsations were observed at the MND within 22:20–23:40 UT, when the R2 southern boundary reached the latitude of that observatory. At the BOR, IPDPs were recorded only within a short interval near 23:25 UT in the upward FAC amplification region.

3.2. The 2003 Nov 20 superstorm

The 2003 Nov 20 superstorm SSC caused by arrival of a powerful interplanetary magnetic cloud was recorded at 08:03 UT. An extended Dst–index minimum (with a peak value = –422 nT) was observed within 18–21 UT (see reference in [*Mishin et al., 2016*]). In both superstorms, one observed several substorm activations [*Huttunen et al., 2002; Baishev et al., 2008*]. During the 2003 Nov 20 superstorm, one observed powerful bursts of geomagnetic pulsations and airglow intensities in the green (557.7 nm) and red (630.0 nm) atomic oxygen lines at the mid-latitude UZR and TOR observatories [*Mishin et al., 2018*]. From the IRT data one in a geomagnetic field H–component in the interval 16:30–21:00 UT can see two bays (activation of substorm activity) with minima at 17:24 UT and 19:39 UT. Let us address the behavior of geomagnetic pulsations in each bay, specifically, within 16:30–18:20 UT, and 18:20–21:00 UT (Fig. 6, *a*, *b*).

Powerful PiB bursts and 557.7 nm emissions were recorded during the first activation of substorm activity (bay) near the storm main phase evolution maximum at 17:32 UT and 17:56 UT (Figs. 6, 7). At the same instants, the auroral oval southern boundary reached the latitude of Irkutsk [*Mishin et al., 2018*]. Herewith, one observed continuous Pi1C, and after the PiB bursts, there came IPDPs (see Fig. 6, *a*). At 17:56 UT, increases in the AE– and AL–indices were observed (Fig. 7). During the next substorm activation within 18:20–21:00 UT, against the continuous Pi1C, IPDPs were also observed (see Fig. 6). Note that the 557.7 nm emission main maximum was recorded during the increase in the Pi1C/IPDP amplitude at 19:15 UT. Herewith, the UZR and TOR appeared within the R2. Later, powerful PiB bursts were observed at 19:35 UT and 20:00 UT, and, between the latter (at 19:45 UT), the 630.0 nm emission main maximum was recorded, when the UZR appeared inside the R2.

4. Discussion

Broad-band PiB bursts are preferentially observed in the auroral and subauroral regions, and their generation is related to precipitating energetic electrons with the ~10 keV energy and increase in the auroral electrojet during substorms [*Heacock, 1967; Kangas et al., 1998*; *Rakhmatulin et al., 1979*]. During the two

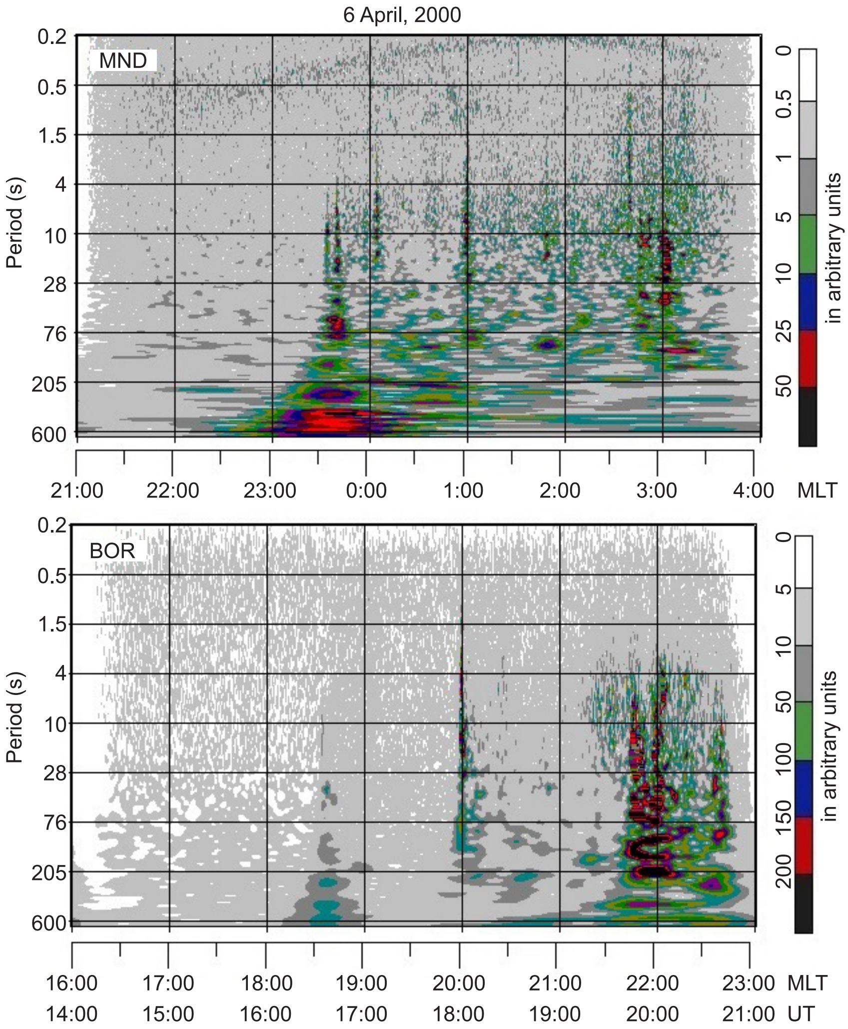

Fig. 3. Dynamic spectra of geomagnetic pulsations from the MND and BOR during the 2000 Apr 6–7 superstorm within 14:00–21:00 UT. Shown are the amplitude variations depending on the period (ordinate), universal time (UT) and magnetic local time (MLT). The relative amplitude values feature a color scale in relative units.

Рис. 3. Динамические спектры геомагнитных пульсаций по данным обсерваторий Монды и Борок во время супербури 6–7 апреля 2000 г. в интервале 14:00–21:00 UT. Показаны вариации амплитуды в зависимости от периода (ордината), мирового времени (UT) и местного магнитного времени (MLT). Значение относительной амплитуды характеризуется цветной шкалой в относительных единицах.

addressed superstorms, broad-band PiB bursts were observed during substorm activity increase against the continuous short-period noise Pi1C pulsations, and were accompanied by IPDP increases and by airglow disturbances in the 557.7 nm and 630.0 nm atomic oxygen emission lines, and in the 391.4 nm ionized nitrogen molecular band at the mid-latitude stations in the MLT spaced sectors.

The 2000 Apr 6 superstorm sudden commencement coincides with the onset of the substorm active phase, because the substorm growth phase started with the IMF southward turn at ~16:00 UT [*Mishin et al., 2010*]. Before the SW inhomogeneity main front caused SSC, two pre-amplifications in the SW density and dynamic pressure were recorded. They could activate geomagnetic activity before the SSC [*Mishin et al., 2013*]. At the SSC instant, against a dramatic jump in the SW dynamic pressure (P_d) and in the IMF transversal components (B_y and B_z), one observed some phenomena characteristic of the indicated substorm active phase onset: AE–index growth, powerful noise burst with the characteristic morphological PiB properties, and the onset of airglow increase. At that instant, the R2 southern boundary was north of the MND and BOR latitudes, where, nonetheless, one observed PiB bursts and 557.7 nm and 630.0 nm emissions in various longitudinal sectors. Supposedly, the pulsations and the increase in the airglow observed at 16:40 UT were related to both a strong compression of the magnetosphere [*Huttunen et al., 2002*] and the substorm development beginning [*Mishin et al., 2010*], as well as to the shock passing through the magnetosphere [*Samsonov et al., 2007*].

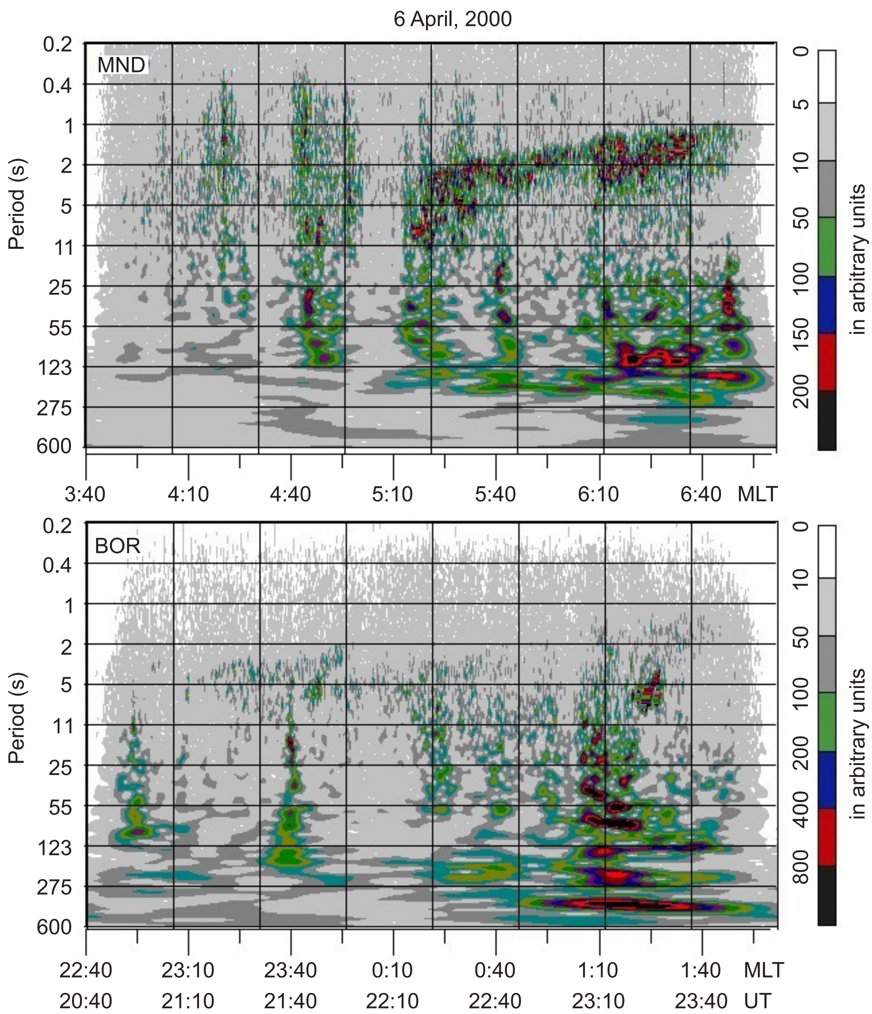

Fig. 4. Dynamic spectra of geomagnetic pulsations from the MND and BOR during the 2000 Apr 6–7 superstorm within 20:40–00:20 UT. Designations are the same as in Fig. 3.

Рис. 4. Динамические спектры геомагнитных пульсаций по данным обсерваторий Монды и Борок во время супербури 6–7 апреля 2000 г. в интервале 20:40–00:20 UT. Обозначения такие же, как на рисунке 3.

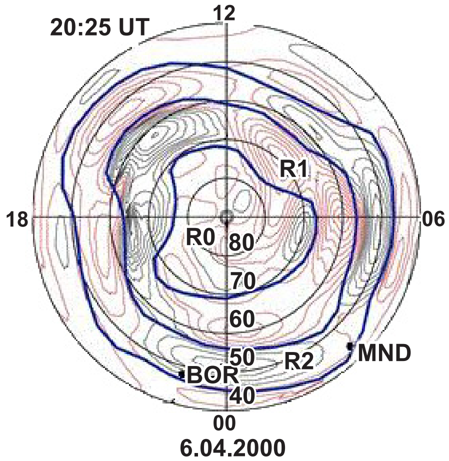

Fig. 5. FAC map for 2000 Apr 6 20:25 UT in the geomagnetic dipole coordinates: the latitude – MLT. Bold blue lines show the boundaries of field-aligned current regions R1, R2 and R0 (polar cap). Auroral oval is between the R0 and R2 boundaries. Black fat points show the positions of the MND and BOR observatories.

Рис. 5. Карта распределения продольных токов для момента времени 20:25 UT 6 апреля 2000 г. в координатах: дипольная геомагнитная широта – MLT. Показаны границы зон продольных токов R0, R1, R2 (жирные синие линии) и положение обсерваторий Монды (MND) и Борок (BOR) (черные жирные точки). Авроральный овал расположен между границами зон R0 и R2.

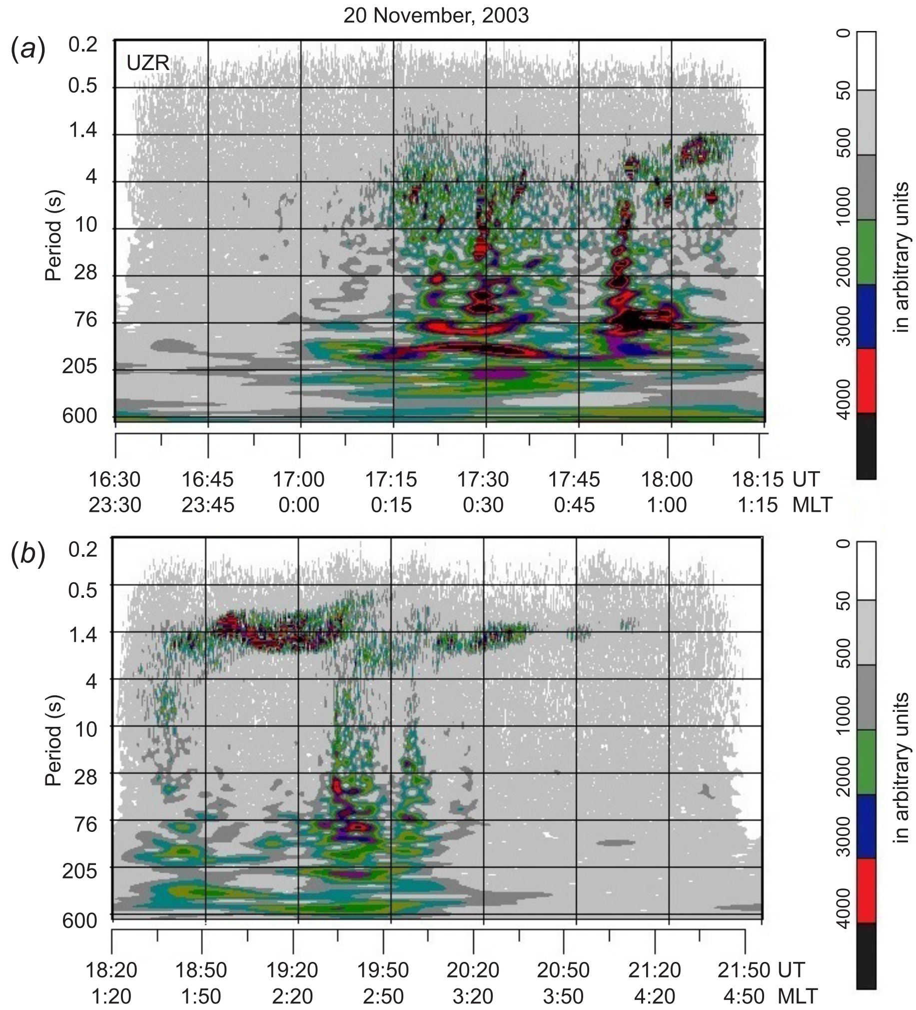

Fig. 6. Dynamic spectra for geomagnetic pulsations from the UZR during the 2003 Nov 20 superstorm for 16:30–18:20 UT (*a*) and 18:20–21:00 UT (*b*).

Рис. 6. Динамические спектры геомагнитных пульсаций по данным обсерваторий Узур (UZR) во время супербури 20 ноября 2003 г. для интервалов 16:30–18:20 UT (*a*) и 18:20–21:00 UT (*b*).

During the following substorm activations at 17:10 UT and 18:06 UT, one observed powerful PiB bursts, but only at the MND for the first instant, and, for the other, it was simultaneously at both observatories in the pre- and post-midnight sectors. These PiB bursts coincided with the onsets of the substorm expansion phases determined from the IMAGE network high-latitude stations located in the dusk sector [*Huttunen et al., 2002*]. Simultaneously with the PiBs, there were noted weak disturbances of 557.7 nm and 630.0 nm emission intensities, as well as of the 391.4 nm nitrogen band intensity. Herewith, the R2 southern boundary did not reach the latitudes of Irkutsk, and, consequently, there were no precipitations of energetic particles at that instant. Geomagnetic field disturbances at the above 17:10 and 18:06 UT were also observed by the observatories of the INTERMAGNET network at high latitudes of the dawn (CMO) and of the premidday (FCC and BLC) sectors, as well as at lower latitudes of the night sector (KAK). We assume that the observed PiBs and disturbances in the airglow were related to the energetic particles, whose precipitations occurred in the north, and might be caused by the SW dynamic pressure jumps (see Fig. 1).

During the 20:00 UT substorm activation, the R2 southern boundary reached the latitudes of the MND and BOR, where powerful PiB bursts were observed. Also, there was a sharp increase in the 557.7 nm and 630.0 nm emission intensities, as well as in the 391.4 nm nitrogen band intensity at the TOR. Hence, one may assume that the PiB bursts and increases in the above intensities at that instant were related to the increases in the upward FACs and the FAC-related precipitations of energetic electrons in the ionosphere (E≥keV) during the substorm activity evolution.

Within the other interval, like in the first, the PiB bursts were observed during the beginnings of the substorm development, when the mid-latitude observato-

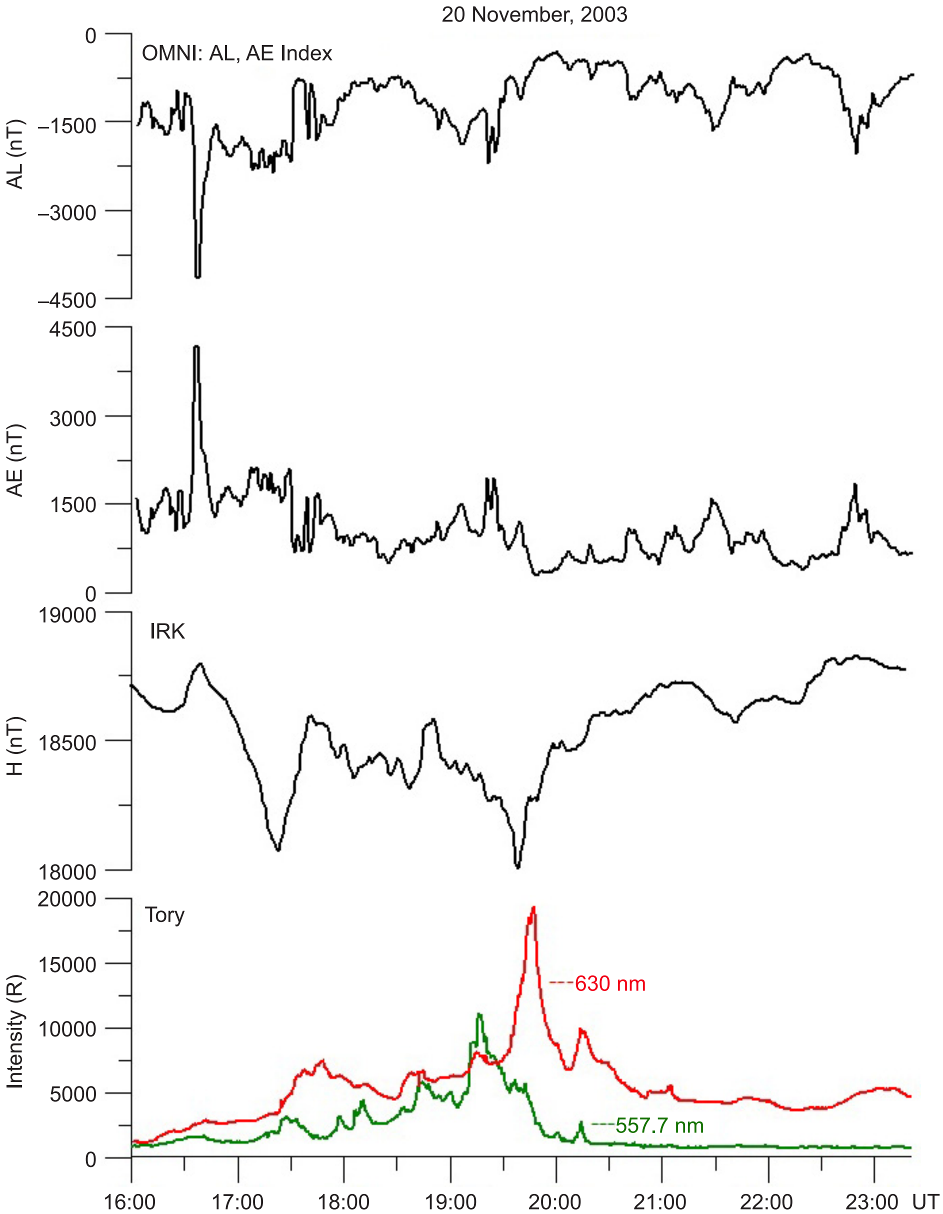

Fig. 7. The 2003 Nov 20 storm. Variations in: auroral activity AL and AE indices, H-component at the IRT, and the 557.7 nm and 630.0 nm emission intensities from the TOR.

Рис. 7. Буря 20 ноября 2003 г. Вариации индексов авроральной активности AE и AL, H-компоненты геомагнитного поля в Иркутске (IRK) и интенсивности эмиссий 557.7, 630 нм по данным обс. Торы.

ries find themselves in the R2 region. Herewith, the PiB burst time at 23:10 UT appeared close to the start of one of the substorms noted in [*Huttunen et al., 2002*]. Generating the observed PiB bursts during substorm activity activations might be related to precipitation of energetic electrons (~keV) into the ionosphere, to activation of the western electrojet and field-aligned currents (see references in [*Parkhomov et al., 2018*]).

One observed the PiB bursts against continuous Pi1C pulsations, and the former were accompanied by IPDPs. *Zolotukhina* [*2005*] assumed (for this event) an association between generating IPDPs in the dawn sector and an extremely strong compression of the magnetosphere. *Mishin* and *Karavaev* [*2017*] showed that the magnetosphere compression caused a strong southward expansion of the polar cap (and, correspondingly, of the oval). The auroral oval arrival at the latitude of Irkutsk might cause strong precipitation of energetic electrons and an increase in the amplitude of the continuous Pi1C/IPDP pulsations in the MLT dawn sector.

During the 2003 Nov 20 storm, the PiB bursts, increases in the Pi1C/IPDP intensities, as well as in the intensities of the 557.7 nm and 630.0 nm emissions and the 391.4 nm nitrogen band intensity at mid-latitudes, were observed at those instants, when the R2 southern boundary reached the latitude of Irkutsk, which evidences their relation to precipitations of energetic electrons [*Mishin et al, 2018*].

Baishev et al. [*2008*] addressed the characteristics for four substorms at the 2003 Nov 20 storm main phase. The onsets of the expanshion phases in these substorms (11:55, 14:37, 16:27, and 17:53 UT) were determined by the times of the PiB increases at low-latitude stations, by the increase in the westward electrojet and in the auroral breakup in the pre-midnight sector from the Yakut meridional chain. Also, the westward electrojet southward shift to the latitude of Irkutsk was revealed after 17:00 UT. At the UZR, the Pi2 pulsations (at ~16:29 UT) were almost simultaneously observed with the beginning of one of the substorms at high latitudes [*Baishev et al., 2008*]. However, their intensity is much lower than the PiB bursts. After the westward electrojet shift toward Irkutsk in each substorm activation, one observed two couples of the PiB bursts with ~20-min interval. Herewith, the 17:36 UT PiB burst practically coincided with the onset of one of the substorms indicated in [*Baishev et al., 2008*]. At 17:56 UT and 20:00 UT, one observed the substorms, whose onsets coincided with the PiB bursts. In the addressed event, the PiB bursts might be related to the substorm activation evolution, increase in the westward electrojet and in the jet-related FACs, fluxes of precipitating energetic electrons. To these activations, the polar and mid-latitude auroras observed at the latitude of Irkutsk were related [*Mishin et al., 2018*].

5. Conclusions

Analyzing the dynamics of geomagnetic pulsations, field-aligned currents, and the mid-latitude airglow in various MLT sectors during the 2000 Apr 6 and 2003 Nov 20 superstorms enables to draw the following conclusions:

1. During substorm activations, when the R2 southern boundary approached the mid-latitude observatories near Irkutsk and Borok, the facilities at these locations recorded the PiB bursts and short-period pulsations of all types (including IPDP). Also, sharp increases in the 557.7 nm and 630.0 nm atomic oxygen emission intensities and in the 391.4 nm ionized nitrogen molecular band intensity were recorded. Hence, these pulsations and emission variations are related to increases in the upward FACs and to precipitations of energetic electrons (~keV) into the ionosphere during substorms.

2. During the substorm activations, when the R2 southern boundary was north of the latitude of the IRT and BOR observatories, one observed the PiB/Pi1C bursts (without IPDP pulsations) simultaneously with the variations (moderate increases as compared with the quiet level) in the night atmosphere emissions. These bursts (increases) were, probably, related to precipitations of energetic particles, that are caused by the SW dynamic pressure jumps.

6. Acknowledgements

The experimental data were obtained by using the equipment of the ANGARA Multi-Access Center at (http://ckp-rf.ru/ckp/3056/). The solar wind parameters and geomagnetic indices AL, AU and SYM–H are obtained through (http://omniweb.gsfc.nasa.gov) and also through the Kyoto WDC Website, we are grateful to PIs of the CANOPUS, INTERMAGNET, GIMA, MACCS, IMAGE international projects; magnetic networks in Arctic and the Antarctic, the Shafer Institute of Cosmo-Physical Research and Aeronomy SB RAS, Arctic and Antarctic Research Institute, and Danish Meteorological Institute; and individual magnetic observatories for providing magnetic data. The study was done with a support from the Russian Foundation for Basic Research, under grants No. 16-05-00563 and 18-05-00437. The study has been conducted within the basic funding from Federal Research Program II.16. B.T. was supported by grant SHUSS-2017/65 of the Ministry of Education, Science, and Sports of Mongolia.

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