Chapter

The Effect of Space Weather on Human Body at the Spitsbergen Archipelago

Natalia K. Belisheva

Abstract

The study of the effects of the space weather on the human body was carried out at the Spitsbergen archipelago. A geophysical feature of the arch. Spitsbergen is its location in the cusp region—a kind of funnel on the dayside of the magnetosphere, where phenomena of space weather most express. Diverse radiation (from ULF to VHF) and waves in the field of polar cusp, covering the entire range of the body rhythms, give credit for studying the effects of space weather in the field of polar cusp. Assessment of the relationship between the dynamics of the monthly morbidity in Russian settlements and indicators of space weather revealed that, practically, all forms of morbidity are associated with solar activity and with the local geomagnetic activity in the polar cusp. A difference in correlations between the monthly incidence of residents in the Barentsburg and geocosmic agents during the polar day and the polar night was found. The links between the incidences of the population and the peculiarities of space weather will make it possible to develop prognoses of the morbidity for preventive measures aimed at increasing human health in high latitudes.

Keywords: space weather, morbidity, Spitsbergen archipelago, polar day and polar night

1. Introduction

The Spitsbergen archipelago is located in the Arctic Ocean, between 76° 26‘ and 80° 50’ north latitude and 10 and 32° east longitude. A geophysical feature of the arch. Spitsbergen is its location in the cusp region [1]—a kind of funnel on the dayside of the magnetosphere with near zero magnetic field magnitude, where, under certain conditions, the solar wind (CW) can burst through powerful plasma jets (**Figure 1**, [2]). The open field lines of the cusp is connected with those of the interplanetary magnetic field (IMF), which allows the shocked solar wind plasma of the magnetosheath to enter the magnetosphere and to penetrate the ionosphere [3].

The Earth’s magnetosphere is a highly dynamic structure that responds dramatically to solar variations [4, 5], especially in the cusp region [6]. The upper atmosphere at high latitudes, associated with cusp, is also called the “Earth’s window to outer space.” Through various electrodynamic coupling processes as well as through direct transfer of particles, many geophysical effects displayed that there are direct manifestations of phenomena occurring in the deep space. In the polar cusps, the

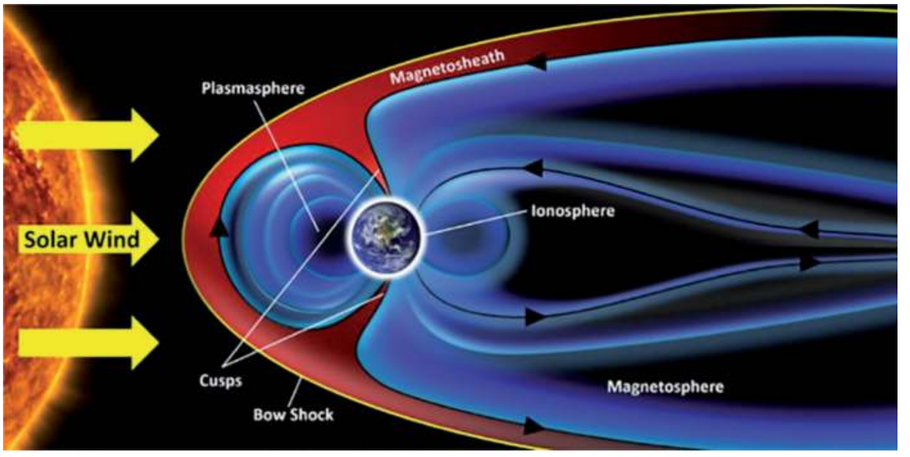

Figure 1.
Earth's protective shield: ***magnetosphere*** *is that area of space, around a planet, that is controlled by the planet's magnetic field, whose shape is the direct result of being blasted by solar wind; a supersonic shock wave is created sunward of earth called the* ***Bow shock****; the* ***magnetosheath*** *is the region of space between the magnetopause (the outer boundary of Earth's confined geomagnetic field) and the Bow shock; the* ***plasmasphere****, or inner magnetosphere, is a region of the Earth's magnetosphere consisting of low energy (cool) plasma; the* ***ionosphere*** *is the ionized part of Earth's upper atmosphere; the polar* ***cusps*** *are funnel-shaped regions in the frontal part of the magnetopause at geomagnetic latitudes of ~75°.*

solar wind plasma has also direct access to the upper atmosphere. The polar regions are thus of extreme importance when it comes to understanding the physical processes in the near space and their effect on our environment" [6].

In the cusp areas, the impacts of the solar wind (SW) on the Earth's magnetosphere manifest most strongly, and multiple phenomena originating as consequences of such interactions are referred to as space weather. It can be truly said that space weather affects everybody, either directly or indirectly. Space weather is defined by the U.S. National Space Weather Program (NSWP) as "conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health" [7, 8].

2. Magnetosphere-ionosphere emissions and waves in the polar regions

Space weather begins at the sun. The sun exhibits an 11-year cycle of sunspots that are visible manifestations of increased solar magnetic field. Certain larger flares produce solar radio bursts of broadband noise from 10 MHz to 10 GHz that may directly affect GPS receivers on the dayside of the earth. Terrestrial effects are the result of three general types of conditions on the Sun: eruptive flares, disappearing filaments, and coronal holes facing Earth [9], on which the nature of magnetosphere-ionosphere interactions depends. The magnetosphere and the ionosphere of the Earth are sources of electromagnetic oscillations and waves, many of which are detected in the form of radiation outside the region of generation, in particular, on the surface of the Earth. The electromagnetic radiation range of the magnetosphere and ionosphere overlaps in frequency by many orders of magnitude—from the lowest frequencies of magnetohydrodynamic (MHD) waves ($f \sim 5\text{–}10^{-3}$ Hz) to X-rays of energetic electrons in the upper atmosphere ($f \sim 10^{18}$ Hz) [10]. The complexity and diversity of physical phenomena associated with solar activity and transmitted to earth through solar-terrestrial connections make the issue of identifying bioeffective agents in the space weather phenomenon nontrivial and rather complicated. Some of the cosmophysical phenomena, as attributes of space weather, are most pronounced and specific for high latitudes and for the polar cusp [11–14].

3. The effect of space weather on human body at the Spitsbergen archipelago

3.1 Material and methods

The unique data characterizing morbidity of the residents in the Russian settlements of the Barentsburg (1985–1993), including the females, were used in the study. The statistics on the complications about pregnancy and the postpartum period in women, who lived in the archipelago during the time of the former USSR, provide invaluable information that allows assessing the effect of space weather associated with the polar cap and the polar cusp on pregnant women. Today, such research is extremely difficult, because the residence of pregnant women in the Spitsbergen archipelago is undesirable.

The monthly statistical reports on the morbidity structure in the Barentsburg mine hospital (1985–1993) were basis for analysis [15]. All data of morbidity were normalized on 1000 people of residents in the Barentsburg. The average number of inhabitants in each Russian settlement (Barentsburg and Pyramid) was about 1000, where one third were women. The average monthly data characterizing the CA were selected in the National Geophysical Data Center (NGDC): Solar Data Services (http: //www.ngdc.noaa.gov/stp/SOLAR/ftp: sunspotnumber.html); intensity of the secondary cosmic rays (CR) was estimated by neutron count rate (ground station of the neutron monitor of the PGI KSC Russian Academy of Sciences in the Apatity and in the Barentsburg). Statistical data analysis was performed using the software Statistica 10.0 and the graphing was carried out using the software package ORIGIN50.

3.2 Results and discussion

3.2.1 Monthly morbidity

The bioefficiency of geocosmic agents is manifested in synchronous dynamics of the functional state of resident's organism in the high latitudes [16–21] or in the coherency of morbidity dynamics of the population in the Arctic territories [22] with variations of the geocosmic agents on the time scales with different resolution (day, month, and year).

The coefficients of cross-correlations between the monthly (01.01.1985–31.12.1989) values on the curves, smoothed by 5 points, of the morbidity and the solar radio flux f10.7_index are demonstrated in **Table 1**.

The synchronism of the incidence diseases follows from the cross-correlation coefficients shown in **Table 1**, where one can see that the monthly values of the incidence of the mental disorders (MD) have significant correlation coefficients with injuries and poisonings (IP) and with f10.7-index. However, IP correlates with other diseases (**Table 1**): with DEA), with DAAV, with IFGO, with ISST, and with the fluxes of solar radio emission (f10.7-index).

One can see certain concordance between the curves of the average monthly angular parameters of the solar wind (sigma-phi-V, deg.,), the monthly dynamics of incidence of the mental disorders (MD), the injuries, and poisoning (IP) in **Figure 2A**. Coefficient correlations between sigma-phi-V and the MD, sigma-phi-V, and IP are $r = 0.32$, $r = 0.44$, and $p < 0.05$, respectively. In this case, the MD and the

	MD	DEA	DAAV	IFGO	ISST	DMSCT	IP	f10.7_index
MD	1.00							
DEA	0.72	1.00						
DAAV	0.39	0.43	1.00					
IFGO	0.25	0.41	0.22	1.00				
ISST	0.33	0.45	0.28	0.34	1.00			
DMSCT	0.61	0.64	0.83	0.48	0.47	1.00		
IP	0.50	0.53	0.77	0.51	0.50	0.86	1.00	
f10.7_index	0.46	0.70	0.69	0.67	0.56	0.83	0.87	1.00

The incidence of the mental disorders (MD); the diseases of the eye and its appendages (DEA); the diseases of arteries, arterioles and veins (DAAV); the incidence of the inflammatory processes of the female pelvic organs and other diseases of the female genital organs (IFGO); the infections of the skin and subcutaneous tissue (ISST); diseases of the musculoskeletal system and connective tissue (DMSSCT); the injuries and poisoning on the way to and from work (IP) and the solar radio flux with wavelength 10.7 cm (f10.7-index). Significant correlations are marked by red color.

Table 1.
Coefficients of cross-correlations ($p < 0.05$) between the monthly (01.01.1985–31.12.1989) values of the morbidity.

IP diseases are not only interconnected by connection with the solar radio emission (**Table 1**, f10.7-index), but also with the parameters of the solar wind (sigma-phi-V, deg). This suggests that the solar wind could generate such conditions in the cusp area, when the physical agents might affect the mental state, and through it, the predisposition to the appearance of the injury.

In **Figure 2B**, one can see concordance between curves of average monthly variations of the solar radio flux at 10.7 cm, dynamics of monthly diseases of arteries, arterioles, and veins and (DAAV), average monthly values of the sigma-theta-V, deg. and average monthly values of the Pc (N)-index. Correlation coefficients between f-10.7-index, sigma-theta-V, deg., Pc (N), and DAAV are r = 0.40; r = 0.29; r = 0.27; and $p < 0.05$, respectively. The positive relationship between the incidence of DAAV, the f-10.7-index, and PC(N) means that with increasing solar activity and associated geomagnetic disturbances, the morbidity of DAAV also increases. The connection between PC and the DAAV demonstrates the effect of the space weather on the vascular system of human organism.

Figure 3A shows the connection between the dynamics of monthly pregnancy complications (IFGO), the parameter of space weather (hydrodynamic pressure of the solar wind), and the ap-index reflecting the local geomagnetic activity. The connection between the dynamics of monthly inflammatory processes of the female pelvic

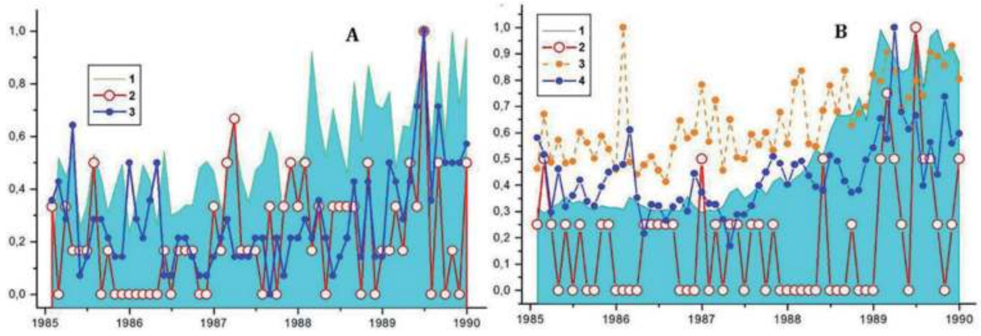

Figure 2.
Coherent dynamics of the average monthly values of the parameters of geocosmic agents and the monthly values of morbidity. A. Parameter of solar wind "sigma-phi-V, deg" (1, graph area—cyan), the incidence of the mental MD (2), incidence of the injuries and poisoning on the way to and from work, IP (3). B. Solar radio emission with wavelength 10.7 cm (1, graph area—cyan), incidence of the diseases of arteries, arterioles, and veins (2), sigma-theta-V, deg. (3), pc (N) index (4). X axis: The months of the year from January 1985 to December 1989; Y axis: the normalized values of the all parameters.

organs and other diseases of the female genital organs (IFGO), the F10.7-index, and PC(N) are shown in **Figure 3B**. Correlation coefficients between IFGO, flow pressure, and ap-index are r = 0.34; r = 0.29, respectively, $p < 0.05$. Correlation coefficients between IFGO, F10.7-index, and PC(N) are −r = 0.34; r = 0.29, respectively, $p < 0.05$.

One can again remark that morbidity, even specific such as diseases of the female genital system, is associated with solar and geomagnetic activity, expressed by the ground indicators of local geomagnetic storm conditions PC(N), ap-index), and the agents in the near Earth space (F10.7-index, variations of the angle velocity of solar wind—sigma-phi-V, sigma-teta-V, deg., flow pressure). The fluctuations of the monthly values of morbidity of the somatic diseases, the mental disorders, and the frequency of injuries and poisoning, as well as the coherency of the diseases among themselves and with the space weather indicators suggest that space weather controls the state of the human body in Svalbard.

3.2.2 Association of the monthly morbidity with space weather agents in the polar day and in the polar night

The source of physical phenomena, some of them could have a pronounced bioefficiency, is the magnetosphere-ionosphere interaction, reflecting the interaction of the solar plasma with the earth's magnetosphere in the polar cusp region. Since the properties of the ionosphere are largely determined by Solar X-*rays* and UV *radiation* as well as fluctuations in the concentration of particles associated with magnetic disturbances, the properties of the ionosphere in the polar cusp region should differ during the polar day and in the polar night.

Ionospheric differences during the polar day and the polar night are also confirmed by differences in the electrical current systems in the summer season and in the winter due to current vortex, which is most noticeable in the summer season [23]. The total electron content (TEC) exhibits significant spatial and temporal variations, when the minimum level of TEC observed in the high latitude of the northern hemisphere in the mid polar night (December) and the maximum level—in the mid polar day [24]. A characteristic feature of geomagnetic disturbances in all hours is the presence of pulsations with large amplitudes and periods of several minutes. And some of them practically disappear during the polar night [14, 25–29].

To appreciate the significance of the space weather agents (geocosmic agents) affecting the human health in the polar days and in the polar night, the monthly data sets of the morbidity in the settlement of Barentsburg were sorted in two

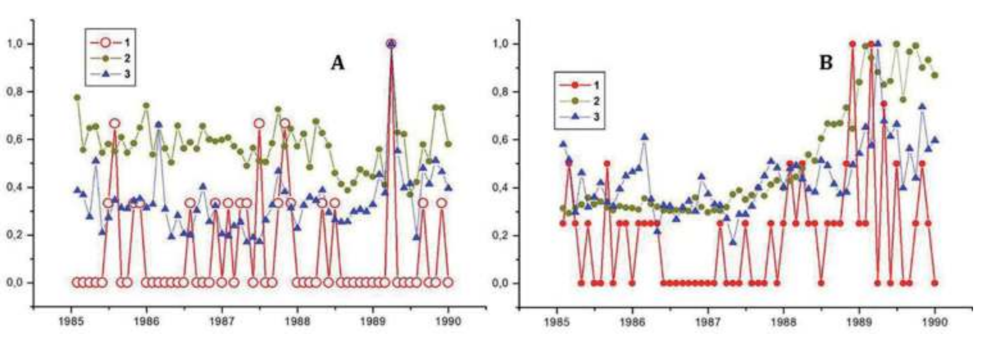

Figure 3.
Coherency dynamics of the monthly values of morbidity and the monthly average values of the parameters of geocosmic agents. A. Incidences of the complications of pregnancy and the postpartum period, CPP (1); flow pressure of the solar wind, (nPa) (2); and ap-index (3). B. Incidences of the inflammatory processes of the female pelvic organs and other diseases of the female genital organs, IFGO(1), the solar radio emission with wavelength 10.7 cm (2), PC(N)-index. X axis: the months of the year from January 1985 to December 1989; Y axis: the normalized values of the all parameters.

groups. In the first group was included the monthly values of morbidity in the polar day (from March to September, n = 35) and in the second group—the monthly values of morbidity in the polar night (from October to February, n = 25). This sorting was performed due to the duration of the dark time (122 days) from 21 October to 20 February at 80 degrees north latitude [30]. Significant differences between the incidence of the population during the polar day and the polar night, as well as differences in the values of geophysical indicators, have been estimated by using the nonparametric (the Mann-Whitney U test, Kolmogorov-Smirnov criterion) and the parametric T-criterion.

It turned out that the monthly values of incidence during the polar day and night significantly differ only in cases of intestinal infections (yersiniosis) and the inflammatory processes of the female pelvic organs and other diseases of the female genital organs (IFGO). During the polar day and the polar night, incidences of intestinal infections were 0.05 ± 0.21 and 0.25 ± 0.49, respectively, $p < 0.05$; incidences of IFGO were 1.89 ± 2.58 and 3.70 ± 3.62 in the polar day and in the polar night (according to the Mann-Whitney U-test T-criterion). The geophysical indices differed only in the monthly average values of atmospheric pressure (992.36 ± 4.01 and 987.58 ± 7.70, $p < 0.005$, mb), in the Bulk flow latitude (2, 24 ± 0.67 and 1.16 ± 0.93, $p < 0.001$, degrees), in the DST index (−16.07 ± 12.79 and − 22.16 ± 8.91, nT, $p < 0.025$), and in the PC (N) index (0.96 ± 0.35 and 1.14 ± 0.24, $p < 0.005$), respectively, in the polar day and in the polar night. That is, in fact, the incidence rate on the polar day and on the polar night, with a few exceptions, just as the monthly average of geophysical agents, with the exception of 2 indices characterizing geomagnetic activity, does not differ.

However, when correlations between the monthly values of morbidity and the monthly average values of geophysical agents corresponding to the polar day and to the polar night periods were compared, it turned out that there are large differences between them. These differences indicate that during the polar day and during the polar night, the roles of similar geophysical agents are different.

One can see above (**Table 1**) that the monthly values of the incidences of the MD, DEA, DAAV, IFGO, ISST, DMSSCT, and IP are associated with solar radio flux with a wavelength of 10.7 cm (f10.7_index), characterizing the solar activity (SA). This means that the Sun is the source of causal relationships, starting with SA and ending with the morbidity of the population on the Earth. But at the same time, the cause of the morbidity can be other bioeffective agents associated with SA, whose contribution to the morbidity can depend on multiple reasons, including the properties of the ionosphere during periods of the polar day and the polar night.

A comparative analysis of the correlations of the same classes of morbidity with geophysical indices, separately for the polar day and for the polar night, showed that there are both general and particular trends in the nature of the relationship between the morbidity and geocosmic agents. There are correlations, which appear only during the polar day: mental disorder (MD), diseases of the arteries, arterioles, and veins (DAAV), the gastritis, the kidney and urinary tract diseases, the complications of pregnancy and the postpartum period, and other diseases. Diseases such as the pneumonia, the ischemic heart disease, and other forms of heart disease without hypertension are correlated with geocosmic agents only during the polar night. There are diseases with a mixed nature of the connections with geocosmic agents during the polar day and the polar night.

Figure 4 shows that during the period of the polar day, dynamics of the monthly values of incidences of the mental disorders, MD, and dynamics of the monthly values of incidences of the diseases of arteries, arterioles, and veins (DAAV) are associated with variations of solar wind parameters such as "sigma-phi-V" and the solar radio emission with wavelength 10.7 cm. Along with these parameters of geocosmic agents, other parameters of IMF and SW, as well as, possibly, their combination and interaction, can make a certain contribution to the modulation of cases of mental disorders (**Table 2**).

The same can be seen in **Table 3**, which shows the links of the diseases of arteries, arterioles, and veins (DAAV) with variations of geocosmic agents, reflecting the complex nature of the effects of physical agents on the diseases of blood vessels.

In general, it can be seen that cases of mental disorders and vascular morbidity are associated with SA, manifested by variability of the solar wind (SW) and IMF during the polar day period. This may mean that, as a result of the interaction of the SW and IMP with the Earth's magnetosphere, physical phenomena generated in the polar cusp region during polar day could contribute to an unstable mental state and vascular disorders.

One can assume that these phenomena have an electromagnetic and wave nature, which determines their bioefficiency. One of the most likely candidates in a wide range of physical phenomena detected in the cusp region is low-frequency pulsations [14].

The pulsations in the spectral range (1–5 mHz) with different morphological properties and, accordingly, with different physical nature are observed at high latitudes (Φ > 70°). It is established that the long-period (T ~ 4–60 min) geomagnetic pulsations observed both in daytime and nighttime hours are typical phenomena on the polar cusp latitudes. The most typical fluctuations of the daytime cusp observed on the earth's surface are specific broadband irregular pulsations of the Pc5 range (f ~ 1.5–5.0 mHz) with an amplitude of the order of 15–60 nT, named by V.A. Troitskaya *ipcl (irregular pulsation cusp latitudes)*. Pulsations of the *ipcl* type are observed almost daily, but their intensity is 3–4 times higher in the summer than in the winter. This fact indicates that the source of *ipcl* pulsations is, in essence, a current generator, which creates the greatest disturbance in the illuminated ionosphere [14].

The daytime geomagnetic pulsations *ipcl* are divided into at least two classes [29]: *np* pulsations having a noise-like character (P = 6–15 min), and relatively regular *vlp* (very long period) pulsations (P = 20–40 min) occurring near the equatorial cusp boundary [29]. In the winter, as a rule, *vlp* pulsations are not detected [14, 29].

In the higher frequency range, the broadband noises from Pc3–4 (10–40 mHz) to ELF choirs (0.3–3.0 kHz) are often observed in the high latitude. The intensity of the Pc3–4 waves in the polar cusp depends on the ionospheric conductivity, which causes a sharp weakening of the waves during the polar night [28, 31, 32].

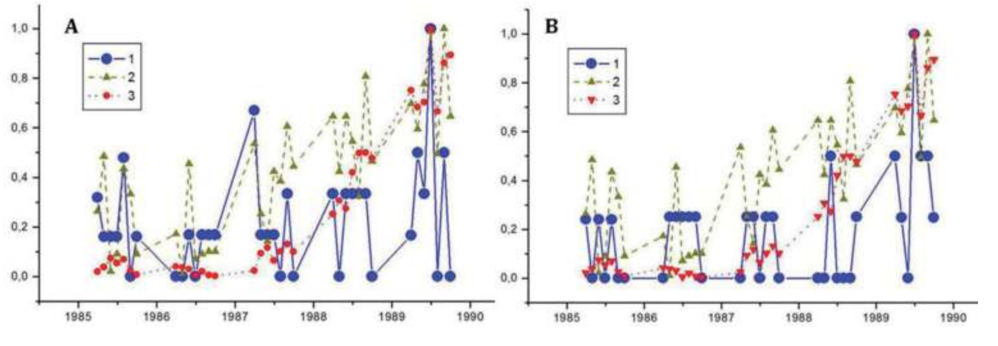

Figure 4.
The relationship between morbidity and geocosmic agents, which appears only in the period of the polar day. A. Dynamics of the monthly values of incidences of the mental disorders, MD (1). B. Dynamics of the monthly values of incidences of the diseases of arteries, arterioles, and veins, DAAV (1); A, B. Dynamics of the monthly average magnitudes of the solar wind parameters "sigma-phi-V" (2) and the solar radio emission with wavelength 10.7 cm (3). X axis: the months of the year from January 1985 to December 1989, where months from March to September are included in the period of the polar day (A, B); Y axis: all normalized parameters.

Period	M ± δ	NM	Pres	Bz	Pr-Den	δ phi	R	f10.7	PC(N)	Makh
PD	1.21 ± 1.20	−0.49	0.43	−0.36	−0.38	0.56	0.41	0.38	0.35	−0.33
PN	1.08 ± 1.08	−0.04	−0.06	0.02	0.07	0.13	0.13	0.16	−0.06	−0.26

NM—count rate of ground based on neutron monitor (counts/s); Pres—atmospheric pressure (mb); Bz-BzGSE—Bz component of interplanetary magnetic field (IMF) in the geocentric solar-ecliptic coordinate systems, nT; Pr-Den—proton density in the solar wind, N/cm^3; δ ph—sigma-phi-V—solar wind angle parameter, deg.; R—sunspot number; f10.7-index of the solar radio flux with wavelength 10.7 cm in solar flux units (s.f.u.), (10^{-22}), Watts/meter sq/hertz; PC(N)—Index of geomagnetic activity in the high latitude; Makh—Magnetosonic mach number = V/ Magnetosonic speed. Coefficient values marked in red color correspond to the level of significance p < 0.05.

Table 2.
Correlation coefficients between monthly values of incidents of the mental disorders (MD) and monthly average magnitudes of the parameters of geocosmic agents during the polar day (PD) and polar night (PN).

Summarizing the descriptions of physical phenomena associated with the processes of the interaction of the solar wind and IMF with the earth's magnetosphere in the polar cusp region, one can see that the polar day differs from the polar night by more diverse geocosmic events. These events are dependent on ionospheric conductivity, which determines diverse phenomena, including amplitude and frequency characteristics of high latitude pulsations.

It has now been established [33–36] that brain rhythms include ultra-slow frequency oscillations (USFO), which are usually not detected by standard electroencephalogram measurements. The frequency range of these oscillations corresponds to very low-frequency pulsations Pc3–4 characteristic of a polar cusp. Among the ultra-slow fluctuations, the rhythm with a period of 15–40 s is remarkable in that the human brain is accompanied by transitions of levels of consciousness, for example, transitions to the hypnotic state. The fluctuations in the decasecond range correspond to the period of fluctuations of the pulsations Pc3, the amplitude and intensity of which are significantly higher during the polar day than in the polar night. It is not excluded that Pc3–4 pulsations can contribute, along with other factors, to the unstable mental state of the residents of arch. Spitsbergen.

Significance ($p < 0.05$) of correlation coefficients between MD and DAAV ($r = 0.40$), between MD and DAAV and solar activity (**Tables 2** and **3**) in the polar day and the absence of significance of correlations between these morbidity and SA indices (R, F10.7) during the polar night indicate common causes, which determine the relationship between the morbidity and geophysical agents in the polar day. We assume that such common causes may be geophysical agents associated with the illuminated ionosphere during the polar day. It is possible that geomagnetic pulsations, in the ultralow frequency range, most pronounced during the polar day, could modulate brain and vascular functional activity and, accordingly, certain mental states. In particular, they might suppress the cognitive processing and

Period	M ± δ	NM	δ-By	δ-Bz	Na/Np	δ-phi	δ-theta	R	f10.7
PD	0.70 ± 0.79	−0.52	0.41	0.35	0.38	0.37	0.39	0.51	0.51
PN	0.61 ± 0.81	−0.20	−0.22	−0.06	−0.06	0.04	0.24	0.26	0.31

NM—count rate of ground based on neutron monitor (counts/s); δ-By—sigma By—variability of By-component of IMF, nT; δ-Bz—sigma Bz—variability of Bz-component of IMF, nT; Na/Np—alpha/proton ratio in the solar wind; δ phi, δ-theta—sigma-phi-V, sigma-theta-V—solar wind angle parameters, deg.; R—sunspot number; f10.7-index of the solar radio flux with wavelength 10.7 cm in solar flux units (s.f.u.), (10^{-22}), Watts/meter sq/hertz. Coefficient values marked in red color correspond to the level of significance p < 0.05.

Table 3.
Correlation coefficients between monthly values of incidents of the diseases of arteries, arterioles, and veins (DAAV) and the monthly average magnitudes of the parameters of geocosmic agents during the polar day (PD) and polar night (PN).

promote switching of the brain to its noncognitive "idling" state or activation of default cortical networks whose activity is suppressed during cognitive processing [37, 38].

The different significance of physical agents for different systems of the body can be seen on the basis of the mutually exclusive nature of the connections with similar geocosmic agents in the polar day and in the polar night (**Figure 5**, **Table 4**).

The only difference in the nature of the connections between these diseases and geocosmic agents is the connection with the Bz-component of IMF. This connection has a negative sign with the incidence of DMSSCT and positive sign with the incidence of ISST in the polar day. Since the negative value of the Bz-component characterizes a high GMA, it can be assumed that GMA, along with other factors, including ultraviolet irradiation, contributes to the incidence of the DMSSCT in the polar day.

On the other hand, excessive irradiation of ultraviolet light during the polar day can inhibit the growth of pathogenic microflora, which causes skin diseases (ISST). But in the polar night, in the absence of ultraviolet light, the growth of pathogenic microflora can increase under the influence of factors associated with the variability of the SW and IMF [39].

The importance of SA for human behavior manifests in the correlations with the cases of injury and poisoning on the way to and from work of the residents of arch. Spitsbergen (**Figure 6**, **Table 5**). Most likely, this definition hides injuries caused by the state of altered consciousness under the influence of alcohol.

It can be assumed that an increase in SA is accompanied by the neuropsychic arousal, the anxiety, the decrease in health, and the mood, which can be causes provoking the need for alcohol in a certain category of persons. Since the level of SA in the summer and winter periods does not differ significantly, the connection of the frequency of injuries and poisonings on the way to work and from working with SA appears equally on a polar day and on a polar night according to the level of the solar activity.

Monitoring of the daily psycho-emotional state of the healthy volunteers in the settlement Barentsburg (arch. Spitsbergen) during polar day revealed correlations between situational anxiety, mood, activity, and indices of SA of proton fluxes with energy >10 MeV [40, 41]. It was also found that health, the activity, and the mood decreased and the situational anxiety increased under increase of SA and GMA [40, 41]. Thus, one of the causes for the increase in injuries and poisoning could be an arising of the psycho-emotional instability associated with increase in SA.

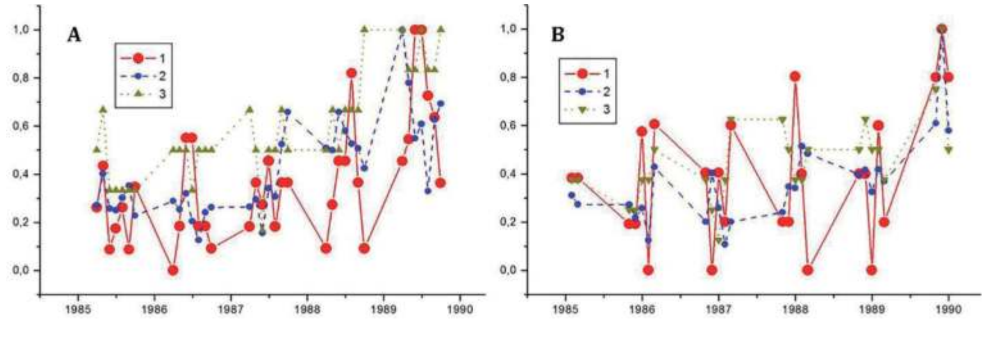

Figure 5.
The mutually exclusive nature of the connections with similar geocosmic agents of the various diseases in the polar day (A) and in the polar night (B). A. Dynamics of the monthly values of incidences of diseases of the musculoskeletal system and connective tissue (DMSSCT) (1), the monthly average magnitudes of interplanetary magnetic field (IMF), nT (2), the monthly average magnitudes of the alpha/proton ratio in the solar wind (Na/Np), (3); B. Dynamics of the monthly values of incidence of the infections of the skin and subcutaneous tissue (ISST) (1), the monthly average magnitudes of IMF (2), the monthly average magnitudes of the Na/Np (3). X axis: the months from January 1985 to December 1989, where months from March to September are included in the spans of the polar day (A); the months from October to February are included in the spans of the polar night (B); Y axis: all normalized parameters.

Period	M ± δ	NM	IMF	FV|<B>|	Bz,GSM	δ-B	δ-By	δ-Bz	Na/Np
Diseases of the musculoskeletal system and connective tissue (DMSSCT)									
PD	3.66 ± 2.48	−0.63	0.44	0.38	−0.39	0.47	0.47	0.44	0.46
PN	3.42 ± 2.95	−0.25	0.26	0.31	−0.21	0.15	0.17	0.21	0.16
The infections of the skin and subcutaneous tissue (ISST)									
PD	1.83 ± 1.61	−0.20	0.23	0.25	−0.12	0.16	0.13	0.12	0.15
PN	1.76 ± 1.27	−0.50	0.57	0.53	0.53	0.50	0.47	0.47	0.50

NM—count rate of ground based on neutron monitor (counts/s); IMF—field magnitude Avg, <F>, nT; FV|<B>|—magnitude of average, field vector, |<B>|, nT; Bz, GSM-Bz—component INF in the geocentric solar-magnetospheric coordinate systems; δ-B—variability of the magnetic field strength; δ-By—Sigma By—variability of By—component of IMF, nT; δ-Bz—Sigma Bz—variability of Bz—component of IMF, nT; Na/Np—alpha/proton ratio in the solar wind. Coefficient values marked in red color correspond to the level of significance p < 0.05.

Table 4.
Correlation coefficients between monthly values of incidents of the diseases of the musculoskeletal system and connective tissue (DMSSCT), the infections of the skin and subcutaneous tissue (ISST), and the monthly average magnitudes of the parameters of geocosmic agents during the polar day (PD) and polar night (PN).

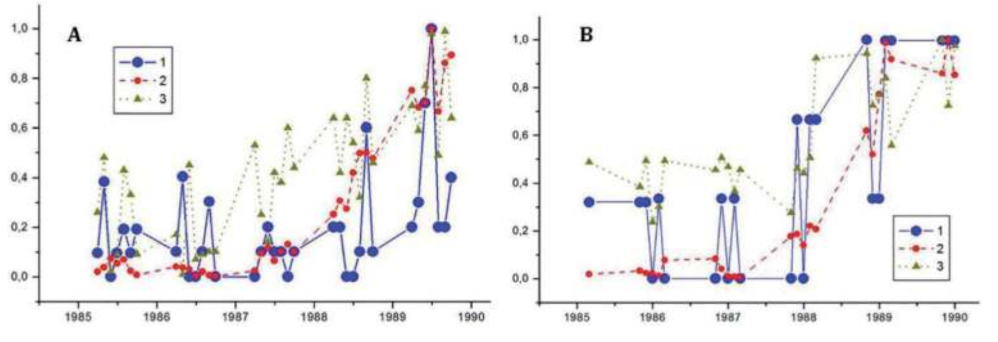

Figure 6.
The stable links between injury rates and poisoning on the way to work and from work with similar geocosmic agents during the polar day (A) and the polar night (B). A, B. Dynamics of the monthly values of incidence of the injury and poisoning on the way to work and from work (1), the monthly average magnitudes of the solar radio emission with wavelength 10.7 cm (2), and the solar wind parameter "sigma-phi-V"(3). X axis: the months from January 1985 to December 1989, where months from March to September are included in the period of the polar day (A); the months from October to February are included in the period of the polar night (B); Y axis: all normalized parameters.

Period	M ± δ	NM	δ phi-	δ theta	Pl beta	AMN	Kp * 10	R	f10.7	PC(N)	MMN
PD	1.75 ± 1.97	−0.52	0.48	0.46	−0.38	−0.43	0.26	0.61	0.58	0.39	−0.43
PN	1.26 ± 1.07	−0.55	0.54	0.51	−0.55	−0.61	0.47	0.67	0.72	0.58	−0.55

*NM—count rate of ground based on neutron monitor (counts/s); δ phi, δ-theta—sigma-phi-V, sigma-theta-V—solar wind angle parameters, deg.; Pl beta—plasma beta (Beta = $[(T * 4.16/10^5) + 5.34] * Np/B^2$; AMN—Alfven mach number (Ma = $(V * Np^{0.5})/20 * B$); Kp * 10-index of geomagnetic activity (GMA); R—sunspot number; f10.7-index of the solar radio flux with wavelength 10.7 cm in solar flux units (s.f.u.), (10^{-22}), Watts/meter sq/hertz; PC(N)—high latitude index of GMA; MMN—magnetosonic mach number = V/Magnetosonic_speed. Coefficient values marked in red color correspond to the level of significance p < 0.05.*

Table 5.
Correlation coefficients between monthly values of incidents of the injury and poisoning on the way to work and from work and the monthly average magnitudes of the geocosmic agents during the polar day (PD) and polar night (PN).

The revealed differences in the nature of the links between the morbidity of the population in the Barentsburg during the polar day and the polar night show that the diverse diseases are associated with a combination of separated characteristics of the SV, MMP, GMA, and SA, the significance of which for the morbidity varies with the season.

4. Conclusion

A geophysical feature of the arch. Spitsbergen is its location in the cusp region—a kind of funnel on the dayside of the magnetosphere with near zero magnetic field magnitude. The open field lines of the cusp are connected with those of the interplanetary magnetic field (IMF), which allows the shocked solar wind plasma of the magnetosheath to enter the magnetosphere and to penetrate the ionosphere.

In the cusp areas, the impacts of the solar wind (SW) on the Earth's magnetosphere manifest most strongly, and multiple phenomena originating as consequences of such interactions are referred to as the space weather. The magnetosphere and the ionosphere of the Earth are sources of electromagnetic oscillations and waves, many of which are detected in the form of radiation outside the region of generation, in particular, on the surface of the Earth.

The feature of the cusp is the existence of the geomagnetic pulsations not only in the period of geomagnetic disturbances but also during the quiet period. One can see that narrow band waves at frequencies 0.2 to 3 Hz are a permanent feature in the vicinity of the polar cusp. The waves have been found in the magnetosphere adjacent to the cusp (both poleward and equatorward of the cusp) and in the cusp itself. It is an established fact that the daytime polar cusp latitudes are typically characterized by long-period (T ~4–60 min) geomagnetic pulsations observed both in daytime and nighttime hours. Diverse radiation (from ULF to VHF) and waves in the field of polar cusp, covering the entire range of the body rhythms, give credit for studying the effects of space weather in the field of polar cusp. The study of the dependence cases of diseases on effects of space weather has shown that diverse forms of morbidity varied synchronously and they are associated with variations of space weather agents. Assessment of the relationship between the dynamics of the monthly morbidity in Russian settlements and indicators of space weather revealed that, practically, all forms of morbidity are associated with solar activity: with F10.7 index, with variations of solar wind parameters, and with indices characterizing the local geomagnetic activity in the polar cusp.

It has been found that mental disorders are associated with the variability of the solar wind and the radio emission of the Sun, as well as the frequency of injuries and poisoning at the work and at the home. A high degree of association of the diseases of arteries, arterioles, and veins with the parameters of the solar wind and the geomagnetic indices, characterizing the local geomagnetic activity in the polar cusp, was shown.

A high sensitivity of the female organism to variations of space weather in the polar cusp was revealed. This phenomenon is manifested in the increase of pregnancy complications, cases of inflammation of the genital organs, etc., according to the increase in geomagnetic activity in the polar cusp.

The revealed differences in the nature of the links between the morbidity of the population in the Barentsburg during the polar day and the polar night show that the diverse diseases are associated with a combination of separated characteristics of the SV, MMP, GMA, and SA, the significance of which for the morbidity varies with the season.

However, it has been found that certain diseases are associated only with the polar day or with the polar night. This allows selecting the physical agents that could modulate morbidity rate in the alternative season. In particular, agents such as long-period oscillations, with the frequency range that coincides with the range of the ultraslow fluctuations of the constant potential (USFCP) in the brain, could modulate the morbidity of the MD and DAAV in the polar day.

The absence of solar radiation during the polar night, such as UV radiation, and the association of the incidence of the inflectional diseases of skin with GMA only during the polar night indicate the role of UV in suppressing the growth of pathogenic microflora. Correlations of the inflectional diseases of skin with GMA in the absence of UV radiation demonstrate the significance of GMA for the microorganism growth.

In general, it should be noted that, probably, many of the bioeffective agents associated with CA were left out of consideration. The health of the population most likely depends on a combination of geophysical agents, some of which are simply not registered and are not reflected in the indicators of the database (OMNI). On the other hand, the state of the human body during the periods of the polar day and the polar night may also differ in sensitivity to the effects of geophysical agents. In general, the polar day is characterized by a larger number of influencing physical agents on the human body, than the polar night.

The found links between the morbidity of the population and the peculiarities of space weather will make it possible to develop prognoses of the morbidity for preventive measures aimed at reducing the morbidity in high latitudes.

The task of studying the labor activity in the difficult arctic conditions demands the need to develop criteria for determining the mental state of a person and his working capacity, as well as predicting a shift in the functional state of the CNS. The solution of such a problem should take into account the possibility of modulation of the mental and of the physiological state of people of the dangerous professions by the high latitude geocosmic agents, the effects of which might also express in the seasonal manifestation of morbidity.

Author details

Natalia K. Belisheva
Research Centre for Human Adaptation in the Arctic, Branch of the Federal Research Centre "Kola Science Centre of the Russian Academy of Science", International Academy of Ecology, Man and Nature Protection Sciences, Apatity, Murmansk Region, Russia

*Address all correspondence to: natalybelisheva@mail.ru

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