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Editorial

The Effect of Helio-Geomagnetic Activity in the Geo-Environment and by Extension to Human Health

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1. Introduction

Solar activity encompasses various phenomena within the solar atmosphere, notably including eruptive events like solar flares and coronal mass ejections (CMEs). These events are spread throughout the Sun's constant outflow of solar wind, influence the very nature of the interplanetary space, and interact with the terrestrial magnetosphere. Consequently, energetic particles, waves, and radiation originating from the solar atmosphere extend into the Earth's environment [1,2]. This results in the recording of phenomena such as geomagnetic substorms and storms [3,4], and disturbances in the ionosphere [5]. Upper atmospheric climatic parameters are also affected.

The influence of this helio-geomagnetic activity on human technology is widely recognized, affecting the operation of artificial satellites, air travel, electricity networks, gas pipelines, and more. Furthermore, its ramifications extend to the well-being of astronauts, both aboard space stations and during journeys to celestial bodies like the Moon and Mars. Numerous studies have extensively investigated the repercussions of these events for weather and climate [6–8]. Yet, despite identifying certain correlations between solar activity and diverse climatic factors, the question remains open.

The purpose of the present Special Issue is to amass and categorize an extensive array of studies on these subjects. This will give future researchers the opportunity to access aggregate results and therefore make it easier to continue research on this topic, which is related to the very existence of life on earth.

2. Results

The articles featured in this Special Issue encompass a range of research articles in two primary areas: (a) the geomagnetic and ionospheric disturbances due to solar activity and [1–8] (b) their possible effect on human physiology and health [9–13]. The Special Issue contains ten published studies referring to the two above-mentioned sections. A brief overview of the main findings and conclusions of these studies will be presented below in Sections 2.1 and 2.2 (the numbers of the manuscripts correspond to the List of Contributions).

2.1. Geospace Disturbances Due to Solar Activity

Geospace disturbances refer to the variation in the geomagnetic field and the trapped particle populations in near-Earth space. Katsavrias et al. present the results of the application of wavelet methods in the behavior of the geomagnetic field, the magnetospheric particles, and the ultra-low-frequency (ULF) waves. It is a review of the wavelets methods used in the investigation of geomagnetic field oscillations. The authors highlighted the significant contribution of these methods in research into solar-terrestrial coupling and geospace disturbances.

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Balasis et al. exploit the ESA's Swarm mission-derived geomagnetic activity indices using wavelet transforms, Hurst exponent, Shannon entropy, non-extensive Tsallis entropy, and Fisher information around the most intense magnetic storms of the previous solar cycle, aiming to infer the crucial signatures of the transition from the quiettime to the stormtime of the magnetosphere. They analyzed the Swarm mission-derived magnetic indices from 2015, a year that included three out of the four most intense magnetic storm events of the solar cycle 24. The comparison of Swarm-based with ground-based indices shows very good agreement, indicating that Swarm magnetic field data can be used to provide new satellite-based global indices to monitor the level of geomagnetic activity. The authors conclude that 'these findings may be utilized in order to improve forecast schemes and models of the coupled solar wind-magnetosphere-ionosphere system in terms of including information on the preconditioning of the system by the existing state of the magnetosphere'.

During geomagnetic storm events, the highly variable solar wind energy input in the magnetosphere significantly alters the structure of the Earth's upper atmosphere through the interaction of the ionospheric plasma with atmospheric neutrals. Ionospheric storms constitute an important link in the complex chain of solar–terrestrial relations. A key element of the ionospheric storm-time response is considered to be the large-scale increases and decreases in the peak electron density (disturbances in the peak electron density and column density) that are observed to globally formulate the so-called positive and negative ionospheric storms, respectively. Tsagouri attempts a brief survey of present knowledge on the fundamental aspects of large-scale ionospheric storm time response at middle latitudes and the F region. The author provides extensive information and a very useful bibliography, while pointing out the contemporary open issues for the research community.

Earthquakes constitute one of the most serious natural hazards. A vast number of methods and proposals have been communicated on the problem of earthquake prediction. Among others, various ionospheric disturbances are proposed as preseismic signals. Additionally, a group of methods which seek seismic precursors in the electromagnetic time series of fields and currents of different kinds and frequencies are presented in the bibliography. A very important question that still has not been answered is whether some particular variations in the ELF recordings, especially in the 2–50 Hz range (Schumann esonances/SR) operate as precursors of forthcoming seismic activity. Tritakis et al. analyzed data collected for almost five years by two SR stations located in north and south edge of Greek territory, respectively. Their 'initial' conclusion is that 'these observations are very hopeful but not enough to contribute significantly to the very important problem of confident Earthquakes prediction'. They need to be complemented with additional observations of adjoining effects which can contribute to the final decision. In addition, a possible mechanism of the connection from the ground to the ionosphere should be found.

The anti-correlation observed between cosmic radiation intensity and solar activity is well known. Thus, it is expected that the dose rate will exhibit a similar behavior, since it is utterly dependent on the intensity of the incoming cosmic ray particles. Tezari et al. present the radiation dosimetry calculations performed with a software application (DYASTIMA-R) for the time period 2009–2019, covering solar cycles 23 and 24. The Monte Carlo simulations have been performed for different geographic locations, covering the whole range of magnetic cut-off rigidity thresholds (Rc = 0–17 GV).

2.2. The Possibility Influence of Geospace Disturbances on Human Physiology

Various manifestations of space weather can influence a wide range of human activities, ranging from technological systems to human health. Mavromichalaki et al. present an overview of their team's investigations in regard to the possible effect of solar, geomagnetic and cosmic ray activity on human physiological parameters, focusing on cardiological problems. The results of four projects, conducted using data from different geographical regions (Bakou in Azerbaijan, Kosice in Slovakia, Tbilisi in Georgia, Piraeus in Greece), covering different time periods and time scales, and referring to different groups of individuals, are presented. The authors concluded that 'the space weather phenomena can influence the human physiological state and can be related to variations of physiological parameters or the number of incidents of different diseases'.

Hanzelka et al. evaluate the impact of changes in solar activity on three human psychophysiological parameters: skin conductance, electromyography and the share of abdominal and diaphragmatic breathing in overall ventilation. The authors discuss the impacts of low-level magnetic fields induced by solar activity on some of the parameters characterizing or found in a healthy individual, including skin resistance, muscular contractions and the proportion of thoracic breathing to diaphragmatic respiration. Regarding low-level magnetic fields, these comprise low-frequency fields at f = 0.01–3 kHz within the bands: ULF (300 Hz–3 kHz), SLF (30–300 Hz) and ELF (0.1–30 Hz).

Podolska statistically examines whether there are different patterns in daily numbers of deaths during the quiet periods of solar activity (13 September–24 October 1996, 21 July–20 August 2008, 31 July–31 August 2009) in contrast to the periods of strong solar storms (14 July 2000, 28 October 2003 and 17 March 2015). The study focused on diseases of the nervous system and circulatory system. The medical data were provided by Czech Statistical Office. In quiet periods of solar activity, 'none of the examined groups according to age, sex and group of diagnoses was found to have a connection between the daily number of deaths and all indices of solar and geomagnetic activity, in contrast to the periods of the solar storms where Male 40+ and Female 40+ dependence is found for diseases of the circulatory system'. Moreover, the daily number of deaths in the diagnostic group of diseases of nervous system and in the diagnostic group of diseases of circulatory system, according to age and sex, showed different statistical characteristics in the time period 30 days before solar storm and 30 days after solar storm. For the time periods after solar storms, a connection was identified between daily number for diseases of circulatory system and geomagnetic activity.

Stupishina et al. studied the health of Saint Petersburg habitants on the basis of cardiology cases. The authors analyzed and compared the status of and variations interrestrial and space weather characteristics near the days with normal season numbers of ischemia cases vs. days that were absolutely free of the same cases. The primary importance of the geomagnetic parameters as the space weather factors and the humidity parameters as the terrestrial factors for the ischemia outcomes is noted. The daily spread of the geomagnetic total vector in near-earth space turned out to be important for ischemic patients in the autumns of solar activity cycle falling phase.

Geronikolou et al. looked for some connection between the total solar irradiance and stroke mortality in Piraeus, a Greek city. The time period studied was 1985–1989 (the minimum of the solar cycle 21 and part of the ascending phase of cycle 22).

3. Conclusions

Helio-geomagnetic activity and its effects on the Earth's environment, and especially on human physiology, is an interesting research field of space physics. The contents featured in this Special Issue only represent a limited segment of this expansive and captivating research domain. Through these studies and the abundant references thoughtfully provided by the authors, readers will attain an understanding of the discoveries derived from these investigations, as well as the pressing challenges that the scientific community is called upon to resolve.

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