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Disturbances in the geomagnetic field recorded on February 6, 2023

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Keywords: geomagnetic field, disturbances, ULF, spectral analysis

Abstract
Data on the variations of the geomagnetic field from three geomagnetic observatories: PAG (Bulgaria), PEG (Greece), and WIC (Austria), along with the solar wind parameters, and the Interplanetary Magnetic Field (Bz) recorded in the period February 5–6, 2023, are analyzed. Through performing spectral and comparison analyses, two types of disturbances are found. The first type manifests itself as an ultra-low-frequency wave (in the spectrum of Pc3–4 pulsations) in the horizontal components of all three stations. It starts at 00:52 UTC and lasts about 25 minutes. It represents a global phenomenon caused by changes in the values of the parameters of the solar wind. The second type occurs locally (at PAG Station) only in the east-west component of the magnetic vector. This is expressed in a smooth increase in its values as well as sharp peaks for the time interval 1:30–7:30 UTC. This is likely related to post-seismic effects in the geomagnetic field as a result of the great earthquake in the Republic of Turkey on February 6, 2023, with a magnitude of 7.8.

Смущения в геомагнитното поле, записани на 06.02.2023

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Ключови думи: геомагнитно поле, смущения, ULF, спектрален анализ

Резюме
Анализирани са данни за вариациите на геомагнитното поле, записани в периода 5-6 февруари 2023г. в три геомагнитни обсерватории- PAG (България), PEG (Гърция) и WIC (Австрия). След прилагането на спектрален анализ и сравняване с параметрите на слънчевия вятър, измененията в стойностите на вариациите междупланетното магнитно поле (Bz), са намерени два типа смущения. Първият тип се проявява като ултра-нискочестотна вълна (в спектъра на Pc3-4 пулсациите) в хоризонталните компоненти и на трите станции. Има начало в 00:52UTC и продължителност около 25 минути. Представяла глобално явление, породено от изменения в стойностите на параметрите на слънчевия вятър. Вторият тип се проявява локално (станция PAG) само в компонентата изток-запад на магнитния вектор. Изразява се в плавно повишение на стойностите ѝ, както и в резки пикове за часовия интервал 1:30 - 7:30 UTC и не е изключено да е свързан с пост-сеизмични ефекти в следствие на голямото земетресение в Република Турция от 6.02.2023 с магнитуд M=7.8.

Introduction
Disturbances in the geomagnetic field in terms of their origin can generally be divided into those of magnetospheric-ionospheric origin, those of intra-terrestrial origin (Li et al., 2019) and disturbances caused by human activity (Villante et al., 2014). The first one is mainly due to the interaction between the solar wind (SW) - fully ionized plasma, and the magnetosphere of the Earth (Němeček et al., 2020). The Alfven waves are magnetic waves that can transfer energy from the surface of the Sun into the solar wind (Gosling et al., 2009). The SW parameters that usually affect the magnetosphere-ionosphere system are for instance the SW plasma speed, the dynamic pressure, the magnetic-field strength, the number density, and other (Borovsky, 2020). There many papers that investigate disturbances in the geomagnetic variations recorded during the geomagnetic storms and during the quiet periods (Chamati, 2022; Chamati and Andonov, 2022; Dahal et al., 2022; Dai et al., 2015; Lakhina and Tsurutani, 2021; Menk, 1988).
In this paper, the two types of geomagnetic disturbances recorded at 1 s resolution on February 5-6, 2023, by three geomagnetic observatories (Panagjurishte (PAG), Bulgaria, Conrad Observatory (WIC), Austria, and Pedeli (PEG), Greece are analyzed and discussed.

Results and discussion

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Figure 1 presents the geomagnetic field variations along the X (north-south), the Y (east-west), and the Z (down) directions. They are recorded at PAG station, Bulgaria, from 22 UTC on February 5, 2023 until 14 UTC on February 6, 2023. About 01 UTC, the clearly visible disturbances along the X and Y components are observed. The first type of disturbances is observed simultaneously along X and Y. It appears about 00:52 UTC and lasts about 25 minutes (figure 2, bottom panel).

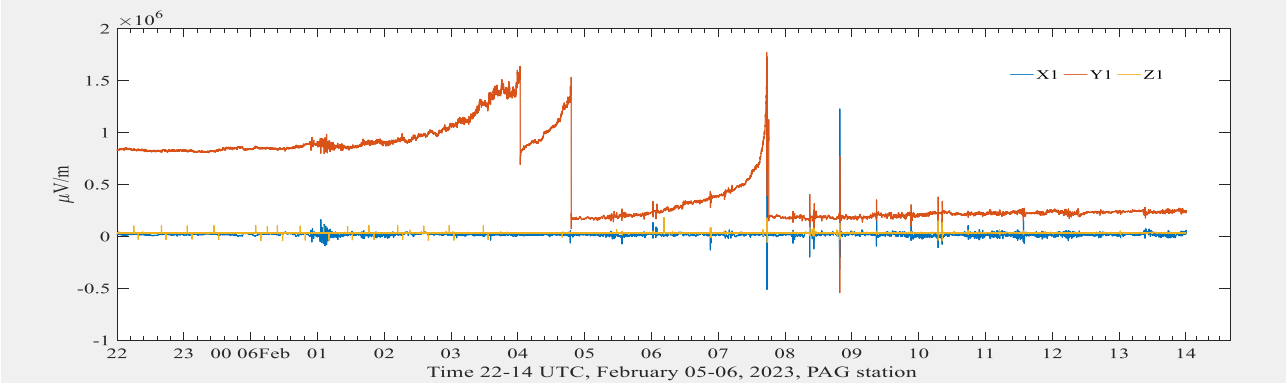


Figure 1 Geomagnetic variations (X, Y, Z directions), 22-14 UTC, February 5-6, 2023, PAG station

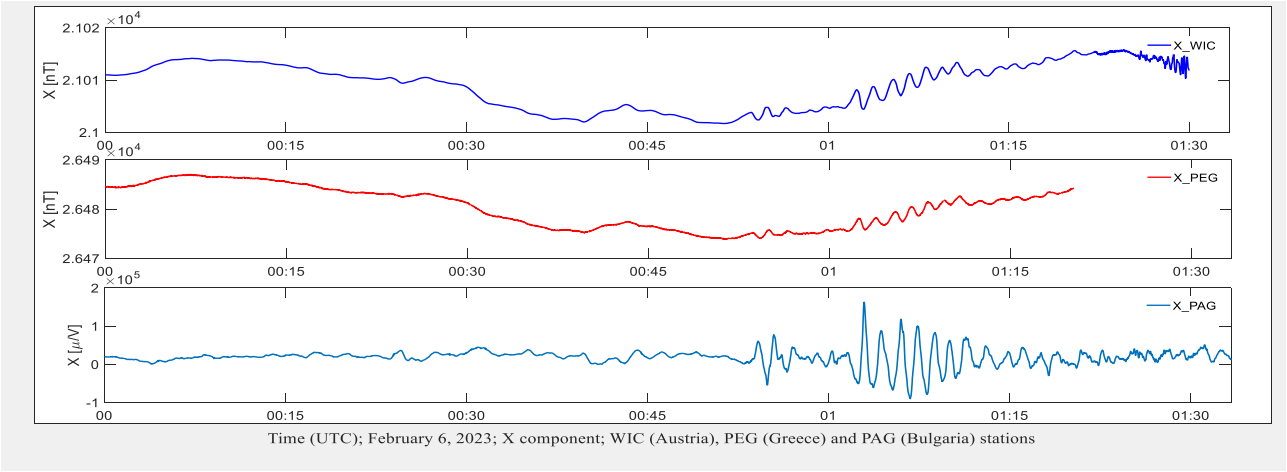


Figure 2 Time: 00:00-01:30 UTC, X component, WIC, PEG and PAG stations

For comparison, records of the geomagnetic field variations along the X component at PEG Station (Pedeli, Greece) and at WIC Station (Conrad Observatory, Austria) are presented in figure 2. In all three stations, disturbances are simultaneously observed. The visible difference in the waveform is due to the fact that at PAG Station, the recordings were made with of an induction magnetometer, where the diurnal course of the magnetic variations was taken away. Figure 2 shows that this is a disturbance with a global manifestation and it is not a local property.

Figure 3 presents the Interplanetary Magnetic Field (IMF) Bz component, the flow dynamic pressure, the Dst and the Kp indices and the SW plasma speed. After about 00 UTC on February 6, 2023, sharp and step-like changes in the values of all parameters are observed. The SW plasma speed is steadily increasing. The global and local (Metodiev, M. and Trifonova, P., 2021) K indices do not exceed values of 3.5. As it is known from the literature, changes in these parameters lead to the appearance of ULF waves with different frequency spectra that can be recorded by magnetometers on the ground. Their distribution at different geographical longitudes can be characterized by a different spectral composition. The spectral analysis based on the wavelet transform depicts the temporal evolution, the power, and the periodicity of the disturbance recorded at mid-latitudes, presented by PAG and WIC stations (figures 4 and 5). For both stations the disturbance manifested in Pc3-4 ULF range: period vary between 25-110 seconds and have main period 68 seconds. Differences in the power of the signal might be due to different types of instruments that operate in the geomagnetic observatories (their technical specifications) and their sensitivity or/and specifics in the longitudinal propagation of the disturbance.

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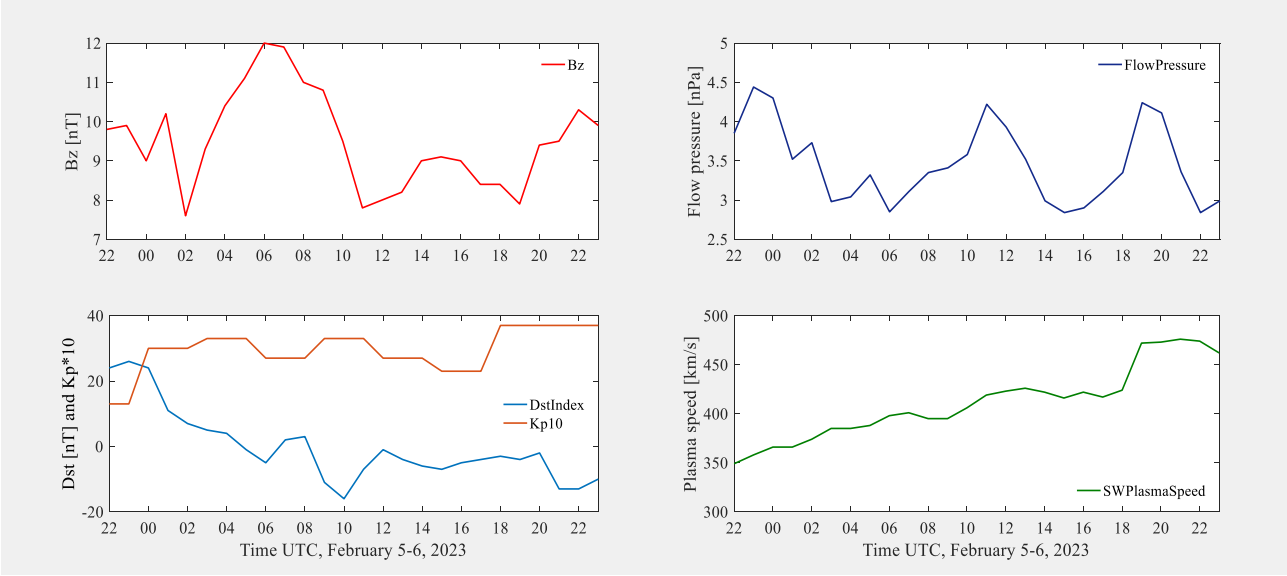


Figure 3 The IMF Bz component, the flow dynamic pressure, the Dst and the Kp indices and the SW plasma speed

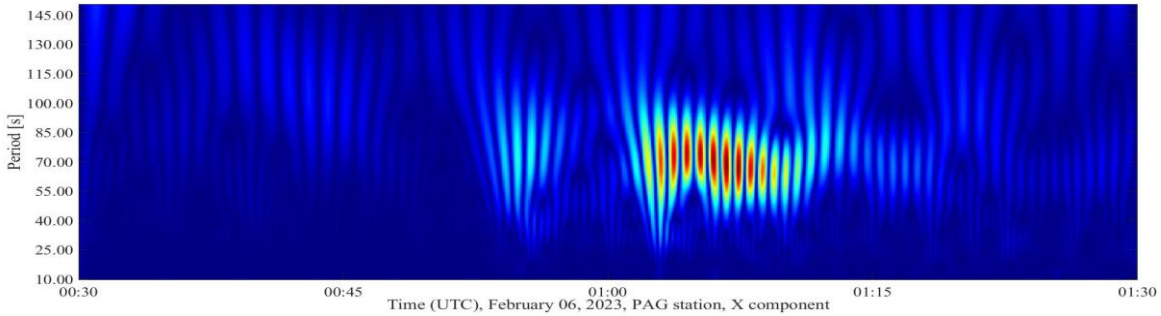


Figure 4 Wavelet spectrum, PAG station (Bulgaria); February 6, 2023; 00-01:30 UTC

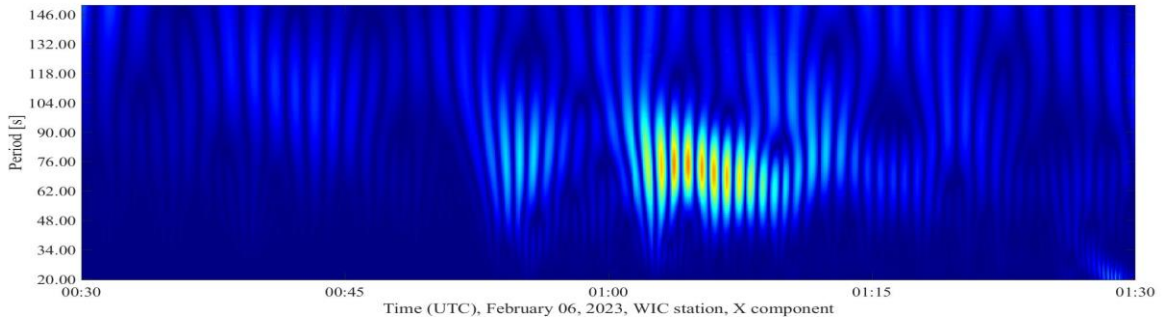


Figure 5 Wavelet spectrum, WIC station (Austria) ; February 6, 2023; 00-01:30 UTC

The second type of disturbances are observed only at PAG Station, and they are recorded only along the Y direction (figure 1). This is expressed in a smooth increase of their value after about 01:30 UTC and sharp "jumps", which lasts till 07:30 UTC. Due to the fact that the disturbance was recorded only locally, it cannot be ruled out that this is related to seismic activity both locally (Popova et al., 2021) and to the 7.8-magnitude earthquake that occurred on February 6, 2023, on Republic of Turkey territory.

Conclusion

Records of geomagnetic variations from February 5-6, 2023, in three geomagnetic observatories (PAG, WIC, and PEG) are analyzed. Two types of disturbances are found in the horizontal components of the geomagnetic vector. The first one is found to occur at all three observatories and have global character, starting at 0:52 on February 6. It appears as a ULF wave in the area of the Pc3-4 spectrum. It has a main period of 68 seconds. The second one appears only at PAG station and manifests itself as a smooth increase of its value after about 01:30 UTC and sharp "jumps", which lasts till 07:30 UTC. Referring to the fact that it has a local character

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and appears only in the east-west direction of the magnetic vector, the possibility that it is also related to post-seismic effects on the magnetic field after the strong earthquake that occurred in Turkey on February 6, 2023, cannot be ruled out.

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