Solar Wind Plasma Temperature Influence on Earth's Magnetic Field Variation During 2024

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Abstract
Solar wind parameters play a central role in controlling the interaction between the sun plasma and the Earth's magnetic field. One of these parameters is the Solar Wind Temperature (SWT), which is considered a highly important indicator of the dynamic conditions in interplanetary space. So, we study the effect of the SWT on the Earth's magnetic field (EMF) in year 2024. We analyzed the Solar Wind Temperature (SWT) data along with measurements of Earth's magnetic field (EMF) to understand their relationship and the extent to which solar wind temperature affects Earth's magnetism. From the results, we found that a moderate positive correlation (r= 0.35)was found between SWT and EMF, which means that the relationship between them is weak to moderate, the change in the magnetic field is controlled by the current systems, not by direct reinforcement.

Keywords: Solar wind temperature; Earth magnetic field; Solar wind-magnetosphere interaction; Space weather
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1. Introduction

The Earth has dipolar magnetic field which is affected by a magnetized plasma wind that coming from the Sun. So, this magnetic field keep the surface of the Earth from penetrating high energy solar wind, and cosmic rays between stars. The magnetic dipole has reflected sign some hundreds of millions of years [1]. The magnetic field composed by the motion of molten iron within its outer core. This magnetic field comes out into space and forms a protective region known as the magnetosphere. The magnetosphere acts as a natural protective layer that deflects the incoming solar wind particles, shield the Earth's atmosphere and technological systems from harmful radiation and energetic particles [2]. The solar wind is formed from hot corona's base which its speeds accelerated near the similar Sun. It inflates the heliosphere by its continuously flows. The solar wind has nearly equal numbers of ions and electrons, and its ion component consists predominantly of 95% protons, a small amount of ionized helium with small amounts of heavy ions. The solar wind varies in its speed, temperature and density, and strength and direction of the magnetic field inside it. The solar wind has speeds range between about 250-800 km/s Away from the Sun. The solar wind's similar with Sun's interior in elemental composition which mass nearly 78% hydrogen, 20% helium, and 2% elements like carbon, oxygen, neon, iron, magnesium, nitrogen, and silicon. By these atoms, ions, and electrons, magnetized fluid forms the outer extension of the Sun's atmosphere [3].

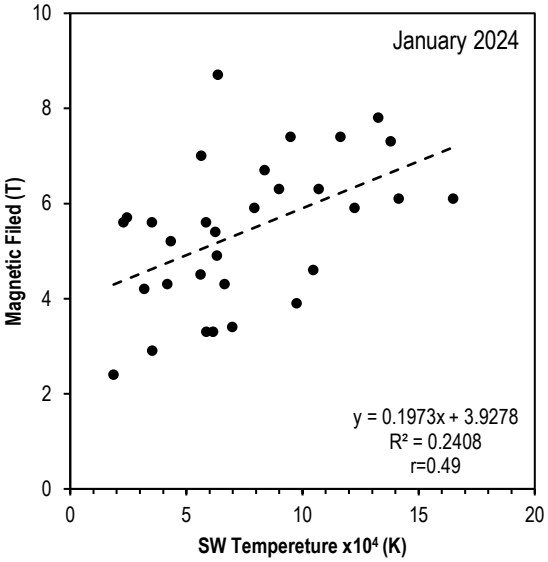
The coupling between magnetosphere and solar wind and the can lead to several space phenomena like geomagnetic storms and auroras, it happens when the solar wind enters the and accelerates toward the polar regions of magnetosphere, this interaction is important for space weather and satellites protection and communication systems [4]. Many scientific studies have investigated the interaction between solar wind and Earth's magnetosphere. Zhu and He (2024) have studied the relationships between solar wind parameters and solar activity across multiple solar cycles, specifically from SC-21 to SC-25. The result show there is relationship between SSN and various solar wind parameters, and all appear periodic regulation every 27 day and 10.8 year [5].

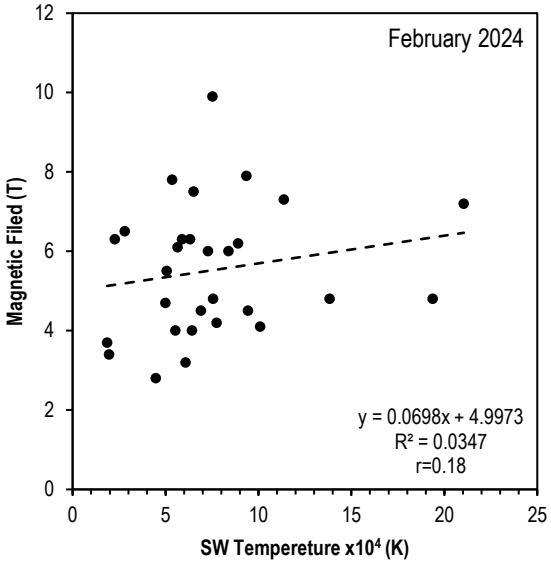
Saiz et al. (2013) has studied the complex interactions between the Earth's magnetosphere and the solar wind with forecasting techniques developed to understand solar–terrestrial interactions and advances in numerical modeling. The authors confirm the importance of Type II and Type IV radio emissions, parameters such as solar X-ray flares and solar energetic particles in improve the model of prediction which using artificial neural networks (ANN). Also, this study discusses the temporal evolution of the ring current during geomagnetic storms and analyzes geomagnetic responses at

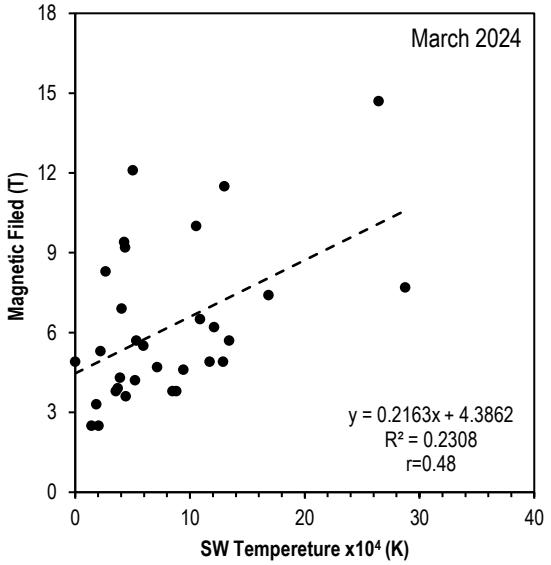
different latitudes and it defines the role of field-aligned currents in ionosphere heating [6].

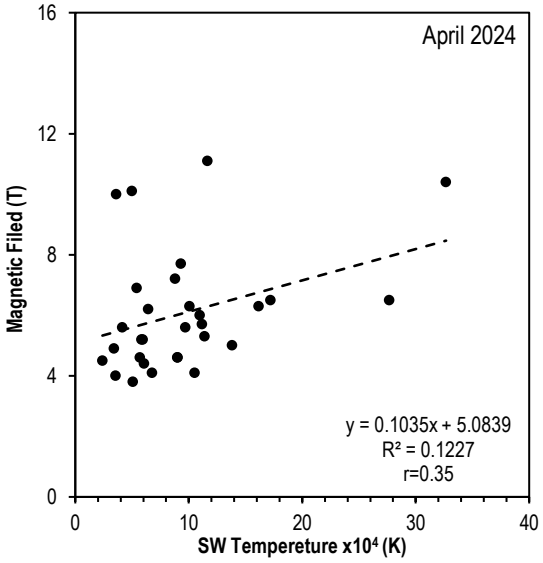
3. Results and Discussion

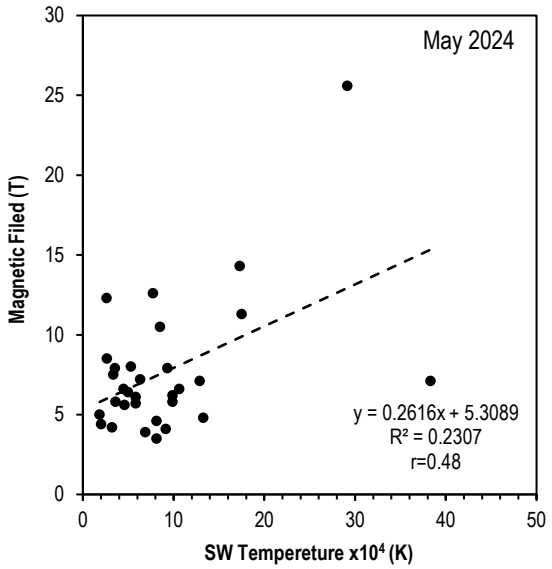
In our research, we have selected the Solar Wind Temperature (SWT) and Earth magnetic field (EMF) to study its effect on each other and to the understanding the space dynamics under different solar activity conditions, our study was during year 2024. The predicted SWT and Earth magnetic field data was obtained from NASA OMNIWeb database (https://omniweb.gsfc.nasa.gov/omniweb/?utm_source=chatgpt.com). After that, we plotted the relationship between the solar wind temperature and the Earth's magnetic field for each month of the year chosen in the study 2024, as shown in Fig. (1). To reduce the possible spurious correlation, the detrending was applied then the results indicate that an increase or rise in the solar wind plasma temperature is generally associated with an increase in solar wind pressure and stronger interactions with the Earth's magnetic field, which causes disturbances in the Earth's magnetism. That is, the relationship between them is weak or moderate relation, meaning that when the solar wind temperature increases, the magnetic field intensity is increases or decrease. The temperature of the solar wind is related to pressure according to the mathematical relationship (P= nkT), but the actual effect depends on the speed, density, and Interplanetary magnetic field IMF.

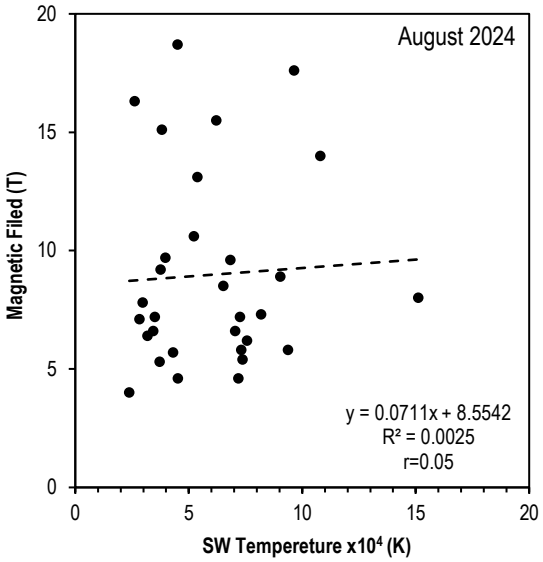


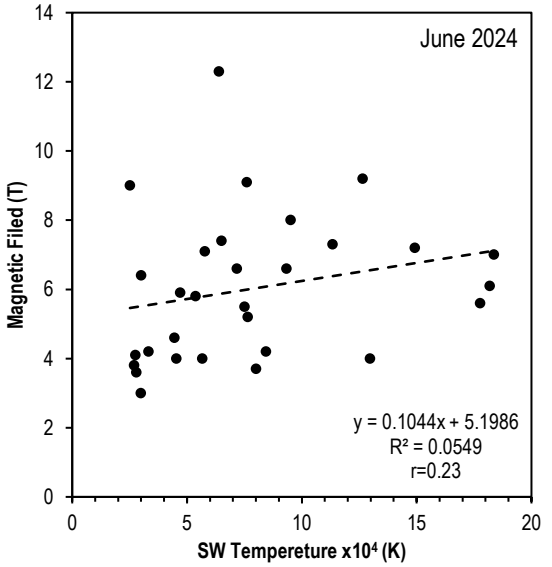


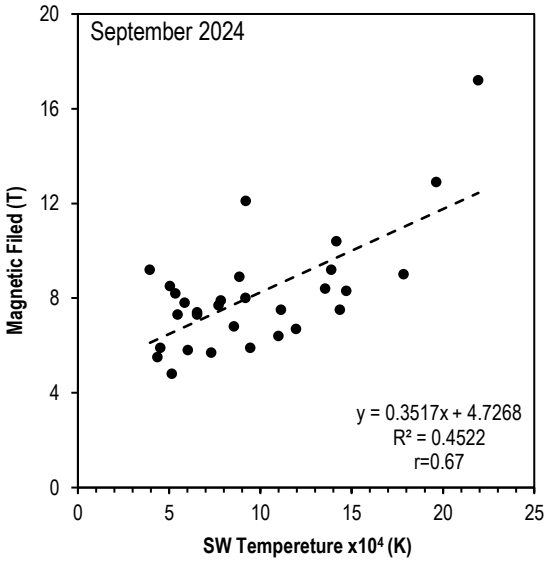


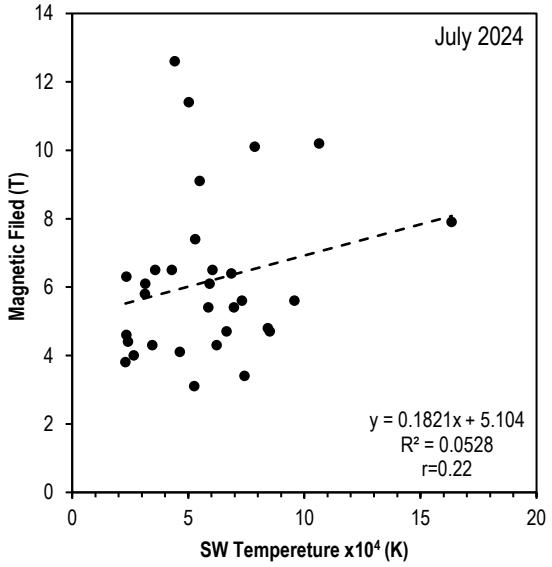


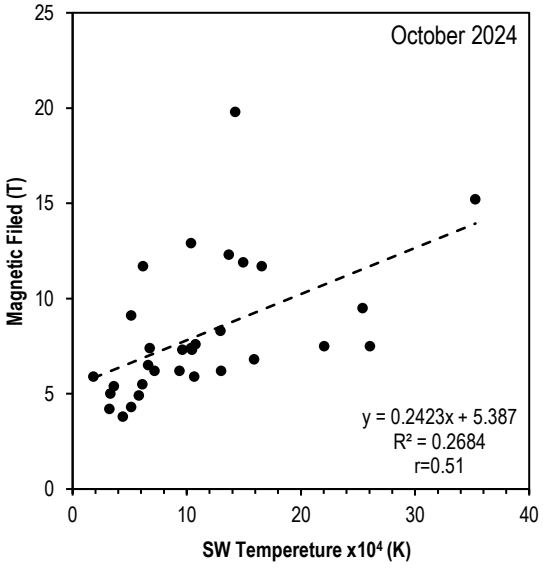












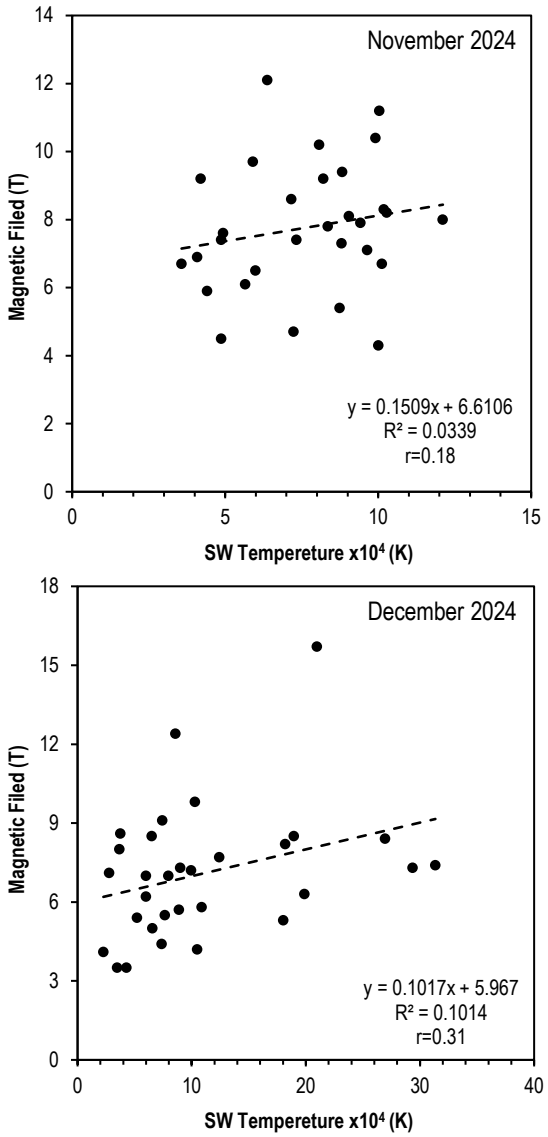


Fig. (1) The relationship between Solar Wind Temperature (SWT) and Earth Magnetic Field for Year 2024

4. Conclusion

From this study, we concluded that an increase or rise in solar wind plasma temperature is usually associated with stronger interactions with Earth's magnetosphere, which causes disturbances in Earth's magnetism. That's mean, the relationship between them is weak or moderate relationship, meaning that when the solar wind temperature increases, the magnetic field intensity also increases or decrease. This study provides an understanding of the extent of the role of solar wind plasma parameters, particularly its temperature, in improving the understanding of space dynamics under solar activity conditions observed during the year 2024. The IMF-Bz parameter was not included in the present analysis and will be considered in future work as it plays a kay role in solar wind and magnetosphere together. There is a moderate positive correlation (r= 0.35)was found between SWT and EMF, which means that the relationship between them is weak to moderate, the change in the magnetic field is controlled by the current systems, not by direct reinforcement.

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