Solar flares and geomagnetic storms: The Earth-Sun Interplay

Solar Flares

Solar flares are powerful bursts of radiation emanating from the Sun's surface. They occur when magnetic energy built up in the solar atmosphere is suddenly released. These intense explosions of energy can affect space weather, impacting satellite communications, navigation systems, and even power grids on Earth. Solar flares often accompany solar storms and are characterized by sudden flashes of brightness observed in the Sun's outer atmosphere.

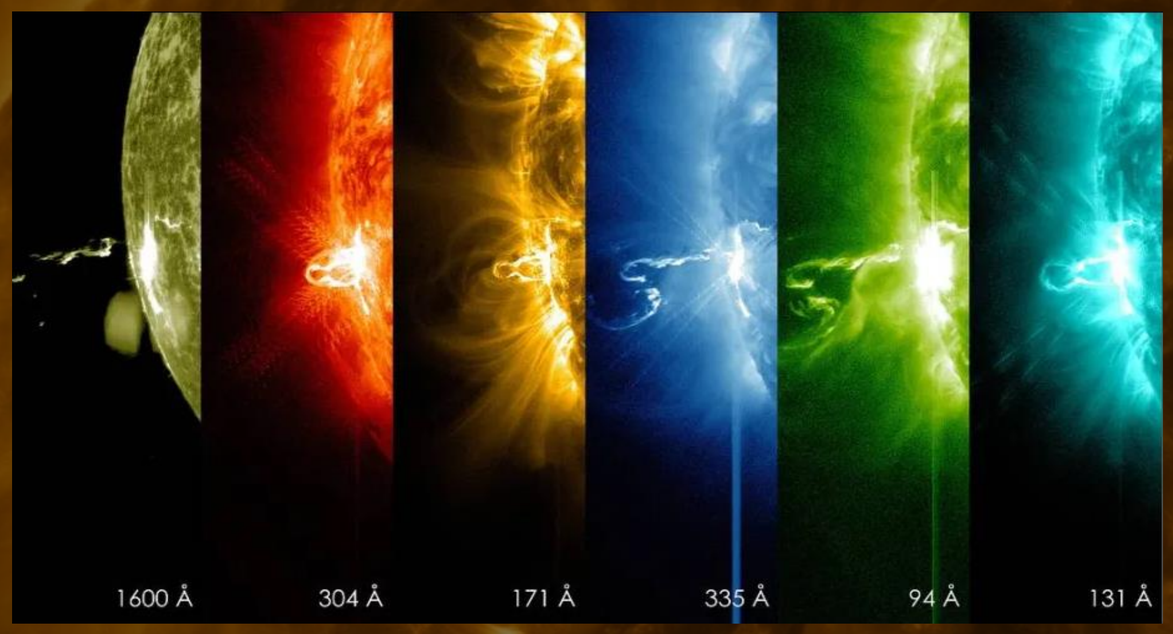

Fig 1: A solar flare in 6 different wavelengths. Source: NASA

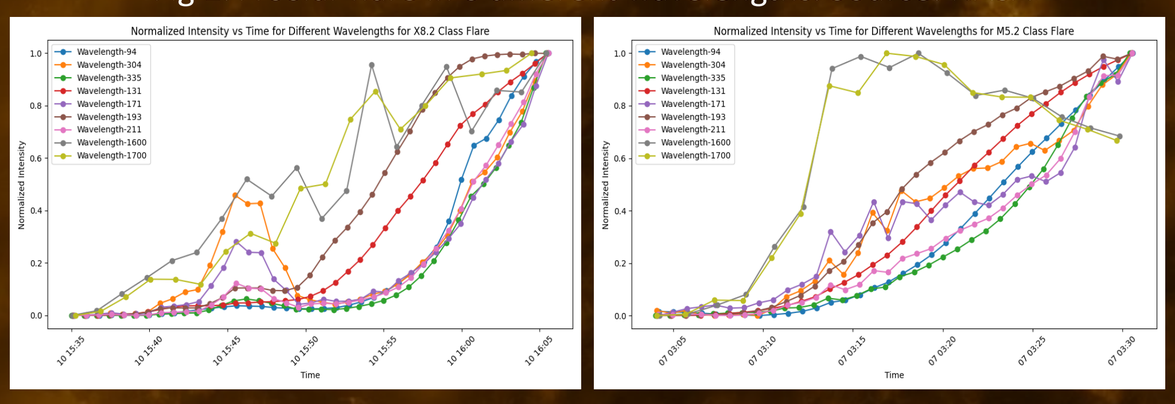

Fig 2: An X and M class solar flare's evolution in various wavelengths shown as normalized light curves from the start time to the peak time of the flares.

Geomagnetic Storms

Geomagnetic storms are disturbances in Earth's magnetosphere caused by the solar wind's interaction with our planet's magnetic field. These storms occur when a large burst of solar wind and magnetic fields from the Sun, often associated with solar flares and coronal mass ejections (CMEs), hits Earth. The resulting energy transfer can cause fluctuations in the magnetosphere, leading to beautiful auroras, disruptions in satellite communications, navigation systems, and power grids, and increased radiation exposure for high-altitude flights and space missions.

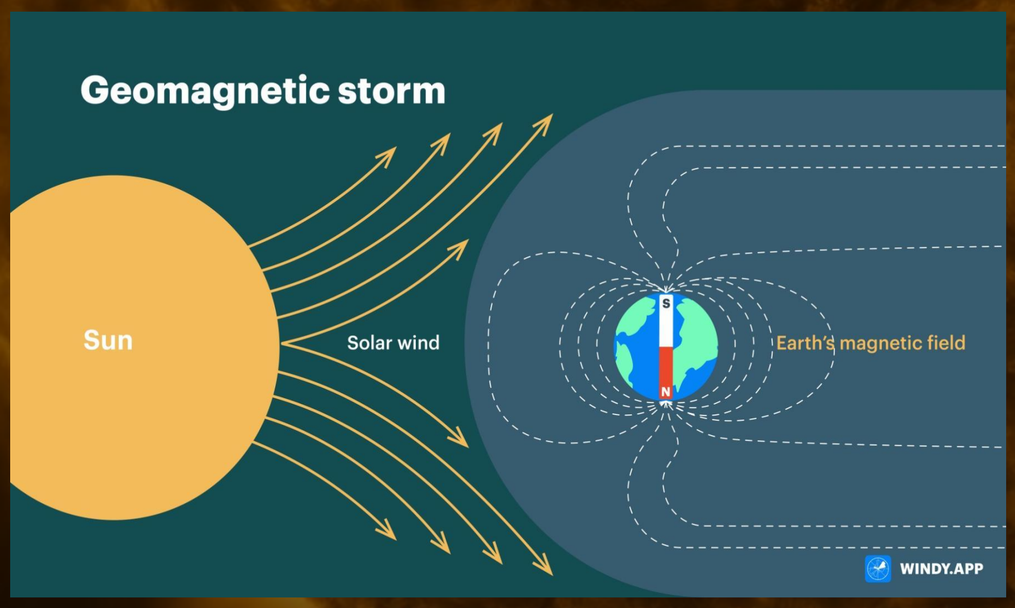

Fig 3: A schematic of how solar activity causes geomagnetic activity

Aims and Objectives

1. We examined the evolution of flares of various classes across different AIA wavelengths, tracking their progression from start to peak.

2. We investigated the impact of individual flares of different classes on geomagnetic activity up to 5 days after the flare.

3. We analyzed the collective impact of solar flares, as a representation of solar activity, on geomagnetic activity.

The effect of solar flares on geomagnetic activity

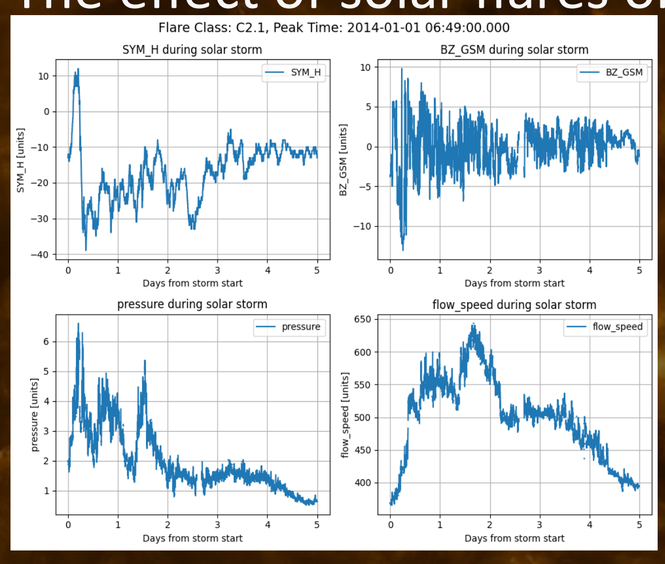

Fig 4: C class flares do not result in increase in geomagnetic activity, pr essure or flow speed of solar wind

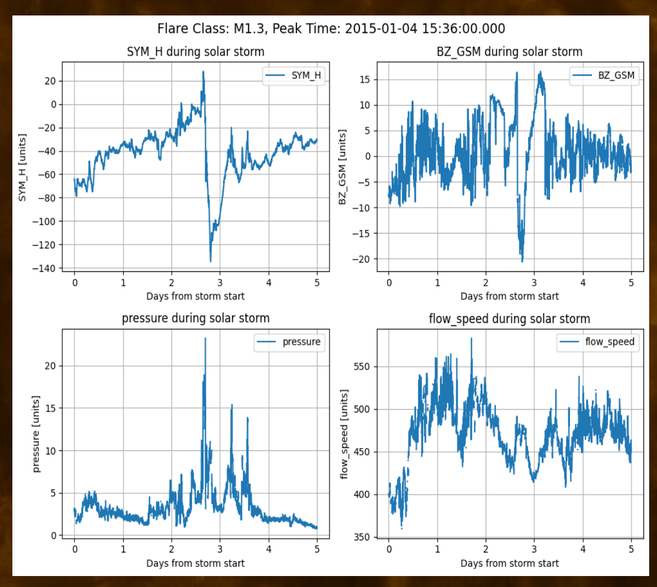

Fig 5: M class flares do result in geomagnetic activity when B_Z is negative.

They are sometimes followed by increase in flow speed but the increase in speed had no relation with strength of geomagnetic activity.

The increase in geomagnetic activity did coincide with increased pressure consistently

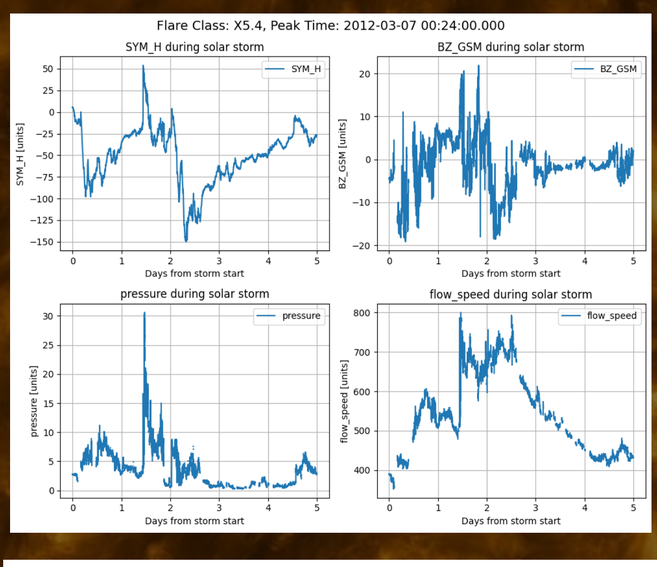

Fig 6: X class flares do result in high amount of geomagnetic activity when B_Z is negative.

X-class flares consistently exhibited an increase in flow speed alongside an increase in geomagnetic activity.

The rise in geomagnetic activity consistently coincided with increased pressure. However, in the instance presented here, the pressure and speed peaked almost a day before the geomagnetic activity reached its peak.

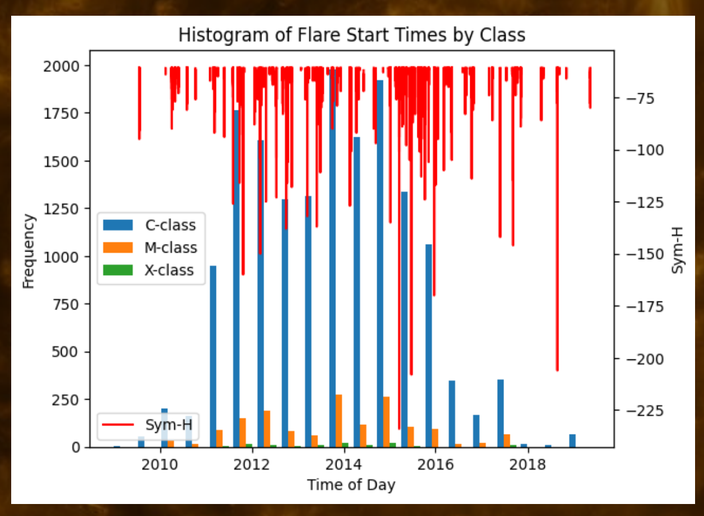

Fig 7: Examining significant geomagnetic activity (Sym-H < -60) and the frequency of flares over the course of Solar Cycle 24, we observe that increases in geomagnetic activity coincide with increases in the number of flares.

The observed impacts of various classes of flares on geomagnetic activity, as well as on the pressure and flow speed of the solar wind, are derived from a relatively small sample of flares. Further investigation is necessary to enhance confidence in these findings and to gain a deeper understanding of the underlying mechanisms.

CONCLUSION

When analysing the effects of individual flares, C-class flares did not result in any increase in geomagnetic activity. However, when considering the cumulative effect of flares, with C-class flares being the most frequent, peaks in geomagnetic activity were observed to coincide with peaks in the overall number of flares. A more rigorous statistical analysis is required to investigate this further.