STATISTICAL COMPARISON OF THE OCCURRENCES OF GEOMAGNETIC STORMS DURING THE RISING PHASES OF SOLAR CYCLES 21 – 24.

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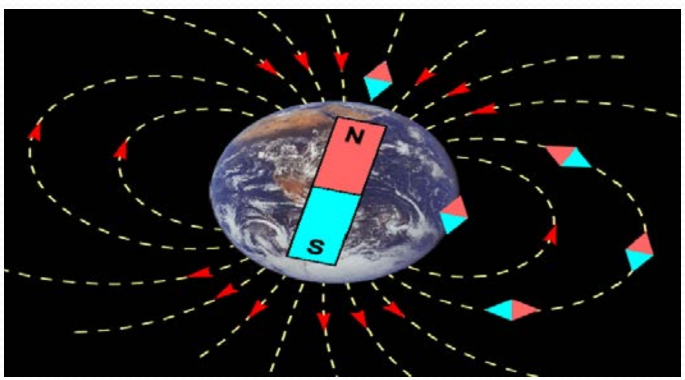
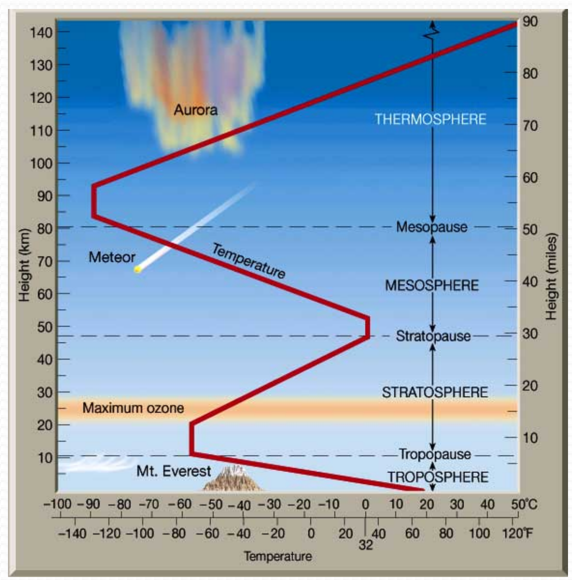
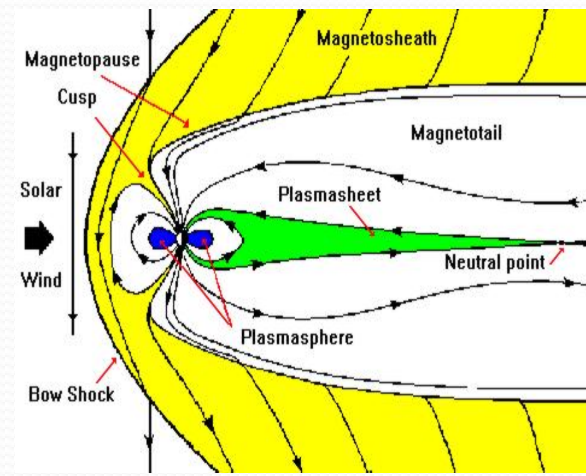
INTRODUCTION

➢The earth is a huge magnet, and its magnetic effect extends far into space. It has a powerful magnetic field caused by the nickel-iron core coupled with its rotation. The strong magnetic bubble that surrounds the earth is called the magnetosphere.

➢ The magnetosphere is the region of space surrounding the earth in which the magnetic field of the earth has a dominant control over the motion of charged particles.







Geomagnetic storms

- A geomagnetic storm is a large disturbance of the earth`s magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding the earth.

Solar wind energy input into the magnetosphere is given as

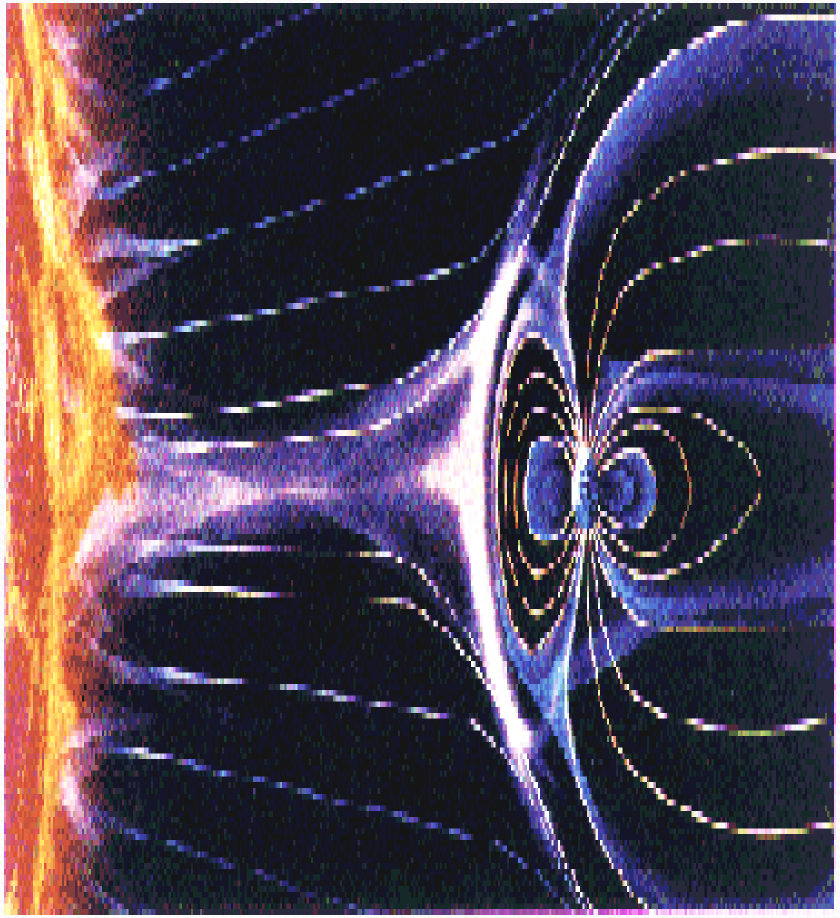
$$E = l_o^2 V_{SW} B^2 \mathrm{Sin}^4(\acute{Ø}/2)$$

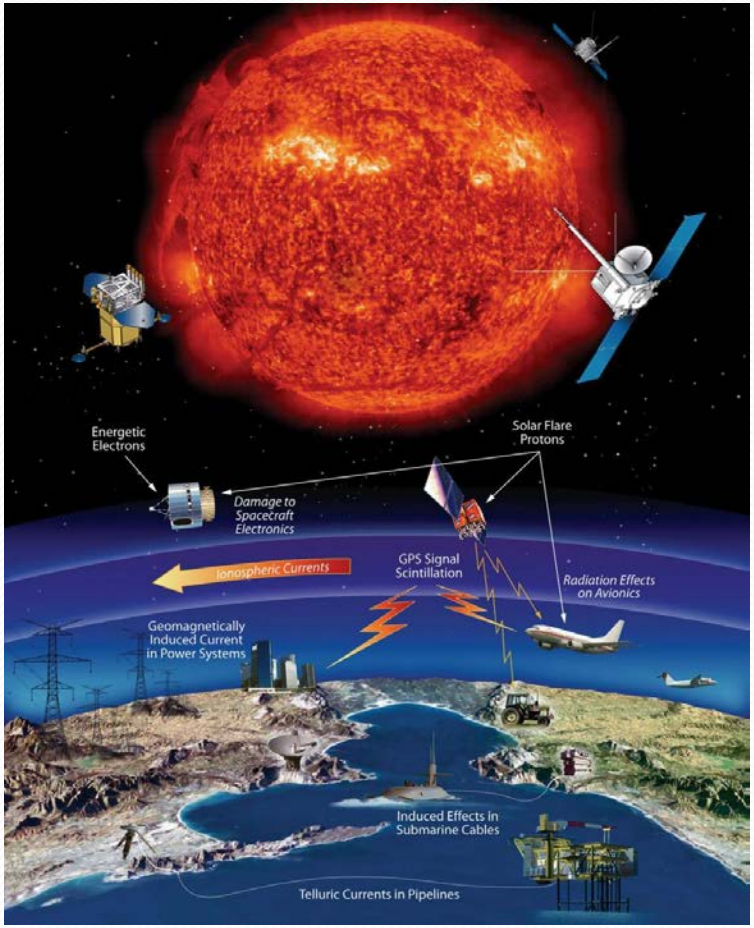
[Perrealt and Akasofu, 1978]

- It is caused by a massive burst of plasma with its embedded magnetic field from the sun. This is called coronal mass ejection (CMEs) CMEs driven storms are more common during the maximum of the solar cycle. They most often originate from active regions on the sun`s surface such as groupings of sunspots associated with frequent flares.

- The high-speed solar wind stream is another cause of geomagnetic storms. Solar streams are streams of plasma released from the upper atmosphere of the sun, consisting of mostly electrons protons and alpha particles. Geomagnetic storms can negatively affect satellite communications systems, navigation, electric power systems and a host of other infrastructures.

Some Effects of Geomagnetic Storms





MOTIVATION

- To investigate to the geomagnetic activity levels during the rising phases of the Solar Cycles 21 – 24.

- To determine the contributions of ICME and high speed streams to geomagnetic storm rates during the rising phases of Solar Cycle 21 – 24.

- To study the relationship between the frequency of occurrences of geomagnetic storms and peak sunspot number (SSN) during solar cycles 21 – 24.

METHODOLOGY

Data

The data used for the research were the Dst data from the Solar Physics Interactive Data Resources (SPIDR) and International Sunspot Number (SSN) from Solar Influences Data Analysis Centre (SIDC).

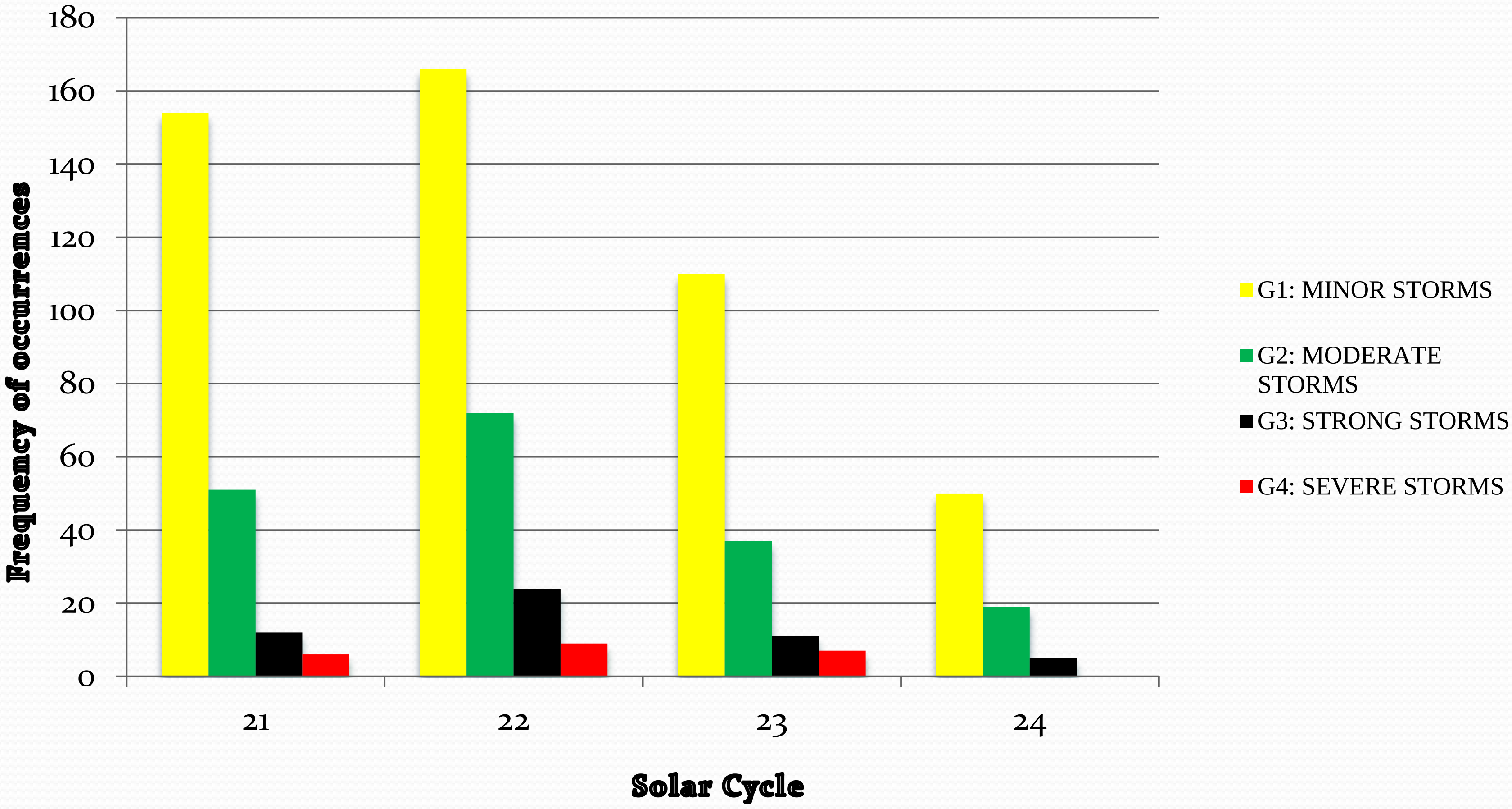
The methods used for this research are outlined below:

- The data obtained were analysed using statistical method of analysis.
- A plot showing the frequency of occurrences of G1, G2, G3 and G4 storms during the first 4 years was done against the solar cycles 21 - 24 in order to investigate the geomagnetic levels during theses periods
- Another plot was made to show the contribution of ICME and/or with their associated sheaths and high speed streams to minor and moderate storms using the data obtained from OMNI data set.
- To study the relationship between yearly sunspot number and the frequency of occurrences of minor, moderate and strong storms, cumulative G1, G2, or G3, storm rates in year 4 of cycles 21 – 24 was plotted against the peak smoothed SSN in each cycle.
- The plot thus led to the results and discussions on the outcome of the project work.

Results and discussion

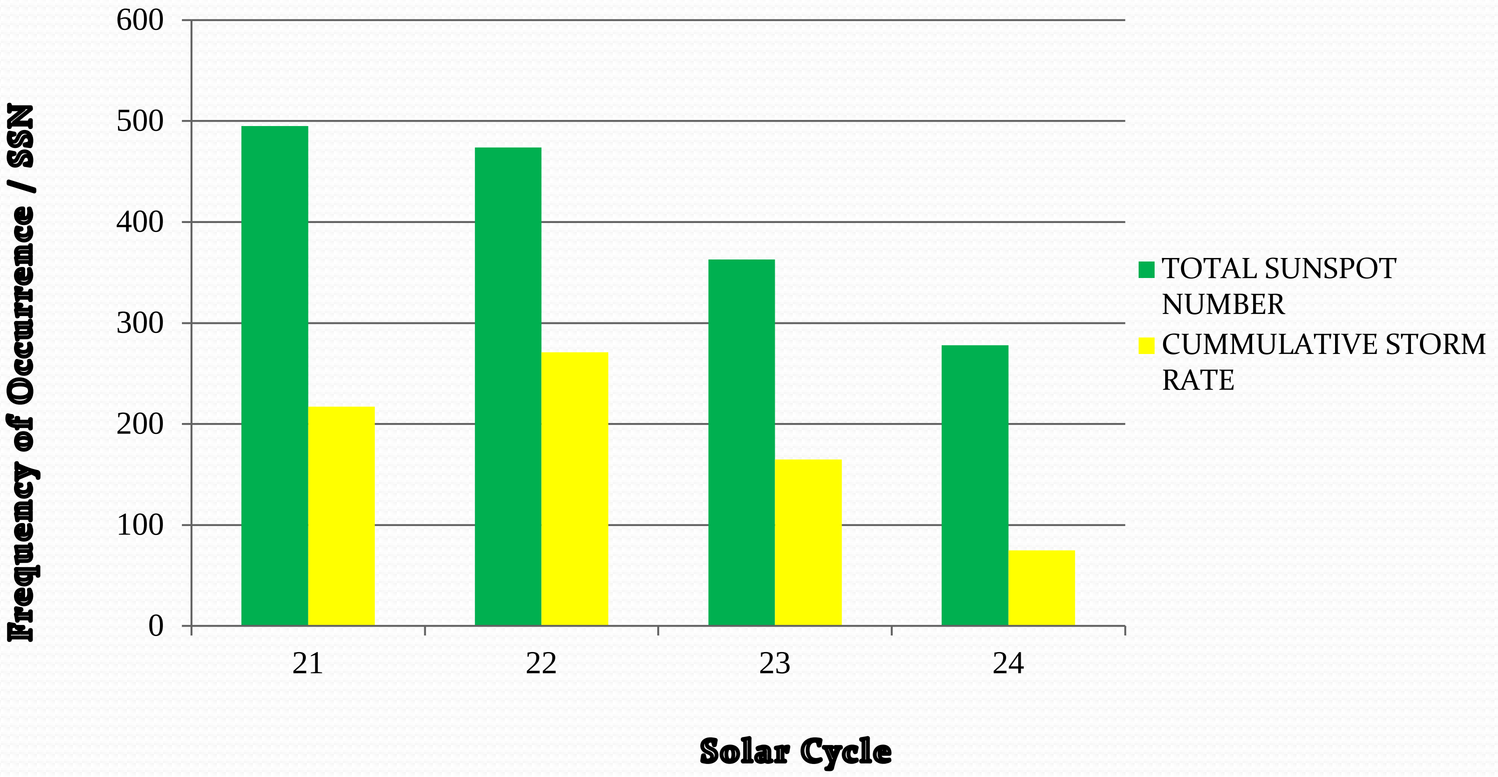
Result 1

Fig. 1: Cumulative rate of G1 to G4 storms days during the first 4 years of solar cycle 21- 24.



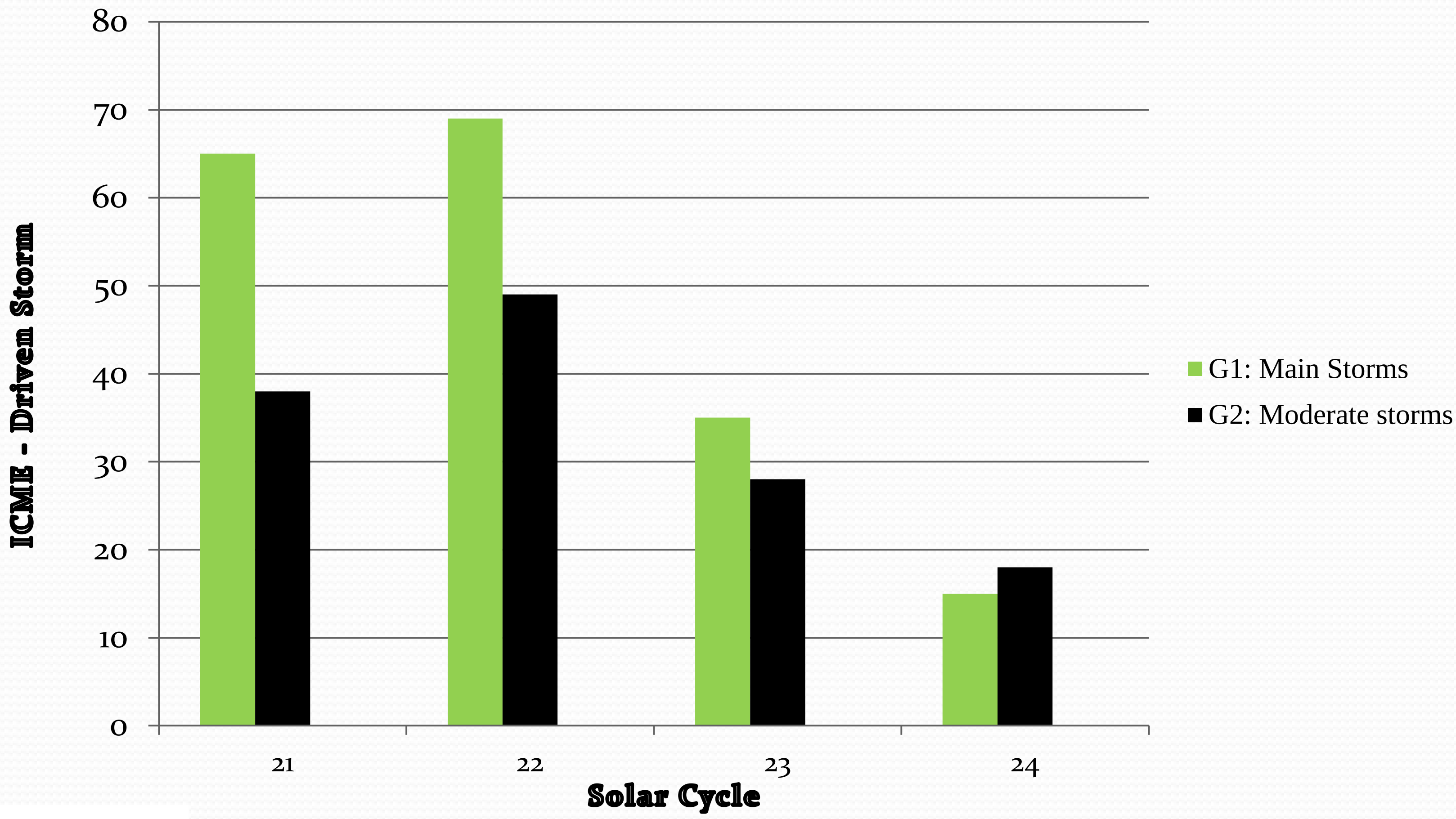
Result 2

Fig. 2 – Frequency distribution showing sunspot number and cumulative storm rate Solar Cycle 21 – 24



Result 3

Fig. 3: Yearly rates Sun G1 and G2 storms driven by ICME during the first 4 years of cycles 21 – 24.



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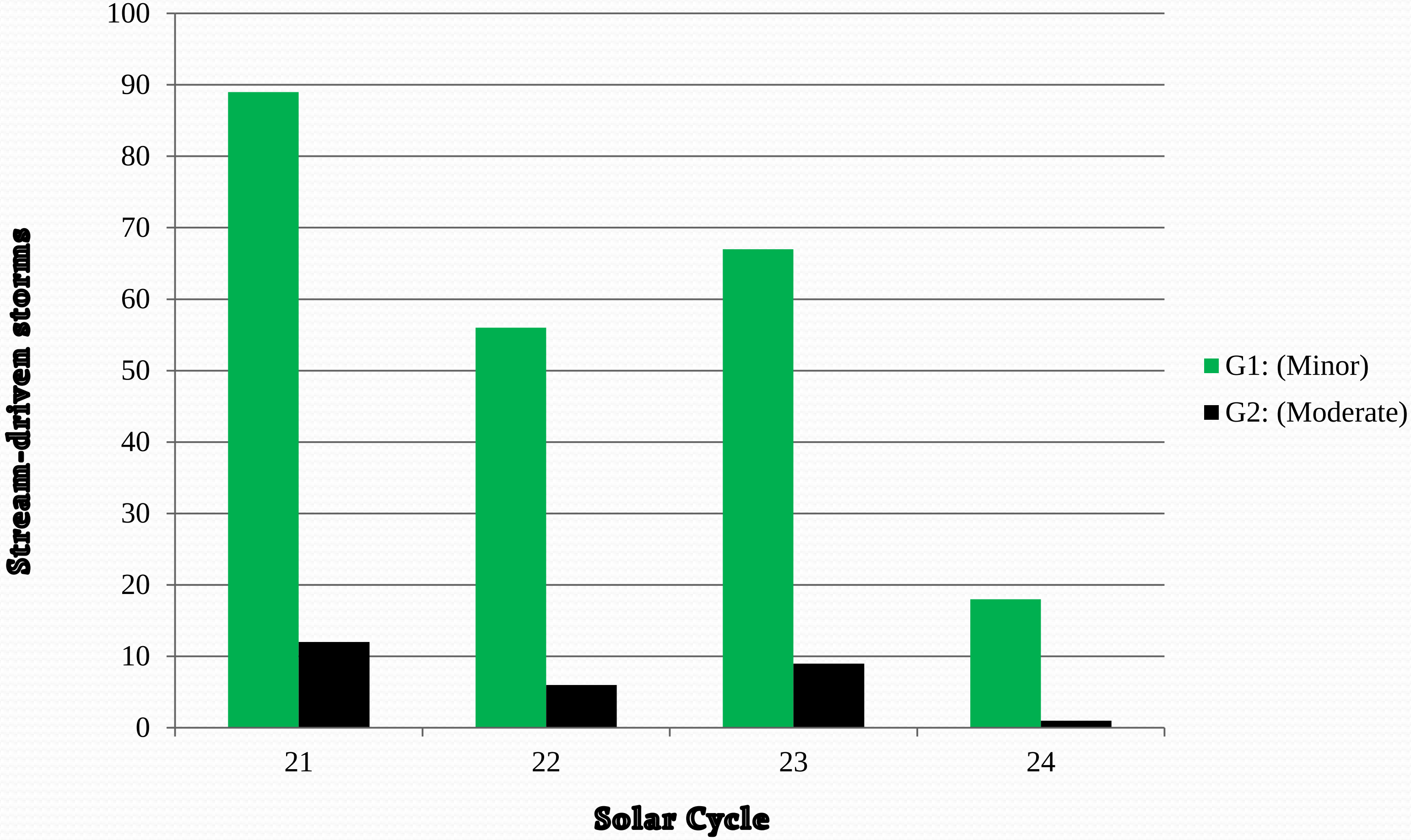
Result 4

Fig. 4: The yearly rates of G1 and G2 storms driven by high speed stream during the first 4 years of solar cycle 21 – 24.



Discussions:

Fig. 1 shows the plot of the frequency of occurrences of G1 to G4 storms during the first 4 years of solar cycle 21 – 24. Solar cycle 22 has the highest number of each storm category followed by cycle 21, then 23 and the solar cycle 24 having the lowest number. As shown in *Fig. 2,* the sunspot number decreases progressively from solar cycle 21 and have the lowest value in Solar cycle 24. Except for Solar cycle 21, there is a corresponding progressive decrease in geomagnetic storm rate from cycle 22 to 24.

Both ICME and HSS make more significant contributions to the G1 storms than the G2 storms as shown in *Fig. 3* and *Fig. 4* . For the G1 storms, the ICME driven storm rate increases when sunspot number increases as might be expected, whereas the stream-associated storm rate is more variable, with no clear trend with time. Also, the contribution from corotating streams to larger storms G2, is substantially lower than for G1 storms. In other words, the contribution to the total G2 storms by ICME is much more than by HSS.

CONCLUSIONS

The conclusions arrived at in this research work are as summarized below:

- Geomagnetic activity levels during the rise phases of solar cycle 21 – 24 were progressively decreasing with cycle 24 having the least storm rates.

- There is greater number of minor storms than other types in all the cycles under study. Solar cycle 22 has the highest number of each category of storms followed by cycle 21, then cycle 23 with cycle 24 being the one with the lowest number.

- Severe storms (Dst < - 250nT) were present during the first 4 years of each cycle under study except for cycle 24 and the occurrence of intense storms (Dst < - 100nT) was also much reduced in cycle 24.

- Both ICME – and high speed stream – related storm activities were reduced in the rise of the cycle 24 compared to cycles 21 – 23. ICME makes a more significant contribution to the G1 storms than the G2 storms.

- Unlike ICME – associated storms, the high speed stream – associated storm rate is more variable from cycle 21 – 24 with no clear trend with time. Corotating streams make substantial contributions to G1 storm rates. The G2 storms show similar pattern but clearly the effect from corotating streams to these larger storms is very much lower than for G1 storms.

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THANK YOU