



“The Solar-Terrestrial Links and Energy Transfer Mechanism in Recurrent Geomagnetic activities and Variation Of Initial, Main, & Recovery Phases”

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Abstract

Geomagnetic storms are the most dramatic manifestation of solar-terrestrial coupling they involve the injection of large amounts of energy from the solar wind into the earth's magnetosphere, Ionosphere and thermosphere. There are number of solar sources, two types of solar wind streams and different interplanetary parameters that are responsible for geomagnetic storms have been investigated by many researcher. Recurrent storms occur most frequently in the declining phase of the solar cycle. geomagnetic storms occur most frequently near solar maximum. The low-energy ions that replace them contribute little current, and so the strength of the ring current decreases with time. and general study and different characteristics of above selected 158 large geomagnetic storms are performed in this section. Out of the selected large geomagnetic storm events, 82 are sudden commencement type and rest 76 is gradual commencement type. Geomagnetic storms are the most dramatic manifestation of solar-terrestrial coupling. They involve the injection of large amounts of energy from the solar wind into the earth's magnetosphere, ionosphere and thermosphere.

Introduction

There are number of solar sources, two types of solar wind streams and different interplanetary parameters that are responsible for geomagnetic storms have been investigated by many researcher. Recently, it is believed that the coronal mass ejections and coronal holes are most violent solar source activities and are responsible for large geomagnetic storms. These solar transients can produce shock waves in solar wind. The shock waves travels in space in sunlit direction and interact with geomagnetosphere causes ionospheric disturbances, (Allan,D.W.)¹. There are number of solar sources, two types of solar wind streams and different interplanetary

parameters that are responsible for geomagnetic storms have been investigated by many researcher. Recently, The geomagnetic disturbances can be observed at various locations of the earth's surface such as polar, mid-latitude and equatorial regions. (Busse, F.H.)². These geomagnetic disturbances are generally observed and represented by different geomagnetic indices A_E , K_p or A_p and equatorial D_{st} values respectively. They are caused by interplanetary disturbances driven by fast coronal mass ejections and typically involve an encounter with both the interplanetary shock wave and the coronal mass ejections (CMEs) that drives it.

Solar Terrestrial Links

They involve the injection of large amounts of energy from the solar wind into the earth's magnetosphere, ionosphere and thermosphere geomagnetic storms and auroral display. (Chree, C.)³. Geomagnetic storms also have major effects on technical systems in space. The events of significant scientific and natural interest. Figure 1. Energy Transfer Mechanism,

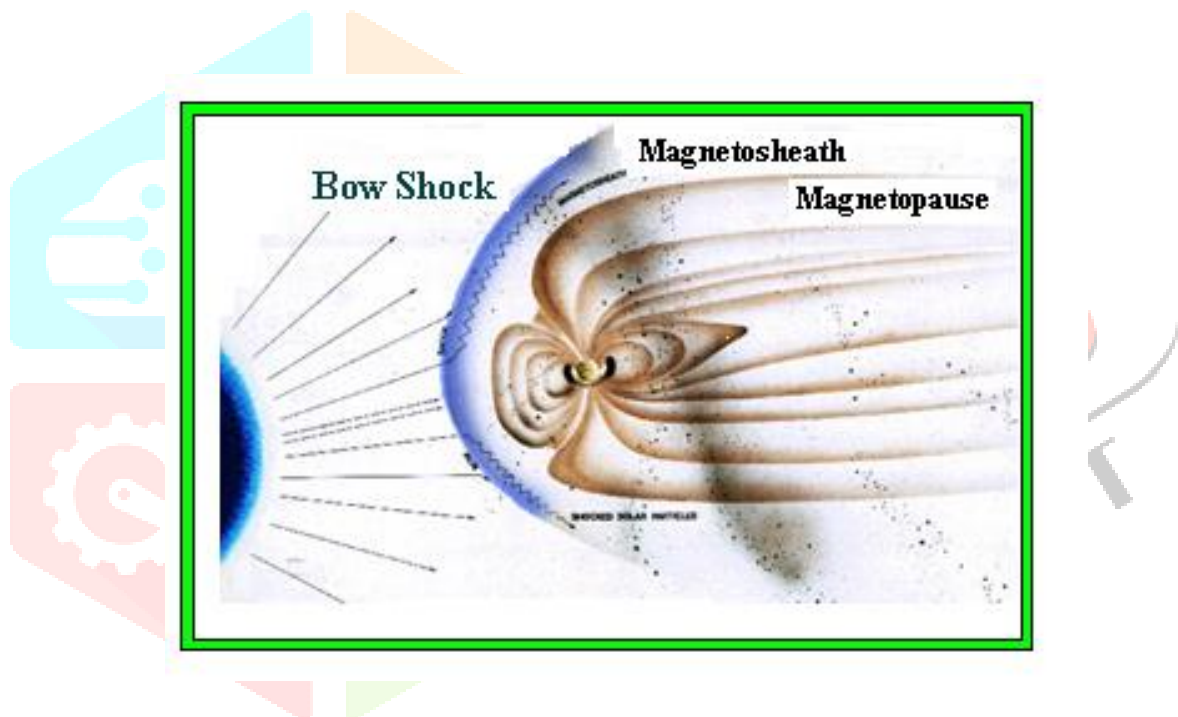


Figure 1. Shows the formation of the bow shock front. In this figure bow shocks are formed on frontal surface of the magnetosphere, where the solar wind has its first impact with geomagnetic field.

There is a growing evidence that the changes in the geomagnetic field affect biological systems. Recent studies indicate that physically stressed human biological systems may respond to fluctuations in the geomagnetic field. (Heikkila, W.J.)⁴. Possibly the most closely studied of the variable Sun's biological effects has been the degradation of homing pigeons navigational abilities during geomagnetic storms. Pigeons and other migratory animals, such as dolphins and whales. Have internal biological compasses composed of the mineral magnetite wrapped in bundles of nerve cells. While this probably is not their primary method of navigation, there have been many pigeon race

smashes a term used when only a small percentage of birds return home from a release site. (Hewish,A)⁵. Because these losses have occurred during geomagnetic storms, pigeon handlers have learned to ask for geomagnetic alerts and warnings as an aid to scheduling races.

Geomagnetic hazards

Geomagnetic storms are large scale disturbances on the earth's magnetosphere and decreases horizontal component (H) of earth's magnetic field. The solar wind pressure on the magnetosphere will increase or decrease depending on the solar activities. Solar wind pressure changes modify the electric currents in the ionosphere. . (Kahler,S.W.)⁶. The solar wind also carries with it the magnetic field of the Sun. This field will have either a north or south orientation. Either the solar wind has energetic bursts, contracting and expanding the magnetosphere, or the solar wind takes a southward polarization. The southward field causes magnetic reconnection of the dayside magnetopause, rapidly injecting magnetic and particle energy into the earth's magnetosphere. During a geomagnetic storm the ionosphere's F₂ layer will become unstable, fragment, and may even disappear.(SGD Solar Geophysical Data, NOAA,)⁷.In the northern and southern pole regions of the Earth aurora will be observable in the sky. A complete morphology of formation of the magnetosphere, during storm time and its different regions alongwith reconnection technique are displayed in Figure 2.

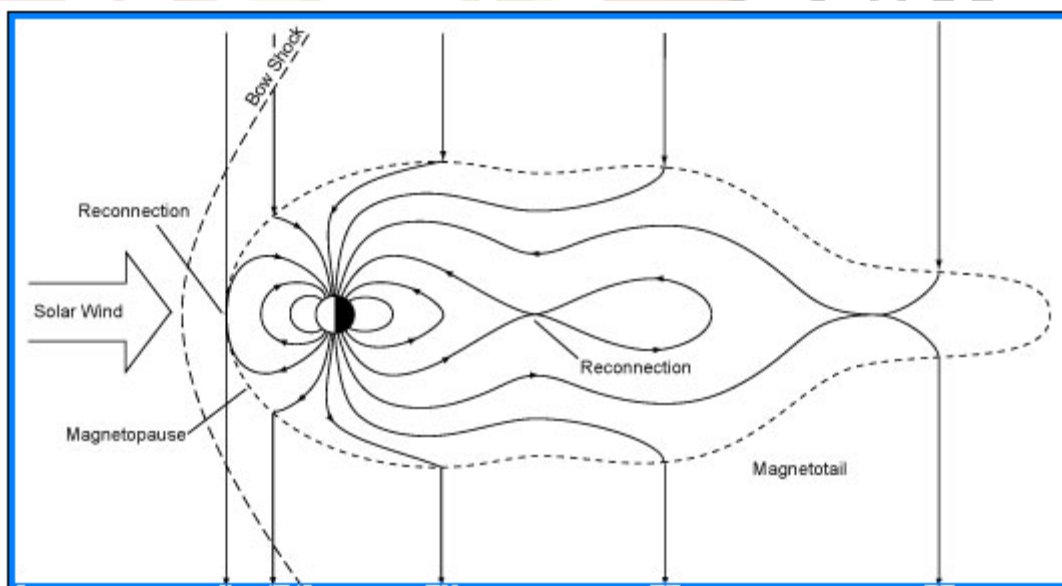


Figure 2.Shows the formation of the magnetosphere, during storm time. The different regions and process occur on magnetosphere alongwith reconnection technique are displayed in the figure.

Space weather phenomena are highly concerned with geomagnetic activities. Energetic particles thrown out from the Sun interact with the geomagnetic field producing magnetic disturbances and increased ionization in the ionosphere,

Geomagnetic storms are large disturbances

The geomagnetic storms earth's magnetosphere, Often persisting for several days are more. During geomagnetic storms strong electric currents flowing within the geomagnetosphere and ionosphere. These currents perturb the magnetic field measured at the earth's surface, the aurora brightens and extended to low magnetic latitudes, and intense fluxes of energetic charge particles are generated within the magnetosphere. Solar output in term of solar plasma and magnetic field ejected out into interplanetary medium consequently create the perturbation in the geomagnetic field. (Tsurutani, B.T. Anne.)⁸. *Geophysica* When these plasmas and fields reach on the earth's magnetosphere produce extra ionization in the sunlit part of the Earth and exhibit peculiar storm time changes in the geomagnetic field. The variation of earth's magnetic field is usually expressed through magnetograms of. A large number of geomagnetic storms occurred during the maximum phase of 11-year sunspot cycle because many solar activities are vastly occurring during this time.

Standard Geomagnetic Storms

A standard geomagnetic storm is temporary disturbances in the earth's magnetosphere. Shock waves that may be associated with solar coronal mass ejections or coronal hole arrive 24 to 36 hours after occurring event. When the shock wave front is perpendicular to the Sun-Earth line, the magnetosphere, from its apex towards the tail, is exposed to the post-shock solar wind. Thus the magnetosphere adjusts itself to a new solar wind condition from its apex. Eventually a new steady electric current ring current is established through out the magnetopause and hydromagnetic waves of the different modes are generated. The propagation of hydromagnetic waves is complicated during the passage of the wave through ionospheric medium, which is very weakly ionized plasma. Finally, part of the wave descends through the basis of ionosphere and reaches the earth's surface resulting in the SSC. The SSC is characterized in low and moderate latitude by an increase in the horizontal component (H) of the geomagnetic field. (Tsurutani, B.T. 1997 *The Interplanetary Causes*)⁹. A standard type of geomagnetic storm can be classified as: sudden commencement storm and gradual commencement storm. Sudden commencement storms consists initial, main and recovery phase, whereas, gradual commencement storm having only main and recovery phase. Once the initial shock wave has passed the solar wind returns to normal pressure and the magnetosphere recovers. Over the next several hours, the magnetic field remains fairly

stable with only minor fluctuations. It is not necessary that all geomagnetic storms begin with a sudden storm commencement (SSC). Fast solar eruptions and huge solar explosions mostly cause SSC impulses. Some storms begin with the main phase that is usually caused by coronal holes that can eject solar materials without the violent explosions and fast solar transients.

Variation of initial, main, and recovery phase durations

A standard classical geomagnetic storm can be divided into three phases, namely initial phase main phase and recovery phase. In this study, the best-fit initial, main and recovery phase durations have been analysed for above selected large geomagnetic storm events. Figure 3 shows the compiled plots for initial phase, main phase and recovery phase durations. The initial phase is magnetic manifestation of the interaction between post-shock solar wind and the magnetosphere. (Zhu,B.Y.)¹⁰. An enhancement in H-component is measured through ground magnetometer, during initial phase. For the study of the initial phase duration, the number of such storm events have been selected whose initial phase duration varies in the time intervals of 0-2, 3-4, 5-6, 7-8 and > 8 hours. Similarly, for the main phase, time intervals of 0-6, 7-12, 13-18, 19-24 and > 24 hours have been selected.

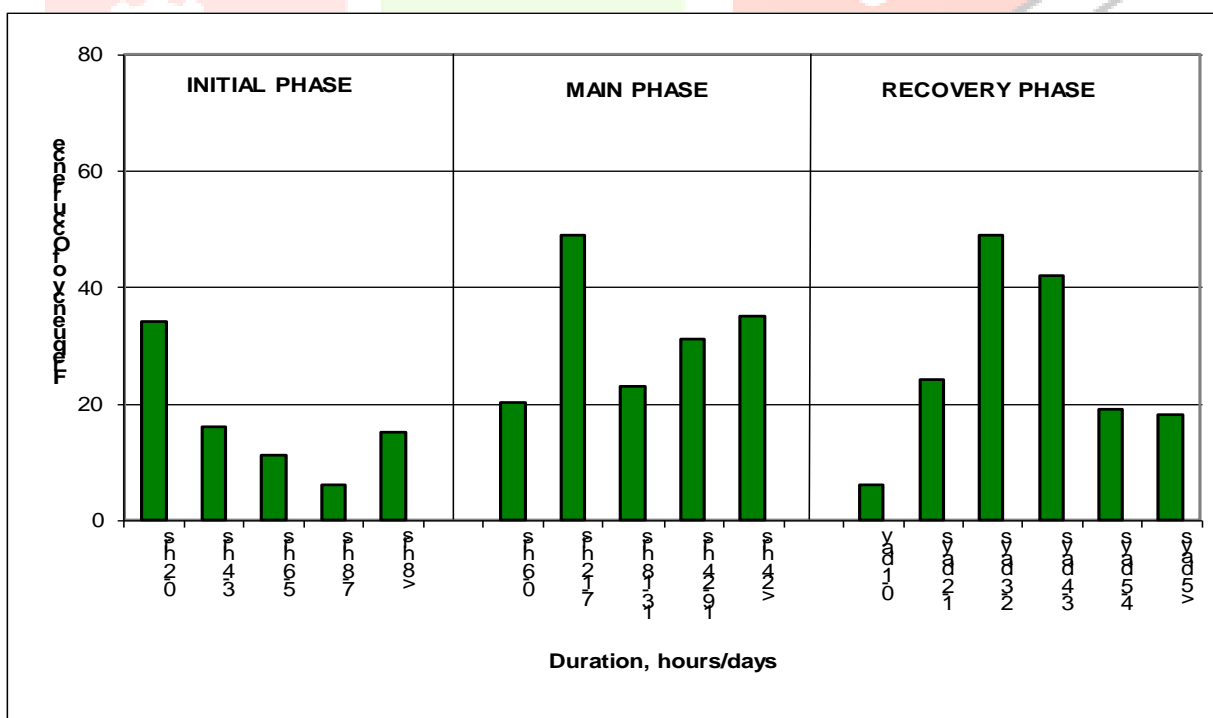


Figure 3. Frequency occurrence histogram shows the initial, main and recovery phase duration for selected 158 large geomagnetic storms in a specific range that is observed during 2001-2017.

Generally, the recovery phase of storms takes more time, so the time intervals varying in the range of 0-1, 1-2, 2-3, 3-4, 4-5 and > 5 days have been chosen. From these plots, it is clear that the best initial phase duration lies between 0 and 2 hours. The initial phase is caused by an enhancement of solar wind behind the shock wave. It is a quasi-steady state preceded by sudden storm commencement. The main phase duration for maximum number of intense storms lies between 7-12 hours. The main phase of the geomagnetic storm is characterized by the decrease in H-component of the earth's magnetic field and followed with the sudden ionospheric disturbances (SIDs) and ring current system. Storm associated with SSC shows faster recovery in comparison to other storm that is not associated with SSC. About three to six hours after the SSC, the main phase of the storm begins. At this time, particles that have been ejected from the fast solar eruptions arrive at magnetosphere and produce ring currents. The ring current causes large decrease in H component of the geomagnetic field, known as geomagnetic storms. As long as injection of the particles continues, the ring current will glow toward some asymptotic value in which the rate of injection equals the rate of loss. The time during, which the ring current is glowing, (Farrugia,C.J.)¹¹. Is called the main phase of geomagnetic storms. Simply the main phase is characterized by a decrease in the mean value of H first below high mean of the initial phase and then below the normal prestorm value. The magnitude of H decreases by several hundred nT in a few hours. The main phase of geomagnetic storms generally lasts 12 to 24 hours and tends to be noisy.

Conclusions

They involve the injection of large amounts of energy from the solar wind into the earth's magnetosphere, ionosphere and thermosphere. The shock waves travels in space in sunlit direction and interact with geomagnetosphere causes ionospheric disturbances, (Feynman, J and J. *Geophys*)¹². There are number of solar sources, two types of solar wind streams and different interplanetary parameters that are responsible for geomagnetic storms have been investigated by many researcher. A term used when only a small percentage of birds return home from a release site. Because these losses have occurred during geomagnetic storms, pigeon handlers have learned to ask for geomagnetic alerts and warnings as an aid to scheduling races. The initial phase is magnetic manifestation of the interaction between post-shock solar wind and the magnetosphere. It is a quasi-steady state preceded sudden storm commencement. An enhancement in H-component is measured through ground magnetometer, during initial phase. For the study of the initial phase duration,

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