Geoeffectiveness Structure of some Geomagnetic and Interplanetary Parameters in Extreme Perturbations of GIC Proxy Index: Observation and Simulation Results

Babatunde O. Adebesin,*[1,] Antti Pulkkinen,[2] Chigomezyo M. Ngwira[3, 4.]

[1]*Space Weather Group, Department of Physical Sciences, Landmark University, P.M.B. 1001, Omu-Aran, Nigeria*

[2]*Space Weather Research Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA.*

[3]*ASTRA LLC, Louisville, CO 80027.*

[4]*Department of Physics, Catholic University of America, Washington, DC, USA.*

**Corresponding author: f_adebesin@yahoo.co.uk; adebesin.olufemi@lmu.edu.ng; +234-805-8051-253.*

Present Address: Department of Physical Sciences, Landmark University, P.M.B. 1001,

Extended Abstract

The time derivatives of the ground magnetic field variation (*dB/dt*) had been found to be a good proxy parameter for identifying the activities of Geomagnetic Induced currents (GICs), especially during magnetic disturbed periods. This is because GICs are quantified by the geoelectric field conditions, which are proportional to *dB/dt* variations. The geoelectric field induced on ground, by spatio-temporally fluctuating ionospheric and magnetospheric current systems is the main physical quantity driving GICs. The study of GIC which is a manifestation of space weather has been on the increase because of its adverse effects on ground-based infrastructure and other sensitive equipment in the environment.

More recently it has been shown [Adebesin et al., 2016] that though the rapid *dB/dt* enhancements/perturbations are as a consequence of the magnetospheric current, it is however being enhanced by solar proton density (and dynamic pressure) variations, in which case the proton density and bulk wind speed together can be used as a predictor of the extreme *dB/dt* enhancements, and hence GIC precursor. Consequently, this work aims at investigating the geoeffectiveness structure of each of the IMF *Bz*, solar proton density, and flow speed in the generation of extreme *dB/dt* enhancements during a severe geomagnetic storm event, across several latitudes. The essence is to be able to ascertain which particular parameter out of the three under consideration is most prevalent in affecting reasonable *dB/dt* perturbations in each latitude and to what extent. This is done using both observational and simulation data analysis.

1-minute resolution solar wind and geomagnetic data obtained from 8 high-, mid-, low- and equatorial/low-latitude stations (within the 285^0E – 307^0E longitude chain) during the extreme geomagnetic activity of 20 November 2003 (SYM-H = -488 nT) was used to investigate the extreme *dB/dt* perturbations. While the solar and interplanetary data were obtained from the NASA CDAWEB facility (http://cdaweb.gsfc.nasa.gov.),that of the ground-based magnetic data was obtained from INTERMAGNET database (www.intermagnet.org). Simulations of the magnetospheric-ionospheric environment were also performed for varying amplitudes of the solar proton density, Flow speed, and IMF-Bz using the SWMF/BATS-R-US+RCM model (available for runs-on-request at http://ccmc.gsfc.nasa.gov).

In other to quantify the geoeffectiveness of each of the three parameters (i.e. *IM- Bz, Np* and *V*) under investigation, the model chain was run with three different varying magnitudes and respective fixed values for the model parameters

i. For varying magnitudes of *Np*: *Bx* = 0, *By* = *Bz* = -5 nT, *Vx* = 450 km/s, *Vy* = *Vz* = 0, and *T* = 50000 K
ii. For varying magnitudes of *Vx*: *Bx* = 0, *By* = *Bz* = -5 nT, *Np* = 5 /cm^3, *Vy* = *Vz* = 0, and *T* = 50000 K
iii. For varying magnitudes of *Bz*: *Bx* = 0, *By* = -5 nT, *Np* = 5 /cm^3, *Vx* = 450 km/s, *Vy* = *Vz* = 0, and *T* = 50000 K

The observational result shows that the largest *dB/dt* values occur in the high latitudes and decreases with decreasing latitude except at equatorial location whose magnitude upshots mid-latitudes. The amplification factor (A_f,) defined by *[dB/dt]/[d(SYM-H)/dt]* ratio is highest at equatorial latitude. The simulated result revealed that fluctuating flow speed (*V*) could trigger earlier response from the magnetosphere while the response due to fluctuating proton density (*Np*) could have a lasting effect on the magnetosphere. The simulated *dB/dt* perturbation magnitude for fluctuating V was higher than that of the corresponding *Np* and IMF *Bz*. For all fluctuating conditions, significant perturbation was observed in all latitudes except the high-latitude, where it was suggested that all three parameters must be simultaneously active for the emergence of appreciable *dB/dt* observation.

Our result revealed that different modulators are responsible for extreme *dB/dt* perturbation at high- and equatorial latitudes. On the geoeffectiveness, we conclude that all three parameters are necessary for a proper identification of magnetic field response to geomagnetically disturbed phenomenon. GIC should therefore not be considered as a non-negligible phenomenon at all latitudes.

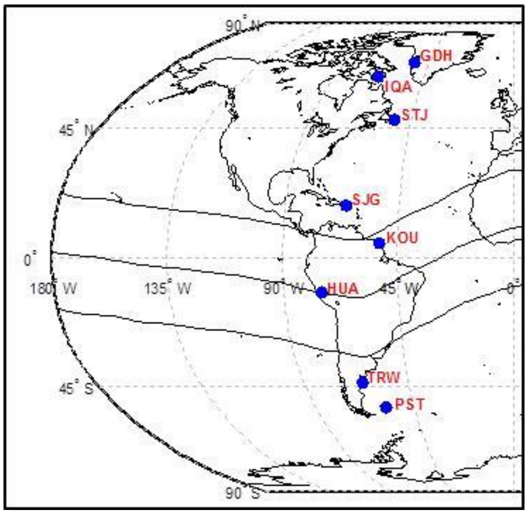

Fig. 1: Map showing the magnetometer stations and locations along a chain of 285^{0}E – 307^{0}E geographic longitude

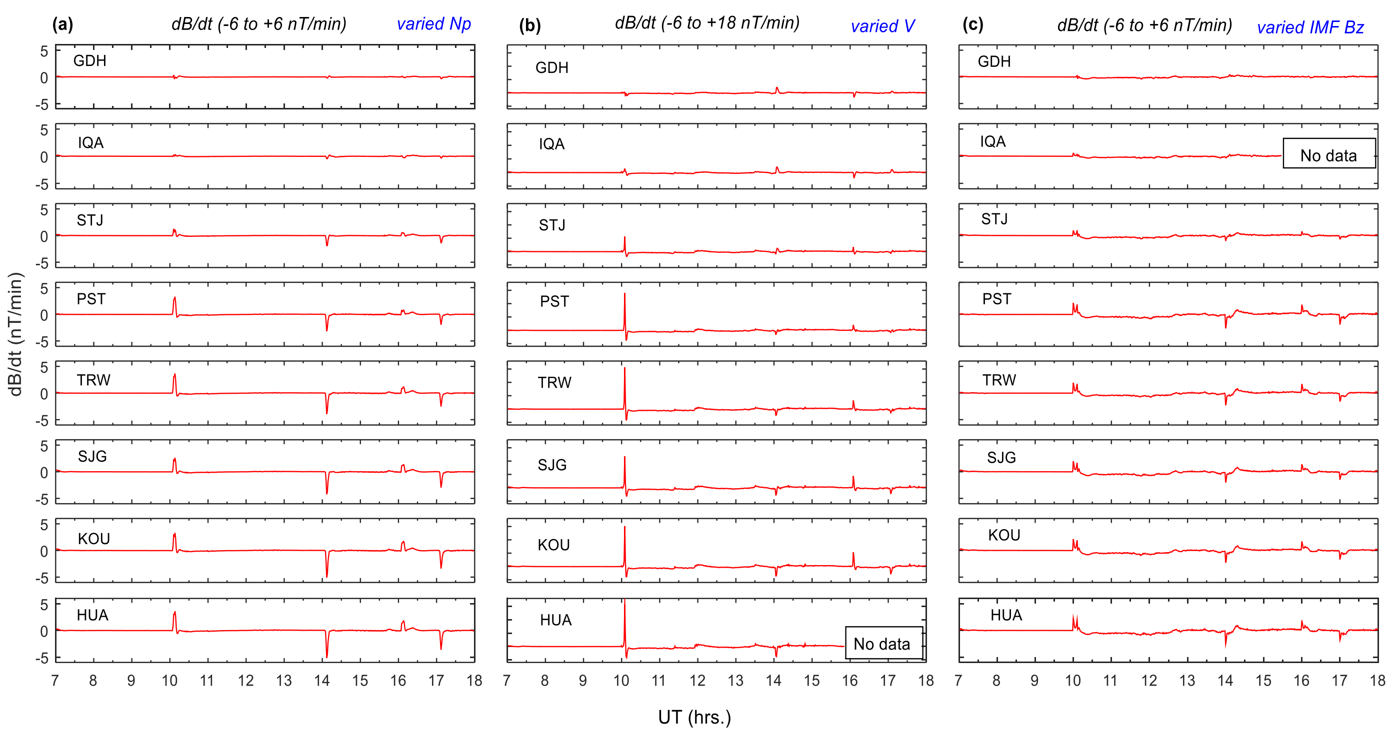

Fig. 2: One-dimensional output plot of SWMF model at different locations due to the simulated data for varying magnitudes of (a) *Np*, (b) *V* and (c) IMF *Bz*.

References:

Adebesin, B. O., A. Pulkkinen, *and* C. M. Ngwira *(*2016*)*, The Interplanetary and Magnetospheric Causes of Extreme d*B*/d*t* at Equatorial Locations, Geophys. Res. Lett., 43, *11,501-11,509. doi:*10.1002/2016GL071526.

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