Influence of Solar Dipole Field on Earthquake Occurrence

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Abstract

In our study, we contribute one another connection between geophysics and planetary science by investigating influence of Solar Dipole field (SDF) and frequency of Earthquake's occurence. First, during period from solar maximum at 2000 to solar maximum at 2012, we compare variations of Number of World's Earthqaukes (NEQKs) , Solar Dipole (SDF) with equatorial (E-SDF) and axial (A-SDF)components which contribute to of Interplanetary Magnetic Field (IMF). Then, to describe diverging of outer core leading to earthquake, we apply a model of spherical shell composed of co-axial circular areas of infinatisimal thickness. The largest of them surrounds equatorial plane. The shell contains bulk of outer core's conductive liquid. According to our model, we focus on total contributions from forces applied by Axial and Equatorial Dipole Fields, of Earth (A-EDF and E-EDF) along the radial distance, to act on azimuthal elecrical flow and convectional elecrical flows, respectively. Influence of Coriolis force decreases whenever the force acting on the convectional flow is effective to push the outer core diverges toward mantle to trigger an earthquake . Plotting of Number of Geomagnetic Storms (N-GMS) per Year is considered, the variations in N-GMS, and the strengths of A-SDF and E-SDF, are seen to be connected with the variations in N-WEQKs, throughout the solar storms, for the period of interest. During rising phase from 2000 to 20003, as the strength of SDF with dominant components of west to east oriented (WE) E-SDF , which contributes mainly to IMF, increases. As the strength of WE IMF, increases, number of solar storms increases. The increasing number of solar storms , which distort the EDF with components of EW E-EDF and northward (NW) Axial EDF (A-EDF), results in decsending N-WEQKs . During rising phase from 2003 to 2009, as the strength of SDF with dominant components of west to east oriented (WE) E-SDF , which contributes mainly to IMF , decreases, the strength of WE IMF and number of solar storms decrease and leads to increase in N-WEQKs . During rising phase from 2009 to 2011, as the strength of SDF with dominant components of southward (SW) SADF , which contributes mainly to IMF, decreases. leads to more effective NW A-EDF which results in ascending N-WEQKs.D uring rising phase from 2011 to 2012, the strength of SDF with dominant east to west oriented (EW) SEDF , which contributes mainly to IMF , increases. The increasing strength of EW IMF leads to less effective NW A-EDF. Hence, N-WEQKs is reduced. To conclude, our study shows that better modeling and forecasting of earthquakes could be done throughout the conditions in Earth-Sun system, instead of conditions just on Earth.

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Purpose

In our study, we find another connection between geophysics and planetary science by investigating influence of Solar Dipole field (SDF) and frequency of Earthquake's occurence.

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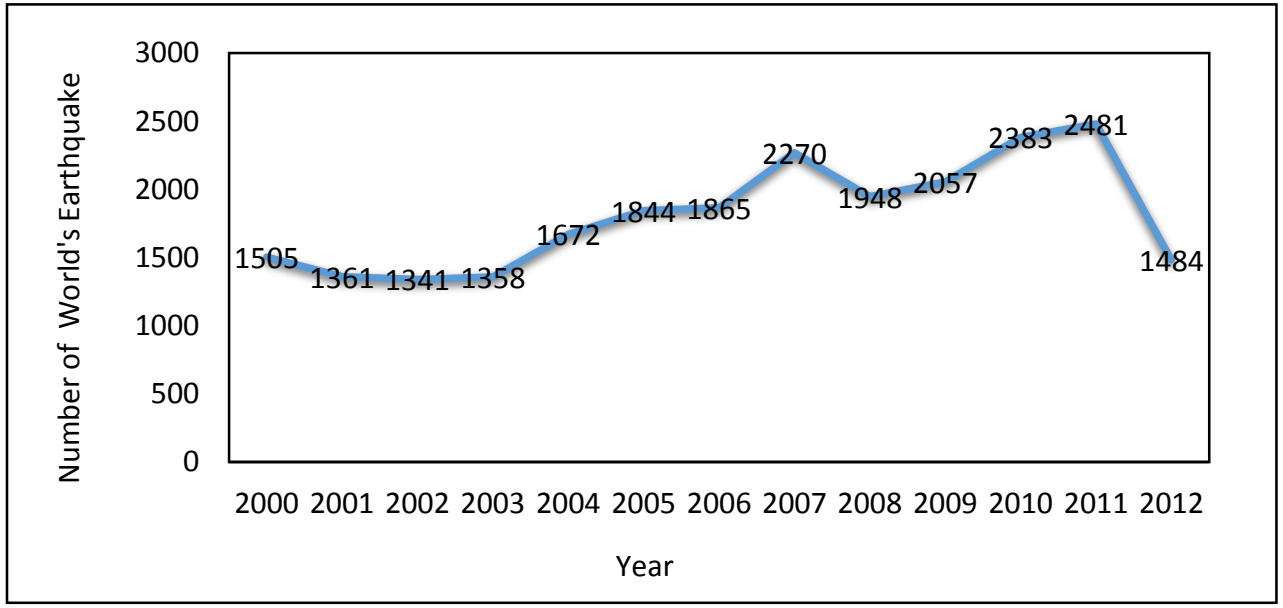
Method

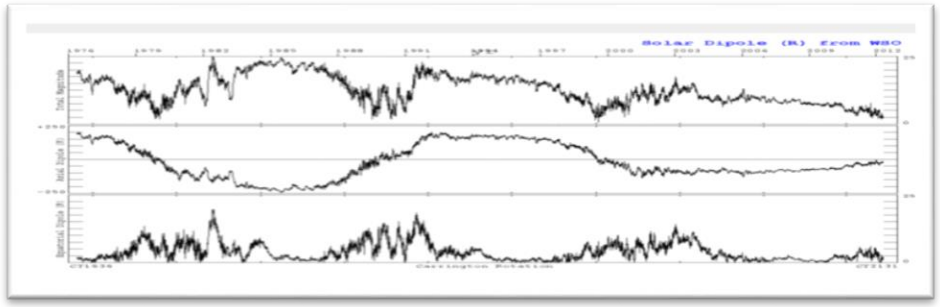
First, we plotted **Number of World Earthquakes** (NWEQKs) with magnitude from 5.0 to 9.9 versus Year to compare the changes in **Interplanetary Magnetic Field (IMF)** from 2000 to 2012, by using data from https://www.livescience.com/45750-chart-of-earthquakes-worldwide-2000-2014 infographic.html.

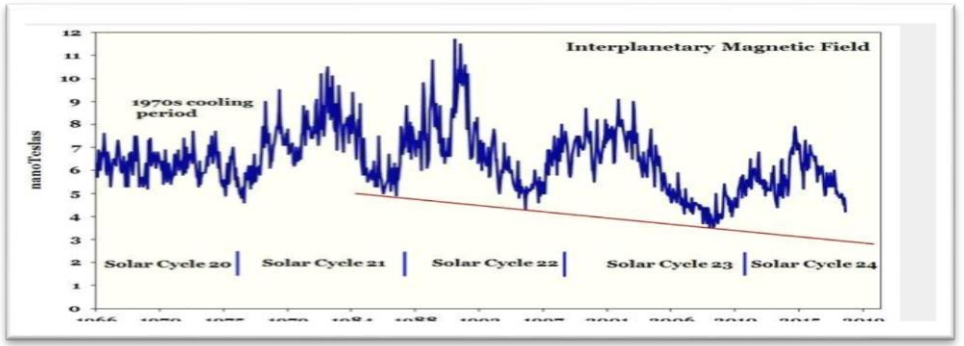


Also, we apply a **model of outer core** as spherical shell built by infinatismal number of co-axial circular areas with infinatismal thickness around Earth's rotational axial and with sizes getting larger from boundary with inner core to the boundary with mantle.

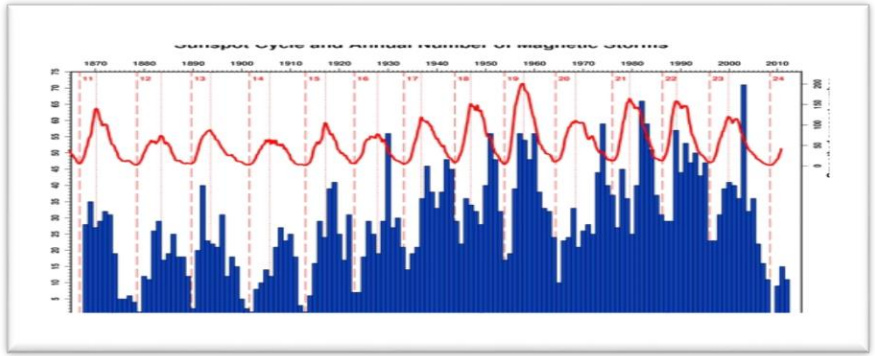
These co-axial circular areas with infinatismal thickness , altogether, builds up the bulk of the outer core.

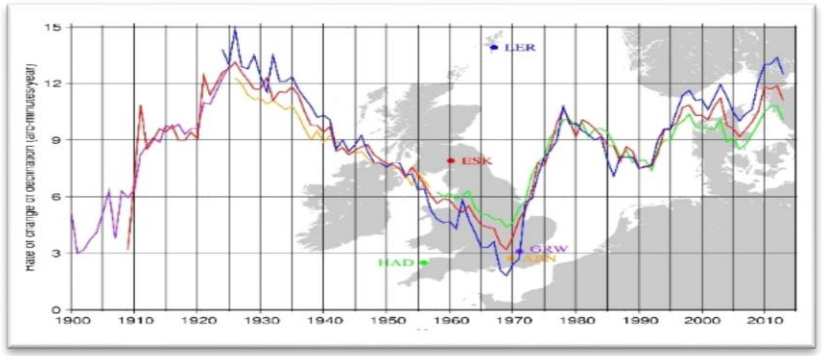
According to our model, to describe diverging and converging of the outer core , we focus on total contributions from $v_\emptyset \times B_z$ -force and $v_z \times B_\emptyset$ -force applied by **Axial and Equatorial Dipole Fields**, (B_z and $B_\emptyset$) of Earth (**A-EDF** and **E-EDF**), along the radial distance.

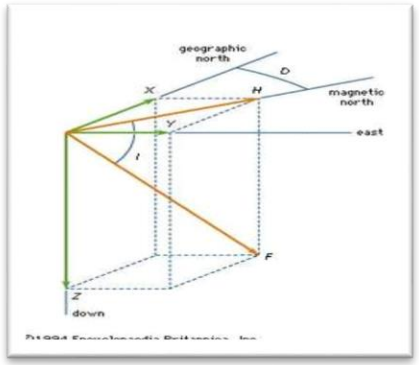




Then , we refer to graphs of **Equatorial and Axial Sun's dipole fields** (**E-SDF** and **A-SDF**) (at the center and bottom panels) per Year (Hoeksema**,** J. T., 2012) and variations of the **IMF** versus Year for the period of interest,2000 to 2012.







http://www.geomag.bgs.ac.uk/education/earthmag.html

https://www.britannica.com/science/geomagnetic-field

Moreover , we consider plottings of Number of Geomagnetic Storms (**N-GMS**) per Year and Rate of Change of **Angle for Declination, D**, (**RC-AD**) of **Earth Magnetic Field** per Year from 2000 to 2012.

These forces act on **azimuthal elecrical flow**, $v_{\emptyset}$,due to rotational motion and **convectional elecrical flows** , v_z ,due to thermal motion along rotational axis being against the gravity, to suppress Coriolis Force, F_C ,respectively.

Case 1 : Decreasing NWEQKs

Influence of Coriolis force, F_C increases, as outer core converges toward inner core due to being pushed by **centripetal** $v_{\emptyset} \times B_z$ **-force** along radial distance inward direction to center of Earth as rotational speed of outer core increases.

Consequently, the outer core liquid along the boundary with solid inner core could squezed to lead super jets observed in magnetosphere (ESA SWARM Mission).

Case 2: Increasing NWEQKs

Influence of Coriolis force, F_c decreases as the outer core diverges toward mantle due to being pushed by **centrifugal** $v_z \times B_{\emptyset}$ **-force** along radial distance outward direction from center of Earth as rotational speed of outer core decreases to cause increase in pressure gradient through lower mantle .

Eventually, stress loading leads to release huge energy through litosphere, in turn, to form faulting, which is typical deformation causing to earthquake.

Results

➢During **decending phase of SC 23** from 2000 to 2009, the variations for **A-SDF**, **E-SDF** and **IMF** are found as the following:

❑From 2000 to 2001, as strength of A-SDF increases.

❑ Also, from 2000 to 2003, the strength of E-SDF and IMF increase up to its highest value.

❑From 2001 to 2009, the strength of the A-SDF smoothly decreases.

❑From 2003 to 2009, the strengths of the E-SDP and the IMF sharply decrease up to a minimum value at 2009, with a local peak value at 2008 between 2007 and 2009.

➢During **rising phase of SC24** from 2009 to 2012, both **E-SDP** and **IMF** go up to a small maximum at 2012, as the **A-SDF** goes to zero.

➢During **decsending phase of SC23** from 2000 to 2009, the **N-WEQKs** changes as the following:

❑ From 2000 to 2003,the NWEQKs decreases.

❑From 2003 the N-WEQKs increases to 2009 with a local deep value at 2008 between 2007 and 2009.

➢During **rising phase of SC24** from 2000 to 2009, the variations in **N-WEQKs** are like in the floowings:

❑From 2009 to 2011, the **N-WEQKs** increases up to the highest value at 2011.

❑From 2011 to 2012 the **N-WEQKs** sharply decreases.

➢During **the period of interest**,2000 to 2012, the variations in **N-GMS**, and **RC-AD** are connected with the variations in the strengths of **N-WEQKs**, **A-SDF** and **E-SDF**, throughout the **solar storms**.

Interpretation

➢During rising phase from 2000 to 20003, as the strength of **SDF** with dominant components of west to east oriented (**WE**) **E-SDF , ** which contributes mainly to **IMF,** increases, the strength of **WE IMF** increases.

- ❑ The **number of solar storms** leads to increase in **RC-AD.**
- ❑ As the **number of solar storms** increases, **N-GMS** goes up.
- ❑ The increasing **number of solar storms** , which distort the **EDF** with components of **EW E-EDF** and northward (**NW**) Axial EDF (**A-EDF)**, results in decsending **N-WEQKs .**

➢During rising phase from 2003 to 2009, as the strength of **SDF** with dominant components of west to east oriented (**WE) E-SDF ,** which contributes mainly to **IMF** , decreases, the strength of **WE IMF** decreases.

- ❑ As the **number of solar storms** decreases, **RC-AD** descends.
- ❑ As the the **number of solar storms** descends, **N-GMS** reduces.
- ❑The decreasing **number of solar storms** leads to increase in **N-WEQKs .**

➢During rising phase from 2009 to 2011, as the strength of **SDF** with dominant components of southward (**SW**) **A-SDF ,**

which contributes mainly to **IMF,** decreases, the strength of **SW IMF** decreases, too .

❑In addition to **solar storms,** the interaction of **SW IMF** with the **EDF** with the **NW A-EDF** leads to **GMS.**

❑ Therefore ,the **N-GMS** increases**.**

❑As the strength of **SW IMF** decreases, **NW A-EDF** becomes more effective to result in ascending **N-WEQKs**

❑As the number of solar storms increases, **RC-AD** increases.

➢During rising phase from 2011 to 2012, as the strength of **SDF** with dominant east to west oriented (**EW**) **E-SDF ,**

which contributes mainly to **IMF** , increases, the strength of **EW IMF** increases , too .

❑As the strength of in the **number of solar storms** increases , **RC-AD** ascends.

❑As the strength of **SW IMF** goes to zero, **N-GMS** decreases, but not too much due to increasing the **number of solar storms.**

❑The increasing strength of **EW IMF** leads to less effective **NW A-EDF.** Hence, **N-WEQKs** is reduced**.**

Conclusion

Our study shows that better modeling and forecasting of earthquakes could be done throughout the conditions in Earth-Sun system, instead of conditions just on Earth.

Reference

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