Non-Uniform Variations of Global Seismic Activity by Hemisphere and Season.

Author: Stefan Michael Burns **Published:** July 17, 2025

Abstract:

Trends in global magnitude 6+ (M6+) seismic activity from 1900 to 2025 was analyzed, revealing a non-uniform distribution of these high magnitude earthquakes across hemispheres and seasons. The Equinoxes and Solstices mark the days when the Earth is tilted exactly perpendicular or parallel to the Sun-Earth line respectively. Earth's tilt relative to the Sun influences the electric field potentials of the Northern and Southern Hemispheres, and powerful earthquakes have demonstrated their connection to the ionosphere energetically through the ionospheric disturbances they create, and sometimes the ionospheric disturbances such as changes to total electron content (TEC) around the site of rupture before the event. It was found that clustering of M6+ earthquakes occurs in the Northern Hemisphere close to the March 20-21st Vernal Equinox, the Cross-Quarter Days of August 1st and October 31st, and also on the December 21st Winter Solstice. Clustering of M6+ earthquakes occurs in the Southern Hemisphere broadly around the September 22nd Autumnal Equinox. The non-uniform distribution of global M6+ seismic activity for this 125 year timeframe strongly suggests that rhythms in earthquake frequency and energy release are not governed purely by internal tectonic factors but are also partly governed by external factors such as the tilt angle of the Earth relative to the Sun and the light/energy output of the Sun through modulation of the electric field potential of the ionosphere.

Introduction:

Earthquakes are a fundamental geological phenomenon that primarily result from the sudden movement of the Earth's tectonic plates and the associated fault lines. The Earth's crust is fragmented into several large and small tectonic plates that are constantly moving at slow rates (cm/yr) due to convection currents in the underlying mantle. Where these plates interact—converging, diverging, or sliding past each other—immense stresses build up in the rocks. When these stresses exceed the strength of the rocks, they rupture along pre-existing or create new faults in the process, releasing accumulated energy which we observe as seismic (sound) waves and often electromagnetic waves as well.

It is important to consider that the Northern Hemisphere contains approximately 68% of the Earth's total landmass, while the Southern Hemisphere holds the remaining 32%. Ocean water is more electrically conductive (3.5-5.8 S/m) than nearly all geologic materials which have conductivities generally less than 10^{-5} S/m), thus the uneven distribution of landmass causes great variation in global surface conductivity (crust and oceans). Furthermore, the greater concentration of faults and boundaries in the Northern Hemisphere would inherently suggest a consistent skew of seismic statistics towards the Northern Hemisphere, unless seasonal factors exert an influence.

Analysis reveals that M6+ earthquakes in the Southern Hemisphere outnumber those in the Northern Hemisphere around the Autumnal Equinox. This occurs just after the Southern

Earth Evolution LLC | All Rights Reserved | CC4.0

Hemisphere has been at its greatest tilt angle away from the Sun and is now rotating back, receiving greater light input from the Sun daily, increasing ionospheric energy. In the Northern Hemisphere, there is a trend towards more M6+ earthquakes during the vernal equinox when it is undergoing increasing greater charging of the ionosphere from the Sun. There is also a variation in the Global Electric Circuit from Solar Minimum to Solar Maximum due to the ~1000x increase in X-ray flux from the Sun during Solar Maximum, as well as greater extreme-ultraviolet (EUV) flux.

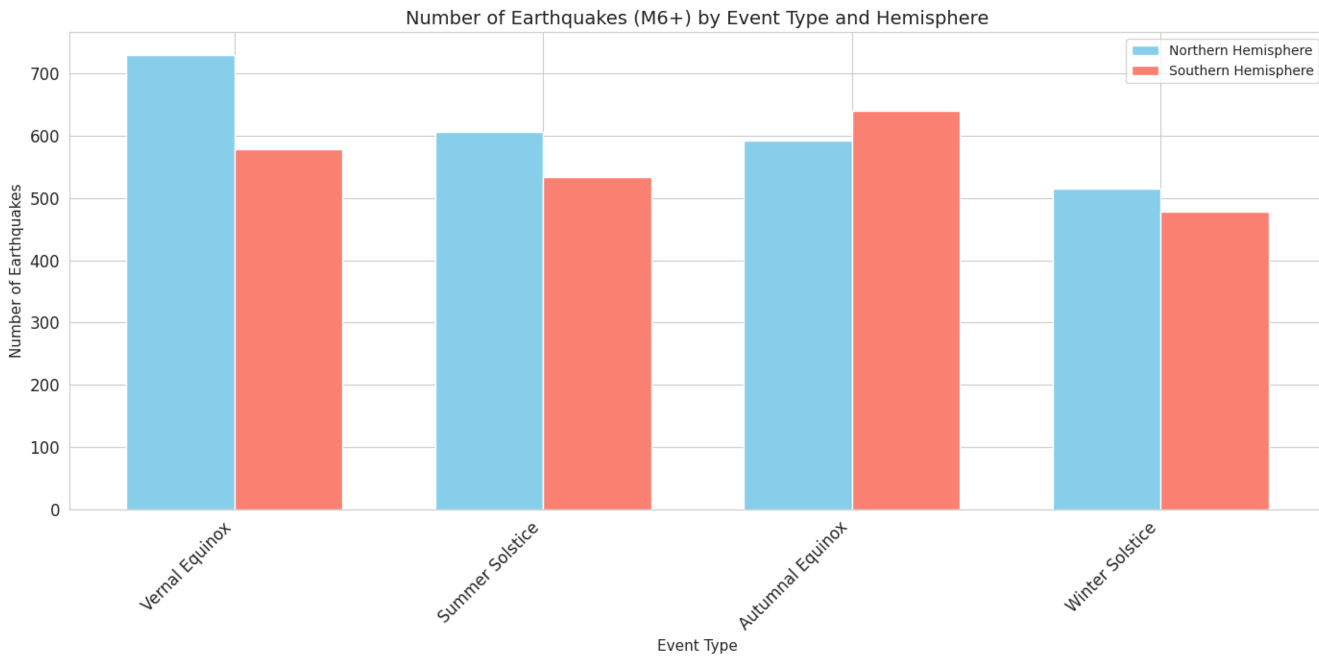

Figure 1 – Number of earthquakes by season January 1st 1900 to July 17th 2025.

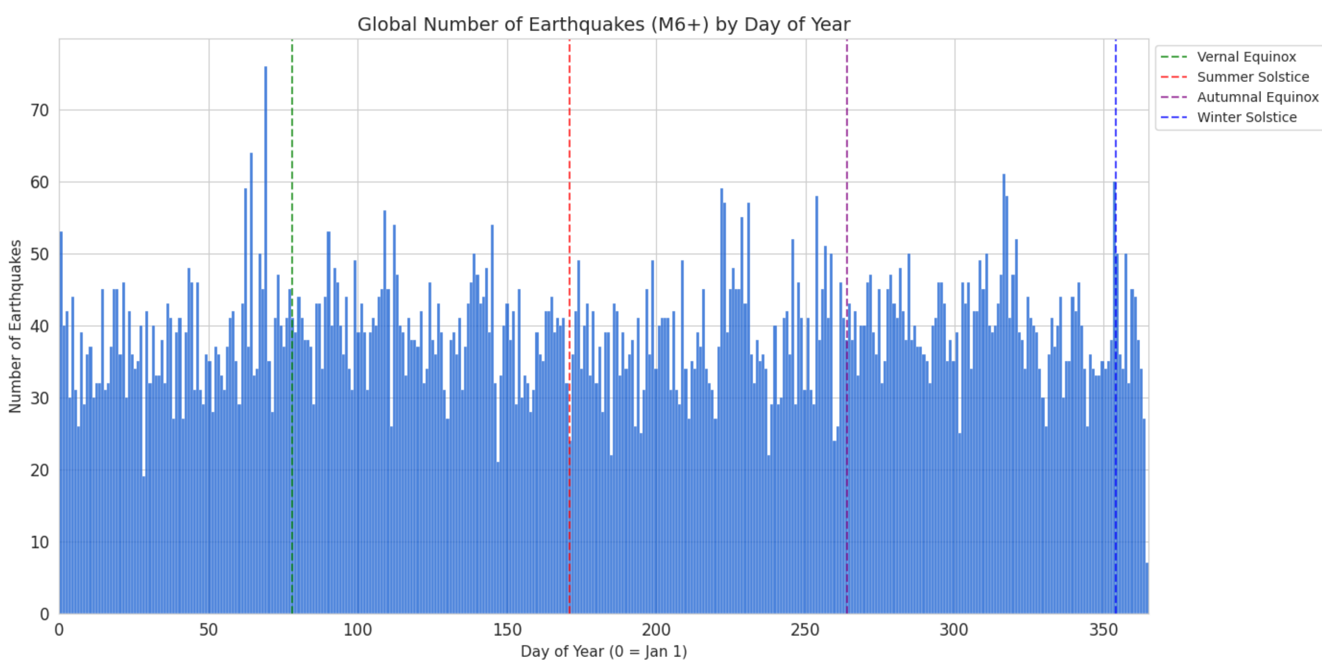

Figure 2 - Number of magnitude 6 earthquakes and greater by globally for each day of the year from January 1st 1900 to July 17th 2025.

Seismic Energy Release and Equinox Clustering:

During this 125-year timespan for the Northern Hemisphere, distinct spikes in seismic activity occur close to the Vernal Equinox, the Cross-Quarter Days of Lammas Day (August 1st) and Samhain (October 31st), and also precisely on Winter Solstice (December 21st). The variation in earthquake clustering is much less for the Southern Hemisphere, with there being a broad trend of more frequent magnitude 6+ earthquakes in the 4-month period centered on the Autumnal Equinox. There is also a spike in M6+ earthquake frequency just before the Vernal Equinox in the Southern Hemisphere around the same time as the spike in the Northern Hemisphere.

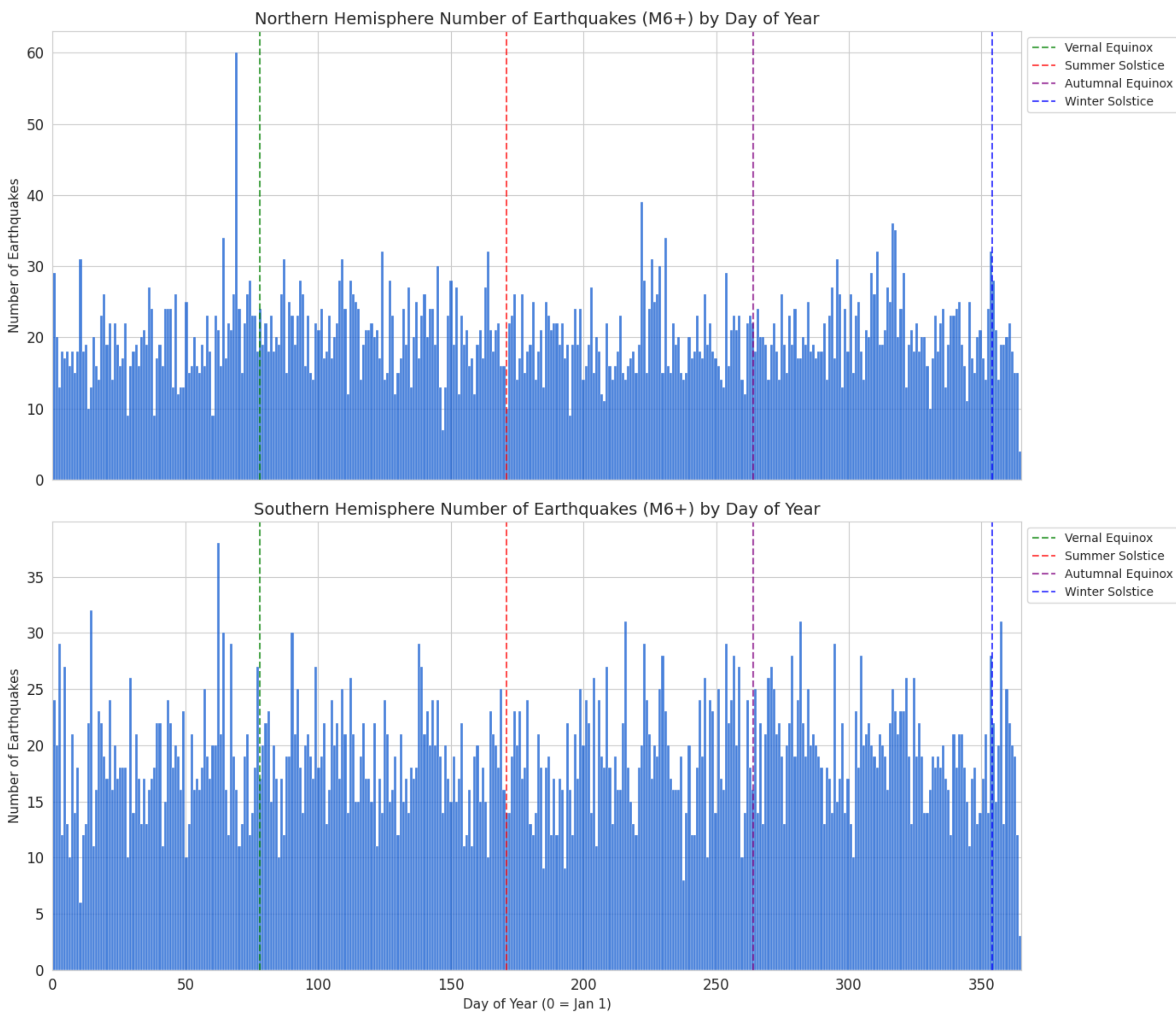

Figure 3 – Number of magnitude 6 earthquakes and greater by hemisphere for each day of the year from January 1st 1900 to July 17th 2025.

Earth Evolution LLC | All Rights Reserved | CC4.0

Discussion: Ionospheric Alteration and Earth's Tilt:

The observed correlation between seismic activity and the equinoxes, particularly with increasing ionospheric energy, suggests a connection between the Earth's tilt relative to the Sun and the electric field potential of the ionosphere, which in turn may influence earthquake occurrence.

Figure 4 – Cumulative seismic energy release measured in TWh by day for January 1st 1900 to July 17th 2025.

Earthquakes are known to generate atmospheric and ionospheric perturbations. During an earthquake, a sudden impulsive forcing from the ground creates atmospheric pressure waves that propagate upward into the atmosphere and ionosphere, reaching the F layer of the ionosphere in approximately 10 minutes. These waves can attain large amplitudes due to the rapid decrease in atmospheric density with altitude, leading to the formation of a shock, often represented by an N-shaped waveform. This N-wave consists of a compression (positive phase) followed by a rarefaction (negative phase).

Earth Evolution LLC | All Rights Reserved | CC4.0

Research has shown that larger earthquakes perturb the ionosphere more strongly and for a longer duration. The amplitude of coseismal total electron content (TEC) variations in the near-field is greater after more powerful earthquakes, and stronger earthquakes (M > 7.9) are generally characterized by a longer negative phase in coseismal perturbations. This negative phase of the N-wave can be seen as a long-lasting ionospheric depletion.

The tilt angle of the Earth in relation to the Sun directly impacts the amount and intensity of solar radiation reaching different parts of the atmosphere, including the ionosphere. This variation in solar radiation influences the ionization of the ionosphere. The observed increase in seismic activity during periods of increasing ionospheric energy around the equinoxes suggests a possible coupling mechanism. While the exact causal relationship requires further investigation, the data points towards a potential link where changes in ionospheric energy, driven by the Earth's orbital dynamics and axial tilt, may play a role in modulating seismic stress release, especially in regions prone to tectonic activity. Stronger earthquakes (M 7.2 - 7.8) typically cause coseismal perturbations with a near-field amplitude of 0.2-0.4 TEC units (TECU) and a negative phase duration of 4-8 minutes, whereas mega-earthquakes (~M9.0) produce much larger perturbations of ~1-3 TECU in amplitude with a negative phase lasting about 30-40 minutes.

Data Collection and Analysis:

Global seismic activity of magnitude 6+ earthquakes from January 1, 1900, to July 17th, 2025 was collected from USGS data. The seismic events were then analyzed based on the seasons to identify any emerging trends.

Acknowledgements: The Author received no funding to conduct this data analysis and declares no conflict of interest.

References:

1) Astafyeva, E., S. Shalimov, E. Olshanskaya, and P. Lognonné (2013), Ionospheric response to earthquakes of different magnitudes: Larger quakes perturb the ionosphere stronger and longer, Geophys. Res. Lett., 40, 1675-1681, doi:10.1002/grl.50398.

Earth Evolution LLC | All Rights Reserved | CC4.0