Multi-parametric Earthquake Forecasting the New Madrid From Electromagnetic Coupling between Solar Corona and Earth System Precursors

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ABSTRACT

Forecasting large earthquakes M ≥ 6.0 with satellite monitoring and Radio Direction Finding techniques of Electro-Magnetic (EM) precursors associated with earthquakes are possible. International Earthquake and Volcano Prediction Center (www.ievpc.org) consider phenomena driving earthquakes within a framework of strong solar EM coupling with the entire Earth system, through EM induction driving ionosphere-air-earth currents. Catastrophic earthquakes have repeatedly stricken the New Madrid Seismic Zone during the last 4 major solar hibernation cycles since 1400 AD. Research suggests another cycle of strong magnitude 6.0 to 8.0 earthquakes in the New Madrid region during the upcoming (~2021-2057), solar minimum period. The 1811–12 earthquakes, occurred in the midst of Dalton Solar Minimum (1793-1830), causing many types of ground failures including lateral spreading and ground subsidence by soil liquefaction across the Mississippi River flood plain and tributaries over 15,000km^2. Studies by USGS and damage assessments by FEMA estimate damages to infrastructure approaching $600 billion. Common denominators between seismic precursors associated with a solar EM driver are found by analyzing data on ionization phenomena in areas under tectonic stress such as: Outgoing Long-wave Radiation (OLR); Total Electron Content (TEC); atmospheric effects, such as Jet Stream and other meteorological phenomena related to earthquake clouds and lights.

Keywords: *Earthquake Forecasting, Radio Direction Finding, Solar EM Coupling, Solar Minimum/Hibernation, New Madrid Seismic Zone, Seismic Precursors, Stellar Transformer, Outgoing Long-wave Radiation, Total Electron Content, Jet Stream Precursors, Earthquake Clouds and Lights.*

1. RECURRING NEW MADRID EARTHQUAKES

Historic New Madrid earthquakes have occurred during every solar minimum, four in a row, since 1400 AD (Fig. 1). And catastrophic New Madrid earthquakes such as ocurred in 1811–1812 were associated with the Dalton Minimum affected the larger New Madrid Seismic Zone (Fig. 1 & 2). Understanding the common denominator between analyzed seismic precursors with an associated solar EM driver should be of major concern. Studies by USGS and damage assessments by FEMA within the past decade estimate damages to infrastructure within the New Madrid Seismic Zone approaching over $600 billion worth of damage [1].

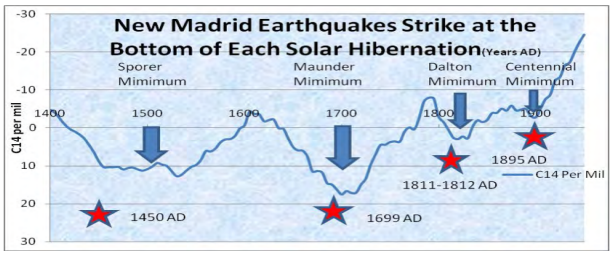

Fig. 1. Solar Activity Deduced from C^{14} Proxy Variation. History of New Madrid earthquakes compared to solar minimums or "solar hibernations" from 1400-1950 AD. Major New Madrid earthquakes as red stars. Source: [2] Data: [3].

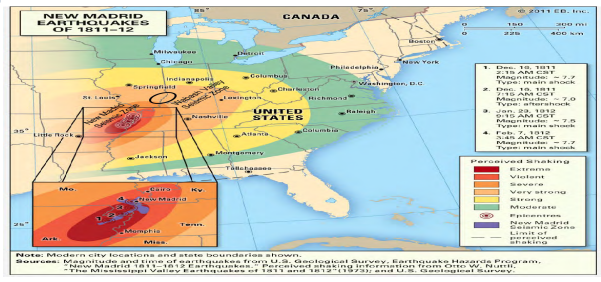

Fig. 2. New Madrid Seismic Zone (NMSZ) earthquakes of 1811-12. Base map cited from Encyclopedia Britannica, Inc. Wabash Valley Seismic Zone is added [4].

2. SOLAR RELATIONSHIPS

Historic records comparing earthquake to solar cycles (Fig. 3) show convincingly an increase in quake and volcanic activities during the solar low cycles throughout the globe [5]. The solar cycles linked to this anti-correlation are theoretically caused by solar induction cycle variations of magnetic fields among celestial bodies within our solar system. When the induction cycles are interrupted during disruptive solar events, violent internal discharges can occur within our planet resulting in large

magnitude earthquakes, mentally conceptualized as lightning from below. This is feasibly explained by Gregori [6], who attributed to the Earth's core being a leaky capacitor or a battery; when solar activity is high, the Earth's core is charged, whereas when the Sun's activity is in low phase, the core in turn discharges energy.

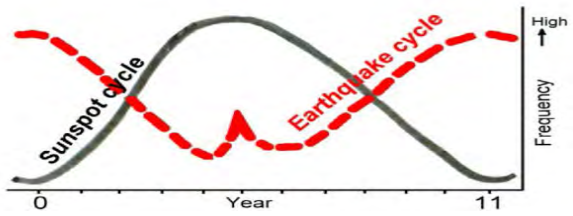

Fig. 3. Anti-correlation between the solar and earthquake cycles [5].

IEVPC understands and monitors precursor signals associated with these disruptive solar events, and on this basis has developed innovative methods of earthquake forecasting. Based on the next arrival of a major prolonged solar low or solar hibernation cycle, which may last until 2050 AD or more. Another series of large earthquakes are expected to strike the New Madrid region [2]. It has also been found that seismic energy transmigrates northward synchronized with the recent accelerated north magnetic polar movement during the declining solar cycle in the Central America-Caribbean area [4] (Fig. 4). This is confirmed by sudden increased earthquake activity since 1990 when the solar cycle 22 peaked and a longer solar cycle started, which includes the 11-year solar cycles 23, 24 and likely 25 and 26. Increased energy inputs from the southern hemisphere expand northward as explained from the mid-ocean ridge coupling to ridges encircling Antarctic (increased radial induction) with increased space weather events as explained by Stellar Transformer concepts [7]. A combination of these facts may well explain the historic devastating New Madrid earthquakes that occurred during every solar minimum, four in a row, since 1400 AD.

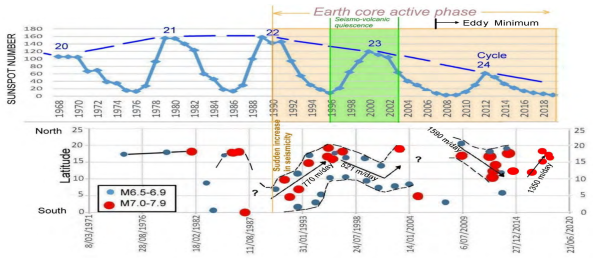

Fig. 4. Solar cycles and earthquake propagation trend in Central American Pacific coast [4.] Note a general trend when earthquakes move northward as the solar cycle is in decline, but southward when the solar cycle rises.

The *Stellar Transformer Concept* [7] contends that simple step down energy induction occurs between Sun and Earth, much like the transformer process that steps down your household energy from higher voltage transmission lines sourced from the power company. The Sun would represent a large coil from the power company, while the Earth represents the smaller coil to your home. The larger coil element generally excites current into the smaller coil element by induction of step down energy. Layers within the Earth hold and release charge acting as condensers, or capacitance layers. To simplifiy understanding of the relationships, solar coronal holes aligned with the Sun's north-south polar axis can be considered as axial induction elements, while those aligned with the equator are considered radial induction elements. These dark coronal holes on the Sun represent the induction current elements of our *Solar Stellar Transformer* (Fig. 5), charging/discharging the Sun from elements within the arm of our spiral galaxy and thereby the Solar System including Earth, via electro-magnetic wavelength and frequency response, in an Electric Universe framework [8].

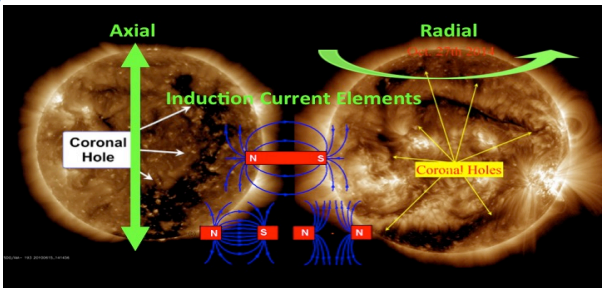

Fig. 5. Solar Stellar Transformer Induction Current Elements Coronal holes express induction elements in axial vs. radial orientations determining axial vs. radial affects on Earth systems. Polarity determines attractive/repulsive force determining charging/discharging relationships [7].

3. SEISMICITY & TECTONIC FRAMEWORK

The arrival of another solar minimum is in harmony with the increased seismic activity in the Caribbean and offshore Central America along Pacific coast, and Mexico, as represented by a large M = 7.5 earthquake offshore Honduras on 10 January 2018. Further support comes from the extremely high water temperature of the Gulf of Mexico observed in March 2018, which followed the earthquake [4]. Energy release from the Earth's outer core dramatically increases during the major solar low cycles indicated from the "Earth core active phase" [4] and seismo-volcanic quiescence [11, 12]. IEVPC studies show a link between deep and shallow earthquakes, originally established by Blot [11], as the Energy Transmigration (ET) concept. Transmigration rates of thermal energy towards the surface from deep-seated earthquakes are on the order of 0.15km/day. The ET concept allows forecast of strong shallow quakes, magnitude 6.5 or greater several years in advance, based on the appearance of strong deep-seated earthquakes. Within the upper mantle, energy transmigration generally takes place in two modes [12]. 1.) One mode surfaces through inclined fracture zones of the Wadati-Benioff zone [13], a planar zone of seismicity corresponding with a down-going slab driven by mantle convection [14]. 2.) Second mode enters sealed porous zones of mantle low seismic velocity lenses or channels [15] and transmigrates laterally until finally rising through fracture systems. These slanted fractures and lateral low velocity lenses provide conduits for outer core-derived EM energy propagating as "lightning from below", emitting long wavelength radio signals at very low frequency in the band above 20kHz, manifesting about 20 hours before an earthquake within the epicenter area [16]. Thus thermal joule energy released from large shallow EM seismic precursor activity may trigger large ground fault earthquakes fairly rapidly. Detecting EM and geomagnetic seismic precursors has rarely been implemented for forecasting, as earthquakes are simplistically

considered the result of grinding plate motions within the Plate Tectonic paradigm, and their true EM nature (solar ***EM induction***[1] triggering "lightning from below") has been ignored by most tectonic theories until Earth Endogenous Energy by Gregori [6] revealed a plasma core construct with anode tufts or sea-urchin spines. The resultant EM propagation has previously been considered the result of a piezoelectric effect. The piezoelectric effect is considered a release of electric energy from motion or sudden fracturing of rock, but detection of radio precursors from EM propagation before earthquakes points to problems of interpretation with this argument.

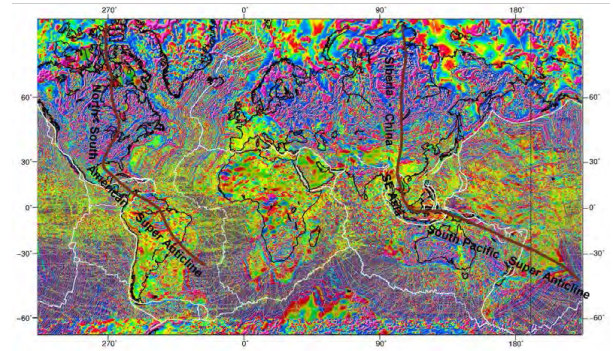

Fig. 6. World Magnetic Anomaly Map [17] **- Antipodal Archean Origin Super-Anticlines** (brown lines) [18, 19]. These anticlines have been repeatedly reactivated during Proterozoic and Phanerozoic. Note that the Caribbean Sea and the Mississippi Valley are situated on the axis of the anticline.

Earthquakes occurring in the NMSZ originate within a unique tectonic settings strongly related to the global-scale geological structure of the North-South American Super-anticline (NSAS) that runs from South America, via the Caribbean and Mississippi Valley, to the Canadian Shield [18, 19] (Fig. 6). It's a fundamental geological structure formed in the Archean stage, the beginning of the Earth's formation. Another antipodal super-anticline extends from SW Pacific, via SE Asia and South China, to Siberia. These anticlinal structures have influenced the subsequent development of the Earth by repeated magmatic and tectonic activities throughout the Phanerozoic, especially since Mesozoic. Earthquake and volcanic energies in the Central America come from the outer core under the Caribbean Sea and transmigrate to the Pacific coast through the oceanized horst structures, one of which now forms the Cayman Trough [4]. The direction of energy movement is controlled by the level of thermal energy input into the Caribbean dome from the outer core, which is inversely correlated with the solar cycle. During the declining solar cycle, earthquake and volcanic swarms move northward, but during the rising cycle, southward. This energy transmigration cycle pattern explains why the catastrophic New Madrid earthquakes have occurred exclusively during the major solar minimums. Bearing the above in mind, a very strong earthquake in the offshore Caribbean north of Honduras (M = 7.5) along the Cayman Tough on 10 January 2018 caught our attention, because of this seismic energy link to the New Madrid Seismic Zone through the (brown line) NSAS (Fig. 6). This earthquake occurred at the *Radial-Axial indution* junction of this global-scale NSAS and the E-W trending Cayman Fault. The seismic energy of this quake is considered to have derived from the outer core through gigantic Archean fracture systems developed in the mantle deep under the Caribbean [4].

[1] *Electro-Magnetic* or *Magnetic Induction* is the production of an electromotive force, or voltage, across an electrical conductor in a changing *Magnetic* field. The induction characteristics are determined by current alignments between layers in the Earth and polarity relationships between of the Earth, Sun and other planets. The alignment and polarity determine the attraction or repulsive forces in Plasma Core physics and determine charging and discharging forces on our planet.

RADIO DIRECTION FINDING (RDF) [16]

The Radio Direction Finding (RDF) Network, developed by the Radio Emissions Project [20] allows 24/7 monitoring of a wide bandwidth of the Earth's background electromagnetic emissions to trace radio anomalies in seismically active areas for a "crustal diagnosis" in real time, on a global scale [16]. By combining RDF information of appropriately spaced antennae array stations (of some tens of km) one can locate the source of EM emission by triangulation and discriminate source direction, position, and distance from the station. The system provides data on the temporal variation of frequency, magnitude, and source intensity. During the experimentation with the Radio Emissions Project strong and precise radio emissions were detected preceding destructive earthquakes worldwide [21, 22]. The station began to provide the first data on the origin of electromagnetic signals in March 2017. On 2 February 2018 monitoring of the United States began in the New Madrid from the station in Lariano Rome, Italy, (Fig. 7). Pre-seismic crustal emissions of radio waves are detected with RDF at very low frequency in the band above 20kHz manifesting about 20 hours before an earthquake revealed 57 earthquakes M $\geq$ 2.5, including earthquakes of magnitude 3.3 and 4.4 in December 2018. In this case the "dark purple" azimuth was kept under strict control focused on the New Madrid Fault 8,500 km away from the monitoring station in Italy [16] (Fig. 7).

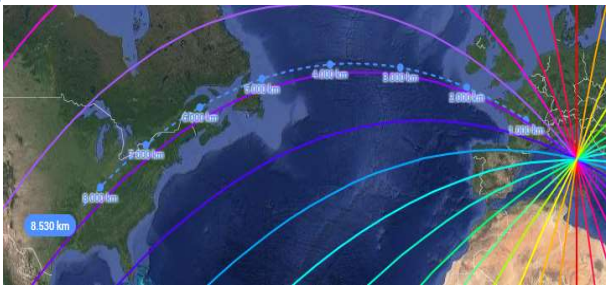

Fig. 7. World Mapping RDF System of the Radio Emissions Project - 8500 km indicated by violet azimuth in NW direction to monitor New Madrid Fault area from RDF monitoring station in Lariano (Rome, Italy) [16]. Source: Google Maps.

The radio-anomalies frequency is inversely proportional to the average electromagnetic frequency of seismic magnitude signals. The periods during many electromagnetic emissions always precede earthquakes of a strong or greater intensity than the average of the period. Groups of signals or single very intense signals preceded the occurrence of earthquakes. It is also evident that solar activity has an important influence on the electromagnetic emissions detected with the RDF system. The study in this case has found that these emission concentrations in a given period of time somewhat follow the Sunspot Number inversely proportional to solar activity (Fig. 8).

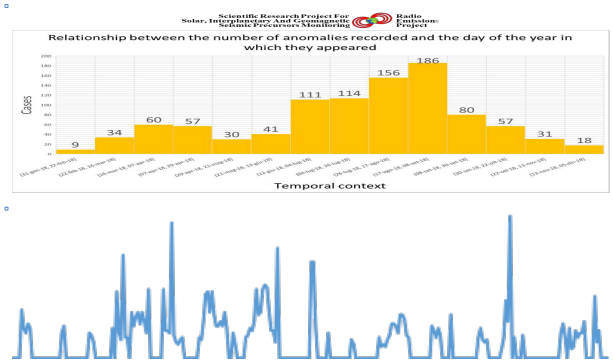

Fig. 8. Inversely Proportional number of radio-anomalies time series [16] (upper inset) follows the number of Sunspots (lower inset). Source: http://www.sidc.be.

OTHER SIGNIFICANT PRECURSORS

Understanding the common denominator between analyzed seismic precursors with an associated solar EM driver should be of concern. The comparison is carried out by collecting data on ionization phenomena in areas under tectonic stress such as: Outgoing Long-wave Radiation (OLR); Total Electron Content (TEC); atmospheric effects, such as Jet Stream and other meteorological phenomena related to earthquake clouds and lights. For example: the Jan. 16, 1995 Kobe earthquake was preceded by earthquake lights [23]; similar observations were reported from Mexico and other seismic regions of the world [24, 25].

Outgoing Long-wave Radiation

Average maximum local temperatures within the potential earthquake zones are higher than normal by 5-7°C, gradually increasing over few days. Usually a rise in the range of 7-12°C or more indicates an imminent earthquake. The temperature rise can be observed ~3-4 days before earthquakes. Outgoing Long wave Radiation (OLR) measurement, a satellite-based measurement can be used as an effective tool to identify the earthquake preparation zones. Atmospheric and surface phenomena like anomalous Outgoing Long-wave Radiation (OLR) normally appear 5 to 30 days before the occurrence of moderate and big earthquakes. Preliminary analysis of a recent Peru earthquake occurring on September 25, 2013 with M = 7.0 is shown (Fig.13) [26]. The appearance of anomalous transient radiation can be correlated with the tectonic stress and thermodynamic processes in the atmosphere. OLR measures radiation from ground, lower atmosphere, and clouds together. An algorithm calculates the OLR, at 8 to 12 μm [27]. An anomalous OLR flux can be defined as change in energy index (dE_index), which signifies the statically defined maximum change in the rate of OLR for a given location and time specific spatial locations and predefined times [28]. The appearance of the short lived OLR anomaly is observed before the occurrence of the Peru earthquake (Fig. 13). Short-lived anomalies appeared thrice before the occurrence of the earthquake on September 25, 2013. An example of first anomaly appeared on September 07, 2013, and it lasted till September 10, 2013. The intensity of the daily current field OLR value slowly increased from September 07, 2013 and it reached peak value on September 10, 2013 (Fig. 13a, b, c & d). The OLR anomaly started disappearing from September 10, 2013 "night", and it was completely disappeared on September 11, 2013, which was recorded by NOAA satellite during "day" pass (Fig. 13e).

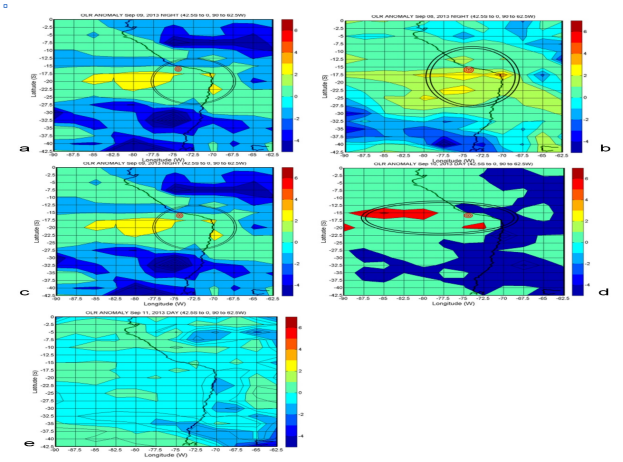

Fig. 13 (a, b, c, d & e): OLR Anomaly evolution for the first time observed before the earthquake occurred at 50km S of Acari, Peru (15.882°S, 74.543°W) on September 25, 2013. The regions with anomalies are circled and epicenter was marked by red concentric circle [26].

Seismo-Electro-Magnetic

When the temperature of any magnetic body increases, the magnet starts losing its magnetic properties. The magnetism decreases as the temperature rises. The temperature at which the magnet entirely loses its magnetism is known as the Curie temperature or Curie point. This effect is extensively manifested at sub-surface temperature level. About 3 to 5 days before the occurrence of an earthquake the rise is sharp and rapid and it peaks on the day of earthquake. As a result of the rise in sub-surface temperature in the hypo-central region, the geomagnetic field declines. The reduction in the magnetic field adversely affects the transmission and propagation of electric and electromagnetic signals coined the Seismo-Electro-Magnetic Effect [29]. It affects radios, telephones and televisions. If a radio station is transmitting a signal at a particular frequency, say 1000 kHz, then the same will be received about ten to twenty hours before the occurrence of the earthquake at 1100, 1200, 1300.... 1900, 2000 kHz, or more. In the case of televisions, there are repeated audio, visual and spectral disturbances. The number of disturbances goes on increasing till the occurrence of the earthquake. It has been seen that these effects are manifested about two to three days in advance and are observed intensely about ten to twenty hours before the earthquake. Thus radio broadcasting may go to higher frequencies, while landlines and inflight communications can be disturbed within the epicenter area 3-4 days beforehand, television broadcast within 15 hours of an event. While mobile phones within 30-40 km of an event may become non-functional within 100 minutes of an event.

Jet Streams

IEVPC case studies show many M ≥ 6.0 earthquake locations were identified with Jet Stream precursors (Fig. 14). In fact, the interruption of velocity flow-lines that cross above an earthquake epicenter occurs 1–70 days prior to the event, with duration 6–12 hours, at ~100 km average distance between Jet Stream's precursor and epicenter [30]. Satellite observation found possible atmospheric disturbances in jet stream velocity before the powerful M = 8.3 Chile Earthquake on 16 Sep. 2015. The jet stream was interrupted at the epicenter on 13 June 2015 at 06:00 UTC (Fig. 14), 96 days prior to the major M = 8.3 Chile Earthquake, and the epicenter deviation was less than 80

km. The prediction posted on 2015/06/14 had the time range from 2015/06/13 to 2015/07/13, in Central Chile at the location (32.3S, 71.6W) and magnitude M > 5.5. The actual event was an M = 8.3 about two months later than predicted on 2015/09/16 - 22:54:33 UTC in Central Chile at location (31.570°S, 71.654°W) at a depth of 25.0 km [30, 31, 32, 33].

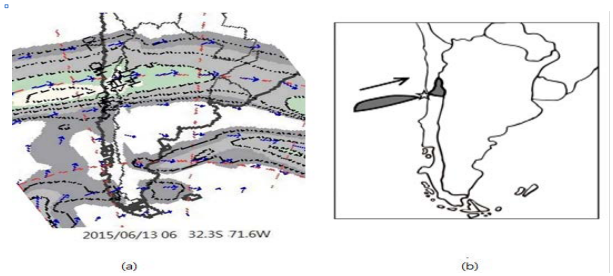

Fig. 14. The anomalous behavior of jet stream: (a) The original jet stream map (S.F. State University), (b) The jet stream at a speed of 130 knots (234km/hour) was interrupted at the epicenter on 13 June 2015 at 06:00 (UTC). The epicenter was located at the interrupted region [30].

CONCLUSIONS

Many sound reasons support Solar EM induction model for New Madrid seismicity. This paper and related references document scientific grounds for linking deep geological structure of the Caribbean Sea to its northern area, the New Madrid Seismic Zone. The following points were documented. 1). The latest gigantic earthquake, January 2018 magnitude 7.5 offshore north Honduras, occurred at the junction of one of Earth's most fundamental structures, the North-South American Super-anticline and the E-W Cayman deep fault, recalling the relationships of *Axial vs. Radial induction.* 2). The quake occurred above a major low velocity lens at 400 to 500 km depth, which is considered an energy transmigration volcanic surge channel likely filled with ionized liquid and gas. 3). The low velocity lens shallows northward to Gulf of Mexico and appears to extend to the New Madrid Seismic Zone, where a distinctive low velocity lens is developed at the top of the mantle. 4). Seismic activity has dramatically increased since 1990, especially since 2007. These years are significant, because the former is the starting year of a one-order longer solar cycle, and the latter the starting year of the current Solar Minimum. 5). A comparison of Central American earthquakes and solar cycle shows that during the declining years of solar cycles, seismic energy transmigrates northward, and during the rising period southward. 6). These facts explain the damaging New Madrid earthquakes that exclusively occurred during the last four major solar minimums. 7). There are strong scientific grounds to forecast another series of major earthquakes in the New Madrid Seismic Zone during the current solar minimum.

In the light of the now confirmed start of a prolonged, solar hibernation for the coming 30 years or so, which are comparable to Dalton Minimum or worst case, a Maunder Minimum ("Little Ice Age"), a repeat of the 1811-12 earthquakes should be expected. The window of highest risk for another major New Madrid earthquake extends roughly from 2021 through 2038. Seismic and volcanic activities in the Caribbean may foretell energy release in the New Madrid region with a delay of only a few years. This warning is further emphasized by the fact that earthquake activity has increased dramatically in recent years in the Caribbean, as represented by the M = 7.5 northern offshore Honduras earthquake in January 2018. We consider this gigantic quake is a harbinger of the coming New Madrid quake. Based on IEVPC's innovative geologic/tectonic expanded electro-dynamic model, within an Earth Endogenous Energy [6] and Stellar Transformer [7] framework, understanding of the Earth's interactions with space weather can be improved. This provides an understanding of some common electromagnetic denominators associated with earthquakes and their seismic precursors. Methods have been individually verified as valid for earthquake forecasting. http://www.ievpc.org/earthquake-papers.html.

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