

General Relativity Theory and Earthquakes

Bakhram Nurtaev

Institute of Helioclimatology, Germany
nurtaev@gmx.net

ABSTRACT

Earthquakes are caused by movements within the Earth's crust and uppermost mantle. Earthquakes epicenters occur mostly along tectonic plate boundaries. Solar energy drives the major processes that happen at the earth's surface, like the water cycle, wind, ocean currents, weathering, erosion, sediments transports and growth of plants. This huge mass transfer in combination with earth's rotation and gravitational effect disturbs the equilibrium of continental plates.

In this paper, we propose a statistical approach to compute the influence of solar energy on earthquakes. Also we estimate the relationship of aa- geomagnetic indices from solar energy. The results show that increase of solar activity leads to the growth of number of earthquake events. Finally, we discuss how general relativity theory interacts as a complex system with earthquakes.

Key words: *significant earthquakes; general relativity; solar irradiance; earth rotation; aa-indices.*

1.Introduction

The goal of this research is to develop a physics-based model of the earthquakes. Earthquake releases enormous amounts of energy. To release a huge amount of energy it is necessary to apply a force equal the same energy. This can be triggered by two forces, either energy of sun or internal processes within the Earth.

The absorbed sunlight drives photosynthesis, fuels evaporation, melts snow and ice, and warms the Earth system. The sun provides 99.97% of the energy required for all physical processes that take place on the earth, 0,025% - geothermal energy, Taylor (2005). The Sun doesn't heat the Earth evenly. Because the Earth is a sphere, the Sun heats equatorial regions more than polar regions. The atmosphere and ocean work non-stop to even out solar heating imbalances through evaporation of surface water, convection, rainfall, winds, and ocean circulation. This coupled atmosphere and ocean circulation is known as Earth's heat engine.

Between the end of the 17th century and the end of the 20th centuries, the Total Solar Irradiance has increased by 1.25 W/m², or about 0.09%, Krivova et al (2010). The slight upward trend since then has led us to conclude that the Sun has played a significant role in earthquakes increase.

In comparison, only about 0.06 W/m² come as heat radiation from inside the Earth. This is more than 2000 times less than the power of the Sun, (Kleidon, 2012).

Mass-energy equivalence is the famous concept in physics represented mathematically by $E=mc^2$, which states that mass and energy are one and the same (Knight, 2008).

Additionally, the equation suggests that energy and mass are interchangeable with each other. In other words, energy can be converted to mass and mass to energy.

In accordance with our hypothesis, earthquakes release huge amounts of energy through the stored solar radiation. The objectives of study are verification of the relationship of earthquakes with solar energy.

2. Method

Over the period of last 300 years have been observed increasing of solar irradiance and significant earthquakes events (Fig.1)

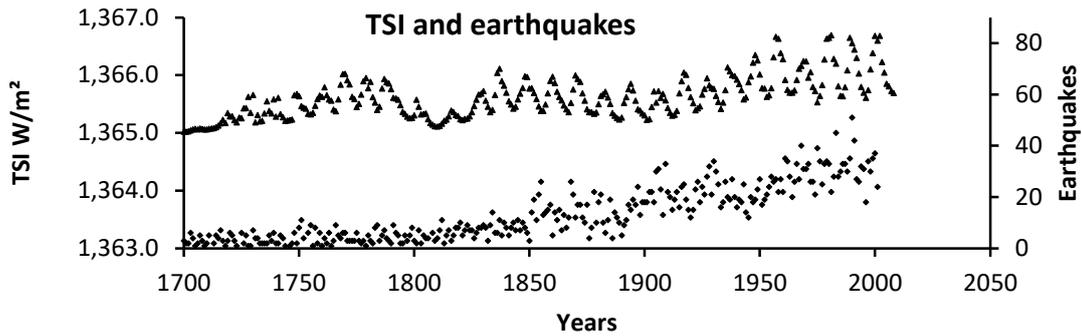


Fig. 1. Solar irradiance and earthquakes over the period 1700-2000.

Annual amount of total significant earthquakes data, in mathematical sense, represents a set of natural numbers and can be described as:

$$EQ = \{eq_0, eq_1, eq_2, eq_i, \dots\}; \quad (1)$$

-where eq_0, eq_i –averaged yearly number of earthquakes.

In accordance with our concept that earthquakes cause from stored solar energy and notion of sets (mathematic), every member of earthquakes “EQ” set is also a member of set solar activity presented as Total Solar Irradiance “TSI” (Nurtaev,2019), then “EQ” is said to be a subset of “TSI” (Fig. 1).

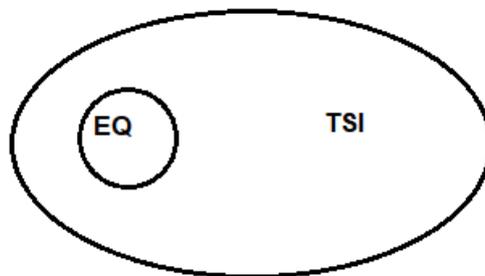


Fig. 2. Earthquakes (EQ) are subsets of solar activity, $EQ \subset TSI$.

$$TSI = \{tsi_0, tsi_1, tsi_2, tsi_3, tsi_i, \dots\}; \quad (2)$$

-where $tsi_1, tsi_2, \dots, tsi_i$ - measured Total Solar Irradiance in W/m^2 .

Each value of tsi_i predetermines the corresponding value of earthquake EQ_i . The conversion of earthquakes series into numerical sets allows working with them as with mathematical objects.

For discovery of relationship a set of data points plotted on an x and y axis to represent two sets of variables is created. An independent variable “tsi” is plotted along the horizontal axis. The observed number of earthquakes or dependent variable EQ is plotted along the vertical axis.

In accordance with concept of mass- energy equivalence and sets theory (Figure 2) –every change of sun output- “tsi”, leads to change of subset earthquakes “EQ”. This means, that every change in average annual solar energy leads to a change of earthquakes amount.

We tested a relationship between amount of earthquakes and solar energy “tsi” over the period 1700-2000. The generally positive relationship between the two variables can be easily discernible from the cloud formed by 300 points (Fig. 3).

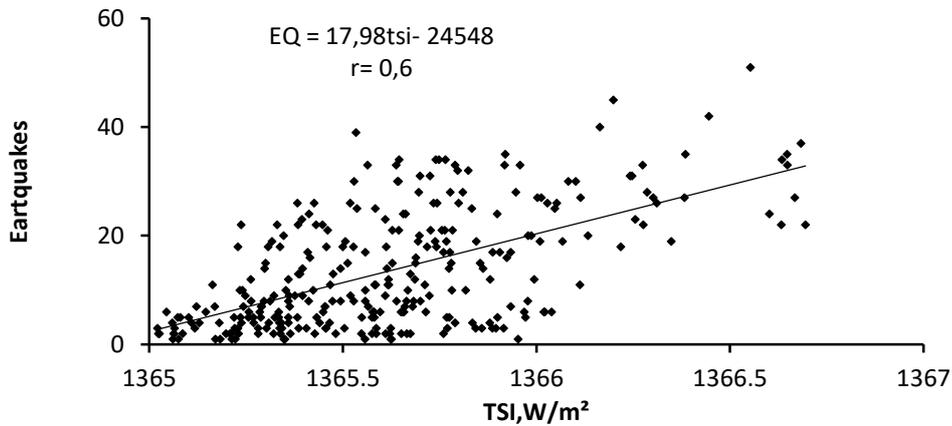


Fig. 3. Dependence of earthquakes from solar energy.

To enhance the trend in the graph, we used an global attractor (Nurtaev, 2018,2019), expressed in the length of the solar cycle.

Observation period for meteorological objects was divided on 11 years solar cycles time intervals for earthquakes and solar irradiance. It was calculated for every such interval averaged Total Solar Irradiance and earthquakes events, Nurtaev (2015):

$$TSI = \frac{1}{n} \sum_{i=0}^n tsi_i; \quad (3)$$

$$EQ = \frac{1}{n} \sum_{i=0}^n EQ_i; \quad (4)$$

where TSI– averaged Total Solar Irradiance for one solar cycle with length $n = 11$ years; EQ – averaged earthquake events for one solar cycle, i - solar cycles.

This averaging allows avoiding a cyclic variability of Total Solar Irradiance as well earthquakes and leads to uniform sampling both parameters in the same time interval. Solar minima and maxima are the two extremes of the Sun's 11-year activity cycle. Averaging over 11 years as a rule gives a smoothing effect and reveals a earthquakes trend at centennial timescales, these are three centuries in our study, Fig.4.

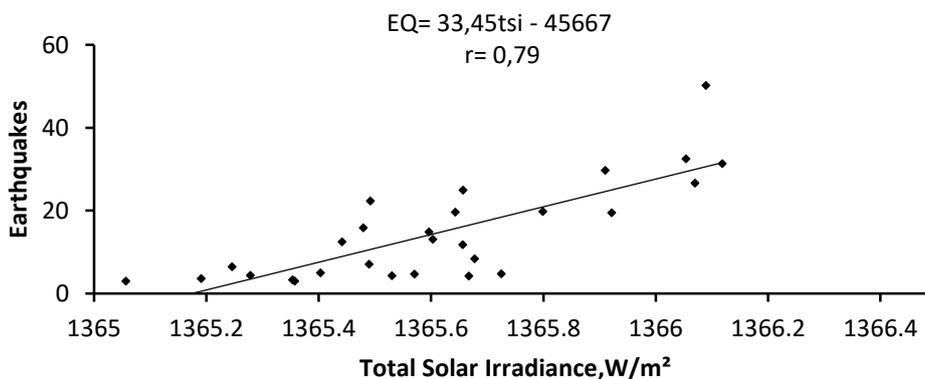


Fig. 4. World Quakes and Total Solar Irradiance over the period 1700-2008.

Electromagnetic waves of solar heat energy also change the magnetic field of the earth, Fig.5.

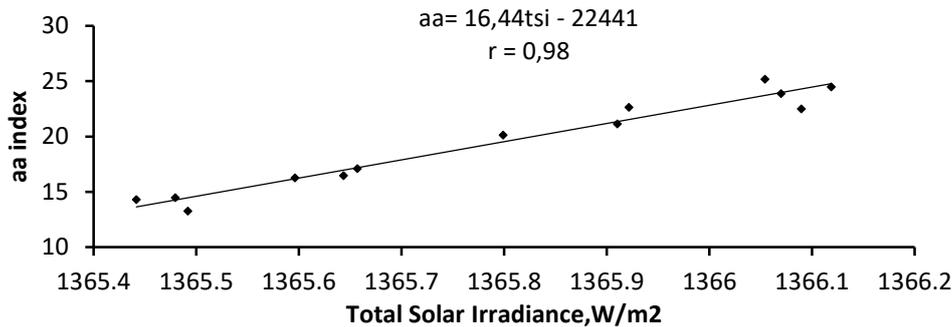


Fig. 5. Dependence of aa- geomagnetic indices from TSI over the period 1878-1996.

Relationship of earthquakes from aa-index over the period of instrumental observation 1867-1996 shows also good correlation:

$$EQ = 1,15aa + 0,55; r = 0,75 \quad (5)$$

3. Discussion

The sun radiates energy uniformly in all directions and the Earth intercepts and receives part of this energy during rotation around the sun. The source of almost all the energy on Earth is the sun. Changes in the Earth's system atmosphere, hydrosphere, biosphere and lithosphere (sedimentary rocks) depend on continuous stream of particles flowing outward from the Sun.

Sun loses about 5.5 million tones of mass every second or about 174 trillion tones of mass every year.

A huge amount of energy- mass transfer from the Sun causes consequences for earth's crust and movable continental plates. The energy mass transfer is transmitted by way of the mass energy transfer, direct pressure (solar sail), and magnetic field.

3.1 Mass energy transfer and gravity forces.

The Sun loses about 5,5 million tons of mass every second to energy (Lang, 2006). Part of this energy reaches the Earth. A total of 173, 000 terawatts (trillions of watts of solar energy) strikes the Earth continuously. That's more than 10,000 times the world's total energy use.

In accordance with the Einstein equation $E=mc^2$, this amount of energy is equivalent to billion ton of mass, entering in the earth's atmosphere. Geothermal energy provides 50 terawatts, the gravitation of the moon and the sun-5 terawatts, (Kleidon .2016).

The solar energy leads to weathering of mother rocks, river sediments transport and redistribution of sediments in different parts of continental plates. For example, just world-wide rivers sediment contributes about 7×10^9 tons of suspended sediment to the ocean yearly, John at al (1983). About 70% of this total is derived from southern Asia and the larger islands in the Pacific and Indian Oceans, where sediment yields are much greater than for other.

This huge amount of mass-energy transfer upsets of plate tectonics equilibrium and increase them inertial mass. Mass and energy are closely related. Due to mass-energy equivalence , every object that has mass also has an equivalent amount of energy and any additional energy acquired by the object above that rest energy will increase the object's total mass just as it increases its total energy. For example, after heating an object, its increase in energy could be measured as a small increase in mass, with a sensitive enough scale.

The Sun transfers in each second and amount of 1367 J (Wagemann,1994) on each square meter of the Earth's diameter. This value calls the "solar constant".

$$E_0 = 1367 \frac{W}{m^2} = 1367 \frac{J}{m^2 s} = 1367 \frac{kg}{s^3} \quad (6)$$

The annual mean solar irradiance is known as the solar constant and is $1367 \pm 2 \text{ W / m}^2$.

This amount of energy, in accordance with energy-mass concept equals to 12,5 kg/sec of mass, entering in earth's atmosphere.

The total photoautotrophic (green plants and photosynthetic bacteria are generally using energy from light are photoautotroph) for the Earth is about 104.9 billion tones C/yr. This translates to about 426 gC/m²/yr land production, and 140 gC/m²/yr for the oceans, (Field et al, 1998). There are 42, 6 kg/m² and 14 kg/m² relatively in the 100 years.

Taking into account earth rotation speed -1,675 kilometers per hour at the equator and square of continental plates it is the enormous load for earth crust.

Gravity change also deforming the Earth and cause earthquakes. Einstein envisioned gravity as a bending of space-time by mass. The geodetic effect is the warping of space and time by the gravitational field of a massive body (in this case, Earth).

GRACE detected a migration pattern of gravity changes due to deep and crustal processes a few months prior to the 2011 Tohoku (Japan) earthquake (Panet et al.2018).

The force of gravity acts to move the particles along the sloping surface on which they are resting.

3.2. Direct pressure (solar sail).

Einstein's equation $E = mc^2$ shows that energy and mass are interchangeable. This equation gives the amount of energy equivalent to a certain mass and is a result derived from Einstein's theory of relativity. The radiation pressure of sunlight on earth is equivalent to that exerted by about a thousandth of a gram on an area of one square meter. Taking into account Earth's surface area- 510 072 000 km², the total pressure acts on the surface of the earth with force of many billions kg/force in year. So a quasi-stationary stream (current) of photons should to perturb equilibrium of the Earth's tectonic plates. A sudden increase in the solar wind velocity directly correlates with maximum in the number of earthquakes, Odintsov et al (2007). Mass/energy simply moves from one place to another. The amount of energy remains constant and energy is neither created nor destroyed.

Dr. Sten Odenwald (NASA) presented calculation of direct mass of solar light in second.

Direct pressure of light: "the ratio of the total mass per second, to that intercepted by the earth is 1.9 kilograms/sec", Total mass falling direct on earth: 59 754 240 kg/year.

3.3. Magnetic field of earth.

The continuous stream of solar particles (solar wind) pushes Earth's magnetic field. As a result, the geomagnetic field, acting as an electromagnetic barrier, is compressed in the direction towards the Sun and is stretched into a (tail) in the direction away from the Sun. Fluctuations in its speed, density, direction, and entrained magnetic field strongly affect Earth's local space environment.

The interaction between the solar wind and Earth's magnetic field, and the influence of the underlying atmosphere and ionosphere, creates various regions of fields and currents inside the magnetosphere such as the plasmasphere, the ring current, and radiation belts.

4. Conclusion

Mass-energy equivalence is the famous concept in physics represented mathematically by $E=mc^2$, which states that mass and energy are one and the same. The Sun bathes the Earth with enormous amount of surface energy. This energy is converted into forces that change earth's surface by way of weathering, sediment transfer and biological production.

These processes are enhanced by relativistic effect of inertial rotation of the Earth.

The presented results derive from cosmological, geological, physics and biological studies.

It has been indicated statistically significant influence of solar irradiance on earthquakes.

We show how quantum of energy during period of long time can affects on the earth crust and finally on earthquakes. Constant tiny change of solar irradiance is accumulated over many years in huge amount of mass. Redistribution of sediments also has a significant impact on plates.

Earthquakes physics demands an ubiquitous knowledge. This knowledge includes a comparison of the methods and results also of relativity theory. General relativity is intended to explain unity of physics. For this it is necessary bringing all our physical, geological and biological knowledge by a single deductive logical system.

Conflicts of interest.

The authors declare that there are no conflicts of interest.

Acknowledgments.

We would like to express our deepest appreciation to all those who provided following open sources: NOAA National Centers for Environmental Information (NCEI), Earthquakes data.

Royal Netherlands Meteorological Institute KNMI, these have invested their full effort for accumulation of many years Databases, Total Solar Irradiance data.

References

- [1] Kleidon A. Was leistet die Erde? Thermodynamik des Erdsystems. 2012. <https://doi.org/10.1002/piuz.201201294>
- [2] Knight R. D. "Relativity" in Physics for Scientists and Engineers: A Strategic Approach, 3rd ed. San Francisco, U.S.A.: Pearson Addison-Wesley, ch.37, sec. 10, 2008, pp.1172-1176.
- [3] Krivova N. A., Vieira L. E. A., Solanki S. K. Reconstruction of solar spectral irradiance since the Maunder Minimum. Journal of Geophysical Research (Space Physics), 115, A12112, 2010, 11 p.
- [4] Nurtaev B. Big data processing in hydrology. East European Scientific Journal, N 6 (46), 2019, pp.41-45.
- [5] Nurtaev B. Observation and Measurement of Solar Activity for Study of Climate Trends. Int. Journal of Science and Engineering Investigations. vol. 7, issue 81, 2018, pp.64-68.
- [6] Nurtaev B. Effect of solar forces on earthquakes. Int. Scientific Conference „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation“, Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 43-44.
- [7] Field C.B, Behrenfeld M.J, Randerson J.T, Falkowski P. Primary production of the biosphere: integrating terrestrial and oceanic components. Science. **281** (5374), 1998, pp. 237–240. Bibcode:1998Sci...281..237F. doi:10.1126/science.281.5374.237. PMID 9657713.
- [8] John D., Milliman, Robert H. World-Wide Delivery of River Sediment to the Oceans. Meade Source: The Journal of Geology, Vol. 91, No. 1, 1983, pp. 1-21.
- [9] Odintsov S.D., Ivanov-Kholodnyi G.S., Georgieva K. Bull. Russ. Acad. Sci. Phys. 71: 593, 2007. <https://doi.org/10.3103/S1062873807040466>
- [10] Odenwald S. (NASA) 2020. <https://image.gsfc.nasa.gov/poetry/ask/a11325.html>
- [11] Taylor F. W. Elementary Climate Physics. Oxford University Press, Oxford, 2005, p. 232.
- [12] Wagemann H-G, Eschrich H. Grundlagen der photovoltaischen. Energiewandlung (= Teubner Studienbücher Physik). Teubner, Stuttgart, ISBN 3-519-03218-X, 1994.
- [13] NOAA National Centers for Environmental Information (NCEI). <https://www.ngdc.noaa.gov/>
- [14] Royal Netherlands Meteorological Institute KNMI, <https://www.knmi.nl>

ფარდობითობის ზოგადი თეორია და მიწისძვრები

ბ. ნურტაევი

რეზიუმე

მიწისძვრები გამოწვეულია მოძრაობებით დედამიწის ქერქში და ყველაზე ზედა მანტიის საზღვრებში. მიწისძვრის ეპიცენტრები ძირითადად ტექტონიკური ფილების საზღვრების გასწვრივ არის განლაგებული. მზის ენერგია აკონტროლებს დედამიწის ზედაპირზე არსებულ ძირითად პროცესებს, როგორცაა წყლის ციკლი, ქარი, ოკეანის დინებები, გამოფიტვა, ეროზია, ნალექების გადატანა და მცენარეთა ზრდა. მასების ეს უზარმაზარი გადატანა, დედამიწის ბრუნვასთან და გრავიტაციულ ეფექტთან ერთად, არღვევს კონტინენტური ფილების წონასწორობას.

ამ სტატიაში ჩვენ გთავაზობთ სტატისტიკურ მიდგომას, რათა გამოვთვალოთ მზის ენერგიის გავლენა მიწისძვრებზე. ჩვენ ასევე ვახდენთ aa - გეომაგნიტური ინდექსების კავშირის შეფასებას მზის ენერგიასთან.

შედეგები აჩვენებს, რომ მზის აქტივობის ზრდა იწვევს მიწისძვრათა რაოდენობის ზრდას. დაბოლოს, ჩვენ განვიხილავთ, თუ როგორ ურთიერთქმედებს ფარდობითობის ზოგადი თეორია, როგორც მიწისძვრათა რთული სისტემა.

Общая теория относительности и землетрясения

Б. Нуртаев

Резюме

Землетрясения вызваны движениями в пределах земной коры и самой верхней мантии. Эпицентры землетрясений расположены в основном вдоль границ тектонических плит. Солнечная энергия управляет основными процессами, которые происходят на поверхности Земли, такими как круговорот воды, ветер, океанические течения, выветривание, эрозия, перенос осадков и рост растений. Этот огромный перенос массы в сочетании с вращением Земли и гравитационным эффектом нарушает равновесие континентальных плит.

В этой статье мы предлагаем статистический подход для расчета влияния солнечной энергии на землетрясения. Также мы оцениваем связь aa - геомагнитных индексов с солнечной энергией.

Результаты показывают, что увеличение солнечной активности приводит к росту числа землетрясений. Наконец, мы обсуждаем, как общая теория относительности взаимодействует как сложная система с землетрясениями.