Earth's rotation variations and earthquakes 2010 - 2011

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S U M M A R Y

The LOD (length of a day) graph for 2010 and beginning of 2011 was characteristic by extremely large (1.5 ms) Earth's deceleration peaks in rhythm of 27.6 days. This triggered strong earthquakes in Central America, South America, Indian plate and Japan. The LOD measurement revealed that the Haiti earthquake of January 12, 2010, 7.0 M occurred exactly in the time of Earth's acceleration. This earthquake is situated on the left-lateral transform fault and reflects the quicker westward movement of the North American plate against the South American. Haiti earthquakes and earthquakes in Mid-Atlantic Ridge are in close relation. The earthquake on Jan. 8, 2010, M 4.7, situated in the most western rim of the Mid-Atlantic Ridge, was a precursor of Haiti Jan. 12, 2010, M 7.0 earthquake. The GPS measurement performed before and after the Maule Chile earthquake M 8.8 of February 27, 2010 has shown that the southern part of the South American continent has moved westward 2-4 cm and in the city of Concepcion, the collapsing movement reached 3.04 m. The earthquake occurred in distinctive Earth's rotation deceleration according to LOD measurement. and was preceded by earthquakes on Mid-Atlantic Ridge as other earthquakes, which followed in 2010 in the South American plate. At the beginning of 2011 the situation was changed. Earthquakes in the Chile Trench occurred at LOD minimum and earthquakes in Mid-Atlantic Ridge occurred after them. This means that after the original westward overthrust the South American plate during the following Earth's accelerations returned back eastward. The GPS measurements in ITRF2005 reference frame found the South American plate as almost stable because this reference frame considers the lithosphere as stable and not the mantle, above which plates move. Seemingly incoherent earthquakes in Chile Trench and Japan Trench over 6 M were triggered by the second LOD minimum (Earth's rotation increment) but in the Chile Trench one months (exactly 27.6 days) sooner. Supposing the continental lithosphere of the South American and Eurasian plates fixed in GPS satellite system, then the mantle beneath rotates during the Earth's rotation acceleration eastward. Rotating mantle drags the Nazca plate down the Chile Trench and the oceanic lithosphere of the Pacific plate moves away from Japan. At the same time it drags the continental lithosphere of northern Honshu 8 feet eastward. The northward movement of the Indian plate is contributed to the Eötvös which is proportional to the Earth's rotation in second power. Similarly as the Great Sumatra earthquake 2004 was triggered in distinctive Earth's rotation acceleration, earthquakes on the Indian plates in 2010 in many cases were triggered in Earth's rotation acceleration following the Earth's deceleration.

I N T R O D U C T I O N

20 years ago at XX. General Assembly of the International Union of Geodesy and Geophysics in Vienna 1991, the author (Ostřihanský 1991) presented a hypothesis that Earth's rotation variations trigger earthquakes and introduce lithospheric plates into movement. In the monograph: "The causes of lithospheric plates movements" (Ostřihanský 1997) the hypothesis was elaborated in detail. The two largest earthquakes of this century the large Denali Fault Alaska Earthquake M 8.9 in 2002 and the Great Sumatra earthquake M 9.0 in 2004 confirmed this hypothesis. The Fig. 1 shows that the Denali Fault earthquake was triggered by the third maximum peak of 27.6 days variation (i.e. Earth's deceleration). The Fig. 2 shows that the Sumatra earthquake was triggered by the third minimum peak of 27.6 variation (i.e. by the Earth's acceleration), typical for winter season. Situation is not so simple as in theses two examples. Already the strong earthquake on Sumatra M 8.6 at May 28, 2005 has occurred 10 days later after distinctive LOD minimum (velocity increment) 1.5 ms (Fig. 2). This earthquake, in distance about 150 km from the earthquake of 26. December 2004, evoked no tsunamis probably lacking any resonance effect, but as it will be shown later, the triggering of earthquakes in LOD minimum is typical for the whole Indian plate. Fig. 3 shows the relation of this earthquake to LOD minimums. Three Earth's velocity increments trigger earthquakes exactly after 2 days of the three 13.66 days LOD maximum.

LOD RECORD OF 2010 AND EARTHQUAKES

Variations of the Earth's rotation are caused by the effects of Moon and Sun deforming the Earth's shape and by this way the Earth's angular polar moment of inertia leading to the change of its rotation velocity according the law of angular momentum conservation (Wahr 1988). The Earth's rotation velocity is measured daily by IERS (International Earth's Rotation Service) (Figs 1 – 4) expressed as the length of a day (LOD) in seconds. The LOD is therefore dependent on Moon and Sun configuration, on position of these bodies to the equator, over which part of the Earth's surface these bodies run over oceans and continents during their apparent daily movement, in less extent on atmospheric effects, however more distinctly on El Nino or La Nina effects (Rosen et al. 1984). The time span from Moon's crossing the equator to another one during its apparent movement takes 13.7 days. However the corresponding decelerations can be different whether the Moon crosses the equator from southern (mostly oceanic) to northern hemisphere (larger deceleration) or from northern hemisphere to southern hemisphere (smaller deceleration). The Sun causes semiannual variations. On LOD graph there are winter and summer accelerations. More distinct is the summer acceleration (shifted to the late summer in July) caused by the heating of the northern mostly continental hemisphere and corresponding volume expansion in summer (Kalenda et al. 2010). Meteorological effect and atmospheric super rotation (e.g. Hide 1984) can be also considered.

In contrast to the LOD record from 2009 with mostly symmetric 13.7 days variations, for the whole 2010 year the record is typical by asymmetric LOD maximums after every 27.6 days corresponding to the Earth's decelerations. This triggered some disastrous earthquakes (Figs 4 and 5) and except of this there are also disastrous earthquakes also in winter and summer minimums.

<u>M 7.0 Haiti region January 12, 2010</u>

Identifying the time of magnitude 7.0 Haiti region earthquake on January 12, 2010 with LOD record, it can be seen that this earthquake corresponds to the quickest Earth's rotation owing to the maximum Moon's declination, deforming the Earth in direction to poles, resulting in a decrease of the polar mass momentum of inertia and the increment of rotation speed in LOD winter minimum (Fig. 4a). The Haiti earthquake occurred (Fig. 4e) on the east-west directing transform fault with left-lateral strike slip faulting on northern side of the Caribbean plate (Enriquillo-Plantain Garden fault system) (USGS Poster 2010). This transform fault expresses therefore the quicker westward movement of the North American plate than the Caribbean plate and probably also than the whole South American plate. No wonder that just during the increment of Earth's rotation velocity (minimum of LOD curve) the earthquake occurred. It is possible to suppose that the contribution to westward drift by Chandler wobble and by accelerating Earth leaving continents owing to inertia behind, plays an important role on northern hemisphere, whereas the tidal friction is more important on southern hemisphere. Tremors with semi-diurnal and diurnal tidal periods, observed by Rubinstein et al. (2008) in Cascadia, occurred exactly in the time of the maximum Earth's rotation velocity (in summer 2004 LOD graph minimum). It was the speediest Earth's rotation velocity ever measured by IERS since 1962.

The quicker movement of the northern hemisphere is also evident from the northward shift of the Mid-Atlantic ridge in the North Atlantic Ocean whereas in the South Atlantic Ocean the Mid-Atlantic ridge keeps its original meridional direction. A smaller opening of the Atlantic Ocean on northern hemisphere shows that also the Eurasian plate moves westward (Fig. 4b).

More detailed explanation of the Haiti earthquake origin the comparison presents of earthquakes in Enriquillo-Plantain Garden transform fault with earthquakes on Mid-Atlantic Ridge, which are in close relation (Figs 4c and 4d). Variations of the Earth's rotation by their accelerations and decelerations open the Mid-Atlantic Ridge and trigger shallow earthquakes in rhythm of inflection points of LOD record. It is not a chance that, consequently from equator to higher latitudes, earthquakes are triggered from the end of Dec. 2009, when an earthquake had occurred at the most western site of the Mid-Atlantic Ridge, where the pressure reached maximum. The westward drift of the American plate enlarged the resonance effect of four LOD minimums caused distinctive westward shift of northern hemisphere and triggering of the Haiti earthquake on the transform fault on the northern side of the Caribbean plate.

M 8.8 Offshore Maule Chile February 27, 2010

Increasing LOD amplitudes at the end of January 2010 are displayed by an increased occurrence of earthquakes in Mid-Atlantic Ridge. After 28 days the largest LOD peak, i.e. the Earth's deceleration is in coincidence with triggering earthquake M 8.8 Offshore Maule Chile Feb. 27, 2010 (Fig. 4f). The earthquake occurred three days before the maximum length of a day, i.e. with the slowest Earth rotation of first half of this year. The Moon of that time was situated on equator during its apparent movement. The Earth has been deformed, enlarged its equatorial size what evoked an increment of the polar mass momentum of inertia and the Earth's rotation deceleration. The enlarged bulging of oceans caused an increment of the westward drag of the lithosphere. Let us mention extremely high tides in Argentina coast, Rio Gallegos 29 m. The fundamental importance for confirmation of the plate movement has brought the GPS measurement performed before and after the earthquake as it is shown as an exceptional westward displacement near epicenter entering the city of Concepcion 3.04 m. The most exciting news came that the whole continent of south central Chile and Argentina have displaced itself westward in Buenos Aires 2 – 4 cm as far north as Chilean border with Peru (Fig. 6). This important discovery has been performed by international, US, Chile, Argentina research groups led by the head of CAP (Central and Southern Andes GPS Project) Mike Bevis (SOEST News 2010). This GPS measurement confirmed the quick westward movement of continental and oceanic part of the South American plate shown before (Ostřihanský 1997) by the movement and opening of the Scotia Sea back-arc basin. This is the final proof that the South American plate overrides the oceanic lithosphere of the Nazca plate, which is static or very slowly moves over the asthenosphere. Next GPS measurements performed later on larger part of southern region of South American continent (Madariaga et al. 2010) has shown that the GPS movements follow exactly the westward direction.

On the Fig. 4a the record of earthquakes shows that earthquakes (mostly aftershocks of the Maule Chile) remained at rest after May 2010 till the end of year. Only two earthquakes occurred over 6th magnitude: The earthquake M 7.1 Ecuador, August 12, 2010 (depth 106 km) and the earthquake M 6.2 in vicinity of Maule Chile earthquake (50 km on the south) at depth 16 km on September 9, 2010. Both these earthquakes coincide exactly with maximums of LOD record corresponding to the Earth's rotation deceleration and the westward movement of the whole South American plate in the same way as the Maule Chile earthquake confirmed.

Most of earthquakes in the Chile Trench similarly as the earthquake M 8.8 Maule Chile are preceded by earthquake on Mid Atlantic Ridge (black bars – Fig. 4f). However at the beginning of the year 2011 the change has occurred. The earthquake M 7.1 Araucania Jan. 2, 2011 occurs at LOD minimum followed by earthquakes in Mid-Atlantic Ridge. Similarly the earthquakes M 6.8 Biobio Chile Jan. 11, 2011 and M 6.6 Offshore Maule Chile Feb. 14, 2011 are with earthquake in Mid–Atlantic Ridge after (Fig. 4f). This is very important change of earthquake occurrence LOD polarity which needs an explanation. Mid-ocean ridge reacts first on Earth's variations however after the continent overthrust the subduction zone is released by melted magma and the reversed process occurs. Subduction zone reacts first on Earth's variations in that moment on LOD minimum. Earthquakes in subduction zone occur first and then in mid-ocean ridge. Therefore initial positive LOD earthquake is changed in reciprocal cycles after 7 days, triggering earthquakes in subducton zone in LOD minimum (Fig. 4g). The last mentioned earthquakes occurred in the second LOD minimum. The next LOD second minimum exactly after 28 days on March 11 will have a crucial effect on Honshu earthquake (described in detail in special paragraph).

Earthquakes in the Indian plate

Several strong earthquakes also occurred in 2010 on the Indian plate (Fig. 4h). Similarly as in the Sumatra earthquake of 26 December 2004, most of earthquakes were triggered on the LOD minimum. The most striking case is the Moro Gulf Philippines earthquake July 27, 2010 exactly corresponding to the summer LOD minimum. To the LOD minimums correspond also earthquakes from Northern Sumatra May 5, 2010 – M 6.6, N. Guinea November 26, 2010 – M 6.1, Kapulauan Mentawai October 25, 2010 – M 7.7, most of earthquakes from Papua: 4. 8. 2010 – M 7.7, 28.9. 2010 – M 6.0, New Zealand 3.9. 2010 – M 7.0. Out from minimum or maximum LOD are earthquakes from Vanuatu (N. Hebrides). This is a collision of two oceanic lithospheres: the oceanic Pacific plate and the oceanic part of the Indian plate, which act against each other and the earthquake triggering is indefinite. Exact coincidence with LOD minimum is for Salomon Is. 26.6.2010 – M 6.7, whereas earthquakes from this area from the beginning of the year are out of coincidence. The earthquake Northern Sumatra 9. 5. 2010 – M 7.9 is for 7 days delayed and situated on smaller LOD maximum. It is the same case as the earthquake of 28. 3. 2005 which is for 10 days delayed. Similarly the earthquake 9. 5.2010 preceded the strong ~ 1.5 ms velocity increment. Conclusion: If the earthquake precedes the strong rotation deceleration (compression) and then quick acceleration, such earthquakes are mostly delayed in LOD minimum.

The earthquake M 7.1 Christchurch Sep. 3, 2010 occurred on the second LOD minimum as most of earthquakes in the Indian plate in autumn 2010 (Fig. 4h) (Fig. 4i). However the disastrous earthquake M 6.3 Christchurch Feb. 21, 2011 occurred in reciprocal cycles in LOD maximum (Fig. 4i).

To distinguish the movement of the Indian plate according to earthquakes triggered by the Earth's variation to the north and to the west a special graphic method was performed (Fig. 4k). To avoid the influence of the Pacific plate on earthquakes only part 90°E – 150°E comprising the Southeast Indian Ocean Ridge mostly of latitudinal direction was taken (Fig. 4j).

The Southeast Indian Ocean Ridge presents a very important proof of force acting on the plate. According to number of earthquakes in ascending and descending branches of LOD record (Fig. 4m) we gain that number of earthquakes on descending branch of LOD record is 33 (blue bars) whereas on ascending one only 22 (orange bars). The result shows that there is force acting during the Earth's acceleration, pushing the plate northward. Because the Eötvös force is proportional to the Earth's rotation in second power, its action on the Indian plate is probable. It can be seen that this force acts in descending part of LOD graph from May to July and also from October to December. Less frequent earthquakes are on the ascending branch from January to March and from September to November. Similar result the year 2008 shows with 29 earthquakes on descending branch and only 19 on ascending one. In the years 2009 and 2007 – 2004 differences between earthquakes on ascending and descending branches are less than ±5 earthquakes.

M 9.0 Near the coast of Honshu Japan March 11, 2011

Under this occasion let us mention the large M 9.0 earthquake Near the coast of Honshu, Japan on March 11, 2011. Surprising was its exact position on the second LOD minimum (Fig. 5a). The second LOD minimum earthquakes are typical for many earthquakes in the second half of year in the Indian plate and also in the Chile Trench. The earthquake M 6.8 Biobio Chile has occurred in the second LOD minimum confirming the reverse mode of Earth's variation triggering when originally the LOD maximum triggering for the whole year 2010 was changed in the beginning of 2011 year into the LOD minimum triggering.

The cause of M 9.0 March 11, 2011 earthquake is following:
Accelerating Earth has left behind on the west by inertia the Eurasian plate. For better understanding, in accordance with GPS measurements, which considers the continental lithosphere as fixed with GPS satellite system, let us imagine that the rolling mantle beneath continental lithosphere shifted the oceanic lithosphere of the Pacific plate eastward, separating it from the Japan Trench and shifted the Japan

continent in Honshu for 8 feet eastward (NASA 2011) (Fig. 5b) and caused the subsidence of oceanic lithosphere resulting in huge tsunami. It is possible to pronounce the hypothesis that earthquakes triggered in subduction zones in LOD minimum can cause tsunami. This is in agreement with many earthquakes including M 9.1 Sumatra Dec. 26, 2004.

DISCUSSION OF FORCES ACTING ON PLATES AND EARTHQUAKES TRIGGERING.

The most significant tectonic features on the Earth are the long mid-ocean ridges roughly of meridional direction, recently manifested by the Mid-Atlantic Ridge and the East Pacific Rise. These originally meridional tectonic faults (from those non-opened as mid-ocean ridges let us name e.g. Rhine Graben, Ninety East Ridge, Ural + Novaya Zemlya, East African Rift + Red Sea etc.) result from the fatigue of the lithosphere strained by semidiurnal and diurnal tidal stress. This is the first and probably the most important action of tidal forces on the Earth.

The tidal friction means that the force couple acts against the Earth's rotation, decelerates it and shifts lithospheric plates westward. The torque exerted by these forces through Moon or Sun can be exactly calculated using the Laser Lunar Ranging estimate of the deceleration of the Moon along its orbit $-27.9''$ (Burša 1987):

$$N_{\mathrm{Moon}} = 4.2\times10^{16}\ \mathrm{N\ m}$$

$$N_{\mathrm{Sun}} = 8.9\times10^{15}\ \mathrm{N\ m}$$

and corresponding tidal forces because of tidal friction are

$F_{\mathrm{Moon}} = 1.1\times10^{8}\ \mathrm{kg\ m\ s^{-2}},\quad F_{\mathrm{Sun}} = 6\times10^{4}\ \mathrm{kg\ m\ s^{-2}}.$

Calculated forces are extremely weak and how these forces can decelerate the Earth's rotation and to move plates westward is a mystery. For Earth's deceleration the mechanism was calculated by Schwiderski (1985), who showed that the major braking is accomplished, without any noteworthy heat generation in the Earth, by the ocean tide bottom pressure working against the Earth tide. Another mechanism was present in recent time by O.A. Andersen (1995). Against Jordan (1974) and Ranalli (2002) arguments about impossibility of the plate movement over asthenosphere, because of mantle viscosity 10^{19} Pa s, can be raised objections that viscosities obtained from the post-glacial rebound are different from those in horizontal direction or a layer with very low viscosity till undiscovered exists in upper mantle. The situation is however far complicated because plates move easily regardless they have deep forehead continent with depth 300 km and the oceanic tail only max. 90 km thick.

At present time it might be supposed that the GPS measurement exactly describe the plate movement. There is however one handicap. The GPS velocities on the Nazca plate show, namely from the EISL position on the western side of the East Pacific Rise, distinctive eastward movement. This of course gives to protagonists of the mantle convection, according to which the oceanic lithosphere is pushed to both sides from the East Pacific Rise by mantle upwelling, a strong argument for this hypothetically non-sense idea originated by Holmes (1939), which remained in minds of many geologists after the discovery of the plate tectonic principle up to now. The reason is that the ITRF2005 reference frame reflects the fixed position of the lithosphere against MIT orbits of satellites, which the GPS uses. This system of course says nothing about the real plate movements over the upper mantle. If we imagine the stable lithosphere, then the mantle beneath moves eastward, but the small plates Nazca, Cocos, Juan de Fuca and Explorer are to mantle connected. The stability of the Nazca plate confirms also the Galapagos hotspot, which is fixed in mantle and without hotspot track in oceanic lithosphere. The Carnegie and Cocos ridges (Fig. 4e) were created when the rolling mantle drifted the Faralon plate (the predecessor of Nazca and Cocos plates) against the American plates and the Faralon plate was torn apart and the rupture propagated from east to west. The Galapagos hotspot fed by its magma this rupture forming apparent doubled hotspot track.

There are two forces, which can cause the westward drift. It is already mentioned the tidal friction, which acts by force couple against the Earth’s rotation and the second are the abrupt Earth’s rotation accelerations, which left behind on the west the lithospheric plates owing to the principle of inertia. This mechanism works in case that on the west is a free space created by dropping down of old oceanic lithosphere by gravity and on the east the ratcheting mechanism works which operates by an ascent of magma in mid-ocean ridges preventing the backward movement during rotation deceleration. The next effect, which accelerates the Earth’s rotation, is the Chandler wobble. Chandler (1891) established that the motion of the pole is the resultant of two components: one is the rotation of the true pole around the (mean) principal moment of inertia axis, counterclockwise as viewed from the north with a period about 1.20 years (Chandler period) and the other is a rotation in the same direction with an annual period. As a consequence of superposition of these two frequencies the beats in the signal occur with the frequency equal to the difference of both frequencies. Comparing minimums of time expansion of pole position, it can be seen that the signal beat occurs almost exactly in 6 years and from it follows the variability of this movement. On the plate movement this effect is well observable on the northern hemisphere where owing to the shortage of oceanic area and formation of water bulging the effect of tidal friction is not so effective as on the southern hemisphere. Because the pole tides have the largest amplitude on 45° latitude (Wahr 1985) the shift movement in rhythm of Chandler wobble in Cascadia subduction zone (Canada Pacific coast) was well observable (Miller 2002, Rogers & Dragert 2003, Rogers et al. 2003). Of course the plate movement in rhythm of Chandler wobble (Fig. 7) is not a rhythmic subduction of oceanic lithosphere beneath the North American continent as authors claim, but the North American plate overrides the oceanic subduction zone and very narrow northern part of oceanic lithosphere of the Explorer plate pushes westward. Nevertheless the permanent action of the tidal friction is also evident as the slope of the GPS graph confirms (Fig. 7). Very evident is also the overriding of the East Pacific Rise by the North American plate because the westward movement of the East Pacific Rise equals to one half speed of the Pacific plate and that is why the North American plate overrides it in northern latitudes.

Hypothetically it is possible to present assumptions why the lithospheric plates move at all when the viscosity of the asthenosphere is so high preventing any movement regarding mantle? The strongest earthquakes show that the resonance effects (Ostřihanský 2010), which play an important role among mutual interactions in nature, influence their triggering. The Sumatra earthquake magnitude 9.1 of December 26, 2004 was triggered exactly on the third stroke of LOD velocity increment (Fig. 2). The Denali Fault Alaska earthquake magnitude 7.9 of November 3, 2002 was triggered exactly on the third stroke of LOD maximum (velocity decrement) (Fig. 1). Therefore the resonance evoked by different types of oscillations, velocity variations, tidal bulging, Earth's wobbling motion shake lithospheric plates destroying the surrounding part of asthenosphere in head and tail of the lithosphere and by this the lithosphere can move regardless whether it has a flat bottom or a deep continental keel. From the same reason the old oceanic lithosphere (older than 180 M.Y.) can fall down by gravity in subduction zones as far as 600 km.

Heat flow measurements confirm that lithosphere behaves as a good insulator. Subtracting heat production from radioactive batholiths we can receive extremely low heat flow from the depth beneath continents ~ 1.5 mWm^{-2} (Ostřihanský 1980). Only directly in sites of the lithosphere broken by external forces, in mid-ocean ridges, subduction zones, back-arc basins and tectonically broken areas the high heat flows exist. Formation of waste areas of oceanic lithosphere from mid-ocean ridges witnesses that mantle material streams easily to mid-ocean ridges as extremely low viscosity liquid. This also gives the answer why lithospheric plates with deep and out-of-flat bottom move easily by extremely weak forces.

Westward drift is therefore caused by two effects: 1. By tidal friction which pushes plates to the west. 2. By the Earth's accelerations which leave plates behind the rotation movement owing to inertia, supposing that a ratcheting mechanism exists preventing the eastward movement and a free space on western side of plates exists which plates can override or fall down by gravity in subduction zones. Earth's acceleration caused by rotation variations and Chandler wobble triggered the Haiti earthquake on the transform fault (Fig.4e) demonstrating the quicker westward movement of the North American plate over the South American, demonstrated also by the westward shift of the northern part of the Mid-Atlantic ridge.

A question remains why the Haiti earthquake and also the Sumatra earthquake 2004 (Fig.1) were triggered just in the winter acceleration (in LOD minimum) and not in the late summer acceleration, which is almost three times stronger. The answer gives the Kalenda et al. (2010) discovery about important effect of insulation and thermal expansion on the movement of plates. In the winter time the North American and Eurasian plates shrink and they release by this way the movement along faults.

The last question is why plates move over asthenosphere, the viscosity of which is so high preventing any movement. The resonance effects give the answer, which can by their permanent action destroy the lithosphere. The Kalenda's thermoelastic wave (Kalenda et al. 2010) propagating through the whole lithosphere belongs also among resonance effects facilitating the plate movement.

The Eötvös force (Eötvös 1913) can be simply calculated, considering the lithospheric block, as gliding on solid equip. surface or submerged into the asthenospheric liquid (Wegener, 1929) and kept (because of the constant volume of the submerged part) by the asthenospheric pressure in a constant distance from equip. surface of the asthenosphere during the movement.

We can follow the manner of Schwinner (1934), originating in Epstein (1921), with some adaptation of Gutenberg (1940):

The acceleration e of the plate moving to the equator can be calculated from equivalence of work done by force e on the elementary length dx towards equator and the length db, by which the center of gravity of the plate sinks on vertical during its movement

$$m\, e\, dx = m\, g\, db$$

where m is the mass of the block.

Because for gravity g and the distance b between the center of gravity and the bottom of the block, the product $g\,b = \mathrm{const.}$ on equipotential surface, then $g\,db = -b\,dg$ and

$$e = -\frac{dg}{dx}\,b$$

With the formula for gravity $g = g_0\,(1 + 0.0053\,\sin^2\varphi)$, where g_0 is the gravity on the equator and φ the latitude, we can get, after derivation, for $dx = -R\,d\varphi,\quad R$ is the Earth's radius, substituting into above, the Eötvös force

$$E = m\,e = m\,\frac{b}{R}\,g_0 \cdot 0.0053\,\sin 2\varphi$$

For the block of constant density and thickness limited by two meridians and situated between latitudes φ_1 and φ_2, integrating over φ and considering that one zone which on equator has the width 1, on latitude φ has the width $\cos\varphi$, we have

$$E_\varphi = m\frac{b}{R}g_0 \cdot 0.0053\int_{\varphi_1}^{\varphi_2}\sin 2\varphi\cos\varphi\,d\varphi$$

After integration

$$E_\varphi = m\frac{b}{R}\,g_0 \cdot 0.0053\,\frac{2}{3}\,(\cos^3\varphi_2 - \cos^3\varphi_1)$$

For one layer between pole and equator $\varphi_1 = 90^{O}, \varphi_2 = 0^{O}$, and of the mass of unit elemental prism $m = \rho\,R$, which on cross-section of the equator limits the area $1\,m^2$, substituting constant density $\rho = 3{,}000\ \mathrm{kg\,m^{-3}}$, $g_0 = 9.81\ \mathrm{m\,s^{-2}}$ and thickness $h = 2b = 100\ \mathrm{km}$, we get the Eötvös force per unit area

$$E_{90^0} = 5.3 \quad 10^6\ \mathrm{N\,m^{-2}}.$$

Introducing the dynamical parameter $q = \dfrac{R\omega^2}{g_0} = 0.0034677$, we get

$$E_\varphi = mb\omega^2\left(\cos^3\varphi_2 - \cos^3\varphi_1\right)$$

The Eötvös force depends on the Earth's velocity of rotation ω^2 in the second power. This calculation is valid for floating body, which can be the continental lithosphere or young oceanic lithosphere. The oceanic lithosphere is not a floating body and moves on the contrary from equator to poles. The continent (Gondwana) with growing oceanic lithosphere behind can move over the pole and then decay. The Eötvös force is very weak however there is not any other force which is able to move plates over pole (Fig. 8) and to move the Indian, African and Pacific plate to the north over equator.

C O N C L U S I O N

Presented results show that earthquakes and Earth's rotation variations are in close relation. Earth's rotation variations are resultant of external forces acting on rotating Earth. Therefore analysis of the record of Earth's rotation the length of a day graph can determine forces acting on lithospheric plates and explain the causes of earthquakes. So it was possible to explain that the M 7.0 Haiti region Jan. 12, 2010 earthquake was caused by the increment of the Earth's rotation, which caused the quicker westward movement of the northern hemisphere and on the joint surface, on the Enriquillo-Plantain Garden transform fault, the earthquake occurred. The earthquake M 8.8 Offshore Maule Chile Feb. 27, 2010 was caused by the Earth's deceleration in the same way as other earthquakes in Chile Trench during 2010, however at the beginning of 2011 earthquakes were triggered by the Earth's acceleration. In the Indian plate earthquakes were found caused both northward and westward forces. Analysis of the Southeast Indian Ocean Ridge earthquakes has shown that during the Earth's acceleration the force exists pushing the plate northward. Mantle rolling beneath continental lithosphere caused by the Earth's acceleration pushed the oceanic lithosphere of the Pacific plate eastward tearing small piece of continent in northern Honshu for 8 feet eastward and caused subsidence of oceanic lithosphere creating huge tsunami of M 9.0 Near the coast of Honshu, Japan March 11, 2011 earthquake.

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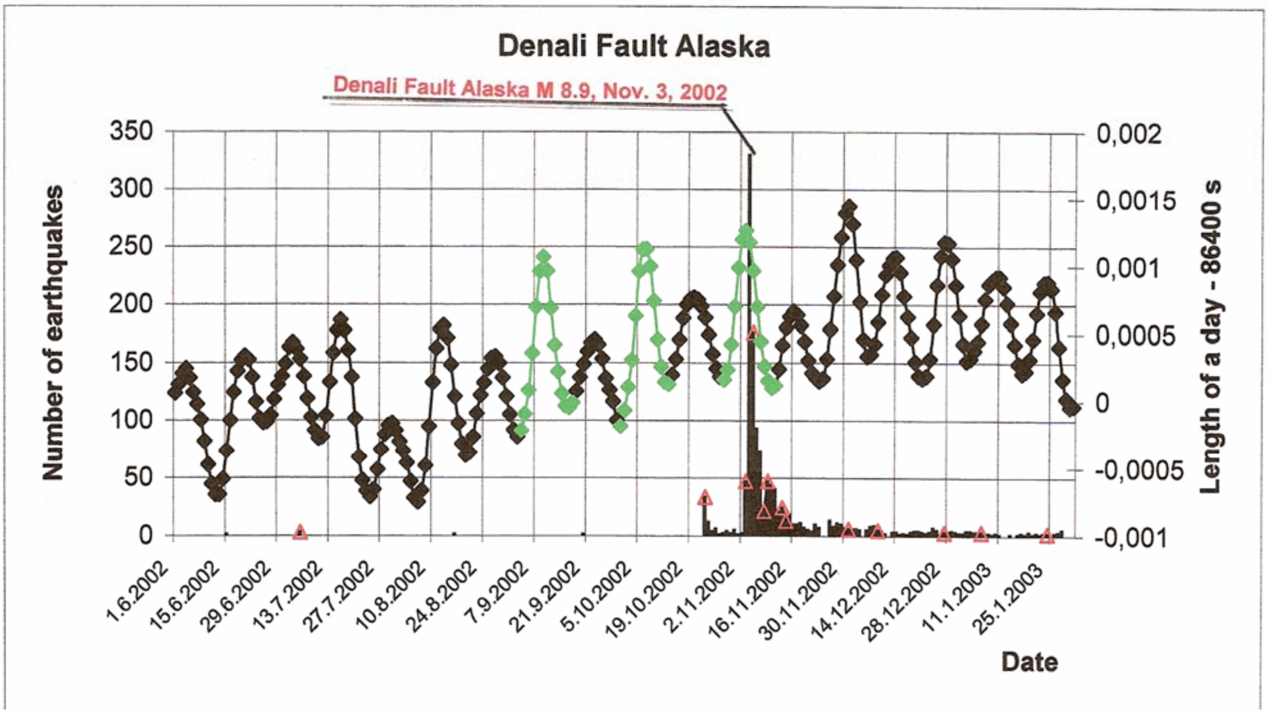

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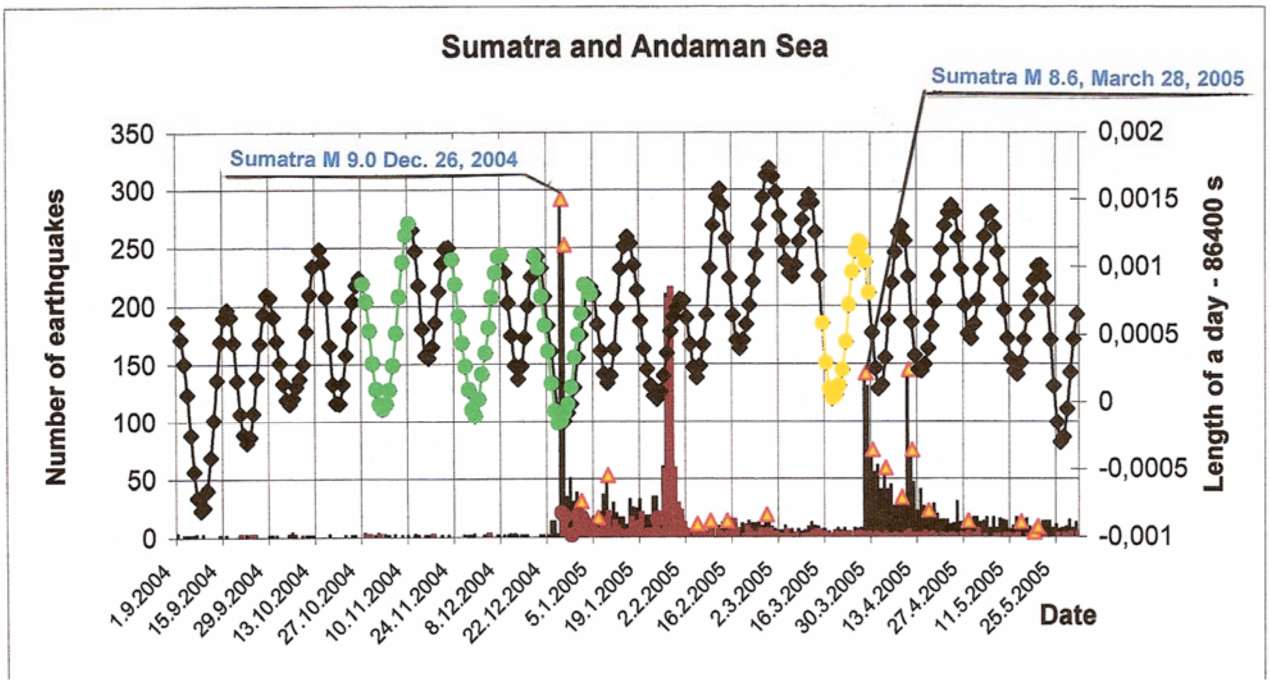

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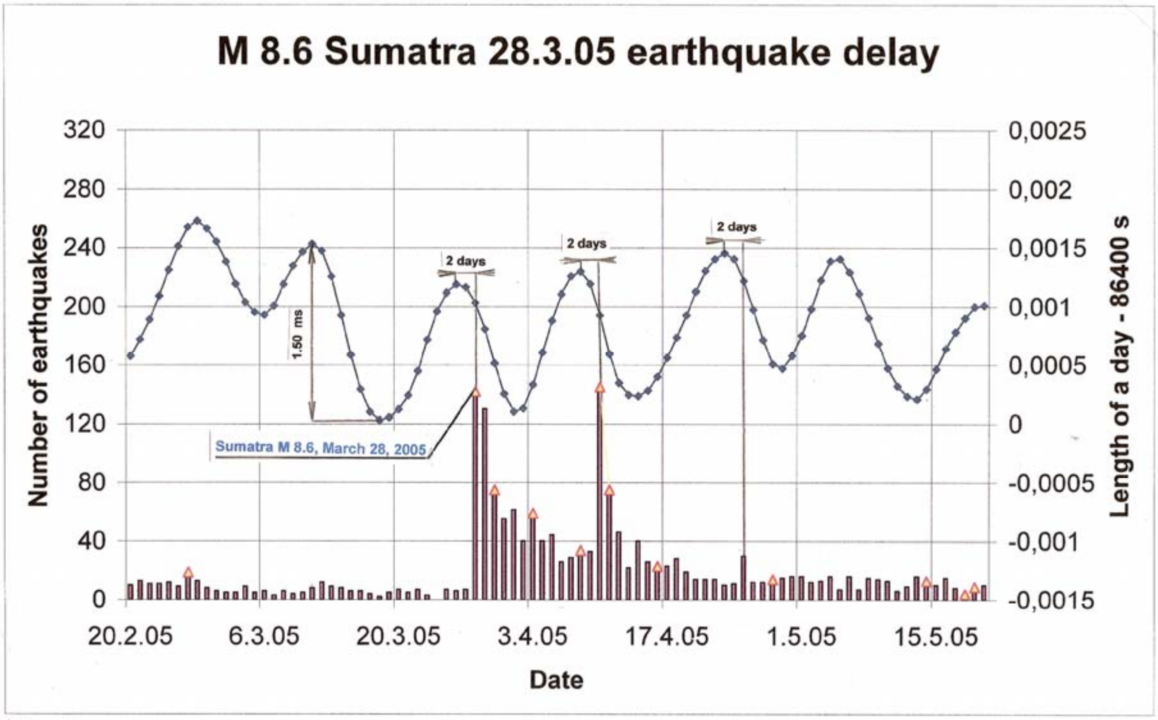

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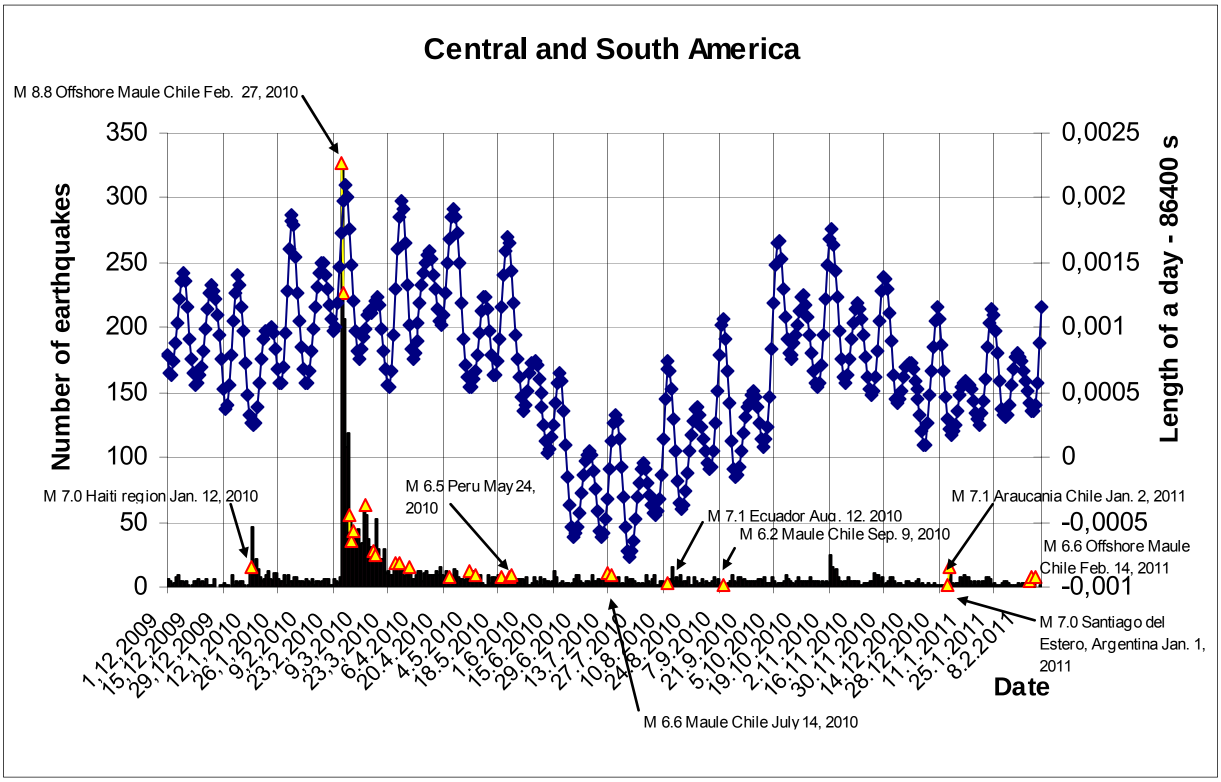

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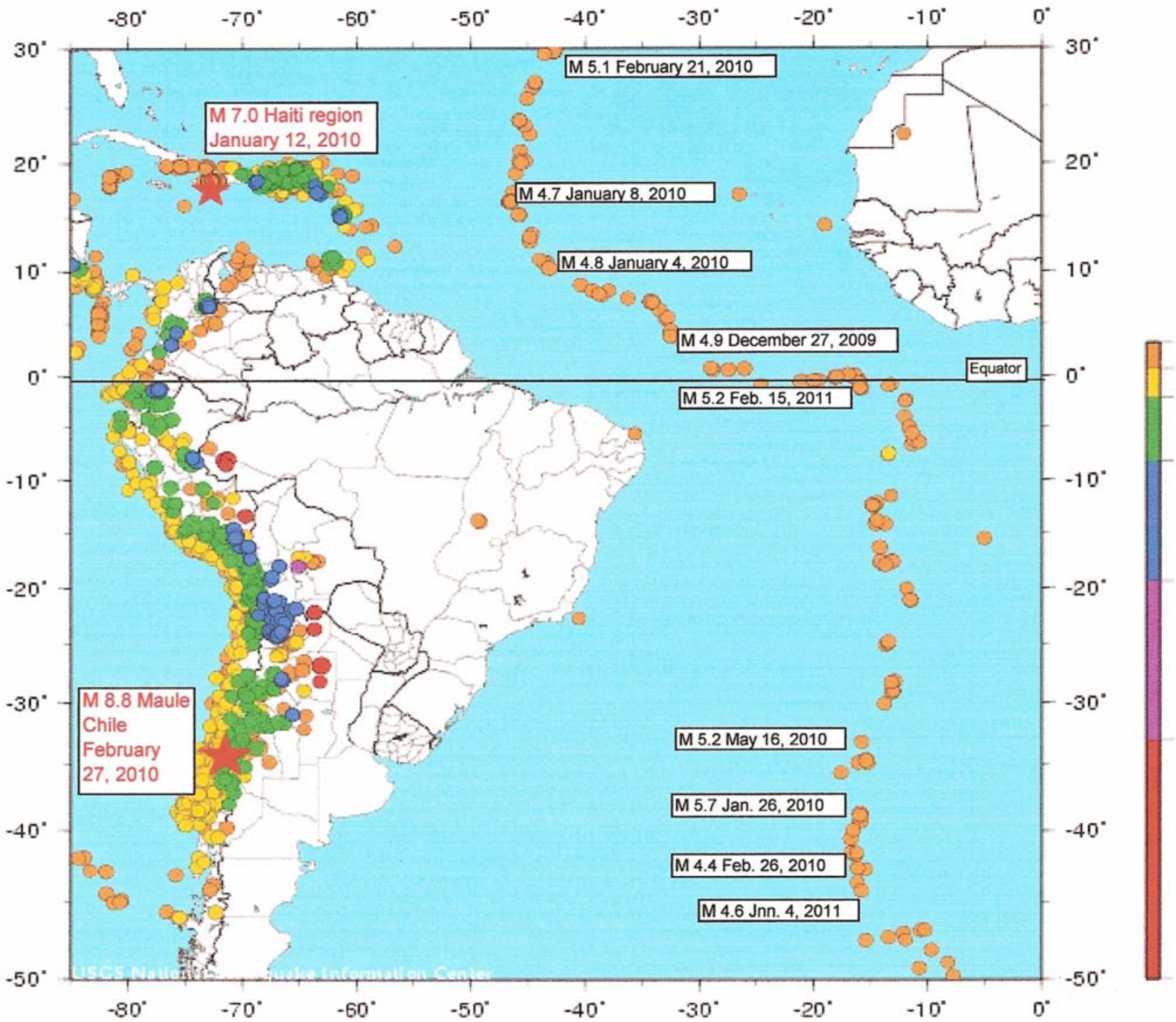

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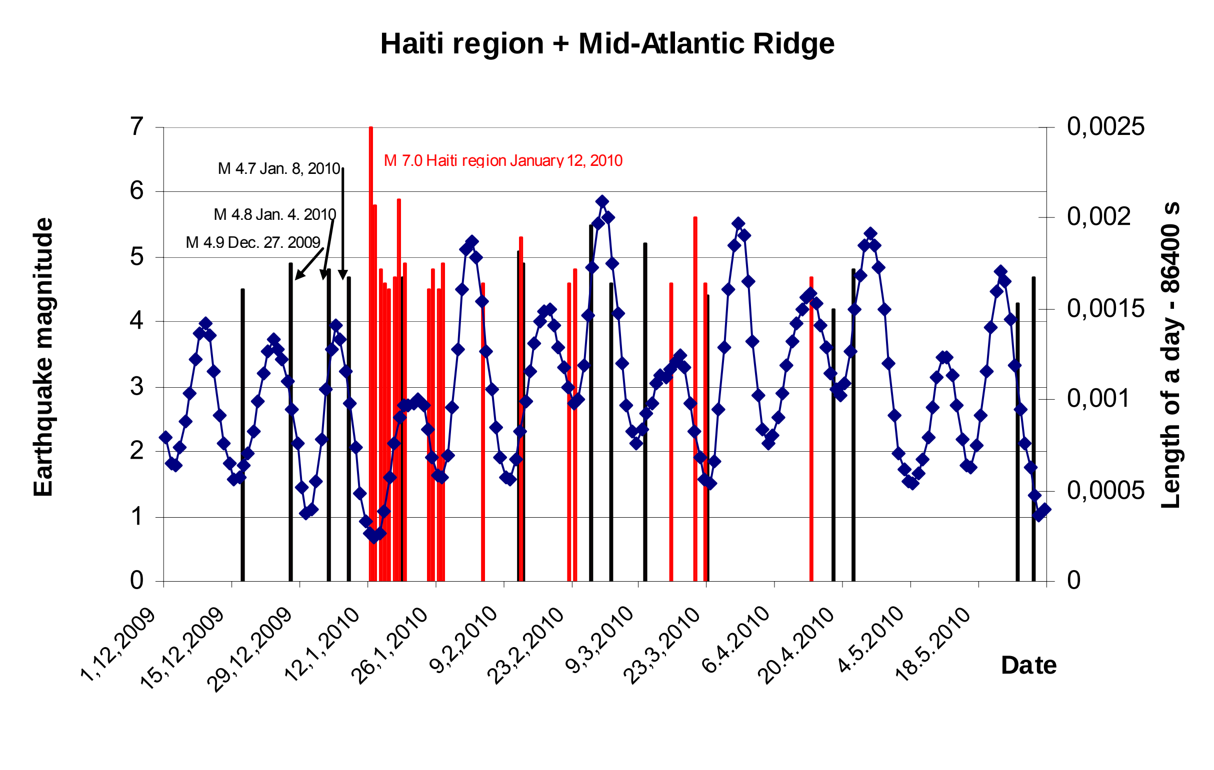

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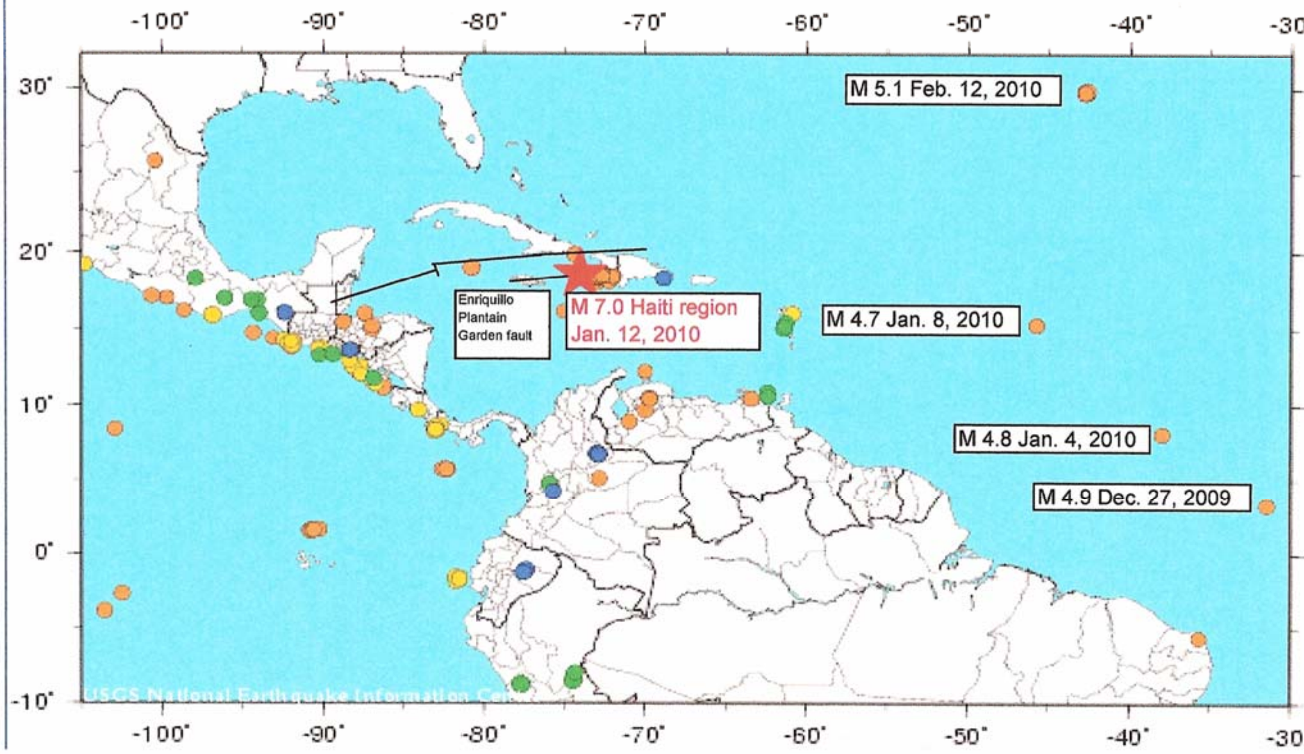

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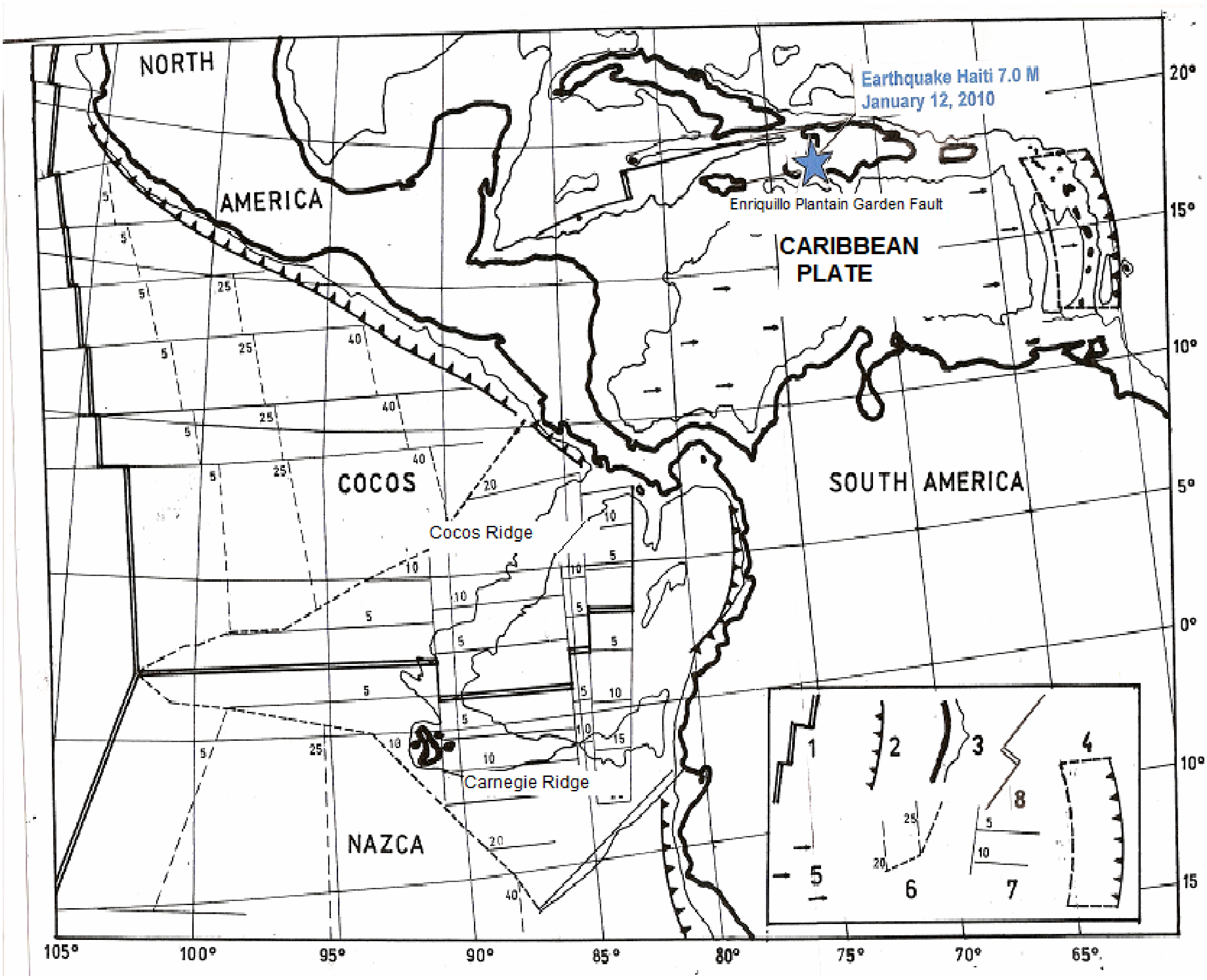

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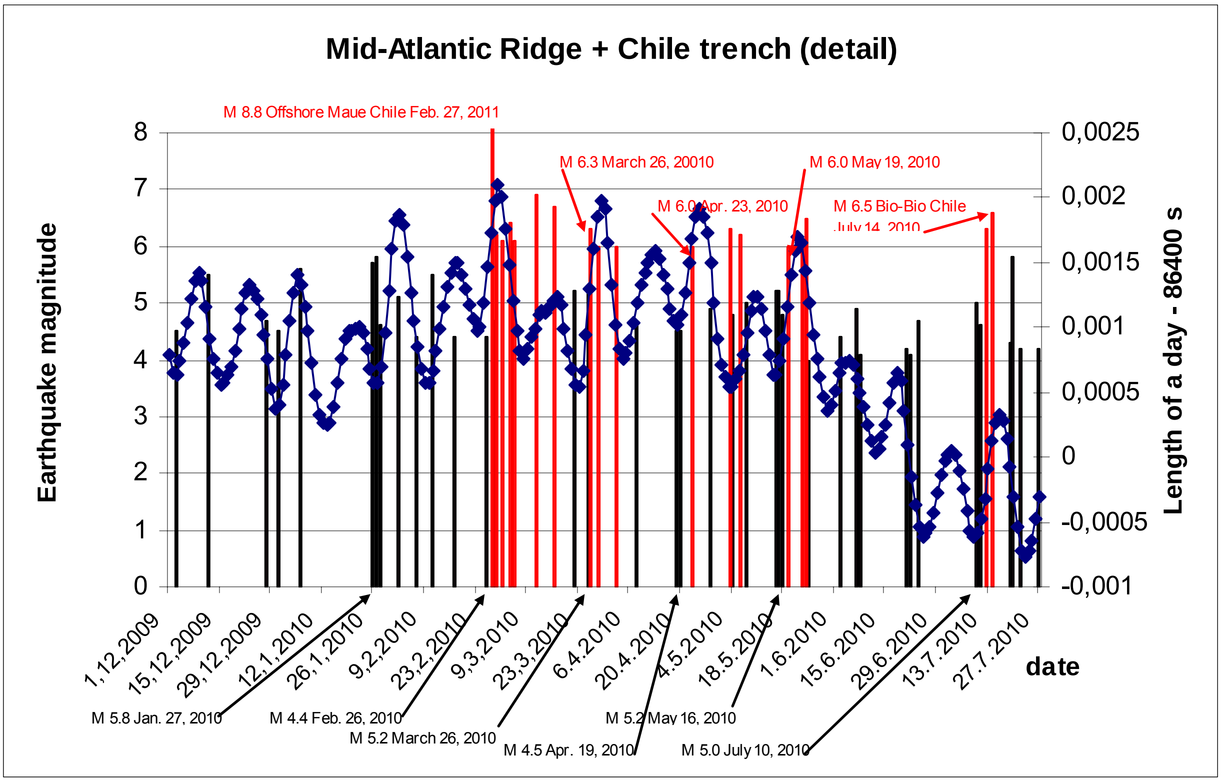

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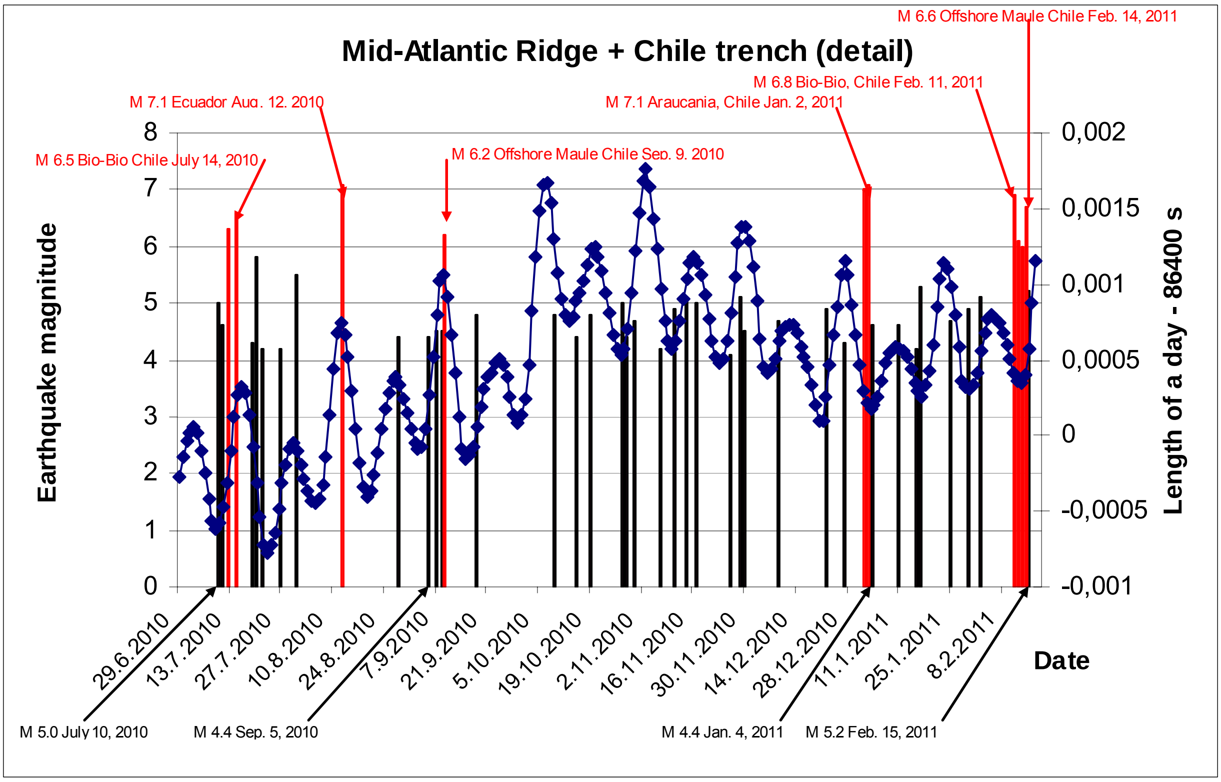

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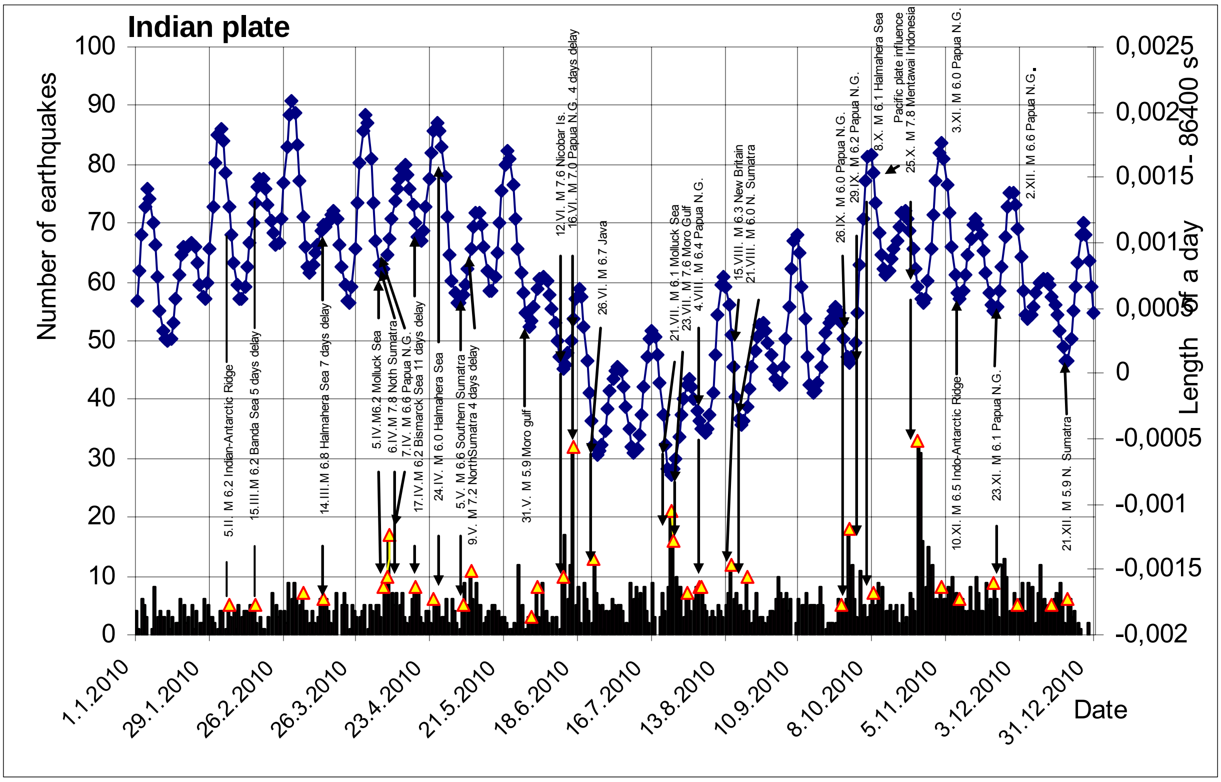

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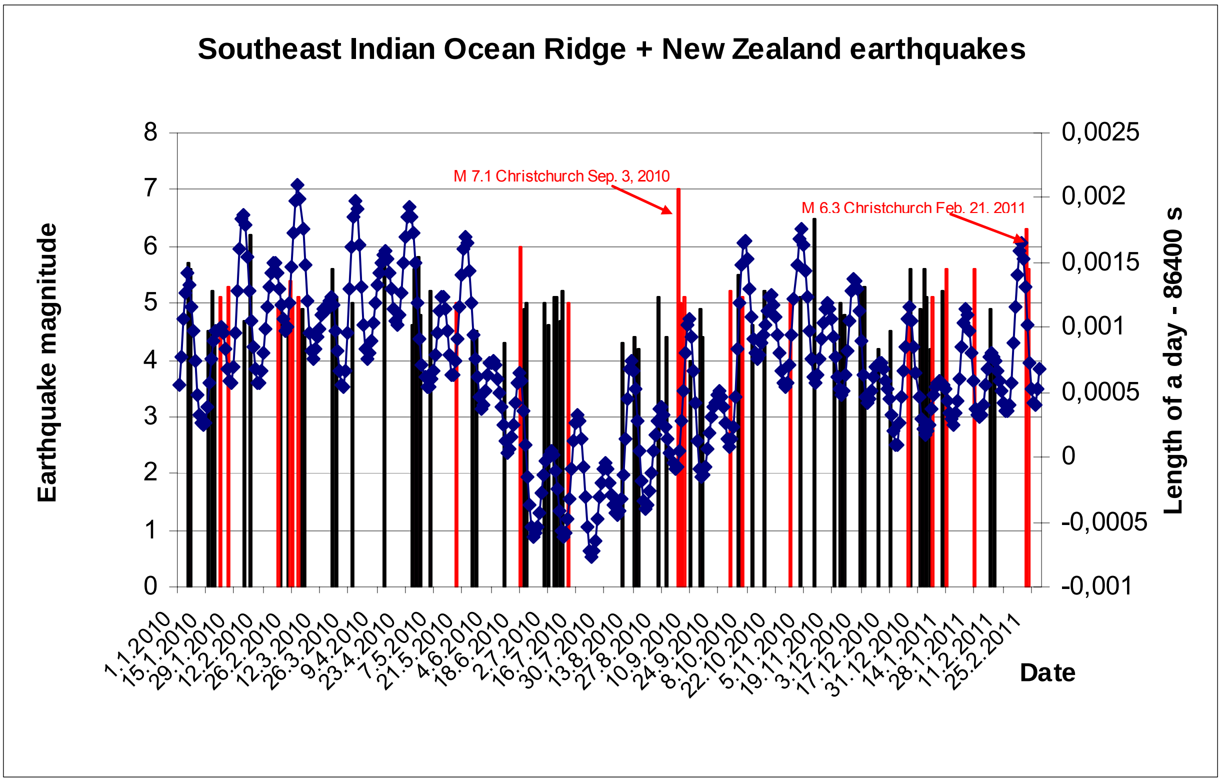

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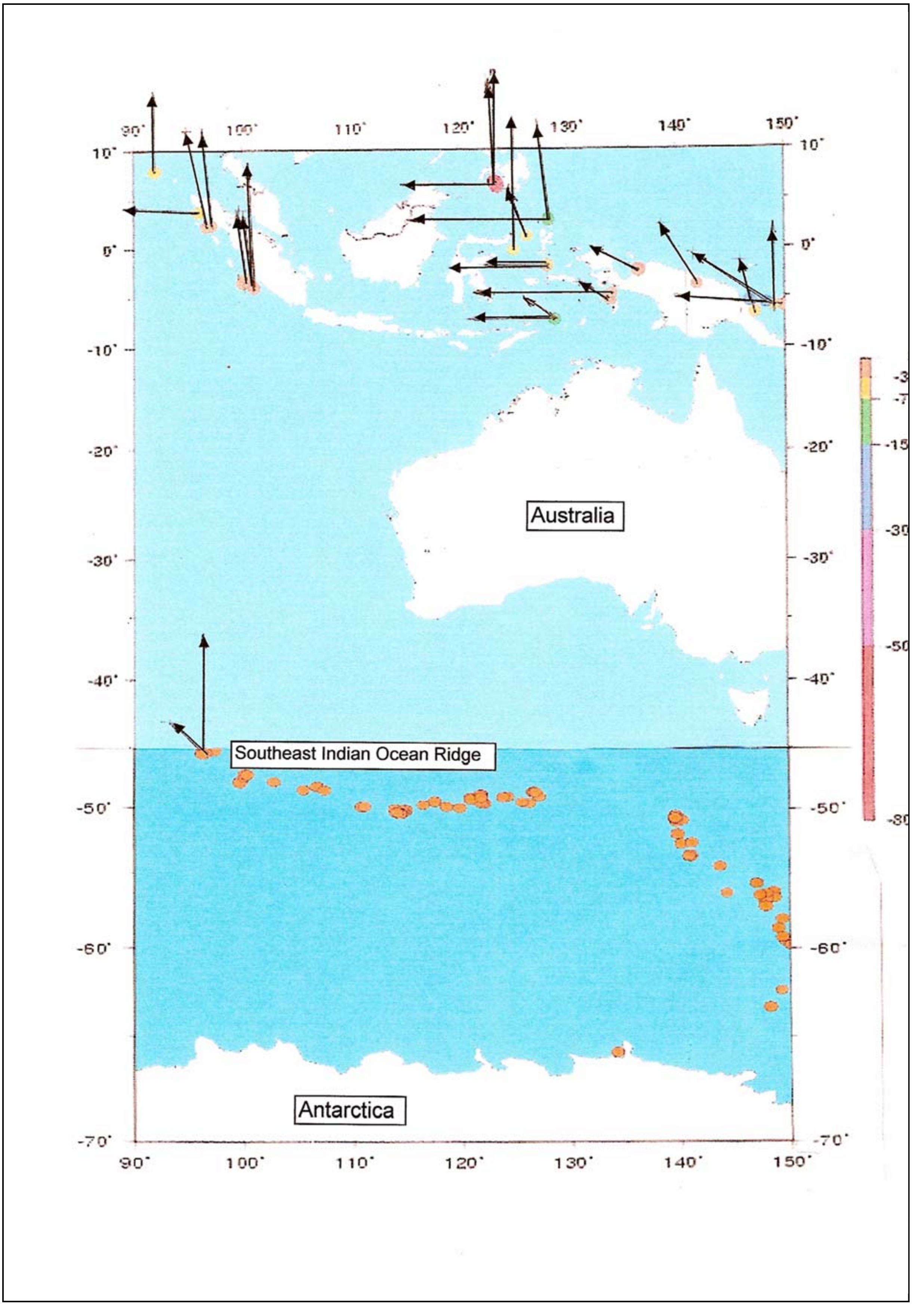

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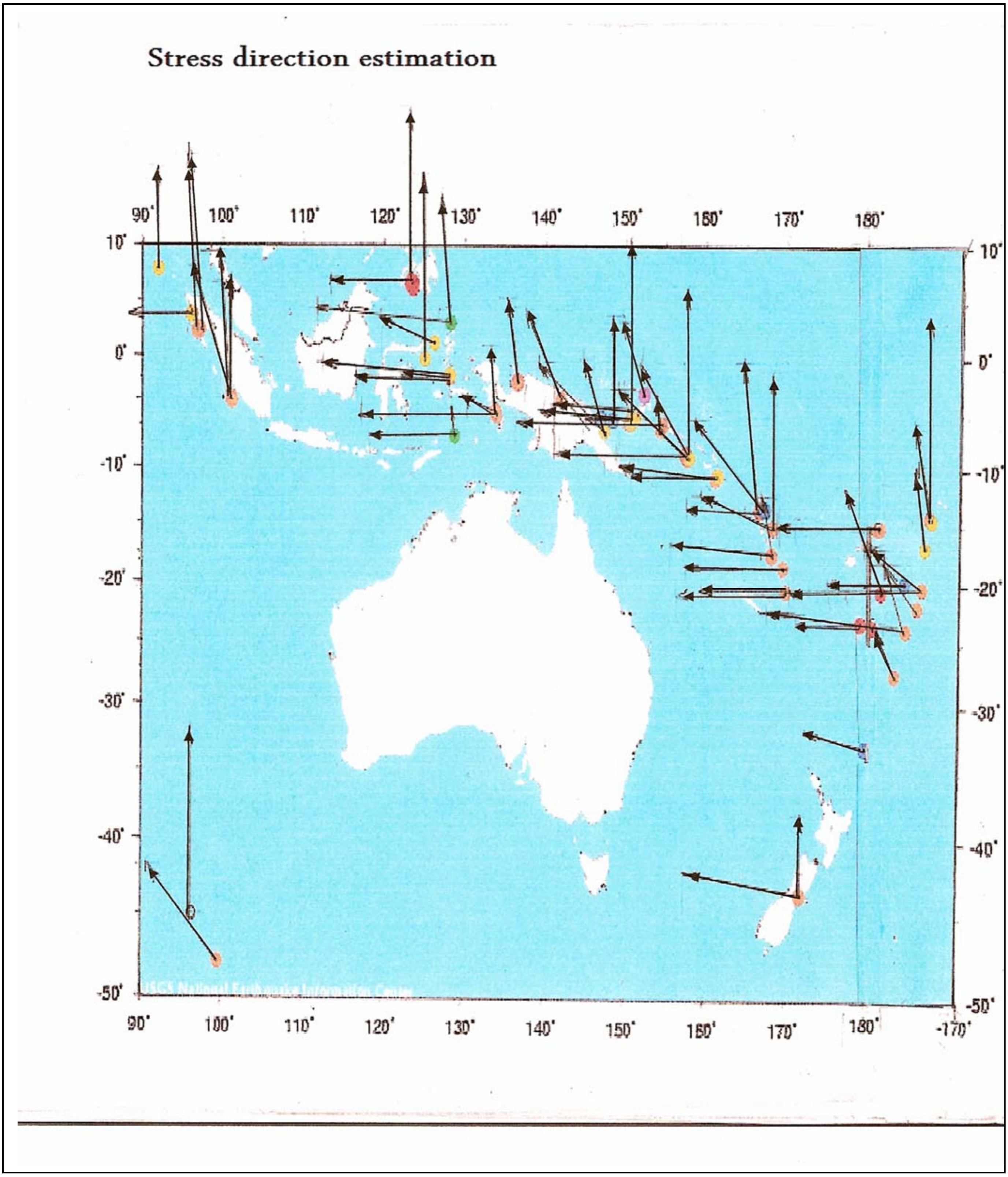

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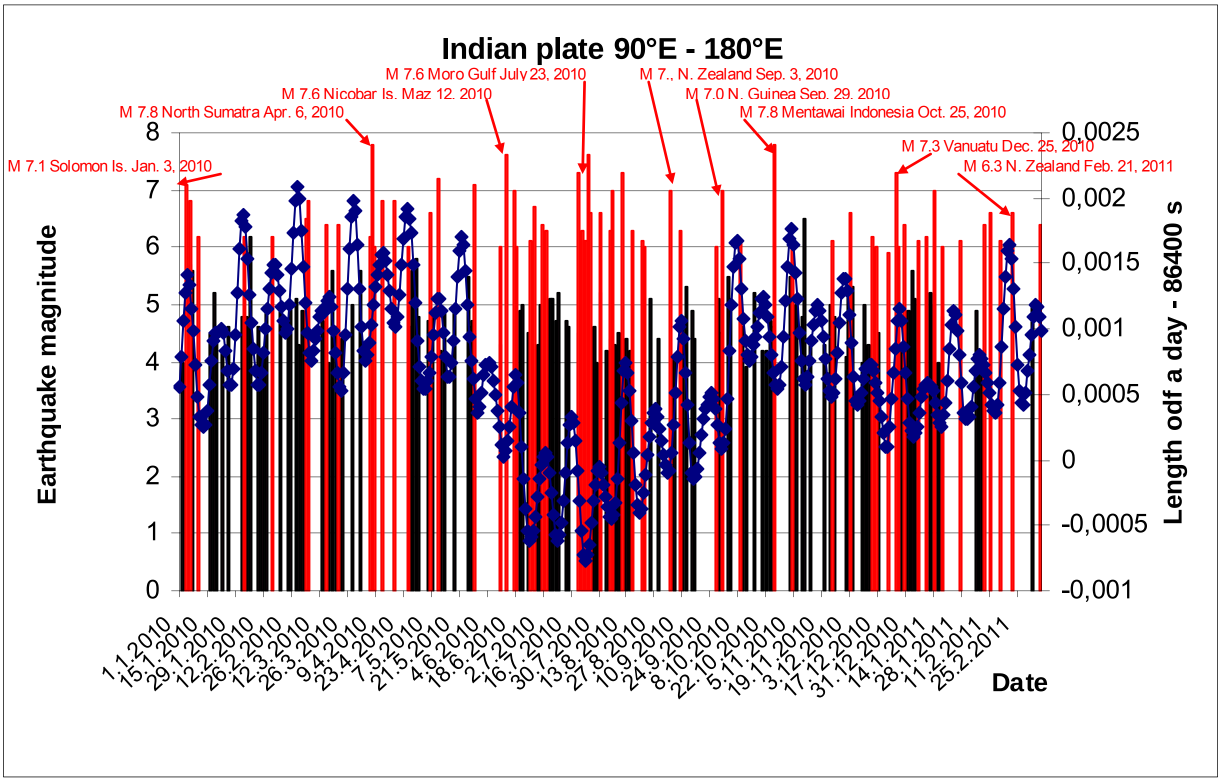

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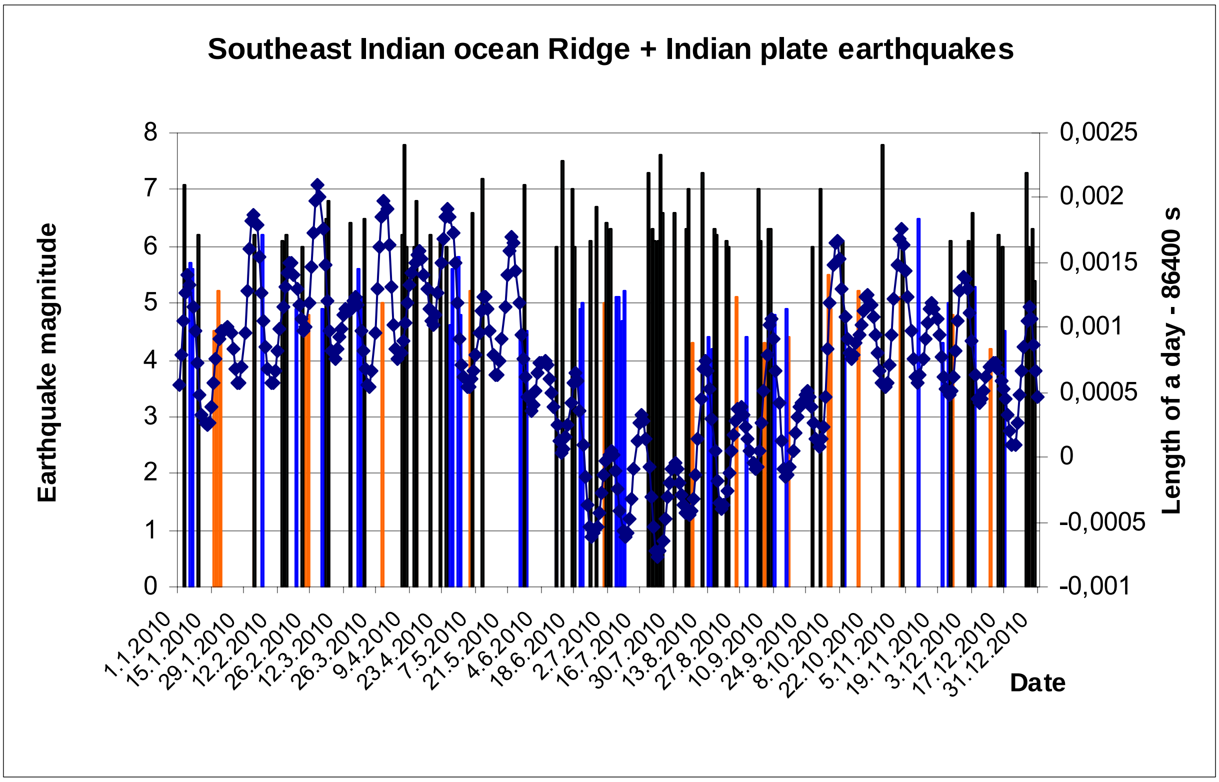

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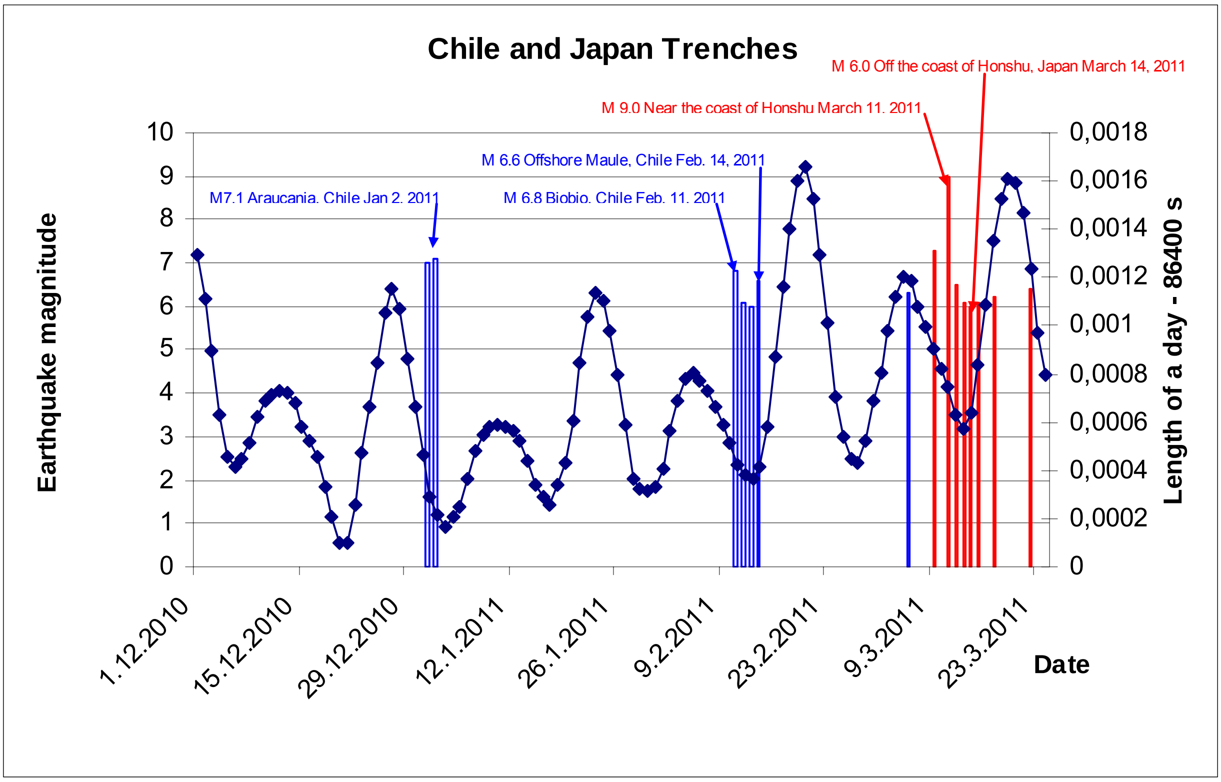

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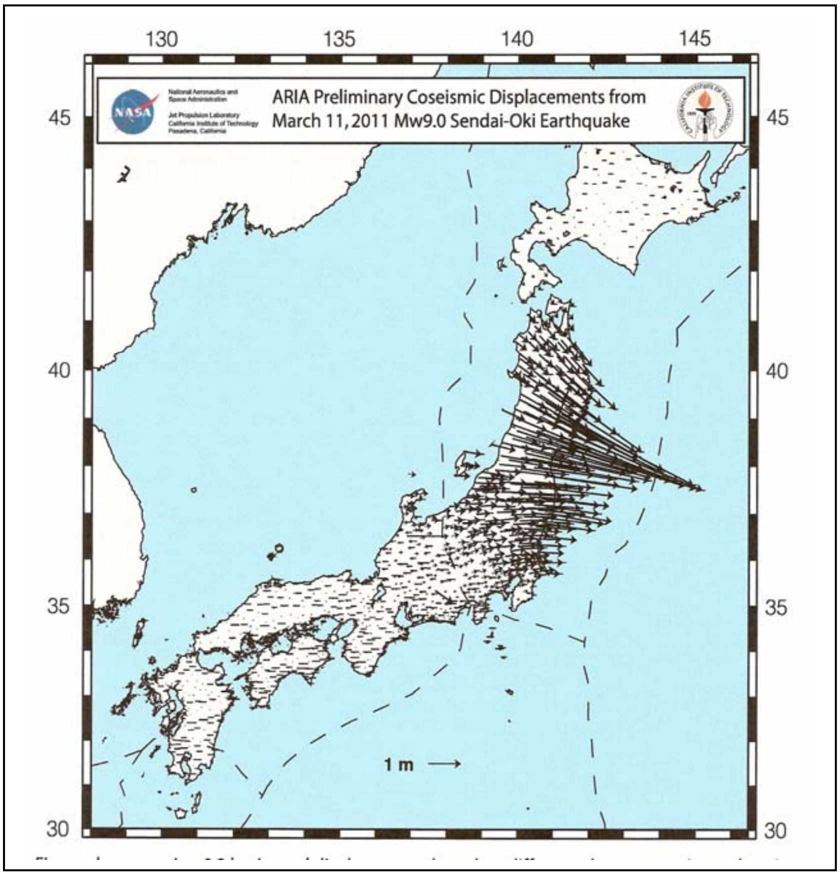

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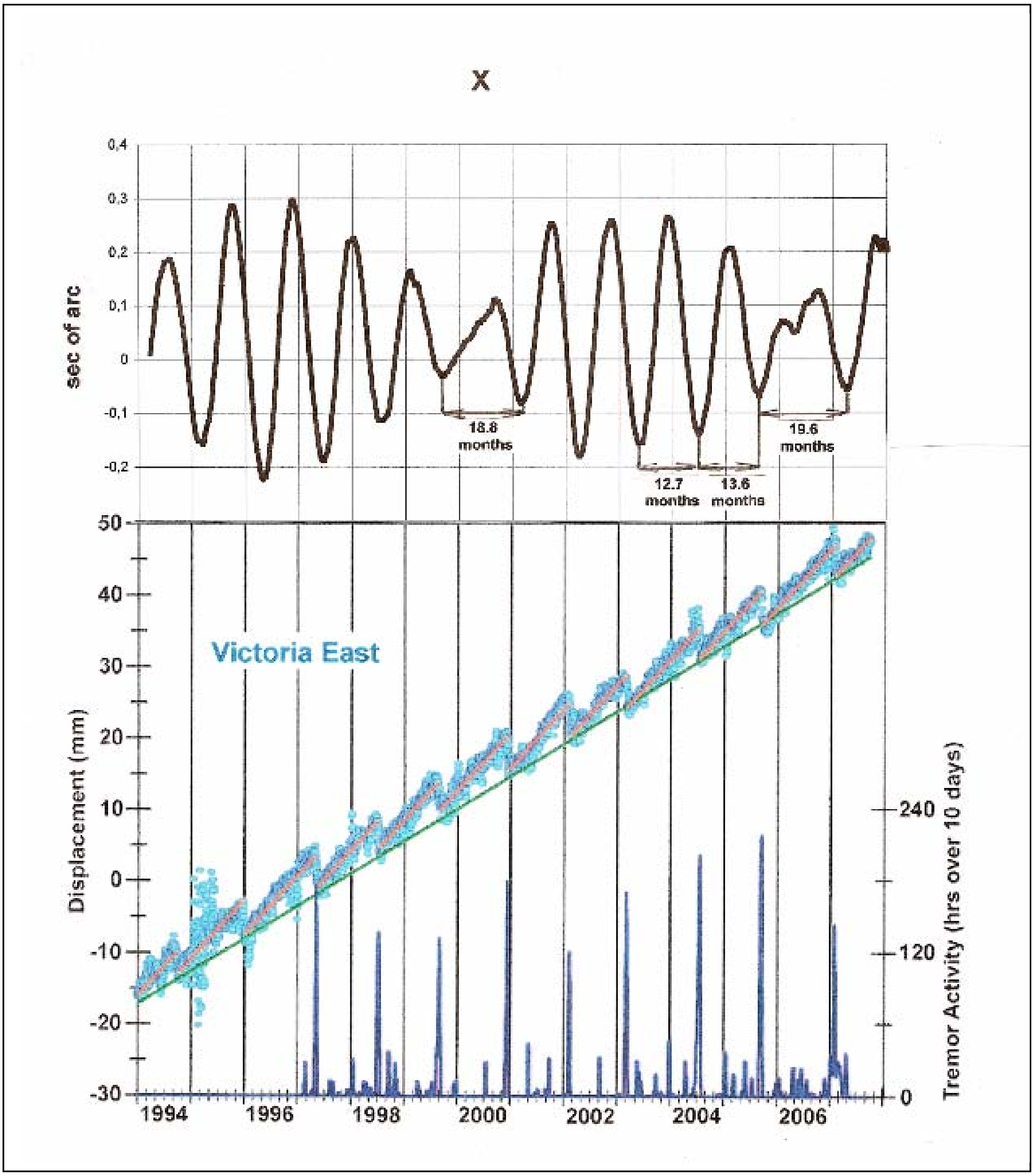

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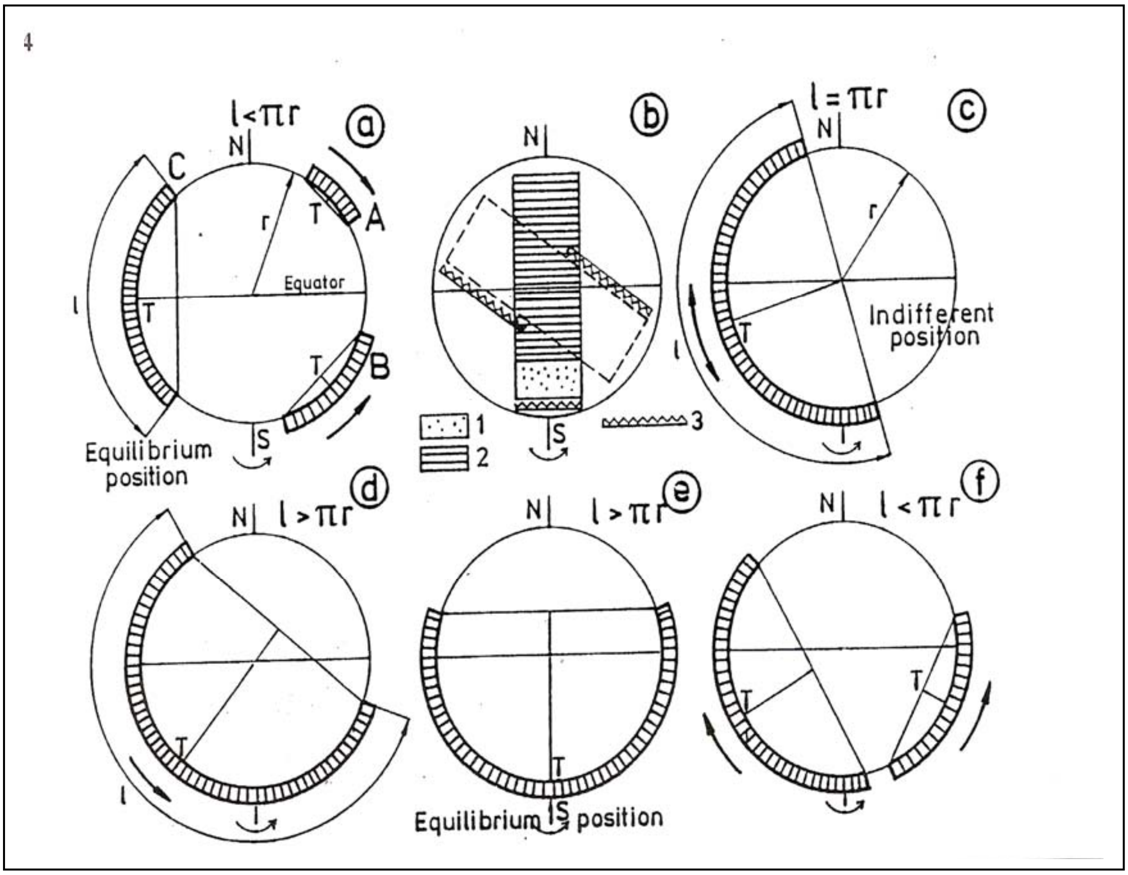

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