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A Multi-Parameter Approach to Earthquake Forecasting

Part 2 of 2

The Japanese Earthquake

Grasenack-Tente: Now you have on this poster here, some things related specifically to the 9.0 earthquake in Japan.

Pulinets: Yes, it was a very difficult case for analysis, for many reasons. One of them is that the earthquake happened between two geomagnetic storms. One of the indicators of the geomagnetic storm, is global equatorial geomagnetic index, which is named the "Dst Index." And this is a graph of this geomagnetic index (**Figure 1**), and when we have the sharp drop, it means the start of the geomagnetic storm. And then we have the recovery phase; we have quiet geomagnetic conditions; and then the next storm, which happened exactly at the moment of the earthquake.

Grasenack-Tente: That's very interesting, because that brings up, as with a lot of these things that we can't see directly, it requires that we need as broad a range of sensory instruments as possible, to correlate and make sure that we can annihilate things—

Pulinets: Okay, the correlation of solar and geomagnetic activity with seismic activities is a very difficult task. Because statistically, some people show the existence of correlation, while other people show there is no correlation. A very careful study of this should be carried out. But I can confirm, that very often, it happens that a geomagnetic storm is very close to the earthquake, but we cannot say that geomagnetic storm [equals] earthquake, no. Sometimes the geomagnetic storms could be one, two days before the earthquake.

FIGURE 1

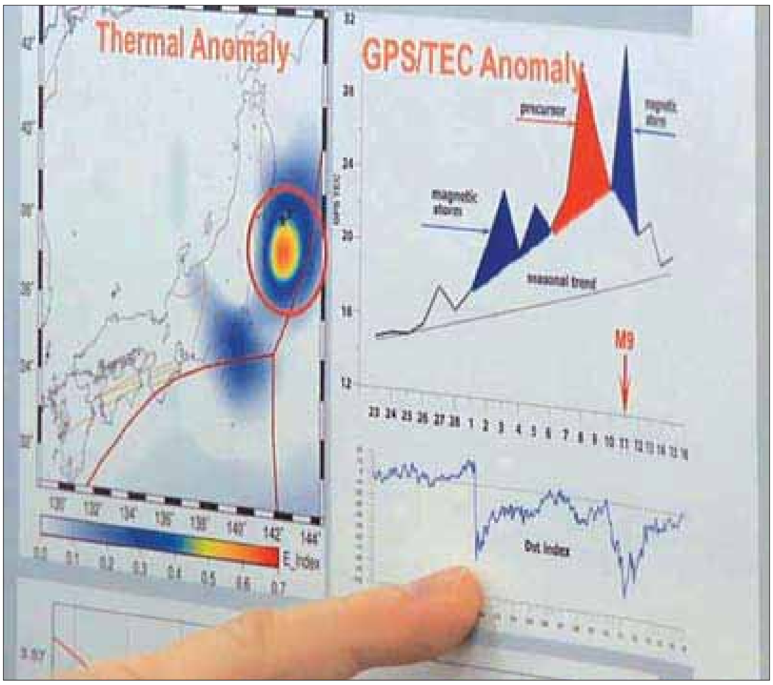
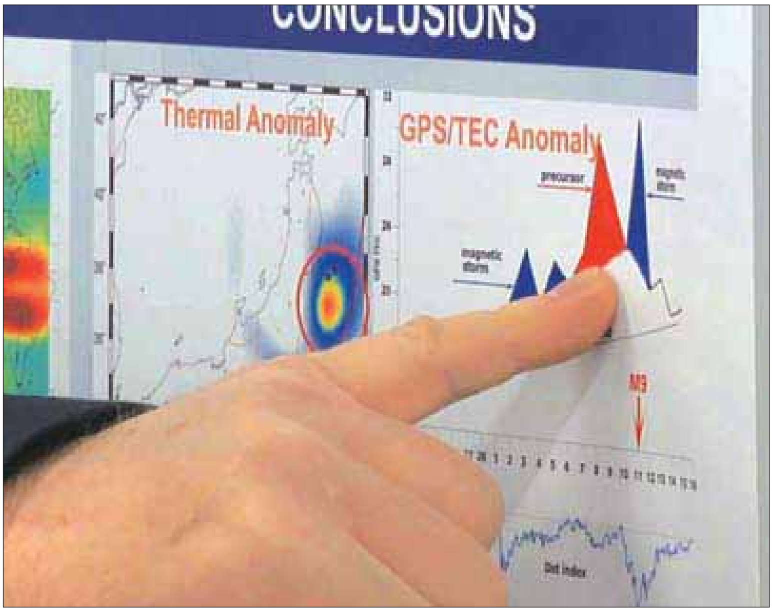


FIGURE 2



Grasenack-Tente: Sometimes after.

Pulinets: Sometimes, one, two days after. Sometimes, like we have here, simultaneously with the earthquake.

So, it looks like we have the common source of origin, which provokes both these events, and they appear close in time.

But, why do we, for example, interpret this as a precursor? Because here (**Figure 2**) this effect of the geomagnetic storm, which is blue, should decay, because here we have a quiet condition. But contrary our expectation, we have the sharp growth of electron concentration on the 8th of March, that is, three days before the earthquake. And this is supported, the GPS TEC, is supported by ionospheric tomography, which is another technique to study the ionosphere—it is a low orbiting satellite—and they have a two-frequency transmitter onboard, and you put it on the ground, like a line or a chain of receivers, which receive the satellite signal, and you can, from this registration, reconstruct the vertical cross-section of the ionosphere in the plane of the satellite orbit.

Like tomography, you have many, many rays between the satellite and several receivers, and you process, by tomography technique, this multitude of rays, and reconstruct from this, by special mathematical procedures, the vertical structure. And this [points to wall chart] is the tomography reconstruction for the chain which is in the Sakhalin region, the Sakhalin Island of Russia, which is very close to the northern part of Japan. These receivers belong to the corporation Russian Space Systems. Our co-authors Romanov and Shahr are responsible for this result. And they also observed the large positive anomaly, again, on the 8th of March.

So, we have completely different techniques [pointing at the chart]: this is GPS TEC (Total Electron Content), this is tomography; and they demonstrate the same thing.

And the next one is the ground-based ionosondes.

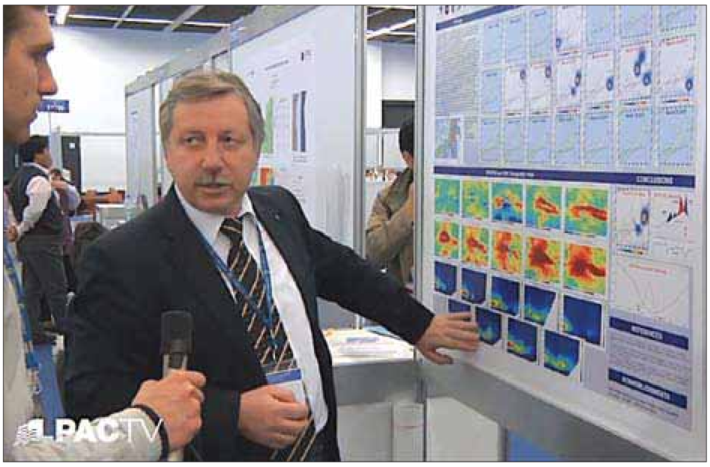
An ionosonde is radar working in the shortwave-frequency band, from 1 to 20 MHz. It is broadcasting, and they actually were designed to monitor and predict the propagation of radio waves. When we had no VHF broadcasting and FM broadcasting in the '30s, '40s, and '50s of the last century, the broadcasting was in the HF [high-frequency] waveband. And these devices were designed especially to monitor the state of the ionosphere, to predict the radio-wave propagation in this frequency band. And now, they are used to monitor space weather, because the ionosphere is very sensitive to solar effects, and every country has its own network of ionosondes. In Japan, we have four ionospheric stations: Wakkanai, Kokubunji (Tokyo), Yamagawa, and Okinawa.

And we were able to elaborate the technique, which shows that, due to the specific variability of the ionosphere before the earthquake, when you have a station close to the epicenter, and try to correlate this station with another station which is far from the epicenter, the cross-correlation coefficient drops before the earthquake. This (**Figure 3**) is a cross-correlation coefficient between Kokubunji, which is close to the epicenter, and the Yamagawa station, which is far from the epicenter. We have the configuration described in our publication.

And again, on the 8th of March, we see the drop of cross-correlation coefficient, like in GPS TEC and ionospheric tomography. So, three independent techniques show the same thing for this earthquake, three days before the main shock.

And the last result: We tried to compare, in the same season, for example, of the year, and mainly, more or less for the same solar activity, because the ionospheric density depends on the solar activity, but last year and this year are not too different in this, so we took the variations of the electron concentration for year 2010, for the period from the 23rd of February to the 23rd of March, and for year 2011, for all four ionospheric stations. And simply, we subtracted from 2011, the 2010 data. And this is the difference.

Grasenack-Tente: Can you say where the origin is, of what's originating the high-frequency waves?



Professor Pulinets indicates anomalies in precursor techniques.

Pulinets: I told you: This wave is emitted; it is like a radar. It's an installation, it sends pulses to the ionosphere, and obtains the reflection—

Grasenack-Tente: Where the radar is, is not—

Pulinets: No, no. Different frequencies are reflected on the different altitudes of the ionosphere. The higher the electron density, the higher frequency you need to reflect from the ionosphere. So, the ionosonde is starting to send pulses from 1 MHz, and goes up to 20 MHz, and received the reflections from the ionosphere. And the specific frequency is named "critical frequency"—the ionosphere is no longer able to reflect the radio waves, and they pass through it. And these are the main parameters used by the ionosonde, and we use just the critical frequency, which reflects the maximum electron concentration in the ionosphere.

So, from 2011, we subtract 2010. And you can see (**Figure 4**), starting from something like the 5th of March, the increase and then decrease. And this is the moment of the earth-

FIGURE 3

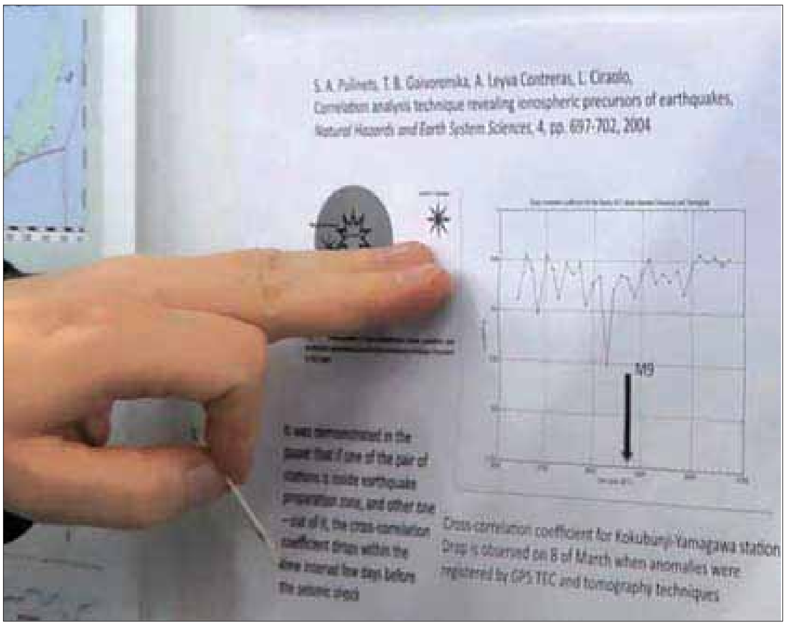
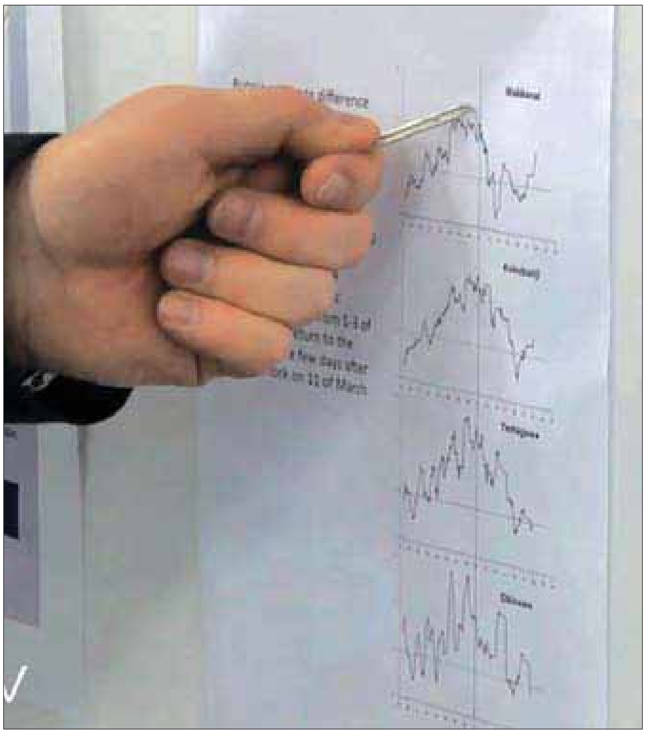


FIGURE 4



quake. So, this is from North to South: Wakkanai, Kokubunji, Yamagawa, Okinawa.

Grasenack-Tente: Yes, a pretty big spike. Okinawa's a bit more erratic.

Pulinets: Yes, but Okinawa is at a low latitude, which is affected by the so-called equatorial anomaly, which appears in the equatorial ionosphere. So, it's much higher variability than at the mid-latitude stations.

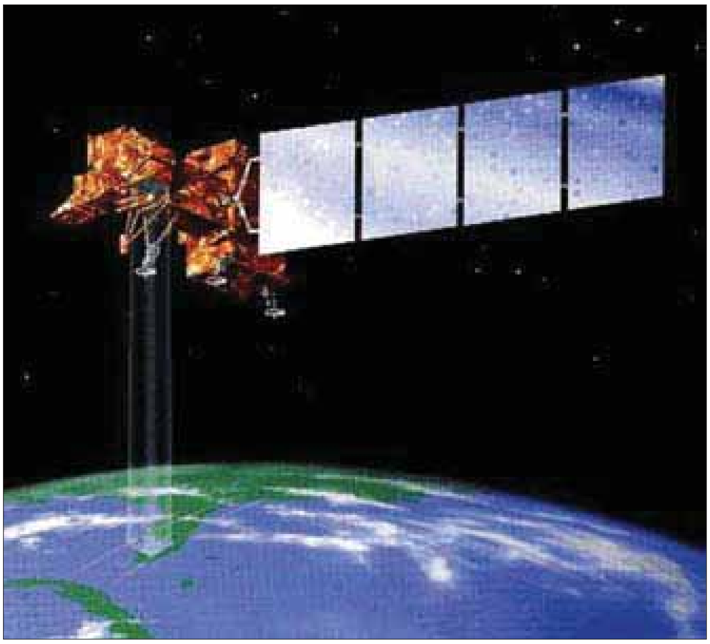
A Multi-Parameter Analysis

So, what I would like to underline more: that our approach is a multi-parameter analysis. We can say that it's very difficult, almost impossible, to make some kind of prediction using only one parameter, for example: thermal, ionospheric, VLF propagation, so on, so on. But if you have something like what we name "synergy" of the processes, we see that all of them are connected, and show the same area, within the same timeinterval, and we see some development of the processes, starting from the ground surface, like surface temperatures, and air temperatures, and at the top of the atmosphere, then the ionosphere, and we see these dynamic, all this complex of the effect, we may say that this is a multi-parameter precursor of the earthquake. This is our approach.

Grasenack-Tente: And it's interesting, because you noted that also with the geomagnetic storms. It poses the question: Well, where's the physical cause? That still needs to be investigated? Where's the principal cause?

Just one thing I wanted to say, because Professor [Pier Francesco] Biagi was saying that their main problem is they just don't have enough sensors. They have very few sensors—throughout Europe there are only seven. And if you had a global array of these things, then they could be looking where all the things are happening all around the world.

Pulinets: There is a difference between groundbased measurement and satellite. With the satellite, we have a global picture, without exclusion. This is an advantage.



Remote-sensing satellites are among the array of detection techniques used for forecasting weather events. Shown: Goddard's Earth Resources Technology Satellite, launched in 1982.

Grasenack-Tente: You're saying you have the instrumentation, is that right? Because right now, we're seeing that NASA's getting huge cuts to its budget.

Pulinets: It's a big pity, because we can develop these technologies, and many other countries are trying to build their own satellites—for example, China is now on the way, building specific and directed satellites to measure electromagnetic precursors of earthquakes, to be launched in 2014. But, I think, looking from the perspective of what we have now in Japan, what a tragic event, how many people, in such a highly developed country—but this demonstrates that nature makes no difference between the poor and the rich country, whether developed, not developed, we cannot fight with nature, we cannot overcome this very strong and disastrous event. So, we need to take *urgent* actions to start our activity now. We have demonstrated that we are able, *at least*, to give some kind of warnings. We can't say about predictions, but we can say, in this area, in the next few days, we expect some seismic shock, and we are able to even estimate the future magnitude.

Of course, many, many things are not clear, but we cannot prolong, into infinity, our investigation. How many victims do we need, to continue our investigations?

Grasenack-Tente: I think it's very important. I think it's clear with the number of victims we have, that we have to do it right now. That we should escalate.

Pulinets: Yes.

Grasenack-Tente: The question I have to you on that, specifically, one, are all the instrumentations here, in place, that you need? And if you didn't have money restrictions, what would you want to see implemented, so that you could immediately begin setting up things that we could use to recognize precursors all around the world? Every nation, along the Rim of Fire, and beyond? What would you need for that?

Pulinets: Okay, at the present moment, we have quite enough remote-sensing satellites, and many countries, including the United States have plans, for example, in the Polis [satellite mapping] project, to launch more satellites having the infrared sensor onboard.

Grasenack-Tente: There was one called DESDynI, that was a [proposed] satellite that was cut, that was actually not launched. Then you had the GOES-11, which was launched, but they didn't have the ground crew to analyze the data! So, it's up there doing stuff, but, you don't have people analyzing the data. And one thing you mentioned before is that, you've done this work, but there's only so much that two or three people can do.

Pulinets: Yes. In principle, we can start now, if we have at least some specific laboratory, with staff, more or less, I estimate, of ten people: It's enough to start to analyze the data on infrared, GPS TEC, VLF propagation. It is enough to do some kind of warning, at least of some areas like California, Japan, the Mediterranean, Mexico. We have enough instrumental means. It does not mean we should now stop, should not develop other types of measurements, and increase our ground-based network.

But we should take, as an example, medicine; for example, the problem of cancer: It was thought that it was *impossible* to overcome! Then, the doctors start to—one kind of cancer now is treatable, then the second one . . . and it is expanding! Because people do not stop! They are doing what they can do, at the present moment! And we should do the same: We should do what we can do at the present moment.

But at the present moment, we need some support, because we are very few, we are under pressure from different sources for different reasons. We need to be living in quiet, good conditions to work, to have more human resources—I said something like a ten-person laboratory. And I'm sure that we are now able to make good progress, improving this technology and elaborating the techniques, especially application techniques for the short-term work.

The 62-Million-Year Cycle

Grasenack-Tente: Well, this is great. You basically answered all my questions. I've just one more. I've sent you some material on the kind of work that [the Basement Team] has been looking into, especially looking at the fossil records showing biodiversity, volcanic activity from volcanic rock, which shows some very clear cycles, of 60-62 million years of increase and decrease of biodiversity and also increase of volcanic activity at around the same time. And because you mentioned that there's also the phenomenon of the geomagnetic increased activity, which goes along with the things that you guys are measuring with some kind of phase-shift, have there been any thoughts to look into that, that there may be an increase in general sensitivity within a longer time frame, due to some external sources?

Pulinets: Okay, yes. What we know from historical data—let's start from the shorter periods, for example, the Maunder minimum of solar activity. In the 16th-17th Century, you know that in Holland we had ice; we have a lot of literature showing the people ice-skating, and so on, and now it's very warm. And from the historical measurements of the solar activity, we have seen that it was very low, extremely low, not at all like the 11-year solar-cycle activity. What we observe now, is that we had an extremely long period of low solar activity; it was not predicted by anybody.

We had a [solar] minimum which lasted at least two years, or up to three years longer than it was expected. One reason is that there is some variability in the activity of our star, which provides the life on the Earth. The second, which is more important, and probably may have more grave consequences, is reversals of the geomagnetic field. From polar geomagnetic data, we have seen that the polarity of the geomagnetic field was changed several times during the history of our planet, and during this period, it's very dangerous because, during the transition, we'll have some period—nobody knows how long it will be—when we will have almost no geomagnetic field.

Grasenack-Tente: There's no polarity, is that what you mean?

Pulinets: Yes, yes. It is flipping.

Grasenack-Tente: It's in flux.

Pulinets: Yes, and this geomagnetic field protects us from the extreme solar energetic particles.

Grasenack-Tente: Cosmic rays.

Pulinets: And cosmic rays. It deflects them. And we will have some period when the geomagnetic field of the Earth will be very low, and this may give rise to changes of biodiversity of our planet.

So, if we do not talk about periodicity, we also have such events, like asteroids and so on, encountering our planet, which can produce huge devastation and changes in our environment, but it is not periodical, it is stochastic.

And another periodic change is a movement of our Solar System, through the arms of our galaxy. Inside the arms, we have the larger concentration of matter, and so, the lower flux of the cosmic rays. And, we now that cosmic rays do have an effect on the cloud coverage and the temperature on our planet. So there are some theories—I have not developed these, but I have seen publications—that in an ice period, and in the higher temperature periods, there were changes with the periodicity of the passing of the Solar System through the arms of the galactic: Between the arms, we have lower [temperature], so higher flux of cosmic rays; inside the arms, lower flux of cosmic rays. This is another source of the variability.

But all these things are more speculations than science. We should make more investigation to say something definite, but your question was, what I think about this.

Grasenack-Tente: Yes. I agree, we need more investigations.

Pulinets: I told you about the possible reasons for periodicity of life.

Grasenack-Tente: We can start with Moon and Mars, looking to see if there's seismic activity there. It would be interesting to see if there's similar activity right now on other planets.

Pulinets: Yes, but it is not so easy.

Grasenack-Tente: But that's human civilization!

Pulinets: Yes, you are young, so you will have more interesting information, and probably the next probes would be able to investigate other planets of our system!

Grasenack-Tente: It depends on if we have politicians who just keep spending money on bank bailouts, and not on science, and investigating the Solar System: Then we have a definite problem, for that perspective. All right. Thanks very much.

Pulinets: Thank you.

In the 16th and 17th centuries, during the last "Little Ice Age," much of Europe experienced extreme cold periods, with ice covering the ground for months at a time. Here, the Flemish artist Pieter Bruegel portrays a scene from the severe Winter of 1565-66.