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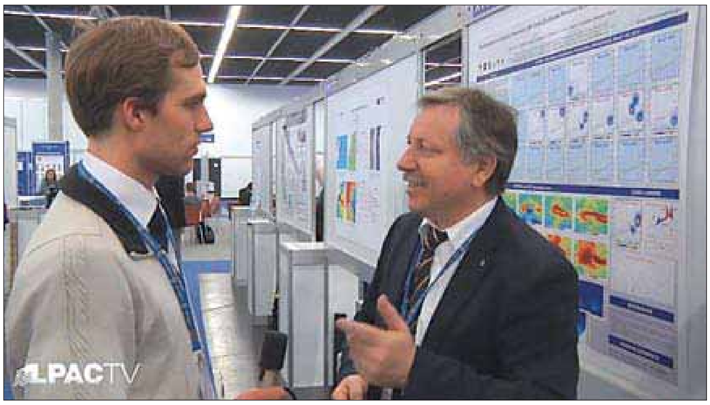
A Multi-Parameter Approach to Earthquake Forecasting

Part 1 of 2

Prof. Sergey Pulinets, a researcher of earthquake precursors at the Fyodorov Institute of Applied Geophysics and the Moscow Center for Ionosphere Monitoring addressed the European Geosciences Conference in Vienna, which took place April 3-8, 2011. Dr. Pulinets was interviewed during the conference by Daniel Grasenack-Tente of the Civil Rights Solidarity Movement (BüSo), the German political party of the LaRouche movement. A video of the interview is available at www.larouchepac.com/node/17944.

Daniel Grasenack-Tente: Professor Pulinets, thank you very much for joining us here. We're at the European Geosciences General Assembly for 2011, and just yesterday there were a number of presentations on the question of the different kinds of precursors in different domains of the electromagnetic spectrum, which we can use to hopefully, at some point, have a real forecasting capability for earthquakes. Let's discuss what you've been looking at. What is the significance of electromagnetic precursors to earthquakes in your work?



Prof. Sergey Pulinets (right), an expert on earthquake percursors, was interviewed by the BüSo's Daniel Grasenack-Tente, at the European Geosciences Union in Vienna.

Pulinets: Okay, I prefer to talk not only on the electromagnetic precursors, but earthquake preparation is a complex physical chemical process, having been started from the Earth's crust, up to the atmosphere and ionosphere. And they have different kinds of manifestations. Within the period—we are talking now about short term prediction—so it is something like a few weeks, up to a few days, and hours, before the seismic shock. And because it is a process which generally connects many factors, we try to find an approach which gives us the opportunity to explain what is happening, why we see so many different variations or anomalies during this preparation period.

The first reason is very natural. When you have a release of energy, which is equivalent to several thousand nuclear bombs, it is impossible to store this underground, and in one moment to release it. The Earth is a living matter, and there are some processes—storing of the stress, and this stress has to manifest itself in some parameters.

So, the most natural is that when you have the formation of cracks inside the crust, you change the system of the gas migration inside the Earth's crust. The main components of this are CO_2, helium, hydrogen, and radon, which is a radioactive gas, which is a product of the decay of uranium. It is present everywhere. For sanitary purposes, when you build your house, you monitor for radon to be safe in your house. It is a heavy, odorless gas. But it was detected many, many years ago, that its release increases before an earthquake, because this gas migration carries this radon and water coming up to the Earth's surface.

Probably you have seen the video from Japan showing water going up during and before the earthquake. So, water also carries radon with it.

And now starts the very interesting process which is characteristic for many, many natural events. For example, you know that now the variations of the cosmic rays associated with the formation of the cloud cover over our planet—why? Because the cosmic rays produce ionization of water. The ions become the centers of condensation of the water vapor. Water vapor condenses around the ions and you obtain the nucleation which is the center of condensation for the formation of clouds.

The same is happening with the coming of radioactive matter of radon, on the ground surface, close to the ground surface, because radon is very heavy. It also produces ionization of air. Ions become the centers of condensation, and form large clusters of these ions, and envelopes of many, many water molecules.

Hydration of Ions

Grasenack-Tente: You mentioned in your presentation the ionization process, and the hydration of the ions.

Pulinets: Hydration, yes. Because it is not pure condensation, because people who know physics quite well say that there should be saturation vapor to have condensation. But hydration does not need saturation. In any level of humidity, relative humidity of air, you will have hydration of the ions. So, with 30% of humidity, still you will have hydration of ions.

And when the molecules of water become attached to the ion, they release their free energy that they had when they were in the air, which is named latent heat. And this latent heat is a source of the thermal energy which is registered just over active tectonic faults. It can be monitored by the satellites. They show very nicely the configuration of the active tectonic faults during the period of preparation of the earthquakes.

Grasenack-Tente: What period are we talking about?

Pulinets: We are talking about a few weeks before the earthquake. We have activation of the tectonic plate where the epicenter is situated. So, we can see the heating of the borders between the tectonic plates, and active tectonic faults, which is a smaller structure.

So, starting from the ground surface, we see the thermal anomalies along the active tectonic faults, which manifest that we have release of radon along the tectonic faults. And the geophysical perpective shows that we have, at the peaks, a maximum of radon concentration over tectonic faults. They are sources of the radon coming from the ground.

So the first level is the ground surface. Then, this heat starts to accumulate, and because you have a temperature difference between the fault and the area outside the fault, it starts mixing, due to the temperature difference. You have the horizontal motion and convection motion, because the heated air tries to go up, and it is transformed into some small spirals. Chirality is formed, and these small chiral structures tend to merge. In chaos theory, it's named reverse cascade instability. They merge and form a large thermal spot, which could be registered in the upper layers of the atmosphere.

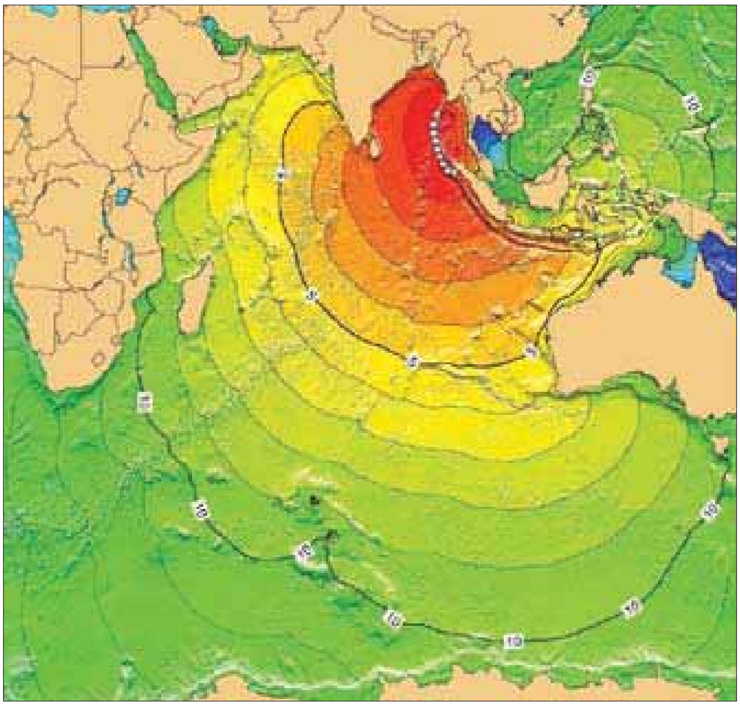
Simultaneously, this transformation of the latent heat also could be registered by satellites. There are some products in some NASA sites, which give you directly the latent heat fluxes over a special region, and we were able to detect these latent heat fluxes before many, many earthquakes.

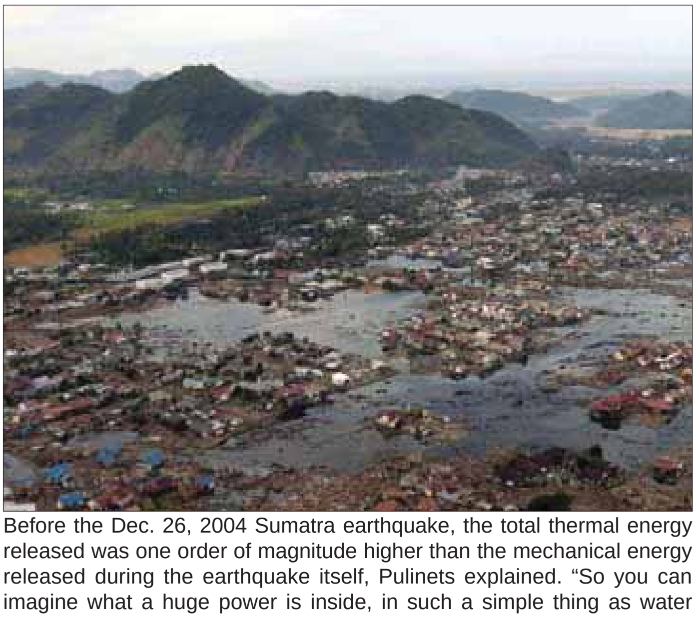
For example, before the [Dec. 26, 2004] Sumatra earthquake, the total thermal energy released was one order of magnitude was higher than the mechanical energy released during the earthquake itself. So you can imagine what huge power is inside, in such a simple thing as water vapor. People ask, what is the source? It is the Sun. The Sun prepares this water vapor because we have constant evaporation of humidity from the rivers, from lakes, from surf, and all the time we have this water vapor which contains this latent heat, and during condensation it is released. So, the source of this energy is the Sun.

But now we come into the electromagnetic.

Grasenack-Tente: Okay, yes.

Pulinets: So these thermal anomalies could be registered not only in the form of heat, that we measure by temperature, but as radiative heat—infrared radiation, which is in the electromagnetic spectrum, with wavelengths from 8 to 12 microns. This is a





Before the Dec. 26, 2004 Sumatra earthquake, the total thermal energy released was one order of magnitude higher than the mechanical energy released during the earthquake itself, Pulinets explained. "So you can imagine what a huge power is inside, in such a simple thing as water vapor. People ask, what is the source? It is the Sun." Shown below: a village near the coast destroyed by the tsunami; inset: graphic showing the power of the 9.4 quake in Sumatra.

window which is transparent for the clouds. And it is possible to measure, even through the clouds. And Dr. [Dimitar] Ouzounov [of NASA/Goddard Space Flight Center's Earth Observing System] is measuring these infrared emissions at the top of the atmosphere. It is something like from 8 to 12 kilometers.

Grasenack-Tente: Under the ionosphere?

Pulinets: No, the ionosphere is much higher, it's 100 kilometers. This is 10 to 12 kilometers altitude. And very precise and special techniques were elaborated, using previous measurements—for example, NOAA [National Oceanic and Atmospheric Administration], 20 years ago. We have a very good background, which allows us to estimate that in this place—

Precursor Anomalies

Grasenack-Tente: Sorry, so these precursors, these phenomena, you mean 20 years—

Pulinets: No, for 20 years we have had measurements to calculate the anomaly against this background. We started our study more or less 10 years ago. And we are able to see the dynamics of the development of these heat anomalies on the top of the atmosphere, before the earthquake. These anomalies usually appear a few days before the earthquake. And there are specific features, that they are sitting over the area of the earthquake preparation. They can move a little bit, exactly along the tectonic plate's border, or along the active tectonic fault, but are very close to the future epicenter. So this is a first, a very reliable, signature of the approaching earthquake. And now we have very good statistics for this. For all recent major earthquakes, we have the data showing the appearance of this OLR anomaly, which is outgoing longwave radiation.

Without any exclusion, we see it over the ocean, inland, near the shore, not dependent on where the epicenter is. It is an advantage in comparison with any other techniques for precursors, because many of these precursors would be detected only inland. But because we deal with the gas, which could be released from water as well, we see anomalies over the water. You can see here, here, here [points to chart on wall], anomalies sitting over the water.

Grasenack-Tente: What instrumentations do you use to measure this?

Pulinets: It is infrared sensors, which are installed on the majority of remote-sensing satellites.

Grasenack-Tente: They all have them?

Pulinets: Like NOAA satellites, Aqua, Terra, it is modest device, a VHRR in NOAA's satellite, and similar devices—for example, on board the Russian Meteor satellite we have a similar device. European satellites, every remote-sensing satellite now has an infrared sensor, and we need the frequency band, or wavelength band, between 8 and 12 microns.

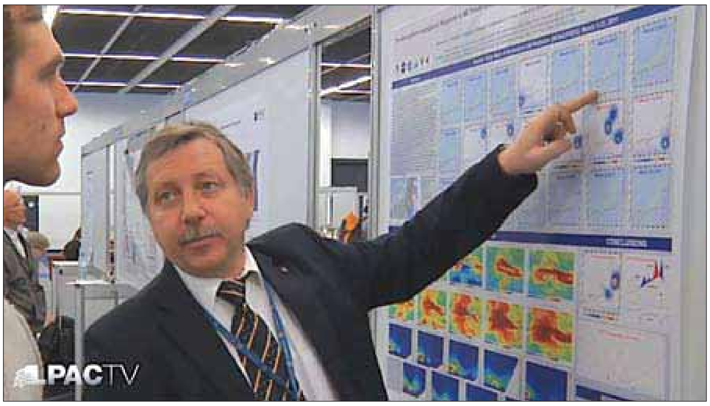
Now, we are going to the upper layers, the ionosphere. The ionosphere is a part of our atmosphere, but partly ionized. Its ionization comes mainly from ultraviolet radiation, emitted by our Sun. Some part is ionized by X-rays, and energetic particles, but the main source of the ionization is ultraviolet radiation.

So, because we have radiation only during the daytime, we have increase of ionization during daytime, and decrease during nighttime, and the variations of electron concentration look like a sinusoid—as you can see in daily variations. And it has been studied for many, many years. We have very good models, which explain the climatology of the ionospheric behavior. Also, we know very well the behavior in this sphere during active solar events, like solar flares, geomagnetic storms; for any point, we have the regional models, which can explain what will be the behavior of the ionosphere during the magnetic storms.

So, we know the behavior of the ionosphere during the quiet time condition, and during the magnetic storm condition. And starting from this, we are looking at some anomalies which are associated with the earthquake, how these anomalies in general can appear in the ionosphere.

Grasenack-Tente: Because there could be different sources for—

Pulinets: No, the source is the same. We live in an electrical environment. We never think about this, but when you're standing here, it is a vertical electric field which has a gradient of 100 to 150



Professor Pulinets indicates anomalies in precursor techniques.

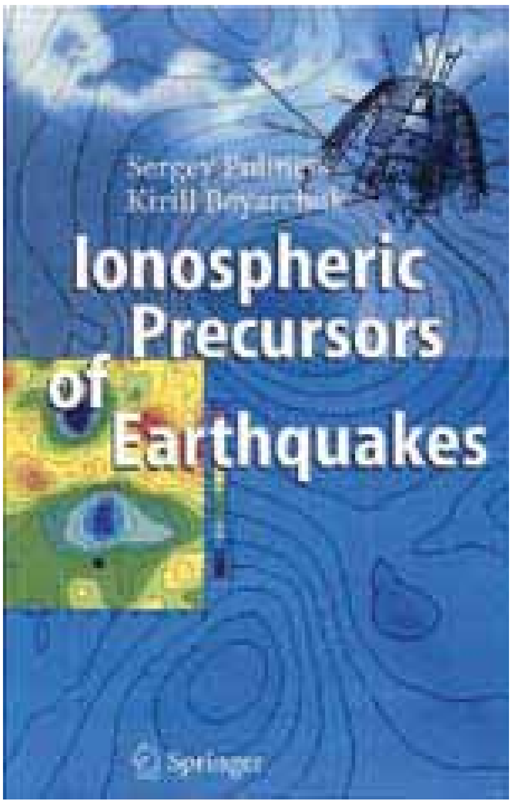
volts per meter. So, between the top of your head and your legs, you have a potential difference of 220 volts, like a power source.

The problem is, that the conductivity of air is very low. So, the current which we have inside the atmosphere is 10–12 amperes per square meter. What is the source of this potential difference? We have a potential difference between the ground and the ionosphere. This potential difference is created by thunderstorm activity. All over the world we have global thunderstorm activity—in Africa, in America—mainly thunderstorm activity is over the land. But this is not so important. The thunderstorm discharges provide the positive potential of the ionosphere in relation to the Earth.

And we have the potential difference between the ground and the ionosphere, which is something like 250, up to 500 kilovolts. And this potential difference is dropped into this bulk of atmosphere, from the ground surface, up to more or less 60 kilometers, for this global electric circuit. Usually, they take the lower border of the ionosphere, near 60 kilometers. But the most potential drop we have is in the so-called boundary layer of the atmosphere. The boundary layer is the layer where we have turbulent motion of the air. In the upper layers, we have no such turbulent motion; it is a continuous gradient, without the mixing that we have in the ground source.

And so, you can imagine—you have a potential difference. You have a resistor, which is our atmosphere.

And if you change the value of this resistance, it means you change the conductivity of this layer, near-ground layer, and this conductivity is changed by the appearance of these ions produced by radon. First, you will observe the increase of conductivity, and then, when these ions grow, and become large clusters which are not moving, and cannot carry the electrical current, you will have the drop of conductivity. Like, for example, in sandstorms, when you have a lot of sand and dirt. For example, in dirty cities, the electric field is larger than in the open field, because due to the presence of dust and aerosols, the conductivity drops.



It's the same thing when you have the formation of these large clusters, which we spoke of before, a drop ofconductivity leads to a change of the ionospheric potential relative to the Earth.

So the ionosphere feels the earthquakes through the global electric circuit, through the change of conductivity of the atmosphere. But the ionosphere is a highly conductive medium. It tries to maintain its equipotentiality. If you have a good conductor, all the parts of this conductor have the same electrical potential. If something changes, it tries to redistribute the electron concentration and ions to maintain its equipotential.

What does it mean to redistribute? There is the appearance of the drift or electric currents within the ionosphere, and you have a formation of irregularity over the area where you have the anomaly of conductivity.

Grasenack-Tente: And that's what you've been talking about with the total electron content.

Pulinets: Yes. And the parameters of the ionosphere could be measured by a multitude of techniques. It is a ground-based vertical sounding, called ionsondes. We can put the same ionsondes on the satellite, and it will be topside ionospheric sounding. You can measure the total electron content between the satellite and the ground. You can make ionospheric tomography from the low-orbiting satellites.

So there are a lot of techniques; all of them were tested, and all of them show the anomalies in the ionosphere.

I have a book published by Springer, *Ionospheric Precursors of the Earthquake*. You can find there everything explained, and what is happening. But I also can say, that from the majority of earthquakes, we see ionospheric anomalies which are very close to the thermal anomalies in their position, and they are also coherent in time. But we see propagation of these anomalies from the ground surface up to the ionosphere, so usually the ionospheric anomalies appear one day later, or the same day as the thermal one.

To be continued...