Are Earthquakes Foreseeable? The Current State of Research

by Sergey Pulinets

Professor Pulinets, from the Institute of Applied Geophysics, Moscow, addressed the Schiller Institute conference in Rüsselsheim, Germany, on July 2. The following is an edited transcript, with a significant portion of his graphics. The full speech can be viewed here.

Good afternoon. We had a meeting with Mr. and Mrs. LaRouche yesterday, and we discussed many problems; I decided to widen the title and content of my presentation a little bit, and I will continue the issues which were raised by Professor Ewert[1] in the previous presentation. We'll start with climate change. Because all these issues are connected with the same physical mechanism, and I would like to show you how simple physical laws and processes can play a very important role in our life, in our environment.

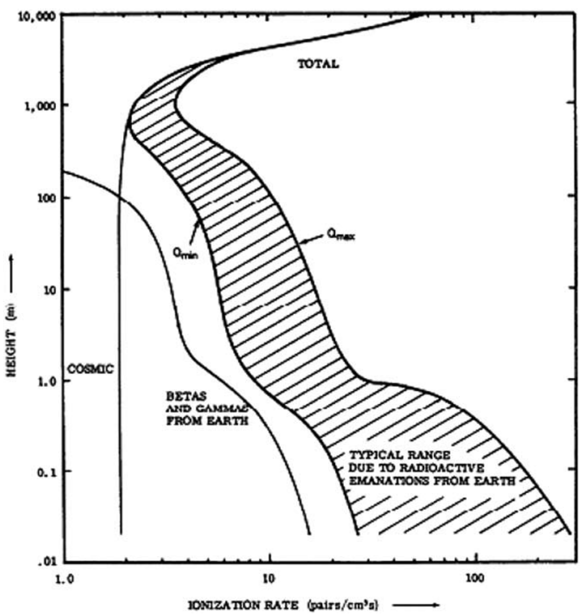
1. Professor emeritus Friedrich-Karl Ewert, Paderborn University, Germany, "The Anthropogenic Climate Change Swindle," http://schillerinstitute.org.

The main thing we will touch on now are the processes that are connected with ionization of air, of our atmosphere. Actually, we have two main natural sources of ionization: The first one is the ground; this is the Earth's radioactivity. We know that the Earth's crust contains uranium, and the products of uranium decay, and especially the gaseous product, radon gas, is released everywhere—even here, you can measure the products of decay of radon.

In **Figure 1** you can see, in the lower part of the graph, the ions produced by natural ground radioactivity. And when we go up, with this profile, the most powerful source we have, our galaxy, is the main source of ionization of the upper layers of the atmosphere; the galactic cosmic rays, which are born in our universe, are accelerated in the neighborhood of the stars, and then penetrate our environment, and make very strong changes, including climate changes.

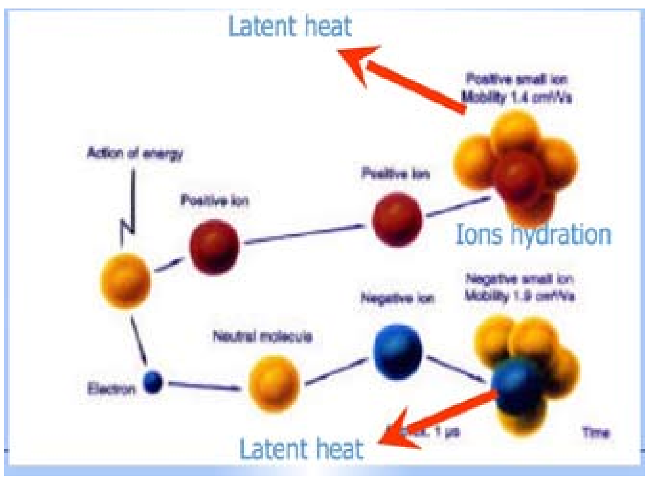
But, first, let us look at what processes are connected with ionization (**Figure 2**). If you have a neutral particle (atmospheric gas molecule), and you have some energetic particles that collide with the neutral molecule, you can obtain a positive ion, by the release of electrons

FIGURE 1
Natural Sources of Air Ionization



W. Hoppel et al., 1986

FIGURE 2
The Main Driver for Energy Release



from their shell. And free electrons can be attached again to a neutral particle, and form a negative ion.

But in our atmosphere, we also always have water vapor. The water molecule's structure is not symmetrical; it has a dipole structure, so one part of the molecule contains the positive charge of hydrogen, and another one, the negative charge of oxygen. Because of this polarity, they become attached to the ions. This is a very interesting thing, which in many works is not taken it into account.

You probably know the saying that a "watched pot never boils." Why? Because, to convert liquid water into vapor, you need additional energy, which is called "latent heat." Because the free water molecule has more energy, it flies through the air, whereas the liquid water is bound up in molecules, and has no such movement. This additional energy, which is necessary for transition of the phase-state of the substance—now, we're speaking about water—is called "latent heat."

So, when you transform the liquid water into vapor, you need to add some energy. When the water molecules became connected with some molecule, they release this energy in the form of heat, and this is the latent heat. We will look at the role of the latent heat in many processes in our environment.

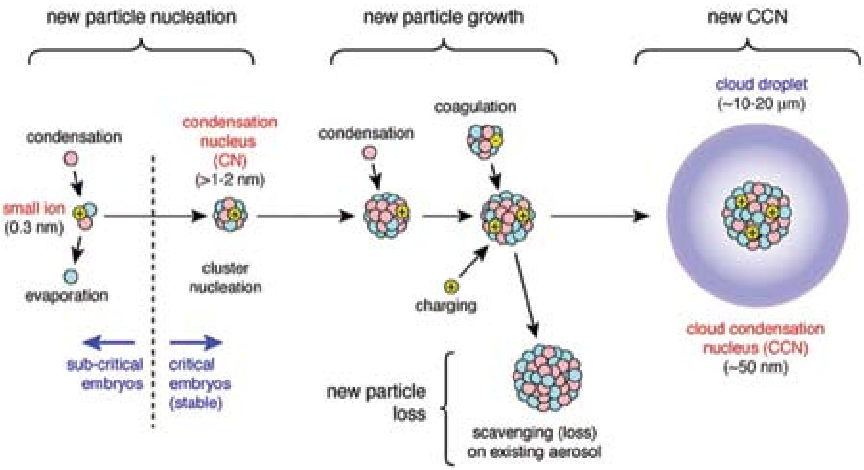
Cosmic Rays and Cloud Formation

Let us start with the formation of clouds (**Figure 3**). There are many scientists working on this area, and probably the most well-known are Henrik Svensmark and Eigil Friis-Christensen, who made the discovery that galactic cosmic rays are responsible for the formation of clouds. Why? Because the ions became very good centers of condensation: When the cosmic rays enter the atmosphere, they produce a lot of ions, and water vapor condensed around them, and these particles grew in size, up to the size of the water droplets in clouds.

And these newly formed ions and clusters enter into different chemical reactions. You probably know that we have sulfuric acid in our atmosphere, nitric acid, and many other types, which are formed during these reactions, in which the ions and hydrated ions—ions with attached water—enter into chemical reactions.

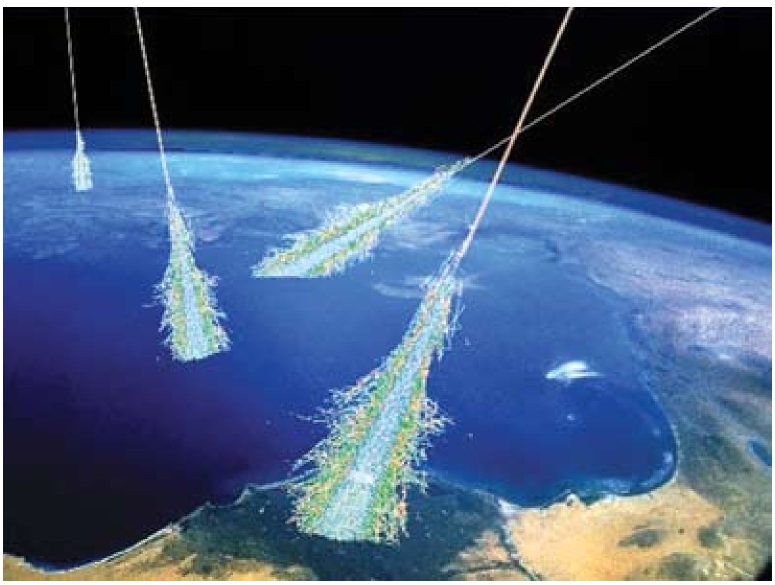
Now, we will talk about the global changes. **Figure 4** is a cartoon of cosmic rays entering our environment. They are very energetic: They have giga-electron volts

FIGURE 3
The Process of Cloud Formation



J. Kirby, 2008

FIGURE 4
Cosmic Rays

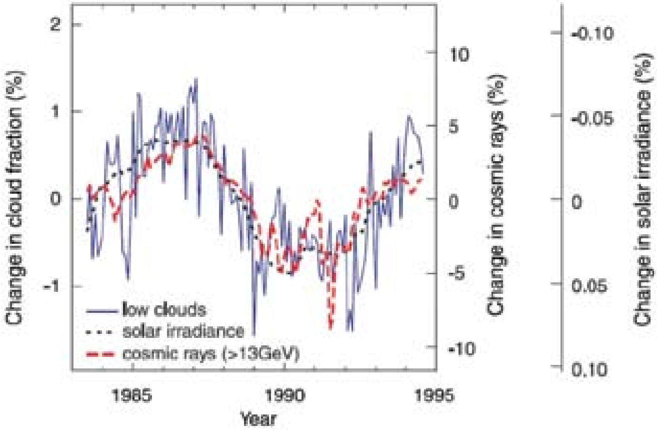


http://apod.nasa.gov/apod/ap060814.html

Artist's rendition.

FIGURE 5

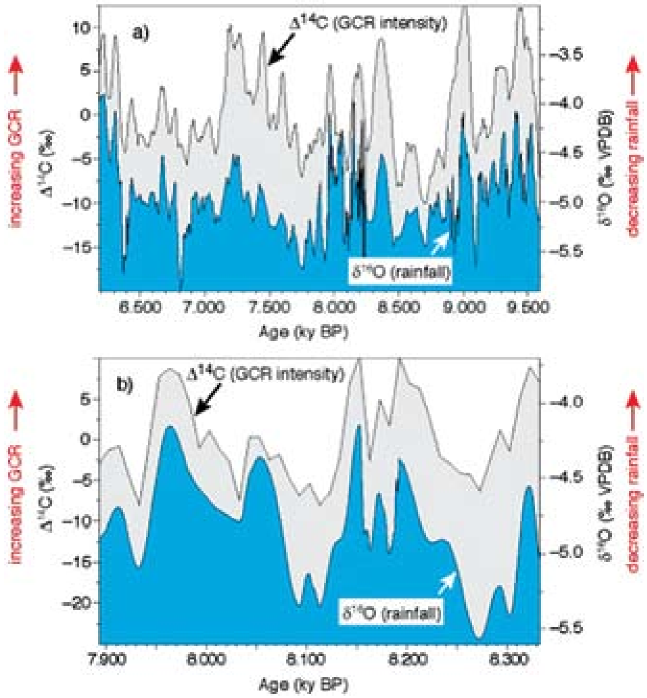
Variation of Low-Altitude Cloud Cover, Cosmic Rays, and Total Solar Irradiance, 1984-94



H. Svensmark, E. Friis-Christensen, *J. Atmos. Solar Terr. Phys.*, 59, 1225 (1997).

FIGURE 6

Glactic Cosmic Rays and Climate, Over Several Millennia



J. Kirby, 2008

Indications that galactic cosmic rays (GCR) affect climate. The amount of rainfall is assessed by analysis of the radioactive isotope of carbon and of stalactites. The correlations are quite close.

of energy, and they produce so-called cascade decays (cosmic ray showers), with many, many energetic particles; these particles collide with atmospheric molecules, and this is called particle showers.

Svensmark and Christensen, in one of their first publications, established the correlation between the variations of the fluxes of the galactic cosmic rays, and global cloud coverage, and you can see that they found a very good correlation between these (**Figure 5**). They did not present the physical mechanism for this; they simply demonstrated the existence of the correlation. But now, at CERN [European Center for Nuclear Research] in Switzerland, there is a huge project named CLOUD, and with special particle accelerators, they are studying cloud formation with the process of ionization.

But in all the literature, practically nobody takes into account the latent heat exhalation during this process. Everybody looks only at the particle formation in clouds; but, along with the formation of clouds, we also have the positive effect at the level of the tropopause—this is the level between 10 and 15 kilometers above the Earth's surface, which is continuously heated by the release of latent heat.

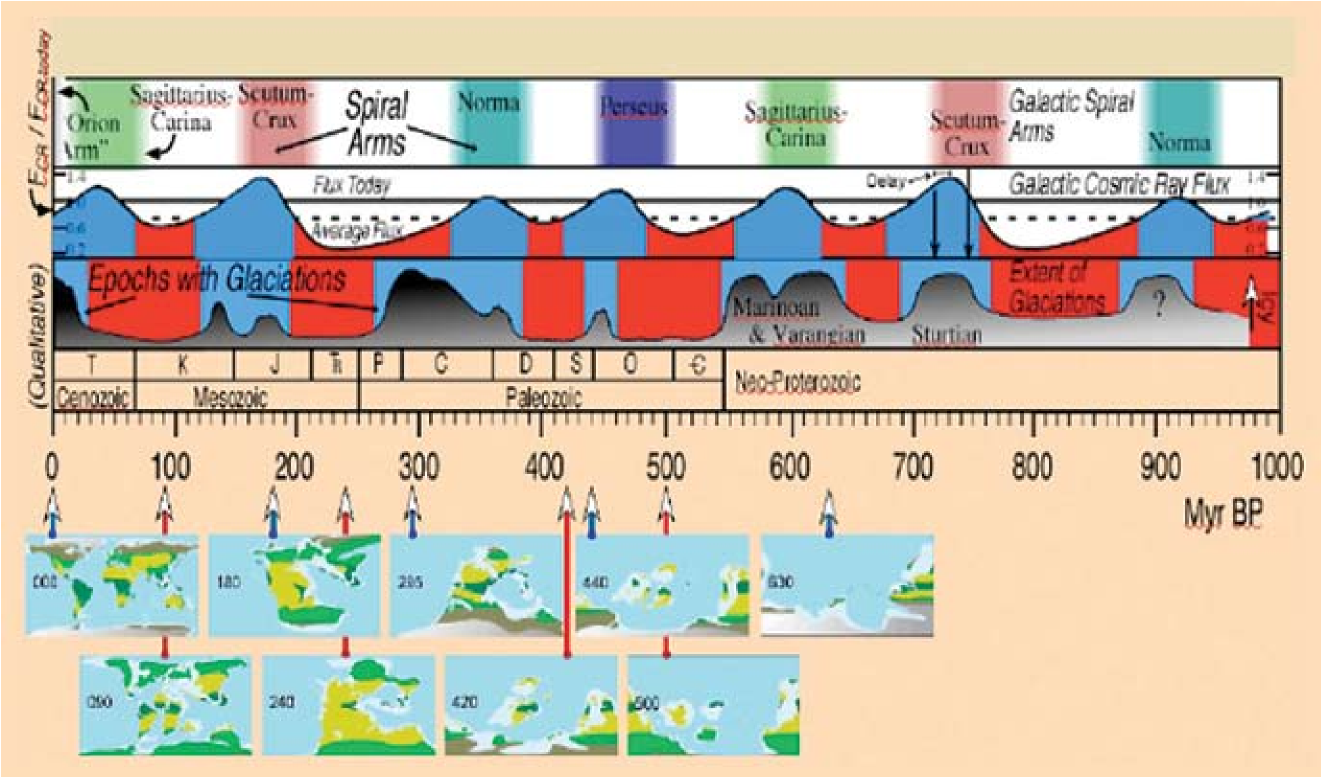
Now, we have this global heating and change which we heard about in the previous presentation. In this light, you can see (**Figure 6**), derived from the analysis of the radioactive isotope of carbon from tree rings in California, and the analysis of stalactites in a cave in Oman, which indicate the amount of the precipitating water. This analysis was made for thousands and hundreds of thousands of years, and the carbon shows the activity of the galactic cosmic rays. You can see that the precipitation and galactic cosmic rays are in very good correlation.

Periodicity of Change

Now, about the origin of the periodicity in these variations: the shorter periods, which we heard about, 100 years; the periodicity of the solar cycle, 11 years; and the very short periodicity of the so-called Forbush effect, which lasts several days, during geomagnetic storms.

The largest known periodicity is probably connected with the position of the Solar System within our galaxy. You know that our galaxy is spiral, and from time to time, the Solar System enters into the arms of our galaxy, where the density of matter is higher, so the fluxes of galactic cosmic rays are lower. If we have lower intensity of galactic cosmic rays, lower cloud coverage, then we have a rise of the temperature on

FIGURE 7
Ice Epochs and Galactic Radiation



J. Kirby, 2008.

As the Solar System moves through the spiral arms of our galaxy, the intensity of galactic cosmic rays changes, as well as the temperature of the Earth (shown here as epochs of glaciation).

Earth. Between the arms, there are more galactic cosmic rays, more cloud coverage, the temperature drops, and in **Figure 7**, you can see, over millions of years, the correlation of the glacier periods and warming on the Earth, connected with the position of the Solar System in our galaxy.

There have been a lot of studies—it is a very popular issue now—and you can find that 75% of the variation of the global temperature, on the scale of hundreds of thousands of years, can be explained by variations in the fluxes of galactic cosmic rays. We have different time scales of solar or galactic cosmic ray correlation with climate:

• the Gyr [gigayear] time scale: Milky Way star formation rate and glacial activity

• 150 Myr [millions of years] cycle: Milky Way arms

• 10-100,000-year cycle: mostly solar activity and climate

• 11-year solar cycle: solar activity and ΔT, clouds

• days: Forbush events and various climate variables.

And of course, the solar activity produces modulation of the galactic cosmic rays, because our magnetosphere is immersed in the solar wind. And during higher solar activity, the density of the solar wind is greater; it compresses the magnetosphere, and this makes it a greater obstacle to galactic cosmic rays. So, during periods of higher solar activity, the fluxes of galactic cosmic rays are also lower.

And we observe the modulation of weather and climate with the activity of the Sun of different lengths of periodicity. The so-called Maunder Minimum during the Middle Ages was demonstrated earlier, when in Holland, all the canals were covered with ice, and people were skating on them, whereas now, they never freeze.

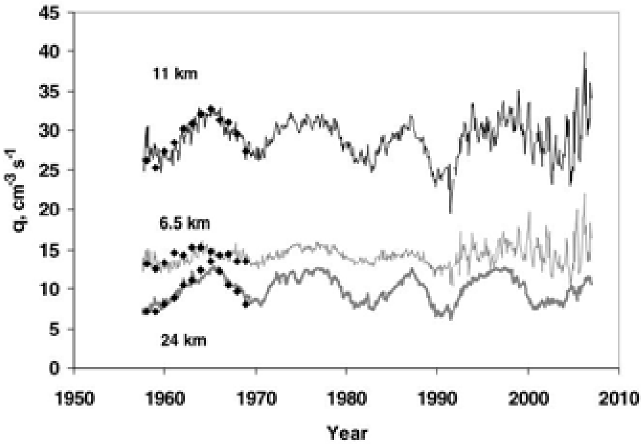
So, we have different periodicities, and different sources of the modulation of the galactic cosmic rays. All these periodicities were discovered in the variations of the global temperature of our planet.

There are a lot of scenarios and models of how it works, taking into account different mechanisms, different processes. I will not go deeper into this, as we do not have time; but believe me, this work is developing very dramatically, and a lot of people are involved in these studies.

Probably you have heard, and you can feel for yourself, that our climate and weather have become very unstable. We have oscillations of the weather, to more extreme conditions, from higher to lower temperatures, high winds, cyclones. In **Figure 8**, you can see how the variability of the production of ions has increased during the last decades; probably this is one of the reasons for such variability of our climate.

FIGURE 8

Increased Ion Production Rate in Recent Decades



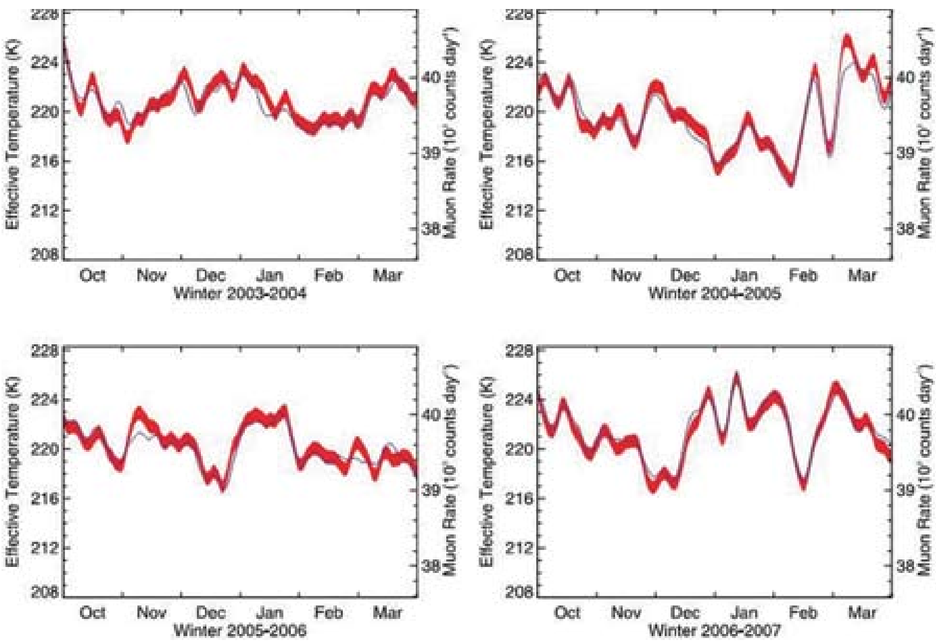
G.A. Bazilevskaya et al., 2008

Figure 9 is a very beautiful example: The measurements were made underground, registering the secondary cosmic rays, and correlated with the temperature in the stratosphere. And here, you cannot even see the blue line, under the red one. The red one shows the temperatures of the Winters 2003-04, 2004-05, 2005-06, and 2007, exactly repeating the variations of the fluxes of secondary galactic cosmic rays (the blue line).

It was a surprise for me, how strong the role of the latent heat is. If we take the total balance of the thermal energy of our atmosphere, only 42% is provided by direct heating by the Sun; 48% is dependent on the changes [in latent heat]—the dew in the morning and evening; and the daily transformation, evaporation, and condensation. And the daily variations of temperature are 48% dependent on this transformation in the latent heat.

FIGURE 9

Short-Term Correlation of Temperature in the Stratosphere and Secondary Cosmic Rays



Scott Osprey et al., 2009

The thick red line shows temperature; the thin blue line shows cosmic rays.

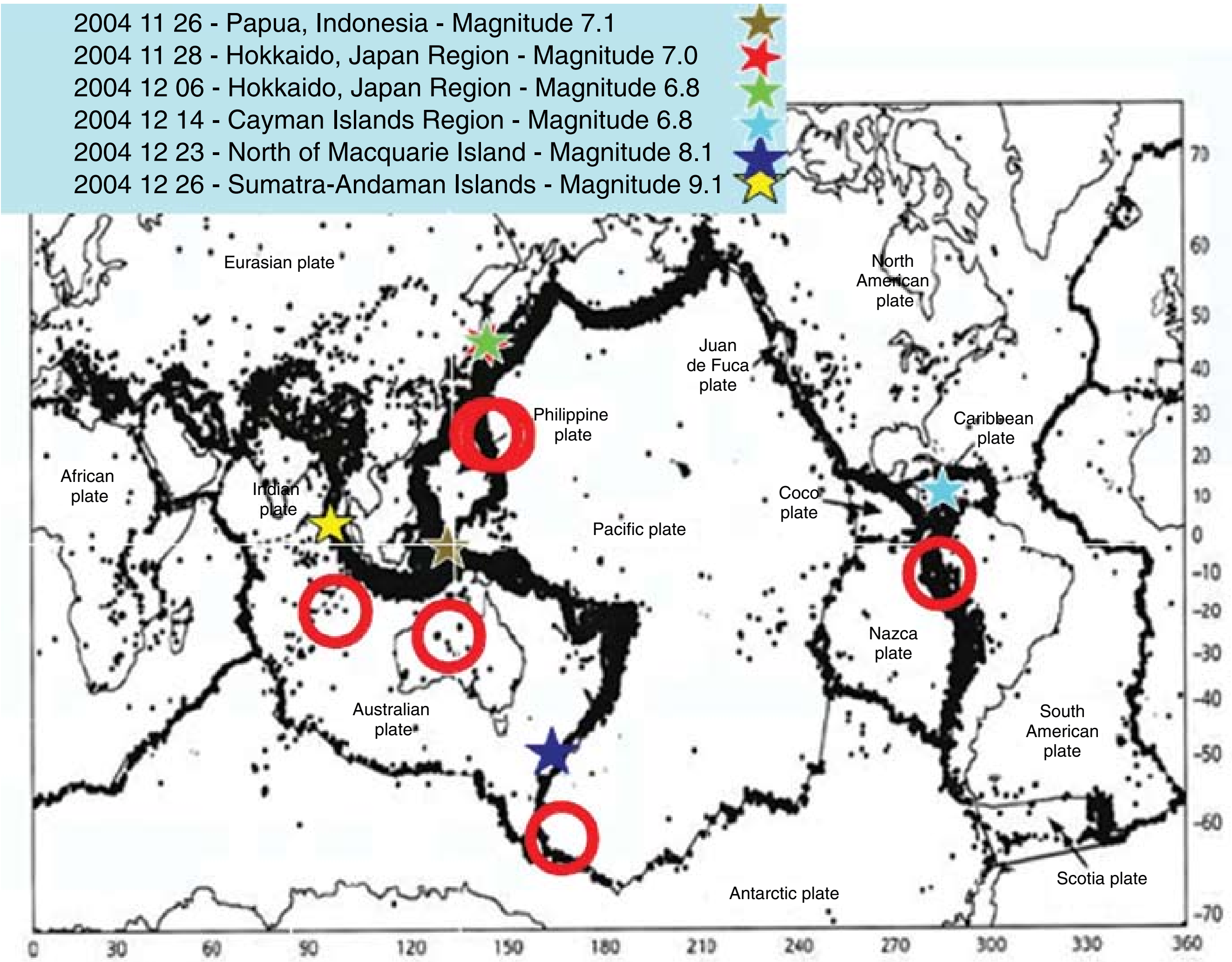
Earthquakes: The Ring of Fire

So, the first part of my presentation was connected with the role of ionization in so-called global change, and the periodicity of the changes in the climate of our planet. Now, we are going to the next item: earthquakes. I have seen a very interesting presentation on LaRouchePAC television about the Ring of Fire.[2] I would like to demonstrate for you how it works. **Figure 10**

2. http://tiny.cc/xb9rg

FIGURE 10

Major Earthquakes: The Pacific Ring of Fire



Courtesy of S.A. Anagnastopoulos, 2011

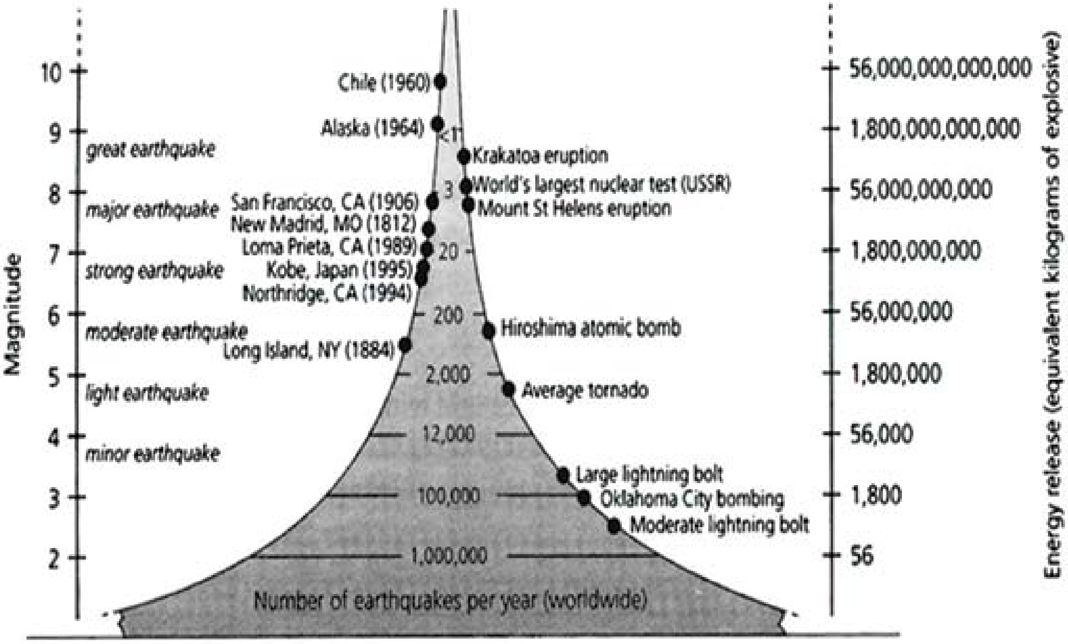
shows November-December 2004, and you can see how earthquakes developed, and all the earthquakes have magnitudes higher than 7. It shows that the whole Ring is activated, and we see the movement of the earthquakes around this Ring.

Now we will talk about the processes that lead up to the earthquake, and first of all, I would like to explain my approach to this.

Figure 11 shows the distribution of the energy of an earthquake in comparison with other processes that we know. The graph doesn't take into account the recent strong earthquakes; the strongest in the 20th Century was the Chilean earthquake in 1960; the second strongest was the Good Friday earthquake in Alaska in 1964. These are at the left part of the graph, the two upper points. And to the right, the second from the top, we have the largest nuclear tests made by the U.S.S.R., in Novaya Zemlya, which was equivalent to 56,000 billion tons of explosives. So you can see how powerful the energies are that are released during these earthquakes.

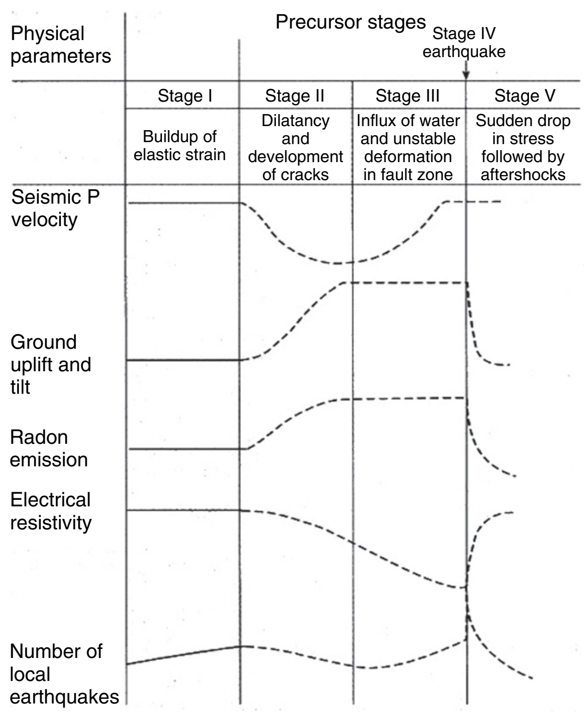
When people tell you that it's impossible to predict earthquakes, that it is stupid to try—you cannot imagine . . . ! Even if you want to make a nuclear bomb, there are precursors! It is organized someplace where it is produced; you hire the people. And you can track all these processes before the production of this bomb! The same with an earthquake: Such huge amounts of energy

FIGURE 11
The Energy of Earthquakes



P.M. Shearer, 1999

FIGURE 12
Classic Approach to Earthquake Study: Physical Precursors



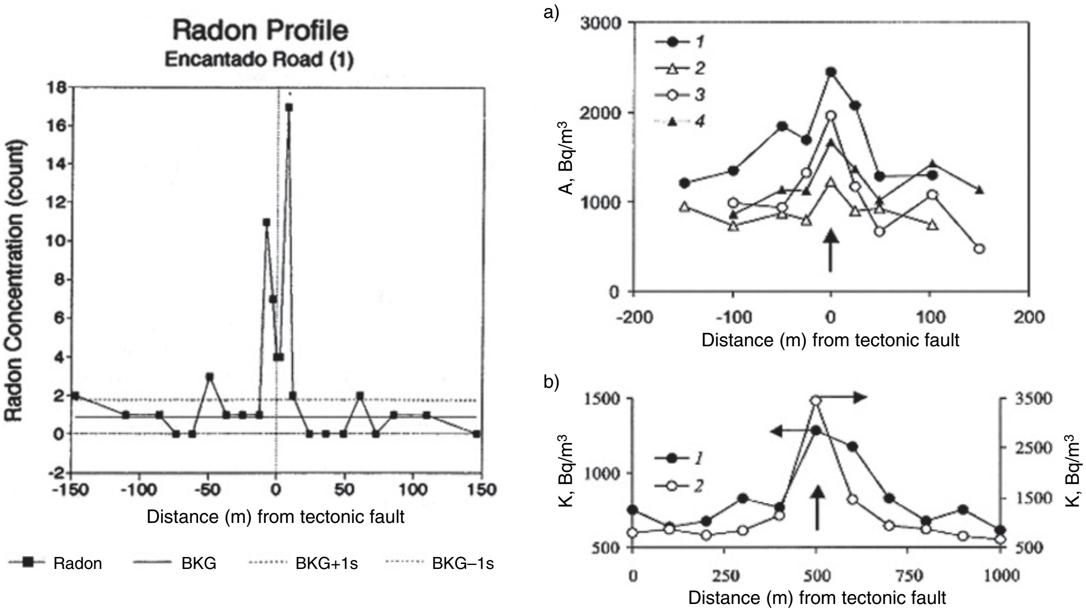
C.H. Scholz et al., *Science*, 1973

are released in one moment, that it is impossible that the Earth would not manifest *anything* beforehand!

In our studies, we use the so-called physical approach, and so-called physical precursors; one of the first papers was published by Christopher Scholz (**Figure 12**), who looked at the process of earthquake preparation from one earthquake to the next, in the same location. And you know that they come with some periodicity—in different places, the periodicity is different—but for strong earthquakes, the periodicity is from 30 to 70 years, and we are looking at the last stage, which is a few months, a few weeks, before the earthquakes. There were several parameters that were monitored by the United States, by the Soviet Union, and other countries, in the 1970s and '80s, and there was great hope that this problem would be resolved.

But after a few failures, in '96-97, there was a discussion in *Science* magazine; the leader of this discussion was a professor at Tokyo University, Robert Geller. And seismologists decided that prediction is impossible, and it was prohibited, in scientific literature, to use the words "earthquake prediction"! The scientists were punished—it is really true!—the scientists were punished for using this term, and their papers were not published, especially in the *Journal of Geophysical Re-*

FIGURE 13
Radon Activity over an Active Tectonic Fault



C.Y. King et al., 1993

A.A. Spivak, 2009

Volumetric activity of radon by volume in the subsoil atmosphere along the line intersecting the magnitude II tectonic dislocation; a) points 3-6 (1-4); b) points 5 (1) and 2 (2) (the vertical arrows show the location of the tectonic fault).

search, or *Geophysical Research Letters*, the *Bulletin of the Seismological Society of America*, and so on.

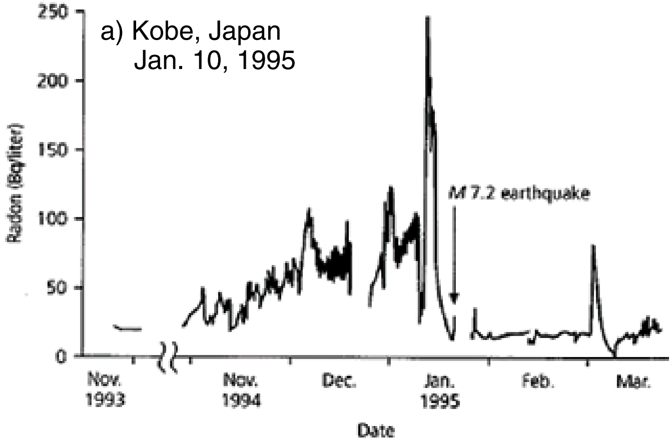
Fortunately, the situation is now changing. In 2005, simultaneously in the United States and Russia, the councils were reestablished that are analyzing the different kinds of earthquake prediction. But still, we are in a situation in which the majority of the seismological community claims that it is "impossible."

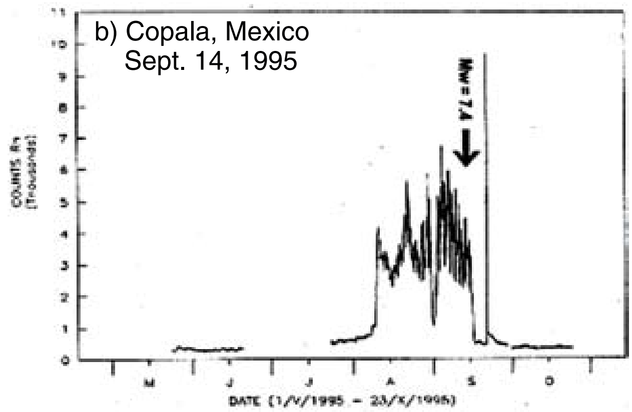
I will start, very briefly, with our model, which explains how these processes are developing. I am, by original training, a space physicist. We don't go deep underground; we start from the ground surface and go up, and study what processes develop within the atmosphere. [The flow-chart of the model] starts with the activation of tectonic activity, which is manifested in the activation of the faults where the earthquake will occur. We have the storing of energy, increasing deformation of this area, and with increasing deformation, the restructuring inside the Earth, and gas migration. You know from oil prospecting, that methane, carbon dioxide, hydrogen, and helium go from deep underground to the Earth's surface; and they carry with them the radon, which starts to be very active in the area of active tectonic faults.

I will not explain the whole model; we will see the pictures, so, please relax! **Figure 13** shows the activity of radon when you have a cross-section across the tectonic fault. You can see how drastically the concentration of radon grows, at the center of the active tectonic fault. In **Figure 14**, you see some examples from several strong earthquakes, how radon develops before the earthquake. Graph **(a)** shows the Kobe, Japan earthquake, 1995; **(b)** is the Copala, Mexico earthquake, close to Acapulco, magnitude 7.2-7.4. Graph **(c)** shows typical variations for the many earthquakes in Turkey—which is the only country where radon monitoring was *not* cut from the budget, as in the United States or Russia. They obtained $11 million for a project of putting in radon sensors all over the country. And the last example **(d)**, is from Signor Gioacchino Giuliani: The red (lower) curve shows the sharp increase of radon activity before the L'Aquila, Italy earthquake.

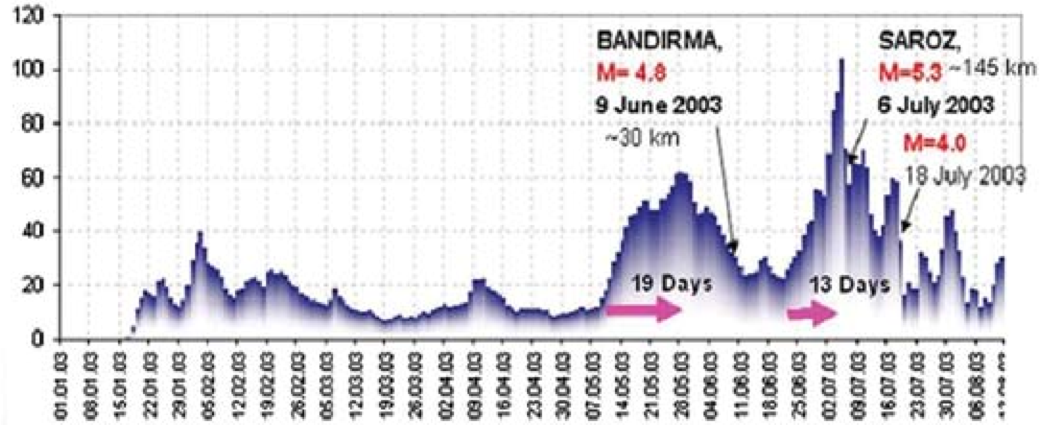
And now, let's go to our mechanism. If radon is going up, because radon is radioactive, it emits alpha particles of high energy, which produce ionization; then, we know this mechanism of condensation of water vapor on ions, and heat release. If you put an infrared sensor on a satellite, you will be able to detect the difference in the temperatures on the ground's surface, and you can see the structures of the active tectonic faults in India, before the Gujarat earthquake (**Figure 15**). The faults existed all along, but these faults were now acti-

FIGURE 14
Radon Anomalies Before Strong Earthquakes





c) Typical radon variations, Turkey



The towns shown, Bandirma and Saroz, are those closest to the epicenter of the particular earthquakes.

d) L'Aquila, Italy, April 6, 2009

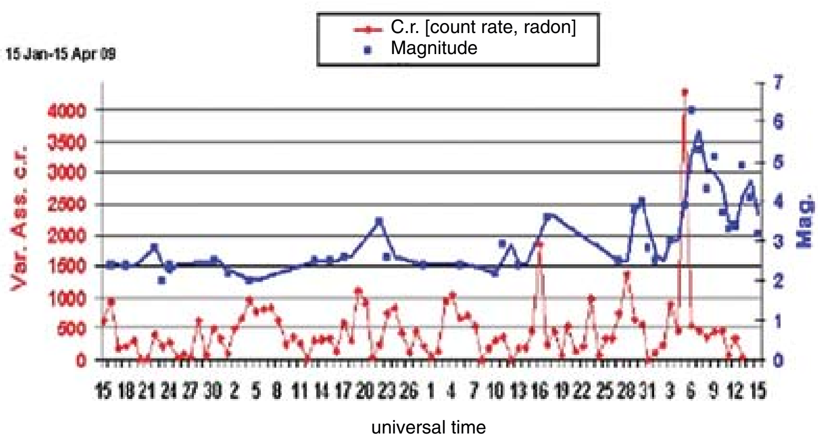
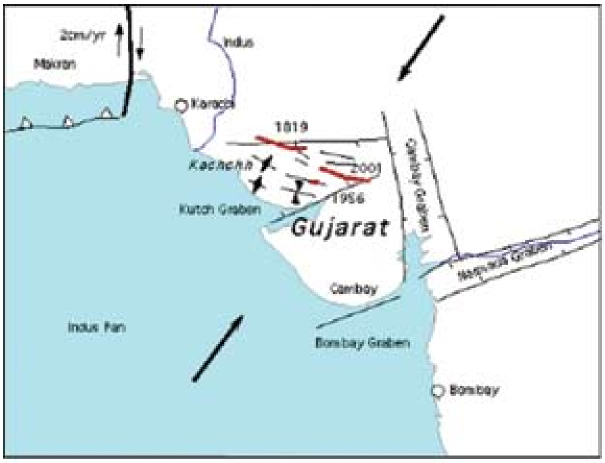
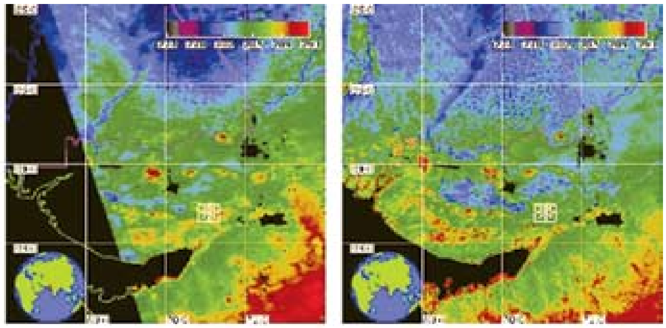


FIGURE 15

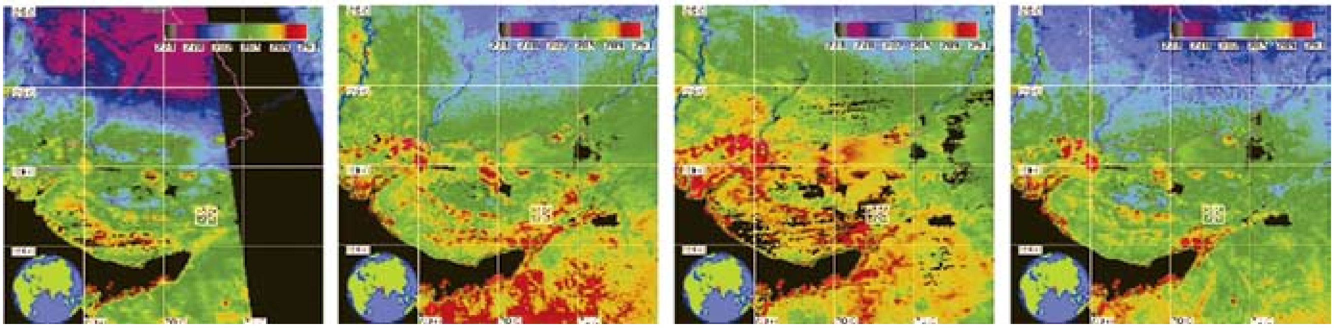
Gujarat Earthquake: Heating Along Tectonic Fault





Jan. 17 Jan. 18

Gujjarat Earthquake (India); Date-Time 2001 01 26 23:40:30 UTC, Location 23.4N 70.32E; Depth 23.6.0 Km; Magnitude 7.7 (USGS NEIC)



Jan. 19 Jan. 20 Jan. 21 Jan. 22

D. Ouzonov and F. Freund, 2004

Infrared emissions, captured by MODIS remote-sensing technology, show heating along the active tectonic faults.

vated. In the map on the upper left, you can see the red lines which follow this system of the tectonic faults. This is data from the Terra/Aqua satellite with the MODIS device, showing the infrared emission which demonstrates the heating of the area exactly in the place of the active tectonic faults.

So, what are the consequences of these processes? If you have condensation of the water vapor, you should have less free water vapor in the atmosphere, and you should observe diminishing relative humidity (**Figure 16**). Graph **(a)** shows the drop of the relative humidity in Islamabad, before the 2005 Kashmir earthquake. Graph **(b)** shows the satellite measurements of the surface temperature increase in the same area. There are some techniques that permit us to measure the anomalous fluxes of latent heat, and in the bottom row, graph **(c)** shows that. It's the same area of Pakistan. Graph **(d)** shows the so-called "outgoing long-wave radiation" (OLR); it's also infrared emission, but it is measured at the altitude of the top of atmosphere, or in the tropopause, between 10 and 15 km up, and you see the red spot close to the epicenter of the impending earthquake. And graph **(e)** shows the developing anomaly of electron concentration within the ionosphere.

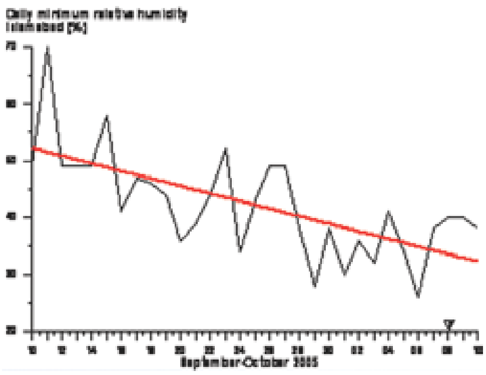
So you have a lot of parameters, a lot of anomalies in the atmosphere, which could be measured; and all of them appear in the same place, almost at the same time, between two weeks and a few days before the impending earthquake.

Another example: **Figure 17** is a sequence of days in 2007, before the strong earthquake in the Sumatra region, and you can see how the latent heat follows the tectonic fault, or the shape of Sumatra. This cannot be explained *by any other processes*, because all these spots are over ocean. Nothing except gases can go out from there. Nobody can explain it; it is impossible to

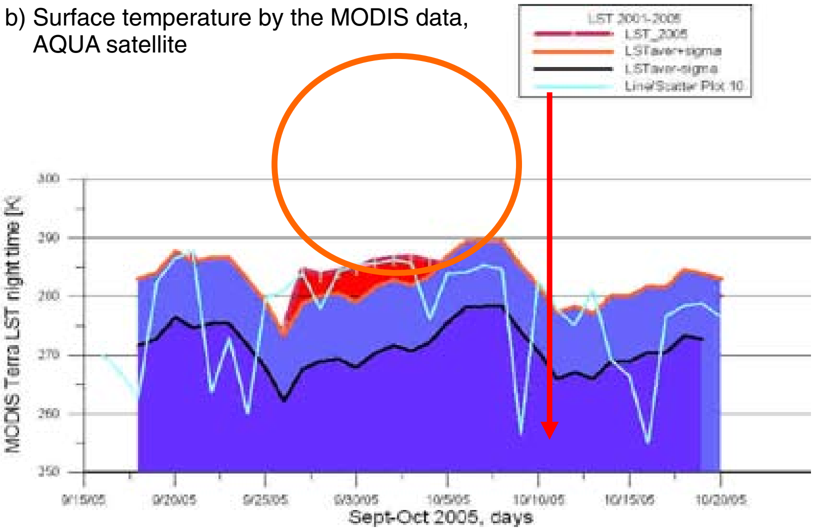
FIGURE 16

The Kashmir Earthquake, Oct. 8, 2005

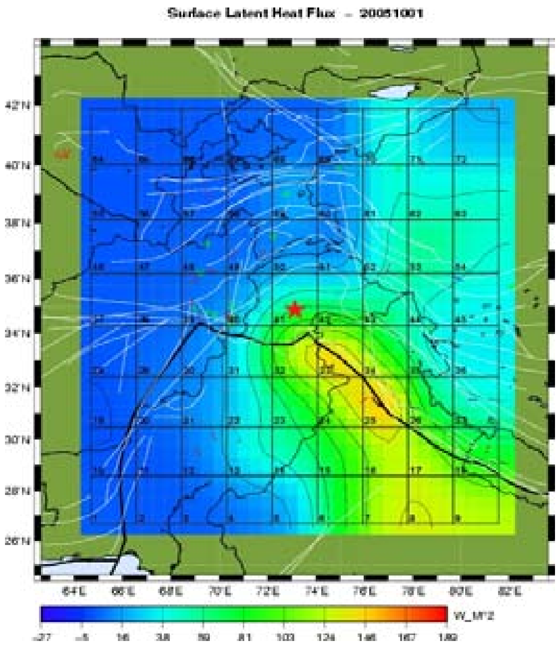
a) Relative humidity drop



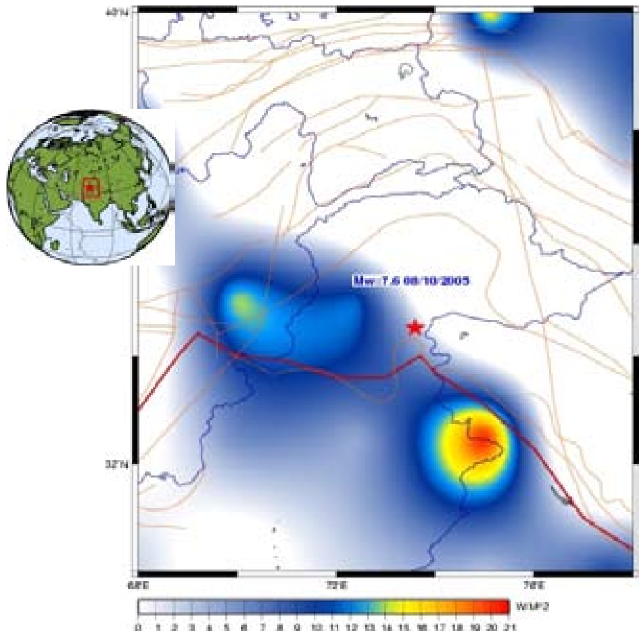
b) Surface temperature by the MODIS data, AQUA satellite



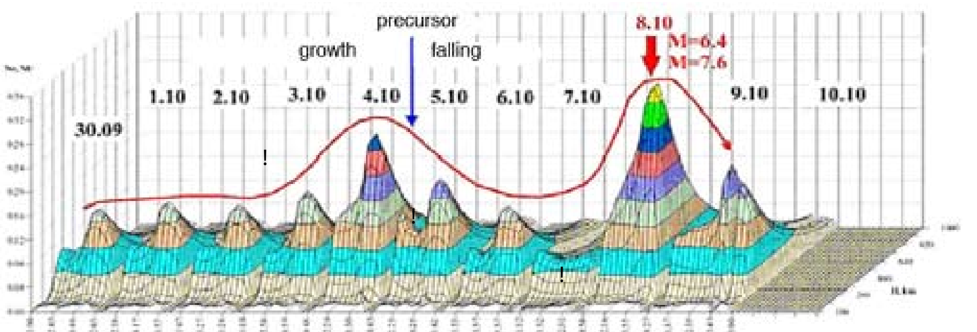
c) Anomalous latent heat flux



d) OLR anomaly one week before the seismic shock



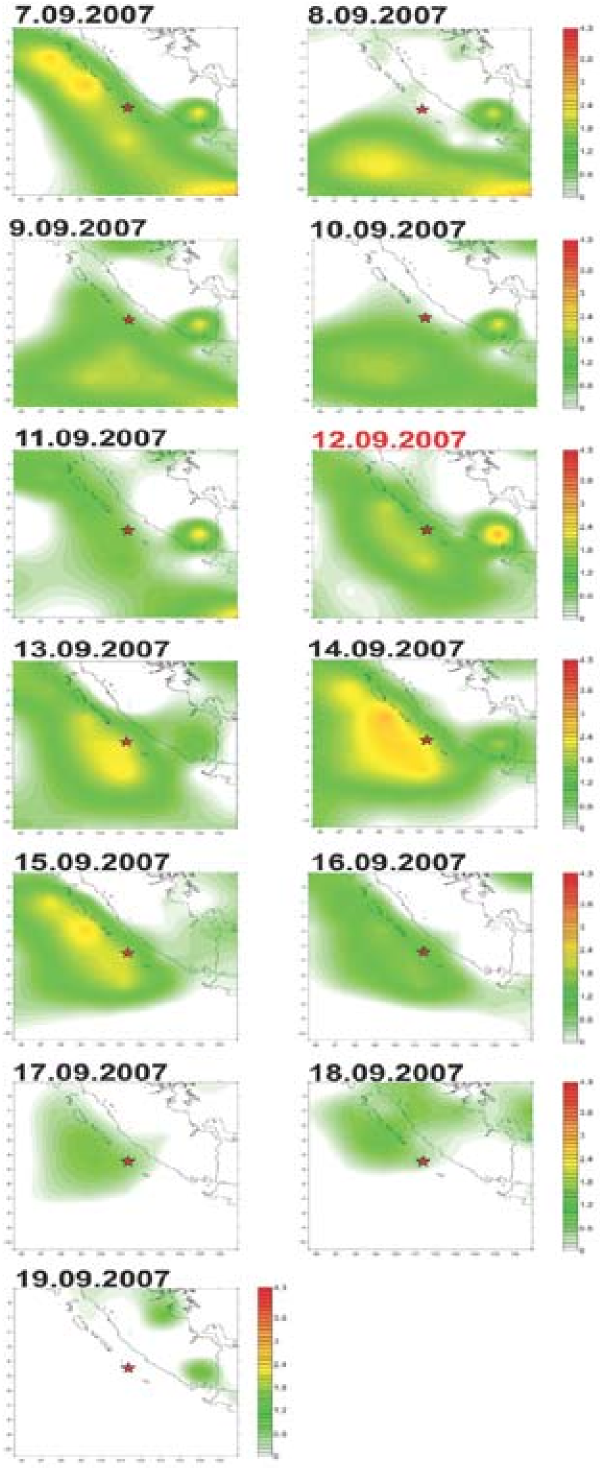
e) GPS/TEC anomaly



V.G. Bondur, 2006

FIGURE 17

Anomalous Latent Heat Dynamics



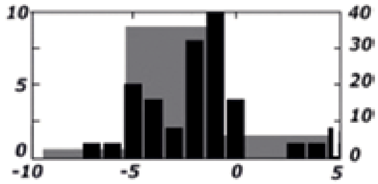
These measurements are around the time of the M8.8 Southern Sumatra Earthquake, Sept. 12, 2007. Note that the dates are in European style: DD/MM/YYYY. Green is cooler, yellow is medium, red is hottest.

FIGURE 18

Lead Time of Ionospheric Precursors

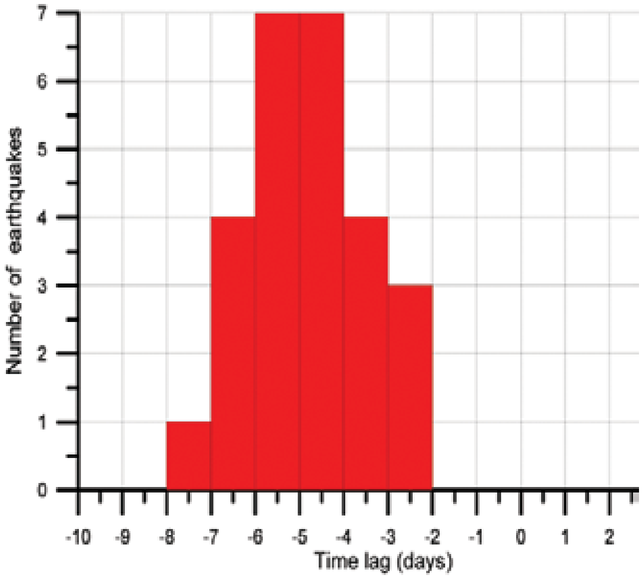
(Anomalies Five Days Before Earthquake)

a) Ionospheric anomalies



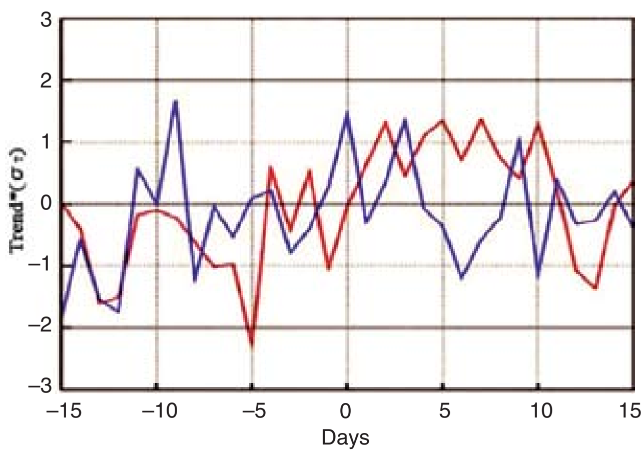
J.Y. Liu et al., 2003

b) Ongoing Long-Wave Radiation (OLR) anomalies



D. Ouzounov et al., 2009

c) Very Low Frequencies (VLF) anomalies

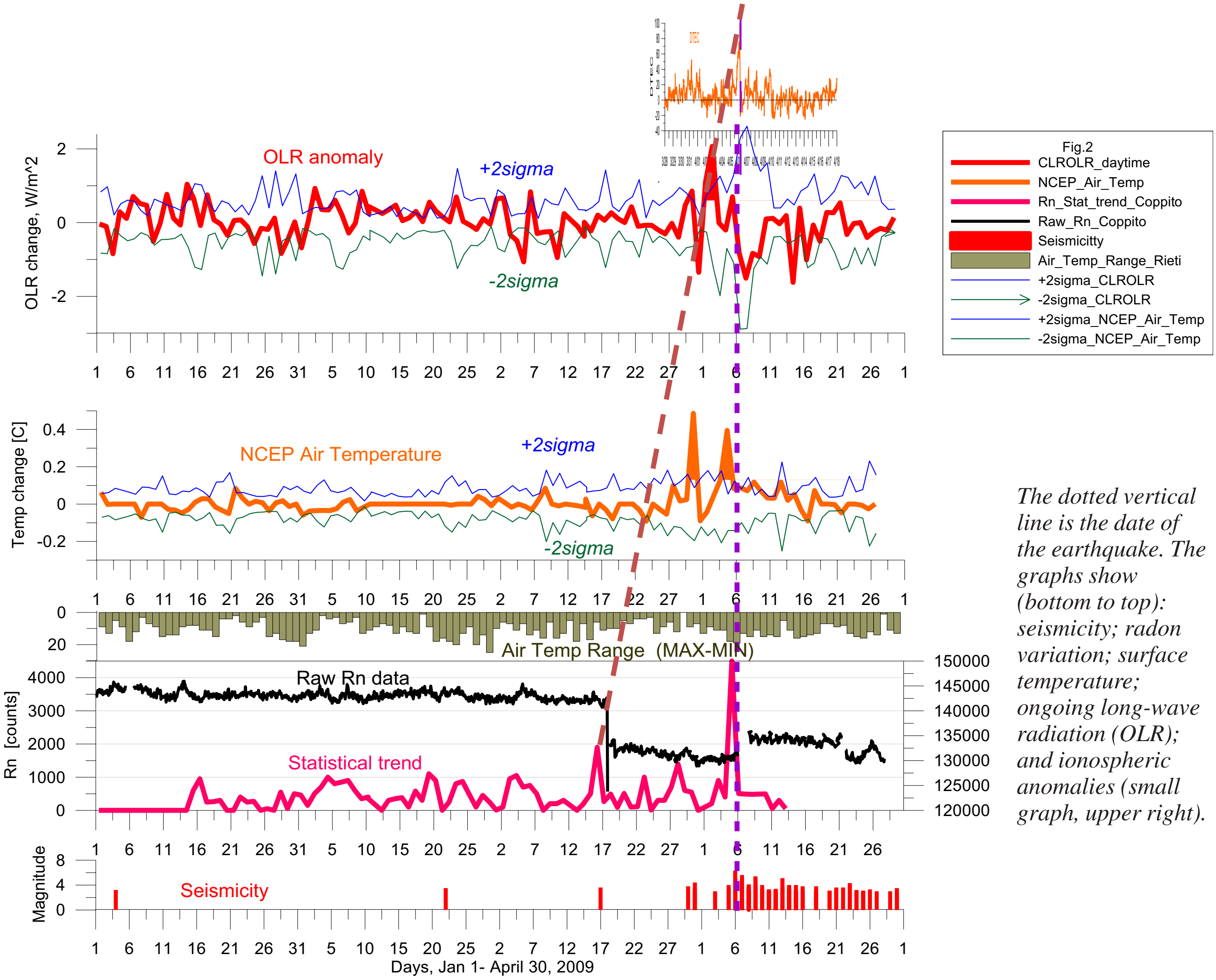


M. Hayakawa et al., 2010

FIGURE 19

Temporal Evolution (Synergy) of Earthquake Precursors

(L'Aquila, Italy, April 6, 2009)



The dotted vertical line is the date of the earthquake. The graphs show (bottom to top): seismicity; radon variation; surface temperature; ongoing long-wave radiation (OLR); and ionospheric anomalies (small graph, upper right).

explain by other mechanisms.

The question is, how powerful is the heating of the atmosphere? We know that there have been some satellite failures because of great magnetic storms, when the atmosphere was heated and expanded, and, for example, the Space Station was braked by the heated atmosphere, and lost its altitude due to braking in the more dense atmosphere in these altitudes. And we were able to detect the braking of a small satellite, of small mass, but it had an accelerometer onboard, so we observed the braking of the satellite when it passed over the epicenter of impending earthquakes; on average, statistics show that braking happens five days before the earthquake. And it corresponds to the statistics of ongoing long-wave validation, which also shows a maximum in its temporal distribution five days before the seismic shock.

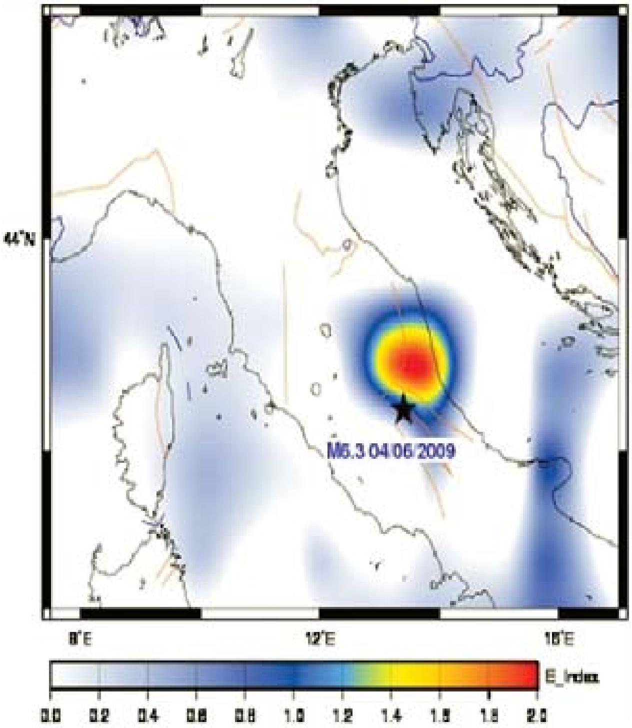
And, if we take completely different parameters (**Figure 18**), the top one is ionospheric anomalies; the middle one is OLR, ongoing long-wave radiation; and the lower one is anomalies in propagation of the very low frequencies [VLF] in the near-ground wave guide—these signals are emitted by the navigational transmitters for navigation of submarines. And all of them show anomalies exactly five days before the earthquake.

And now, if you have a model, and you know how it develops, you have the synergy of the many atmospheric and ionospheric parameters, and you see how

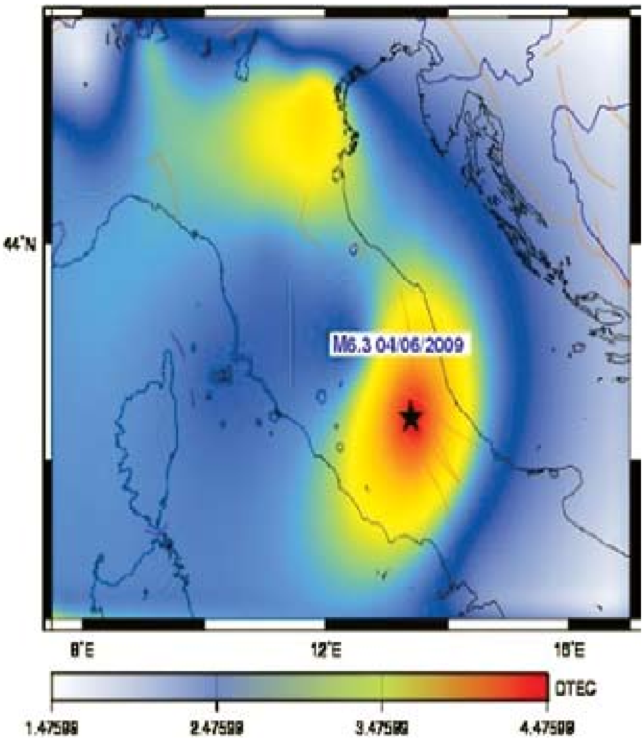
FIGURE 20

Ongoing Long-Wave Radiation (OLR) and Ionospheric Precursors of L'Aquila Earthquake

(April 6, 2009)



OLR anomaly



GPS Total Electron Content (TEC) anomaly

the processes developed from the ground surface. In **Figure 19**, the lower graph is radon variation near L'Aquila in Italy. Then there is the surface temperature; then, there is OLR; and then, there is the ionospheric anomaly. The blue curve shows how this process propagates from the ground surface to the ionosphere, and the red curve, the vertical curve, shows the moment of the earthquake.

Figure 20 is a comparison: On the left, we see infrared emission at the top of the atmosphere, and the red area is the distribution of electron density—the total electron content over L'Aquila. So you are able to detect the location of the impending earthquake.

(Continued on next page)

FIGURE 21

Variations in Earthquake Precursors, Before Earthquake

Geophysical Parameter	Sensor	Sensor name	Spatial	Temporal	Advantages	- Days
Surface temperature (land and sea)	Sat	Polar orbit: AVHRR , EOS MODIS, ASTER	90 m-5km	1-2days	long historic record, high spatial resolution	5-10
Meteorological information		Geosynchronous: GOES, METEOSAT	1-4km	20min-1h	high temporal resolution	4-7
Long Wave Radiation	Sat	NOAA AVHRR 14,14,15,17,18	1 degree	Twice per day	Global pre seismic indicator for major events	30-5
Surface Latent Heat Flux (SLHF)	Sat	NCEP	2 degree	Once per day	coastal strong earthquakes	15-4
Ionospheric perturbations EM waves (VLF) and plasma parameters	Sat	DEMETER	--	1 day	Low atmospheric disturbances	6-2
Space weather	Sat	NOAA	-	-	Kp Dst	
EQ catalog, Deformation maps	Grd	USGS		-	EQ catalog stress maps	
Aerosol contents	Grd	AERONET	Vary	Hourly	High temporal resolution	7-4
GPS/ Total Electron Content	Grd	GPS	Vary	Hourly		5-3
Radon concentrations	Grd	Turkey, Israel	Vary	Hourly		14-3
Air Temperate/ Relative Humidity	Grd	Meteorological network	Vary	Hourly		14-3
Atmospheric & Ground E field	Grd	Taiwan, CA, Mexico	Vary	Hourly		5-2
Magnetic filed	Grd	CA, Israel, Taiwan	Vary	Hourly		4-2

Courtesy of S.A. Anagnastopoulos, 2011

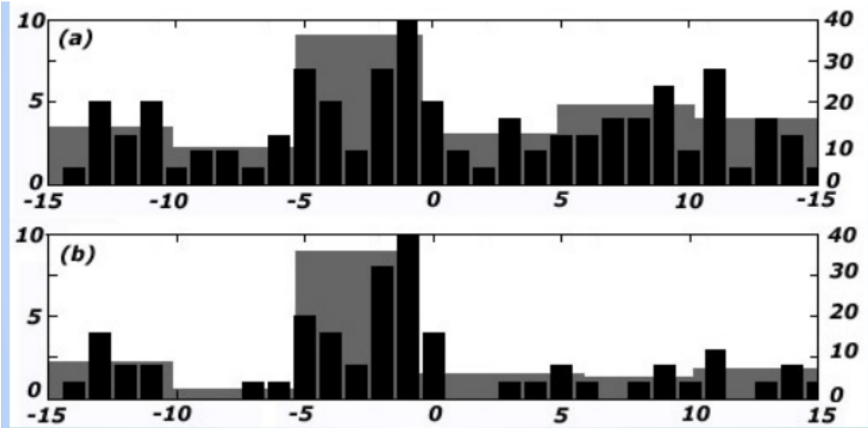
In **Figure 21**, you can see a lot of other variations—of electromagnetic emissions, particle precipitation, and so on—registered on the ground, in the atmosphere, and by satellites, and *all of them show the same lead time before the earthquakes, and all of them were registered experimentally*.

So, from experimental observation, we should develop something practical, to automatically detect these precursor phenomena. First, we study the phenomenology of the event: We develop the physical model; we look for the specific features that differentiate these processes from other natural processes, for example, variations in the ionosphere connected with magnetic storms.

From this study, we create the "mask" of the precursor. Then we make a statistical validation of this mask, and if it shows good results, we produce a practical application for prediction.

(Continued on next page)

FIGURE 22
Precursor Anomalies: Time of Earthquake



	M□5		M□5.5		M□6	
	P(i)	ϒ jP(i)	P(i)	ϒ jP(i)	P(i)	ϒ jP(i)
1 day before	28%	28%	44%	44%	56%	56%
2 days before	14%	42%	21%	65%	11%	67%
3 days before	22%	64%	15%	80%	11%	78%
4 days before	9%	73%	9%	89%	11%	89%
5 days before	0.8%	73.8%	6%	95%	11%	100%

Liu et al., Ann. Geoph., 2004

J.Y. Liu et al., *Ann. Geoph.*, 2004

You can see three parameters which need to be detected: the position of the epicenter, the time of the earthquake, and the magnitude. For position, as you have seen in previous slides, we can quite nicely determine the position of the epicenter. Now, the time, within the window of five days (**Figure 22**). And the magnitude: From some empirical relationships, we determined, from the size of the anomaly—for example, this estimation (**Figure 23**) was made for the Irpinia earthquake in Italy, by ionospheric measurements from the topside sounder installed on the satellite.

But still, we are criticized by seismologists, who say that it's all very nice, but has no relation to seismology.

Finally, we were happy, very happy, when we found a reasonable seismologist who started to talk with us, the Greek seismologist Gerassimos Papadopoulos, very well known worldwide. He studies precisely the catalogs of the earthquakes, and has tried to determine, "Okay, you have a sequence of seismic shocks. Which of them are foreshocks, which is the main shock? Which are aftershocks? And what shocks are there between the long period of the earthquake?" He was able to find out how to determine *exactly* the foreshocks' activity! This is, again, for the L'Aquila earthquake: He looks for the three parameters, the sharp increase of the event rate of the number of small shocks in the area; second, the clustering of the events, so they start to be merged close to the epicenter. And there is a relationship between the frequency and the magnitude of the earthquakes, which is part of this equation; there is a *b*-coefficient from the Gutenberg-Richter relationship, which is characteristic of the process, and it was determined that before the earthquake, the *b*-value dropped.

(Continued on next page)

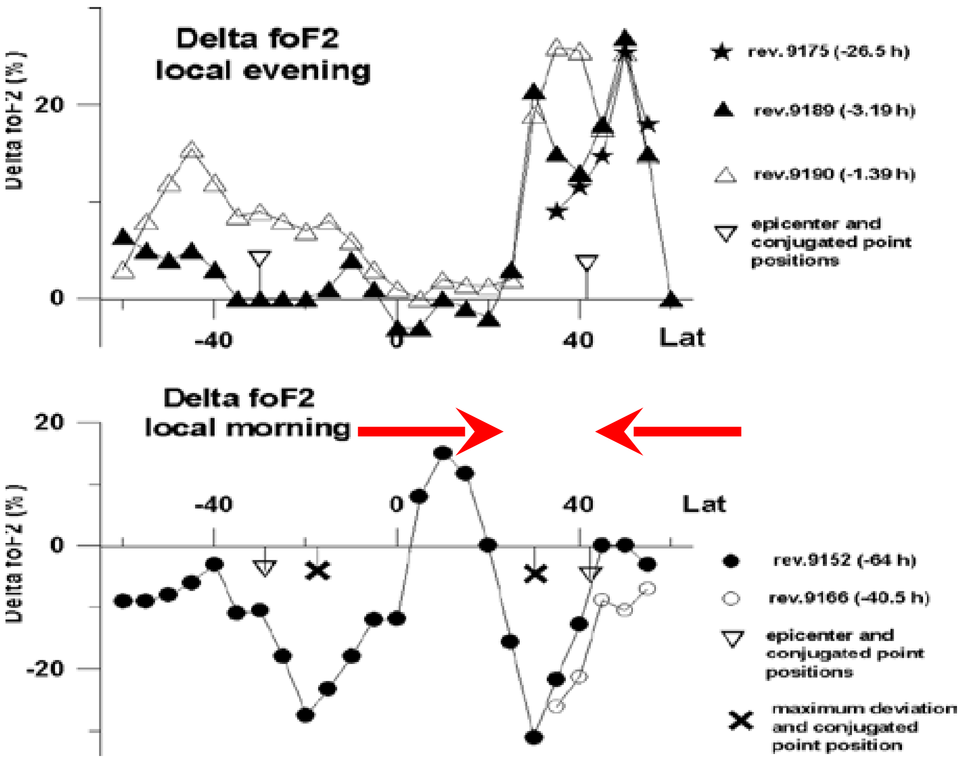
FIGURE 23

Precursor Anomalies: Magnitude of Earthquake

✕ = 100.43M km

Magnitude	3	4	5	6	7	8	9
Earthquake	19.5	52.5	141	380	1022	2754	7413

Irpinia earthquake, Italy, 23 November 1980, M6.9



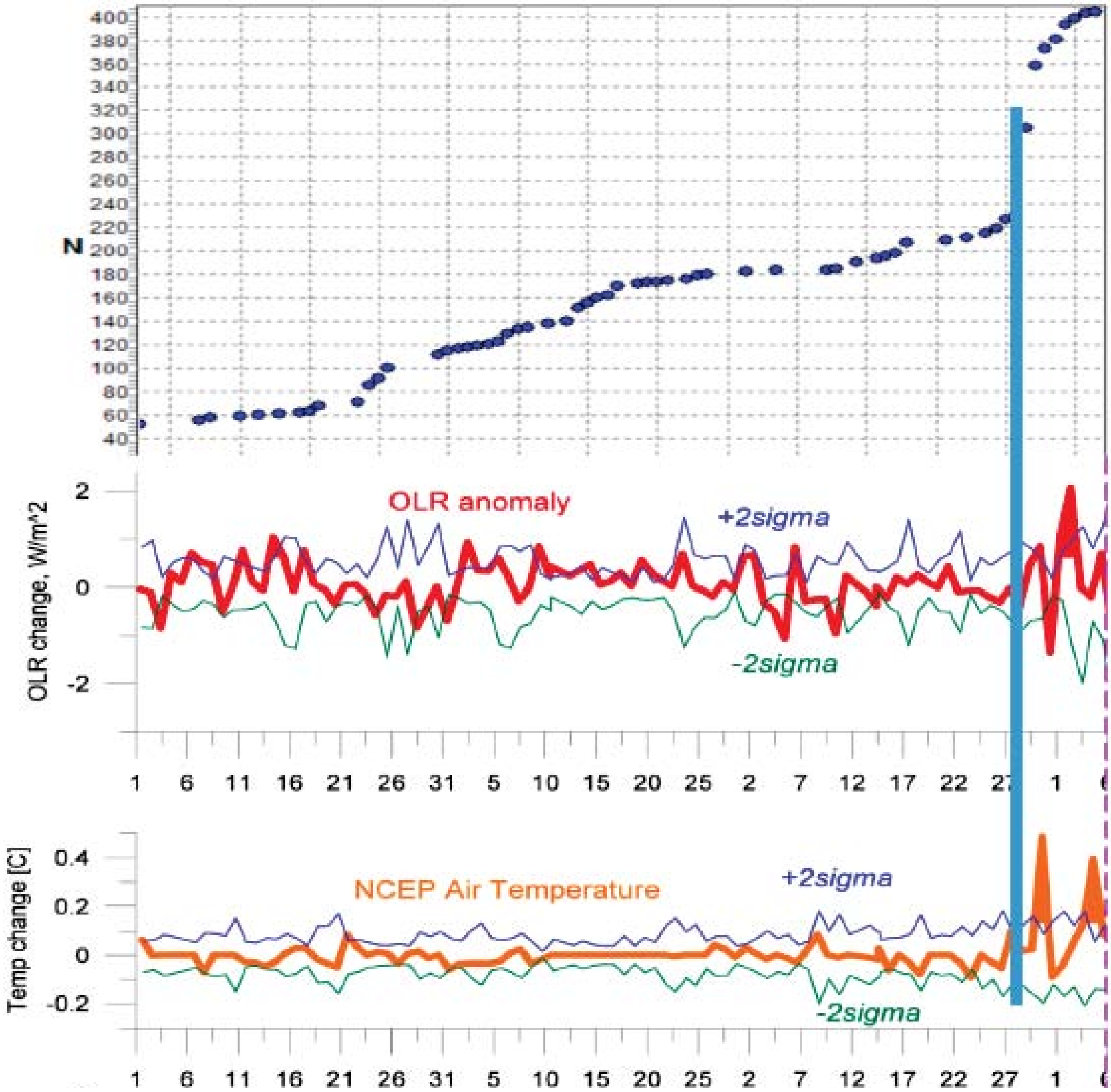
M=[log(900)]/0.43 = 6.9

Dobrovolsky et al., 1979

FIGURE 24

Foreshocks and Short-Term Earthquake Precursors: the Same Physical Process

(L'Aquila Earthquake, 2009)



The graphs show the corresponding anomalies in (bottom to top) air temperature; ongoing long-wave radiation (OLR); seismic activity (foreshocks) (from G. Papadopoulos).

We compared his results with our results for the L'Aquila earthquake, and you can see exactly, that where we see our precursors, he determines the foreshock activity (**Figure 24**).

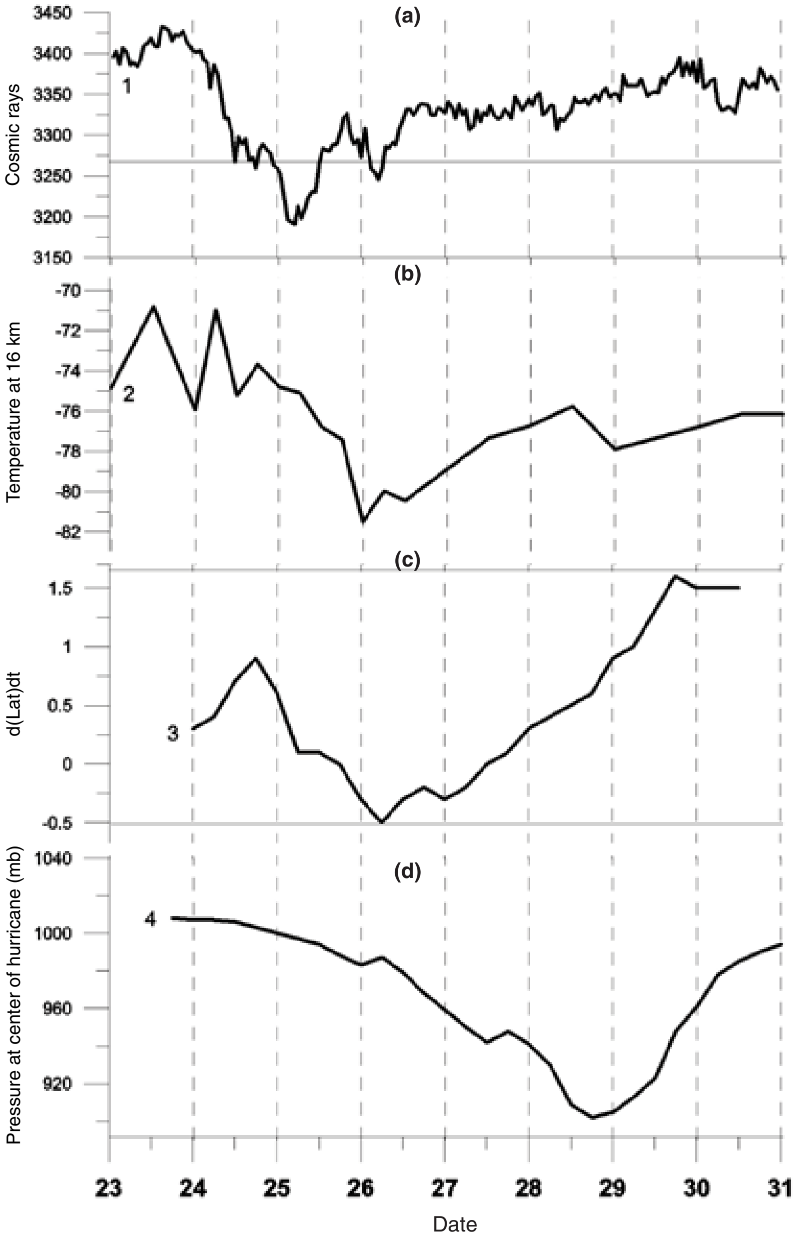
So, finally, we found the relationship between the seismic parameters—and especially foreshock activity, which says that, "for sure, there will be an earthquake"—and our atmospheric parameters. There is no doubt, that what we are measuring are real precursors of the earthquakes.

Can We Predict?

Okay, now that we're finishing with the earthquakes, you will ask me, "If you are so clever, why don't you predict earthquakes?" The answer is very simple: If you have, for example, a fire in your house, and you are by yourself, it's very difficult to fight it. You call the firemen. There are a lot of emergency services. A special service should be created [for studying earthquake precursors]. My friend and co-author Dimitar Ouzounov, who took all the thermal measurements, lives in the United States, and I live in Russia; now I'm here at the conference. But to make predictions, there should be people who are sitting and analyzing information around the clock, in real-time. At least some group should be created to perform this service.

We have zero financing for our research. Everything I've demonstrated was done in the course of our ordinary activity, with no financing. To be successful, we need to create at least one laboratory, and direct it; it will have a few young people, because all this data processing is time consuming. We sit at the computer after a strong earthquake, and try to get information from all over the world, taking the atmospheric parameters—but we have no direct channels to immediately get the information on the air temperature in Japan, in Sumatra, and so on; the humidity; to download the data from satellites; GPS calculations—all this needs special infrastructure. Until it is organized, this problem will not be practically resolved.

FIGURE 25
Anomalies over Hurricane Katrina
(August 2005)



Hurricanes

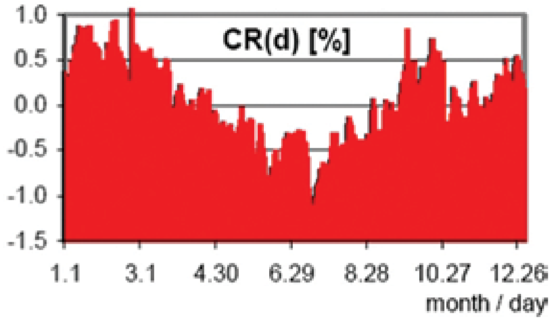
The next thing about the short-time variations in our atmosphere is hurricanes, and I would like to say a few words about them. . . .

Imagine a situation like this: You have the stable flux of galactic cosmic rays; during geomagnetic storms, the Sun makes an obstacle for the galactic cosmic rays, and their flux decreases sharply, on a very small scale, but a very small period of time. So, if you have less of the source of ionization, less heat will be released, and in this area where we have maximum production of particles, we should observe a drop in the air temperature. And it happens.

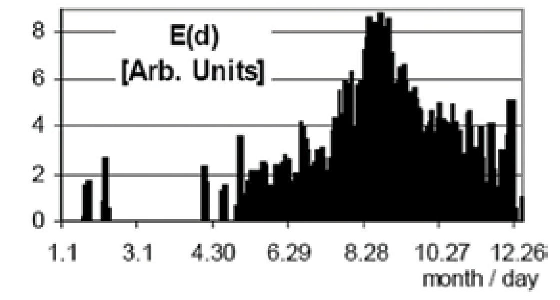
So that at the beginning of the development of Hurricane Katrina, there was a magnetic storm. And you can see in **Figure 25** that graph **(a)** shows the drop in the flux of the galactic cosmic rays, measured by neutron monitoring in the United States; graph **(b)** is the decrease of the temperature at the level of the tropopause. And you can see the vertical profiles of the temperature, over Hurricane Katrina—okay, it was not a hurricane yet—taken by sounding by radiosondes installed on balloons, launched from meteorological stations. And you can see the drop in temperature: It is 8.6°C, which is a huge drop, according to atmospheric parameters. And you can imagine, if you have the ocean surface temperature near 28°C, and the temperature

FIGURE 26
Hurricane Energy and Cosmic Rays
(Hurricane Katrina, August 2005)

a) Average cosmic ray CR[d] density distribution

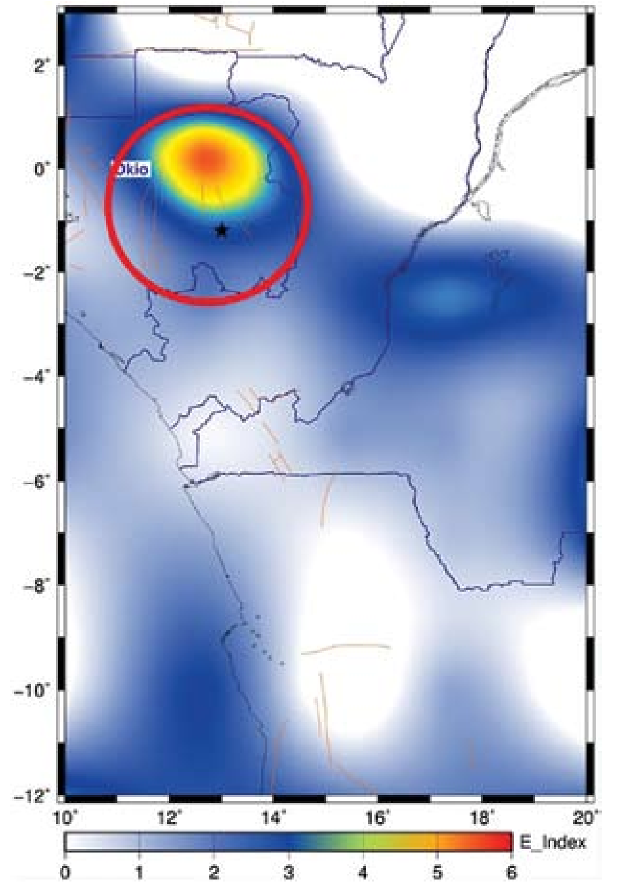


b) Average energy E[d] distribution



S. Kavlakov, 2005

FIGURE 27
The Oklo Natural Fossil Nuclear Reactor, Gabon
(July 2004-10)



The image shows increased air ionization in the area, and a thermal anomaly over the Oklo "reactor."

drops at the top of the hurricane, how this increases the circulation of air. So, it leads to a sharp increase of the vertical convection.

And another effect: Graph **(c)** shows that these changes of temperature are not uniform in space, and our model calculation shows that it's in these circumstances that a hurricane changes its trajectory. And in fact, Katrina changed its trajectory and went into the Gulf of Mexico, where there was an extremely high temperature; and convection was initiated, stimulated by the magnetic storm, increasing more and more, until Katrina reached a Category 5.

This shows that galactic cosmic rays *do* play a role in the intensification of cyclonic activity, and especially in hurricanes.

Now in **Figure 26**, graph **(a)** is the statistical work showing a drop in the galactic cosmic rays, and graph **(b)** is the increased energy of the hurricane. These are statistical results.

So, the process of ionization and release of latent heat play an active role in one more process in our atmosphere.

Radioactive Pollution

The next item I want to touch upon is radioactive pollution of the environment. We started to work on this, because many people have said to us, "How can you prove that your mechanism is working, that the thermal anomalies you observe are connected with ionization? You have plenty of sources of ionization all over the world: Please show that they are having an effect here."

Figure 27 shows a place in Africa, in Gabon, where there is a natural "nuclear reactor," from fossils. There are fossils with a large content of uranium, and there is increased radiation over this area; and you can see the thermal anomaly over Oklo, which is the name of this natural nuclear reactor.

FIGURE 28
Ongoing Long-Wave Radiation (OLR) Anomalies for Fukushima Nuclear Plant
(Thermal anomaly)

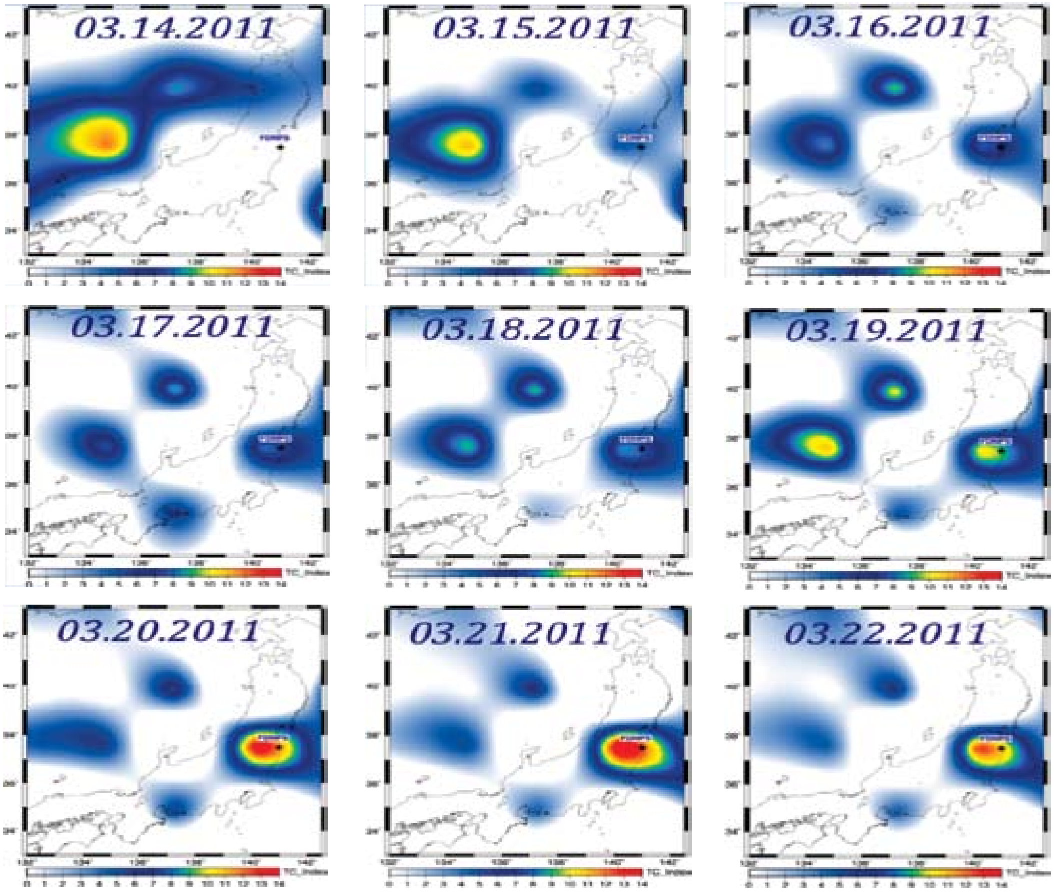
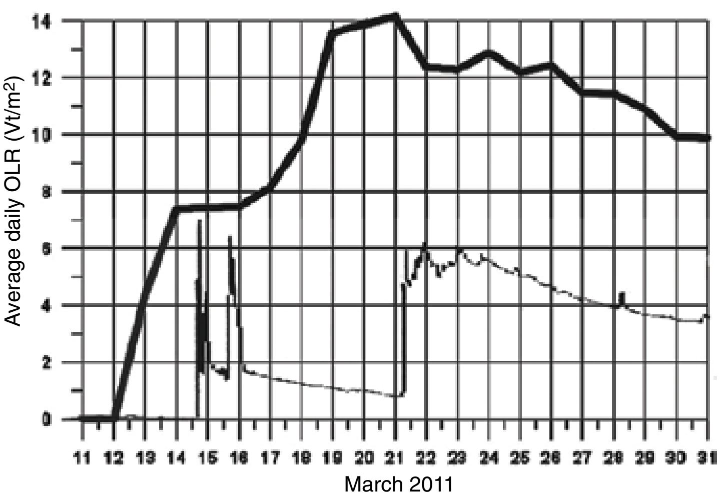


FIGURE 29
Ongoing Long-Wave Radiation (OLR) Anomalies for Fukushima Nuclear Plant
(Thermal anomaly (bold line) and measurement of radioactive substances in hydrogen explosions at the plant [thin line]).



And what about Fukushima? In **Figure 28**), you can see the development of the thermal anomaly over the Fukushima power plant up to the maximum, and then you can see the decrease of this heat. Because it was a very recent event, we were able to study the dynamic. And this is very important, because it is connected with our lives! You remember how the Japanese changed their indicators a thousand times a day, and nobody knew what the real level of radiation was! And this gives you, in hand, an independent source of monitoring radioactive pollution, from a satellite. And in **Figure 29**, you see the level of the thermal anomaly, the bold line; and the thin line shows the indicators of the sensors of the hydrogen explosions that occurred, and which transmitted radioactive substances into the atmosphere. And you can see that these explosions coincide with an increase of the thermal anomaly.

FIGURE 30

Producing Rain with Ionization, Mexico

a) The central mast

b) An example of the installation used

So, another application of our mechanism of latent heat release, is monitoring of radioactive pollution of our environment.

Can Man Change the Weather?

And the last thing, very interesting: If ionization is so powerful, can we do something about our weather? Yes, we can!

I spent a few years in Mexico, where there is a company that worked with agriculture, to produce artificial rain, and they have installations for air ionization to produce the centers for nucleation and creation of clouds. Here is the central mast (**Figure 30**). I will not go deeply into the technology, but these are examples of the actual installations, and **Figure 31** shows the increase of precipitation in the Sonora Desert, when these installations were active.

From 2003 to 2004, fully 2 million cubic meters of additional water were created artificially to fill up the water reservoirs in the small hydroelectric power stations in some regions of Mexico.

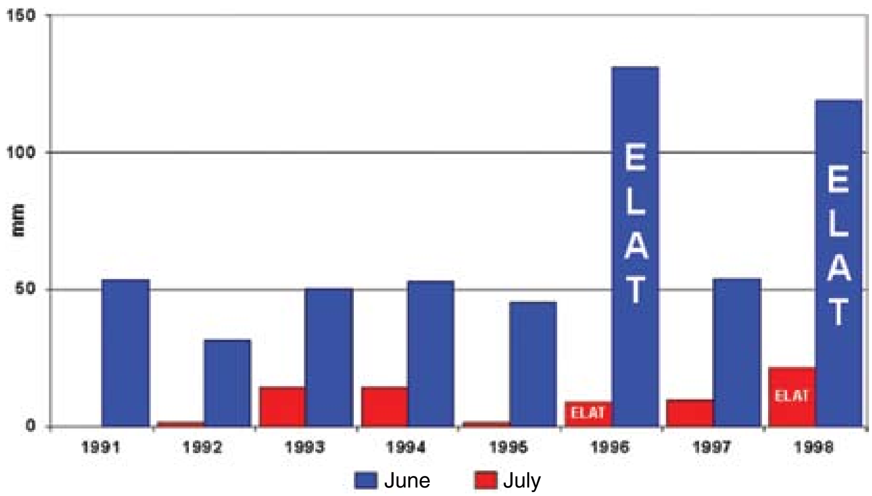
Okay, all of this could be explained within the framework of the global electric circuit, which is based on the potential difference between the ionosphere and the ground (**Figure 32**). This potential difference is created by thunderstorm activity, and the return current goes from the ionosphere to the ground, in areas of fair weather. It is called the global electric circuit; the current is very low, but the gradient of the potential is quite large on the ground surface, something like 100 volts per meter. (From your toe to your head, you have a potential difference of 200 volts.)

If you are able to monitor the density of this current, and produce the ions, you can do many things.

For example, the trajectory of Hurricane Lane [2006] was shifted—it was a tropical storm, and then it converted to a hurricane. There was an agreement with the government of Baja California to protect the recreational areas from hurricanes; and the trajectory of the

FIGURE 31

Precipitation in Sonora, Mexico, 1991-98



Sources: National Water Commission. 1996 and 1998: operation of ELAT station Puerto Liberdad.

ELAT (Electrificacion Local de la Atmosfera Terrestre SA) is the company that increased rainfall in Sonora using air ionization.

FIGURE 32
The Generation of Atmospheric Electricity

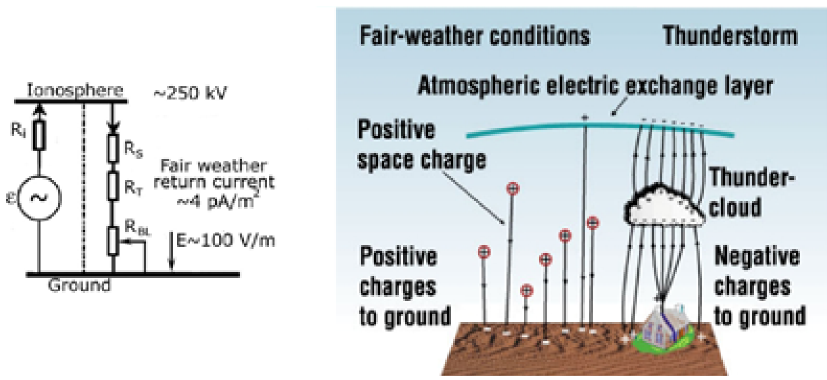
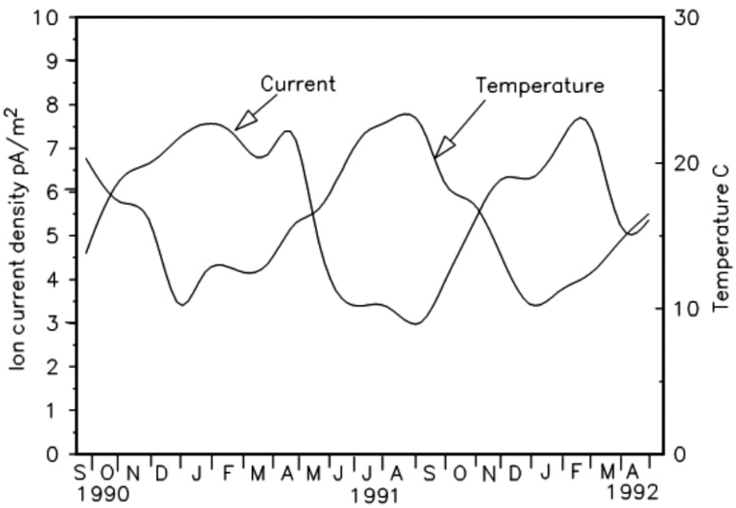


FIGURE 33
Can We Modify the Temperature?



Harrison, 2000

Temperature and the global electrical circuit anticorrelate. If you can control the electrical current, you can control the temperature.

hurricane was changed. It was a special experiment, showing that it is possible to shift it to one or another side. The polarity was changed twice, and the trajectory of the hurricane changed, in comparison with NOAA's prediction.

So we have a lot of possibilities to work with, but it has to be very accurate. You know, it is like a nuclear bomb: We cannot give the military these things! It is very dangerous.

Here is another example (**Figure 33**): It is simply measurements of the variation of the vertical current in the global electrical circuit, and temperature. You have temperature, and you can see that they anti-correlate. So if you are able, in some area, to control the vertical electric current, you can control the temperature.

So, probably, the conclusion for my presentation today is that we should take into account the ionization processes in different areas, and we see that they are connected with climate change, with the detection of earthquake precursors, with activity of tropical cyclones and hurricanes; and the possibility exists of effects on the weather, and that somehow, sometimes, we can correct the weather.

Looking to the Future

I would like to say a few words also about modern science. Unfortunately, we have very narrow specialization. People know only their own field very well, and if something goes on outside of their field of knowledge, it is impossible to talk with them, because they do not understand, and their reply is, "I do not believe."

We are not in church, where you should believe! We are doing science.

So I think that we should develop—I call it a "holistic approach." We should train scientists who have knowledge in different fields, because for this work, you need to know the physics of the atmosphere, the physics of plasma, the chemistry of the atmosphere; atmospheric electricity; thermodynamics, and many, many other things. If you are not able at least to understand the basics, you cannot make progress in such matters.

And this is an issue of our conflicts, for example, with seismologists: They do not know the physics of the ionosphere. They do not know the physics of the atmosphere well. But, when the word "earthquake" appears in the literature, or in discussions, they say, "We are responsible for this! Get out of this field!"

This is a problem, and we should resolve it. We should explain that an earthquake and its preparation is a complex process: It envelops different geospheres which interact. And here we come to the conception of Vernadsky, that all things in our planet are connected, one to another. We should keep this in mind and work carefully to understand our planet.

Thank you very much.