

Prof. Sergey Pulinets

A Journey through Vernadsky's Universe

This is the edited transcript of the presentation of Sergey Pulinets to Panel 1, "Vernadsky's Revolution in Science and Thought," of the Schiller Institute's Nov. 12, 2022, Conference, "The Physical Economy of the Noösphere: Reviving the Heritage of Vladimir Vernadsky." Dr. Pulinets is Principal Research Scientist at the Space Research Institute of the Russian Academy of Sciences in Moscow. Subheads have been added. Some illustrations are omitted; thus some Figure numbers are not shown in the edited transcript.

The full conference video is [available](#) on the Schiller Institute website.



Schiller Institute

Prof. Sergey Pulinets

Before turning to my research related to the scientific legacy of Vernadsky, I would like to say that I consider that the main scientific idea he left us as a legacy is biogeochemistry, which was also mentioned by Lyndon LaRouche and other presenters at this conference. It is extremely important for our worldview, especially as we enter the era of climate change. The evolution of our planet, and the substance it consists of, is largely determined by the evolution of all life on Earth. Look now at this picture:

At the top of Mount Everest, marine limestone and fossils of cephalopods, trilobites, brachiopods, etc. have been found, hinting that the highest point on Earth was once part of the seafloor.

This means that the geological environment, the geological structure of our planet is largely shaped by living matter: These are coal and hydrocarbons, which are the waste products of living organisms, and minerals, which largely consist of the remains of marine organisms of ancient oceans. This is the soil, the composition of which depends on the activity of bacteria and plants. At the same time, human activity has radically changed the appearance of our planet. This is deforestation, mining, construction of cities, roads. All these changes not only the landscape, but also the composition of the Earth's crust. At the same time, the body of living organisms consists of the same

atoms and molecules as substances in inanimate nature.

Until now, consideration of the interaction of living and non-living things in our nature was mechanistic, although the meaning of this interaction is much deeper. Suffice it to say that only living organisms are able to absorb and transform solar energy. In fact, the energy of minerals is the solar energy accumulated in living substances over billions of years. This is a kind of long-term battery that helps us to survive, using the energy released by the Sun many years ago.

Vernadsky and Nuclear Research

... Back in 1911, Vernadsky argued that radioactivity is of great importance in the life of the Earth's crust, in the fate of many minerals, and in the future of mankind. At the end of 1921, he founded the Radium Institute in St. Petersburg and became its Director. He had extensive contacts and was friends with many Soviet physicists. He developed a particularly warm relationship with Leonid Mandelstam. He spoke about the responsibility of scientists to mankind, in particular, to prevent the use of scientific discoveries for the self-destruction of mankind.

In May 1940, Vernadsky received from his son

George the news about the discovered energy of uranium-235, and with great difficulty, through friends of physicists, got a reprint of an article in the *Physical Review*, and already on June 16, 1940, he writes in his diary:

The issue of uranium was discussed in the Presidium [of the Academy of Sciences] yesterday. I made a report, not very successful—but the result was achieved. The vast majority do not understand the historical significance of the moment. Curious—am I wrong or not? We need to send a note to the government. Transform the uranium center at the Geological and Geographical Department into a Commission attached to the Presidium. Introduce physicists and chemists.

Already on July 30, 1940, the Commission on the study of the intranuclear energy of uranium was finally formed by me (deputy chairman)....

But Vernadsky did not manage to take part in the practical work on the atomic project. He died in January 1945.

On Nuclear Energy

In his disputes with other scientists, Vernadsky argued that the use of nuclear energy would revolutionize the life of mankind.

10/12/1940. It seems to me that there are no “laws” of the economy that would not change radically, since a person receives concentrated energy, and 5 kilos of it will be equal to 200,000 tons, which are now required for the same effect?

We can now assess the correctness of his words, not only by looking at the success of nuclear energy in general (which is developing rapidly), but also by learning about the latest achievements in Russia, where an industrial nuclear closed-cycle reactor, based on fast neutrons, has been created (and is already being built). Successful testing of such a reactor means almost waste-free nuclear power with access to uranium-238 (as opposed to classical uranium-235), which will last for millions of years.

In this [fast neutron] reactor, all radioactive elements

are routed back into its reaction without any radioactive pollution. It could transform the nuclear elements *ad infinitum*. This is the first step to get new sources of energy which will stop the use of hydrocarbons and save our planet from air pollution.

Natural Radioactivity: Radon & Earthquakes

Let’s get back to natural radioactivity, which is the direct subject of my research. Here it is necessary to mention one more idea of Vernadsky, which is called “respiration of the Earth.” In addition to methane—which is actively extracted from the Earth’s crust and which is a bone of contention in the current political situation—the Earth’s crust emits a large number of different gases, including CO₂, which is released 50 times more than all anthropogenic sources emit.

What is the connection between the Earth’s gas respiration and radioactivity? This is radon, one of the decay products of radium, which Vernadsky worked on when he founded the Radium Institute. It turned out that variations in the release of radon from the Earth’s crust are indicators of the dynamics of the tectonic and seismic activity of the Earth. Here are examples of radon variations in anticipation of devastating earthquakes.

In **Figure 3**, you can see (upper left) the radon variations before the Kobe, Japan earthquake in 1994-1995. It reaches a peak, goes down, and then the earthquake occurs.

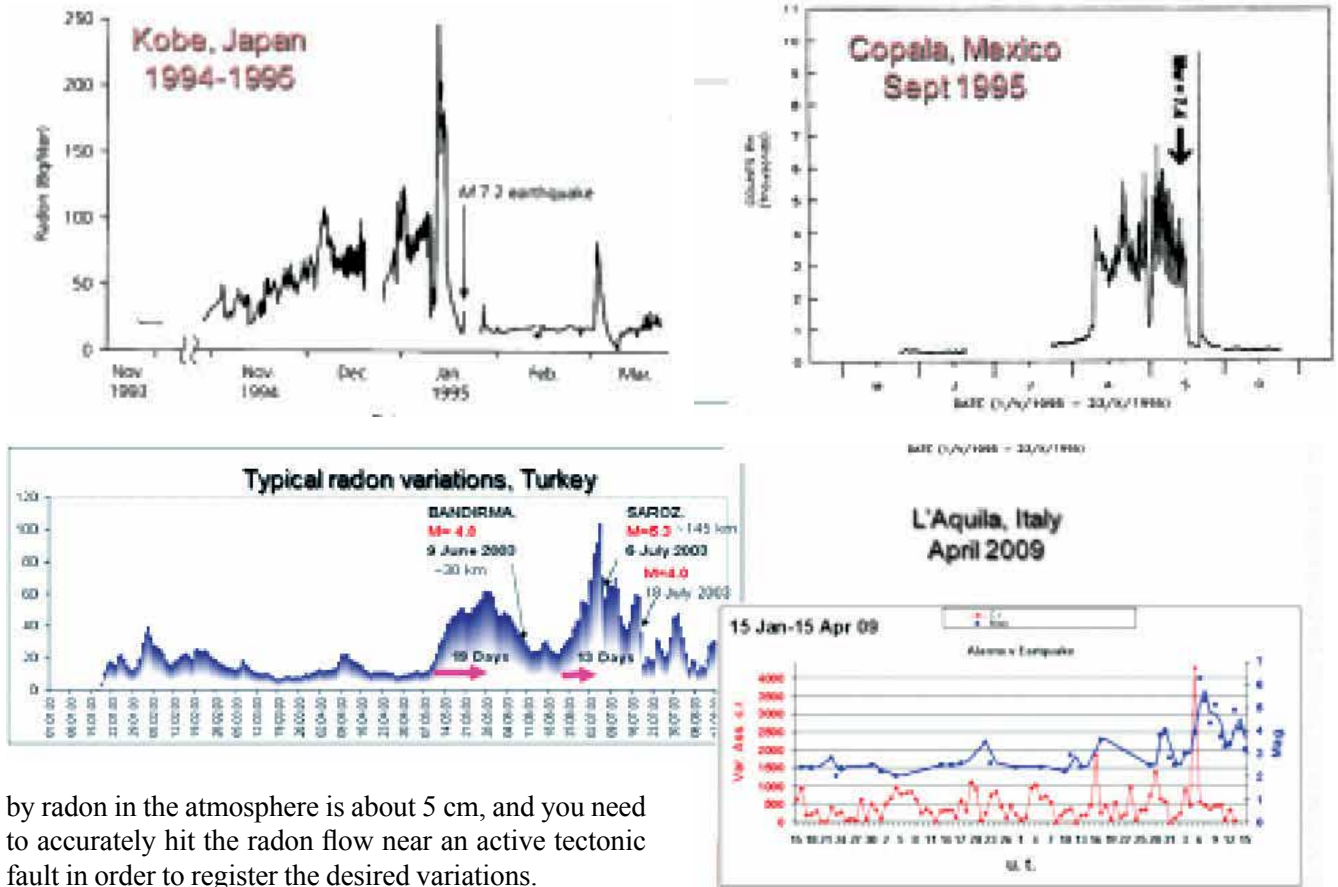
To the right are plotted radon variations before a magnitude 7.4 earthquake in Copala, Guerrero, Mexico, in September 1995. Again, you can see the radon emanation increases, it drops, and then the earthquake occurs.

In the lower left in Figure 3 is plotted a series of earthquakes in Türkiye. Again, the radon levels show the same shape as Kobe and Mexico. In the lower right are charted radon readings preceding the L’Aquila, Italy earthquake in April 2009. The red line shows a sharp drop in radon, and the next day was the earthquake.

It would seem wonderful: measure radon and predict earthquakes. But it turns out not to be as simple as it seems at first glance. A world map showing the distribution of seismic activity (see **Figure 4**) makes it clear that even the richest of the rich countries will not have enough funds to cover its entire territory with radon sensors, given that the range of an alpha particle emitted

FIGURE 3

Typical Radon Variations Before and After Earthquakes

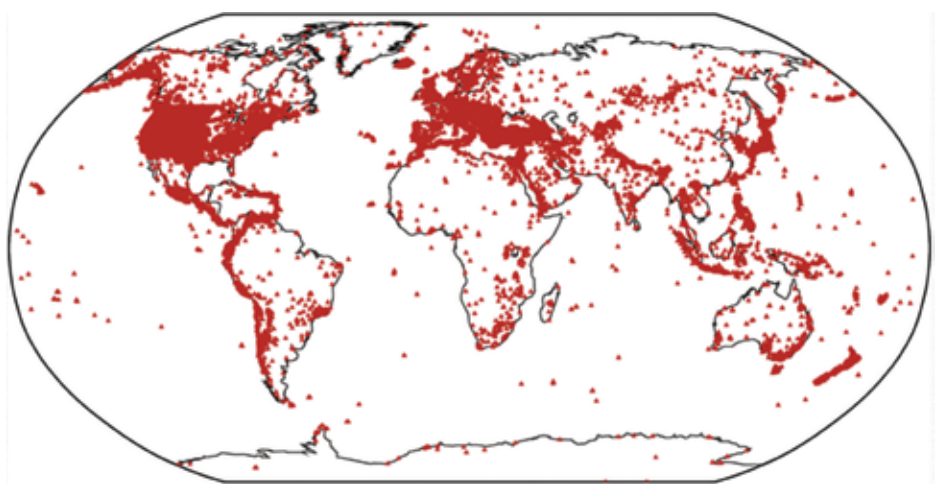


Provided by Sergey Pulinet

by radon in the atmosphere is about 5 cm, and you need to accurately hit the radon flow near an active tectonic fault in order to register the desired variations.

How to solve this problem? We need to find another way to monitor this activity. This is where the ability of radioactivity to produce ionization of atmospheric gases comes to the rescue, due to the high energy of particles emitted by a radioactive substance during decay. The energy of the α -particle emitted by radon is 5.6 MeV. One such particle, only one, creates 3×10^5 electron-ion pairs. And then a process starts, leading to the release of a large amount of heat: Water vapor molecules in the air condense on ions and release the so-called latent heat of vaporization—evaporation and simple condensation. This is the bit of energy that is given to the water molecule when it

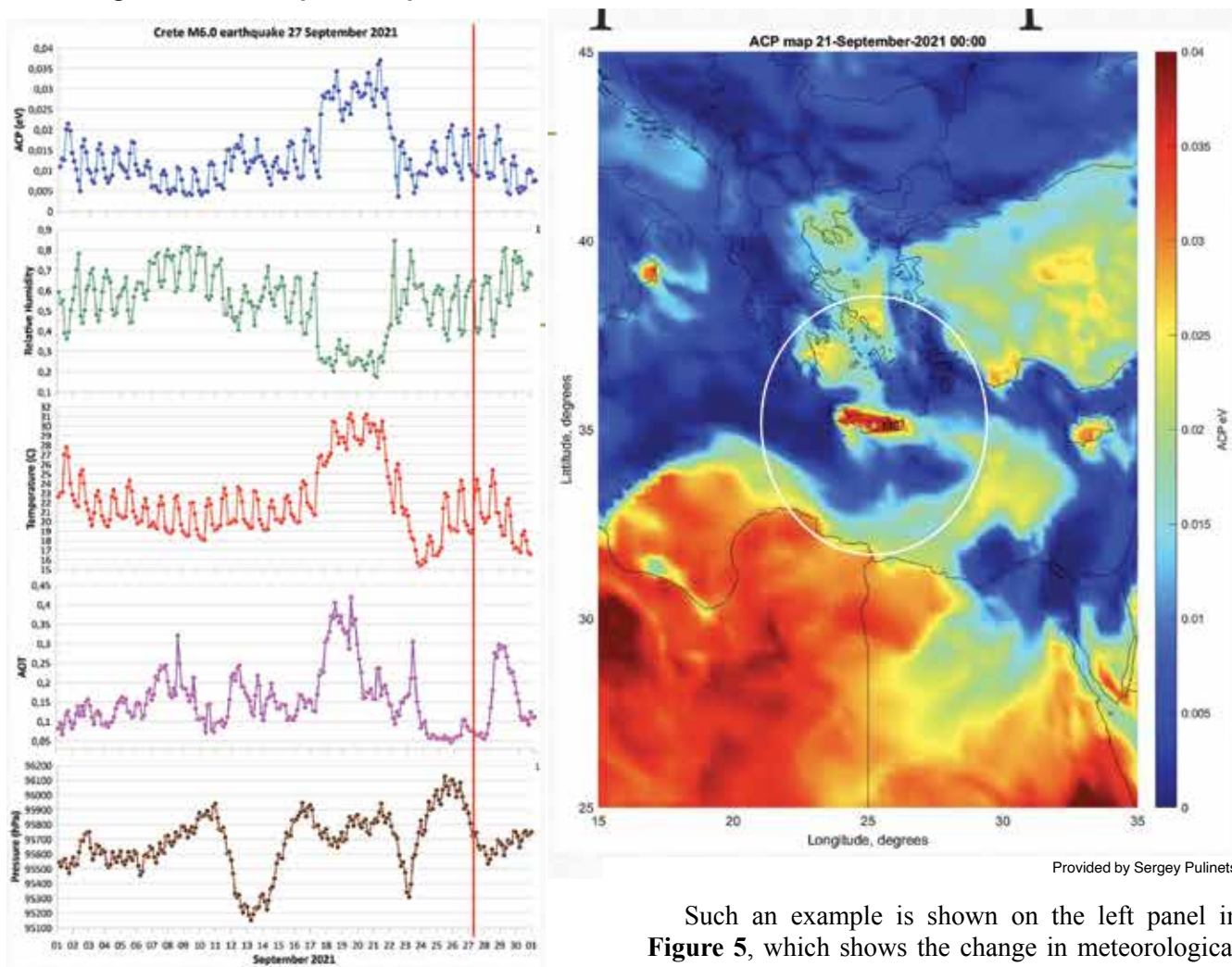
FIGURE 4
Global Distribution of Seismic Activity



Provided by Sergey Pulinet

FIGURE 5

Crete Magnitude 6 Earthquake, September 27, 2021



Provided by Sergey Pulinet

evaporates to make it free and able to float in the air. In this way, in the earthquake preparation zone, areas of increased temperature are created—thermal anomalies—which, with the development of today’s remote sensing technologies, can be recorded from space.

Due to air mixing, these are no longer point anomalies—like radon wells—but large spots, because earthquake preparation zones have diameters of several hundred to thousands of kilometers. For orientation, the radius of the preparation zone for a magnitude 7 earthquake is 1,000 km. The attentive listener will notice that with intensive condensation of water vapor on ions, the relative humidity of the air should decrease, which actually happens. And since the moisture content in the atmosphere decreases, the partial pressure of water vapor decreases, which should also lead to a decrease in pressure.

Such an example is shown on the left panel in **Figure 5**, which shows the change in meteorological parameters before the magnitude 6 earthquake on the island of Crete, September 27, 2021. You can see, over time, the sharp drop in the humidity, a rise in the temperature, and a drop in air pressure. The vertical red line is the moment the earthquake begins.

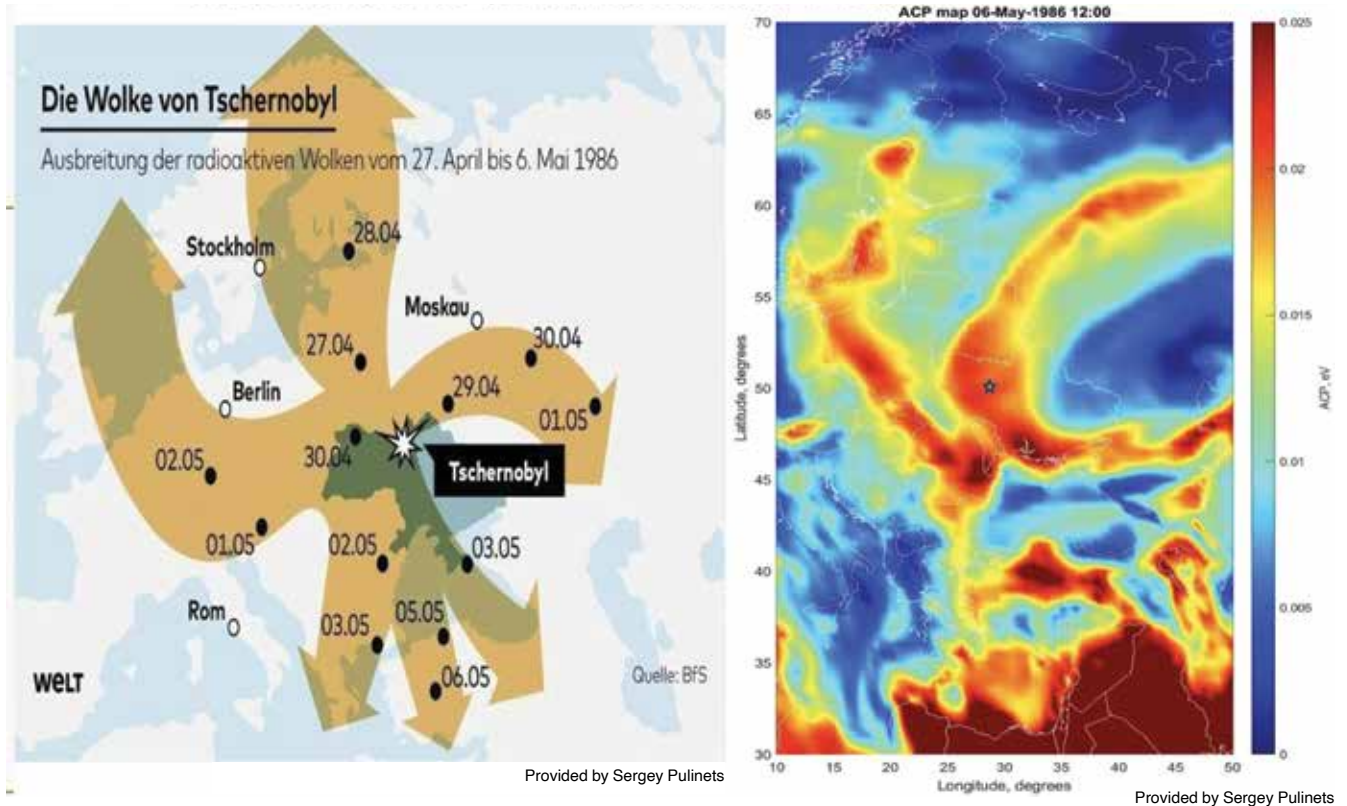
We see anomalies (precursors) appearing near the epicenter more than a week before the earthquake itself. As paradoxical as it sounds, it turns out that earthquakes can be predicted with a thermometer in hand. Further research has shown that simultaneous variations in air temperature and relative humidity can be expressed using an integral parameter, which we called the Atmospheric Chemical Potential (the top curve).

I will not go into further details of its physical nature; I will only say that it estimates the difference in the thermal energy released during the condensation of moisture on ions from the energy released during ordinary condensation.

As with any serious business, there are tricks to

FIGURE 8

Radioactivity from the Chernobyl Accident



The spread of clouds of radioactive Caesium-137 from the Chernobyl nuclear disaster, April 27 to May 6, 1986. The map on the right shows the ionization data; the tiny star marks the power plant's location.

detecting anomalies. The image on the right panel of **Figure 5**, shows a vast red area south of Crete. The climate there is completely different: the temperature is higher and the humidity is lower, but this has nothing to do with the process of preparing an earthquake. In fact, for an accurate assessment of chemical potential anomalies, it is necessary to carry out normalization with respect to weather and climatic conditions in each region. But there is an even smarter approach. Meteorologists, when creating a weather forecast, do not know if radon has been released in this area, and that there will be a sudden rise in temperature and decrease in humidity (for them this is an unpredictable and unexpected anomaly). Therefore, if we subtract from our calculations what is predicted by the weather forecast, we can more clearly distinguish the distribution of the Atmospheric Chemical Potential (ACP).

Such an operation was carried out for the period of preparation a few days before the M5.8 earthquake on April 23, 2022 near the Kuril Islands. Completely fresh results.

The consequence of ionization is also a change in

the electrical properties of the troposphere above the earthquake preparation zone, which leads to changes in the difference in electrical potential between the surface of the Earth and the ionosphere. As a result, positive and negative electron concentration anomalies are formed above the preparation area, which can also be recorded using artificial Earth satellites. The fact that ionospheric anomalies are a regularly fixed phenomenon between earthquakes is proved by the similarity of anomalies recorded over a 57-year interval over Alaska: in 1964 before one of the strongest earthquakes in history; and in 2021 before the M8.2 earthquake of July 29, 2021....

It is also important to note that the mechanism of the impact of ionization on the Earth's atmosphere is universal; it also works in cases where it is not radon that is the source of ionization, but, for example, radioactive contamination in the event of an accident at a nuclear power plant. Everyone remembers the enormous environmental damage caused by the accident at the Chernobyl nuclear power plant.

Figure 8, a map prepared during the Chernobyl

accident, shows how we were able to monitor the radioactive pollution. We got data showing how it looked in reality.

The Interaction of Geospheres in Hurricane Formation

In the final scene on our voyage, I would like to introduce one additional idea of Vernadsky's—what is called the interaction, or coupling, of geospheres demonstrating the effects of the galactic cosmic rays on our environment, especially in the formation of hurricanes.

There is an interaction of interstellar space, where galactic cosmic rays are born, with the heliosphere, which determines the flux intensity modulation of the galactic cosmic rays. Coronal mass ejections from the Sun increase the interplanetary plasma density, which creates a geomagnetic storm. Earth's magnetosphere then deflects the cosmic rays that ionize atmospheric gases, which in turn cause the "Forbush Decrease," and, finally, ocean-atmosphere interactions through convection.

We have, then, a coupling of six different geospheres—all this is our life and all this was predicted by the ideas of Academician Vladimir Vernadsky:

- Interstellar space—where galactic cosmic rays are born
- Heliosphere—determines the flux intensity of galactic cosmic rays
- Sun—coronal mass ejections increase the interplanetary plasma density
- Magnetosphere—deflects the cosmic rays
- Atmosphere—ionization of atmospheric gases, temperature decreases during Forbush events
- Ocean-atmosphere interaction through convection.

Coupling of Geospheres Generates Hurricanes

Established first by Russian physicists, and then experimentally confirmed by Scandinavian scientists, galactic cosmic ray fluxes are partly responsible for the formation of clouds over our planet. What are galactic cosmic rays? They are fluxes of very energetic

(up to 10^{21} eV) particles, mainly protons, produced in the galactic depths during supernova explosions. They come from all directions and enter Earth's atmosphere. In the atmosphere, they ionize atmospheric gas molecules, on which water molecules land, forming condensation centers, and, ultimately, clouds. They also generate secondary energetic particles, as a result of which the so-called particle showers are formed. Galactic cosmic rays suffer the greatest energy losses at the tropopause altitude (12-16 km), giving up most of their energy there, and, accordingly due to the ionization effect, cause the condensation of water on ions, and the release of latent heat.

Galactic cosmic rays entering Earth's troposphere heat it up, but during geomagnetic storms, the flux is reduced in what is termed the "Forbush Decrease," a lowering of the temperature after a rapid decrease in cosmic ray intensity following a coronal mass ejection due to the magnetosphere's deflection of those cosmic rays away from Earth.

Just before Hurricane Katrina, there was a geomagnetic storm. During geomagnetic storms, the Earth's magnetosphere is compressed and deformed under the pressure of the solar wind, which leads to a deflection of the trajectory of galactic cosmic rays, the result of which is that their flux into the atmosphere decreases. This is exactly what happened in the few days that Hurricane Katrina formed. The effect of a decrease in the flux of galactic cosmic rays due to a geomagnetic storm is the Forbush Decrease.

The flux of the galactic cosmic rays dropped, which led to a drop in the temperature in the troposphere by 9°C . The temperature difference between the troposphere and the ocean surface increased by 9°C , which increased the vertical convection, leading to intensification of the hurricane.

Many more examples could be cited showing the development and confirmation of Vernadsky's ideas, but our journey is coming to an end.

Thank you for your attention. I hope it was interesting for you to accompany me in it, and I would like to wish you new discoveries on the way to understanding our very beautiful world. Let us continue our seminar.