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The Next Scientific Frontier: Sun-Earth Interactions

By Washington's Blog
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Quantum computing, nanotechnology and genetic engineering are exciting fields. But understanding the interaction between the Sun and Earth is at least as important as a scientific frontier.

The Sun Affects Clouds and Ozone, Which In Turn Affect Climate

For example, one of the world's most prestigious science labs has just demonstrated that cosmic rays affect cloud formation – which in turn affects climate – on Earth. Because the sun's output directly determines the amount of cosmic rays which reach the Earth, the sun is an important driver of the Earth's climate.

And as I noted last year:

> Intense solar activity can destroy ozone in the Earth's atmosphere, thus affecting climactic temperatures. See this, this, this and this. Indeed, the effects of solar energy on ozone may be one of the main ways in which the sun influences Earth's climate.

The Sun's Output Changes the Rate of Radioactive Decay On Earth

Believe it or not, Stanford University News reported Tuesday that solar flares change the rate of radioactive decay of elements on Earth:

> When researchers found an unusual linkage between solar flares and the inner life of radioactive elements on Earth, it touched off a scientific detective investigation that could end up protecting the lives of space-walking astronauts and maybe rewriting some of the assumptions of physics.
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> The radioactive decay of some elements sitting quietly in laboratories on Earth seemed to be influenced by activities inside the sun, 93 million miles away.
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> Is this possible?
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> Researchers from Stanford and Purdue University believe it is. But their explanation of how it happens opens the door to yet another mystery.
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> There is even an outside chance that this unexpected effect is brought about by a previously unknown particle emitted by the sun. "That would be truly remarkable," said Peter Sturrock, Stanford professor emeritus of applied physics and an expert on the inner workings of the sun.

The story begins, in a sense, in classrooms around the world, where students are taught that the rate of decay of a specific radioactive material is a constant. This concept is relied upon, for example, when anthropologists use carbon-14 to date ancient artifacts and when doctors determine the proper dose of radioactivity to treat a cancer patient.

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As the researchers pored through published data on specific isotopes, they found disagreement in the measured decay rates – odd for supposed physical constants.

Checking data collected at Brookhaven National Laboratory on Long Island and the Federal Physical and Technical Institute in Germany, they came across something even more surprising: long-term observation of the decay rate of silicon-32 and radium-226 seemed to show a small seasonal variation. The decay rate was ever so slightly faster in winter than in summer.

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On Dec 13, 2006, the sun itself provided a crucial clue, when a solar flare sent a stream of particles and radiation toward Earth. Purdue nuclear engineer Jere Jenkins, while measuring the decay rate of manganese-54, a short-lived isotope used in medical diagnostics, noticed that the rate dropped slightly during the flare, a decrease that started about a day and a half before the flare.

If this apparent relationship between flares and decay rates proves true, it could lead to a method of predicting solar flares prior to their occurrence, which could help prevent damage to satellites and electric grids, as well as save the lives of astronauts in space.

The decay-rate aberrations that Jenkins noticed occurred during the middle of the night in Indiana – meaning that something produced by the sun had traveled all the way through the Earth to reach Jenkins' detectors. What could the flare send forth that could have such an effect?

Jenkins and Fischbach guessed that the culprits in this bit of decay-rate mischief were probably solar neutrinos, the almost weightless particles famous for flying at almost the speed of light through the physical world – humans, rocks, oceans or planets – with virtually no interaction with anything.

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Going back to take another look at the decay data from the Brookhaven lab, the researchers found a recurring pattern of 33 days. It was a bit of a surprise, given that most solar observations show a pattern of about 28 days – the rotation rate of the surface of the sun.

The explanation? The core of the sun – where nuclear reactions produce neutrinos – apparently spins more slowly than the surface we see. "It may seem counter-intuitive, but it looks as if the core rotates more slowly than the rest of the sun," Sturrock said.

All of the evidence points toward a conclusion that the sun is "communicating" with radioactive isotopes on Earth, said Fischbach.

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"It doesn't make sense according to conventional ideas," Fischbach said.

> Jenkins whimsically added, "What we're suggesting is that something that doesn't really interact with anything is changing something that can't be changed."
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> "It's an effect that no one yet understands," agreed Sturrock. "Theorists are starting to say, 'What's going on?' But that's what the evidence points to. It's a challenge for the physicists and a challenge for the solar people too."
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> If the mystery particle is not a neutrino, "It would have to be something we don't know about, an unknown particle that is also emitted by the sun and has this effect, and that would be even more remarkable," Sturrock said.

The Sun Interacts With the Earth In Numerous Other Ways

I pointed out last year that the sun affects the Earth in many more ways than scientists knew:

> The sun itself also affects the Earth more than previously understood. For example, according to the European Space Agency:
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>> Scientists … have proven that sounds generated deep inside the Sun cause the Earth to shake and vibrate in sympathy. They have found that Earth's magnetic field, atmosphere and terrestrial systems, all take part in this cosmic sing-along.

And NASA has just discovered that "space weather" causes "spacequakes" on Earth:

> Researchers using NASA's fleet of five THEMIS spacecraft have discovered a form of space weather that packs the punch of an earthquake and plays a key role in sparking bright Northern Lights. They call it "the spacequake."
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> A spacequake is a temblor in Earth's magnetic field. It is felt most strongly in Earth orbit, but is not exclusive to space. The effects can reach all the way down to the surface of Earth itself.
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> "Magnetic reverberations have been detected at ground stations all around the globe, much like seismic detectors measure a large earthquake," says THEMIS principal investigator Vassilis Angelopoulos of UCLA.
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> It's an apt analogy because "the total energy in a spacequake can rival that of a magnitude 5 or 6 earthquake," according to Evgeny Panov of the Space Research Institute in Austria.
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> "Now we know," says THEMIS project scientist David Sibeck of the Goddard Space Flight Center. "Plasma jets trigger spacequakes."
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> According to THEMIS, the jets crash into the geomagnetic field some 30,000 km above Earth's equator. The impact sets off a rebounding process, in which the incoming plasma actually bounces up and down on the reverberating magnetic field. Researchers call it "repetitive flow rebuffing." It's akin to a tennis ball bouncing up and down on a carpeted floor. The first bounce is a big one, followed by bounces of decreasing amplitude as energy is dissipated in the carpet.

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> "When plasma jets hit the inner magnetosphere, vortices with opposite sense of rotation appear and reappear on either side of the plasma jet," explains Rumi Nakamura of the Space Research Institute in Austria, a co-author of the study. "We believe the vortices can generate substantial electrical currents in the near-Earth environment."
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> Acting together, vortices and spacequakes could have a noticeable effect on Earth. The tails of vortices may funnel particles into Earth's atmosphere, sparking auroras and making waves of ionization that disturb radio communications and GPS. By tugging on surface magnetic fields, spacequakes generate currents in the very ground we walk on. Ground current surges can have profound consequences, in extreme cases bringing down power grids over a wide area.

What does this mean?

Some allege that spacequakes cause actual, physical earthquakes on Earth. I have no idea whether or not that is true.

The above-quoted NASA article concludes with a poem which implies such a connection:

> Vortices swirl
> plasma a'twirl
> Richter predicts
> a magnitude six

However, the poem may use artistic license rather than scientific rigor.

What is certain is that the science of the affect of space events on Earth is in its infancy, and that there are many fascinating discoveries in our future.And I wrote in May:

> Mitch Battros theorized in 1998 that large solar flares affect Earth's magnetic field, which in turn shifts the oceanic and atmospheric currents, which can cause earthquakes and extreme weather. As Battros summarizes his formula:
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> > Sunspots => Solar Flares (charged particles) => Magnetic Field Shift => Shifting Ocean and Jet Stream Currents => Extreme Weather and Human Disruption
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> While this may sound crazy, Battros' theories have been endorsed to one degree or another by:
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> - Dr. Ernest Hildner, Director NOAA Space Weather Center
> - Dr. Tom Van Flandern, former US Naval Observatory Chief of Celestial Mechanics
> - Dr. Stefaan Poedts: Lead Scientist University of Leuven Center for Plasma Astrophysics

- Dr. Ronald van der Linden, Director of Solar Physics Department of the Royal Observatory
- Dr. Pål Brekke, Deputy Director of SOHO project- European Space Agency

When scientists understand all of the ways that the Sun and Earth interact, we will know alot more about the Earth and our place in the universe than we do today.

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