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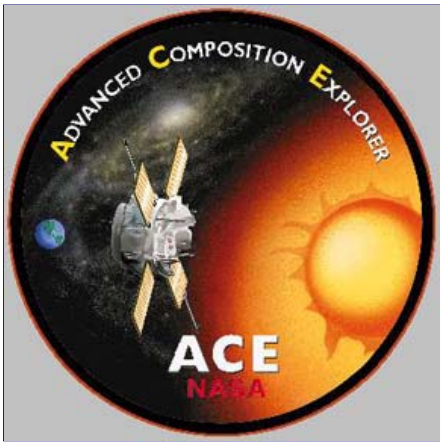
How Long Will Our Sun Remain Quiet and Cosmic Rays Increase?

"We don't have records prior to 1874 that give us details about the sun. Compared to the past 130 years, our sun now is unprecedented as far as how slow this Solar Cycle 24 is taking off - or not taking off!"
- David Hathaway, Ph.D., NASA Heliospheric Team Leader

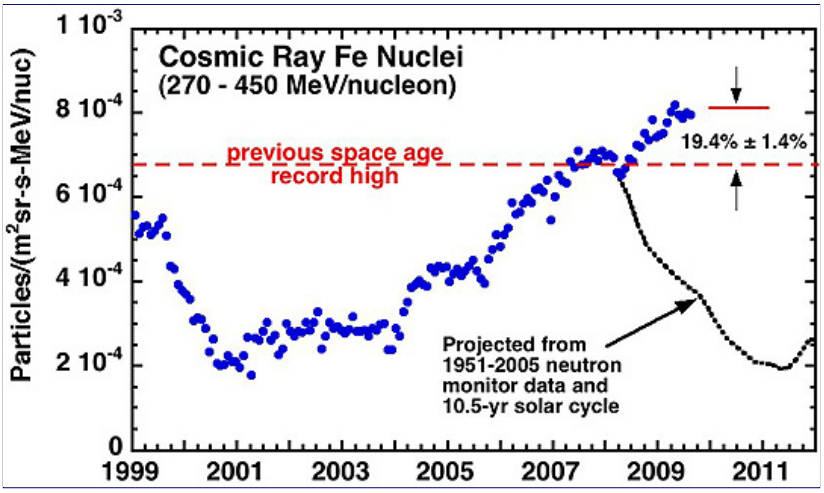


NASA'S Advanced Composition Explorer satellite (ACE) launched August 1997 to study solar particles and galactic cosmic rays. It has nine instruments onboard that helps it track solar wind and galactic cosmic rays from interstellar space beyond the heliosphere. ACE serves as a space weather station while in orbit. ACE can provide a one-hour advance warning of any geomagnetic storms that are caused by coronal mass ejections. Strong solar coronal mass ejections can disrupt radio, TV and telephone communications on Earth. Logo by NASA.

October 30, 2009 Huntsville, Alabama - For twelve years, NASA has had a satellite positioned a million miles in front of Earth with the sun about 92 million miles beyond. Its mission has been to study particles that come near Earth from our sun, the solar system and the galaxy. The satellite is called Advanced Composition Explorer, or ACE, and some of the highly energetic particles ACE has been monitoring are cosmic rays.

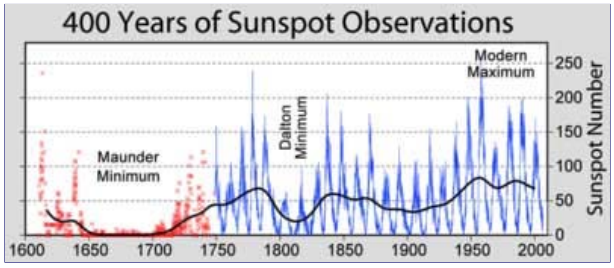
The number of cosmic rays reaching Earth are lower when the sun is active and has a strong, turbulent magnetic field that interferes with cosmic ray travel. But when the sun is not active, more cosmic rays reach Earth. The sun is supposed to be in an increasingly active period of Solar Cycle 24 with a solar maximum originally expected in 2011 to 2012. But the sun has been abnormally quiet. Scientists have not seen such a persistently low sunspot number for at least a century. Further, the magnetic field of the sun is at the lowest strength measured in at least 50 years.

Beginning six months ago, ACE satellite data showed a rise in cosmic rays reaching Earth from the Milky Way galaxy. By now, cosmic ray intensity has increased 19% because our sun is so quiet that its reduced magnetic field isn't deflecting cosmic rays like it has the past few decades. If our sun remains quiet, there could be a 30% increase in cosmic rays reaching Earth in the next year or so – an intensity not seen since 1960. Increased cosmic rays can damage electronic systems and even DNA in living creatures.



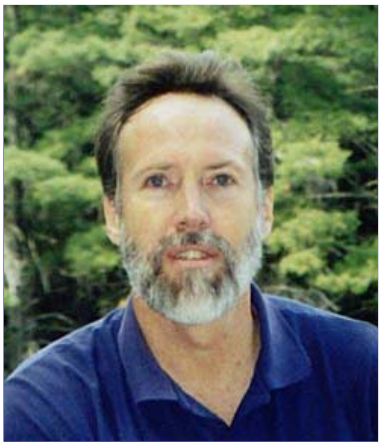
Galactic cosmic ray intensities are 19% higher for all elements in last half of 2009. Graphic by Richard Mewaldt, Cal Tech.

What has happened to our sun? NASA's Heliospheric Team Leader, David Hathaway, says he cannot find another solar minimum in the past that has acted quite like this one that has put out only a few sunspots since Solar Cycle 24 officially began at the end of 2008. Our sun is so quiet that solar physicists from around the world gathered in September to discuss whether we are entering a period similar to the Maunder Minimum of 1645 to 1715, when for 70 years the sun was spotless and there was a mini-ice age. There was no ACE satellite then, but measurements of beryllium concentrations in ice layers indicate that during the Maunder Minimum, cosmic rays were 2.5 times what they are now. Dr. Hathaway points out that Earth scientists did not start measuring cosmic rays until the beginning of the modern Space Age in the early 1960s, and that for the past five decades, our sun might have been unusually active. Also see: **100609Earthfiles**



Between 1645 and 1715, the Maunder Minimum coincided with a period of lower-than-average global temperatures. During one 30-year period within the Maunder Minimum, astronomers observed only about 50 sunspots, as opposed to a more typical 40,000–50,000 sunspots in modern times. Graphic by NASA.

Interview:



David Hathaway, Ph.D., NASA Heliospheric Team Leader

David Hathaway, Ph.D., Heliospheric Team Leader, NASA Marshall Space Flight Center, Huntsville, Alabama: "In the 50 years or so we've been making the (cosmic ray) measurements – yeah! this is by far the highest level of galactic cosmic rays that we're seeing at Earth and we know exactly what is causing it. It's the sun's weakened magnetic fields and weakened solar winds that are all related to this Solar Cycle 24 minimum.

Beryllium is produced in the Earth's upper atmosphere by cosmic rays striking nitrogen in particular and you find it in ice cores. If you look back at the record, there are significant changes. But, the amount that you see also depends on the strength and variations of the Earth's magnetic field.

Periods like the Maunder Minimum occupy about 15% of the time. If you looked over thousands of years of Beryllium 10, it looks like 15% of the time, the sun is in this quiet state where it's not producing sunspots. Given that, we're about due. And I think that's what comes up and why people are actively talking about grand minima like the Maunder Minimum is that if you go by percentages and the fact it has been so active, then we're about due (for a long minimum).

We don't have records prior to 1874 that give us details about the sun. Compared to the past 130 years, our sun now is unprecedented as far as how slow this Solar Cycle 24 is taking off - or not taking off!

Understanding the Peculiar 2008 - 2009 Solar Minimum

The number of days in 2009 without sunspots as of October 29, was 232, or 77% of the time the sun was blank.

WHEN YOU GET TOGETHER NOW WITH YOUR SOLAR AND HELIOSPHERIC COLLEAGUES, DO YOU TALK ABOUT WHAT THE ODDS ARE RIGHT NOW THAT WE COULD BE GOING INTO ANOTHER MAUNDER MINIMUM?

It comes up in conversations all the time! (laughs) There is no doubt about it - it's in the back of our minds!

Certainly the Maunder Minimum comes up. We recently had a meeting of 60 or 70 solar and heliospheric physicists from around the world who met on Mount Desert Island in Maine back in late September.

September 2009 gathering of solar and heliospheric physics from around the world on Mount Desert Island, Maine, to discuss "Understanding the Peculiar Solar Minimum."

The title of the meeting was "Understanding the Peculiar Solar Minimum" – meaning this one! (laughs) The interesting thing is that at one point during that meeting, we took a vote amongst ourselves about how many thought that this Solar Cycle 24 is so peculiar that it would have a name attached to it, like Maunder Minimum or Dalton Minimum. It was a small minority that thought that it was that peculiar.

The vast majority felt that this is a significant minimum. It's smaller than anything we have seen in the 50 years of the Space Age. But it does look like you can go back 100 years or so and find other similar minima.

Now, science is not done by voting! (laughs) So, it remains to be seen about what actually does happen in this Solar Cycle 24.

These were some of the world's experts in these areas that concluded – yes, this is a deep solar minimum, but at this point, we're not quite ready to say this is so weird that we need to give a name to it – that it's something we haven't seen in 200 years.

HOW DID YOU VOTE?

I didn't think it was that peculiar. The only peculiar thing I see about it is that it's so reluctant to get going.

Others are talking about the cosmic rays are through the roof. The number of spotless days is more than we've seen in a hundred years. The sun's poles are weaker than we've seen in 30 years. Boy! We have a lot of things we'd like to do that require sunspots on the sun to help us understand how the sun and solar activity work. And without sunspots, we're kind of shut down! (laughs)

And we also know that at some point, the sun is going to go into another minimum like the

Maunder Minimum, but predicting when – I'm not sure I'm ready to go out on that limb. (laughs)

What Happened to 2006 Predictions of Huge Solar Cycle 24?

ISN'T IT ESPECIALLY STRANGE FOR YOU BECAUSE THREE YEARS AGO, ALL THE PHYSICS OF THE SUN THAT YOU AND NASA AND EVERYBODY ELSE WAS USING WERE ANTICIPATING THAT THIS COULD BE THE BIGGEST SOLAR MAXIMUM ON RECORD?

There were indications back then. I am writing a paper – it's on my computer as we speak (laughs) – basically saying that I made a big mistake – myself and Bob Wilson – when we wrote a paper in 2006, suggesting Solar Cycle 24 was going to be a huge cycle based on conditions at that time. The problem we had with our prediction was that it was based on a method that assumes that we're near sunspot cycle minimum.

We had just previously gone through three or four sunspot cycles that had been only ten years long each, so for the one in 1996 to 2006, it seemed like a reasonable assumption. But as we now know, we were off by at least two years. And if we take conditions on the sun now, it's a completely different story. The conditions now – using even that same technique from 2006 – says that the next sunspot cycle is going to be half what we thought it was back in 2006.

Another big prediction in 2006 was based on a dynamo model – a model for how the sun produces magnetic fields - and it suggested a huge cycle.

But there also were people back at that time saying otherwise. A group of colleagues led by Leif Svalgaard, Ph.D., were looking at the sun's polar fields and saying even at that point, the sun's polar fields were significantly weaker than they had been before and those scientists back then predicted it was going to be a small cycle.

How Small Will Solar Cycle 24 Be?

Sunspot 1029, a Solar Cycle 24 magnetic disturbance, grew from October 24 to 29 and has reached about 32,000 miles (50,000 kilometers) end-to-end as it heads around to the back side of the sun. According to Spaceweather.com, the number of days in 2009 without sunspots as of October 29, was 232, or 77% of the time our sun was blank. Image courtesy SOHO/MDI.

I've come around to that view now. I think there is little doubt in my mind now that we're in for a small cycle. The big question now is how small? I think most of us are predicting small cycles. I think even the techniques I'm using now are suggesting HALF the size of the last three or four solar cycles, but my fear is that even that might be too big just from the fact that it's taken so long for this Solar Cycle 24 to really get off the ground and start producing sunspots.

I have no doubt at this point that it's going to be a little cycle. My current prediction is that it's going to be about half of what we've seen in the last four solar cycles or so. But in my gut, I feel it's going to be smaller than that! (laughs) It's just so slow in taking off and the indicators that we see – both the polar fields and the geomagnetic indicators are lower than anything we've seen before.

No More 2012 Solar Maximum for Cycle 24?

ISN'T IT IRONIC THAT THERE HAS BEEN ALL THIS ANTICIPATION OF 2012 BECAUSE OF THE CLOSING DOWN OF THE MAYAN CALENDAR AND THE EXPECTATION THAT POSSIBLY SOMETHING ON OR FROM THE SUN OR RELATED TO THE SUN MIGHT IMPACT THE EARTH DURING SOME LARGE SOLAR MAXIMUM IN 2012. BUT RIGHT NOW, DOES IT SEEM LIKE THE SUN WILL BE ESPECIALLY QUIET IN 2012?

Indeed. In fact, when we came out with the prediction of a big cycle back in 2006, I got lots of emails from folks. If it was going to be such a big cycle, it should have started in 2006 so by 2012, it ought to be at its peak.

And at this point, it looks like, 'No, I don't think so!' (laughs) Not at all! I think it's going to be a small peak and it's not going to be in 2012. It's going to be in 2013. So, I think any connection that people might try to make between solar activity and the end of the Mayan calendar cycle is problematic.

IN FACT, IN 2012, THE SUN MIGHT BE THE QUIETEST IT HAS BEEN AT A SOLAR MAXIMUM FOR 130 OR MORE YEARS?

Yes, indeed! It might be. The Mayans never said there were going to be disasters. It's just that it's the end of that cycle and you start another one.

IS IT FAIR TO SAY THAT THE SUN IS BOTH PECULIAR AND UNPREDICTABLE?

Yeah, I'd buy that! (laughs) Most definitely!

Our Variable Sun

WHICH IS KIND OF EERIE FOR EARTH LIFE DEPENDENT ON THAT SUN.

Yeah, the good thing is that when you look at what we really depend upon, which is the radiant energy from the sun – even over the full extent of the sunspot cycle, that only varies by 1/10th of 1%. So, we're lucky in that regard. It's a small change. If it were big, I think in terms of evolution, we wouldn't be here talking about it. But the fact is when it comes to variable stars, our sun's variability is tiny. Any big solar variations could really wreak havoc on our climate and survivability.

Our Middle Age Sun Is Getting Brighter

In fact, in the much longer picture looking over billions of years, the sun is getting brighter. The sun now is some 30% brighter as far as the energy it puts out than it was 3.5 or 4 billion years ago. This is just part of how stars work. As they burn up the hydrogen in the core to make helium, the core starts to collapse a bit and heat up and that expands the outer layers and makes the sun brighter.

IN THE EVER-INCREASING BRIGHTNESS OF OUR SUN, IT IS HEADED TO BECOMING A RED GIANT AT ITS DEATH, ISN'T IT?

Yeah – we've got a long time to wait for that – another 4.5 to 5 billion years! But the sun is quite erratic and really hard to predict. I know from very personal experience!" (laughs)

Solar scientists are trying to understand how changes in sunspot activity and other solar events can affect Earth in ways that are indirect, but can have a significant impact. Image courtesy NCAR.

For further information about our sun, solar system and galaxy, please see **Earthfiles Archive** (partial list below):

- 10/06/2009 — Cosmic Rays Reaching Earth At Highest Level in 50 Years
- 07/11/2009 — Update Podcast: Is Sudden Solar Intensity of July 5 - 7 What U.K. Spring Crop Formations Forecast for Oddly Quiet Sun?
- 05/12/2009 — Part 3: Astronomical Information in U.K. 2009 Crop Formations?
- 05/02/2009 — Long Minimums Usually Mean Weaker Maximums, But Sun Could Still Have Big X-Flares in 2011 to 2012
- 04/30/2009 — Part 2: First 2009 U. K. Crop Formations Counting Down to 2012?
- 04/07/2009 — Longest Solar Minimum Since 1913
- 09/23/2008 — Solar Wind Pressure Lowest in 50 Years
- 08/29/2008 — Still No Sunspot Action on the Sun
- 01/10/2008 — Solar Cycle 24 Has Begun
- 08/08/2007 — 2007's Warm, Erratic Global Weather
- 07/11/2007 — Mystery of Night Shining Clouds - Another Global Warming Change?
- 06/21/2007 — Large Lake in Southern Chile Has Disappeared
- 06/01/2007 — Is Earth Close to Dangerous Tipping Point in Global Warming?
- 02/23/2007 — Scientists Hope "Amphibian Arks" Can Save Frogs and Toads
- 01/13/2007 — Confusing Sun: Will Solar Cycle 24 Be Most Intense On Record?
- 01/10/2007 — 2006: USA's Warmest Year On Record
- 12/07/2006 — Earth Headed for Warmest Period in 55 Million Years?
- 09/09/2006 — Methane - Another Threat in Global Warming
- 08/23/2006 — Solar Cycle 24 - Headed for Intense X Flares by 2010-2012?
- 07/18/2006 — 2006 - Hottest Year So Far in U. S. History
- 11/18/2005 — Is the Sun Heating Up?
- 09/23/2005 — 9 X-Class Solar Flares Between September 7 - 19, 2005.
- 03/20/2005 — Astronaut John Young: "The Moon Can Save Earth's Civilization."
- 02/11/2005 — Sunspot Region 720 Emitted Strongest Solar Radiation Since October 1989.
- 10/29/2003 — Fifth Intense Solar X-Flare - What's Happening On the Sun?
- 09/07/2001 — Black Hole At Center of Milky Way - More Evidence
- 10/25/1999 — A Blast of Solar Wind Provokes Aurora Over Northern U. S.

Websites:

Advanced Composition Explorer: **http://www.windows.ucar.edu/tour/link=/space_missions/aceindex.html**

SOHO: **http://sohowww.nascom.nasa.gov/**

Spaceweather.com: **http://www.spaceweather.com/**

National Center for Atmospheric Research, Sun & Space Weather: **http://www.ncar.ucar.edu/research/sun/**

Space Weather: **http://www.windows.ucar.edu/tour/link=/space_weather/space_weather.html**

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