NEWS

Scientists Gaze Inside Sun, Predict Strength of the Next Solar Cycle **03.06.06**

The next solar activity cycle will be 30 to 50 percent stronger than the previous one, and up to a year late in arriving, according to a breakthrough forecast by Dr. Mausumi Dikpati and colleagues at the National Center for Atmospheric Research (NCAR) in Boulder, Colo. The scientists made the first "solar climate" forecast using a combination of groundbreaking observations of the solar interior from space and computer simulation. NASA's Living With a Star program and the National Science Foundation funded the research.

Image right: These three images show the incredible changes in the Sun's atmosphere (corona) from near solar minimum (left panel) to near solar maximum (right panel). They are false-color images taken with SOHO's Extreme-ultraviolet Imaging Telescope. Credit: NASA and the European Space Agency.

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SOHO movie comparing quiet sun to active sun

The sun goes through a roughly 11-year cycle of activity, from stormy to quiet and back again. Predicting the sun's cycles accurately years in advance will help societies plan for active bouts of solar storms, which can disrupt satellite orbits and electronics, interfere with radio communication, and damage power systems. The forecast is important for NASA's long-term Vision for Space Exploration plans, since solar storms can be hazardous to unprotected astronauts as well.

Solar storms begin with tangled magnetic fields generated by the sun's churning electrically charged gas (plasma). Like a rubber band that has been twisted too far, solar magnetic fields can suddenly snap to a new shape, releasing tremendous energy as a solar flare or a coronal mass ejection (CME).

Solar flares are explosions in the sun's atmosphere, with the largest equal to billions of one-megaton nuclear bombs. Solar magnetic energy can also blast billions of tons of plasma into space at millions of miles (kilometers) per hour as a CME. This violent solar activity often occurs near sunspots, dark regions on the sun caused by concentrated magnetic fields. Sunspots and stormy solar weather follow the eleven-year cycle, from few sunspots and calm to many sunspots and active, and back again.

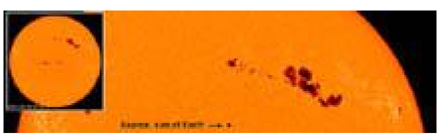

Image left: This is a false-color image of a huge sunspot group in active region 9393 as seen by SOHO's Michelson Doppler Imager instrument. On 30 March 2001, the sunspot area within the group spanned an area more than 13 times the entire surface of the Earth. Caused by intense magnetic fields emerging from the interior, a sunspot appears to be dark only when contrasted against the rest of the solar surface, because it is slightly cooler than the unmarked regions. Credit: NASA and the European Space Agency.

print-resolution copy (1.6 meg tif image)

movie of a different sunspot group taken with the TRACE satellite

Key to predicting the solar activity cycle is an understanding of the flows of plasma in the sun's interior. Magnetic fields are "frozen" into the solar plasma, so plasma currents within the sun transport, concentrate, and help dissipate solar magnetic fields. "We understood these flows in a general way, but the details were unclear, so we could not use them to make predictions before," said Dikpati, who published a paper on this research in the on-line version of Geophysical Review Letters March 3.

The new technique of "helioseismology" revealed these details by allowing researchers to see inside the sun. Helioseismology traces sound waves reverberating inside the sun to build up a picture of the interior, similar to the way an ultrasound scan is used to create a picture of an unborn baby.

Two major plasma flows govern the cycle. The first acts like a conveyor belt: deep beneath the surface, plasma flows from the poles to the equator. At the equator, the plasma rises and flows back to the poles, where it sinks and repeats. The second flow acts like a taffy pull: the surface layer of the sun rotates faster at the equator than it does near the poles. Since the large-scale solar magnetic field crosses the equator as it goes from pole to pole, it gets wrapped around the equator, over and over again, by the faster rotation there. This is what periodically concentrates the solar magnetic field, leading to the peaks in solar storm activity. Solar fireworks in the form of flares and CMEs dissipate some of the magnetic field, and the remnants are carried toward the poles by the conveyor belt flow. This becomes the input for the next cycle.

"Precise helioseismic observations of the 'conveyor belt' flow speed by the Michelson Doppler Imager instrument on board the Solar and Heliospheric Observatory gave us a breakthrough," said Dikpati. "We now know it takes two cycles to fill half the belt with magnetic field – the part where it sinks at the poles and flows toward the equator, reaching mid-latitudes – and another two cycles to fill the other half – from the bottom at mid-latitudes, then rising at the equator and flowing toward the poles again. Because of this, the next solar cycle depends on characteristics from as far back as 40 years previously -- the sun has a magnetic 'memory'."

The magnetic data input comes from the SOHO/MDI instrument and historical records. To test the model, the researchers took magnetic data from the past eight solar cycles and fed it to the computer, and the results matched actual observations over the last 80 years. The team then added current magnetic data and ran the model ahead ten years to get their prediction for the next cycle.

We are currently back in the quiet period for the current cycle (cycle 23). The next cycle will begin with a rise in solar activity in late 2007 or early 2008, according to the team, and there will be 30 to 50 percent more sunspots, flares, and CMEs in cycle 24. This is about one year later than the prediction using previous methods, which rely on statistics, like the strength of the large-scale solar magnetic field and the number of sunspots, to make estimates for the next cycle.

Dikpati's team includes Dr. Giuliana De Toma and Dr. Peter A. Gilman. All are scientists in NCAR's High Altitude Observatory, Boulder, Colo. SOHO is a project of international collaboration between NASA and the European Space Agency. NCAR's primary sponsor is the National Science Foundation.

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