Page last updated at 04:32 GMT, Wednesday, 10 February 2010

Sat-nav devices face big errors as solar activity rises

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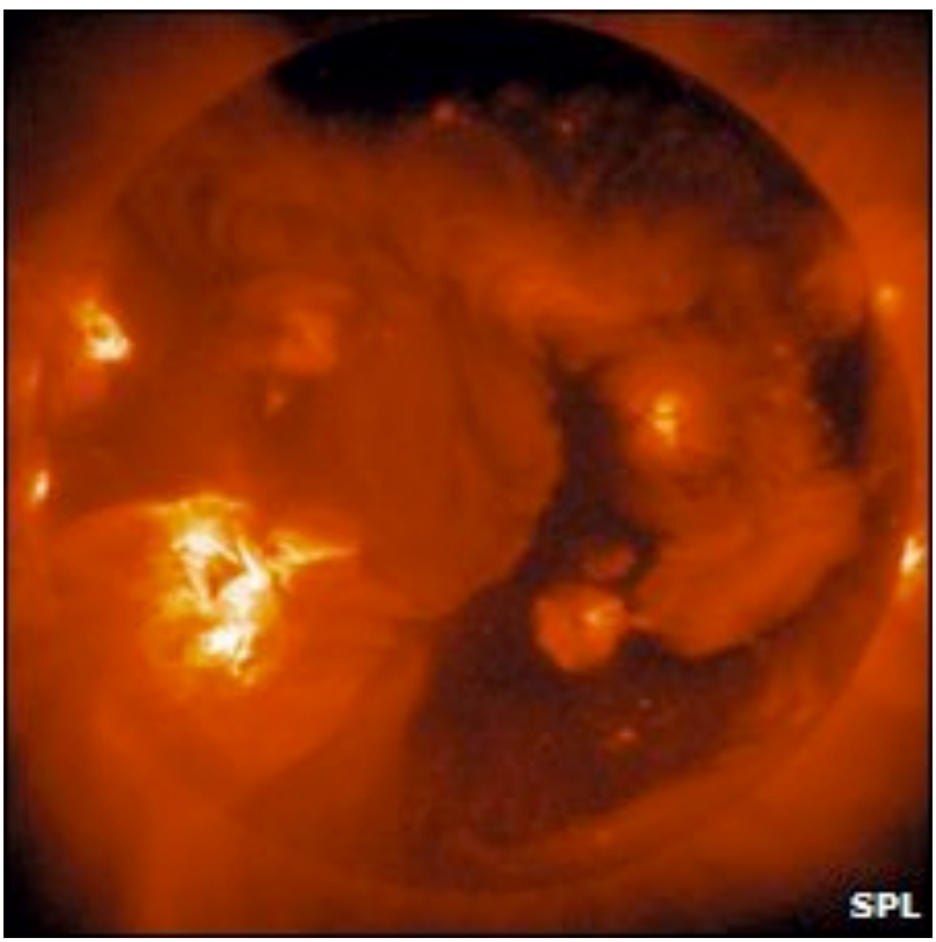
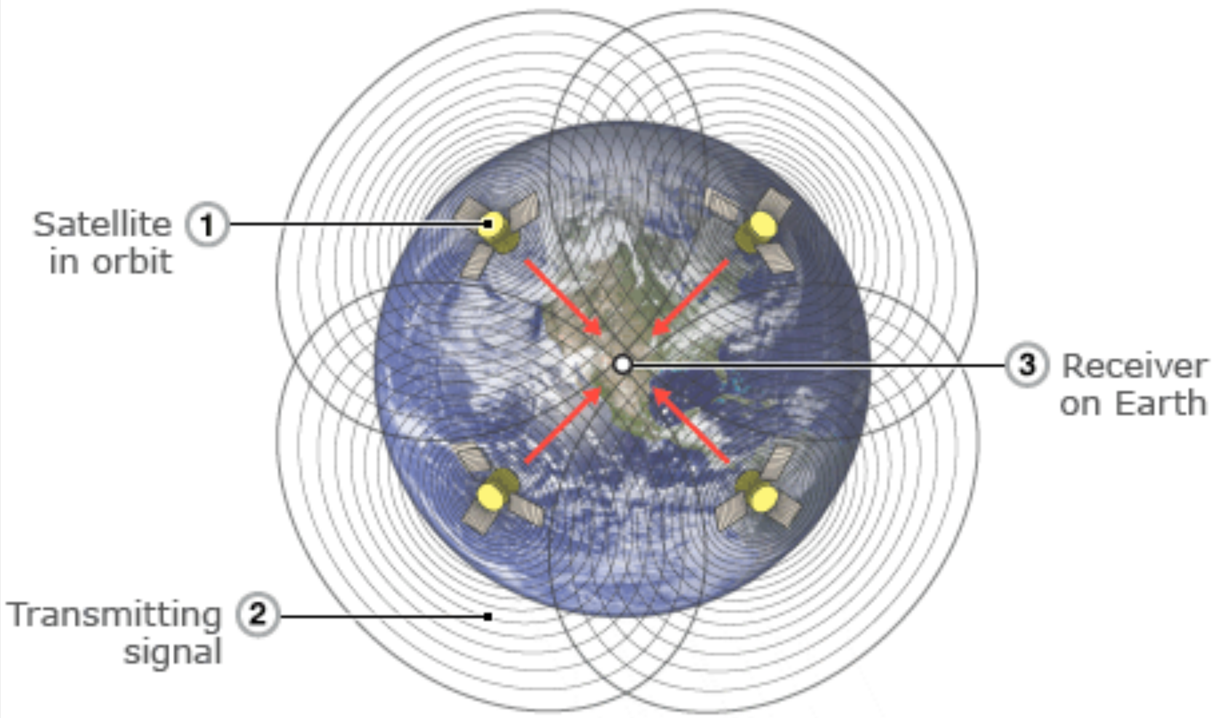


An X-ray image shows activity at the Sun's surface

Researchers say the Sun is awakening after a period of low activity, which does not bode well for a world ever more dependent on satellite navigation.

The Sun's irregular activity can wreak havoc with the weak sat-nav signals we use.
The last time the Sun reached a peak in activity, satellite navigation was barely a consumer product.
But the Sun is on its way to another solar maximum, which could generate large and unpredictable sat-nav errors.
The satellite navigation concept is embodied currently by the US GPS system and Russia's Glonass network, with contenders to come in the form of Europe's Galileo constellation and China's Compass system.
It depends on what is - at its root - a simple triangulation calculation.
A fleet of satellites circling the Earth are constantly beaming a radio signal with two bits of exceptionally precise information: where exactly they are, and at exactly what time.
A sat-nav receiver on Earth - or on a ship or plane - is equipped with a fairly precise clock and the means to collect signals from the satellites that happen to be in its line of sight.
It then works out, based on how long it took those signals to arrive, how far it is from each of those satellites. Some simple geometry yields its position.

How Global Positioning System (GPS) works



1. Satellites advertise their exact position, and the precise time at which they are sending it

2. The signal travels through the outer atmosphere, the ionosphere; its speed depends on how much the Sun's radiation and particle winds are affecting the ionosphere's composition

3. A receiver on Earth determines how long the signals took to arrive from a number of satellites, calculating the position from the time differences

But those signals are incredibly weak and, as researchers have only recently begun to learn, sensitive to the activity on the Sun.
Solar flares - vast exhalations of magnetic energy from the Sun's surface - spray out radiation across the electromagnetic spectrum, from low-energy radio waves through to high-energy gamma-rays, along with bursts of high-energy particles toward the Earth.
The radiation or waves that come from the Sun can make sat-nav receivers unable to pick out the weak signal from satellites from the solar flare's aftermath.
There is little that current technology can do to mitigate this problem, with the exception of complex directional antennas used in military applications.
Sat-nav receivers will be blinded for tens of minutes, probably a few times a year at the solar maximum.

Charged up

A further complication comes from the nature of the outermost layer of the Earth's atmosphere, the ionosphere.
That is composed in part of particles that have ionised, or been ripped apart by radiation from the Sun, with the composition dependent on how much radiation is coming from the Sun at a given time.
The problem comes about because sat-nav technology assumes that signals pass through at a constant speed - which in the ionosphere isn't necessarily the case.
"The key point is how fast the signals actually travelled," said Cathryn Mitchell of the University of Bath.
"When they come through the ionosphere, they slow down by an amount that is actually quite variable, and that adds an error into the system when you do the calculations for your position," Professor Mitchell told BBC News.
The amount of solar activity runs on many cycles; the ionisation will be different on the sun-lit side of the Earth from the night side, and different between summer and winter; each of these cycles imparts a small error to a sat-nav's position.

Video Images of Solar Sun Spot

But the disruption caused by solar flares is significantly higher.
The increased radiation will ionise more molecules, and the bursts of particles can become trapped in the ionosphere as the Earth's magnetic field drags them in.
The effects that sat-nav users will face, however, are difficult to predict.
"We can look at the measurements from the last solar maximum," Professor Mitchell said.
"If we project those forward, it varies quite a lot across the Earth; looking at the UK it will be about 10-metre errors in the positioning."
The errors would be much more long-lasting than the "blindness" problem, lasting hours or even days.
"Ten metres out is probably going to be OK for a sat-nav system in a car, but if you're using the system for something safety-critical like ships coming into harbour for navigation or possibly in the future landing aircraft, you're looking for much greater accuracy and more importantly, much greater reliability."
Bob Cockshott, a director of the government-funded Digital Systems Knowledge Transfer Network, said that for most consumer applications such as sat-nav for cars, the problem will be more troublesome than dangerous.
"You might find for a number of hours or even a day or two you couldn't go out surveying or be able to dock your oil tanker at the deep-ocean oil well," he told BBC News.
"It's more at the annoyance level than something that's going to bankrupt your business."

A number of schemes have been proposed to do real-time corrections to the signals as the atmosphere changes, allowing for local adjustments that are broadcast to receivers by other means such as the mobile phone network.

However, Mr Cockshott said that it remains unclear whether such a correction makes sense economically for manufacturers of sat-nav-enabled technology.

So as the Sun builds up to its crescendo in a few years' time, be aware that your sat-nav may for a time give some strange results - or for a short while none at all.