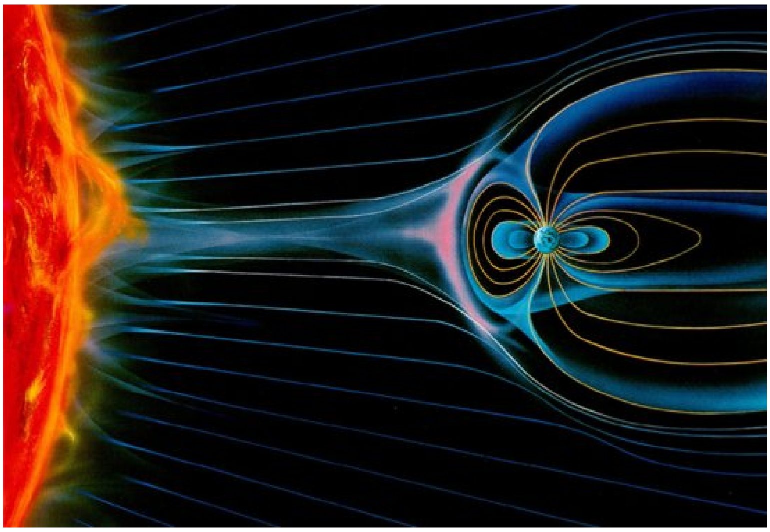
SOLARIS 1: SUNSPOTS UNTANGLED

Sunspots are planet-sized tangled vortices of gas on the surface of the sun which normally occur in pairs and are associated with strong magnetic activity.They appear as dark spots because they block the rising heat from the sun's interior, which is several thousand degrees hotter. Their dark centre is known as the “umbra” meaning “shadow”, surrounded by a lighter rim called the “penumbra” or “partial shadow”. Sunspots typically last just a few weeks then decay.

Because sunspots are the most easily observed of all solar features, they serve as the storm warnings of the solar system. Where there are sunspots there are likely to be solar flares - mass eruptions of solar energy which produce bursts of radiation and charged particles that escape into space and frequently hit the earth. A solar flare in January 2005 released the highest concentration of protons ever directly measured, taking only 15 minutes after observation to reach the earth. While the radiation takes only minutes to get here, the charged particles take a number of hours. These outbursts of solar energy are mostly blocked by the earth’s magnetosphere, the protective cocoon of magnetic field which normally shields us from the sun's magnetic field and other energetic particles of the solar wind.



In conditions such as fog, haze or viewing the sun at sunset it is possible to observe sunspots with the naked eye, but looking at the sun directly is a very dangerous thing to do. Powerful ultraviolet radiation severely burns and permanently damages the eyes, so careful attention to safety precautions when using optical devices is essential.

Sunspot activity is reasonably predictable, with the cycle lasting about eleven years. The point of highest sunspot activity during this cycle is known as the solar maximum when 100 or more spots may be visible on the sun at one time, and the point of lowest activity as the solar minimum. Sometimes whole months may pass without a sunspot being recorded; the last minimum was in 2008- 2009 when there were more than 250 spotless days — a record low since 1913. Once sunspot energy has dwindled and the solar minimum is recognised it is difficult to predict how long it might last and it’s also hard to gauge the rate of increase that will follow. In the seventeenth century there was a 70-year period of spotlessness known as the Maunder Minimum that still baffles scientists. However 2009 ended with a sudden flurry of sunspots so it looks like we are already on the way up. The next maximum is predicted for June 2013.

Just as the ocean conveyor belt controls weather on earth there is a solar conveyor belt which controls weather on the sun, and particularly the sunspot cycle. The sun's conveyor belt is a current of electrically-conducting gas. It flows in a loop from the sun's equator to the sun’s poles and back again. The top of the conveyor belt skims the surface of the sun, sweeping up magnetic fields of old sunspots. These 'corpses' are dragged down at the poles to a depth of 200,000 km where the sun's magnetic dynamo can amplify them. Once the corpses are reincarnated they become buoyant and float back to the surface. Hey presto—new sunspots! It takes between 30 and 50 years for the belt to complete one loop. When the belt is looping quickly it means that lots of magnetic fields are being swept up. This knowledge helps us predict the next cycle. The fast turn around during 1986-1996 has scientists suggesting a significant sunspot build up from 2010. Some scientists are predicting that the next sunspot cycle could be 30 to 50% stronger than the last one, which would be close to an epic high that occurred in 1958.

Jane Roper, 2 years and 2 months into Solar Cycle 24

SOLARIS 2: SUNSPOT EFFECTS ON EARTH

The sunspot effects most obvious on earth are the auroras, the light displays near the northern and southern poles. When the solar energy hits the magnetosphere it has the same effect as striking a bell, with the vibrations moving up and down the entire shield. Despite this protective layer charged particles accelerated by the solar wind can enter our atmosphere through the magnetic field lines at the north and south poles. When the sun's particles strike molecules of air they glow, creating beautiful flowing arcs or curtains of colour. The down side is radio interference which can be so loud it causes broadcasting and receiving difficulties. The solar wind tends to affect lower radio frequencies so there is little effect on UHF and microwaves.

The Aurora Borealis in Canada

During a solar maximum, flares are frequent and intense. One such was recorded in 1859 when a scientist watched a massive solar flare erupting. A few hours later telegraph operators received electric shocks as they worked, and the aurora borealis was visible in southern Europe. Another maximum occurred in 1958 when the aurora was visible in Mexico. This was the dawn of the space age; Sputnik and the first US satellite had just been launched. Today our reliance on space based technologies means that we are far more vulnerable to space weather than in the past. Charged particles can hit wiring and cabling in satellites' computers and sometimes cause drag which can make satellites fall out of orbit. Astronauts working in space are at risk of solar generated radiation. Satellite transmissions of television, telephone and GPS navigation signals can be interrupted. Scientists are warning us that a solar maximum could be bang in the middle of the London Olympic Games, risking considerable disruption to television and internet networks. Even long stretches of power transmission lines on earth are vulnerable to surges from solar storm energy, although with notice operators can take measures to reduce overloads.

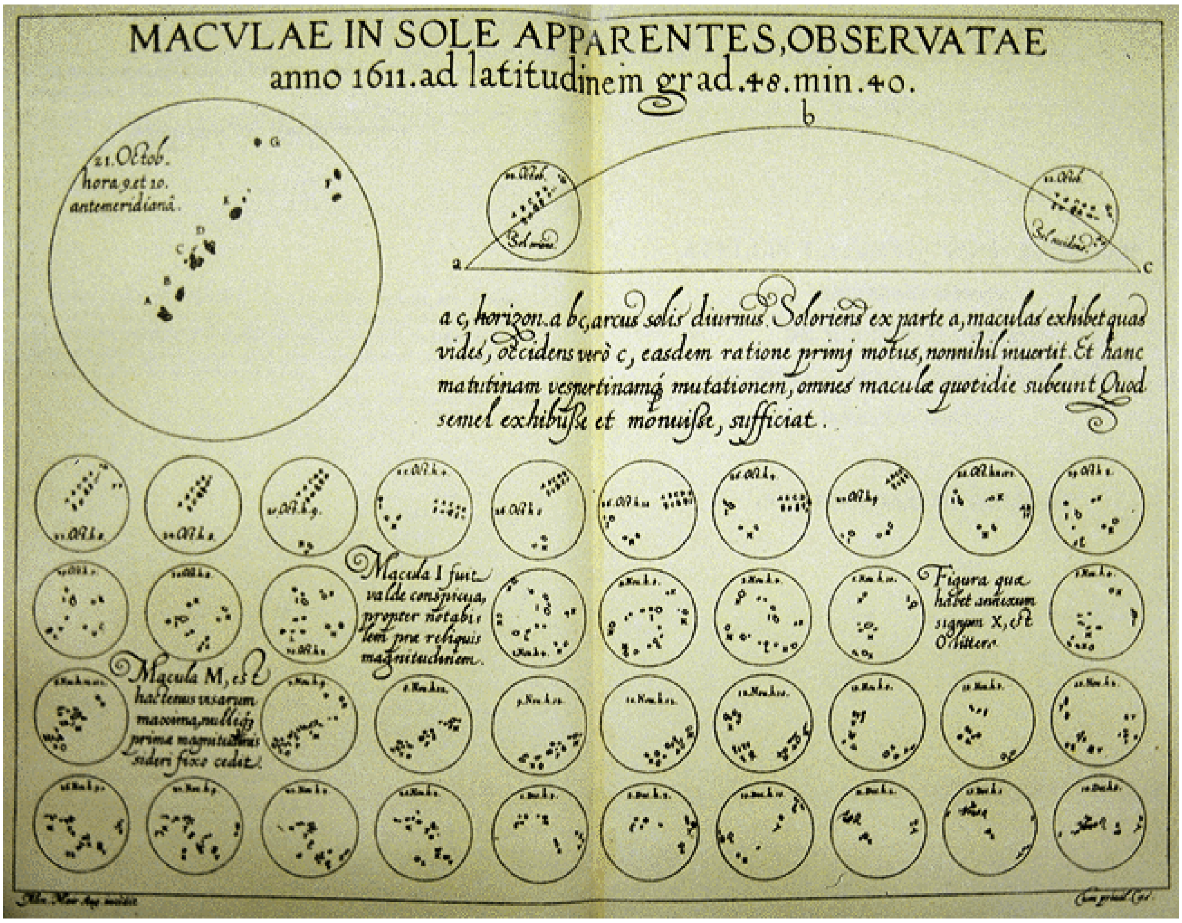
Predicting these solar flares and storms has been almost impossible in the past, but it is hoped that NASA's Solar Dynamics Observatory, recently launched, will be able to give warnings of approaching extreme activity. The probe will spend five years orbiting the Earth, sending back data equivalent to downloading 500,000 music tracks from the internet a day - providing it doesn't get hit itself! By turning off sensitive electronic circuits storm damage to satellite transmitters and the resulting disruption can be minimised, but a solar event like the ones described above would still cause a lot of damage. Mobile phones, desktop computers and the internet would be affected, and it will be essential for operators to have backup and disaster recovery plans. A move to fibre-optic networks could partially protect us since the electronics that control these networks could be damaged but the cables themselves would be unaffected. Power companies and satellite operators know about these issues and are taking steps to minimise the risks. Realistically however, there is nothing they can do if there is an extreme event – except replace all the equipment afterwards. So if you see an aurora anywhere near the equator and it is not caused by a thunderstorm, then you know a major solar flare has hit, but by then it's too late for your equipment and data!

NASA's Soar Dynamics Observatory

Jane Roper, 2 years and 2 months into Solar Cycle 24

SOLARIS 3: SUNSPOT INQUIRY

In many prehistoric and ancient cultures the sun was thought to be a solar deity or supernatural phenomenon. The Aztecs depicted their sun god with pockmarks on his face, suggesting that they had observed sunspots. As early as 28 BC ancient Chinese astronomers recorded observations of dark patches on the sun that appeared to change size and position. In contrast the ancient Greeks described the Sun as a perfect heavenly sphere without any flaws, an idea that was adopted by the Catholic Church in Europe. The sun's random marks were a hot topic for debate in the early years of telescopes, engraving and printing. In 1611 there were four men in various parts of Europe observing sunspots through their telescopes and drawing and distributing their observations: Christopher Scheiner in Germany (a great name for a solar astronomer) Johann Goldsmid in Holland, Thomas Herriot in England, and Galileo Galilei in Italy.



Scheiner's sunspot observations

Galileo was convinced that the sunspots were part of the sun itself, but others believed the Catholic Church's doctrine that the heavens were perfect, so each sphere was without blemish, and to admit otherwise would have been blasphemy. Scheiner was a believer in the Church's doctrine and so argued that the spots must be planets or moons orbiting the sun. Galileo was able to make the important breakthrough, observing that the shape of the sunspots foreshortened as they neared the edge of the Sun, and reasoned that this would only happen if sunspots were on the surface of the Sun and not in orbit as planets and moons would have been. He still had no clue what sunspots were, or what caused them.

Galileo's wood and leather telescope, made 1609/10

"The sun will also give signs; who would dare call it a liar?"

So wrote the German Jesuit astronomer Christoph Scheiner in 1611; his idea that the sun could give us a meaningful set of signs through the medium of its markings as relevant today as it was then. There is so much about sunspots we don't yet understand. Why are the weeks around the spring and autumn equinoxes twice as likely as other times of the year to have geomagnetic storms? Why is there a correlation between years of high sunspot numbers and the severity of weather systems in the northern hemisphere? What are the effects of the sun's magnetism on us and other animals? What will be the effects of the recently plotted holes in the magnetosphere and the sun's increasing magnetic field? If you fancy a lifetime of scientific enquiry untangling sunspots seems a very good place to start!

For a daily space weather update go to www.spaceweather.com

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