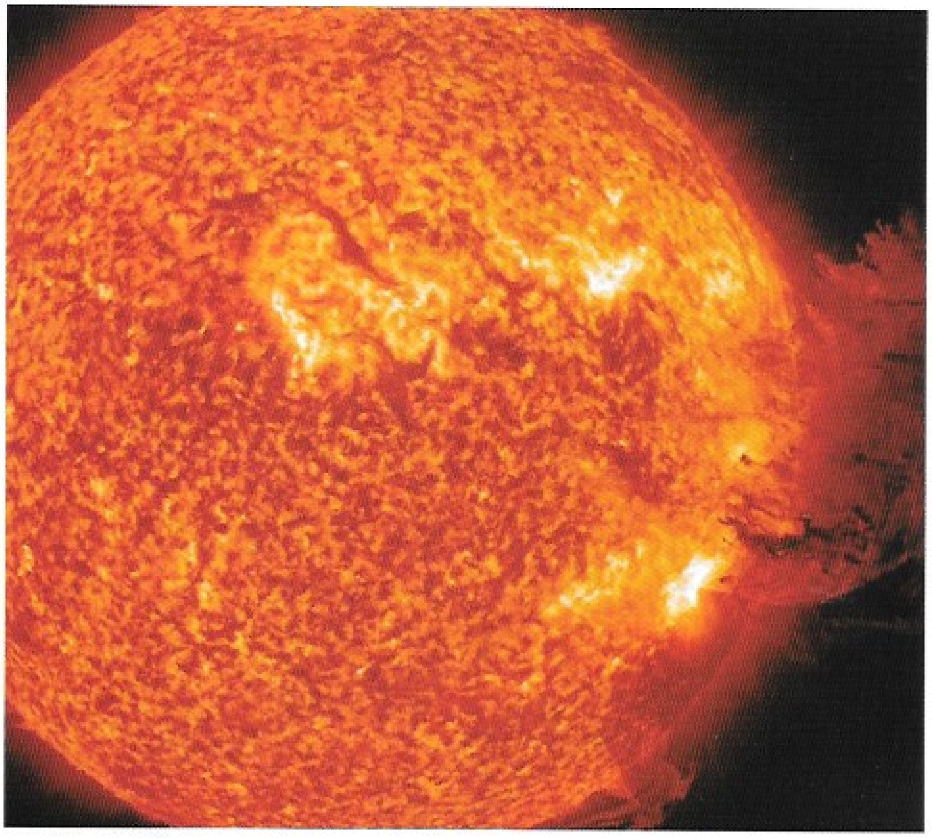
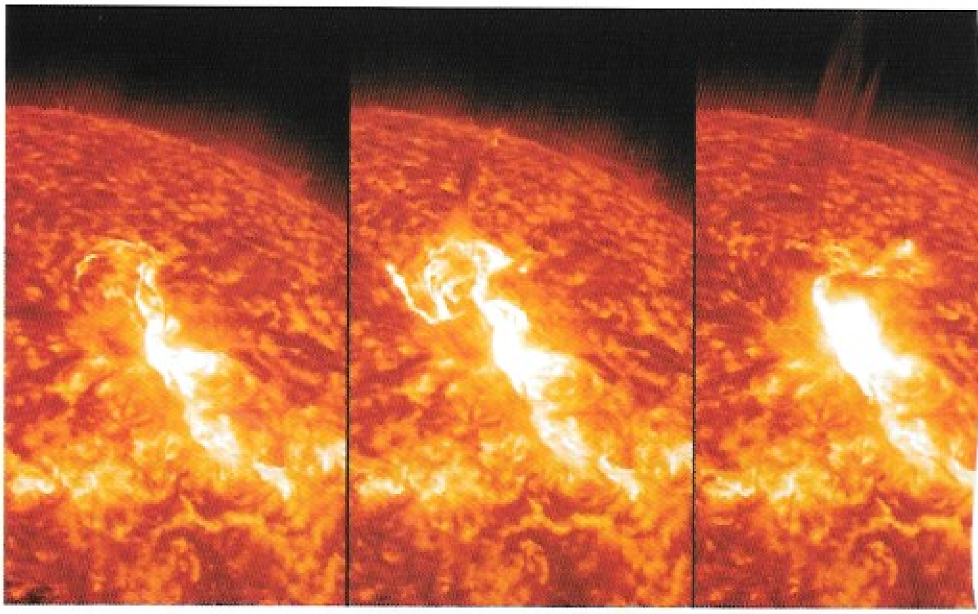


STORM WARNINGS

Earth is faced with massive communication and navigational disruptions– among other problems

Henry M. Holden reports



IN OCTOBER 1957, the Space Age was born: Sputnik was launched and Explorer 1 (the first US satellite) was launched in January 1958. You could not tell if a monster solar storm was rolling your way by checking your cell phone signal because cell phones did not exist.

But people knew something big was happening when the Aurora Borealis (the Northern Lights) were sighted three times in Mexico. A similar event now would be noticed by its effect on cell phones, GPS, weather satellites *et al*.

What happens if Earth is hit with a solar storm? The answer is either not much, or it will be a big deal. Researchers say a storm is building – the most intense solar storm in 50 years, and the world will get as little as 12 hours warning if a huge explosion of high energy particles from the surface of the sun heads our way.

GPS systems could go down for up to three days, causing widespread chaos. A major solar storm could trigger extensive train and air travel disruptions, and blackouts in some areas.

While mobile phones and landlines are expected to be unaffected, satellite communication and high frequency radio communication used by shipping and aircraft, could also go down for several days.

These high-energy particles, which are triggered by the solar flares, make their presence felt when they create the Northern and Southern Lights.

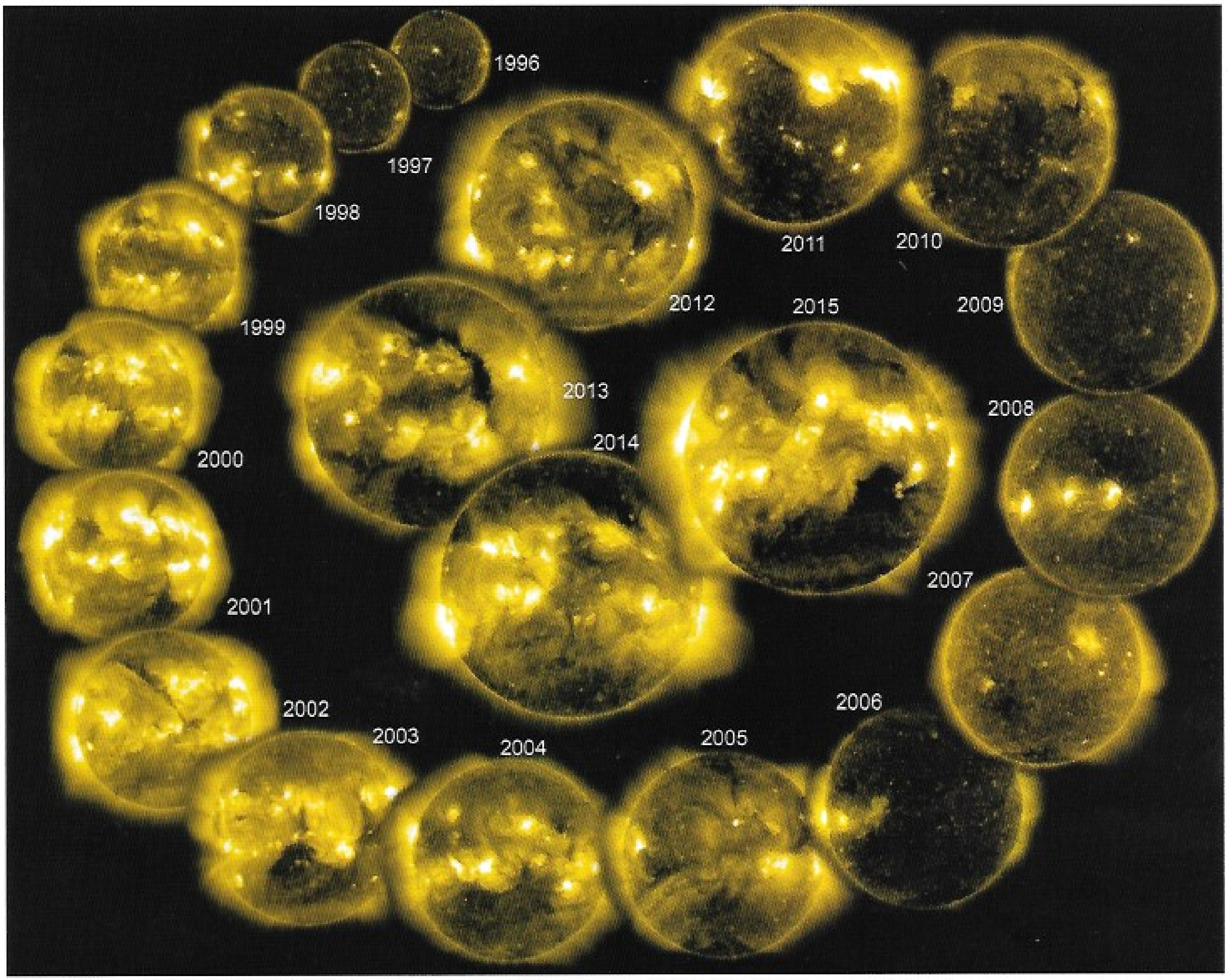
Sunspot activity is not just a Northern Hemisphere anomaly; sunspot activity also affects the Southern Hemisphere producing its Aurora Australis.

CYCLES OF DROUGHT IN AFRICA

According to the *South African Journal of Science; January/February 2014*, a NASA model demonstrates a highly predictive skill in estimating monthly values of rainfall for the period from 1901 to 2020 for Kenya using sunspot activity. The model can be used not only to estimate historical values of rainfall, but also to predict monthly total rainfall.

"The 11-year solar sunspot cycle has an influence on the frequency and timing of extreme hydrology events in Kenya," the journal said. "Periods of low sunspot activities some scientists attribute to increased drought conditions and global warming. Sunspots may have influenced the occurrence of the Sahelian drought of the mid-1980s that affected the Sahel region including the Gretare Horn of Africa."

Using sunspot data scientists have a 95 percent level of confidence that drought conditions similar to those of the early 1920s may reoccur in the year 2020 or soon after.



Opposite page*: A Corona mass ejection as viewed by the Solar Dynamics Observatory on June 7, 2011.* (Image: NASA/SDO)

Opposite left*: These three images show a solar flare as observed over a 45-minute period on January 23, 2012. Note the brightening of the solar surface as gas was superheated and magnetically supercharged. By the third (right) image, a stream of solar material is seen flowing off into space above the hot spot, likely solar protons and a coronal mass ejection.* (Image: NASA/SOHO)

Above*: The Solar and Heliospheric Observatory (SOHO) has been watching the Sun for almost 20 years. In that time it has seen solar activity ramp up and die down repeatedly. Its extreme ultraviolet imaging telescope has taken images of the resulting waxing and waning of the Sun's corona – its atmosphere – that are impossible to record from the ground. Brighter images show times when there was more activity on the Sun.* (Image: NASA/SOHO)

SUNSPOT ROLLER COASTER

The sun's surface acts like a roller coaster of electrically-conducting gas. It flows in a loop from the sun's equator to the poles and back again. This roller coaster-like activity controls the weather on the Earth and, in particular, the sunspot cycle on the sun.

Solar physicist David Hathaway, of the National Space Science and Technology Centre explains: "First, remember what sunspots are: tangled knots of magnetism generated by the sun's inner dynamo. A typical sunspot exists for just a few weeks. Then it decays, leaving behind a 'corpse' of weak magnetic fields.

"The roller coaster skims the surface of the sun, sweeping up the magnetic fields of old, ...d sunspots. The 'corpses' are dragged down at the po... depth of 200 000 km where the sun's magnetic dynamo can amplify them.

"Once the magnetic knots are reincarnated (amplified), they become buoyant and head up the track, creating new sunspots."

MASSIVE SLOWNESS

"It takes about 40 years to complete one loop," said Hathaway. "The speed varies anywhere from a 50-year pace (slow) to a 30-year pace (fast)."

In the fast mode, lots of magnetic fields are being swept up, and that means a future sunspot cycle is going to be intense. This is a basis for forecasting.

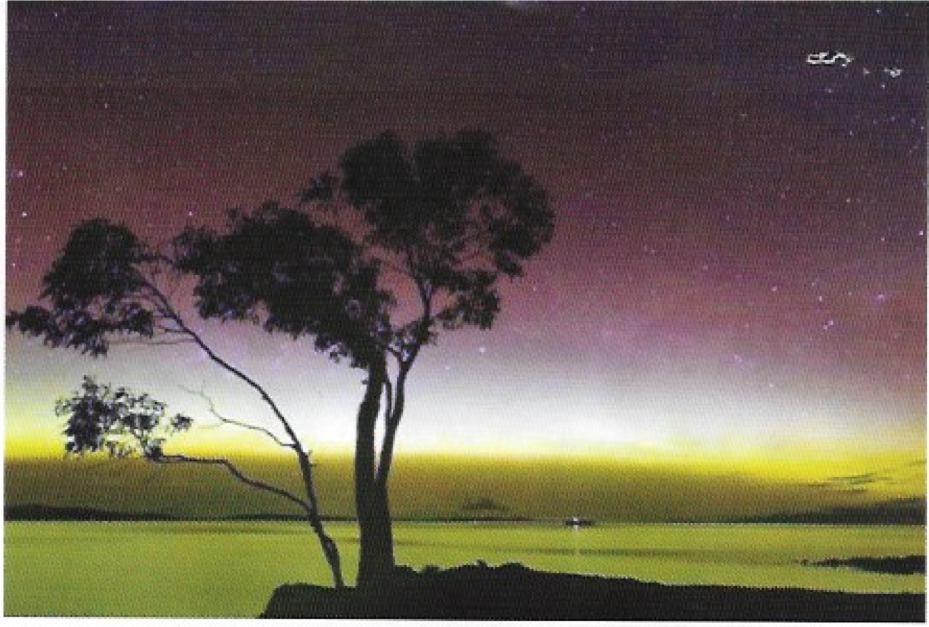
"There was a fast mode in 1986-1996," says Hathaway. "Old magnetic fields swept up then should re-appear as big sunspots in the years ahead."

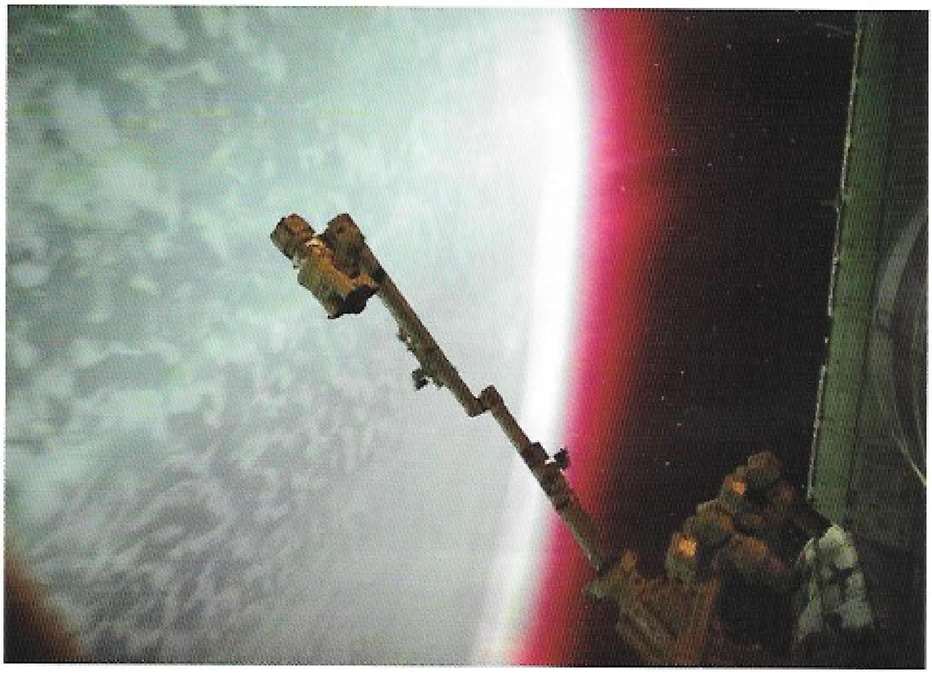
SANDBLASTING THE MOON

Solar storms and Coronal mass ejections (CME) can erode the lunar surface according to a new set of computer simulations by NASA scientists. In addition to removing a surprisingly large amount of material from the lunar surface, this could be a major method of atmospheric loss for planets like Mars that are unprotected by a global magnetic field.

CMEs are an intense gust of the normal solar wind, a diffuse stream of electrically conductive gas called plasma that is blown outward from the surface of the Sun into space. A strong CME may contain around a billion tons of plasma moving at up to a million miles per hour in a cloud many times the size of Earth.

Coronal mass ejections reach velocities between 20 to 3 200 km/s (12 to 1 988mi/s) with an average speed of 489 km/s (304 mi/s), based on the Solar and Heliospheric





Top: The-Aurora-Australis-Tasmania or the Southern Lights, is one of nature's most impressive displays, because these lights can only be seen over the southern polar region.

(Image: admin/thegypsynomads.com)

Above: *Planet Earth seen through the shimmering glow of aurorae from the International Space Station about 400 kilometres above the orbiting station is itself. Aurorae have the signature colours of excited molecules and atoms at the low densities found at extreme altitudes. The eerie greenish glow of molecular oxygen dominates this view. But higher, just above the space station's horizon, is a rarer red band of aurora from atomic oxygen. The ongoing geomagnetic storm began after a Coronal mass ejection's recent impact on Earth's magnetosphere.* (Image: Scott Kelly, Expedition 44, NASA).

Observatory (SOHO) measurements between 1996 and 2003. These speeds correspond to transit times from the sun out to the mean radius of Earth's orbit of about 86 days to 13 hours (extremes) with a 3,5-day average.

The moon has little atmosphere, technically called an exosphere, because it is so weak, which leaves it vulnerable to CME effects. The plasma from CMEs impacts the lunar surface, and atoms from the surface are ejected in a process called "sputtering."

"We found that when this massive cloud of plasma strikes the moon, it acts as a sandblaster and easily removes volatile material from the surface," said William Farrell, of the Dynamic Response of the Environment At the Moon (DREAM) team lead at NASA Goddard. "The model predicts 100 to 200 tons of lunar material – the equivalent of 10 dump truck loads – could be stripped off the lunar surface during the typical two-day passage of a CME."

"Sputtering is among the top five processes that create the moon's exosphere under normal solar conditions, but our model predicts that during a CME, it becomes the dominant method by far, with up to 50 times the yield of the other methods," said Rosemary Killen, lead author of a paper on this research which appeared in a special issue of the *Journal of Geophysical Research: Planets.*

OZONE DAMAGE

From July 14 to 16, 2000, the surface of the sun exploded producing a massive flare. Huge, bright flares spewed out into space like fountains colourfully lit from beneath.

Within a few hours, the solar storm bombarded Earth with a shower of positively-charged hydrogen atoms, called protons, causing scientific and communications satellites to short-circuit.

Through a series of chemical reactions in our atmosphere, the protons drastically diminished the upper-most areas of the ozone layer, a protective blanket mostly in the stratosphere that blocks life-threatening ultraviolet radiation from reaching the Earth.

This shower of protons, known by solar science insiders as the Bastille Day event, was the third largest of its kind in the last 30 years.

Above the visible surface of the Sun is a blanket of plasma, gas that is so hot that some atoms have become "unglued." Invisible to the naked eye except during a solar eclipse, this plasma, called the corona, is about two-million Kelvin (3,6 million degrees Fahrenheit).

On December 13, 2006, the Sun unleashed a large solar flare and a CME that appeared to be headed towards Earth.

A shower of high-energy particles appeared as specks and white streaks on the imagers aboard NASA's SOHO satellite.

Flares occur in active regions of the Sun where magnetic fields are strong. These active regions are home to sunspots, dark spots on the Sun's surface that indicate areas of relatively cooler temperatures and especially strong magnetic flux.

The storm did not present a danger to the astronauts onboard the Space Shuttle, or the International Space Station, as they were within the Earth's protective magnetic shield, and in the protective walls of the spacecraft.

However, the bulk of the cloud of particles from the CME reached Earth within a day. It generated a colourful aurora and posed some relatively minor threats for satellites, communications equipment, and power systems

Scientists at the National Centre for Atmospheric Research predict the next sunspot cycle will be 30 percent to 50 percent stronger than the previous one.

If their predictions are indeed correct, then the years ahead could produce a burst of solar activity second only to the historic solar storm of 1958. ✈