ABC NEWS

SCIENCE

Just how bad could a big solar storm be in the internet age? And how would Australia be affected?

ABC Science / By Genelle Weule

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An enormous coronal mass ejection bursts from the Sun in 2012. Luckily this one missed Earth. *(NASA/GSFC/SDO)*

Samuel McGowan was an early adopter of technology for his time.

Within a year of arriving in Victoria in 1853 from Canada, the entrepreneurial engineer had overseen the construction of the southern hemisphere's first experimental telegraph, an 18-kilometre-long wire stretching between Melbourne and Williamstown.

By 1859, Melbourne was connected by telegraph to the booming goldfield settlements of Ballarat and Bendigo, and lines ran to Sydney and Adelaide.

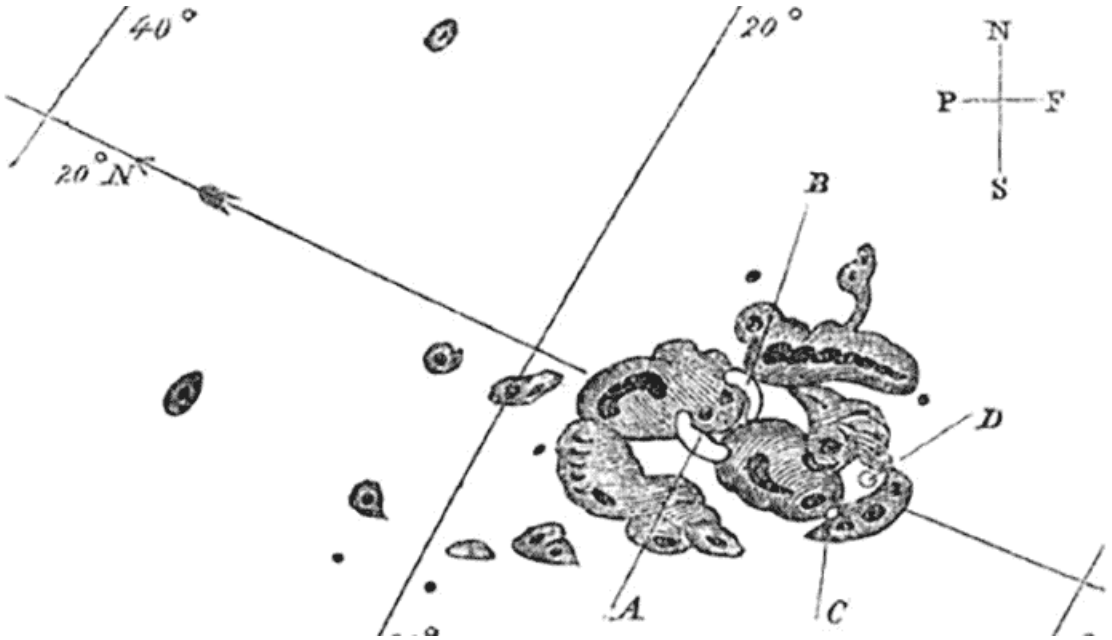
But something weird happened on August 29 and September 2 of that year.

Mr McGowan told the Victorian parliament that the transmission of signals was affected by fluctuating electrical currents in the atmosphere coinciding with the aurora australis, a phenomenon he'd seen

before in his home country.

> "On one occasion during this interesting disturbance of the natural elements, I communicated with, and received an acknowledgement from, a station distant 32 miles, through atmospheric currents alone, there being at the time no battery on the line."

Mr McGowan witnessed the fallout of what has become known as the Carrington event.



Drawing of sunspots by English astronomer Richard Carrington from 1859 *(Wikimedia)*

The 1859 solar storm is the most powerful in recorded history — it played havoc with fledgling telegraph systems, sparking fires around the world, and created auroras that stretched to northern Queensland.

All this happened at least a decade before the bunch of separate states on the Australian mainland were connected to the rest of the world. And it was even longer until the first electrical lights flickered in the streets of Tamworth, the first petrol motor car hit our dusty tracks and the first plane flew in our skies.

So what would happen if a Carrington event hit us today?

Anatomy of a space storm

Solar storms like the Carrington event are caused by explosive bursts of charged particles flung from the Sun in a phenomenon known as a coronal mass ejection (CME).

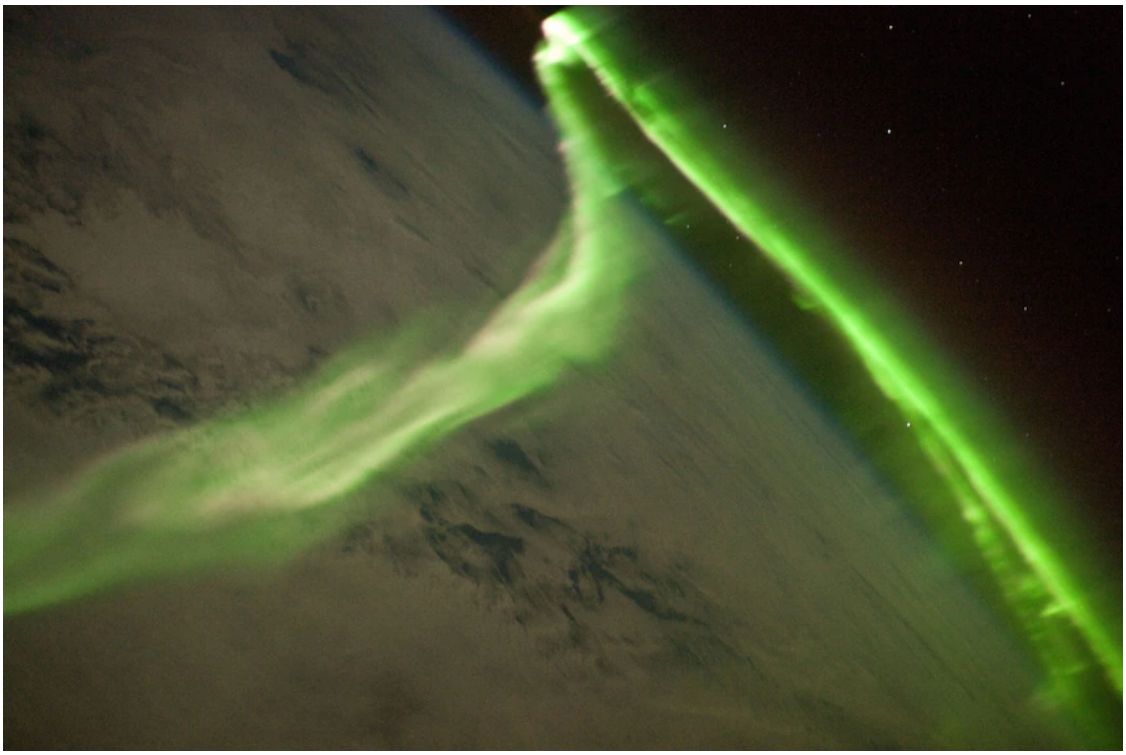
A CME really only affects us if the stream of particles, or solar wind, is pointed in our direction, says Hannah Schunker, a solar physicist at the University of Newcastle.

YOUTUBE: Dr Hannah Schunker explains the physics of a solar storm on Catalyst.

If the Sun's magnetic field is the opposite of Earth's magnetic field at the time, the charged particles are able to enter Earth's upper atmosphere travelling down to the polar regions.

This sudden burst of electromagnetic energy creates stunning auroras, but it can also fry anything that conducts electricity.

In the 160 years since Mr McGowan's telegraph lines went haywire there have only been a couple of solar storms that come anywhere near the strength of the Carrington event.



The aurora australis lights up the sky over the southern Indian Ocean as seen from the ISS. *(Supplied: NASA)*

On March 13, 1989, the entire Canadian province of Quebec was plummeted into a blackout for 12 hours as a surge of power knocked out the electricity network.

People were left without heating, and the train network and airport shut down.

The solar storm also affected the power grids in the US and a number of satellites tumbled out of control for several hours.

This space storm, dubbed "the worst in the space age" by NASA, was roughly about half the strength of a Carrington event.

The solar wind collides with Earth's magnetosphere, sending charged particles towards the poles. *(NASA)*

But we are yet to see a superstorm in the digital age, says Sangeetha Abdu Jyothi, a computer scientist who studies internet resilience at the University of California, Irvine.

"The internet's infrastructure was laid out in the past three decades, Dr Abdu Jyothi says.

"During [this time] there have been no big events ... so our infrastructure isn't prepared."

We had a lucky miss in 2012 when a superstorm of the same magnitude as a Carrington event missed Earth.

And many scientists believe it is only a matter of time before our luck runs out.

Sun's cycle is ramping up

The Sun goes through cycles where sunspot activity increases roughly every 11 years when the poles flip.

We're now about two years into the 25th cycle recorded since 1755.

Dr Schunker says the solar maximum in this cycle is likely to occur around 2025 (give or take a year).

"That means that the Sun is becoming more and more magnetically active ... and this is when flares and CMEs occur."

YOUTUBE: Watch how the Sun changes over 10 years. Source: NASA Goddard Space Flight Center/SDO

NASA predicts that Cycle 25 will be relatively quiet, and even though there was a solar storm recently that knocked out 40 SpaceX satellites, it's living up to that so far, Dr Schunker says.

"It's a bit slow, but it's consistent with predicting a quiet cycle. It's not alarming."

But that doesn't mean we couldn't get hit by a big storm.

The 2012 storm that missed Earth occurred in the last cycle, which was also predicted to be quiet.

"Forecasting solar cycles is extremely difficult and unreliable," Dr Schunker says.

"Most people do predict [this cycle] will be fairly quiet ... but it doesn't mean that those conditions for a large CME or a large flare can't occur."

Scientists are constantly monitoring activity on the Sun and the solar wind using spacecraft such as The Solar Dynamics Observatory (SDO) and the Deep Space Climate Observatory (DSCOVR).

But once a CME is detected, we only have about 12 hours' notice before it arrives at Earth, and less than an hour before we know how bad it will be.

How Australia could be affected

As the electrically charged particles hit the protective bubble surrounding our planet, they create turbulence in our upper atmosphere.

This turbulence disturbs the signals used by satellites to communicate with Earth, affecting communications and GPS systems.

The surge in electrical current could also damage satellites, and even cause them to drop out of orbit and burn up.

Power lines and the long-distance undersea cables that form the backbone of the internet on Earth may also not cope with the massive spikes in electrical current.

A solar storm can disrupt services that rely on satellites, GPS signals, power networks and long-distance cables, which form the backbone of the internet. *(NASA)*

Along with causing power outages that affect our homes and businesses, a big hit could take out much of the technology we now take for granted.

"We're not going to have GPS positioning, we're not going to have access to Google Maps or our phones," Dr Schunker says.

"ATMs ... or our payWave devices are not going to be working, so to be able to purchase anything, we're going to need cash."

People living at high latitude locations towards the north and south pole will be the worst affected.

This is where the charged particles are directed down towards Earth, producing spectacular auroras.

But it may not just be places that regularly see curtains of green and pink shimmering across the sky — like Tasmania — that will be hit.

The aurora australis, also known as the southern lights, is a regular feature in Tasmania's sky. *(ABC My Photo contributor @sophiefaz)*

A solar storm in 1972 may actually have even been responsible for triggering undersea bombs during the Vietnam War, Dr Schunker says.

"Vietnam is not at a high latitude," she says.

"I think that the effects in the higher atmosphere at low latitudes just hasn't been studied enough."

Then in 2003, a series of superstorms about two-thirds the strength of the 1989 storm hit Earth around Halloween.

At their peak they:

- caused aircraft to be rerouted;
- played havoc with many satellite and communication systems;
- shut down spacecraft;
- blacked out communications in Antarctica for more than five days;
- caused a power outage in Sweden for about an hour

But they didn't just affect high-latitude countries; they also burnt out transformers on South Africa's power network.

With growing evidence that a superstorm could affect mid- to low-latitude parts of the world — such as mainland Australia — scientists have begun looking more closely at mid-latitude countries as well.

A 2017 study looked at the impact of a storm of this scale on Tasmania's and Queensland's energy networks.

It found that even though Queensland is further away from the poles than Tasmania, it's slightly more vulnerable to a storm of this intensity.

That's because power lines in Queensland cover longer distances, and are predominantly aligned in an east-west direction in south-east Queensland.

The internet has not been tested

While modelling of the power networks across the world has been underway for decades, internet researchers and operators are mostly blind to the impact of a rare and hard-to-predict event, Dr Abdu Jyothi argues.

Last year she presented preliminary modelling of the impact of a major solar storm on the global network.

Her analysis suggests that while Australia is not likely to lose communication across the continent, we could be cut off from some parts of the world.

Australia is connected to the rest of the world via long-distance cables that run under the Pacific Ocean to the US, as well as cables that run to Singapore.

The undersea cable network forms the backbone of the internet. *(Supplied: Telegeography)*

Long-distance undersea cables rely on repeaters, which are powered by an electrical line that runs along the length of the cable, to boost the signal.

"The vulnerability of submarine cables under large scale storms has not been studied in depth, so we don't know which of them would fail," she says.

In the event of a large storm, Dr Abdu Jyothi's analysis suggests Australia will likely stay connected to New Zealand, but lose direct contact with the US.

"If Australians need to access a service that's only in the US and the service is disrupted, then you basically cannot access that," she says.

"[But] the preliminary analysis shows the connection to Asia could remain."

As we've seen with the Tonga volcano disaster, damage to undersea cables can take weeks, or even months, to repair.

But satellite communications would be faster to restore, says Dr Adbu Jyothi, who is also studying the resilience of satellite systems.

"One good thing with satellites is that if some parts of the globe are not affected, we could launch satellites from there," she says.

"If we have satellites and rockets ready, it takes only five days to get it operational."

Then it will also need to be in contact with ground stations in unaffected areas to ensure it is working and in the right orbit, she adds.

What content you can access will depend upon where the data centres are located, with companies in the high latitudes at greater risk of being affected by power outages.

While some tech companies such as Google and Microsoft have data centres in Singapore, others such as Facebook are concentrated in the US, Dr Abdu Jyothi says.

"If [content providers] have their data centres in a more distributed fashion, they are more resilient," she says.

But there is still much more work needed to understand just how much disruption to the internet a Carrington event could cause.

"In the past 30 years we've never had an instance of internet reset, where the whole system is shut down and has to come back up," Dr Abdu Jyothi says.

"Even when there are attacks which are targeting specific providers or specific services, a lot of dependent services [like hospitals and airlines] fail.

"We could handle the pandemic because we had good connectivity of the internet.

"But if there is no internet and power, I don't know how we'll manage the next once-in-100-year disaster."

A big hit could give us a taste of what life was like back in Samuel McGowan's day.

Find out how scientists are working to help us predict the next big solar event on Catalyst episode Solar Storms: A Warning from Space, at 8:30pm on March 1 on ABC TV and ABC iview.