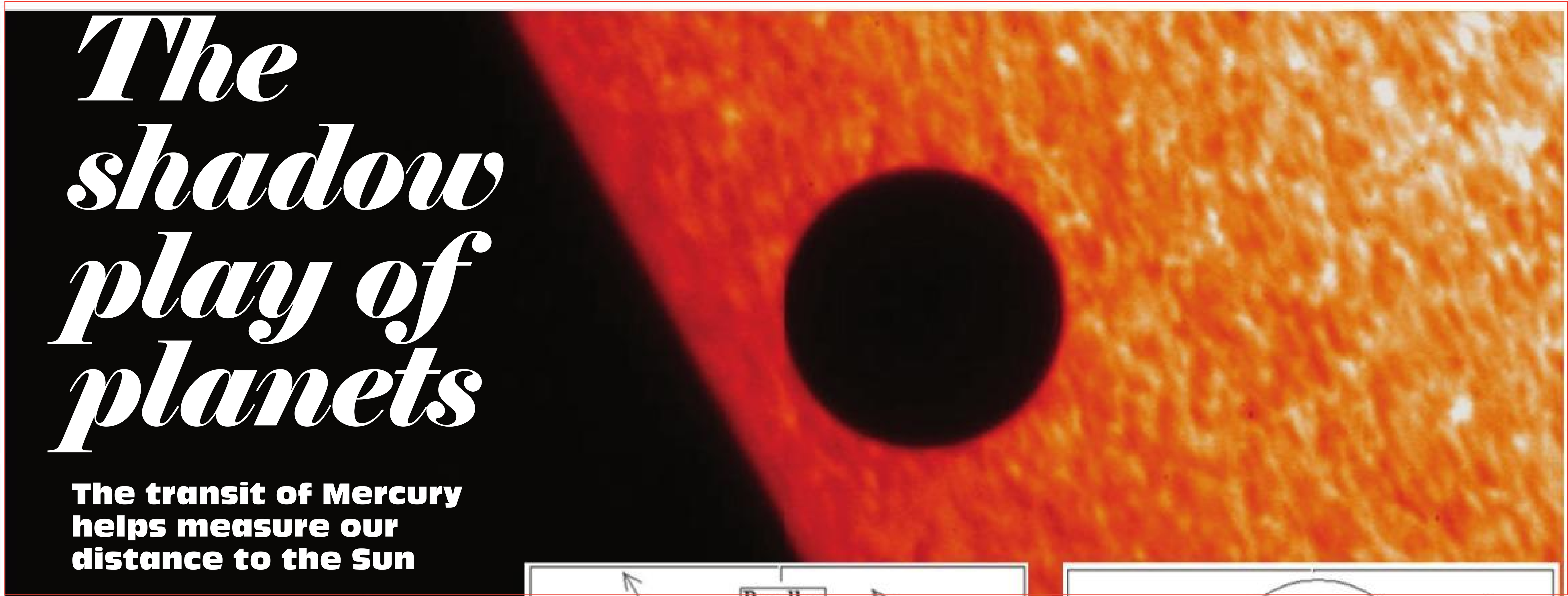
The shadow play of planets



The transit of Mercury helps measure our distance to the Sun

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The planet Mercury crossed the disc of the Sun, as viewed from Earth, on 11 November 2019. The event lasted for five and a half hours and could be seen from most parts of the world.

Transit of a planet occurs when the planet moves directly through the path between the Earth and Sun. This, naturally, can happen only with planets whose orbits are within the orbit of the Earth. Hence, in the Solar System, it can happen only with the planets, Venus and Mercury.

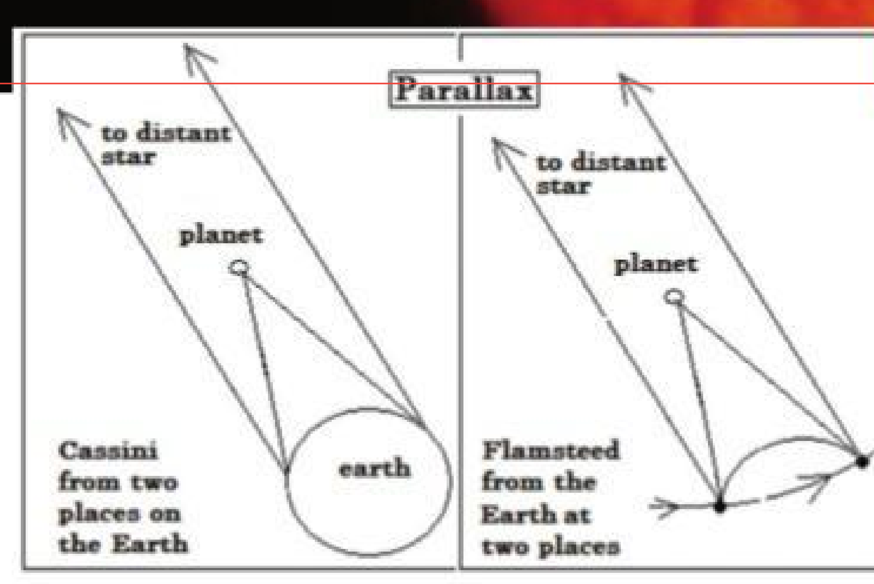
In the case of Mercury, the planet goes around the Sun once every 88 days. As the Earth also moves by the time Mercury comes round, it passes between the Earth and the Sun once every 116 days.

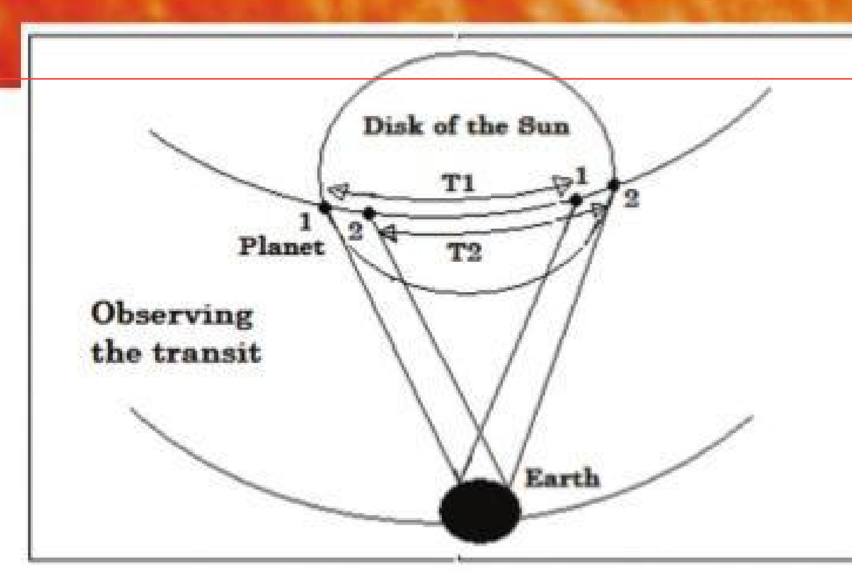
However, as the plane of the orbit of Mercury is tilted, compared to that of Earth, the path of Mercury does not come between the Earth and Sun every time it goes past. The transit is thus a relatively rare event, just 13 or 14 in a century — the last was June 2016, and the next is expected in 2032.

Transits also occur with planets in orbit around distant stars. Even with our own Moon, a solar eclipse is a transit event. These events are useful because they give us a different view of celestial objects. We normally see these objects by the reflection of light that their mother star shines on them. During a transit, what we see is the shadow of the object.

In the case of distant planets, their reflected light is hardly visible in the glare of the mother star. It is hence only by the transit that they can be made out. This has now helped detect and estimate the orbit of thousands of planets around stars in remote parts of space.

Another use of a transit event, particularly within the Solar System, is that at just beyond the edges of the shadow, we can see light from the Sun that comes through the atmosphere of the planet. Analysis of the light that comes through reveals things about the planet that cannot be made out by other means. But the first, and important use, which was made of transit events was to determine the distance of the Earth from the Sun.





The wonderful thing about the Solar System is that the distances of the planets from the Sun and the time they take to go around it are related by a simple mathematical relation — the closer the planet, the shorter the time of its year. It was with the help of this idea that it was confirmed, for instance, that Mercury and Venus are closer to the Sun than Earth, unlike the remaining planets, which are farther away.

It was hence possible, once any one distance was known, to tell the distance of other planets from the Sun. The quest was hence to find at least one distance .

The method to discover this any one distance was the same as our eyes use to tell the distance of things around us. As our eyes are a few inches apart, what one eye sees is not the same as what the other one sees. The brain can thus use the images to work out the distance.

The first estimates of planetary distances were made in this way by sighting the planets from places as far apart as possible. In 1672, Cassini and his partner, Richer, measured the angle of a sighting of the planet, Mars, from Paris at one end of the Earth and the Cayenne Island in South America, at the other. A year later, Flamsteed made similar measurements, but from the same place and one day apart, using the motion of the Earth for the separation. From these sightings thousands of kilometres apart, they could work out the distance to Mars, and from this, the distance of Earth from the Sun. The distance they got was 87 million miles, which is quite close to the accepted figure of 93 million miles, or 150 million kilometres.

Transit of Venus

A century later, in June 1769, the transit of Venus gave astronomers the opportunity for a more accurate measurement. In the case of a transit, the planet that is being viewed enters and exits the disk of the Sun a good few hours apart. The timing of transit depends on the parts of the Earth where the points of observation lie and the difference permits accurate calculation of the distance of the planet from Earth.

The quality of chronometers and telescopes had improved and the scientific community was more organised. Teams were stationed at different parts of the globe and the observations brought together. It took till 1771 for the data to be analysed and the distance worked out was 95 million miles, a lot closer to the correct value than before.

We now have more sophisticated means of measuring distances, specifically Radar, which bounces a radio signal off the distant object and receives the echo. Unlike differences in millions of miles, we can now be correct to three parts in a billion — over 93 million miles, this works out to be something like 400 metres.

Now that we are sure of the distance to such a fine level of accuracy, it has become possible to make out changes in the distance. And it is found that the distance is gradually increasing. The increase is because the Sun is constantly losing energy and hence it's mass, which allows the planets to move to larger orbits.

But the start was the first sighting of a transit, 250 years ago and every time transits happen, there are new experiments to test and refine what was seen the last time around.

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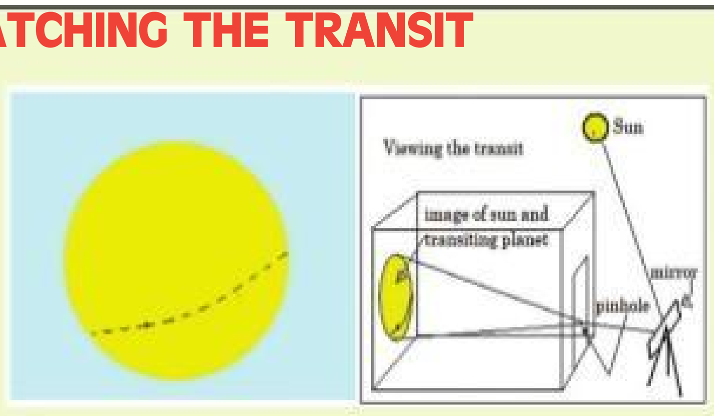
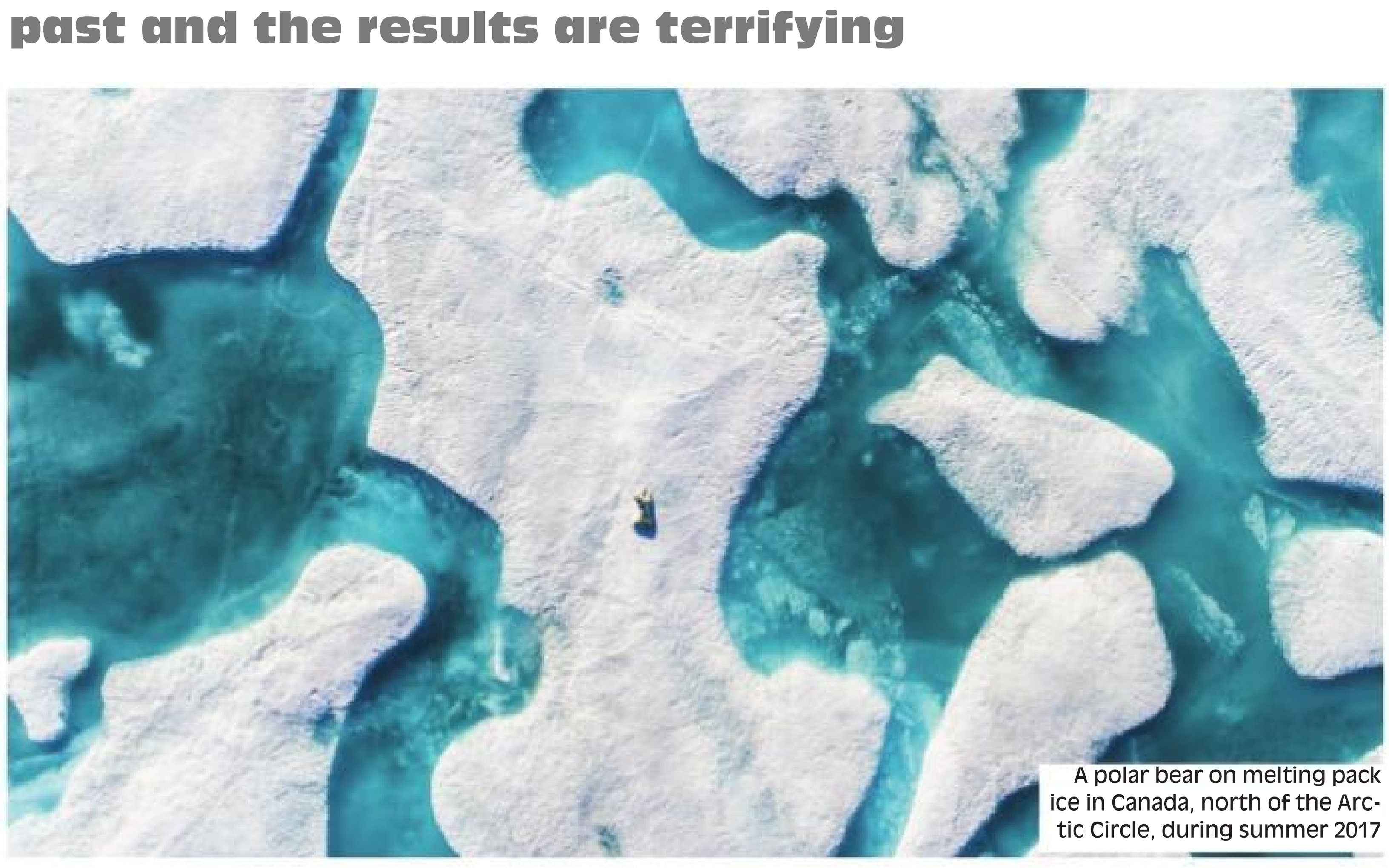
WATCHING THE TRANSIT



Those who watched the transit of Mercury on 11 November would have seen projection of the disk of the Sun with Mercury as a small black dot, slowly moving across. This cannot be seen by looking directly at the Sun, of course, as the glare would be unbearable. One good way to see the transit is by focusing an image of the Sun on a screen, with the help of a pair of lenses. Another effective way is simply with a pinhole camera. With the help of a mirror, a darkened room could be the camera, with sunlight shining on a keyhole.

Taste of what's to come?

Scientists looked at sea levels 125,000 years in the past and the results are terrifying


A polar bear on melting pack ice in Canada, north of the Arctic Circle, during summer 2017

FIONA HIBBERT, EELCO ROHLING & KATHARINE GRANT

Sea levels rose 10 metres above present levels during Earth's last warm period 125,000 years ago, according to new research that offers a glimpse of what may happen under our current climate change trajectory.

Our paper, published in *Nature Communications*, shows that melting ice from Antarctica was the main driver of sea level rise in the last interglacial period, which lasted about 10,000 years.

Rising sea levels are one of the biggest challenges to humanity posed by climate change, and sound predictions are crucial if we are to adapt. This research shows that Antarctica, long thought to be the "sleeping giant" of sea level rise, is actually a key player. Its ice sheets can change quickly, and in ways that could have huge implications for coastal communities and infrastructure in future.

A warning from the past

Earth's cycles consist of both cold glacial periods — or ice ages — when large parts of the world are covered in large ice sheets, and warmer interglacial periods when the ice thaws and sea levels rise.

The Earth is presently in an interglacial period, which began about 10,000 years ago. But greenhouse gas emissions over the past 200 years have caused climate changes that are faster and more extreme than experienced during the last interglacial. This means past rates of sea level rise provide only low-end predictions of what might happen in future.

We examined data from the last interglacial, which occurred 125,000 to 118,000 years ago. Temperatures were up to one Celsius higher than today — similar to those projected for the near future. Our research reveals that ice melt in the last interglacial period caused global seas to rise about 10 metres above the present level. The ice melted first in Antarctica, then a few thousand years later in Greenland.

Sea levels rose at up to three metres per century, far exceeding the roughly 0.3-metre rise observed over the past 150 years. The early ice loss in Antarctica occurred when the Southern Ocean warmed at the start of the interglacial. This meltwater changed the way Earth's oceans circulated, which caused warming in the northern polar region and triggered ice melt in Greenland.

Understanding the data


Dogs hauling a sled through meltwater on coastal sea ice during an expedition in northwest Greenland,June 2019

Global average sea level is currently estimated to be rising at more than three millimetres a year. This rate is projected to increase and total sea-level rise by 2100 (relative to 2000) is projected to reach 70-100 centimetres, depending on which greenhouse gas emissions pathway we follow.

Such projections usually rely on records gathered this century from tide gauges, and since the 1990s from satellite data. Most of these projections do not account for a key natural process — ice-cliff instability — which is not observed in the short instrumental record. This is why geological observations are vital.

When ice reaches the ocean, it becomes a floating ice-shelf, which ends in an ice-cliff. When these cliffs get very large, they become unstable and can rapidly collapse. This collapse increases the discharge of land ice into the ocean. The end result is global sea-level rise.

A few models have attempted to include ice-cliff instability, but the results are contentious. Outputs from these models do, however, predict rates of sea-level rise that are intriguingly similar to our newly observed last interglacial data.

Our work examines records of total sea-level change, which by definition includes all relevant natural processes. We examined chemical changes in fossil plankton shells in marine sediments from the Red Sea, which reliably relate to changes in sea level.

Together with evidence of meltwater input around Antarctica and Greenland, this record reveals how rapidly sea level rose, and distinguishes between different ice sheet contributions.

Looking to the future

What is striking about the last interglacial record is how high and quickly sea levels rose above present levels. Temperatures during the last interglacial were similar to those projected for the near future, which means melting polar ice sheets will likely affect future sea levels far more dramatically than anticipated to date.

The last interglacial is not a perfect scenario for the future. Incoming solar radiation was higher than today because of differences in Earth's position relative to the Sun. Carbon dioxide levels were only 280 parts per million, compared with more than 410 parts per million today.

Crucially, warming between the two poles in the last interglacial did not happen simultaneously. But under today's greenhouse gas-driven climate change, warming and ice loss are happening in both regions at the same time.

This means that if climate change continues unabated, Earth's past dramatic sea level rise could be a small taste of what's to come.

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PLUS POINTS

Getting hotter

Last month was the hottest October on record globally, with temperatures "well above average" in many regions, according to European Union scientists. October 2019's global surface air temperature was 0.69°C warmer than the average between 1981 and 2010, the Copernicus Climate Change Service said. It narrowly edged out October 2015 as the hottest on record. In Europe, the month was 1.1°C hotter than the average October over the same period.

It comes after 2019 saw the warmest September and June on record globally, as well as the second hottest August and joint-warmest July, according to Copernicus data obtained by satellites and ground sensors. The findings mean the year is almost certain to be one of the hottest on record overall, continuing a trend of global warming, which scientists say is being caused by increased greenhouse gases. Over the last 12 months the global surface air temperature has averaged above the 1981-2010 average across most of the world, and far higher in the Arctic.

Copernicus scientists said October 2019 temperatures were "markedly above average" over parts of the Arctic, eastern North America, West Asia, and much of North Africa and Russia. Temperatures were also well above average over southern Brazil, southern Africa, western and southern Australia, and most of eastern Antarctica. Earlier this year Jean-Noel Thepaut, the head of the Copernicus programme, warned Europe was "likely to see" more extreme weather events due to the climate crisis.

The release of October data came on a day 11,000 scientists from across the world published a joint letter warning "untold human suffering" will be unavoidable without huge shifts in way of life. "Despite 40 years of major global negotiations, we have continued to conduct business as usual and have failed to address this crisis," said William Ripple, professor of ecology at Oregon State University, who spearheaded the letter.

The independent

Superbug treatment

Scientists have discovered how a potent bacterial toxin is able to target and kill Methicillin-resistant *Staphylococcus aureus*, paving the way for potential new treatments for superbugs.

New research, led by Stéphane Mesnage from the University of Sheffield in the UK, has explained how lysostaphin specifically recognises MRSA cell walls and quickly causes the breakdown of this pathogen. The lysostaphin is able to increase the number of its molecules bound to the surface of the MRSA cell and this allows the enzyme to "walk" along the cell walls and cause rapid breakdown.

Lysostaphin is an enzyme that has been shown to eradicate *Staphylococcal* infections, such as MRSA, alone or in combination with antibiotics. Although it was discovered over 50 years ago, not much has been known about how it kills these infections. The scientists hope to use their findings to develop new treatments for MRSA and other antibiotic resistant superbugs, which target the infection in a similar way. MRSA is a bacterial superbug that is resistant to several antibiotics and frequently spreads in hospitals where people are more susceptible to infection.

Mesnage, senior lecturer in molecular biology and biotechnology, said, "Lysostaphin is arguably the most studied enzyme after lysozyme, so we are delighted that our research is able to explain the mechanism underpinning its potent antibacterial activity.

"Our study explains how this enzyme is able to target and digest the MRSA bacteria and why it is so potent. Hospital-acquired infections caused by bacteria resistant to last resort antibiotics are on the rise, but our work could lead to the development of new treatments for these superbugs that use the same targeting mechanism."

The paper, "Two-site recognition of Staphylococcus aureus peptidoglycan by lysostaphin SH3b", has been published in *Nature Chemical Biology*.