



Air & Light

Highest atmospheric phenomenon

Aurorae - also known as the northern and southern lights – occur some 400 km (250 mi) above Earth's surface. These dazzling light shows, most prevalent towards the poles, are created when solar winds carrying charged particles from the Sun collide with Earth's upper atmosphere.

Largest steam rings

Mount Etna in Sicily, Italy, can emit vapour rings with a diameter of around 200 m (650 ft). The rings can last for around 10 minutes, drifting to a height of 1,000 m (3,280 ft) above the volcanic vent. The precise reason for this unusual phenomenon remains unknown.

Longest single clouds

"Morning Glory" are backward-rolling cloud formations best known from the Gulf of Carpentaria in Australia, which can reach 1,000 km (620 mi) in length - the distance between London, UK, and Monaco.

The tallest clouds are cumulonimbus clouds. In the tropics, they have been observed to reach a height of nearly 20,000 m (65,600 ft). This is more than twice the height of Mount Everest.

Noctilucent clouds are the highest clouds, forming at altitudes of c. 80 km (50 mi) above 99.9% of Earth's atmosphere.

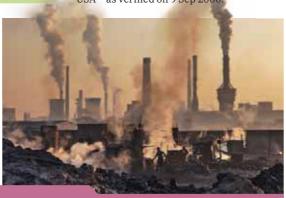
Coldest cloud tops

At 04:21 UTC (Coordinated Universal Time) on 30 Nov 2019, the Visible Infrared Imaging Radiometer Suite on board the polar-orbiting NOAA-20 satellite recorded an infrared temperature of -109.35°C (-164.83°F) in a Category 1 storm system in the west Pacific Ocean. The high-altitude cloud was associated with Typhoon Kammuri. Scientists estimated that the cloud tops were around 19,500 m (64,000 ft) above Earth's surface at their coldest point.

Smallest hole in the ozone layer

On 8 Sep 2019, NOAA and NASA scientists reported that the hole in the ozone layer above Antarctica had reached a peak size of 16.4 million km2 (6.3 million sq mi), the smallest observed since 1982. Over the next two months, it shrank further still to less than 10 million km² (3.9 million sq mi).

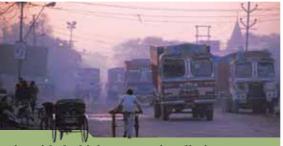
The largest hole in the ozone layer measured 29.9 million km² (11.54 million sq mi) - about three times the area of the USA - as verified on 9 Sep 2000.



Highest annual atmospheric CO, concentration Average levels of carbon dioxide (CO2) in the atmosphere reached 407.8 ppm (parts per million) in 2018, according to the World Meteorological Organization's Greenhouse Gas Bulletin. This was a rise of 0.57% from the previous highest level, recorded in 2017, and is up 147% since pre-industrial levels in 1750. Preliminary reports indicate that levels were 409.5 ppm in 2019.

Fastest jet stream on Earth

A jet stream is a narrow channel of verv fast-moving air, normally found at high elevations in the atmosphere, caused largely by heat differential between the equator and the poles. Based on data collected by the Integrated Global Radiosonde Archive since 1905, the fastest jet stream recorded by a weather balloon is 115.7 m/s (416.5 km/h; 258.8 mph). The reading was taken at a pressure of 250 millibars. which corresponds to an altitude of around 10,400 m (34,120 ft), near Yonago in Tottori, Japan, from where it launched on 5 Feb 2004. Climate change may be strengthening the intensity of jet streams - something that pilots are able to take advantage of to expedite long-haul flights (see p.169).



City with the highest PM2 5 air pollution Kanpur in India had an average PM_{2.5} level of 173 micrograms per m³ in 2016, according to a 2018 World Health Organization (WHO) report. This is more than 17 times higher than the WHO's advised maximum. Industrial burning and vehicle emissions contribute to Kanpur's polluted air.

> The term PM_{2.5} describes particulate matter with a diameter of less than $2.5\ micrometres\ (\mu m; 1\ millionth\ of\ a\ metre),\ such\ as\ fine\ soot.\ PM_{_{10}},\ meanwhile,$ refers to larger pollutants up to 10 μm in diameter, such as dust or pollen.

LONGEST CAREER AS A HURRICANE HUNTER



Eighty-six-year-old meteorologist Dr James McFadden (USA) had worked at the National Oceanic and Atmospheric Administration as a "hurricane hunter" for 52 years 352 days, as of his flight into Tropical Storm Jerry on 22 Sep 2019.

Tell us about your flight into Hurricane Dorian in 2019.

Dorian was the most savage hurricane of the season, causing massive destruction to the islands just east of the Florida coast. My last flight into it was very rough, with wind speeds between 130 and 156 mph [209-251 km/h]. One could only imagine what the folks on the ground were going through.

What's the strongest hurricane you've ever flown into?

The most terrifying was Hurricane Hugo in 1989. It was a Category 5 storm - the strongest on the Saffir-Simpson scale. We entered the eyewall at 1,500 ft [457 m] and encountered winds in excess of 200 mph [321 km/h], along with severe turbulence. We suffered an engine failure at a critical time and there were a few anxious moments before the pilots regained control.

Has anything ever gone majorly wrong during one of your flights? Three engines failed within four minutes during a night flight over the Atlantic in February 2007, but the flight crew was able to restart all three and get us back to base.

Are hurricanes getting more severe? Is this a knock-on effect of climate change?

It's complicated and I think one has to be careful to blame climate change for all of it – but as global temperatures rise, I believe that the catalyst is there for stronger storms.

What does it take to be a hurricane hunter?

Being smart and being safe. They go hand in hand, and without them you can get into a world of hurt.

Do you foresee yourself still flying on missions for years to come? In 2022, we'll be introducing a new high-altitude jet, a Gulfstream 550, into the hurricane programme. That may be worth waiting around to see.



Greatest display of solar haloes

On 11 Jan 1999, at least 24 types of solar halo were witnessed at the Geographic South Pole. Solar haloes are formed by the reflection and refraction of sunlight by ice crystals in the atmosphere, causing rings around the Sun and brightly coloured patches in the sky. The rings tend to be positioned 22° from the Sun, so scientists call them "22° haloes".

Fastest recorded wind speed

On 10 Apr 1996, a weather station on Barrow Island off Western Australia logged a 408-km/h (253-mph) gust during Tropical Cyclone Olivia. This is the strongest surface wind measurement taken by an anemometer not associated with a hurricane.

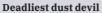
Scientists from the University of Oklahoma recorded the **fastest estimated wind speed** on 3 May 1999. A tornado that struck near Bridge Creek in Oklahoma, USA, peaked at 486 km/h (301 mph) – give or take 32 km/h (20 mph) – according to a "Doppler on Wheels" mobile weather observatory.

Most tornadoes in 24 hours

During a four-day "super outbreak" of storms over southern USA, the WMO logged 207 distinct twisters over a 24-hr period on 27–28 Apr 2011. More than 300 people were killed and the total cost of the damage was \$11 bn (£6.6 bn).

The **most tornadoes spawned by a hurricane** is 119, by Hurricane Ivan on 15–17 Sep 2004 in the Caribbean Sea.

The **largest tornado** had a diameter of 4.18 km (2.59 mi), as measured on 31 May 2013 using Doppler radar by the US National Weather Service in El Reno, Oklahoma, USA.



Dust devils are short-lived whirlwinds with a primarily upward motion that tend to form over hot, dry surfaces. There are only two recorded incidents of fatalities caused by dust devils – both in the USA: on 19 May 2003, a house fell in and killed a man in Lebanon, Maine; and on 18 Jun 2008, a woman died in a collapsed shed in Casper, Wyoming.



A series of swirling cloud eddies over the Norwegian island of Jan Mayen extended for c. 300 km (186 mi) in Jun 2001. Such vortices are a feature of "cloud streets", parallel rows of marine stratocumulus that can form when air currents encounter isolated islands or mountains.



Longest-lasting rainbow

On 30 Nov 2017, a rainbow over Yangmingshan in Chinese Taipei was continuously observed for 8 hr 58 min by members of the Atmospheric Sciences department of Chinese Culture University (TPE). It was believed to have been caused by a seasonal monsoon wind carrying water vapour from the sea.



rolling across Erg Chebbi in Saharan Morocco.

The Bodélé Depression is a former lake bed on the

southern edge of the Sahara Desert, located between

two mountainous regions. Winds funnelling through

this area disturb the surface sediments, whipping

up around 100 dust storms each year and injecting

some 700,000 tonnes (771,600 US tons) of dust into

the atmosphere every day. Pictured is a dust storm

Largest source of dust storms

Supercells are powerful thunderstorms that form around deep, rotating updrafts known as mesocyclones. They can measure kilometres across and last for several hours, producing torrential rainfall, hail and high winds. Around 30% of supercells spawn tornadoes. They often occur on the Great Plains of the USA, in the area known informally as "Tornado Alley".





GWR 2021 has been compiled from applications from the public but also submissions from a global network of institutions and experts,

whom we'd like to thank. Find a full list at www.guinnessworldrecords. com/about-us/partners.

8000ers.com

Eberhard Jurgalski has developed the system of "Elevation Equality", a method of classifying mountain ranges and peaks. His website has become the main source of altitude statistics for the Himalayas and Karakoram ranges.

American Society of Ichthyologists and Herpetologists

The ASIH was founded in 1913 and is dedicated to the scientific study of fishes, amphibians and reptiles. It aims to increase knowledge about these organisms and to support young scientists in these fields.

Archaeology in the Community

Established by Dr Alexandra Jones, this not-for-profit - based in Washington, DC, USA - promotes the study and public understanding of archaeological heritage through informal educational programmes and community events.

Berkeley Seismology Lab

Professor Michael Manga is chair of Earth and Planetary Science at UC Berkeley – also home of the Berkeley Seismology Lab - in California, USA, He specializes in volcanic eruptions and geysers on Earth and other planets.

British Microlight Aircraft Association

Approved by the Civil Aviation Authority, the BMAA looks after the interests of microlight pilots and enthusiasts in the UK. It is chaired by Rob Hughes, who is also 1st Vice-President to the FAI Microlight & Paramotor Commission

CANNA UK National Giant Vegetables Championship

Every September, Martyn Davis welcomes expert growers to the Malvern Autumn Show held in Worcestershire, UK. Martyn ensures all the vegetables comply with the strict criteria and are measured appropriately.

Channel Swimming Association

The CSA supports swimmers with the logistics of crossing the Strait of Dover and has been the governing body of Channel swimming since 1927. The CSA only ratifies swims that are conducted under its rules and that are accompanied by its observers.

Council on Tall Buildings and Urban Habitat

Based in Chicago, Illinois, USA, the Council on Tall Buildings and Urban Habitat is the world's leading resource for professionals focused on the design. construction and operation of tall buildings and future cities.

Desert Research Institute

Dr Nick Lancaster is Research Professor Emeritus of the DRI in Nevada, USA, where his specialisms are desert geomorphology and the impacts of climate change on desert regions.

DogFest is the UK's ultimate summer festival for dogs, held each year at three locations. Visitors can get involved in activities including dock diving and flyball. In 2019, GWR attended the event with its live "Record Barkers" show to scout for new canine talent.

ESPN X Games

Since its inception in 1995, ESPN's X Games have become the leading action-sports competition, spotlighting the world's best action-sports athletes in BMX, skateboard and Moto X in the summer as well as the crème de la crème of skiing, snowboarding and snowmobiling at its winter events.

Foundation for **Environmental Education**

With members in 77 countries, the Denmark-headquartered FEE is the world's largest organization of its kind. Its globally recognized Green Key and Blue Flag initiatives promote the protection of natural resources.

Gareth Jones' Lab

GJL conducts research on ecology, conservation biology and animal behaviour, with a particular focus on bats. Professor Jones has published around 300 scientific papers; his work ranges from acoustics to tracking animal movements.

Gerontology Research Group

Established in 1990, the GRG's mission is to slow and ultimately reverse ageing via the application and sharing of scientific knowledge. It also keeps the largest database of supercentenarians (people aged 110+), a division that is managed by Robert Young.

Great Pumpkin Commonwealth

/FRPOOL

The GPC cultivates the growing of giant pumpkins - as well as other prodigious produce – by establishing universal standards and regulations that ensure quality of fruit and fairness of competition across the world.

International Ice Swimming Association

Founded by Ram Barkai, the IISA was formed in 2009 with a vision to formalize swimming in icy water. It has put in place a set of rules to allow for maximum safety measures and to regulate swim integrity in terms of distance, time and conditions.

International Mineralogical Association

The IMA consists of 39 member societies across six continents. Its mandate ranges from streamlining the nomenclature and classification of minerals to the preservation of mineralogical heritage.

International Ornithologists' Union

The IOU is a member-supported global organization dedicated to research in avian biology from ecosystems to molecules, linking basic and applied research, and nurturing education and outreach. Its current president. tenured between 2018 and 2022, is Dr Dominique Homberger.

International Slackline Association

The ISA aims to support and develop slackline communities of all sizes. as well as providing governance for slacklining as a competitive sport.

International Society of Limnology

Founded in 1922, SIL is devoted to the study of inland waters (e.g., lakes, rivers and inland seas), with some 1.250 members from 70 countries. Dr Tamar Zohary has been General Secretary-Treasurer since 2013.

IUCN SSC Small Mammal Specialist Group

The Small Mammal Specialist Group (part of the International Union for Conservation of Nature) is a global network of scientists and conservationists who share a passion for rodents, shrews, moles, hedgehogs and tree shrews.

IUCN World Commission on Protected Areas

The IUCN's WCPA is the world's premier network of protected-area expertise. Administered by IUCN's Global Programme on Protected Areas, it boasts more than 2,500 members, spanning 140 countries.

Marine Megafauna Foundation

The MMF was created in 2009 to research, protect and conserve the populations of threatened marine megafauna around the world. Ocean giants that fall under its remit include whales, sharks, rays and sea turtles.

Metacritic

Since 2001, Metacritic has distilled opinions from the world's most respected and reliable entertainment critics into an easy-to-understand rating for films, music, games and TV.

MonumentalTrees.com

Tim Bekaert is the administrator of MonumentalTrees.com, a community website listing thousands of girth and height measurements for noteworthy trees, as well as photos and location details of otherwise undocumented remarkable specimens.

National Museum of Computing

The National Museum of Computing at Bletchley Park in Oxfordshire, UK, is an independent charity housing a vast collection of functional historic computers such as Colossus, the first code-breaking computer, and the oldest working digital computer, the WITCH.

National Oceanic and Atmospheric Administration

NOAA's reach extends from the surface of the Sun to the depths of the ocean floor as it works to keep the public informed of the changing environment around them. Its scope ranges from daily weather forecasts and severe storm warnings to coastal restoration and marine-commerce support.

National Pet Show

The UK's National Pet Show is an annual event held each November at the National Exhibition Centre in Birmingham. It's attended by all manner of domestic animal professionals, including those with expertise in dogs, cats, birds, reptiles, rodents, livestock and even insects.

National Speleological Society

The NSS is a non-profit membership organization dedicated to the scientific study, exploration, protection and conservation of caves and karst.

Natural History Museum Vienna

Dr Ludovic Ferrière is a geologist and expert on meteorites and impact craters. He is chief curator of the prestigious meteorite and impactite collections at the Natural History Museum Vienna in Austria.

Ocean Rowing Society

The ORS was established in 1983 by Kenneth F Crutchlow and Peter Bird, later joined by Tom Lynch and Tatiana Rezvaya-Crutchlow. The organization documents all attempts to row the oceans and major bodies of water, and classifies, verifies and adjudicates ocean-rowing achievements.





























The Cornell Lab

Bioacoustics Research Program





RESEARCH GROUP



























Parrot Analytics

Parrot Analytics is the leading global content demand analytics company for the modern multi-platform TV business. The company currently tracks more than 1.5 billion daily expressions of demand in over 100 languages.

Paul Zimnisky Diamond Analytics

Paul Zimnisky is a leading global diamond industry analyst. His research is used by financial institutions, governments and universities.

Roller Coaster DataBase

The RCDB is a repository of theme-park statistics started by Duane Marden in 1996. It now features more than 5,000 rollercoasters. GWR is kept "in the loop" by RCDB researcher Justin Garvanovic.

Royal Botanic Gardens, Kew

Kew Gardens in London, UK, is a worldfamous scientific organization, globally respected for its outstanding collections as well as its scientific expertise in plant diversity, conservation and sustainable development. It was accredited as a UNESCO World Heritage Site in 2003.

School of Ants Australia

Dr Kirsti Abbott is an ant ecologist who runs School of Ants in Australia. a citizen-science project that aims to document the diversity and distribution of ants in urban landscapes.

Scott Polar Research Institute

The SPRI of Cambridge University, UK, was formed in 1920 as a memorial to those who died during Captain Scott's 1910–13 South Pole expedition. Its resources, including a vast library, cover the entire Arctic and Antarctic.

Speedrun.com

Speedrun.com provides leaderboards, resources, forums and more for speedrunning - the act of playing a videogame with the intent of completing it as quickly as possible. The site has amassed a database of more than 930,000 runs across 16,648 games.

The Cornell Lab

Directed by Dr Holger Klinck, the Center for Conservation Bioacoustics at The Cornell Lab of Ornithology in Ithaca, New York, USA, is a team of scientists, engineers and students working on a wide variety of terrestrial, aquatic and marine bioacoustic research projects.

The H J Lutcher Stark Center

for Physical Culture & Sports Based at the University of Texas in Austin, USA, the Stark Center is directed by Professor Jan Todd and houses the world's foremost collection dedicated to physical culture.

The International Cat Association

TICA® is the world's largest genetic registry of pedigreed and household pet cats. It supports the health and welfare of all domestic cats through education, and promotes proper care to the owners of millions of cats worldwide.

The Numbers

The-Numbers.com is the web's biggest database of cinema box-office information, with figures on more than 38,000 movies and 160,000 people in the film industry. It was founded in 1997 by Bruce Nash and is visited by more than 8 million people every year.

UK Timing Association

The UKTA was established in 2013 when personnel from Straightliners Ltd and SPEE3D Ltd joined forces to enhance and promote land-speed record-breaking in Britain and Europe. It ensures that land-speed contenders can compete under all governances.

University College London: The Bartlett School of Architecture

Iain Borden is Professor of Architecture & Urban Culture at The Bartlett School at UCL London, UK. He has authored more than 100 books and articles including numerous titles on architects. buildings and cities.

University of Liverpool: Integrative Genomics of Ageing Group

Dr João Pedro de Magalhães leads the Integrative Genomics of Ageing Group at the UK's University of Liverpool, focusing on the genetic, cellular and molecular mechanisms of ageing. He also manages the AnAge database, logging the oldest animals in captivity.

University of Southern California

Primatologist Dr Craig Stanford is the Professor of Anthropology and Biological Sciences at the University of Southern California, USA. He has conducted field research on primates in East Africa, Asia and South America.

VGChartz

Established in 2005 by Brett Walton, VGChartz is a business intelligence and research firm. It publishes over 7,000 unique weekly estimates relating to videogaming hardware and software sales, and hosts an ever-expanding game database with over 40,000 titles.

Whale and Dolphin Conservation

WDC is the leading global charity dedicated to the conservation and protection of whales and dolphins. It defends cetaceans against the threats they face through campaigns, lobbying, advising governments, conservation projects, field research and rescue.

World Cube Association

The WCA governs competitions for mechanical puzzles that are operated by twisting groups of pieces, such as the Rubik's Cube. Its mission is to have more competitions in more countries with more people, all participating under fair and equal conditions.

World Memory Sports Council

The mind sport of memory was founded in 1991 by Tony Buzan and Raymond Keene OBE. The 10 disciplines which formed the basis of the first competition have since been adopted worldwide as the basis for all competitive memory contests.

World Meteorological Organization

Dr Randall Cerveny is a President's Professor in Geographical Sciences who specializes in weather and climate. He has held the position of Rapporteur of Weather and Climate Extremes for the WMO since 2007.

World Open Water Swimming Association

Founded by Steven Munatones in 2005, WOWSA is the international governing body for the sport of open-water swimming. It provides membership and certification programmes as well as publications and online resources.

World Sailing Speed Record Council

The WSSRC was recognized by the International Yacht Racing Union (now World Sailing) in 1972. The council of experts draws members from Australia. France, Great Britain and the USA.

World Sport Stacking Association

As the official global governing body for the fast-paced pastime of sport stacking, the WSSA promotes the standardization and advancement of the discipline's rules, records and events.

World Surf League

The WSL is dedicated to celebrating the world's best surfing on the best waves. It has been championing competitive surfing since 1976, running more than 180 global events annually.

World UltraCycling Association

WUCA (formerly known as UMCA) is a non-profit organization dedicated to supporting ultra-cycling across the world. It holds the largest repository of cycling records for all bike types and certifies records for its members.

ZSL Institute of Zoology

The Institute of Zoology is the academic research division of the Zoological Society of London in the UK. It is a world-renowned research centre at the cutting edge of conservation science.

Solar System

Claire Andreoli, Mark Aston, Ravi Kumar Kopparapu, Timur Kryachko, Catherine l'Hostis & Marc Fulconis, Jonathan McDowell, Carolyn Porco. Peter Schultz, Scott S Sheppard

Natural World

Nikolai Aladin, Andrew Baldwin, Nellie Barnett, Michael Caldwell, Anton Chakhmouradian, Karen Chin, Peter Clarkson, Gerardo Aguirre Diaz, Wenyuan Fan, Rory Flood, Mike Fromm, Robert Headland, Vincent Johan van Hinsberg, Robert Holzworth, Dan Laffoley, Mathieu Morlighem, David Peterson, Simon Poppinga, Stephen Pyne, Alan Robock, Ryan Said, Marc Schallenberg, Roger Seymour, John Sinton, Jon Slate, John Smellie, David J Smith, Thomas Speck, Chris Stokes, Brian Toon, Maximillian Van Wyk De Vries, Paul Williams

Animals

Tycho Anker-Nilssen, Joseph Bump, Chris Carbone, Dan Challender, William Crampton, Phil Currie, Dyan deNapoli, Tanya Detto, Coen Elemans, Christo Fabricius, Peter Flood, Eva Fuglei, Semyon Grigoriev, Adam Hartstone-Rose, Matthew Hayward, Jutta Heuer, Craig Hilton-Taylor, Dominique Homberger, Blanca Huertas, Simon Ingram, Paul Johnsgard, Stephen Kajiura, Alec Lackmann, Robin Moule, Christopher Murray, Mark O'Shea, Aniruddh D Patel, W Scott Persons, Robert Pitman, Grigory Potapov, Liz Sandeman, Kate Sanders, Karl P N Shuker, Heather Sohl, Katharina Sperling, Arnaud Tarroux, Samuel Turvey, Oliver Wearn, Richard Weigl, Becky Williams, Alan Wilson, Harald Wolf, Trevor Worthy, Jhala Yadvendradev

Edward Bell, Donald Rau, Nancy Segal, Kira Westaway, Robert Young

Recordmania / Against the Clock Andrew Aldridge, Martyn Davis, Todd Kline, Ian Woodcock

Adventurers

Ned Denison, Thaneswar Guragai, Rob Hughes, Steve Jones, Pádraig Mallon, Richard Meredith-Hardy, David Monks, Larry Oslund

Culture & Society

Amanda Abrell, Stuart Ackland, Alexis Albion, Alaia Berriozabal, Aliza Bran, Lauren Clement, Mike Dunn, Marshall Gerometta, Sophie Bachet Granados, Hannah Hess, Ioanna Iordanou, Alexandra Jones, Darren Julien, "Matt L", Peter Marsters, Valerie Miller, Chris Moran, Alistair Pike, Harro Ranter, Barry Roche, Monique Turner

Pop Culture / Gaming

Dick Fiddy, Jane Klain, Dan Peel, James Proud, Matthew White

Technology

Evan Ackerman, Michael Blakemore, Inge Buytaert, Martin Campbell-Kelly, Jessie Clark, Nigel Crowe, Stephen Fleming, Justin Garvanovic, Andrew Good, Veselin Kostov, Judi Lalor, Beck Lockwood, Beatriz Alcalá López, Sam Mason, Fran Read, Gary Settles, Jules Tipler, Richard Wynne, Hua Zhao

Tom Beckerlegge, Grace Coryell, David Fischer, Matthew White







INTERNATIONA ORNITHOLOGISTS









