WORLD
METEOROLOGICAL
ORGANIZATION

THE SUN THE EARTH AND THE WEATHER

23 MARCH 2019

WORLD METEOROLOGICAL DAY

World Meteorological Day 2019

World Meteorological Day 2019 is celebrated all over the world on 23rd of March, at Saturday.

History of World Meteorological Day

The World meteorological day was founded by the World Meteorological Organization (WMO) which is an inter-governmental organization established for meteorology and having approximately the membership of 191 world-wide Member States as well as Territories. It was first founded and originated from the "International Meteorological Organization" which was established by the International Meteorological Congress at Vienna, Austria in the year 1873.

Whereas, World Meteorological Organization was first established on 23rd of March in the year 1950 and had become the specialized meteorology agency of the United Nations to operate the weather and climate from one place as well as performing the operational hydrology including all the related geophysical sciences. The headquarters of the World Meteorological Organization is in the Geneva, Switzerland which is a member of the Development Group, United Nations.

The World Meteorological Organization has been established as a specialized agency in 1951 for meteorology to keep current details about the Earth's atmosphere behavior, atmospheric interactions with the oceans, resulting climate and distribution of the water resources. According to the statistics of 2013, this organization includes around 191 member states and territories membership, the conference of which was held on 11th of October in 1947 and approved in the year 1950.

Why World Meteorological Day is Celebrated

The organization was established aiming establishing a big meteorological station networks contributing towards the safety and efficiency of the shipping services as well as safety and welfare of the people. It also offers very significant role towards the water resources safety, food security and transport.

A world level international cooperation is required for the continuous growth and development of the meteorology and operational hydrology research activities, as environment, weather, climate and water cycle are very natural resources which never consider any national or international boundaries. WMO is an international organization for the meteorology offering a best support for such international cooperation.

It has been playing very unique and commanding role in the field of meteorology which contributes to safety and wellbeing of the humanity. Its leadership for organizing programs for National Meteorological and Hydrological Services provides a lot help by protecting life and property from the natural disasters. It safeguards earth's environment and enhances the people's economic and social wellbeing through the security of food, water resources and transport.

How World Meteorological Day is Celebrated

The World Meteorological Day is celebrated every year by organizing variety of programmers and activities. The World Meteorological Organization organizes Scientific and Technical Forum, to discuss an outline of all the past activities and achievements of the World Weather Watch (telecommunications and meteorological forecasts) as well as to implement its evolutions in the next century, in the Geneva headquarters on 23rd of March to commemorate the World Meteorological Day.

Secretary-General's Message

World Meteorological Day 2019 is devoted to the theme “The Sun, the Earth and the Weather”.

The Sun delivers the energy that powers all life on Earth. It drives the weather, ocean currents and hydrological cycle. It shapes our moods and daily activities. It is the inspiration for music, photography and art.

Located nearly 150 million kilometres from Earth, the Sun is the heart of our solar system and keeps our planet warm enough for living things to thrive. For over 4.5 billion years, this hot ball of glowing plasma has been the driving force behind weather and climate, and life on Earth.

Satellite measurements taken over the past 30 years show that the Sun’s energy output has not increased and that the recent warming observed on Earth cannot be attributed to changes in Sun activity.

The rise in temperatures – which are melting ice and heating the oceans – is driven by long-lived greenhouse gases in the atmosphere. Carbon dioxide concentrations reached 405.5 parts per million in 2017 and continue to rise.

As a consequence, since 1990, there has been a 41% increase in total radiative forcing – the warming effect on the climate - by long-lived greenhouse gases. CO2 accounts for about 82% of the increase in radiative forcing over the past decade.

If the current trend in greenhouse gas concentrations continues, we may see temperature increases of 3 °C to 5 °C by the end of the century. This is well above the target of the Paris Agreement of the United Nations Framework Convention on Climate Change, which aims to hold the global average temperature increase to below 2 °C and as close as possible to 1.5 °C.

Climate change has led to an increase in heat extremes, and new temperature records – at local daily levels as well as at national, regional and global level. Heatwaves are starting earlier and ending later in the year and becoming more frequent and intense as a result of climate change.

Climate models project increases in mean temperature in most land and ocean regions, hot extremes in most inhabited regions, heavy precipitation in several regions and the probability of drought and precipitation deficits in some regions. Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming.

The Sun can provide an alternative source of energy, which can be harnessed even in cloudy weather. Solar energy is indeed used worldwide and is increasingly popular for generating electricity or heating and desalinating water.

Understanding how the Sun influence weather and climate phenomena is therefore critical to the core mission of WMO of building resilient societies.

The integrated Earth System approach of the WMO community will provide the best possible science and operational services to support countries for weather, climate, hydrology, oceans and the environment.

Petteri Taalas
Secretary-General
World Meteorological Organization

The Sun

The Sun delivers the energy that powers all life on Earth. It drives the weather, ocean currents and the hydrological cycle. It shapes our mood and our daily activities. It is the inspiration for music, photography and art.

The Sun is a star, just like the ones we can see in the night sky, but much, much closer. Located nearly 150 million kilometres from the Earth, it is the heart of our solar system and keeps our planet warm enough for living things to thrive. For over 4.5 billion years, this hot ball of glowing plasma has been the driving force behind weather, climate and life on Earth.

The Sun's diameter is about 1.39 million kilometres (864 000 miles), or 109 times that of the Earth.

At its core, its temperature is about 15 million °C (27 million °F). The surface of the Sun – the part we can see – is about 5 500 °C (10 000 °F).

Without the steady light and heat of the Sun, life on Earth would cease to exist. The Sun's heat makes liquid water on our planet possible. And all life – bacteria, plants, insects, animals, humans – needs liquid water to survive. The Sun powers the hydrological cycle, constantly evaporating water into the atmosphere, which then falls back to Earth.

Over the span of 11 years, the Sun's activity waxes and wanes as magnetic field lines that are wound and tangled inside the Sun periodically break through to the surface, producing sunspots that travel across the face of the Sun. The heightened magnetic activity associated with sunspots can lead to solar flares, coronal mass ejections, and other far-reaching electromagnetic phenomena. The Aurora Borealis (Northern Lights) and Aurora Australis (Southern Lights) are visible manifestations of space weather.

The Sun and seasons

The tilt of Earth's axis relative to its orbit around the Sun determines the duration of daylight and the amount of sunlight received at any latitude, ranging from polar to equatorial regions. These changes cause the annual cycle of seasons and associated temperature changes.

Equinox

The Equinox in the Northern Hemisphere occurs twice a year around 20 March (the spring equinox) and around 22 September (the autumn equinox). They occur between the summer and winter solstices marking the point the sun crosses the equator's path and becomes positioned exactly above the equator between the Northern and Southern Hemisphere. Except at the equator, the equinoxes are the only dates with equal daylight and dark. At the equator, all days of the year have the same number of hours of light and dark.

Solstice

These occur twice a year and are referred to as the 'summer solstice' and 'winter solstice'. The summer solstice - which occurs around the 21 June in the Northern Hemisphere - is the day of the year with the longest period of daylight while the winter solstice - on or around the 21 December in the Northern Hemisphere - is the day with the shortest period of daylight.

When it is the summer solstice in the Northern Hemisphere, the areas north of the Arctic circle receive sunlight for a full 24 hours, while areas south of the Antarctic circle have a full day of total darkness. This situation is reversed at the winter solstice.

At the summer solstice, the sun reaches its highest point of the year, while at the winter solstice, the noon sun is the lowest it will be all year. During the summer solstice the Northern Hemisphere of Earth is tilted towards the sun resulting in increased sunlight and warmer temperatures, this results in continuous daylight in far northern countries such as Iceland and Norway.

Fast Facts

The Sun is located some 149.60 million kilometres (92.92 million miles) from Earth.

The Sun's volume would need 1.3 million Earths to fill it.

The Sun's rotation period at the Equator is about 27 days and at the Poles about 36 days.

A solar eclipse happens when the moon comes between the Sun and Earth. When the moon only blocks out part of the Sun's light, it's called a partial solar eclipse. Sometimes, the moon blocks all of the Sun's light. This is called a total solar eclipse.

The word Equinox comes from the Latin *equi* (meaning 'equal') and *nox* (meaning 'night').

The spring equinox marks the beginning of Spring and from this day forward the day is longer than the night. Similarly the autumn equinox marks the start of autumn as the night becomes longer than the day.

The *equilux* is when day and night are equal and occurs a few days before the spring equinox, and a few days after the autumn equinox.

The Sun's impact on the Earth

The air surrounding us consists of different gases and also some particles. This layer of air, known as the Earth's atmosphere, is retained by gravity. The two main components are nitrogen (78%) and oxygen (21%). Besides containing the oxygen human beings and other organisms need to live, the atmosphere has a number of other "features" such as absorption of ultraviolet radiation from the Sun by the ozone layer and heat retention known as the greenhouse effect.

Solar radiation that is not absorbed or reflected by the atmosphere (for example by clouds) reaches the surface of the Earth. The Earth absorbs most of the energy reaching its surface, a small fraction is reflected. In total approximately 70% of incoming radiation is absorbed by the atmosphere and the Earth's surface while around 30% is reflected back to space and does not heat the surface. The Earth radiates energy at wavelengths much longer than the Sun because it is colder. Part of this longwave radiation is absorbed by greenhouse gases which then radiate energy into all directions, including downwards and thereby trapping heat in the atmosphere.

Without this natural greenhouse effect, the Earth's average surface temperature would be an inhospitable -18°C (0°F) instead of the 14°C (59°F) we experience today. This effect is enhanced by increasing greenhouse gas concentrations in the atmosphere due to emissions by human activities such as burning fossil fuels. The main long-lived greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). But they are not the only forces at work.

Water vapour

Water vapour is the most abundant greenhouse gas. It does not stay in the atmosphere for very long but plays a key role in our climate and its variability and change.

Ozone

Ozone in the lower part of the atmosphere acts as a greenhouse gas and is a major pollutant. Higher up, in the stratosphere, the ozone layer absorbs solar ultra-violet radiation and affects how much of the Sun's heat is radiated back into space. The ozone layer shields us from the harmful effects of excessive UV radiation, which can lead to sunburn, skin cancer and eye damage.

Aerosols

The atmosphere also contains small suspended solid and liquid particles. Aerosols are small dust particles that float in the atmosphere. They result mostly from chemical reactions between gaseous air pollutants, rising sand or sea spray, forest fires, agricultural and industrial activities and vehicle exhausts.

Aerosols affect many aspects of human health and the environment, visible in the case of strong smog or haze events. Aerosols influence Earth's climate both directly, by scattering and absorbing sunlight, and indirectly, by altering the reflectivity of clouds. In general, aerosols have a cooling effect on climate, which partially counterbalances the heating effect of greenhouse gases. Under certain circumstances, however, they may cause additional heating, such as the case of black carbon in soot.

The gases and dust particles thrown into the atmosphere during volcanic eruptions have influences on climate and cool the planet by shading incoming solar radiation. The cooling effect can sometimes last for months to years.

Albedo effect

Albedo is the ability of a surface to reflect sunlight (solar radiation). Snow and ice have high albedo – much of the sunlight hitting surfaces covered with snow and ice bounces back. In contrast, dark earthy surfaces have a low albedo, therefore, they absorb more sunlight. Thus, the proportion of Earth's surface that is covered by ice and snow affects how much of the Sun's solar radiation is absorbed, warming the planet, or reflected. Therefore, snow and ice which are covered in soot from pollution no longer reflect sunlight, but absorb it and so melting increases.

The more snow and ice in the Arctic and Antarctic melt, the more dark surfaces. Hence, the feedback of climate change in the Polar regions is further warming, exacerbating climate change globally.

The Sun and the Water Cycle

Earth contains about 1.4 billion km3 of water. The oceans hold 1.3 billion km3, and 71 km3 is fresh water, of which more than two thirds is in the form of snow or ice.

The Sun plays a key role in the hydrological cycle, constantly evaporating water into the atmosphere. Some of that water is returned as rain, snow and dew. Part of this precipitation is rapidly evaporated back into the atmosphere. Some drains into lakes and rivers to commence a journey back to the sea. Some infiltrates into the soil to sustain groundwater or soil moisture. Under natural conditions, the groundwater gradually works its way back into surface waters and makes up the main source of dependable river flow. Plants incorporate some of the soil moisture and groundwater into their tissues, and release some into the atmosphere in the process of transpiration. The hydrological cycle moves enormous quantities of water about the globe, all thanks to the energy from the sun.

Solar Activity and Space weather

Over the span of 11 years, the Sun's activity waxes and wanes as magnetic field lines that are wound and tangled inside the Sun periodically break through to the surface. These breakthroughs produce sunspots that travel together across the face of the Sun. A number of national meteorological services are developing a space weather forecasting system to meet these challenges.

"Space Weather" designates the physical and phenomenological state of the natural space environment, including the Sun and the interplanetary and planetary environments. The associated discipline aims at observing, understanding and predicting the state of the Sun, of the planetary and interplanetary environments and their disturbances, with particular attention to the potential impacts of these disturbances on biological and technological systems.

The effects of Space Weather can range from damage to satellites arising from charged particles to disruption of power grids on Earth during geomagnetic storms, radio black-out on trans-polar aircraft routes, or disturbance of satellite positioning systems. Space Weather monitoring, study and applications are more and more important with the increasing use of space in day-to-day life for telecommunications, observation and navigation.

Aurora Borealis/Aurora Australis

The Aurora Borealis (Northern Lights) and Aurora Australis (Southern Lights) are the only visible manifestation of space weather. Energy from the ever-present solar wind or from coronal mass ejections is transferred into the Earth system and ultimately leads to the excitation of oxygen and nitrogen molecules in the upper atmosphere. When these molecules relax back down to lower energy states, they release their energy in the form of light, similar to how a neon light works.

Due to the shape of Earth's own magnetic field, the aurora appears in two ovals around Earth's magnetic poles. As the driving geomagnetic storm intensifies, these ovals expand equatorward. In the most extreme geomagnetic storms, this can lead to aurora being visible nearly worldwide.

Source: AUSTRALIAN ANTARCTIC DIVISION/Frederique OLIVIER, 2007.

Fast Facts

An ash cloud from the eruption of Mount Pinatubo in the Philippines in 1991 — one of the largest in the past 100 years — circled the globe in 22 days and caused the equivalent to a global cooling of at least 0.5 to 0.7°C.

Furnace Creek in Death Valley, California, holds the record for the hottest air temperature ever measured, at 56.7 °C (134 °F) on July 10, 1913.

The Sun and climate change

When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable. However, since the start of the industrial era in the second part of the 19th century, average global temperatures have risen by about 1 °C.

This current climate change is happening in order of magnitudes faster compared to climate fluctuations due to Earth's orbit around the Sun. This unprecedented speed makes it hard for ecosystems as well as humankind to adapt.

Satellite measurements taken over the past 30 years show that the Sun's energy output has not increased and that the recent warming observed on Earth cannot be attributed to changes in Sun activity.

The rise in temperatures – which are melting ice and heating the oceans – is driven by long-lived greenhouse gases in the atmosphere. Carbon dioxide (CO2) concentrations reached 405.5 parts per million (ppm) in 2017 and continue to rise. Since 1990, there has been a 41% increase in total radiative forcing – the warming effect on the climate - by long-lived greenhouse gases. CO2 accounts for about 82% of the increase in radiative forcing over the past decade.

If the current trend in greenhouse gas concentrations continues, we may see temperature increases of 3°C to 5°C by the end of the century. This is well above the target of the Paris Agreement of the United Nations

Framework Convention on Climate Change (UNFCCC), which aims to hold the global average temperature increase to below 2°C and as close as possible to 1.5°C.

The 20 warmest years on record have been in the past 22 years, with the top four in the past four years.

Fast Facts

The Earth has had more than 400 consecutive months with global temperatures above the 20th century average. The last colder than average month was in December 1984.

Global average temperature is about 1°C above the pre-industrial era. Global emissions of CO2 need to reach 'net zero' around 2050 to keep temperature increases to 1.5°C.

IPCC: Limiting warming to 1.5 °C rather than 2 °C could result in 420 million fewer people being exposed to severe heatwaves.

The Sun and renewable energy

Energy can be harnessed directly from the sun, even in cloudy weather. Solar energy is used worldwide and is increasingly popular for generating electricity or heating and desalinating water.

The rapidly declining manufacturing costs of solar panels and national and regional subsidies are stimulating this growth.

Solar power is generated in two main ways:

Photovoltaics (PV), also called solar cells, are electronic devices that convert sunlight directly into electricity. Such solar cells can be seen everywhere –on roof and windows of houses and office buildings, battery chargers and computers, new cars and airplanes, solar farms, the list is endless. Today, PV is one of the fastest-growing renewable energy technologies, and is ready to play a major role in the future global electricity generation mix.

Solar PV installations can be combined to provide electricity on a commercial scale, or arranged in smaller configurations for mini-grids or personal use. Using solar PV to power mini-grids is an excellent way to bring electricity access to people who live in remote locations, particularly in developing countries with excellent solar energy resources.

The cost of manufacturing solar panels has plummeted dramatically in the last decade, making them not only affordable but often the cheapest form of electricity. Technological advances have also made them more efficient. Solar panels have a lifespan of roughly 30 years, and come in variety of shades depending on the type of material used in manufacturing.

Concentrated solar power (CSP), uses mirrors to concentrate solar rays. These rays heat fluid, which creates steam to drive a turbine and generate electricity. CSP is used to generate electricity in large-scale power plants.

A CSP power plant usually features a field of mirrors that redirect rays to a tall thin tower. One of the main advantages of a CSP power plant over a solar PV power plant is that it can be equipped with molten salts in which heat can be stored, allowing electricity to be generated after the sun has set.

Solar energy has soared in the past few years. Installed capacity rose from under 10 000 megawatts in 2007 to nearly 390 000 MW in 2017, according to the International Renewable Energy Agency.

Renewable energy – including solar – have become the technology of choice, making up almost two-thirds of global capacity additions to 2040, thanks to falling costs and supportive government policies. This is transforming the global power mix, with the share of renewables in generation rising to over 40% by 2040, from 25% today, according to the International Energy Agency.

Power generation from photovoltaics is strongly dependent on the weather. Therefore, reliable meteorological forecasts are indispensable for balancing the power grid and will gain even more importance, as the renewable energy sector expands. For this reason, weather forecasts optimized for energy applications are required.

The requirements from the energy sector pose a new challenge and opportunities for national meteorological services. For this reason, the Global Framework for Climate Services (GFCS) is leading international efforts to enhance the quality, quantity and application of climate information and predictions in support of decision-making by renewable energy producers.

Fast Facts

Morocco is developing the largest concentrated solar power (CSP) plant in the world. The Nour Solar Complex in Ouarzazate is expected to generate enough power to provide electricity to over one million people.

Solar energy has been used for over 2700 years. In 700 BC, glass lenses were used to make fire by magnifying the sun's rays.

Solar impulse: In 2016, two Swiss pilots completed the first circumnavigation of the globe with no fuel, flying 40,000 km to promote the use of solar and other renewable energies.

Measuring sunlight

Scientists use solar radiation measurements in order to study climate variability and change and to forecast the weather.

Measuring sunlight, however, is not as easy as it may sound. Long-term measurements that are comparable from place to place, from time to time, and from instrument to instrument are essential. This requires a special effort to finely calibrate thousands of ground-based instruments all around the world.

Radiation measurements are essential for decision-makers in the solar energy industry. To calculate how much electricity a proposed solar energy installation will produce, they need to know how much sunlight will be available on sunny days and cloudy days, or on short winter days versus long summer days. These estimates are used by decision-makers and commercial investors to identify suitable locations for solar power plants.

Its role is to make sure that everybody uses the same accurate scale for measuring solar irradiance in order to make those measurements comparable to each other and to measurements that have been taken in the past and will be taken in the future.

Without this WMO-led international collaboration on carrying out this rigorous, behind-the-scenes work, scientists would have a much weaker understanding of the climate system, and the solar energy industry would be less efficient.

Fast Facts

Germany had its sunniest year on record in 2018, with 2 015 hours of sunshine. The United Kingdom had its second sunniest year on record in 2018, with close to 1 575 hours of sunshine.

Countries in high latitudes in the northern hemisphere, which suffer from long Arctic nights in winter, also enjoy “Midnight sun” in June.

The Sun, our well-being and health

Sunlight plays a pivotal role in human health and well-being. Too little Sun impacts our mood and well-being and increases the risk of Vitamin D deficiency. Overexposure to sunlight causes harmful effects on the skin, eyes, and immune system. Experts believe that four out of five cases of skin cancer could be prevented, as UV damage is mostly avoidable.

The ultraviolet index or UV Index is an international standard measurement of the strength of sunburn-producing ultraviolet radiation at a particular place and time. Many national meteorological services provide information and alerts on UV levels, and work with health authorities to disseminate safety tips to the public.

Sunburn occurs when skin is overexposed to UV radiation. Protection against sunburn is very important as excessive UV radiation directly damages the DNA in our skin cells. Often not all of the sun damage will be fully repaired by the body's defence system, so it will gradually cause skin ageing over the years and may lead to skin cancer.

UV radiation can have serious effects on the condition of our eyes and damage the eye's surface tissues as well as the cornea and lens. UV can burn the surface of the eye much like sunburn on skin. Long term exposure to UV radiation can be more serious. Exposure to UV is a significant risk factor for cataract development, which is the leading cause of blindness in the world.

People enjoying winter sun on the ski slopes also need to be aware. At altitude there is less atmosphere to filter UV rays. Snow reflects around 85% of the sun's UV rays so can cause sunburn to exposed parts of the body. Up to 80% of the Sun's UV rays penetrate light clouds, and what gets through can reflect back and forth between the clouds and the snow.

Simple precautions make a big difference. Shade, clothing, hats and UV-protective sunglasses provide the best protection – applying sunscreen becomes necessary on those parts of the body that remain exposed like the face and hands.

Sunshine hours trigger increased production of serotonin which influence how we feel. This influence is seen in seasonal variations of psychiatric phenomena related to exposure to longer and shorter sunlight hours, especially mood and anxiety symptoms, as well as suicide.

Sunlight is also necessary for the production of vitamin D, which helps to regulate the amount of calcium and phosphate in the body, both are needed to keep bones and teeth healthy. The amount of time needed to generate enough vitamin D varies from person to person – sometimes a few minutes is enough.

The ozone layer

The stratospheric ozone layer protects humans from dangerous ultraviolet and other forms of radiation from the Sun. Ozone concentrations in the atmosphere vary naturally with sunspots, seasons, and latitude. However, in the mid-1980s it was discovered that the ozone shield was being depleted well beyond natural processes as a result of chlorine and bromine atoms coming into contact with ozone and destroying ozone molecules.

The discovery of the ozone hole led to international action to phase out the most damaging chemicals such as chlorine-releasing chlorofluorocarbons (CFCs), used in in refrigeration and air conditioning, and bromine-releasing halons, used as fire-extinguishing agents. Thanks to measures taken under the Montreal Protocol on Substances that Deplete the Ozone Layer, the destruction of the stratospheric ozone layer has been halted.

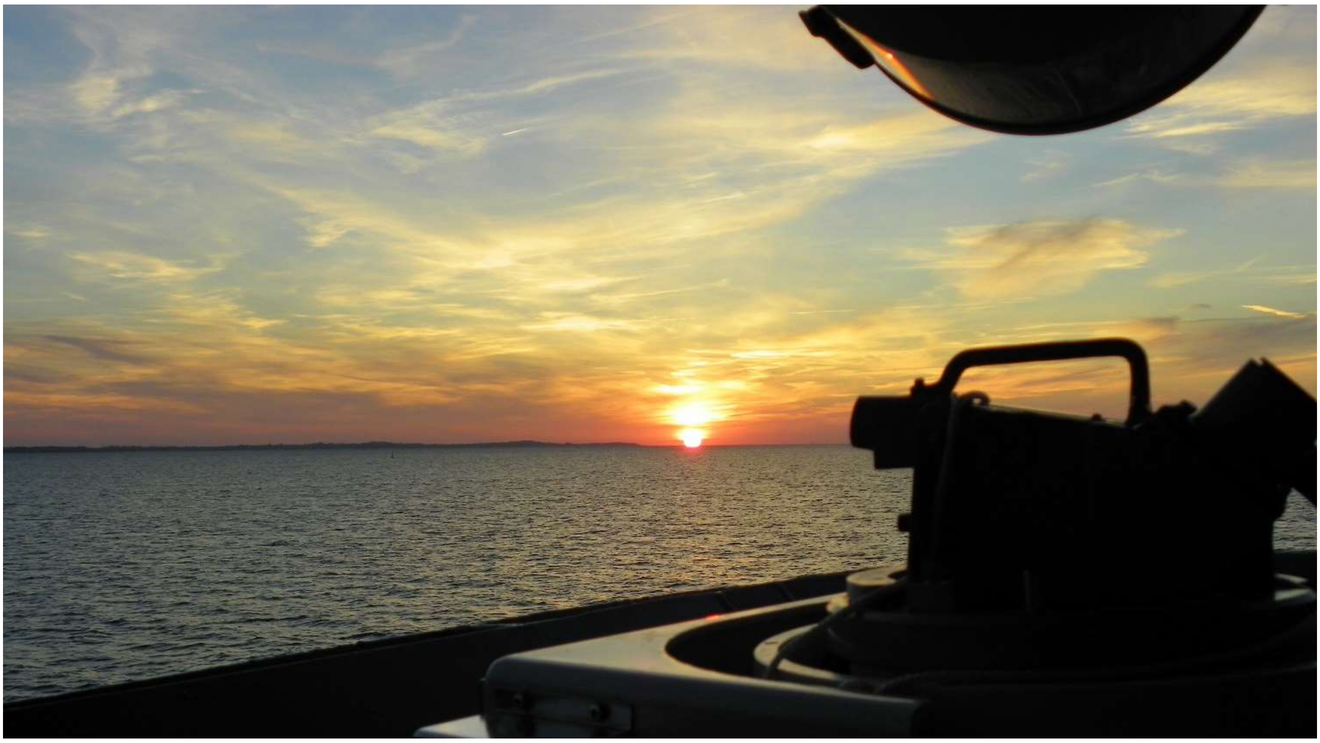
At projected rates, Northern Hemisphere and mid-latitude ozone is scheduled to heal completely by the 2030s, followed by the Southern Hemisphere in the 2050s and polar regions by 2060.

The Montreal Protocol is the world's most successful global environmental treaty and has also had tremendous health benefits. By the end of this century, an estimated 100 million cases of skin cancer will have been avoided and many millions of extra cases of eye cataracts will have been prevented. By limiting ozone depletion, the treaty also protects the human immune function and protect food security by reducing UV damage to crops and marine life-supporting ecosystems vital for fisheries.

Heat and health

Every year, tens of thousands of people die as a result of avoidable extreme heat-related problems such as heat stroke, cardiovascular disease, mental health, dehydration, and other complications of heat stress.

Fortunately, nearly all adverse health outcomes of human exposure to dangerous heat are preventable with targeted and informed interventions. WMO works with the World Health Organization (WHO) to promote the development of heat-health early warning systems as well as closer collaboration between national meteorological services and health authorities. These heat-health action plans have averted many unnecessary deaths, but more needs to be done.



Source: Photo C. Dyrcz.

Fast Facts

The total economic benefit of the Montreal Protocol is estimated to be US$ 1.8 trillion by 2060, with avoided healthcare costs accounting for about 80% of this.

Altitude—at higher altitudes, a thinner atmosphere filters less UV radiation. With every 1000 metres increase in altitude, UV levels increase by 10% to 12%.

Source: World Meteorological Organization https://worldmetday.wmo.int/ [15.03.2019].

Prepared by Czesław Dyrcz based on WMO materials.