WORLD
METEOROLOGICAL
ORGANIZATION

THE SUN
THE EARTH
AND THE WEATHER

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WORLD METEOROLOGICAL DAY

WEATHER CLIMATE WATER

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.

National Meteorological and Hydrological Services provide expertise and services both to harness the power of the Sun and to protect us from it. These include 24/7 weather observations and forecasts, as well as monitoring of atmospheric greenhouse gases, ultraviolet radiation, aerosols and ozone and their consequent effects on people, climate, air and water quality and marine and terrestrial life.

THE SUN'S IMPACT ON THE EARTH

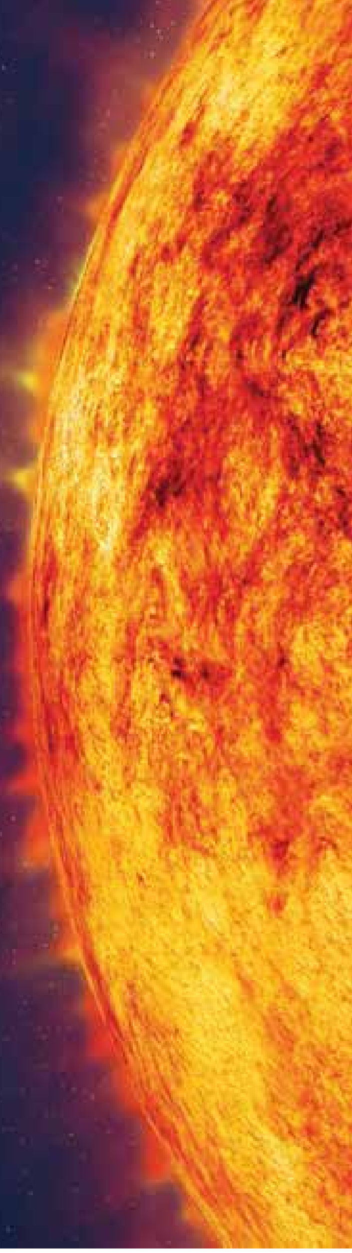
Throughout Earth's history, the amount of energy received from the Sun has varied, with major consequences for the climate and all living things. Since the end of the last Ice Age nearly 12 000 years ago, the climate has been relatively stable, although it has regularly been affected by small changes in the amount of solar radiation reaching the Earth's surface. These minor variations are often caused by long-term cycles affecting the Earth's orbit around the Sun, changes in cloud cover and other fluctuations here on Earth. Even relatively small climate fluctuations have had drastic regional effects on human civilizations and caused empires like the Mayans or the Old Kingdom of Egypt to rise and fall.

The amount of sunlight received on Earth's surface depends on the output of the Sun, its overhead angle and the cyclical variations of Earth's orbit around the Sun, as well as how much sunlight is absorbed or reflected back into space by the atmosphere.

Solar radiation that is not absorbed or reflected by the atmosphere (for example by clouds) reaches Earth's surface. Earth absorbs most of this energy, and a small fraction is reflected back into space. In total, approximately 70% of incoming radiation is absorbed by either Earth's atmosphere or its surface, while around 30% is reflected back into space and does not heat the planet.

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 natural greenhouse effect is enhanced by ever increasing greenhouse gas concentrations in the atmosphere due to emissions by human activities such as the burning of fossil fuels.

THE SUN AND CLIMATE CHANGE



Climate fluctuations induced by the Earth's orbit around the Sun are on a time scale of millennia, whereas climate change linked to human activities has occurred since the start of the industrial era. The unprecedented speed at which climate change is presently occurring makes it hard for ecosystems as well as humankind to adapt.

The burning of fossil fuels and other industrial and agricultural activities release carbon dioxide and other greenhouse gases into the atmosphere. These gases trap the Sun's heat and disrupt the Earth's energy balance.

Carbon dioxide (CO_2) 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. CO_2 accounts for about 82% of the increase in radiative forcing over the past decade.

Since the start of the industrial era in the second part of the 19th century, average global temperatures have risen by about 1 °C. As a result, ice is melting at the poles, oceans are warming and sea levels are rising, which in turn all fuel more extreme weather.

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 SUN, OUR WELL-BEING AND HEALTH

Sunlight plays a pivotal role in human health and well-being. It triggers an increased production of serotonin, which influences how we feel. Limited exposure to sunlight, in addition to increasing the risk of Vitamin D deficiency, negatively impacts our mood. This 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.

> Overexposure to sunlight causes harmful effects to the skin, eyes and immune system. Experts believe that four out of five cases of skin cancer could be prevented, as the damage caused by sunburn-producing ultraviolet (UV) radiation is mostly avoidable.

The UV Index is an international standard measurement of the strength of 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.

The stratospheric ozone layer protects humans from dangerous ultraviolet and other solar radiation. Ozone concentrations in the atmosphere vary naturally according to the season, latitude and presence of sunspots. 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. This led to international action to phase out the production of the most damaging chemicals. 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.

MEASURING SUNLIGHT

Scientists use solar radiation measurements 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, decision-makers need to know how much sunlight will be available on sunny days and cloudy days, or on short winter days versus long summer days.

The Physikalisch-Meteorologisches Observatorium Davos (PMOD) institute in Davos, Switzerland, has been studying how to measure sunlight for over one hundred years. Serving as the WMO World Radiation Centre since 1971, it maintains the primary standard for measuring the Sun's irradiance, the World Radiometric Reference. This ensures that these highly sensitive instruments, known as pyrheliometers, are accurate and their data are comparable.

Without this WMO-led international collaboration, scientists would have a much weaker understanding of the climate system, and the solar energy industry would be less efficient.

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THE SUN AND RENEWABLE ENERGY

The sun provides us with a valuable tool for climate change mitigation in the form of solar energy, which is becoming cheaper and more widely available and has the potential to replace fossil fuels like coal or oil as a major source of electricity.

Energy can be harnessed directly from the sun, even in cloudy weather. Solar energy is increasingly popular for generating electricity and heating and desalinating water. Renewable energy, including solar energy, has 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 from 25% today to over 40% by 2040, according to the International Energy Agency.

SOLAR POWER IS GENERATED IN TWO MAIN WAYS:

Photovoltaics (PV), also called solar cells, are electronic devices that convert sunlight directly into electricity. These solar cells can be seen everywhere – on roofs 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.

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.

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. 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.