Teaching material (students):

Deep Space Climate Observatory (DSCOVR)

„How does continuous global Earth observation by the DSCOVR satellite help to improve our understanding of the complex interactions and processes in the Earth's atmosphere?"

1. General introduction to the Deep Space Climate Observatory (DSCOVR):

The Deep Space Climate Observatory (DSCOVR) is the first Earth observation satellite in orbit at Lagrange point L1, between the Earth and the Sun, approximately 1.5 million km from Earth. The gravitational forces of the two celestial bodies balance each other out at this point, allowing the satellite to remain stable in orbit at L1. On the imaginary line between the Sun and the Earth, this offers the DSCOVR satellite the advantage of a perspective where the Earth is always being illuminated by the Sun.

DSCOVR will observe the Earth from a unique perspective and monitor solar activity in the form of solar flares and solar winds and their influence on the Earth's magnetic field. DSCOVR takes global images of the sunlit side of the Earth approximately every two hours and can process them faster than other Earth observation satellites.

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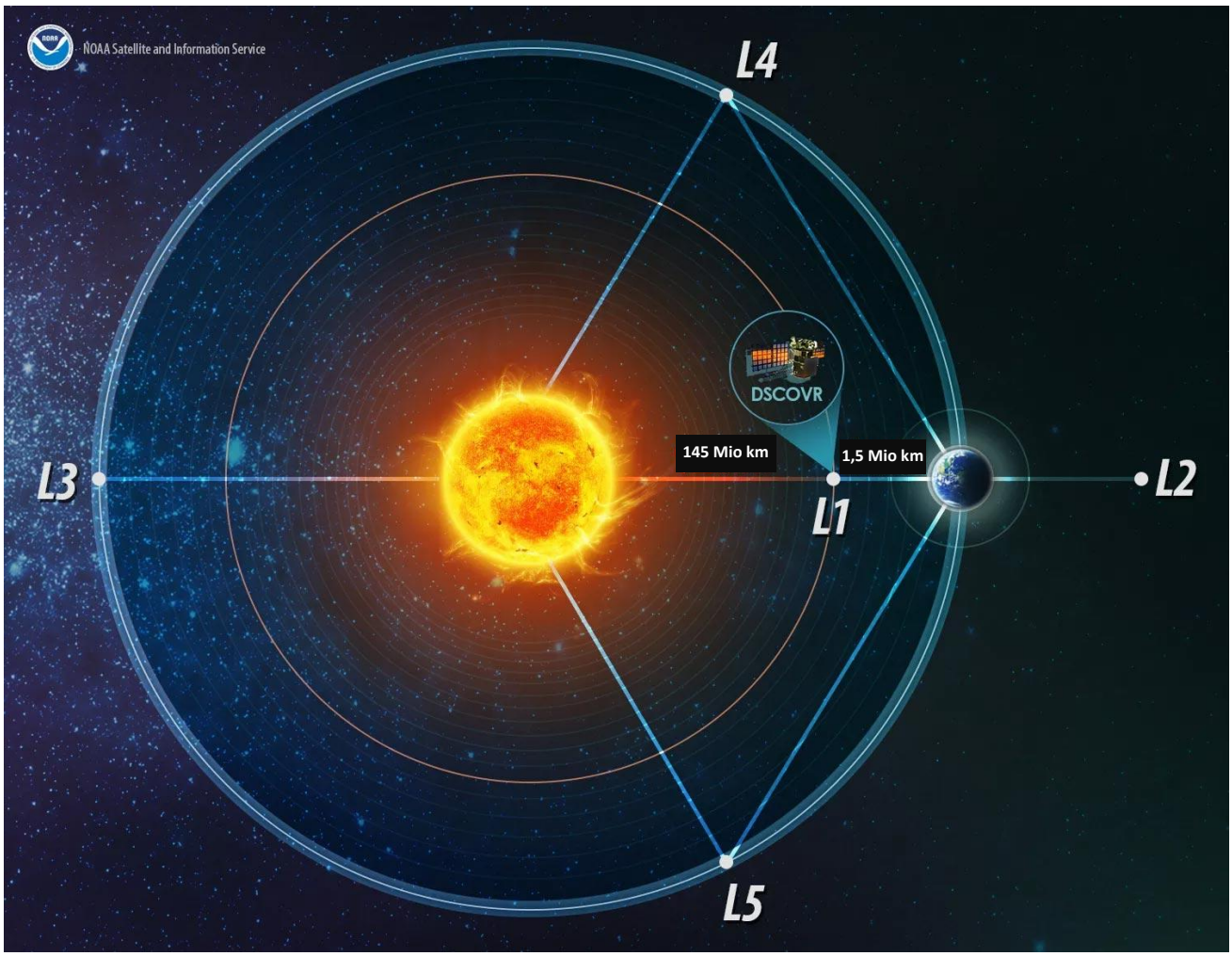
Funding: By the German Space Agency at the German Aerospace Center with funds from the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag under the funding code 50TD2201.



The instruments attached to the DSCOVR satellite are:

- **EPIC** (Earth Polychromatic Imaging Camera)
- **NISTAR** (National Institute of Standards and Technology Advanced Radiometer)
- **PlasMag** (Plasma Magnetometer)

EPIC and **NISTAR** are Earth observation instruments that are directed towards Earth. Among other things, the instruments provide global data on ozone distribution, aerosol distribution, volcanic ash, cloud heights, vegetation cover, and radiation values on Earth. **PlasMag** is directed towards the Sun and provides data on the strength and direction of the solar wind to warn of geomagnetic storms on Earth. The major advantage of DSCOVR over other satellites is its global perspective of the Earth, whereas other satellites focus on smaller-scale observations. This global perspective, where the sunlit part of the Earth can be observed continuously, enables a new perspective on the data mentioned above and can be used in particular for analyzing atmospheric processes and natural disasters.

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DSCOVR is a joint mission between NASA (**N**ational **A**eronautics and **S**pace **A**dministration), NOAA (**N**ational **O**ceanic and **A**tmospheric **A**dministration) and the US Air Force.

2. Overview of the available data:

The data is available in the form of videos showing the sunlit side of the Earth over the course of a day.

- Moon flyby: Due to the average distance of the Moon from Earth of approximately 380,000 km, the Moon moves in its orbit around Earth exactly between the DSCOVR satellite and Earth. This provides satellite images in which the Moon and Earth can be seen in one image. From the satellite, you can see the far side of the Moon, which is never visible from Earth.

- Solar eclipse: A solar eclipse can also be observed by the DSCOVR satellite. In this case, it is a solar eclipse from 2024, during which the Moon moves exactly between the Earth and the Sun and covers large parts of North America during the course of the day. This can be seen in the DSCOVR images as shadows on the Earth.

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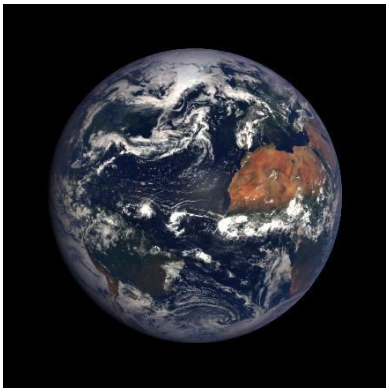
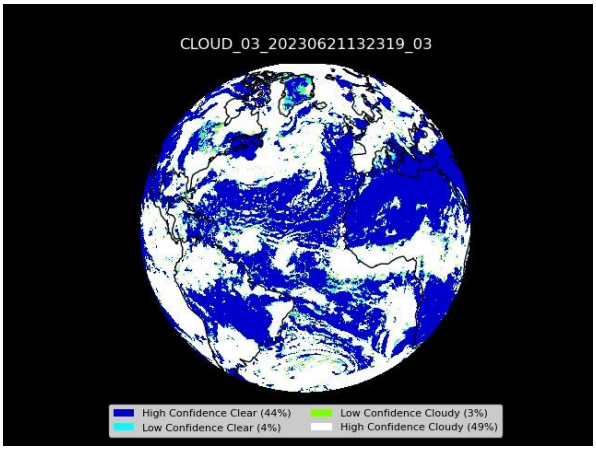
- The Earth during the course of the day at the summer solstice, winter solstice, and with the Sun at the zenith of the equator: DSCOVR makes it possible to show the Earth at different times of the year and the associated different inclinations towards the Sun. The satellite is permanently located approximately at the zenith of the Sun's rays.



- Cloud cover percentage: This dataset shows global cloud cover in the Earth's atmosphere throughout the day. Data for different seasons is also available.



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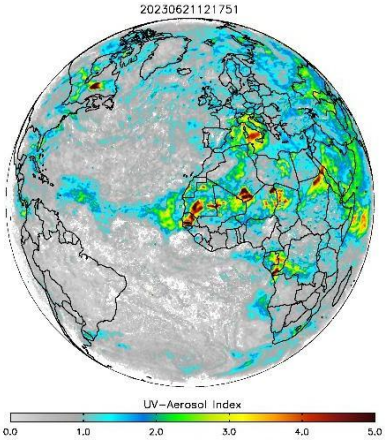
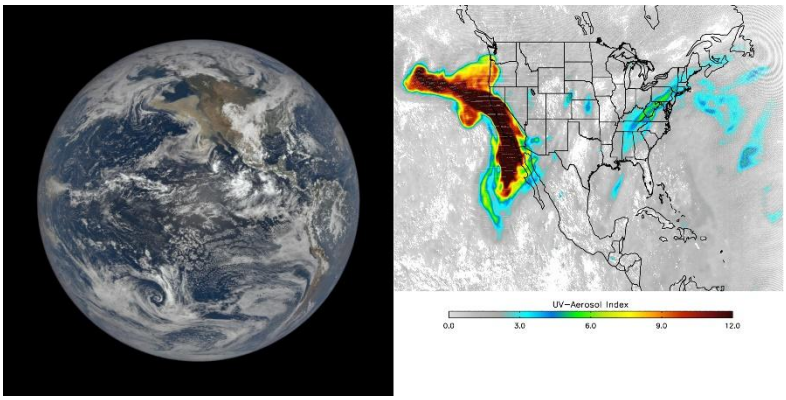
- UV aerosols: The UV aerosol dataset shows global aerosol pollution on Earth over the course of a day. The data is obtained from the UV bands of EPIC-DSCOVR.



- Forest fires: This dataset shows forest fires on the North American west coast from September 9 to 12, 2020, using UV aerosols.



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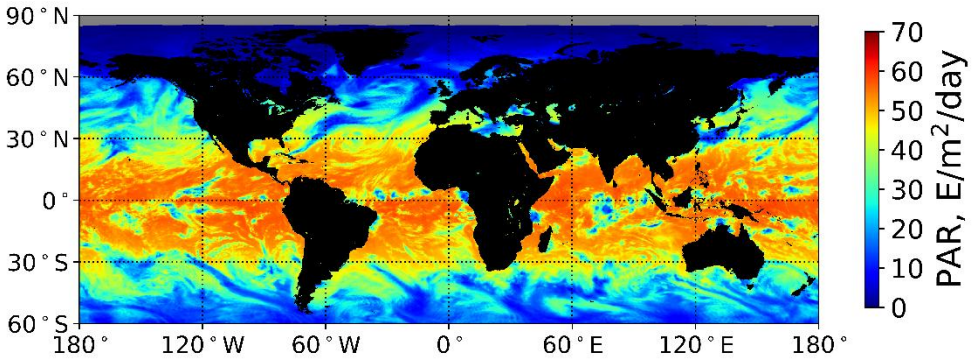
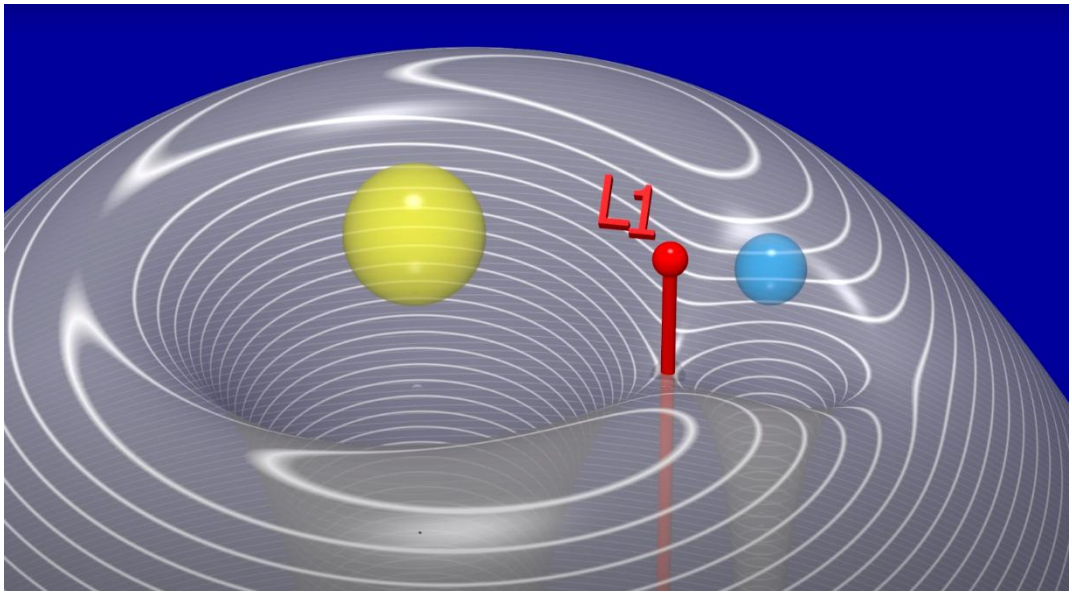
- PAR - **P**hotosynthetically **A**ctive **R**adiation: PAR is a dataset that indicates the global PAR of the Earth over a day. In this case, PAR is expressed in terms of Einstein (E) per square meter per day. PAR indicates the strength of radiation that can potentially be utilized by photosynthetic organisms.



3. Physics:

3.1 The Lagrange point L1:

- Read the text about Lagrange point L1 and study the illustration and video.
- Consider the advantages and disadvantages of the DSCOVR satellite at Lagrange point L1 for observing the Earth and the Sun.



In a system of two celestial bodies with a significant mass difference of at least 1/25, five so-called Lagrange points are formed. At a Lagrange point, such as in the Sun-Earth system (see figure), an object can remain and is permanently located at approximately the same position in

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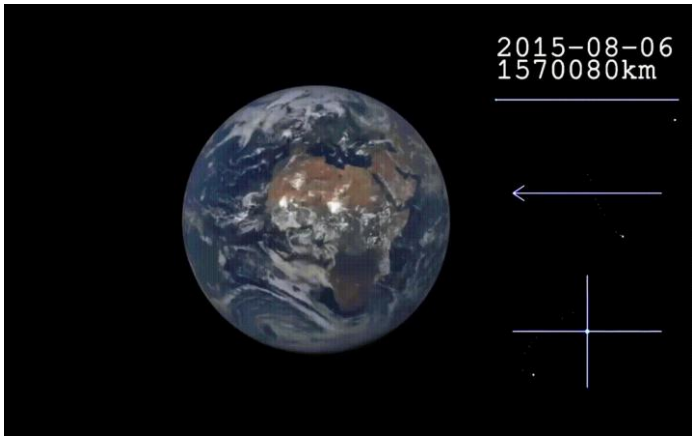
the system. The Lagrange point L1 is located exactly at the position on an imaginary line connecting the two celestial bodies where the gravitational forces balance each other out, in this case approximately 1.5 million km from Earth. While the Earth is in orbit around the Sun, the Lagrange point L1 also moves along this connecting line. However, it is not completely stable due to various influencing factors.

The DSCOVR satellite is therefore not located exactly at Lagrange point L1, but in its own orbit (known as a Lissajous orbit) around this point. If the distance to Lagrange point L1 is too great, there is a risk that the satellite will leave its orbit. To counteract this, the satellite can be moved into the correct orbit using its own propulsion system. Due to these circumstances, the view of Earth is therefore always slightly offset over the course of the year. This can be seen in the following video:



3.2 Observation of the solar eclipse:

- Describe what you notice about the solar eclipse in the video.
- Explain why solar eclipses are important for understanding the solar system and explain in your own words how a solar eclipse occurs.
- Distinguish between total and partial solar eclipses.

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A solar eclipse always occurs during a new moon.

Although the Moon orbits the Earth in about a month, this phenomenon does not occur every month because the orbits of the Earth and the Moon are slightly tilted. These phenomena give us the opportunity to better understand the dynamics of our solar system.

It is important to note that a solar eclipse is not visible everywhere on Earth at the same time. Only those in the shadow zone can observe the phenomenon. The video shows a solar eclipse in 2024 captured by the DSCOVR satellite.

3.3 Photosynthetically Active Radiation (PAR):

- Interpret how PAR affects plant growth.
- Discuss the influence of PAR on the ecosystem.
- Determine which of the three maps corresponds to which season.

Photosynthetically Active Radiation (PAR) refers to the range of the electromagnetic radiation spectrum that is available for the process of photosynthesis in plants. This range includes light with wavelengths between 400 and 700 nanometers and is therefore within the visible spectrum of light. In photosynthesis, plants use light as an energy source to produce glucose and oxygen from water and carbon dioxide. The range from 400 to 700 nanometers is considered the photosynthetically active radiation spectrum, as this is the range in which chlorophyll, the pigment responsible for photosynthesis in plant cells, absorbs light most effectively. In this case, PAR is measured in Einsteins per square meter per day ($E/m^2/d$) and indicates the amount of photosynthetically active radiation that strikes a given area in a given time. This measurement is important for quantifying the light available for plant growth.

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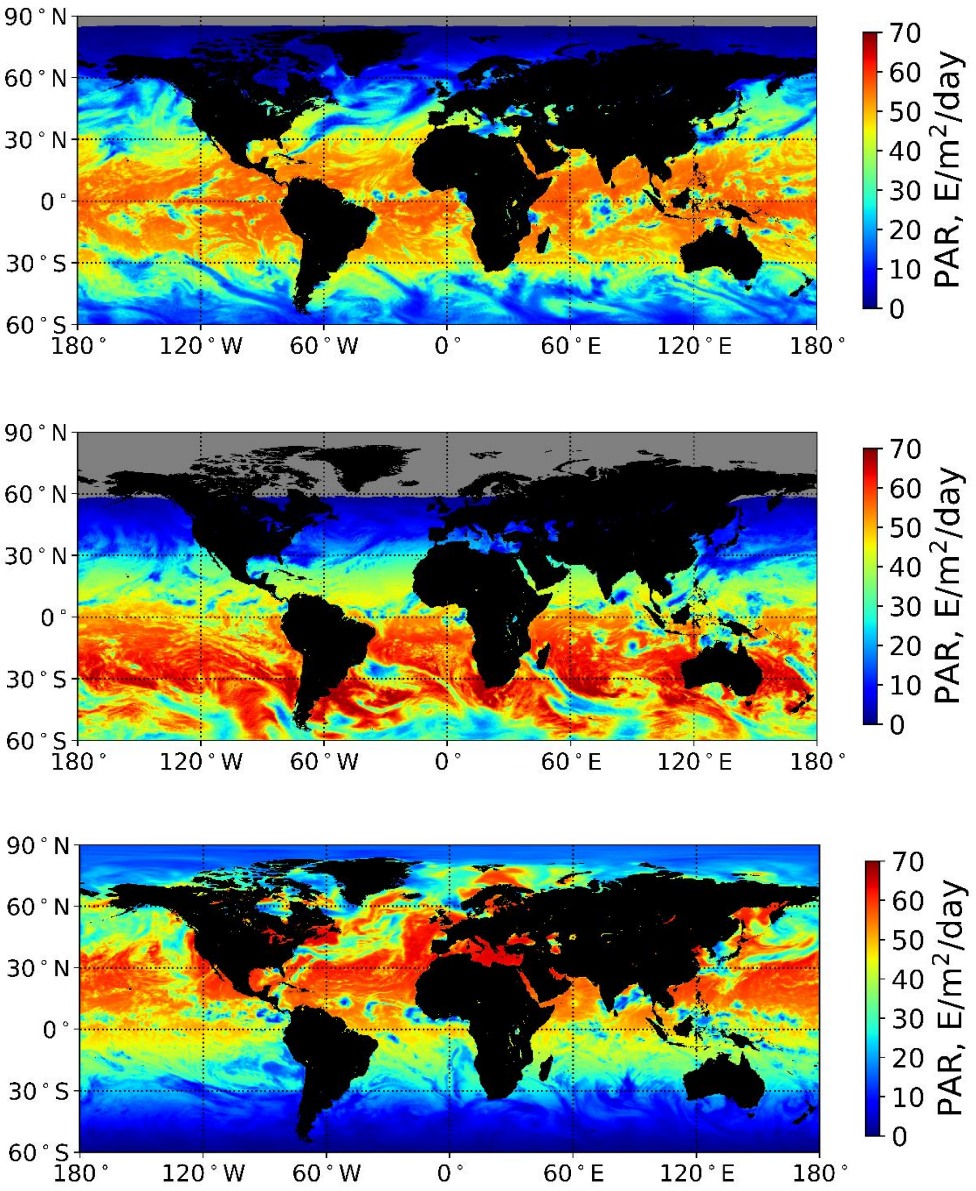
PAR is not only important for plants but also plays a role in ecosystems. The availability of PAR influences the growth of phytoplankton and other photosynthetically active organisms in the ocean, which in turn has an impact on the entire food chain. In climate research and agriculture, PAR measurements are used to monitor plant growth, understand energy exchange between the Earth and the atmosphere, and improve ecological models. PAR measurements can also play a role in optimizing agricultural practices and developing sustainable farming methods.



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4. Geography:

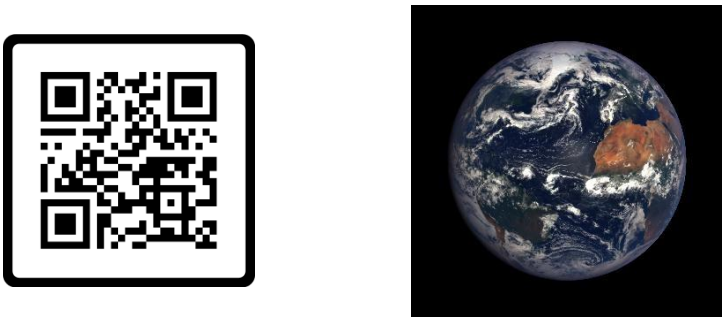
4.1 Looking at the Earth over the course of a day:

- Watch the three different videos and discuss how the different inclinations of the Earth's axis lead to the formation of the seasons.
- Discuss how the Earth's axial tilt and the resulting variations in solar radiation influence the Earth's climate.

The DSCOVR satellite provides us with fascinating insights into the variations in solar radiation on Earth during a day and throughout the year. These three images represent different positions of the Earth relative to the Sun, caused by the tilt of the Earth's axis.

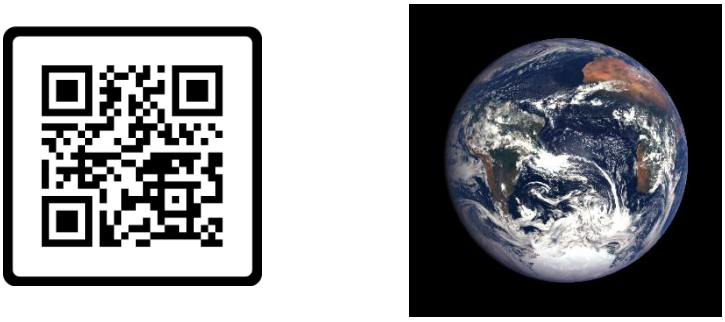
Summer solstice:

In summer, the northern hemisphere of the Earth tilts towards the Sun. The Sun then reaches a higher angle in the sky, resulting in longer daylight hours.



Winter solstice:

In winter, the northern hemisphere tilts away from the Sun. The Sun reaches a lower angle, resulting in shorter daylight hours.



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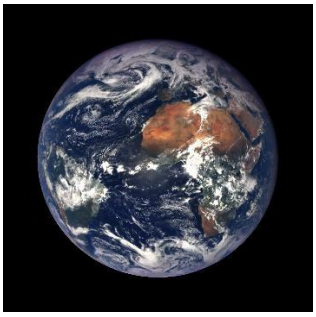
Sun at the zenith of the equator:

On March 21 and September 23, the Earth is in a position where the Sun is at its zenith at the equator. Day and night are then approximately equal in length at the equator.

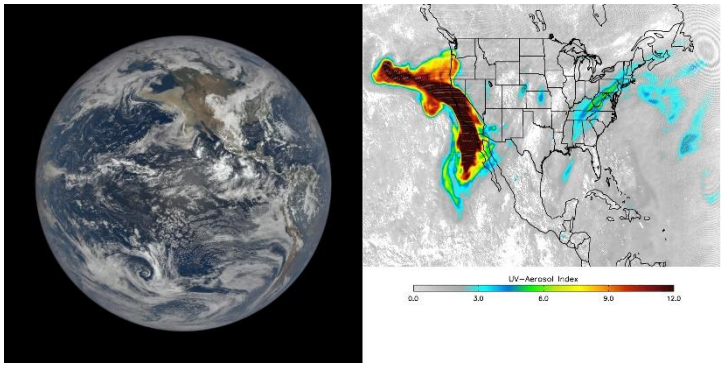


4.2 Forest fires at the US west coast:

Explain how these events are related to climate change.

Causes and effects of forest fires:

Forest fires are complex natural phenomena that can have various causes. The most common causes include lightning strikes, human activities such as (unintentional) arson, and natural factors such as volcanic eruptions. The effects of forest fires are manifold and range from the destruction of habitats and the loss of flora and fauna to air pollution and health hazards for humans and animals. However, forest fires can also have positive effects on the ecosystem.



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Relevance of the DSCOVR satellite for natural hazards:

The DSCOVR satellite plays a crucial role in monitoring and detecting natural hazards, including forest fires. With its ability to continuously capture images of Earth from space, the satellite provides important data for the early detection of fires, monitoring their spread, and analyzing their impact on the environment. This information is crucial for authorities and organizations to respond effectively to natural disasters.

5. Summary and discussion:

- Answer the key question: "How does continuous global Earth observation by the DSCOVR satellite help to improve our understanding of the complex interactions and processes in the Earth's atmosphere?"

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