Teaching material DSCOVR (Teachers)

Overview

Topics:	Astronomy, Remote Sensing, Earth observation, Earth-Moon relationship
Subjects:	Geography, Physics (astronomy)
Grade:	9-13
Media & Materials	Thematic maps and videos from DSCOVR remote sensing data, worksheet
Duration:	90 minutes (less, if only geography or physics are carried out)
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?"

Competences

Subject competences

The students...

... describe the various processed data sets from the DSCOVR satellite and classify them into the context of Earth observation.

... show which thematic data sets are suitable for which geographical and geophysical issues.

Methodological competences

The students...

... use satellite-based data of the Earth (and the Moon) to analyze the facts.

... find a way to present more complex presentation materials and working materials (graphically) and linguistically using a combination of worksheets and DSCOVR material.

... experience the process of gaining knowledge by discussing their approaches and results.

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Judgmental competences

The students...

... evaluate their methodological approach regarding the analysis of the data provided by the DSCOVR satellite and placing it in the context of Earth observation.

... assess how suitable the materials provided are for the work assignments and to what extent there is potential for improvement in the materials.

Executive competences

The students...

... present their work results in a relevant and technically appropriate manner.

Curriculum

This lesson focuses on the process of acquiring knowledge, a process-related skill. Content links can be established to all core curricula of the federal states. There are opportunities to link to existing content areas. In physics, this refers to the astronomical component and dynamics, and in geography to the Earth-Moon relationship, atmospheric and exogenous processes, remote sensing, and location factors. This unit covers many sub-skills of knowledge acquisition that are evident in scientific ways of thinking and working. Examples of German curriculum references can be found in the table below.

Subject	Geography	Physics
Topics	Remote sensing, planetary processes, climate change, weather, natural hazards	Astronomy, planetary processes
Baden-Württemberg	9/10: Digital orientation (GIS, remote sensing), exogenous processes 11/12: The Earth system, spheres in the Earth system (processes in the atmosphere), climate change	9/10: Mechanics and dynamics 11/12: Astrophysics
Bavaria	10: Geographical working techniques and methods	11: Astronomical world views, cosmology 12/13: Astrophysics

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	11/12/13: Geographical working techniques and methods, climate and climate change, natural disasters	
Bremen	Q: Physical geography fundamentals and processes (exogenous forces, atmospheric processes)	EPH: Mechanics of the planetary system, climate change Q: Development of the astronomical world view, electromagnetic spectrum
Berlin / Brandenburg	EPH and Q: Geosphere, exogenous processes	Upper secondary level: Movement of artificial satellites, rotation of the Earth, space travel, complete topic area on the gravitational field, electric and magnetic fields
Lower Saxony	Upper secondary level: physical-geographical factors, spatial orientation	EPH: Dynamics (uniform circular motion), optical imaging (satellites)
North Rhine Westphalia	EPH and Q: changing significance of location factors, GIS and digital map content	EPH and Q: circular motion, gravity, and physical worldviews
Thuringia	11: Climate and weather (exogenous processes) 12: Atmospheric circulation, climate change	11: Gravity (weight, planetary motion), circular motion 12: Gravity, climate protection, and sustainability

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Didactic commentary:

The teacher introduces the unit by asking students to think about the role a satellite four times the distance of the Moon plays in Earth observation and how it can influence our understanding of atmospheric processes and the global climate system. This raises questions about the importance of global Earth observations from Lagrange point L1. A focused discussion on how information about atmospheric processes and the climate can be obtained from space serves as a starting point for the unit. The teacher provides the students with the worksheet and video materials that illustrate various aspects of the DSCOVR satellite and the available data, including the Moon flyby, the solar eclipse, cloud cover, UV aerosols, forest fires, and photosynthetically active radiation (PAR: photosynthetically active radiation). In addition, there are the different perspectives due to the different angles to the sun during the summer solstice, winter solstice, and at the zenith of the equator. The students should then examine the specific characteristics of these data sources and consider how they contribute to Earth observation. To do this, they first study the texts and illustrations from the first and second sub-sections of the material.

This is followed by physics and geography tasks. In physics, students examine the special features of Lagrange point L1, which marks a highly interesting gravitational area between the Earth and the Sun. Here, students highlight why this point is particularly well suited for global Earth observation. The other two tasks relate to observing a solar eclipse from the L1 point and the photosynthetically active radiation (PAR) measured by DSCOVR, in which students are asked to interpret how PAR influences plant growth in different seasons and what impact this has on the ecosystem.

This is followed by an initial review in a group discussion, where the results from the physics tasks are compiled and discussed.

Now it's time for the geography tasks. Here, the focus is on understanding the Earth's axial tilt and its position relative to the sun during the different seasons. This phenomenon can also be seen very clearly with the help of DSCOVR. In addition, students learn how to measure aerosol concentrations in the atmosphere and how this can be used to detect and monitor forest fires. The connection to climate change plays an important role here.

In the final consolidation phase, the results, difficulties, and possible conflicts are presented, discussed, and consolidated in a plenary session. Reference is also made to the key question formulated at the beginning. By combining physics and geography, students can develop a holistic understanding of the role of DSCOVR in climate research.

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Lesson plan

Time	Phase	Lesson activities	Methodological-didactic comments	Social form	Media
10 min	Introduction + Problematization	The teacher begins with an introductory question.	Students should think about the role a satellite four times the distance of the Moon plays in exploring Earth by asking specific questions about the importance of global Earth observations from Lagrange point L1. The teacher notes the students' thoughts on the board in bullet points. A discussion about how information about atmospheric processes and the climate can be obtained from space serves as a starting point. The teacher writes the key question on the board so that it is clearly visible.	Class discussion	Board / Projector
25 min	Development 1	The teacher provides the students with the worksheet and the video materials. The students work on the physics tasks.	The students watch the video materials, which show various aspects of the DSCOVR satellite and the available data. The students examine the special features of Lagrange point L1 and complete the corresponding tasks on the worksheet.	Individual or partner work (if necessary)	Worksheet, Videos

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15 min	Interim review	The results from the physics section are presented and compared in a plenary session.	The teacher has the opportunity to intervene and correct any mistakes. If necessary, an initial interim assessment can be carried out earlier. This can be done, for example, after half of the subtasks have been completed.	Class discussion	Board / Projector
20 min	Development 2	The students work on the geography tasks.	In connection with DSCOVR, the students examine the Earth's axial tilt and the formation of the seasons. In addition, students learn how to measure aerosol concentrations in the atmosphere and the benefits of doing so.	Individual or partner work (if necessary)	Worksheet, Videos
15 min	Review	The results from the geography section are presented and compared in a plenary session. Answering the key question through integrative observation and interdisciplinary teaching of physics and geography.	The teacher has the opportunity to intervene and correct any mistakes. If necessary, an initial interim assessment can be carried out earlier. This can be done, for example, after half of the subtasks have been completed.	Class discussion	Board / Projector
5 min	Outlook			Class discussion	

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Possible solutions to the students' tasks

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

2. Overview of the available data

3. Physics

3.1 Consider the advantages and disadvantages of the DSCOVR satellite at Lagrange point L1 for observing the Earth and the Sun.

By positioning DSCOVR at Lagrange point L1 (mass equilibrium between the Sun and the Earth), the satellite's sensors can continuously observe the sunlit part of the Earth throughout the day, year-round, and thus also across the different seasons globally. This is unique for satellite-based Earth observation. Processes such as climate change, natural disasters, and aerosol distribution can thus be observed and analyzed globally on a daily basis. In addition, it is possible to observe the Earth-Moon system in a single image during the Moon's flyby.

Regarding solar observation, this position offers the opportunity to observe solar storms without any interference from the Earth's atmosphere.

Because the satellite is located much further away from Earth than most other Earth observation satellites, DSCOVR also has a lower spatial resolution. However, this is not particularly relevant given the intention to analyze Earth on a larger scale. It can, however, be cited as a disadvantage.

3.2 View of the solar eclipse of 2024

The shadow of the solar eclipse approaches from the southwest. The shadow first moves over Mexico. It then travels northward, passing through several states in the US. The shadow's final stop is in Canada before it disappears.

A solar eclipse occurs when the Moon passes between the sun and the Earth, blocking the sunlight. This always happens during a new moon. A solar eclipse is not visible everywhere on Earth at the same time. Only those who are in the shadow zone can observe the phenomenon.

Solar eclipses are important events that advance our understanding of the solar system in many ways:

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- Research into the solar corona
- Insights into planetary motion
- Application of astronomical methods
- Analysis of the Sun-Earth-Moon system

A total solar eclipse can be observed at the center of the shadow cast on Earth. During this event, the entire disk of the Sun is obscured by the Moon. A partial solar eclipse can be observed at the edges of the shadow cast on Earth. During this event, only parts of the Sun are obscured by the Moon.

3.3 Interpret how PAR affects plant growth.

Photosynthetically active radiation (PAR) encompasses light in the range of 400 to 700 nanometers, which is necessary for photosynthesis. Blue light promotes vegetative growth and leaf development, while red light supports flowering and fruit formation. The intensity and duration of exposure influence the rate of photosynthesis and developmental processes such as flowering and seed formation. Uniform light distribution within the plant population is important for uniform growth. PAR works in conjunction with other environmental factors such as water and nutrients to ensure optimal plant growth.
Overall, PAR plays a crucial role in the balance of the ecosystem by supporting plants and thus all life. A sufficient amount of PAR promotes plant growth. Healthy plants produce more oxygen and provide habitat for many animals. Plants are the basis of most food webs. When they grow well, there is more food for herbivores, which in turn supports the carnivores that depend on them. Healthy plants improve the soil by returning nutrients and reducing erosion. Different light conditions in different habitats influence which plant species can grow. This has an impact on biodiversity, i.e., the variety of animals and other organisms living in these areas.

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Map 1: Spring in the northern hemisphere

Map 2: Winter in the northern hemisphere

Map 3: Summer in the northern hemisphere

4. Geography

4.1 View of the Earth during the course of a day

The tilt of the Earth's axis is the main reason for the seasons. The Earth moves in a slightly elliptical orbit around the Sun. This movement means that different parts of the Earth are illuminated by the Sun to varying degrees at different times of the year.
When the northern hemisphere is tilted towards the Sun, it receives more direct sunlight. This results in longer days and higher temperatures – it is summer in the northern hemisphere (summer solstice).
When the northern hemisphere is tilted away from the sun, it receives less direct sunlight. The days are shorter, and the temperatures are lower – it is winter in the northern hemisphere (winter solstice).
When the sun is directly overhead at the equator, it is spring or fall in the northern hemisphere. Day and night are then approximately equal in length at the equator (sun at the zenith of the equator).
In addition, variations in solar radiation have a profound impact on the Earth's climate. They influence long-term climate patterns, weather systems, and the distribution of habitats. Some examples of climatic effects are:

- Temperature gradients and uneven warming of the Earth's surface
  - Warming is strongest in the tropics, resulting in warm and humid climatic conditions – In the polar regions, there is less warming, resulting in cold and dry conditions
- Temperature differences drive atmospheric circulation between the equator and the poles
- Wind patterns such as trade winds, which influence weather and climate globally
- Distribution and seasonality of precipitation – year-round in the tropics and seasonal rainy and dry periods in subtropical and temperate zones
- Ocean circulation, such as the Gulf Stream

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Changes in the Earth's axial tilt and orbit also cause cyclical climate changes known as Milankovic cycles. These cycles are largely responsible for the occurrence of ice ages and warm periods.

4.2 Forest fires on the US west coast

The high UV aerosol index over California, especially in connection with forest fires, is closely linked to climate change. Forest fires release large quantities of aerosols. The UV aerosol index measures the number of particles in the atmosphere that absorb or scatter UV radiation. Aerosols are released in large quantities during forest fires, including ash and organic particles. During a severe forest fire, the concentration of aerosols in the atmosphere increases massively. Climate change contributes to an increase in the frequency, intensity, and duration of forest fires. This is mainly because climate change creates conditions such as low rainfall that favor forest fires.

Connections:

- Climate change leads to rising global average temperatures, more intense and frequent heat waves, increased evaporation rates, and dry soils — ideal conditions for forest fires to start and spread.
- Changing precipitation patterns, droughts, irregular and unpredictable rainfall
- Spread of combustible vegetation and changes in vegetation patterns due to shifting climate zones
- Longer fire season
- Interaction through the release of CO2 and aerosols, loss of carbon sinks

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5. Answers 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?"

    The DSCOVR satellite provides us with impressive insights into changes in solar radiation on Earth over the course of a day and throughout the year. It captures global images of the illuminated part of the Earth approximately every two hours. Through these continuous recordings, DSCOVR contributes to improve our understanding of climate by providing valuable information about changes in the radiation balance. With its EPIC (Earth Polychromatic Imaging Camera) instrument, it also monitors the global distribution of aerosols in the atmosphere, their impact on the climate, and their interactions with clouds. DSCOVR provides important data on aerosol concentrations and their influence on climate change and air quality, particularly during natural events such as forest fires, volcanic eruptions, and storms. Thanks to its comprehensive and long-term observations, the satellite contributes to a better understanding of both climate change and short-term weather events. This information is crucial for tackling the global challenges of climate change, understanding the associated interactions and processes, and recording the Earth's responses to natural and human influences.

    In summary, through its continuous Earth observation and provision of comprehensive data, the DSCOVR satellite makes a significant contribution to understanding the complex processes and interactions in the Earth's atmosphere. These findings are crucial for climate research, weather forecasting, and the development of strategies to combat climate change.

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