SEA ICE FROM SPACE

Læringsressurs for videregående skole
Brief description
In this set of activities, you will investigate Arctic sea ice. It includes two hands-on activities you can easily do at home– looking into what happens when the ocean freezes. Then, you will use satellite images to analyze the sea ice concentration and extent and how these parameters have changed in the last decades. You will learn where in the world it is possible to find sea ice and analyze up to-date and long-term satellite data about sea ice concentration in the Arctic. This activity deals with one of the most important indicators scientists have, to study climate change and its possible consequences.

Learning outcomes
• Learn what sea ice is and where it can be found on Earth.
• Understand the importance of sea ice and its relation to Earth’s climate.
• Understand how human actions and physical processes interact to influence and change landscapes, environments, and the climate.
• Use tools available on the internet to collect and analyze satellite data. Understand how Earth observation satellites can be used to characterize and monitor sea ice.

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Introduction
Each year, the polar oceans experience the formation and then melting of vast amounts of sea ice. This seasonal cycle of sea ice is one of the most dynamic components of Earth's climate system. Although sea ice is found primarily in the polar regions, it influences our global climate. Sea ice changes the reflectivity of the ocean and acts as a barrier to the exchange of heat and moisture between the ocean and the atmosphere. The seasonal changes of polar sea ice also play a significant role in global ocean circulation. As ice forms, the salinity and density of the surface water increase. Cold, dense, polar water sinks and moves along the ocean floor toward the equator, while warm water travels from the equator towards the poles. As ice melts it sends a flux of fresh water into the upper ocean; this decreases the salinity and density of the water, and the lighter, less dense water forms a fresh layer at the surface.

The seasonal sea ice cycle affects not only climate but also human activities like shipping as well as biological habitats. The Arctic ecosystem is home to many organisms, from microscopic bacteria, phytoplankton and algae, to large animals like polar bears and seals that depend on sea ice for their survival.

Satellites give us a unique overview of the polar regions, providing measurements that were previously impossible to acquire in such hostile and remote areas. Different types of sensors, from optical to passive microwave or infrared sensors, can be used to observe and monitor sea ice. Several European Space Agency (ESA) missions have studied or are studying sea ice on Earth. Among them are

*Figure: ESA's Cryosat satellite is dedicated to measuring polar sea ice thickness*
What is sea ice?
Sea ice is simply frozen seawater. In contrast to icebergs or glaciers that originate on land, sea ice forms, grows and melts in the ocean. The formation of sea ice is a complex process that is influenced by the basic properties of water and ice. The salt content of water influences the freezing point: the higher the salt content, the lower the freezing point.

Habitat for microscopic life
Sea ice contains little salt, as most of it is rejected as the ice forms. The salt ions do not fit in the crystal structure of water ice and for that reason the salt is expelled. The salt that is rejected is either forced out into the surrounding water or trapped in small pockets or channels between ice crystals. These are called brines. The high concentration of salt prevents the brines from freezing.

The brines in sea ice consist not only of salt, but also trap microorganisms like plankton. Different processes wash out of brines that make it possible for photosynthetic algae to grow on the bottom of the sea ice. The algae serve as food for small animals in the ocean and even for whales. During winter, when there is no sunlight in the Arctic, the organisms are not active. During spring, when light becomes available for photosynthesis, and throughout the summer, when the waters warms up, sea ice melts and releases algae cells and tiny animals back to the sea and they become food for larger animals.
The Arctic is the most northerly area of the globe. The Arctic Ocean areas are entirely or partly covered by sea ice most of the year. Central or western parts of the Arctic basin are covered with ice all year round, while the areas near the coast are mainly free of ice in summer. Studies of satellite data over the past 20 years show that the ice in the Arctic has receded over an area larger than the entire landmass of Germany.

The density of the water is very important because it can change the currents and, therefore, the climate. The salinity of the water is an important parameter that defines the density. The salinity of the artic water increases when the sea water freezes into sea ice and decrease if large amounts of sea ice melt. Therefore, it is important to monitor these processes.

Satellites have been used since 1987 to monitor the sea ice. Different kinds of technologies have been used to achieve this. From 1987 to 2010 satellite information shows that the extent of newly frozen sea ice (first-year ice) in the Arctic has been reduced by 3% per year. This equals twice the size of Norway. The area covered with multi-year ice decreased around 7%. This could have an important impact over the Gulf Stream Current.

**Did you know?**

To make sure that data from satellites is accurate, measurements are taken by scientists in the field, either on land, at sea or from the air. These campaigns validate the satellite data and are carried out all over the world, from tropical rain forests to the icy reaches of the Arctic and Antarctica. Also, when instruments to be carried by satellites are developed, the new techniques need to be tested. You can follow some of ESA’s campaign teams as they carry out a range of field experiments to support ESA’s Earth observation missions and new instrument development at [http://blogs.esa.int/campaignearth](http://blogs.esa.int/campaignearth).
Activity 1: When the ocean melts

In this activity, you do a hands-on experiment to investigate what happens if the sea ice in the Arctic melts.

Did you know?

Did you know that the amount of energy needed to change the phase from 1 kg of ice at 0 degrees Celsius into water at 0 degrees Celsius (333.55 Joules) is almost the same than the amount of energy that needed to heat 1 liter of water from 0 degrees Celsius to 80 degrees Celsius (334.4 Joules)? Change of phase from ice to liquid water needs a lot of energy!

Equipment
Glass, water, ice cubes, marker pen.

Exercise

Before doing the experiment, what do you expect will happen? Write it down.

1. Imagine that you have a glass of water, and you add a couple of ice cubes. Think about the level that reach the water right after setting the ice cubes. What do you expect will happen to the level of water after the ice cubes melt? Why?

2. Fill a glass with water and put a few ice cubes into it and let them float in the water. Mark the height of the level of the water in the glass. Wait until the ice has melted. Check the water level. What is the result?

3. Do the result agree with your expectations (ex. 1)?
Activity 2: When the ocean freezes
In this activity, you will investigate some properties of sea ice by comparing ice blocks made from freshwater and saltwater.

Equipment
- Two 250ml jars or cups (plastic cups may be easier to use, as you can cut the cup to remove the ice. If using reusable plastic cups or jars, place them in warm water to release the ice).
- Table salt
- Teaspoon
- Food coloring
- Measuring jar
- Tray

Exercise
Note: Steps 1 to 4 to be done the day before

1. Fill each jar with about 200 ml of tap water.
2. In one of the jars, add 1.5 teaspoons of salt and stir until all the salt dissolves.
3. Label the containers.
4. Put them in the freezer overnight.
5. Take the two ice blocks out of the jars and place them on the tray with the top side up. Describe their appearance in table 1.
6. What do you think will happen if you add food coloring to the ice blocks? Will the food coloring behave the same way on both blocks? Write it down.
7. Add some drops of food coloring to the block of freshwater ice and observe what happens. Write your observations in table 1.
8. Add some drops of food coloring to the block of saltwater ice and observe what happens. Write your observations in table 1.
Results and discussion

<table>
<thead>
<tr>
<th></th>
<th>Freshwater ice</th>
<th>Salt water ice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before adding food color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After adding food color</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Summary of results

1. Describe and explain any differences between the two ice blocks before adding food coloring.

2. Describe the difference between the two blocks of ice after the food coloring was added. Do the results agree with your prediction?

3. Why do you think it is important to study sea ice?
Activity 3: Sea-ice today

In this activity, we will use satellites images to analyze the sea ice concentration and extent, and how these parameters have changed dramatically in the last decades. This activity therefore deals with one of the most important indicators scientists have, to study the climate change and its possible consequences.

For the last twenty-thirty years, the Arctic has experienced a much greater warmth than the rest of the globe, and the ice cover has also been greatly reduced. Such changes have a major impact on climate and the environment, both locally and globally.

Did you know?
To measure the ice in the sea, many satellites does not take normal images, like the ones we take with our mobile cameras. The detectors in the satellites register microwave radiation. The same waves you use at home for warming food. This can map very well the sea ice. The big advantage over normal cameras (using optical light) or infrared cameras is that microwave detectors can “see” the sea ice through clouds and when it is dark. This is very convenient in the artic areas, where it is dark the whole winter.

Equipment

PC and internet access.

Exercise

Before we start to explore, let’s think about sea ice extension:

1. Figure 1 below shows part of the Northern Hemisphere. Indicate the areas (number 1 to 8) where we expect to find sea ice. Explain why.

2. Sea ice is frozen ocean water. Would you also expect to find sea ice in the southern Hemisphere? If so, where?

3. Let’s assume that there is no global warming. Do we expect changes in the surface cover by the sea ice in different months of the same year? Why? Do we expect significant changes in the sea ice extension by comparing the same month in different years?
Exploring and learning with satellite images.

4. Click on the following link from the University of Bremen: [https://seaice.uni-bremen.de/sea-ice-concentration](https://seaice.uni-bremen.de/sea-ice-concentration).

From this link you can study today's arctic sea ice concentration. Click to enlarge the image to the right. After opening the image, you can zoom to see better details. The different colours indicate different concentrations (see explanation box in the image).

a) Identify the areas where you can find sea ice and describe the sea ice concentration

b) Identify areas 2 and 3 from figure 1. These areas are around the same distance from the North Pole. Is the sea ice concentration similar? If not, explain why?

c) Compare your expectations from question 1 with the analysis of today's ice concentration have completed in question 4. Did you find ice in the areas you had expected?
5. Figure 2 shows an example taken the 2nd May 2018. Compare this image with today's image that you analysed in question 4. Do you find significant changes? Describe them.

![Image of sea ice concentration map]

*Figure 2: Sea-ice concentration the 2nd May 2018. The color legend indicates the sea ice concentration.*

6. Why do you think it's important to use satellites to investigate sea ice?
Activity 4: Sea ice through the seasons

Satellites have been observing sea ice for more than three decades. Scientists analyse this data in order to identify short- and long-term trends that help characterise and monitor sea ice. In this activity you will analyse long-term data about sea ice extent and discuss seasonal changes of sea ice.

Exercise
1. Before you start analysing sea ice data, discuss your expectations
   a) Do you expect the sea ice extent to change within the year? Why?
   b) In which months do you expect to find the least and the most sea ice?
   c) Do you expect the sea ice extent to change over the years? Why?

2. Figure 3 (in the Annex) shows images of the sea-ice cover through March 2019 to February 2020. It is recommended that you go to [https://climate.copernicus.eu/sea-ice](https://climate.copernicus.eu/sea-ice) and download the images to get a better resolution.

   Analyse and compare sea ice variations in different months during the same year. Describe the change of sea ice extent over the course of one year. In which months do you find the least and most sea ice?

3. Figure 4 (in the Appendix) shows the annual mean sea ice extent for different years. Describe the annual mean extent for different years and compare it with the overall trend.

4. Is your analyses of the seasonal changes and the changes for different years similar to your expectations in question 1? Try to explain any differences.
Appendix

Figure 3: Sea-ice cover through one year, from March 2019 to February 2020

Sea-ice cover for March 2019

Sea-ice cover for April 2019
Arctic sea-ice concentration for November 2019

Average concentration

Anomaly relative to 1981-2010

Arctic sea-ice concentration for December 2019

Average concentration

Anomaly relative to 1981-2010

Kildehenvisninger

Utviklet av ESA Education og ESERO, tilpasset av NAROM.