INTER ⇄ ACT

EDUCATIONAL TOOL-KIT

STUDENTS' WORKSHEET
– VERSION FOR TEACHERS

ARCTIC ISSUES:
THE CHANGING ARCTIC

TASK 1.
Match the beginning of the sentence on the left with a proper end on the right:

The most important greenhouse gases are: water vapour, …	… move a system away from its equilibrium state and make it more unstable.
Greenhouse gases transmit radiation emitted by the Sun and absorb radiation emitted from the Earth's surface. This way…	… and less sun radiation reach the Earth's surface.
The greenhouse effect is the phenomenon of increasing the temperature of the planet due to greenhouse gases present in its atmosphere. …	… and it increases the air temperature, which causes further melting of sea ice.
A positive feedback loop enhances or amplifies changes. This tends to …	… reveals the darker ocean surface. It cause the decrease of albedo.
When the sea ice cover melts, heat escapes from the ocean to the atmosphere …	… It changes the Earth's surface temperature by 33°C.
The extent of sea ice is decreasing due to climate change and …	… carbon dioxide and methane.
Due to higher temperature, evaporation increases. There are more clouds …	… an isolation layer and prevent energy radiation from the Earth's surface.
However, during winter clouds act as …	… they retain part of the energy that causes the increase of temperature.

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TASK 2.
Complete the terms and definitions
Complete the table by adding missing terms or definitions.

Term	Definition
Albedo	a measure of surface reflectivity; in case of the Earth, it says how much sunlight (energy) is reflected back to space
Feedback loop	an interaction of the output signals of the process on its input signals. Feedback occurs when outputs of a system are routed back as inputs as part of a cause-and-effect that forms a loop. The feedback can be positive or negative. Positive feedback loop make the system unstable, whereas negative feedback loop stabilizes the process.
Sea ice	a type of ice formed by the freezing of seawater
Greenhouse effect	phenomenon caused by the greenhouse gases in the atmosphere, which trap some of the heat radiated from the planet's surface, raising its temperature.

TASK 3.
Calculate sea ice loss
The area covered by sea ice in the Arctic varies over seasons, but also over years due to climate change. Sea Ice Extent index [mln km2] provides a quick look on changes in sea ice in the Arctic. It provides daily, consistently processed ice extent and concentration from images taken by satellites since 1979. You may play a short quiz about the sea ice extent: https://polarpedia.eu/en/fill-in-the-gaps-sea-ice-extent-index/.
Check the latest data on the sea ice extent in the Arctic on the website: https://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/.

Minimum sea ice extent is observed usually in mid-September, when the average air temperature drops below 0°C. Check the average minimum extent and the minimum extent in the last September. Fill in the table below, calculate the sea ice loss and compare it to the area of your country.

For calculations I chose 2023 year and Poland.

Average minimum sea ice extent (median of 1981-2010)	6 354 mln km2
Minimum sea ice extent in last September	4 230 mln km2 (Sept 19, 2023)
Sea ice loss area	2 124 mln km2

Percentage change (sea ice loss area/median area x 100%)	33%
Area of your country (Poland)	312 000 km2=0,312 mln km2
Sea ice loss area/Area of your country	6 808

Conclusion: During last summer the sea ice loss area was 6 808 time higher than the area of Poland.

TASK 4.

Are these phenomena examples of POSITIVE or NEGATIVE Feedback loop? (underline the correct answer).

With the higher temperature, the sea ice extent in the Arctic decreases. It changes the albedo and causes further rise of the air temperature.
POSITIVE/NEGATIVE Feedback loop

Higher temperature increases evaporation. More clouds are formed, which reflect solar radiation and less energy comes to the ground.
POSITIVE/NEGATIVE Feedback loop

Higher temperature increases evaporation. More clouds are formed, which block the radiation from the Earth and keep warmth below the cloud level.
POSITIVE/NEGATIVE Feedback loop

Less snow cover in boreal forests reduce humidity. Forests are more exposed to fires. Fires cause additional emissions of CO_2 to the atmosphere.
POSITIVE/NEGATIVE Feedback loop

Permafrost contains organic matter. When it thaws, organic matter starts to decay and additional greenhouse gases are released to the atmosphere.
POSITIVE/NEGATIVE Feedback loop

TASK 5.

Melting Greenland ice sheet

Greenland ice sheet has lost 4,7 trillion tons ($4,7*10^{12}$ tons) of ice since 2000.

During only one summer in 2019 it lost 600 billion tons of ice.
Let's check how deep would be the layer of water from the Greenlandic ice, if it was poured on the surface of your country.
Use the data below to calculate (theoretically) how much water would cover the area of your country.
NOTE that these calculations are more demonstrative than accurate!

Greenlandic ice melt	*600 000 000 000 tons*
Volume of melted water (m^3)	*600 000 000 000*
Area of your country (km^2)	*312 000*
Area of your country (m^2)	*312 000 000 000*
Height of water poured on the surface of your country (m or cm)	*1,92 m*

REMEMBER: volume = area x height, so height = volume/area

UNITS:
Area – km^2, m^2
Height – km, m
Volume – m^3
TIPS: First, calculate volume of water. Next change the units of area of your country from km^2 to m^2, remember that 1 km^2=1 000 000 m^2.

TASK 6.
Many scientists say: "What happens in the Arctic, doesn't stay in the Arctic." How can you explain this sentence? How do the changes in the Arctic affect the weather patterns in mid latitudes?

Jet streams are fast flowing air currents in the atmosphere. The strongest jet streams are polar jets. They are driven by differences in temperature. As the temperature in the Arctic is rising more rapidly than in the rest of the globe and the temperature on the Equator is increasing slowly, the differences between the North Pole and the Equator are decreasing. Arctic amplification may slow and destabilize jet streams. It slows down the global circulation and may affect the weather patterns far beyond the Arctic.