EDUCATIONAL BOOKLETS
TÉMOINS POLAIRES
À l'écoute du climat.
MADE BY

UNDER ANTARCTICA EXPEDITION 2025

UNDER ANTARCTICA

Booklet n°4 - Glaciers as climate witnesses

Heïdi

Paco

Matthieu

SPECIAL EDITION

The Antarctica Times

SPECIAL EDITION

Antarctica

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When the ice waves knock us around

AMID STRONG WINDS AND ROUGH ICE, OUR EXPLORERS AND THEIR GEAR KEEP MOVING FORWARD DESPITE THE CHALLENGES

"We've had to pack away one of our radars as the terrain has been getting too rough with all the sastrugi. We've even had a few scares.
Sometimes our pulkas get stuck on a block of ice and, with the wind filling the kite, we can end up flying upwards.
Luckily, no injuries!"

Sastrugi are frozen snow waves carved by the wind.

"Every day we find small areas of damage on our gear : a loose seam, a hole to fix in the tent or the pulka. Nothing serious, but it all means we have to stay locked in!"

"Yesterday, right in the middle of the sastrugi, Matthieu's pulka hit a big block of ice and damaged an important attachment point. Fortunately, we managed to fix it!"

"We have now travelled more that 1,000 kms by kite since the start of the expedition."

"For the last 28 days, we've been moving slowly but surely toward our first big goal: the Pole of Inaccessibility !"

Here it's white, there... white as well... Everything is white! After a while, even my thoughts turn white... Since there's nothing on the snow, I don't see what you're looking for underneath with your big radars!

Can I go down to stretch my legs? I've eaten too much and I'd like to do a bit of sliding!

Stop sulking, Paco, we're going to take a break. There's a nice place we'd like to show you.

Look over there! THERE'S A HEAD STICKING OUT OF THE SNOW!! Heïdi, Matthieu, we have to go rescue this person.

Wait, but why are you laughing? And why does his body look like a barrel like that?

Paco, don't panic, you might fall! It's just a statue, that's what we wanted to show you!

And here we are, finally at the Southern Pole of Inaccessibility : the furthest point from all seas. We are at 1,590 kilometers from the nearest water!

CHAPTER IV : MAKING ACCESSIBLE THE SOUTHERN POLE OF INACCESSIBILITY

Good grief! if this place is inaccessible, does that mean we're the first ones to arrive here?! Oh no, if there's already a statue...

Haha, well spotted, Paco! A few expeditions reached it before us. The first were Russians, in 1958. They set up a station here and a bust of their former leader, Lenin. We are not the first humans, but you are surely the first penguin crazy enough to come here!

The station was called Sovetskaya, right? Heidi told me about it. It was quickly abandoned because of the extreme conditions...

Did you know?

Lenin's bust faces Moscow's direction, the capital of Russia.

Today, many places like here, that were once inaccessible, can be reached thanks to transportation powered by fossil fuels, such as planes, snowmobiles, or tractors.

Why did Matthieu say last week that, to preserve the ice, we need to reduce our use of fossil fuels?

Let me explain: these forms of energy are produced from three **fossil fuels** formed from the remains of plants and animals that **decomposed** and were buried underground. After millions of years, they can be used as powerful energy sources.


COAL


GAS


OIL

Oil allows planes and cars to move forward.

The three of them can produce electricity, right?

Exactly! So our way of life in 2025 mostly depends on these energies: they make our cars run, light up our homes, and have allowed us to create plastic. They are abundant, and we use them like a **superpower** to do everything...

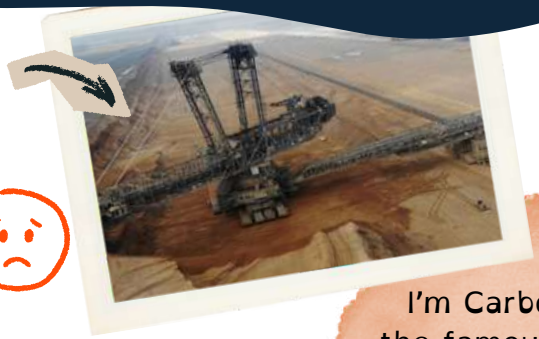
...Unfortunately, today we also realize the major **downsides** of these energies. Their use causes pollution of


Air


water


Soil

And humans also destroy entire ecosystems to obtain them.



But above all, when we burn them to use their energy, they release some special gases called **greenhouse gases.** The more there are, the warmer it gets.

That's why Mr. Glacier melted... This is a phenomenon called the **greenhouse effect.**
Look here, I'll show you more clearly.

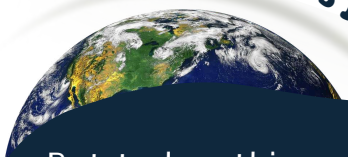
I'm Carbon Dioxide, the famous CO_2! I come from exhaust pipes, factories, and airplanes. People talk about me everywhere; I'm the celebrity of greenhouse gases.

I'm Methane! I come from cow burps, rice paddies, and landfills. Not glamorous, I know... but I make the temperature rise faster than ever!

Here is the **atmosphere**, the large gaseous blanket that surrounds the Earth. It naturally protects us from certain dangerous rays from the Sun, gives us the air we need to breathe and, thanks to the **greenhouse effect**, it allowed life to emerge on Earth.

THANKS TO THE NATURAL GREENHOUSE EFFECT THE TEMPERATURE IS 15 °C

WITHOUT THE GREENHOUSE EFFECT THE EARTH'S AVERAGE TEMPERATURE WOULD BE -18 °C.



But today, this greenhouse effect is being amplified by gases emitted from burning fossil fuels. The atmosphere is warming.

1

The sun sends its radiation (light and heat) to the Earth.

CO^2

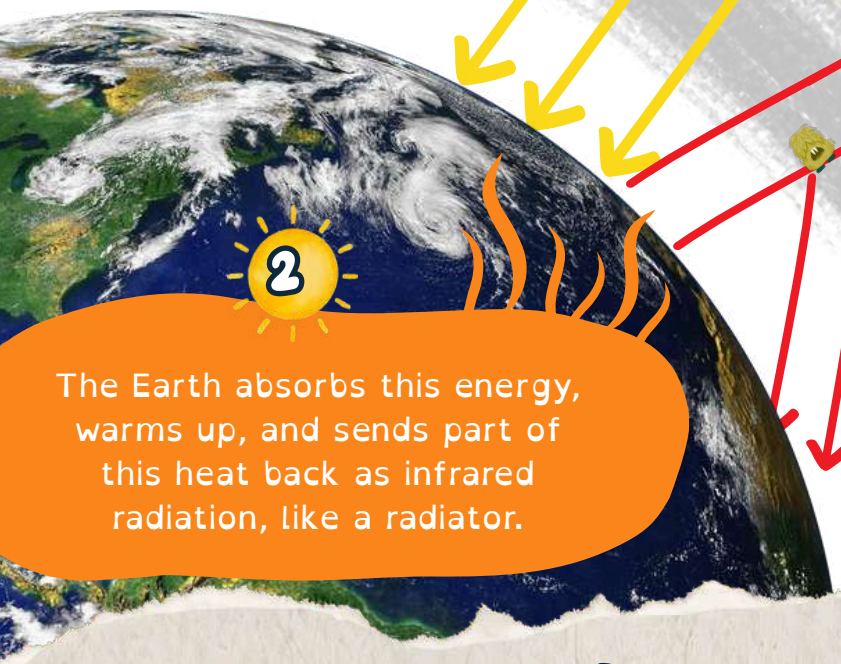
CH_4

2

The Earth absorbs this energy, warms up, and sends part of this heat back as infrared radiation, like a radiator.

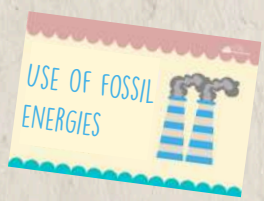
3

Greenhouse gases capture part of this radiation and send some of it back toward the Earth. The more there are, the more heat gets trapped.



Help Paco !

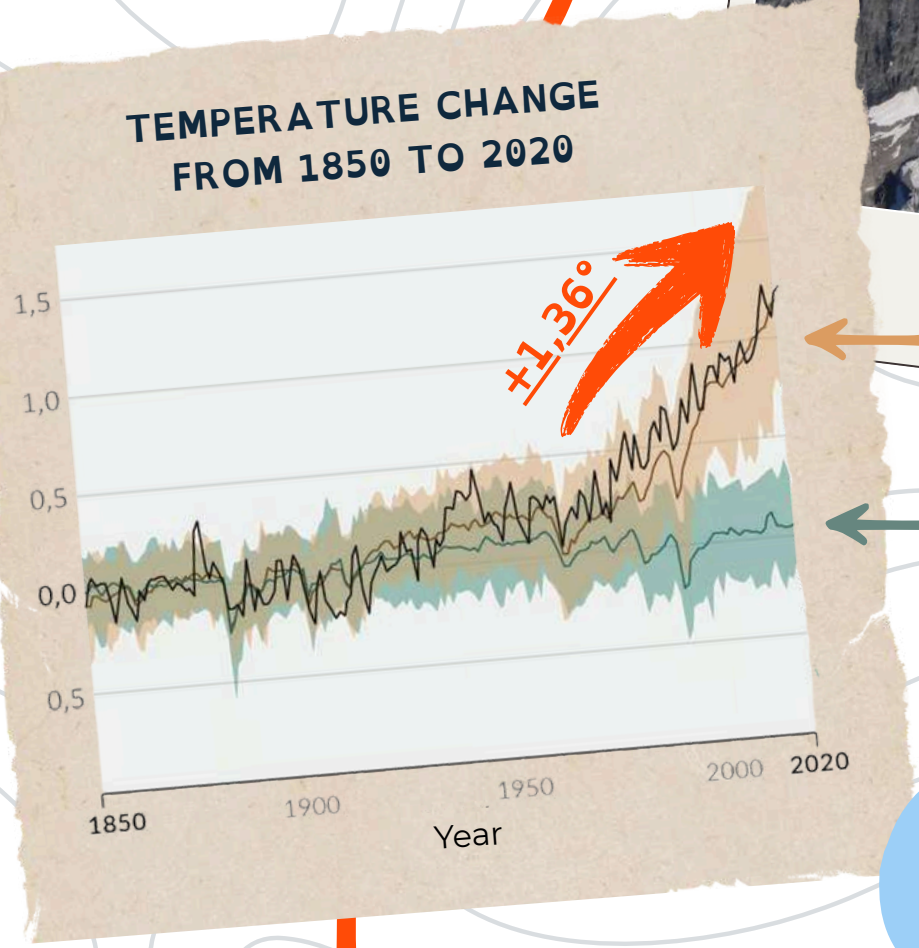
Put these causes and effects in order using arrows!



So, it's because of greenhouse gases that the glaciers are melting?! Does this increase in methane and CO_2 really warm the Earth?

You know, since 1850 and the use of fossil fuels, the average temperature on Earth has increased by +1.36°C. If we don't reduce the use of fossil fuels, the average temperature by 2100 could rise by 3°C.

1 kg of CO2 emitted = 15 kg of ice melted



Actual temperature change

Temperature change on Earth if we hadn't used fossil fuels

+3°C isn't much, ! Yesterday it was -25°C, today -22°C, and I assure you I barely felt the difference!

You're talking about weather, not climate! When you have a 40 °C fever, it's only three degrees more than your normal body temperature. Yet you don't feel well, do you? The Earth is the same, just a few degrees more in the climate can have huge consequences...

I think I still don't really understand the difference between weather and climate...

Weather is a snapshot of the sky, like a photo taken today. Climate is the full album, gathering thousands of photos taken in the same place over decades. It's like you: in general, you're kind and gentle (climate), but some days you're grumpy and sulky, like a rainy day (weather).

Weather

The weather over a short period: day, week. The weather changes all the time.

Climate

The weather over a long period: years, decades. The climate changes very slowly: tens of thousands of years.

N

Game

Help Paco figure out whether we are talking about climate or weather in the following sentences.

Winters have been getting milder over the past twenty years.	☐	☐
A storm is arriving on the Atlantic coast this weekend.	☐	☐
Antarctica is the coldest and driest continent on the planet.	☐	☐
It rained every day during the February holidays.	☐	☐
The average global temperature has risen by about 1°C since 1900.	☐	☐

But can the climate change, like the weather does?

Absolutely! For the past 2.4 million years, the Earth has experienced very cold periods, called glacial periods, and warmer periods, called interglacial periods.

cold period (glacial period)

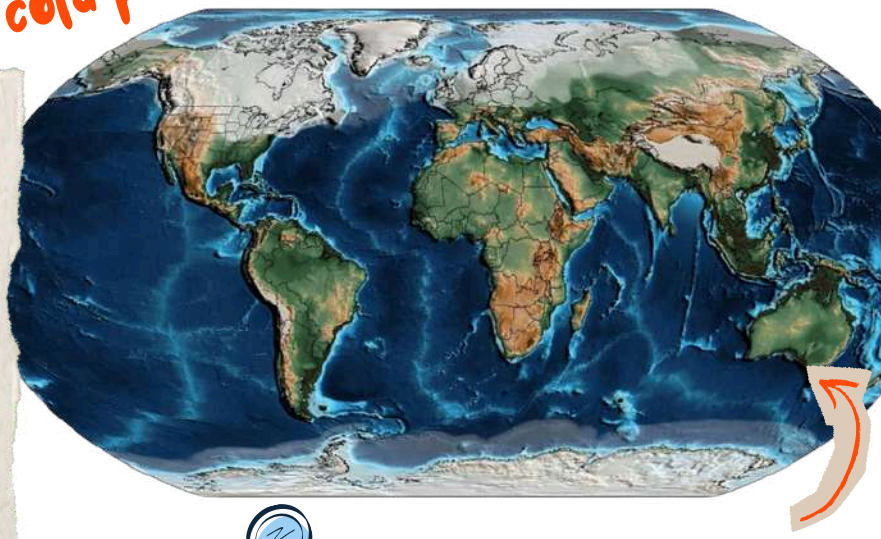
Average temperature: -5°C compared to today

Ice volume: 2 to 3 times greater

Sea level: Low; you could walk from France to the United Kingdom

Average duration: Several tens of thousands of years (about 90,000 years)

The last glacial period ended about 11,700 years ago



Look how glaciers used to extend southward

warm period (interglacial period)

like nowadays!

Average temperature: +5°C compared to a glacial period

Ice volume: Less ice, development of fauna and flora

Sea level: Higher

Average duration: About 10,000 to 15,000 years

We are in an interglacial period, which began around 11,700 years ago

As you can see, just a few degrees radically change the face of the world. At the end of the last glacial period, the Earth naturally warmed by +4°C... over 8,000 years. In the past 150 years, the temperature has risen by 1.36°C, and this is due to the consumption of fossil fuels.

By the way, our friend Mr. Glacier has kept traces of this climate evolution, alternating cold and warm periods. It's like a big library of the past, thanks to Flok the snowflake!

1

This is the story of Flok, the snowflake, who falls on the vast Antarctic ice sheet.

2

It's so cold here that Flok doesn't melt.

3

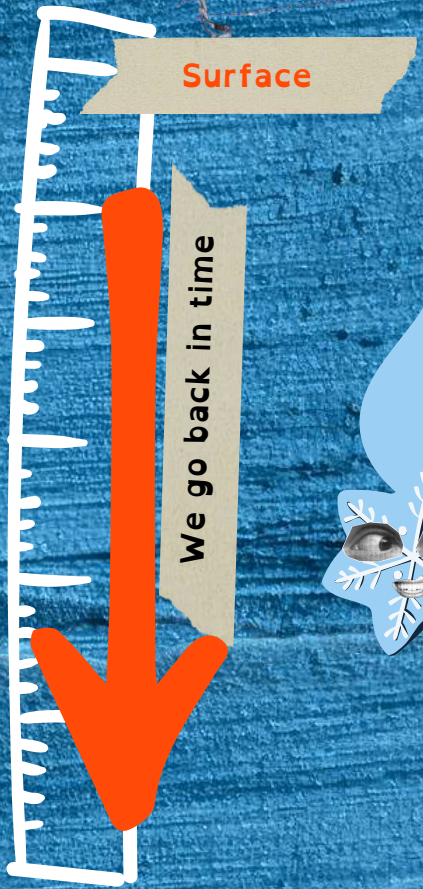
Other snowflakes land on top of him, again and again, for centuries.

4

Flok, who landed on the surface, will gradually be buried hundreds of meters deep over time.

5

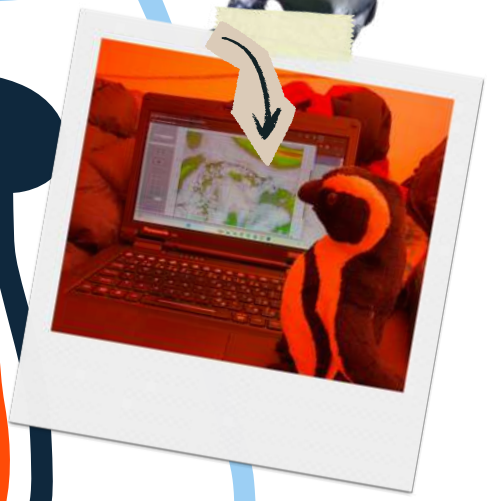
Slowly, under the accumulated weight and pressure of the snow, Flok turns into ice along with all the other snowflakes of his layer, and Mr. Glacier is born, with many layers of ice that have built up!



The deeper you go, the older the ice, and the further you can go back in time. And to observe this past, we have our radar!

This is actually the role of one of our two radars: the surface radar. It measures the transition between snow and ice as far down as 50 to 100 meters deep. It makes it possible to determine the amount of snowfall and to understand whether climate warming is changing precipitation in East Antarctica.

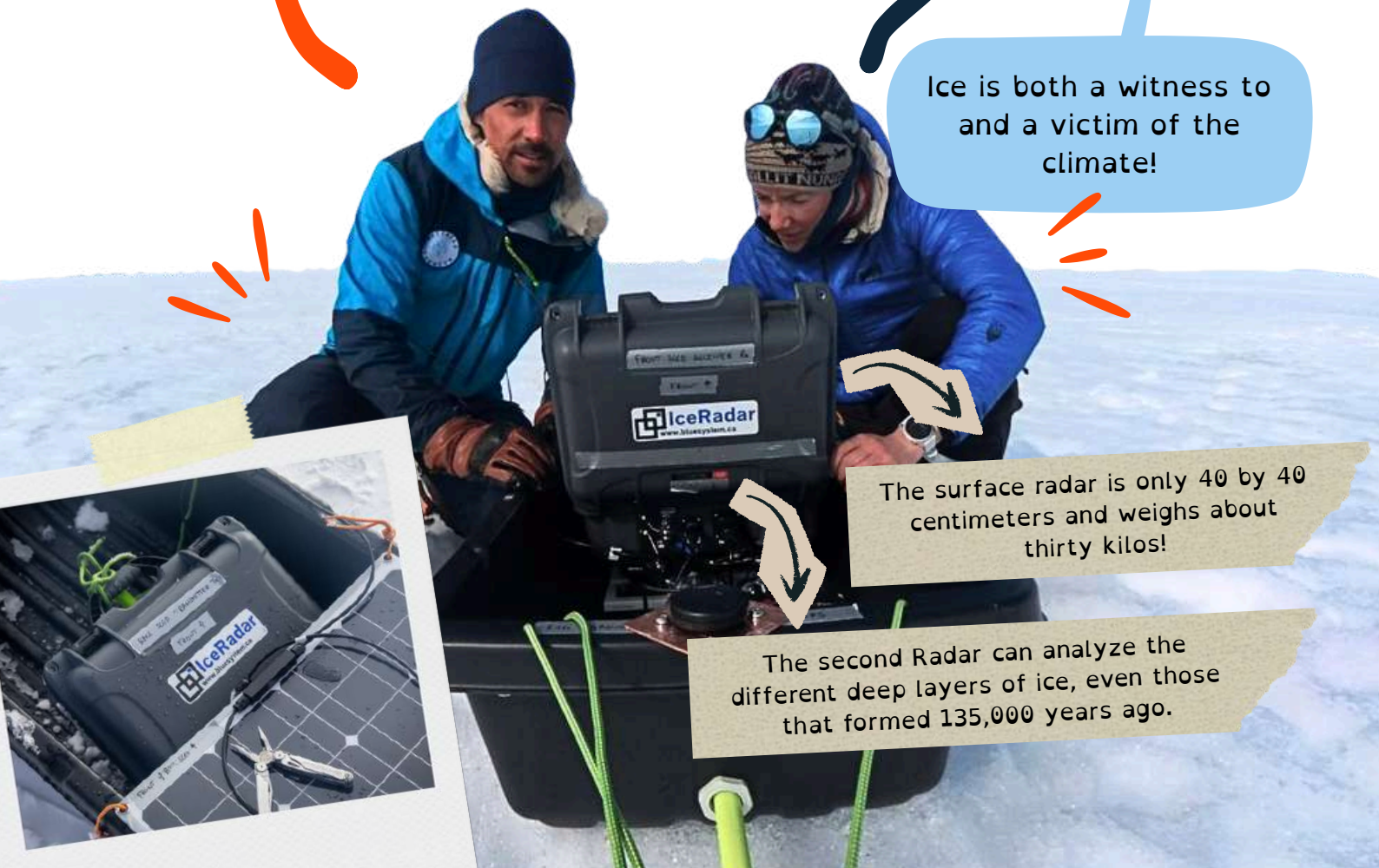
Ahhh, I finally understand the purpose of the radar. And what about the results of the second radar? Is that what you were looking at yesterday in the tent on the laptop?



No, that was just a map showing the weather and the winds!

At 120 meters long, the second radar probes the ice more than 2 km deep, reaching the oldest layers of ice. Heïdi and I hope that these two radars will help predict how climate warming will impact Antarctica, and therefore help anticipate sea-level rise. We will discuss this topic in more detail soon!

Ice is both a witness to and a victim of the climate!



The surface radar is only 40 by 40 centimeters and weighs about thirty kilos!

The second Radar can analyze the different deep layers of ice, even those that formed 135,000 years ago.

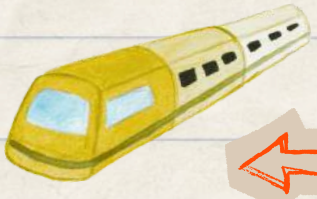
Here is a little sheet to show that, even without being a scientist, everyone can help protect glaciers by reducing their use of fossil fuels. Here are some concrete examples!

Reduce your fossil fuel consumption

Choose to wear a sweater instead of turning on the heating

Use a bike or walk for short trips

Use reusable items instead of plastic (which is made from oil)



Prefer to travel by train or bus instead of flying

Buy unpackaged/ in bulk products or food to reduce waste which is often incinerated or buried

Try vegetarian and vegan recipes. Meat is responsible for 14.5% of greenhouse gases worldwide coming from human activities. (2013 FAO Report)

Buy second-hand: clothes and things : there are already enough clothes to dress the population 6 times.

Come on, friends, let's get motivated and reduce our fossil fuel consumption!

Any ideas?

Send us your ideas by email on how to reduce the use of fossil fuels in daily life; it will help me for the Penguin Council!

Good grief, why does the sun never disappear? I'm starting to miss the night!

At the Geographic South Pole, from October to March, the sun does not set.

...Aller Paco, Paco, it's time to sleep! You've asked enough questions for an entire expedition, and on top of that, you're taking up all the space!

Well... since no one wants to talk to me anymore, I'll write here. This week, I discovered the famous greenhouse effect — the one that makes our planet's temperature rise. So it's it, that rascal, who melted Mr. Glacier... Sniff.

Luckily, I also met Flok the Snowflake. When they fall and turn into ice, they form layers of ice together with others, and those are the layers that Heidi and Matthieu's radar can analyze.

What I've learned is that by reducing our consumption of fossil fuels, we can truly help the ice and everyone who depends on it. That's a good idea I could present to the Penguin Council.

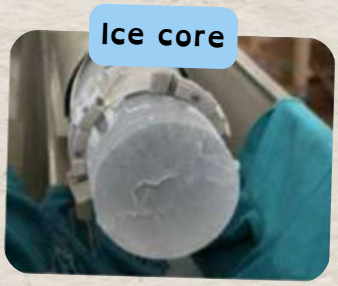
Byyye, see you soon!

Paco

Shall we play?

1 Thanks to these elements, we can read the past climate : circle the odd one out!

The last million years

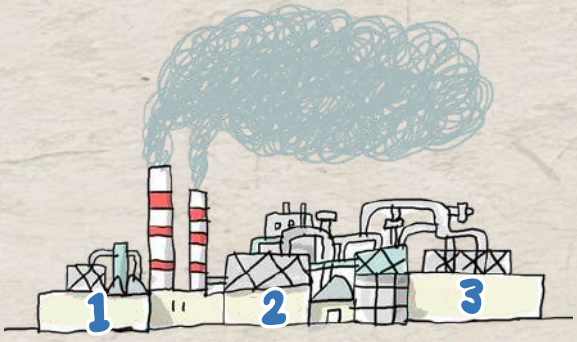


Last million years

Last thousands of years

Past days

2 Help Paco write the names of the 3 fossil fuels.



1 ____
2 ____
3 _____

3 Rank the modes of transport from the lowest to the highest greenhouse gas emissions, for the same distance traveled :

4 To go on vacation, 100 km from home, you decide to carpool. Instead of 2 people, there are 4 of you, which divides your CO_2 emissions per person by two.

2 people : 20 kg of CO_2 emitted per person

10 kg of CO2 avoided, WELL DONE!!

4 people : 10 kg of CO_2 emitted per person.

Since 1 kg of CO_2 melts 15 kg of ice, how much ice did you manage to prevent from melting?

☐ 15 kg ☐ 50 kg ☐ 150 kg

Lexicon

Atmosphere: The layer of air and gases that surrounds the Earth.

Bulk: Buying food without packaging.

Greenhouse effect: The greenhouse effect is a natural phenomenon in which gases naturally present in the atmosphere (mainly water vapor) trap part of the heat emitted by our planet.

Ice core: A cylindrical sample drilled deep into a glacier or ice sheet, which preserves layers of ice accumulated over thousands of years and allows scientists to study for example past climates.

Marine sediment core: A long tube of sand, mud, or small shells taken from the sea floor to study the history of the Earth and climate.

Rice paddy: A field filled with water where rice is grown. By consuming the organic matter in the water, certain bacteria release methane.

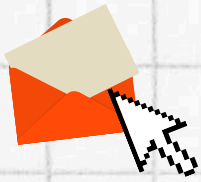
Second-hand: Refers to an object or piece of clothing that has already been used by one or more people and then resold or given away.

Vegan: A person who does not eat any food from animals, such as meat, fish, eggs, or milk.

Vegetarian: A person who does not eat meat or fish but may eat eggs, milk, and other animal-derived products.

Any question?

Got a question or a kind word for Heïdi and Matthieu? Send it through their mailbox. They'll reply as soon as possible!



To go further

Video about the global warming

The IPCC report for parents or teachers

TÉMOINS POLAIRES
À l'écoute du climat.

Cut out the images

GAMES SOLUTIONS

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- « Winters have been getting milder over the past twenty years. » ➡️ Climate
- « A storm is arriving on the Atlantic coast this weekend. » ➡️ Weather
- « Antarctica is the coldest and driest continent on the planet. » ➡️ Climate
- « It rained every day during the February holidays. » ➡️ Weather
- « The average global temperature has risen by about 1°C since 1900. » ➡️ Climate

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1. The odd one are the clouds.
2. Gas, Oil, Coal
3. Walk, bike, train, car, plane
4. 150kg