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

UNDER ANTARCTICA EXPEDITION 2025

UNDER ANTARCTICA

Booklet n°6 - Glaciers and water in all its forms

SPECIAL EDITION

The Antarctica Times

SPECIAL EDITION

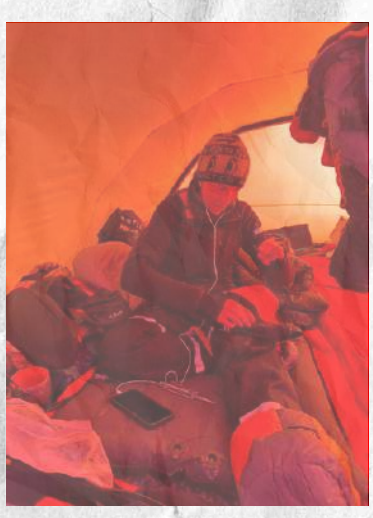
Antarctica 17 December 2025

Skiing, reparing, skiing, reparing

INSTEAD OF BEING ABLE TO SPEED UP IN RECENT DAYS, HEÏDI, MATTHIEU AND PACO WERE UNABLE TO MAKE PROGRESS FOR 36 HOURS DUE TO A LACK OF WIND.

"As we were stuck for 36 hours without being able to move forward, despite our large kite sails, we took advantage of this time to repair our equipment.

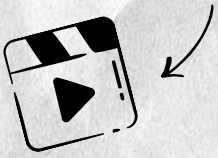
There are many things you don't think about until you actually need them, such as adding insulation back into our thermos flasks or recharging the batteries. Most importantly, we were able to do what mattered most: give news to our family and loved ones, to reassure them."



Heïdi needs to stitch the overboots back onto our ski boots.

Do you remember the South Pole of Inaccessibility? Here are our brave adventurers and the penguinstar, Paco."

Heïdi and Matthieu on french national TV



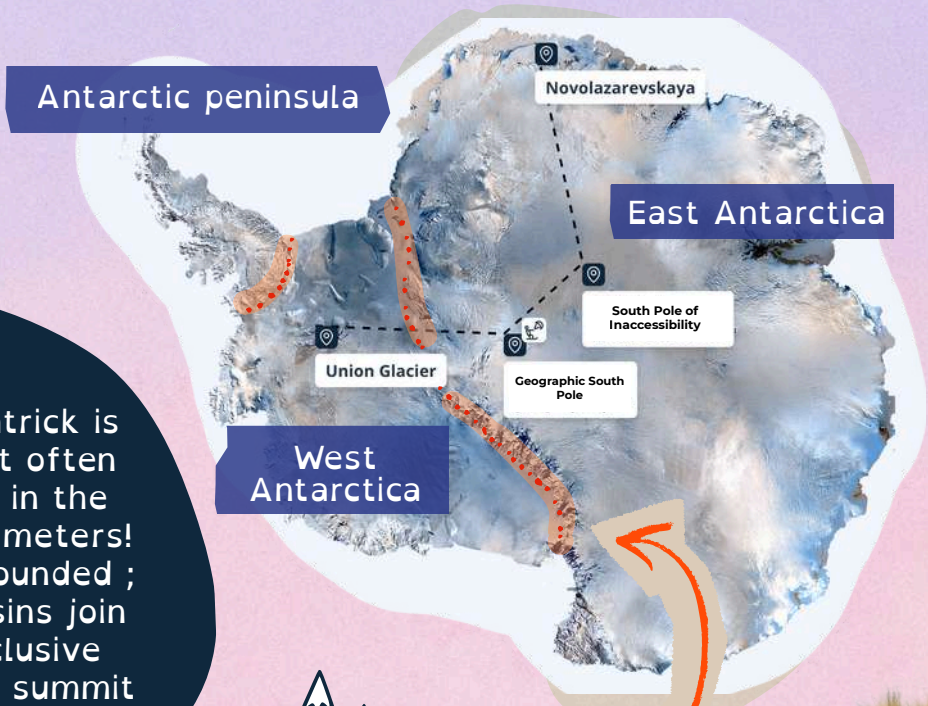
Sign up now for the live video call with Heïdi, Matthieu and Paco on 19/12!

On Friday, December 19 at 10 a.m. (French time), you will have the opportunity to speak live with Heïdi Sevestre and Matthieu Tordeur from their expedition in Antarctica.

This is the perfect moment to ask them all your questions about the daily life of a scientific expedition, Antarctica, and the various themes explored in the activity booklets. They are very much looking forward to meeting you!

Here is the registration link for the video call. Don't forget to fill it in to receive the Zoom link for the big day.

Here we are!! We're now in front of the Transantarctic Mountains. Wow, look, Paco! These mountains stretch from one ocean to the other like a gigantic wall of ice!



Mount Kirkpatrick is so tall that it often has its head in the clouds: 4,528 meters! It is well surrounded ; 20 other cousins join it in the exclusive +4,000 meter summit club.

The Transantarctic Mountains

The mountain range separates East and West Antarctica. East Antarctica is a very high, cold ice plateau and has a stable health balance. On the other side lies West Antarctica, which is losing more ice and is therefore more fragile.

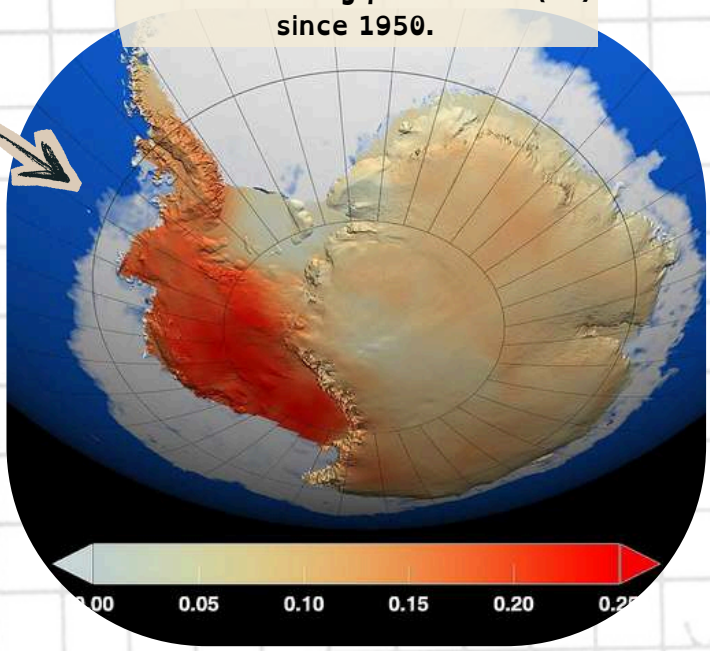
Are you talking about me?

Fragile like a baby penguin that doesn't know how to swim?

An emperor penguin chick.

Look at the images: the West is warming up faster than the East!

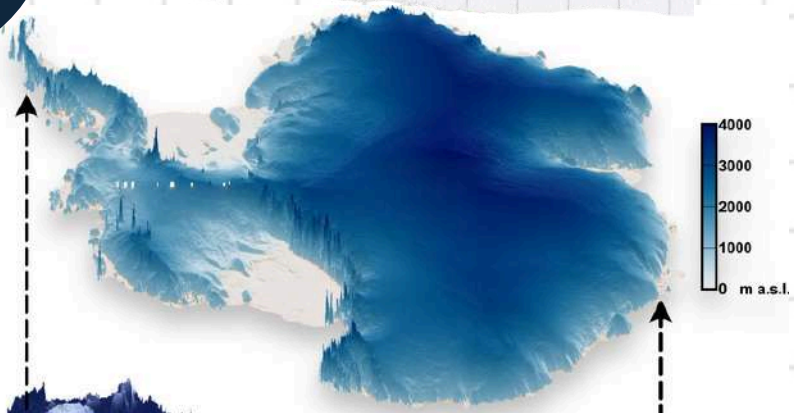
Surface warming per decade (°C) since 1950.



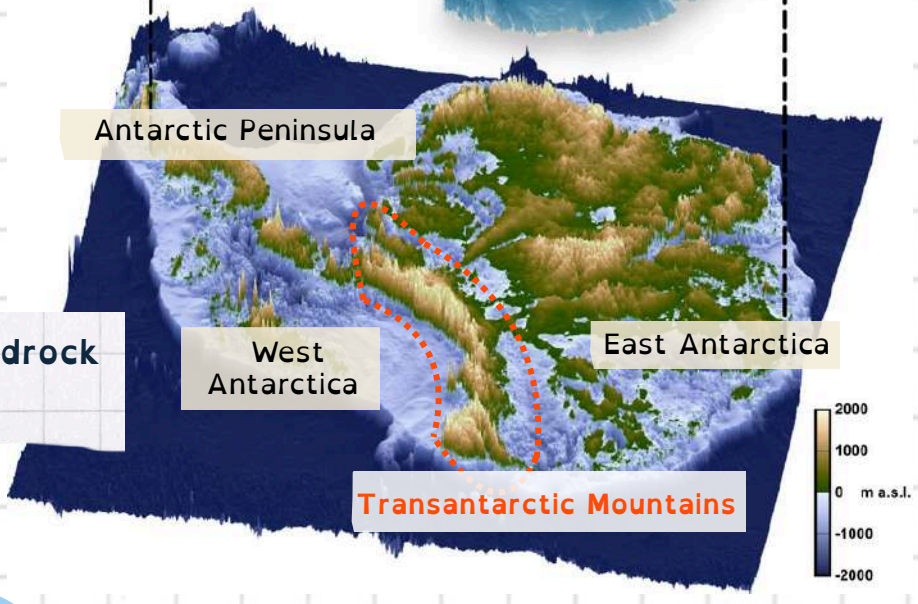
The reasons are complex, but one key point is that the East forms a true cold fortress, with a thicker and higher ice sheet.

By contrast, the West has a highly fragmented landscape : mountains, deep basins, and numerous islands ; which puts it in greater contact with the ocean and therefore promotes warming.

Map of Antarctic ice surface elevation.



Map of Antarctic bedrock elevation.



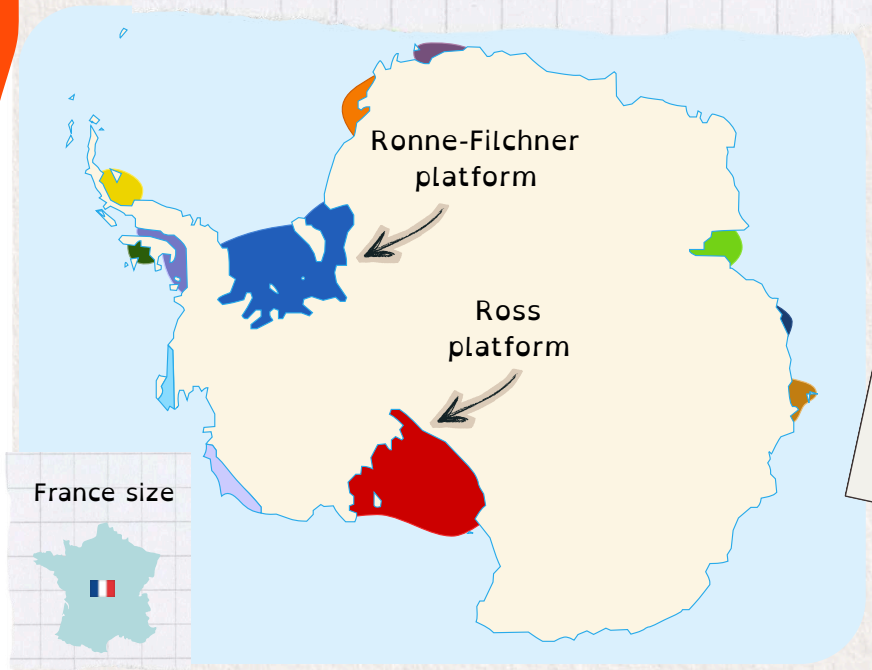
Oh, it's as if its ice hat had been taken off!

Above sea level

Below sea level

Even more impressive, Antarctic glaciers extend out over the sea and form what are called ice shelves. Since ice is less dense than water, they float, but remain attached to the mainland.

Map of Antarctica showing ice shelves in color.



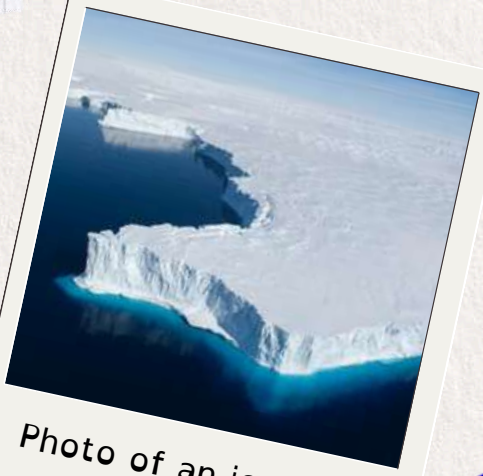
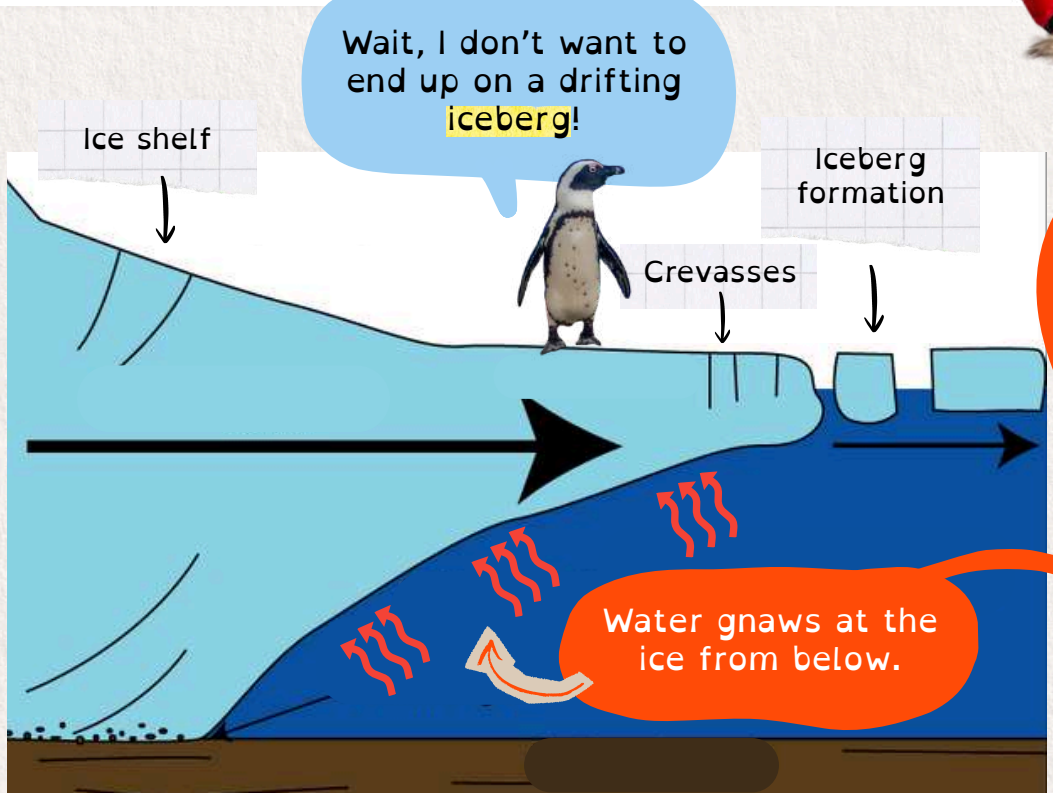


Photo of an ice shelf

Climate change warms the air, but it also warms the ocean and alters its currents! As the currents warm, ice shelves melt even faster from below.



In water, ice melts much faster.

For example, in a room at 20°C, an ice cube that melts in 1 hour in air can melt in 2 to 5 minutes in water. Water conducts heat about 20 to 25 times better than air.

Oops, what exactly is an ocean current again?

They are like gigantic rivers in the ocean.

They carry much more than water, for example heat, plankton, nutrients and even animals.

Ocean currents move thanks to five drivers: heat, salinity, wind, underwater topography, and the Earth's rotation.

Thanks to them, the oceans stay alive and in motion, and our planet keeps its climates balanced.

You're still here? But where do you come from, and how do you know all this?

Help Paco !

Video about ocean currents

Based on the video, can you find the name of the ocean current that flows between America and Europe?

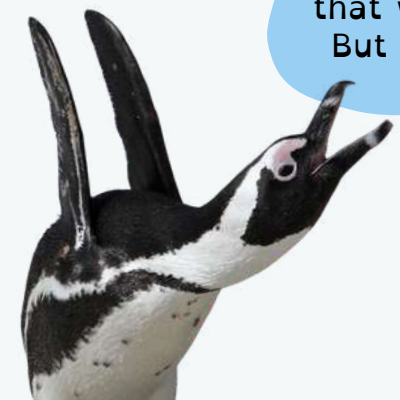
You know, I know a thing or two as well! You're not the only penguin who knows about this stuff... I wandered too far away from my parents and got lost. Anyway, I'm off.
Alright, CIAO, OLD PENGUIN!

The Antarctic Circumpolar Current forms a protective belt by isolating Antarctica from the warm waters of the North, preventing them from mixing easily with the very cold waters of the South.

The Antarctic Circumpolar Current

Antarctica is surrounded by the Southern Ocean, which hosts the most powerful ocean current in the world: the Antarctic Circumpolar Current (ACC). Imagine a giant river, 2,000 km wide, endlessly circling the continent!

Today, climate change is disrupting its "behavior." Melting glaciers pour fresh water into it, which is less dense than salty water, slowing it down and weakening its role as a protective "barrier." At the same time, warmer waters are gnawing away from below at the ice shelves I mentioned earlier.



Uh... yes, thanks Heidi, that was very interesting. But where did that rude big chick go?

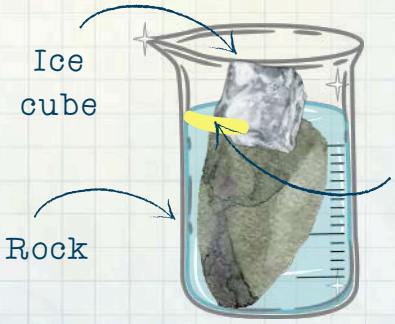
What chick are you talking about? I didn't see any chick!

When an ice shelf or sea ice melts, it does not add extra water to the ocean because they are already in the water. However, when glaciers resting on land melt, they add water to the oceans and make sea levels rise.

Paco, focus and stop thinking about the chick. If you want to be a glaciologist, do this experiment to check what I'm telling you!

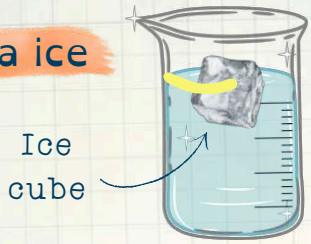
1 To do the experiment, follow this protocol using 2 glasses at home.

Glacier



2 When adding an ice cube place one on a stone and the other just in water. Put a rubber band at the water level.

Sea ice



3 Now, wait for it to melt and observe what happens.

A rise in sea level...

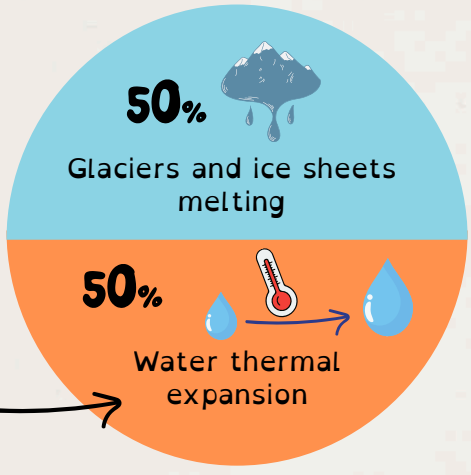
↗ +23 centimeters since 1880.

...which is accelerating

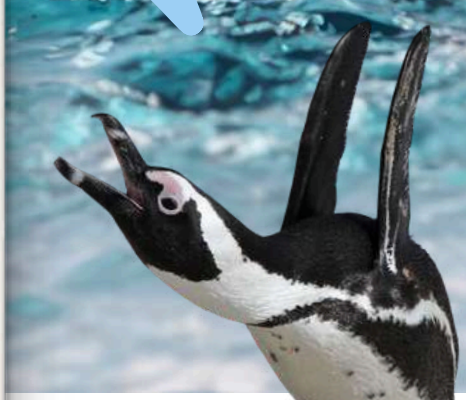
Today, it rises almost 6 millimeters per year, whereas between 1901 and 1971 it rose about 1 millimeter per year.

Causes :

When ocean water warms, it expands and takes up more space. Sea levels rise.



I didn't realize that glaciers and the ocean were so closely connected!



I'm going to tell you the story of a huge ice shelf with the gentle name of Larsen B.

When it collapsed over just a few weeks in 2002, it acted like a shaken champagne cork: the glaciers it was holding back sped up towards the sea, plunging in and raising the waters.

Larsen B is located here, on the Antarctic Peninsula.

31 January 2002

The ice shelf (on the left) is marked with parallel lines of blue dots. These dots are meltwater ponds.

The front edge of the C-shaped shelf has already retreated about 10 kilometers. The first large icebergs that broke off can be seen.

17 February 2002

7 March 2002

The shelf almost completely disintegrated into a bluish mixture of melted snow and icebergs. Between January 31 and March 7, the shelf lost 2,717 km² of ice, the size of Reunion Island.

On March 17, we see the icebergs scattering beyond the edge of the image.

17 March 2002

Match the date to each satellite image

A ___

B ___

C ___

D ___

Consequences of this collapse on the glaciers that were held back by the Larsen B ice shelf:

x3 increase in speed **x10 increase in ice loss**

East Antarctica is stable but West Antarctica, on the other hand, is more sensitive to global warming.

Do you remember when we talked about glacial and interglacial periods? 130,000 years ago, the Earth was in a warm period, almost as warm as it could be in 2100. With our radar, we wonder: did the ice of West Antarctica survive... or did it collapse?

Radar Mission

If our deep radar detects ice layers older than 130,000 years: the ice sheet has survived.

Otherwise, it would mean it has already collapsed... and with current warming, it could happen again in the long term.

Deep radar

The answer is crucial: if this immense ice mass disappeared, sea levels would rise by several meters. Scientific research in Antarctica, like our expedition, helps anticipate what could also happen to the ice sheet and its impact on rising waters.

Matthieu, what are the consequences of rising sea levels?

Rising sea levels

Sea Saltwater contaminates underground freshwater sources.

Some species of fish, birds, and plants lose their habitat.

Coastal populations are forced to move.

The risks of marine submersion will rise during storm events

Submerged farmland becomes unusable.

Coasts erode, and wetlands flood.

Help Paco!

Interactive activity on the links between sea level rise, the cryosphere, and human activities.

This photo illustrates two consequences of rising sea levels. Can you identify which ones?

La Manche department, France

Today, 110 million people live less than 1 meter above sea level: that's like the combined population of France and Spain. About 680 million live less than 10 meters above sea level: almost as many as the whole of Europe. These maps show what two regions of the world could look like in 2050, with the actual global warming scenario. Areas in red would be flooded at least once a year.

North Sea (Netherlands, Belgium, France, Germany)

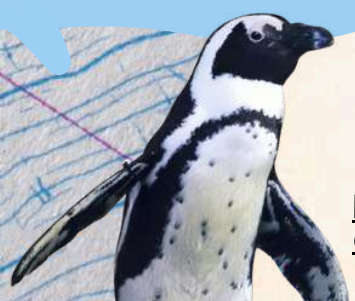
- Major cities: Amsterdam, Rotterdam, Bruges, The Hague
- Major economic and port area

Ganges-Brahmapoutre-Meghna Delta (Bangladesh and India)

- Densely populated area
- Intensive agricultural production
- Exceptional biodiversity

Council of Ministers in the Maldives in 2009 to raise awareness about the consequences of rising sea levels in their country.

Okay, we know how to measure sea level rise, but concretely, what can we do to limit the damage get worse?



Help Paco!

In 2022, Indonesia decided to move its capital, Jakarta, to a new city called Nusantara partly because of rising sea levels.

What is the link between this decision and the glaciers?

Look at what will happen in your country and region in 2050 and beyond.

Reducing our greenhouse gas emissions

The most important thing is to tackle the causes and reduce our greenhouse gas emissions. This way, we can limit global warming.

It is the best way to protect glaciers and areas affected by rising sea levels. This is the most important action because it addresses the problem at its source! Acting now will cost countries less than letting the damage worsen.

But what can be done when rising sea levels are already impacting territories?

Adapting to changes

Solutions must be adapted to each coastline. Since sea level rise does not have the same effects everywhere, every place needs a specific response. Sometimes, houses must be relocated to stay safe. Often, nature helps us: dunes and coastal plants slow down waves, and wetlands absorb water like sponges. Most importantly, we should avoid building in areas that could be flooded later.

Your turn!

Imagine the inhabitants of the imaginary village of Pacocity ask you for advice to protect their territory from storm waves that often flood the main road. What would you advise them? (Several answers possible)

a. ☐ Remove sand and vegetation from the shoreline.

b. ☐ Restrict access to this road depending on the weather.

c. ☐ Strengthen and protect the dunes with plants adapted to the coast.

Fighting climate change is a bit like our expedition today: we face obstacles, but we must keep moving forward. Look around us! The landscape is particularly chaotic!

Oh, that's true, especially those horrible snow waves that keep shaking us nonstop!

Those waves sculpted by the wind are called sastrugi. The Antarctic ice sheet is a world in motion: look, I took several photos of all we can encounter here. Before setting out, we carefully studied our route to avoid them. But in reality, we have to adapt day by day, depending on the wind and new obstacles we encounter.

Blue ice areas (very slippery)

Crevasses

Sastrugis

Nunataks
(emerged mountain summit)

Supraglacial lakes and rivers

Hi folks!

This week was action-packed. I discovered the Transantarctic Mountains, an immense wall of mountains that separates East Antarctica from West Antarctica.

I also saw glaciers moving toward the sea and ocean currents. It made me understand that melting glaciers affect sea level rise. And that has consequences for animals, humans, and their habitats.

But together, humans can lessen the problem by reducing global warming and adapt locally with the help of nature.

See you soon my friends!

Paco
Trainee glaciologist

By the way, Paco, we also have a sweet little note for you ...

It's already been six weeks that we've been sliding together across the vast white expanse.

Who would have thought that a little Cape penguin would become such an indispensable travel companion?

With you, the cold tickles us more than it scares us, and even the endless waiting for the wind to fill our kites eventually makes us laugh. Together, we make an amazing team: two slightly crazy humans and a penguin always ready to see what's behind the next sastrugi.

Little Paco, thank you for your unwavering courage, your insatiable curiosity, and your ability to remind us that exploring also means marveling and laughing, even when the thermometer is on strike.

We are convinced that you will have all the qualities needed to sit on the Penguin Council and provide valuable help.

Without you, Antarctica would be much quieter... and far less fun.

With all our polar friendship!

Heïdi & Matthieu

The Little Scientists' Games

Hi there! Would you mind helping me complete my notes? I'll keep your work carefully to use it at the Penguin Council. Thanks!!!

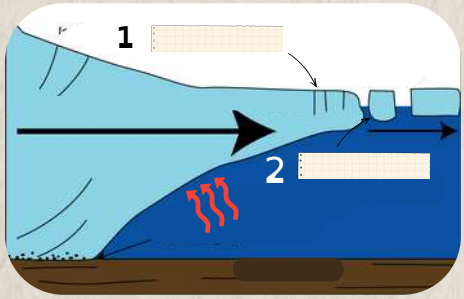
1 Antarctica

Color the ice sheet light blue, the ocean dark blue, and an ice shelf red.

Ice shelves are important because:

a. ☐ They slow down the flow of glaciers into the ocean.
b. ☐ They serve as a habitat for Antarctic vegetation.

2 Ice shelves



Complete the diagram and this sentence.

Water melts ice by _____

3 Ocean currents

1 - What are ocean currents for?

☐ To decorate the ocean
☐ To transport water, heat, plankton and animals

2 - The Southern Ocean is the only ocean in the world that completely surrounds a continent.

☐ True
☐ False

4 Rising sea levels

In your opinion, which city will be most affected by rising sea levels?

☐ Bogotá (Colombia): 2,640 meters above sea level

☐ Venice (Italy): 1 meter above sea level

Bonus

And you, write three things we could do to limit glacier melting and protect the planet on our scale?

Lexicon

Density: A material is said to be less dense than another if, for the same size (same volume), it is lighter. This is the case for ice compared to water. It floats.

Erosion: Process that wears down, breaks apart, and moves rocks, soil, or coastlines due to wind, water, ice, or human activities. Coastal erosion is caused by human activities and rising sea levels.

Marine submersion: Temporary or permanent flooding of coastal areas by the sea, with saltwater, caused by high tides, storms, sea level rise, or tsunamis.

Plankton : collective term for microscopic or tiny organisms (plants, animals, bacteria) that drift in oceans or freshwater, forming the base of the aquatic food chain and playing a key role in oxygen production.

Relief: The set of shapes and irregularities (mountains, valleys, plateaus, plains, etc.) that shape the surface of the Earth.

Scenario: A projection of future climate changes based on greenhouse gas emission levels and human actions. Under the current scenario, the global temperature in 2100 is projected to rise by +2.9°C compared to 1850.

Supraglacial lake: Temporary body of water that forms on the surface of glaciers or ice sheets during summer melting.

To go further

Amundsen Sea

West Antarctica

an unstable ice sheet

Antarctica

70%

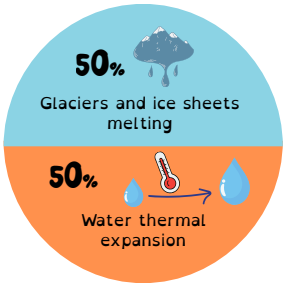
freshwater reserve

When glaciers melt

sea levels rise

Cut out the images

The Transantarctic Mountains



Reducing our greenhouse gas emissions

The Antarctic Circumpolar Current

GAMES SOLUTIONS

Page 9

A → 7 March
B → 31 january
C → 17 March
D → 17 february

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- Coastal populations are forced to move.
- Coasts erode

Page 12

Answers b. and c.

Page 13

The link between this relocation and glaciers is as follows:
The melting of glaciers and ice sheets contributes to rising sea levels worldwide. Indonesia is the largest archipelago in the world (made up of islands) and is therefore one of the countries most exposed to sea level rise. Jakarta is at risk of being partially submerged, due partially to the sea level rise, which prompted the government to move the capital to a safer area. This example shows that what happens far from us can have consequences here.

Page 17

1 → Answer a.

2 → 1 → Crevasse
2 → Iceberg

Water melts ice from underneath

3 → 1. To transport water, heat, plankton and animals
2. True

4 → Venice, because the city lies on the coast at a very low altitude