Frozen-Ground cartoons
AN INTERNATIONAL COLLABORATION BETWEEN ARTISTS AND PERMAFROST SCIENTISTS

HETA NÄÄS
NOÉMIE ROSS
CONTENTS

3 FOREWORD

4 A COLLABORATION BETWEEN ARTISTS AND PERMAFROST SCIENTISTS

6 NOÉMIE ROSS’S CARTOONS

17 HETA NÄÄS’S CARTOONS

THE FROZEN-GROUND CARTOONS SCIENCE TEAM

Frédéric Bouchard (lead), Michel Paquette and Audrey Vellette. Department of Geography, Université de Montréal & Centre d’études nordiques (CEN), Université Laval, ffoada, Canada Michael Fritz and Stefanie Weege Alfred Wegner Institute Helmholtz Centre for Polar and Marine Research (AWI), Germany Julie Malenfant-Lepage Department of Civil and Water Engineering & CEN, Université Laval, Canada Bethany Deshpande Department of Biology & CEN, Université Laval, Canada Alexander Nieuwendam Centro de Estudios Geográficos/IGOT, Universidade de Lisboa, Portugal Ashley Rudy Department of Geography and Planning, Queen’s University, Canada Matthias Sievert Department of Ecology and Environmental Sciences, Umeå University, Sweden Ylva Sjöberg Department of Physical Geography and the Bolin Center for Climate Research, Stockholm University, Sweden Jon Harbor Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, USA (senior advisor) J Otto Habeck Institute for Social and Cultural Anthropology, Universität Hamburg, Germany (senior advisor).

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This project started in October 2015 with a crazy idea: prepare and submit a funding application for an international, multidisciplinary and non-traditional scientific outreach project… within the next 48 hours.

Well, it worked out. A group of highly motivated young researchers from Canada and Europe united to combine arts and science and produce a series of outreach comic strips about permafrost (frozen ground). The aim of the project is to present and explain scientific research conducted across the circumpolar Arctic, placing emphasis on field work and the rapidly changing northern environment. The target audience is kids, youth, parents and teachers, with the general goal of making permafrost science more fun and accessible to the public.

Because guess what: permafrost represents an area of more than twenty million km² in the Northern Hemisphere, a huge area. As the climate warms, permafrost thaws and becomes unstable for houses, roads and airports. This rapid thawing of previously frozen ground also disrupts plant and animal habitats, impacts water quality and the ecology of lakes, and releases carbon into the atmosphere as greenhouse gases, making climate change even stronger. Hence permafrost and its response to climate change concerns us all. The project received initial support from the International Permafrost Association (IPA) as a targeted ‘Action Group’, and since then several other sponsors have joined the project.

Here we are, now, two years after this first idea. What you are about to read is the result of an iterative process of exchanging ideas between artists and scientists. We first made an application call and received 49 applications from artists in 16 countries. Through a formal review process, we then selected two artists to work on this project: Noémie Ross from Canada, and Heta Nääs from Finland. With input from scientists, Noémie and Heta created fantastic cartoons that explain some of the changes happening to the environment in permafrost areas, how they affect people and wildlife, and what scientists are doing to better understand these changes to help people find innovative ways to adapt. We wish everyone plenty of fun reading this booklet and we would like to thank all those who supported this project.
Tundra – A type of landscape with a cold climate, frozen ground (permafrost), low growing vegetation (mostly grasses) and usually no trees.

Permafrost – Ground that remains at or below 0°C for at least two years in a row. Usually that means that the ground is frozen and does not thaw during summer. Ground includes soil, rocks, sediment, organic material and ice.

Seasonal frost – Ground that is frozen only during winter. Snow insulates the ground during the winter, so with more snow the ground usually freezes less than with less snow.

Thaw slump – Landslides where ice-rich permafrost on the slopes of a valley thaws out rapidly, leaving eroded areas of exposed soil.

Active layer – The upper layer of the ground in permafrost areas, which thaws during the summer. The active layer is often between 0.5 m and 2 m thick, depending on local climate and ground properties.

Thermokarst – Erosion and settlement that results from the thawing ice-rich permafrost, which decreases the stability of the ground material.

Landslide – Landslides can occur when the ground loses its structural stability, for example when ice-rich permafrost thaws. The ground then starts to move, which can lead to damage of buildings, roads and airports in permafrost areas.

Tundrakart – When the ground freezes it often cracks in a polygonal pattern. Snowmelt water and rain can flow into the cracks and freeze, and in this way ice wedges are built up over long time and can grow to several meters thickness. The ice wedges can create polygonal patterns on the ground covering vast areas of the Arctic tundra.

Geomorphology – The science that deals with landforms and landscape development.

Sediments – Rocks, gravel, sand, and clay that have been deposited by rivers, glaciers or in lakes. The ground, including permafrost, contains massive amounts of sediments.

Permafrost zones – Permafrost areas are divided into zones based on the amount of frozen ground in the area. In the continuous permafrost zone almost all of the ground (90-100%) is frozen; in the discontinuous zone 50-90% of the ground is frozen; in the sporadic zone 10-50% of the ground is frozen; and in the isolated zone less than 10% of the ground is frozen.

Organic material – Pieces of dead plants and animals, which can be found in the ground, including the permafrost. Organic material is rich in carbon. It decomposes very slowly or not at all in cold, wet or frozen conditions. This is why a lot of organic material from previous vegetation remains undecomposed and stored in frozen Arctic soils.

Sediments – Rocks, gravel, sand, and clay that have been deposited by rivers, glaciers or in lakes. The ground, including permafrost, contains massive amounts of sediments.

Thermistor – A device used for measuring temperature.

I am Noémie Ross from Montréal, in Québec, Canada. I love to transfer information through my creative work. If I want to draw interesting cartoons, I need to ask: what is permafrost?

I am Heta Nääs from Helsinki, Finland. I find it interesting to draw comics about something unfamiliar to me, as permafrost science. Now that the scientists have answered my questions, I’m ready to work on a story!
So, an easy question to start with: what is permafrost?

Permafrost is a thermal state... Nice!

Like I thought, he is the famous international permafrost scientist.

Oh for real? You mean the star speaker at conferences! Cool!

...but now you’re saying there is no danger with permafrost melting?

No, no, no...

Yes, yes, yes...

But, as I said, frossenground is a ssermal condition of the ground.

Zaz is a common mistake.

Because as I said earlier, it is not only ice and snow, it can also be rock, sand...

It ssaws!

Like a turkey!

You need a little demonstration...

Hold it for me, please!

But a turkey zat comes out of the freezer...

?...does not turn into a puddle!

O-k-a-y!

Now it’s clear!

The warming at ze poles could allow the methane trapped in ze ground to be released in ze air.

Oh, okay, I thought I was mistaken...

You are mistaken...

...because we can not say zat ze frossenground melts.

Changing climate is a concern because permafrost is directly linked to ze temperature of ze air.

Oh, okay, I thought I was mistaken...

He means it thaws!

O-k-a-y! Now it’s clear!

Zat’s it!

A snowball melts, right?

It...what?

sauce?

souws?

saws?

The star speaker is a common mistake.

Zat is why it is more exact to say zat it ssaws.

Students, listen please!

We are really lucky to have a special guest here to give you an introduction to permafrost.

So Dr. Petit, they are just starting to study permafrost science.

Often people sink zat frossenground is characterized only by snow and ice.

I like his charming accent and don’t want to miss a word!

We define permafrost as ground, or materials, zat remains frozen for at least two consecutive years.

In Siberia, we can have permafrost zat is almost two kilometers deep.

You have a question?

With climate warming, should we be worried about the permafrost melting?

No, no, no...

Oh, I...I...I thought it was a real threat...

Yes, yes, yes...

Sand...

... and any ozer kind of soil.

Changing climate is a concern because permafrost is directly linked to ze temperature of ze air.

Oh, okay, I thought I was mistaken...

You are mistaken...

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O-k-a-y! Now it’s clear!

Zat’s it!

A snowball melts, right?
climate is changing, my dear reindeer!

Mom, I don’t want to wear those!

You don’t have any choice! You must wear your arm floaties.

Did you wear them too when you were little?

There was no need to wear them when I was young.

Then why should I be wearing them?

Because climate is changing, my dear reindeer!

You know what happened to your uncle...

Yeah, but why did that happen?

The global temperature is warmer and the soil that used to be frozen tends to be less frozen... he drowned in soil that had become too weak...

People are trying to do something but it is not a simple phenomenon to stop.

People from many countries are working together on a plan to slow down climate warming.

CO₂ is the main reason for warming. That originates mostly from industry. It is very hard to slow down and even when a plan is set up it will take many years before we will see a positive effect.

I’m singing in the rain...

There are more precipitation...

Is it only here that climate is changing?

No, it has had an impact all around the globe...

Mom, I’m serious, I want to do something useful for future generations!

Oh, I’m as serious as you are.

If you want to see future generations...

... if you want to have kids yourself...

Oh, I’m as serious as you are.

If you want to see future generations...

... if you want to have kids yourself...

That originates mostly from industry. It is very hard to slow down and even when a plan is set up it will take many years before we will see a positive effect.

Mom, I don’t want to wear those! You know I can swim!

Son, you know the ice is rare, you will have to swim a lot!

But it is true that the effects are greater and faster in the North.

The arctic ice cover is getting thinner every year and is retreating sooner so boats are now able to travel far north. You’ll see more and more of those boats, son!

Why is that?

The atmospheric layer that has to warm in order to warm the surface is thinner in the Arctic. That’s why it is warming even faster where we live.

Why isn’t anyone doing anything about it then?

Then everybody has to start making an effort starting now!

You’re right!

Mom, I’m serious, I want to do something useful for future generations!

Oh, I’m as serious as you are.

If you want to see future generations...

... if you want to have kids yourself...

Oh, I’m as serious as you are.

If you want to see future generations...

... if you want to have kids yourself...

Let’s go!

Not cool!

The snow and ice cover melt and the darker land and ocean surfaces absorb more energy... and that makes it warmer.

The atmospheric layer that has to warm in order to warm the surface is thinner in the Arctic. That’s why it is warming even faster where we live.

Then why should I be wearing them?

Because climate is changing, my dear reindeer!

You know when I was young, I used to live more in the south in the tundra, we had a lot of food...

But now the growing season is longer and warmer. Trees have replaced our sedges...

People started to cultivate the soil...

You don’t have any choice!

You must wear your arm floaties.

You know when I was young, I used to live more in the south in the tundra, we had a lot of food...

There are bugs we didn’t use to see, there are forest fires...

There are more precipitation...

I’m singing in the rain...

... first of all, you have to ensure...

... to keep safe!
The Reindeer and the Mosquitoes

It’s getting warm. It’s time to round up the herd to bring the reindeers to a lake.

Dad, I’m so happy school is finished for the summer and to come work with you!

We might find some reindeers over there.

How do you know that, dad?

Now that the herd is rounded up, let’s go to that lake...

You must cross them with a right angle.

...a bad angle, you might break the skis of your sledge or snowmobile.

You see those polygons. They are separated by crevasses. If you cross the crevasses with...

It won’t take long! It’s not too far!

You must cross them with a right angle.

Okay!

Suddenly, it seems a looooot longer!

That kind of elliptic-shaped lake is more shallow and has really clean water for reindeers.

And even for us... In winter, we cut cubes in those lakes to get clean water to drink.

The only disadvantage is that there are no fish in there.

Another good point: mosquitoes tend to avoid living near that kind of lake because it has less swampy banks, their natural habitat.

Mosquitoes and reindeers can really be a dangerous match!

Believe me, son, at the peak of the season, in July, mosquitoes bother and attack the reindeers.

They go fast, and for such a length of time, that they may themselves create a living earth.

OH NO! The herd is actually being attacked by mosquitoes!

To protect the soil and the herd, we must move the herd up the hill.

There’s less chance up there to create a living earth.

Alright! It’s quiet again.

Dad, I thought it would never finish... I’m so tired!

Son, you’ve learned a lot in one day!

Now I agree: little mosquitoes can be a big problem!

But how could a little mosquito be a danger for reindeer?

You told me strange stories where the soil becomes soft and sludgy, the living earth, in which reindeers are in danger of drowning.

The herd becomes upset... and gathers...

...and ultimately starts to run in a circle, forming a reindeer mill.

The herd becomes upset...

and gathers...

You told me sad stories about wolves and reindeer newborns...

Dad, are you serious?

I mean you told me sad stories about wolves and reindeer newborns...

You told me strange stories where the soil becomes soft and sludgy, the living earth, in which reindeers are in danger of drowning.

But how could a little mosquito be a danger for reindeer?

Mosquitoes and reindeers can really be a dangerous match!

And even for us... In winter, we cut cubes in those lakes to get clean water to drink.

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Alright! It’s quiet again.

Dad, I thought it would never finish... I’m so tired!

Son, you’ve learned a lot in one day!

Now I agree: little mosquitoes can be a big problem!
Hey Valery! Long time no see. You’re going on vacation?

Yes! I’m going south! I’m so excited!

I bought my ticket one month ago and my suitcase has been packed for weeks. I can’t wait to get there! I opted for an all-inclusive package.

... to meet and work with people from northern communities... 
... to explore unique and amazing landscapes and live outdoors...
... to spend time with friends and colleagues from around the world...

Well it may sound strange, but I really enjoy spending time in the north.

... it’s really important to get away from a desk and see what is actually happening on the ground...
... and honestly a more physical work is welcome after an all-year routine!

Hey Eva!

I bought my ticket one month ago and my suitcase has been packed for weeks! I can’t wait to get there!

... to explore a new landscape... 
... to take advantage of the long days... as the sun sets later...
... it’s really important to get away from a desk and see what is actually happening on the ground...
... and honestly a more physical work is welcome after an all-year routine!

I’m confused, isn’t that work? That can’t be a vacation, can it?

And you? Are you going on vacation too?

Yes, yes. I’m going north.

... to change my routine...
... to spend time with my friends and make new ones...
... to explore a new landscape... 
... to take advantage of the long days... as the sun sets later...
... it’s really important to get away from a desk and see what is actually happening on the ground...
... and honestly a more physical work is welcome after an all-year routine!

Will you send me pictures of your trip?

I will!

Yes, yes! I’m going north.

Yes!!! I’m going south! I’m so excited!

All-inclusive field vacation

I am planning on collecting a number of different samples of the frozen ground... also known as permafrost... and even samples of lake ice... that we collect with a chainsaw...

... to change my routine...
... to spend time with my friends and make new ones...
... to explore a new landscape...
... to meet and work with people from northern communities...
... to explore unique and amazing landscapes and live outdoors...
... to spend time with friends and colleagues from around the world...

... it’s really important to get away from a desk and see what is actually happening on the ground...
... and honestly a more physical work is welcome after an all-year routine!

I am the one who can’t wait to unpack!

Miss, please!

No need this.

... to spend time with friends and colleagues from around the world...
... to explore a new landscape...
... to meet and work with people from northern communities...
... to explore unique and amazing landscapes and live outdoors...

... it’s really important to get away from a desk and see what is actually happening on the ground...
... and honestly a more physical work is welcome after an all-year routine!

... to change my routine...
... to spend time with my friends and make new ones...
... to explore a new landscape...
... to meet and work with people from northern communities...
... to explore unique and amazing landscapes and live outdoors...
... to spend time with friends and colleagues from around the world...
A landslide occurred three months ago in the village. Fortunately, despite the scale of the landslide, nobody was injured. That landslide was the result of the melting of ground ice, which generated a lot of water in the soil.

So we want to take actions to better plan the future.

Very good. Let’s talk about the work to be done! It is quite an important issue for our village. That is why we need your knowledge and expertise: we need you to study the area, to map the landscape and give us precise information on the best locations to build safe and sustainable infrastructure in the future.

He has a lot of great field experience. However the consequences could have been more serious since we were about to start building houses on this land!

I feel like I’m giving a mission to a team of permafrost superheroes...

As you might have heard... That is why we need your knowledge and expertise: we need you to study the area, to map the landscape and give us precise information on the best locations to build safe and sustainable infrastructure in the future.

A landslide occurred three months ago in the village. Fortunately, despite the scale of the landslide, nobody was injured. That landslide was the result of the melting of ground ice, which generated a lot of water in the soil.

We need your knowledge and expertise: we need you to study the area, to map the landscape and give us precise information on the best locations to build safe and sustainable infrastructure in the future.

I feel like I’m giving a mission to a team of permafrost superheroes...
We have a problem!

Fred broke his thumb again!
He cannot be part of the team!

What?

But we need a complete team!

I agree, Fred has to be replaced.

So close to the beginning of the season, everyone is booked on a project!

Yeah, everybody I’m thinking of is already engaged.
Me too.

Hum… okay, anyone knows someone, with scientific interests and good resistance?

Good job!

Walking on a giant

Andre Baquist reports for University Magazine

On my first day, I took part in data gathering with researchers.

So, where is it, the Permafrost? Aha.

Don’t you worry, we can see exposed permafrost in front. Yup.

Yeah, we’re here.

What!?

Ahem.

I was hops, for a picture.

Don’t you worry, we can see exposed permafrost in front.

What? That?

A landscape carved by drilling.

I think it’s impact.

It’s heavy enough.

Did you eat it?

I think it’s impact.

Yes, also organic carbon and other elements.

There’s ice and sediment right?

Yes.

We might turn the same bacteria back at the lab.

Reviving after 3 million years.

That’s amazing.

Fascinating.

You know what?

Temperature, imagery, samples, patient’s context…
That makes sense to me!

Yes!

Finally, I have the pleasure to meet the patient.

I’m in!

Temperature, imagery, samples, patient’s context…
That makes sense to me!

Yes!

Finally, I have the pleasure to meet the patient.

I’m in!

He plans to study medicine. Does a lot of outdoors activities.

Okay, the difference is you need to drill a hole in the ground to install thermometers to log data of temperatures at different depths.

Rafael, I’m surprised you call me. I mean, I know nothing about permafrost and stuff…

Some imagery tests are also conducted to get a 2D image of the soil transect.

And finally, data about the ground only would be useless. We also collect data of the surroundings, as soil humidity, air temperature, snow depth… to get a complete top.

Chut!

You know what?

Temperature, imagery, samples, patient’s context…
That makes sense to me!

Yes!

Finally, I have the pleasure to meet the patient.

I’m in!

We want to know the depth of that active-layer.

So, you need how would feel a person with fever… so does the ground.

The top layer thaws and re-freezes every year; it’s the active-layer.

Another exciting but delicate step: collecting samples. Those are sent to labs for further analysis.

Why do you say it’s delicate?

Secondly, you know how weak feels a person with fever… so does the ground.

Fascinating.

You know what?

Temperature, imagery, samples, patient’s context…
That makes sense to me!

Yes!

Finally, I have the pleasure to meet the patient.

I’m in!

I think it’s impact.

It’s heavy enough.

Did you eat it?

I think it’s impact.

Yes, also organic carbon and other elements.

We might turn the same bacteria back at the lab.

Reviving after 3 million years.

That’s amazing.

I’m in!
the bumpy road

A village in the Subarctic Arctic

Sure you’ve got everything?

Ranger’s gear for monitoring and managing the environment

The bumpy road scenario and drawings

Edel, an Arctic Ranger

Can I come with you?

Ranger’s outfit protects against mosquitoes

Backpack: bug shirt, bear spray, sunglasses, notebook, walkie talkie, rubber boots, pullover, pullover

Sure. Here’s a gun for bear emergencies situations.

Anir, also a Ranger. Good morning, partner.

I like your new house.

Hello! That’s your area then. And you can handle the road.

Remember, as a Ranger, you’ll work with both the villagers and the scientists.

This structure prevents the house from sinking when the active layer thaws, or if the permafrost degrades.

Frozen ground/permafrost, ground that stays below 0°C for 2 or more consecutive years.

This project starts tomorrow. Air will keep the ground icy under our house.

Hey, when they first came to introduce the project to fix this supply road, didn’t they also mention something about fish?

My first science mission!

That was about silt and fish health.

Organic material, stones, sediment, sometimes ice
**Timur’s Golden Days**

The effect of climate change was weaker. From present to the future, climate change has a stronger impact. The ground thaws and becomes susceptible. The permafrost is changing and becoming thinner. The permafrost was more stable.

**What Warming Means for Roads Placed on Permafrost**

When ground temperatures rise above 0°C, ice crystals melt and water flows away, causing frost heave and damage. Unfrozen ground can move. Ice wedges grow when water plants into cracks and evaporation causes permafrost thawing.

**HMP, Things Have Changed Since I Started Working with Permafrost**

Are you talking about the warming climate? Well, it has definitely changed the Arctic as well as Arctic research. Is there really such a contrast?

**I Wonder How Things Will Change During Our Careers**

Indeed! I used to fish around here!

**On the Big Lake?**

Hey! Things have changed there too.

**A Retrogressive Thaw Slump**

Retrogressive thaw slumps form in permafrost where there is a lot of ice. They can enlarge up to 10m/year.

Water from the melting ice lubricates the sediments creating new channels of eroding thawed permafrost. Sediment that flows into the lake impacts the water conditions and the inhabitants of the lake.

That wasn’t there before.

HMP!
**People and Permafrost**

Almost 400 million people live in the Arctic, including many distinctive Indigenous groups. They are affected by the changes in climate and permafrost.

We will be looking for volunteers to take part in surveying the permafrost around the road.

What about the Big Lake? That too.

Also, there are many people who can tell you about the changes in the local environment.

Will you show us your science gear?

For sure, even though most of you have seen it many times before.

See you tomorrow!

Good night!

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**The Animals of the Changing Arctic**

The hunting grounds of the polar bears have become scarce because of the reduced sea ice. They have started hunting on land instead.

The caribou herds have faced difficulties due to changes in vegetation and thawing ground.

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Polar bears look so odd wandering out of their habitat.

Hi, guys!

Maria!

Edel!

Hi, Amel!

Hello! Nice to meet you!

Let’s set up your camp and have dinner at our place.

Sounds wonderful!

Thank you!

Ah, an Arctic fox.

I spotted something too!

Maria!

Edel!

Hi, Amel!

Hello! Nice to meet you!

Maria!

Edel!

Hi, Amel!

Hello! Nice to meet you!

Let’s set up your camp and have dinner at our place.

Sounds wonderful!

Thank you!

You are late.

Sorry! We were planning a barbecue.

For tomorrow?

What about learning ranger signs?

---
Thank you all for supporting this project. As you know, before figuring out how to secure the area, we need to study the ground.

One way is to take ground samples, and to study their structure and other qualities. I assume you'll take several samples from the area.

Correct! And we'll use a grid pattern to keep it organized.

But the tumaks will be full of holes, don't worry, we'll cover them and leave no marks.

What's this? Is it a lawn-mower? Actually, this is sort of an X-ray machine for the ground. It's called ground penetrating radar.

It shows the depth of different features in the ground.

See? Those are ice wedges. Can we try? Sure!

Tests can be run to examine ice content, structure, grain size of sediments, carbon content and other element concentrations.

Three holes to collect data about changes in ground temperature.

Such data shows how different areas are warming during the year. Why do you need to know that?

The results help to predict ground stability.

Ground penetrating radar works by sending electromagnetic waves into the ground.

Can you help me at the lake? Certainly. I have a boat we can use to collect samples. Oh! See you! See you at the first meeting!
An international collaboration between artists and permafrost scientists resulting in 22 pages of cartoons about permafrost, climate change, research in the North and reindeer!

FROZENGROUNDCARTOON.COM