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Research, part of a Special Feature on Everyday Adaptations to Climate Change

The Yamal Nenets' traditional and contemporary environmental knowledge of snow, ice, and permafrost

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ABSTRACT. Traditional knowledge about snow and ice conditions on and in the ground is essential in the life of the Yamal Nenets. This holistic knowledge helps the Nenets to travel in the tundra, find good pastures for their domesticated reindeer herds, select proper places for making their camps, find firewood, and locate clean snow or ice for drinking water. It is particularly important for reindeer herders, because looking at different characteristics of snow (layers, hardness, and granularity) enables them to find good pastures for their animals. If there are dangers posed by a crust of ice on the snow, herders have to move their herds to other pastures. Moreover, even reindeer know which kind of snow is easier for them to break with their hooves and where good forage is found. Significantly, the Nenets language has developed a sophisticated terminology describing different types of snow and ice, and similarly permafrost has a special name. Like many other Indigenous peoples of Siberia, the Nenets have noticed that climate change in the Arctic is dramatically affecting their life: it is changing the tundra landscape, the seasons, and the conditions under which they live and herd reindeer. In consequence, the reindeer-herding culture itself helps the people to preserve this knowledge of how to live in the tundra, but to remain relevant, the Nenets' knowledge of tundra ecology and their words for snow, ice, and permafrost must continuously adapt to new realities of the tundra. However, if that culture disappears in the Yamal, this resource will also be difficult to save.

Key Words: *climate change; icing events; Nenets reindeer herding; permafrost; snow terminology; traditional environmental knowledge*

INTRODUCTION

The Nenets represent the largest Northern Indigenous nation of the Russian Federation. They live and work with domesticated reindeer herds in the European part of the Russian North and in western Siberia. The Nenets have unique terminology for snow, ice, and permafrost that exists only in their language. This facet of traditional knowledge is important for reindeer herding. A principal aim of this work is to present and analyze the Yamal Nenets' knowledge of snow, ice, and permafrost. Therefore, in the first part of this article, I will describe in detail the Nenets' names for these three cryospheric parameters through an example of their work with reindeer.

In the second part of the article, I will describe the reindeer herders' observations of recent changes in the tundra climate and how these are reflected in their work and life in the tundra. I define it as "the Nenets' observations of changes in snow, ice, and permafrost in Yamal." Then I will explore the following questions: How does the Nenets' language-coded ecological knowledge facilitate observation of the impacts of climate change? How do the Nenets words for snow and ice enable these people to sense changes differently from other Arctic people? How can this knowledge be updated for the Nenets' needs of climate change adaptation?

My Nenets background and knowledge of the Nenets language and culture helped me obtain this information from original sources and in the original language of my research partners. It is beyond dispute that Indigenous peoples' traditional way of life and traditional knowledge about the environment keep them safe and help in all aspects of their life and work in the Arctic (Fig. 1).

TRADITIONAL KNOWLEDGE, CONTEMPORARY KNOWLEDGE, AND ENVIRONMENTAL KNOWLEDGE OF ARCTIC COMMUNITIES

The term "traditional environmental knowledge" (TEK) encompasses Indigenous communities' knowledge of technologies of subsistence in the natural environment where they live and work (Smith 2021, LeSage et al. 2022).

Fig. 1. Winter chums in the tundra provide good protection with reindeer hides (*jea*) sewn together and wrapped around wooden poles, which are organized in a circle with snow insulation (*takha*). Photo credit Roza Laptander.

It is also grounded in the relationship of Indigenous peoples to their environment as an integral part of their cosmology and religion (Berlin 1992, Johnson and Hunn 2010, Ramos [Daxootsú] 2020). Arctic communities have used TEK in different ways to support their way of life over thousands of years, and their knowledge of the environment helps maintain their survival in cold northern climates (Magga 2006, Johns 2010, Krupnik et al. 2010, Riseth et al. 2011, Bogoslovskaya and Krupnik 2013). In the case of the Nenets, TEK provides understanding about snow, ice, permafrost, and past extreme weather and climate events in Yamal, such as icings in the tundra. Although climate change is dramatically influencing the daily lives of Indigenous

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peoples all over the world today, Indigenous peoples in the Arctic noticed significant climate variation and changes decades ago. At the present time, TEK, which previously helped many Arctic people predict weather and seasonal temperatures, is not as reliable as it once was; it cannot ensure accurate predictions (Jolly et al. 2003, Lavrillier and Gabyshev 2017, Lavrillier et al. 2022). Contemporary, Western science–based research about contemporary environmental knowledge has been producing information about the impact of climate change on the Arctic environment (Jolly et al. 2003, Bartsch et al. 2010, Tyler 2010). Because Western science is assumed to be objective and quantitative, whereas the traditional environmental knowledge of Indigenous peoples is mainly viewed as subjective and qualitative (Mazzocchi 2006, Naess 2013, Roothaan 2019), TEK has never been considered relevant for purposes of serious scientific research. However, in recent years this attitude has changed, and now Indigenous peoples' traditional knowledge is also deemed valuable for science (Eira 2018). Reflecting this shift, many global environmental change projects have begun to take more community-centered approaches (Mathiesen et al. 2018, Huntington et al. 2019). Combining two different approaches in this way creates a complementary synergy.

STUDY AREA, METHODS, DATA COLLECTION, AND DATA ANALYSIS

This study was conducted in Yamal or the Yamalo-Nenets Autonomous Okrug (district; YNAO), a region in the northwest Siberia of the Russian Federation. The word *Ya' mal* is translated from the Nenets language as "the end of the world." The landscape of the Yamal peninsula is represented by arctic/subarctic tundra that consists mostly of permafrost ground, with a humid continental climate characterized by long, cold winters (eight to nine months in length) with very low temperatures (the lowest temperature can be −57 °C), and short, three-month summers.

In YNAO there are 30,000 Nenets, representing almost six per cent of the district's Indigenous population. Among them are approximately 5000 Nenets people who are nomadic and herd reindeer (Forbes 2009). The Yamal peninsula is home to the largest herd of domesticated reindeer. It is also a main Gazprom gas extractive field, which is highly regarded by the Russian state as an important state-owned business that provides a large amount of capital. The Russian state strictly controls its Indigenous peoples (Golovnev and Abramov 2014). However, the Nenets reindeer herders have succeeded in keeping their rights to live and follow their traditional way of life in the tundra (Laptander 2020).

The methods of language documentation, linguistic anthropology, and ethnolinguistics that I used during my work have their origin in the study of language and culture as one of the major subfields of anthropology (Hymes 1964, Herzfeld 2011). The work of collecting research data includes observing, attending, and participating in the life of the tundra people during fieldwork. Working with interviews means not only making recordings but also listening to people's stories and making notes. After the field trips, most of the interviews were analyzed with further transcription and translation into English. My work followed the guidelines of ethics of anthropological research of the American Anthropological Association and the University of Lapland, including prior WP3 Informed Consent Form developed specially for the CHARTER project (Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity, https://www.charter-arctic.org). Participation in the research by individuals who provided consultations about the Nenets language, traditional knowledge, and contemporary observations of changes in the tundra environment has been anonymous.

It helped to acquire a first-hand report from Nenets reindeer herders about the weather and extreme weather events in Yamal during the last years. My Nenets background and knowledge of the Nenets language and culture helped me obtain this information from original sources and in the original language of my research partners.

For conducting my work, I traveled over a period of several years from 2009 to 2021 to the Yamal peninsula, where I lived and migrated with the Tundra Nenets nomadic families as a female member of Nenets society. I collected around 60 interviews from the Nenets reindeer herders through Tundra Nenets language in Baydaratskaja, Yarsalinskaja, and Yamal'skaja (Tambey) tundras, as well from the semi-nomadic reindeer herders from the Yuribey and the Mordy-Yakha rivers in the Yamal Peninsula. In addition, I visited a number of settlements, where I conducted 16 interviews with Nenets elders and young people. The Nenets people speak both the Nenets and Russian languages. Whereas most of the elders speak Nenets and only a small amount of Russian, the young people speak mostly Russian and are not fluent in their native language. As a consequence, a native language is not being passed down to the young people, who, without the knowledge inherent in the Nenets language, will have a much harder time identifying the nuances of snow, ice, and permafrost, and surviving in the tundra, and their cultural inheritance relies on this knowledge and language. During my work I not only collected and documented Nenets words for snow and different qualities of snow and ice in the tundra, I also interviewed Nenets elders and young reindeer herders about climate change and recent extreme events in the tundra. Later I transcribed all interviews, for which I received permission to use for publication, translated them into the English language, and analyzed the information relevant to my topic of research about the snow and ice, as well as extreme icing events in the tundra.

Moreover, the Nenets' traditional descriptions of snow, ice, and permafrost and contemporary knowledge about them will meaningfully complement larger-scale Western research projects because this work was supported by funding under the European Union's Horizon 2020 Research and Innovation Programme (CHARTER) and the Arctic Rain on Snow Study (AROSS) at NSIDC, funded by the National Science Foundation.

THE NENETS WORDS FOR SNOW, ICE, AND PERMAFROST

During migrations in the Arctic tundra, the Nenets stay outside on the tundra all day long, sometimes even without any shelter. The Nenets are familiar with the tundra landscape and are highly skilled in orienteering on it. They know how to deal effectively with different Arctic weather conditions in the tundra.

Quite often they may experience wind (*myertsya*), fog (*syinyu*), rain (*saryo*), blizzards or snowstorms (*khad*), or rain on snow (*salaba saryo*). Hail may fall, and severe frost may occur,

accompanied by temperatures lower than −57 °C and cold wind. Among other means to protect themselves, the Nenets use warm clothes and boots made from reindeer fur. They make their nomadic *chums* [tʃu:ms] of reindeer hides sewn together and wrapped around wooden poles that are organized in a circle. For additional protection, the tundra people fix their tents to the ground with snow. In the tundra, people obtain drinking water by melting clean snow or ice.

The Nenets' knowledge of ecology and natural landscapes is built around many different names for snow, ice, and permafrost. All of the words for different kinds of snow, ice, and permafrost are native Nenets (Laptander 2014). Some are independent lexical items, others are compounds consisting of an adjective and a noun. Together they comprise a terminology for the different kinds of snow and ice that the tundra people can use for their everyday needs. This terminology describes:

- types of snow, its layers, depth, and different degrees of softness and hardness;
- different snow conditions and their quality on reindeer pastures;
- types of ice;
- the reliability of winter roads (strong snow and ice are important for migrations in the tundra); and
- the state of permafrost (the frozen ground).

The Nenets word for snow is *syra*, which is also a name for winter. Many Nenets words for snow define the size and the form of snowflakes. The name for the snowflake is *syra' sew'*, which can be translated as "an eye of snow," a big snowflake is *syra' nyalpey sew*, and a small snowflake is *pydyako syra' sew*. In the following sections there are words with the same stem, *syra*.

Other words describe the condition of the snow surface, giving characteristics of depth, layers, color, moisture content, structure (weak or strong), age (when it has fallen), as well as seasonal features. There are also names for snow that are connected to descriptions of particular seasons and tundra landscapes with special types of snow. The first snow is always very soft. This snow falls during early winter and is good for reindeer pastures. Reindeer can easily break through such snow with their hooves to access forage, such as lichen.

Snow in the tundra is always denser than that in the forest. Descriptive characteristics of very soft, loose, and very deep snow can be captured in the term *idebya syra*. It describes a type of very deep and soft snow, which is difficult for reindeer to walk in.

The Nenets name for hard snow include *maryiko* and *panyi syra* ("hard snow"), *manombey syra* ("hard old snow near chums") and *yabtiy syra* ("hard and sharp snow").

Ridges of snow formed by wind blowing snow on ice are called *paromdey*. A name for a snowdrift is *puder"*. A layer of hard snow on the surface is called *nara* ("a crust of ice on top of snow"). *Pani syra* is a special term for trampled snow.

During their work, herders check the type of snow surface, its temperature and moisture; they also note wind directions and determine whether the conditions of pastures are good for their animals. In addition, they observe the behavior of the herd: if reindeer stay in one place and graze, this means that there is enough forage there.

Every Nenets herder has a special wooden shovel, called *nyada yanggats*, for sampling snow and checking for lichen under it. This shovel is made of birch and is used to break the snow surface to determine the quality of the pastures underneath. With this tool herders check the hardness of the snow surface, the snow profile, and the condition of untouched snow on pastures. The Nenets reindeer herders explain that reindeer have a knowledge of their own with regard to snow, which is based on their experience of digging for forage under snow. They can find proper grazing places in the tundra themselves. Indeed, quite often reindeer herders let their animals choose the place where and how they want to graze. In winter, reindeer dig and make holes in snow to access food on the ground. If the animals can break through all of the layers of snow on the ground and gain access to reindeer lichen and other reindeer forage, then a pasture is good. Male reindeer can dig through hard snow that is impenetrable for most female reindeer, thus enabling herders to use otherwise unusable pasturelands. Particularly in the late winter with some icing on the ground, the presence of strong male reindeer is enough to help female reindeer and calves to gain access to forage (see also Istomin et al. 2022).

Words for snow

Quality and color of snow

Quite often people have the perception that all colors of the winter tundra are shades of white. That is not correct, however, because there is no pure white color in nature. Snow exhibits variations across the color spectrum. Indeed, it is given different names in Nenets according to color: *serako syra* ("white snow"), *serakorka syra* ("not really white snow"), *sere"e* ("extremely white snow"), and *yabyeryena syra* ("shining white color of snow"). *Te"morpey syra* ("yellow, dark snow") differs from polluted snow in the tundra or snow that, when melted for water, contains a black sediment. This snow is called *paridenya syra* ("black snow"), which is also a rather new name for dirty (polluted) snow near Gazprom's oil and gas fields.

Spring and autumn snow

The terms describing springtime snow include *syrad* ("deep hard snow near rivers and lakes in late spring"), *nyir* ("hard snow on ice in spring"), *narey syra* ("spring snow with crystals"), *ngay* ("thaw"), and *ngay syra* ("thaw snow"). The late autumnal snow wet with rain is called *ngamnelyo*. There is also *tadnggana syra* ("wet and sticky snow").

Names for granular snow

Granular snow, or snow with crystals resembling sugar (*inggyem' syra*), is found between the ground and a hard layer of snow on top (Tereshchenko 2003:146). This friable layer of snow resembles groats, acts as a kind of insulation, and is important in regulating the temperature on the ground. It is important for the survival of tundra plants during the severe winter and it is crucial in enabling small animals to move under snow. This type of snow is also very important for reindeer herders because it indicates high-quality pastures with good forage. In pastures with this type of snow, reindeer can get enough food and good lichen. Even though *inggyem* appears to consist of little granules of ice, it is very different from *salaba* ("ice on top of the ground") and *seryer"* ("the frozen ground").

Snow in the tundra people's daily lives
For chum insulation (*takha*) the Nenets select soft snow, which is laid around the base of the tent. Then women or children go to the tundra to bring pieces of clean and compacted snow (*syekhe*) to obtain drinking water in winter (Fig. 2). Interestingly, Nenets herders characterize the snow cover and snow types and describe their different dimensions the way Sami reindeer herders do (Eira et al. 2018), according to (1) humans' access to water and their animals' access to food and space; (2) physical activity, shelter, and rest; (3) mobility for reindeer and herders; (4) visibility of tracks in snow; and (5) visibility of animals' spoors on the surface of snow.

Fig. 2. A Nenets woman melting snow for drinking water. Photo credit Roza Laptander.

Words for ice
A Nenets name for ice on the ground and on rivers and lakes is *salaba*. A winter rain is *salaba saryo* ("icing rain"). This can be translated as "hail," but it is more specific, meaning "winter rain on snow or bare ground." *Serad" syra* is hard snow with thick layers of ice in it; *serad" saryo* is rain in winter. This in turn is the source of the term *serad" po*, "a bad, unlucky, trouble year with winter rains on snow," because *serad*" means misfortune in Nenets. *Seradt"* is a name for ice on top of snow after rain or sleet has fallen, or for a coat of ice on trees and bushes. *Seradt"* is also a name for the most dangerous weather in the tundra, when rain falls on unfrozen ground and later freezes solid. Ice then covers the tundra surface as well as all the plants that are important sources of food for reindeer. If the ground is covered with such ice, it is difficult for reindeer to forage. An interesting aspect of the Nenets reindeer herders is that they have special terms for icing and bad reindeer pastures with ice on the ground, similar to the way that Sami and Chukchi do (Eira et al. 2013, Nuvano 2013).

Frozen ground (permafrost) or sub-soil (underground) ice
In some places in the tundra there is snow that does not melt at all, even in summer. It is usually found in gullies and on river banks and is called *ninya kholkanggana syra* ("never melted snow inside the ground," or "perennial snow"). This snow is different from permafrost, which is called *seryer"*, a soil in which the moisture/water is permanently frozen or in which the moisture/water may melt to a depth of several centimeters in summer and freeze again in winter. From personal experience I know that in the summer reindeer herders have a variety of practices when it comes to using locations with permafrost for grazing their herds. Istomin and Habeck (2016, 2019) have proven in their work that permafrost conditions are very important in determining the condition of a pasture and thus in herding. Places without permafrost usually are very dry and without lichen.

The term *ya' seryer"* also signifies ice inside of the soil that acts like a boundary protecting people from dangerous underground spirits. Early works on the Nenets people and their religion mention that the tundra people believed that some tundra hills, especially pingo hills, were made by *ya' khora*, "the underground bulls" or mammoths. When the craters explode in the Yamal tundra, people believe that the dangerous underground spirit *Nga* may come out of such holes. Only seven layers of permafrost can stop dangerous underground spirits and diseases.

THE NENETS' OBSERVATIONS OF CHANGES IN SNOW, ICE, AND PERMAFROST IN YAMAL

As was described above, the Nenets have special words to describe the details of the natural world around them. They sense environmental changes differently from other Arctic people because they live with nature, and the richness of their knowledge about their land and weather is reflected in their language. Reindeer herders benefit from these detailed terms because as the environment changes around them, they notice when they are using terms less frequently (or that they are seeing less variation in snow types, and more types of challenging conditions that once were rare). Therefore they recognize a need to update their knowledge to reflect a changing climate and a need to understand the new signs and what the changes mean.

The warming of the Arctic regions has caused many changes in the climate. In recent years the weather conditions and weather have been changing rapidly in the Yamal tundra. For example, in their interviews Nenets reindeer herders pointed out that these changes have been so rapid that their traditional environmental knowledge can no longer help them predict the weather as they were able to in the past (Volkovitskyj and Teryokhina 2022).

Winter and winter snow

Reindeer herders reported the following: (1) During recent winters there has been less seasonal snow in the tundra. (2) Winter snow does not appear on time and not in the common seasonal order. For example, quite often the period with wet snow can be long in autumn. Therefore it becomes more difficult to travel on the tundra with snowmobiles. (3) There are more extreme weather events than in previous years. Icing events in winters are happening more often than they did before. (4) Permafrost is thawing and now is much deeper in the ground (Fig. 3).

Fig. 3. Ice-covered ground in the south of the Yamal Peninsula at the end of April 2019. Photo credit Roza Laptander.

Ice and icing events

The icing event on the tundra in 2013–2014 was the most trying time in recent memory for many herders on the Yamal Peninsula. During that time a thick layer of ice covered the entire tundra, and reindeer were physically unable to break through it with their hooves. They had no proper forage for several winter months and almost half of the reindeer population of the Yamal Peninsula starved. This catastrophic winter is now referred in Nenets as the *serad" po*, which refers both to "year with the ice crust on the ground" and "misfortune, trouble, poverty, misery." Reindeer from different herds became mixed, were lost, died on their feet and lay encased in snow and ice in the tundra (Perevalova 2015, Forbes et al. 2016, Golovnev 2017, Laptander 2018, 2020, Burgess and Wang 2023).

The reaction of Nenets to the regular icing events in the tundra and their description of different types of ice on snow are presented below in excerpts from interviews.

A reindeer herder from the Baydaratskaya tundra tells about this year in the following quotes:

> *Then I lost many reindeer, and reindeer from different herds all mixed together, because they were searching for food. A lot of reindeer died from starvation then and many tundra people lost all their animals. It was good that there were no wolves that year.*

Permafrost and permafrost thaw

The reindeer herders from Yamal emphasized that in recent years thawing of permafrost has been intensified by hot summers, which are not common in Yamal. Proper summer grazing is very important for reindeer, improving their chance of survival in winter, but the drier surface soil cannot support enough vegetation and water to provide adequate reindeer forage for animals. Herders also suggested that the same process may be the cause of the anthrax outbreak in 2016 (Laptander and Stammler 2017). All in all, this development causes many difficulties in herding.

Two reindeer-herding women living near the Mordy-Yakha River reported the following in an interview in summer 2017:

> *Last autumn the ground was dry, and later it was covered by dry snow. This snow did not melt the whole winter. Last winter was also cold and dry. The snow on the ground was good and very soft. There was no icing on the tundra.*
>
> *However, in the previous five years there has been ice on the ground almost every year. Every autumn, in November, there have been winter rains, which have left the ground everywhere wet. Low temperatures then turned the wet snow into ice. As a result, there was ice on the ground.*
>
> *Craters have begun appearing in the tundra, although there have been craters in the past as well. I think that the craters could be a result of permafrost thawing. You see, there is no longer permafrost in the ground keeping water on the surface. Water penetrates the ground and causes permafrost to thaw even deeper.* (Fieldwork interview 2017)

The woman's daughter-in-law added that in the past the Nenets people believed that if such craters appeared in the tundra, evil spirits could use them as doors to come up from the underground world and bring people and reindeer disaster and illness.

In their interviews, reindeer herders said that they believe that when gas and oil workers started digging in the frozen ground of the tundra, they hastened the thawing of the permafrost. The frozen ground can no longer contain the methane beneath it. When this gas blows through permafrost, it makes such craters. Clearly, the Nenets reindeer herders understand that the appearance of craters and the recent anthrax outbreak in 2016 could be connected to thawing permafrost in the Yamal tundra (fieldwork materials 2017).

During this work, many Yamal reindeer herders expressed the need to obtain weather forecast information using modern technologies that could inform the tundra people about expected extreme weather events in advance (Fig. 4). They surmised that this would help them to plan their work with reindeer during icing events or other difficult weather conditions in the future (fieldwork interview 2019). Moreover, because young Nenets do not know the Nenets words for snow, ice, and permafrost, this unique terminology is in danger not because of climate change but because of the dominance of the Russian language. When young people do not speak their native language, they do not know the words for many aspects of their traditional way of life and culture (Fig. 5).

Fig. 4. In recent years, Nenets reindeer herders use snowmobiles for traveling in the tundra. Snowmobiles are a particularly important means of transportation during icing years in the tundra. They are also good for herding reindeer. Photo credit Roza Laptander.

Fig. 5. In winter the Nenets herders keep their reindeer in the forest-tundra zone in the south of Yamal Peninsula, in places with trees and lichens. Photo credit Roza Laptander.

CONCLUSIONS

This article about environmental knowledge of the Yamal Nenets has provided evidence that the Nenets language has a well-developed knowledge and terminology for describing snow, ice, and permafrost. The words embody both general and specific descriptions of these elements of the tundra environment. This present research also contributes to the description of the processes of a changing climate, common among the Indigenous peoples of the Arctic regions (Magga 2006, Johns 2010, Krupnik et al. 2010, Riseth et al. 2011, Bogoslovskaya and Krupnik 2013). Generally described as a global concern, the warming climate is very much a local concern for the Nenets. As people who live directly from nature, they have been the first to notice these changes on the ground, literally, in the state of snow and ice in the Arctic.

The regular occurrence of extreme and unprecedented environmental events urges a new understanding of disasters in the tundra (for example, icing events). Winters with ice on the ground (known as an Arctic "rain on snow" event) are among recent anomalous weather events on the Yamal Peninsula. During the last decade, such events have occurred more frequently, almost every year, in the region. Many Nenets families who lost reindeer as a result of the icing events have moved to villages because they cannot live in the tundra without reindeer to herd.

My data show similarities and differences between past and present events of icing in the tundra and the Nenets reindeer herders' perceptions of such events. The difference between perceptions of past icing events and current accounts of such events indicates that the Nenets reindeer herders today have many difficulties in their work with reindeer. Therefore, they need modern ways of obtaining information about possible extreme weather events. They also recognized their traditional ecological knowledge about the tundra environment, including special words that describe snow, ice, and permafrost, as an important cultural resource in their work, which is essential for sustainability of the Nenets culture and preservation of traditional ways of living in the tundra.

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Data Availability:

In my article I provide interviews collected from the Nenets reindeer herders about their observation of the climate change in the tundra of the Yamal peninsula, Western Siberia, Russian North. All names of interviewed people are anonymized to protect participants.

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