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Traditional Sámi snow terminology and physical snow classification

- two ways of knowing.

Inger Marie Gaup Eira[a], Christian Jaedicke[b], Ole Henrik Magga[a], Nancy Maynard[d], Dagrun Vikhamar-Schuler[f], Svein D. Mathiesen [c,e]

[a] Sámi university College, Hánnoluohkká 45, 9520 Kautokeino, Norway,
[b] Norwegian Geotechnical Institute, Oslo, Norway
c Norwegian School of Veterinary Science, Sjøgt 39, 9000 Tromsø, Norway
d, NASA Goddard Space Flight Center, Greenbelt, MD , USA
f, The Norwegian Meteorological Institute, Blindern Oslo, Norway
e, International Centre for Reindeer Husbandry, boks XXX 9520 Kautokeino Norway
Corresponding author: ingermge@samiskhs.no , Telephone: +47 95206794

Abstract

Humans describe the natural environment on the basis of their local experience and their interactions with nature in terms of its relevance to their daily lives. These descriptions are incorporated into traditional local languages and form a specialized terminology that is unique and specifically applicable to local needs and practices. In the Northern part of Norway – the region around Guovdageaidnu (Kautokeino), the heart of Sámi reindeer husbandry, snow covers the ground more than seven months of the year in winter. Therefore, snow defines most of the conditions which must be met to support reindeer pastoralism across Eurasia. Snow is a prerequisite for mobility, tracking, visibility and availability of pasture plants like lichens and grasses. The terms used to describe the snow on the ground include characteristics needed to communicate snow properties relevant to reindeer husbandry in the region. In this paper, traditional Sámi snow terms and their definitions are compared with the latest version of the scientific and physical classification of snow on the ground. The study of traditional Sámi snow terms was carried out through historical documentation and interviews with the herders. The results showed that many traditional Sámi terms describe snow conditions as they are defined by the international standard; whereas, other traditional terms describe the physical processes leading up to certain snow conditions. A group of snow terms have as their main purpose the clear communication of the snow conditions for reindeer herding itself to serve as a tool for internal communication within the herding community. A major finding was the herders' snow knowledge was more holistic and integrated into the ecology of the herd and pastures than the international standard snow terms. The richness and relevance to reindeer herders of Sámi traditional snow terms shows a distinctly different view of snow compared to the purely physically-based international classifications. This paper gives an overview of the most important traditional terms, their definitions, and the physical processes associated with those terms. Finally, the winter season 2007/2008 was used as an example to illustrate the evolution of the snow conditions and use of the Sámi traditional snow terms. The application of the terms was compared to local weather conditions and the physical processes that created the different snow conditions on the ground. The analysis underscores the richness and accuracy of traditional snow terminology which includes the physical understanding of the seasonal snow on the ground. In addition, this study illustrates the importance of using traditional Sámi terminology when developing climate change adaptation governance strategies for Sámi reindeer husbandry emphasizing the importance of two ways of knowing.

Keyword: snow, sámi snow concepts, 'seaŋáš', reindeer husbandry

1. Introduction

Snow research is an interdisciplinary field (Fierz et al., 2009) and the study of snow and climate is a rapidly evolving science (Armstrong, 2008). Snow scientists describe snow cover by three primary properties: depth, density and snow water equivalent. The International Classification for Seasonal Snow on the ground (ICSSG) presents and describes the most important features of seasonal snow on the ground, such as, density, hardness and snow microstructure (grain size and form) in the snow cover. Definitions and tools are provided for example to describe the stratification of layered snow profiles (Fierz et al., 2009). Snow and avalanche research related physics, hydrology and meteorology is a well established field probably because of its societal, economical, and cultural importance of the northern hemisphere. Arctic indigenous people's knowledge related to snow and snow change on the other hand is not well documented and understood but a number of descriptive studies of Sámi snow terminology has been publishes (Nielsen, 1979; Ruong, 1964; Svonni, 1981; Eira 1994; Jernsletten, 1994; Magga, 2006; Ryd, 2007).

Arctic indigenous people describe the natural environment on the basis of their local experience and their interactions with nature in terms of its relevance to their daily lives. These descriptions are incorporated into traditional local languages and often form a specialised terminology that is unique and adapted to local needs and practices. Sámi reindeer herders use their language in the same manner to describe their understanding of nature and how they deal the specific knowledge about all kind of natural phenomena, including snow and the winter environment (Eira et al., 2010; Riseth et al., 2010). The ecological survival niches for reindeer are the snow and ice-covered areas in the north.

Sámi reindeer herding is practiced in Norway, Sweden, Finland and Russia, and it represents about one third of the world's reindeer herding and its traditional practices (Jernsletten and Klokov, 2002). The heart of Sámi reindeer husbandry is located in northern Norway in the region around Guovdageaidnu (Kautokeino) (69N, 23E). In this region traditional industry and lifestyle involves about 1700 people and 93,500 reindeer (Reindriftsforvaltningen 2010) which migrate between seasonal pastures each year. The region is one of the largest reindeer herding regions in the world (Magga et al. 2011). In Guovdageaidnu 90 % of the human population use Sámi language as mother tongue and is therefore important for viability of Sámi culture in Norway (www.Kautokeino.kommune.no). The unique natural environment is both the basis of and background for the practical development of reindeer husbandry in Guovdageaidnu and is an important part of the sustainability of local culture. The economics of reindeer husbandry are of particular significance in the Sámi society.

Snow covers the ground in Guovdageaidnu for more than 7 months and, therefore, strongly influences the reindeer herding community and defines most of the conditions which must be met for a successful society to evolve. Sámi reindeer husbandry is complex human-coupled ecosystem (Magga et al 2011) describing the interdependency of herders, reindeer and pastures. According to Liu et al. (2007), coupled human and natural systems are integrated systems in which people interact with natural components. The complexity of coupled systems has not been well understood (Berkes et al., 2003). The lack of progress in understanding the importance of snow in this complex system is largely due to the traditional separation of research related to natural science and social sciences. Especially for reindeer herders, a clear understanding of snow, precipitation, and ice conditions in their area has been critical to their and their herd's survival (Maynard et al., 2010). Knowledge about snow and snow conditions has been developed because of their necessity to survive under extremely challenging and constantly changing climatic conditions. Many essential parts of reindeer husbandry in its present form are thousands of years old (Federova, 2003). The Sámi culture bears evidence of a long intimate relationship with the Arctic environment and Sámi languages have a rich terminology for snow and ice, containing descriptions of snow types, temperatures, wind, snow density, snow depth, snow layers, physical snow processes on the ground and on trees (Ruong, 1964; Svonni, 1984; Jernsletten 1994; Riedlinger and Berkes, 2001; Nichols et al., 2004; Magga, 2006; Eira et al., 2010). Language plays a key role in structuring of knowledge and knowledge sharing (Berkes 2008). This knowledge is part of Sámi reindeer herders' way of life and it is a part of the individual herder's actions and decisions in relation to daily work with the reindeer herd. Snow is a prerequisite for mobility, tracking, visibility and availability of pasture plants such as lichens and grasses (Eira et al. 2010).

The terms used to describe the snow on the ground imply characteristics needed to communicate snow properties relevant to reindeer husbandry, reindeer ecology and related the economy of herding. In the characterization of the snow cover and snow type, there are five key factors for reindeer herding in winter season, 1) access to water, food, and space, 2) physical activity, shelter, and rest, 3) mobility for reindeer and herders, 4) visibility of tracks in the snow, and 5) visibility of animals and environment. (Eira et al., 2010). In this paper, we present an in-depth comparison of physical snow classification compared with traditional Sámi reindeer herders' snow terminology. This study provides a detailed analysis of some of the most important traditional Sámi terms, their definitions, and the physical processes involved in their definition. We propose that the complex winter ecology of Sámi reindeer husbandry only can be revealed by a multidisplinary study involving herders' specialized language and snow physics at the same time. Finally, we propose that the snow which covers the ground is a coupling tool used by herders to link reindeer and humans together in a system which highlights the importance of both systems of knowledge for the future sustainability of reindeer husbandry in a changing climate.

2. Study area

This study was carried out in Northern Norway, Guovdageaidnu/Kautokeino (69° N, 23° E), (figure 1), a region in which 45% of the Sámi reindeer pastoralists in Norway are living. Snow and winter grazing condition were studied at five different herders' stations (siida's[1]) in this region.

The mean monthly temperature and precipitation sums for the normal period 1961-1990 for Kautokeino are presented in Figure 2. The lowest monthly values for both temperature (-16 ºC) and precipitation (11 mm) are found during winter. Correspondingly, the highest monthly values are found during summer. In July the mean temperature is 12ºC and the mean precipitation sum is 68 mm. On an annual basis, and especially during winter, inland Finnmark is the coldest and driest area in the Nordic countries (Tveito et al., 1997, 2000). The snow cover is therefore rather shallow.

3. Methodology

Since this study of snow as a phenomenon has an interdisciplinary approach, the methodology has involved both social and physical sciences. Different methods were used to highlight snow, snow change and winter grazing conditions from different scientific angles and experiences. To obtain data on reindeer herders' daily use of snow concepts in connection with herding and to clarify the herders' knowledge of snow, we have developed a new methodology. The codification of herders' knowledge about snow and snow transformation, and the integration of herders' knowledge with scientific data were performed using techniques from semantic, pragmatic, linguistics appropriately modified and refined to the requirements of this study.

3.1 Semi-structured interviews about snow and herding

A literature review of Sámi snow terminology shows a new understanding as well as clarification of concepts, definitions and terms. Insights were established using semi-structured interviews (Kvale, 1998). The focus of the interviews was to obtain information about the central research questions regarding reindeer herders' knowledge of snow, snow structure and change in relation to reindeer herding. Based on the documentation of traditional reindeer herders' knowledge and interviews with older herders, it was possible to collect detailed descriptions of snow conditions, snow structure, and snow changes.

1 Siida is a reindeer working partnership, and also the central foundation of the traditional use of reindeer grazing areas. (Strøm Bull et al, 2001)

We conducted 38 interviews (17 women and 21 men) in Northern Sámi language with Sámi reindeer herders living in the Guovdageaidnu area. All interviews were recorded and then transcribed. The interviews provide 915 pages of transcripts in Sámi language related to snow and reindeer husbandry. Parts of the transcriptions were translated to English. For the interviews, we developed a semi structured interview guide with thematic points about different types of snow combined with other defined issues of relevance to reindeer husbandry. Word for word transcription of the reindeer herders' answers ensured us that we collected in-depth information and conducted sufficiently detailed analysis. Copies of the tape and the written transcriptions were sent to each interviewee for verification.

3.2 Linguistic analyzes

Concepts are vital to the efficient functioning of human cognition. They are organized bundles of stored knowledge which represent an articulation of events, entities and experiences in our expression (Cruse, 2004). Concepts serve to categorize experience and give access to knowledge concerning entities which fall into categories (Cruse, 2004). Conceptual analysis identifies the essential characteristics of a concept and examines the references to which this concept can be linked (Spri Report 481, 1999). Characteristics of the concept have substantial meaning when analyzing the definitions of concepts and the terminology of some fields. The method for defining concepts and terms in the field of snow physics vs. snow in reindeer herding is partly based on a terminological concept analysis, which is a method for analyzing concept systems and concept relations. The method was introduced by Anita Nuopponen (1994). Analysis of conceptual content involves a systematic determine of characteristics to examine whether and how it is possible to distinguish between the concepts and the relationships they have to other concepts. Therefore, definitions, as they relate to conceptual content are important (Nuopponen, 1994). Definitions, verbal descriptions of concepts, are needed so that communication can occur without misunderstandings. A definition specifies and defines the concept, sharpens the concept and its designation, and creates norms for the usage of the concept (Lauren et al., 1997).

3.3 Herding dairies from five siida's

Reindeer herders' knowledge about snow and their ability to monitor snow conditions on the ground was collected systematically with dairies in which each herder daily recorded the snow condition in the area the herd was grazing (Eira & Mathiesen, in prep). Through the dairies, it was analyzed how reindeer herders use the different snow concepts in their daily tasks. Every day for three years, reindeer herders in five herding stations (called siida's) in the region investigated and recorded

"traditional" snow characteristics of grazing conditions on specially-designed data log sheets containing GPS location, time/date of their daily observations and data on eleven weather parameters (e.g., wind, cloud cover, precipitation, temperatures). In addition, they recorded their use of traditional Sámi snow terms, traditional insights to the in physics of the snow, snow depth, type, description of snow conditions, and herd behavior. The dairies give a detailed impression of the winter snow conditions in five winter grazing areas in the Kautokeino region in 2007-2009. The winter season 2007/2008 was used as an example to illustrate the evolution and use of the traditional terms in comparison with weather parameters driving the physical processes causing the different snow conditions on the ground.

3.4 Physical measurements of snow conditions

In each siidas' winter gazing area air temperature was measured 1.5 meters above ground. Snow temperatures were monitored at ground level, 10 and 15 cm above ground (Figure 3) by use of Temperature Monitoring Solutions Thermochrons (DS1922L Thermochron). A Thermochron is a special iButton that is equipped with a self-contained temperature sensor, clock, and data logger enclosed in a watertight two-terminal stainless steel casing (Hubbart et al. 2005:1517). These small devices were set to take temperature recordings at 6 intervals daily throughout the snow season (thermodata 2010), (Maynard et al 2010). The data were downloaded at the end of the snow season and graphically displayed.

Snow and the snowpack properties were also documented by characterizing distinct layers of snow, and measuring snow depth, snow temperature, snow density, snow hardness, layer thickness, and grain shape. Additional observations of snow, snowpack, and weather conditions essential to assess grazing conditions for reindeer were made including information on the structure, water content, and hardness of the snowpack within reindeer winter grazing area.

3.5 Modeling the snowpack layers

To compare terminology used by snow scientists (Fierz et al, 2009) and Sámi traditional snow terms, we selected the winter season 2007/2008 as an example to illustrate the evolution of the snowpack. In snow science, physical snow models are extensively used to model various snow properties (Brun et al., 2008). For this purpose, we selected the SNOWPACK model (Bartelt and Lehning, 2002; Lehning et al., 2002), which is developed for avalanche warning services in Switzerland, to model the evolution of the snowpack in Kautokeino for the winter season 2007/2008. We used hourly meteorological observations of wind, snow depth, air temperature, ground surface temperature,

relative air humidity and cloudiness from the Kautokeino weather station to drive the SNOWPACK model. As radiation measurements were not observed at the station, we modeled the potential incoming radiation (Hock, 1999). Snow surface temperature was set equivalent to the 2 m air temperature measurements. As ground temperature also was missing, we applied an empirical ground surface model using snow depth and air temperature as input data (Schuler, 2011).

For every time step, the model simulates the layer stratigraphy of snow properties such as density, temperature, grain size and grain type. Results have been evaluated using direct snowpack observations made during the winter season 2007/2008 (Vikhamar-Schuler et al., 2011).

4. Results and analyses

This section describes firstly the reindeer herders' characterization of snow in the light of international snow classification systems. Secondly, we provide herders' traditional observation of grazing condition in winter related to temperature variations in the air and within the snowpack. Finally, we present the winter season 2007/2008 as an example to illustrate the evolution of the snow conditions and the use of the Sámi traditional snow terms.

4.1 Reindeer herders' characterization of snow compared in light of the international classification of snow.

We selected 18 snow terms which are especially important for the herding economy and for understanding reindeer pastoralism in winter and we described them according to both traditional and scientific classifications systems (Table 1). These concepts included understanding of wet and dry snow, snow and ice layers and rime snow. Some of the concepts did not have an equivalent in the snow classification system, such as *čiegar* and was regarded as genuine reindeer herders' knowledge. The findings illustrate the diversity and richness of the traditional Sámi reindeer herders snow vocabulary used in Kautokeino. Furthermore, some Sámi traditional snow terms were furthermore holistically defined by multidimensional content, with multiple elements of snow physics together with strategic factors that are relevant to the herding. The specificity of some of the Sámi snow concepts used by the herders was supported by the snow physical measurements (Table 1). We believe that some concepts such as *seaŋáš*, *vahca* and *geardni* can be directly compared and used in the standard physical snow classification (depth hoar, new snow, ice layer). During the snow season, different Sámi snow terms are used depending on weather, temperature and precipitation and their application to conditions in the snowpack (Table 1). Most of the traditional snow terms are used during specific periods of the winter and in defined layers of the snowpack and some terms are highly temperature dependent. The herders use the traditional snow concepts systematically according to season, snowpack stratification, and their relation to herding strategy (Figure 4). In addition, the

definitions of the most important Sámi snow terms in Sámi- and English languages parallel the current physical classifications of snow on the ground, including an analysis of the snow terms relation to mobility, tracking, visibility and availability of pasture plants through the snow are shown in Table 1.

We will describe four Sámi snow terms *vahca, seaŋáš, čearga and geardni* in detail to exemplify traditional snow characteristics in addition to snow physical characterization. The different concepts represented by each term are of special importance to the herders' economic well-being during the seasonal snow period. They represent characteristics that can either improve the snow conditions and thus avoid the loss of reindeer or deteriorate snow conditions, with significant danger of loss. By comparing physical snow properties with the linguistic analysis of the Sámi snow concept, a number of characteristics have been defined that affect both snow physical characteristics such as hardness, density, temperature gradient, grain shape, physical process, place of formation, liquid water content, layer thickness, snow water equivalent, snow depth as well as the characteristics that are important for reindeer herding such access to water, food, mobility and tracking (Table 2).

Firstly the term *vahca* is described by Sámi reindeer herders as fresh snow on the surface of the snowpack. A variant of *vahca* is *ođđa vahca* signifying that the snow has just fallen. *Vahca* may help soften the layer of already hard snow thus improving the grazing conditions for reindeer. During *vahca* snow conditions, it can be difficult for reindeer herders to walk in the snow, but it is easier to track reindeer that have disappeared from the main herd by following the tracks in the snow. Therefore, daily reading of animal tracks as they relate to the herd and individual animals' behavior is a basic task for the herder and is included in the herding strategy. Individual reindeer are often calm but feel free to walk in different directions under such conditions. Sámi reindeer herders use the term *vahca* throughout the snow season from *bievla* (bare ground) from the first day with snow on the ground to the last day of snow on the ground (Figure 4). The traditional term *vahca* can be related to snow characteristics found the International Classification for Seasonal Snow on the Ground (Fierz et al., 2009) to the category of precipitation particles (class PP). Precipitation particles are newly fallen snow crystals in their original form as they reach the ground. The form and size of the particles depends on the temperature and wind speed in the cloud environment where they are formed and on the conditions on the way down to the surface. The snow has usually a very low density, especially when deposited in cold and calm weather (density: 156 kg/m^3). *Vahca* snow conditions change immediately when the snow crystals reach the ground due to the onset of destructive snow metamorphism (Jaedicke 2001; Halfpenny, 1989).

Secondly the traditional snow term *seaŋáš*, was found to be one of the most important snow types for Sámi reindeer herders. *Seaŋáš* is granulated snow which forms at the bottom of the snowpack. Sámi reindeer herders describe the *seaŋáš*-process (seaŋkut) that is changing the snow consistency to *seaŋáš* when the winter has been cold. They characterize this as good snow conditions for the reindeer and improving the grazing conditions. When the herders know that the snowpack contains *seaŋáš*, then they know that it is easy for the reindeer to dig through *seaŋáš* to the pasture plant beneath. Sámi reindeer herders explain that *seaŋaš* is the type of snow that rapidly melts, thus it is also important because it represents clean water supply. *Seaŋáš* is located at the bottom of the snowpack, close to the ground. If there is little snow on the ground, there can be more *seaŋáš* and good reindeer pastures. In contrast to *vahca*, Sámi reindeer herders do not use *seaŋáš* in connection with the description of reindeer tracks. The concept of *seaŋáš* is used from January to April (figure 4) the traditional term *seaŋáš* can be related to snow characteristics in the international snow classification to depth hoar (class DH). *Seaŋáš* develops in shallow snowpack usually in the beginning of the season when the temperature gradient is > -10 °C/100 cm snow depth. It is a result of constructive metamorphism caused by the transport of water vapor from warmer to colder layers in the snowpack. The snow in depth hoar layers looses much of its strength and has usually low densities (density: 267 kg/m^3). The resulting crystals have distinct hollow or cup shaped form (Figure 5). In many circumstances depth hoar has the undesirable effect of causing avalanches or poor bearing capacity but for traditional reindeer herders, this type of snow is positive and important for the winter ecology.

Thirdly, the wind is an important modifier of snow crystals and the snowpack. It leads to development of *čearga* snow conditions. When strong cold winds transport the snow, snow particles are broken down in turbulent drift. These broken particles often form a strong and dense snowpack. *Čearga* can be so hard that neither reindeer nor people can dig through the snow. In areas with *čearga*, reindeer are "locked out" from grazing on the plants beneath the snow. This causes poor feeding conditions for the reindeer. The thickness of a čearga layer can be from 5 cm to one meter deep. *Čearga* conditions affect the mobility of both reindeer and humans as it is easy to travel on this type of snow. Consequently the herders have to be very careful not to lose individual reindeer to neighboring herds. However, in terms of tracking capabilities, *čearga* is unfavorable. It is difficult to see where individual reindeer have been walking. *Čearga* is at the top of the snowpack, but may include as much as half the snowpack when grazing conditions are poor. The term *čearga* is used in winter, from January to April. The traditional term *čearga* can be related to snow characteristics in the International Snow Classification to wind-packed rounded grains (class RGwp). The particles are small, broken and closely-packed. Wind action at the snow surface leads to the destruction of precipitation crystals and small broken particles. After deposition the process of sintering (molecular growth of bonds between single snow crystals) leads to a hard and dense snow layer (density 250-450 kg/m^3). The hardness

increases with wind speed, decreasing particle size and moderately cold temperatures (which promotes the sintering process). *Čearga* evolves into either a hard but usually breakable wind crust or a thicker wind slab.

Finally, *geardni* is a layer of ice which can be from millimeters to several centimeters thick and it is the result of refrozen wet snow after a period of mild weather and/or rain on snow (ROS). *Geardni* is not so hard that reindeer can't break it, but geardni can sometimes contribute to poor grazing conditions. When the geardni layer is buried in the snowpack by new snow precipitation on the top, it turns into *gaskageardni*. During the winter several such layers can develop in the snowpack. If the ice layers within the snowpack are not weakened, but remain hard it may make it difficult for the reindeer to dig through the ice layer. This can lead to poor grazing conditions with fatal consequences for individual reindeer and the herd. *Gaskageardni* conditions will improve under the right conditions by an acceleration of the *seakŋun*-process underneath the ice layer (development of faceted crystals). The term *geardni* is used in fall - winter and gaskageardni is used also as a winter term (Figure 4). While ROS (*geardni* production) in Kautokeino occurs early in midwinter, the term is used all the winter through. The traditional term *geardni* and *gaskageardni* can be related to snow characteristics in the International Classification to describe a melt-freeze crust (class MFcr) or rain crust (class IFrc). These two classes are often difficult to distinguish from each other and have some of the same properties. *Geardni* is a thin, transparent glaze or clear film of ice, which is located at the surface (IFrc). If this layer is porous and not polished ice, it can also belong to the Melt Forms (MFcr). For both types, wet snow at the surface (either by melting of because of rainfall) refreezes when temperatures fall again below zero after the melting event. *Geardni* can be from millimeters to centimeters thick and the strength depends on the porosity of the layer. Densities of 704 kg/m^3 have been observed in *geardni* in the study area. Both types of ice layers, geardni and gaskageardni, can occur directly on the soil surface or in the ground covering vegetation. This often happens in the beginning of the winter when the first snow is followed by an intense period of mild weather and immediate refreezing. This ice layer at the bottom of the snowpack is called *bodneskárta* (Table 1). Once *bodneskárta* develops in the snowpack it can be a persistent layer through the whole winter until spring melt. Such events have dramatic impacts on grazing conditions for reindeer. In October 1967 a weather event similar to this created geardni conditions with fatal results for the reindeer herds as well as the economy of Sámi herding in the Kautokeino herding region.

4.2 Herders' observations of snow related to variation of temperature in the air and within the snowpack.

Their observations (herding station 4) of snow and grazing conditions were compared to air and ground temperatures in the snowpack from 19 January to 31 March 2008 to demonstrate how some of

the traditional snow terms are used in practical reindeer herding. Data from snow temperature measurements (Figure 6) show that the temperature at the bottom of the snowpack in the winter grazing area was stable throughout the study period in winter 2008, with a slight variation between -2 ^{o}C and -4 ^{o}C. Air temperatures at the same station varied during the winter, from 0 ^{o}C to -32 ^{o}C at same station. Reindeer herders' daily observations of the snowpack condition during this period show that cold days with low temperatures produced a snowpack that contains *seaŋáš*. The *seaŋáš* conditions continued until air temperatures increased above 0 ^{o}C. From the middle of February the snowpack structure changed and reindeer herders observed a hard layer of snow, or *čearga* conditions, after the wind had packed the snow hard. According to the data collected, this hard snow layer did not have a significant impact on the availability of pasture plants underneath the snow to the herd investigated in this study. Reindeer herders characterized the snow conditions with regard to its *guohtun,* the availability of winter pastures for their reindeer herds through the snow. They noted that snow conditions at this station was generally good, varying from very good some days to quite good on other days (Figure 6). Data from the herders' journals were used to document the traditional snow terms that were applied by the herders' dairies this specific study period. According to the herding journal f, the conditions creating the *geardni and gaskageardni* snow types in winter 2008 were rain and frost on December 14th and 15th, 2007, (Figure 6).

4.3 Modeling the snowpack layers for the winter 2007/2008

We compared the terminology used by snow scientists (Fierz et al, 2009) with Sámi traditional snow terms by using the winter season 2007/2008 as an example to visualize the typical evolution of a snowpack in Kautokeino. For this purpose, we applied the multi-layer snow model SNOWPACK. Results for this winter season, including individual snow layers and grain types, are shown in Figure 7. The classification of grain types follows the International Classification for Seasonal Snow on the Ground (Fierz et al, 2009).

We describe this winter snowpack with examples from three events/periods: 1) A rain-on-snow event (15th Dec. 2007); 2) the mid-winter snowpack (9 March 2008) and 3) the snowmelt period (10 May 2008). A mild weather event occurred from 14-19 December 2007 with temperatures up to +6.5 ºC, including minor rain on a 25 cm snow cover. The snowpack became isothermal and its density increased. The period was followed by low temperatures, leading to refrozen snow grains and a thin ice layer on the snow surface (*geardni* in Figure 7). This layer was subsequently buried by several snowfalls (gaskageardni) and maintained throughout winter into spring. Still, this winter, it was not a problem for reindeer herders since the layer was rather soft and only 1 cm thick.

A profile of a typical mid-winter snowpack is shown in Figure 7 (9 March 2008). High temperature gradients due to low air temperatures and shallow snow cover created depth hoar crystals in the bottom layer (*seaŋáš*) and the refrozen snow layer was still present above (gaskageardni). Over these layers, wind-transported snow with small rounded grains accumulated into a hard and compact snow layer (*čearga*). New precipitation particles (wind broken or partly decomposed) which were on the very top snow surface correspond to the Sámi term *vahca*.

A typical profile of an isothermal wet snowpack during the spring melt period is shown in Figure 7 with clustered snow grains. This layer corresponds to the Sámi term *sievlla*. Melt-freeze crystals often occur on a top layer during periods with freezing night temperatures. Usually at this time of the year, the reindeer herd has subsequently migrated to the summer pasture at the coast.

5. Discussion and conclusions

5.1 Monitoring, measuring and understanding snow

The main premises for understanding a complex system, such as the reindeer-human-snow interaction, is that key elements of human thinking are not numbers, but labels of fuzzy sets (Zadeh, 1973; Berkes, et al., 2009). The starting point of fuzzy logic was introduced as a mathematical approach for dealing with complex systems in which only approximate information on components and connections are available (Zadeh, 1973). Originally it is a classification method in statistics, a way to deal with uncertainty. According Berkes (2008) Fuzzy logic appears to be a good fit with indigenous knowledge, and an approach that may help understand, or provide insights, on the question of how local and indigenous knowledge systems may be dealing with complexity. Fuzzy logic provides the tools to classify information into broad categorizations or groupings, simulating the workings of the human mind. One of three main distinguishing features of fuzzy logic is the use of linguistic variables in place of numerical variables (Berkes 2008). We can use fuzzy logic to better understand reindeer herders' ways of dealing with complexity as it relates to snow and reindeer herding as well as their risk analyses related to the welfare of their own herd. The data from herders' monitoring are language-based, rather than number-based, and comparisons are performed on perceived rankings (e.g., snow characterized as hard, soft, and/or thin; snow depth in relation to reindeer body length). These snow characterizations and their daily application are strongly dependant on the terminology use. Although Sámi snow concepts contain many physical elements with numerical variables, we emphasized the use of linguistic variables and fuzzy logic in measuring snow, like *'assas geardni'* (thick ice layer created after rain on snow instead of 5 cm geardni).

The observations and monitoring provided by herders are significant to reveal a picture of how the snow conditions are described and characterized in reindeer herding. The mental processes of "data

collection" and mental model formation among indigenous people follow patterns consistent with the language used because language shapes its terms and concepts (Berkes et al., 2009). Herding dairies used in this investigation are a community-based monitoring system (Eira & Mathiesen, in preparation), which is based on ideas from people who observe the environment in detail (Berkes, 2008), while at the same time they are monitoring multiple, complex variables in their herding over time. For example, The SNOWPACK simulation model was used to investigate *guohtun* condition (availability of pasture plants through the snow) in the Kautokeino reindeer herding area from October to April (Figure 7), showing time series of snow properties throughout the snow season. The snowpack simulation model gives detailed insights about the everyday condition of the snowpack (figure 7), but the reindeer herders tend to consider the whole winter season and how the snow and weather conditions might influence their future economy and the condition of the herd.

The richness and relevance to reindeer herders of Sámi traditional snow terms shows a distinctly different view of snow compared to the purely physically-based international classifications. Herders characterize snow cover, temperature, moisture, wind behavior of the herd, and condition of the animals. Both traditional holistic knowledge and herders' snow physical observations play a key role in the management of the herd. In some ways, they herders are using "reindeer herders' rules of thumb" for implementing herding (Berkes et al., 2009), without the details about snow grains the snowpack models provide (figure 7). Herders' rules of thumb regarding herding and snow change are: 1) checking the hardness of the snow and looking at the snow profile and 2) looking at snow conditions at the leading edge of the herd. Characterizations in the form of rules of thumb have the advantage of turning complex decisions into rules that can be remembered easily and enforced locally through social means (Berkes et al., 2009).

5.2 Two ways of knowing about snow condition from the perspective of Sámi reindeer herding.

A detailed analysis of some of the most important traditional Sámi snow concepts, their definitions, and the physical processes involved in their definition shows that the content of Sámi snow concept has both similarities with and differences from snow physics. Comparison of traditional knowledge with scientific observations shows that many traditional concepts can describe snow conditions in the way they are defined in the international standards, whereas, other traditional terms describe the physical processes leading up to certain snow conditions, but from a different perspective. Both identify snow phenomena, their description and the definition of terms, but within the scientific community the aim is the creation and maintenance of a common language for all level of users in all countries (Fierz et al., 2009). Both knowledge systems have many terms for snow depending on its texture, temperature, humidity, depth, density, grain, consistency and surface wind patterns. However,

there are also differences in regarding snow characteristics, measures of snow, and the naming of concepts. The analysis underscores the richness and accuracy of traditional snow terminology which includes the physical understanding of the seasonal snow on the ground.

The concepts that snow scientists use are based on measurable and quantitative characteristics and less colored by the context. Also, traditional snow concepts often have objective characteristics as a core, but they also contain information and associations to practical matters such as grazing conditions, weather and movement opportunities for the reindeer and the future welfare of the herd. This indicates that the reindeer herders' knowledge of snow also applies to the physical aspects of snow, as well as the ecology of herding. As an example of two ways of knowing reindeer herders' perceptions of the concept of snow interface with snow physics, contrasts with how snow scientists conducts snow research and how these data are presented (Table 2, Fierz et al., 2009). On the other hand, herders' knowledge about snow belongs to a specialized vocabulary that is used in internal communications about factors affecting reindeer herding such as moving the herd, topography, or climate impacts, which are all part of the complexity of this ecosystem. For herders, these two perspectives usually exist side by side as part of a holistic view, no matter which term is being used. This demonstrates how herders' snow knowledge is holistic and integrated into the ecology of the herd and pastures used. The knowledge and adaptation of the reindeer herders, reflected in their herding strategies and their herding language linked with climate, the environment and reindeer enable them to perceive important changes in the snow and climate as they have done for thousands of years (Federova 2003) to survive in the harsh and changeable weather conditions of the North.

Indigenous knowledge and western science are ultimately based on observations of the environment, both provide a way of knowing based on these observations and both emerge from the same intellectual process of creating order out of disorder (Berkes & Berkes, 2009). Indigenous knowledge traditions have their own rules about the processes of knowing, and these tend to be different from the rules of science regarding evidence, repeatability and quantification. There has been a considerable amount of environmental research which has included perspectives of indigenous people (Berkes et al., 2009) but, from a one-sided point of view. The western scientific research and observations has long been the only accepted path of knowledge and they have created standards for how research should be conducted. In some research groups (Roturier & Roué, 2009), one can see that a change in this has occurred because knowledge from "user groups" like reindeer herders is being included in their data collection and presentation of results. Information-sharing can contribute new information, enhance existing knowledge, contribute new insights to complement scientific research and provide broader universe for research on the impacts of climate change. Traditional knowledge and ways of managing natural resources can also provide valid information for sustainable development. "Traditional systems of management have been the main means by which societies have managed natural resources for millennia." (Berkes & Folke, 1998). According to Nichols (et al. 2004) one

drawback of using traditional knowledge alongside western science has been the challenge of translating technical terms and concepts translation is often inadequate or misleading because translators or interpreters rarely know both of these specialized terminologies. Thus, a face-to-face discussion between local and scientific experts about snow characteristics is fraught with opportunities for mistranslation. According to Riseth et al (2010), a challenge for scientist as outsiders is to interpret the meaning of reality as indigenous group perceive it. According to Roturier & Roué (2009) who studied Sámi reindeer herders' knowledge of winter pastures in northern Sweden, the Sámi snow concepts are used in their presentation of results and discussion related to the effects of modern Swedish forest indutries impact on reindeer husbandry. This shows that non Sámi scientists have emphasized the reindeer herders' knowledge about snow and reindeer as important for the understanding of conflicts between herders and modern forestry. Sharing of information between two systems of knowledge can be mutually beneficial. Future projected increase in winter temperature in Kautokeino reindeer herding region (average increase 8 degrees C and 1 month less snow cover next 100 years) (Hanssen-Bauer et al, in prep.) firmly calls for all kinds of knowledge to be taken into account. Hence, in management of Sámi reindeer husbandry, it is important to introduce systems that guarantee the participation of the other type of knowledge than western science. Therefore a future sustainable Sámi reindeer husbandry requires different ways of knowing included. We conclude that adaptation to climate change in Sámi reindeer husbandry must include two ways of thinking, which combines both indigenous reindeer herders' experienced-based traditional knowledge and snow scientist data and knowledge about snow and snow change.

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[2]*EALÁT* is an interdisciplinary, intercultural study that will assess the vulnerability of reindeer herding, a coupled human-ecological system, to change in key aspects of the natural and human environments, actively involving reindeer herders, linguists, lawyers, anthropologists, biologists, geographers, economists, philosophers (to address the ethical dimension) as well as indigenous institutions and organizations, commercial interests and management authorities.

Ethics.

This research was carried out according to the ethics guidelines of Sámi University College, Kautokeino, Norway, the International Centre for Reindeer husbandry and the Norwegian committee for ethical guidelines in natural science and technology (NENT) (www.nent.org), especially, in any instances where reindeer herders were involved. All participation in the study by individuals who contributed traditional knowledge (e.g., *siida* members, reindeer herders) has been anonymous in accordance with the wish of the herders themselves.

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Árbevirolaš sámi muohtaterminologiija ja muohttaga fysihkalaš ieŠvuođaid čilgen - guokte diehtovuogi

Inger Marie Gaup Eira[a], Christian Jaedicke[b], Ole Henrik Magga[a], Nancy Maynard[d], Dagrun Vikhamar-Schuler[f], Svein D. Mathiesen [c,e]

[a] Sámi allaskuvla, Hánnoluohkká 45, 9520 Guovdageaidnu, Norga,
[b] Norgga Geoteknihkalaš Instituhtta, Oslo, Norga
c Norgga veterinearadieđaskuvla, Sjøgt 39, 9000 Tromsø, Norga
d, NASA Goddard Space Flight Center, Greenbelt, MD , USA
f, Norgga Meteorologlaš Instituhtta, Blindern Oslo, Norga
e, Riikkaidgaskasaš boazodoalloguovddáš, 9520 Guovdageaidnu, Norga
Gulahalli čálli: ingermge@samiskhs.no , telf.: +47 95206794

Oktiigeassu

Olbmot čilgejit luonddu birrasa iežaset báikkálaš vásáhusaid vuođul ja iežaset ovttasdoaibmamiid vuođul luondduin dađi mielde go dat leat guoskan sin beaivválaš eallimii. Dákkár čilgehusat leat sajáiduvvan oassin báikkálaš gielaide mihtilmas terminologiija hámis mii lea earenoamážit heivehuvvon báikkálaš dárbbuide ja bargovugiide. Norgga davimus osiin, namalassii Guovdageainnu birrasiin, mii lea sámi boazodoalu guovddášguovlu, gokčá muohta eatnama eanet go čieža mánu jagis. Dan dihte muohta mearrida eanas diliid maid rájiid siste boazodoallu ferte birget doppe nu go muđuige miehtá Eurásia. Muohta mearrida johtaleami, vuohttima, oaidnima ja guohtundiliid, namalassii movt boazu beassá muohttaga čađa jeahkálii ja eará šattuide. Sániin mat adnojit muohttaga čilgemii, leat dovdomearkkat maid dárbbaša go galgá kommuniseret muohttaga ieŠvuođaid birra mat mearridit boazodoalu dili dán guovllus. Dán čilgehusas mii buohtastahttit árbevirolaš sámi muohtadoahpagiid ja daid definišuvnnaid ođđaseamos dieđalaš ja fysihkalaš muohtaklassifiseremiiguin. Sámi árbevirolaš muohtadoahpagiid suokkardeapmi lea dahkkon ovdalaččas čohkkejuvvon dieđuid vuođul ja boazovázziid jearahallamiid vuođul. Bohtosat čájehit ahte moanat árbevirolaš doahpagat čilgejit muohtadiliid seamma láhkai go riikkaidgaskasaš čilgenvuogit. Muhto muhtun muohtadoahpagiid vuođđun leat proseassat mat ráhkadit dihto muohtadiliid. Muhtun doahpagiid ulbmil lea fas doaibmat gaskaoapmin nu ahte sáhttá čielgasit gulahallat ealáhusa siskkobealde. Okta váldofuomášupmi lei ahte boazovázziid muohtamáhttu lea ollislaččat go riikkaidgaskasaš klassifiserenvuogit ja eanet huksejuvvon ealu ekologalaš vuođu ja guohtuneatnamiid ekologiija ala. Sámi árbevirolaš muohtadoahpagiid valljugasvuohta ja anolašvuohta boazobarggus duođašta ipmárdusa mii lea oalle earalágán go dakkár klassifiseren man vuođđun leat dušše fal muohttaga fysihkalaš ieŠvuođat. Dás čilget dehálaččamus árbevirolaš doahpagiid, daid definišuvnnaid ja fysihkalaš proseassaid mat leat daid vuođđun. 2007/2008-dálvi lea geavahuvvon ovdamearkan das movt muohtadilli rievdá ja movt muohtadoahpagat geavahuvvojit. Doahpagiid čilgehusaid mii leat buohtastahttán báikkálaš dálkediliiguin ja fysihkalaš proseassaiguin mat dan dálvvi duddjojedje máŋggalágán muohtadiliid eatnama alde. Analiisa deattuha árbevirolaš sámegiela muohtadoahpagiid valljodaga ja dárkilvuođa, mas lea maiddái mielde jagiáiggi fysihkalaš ipmárdus muohttaga birra eatnamis. Lassin čájeha dát suokkardeapmi man dehálaš lea geavahit sámi terminologiija go sámi boazodoalu várás hálddahusdásis hutká heivehanstrategiijaid dálkkádatrievdamiidda, ja dat deattuha man dárbbašlaš dása lea geavahit guokte máhttovuogi, namalassii dieđalaš máhtu ja árbevirolaš máhtu.

Čoavddassánit: muohta, sámegiela muohtadoahpagat, seaŋáš, boazodoallu.

1. Álggahus

Muohtadutkan lea fágaidrasttideaddji dutkanvuohki (Fierz *et al*., 2009) ja muohtadutkan ja dálkkádatdutkan leat dutkamat mat rivdet ja ovdánit jođánit (Armstrong, 2008). Muohtadutkit govvidit muohttaga golmma iešvuođa vuođul: muohttaga gassodaga, muohttaga daškatvuođa ja muohttaga čáhcesisdoalu vuođul. Riikkaidgaskasaš jagiáiggiid muohttaga klassifiserenvuogádat (The International Classification for Seasonal Snow on the ground, (ICSSG) čájeha ja čilge muohttaga deháleamos iešvuođaid nu go daškatvuođa, garasvuođa ja muohtačalmmiid hámi ja sturrodaga. Leat ráhkaduvvon definišuvnnat ja gaskaoamit maiguin sáhttá čilget muohttaga gerddiid ja muohttaga geardehámádaga (Fierz *et al*., 2009). Muohtadutkama ja muohtauđasdutkama fysihkka, hydrologiija ja meterologiija lea nannosit sajáiduvvan dutkansuorgi várra dainna go das lea alla servodatárvu, ekonomalaš árvu ja kultuvrralaš mearkkašupmi davviguovlluide. Eamiálbmogiid máhttu muohttaga ja muohtarievdamiid birra gal fas ii leat fávdnádit dokumenterejuvvon ii ge ipmirduvvon, muhto sámi muohtaterminologiija birra gal leat muhtun dutkamat almmuhuvvon (Nielsen, 1979; Ruong, 1964; Svonni, 1981; Eira 1994; Jernsletten, 1994; Magga, 2006; Ryd, 2007).

Olbmot čilgejit luonddu birrasa iežaset báikkálaš vásáhusaid vuođul ja iežaset ovttasdoaibmamiid vuođul luondduin dađi mielde go dat leat guoskan sin beaivválaš eallimii. Dakkár čilgehusat leat cieggan oassin árbevirolaš báikkálaš gielaide ja dávjá leat oassin giela terminologiijas mii muhtomin lea hui earánoamáš ja heivehuvvon báikkálaš dárbbuide ja bargguide. Sámi boazovázzit geavahit iežaset giela seamma láhkái go galget čilget luonddu ja movt sii hálddašit iežaset earenoamáš máhtu iešguđetlágán luonddufenomenaid ektui, masa maiddái gullet muohta ja dálvemáilbmi (Eira *et al*., 2010; Riseth *et al*., 2010). Muohta- ja jiekŋaguovllut davvin leat bohcco ekologalaš ceavzinsajit. Bohcco ekologalaš ceavzinsajit leat jura davvimáilmmi muohta- ja jiekŋaguovllut.

Sámi boazodoallu doaimmahuvvo Norggas, Ruotas, Suomas ja Ruoššas, ja dat dahká sullii goalmmádasoasi máilmmi boazodoalus ja árbevirolaš boazobargguin (Jernsletten ja Klokov, 2002).

Sámi boazodoalu guovddášguovlu lea Norgga davágeahčen, namalassii Guovdageainnu birrasiin (69N, 23E). Dán guovllu árbevirolaš boazodoalus leat sullii 1700 olbmo ja 93 500 bohcco (Boazodoallohálddahus, 2010) mat johtalit čakča-, dálve- , giđđa- ja geasseorohagaid gaskka jagi áiggiid mielde. Guovlu lea okta stuorimus boazodoalloguovlluin máilmmis (Magga *et al*., 2011). Birrasiid 90% Guovdageainnu olbmuin lea sámegiella eatnigiellan ja guovlu lea dan dihte earenoamáš dehálaš vuođđun sámi kultuvrra ceavzimii Norggas (www.Kautokeino.kommune.no). Dát earenoamáš luonddubiras lea sihke vuođđun ja duogážin boazodoalu geavatlaš ovdáneapmái ja maiddái dehálaš oassin báikkálaš kultuvrra ceavzimis. Boazodoalu ekonomiijas lea stuora árvu olles sámi servodahkii.

Guovdageainnus gokčá muohta eatnama eanet go 7 mánu jagis ja dan dihte váikkuha hui fámolaččat boazodoalloservodahkii ja mearrida eanas diliid main olmmoš ferte birget jus olles servodat galggaš ceavzit. Sámi boazodoallu lea kompleaksa ekologalaš vuogádat mii lea olbmuin sparrolaga (Magga *et al.*, 2011) ja mas boazovázzit, bohccot ja guohtuneatnamat čađat váikkuhit nuppiidasaset. (Liu *et al*., 2007) čilgehusa mielde lea dákkáraš sparrovuogádaga dovdomearka ahte olmmoš ja luondu doibmet ovttas. Dákkáraš kompleaksa ekologalaš vuogádagat eai leat bures ipmirduvvon (Berkes *et al*., 2003). Árbevirolaš juohku luonddudiehtagiid ja sosiála diehtagiid gaskka lea sivvan dasa ahte váilu ipmárdus das man dehálaš muohta lea dákkár kompleaksa vuogádagas. Earenoamážit lea boazovázziide leamaš áibbas dárbbašlaš ipmirdit muohttaga, borgga ja arvvi ja jiekŋuma iežaset guovlluin jus galggažit birgehit iežaset ja ealuideaset (Maynard *et al*., 2010). Diehtu muohttaga ja muohtadiliid birra lea čohkkejuvvon ja lassánan danne go olbmot leat duháhiid jagiid ferten birget earenoamáš hástaleaddji ja čađat rievddadeaddji dálkkádatdiliin. Dálá boazodoalus leat máŋga dehálaš oasi duháhiid jagiid boarrásat (Federova, 2003). Sámi kultuvrras leat mearkkat das ahte kultuvrras leat leamaš guhkes áiggiid čađa lagas oktavuođat davviguovlluid birrasiin, ja sámegielas lea rikkis terminologiija muohttaga ja jieŋa birra, mas leat čilgehusat muohtašlájaid, temperatuvrra birra, biekka, muohtadaškodaga, muohtagassodaga, muohtagerddiid ja fysihkalaš muohtarievdamiid birra eatnama alde. (Ruong, 1964; Svonni, 1984; Jernsletten 1994; Riedlinger and Berkes, 2001; Nichols *et al*., 2004; Magga, 2006; Eira *et al*., 2010). Gielas lea dehálaš doaibma struktureret dieđu ja máhttolonohallama (Berkes 2008). Dát máhttu lea oassin sámi boazovázziid eallinvuogis ja das movt ovttaskas boazovázzi doaibmá ja maid mearrida beaivválaš guođoheamis. Muohta mearrida movt lihkadeapmi, vuohttin ja oaidnin lihkostuvvá ja bohcco guohtunvejolašvuođa (Eira *et al*. 2010).

Sánit mat adnojuvvojit go galgá čilget muohttaga, sisttisdollet dieđuid maid dárbbaša go nubbi galgá nubbái muitalit muohttaga ješvuođaid maid dárbbaša diehtit boazodoalu birra, namalassii bohcco ekologiija ja guođohanekonomiija birra. Go galgá čilget muohtagokčasa ja muohtašlájaid, de leat vihtta eavttu maid dálvet ferte atnit vuođđun, namalassii ahte 1) bohccui lea biebmu, lávttas ja sadji, 2) bohccos lea lihkadanvejolašvuohta, suodji ja vuoiŋŋastanvejolašvuohta 3) sihke boazu ja guođoheaddji goastaba lihkadit, 4) vuohttinvejolašvuohta ja 5) ahte sihke olmmoš ja boazu oaidniba duovdagiid. (Eira *et al*., 2010). Dán čállagis mii buohtastahttit fysihkalaš muohtaklassifiserema árbevirolaš sámi boazodoalloterminologiijain. Dás leat dárkilis čilgehusat muhtun dehálaš sámi doahpagiin, daid definišuvnnain ja fysihkalaš proseassain, mat leat daid definišuvnnaid vuođđun. Mii árvalit ahte sámi boazodoalu kompleaksa dálveekologiija sáhttá ipmirduvvot fágaidrasttideaddji suokkardemiin mas oktanaga adnojuvvo boazovázziid earenoamáš giella ja muohtafysihkka. Ja loahpas mii árvalit ahte muohta eatnama alde lea dat mainna boazovázzi čatná bohcco ja olbmo oktii vuogádahkan, mas deattuhuvvojit goappašat máhttovuogádagat mat dárbbašuvvojit jos boazodoallu galgá ceavzit boahtte áiggi rievddadeaddji dálkkádagaid čađa.

Dutkanguovlu

Dát dutkan lea dahkkon Davvi-Norggas, Guovdageainnus (69° N, 23° E), (govus 1), guovllus gos 45% buot Norgga boazosápmelaččain orrot. Muohta ja dálveguohtundilit suokkarduvvojedje viđa dálvesiiddas dán guovllus. Gaskamearálaš mánnotemperatuvra ja arve- ja muohtamihtideamit 1961-1990 áigodagas, mii leai oalle dábálaš dálkkádaga hárrái, oidnojit govvosis nr. 2. Temperatuvra- ja arve-/muohta-mihtidemiid vuolimus (galbmaseamos) mánnosaš mihtideamit (-16 ^{oC} ja 11 mm) ledje dálvet. Vástideaddji alimus (lieggaseamos) mánnosaš mihtidanlogut ledje geasset. Suoidnemánus lei gaskamearretemperatuvra 12 ^{o}C ja gaskamearálaš arve-/muohtamihtideapmi lei 68 mm. Olles jagi ektui ja earenoamážit dálvet lea Finnmárkku siseanan galbmaseamos ja Davviriikkaid goikáseamos guovlu (Tveito *et al*., 1997, 2000). Dát mearkkaša ahte dáin duovdagiin lea muohta seaggi.

3. Metoda

Go dát suokkardeapmi lea čađahuvvon fágaidrasttideaddji lahkonemiin, de leat adnon sihke gielladutkama ja luonddudiehtaga dutkanvuogit. Iešguđetlágán vuogit adnojuvvojedje suokkardit dárkileappot muohttaga, muohtarievdama ja dálveguohtundilálašvuođaid iešguđet dieđalaš ipmárdusvuogi mielde ja vásáhusaid vuođul. Mii leat hutkan ođđa metodologiija dasa movt sáhttá čohkket dieđuid boazovázziid beaivválaš doabageavaheamis guođohettiin ja čilget sin máhtu muohttaga birra.

Boazovázziid máhtu kodifiseremii muohttaga ja muohtarievdamiid birra ja boazovázziid máhtu ovttastahttimii dieđalaš dátaiguin leat geavahan vugiid sihke semantihkalaš ja pragmatihkalaš lingvistihkas, heivehuvvon ja muddejuvvon dán suokkardeami dárbbuid mielde.

3.1. Semi-struktuvrralaš jearahallamat muohttaga ja guođoheami birra

Sámegiela muohtaterminologiija girjjálašvuođa guorahallan lea duddjon ođđa ipmárdusa ja dahkan čielgaseabbon doahpagiid, definišuvnnaid ja tearpmaid. Dieđuid čoaggin dahkkui semi-struktuvrralaš jearahallamiiguin (Kvale, 1998). Jearahallamiid váldoulbmil lei čohkket dieđuid suokkardeami guovddáš dutkangažaldagaid birra, namalassii boazovázziid máhtu muohttaga, muohtastruktuvrra ja muohttaga rievdama birra mat adnojit boazodoalus. Árbevirolaš boazodoallomáhtu dokumentašuvnna vuođul ja vuorrasit boazovázziid jearahallamiid vuođul lei vejolaš čohkket dárkilis čilgehusaid muohtadiliid, muohtastruktuvrra ja muohtarievdamiid birra.

Mii jearahalaimet 34 olbmo (16 nissonolbmo ja 18 dievdoolbmo) davvisámegillii, geat ásset Guovdageainnus. Jearahallamat báddejuvvojedje ja transkriberejuvvojedje. Jearahallamat sámegillii muohttaga ja boazodoalu birra devdet 915 siiddu. Oasit transkripšuvnnain leat jorgaluvvon eaŋgalasgillii. Jearahallamiid vuođđun ráhkadeimmet semi-struktuvrralaš jearahallanskovi mas ledje

temáid mielde jearaldagat iešguđet muohtašlájaid birra ja mat jerrojuvvojedje searválaga eará gažaldagaiguin boazodoalu birra. Boazovázziid vástádusat, mat leat transkriberejuvvon sánis sátnái, sihkkaraste dárkilis dieđuid ja dahke dárkilis analiissa vejolažžan. Jietnabáddekopiijat juohke jearahallamis ja čállojuvvon transkripšuvnnat sáddejuvvojedje juohkehažžii gii lei jearahallon nu ahte sáhtte dárkkistit ja duođaštit iežaset dieđuid.

3.2 Gielalaš analiisa

Doahpagat leat olbmuid gulahallama vuođđun. Doahpagat leat organiserejuvvon diehtogihput mat ovddastit artikulerejuvvon dáhpáhusaid, ráddjejuvvon dieđuid eaŋkil áššiid ja vásáhusaid birra (Cruse, 2004). Doahpagat dahket vejolažžan kategoriseret vásáhusaid ja dahkat vejolažžan fáhtet dieđuid maid sáhttá juohkit kategoriijan (Cruse, 2004). Doabaanaliisa čilge doahpaga guovddážeamos dovdomearkkaid ja guorahallá referánssaid maid doaba fátmmasta (Spri Report 481, 1999). Doahpaga guovddážeamos dovdomearkkat leat earenoamáš anolaččat go galgá čilget definišuvnnaid ja muhtun fágasuorggi ollislaš terminologiija. Metoda mainna leat defineren muohtafysihka doahpagiid ja boazodoalu muohtadoahpagiid, sisttisdoallá muhtun muddui terminologiija analiissa, mii lea metoda analyseret doabavuogádaga ja doabarelašuvnnaid. Dán vuogi lea álggahan Anita Nuopponen (1994). Doahpagiid sisdoalu analiisa sisttisdoallá systemáhtalaš guorahallan dan birra sáhttá go ja movt sáhttá earuhit doahpagiid nuppi nuppis ja makkárat leat daid gaskasaš relašuvnnat. Dan dihte leat definišuvnnat mat čilgejit doahpagiid sisdoalu hui dehálaččat (Nuopponen 1994). Definišuvnnaide, namalassii čilget sániiguin doahpagiid sisdoalu, lea dárbu jus gulahallan galgá sáhttit doaibmat nu ahte eai čuožžil boasttuipmárdusat. Definišuvdna spesifisere ja definere doahpaga, bastilmahttá doahpaga ja dan namahusa ja ásaha norpmaid maid mielde doaba geavahuvvo (Lauren *et al*., 1997).

3.3 Viđa siidda guođohanbeaivegirjjit

Boazovázziid máhttu muohttaga birra ja sin dáiddut gozihit muohtadiliid eatnama alde čohkkejuvvojedje systemáhtalaččat beaivegirjjiide masa boazovázzit beaivválaččat registrerejedje muohtadiliid dan guovllus gos eallu lei. (Eira & Mathiesen, giehtačálus). Beaivegirjjiid vuođul analyseriimet movt boazovázzit geavahit muohtadoahpagiid iežaset beaivválaš barggus. Juohke beaivvi golbma jagi boazovázzit viđa stašuvnnas (mat leat siiddat) dán guovllus leat guorahallan ja čállán árbevirolaš muohtačilgehusaid earenoamážit ráhkaduvvon dátaloggii, masa maiddái leat merken GPS-báikki, beaivválaš áicamiid áiggi/dáhtona ja oktanuppelohkái dálkepáramehtera (dieđuid nugo, biekka, áimmu, muohttaga/arvvi, temperatuvrraid birra). Dása lassin sii čálle movt sii govvidedje dili árbevirolaš muohtadoahpagiiguin, movt árbevirolaččat govvidedje muohtafysihka, man gassat muohta lei, muohtašlája, muohtadiliid karakteriserema ja ealu láhttema. Beaivegirjjit addet dárkilis gova das makkár muohtadilli lea leamaš dien dálvvi viđa dálveguohtoneatnamis Guovdageainnus 2007-2009.

2007/2008-dálvi geavahuvvui ovdamearkan čájehan várás árbevirolaš doahpagiid geavaheami ovttas dálkeparamehtariiguin mat váikkuhit fysihkalaš proseassaide ja mat fas dagahit iešguđetlágan muohtadiliid eatnama alde.

3.4 Fysihkalaš muohtadiliid mihtideamit

Juohke siiddas dálveguohtoneatnamis mihtideimmet áibmotemperatuvrra beannot mehtara bajábealde eatnama. Muohtatemperatuvrraid mihtideimmet botnis, eatnamis, 10 ja 15 cm bajábealde eatnama (govus 3) masa geavaheimmet mihtidanrusttega "Temperature Monitoring Solutions Thermochrons" (DS1922L Thermochron). Termokrona lea earenoamáš "iButton", mii lea čáhcejeahkki stálledoasáš, mii ii ruosto ja mas leat alddis temperatuvrasensor, diibmu ja dátalogga (Hubbart *et al*., 2005). Dát smávva rusttegat mihtidedje temperatuvrra guđa intervállas jándoris muohtaáigodagas (Maynard *et al* 2010). Dátaid vieččaimet maŋŋil go muohta suttai ja daid sáhttá govvidit gráfalaččat.

Muohttaga iešvuođat dokumenterejuvvojedje nu ahte karakteriserejuvvojedje muohttaga gerddiid, man gassat muohta lei, muohtatemperatuvrrat, muohttaga garasvuohta, man assát gearddit ledje ja muohtačalmmiid hámit. Dáidda lassin árvvoštallojuvvojedje muohta, muohtagovčča s ja dálkedilit, mat váikkuhit guohtumii, ja dan olis maiddái muohtagokčasa struktuvra, čáhcesisdoallu ja muohttaga garasvuohta dáin dálveguohtunduovdagiin.

3.5 Muohtagerddiid modelleren

Buohtastahttin dihte muohtadutkiid terminologiija (Fierz *et al*, 2009) sámegiela muohtatearpmaiguin, válljiimet 2007/2008-dálvvi ovdamearkan čájehit movt muohtagovčča s rievdá. Muohtadutkamis fysihkalaš muohtamodeallat adnojuvvojit iešguđetlágan muohtaiešvuođaid modelleremii(Brun *et al*., 2008). Dan atnui mii válljiimet SNOWPACK-modealla (Bartelt and Lehning, 2002; Lehning *et al*., 2002), mii lea ráhkaduvvon Sveitsa uđasvárrenbálvalusa várás ja dainna ráhkadeimmet modealla movt muohta lei Guovdageainnus 2007/2008 dálvvi. SNOWPACK-modealla ráhkadeapmái geavaheimmet diibmosaš meterologalaš biegga-, muohtagassodat-, áibmotemperatuvra-, eanantemperatuvra-, áibmolávttas- ja balvaobservašuvnnaid Guovdageainnu dálkestašuvnnas. Go dán stašuvnnas eai mihtiduvvo suonjardeamit, de modelleriimet navdojuvvon suonjardeami vuođul (Hock, 1999). Muohtagierraga temperatuvra navdojuvvui leat seamma go áibmotemperatuvrramihttu 2 mehtaris. Go eai lean eanantemperatuvramihtideamit, de geavaheimmet empiralaš eananmodealla masa bijaimet muohtagassodaga ja áibmotemperatuvrra dátaid (Schuler, 2011).

Dát modealla simulere dahje čájeha muohttaga stratigrafiijas gerddiid ieŠvuođaid áiggi ektui nugo man garas muohta lea, temperatuvrra, muohtačalmmiid sturrodaga ja šlája. Dáid bohtosiid leat árvvoštallan muohtaobservašuvnnaiguin maid leat čađahan 2007/2008-dálvvi (Vikhamar-Schuler *et al*., 2011).

4. Bohtosat ja analiisat

Dán oasis čilget álggos boazovázziid muohtakarakteriserema riikkaidgaskasaš muohtaklassifikašuvnna ektui. Dasto ovdanbuktit boazovázziid guohtunobservašuvnnaid dálvet áibmo- ja muohtatemperatuvrraid ektui. Loahpas čájehit 2007/2008 dálvvi ovdamearkan das movt muohta rievdá ja movt sámegiela muohtaterminologiija geavahuvvo.

4.1 Boazovázziid muohtačilgehusat buohtastahttojuvvon riikkaidgaskasaš muohtaklassifikašuvnnain

Mii válljiimet 18 muohtatearpma mat leat earenoamáš dehálaččat guođoheami ekonomiijai ja boazodoalu pastoralisma ipmirdeapmái dálvet, ja mii čilget daid sihke árbevirolaš ja riikkaidgaskasaš muohtaklassifikašuvnna vuogádagaid mielde (Tabealla 1). Dát doahpagat sisttisdollet ipmárdusa sihke njuoska ja goike muohttaga birra, muohta- ja jiekŋagerddiid birra ja rini ja bizi birra. Muhtun doahpagiidda ii lean vástideaddji doaba muohtaklassifikašuvnna vuogádagas, nugo doahpagii *čiegar* go dán sisdoalu ferte árvvoštallat čielga boazovázziid máhttun. Bohtosat čájehit man girjái ja rikkis boazosápmelaččaid árbevirolaš muohtasátnečoakkáldat Guovdageainnus lea. Dasa lassin leat muhtun sámegiela muohtadoahpagat eanet holistalaččat, definerejuvvon máŋggadimenšunála sisdoaluin, mas leat sihke muohtafysihkalaš elemeanttat ja strategalaš faktorat mat leat dehálaččat guođoheamis. Muhtun dárkilis muohtadoahpagiid čilgehusaid maid boazovázzit geavahit, dorjot muohtafysihkka-vuđot čilgehusat (Tabealla 1). Mii navdit ahte muhtun doahpagiid, nugo doahpagiid *seaŋáš*, *vahca* ja *geardni* sáhttá njuolgut buohtastahttit ja geavahit standárda muohtafysihka klassifikašuvnnas (*depth hoare*, *new snow*, *ice layer*). Muohtadoahpagiid geavahus lea áigodagaid mielde dan ektui makkár dálki, temperatuvra ja muohta/arvi lea ja maiddái dan mielde movt dat heivejit muohttaga govvideapmái (Tabealla 1). Eanas árbevirolaš muohtatearpmaid geavahit dihto áiggiid dálvet ja dihto muohtagerddiid govvideapmái, ja muhtun tearpmaid geavaheami váikkuha temperatuvra garrasit. Boazovázzit geavahit muohtadoahpagiid hui systemáhtalaččat jagi áiggi mielde, muohttaga stratifikašuvnna mielde, ja tearpmaid guođohanstrategiija čilgema ektui (Govus 4). Tabeallas 1 leat dehálеamos sámi tearpmaid definišuvnnat sámegillii ja eaŋgalasgillii leat buohtastahtton muohtaklassifiserentearpmaiguin, nu maiddái tearpmat mat čilgejit muohtadili vánddardeami, vuohttima, oaidnima ja guohtuma ektui.

Ovdamearkan mii geavahit njeallje sámegiela muohtatearpma *vahca, seaŋáš, čearga ja geardni* ja dáid čilget dárkilit čájehan dihte árbevirolaš muohtagovvideami ovttas muohtafysihka karakteristihkaiguin. Dát iešguđetlágan doahpagat maid dát tearpmat ovddastit, leat earenoamáš dehálaččat boazovázziid ekonomalaš dillái muohtan. Dáin leat dovdomearkat mat sáhttet juogo buoridit guohtuma ja nu hehttet boazomassima dahje heajudit guohtuma, mii sáhttá váikkuhit massimiid. Go buohtastahttá muohtadoahpagiid fysihkalaš muohtaiešvuođaid sámegiela muohtadoahpagiid gielalaš analiissain, de leat áicojuvvon moanat dovdomearkkat mat váikkuhit muohttaga fysihkalaš iešvuođaide, nugo garasvuhtii, temperatuvragradientii, muohtačalmmiid hámiide, fysihkalaš prosessii, gokko guhtege iešvuohta lea muohttagis, man ollu čáhci lea muohttagis, geartni assodahkii, muohtaassodahkii ja dovdomearkkaide mat leat boazodollui dehálaččat, namalassii biebmu, lavttas, lihkadeapmi ja vuohttin (Tabealla 2).

Boazovázzit čilgejit *vahca*-tearpma sisdoalu varas muohtan muohtagierragis. Variántan lea *ođđa vahca*, man mearkkašupmi lea muohta man easka lea borgan. *Vahca* sáhttá dipmadit garra muohttaga ja nu buoridit guohtuma. Boazovázziide sáhttá leat lossat vánddardit go vazádat lea, muhto vahcan lea álkit vuohttit bohcco luottaid muohttagis. Danne lea okta boazovázzi vuođđodoaimmain, mii maid gullá guođohanstrategiijai, beaivválaččat časkilit sihke ealu ja ovttaskas bohccuid luottaid. Boazu lea gal lodji vahcan, muhto lea maid jálut vuolgit doarrás. Boazovázzit geavahit *vahca* –tearpma olles muohtaáiggi, bievlla rájes, go vuosttaš muohttaga bidjá ja gitta dassážii go muohta suddá ja fas bievlá. (Govus 4). Vahca-tearpma sáhttá relateret muohtakarakteristihkaide mat leat Riikkaidgaskasaš jagiáiggiid muohttaga klassifiserenvuogádagas (The International Classification for Seasonal Snow on the ground, ICSSG) (Fierz *et al*., 2009), namalassii muohttimuohtapartihkkaliid kategoriijai (klássa PP). Muohttimuohtapartihkkalat leat aitto gahččan muohtakristállat mat doalahit iežaset vuođđohámi go leat ollen eatnamii. Dáid partihkkaliid hápmi ja sturrodat vuolgá das makkár temperatuvra lea ja man garra biegga lea balvabirrasis, gos dát hábmejuvvojit, ja dasa lassin vel makkár dilli lea go dat gahččet eatnamii dahje muohtagierragii. Dát muohta lea dábálaččat hui luotkkus, namalassii dat ii leat daškkes, earenoamážit go lea galmmas ja goalki (daškesvuohta: 156 kg/m^3). Vahca rievdá ovttatmano go olle eatnamii danne go de dakkaviđe álgá destruktiiva muohtamatemorfisma (Jaedicke, 2001; Halfpenny, 1989).

Boazosápmelaččaide lea *seaŋáš* hui dehálaš muohtašládja. *Seaŋáš* lea roavva, gordnelágan muohta lahka eatnama, botnis. Boazosápmelaččat čilgejit ahte go leat leamaš buolaš dálvet, de *seaŋáš*-proseassa, namalassii *seakŋun*, nuppástuhttá muohtakonsisteanssa *seaŋážin*. Sii karakteriserejit dákkár muohttaga leat buorren guohtumin ja mii maiddái buorida guohtuma. Boazovázzit dihtet ahte go bodnemuohta lea *seaŋáš*, de lea bohccui álki goaivut biepmu rádjái. Sii maiddái čilgejit ahte *seaŋaš* lea dakkár muohta mii jođánit suddá, ja nu lea ge dehálaš go das oažžu ráinnas čázi. *Seaŋáš*, lea muohttaga botnis. Jus muohta lea seaggi , de sáhttá šaddat eanet seaŋáš ja de lea buorre guohtun. Boazovázzit eai geavat *seaŋáš*-doahpaga čilget luottaid. Seaŋáš-doahpaga geavahit ođđajagimánus

gitta cuoŋománnui (govus 4). S*eaŋáš*-doahpaga sáhttá relateret Riikkaidgaskasaš muohtaklassifikašuvnna muohtakarakteristihka "*depth hoar"*- doahpagiin (klássa DH). Muohta seakŋu dábálaččat álggugeahčen muohtaáigodaga dalle go lea unnán muohta ja go temperatuvragradieanta lea > -10 °C/100 cm muohta. Dát lea konstruktiiva metamorfosa boađus mii dáhpáhuvvá go čáhcelievdi fievrreduvvo muohttagis, lieggasit gearddis galbmasit geardái. Seaŋáš muohttagis leat dipmá gearddit ja dát eai leat dábálaččat daškadat (daškatvuohta: 267 kg/m^3). Seaŋáškristállain lea iešguđetlágan skoavdehápmi, main lea ráigi ja gohppolágan hápmi. (Govus 5). Máŋgga dilálašvuođas sáhttá seaŋáš dagahit muohtauđđasa dahje dat ii guotte, muhto boazovázziide lea dákkár muohta buorre ja lea dehálaš dálveekologiijai.

Biegga lea dehálaš danne go dat nuppástuhttá muohtakristállaid ja muohttaga, ja nu sáhttá *čeargadit* muohttaga. Go garra biekkat fievrredit ja fierahit muohttaga, de muohtapartihkkalat cuovkanit. Dakkár cuovkanan partihkkalat ráhkadit garra ja deškes muohttaga. *Čearga* sáhttá leat nu garas ahte ii boazu iige olmmoš beasa čađa. Čeargabáikkiid lásse nu ahte boazu ii beasa muohttaga čađa guohtut šattuid. *Čearga* sáhttá lea 5 centimehteris gitta mehtera asu. *Čearga*n lea álki vánddardit sihke olbmui ja bohccui. Dákkár dilis fertejit boazovázzit guođohit garrasit amas masttahit ránnjáide. Vuohttima oktavuođas ii leat *čearga* buorre, go dalle ii báljo vuohte bohcco. *Čearga* lea muohtagierragis vulos, muhto bealli muohttagis sáhttá leat čeargan go lea heajos guohtun. *Čearga* –doaba geavahuvvo dálvet, ođđajagimánus gitta cuoŋománnui. *Čearga* –doahpaga sáhttá relateret Riikkaidgaskasaš muohtaklassifikašuvnnaid muohtakarakteristihkaide, bieggadekčojuvvon jorba muohtačalmmiide (klássa RGwp). Dát partihkkalat lea unnit, cuovkanan ja deakčasan. Biegga molle muohtagierragis muohtakristállaid ja cuovkanan partihkkaliid. Maŋŋil go dákkár muohtapartihkkalat leat bisánan, de nuppástuvvet sinterema geažil (molekyleara čanastagat nanusmuvvet ovttaskas kristállaid gaskka) mii dagaha garra ja deškkes muohtagearddi (daškatvuohta: 250-450 kg/m^3). Muohta garra dan mielde man garas biegga lea, go partihkkalat unnot ja go leat galbma temperatuvrrat (mii ovddida sinterenproseassa). Čearga šaddá juogo hui garra geardin maid dábálaččat sáhttá cuvket, dahje bieggagarradan gassa geardin.

Geardni lea jiekŋageardi mii sáhttá leat moatti milimehtaris gitta máŋgga centimehtera asu ja mii lea šaddan danne go suddan muohta lea jikŋon maŋŋel liehmu dálkki ja/dahje go lea arván muohttaga nala (ROS). *Geardni* ii leat nu garas ahte boazu ii nagot cuvket, muhto geardni sáhttá muhtomin dagahit heajos guohtuma. Go fas muohttá ođđa muohttaga geartni nala, de geardni šaddá gaskageardnin. Dálvvi mielde sáhttet šaddat máŋga gearddi muohttagii. Jus gaskageardni ii dima, muhto lea hui garas, de dát hehtte bohcco goaivunvejolašvuođa. Dát sáhttá de dagahit heajos guohtuma, mii sáhttá garrasit váikkuhit negatiivvalaččat ovttaskas bohccui ja ellui. *Gaskageardni* sáhttá rievdat buori guvlui jus šaddet rievttes dálkedilit mat seakŋudit muohttaga jiekŋagearddi vuolil. *Geardni*-doaba geavahuvvo čakčadálvvi ja *gaskageardni* –doaba geavahuvvo maiddái dálvet (Govus 4). *Geardni* šaddá gal Guovdageainnus árra dálvvi, muhto doaba adno miehtá dálvvi. *Geardni*- ja *gaskageardni*-doahpagiid

sáhttá relateret Riikkaidgaskasaš muohtaklassifikašuvnna muohtakarakteristihkaide, mat čilgejit suddan-galbmon gerddiid (klássa MFcr), dahje arvegerddiid (klássa IFrc). Dáid klássaid lea dávjá váttis earuhit nubbi nuppis danne go dain leat ovttalágan ješvuođat. *Geardni* lea asehis, measta čađačuovgi jiekŋa dahje jiekŋalágan geardi muohtagierragis (IFrc). Jus geardni lea dakkár mas leat ráiggažat dahje ii leat šelges jiekŋa, de sáhttá dat maiddái heivet suddan hámiide (MFcr). Goappašat šlájaide, njuoska muohta muohtagierragis (suddan dahje arvohallan) galbmo go temperatuvrrat njidjet nulla gráda vuolábeallái maŋŋel go ledje suddan. *Geardni* sáhttá leat moatti millimehtera assodagas gitta máŋga centimehtera assodahkii. Man garas dat lea vuolgá das man sáiggas geardni lea. Dutkanguovllus leat registreren geartni, man dáškesvuohta lea 704 kg/m^3. Goappašat jiekŋagearddit, geardni ja gaskageardni, sáhttet leat njuolga eatnama vuostá dahje vegetašuvnna alde. Dát dávjá dáhpáhuvvá dálvvi álggus dalle go vuosttaš muohttaga maŋŋil šaddet bivvalis dálkkit ja go fas jiekŋu. Dakkár jiekŋageardi mii lea eatnama vuostá, gohčoduvvo *bodneskártan* (Tabealla 1). Go *bodneskárta* vuos beassá šaddat, de dakkár geardni sáhttá bistit gitta dassážii go bievlá. Dákkár muohtadilit sáhttet dagahit dramáhtalaš guohtundiliid. Golggotmánus 1967:as šattai bodneskárta mii dagahii roassodiliid ja nu váikkuhii mearihis garrasit Guovdageainnu ealuide ja boazodoalloguovllu boazodoalloekonomiijai.

4.2 Boazovázziid muohtaobservašuvnnat relatarejuvvon áibmo- ja muohtatemperatuvrra variašuvnnaide.

Mii leat buohtastahttán boazovázziid (guođohanstašuvnna 4) muohta- ja guohtundiliid observašuvnnaid áibmo- ja muohtatemperatuvrraiguin ođđajagimánu 19.beaivvi rájes gitta njukčamánu 31.beaivvi rádjái 2008 čájehan dihte movt muhtun muohtadoahpagat geavahuvvojit boazodoalus. Muohtamihtidandáhtat (govus 6) čájehit ahte temperatuvra muohttaga botnis dálvet lei hui dásset olles 2008 dálvvi, dušše veahá rievddadii gaskal -2 ^{o}C ja -4 ^{o}C. Áibmotemperatuvra mihtiduvvon seamma stašuvnnas rievddadii dálvet gaskkal 0^{o}C gitta -32^{o}C. Boazovázziid beaivválaš muohtadiliid áicamat seamma áigodagas čájehit ahte buolaš beivviid, dalle go ledje buolaš temperatuvrrat, seakŋudii muohttaga nu ahte šattai seaŋáš. Seaŋáš-dilli bisttii dassážii go áibmotemperatuvra loktanii 0^{o}C bajábeallái. Gaskamutto guovvamánu muohtastruktuvra nuppástuvai go boazovázzit dieđihedje ahte muohta lei garran, čeargan, maŋŋil go biegga lei garradan muohttaga. Čohkkejuvvon dátaid mielde, dán garra muohtagearddis ii lean mearkkašahtti váikkuhus guohtumii. Boazovázzit karakteriserejit muohtadiliid guohtuma ektui, man álki lea bohccui beassat muohttaga čađa. Sii čálle ahte muohtadilli dán stašuvnnas lei dábálaš buorre, go rievddadii nu ahte muhtun beivviid lei hui buorre guohtun ja eará beivviid fas oalle buorre. (Govus 6). Guođohanbeaivegirjjiid dátat geavahuvvojedje dokumenteret árbevirolaš muohtadoahpagiid mat ledje geavahuvvon vissis

áigodagas. Guođohanbeaivegirjjiin sáhttá oaidnit juovlamánu 14. ja 15.beivviid 2007 lei arvi ja buolaš mii nuppástuhtii muohtašlájaid *geardnin* ja *gaskageardnin* 2008 dálvvi (Govus 6).

4.3 2007/2008 dálvvi muohtagerddiid modelleren

Mii buohtastahtiimet muohtadutkiid terminologiija (Fierz *et al*, 2009) sámegiela árbevirolaš muohtatearpmaiguin ja aniimet 2007/2008 jagi ovdamearkan čájehan várás mo muohtagovčča rievdá dálvvi mielde. Dása mii geavaheimmet muohtamodealla SNOWPACK mas leat máŋga gearddi. Bohtosat dán dálveáigodagas, mas maiddái leat iešguđetge sierranas muohtagearddit ja muohtačalbmešlájat, oidnojit govvosis 7. Muohtačalbmešlájaid klassifikašuvdna lea Riikkaidgaskasaš muohtaklassifikašuvnna mielde (Fiertz *et al*, 2009).

Mii čilgiimet dálvvi muohtagokčasa ovdamearkkaiguin golmma áigodagas: 1) Arvi muohttaga ala (juovlamánu 15.beaivvi 2007); 2) guovddášdálvvi muohtagokčasa (njukčamánu 9.beaivvi 2008) ja 3) muohtasuddanáigodaga (miessemánu 10.beaivvi 2008). Liehmudálkkit ledje juovlamánu 14.-19.beivviid 2007, temperatuvrrat gitta +6.5 ºC rádjái, ja dalle maid arvvii veahá muohttaga ala , mii lei 25 cm asu. Muohtagovčča šattai isotermálan ja daškaluvai. Maŋŋil dan, de lei áigodat go ledje vuollegis temperatuvrrat, mii dagahii ahte muohtačalmmit jikŋo ja šattai asehis jiekŋageardi muohtagierragii (geardni govvosis 7). Dán gearddi ala muhtii máŋgga háve (šattai gaskageardni) ja ná dat bisttii dálvvi miehtá gitta giđđii. Vaikko lei ná, de ii dagahan váttisvuođaid boazovázziide danne go dát geardni ii lean nu garas ja lei dušše 1 cm asu.

Gasku dálvvi muohtagokčasa profiila čájehuvvo govvosis 7 (njukčamánu 9.beaivvi 2008). Vuollegis áibmotemperatuvrrat ja seakka muohta dagahedje alla temperatuvragradieanttaid, mii seakŋudii botni, ja maiddái danne go dan bajábealde ođđasit galbmon muohtageardi (gaskageardni) lei ain bistime. Dáid gerddiid bajábealde lei muohta maid biegga lei fievrredan, mas ledje smávva jorbejuvvon muohtačalmmit mat de šadde garra, deškes muohtan (*čearga*). Ođđa muohttaga partihkkalat (maid biegga unnit dahje eanet lei cuvken) mii lei muohtagierraga bajimusas, lei *vahca*.

Dábálaš isotermála njuoska muohttaga profiila giđđat go muohta suddá čájehuvvo govvosis 7 mas leat muohtačalmmit gihppolagaid. Dán gearddi heive govvidit sámegiela *sievlla*-tearpmain. Suddan-galbmon kristállat šaddet dávjá muohtagierragii go leat buolaš ijat. Dábálaččat dán muttos áiggi leat ealut johttán dahje johtime geasseorohagaide mat leat mearariikkas.

5. Digaštallan ja čoahkkáigeassu

5.1 Gozihit, mihtidit ja ipmirdit muohttaga

Vuođđoeaktun go galgá ipmirdit kompleaksa vuogádagaid, nugo bohcco-olbmo-muohttaga ovttasdoaibmama, lea ahte váldoelemeanttat olbmo jurddašeamis eai leat logut, muhto sulaid meroštallan čohkiid gilkorat (Zadeh, 1973; Berkes, *et al*., 2009). Sulaid meroštallama ipmárdus introduserejuvvui matematihka láhkásaš lahkonanvuohkin hálddašit kompleaksa vuogádagaid, main lea vejolaš diehtit dušše sulladieđuid komponeanttaid ja daid gaskavuođaid birra (Zadeh, 1973). Dás lea vuođus statistihka klassifiserenmetoda mainna sáhttá gieđahallat eahpesihkarvuođa. Berkes (2008) oaivvilda ahte sulaid meroštallan ipmárdus heive bures oktii eamiálbmotárbevirolašmáhtuin, ja dát lahkonanvuohki veahkeha ipmirdit movt báikkálaš- ja eamiálbmotmáhttovuogádagat gieđahallet kompleaksitehta. Sulaid meroštallan ipmárdus lea veahkkeneavvu mii klassifisere dieđuid viiddis kategoriijan dahje gihppun, ja áđđestalle simuleremiin movt olbmo jierbmi doaibmá. Okta sulaid meroštallama ipmárdusa golmma váldoiešvuođas lea geavahit gielalaš variábeliid lohkovariábeliid sajis (Berkes 2008). Mii sáhttit geavahit sulaid meroštallama ipmárdusa veahkkin go galgat buorebut ipmirdit movt boazovázzit dulkojit kompleaksitehta, mii guoská muohttagii ja guođoheapmái ja maiddái riskaanaliisii, mii fas guoská bohcco ja ealu ahtanuššamii. Boazovázziid goziheamis leat vuosttažettiin giellavuđot dátat, dan sadjái go logut, ja buohtastahttimiid vuođđu lea dásiid čilgehusaid mielde (omd. muohta karakteriserejuvvo garasin, dimisin, asehažžan ja man ollu muohta lea buohtastahtto man muddui dat lea bohccui/olbmui). Dát muohtakarakteriseremat ja dáid beaivválaš geavahus čatnasit nannosit terminologiija geavaheapmái. Vaikko sámegiela muohtadoahpagat sisttisdollet ollu fysihkalaš elemeanttaid main leat lohkovariábelat, de mihtideamis deattuhit gielalaš variábeliid geavaheami ja sulaid meroštallan ipmárdusa, nugo *assás geardni* (assás jiekŋageardi mii lea šaddan maŋŋil go lea arván muohttaga nala dan sadjái go 5 cm geardni).

Boazovázziid observašuvnnain ja gozihemiin lea mearkkašupmi go galgá oažžut gova das movt sii leat čilgen ja karakteriseren muohtadiliid guođoheami oktavuođas. Eamiálbmogiid "dátačohkkema" mentála proseassa ja mentála modeallaid hábmen čuvvot giellageavahanvugiid danne go giella hábme tearpmaid ja doahpagiid (Berkes *et al*., 2009). Guođohanbeaivegirjjit, mat dán dutkamis leat geavahuvvon, lea báikegoddevuđot gozihanvuogádat (Eira & Mathiesen, manus), mii lea ráhkaduvvon olbmuid fuomášumiid vuođul, geat dárkilit observerejit birrasa (Berkes, 2008), go guođohettiin gozihit seamma áiggis ollu kompleaksa variábeliid áiggi čađa. Ovdamearkka dihte SNOWPACK-simulašuvdnamodealla geavahuvvui suokkardallat guohtundiliid (vejolašvuohta beassat muohttaga čađa šattuid rádjái) Guovdageainnus golggotmánu rájes cuoŋománus rádjái (govus 7), čájehan dihte muohtaiešvuođaid áigeráidduid muohtaáigodagas. SNOWPACK- simulašuvdnamodealla addá dárkilis dieđuid beaivválaš muohtadiliin (govus 7), muhto boazovázzit orrot geahččame muohtaáiggi ollislaččat ja movt dálkedilit sáhttet váikkuhit boahtteáiggi ekonomiijai ja ealu dillái.

Boazovázziid árbevirolaš muohtatearpmaid girjáivuohta ja mearkkašupmi čájeha earálágan áddejumi muohttagis go buohtastahttá čielgasit fysihkkavuđot riikkaidgaskasaš klassifikašuvnnain. Boazovázzit čilgejit muohtagokčasa, temperatuvrra, láktasa, biekka, ealu láhttema ja bohccuid dili. Sihke árbevirolaš holisttalaš máhtus ja boazovázziid muohtafysihkalaš observašuvnnain lea guđesge su doaibma ealu hálddašeamis. Soames ládje boazovázzit geavahit "boazovázziid goartilastinvuogi" (Berkes *et al*., 2009) go guođohit, eaige dárbbaš dárkilit čilget muohtačalmmiid nu movt SNOWPACK- modealla dahká (govus 7). "Boazovázziid goartilastinvuohki" guođoheami ja muohtarievdama ektui leat: 1) isket man garas muohta lea ja geahččat makkár muohtaprofiila lea ja 2) geahččat muohtadiliid dan mielde movt eallu bissu ja movt njunuš ja ravddat leat. Iežaset "goartilastinvuogis" lea dat ovdamunni ahte dainna sáhttá dulkot kompleaksa mearrádusaid njuolggadussan maid lea álki muitit ja maid sáhttá čađahit báikkálaš sosiála veahkkeneavvuid bokte (Berkes *et al*., 2009).

5.2 Guokte máhttovuogi muohtadiliid birra sámi boazodoalu perspektiivvas.

Muhtun dain deháleamos árbevirolaš sámegiela muohtadoahpagiid analiisa, dáid definišuvnnat ja fysihkalaš proseassaid čilgehusat čájehit ahte sámegiela muohtadoahpagat leat muhtun muddui seammaláganat go muohtafysihka doahpagat, muhto maiddái erohusaid muohtafysihka ektui. Go buohtastahttá árbevirolaš máhtu dieđalaš observašuvnnaiguin, de oaidná ahte ollu árbevirolaš doahpagat čilgejit muohttaga nu movt riikkaidgaskasaš standárdadoahpagat, muhto muhtun árbevirolaš tearpmat čilgejit fysihkalaš proseassaid mat ráhkadit muohtadiliid, muhto eará perspektiivvas. Goappaš vuogit identifiserejit muohtafenomenaid, dáid čilgehusaid ja tearbmadefinišuvnnaid, muhto dieđalaš servodaga ulbmil lea ráhkadit ja doalahit oktasaš giela buot dási geavaheddjiid várás buot riikkain. (Fierz *et al*., 2009). Goappašat máhttovuogádagain leat ollu muohtatearpmat muohttaga struktuvrra, temperatuvrra, áibmoláktasa, muohtagassodaga, daškatvuođa, muohtačalmmiid, konsisteanssa ja muohtagierraga bieggaminstara mielde. Muhto leat maiddái erohusat das movt karakteriserejit ja mihtidit muohttaga, ja makkárat muohtadoahpagat leat. Dát analiisa duođašta ahte árbevirolaš muohtaterminologiija lea rikkis ja dárkil, mas maiddái lea mielde muohtafysihkalaš ipmárdus muohttagis eatnama nalde.

Muohtadutkiid doahpagiid vuođđun leat dovdomearkkat maid sáhttá mihtidit ja kvantifiseret ja maid konteaksta unnán báidná. Maiddái árbevirolaš muohtadoahpagiin leat objektiivvalaš dovdomearkkat guovddážis, muhto dat sisttisdollet lassin geavatlaš dieđuid ja assosiašuvnnaid geavatlaš diliide nu go guohtundiliide, dálkái ja bohccuid lihkadanvejolašvuođaide ja ealu ahtanuššanvejolašvuođaide boahtteáiggis. Dát čájeha ahte boazovázziid muohtamáhttu fátmmasta sihke muohttaga fysihkalaš aspeavttaid ja guođohanekologiija. Ovdamearkan guovtti máhttovuogi geavaheamis leat čájehan boazovázziid muohtadoabaipmárdusa muohtafysihka ipmárdusa ektui. Dat orru leamen oalle

nuppelágan dan ektui mo muohtadutkit čađahit muohtadutkamiid ja movt si ovdanbuktet dáhtáid (Tabealla 2, Fierz *et al*., 2009). Nuppe dáfus boazovázziid máhttu gullá earenoamáš sátnečoakkáldahkii, mii geavahuvvo go siskkáldasat ságastallat fáktoriid birra mat váikkuhit guođoheapmái, nugo ealu sirdimii, topografiijii dahje dálkkádatváikkuhusaide, mat buohkat gullet ekovuogádaga kompleksitehtii. Boazovázziide dát guokte máhttoperspektiivva leat álo bálddalaga holisttalaš oaidninvuogi oassin, geavahuvvos guhte fal tearbma. Dát čájeha movt boazovázziid muohtamáhttu lea holisttalaš ja lea lakton oktii ealu ekologiijai ja guođohaneatnamiid geavaheapmái. Boazovázziid máhttu ja dan heiveheapmi, mii vuhtto guođohanstrategiijain ja giellageavaheamis, lea oktiilakton dálkkádagain, birrasiin ja bohccuin, ja dahká vejolažžan fuomášit dehálaš rievdamiid muohttagis ja dálkkádagas nu go leat dahkan duháhiid jagiid (Federova 2003) ja mii dahká vejolažžan ceavzit davvin garra ja rievddadeaddji dálkediliin.

Eamiálbmotmáhtu ja oarjemáilmmi diehtaga vuođđun leat loahpa-loahpas birasobservašuvnnat. Goappašagain lea máhttomálle, maid vuođđu leat observašuvnnat, ja goappašagaid vuolggasadji lea seamma intellektuálalaš proseassa, namalassii čilget dakkára mii álggus neaktá moivvasin (Berkes & Berkes, 2009). Eamiálbmotmáhtu árbevieruin leat iežaset njuolggadusat máhttoproseassa birra, ja dat orrot leamen earáláganat go oarjemáilmmi diehtaga gáibádusat duođaštusaid, geardduhemiid ja kvantifiseremiid hárrái. Leat dahkkon ollu birasdutkamat main leat leamaš mielde eamiálbmotperspektiivvat (Berkes *et al*., 2009), muhto main lea dušše čalbmetbealát perspektiiva. Oarjemáilmmi dutkan ja observašuvnnat leat guhká leamašan áidna dohkkehuvvon vuohki ja dat leat ráhkadan standariid movt dutkan galggašii čađahuvvot (Roturier & Roué, 2009). Sáhttá oaidnit ahte diet lea rievdame danne go iešguđet geavahanjoavkkuid máhttu, nu go boazovázziid máhttu lea váldon mielde dátačohkkemii ja bohtosiid ovdanbuktimii. Dieđuid juogadeapmi sáhttá addit ođđa dieđu ja buoridit dála dieđu ja addit eanet dieđu lassin dieđalaš dutkamiidda ja viiddit "dutkanmáilmmi" dálkkádatrievdama váikkuhusaid birra. Árbevirolaš máhttu ja árbevirolaš luondduresursahálddašanvuogit sáhttet lasihit nana dieđuid ceavzilis ovdáneapmái. Árbevirolaš hálddašanvuogádagat leat leamaš váldovuogit maid bokte servodagat duhátjagiid leat hálddašan luondduriggodagaid. (Berkes & Folke, 1998). Nichols (*et al*. 2004) oaivvildit ahte heajut bealli das go galgá geavahit árbevirolaš máhtu ovttas oarjemáilmmi diehtagiin lea leamaš hástalus jorgalit teknihkalaš tearpmaid ja doahpagiid danne go fágadoahpagiid jorgaleamis sáhttá dávjá geavvat boastut go jorgaleaddjit dahje dulkkat hárve dovdet dáid spesialiserejuvvon terminologiijaid. Báikkálaš árbevirolaš áššedovdiid ja dutkiid digaštallamis muohtakarakteristihkaid birra sáhttá dávjá dulkojuvvot boastut. Riseth ja earát (2010) oaivvildit ahte olggobeale dutkái lea hástalussan dulkot duohtavuođa mearkkašumi nu movt báikkálaš eamiálbmotášše dovdit ipmirdit. Roturier & Roué (2009) dutkkaiga sámi boazovázziid máhtu dálveguohtoneatnamis Davvi Ruotas ja geavaheigga sámegiela muohtadoahpagiid bohtosiid ovdanbuktimis ja digaštallamis das makkár váikkuhus Ruota ođđaáigásaš vuovdeindustriijas lea boazodollui. Dát čájeha ahte oarjemáilmmi dutkit leat deattuhan

boazodoalomáhtu muohttaga ja bohcco birra dehálažžan go galgá ipmirdit riidduid gaskal boazodoalu ja vuovdeindustriija. Guovtti máhttovuogádaga diehtolonohallan sáhttá leat ovdamunnin goappašagaide. Boahtteáiggi einnostuvvon temperatuvraloktaneapmi Guovdageainnu boazodoalloguovllus (gaskamearálaš loktaneapmi 8 grádain C ja ovtta mánu unnit muohta boahtte 100 jagi geahčen) (Hanssen-Bauer *et al*, in prep.) hástala váldit vuhtii buotlágan máhtu. Danne lea boazodoalu hálddašeamis dehálaš ráhkadit vuogádaga mii dáhkida ahte maiddái vuhtii váldojuvvo earálagan máhttu go dušše oarjemáilmmi dutkanmáhttu. Jos boahtteáiggi galgá leat ceavzilis boazodoallu, de ferte geavahuvvot iešguđetlágan máhttu. Min loahppajurdda lea ahte dálkkádatrievdamiid heiveheami oktavuođas ferte váldit vuhtii iešguđetlágan diehtovugiid, mas ovttastahttojuvvo eamiálbmot boazovázziid vásáhusvuđot máhttu ja muohtadutkiid máhttu muohttaga ja muohtarievdama birra.

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Govus- ja tabeallalistu

For Article 3/3. artihkkalii

Figures and tables/govvosat ja tabeallat

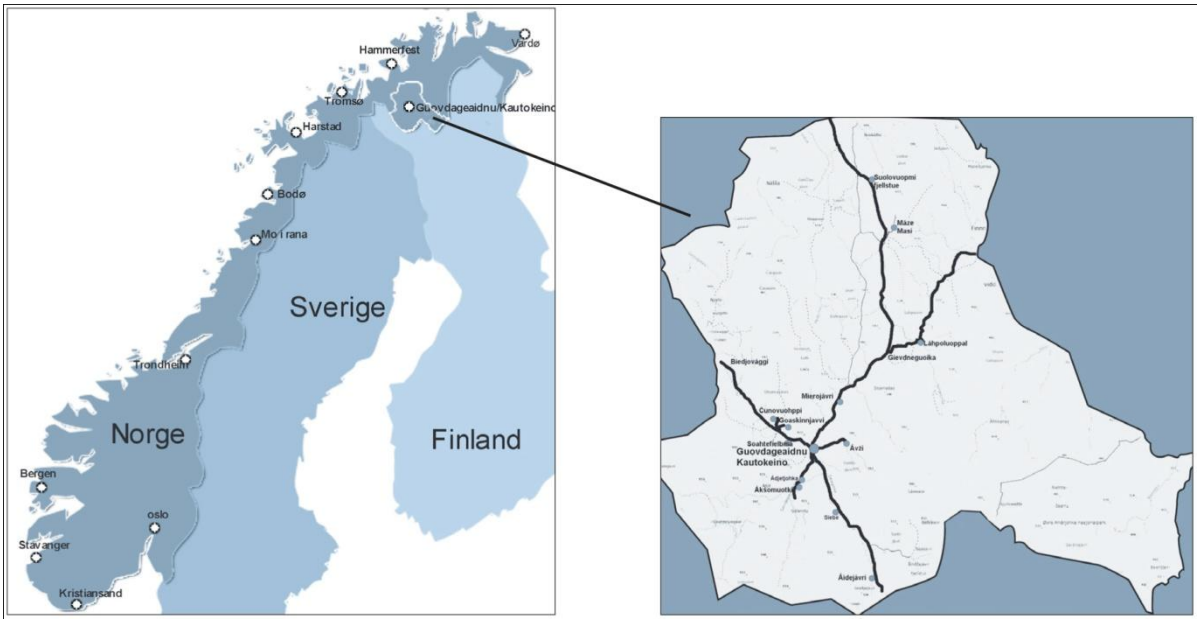

Figure 1: The study area, winter pasture land for reindeer herding in Guovdageaidnu.
Govus 1: Dutkanguovlu, Guovdageainnu boazodoalu dálveorohagat.

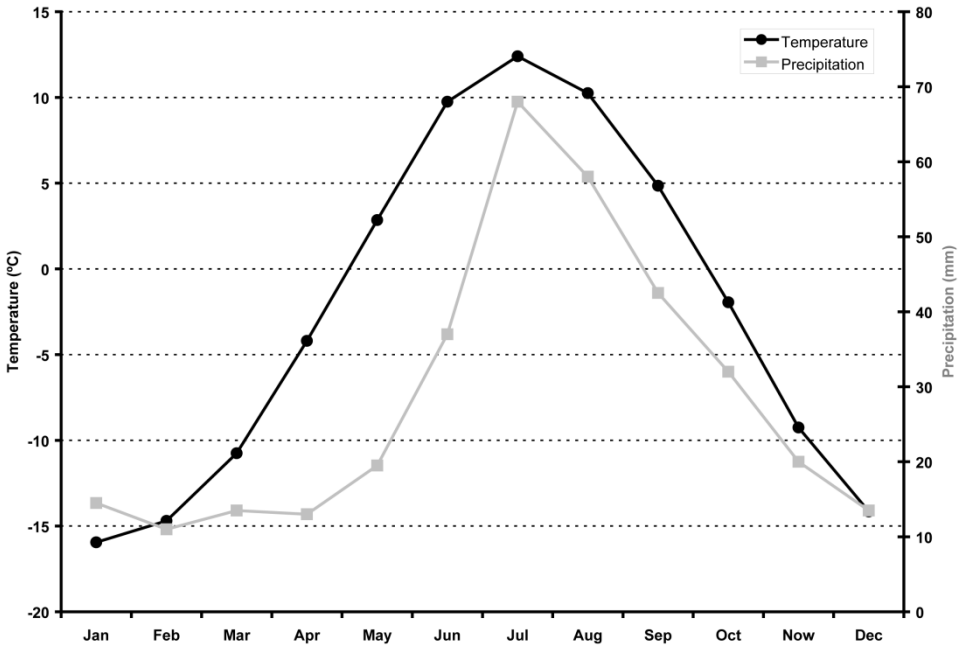

Figure 2: The mean monthly temperature and precipitation sums for the normal period 1961-1990 for Kautokeino.

Govus 2: Guovdageainnus gaskamearálaš mánnosaš temperatuvra ja muohta/arvi dábálaš áigodagas 1961-1990.

Figure 3: Temperature Monitoring Solutions Thermochrons on a pole in a winter pasture area in Kautokeino, des. 2008.

Govus 3: Temperatuvra gozihantermokronat stoalppus dálveguohtuneatnamis Guovdageainnus, juovlamánu 2008.

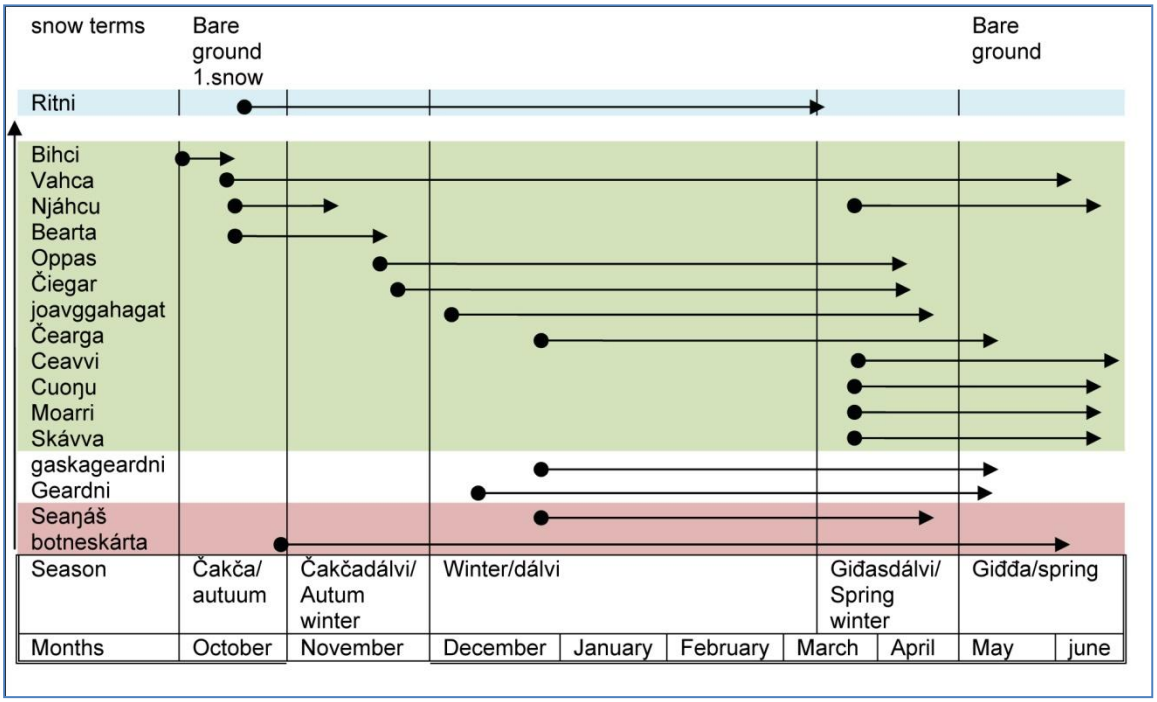

Figure 4: Schematic overview of Sámi snow concepts used at different time during winter in reindeer herding and how they occur in the snow pack (Blue: snow formation related to air, green snow formation related to the surface and snow pack top layer, white mid snowpack layer, pink illustrate bottom snow layer). The arrows illustrate the duration of use of different concepts.

Govus 4: Šemáhtalaš oppalašgeahčastat sámegiela muohtadoahpagiin mat boazodoalus adnojit iešguđet áiggis dálvvis, dan mielde gokko leat muohttagis (alit: muohta mii gullá áibmui; ruoná:

muohtašlájat muohtagierragis ja bajemusas muohttagis; vielgat, gasku muohttagis; čuvges ruoksat, botnis). Njuolat čajehit goas geavahišgohte muohtadoahpaga ja man guhká.

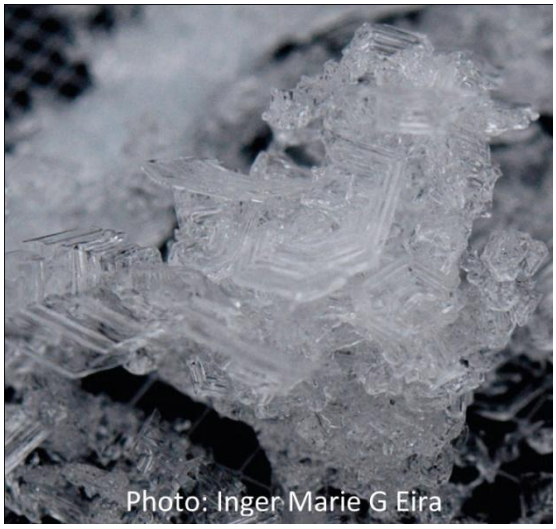

Figure 5: Macro photographic picture of *Seaŋáš*, depth hoar crystal (2 mm wide) from the bottom of the snowpack from a reindeer pasture in January in Kautokeino.

Govus 5: Lahka govvejuvvon govva *seaŋážis*, (depth hoar crystal), (2 mm stuoru), botnis muohttagis, Guovdageainnus ođđajagi mánu.

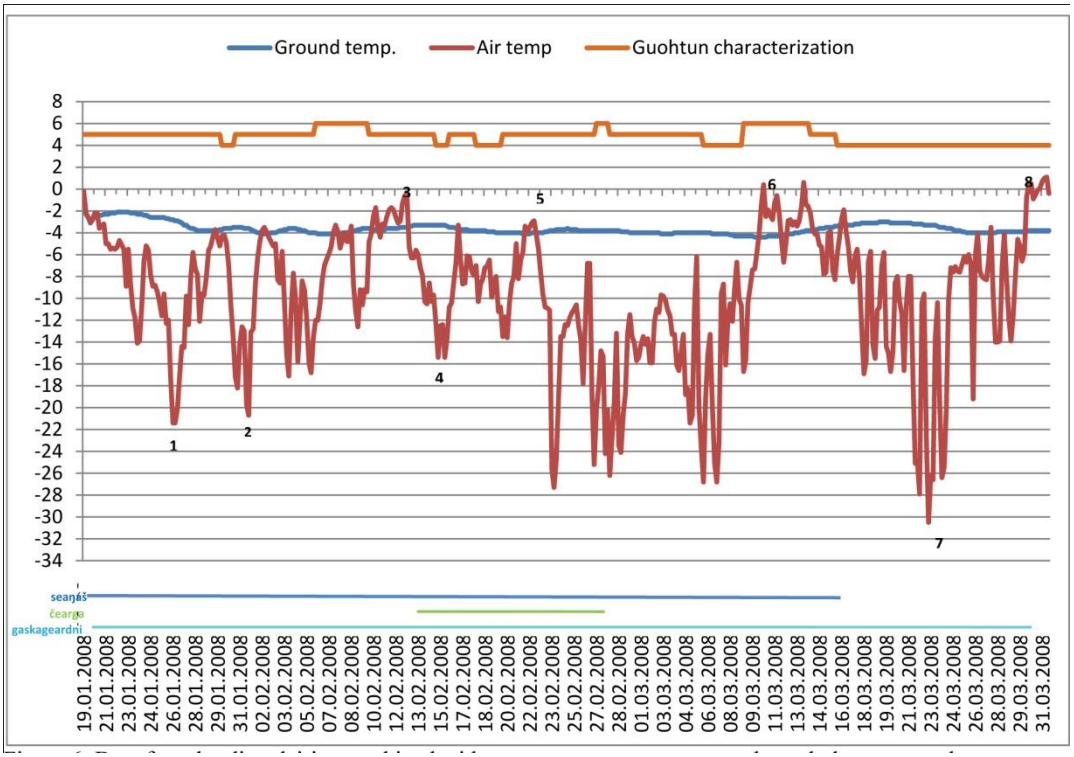

Figure 6: Data from herding dairies combined with temperature measurements with thermocrons.

Govus 6: Dieđut guođohanbeaivegirjjiin mas maid leat temperatuvradatat mihtiduvvon termokronaiguin.

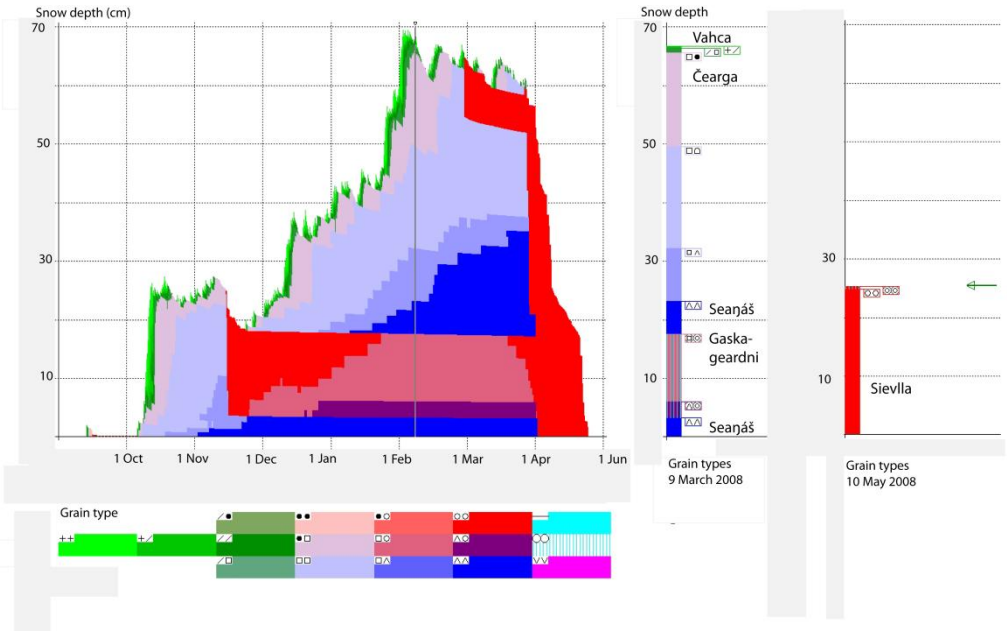

Figure 7: Modeled snow layers using the SNOWPACK model for the winter season October 2007 to May 2008. Different snow grain types are expressed with different colors, following the snow classification standard (Fierz et al., 2009). The illustration includes a mid-winter situation (9 March 2008) and a snowmelt situation (10 May 2008), where traditional Sámi snow terms are included.

Govus 7: Muohtageardemodealla SNOWPACK mainna čájehit muohttaga dálvet, golggotmánus 2007 gitta miessemánnui 2008. Iešguđet muohtačalbmešlájat čájehuvvon iešguđet ivnniin, ja mas maid lea muohtaklassifiseren standar (Fierz *et al*., 2009). Dán govvosis lea gaskudálvvi dilli (njukčamánu 9. b. 2008) ja suddandilli (miessemánu 10. b 2008), ja mas maiddái leat sámegiela muohtatearpmat.

Table2: Sámi snow concepts: a set of characteristics, both snow physical characteristics - characteristics that are important for the reindeer herding strategies.

Tabealla 2: Sámegiela muohtadoahpagat: dovdomearkačoahkit, mas leat sihke muohta fyishkalaš dovdomearkkat ja dovdomearkkat mat leat dehálaččat guođohanstraegiijas

Snow terms	Snow physical characteristics										Characteristics important for traditional herding strategies			
	Hardness	Density	Temp.	Shape	Physical process	Place for Formation	Liquid water Content	Layer Thick-ness	Snow water Equivalent	Snow depth	Access to water/ food	Physical activity	Mobility	Tracing
Vahca	X	X			X	X			X	X	X	X	X	X
Seaŋáš	X	X	X	X	X	X	X		X		X			
čearga	X	X	X	X	X	X		X			X	X	X	X
geardni	X			X	X	X		X			X	X		

Table 1: Concepts that are important for herd economy compared with snow classifications.

	Snow term	**Definition Sámi language**	**English translation of Sámi definition**	***Characteristics important for herding exercise***							**Physical explanation and classification**
				Condition of snow for access to Food = guohtun	Traffic / Mobility	Tracks	Visibility	The time aspect of use of the concept	Place of formation	Variations + additional information	
1.	Vahca	Varas muohta maid aitto lea borgan. Lea lossat vánddardit go vazadat lea. Vahcan vuohttá gosa boazu lea mannan. Vahca sáhttá dipmadit garra muohttaga. Boazu lea jálut vuolgit doarrás go lea vahca alde.	*Vahca* is new snow. *Vahca* causes bad travel conditions, but makes it easy to see where the reindeer have gone (track). Vahca can soften hard snow. The reindeer feel free to walk in different directions under such conditions.	Vahca may contribute to the softening of layers of hard snow or ice that otherwise could make it difficult for the reindeer to dig through the snow.	Causes bad conditions for moving the herd.	Vahca makes it easy to see tracks		The entire snow season.	At the top of the snow cover, on the surface	Ođđa vahca = snow that has just snowed	Precipitation Particles, class PP. Shape and properties are affected by the temperature and wind speed during snowfall
2.	Čearga	Garra biegga bosson ja fieraha dan muohttaga, nu ahte šaddá garas. Šaddá dakkár maid ii beasa čađa boazu ja ii ge olmmoš ge. Dakko gokko lea čeargan, dakko lea lássen (heaitot guohtun). Čearga sáhttá vaikko mettara asu. Gasku dálvvi.	*Čearga* is created by strong winds which have blown the snow and rolled it to become hard. Čearga is so hard that neither reindeer nor herders can dig through it. Where *čearga* occurs, grazing is prevented and reindeer are "locked out" of the pasture. Čearga can have a thickness of one meter.	Hard snow - from 5 cm to 1 meter thick. Grazing may be prevented because reindeer are unable to dig through hard snow to access forage.	It is Easy to travel on this type of snow.	It is difficult to see tracks.		In winter, from January to April and beyond.	at the top of the snowpack, but can extend deeper into the snowpack.		Rounded snow grains. Wind influenced on the surface. Class RGwp
3.	Seaŋáš	Dálvet go buollašat leat veahá leamašan muhtin áiggi, de seakŋu. Buollašat seakŋudit, muhto giđđat fas biekkat seakŋuda. Muohta leat dego bulvarat. Dat ii leat gitta ii veaháge eatnamis, dan lea geahpas lihkahallat.	In the winter, when it has been cold for a while, then the *seaŋáš* process (*seaŋkut*) starts. Refrigeration promotes this process. In spring, the wind can change the snow to *seaŋáš*. The snow is grainier and is not stuck to the ground. It	When it is seaŋáš, pasture conditions are good because the reindeer can access the vegetation under the loose snow..	If the snow depth is shallow with a lot of seaŋáš, it may contribute to traveling condition	Herders don't use this concept in connection with tracking.		In winter, from January to April and beyond.	It is located in the bottom of the snowpack, near the ground.	Sami people use this snow to heat water for coffee/water	Hoar Crystals, Class DH. Occurs where there is little snow and cold air temperatures. Requires a temperature gradient of more than 1 degree / 10 cm. Can occur in various forms when the air temperature changes often.

		Boazu rábasta nu geahppasit eret. Dat botnis,eatnama lagamusas, geartni vuolábealde.	is easy to move it and the reindeer can easily dig through *seaŋáš* to access food.								
4.	sievlla	Galgá leat oalle guhka leamašan njáhcu, čađa liggen, bivaldan, de lea juo oalát njázudan. Dat lea njuoska muohta. Dan lea lossat vánddardit, sáhttá mannat gitta vulos eatnama ala ja sievlan gal ge sáhtát darvánit. Dat lea muohtagierragis gitta eatnamii.	*Sievlla* is very wet snow which occurs when the weather has been mild and the snow has begun to thaw completely through. The snow is wet and it is hard to walk on because a person or animal will sink completely through the snow to the ground.	Not discussed in connection with guohtun The snow is soft and wet.	Contributes to difficult traveling conditions.	Not discussed in connection with tracking		Spring	Throughout the entire snowpack, from the top to the ground.	One of the elements in the spring cycle.	Melted form, Class MF. The snow is at zero degrees and snow crystals lose their bridges and links. The snow is wet and without bearing structure. Water cannot be expelled.
5.	Soavli	De gal lea čáhci ja muohta, dasa ii ábut mannat go dat sáhttá vaikko man čieŋal bajil, dat sáhtte guokte goartila soavli doppe dan muohttaga vuolde. Go muohta lea álgán suddat ja dat álgá dieđusge doppe vuolil dat muohta nai, dat ii oidno.	*Soavli* is a mix of snow and water in which the snow melts from the bottom of the snow upwards. It is important to be careful when traveling in *soavli*, because the snow can be deep on the upper side of *soavli*, but soft and wet at the very base.	Not discussed in connection with guohtun The snow is soft.	Contributes to difficult traveling conditions	Not discussed in connection with tracking		spring	Could be at the top as well as within the snow pack	One of the elements in the spring cycle.	Melted forms. Class MFsl. Slush. The snow is water saturated and without structure. Water can be squeezed out.
6.	Bihci	dalle go lea leamašan na bievla ja de hirbmat buollašat, bievlla alde buolašta na de bihcu. Bihci lea eatnama birra.	*Bihci* (ground surface frost) occurs when the ground is snow-free and cold. The cold conditions form *bihci* on the surface of the ground. The use of the concept *Bihci* is entirely associated with conditions on the ground	Not discussed in connection with guohtun	Herders don't use this concept in connection with traveling conditions	Herders don't use this concept in connection with tracking		Fall	On the ground	Can be characterized as the beginning of winter	Surface frost
7.	Ritni	Dakkár dálkesorta ahte muoraide darvána ritni. De vel borgá daid ala, de šaddá nu ritnálat. Dalle ii bievlan, ferte leat muohta vuos	*Ritni* (frost on trees) is primarily formed on trees from warm moist air interacting with very cold snow surfaces. Specific	Not discussed in connection with guohtun	Not discussed in connection with traveling conditions	Not discussed in connection with tracking	makes it difficult for the reindeer herders to see the	Fall, winter	On trees		Surface frost is deposited on the snow. Class SHsu. This happens on cold snow surfaces or on trees, when warmer, moist air hits the cold

		eatnamis ovdal ritni sáhttá. issoras guhkes buollašat ledje, na gal dat ritne-vuovddit, ii oainne maide.	weather conditions lead to the formation of *ritni*. Ritni sometimes occurs when there are is bare ground, but the snow must have been deposited before the warmer air arrives. If it has been cold for a long period of time, then "ritni" wood will occur and then it becomes difficult to see anything at all.				reindeer				snow. It can snow again later and form very delicate shapes in the trees. Extremely sensitive to the wind. A small gust of wind will destroy many of the crystals.
8.	Njáhcu	Maŋŋel go lea borgan, de lea liggen fas muohttaga, de šaddá njuoska muohta. Dát gáržžida guohtuma. Jus Hállemas-njáhcu ii boađe dieid beivviid. de šaddá heitot dálvi. Sáhttá arvit juste dálvet goas ii galggaše arvit ja bivaldit, ja nu geartni ráhkada ja botneskárta šaddá. Njáhcu lea čakčat ja skábman, muhto lea dábáleamos giđđadálvvi.	*Njahcu* is wet snow which occurs as a result of alternating snows and thaws. This prevents reindeer from grazing. Should there be *njáhcu* in occurring in connection with All Saints Day, it will become a bad winter because subsequent rain and warmer, then colder temperatures will form *geardni* (ice) and produce bodneskárta conditions..	These types of snow lead to deterioration of guohtun	Not discussed in connection with traveling conditions	Not discussed in connection with tracking		Spring *Njáhcu* occurs in the fall and the darkness of winter, but it is most common in spring	surface	One of the elements in the spring cycle.	Melting forms on the surface, Class MFcl MFpc or if they are frozen again. Happens in the fall or spring where the temperature is around zero degrees during the day and below zero at night.
9.	Geardni	Go muohttá vuos álggos ja de arvá ja jiekŋu. Muohta-gierraga njuoskada ja de galbmá, šaddá jiekŋa vajahas muohta-gierragis.	*Geardni* is a thin ice layer on the top surface of the snowpack. It occurs when it rains on the snowpack and then the rain freezes. The snow surface first becomes wet then frozen resulting in a thin ice layer on the top of the snow.	The ice layer is not so hard that the deer are not able to break it, but this condition can contribute to poor guohtun.	Not discussed in connection with traveling conditions	Not discussed in connection with tracking		Fall – winter	surface		Ice layer. Class IFRC. Occurs when it rains on a cold snow surface so that it forms a thin, hard layer of ice
10.	Gaska-geardni	Go fas muohttá jieŋa ala. Dat lea jiekŋa mii botke muohttaga. Jus gaskageardni ii diima, muhto lea hui garas, dat gáržžida bohcco	*Gaskageardni* is a condition in which one or more hard ice layers within the snow pack which occurs when it snows on top of a	If this ice layer is so hard that the reindeer are not able to break through it, it contributes to	Not discussed in connection with traveling conditions	Not discussed in connection with tracking		Fall through early winter	Within the snowpack		Ice, buried in the snow. Class IFRC (same as before), but buried under the snow. When this layer is porous and not polished ice can also be

		goivunvejolašvuođa roggat. Sáhttet máŋga gearddi leat muohttagis. Árat dálvvi.	geardni ice layer. If the ice layer in the middle is not softened, but is still hard, it will limit the reindeers 'ability to dig through the ice to access their forage. There may be several layers within the snowpack.	very poor *guohtun*.							MFcr.
11.	Bodne-skárta	čakčat deavdá njuoska vaza ja de galbmá nu ahte jiekŋu, šaddá jiekŋa mii lea darvánan giitá jeahkálii. Boazu ii beasa bodnái. Dát dagaha dálvet rutneguohtuma. Čakčat/čakčadálvvi	*Bodneskarta* is a condition that occurs in the fall when the early snow first melts across the ground and plants, then that water freezes, forming a hard coating of ice. The reindeer are not easily able to break through this layer to reach their food and this leads to a *rudneguohtun* winter.	Very poor guohtun	Not discussed in connection with traveling conditions	Not discussed in connection with tracking		Fall Fall- Winter	At the bottom of the snowpack, coating the vegetation and ground.		This is bottom ice. Class IFbi. Occurs when the first snow partially melts and the water freezes on the ground and in the plants.
12.	Moarri	Go algá galbmot muohtagiera, go álgá njázudit ja cuoŋudit omd, beaivet lea liggen muohttaga, go de galbmigoahtá ja de boahtá dan muddui ahte gosii guoddá, muhto ii dette guotte bajil lea nu garas ja ii ge dette guotte. Dat lea doajadat muohta, sáhttá nádjat maid julggiid. Boazu lea dalle árggit, dat ii mana moarrin, dat vuordá dassá cuoŋuda. Jus don vuojehat, dat lea hui lossat mannat moarrin. Giđđa-dálvve, giđđat. Measta guoddá, muhto ii dettege guotte bohcco.	*Moarri* is a condition in which a crust is formed on the surface of the snow as a result of alternative thawing and refreezing of the top layers. The crust is not quite hard enough to support the weight of people or reindeer and will cut the feet when one breaks through. The reindeer avoid going into *moarri* and will wait until it becomes *cuoŋu*. If you are trying to move the herd, it becomes very difficult to do so because it is hard for the reindeer to move through this type of snowpack. *Moarri* is almost hard enough to support the weight of the reindeer,	it can contribute to poor guohtun, but not always	This snow improves traveling conditions for humans, but contributes to difficult traveling conditions for the reindeer	Not discussed in connection with tracking		Spring – winter, spring	Surface	One of the elements of the spring cycle.	In the Norwegian language, this is called "break" crust. During the day: Melting, Class MFcl MFpc formulas. At night: Melting, MFcr The strength of the layers depends on the crust thickness and on the temperature range of heating and cooling . The less the temperature differences between night and day, the weaker the crust.

			but breaks once they step onto it,								
13.	Skáva	go lea leamaš beaivet garra beaivvádat ja veaigái de čoasku, na de šaddá skáva, álggos dal skávvu ja maŋŋil de cuoŋuda seamma beaivvis seamma jándoris.	*Skáva* is the formation of an ice layer or snow crust from sun melt at the surface of the snowpack during the day, followed quickly by cooling later in the evening. *Skáva* conditions are usually followed by *cuoŋu* conditions within the same day.	Not discussed in connection with *guohtun*	This snow improved traveling conditions for human.	Not discussed in connection with tracking.		Spring – winter, spring	surface	One of the elements in the spring cycle.	Ice layers and crust from sun melt, Class IFSC. This condition occurs when the sun melts just the snow at the surface and then the surface becomes cooled enough to form an ice layer. Can form a mirror surface.
14.	cuoŋu	Álggos go lea hirbmat beaivvádat ja bivval ja sáhttá vaikko vel arvi nai.. de šaddá muohta sievlla ja dat šaddá soavli javri.. de šaddá nu čoaskkis ja dat lea gal dábálaš dat lea ihkku dat čoaskis šaddá. de dat galbmo bajil dat muohta, šaddá measta dego jiekŋa. Buorre siivu. Dasa mii galgá vánddardit, dasa lea buorre, muhto dasa mii bohccuid galgá guođohit, dasa gal ii leat buorre dat. Boazu ii beasa guohtut ja ii leat buorre ealát. Giđđat. Vumiin dat cuoŋuda oainnát ovddemuš.	*Cuoŋu* snow conditions are different forms of melting snow which develop when the weather is very warm, sunny, and mild then followed by rain. The snow then becomes *sievlla* (and on the lakes it becomes *soavli*). But subsequently, when it becomes very cold and that snow freezes, it will be almost like ice. Then, it is good traveling conditions for the reindeer. But difficult traveling conditions for the herders. In the forest areas, *cuoŋu* develops first under these conditions..	Very poor guohtun. Hard snow. The reindeer cannot graze and it is not good *ealát*.	Good traveling conditions	It is difficult to see tracks.		Spring – winter, spring	surface	One of the elements in the spring cycle.	Melt forms of snow, Class MFcr. This can include pouring the snowpack, which leads to a very hard and strong surface layer. If the snow freezes again after its initial freeze – thaw, it is not possible to dig through this snow. This condition does not happen very often.
15.	Oppas	1) lea gokko eai leat guhton bohccot. Dakko beassá guođohit jus lea ealát. boazu beassá čađa 2) Borggai nu olu aht ii goastá ii gosage	Two types of *oppas* (untouched snow) are: 1) One type of *oppas* describes an area where there has not been re-feeding. The snow is soft and it is easy for the reindeer dig through the snow pack to reach the food at the bottom of the	1) it is estimated that this type of *oppas* can provide good pasture access (guohtun) because the snow has not been touched	2) this type of *oppas* contributes to difficult traveling conditions for the reindeer and herders	Good for tracking		Entire snow season	Throughout the entire snowpack. Includes all the snow types in the snow pack, from the surface to the bottom (i.e. *seaŋáš*).		Untouched snow. We cannot find a comparable physical explanation of this classification. When the reindeer are grazing, the trampling destroys the mechanical snow crystal structure, which, in turn, causes the sintering process to

			snowpack. These conditions enable the herd to move in pastures for feeding. 2) Another type of *oppas* is characterized by very deep snow which makes it difficult to travel because it is necessary to wade.								accelerate. Then, the snow becomes hard for the reindeer to dig through to graze. The same process occurs in a snow scooter track.
16.	Seakŋut	go seakŋu muohta, de váldá visot dan bodneskártta ja geartni ja visot gearddi.	This is a verb which describes the process by which *Seaŋáš* changes the snow so that it becomes more porous, and both *bodneskárta* and geardni disappear.	Contributes to good guohtun						Transformation process that causes hard snow to be converted to *Seaŋáš*.	The process which changes snow from faceted crystals, Class FC, to cup crystals, Class DH. This can happen, but the process goes very slowly.
17.	čiegar	Ferte leat muohta jus galgá šaddat čiegar. Doppe lea guđohagat, eambbo bohccot leat leamašan dakko ja guhton, ja galbma suovnnjit. Dat garas. Dakko ii leat ealát. Garra muohta. Dakko ii sáhte guođohit Unnán muohttagiin ii šatta čiegarin. Jus dalle čiegarduvvo, de láve ovddabeal juovllaid fas dakko sáhttit guođohit ođđasit. Don it sáhte dakko gal balljo dan dálvvi guođohit ,dat lea gal hui hárve goit dakkár eanan. Jus dal jur lea hui buorre jeagel-eanan, de gal dieđusge soaitá vel aht dat, dat fas buorida doppe dan vuođu nu ahte guođohit ganske, muhto, ii guorbaset eatnamiid gal dat... daid ii sáhte moatte háve guođohit ovtta dálvve.	Čiegar is hard snow which has been heavily trampled by reindeer and, thus, compressed into snow so hard that the reindeer are not able to dig through it to access the plants and the herders should avoid these areas. Sometimes the *čiegar* conditions can change to a more favorable snow state for grazing, and if it is an area rich in lichens, then the reindeer can be allowed to graze there. In the very rare cases where an area with small amounts of snow develops into *čiegar* conditions and the lichens are abundant, it is possible to let the reindeer graze this area before Christmas, but not throughout the winter. Reindeer cannot be returned	Very poor *guohtun* condition of hard snow, because the reindeer herd have trampled the snow and grazed the available forage.	Contributes to difficult traveling conditions	It is difficult to see tracks.		Winter, spring-winter	Almost the entire snowpack, although there is not much snow.	Snow transformation caused by animals.	No direct analogy but this describes areas where reindeer have grazed and trampled down the snow. The mechanical breakdown and sintering described in 15 and 16 describe the opposite process to *čiegar*.

		Dat ii liegganan dat bodni. Giđđadálvvi gal lea čiegar.	repeatedly to these thinner snow areas to graze because the bottom of this snowpack will be frozen too hard to permit access to food.								
18.	Bearta	Čakčat lea leamaš muohtavahca ja lea bivaldan ja dat liegganan, dat muohta šaddá measta dego jiekŋan, hui rušas ja garas. Muhtun saji bievla ja muhtun saje veahá muohta. Lea gaskadilli mii ii leat goabbá ge, ii leat bievla ii ge leat dálvi ge. Oaidnimii ja mátkkošteapmái ii leat nu buorre. Dalle šaddá hirbmadit guođohit go eallu hilbi. Boazu vázzá hirbmadit dan muohttaga nalde, girjját eananbievla-dielkkuid, bovdna-oivviid mielde. Dalle ii leat buorre vuohttit daid luottaid. Čakčat, sáhttá maid leat čakčadálvvi	*Bearta* is an intermediate condition which involves both bare ground and/or snowpack, which occurs in the fall after it has been snowing but when the weather has become milder again. The snow and ground become like ice - rough and hard. In some areas, it is bare ground; and in others, snow. It is difficult to see tracks and it is difficult to travel. The reindeer tend to walk a lot when it is *bearta*,	Not discussed in connection with guohtun	Contributes to difficult traveling condition	It is difficult to see tracks.	Visibility is bad.	fall	The entire snowpack – with litle snow		No direct analogy. This phenomenon describes snow distribution and does not fit any specific snow classification category.