Recent Snow Cover Changes of Lemming Habitats in Greenland as derived from Landsat Imagery

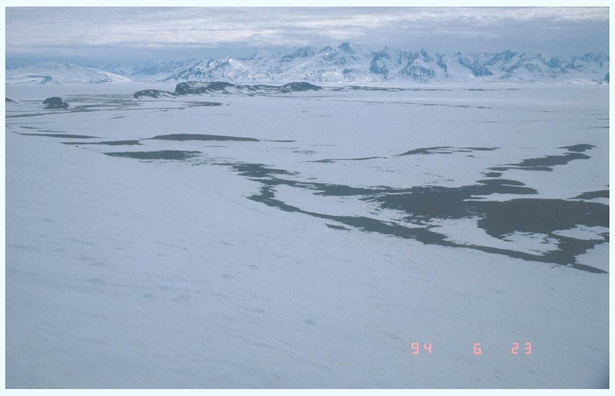
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Snow cover, one of the most prominent factors for life in Arctic environment

Arctic landscapes, home of so-called chinophile species





Northern tundra ecosystems may experience comprehensive snow cover for up to 9 months, until mid June.

Lemmings, among the best adapted mammals for life in snow habitats

Living in habitats covered with snow up to 9 months/year, lemmings are best adapted to live in a subnivean environment.
Winter breeding that is their forte is the prerequisite to the population outbreaks leading to peaks.





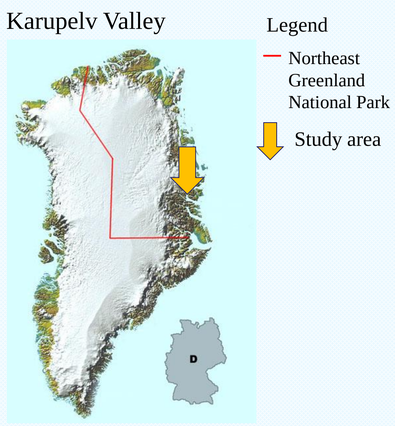
Lemming winter nest revealed during snow melt

Long term monitoring of winternests (1988 – 2013) has provided unprecedend insights into the cycling dynamics of lemmings.

Snow cover mediating reproductive output as well as interactions with predators such as stoats.

Assessing caracteristics of arctic snow cover, a challenging approach

Study site in High Arctic Greenland,



Critical snow-related parameters for lemmings include

Yearly chronology of snow events

- Establishment of automnal snow pack
- Length of snow covered period versus length of snow free period
- Timing of snow melt

Related changes and dynamics of snow quality

But: monitoring of such snow data an often sidelined component of weather stations, since also hard to get assessed automatically

For whole NE Greenland, such data are largely missing

Landsat Imagery as a substitute providing snow information !

- Unique time series for terrestrial remote sensing (since 70-ties)
- Valuable insights into snow cover in the most remote regions
- until now, poorly used to assess changes of snow conditions in high arctic ecosystems

Diachronic analysis of snow cover and changes by a visual assessment of Landsat sceneries

Availability of Landsat data for NE Greenland

Overlap of orbits near the Poles enhances repetition cycle = more sceneries including study area (frames i.e orbit-paths 227/9; 228/9, 229/9, 230/9)

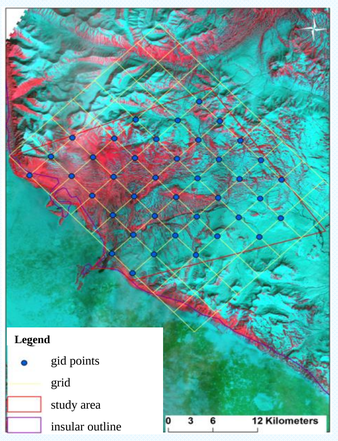
For the purpose of the present study, selection of

- Sceneries in Spring and Autumn
- Only sceneries whose quality allows for visual retrieval on snow information

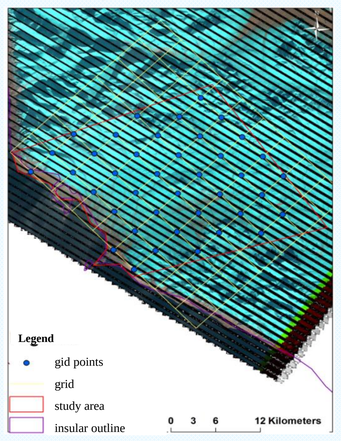
Criteria adopted to select relevant sceneries

- Delineation of area: Lowlands Karupelv Valley (around 650 km^2)
- Analysis of a total of 40 grid points evenly spaced 4000 m apart
- Each grid point was then assigned to one of 4 main groups (snow, no snow, snow in transition zones, status undetectable) based on an ***interpretation key***

Examples of selected images depicting snow cover pattern in Karupelv Valley during Spring melt as well as after a first autumnal snow event that blanketted the valley. Note also the even distribution of the 40 grid points assigned to the prevailing snow status as retrieved by the Landsat sensors



Left – 3 july 1994, during snow melt

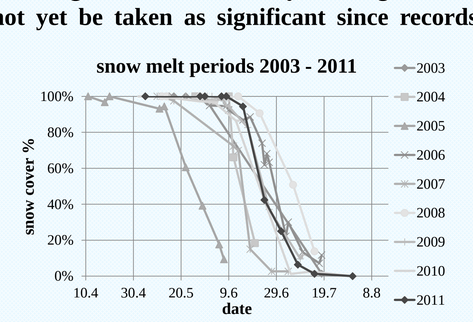


right – 19 september 2006, after new snow event

Main results : Record of both subtle as well as prominent trends emerging from a great natural variability

Patterns for the timing of snow melt

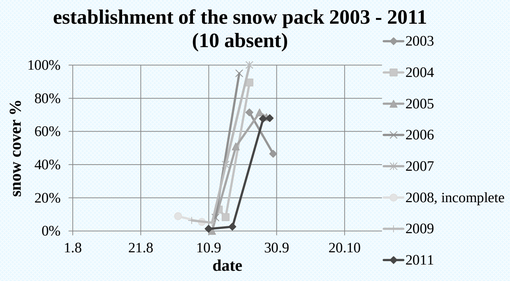
For the sake of clarity, snow depletion curves were grouped in sequences covering each 9 years. While relying on a variable number of usable scenes, they depict also a high variability between the years, with melt generally completed by the end of June. Due to complexity of processes involved and this high natural variability, the slight advancement trend assessed cannot yet be taken as significant since records are not long enough.



Establishment of the automnal snow pack

Contrasting with the more gradual ablation of snow in spring, the establishment of the ne snow pack in autumn is generally a process that occurs in a short time lapse.

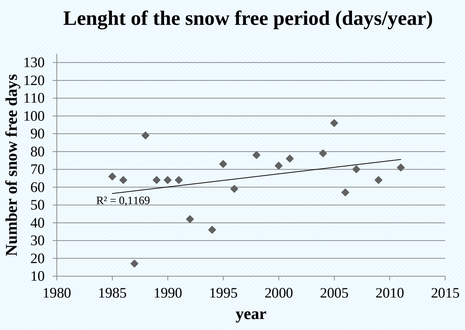
The comparisons suggest a significant trend towards a later covering of the area by fresh snow in autumn.

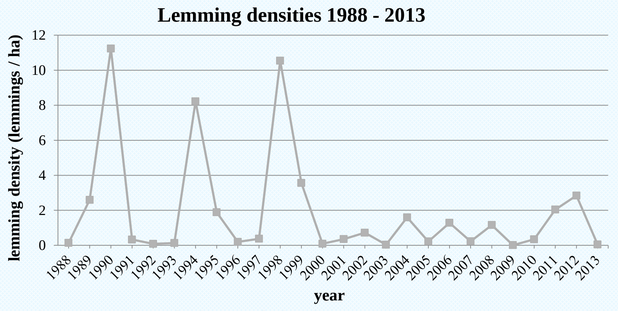


Trends in the length of the snow free period

A regression line based on the variation in the length of the snow free periods shows a light positive trend.

It indicates a lengthening of the snow free period from 1985 to 2011 of 0,57 days per year for a total of 21 days (p=0,14).





The apparent fading of the lemming cycles as assessed in this long term monitoring of winter nests (1988 – 2013)

Significant trends in the increase of the snow free period since more than a decade may in fact have induced these prominent changes in fluctuation patterns, with no longer any spectacular population outbreaks resulting from reproductive output in the subnivean environment.

Getting better insights in related processes will become a major issue within this ongoing long term project.

Discussion and Outlook

This remote sensing approach has provided evidence of some **pervasive changes of snow cover** in this high arctic site in NE Greenland, **in agreement with trends reported on a more general scale for the Arctic**. While stressing the potential of Landsat as a data source for such approach, observations achieved here call however for some critical appraisals of their significance and validity.

First, due to the resolution imposed by Landsat data, snow conditions actually experienced by the lemmings that select **small micro-habitats featured by the greatest accumulations of snow cannot be directly addressed in this study**

Further, while winter reproduction in subnivean habitats is essential for population increases, **it remains uncertain to what extent the shortening of the snow covered period really affects the apparent weakening of the reproduction output** as empirically revealed by this long term monitoring based on a survey of winter nests (see figure). Likewise the approach adopted here provides **no insight on changes in the quality of snow** as another important factor governing the ecology of lemmings and their predators.

Besides the need for longer time series, some of the shortcomings could be surmounted by **complementing this approach with the use of Radarsat data** whose potential to address snow conditions experienced by high arctic communities still remains to become evaluated.

The need to relate such changes in abiotic factors to the response of arctic animal communities as an approach seldom done is also highlighted by this long term study.

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