Permafrost decline and land cover changes (1986 – 2009) in Umiujaq, Northern Quebec, observed by high-resolution remote sensing data

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Introduction

The ongoing permafrost decline and land cover changes, accompanied by lithalsa degradation and the development of thermokarst features in Umiujaq, Northern Quebec was investigated. For it, high resolution remote-sensing images from 2004 and 2009, combined with 4 Landsat scenes from 1986, 1990, 2001 and 2008 and an ASTER image captured in 2001, served as analysis base. All images date to the summer of the respective year and hence allow a comparison in terms of the land cover. The intention was to confirm and to quantify earlier studies in this area, based on aerial photographies, and to update it to recent date. For the analysis different change detection techniques were applied and their results compared. The findings show an obvious increase of the vegetation cover within the time period of 23 years and highlight regions, where most of the alterations happen.

Methods

The general procedure for the analysis was first the typical preprocessing of the data including geometric and radiometric correction as well as image enhancement. Second a classification of the images in terms of their vegetation cover and third the application of different change-detection techniques depending on the sensor. These were the write function memory insertion, cross-correlation analysis, index differencing and tasseled-Cap-Transformation.

Results

The findings of the change detection analysis by using optical sensors show more or less similar results no matter what kind of technique was applied:

- Increasing vegetation cover was obvious between the period of 1986 and 2009.
- A general westwards shift of shrubs and small trees could be observed.
- A decrease of 6 % of the area covered by lithalsas was detected.
- The eastern part of the test site was clearly highlighted as the region where most changes happen.
- Also the lithalsas dynamics and the generation of new thermokarst ponds occurred primarily in the east.

Moreover it got clear that especially forested areas experienced an increase at the expenses on bushes and that barrow land is more and more captured by pioneer vegetation such as lichens and mosses.

Discussion

As with all the different applied method increasing vegetation was disclosed, it is an incontrovertible fact, that the changing climatic conditions are affecting the area in a high extent. It could also be shown that mainly the eastern part of the test site is affected by changes which is probably due to its location in the lee side of the Cuestas, where temperatures might already climb higher than on the west side. Consequently it can be stated, that the detected vegetation change and the degrading lithalsas are representing ongoing permafrost decline and adaptation strategies to avoid serious consequences for communities and the ecosystem are highly needed.

Conclusion

These outcomes are confirming to a great extent the expected scenic alteration, caused by climate change and permafrost degradation. This investigation could prove and validate the application of high-resolution satellite imagery and several analysis techniques for the detection indicators standing for permafrost changes and does hence contribute to ameliorate the monitoring of permafrost dynamics.