LAND USE AND LAND COVER CHANGE IN 1988 ~ 2007 IN THE YAMAL PENINSULA, RUSSIA

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1. INTRODUCTION

The Yamal Peninsula region in northwest Siberia has been identified as a "hot spot" of land cover change, since it is affected by climate change and various anthropogenic forcings. Large-scale oil and gas development combined with managed nomadic reindeer herds interact with sensitive tundra vegetation to produce extensive land cover changes. Oil and gas development can cause extraordinary change in land surface since a road and pipeline network is in need for oil and gas transportation. Changes in permafrost, drainage patterns and terrain and associated changes in vegetation caused by road construction have been documented and discussed. These plot-scale studies did shed light on how road construction and associated dust affected tundra vegetation. However, limited in space and time, these studies cannot offer insights on how spatial cumulative effects on both tundra vegetation and soil hydrology vary over time at a broader scale. The influence of fine-scale ecological patterns and processes at local sites on broader-scale patterns at regional to continental and global scales is poorly understood. How human activities change land cover in the Arctic and affect tundra vegetation needs further investigation.

Satellite imagery, observes systems at various spatial scales and potentially over longer time periods. Using the Normalized Difference Vegetation Index (NDVI) derived from Advanced Very High Resolution Radiometer (AVHRR) data, a 'greening' trend in arctic tundra vegetation consistent with increasing temperatures has been reported[1]. Shrub expansion in the Arctic, presumably caused by warming, has been captured by studies using repeat aerial photographs [2]. Many other physical and environmental parameters related to vegetation dynamics can also be retrieved from remotely sensed data, such as surface temperature, snow cover, soil freeze-thaw state, and growing season timing and length. In addition to these studies, remote sensing has been playing a crucial role in land cover and land use change research in the Arctic.

The objective of this study is to evaluate an image classification methodology based on satellite derived NDVI, albedo, surface temperature and NDWI in order to quantify the changes based on these variables.

2. METHODOLOGY

2.1 Study area and image data

The Yamal Peninsula is not only the source of much of Europe's current and future energy resources and as a result is of enormous strategic importance to Russia, but it is also the home of the world's largest area of reindeer husbandry. Study site chosen on the Yamal Peninsula for this study is a region encompasses Nadym city (northern boreal forest, forest-tundra transition), relatively close to oil and gas field facilities. The image pair chosen was mainly associated with the field sites set up in the Yamal Peninsula which can offer certain amount of ground information [3]. Satellite images used in the study is shown in the following table.

Study site	Date	Mission and Sensor	Path/row
Nadym	1988-6-19	Landsat-4, TM	160/14
	2007-7-7	Landsat-5, TM	160/14

2.2 image processing

First the image pair was first preprocessed. After calibrating the image from digital numbers (DN) to radiance values, we conducted a simple atmospheric correction using dark subtract. Then reflectance values were calculated, based on which we then calculated NDVI, NDWI and surface temperature [4, 5]. Albedo was also calculated based on the equation derived for Landsat imagery assuming that the surface was lambertian [6]. The equations are given below:

$$\text{NDVI} = \frac{\rho_{\text{RED}} - \rho_{\text{NIR}}}{\rho_{\text{RED}} + \rho_{\text{NIR}}} \text{ (TM band 3 and band 4)}$$

$$\text{Albedo} = -0.0018 + 0.356\rho_1 + 0.130\rho_3 + 0.373\rho_4 + 0.085\rho_5 + 0.072\rho_7$$

$$\text{NDWI} = \frac{\rho_{\text{NIR}} - \rho_{\text{SWIR}}}{\rho_{\text{NIR}} + \rho_{\text{SWIR}}} \text{ (TM band 4 and band 5)}$$

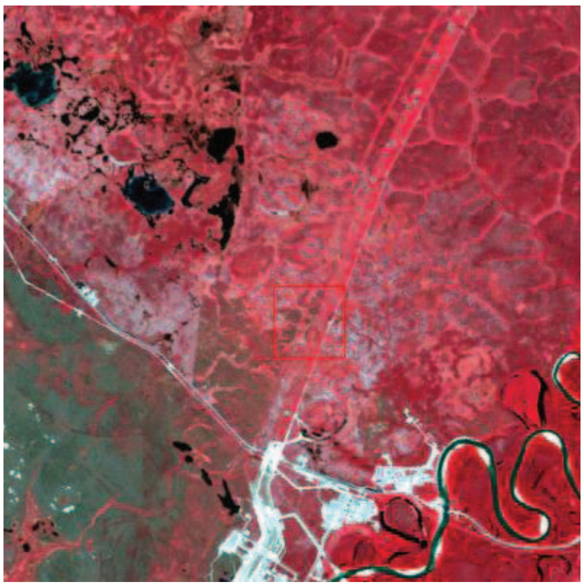
2.3 relative normalization and difference maps

In order to minimize the phenology effects, we normalized the image by subtracting the mean difference between images. To be specific, we calculated the mean value for each image (mean1 and mean2), then for the final difference map of NDVI, NDWI, Ts and albedo we use the equation:

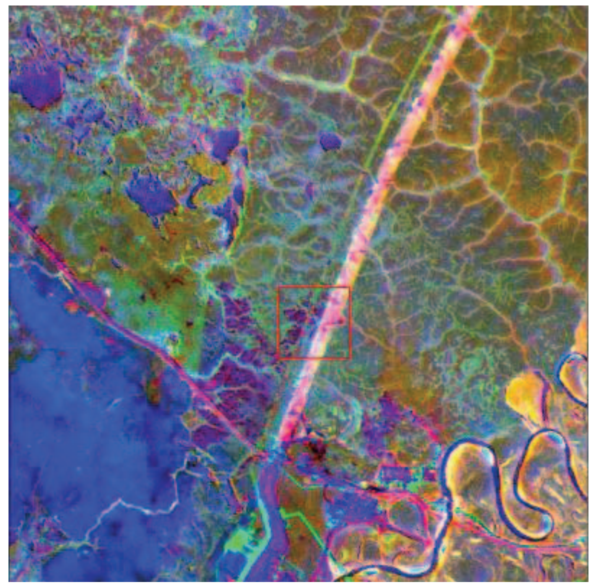
Variable difference map = Image [2007] - (mean [2007] - mean [1988])

3. RESULTS

Based on the difference images for NDVI, NDWI, albedo and surface temperature, we detected different kinds of land use change in Nadym. For the Nadym site, where the field sites were close to the city, we could easily locate the changes such as new expanded facilities and roads. NDVI and albedo difference images can provide the information on the recovery of vegetation around pipelines and new-built pipelines, suggesting that multi-temporal Landsat imagery can be very well used to detect land use changes such as road, building and gas facility constructions. While using multi-temporal Landsat images can help detect infrastructure changes in the Yamal region, application of these images to detect other more subtle changes to the vegetation are limited by the phenological and hydrological differences that were caused by the different times during the summer that the images were obtained.



Landsat TM 2007 spectral image, Red- band 4, Green- band 3, Blue – band2



Difference map 2007-1988Red - NDVI, Green - albedo, Blue - Ts

4. REFERENCES

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