Satellite Image Based Mapping of Wetland Tundra Landscapes Using ILWIS GIS

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Research Goals

- Distribution of different types of landscapes in the wetland tundra of the Yamal Peninsula
- Monitoring changes in the landscapes of tundra
- Analysis of the landscape dynamics for 2 decades (1988-2011).
- Data: Landsat TM satellite images for 1988 and 2011
- Application of ILWIS GIS for spatial analysis and data processing on the region of Bovanenkovo, Yamal.
- Technical approach: Remote sensing data processing by ILWIS GIS.
- Methods: Supervised classification of Landsat TM images
- Study area: tundra landscapes in the wetlands of the Yamal Peninsula in the Far North of Russia

Geomorphology of the Yamal Peninsula

Key points on the Yamal geomorphology:

- Elevations almost flat, terrain less than 90 m.
- Seasonal flooding
- Active processes of erosion
- Permafrost distribution
- Local formation of ground cryogenic landslides
- Specific ecological and climatic conditions (Arctic)

Landscapes of the Yamal Peninsula

* Cryogenic landslides are formed as a result of the soil erosion are typical processes in the Yamal Peninsula
* Soil erosion develop as a result of the soil subsidence and soil thawing
* Cryogen landslides have a negative impact on the local ecosystems
* Cryogen landslides disrupt the strata of the soil and slow down restoration of vegetation after the landslide

Cryogenic Landslides on the Yamal Peninsula

- The negative effect of cryogenic landslides - changes in types of vegetation cover at the place of their formation.
- For 10 years after active cryogenic landslide processes, the area of their occurrence remains uncovered.
- Then, over the next few years, a process of slow restoration of the soil and vegetation cover takes place
- Vegetation succession: plant communities with dominant herbs, mosses, lichens and sedge, willow and meadows with short shrubs.
- Vegetation in the early stages of restoration (mosses, lichens) indirectly indicates recent formation of the cryogenic landslides
- Meadows and willow shrub, on the contrary, indicate a relatively developed and restored plant community.
- Areas subjected to the formation of cryogenic landslides in past 2-3 decades are usually characterized by the spread of willow and shrubbery, an indirect indicator of these processes in the past.

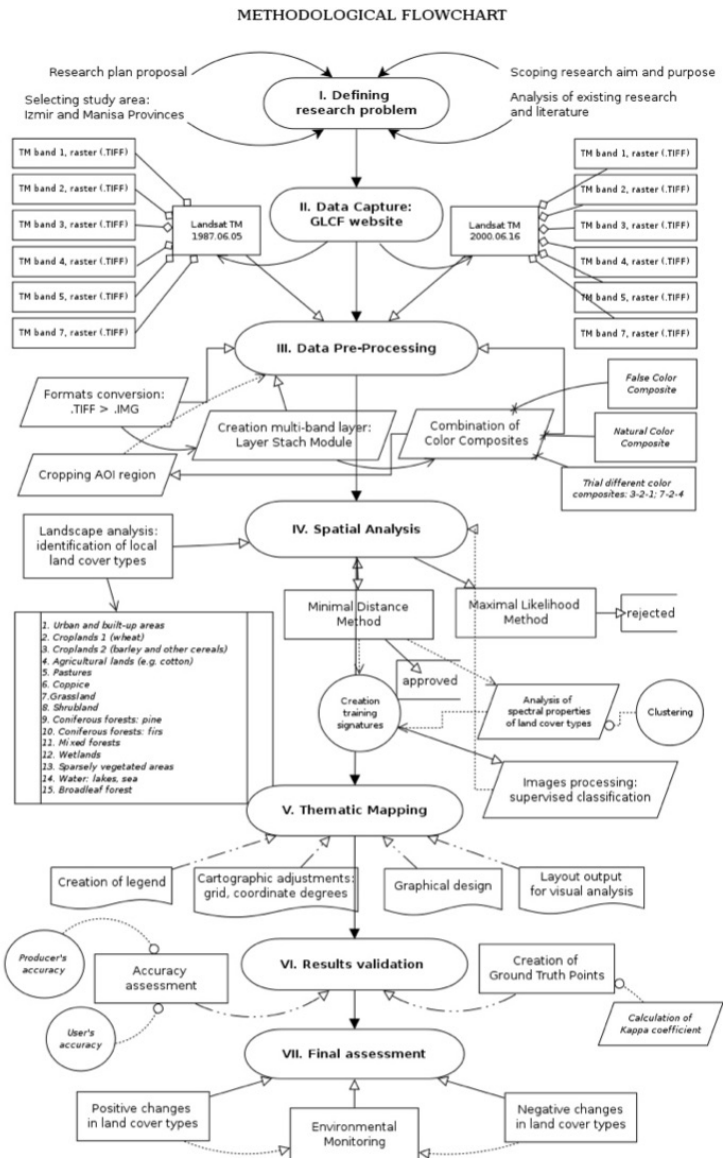
Data Processing Algorithm

Examples of various types of the vegetation typical for the Yamal tundra, Arctic.

Algorithms of the data processing in ILWIS GIS:

i. Data collection, import and conversion
ii. Data: 2 Landsat TM images, 1988 & 2011
iii. Data pre-processing
iv. Georeferencing: WGS 1984 ellipsoid to UTM, E42, NW
v. 3 spectral channels for image processing: color composite& multi-band layers
vi. Clustering segmentation and classification
vii. GIS mapping, spatial analysis
viii. Google Earth imagery verification
ix. Results interpretation

Research Questions and Aims



Research questions and aims:

(I) The aim of the work is the use of GIS and RS data (Landsat TM) for monitoring tundra land cover types

(II) Approaches: images classification, visualization and mapping

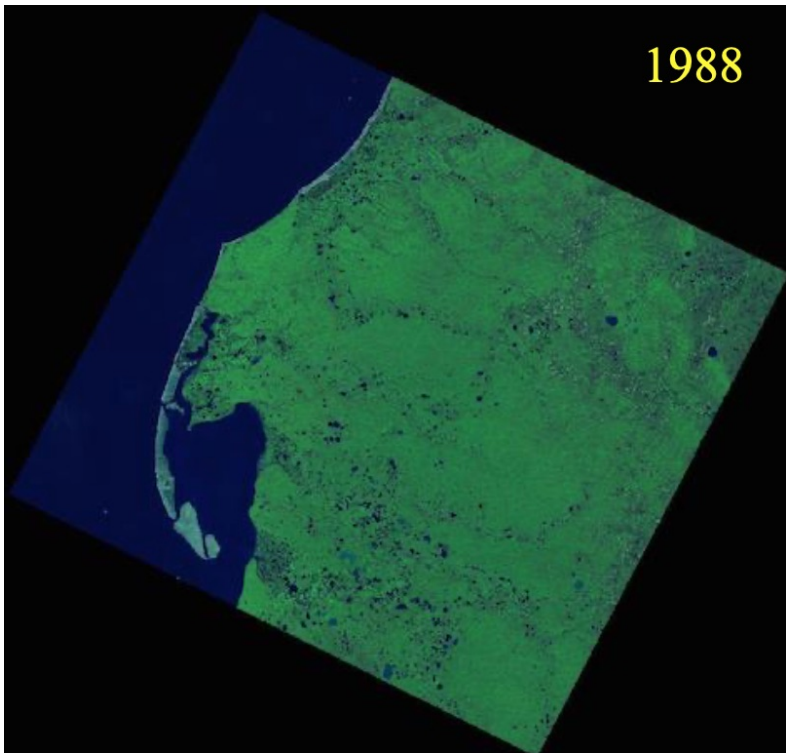
(III) Have landscapes within the test territory of the study region changed over the past 14 years (1988-2011)?

(IV) What types of land cover types were dominating previously, and which ones are now ?

(V) Methodologically, how ILWIS GIS can be used to process RS data ?

Landsat TM images

- AOI mask: 67°00'-72°00'E-70°00'-71°00'N
- Time span: 23 years (1988-2011)
- Images taken during June to assess vegetation
- Original Landsat TM images (.tiff) were converted to the Erdas Imagine .img format.



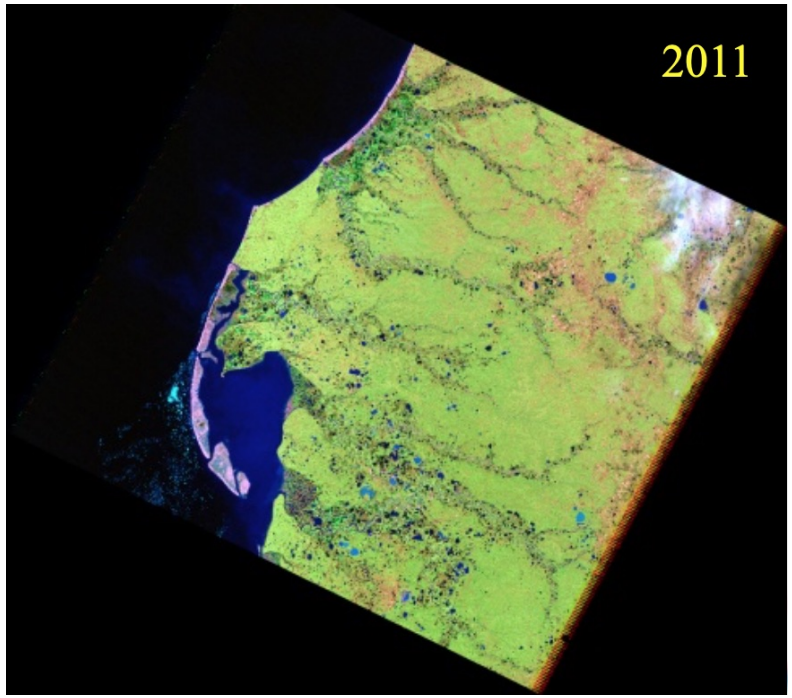
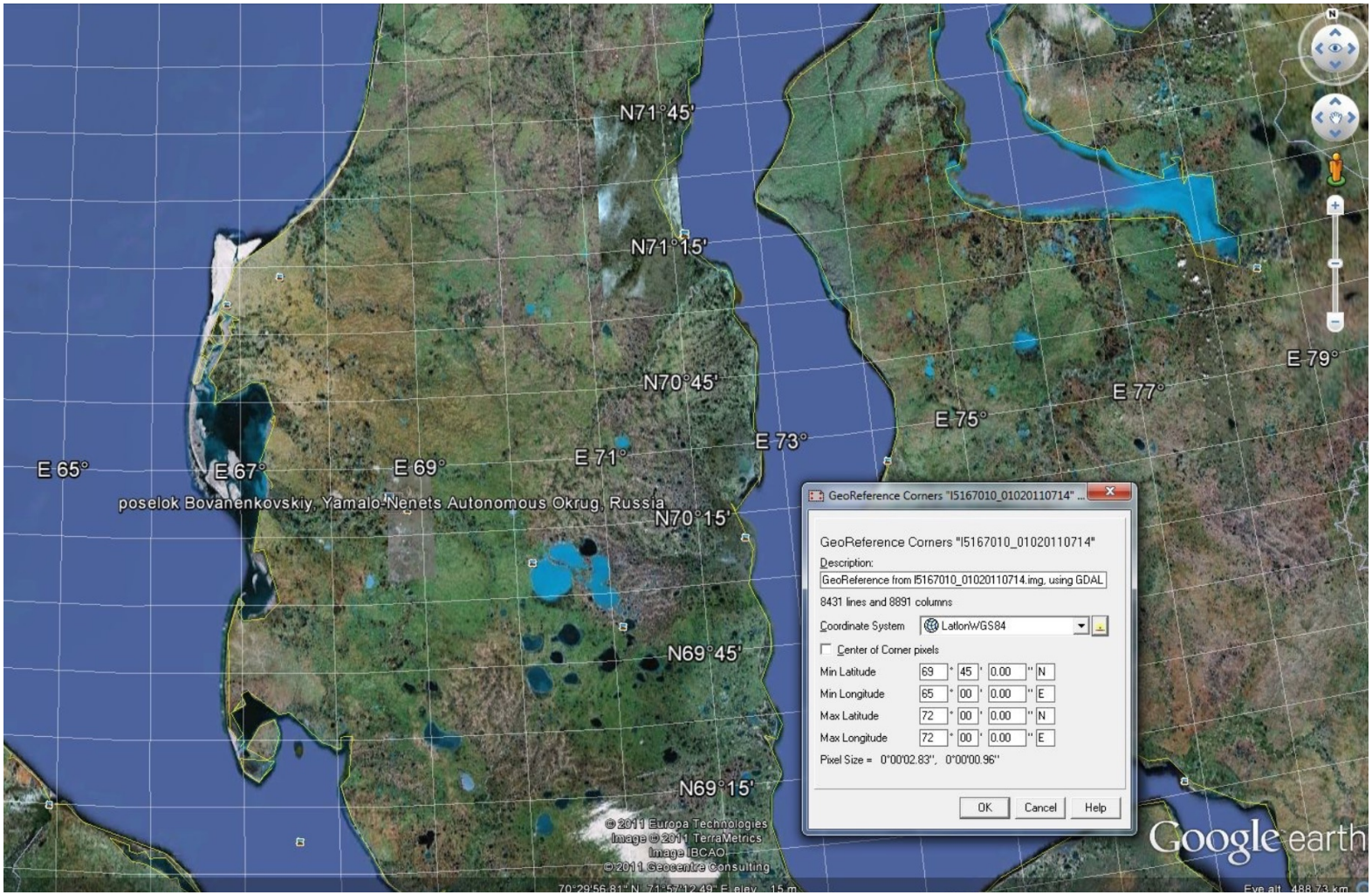


Image Georeferencing



Georeference Corner Editor of ILWIS GIS

Spectral Reflectance (SR)

SR i. Image classification is grouping pixels into classes (merging pixels)

SR ii. Clusters correspond to the types of vegetation cover according to the AOI settings

SR iii. Classification is based on using spectral brightness of the image pixels

SR iv. Spectral and texture characteristics of various land cover types are displayed on the image as different spectral brightnesses of the pixels

SR v. Spectral reflectances show spectral reflectivity of the land cover types (through pixels' spectral brightness) and individual properties of the vegetation objects detected on a raster image

Image Clustering

(a) Cluster analysis is a statistical procedure for grouping objects (pixels on a raster image)

(b) Pixels are ordered into homogeneous thematic groups (clusters)

(c) Each digital pixel in the image is assigned to the corresponding land cover type group

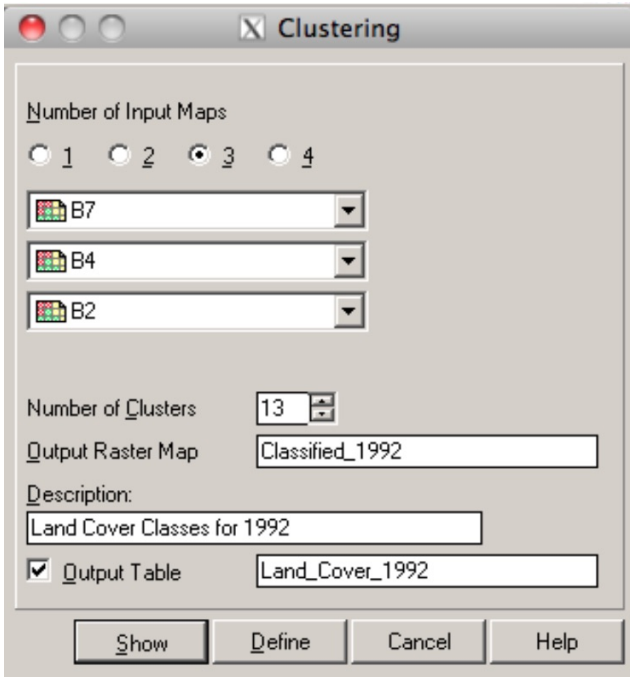
(d) Grouping is based on the proximity of the spectral brightness value (Digital Number, DN) of the pixel to the centroid.

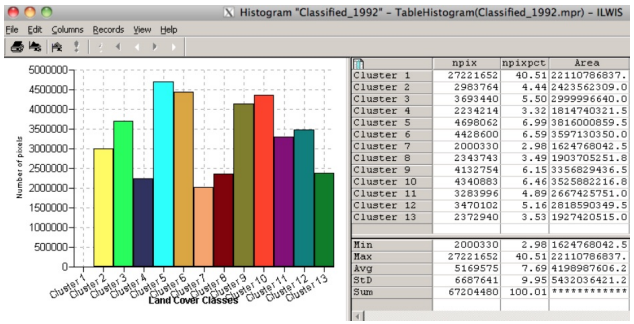
(e) The logical segmentation algorithm consists of grouping the pixels in the image (merging pixels) into clusters.

(f) Grouping pixels occurs in semi-automatic mode based on the distinctness from neighboring (neighbor pixels).

(g) The process is repeated interactively until optimal values of the classes (and pixels attached to these classes) are reached.

Image Classification (IC)





IC-1 Thematic mapping is based on the results of the classification of images

IC-2 Visualization of the landscapes' structure and vegetation types within the AOI.

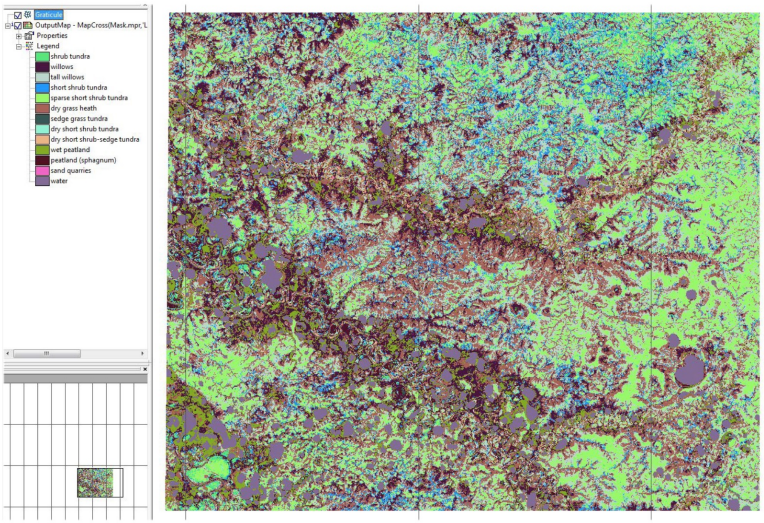
IC-3 To classify land cover types, image pixels were identified for each category and grouped into different land categories.

IC-4 Land cover types were evaluated and identified with each land cover class

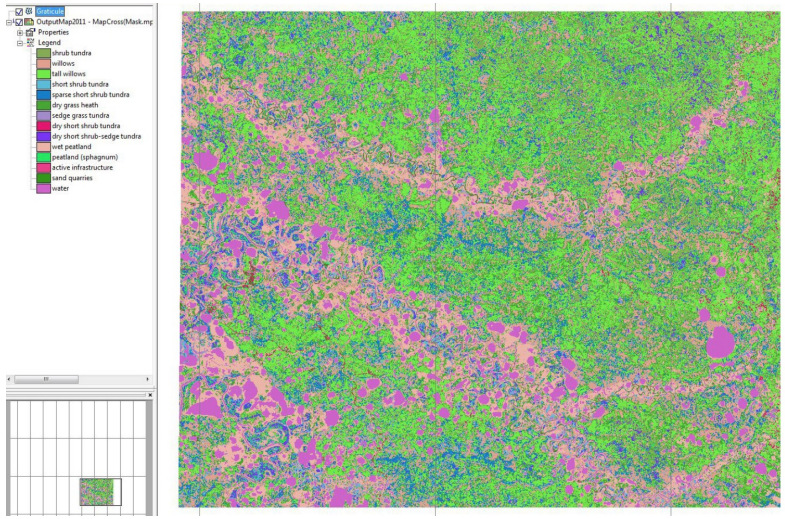
IC-5 Number of cluster groups is 13 representing vegetation land cover types of the Yamal tundra

Mapping Results

1988



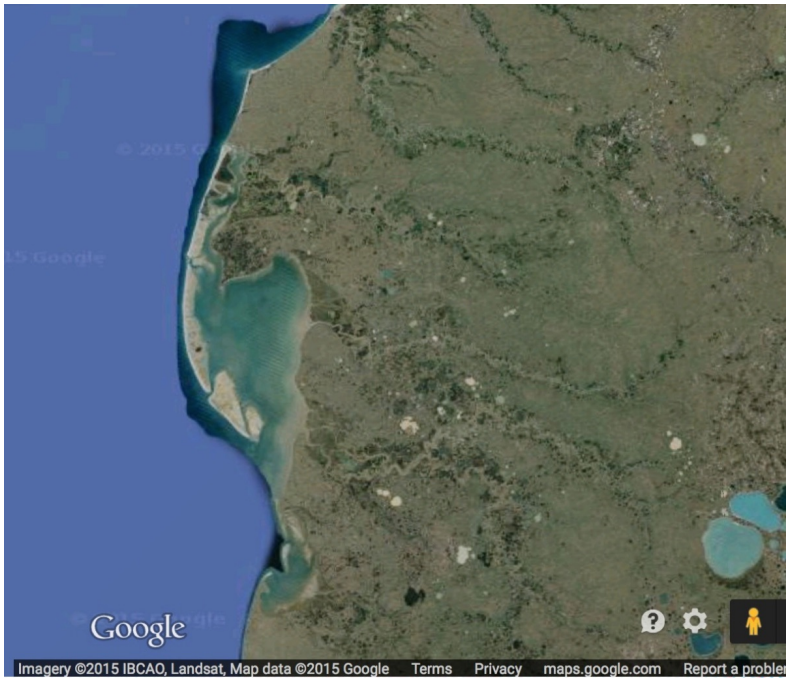
2011



Results Interpretation

- Statistical results of calculations of types of vegetation cover were obtained in a semi-automatic mode in ILWIS GIS
- 1988 'willow shrubs' type covered 412,292 pixels from the total part of the AOI, and 'high willow' class is 823,430 pixels
- 2011: willow increased to 651427 pixels, ('willow shrubs'), and 893092 pixels ('high willows')
- Both combined classes of willows, typical for AOI with a high water content, cover total 1544519 pixels, which is 40.27 %.
- Area of grasses decreased compared to shrub and willow
- Max area covered by class 'heather and dry grass' is 933798 pixels

Google Earth Verification



The selected area represents one of the most diversified part of the tundra landscapes of Yamal

- AOI has a complex structure of boggy landscapes and unique types of vegetation
- Therefore, in order to control the most difficult areas, the images were verified by Google Earth
- Visualization of the same area in the satellite image and Google Earth image at the same time.
- This made it possible to visually check heterogeneous areas with mixed land cover types and landscapes

Conclusions

I. Monitoring landscape changes is an important tool for assessing the ecological stability of a region

II. Spatial analysis of the multi-temporal satellite images by ILWIS GIS algorithms is an effective tool

III. Research demonstrated how Yamal wetland tundra landscapes changed over a 23-year period of time

IV. Data included LandsatTM satellite imagery covering the Yamal Peninsula, Far North of Russia

V. Image processing was done by classification methods.

VI. Results shown changes in the landscapes from 1988 to 2011

VII. Results confirm presence of the destructive processes caused changes in tundra boggy landscapes.

VIII. Research demonstrated successful ILWIS GIS based of the RS data analysis, effective for tundra monitoring

Thanks

Thank you for attention !

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