

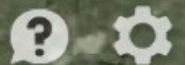


*Charles University in Prague,  
Institute of Environmental Studies  
Czech Republic*

Lemenkova P.

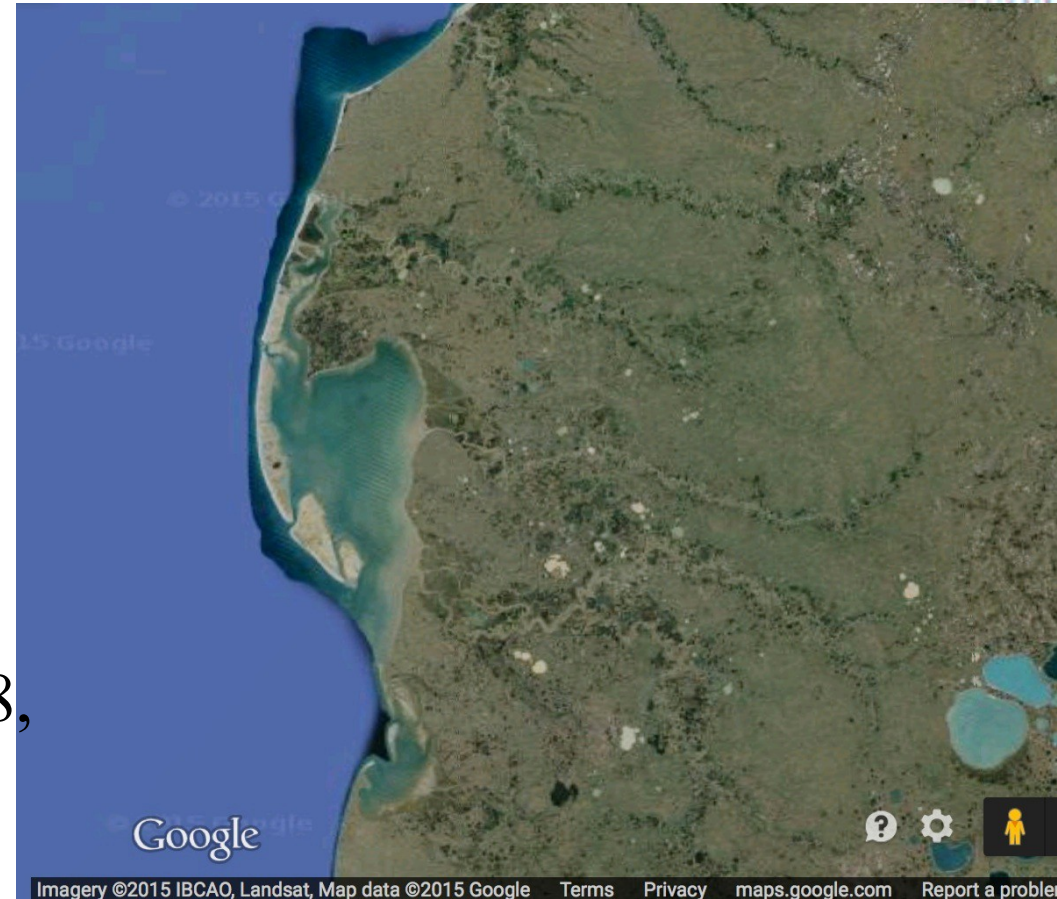
# **ANALYSIS OF LANDSAT NDVI TIME SERIES FOR DETECTING DEGRADATION OF VEGETATION**

Google



# 1 Brief Summary of Research Aims

- 1) GIS and RS application for environmental studies of Yamal
- 2) Calculation of NDVI
- 3) Monitoring vegetation changes in tundra landscapes
- 4) Analysis of the vegetation dynamics in the past two decades (1988-2011).
- 5) Data: Landsat TM scenes for 1988, 2001 and 2011
- 6) Originality: Application of ILWIS GIS spatial analysis tools and Landsat imagery for Bovanenkovo region in Yamal Peninsula, Russian Extreme North

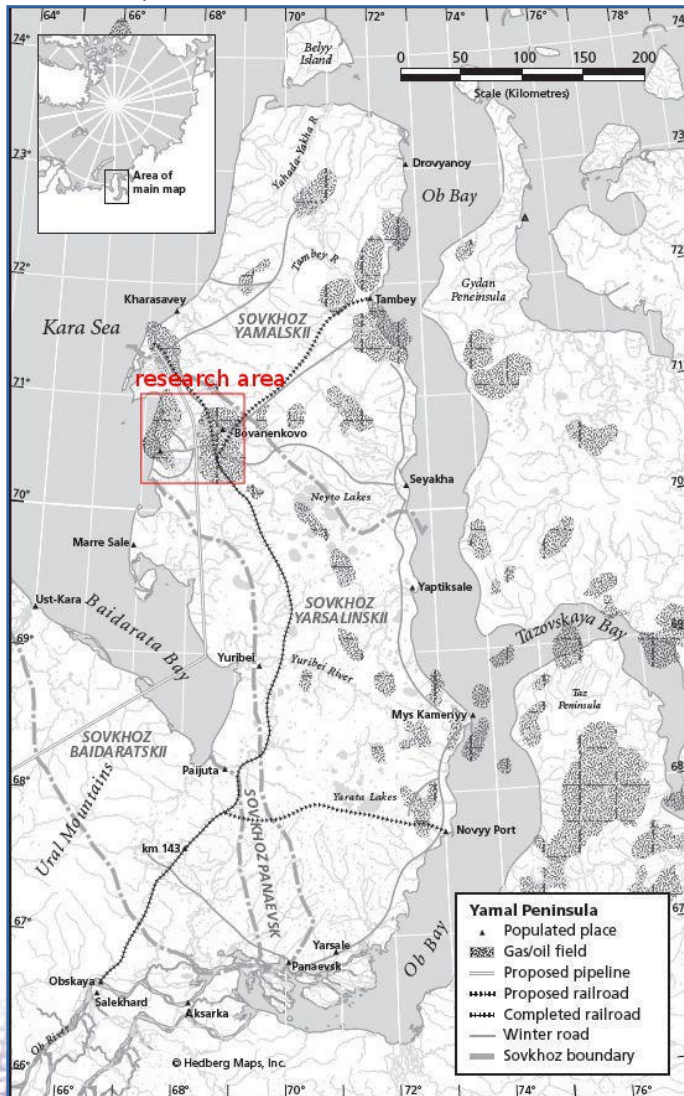


# Цели и задачи исследования :

- 1) Применение средств ГИС и данных дистанционного зондирования Земли (спутниковые снимки Ландсат ТМ) для мониторинга окружающей среды
- 2) Применить методы визуализации и ГИС-картографирования для изучения экологического состояния тундровых земель
- 3) Изменились ли значения индекса NDVI (и соответственно, состояние растительного покрова) в пределах тестируемой территории региона исследования за 1988-2011 ?
- 4) Методологически – как данные ДДЗ в сочетании с ПО ILWIS GIS может быть использовано для решения поставленных вопросов

# Study Area

Geographic location: Yamal Peninsula, north Russia



(a) Geographic location of Yamal  
(b) Location of the study Peninsula Map  
source: google.com area on Yamal  
(western coast). Source: B. Forbes

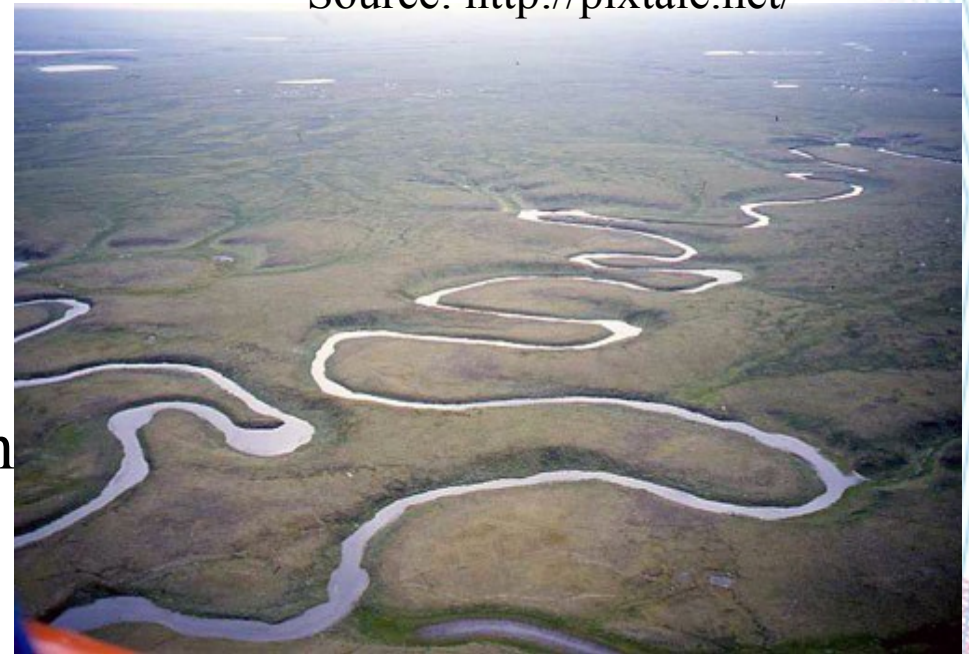
# Specific climatic-environmental settings of Yamal

Yamal Peninsula: geomorphology :  
flat geomorphology, elevations < 90 m

Landscapes of Yamal.  
Source: <http://pixtale.net/>

Processes:

- seasonal flooding,
- active erosion processing,
- permafrost distribution and
- cryogenic landslides formation



Landslides affect local ecosystem structure.

They change vegetation types recovering after the disaster.

# Landscapes of Yamal Peninsula



Yamal shrub tundra.

Source: [www.novaonline.nvcc.edu/](http://www.novaonline.nvcc.edu/)



Dwarf willows. Source:

[www.travelanguist.com](http://www.travelanguist.com)



Arctic willows.

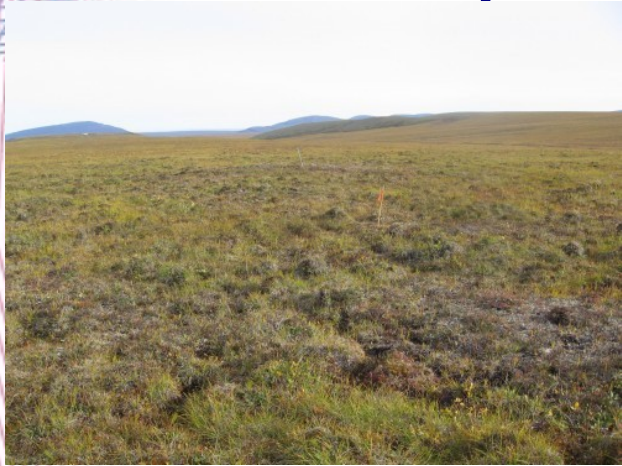
Source: <http://nature-plants.com>



Sparse short shrub

Source: [www.polarfield.com](http://www.polarfield.com)

# Landscapes of Yamal Peninsula



Сухотравная вересковая тундра (Dry grass heath tundra)



Осоко-пушицевая тундра (Sedge grass tundra)



Сухая кочкарная кустарниковая тундра (Dry short shrub tundra)



Landscapes of Yamal



Моховая тундра сфагнум (Sphagnum moss)

# Landscapes of Yamal Peninsula



Кустарниково-осоковая тундра  
(Dry short shrub sedge tundra)



Заболоченная тундра (Wetlands)



Коротко-кустарниковая тундра  
(Short shrub tundra)



# Methodology

**Technical tools:** The RS data processing was performed in ILWIS GIS software: Fig.1

**Research Method:**

- Image interpretation ( Landsat TM scenes)
- NDVI calculation.

Producing vegetation indices has been done in this research using mathematic calculation of the channels:  $(\text{NIR}-\text{VIS}) / (\text{NIR}+\text{VIS})$ , or a ratio for channels:

$(\text{Band4}-\text{Band3}) / (\text{Band4} +\text{Band3})$ .

NDVI values lie in the **range of 0 – 1** and never become negative or extend over 1, since NDVI is a linear algebraic function of these bands

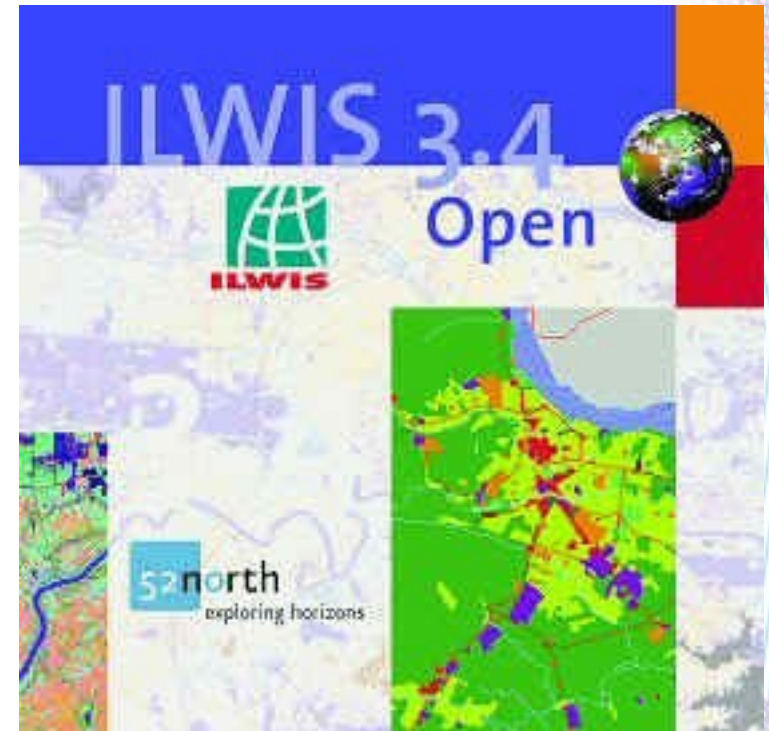


Figure: 1. ILWIS GIS.  
Source: [www.ilwis.org/](http://www.ilwis.org/)

# Advantages of NDVI

Calculation of vegetation indices, especially and in this case **Normalized Difference Vegetation Index (NDVI)**, has become one of the most successful, popular and traditional attempts in biogeographical research methods.

NDVI has certain advantages over other vegetation indices or band combinations:

- NDVI is less depending on soil properties of study area
- NDVI is less depending on the daytime illumination comparing to simple red-infrared bands combination
- NDVI is well adjusted specially for the analysis of vegetation properties
- NDVI can be indirectly interpreted from the objects colors, as shown on the raster image

# Workflow

## Data pre-processing

- i. import .img into ASCII raster format (GDAL). After converting, each image contained collection of 7 raster bands
- ii. Pre-processing (visual color and contrast enhancement)
- iii. Geographic referencing of Landsat scenes, initially based on WGS 1984 datum: UTM (Universal Transverse Mercator) Projection, Eastern Zone 42, Northern Zone W, (Georeference Corner Editor)
- iv. Crop of study area: the area of interest (AOI) was identified and cropped on the raw images. This area shows Bovanenkovo region in a large scale and best represents typical tundra landscapes.
- v. NDVI Calculation
- vi. GIS visualization and mapping

# Техническое исполнение

Технически, работа включает в себя следующие шаги:

- ❑ Сбор, импорт и конвертация данных (2 разновременных снимка Landsat TM на 1988 и 2011 г.г., соответственно)
- ❑ Геореференсирование снимков Ландсат, изначально имевших референсирование эллипсоид WGS 1984: UTM (Universal Transverse Mercator) проекция, Eastern Zone 42, Northern Zone W, с использованием Georeference Corner Editor, ILWIS.
- ❑ Пре-процессинг и предварительная обработка данных
- ❑ Создание цветных композитных снимков из 3 спектральных каналов Landsat TM (multi-band layer & color composite)
- ❑ Вычисление индекса NDVI
- ❑ ГИС картографирование и пространственный анализ
- ❑ Анализ и интерпретация результатов

# I. Import and data conversion /

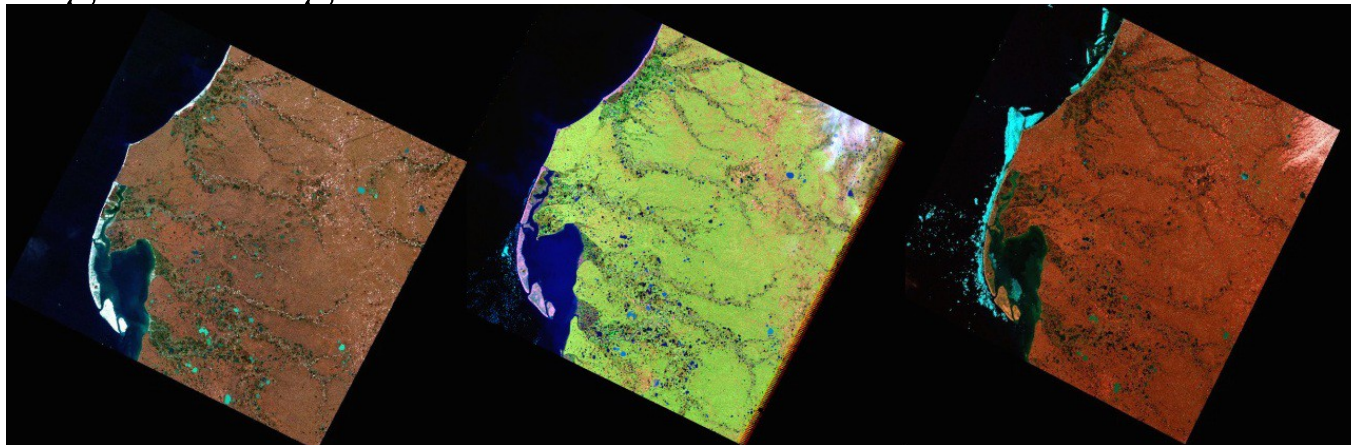
## Импорт и конвертация данных

Test area selection (Mask) / Для выбора нужной территории была наложена маска с координатами  $67^{\circ}00' - 72^{\circ}00'$  в.д. -  $70^{\circ}00' - 71^{\circ}00'$  с.ш.

Выбранные снимки показывают регион Ямала в 1988, 2001, 2011

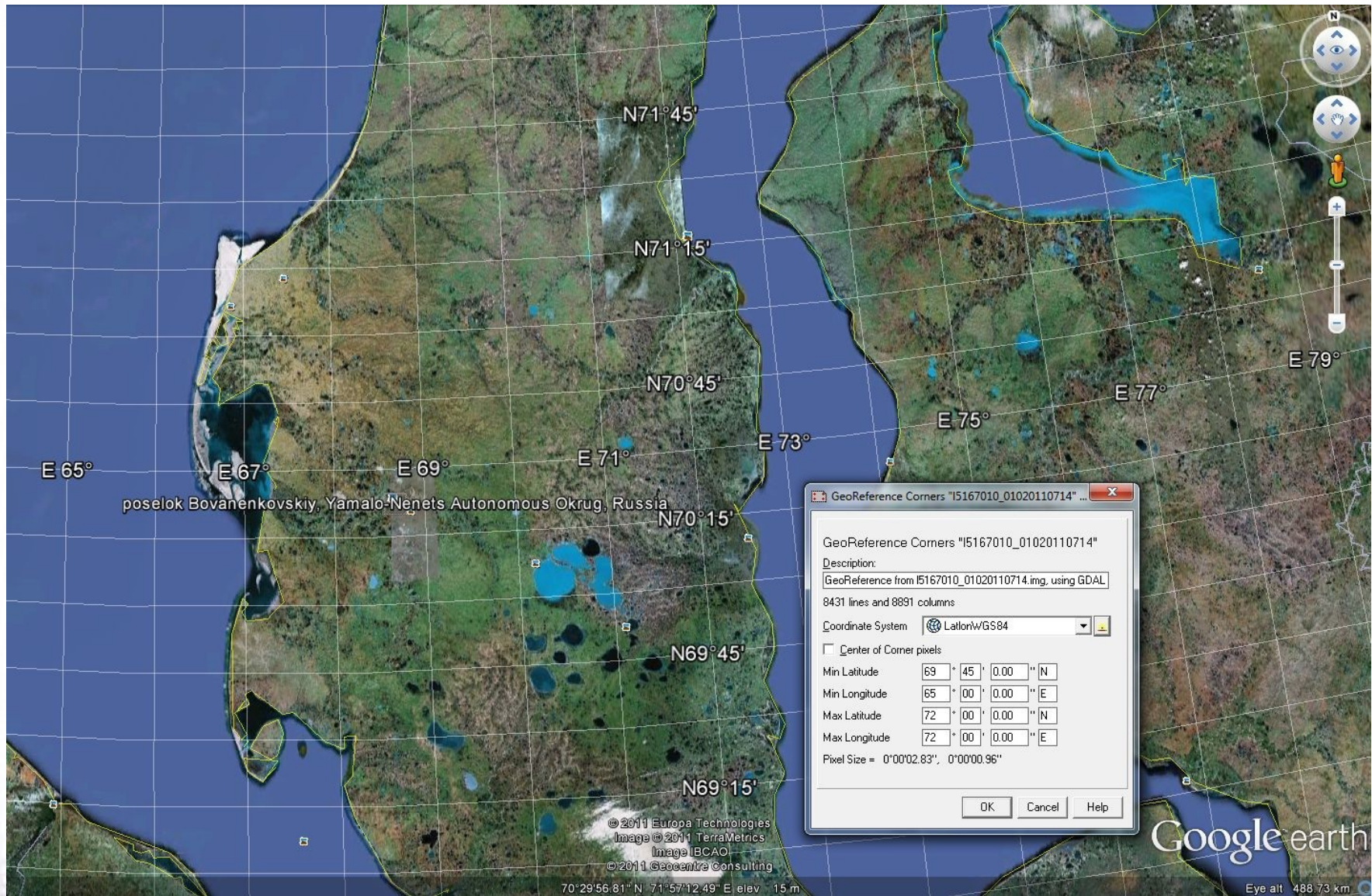
**3 Landsat TM images / 3** спутниковых снимка Ландсат ТМ:

- time span 23 years / имеют временную разницу в 23-г (1988, 2001, 2011)
- summer months / выбраны в летние месяцы для оценки растительности.
- data conversion / изначальные снимки в формате .TIFF конвертированы в Erdas Imagine “.img” .



Initial remote sensing data, left to right: Landsat TM 1988, bands 7-3-1; Landsat TM 2011, pseudo natural colors composite; Landsat ETM+ 2011 bands 6-3-1.

# Georeferencing / Геореференсирование



# NDVI Calculation

To model the NDVI I used Map Calculation tool in command line of the Raster Operations menu in ILWIS GIS, which enables to perform spatial analysis and modeling by combination of queries, arithmetic expressions and overlays of selected raster images. The NDVI was calculated using following equation:

$$\text{NDVI} = (\text{Band4} - \text{Band3}) / (\text{Band4} + \text{Band3}),$$

where Band 4 is DN values of spectral reflectance in NIR (near infra-red) and Band 3 is DN values of spectral reflectance in VIS (visual).

The NDVI was calculated automatically in ILWIS GIS using arguments of images: VegIndex = NDVI (Band3, Band4). Two Landsat bands have been used: Band4, containing red reflectance and Band3 with infra-red reflectance: VegIndex=NDVI(TM\_3, TM\_4).

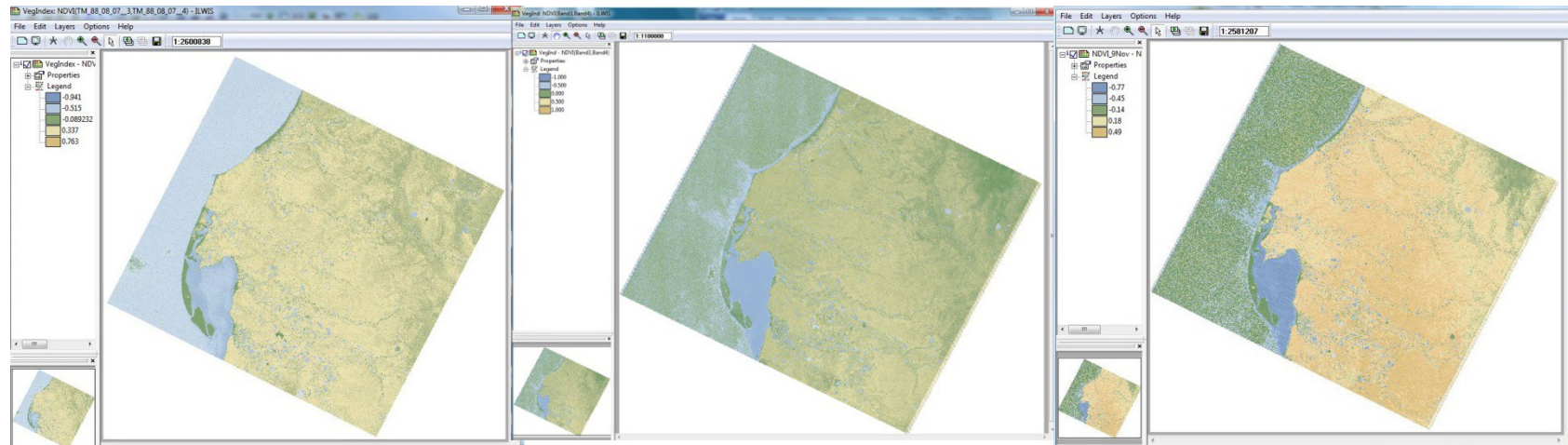
Other Landsat scenes were classified individually using the same method scheme in ILWIS GIS in the same way described above.

# Results / Результаты

1988

2001

2011



The resulting images shows distribution of the vegetation over the Bovanenkovo region within three (3) years: 1988, 2001 and 2011.

- The results for 2001 show that vegetation has very moderate overall index, reaching NDVI value 0,50 as a maximal.
- The maximal NDVI values in year 2011 are 0.49,
- The maximal NDVI values in year 1988 was 0.76.

Comparison of these results shows gradual decrease in the biomass values during the past two decades.



# Discussion / Заключение

- This research presented GIS based studies of environmental of Yamal
- The study is technically supported by means of ILWIS GIS which proved to be effective tool for spatial analysis
- Performed analysis demonstrated changes in the NDVI during period of 1988— 2011, calculated on the on the Landsat TM images
- The results show decrease in overall NDVI values for the study area, which is caused by the environmental and anthropogenic factors.
- The results of spatial analysis are presented as 3 GIS maps illustrating changes in vegetation based on the image analysis using NDVI.
- The calculated NDVI indicated biomass and can be also used as indicator of “greenness” of the vegetation.
- Application of RS data is especially important for studies of northern ecosystems, as it enables study of remotely located areas of Arctic
- GIS-based processing of the RS data ( Landsat TM) improves technical aspects of the landscape studies and monitoring

# Выводы

- Мониторинг изменений ландшафтов – важное средство для оценки экологической стабильности региона. Для этого, пространственный анализ разновременных космических снимков методами и алгоритмами ГИС представляется наиболее эффективным инструментом.
- Работа показала изменение растительности в тундровых ландшафтах в заболоченной местности за 23-летний промежуток времени (1988-2011).
- Данные включали спутниковые снимки Landsat TM, покрывающие п-ов Ямал, Крайний Север России. Обработка снимков была проведена с использованием методов ГИС (ILWIS GIS).
- Результаты показали изменения в значениях индекса NDVI с 1988 по 2011, что подтверждает наличие процессов разрушения тундровых ландшафтов.
- Работа продемонстрировала успешное применение методов ДЗЗ и пространственного ГИС-анализа, эффективные для мониторинга тундры.
- Представленный кейс продемонстрировал успешное применение ГИС-технологий для обработки данных спутниковых снимков для изучения изменений тундровых ландшафтов

# Literature / Литература (основные работы)

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**Thank you for attention**  
**Спасибо за внимание**