# Land cover classification of tundra environments in the Arctic Lena Delta based on Landsat 7 ETM+ data and its application for upscaling of methane emissions

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## 1. Introduction

Arctic river deltas are unique in terms of genesis, geomorphology, climate conditions and cryospheric and biological processes. They are dominated by various types of tundra wetlands and play an important role in the global carbon cycle. Processes leading to greenhouse gas emissions from these wetlands are of high spatial variability. Consequently, high resolution information on the distribution and extend of habitats and land cover units are necessary for an accurate spatial quantification of biogeo-chemical processes like methane emissions.


## 2. Study area

**Location**: Northern Siberia, Laptev Sea coast

**Coverage**: 29.000 km² (largest Arctic delta)

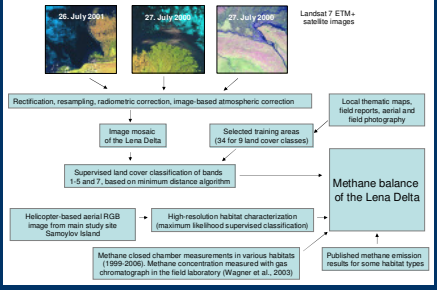
**Vegetation zone**: Lowland tundra

**Geomorphology**: Three main terraces + active floodplain

**Sedimentology**: Silty to sandy, often organic-rich deposits

**Special conditions**: Situated in the zone of continuous permafrost (sediments are perennially frozen)

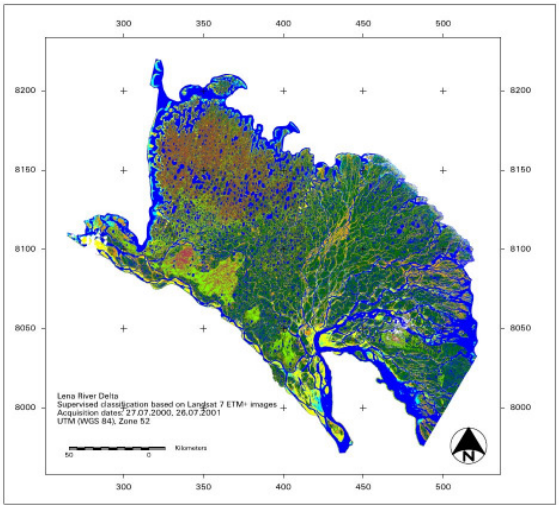
## 3. Data and methods

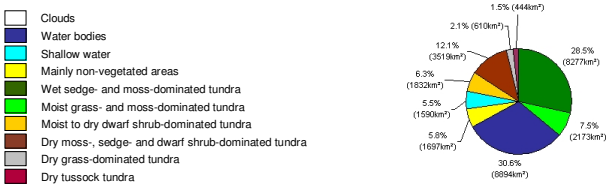



## 4. Results

### 4.1 Supervised classification of the Landsat 7 ETM+ images

The land cover classification reflects the different river terraces and floodplains of the Lena Delta. Nearly 1/3 of the total area of the Lena Delta is occupied by *water bodies*. Together with the land cover classes *shallow water*, *wet sedge- and moss-dominated tundra* and *moist grass- and moss-dominated tundra* this amounts to 72 % of the Lena Delta area, indicating the dominance of wet land cover classes in the delta. The distribution of land cover classes varies for the three main river terraces. In contrast to the first and the third terrace, the second terrace is dominated by classes indicating mainly dry conditions.

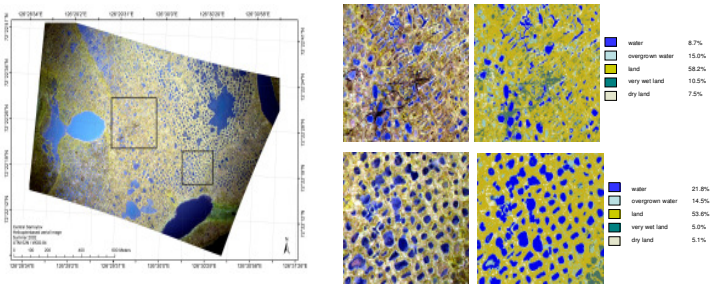



Results of the land cover classification of the Lena Delta based on Landsat 7 ETM+ images

### 4.2 Supervised classification of the helicopter based images

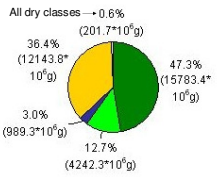
The supervised classification of the helicopter-based images of the polygonal tundra of Samoylov Island which is mainly covered by the class *wet sedge- and moss-dominated tundra* showed the high small-scale spatial variability within this wet land cover class. More than 50 % of the class *wet sedge- and moss-dominated tundra* is occupied by moist to dry micro-habitats (e.g. polygon rims). Although the two classified areas are located close to each other, the differences in the spatial distribution and percentage of the micro-habitats are high. The percentage coverage of very wet vegetated micro-habitats (e.g. non-water filled polygon centres) of the northern area is double compared to the southern area. Due to the water-filled polygon centres, the extent of the open water area is two times greater in the southern classified area than in the northern area.




Land cover classification of polygonal tundra of the first terrace based on helicopter based aerial image

### 4.3 Upscaling of methane emissions

We concentrated on upscaling of methane ($CH_4$) emissions from the land cover class *wet sedge- and moss-dominated tundra*. This class consists of strong polygonal micro-relief and lakes of different sizes. High emission rates origin from wet polygon centres, lower emission rates from drier polygon rims, open water ponds, and the vegetated lake margins. The weighted calculation shows that the daily $CH_4$ emission rates of this class range from 10.8 to 23.2 mg $CH_4$ $m^{-2}d^{-1}$, with a mean at 16.8 mg $CH_4$ $m^{-2}d^{-1}$. We compared the weighted calculation with a simple calculation based on the assumption that the polygonal tundra is covered by only wet and dry sites to 50 % each. This oversimplified approach would overestimate the $CH_4$ emission of the land cover class *wet sedge- and moss-dominated tundra* by a factor of three (mean 49.2 $CH_4$ $m^{-2}d^{-1}$) .




The calculated annual $CH_4$ emission of the Lena Delta based on the land cover classification of Landsat 7 ETM+ images and the $CH_4$ flux measurements in the Lena Delta is 33360.5*10⁶ g $CH_4$.

Results of the upscaling of methane emissions in the Lena Delta: annual $CH_4$ emission of each land cover class and the percentage of $CH_4$ emission of the individual land cover classes at the total $CH_4$ emission of the Lena Delta

## 5. Discussion

We provide the first high-resolution land cover classification of the entire Lena Delta. We tested both unsupervised and supervised classification techniques. Best results for classes representing relatively homogeneous land cover types were obtained using a supervised *minimum distance algorithm,* which was also more efficient than the often used *maximum likelihood algorithm*. Three types of potential errors for a land cover classification may occur in our classification: misclassification, cutpoint error and incomplete description of classes. Nevertheless, we are confident that our classification very well reflects the land cover distribution in the Lena Delta.

The measured $CH_4$ emissions in the Lena Delta are similar to those reported from analogous areas in high latitudes. However, the regionally weighted mean daily $CH_4$ emission of the Lena Delta (10 mg $CH_4$ $m^{-2}d^{-1}$) is only one fifth of the value calculated for the arctic tundra by Whalen & Reeburgh (1990) (52 mg $CH_4$ $m^{-2}d^{-1}$). The weighted average $CH_4$ emission of the Lena Delta wetlands is 17 mg $CH_4$ $m^{-2}d^{-1}$. This is less than half of the 40 - 50 mg $CH_4$ $m^{-2}d^{-1}$ estimated by Christensen et al. (1995) for northern wetlands.

## 6. Conclusions

-Supervised classification of Landsat 7 ETM+ images is particularly suitable to detect ecosystems of the Lena Delta

-Analysis of high-resolution helicopter-based images demonstrate high spatial variability of micro-habitats within the respective land cover classes

- For upscaling of $CH_4$ emissions from point measurements to regional scale the complete scaling ladder (point → near aerial photography → satellite imagery → region) should be considered to avoid serious bias

- Taking this recommendation into account the methane source strength of wetlands is expected to be lower than calculations based on coarser scales

## References

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