Characteristics and Spectral Properties of Periglacial Landforms in the Lena-Delta, Arctic Russia

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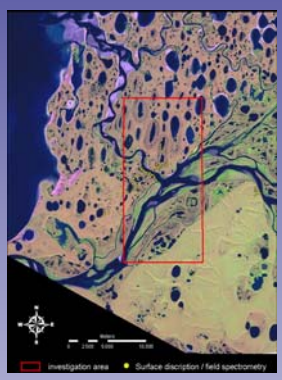
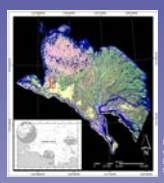
Arctic permafrost landscapes are very sensitive to climatic change. Remote sensing and spatial data analysis are qualified tools to detect and quantify changes on large scales. Nevertheless, the successful interpretation of multi- and hyperspectral remote sensing data of spatially complex permafrost landscapes requires considerable field work for ground truth. This includes the acquisition of data on vegetation, soils, geomorphology, and spectral surface properties.





Landsat-7 ETM+ Mosaic of the Lena-Delta. Red box marks the investigation area.

Investigation area

Lena-Delta: largest Arctic Delta (29,000 km²), dominated by fluvial-deltaic and periglacial processes, continuous permafrost, dominated by typical tundra vegetation, subdivided into 3 geomorphological main terraces based on differences in cryolithology, hydrology and geomorphology

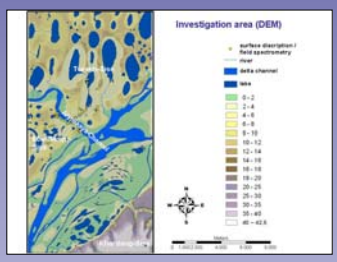
1st terrace: Recent floodplains and Holocene sandy deposits (the modern "active" delta) (ca: 1 – 12 m a.s.l.)

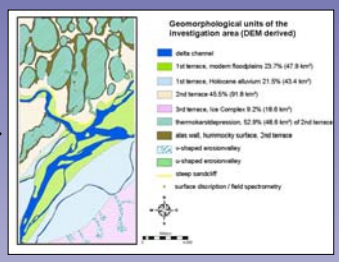
2nd terrace: Characterized by sandy deposits, probably of Late Pleistocene fluvial genesis (ca: 11 – 30 m a.s.l.)

3rd terrace: Late Pleistocene accumulation plain of ice- and organic-rich deposits ("Ice Complex") (ca: 30 – 60 m a.s.l.)

Objectives

To develop a general spectral characterization and classification of periglacial surfaces and geomorphological units in the Lena-Delta for the validation and refinement of an existing Landsat-7-based landcover classification of the entire delta and for the validation and classification of future hyperspectral data from the Lena-Delta and other periglacial tundra





Methods

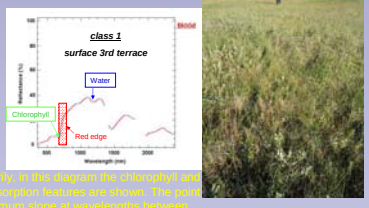
-Geomorphological mapping

-Discription of surface properties (vegetation, soil, active layer depths)

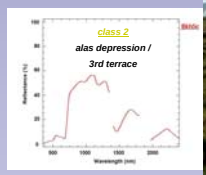
-Collection of spectral data from typical periglacial surfaces using a portable field spectrometer (ASD FieldSpec® ProFR)

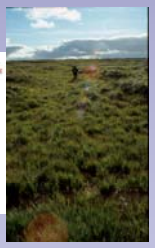
-Classification of the field spectra (unsupervised classification, visual analysis, application of spectra analysis techniques like continuum removal)

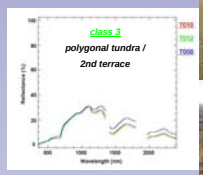
-GIS-based analysis of ground truth data and a supervised maximum-likelihood classification from Landsat 7 ETM+ data

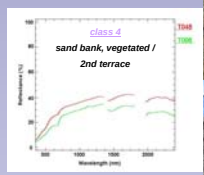


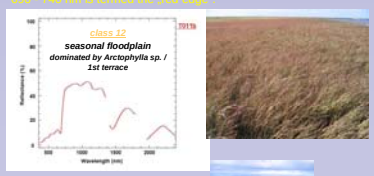
Exemplarily, in this diagram the chlorophyll and water absorption features are shown. The point of maximum slope in wavelengths between 690 - 740 nm is termed the „red edge".

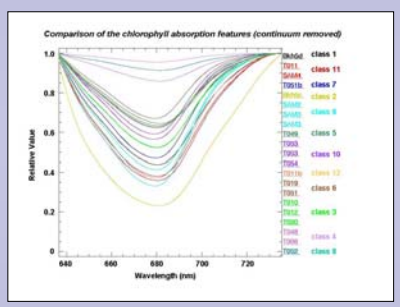


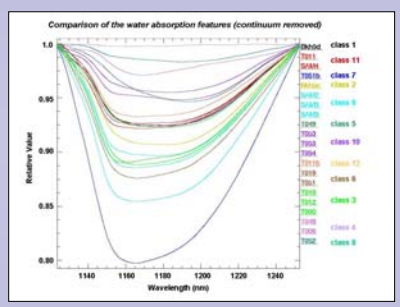


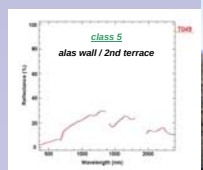


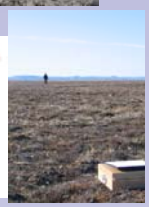


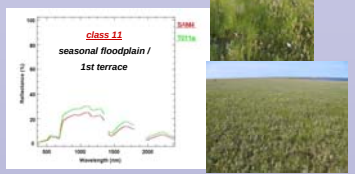


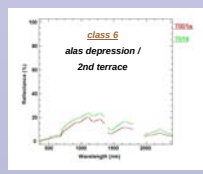




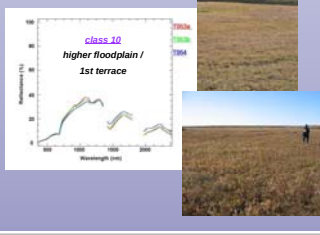


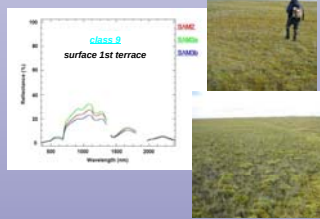


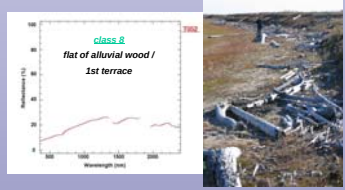


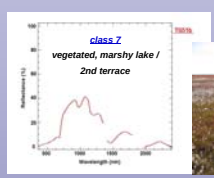


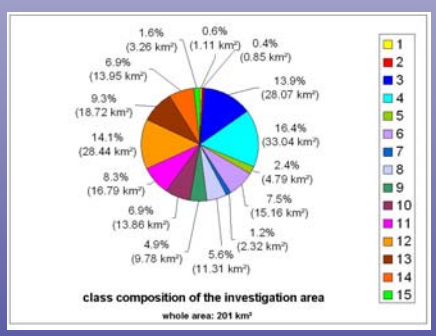
Individual absorption features of the field spectra after applying a continuum removal

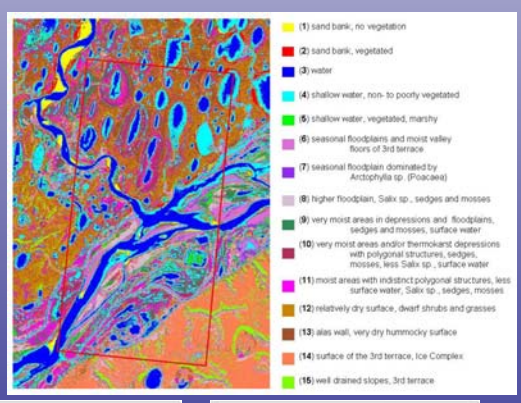




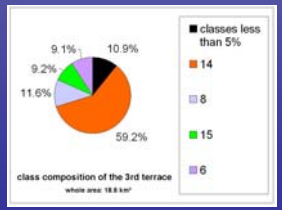


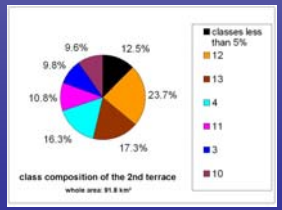


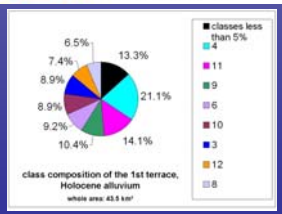




Maximum-likelihood classificationof a Landsat 7 ETM+ subset and class composition for the geomorphological units of the investigation area (red box).







Results

-More than 500 field spectra were aquired from 19 sites in the delta

-12 different surface classes were extracted from the field spectra

-15 terrain surface classes based on spectral characteristics, periglacial surface conditions and geomorphology were obtained applying a supervised maximum-likelihood classification on a Landsat 7 ETM+ subset of the investigation area

-Spatial analyses were carried out indicating the composition for the geomorphological units

Conclusion

-The analysis of field spectral data in combination with geomorphological and vegetation data provided an excellent ground truth dataset for the analysis of our multispectral remote sensing imagery and allowed the characterization and classification of periglacial surfaces.

-This unique dataset provides the base for further spectral data acquisition by field spectrometer and hyperspectral sensors (e.g. Chris/Proba) in the tundra landscape of the Arctic Lena-Delta.

-The classification of field spectra indicates significant differences in surface properties between the delta main terrace, and thus a good spectral separability of these units.

-These differences are mainly based on vegetation type, moisture content and vitality of vegetation cover, which can be detected from the spectra shape (e.g. reflectance, red edge ca: 690 – 740 nm) and by significant absorption features (e.g. chlorophyll ca: 680 nm, water ca: 1140 – 1220 nm) in the field spectra.

-The spatial and spectral composition of the delta terraces in the investigation area were successfully determined by analysing the individual classes in a supervised Landsat 7 ETM+ classification.