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Characteristics and spectral properties of periglacial landforms in the Lena Delta, Arctic Russia

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Arctic permafrost landscapes are considered to be very sensitive to climatic change as is predicted by many climate simulations covering the next century. Currently, regions of wet tundra in periglacial landscapes are considered to be important sinks of carbon (e.g. peat accumulation, permafrost aggradation) and strong methane sources. Under changing climatic conditions, i.e. climate warming, various environmental parameters in permafrost landscapes will be altered (permafrost temperature, active layer depth, soil moisture, precipitation, etc.), resulting possibly in an enhanced release of greenhouse gasses from this large carbon storage.

Remote sensing and spatial data analysis are the most prospective tools to detect and quantify such changes on large scales. The successful interpretation of multispectral- and hyperspectral remote sensing data of spatially complex Arctic permafrost landscapes requires considerable field work for ground truth. This includes the acquisition of data on vegetation, soils, geomorphology, and also spectral surface properties. We collected extensive ground truth data in the Lena Delta, NE Siberia, during the joint Russian-German expedition “Lena Delta 2005”. The Lena Delta is the largest Arctic Delta and dominated by fluvial-deltaic and periglacial processes. Continuous permafrost with depths between 200-600 m occurs in this region. Generally, the landscapes of the Lena Delta are dominated by typical tundra vegetation. The delta is subdivided into three geomorphological terraces, which distinctly differ in their cryolithological, hydrological and geomorphological properties.

Recent floodplains and Holocene sandy deposits form the first terrace, which is assumed to represent the modern “active” delta. The second terrace, mainly consisting of the large Arga-Muora-Sise Complex in the NW of the delta, is characterized by sandy deposits. Its probably fluvial genesis and Late Pleistocene origin is still under investigation and discussion. The third terrace consists of remnants of a Late Pleistocene accumulation plain of ice- and organic-rich deposits (“Ice Complex”) underlayed by sandy sequences.

The difference of surface properties of these delta main units results in individual spectral characteristics of each terrace and a good spectral separability of these units. Thus, beyond general geomorphological mapping and description of surface properties, we used a portable field spectrometer (ASD FieldSpec Pro FR®) to collect spectral data of a variety of typical periglacial surfaces in the central and western delta.

There were two main goals for our research:

1. A general characterization and classification of periglacial surfaces and geomorphological units in the Lena Delta by their spectral properties.

2. Validation and refinement of an existing large-scale Landsat-7-based land cover classification of the Lena Delta by comparison of key regions with classifications based on ground truth data and newly acquired hyperspectral data by the ChrisProba satellite (European Space Agency).

During the field work we carried out point and profile measurements with the spectrometer. For each location, soil properties, active layer depths, geomorphological situation, and vegetation properties were recorded. The combination of these various data sets resulted in an excellent ground truthing for the analysis of our Landsat-7 and ChrisProba remote sensing data. Additionally, with this work we acquired a comprehensive dataset on spectral properties of periglacial tundra surfaces in the Lena Delta for the first time. To our knowledge, this dataset is currently unique for the large region of Northeast Siberia. Thus, it provides not only an important basis for remote sensing studies in the Lena Delta, but is also valuable for the comparison of spectral properties of tundra landscapes on a pan-Arctic scale.