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Analysis of permafrost and its spatial characteristics

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I. Introduction

The ground truthing of modern environmental processes is the basis for the understanding, the modelling, and the prediction of regional and global climatic processes as well as environmental feedbacks.
Modern periglacial process studies are based on an interdiscplinary research approach (Geomorphology, Microbiology, Limnogeology, Geoecology, Geochemistry, Soil Physics, Remote Sensing), to analyse permafrost soils, ancient frozen deposits, lake sediments, and ice records.

II. Ground truthing: Subsurface and Surface Measurements

Subsurface measurements
- Ground penetrating radar
- Bathymetry
- Electrical Resistivity Tomography
- Temperature and moisture profiles
- Boreholes

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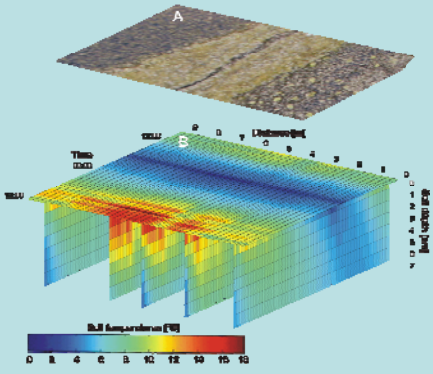
Soil characteristics
Detection of thermokarst
Ground energy fluxes
Thaw depth

Short and longwave radiation scanner on Samoilov Island, Lena-Delta, Siberia



Results of scanner system
(a) Aerial view of scanner transect showing two polygonal centers and rims
(b) Surface and soil temperatures based on measurements and calculations

Surface measurements
- Short and longwave radiation scanner
- EDDY covariance
- Spectrometry
- Tachymetry
- Vegetation mapping

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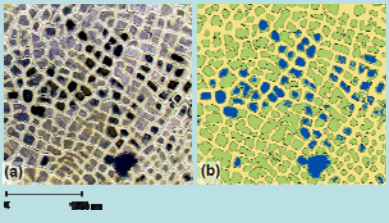
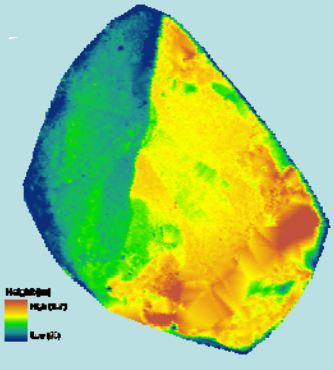
Landscape morphology and vegetation characteristics
Radiation budget (spectral characteristics)
Surface temperatures
Sensible and latent heat flux

III. Upscaling

Ground truth data is used in combination with high-resolution VIS and NIR aerial pictures and digital elevation models to infer spatial classifications of surface parameters like bare soil, water and vegetation.



High-resolution aerial image of Samoilov Island, Lena-Delta, Siberia before (a) and after (b) classification. Dry polygon rims are showwn in yellow, moist polygon centers in green and open water surface in blue.

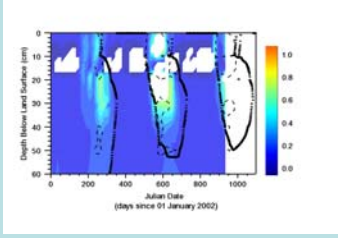


Digital elevation model (DEM) of Samoilov Island, Lena-Delta, Siberia.

Classfication results are then used in combination with metereological measurements to estimate energy and trace gas fluxes for scales up to several kilometers.

IV. Modelling

Simulation of snow cover, stream flow, and soil moisture in continuous and discontinuous permafrost conditions



Simulation of the freeze-thaw interface (dark dots) at a hill slope site at Imnavait Creek, Alaska. The -0.1°C isotherm (dark dashes) and unfrozen soil moisture content (background) are also shown for comparison. Color bar indicates volumetric soil moisture content. Solid white regions indicate missing data.

V. Outlook - Link to ESA

For future analysis and monitoring of **permafrost, state key variables** are needed in high-resolution quality describing permafrost surface physical state (surface temperature and moisture), snow characteristics (snow depth and water equivalent) and surface characteristics (topography, vegetation, water bodies). **High spatial resolution** (e.g. multispectral imagery with a resolution of 2.5 m, digital elevation models with a resolution of 5 m) and **high temporal resolution** imagery (3 times a day) are required.