Characterizing thermo-erosional landforms in Siberian ice-rich permafrost

Morphometric investigations using high resolution satellite imagery and digital elevation models

Background:
Accelerated degradation of Siberian ice-rich permafrost (Romanovski et al. 2010) could have substantial impacts on regional (e.g. water & energy balances) to global scale (e.g. carbon release to the atmosphere, Koven et al. 2011). The role of linear permafrost degradation features in this context is still uncertain (Morgenstern 2012).

Key Questions:
• What is the spatial distribution of thermo-erosional features in the study area?
• Which types of thermo-erosional features can be distinguished and what are their driving factors?
• Can morphometric characteristics of thermo-erosional features serve as indicators for delineation of stratigraphic units?

1. Field work & Data fusion

Fig. 2: Overview of satellite images used and field data [July 2013] for one of three study sites.

2. DEM generation & validation

Fig. 3: Several combinations of 14 ALOS PRISM stereopairs were tested to 1) get better matching results on low-contrast and low-slope gradient areas, 2) decrease effect of occlusion in valley floors, 3) decrease error in areas with coastal erosion. Validation was done using 1104 DGPS points (Range 0-58 m a.s.l.), classified in 2m steps from 0 to 58 m. The final thematic product (QP) is the standard deviation of the mean error per class. a) DEM from 6 stereopairs (2006 and 2009 imagery, 57% matching). b) DEM from 2 stereopairs (2009 imagery, 29% matching). c) Error ranges of several generated DEMs with a) marked in green and c) marked in red.

3. Results

Total stream length: 336 km
• Total flow length = 336 km
• Drainage density = 0.8
• Majority is first order (Fig. 4)
• 50% are shorter than 230 m
• Mainly on slopes of thermokarst basins and at the coastline
• Longer streams with higher order are mainly present within thermokarst basins and connect these with each other

Fig. 4: Stream network of Kurungnakh Island. Stream order after Strahler (1957). Letters show the study sites (Fig. 5).

4. CONCLUSIONS

Thermo-erosional landforms play an important role in permafrost degradation and are strongly connected to thermokarst features. Short and non-complex linear permafrost degradation features are the predominant type on Kurungnakh Island. Complex valley networks develop in areas of ice-rich permafrost that are highly degraded by thermokarst activity.

References