Dynamics of tundra vegetation on cryogenic landslides of Yamal Peninsula, Northern Russia

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Cryogenic landslides on Yamal

- One of the most important geomorphological processes on Yamal peninsula

  Ø Retrogressive thaw slumps (RTSs)

  -> Increasing (re-)activation since 2012 (Khomutov, et al. 2017)

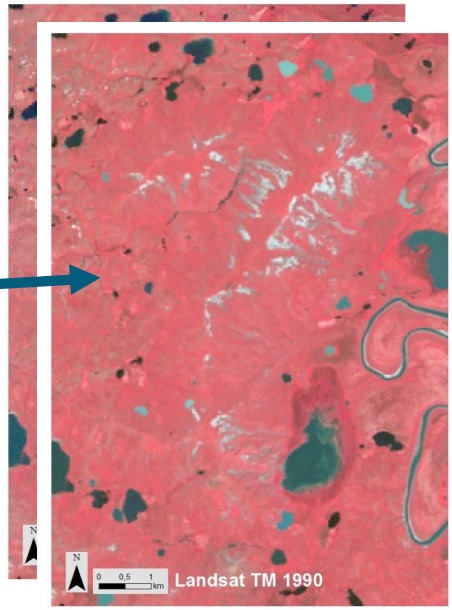
  Ø Active-layer detachments (ALDs)

  -> Last large-scale landsliding in Central Yamal in 1989

Cryogenic landslides on Yamal

Satellite image time series

Satellite/Sensor	Year	Month
CORONA	1969	July
KH-9	1976	August
Landsat TM	1988	August
Landsat TM	1990	July
Landsat ETM+	2001	July
Landsat TM	2009	July
Landsat TM	2011	July
Landsat OLI8	2013	July
Landsat OLI8	2017	July
Sentinel 2	2017	July
QuickBird-2	2004	July
WorldView-2	2013	July
WorldView-3	2017	July



The key study area

- ca. 10 km long, 2-3 km wide ridge near Mordy-Yakha river (70 N 68 E)
- Max. heights ca. 80 m asl
- The deposits are fine grained, sandy to clayey, marine and alluvial-marine.
- MAAT -7.0 C° (1988-2017)
  - 2012-2017: -5.5 C°
- Bioclimatic subzone D on *the Circumpolar Arctic Vegetation Map* (dominating species: erect dwarf shrubs, sedges, mosses)

Aims of the study

HR sat. data <–> VHR sat. data <–> Ultra HR Unmanned Aerial Systems (UAS) data

- How can past and present cryogenic landslides be detected from various Remote Sensing (RS) data?
- How does landsliding affect shrubbyfication (and Greenin/Browning in the Arctic)?
- How the succession of vegetation on shear surfaces shows on various RS data?

Field observations and data collection:
2011, 2013, 2014, 2015 & 2017

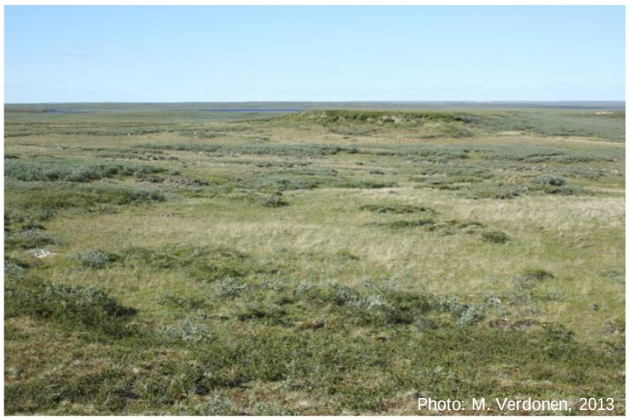
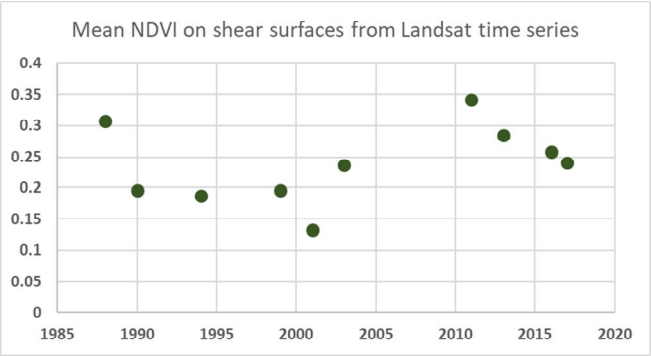
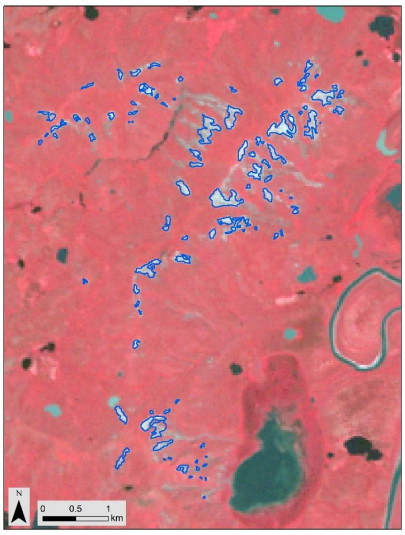


Photo: M. Verdonen, 2013

Following revegetation of shear surfaces

from Landsat time series 1988-2017: Normalized Difference Vegetation Index





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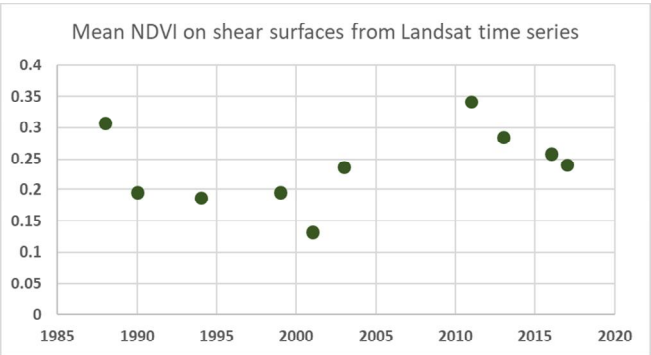
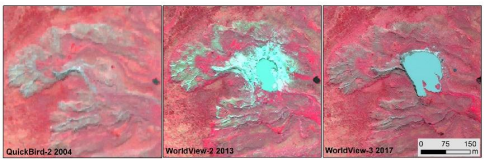


Differences in temperature/precipitation?

Differences in phenological stages at the time of acquisition?

Browning signal?

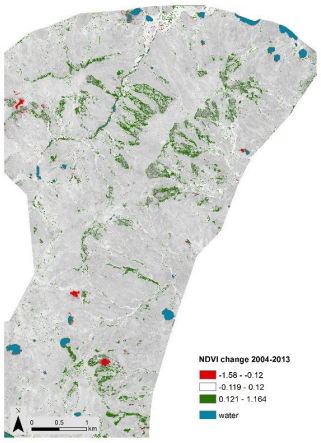
Effect of a crater appearing in 2012?



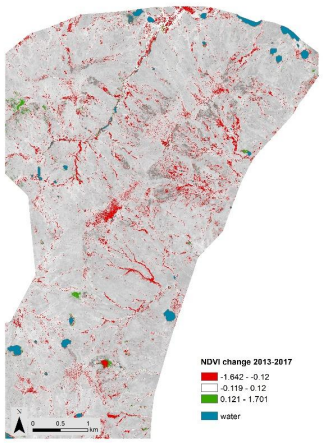
Following revegetation of shear surfaces

from VHR sat. images:

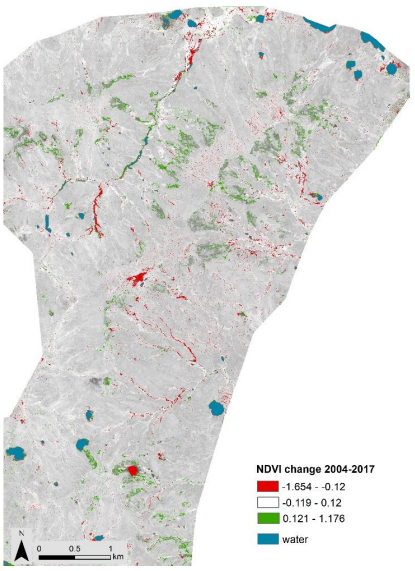
NDVI change 2004-2013



NDVI change 2013-2017



NDVI change 2004-2017



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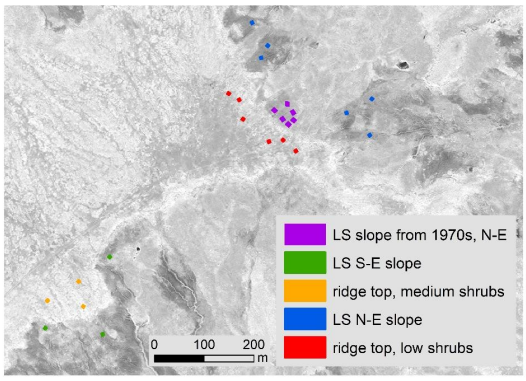
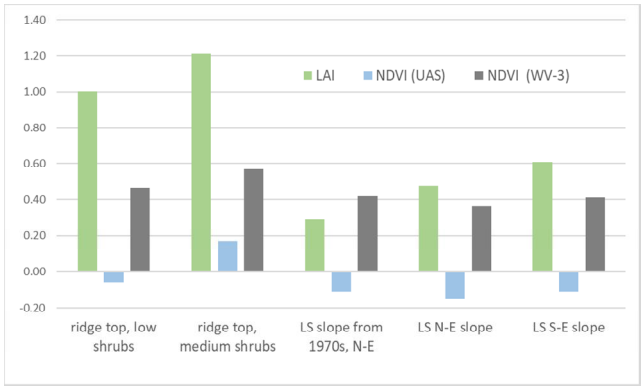
Following revegetation of shear surfaces

from UAS data and Leaf Area Index (LAI) measurements on sample plots:





Low NDVI values from UAS due to
higher spatial resolution (UAS: n. 0,1 m vs. WV-3: 1,2 m)
-> greater effect of e.g. bare soil pixels.

Monitoring of the Retrogressive Thaw Slumps

- Most of RTSs in the region are too small for the resolution of Landsat (30m ms)

-> Very High Resolution needed
(e.g. QuickBird, Worldview)

- Generally increasing in number and area between 2004 and 2017.

Conclusions

- The revegetation of 1989 ALDs can be followed from Landsat time series. However, the decrease of NDVI values after 2013 needs more investigation.
- The NDVI-change 2004–2013 showed clearly revegetation process of 1989-slides' shear surfaces. The 2017 NDVI lower than 2013 in many parts and weakens the signal of revegetation.
- Preliminary results show some positive correlation between measured LAI and NDVI values from VHR sat. image. More systematic LAI measurements needed. The UAS data allows to study (re-)vegetation in great details. More sample plots and adjustment for soil effect could show better relation with VHR sat. data.
- No new large-scale ALDs have been detected since 1989 landsliding, but tens of smaller slides, mainly slope failures on lake shores have occurred since 2004. Most of the new landslides detected from 2013 image had increased in area and/or revegetated by July 2017.


Thank you!
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