Cryogenic processes distribution, monitoring and prediction using remote-sensing data

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Manual processing and visual interpretation were implied to very high resolution data (Qiuckbird, Geoeye satellites). Various types of anthropogenic landscapes are easily identifiable, such as geocryological relief forms within Vaskiny Dachi research station.

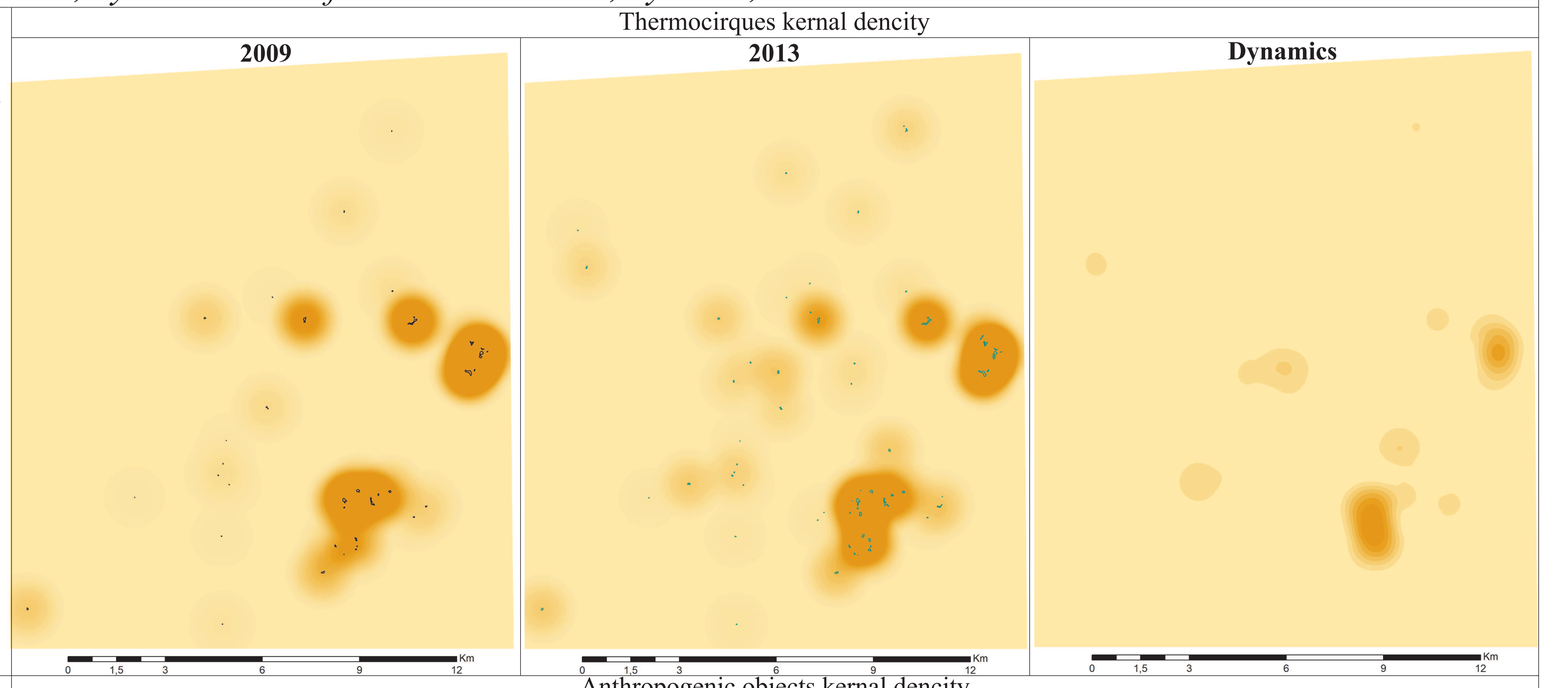
Using this precise data, “Object density” maps of anthropogenic areas and thermocirques were created with the usage of «Kernel Density» tool for years 2009 and 2013 .

After this, density growth rate was estimated. Spatial correlation was applied to changing objects of the study area. Correlation type appeared to be weak positive and equals 0.15.

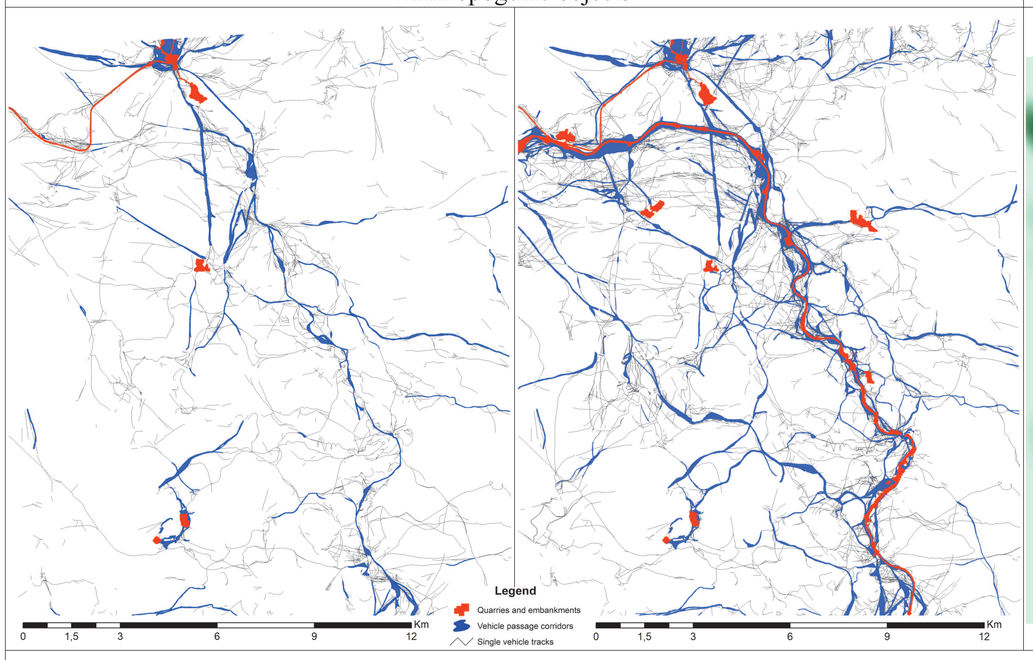
Area of thermocirques increased by 49 550 sq. m, relation of active thermocirques to inactive ones changed from 6/38 in 2009 to 65/10 in 2013 due to 31 new thermocirques.

Area of technogenic impact increase by 13,3 sq. km, out of which vehicle tracks increased by 10,6 sq. km, and quarries and embankments by 2,7 sq. km.

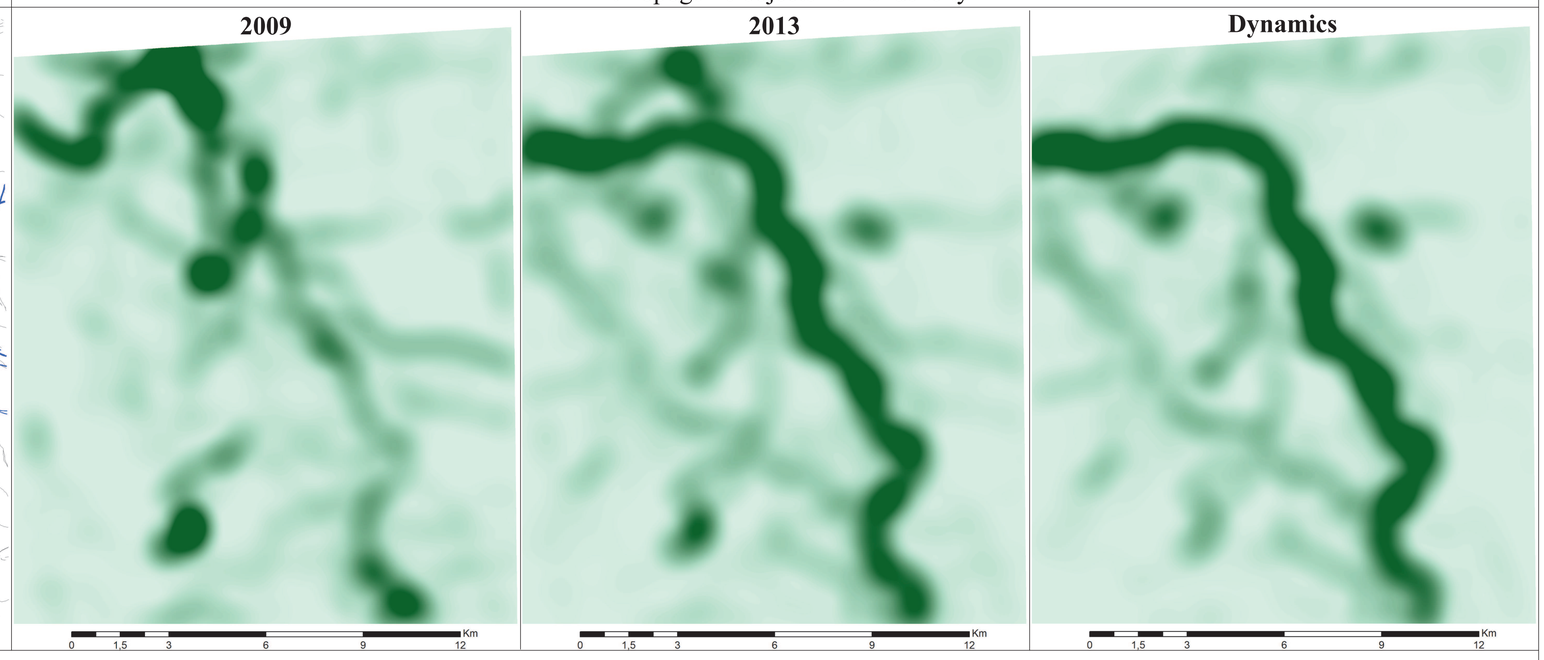
Thermocirques kernal dencity



Anthropogenic objects



Anthropogenic objects kernal dencity



Gas-emission craters (GEC) are relatively a new type of hazardous natural phenomenon, which may have a significant influence on the infrastructure in the Arctic as well as on indigenous communities.

Therefore, prediction of such processes in permafrost environment is highly important. Within this research, we tried to create a prediction map based on several potential controls of GEC formation included in our current hypothesis.

Work has been done with usage of Sentinel-2 satellite image, obtained 16.09.2017 and chosen as the least cloudy

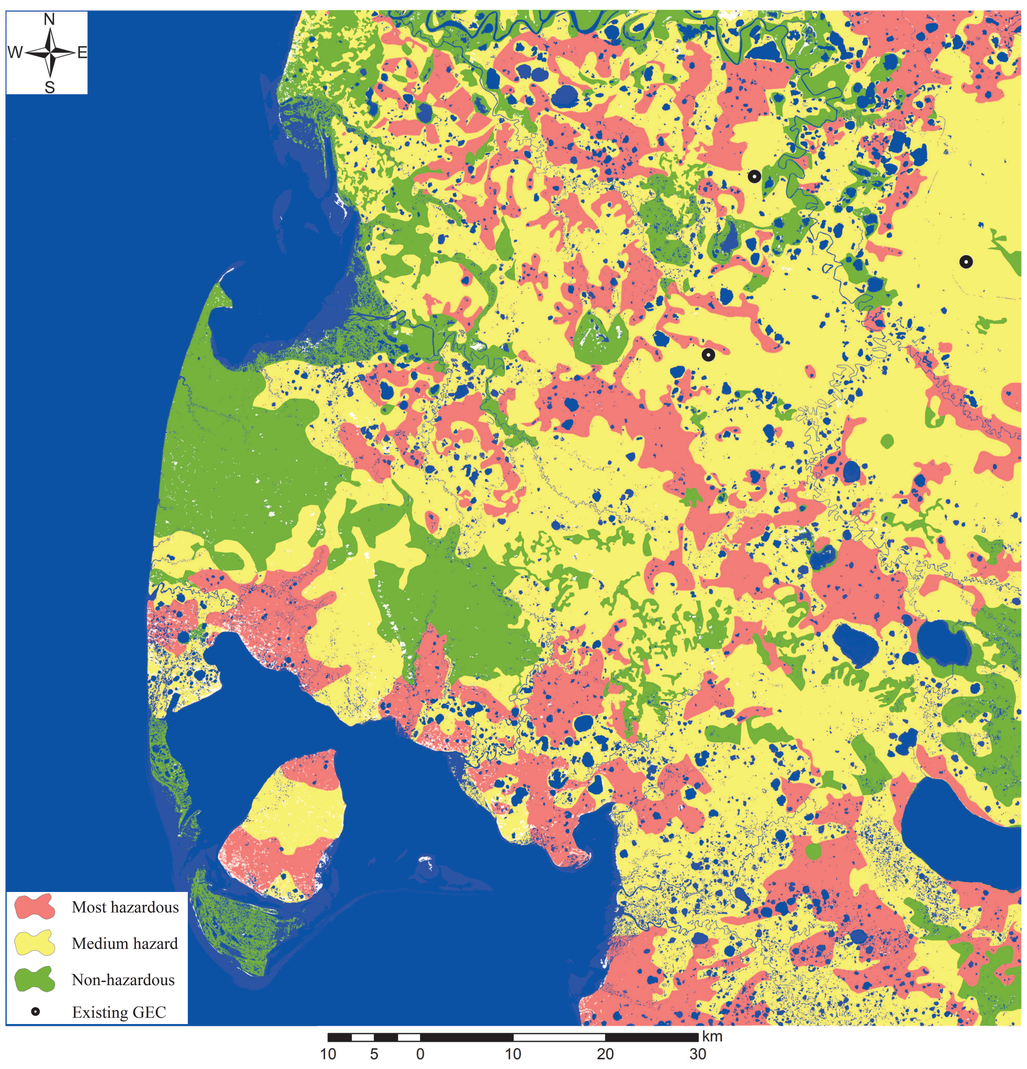
We have chosen a depth of tabular ground ice (TGI) table as a first control. According to our current hypothesis, we consider tabular ground ice bodies close to ground surface more favorable for GEC formation.

Second main control was a concentration of dissolved methane in lake water. We used relation between CDOM and dissolved methane concentration based on field and laboratory measurements, to map methane-rich lakes using lake CDOM map obtained through analysis of remote-sensing data.

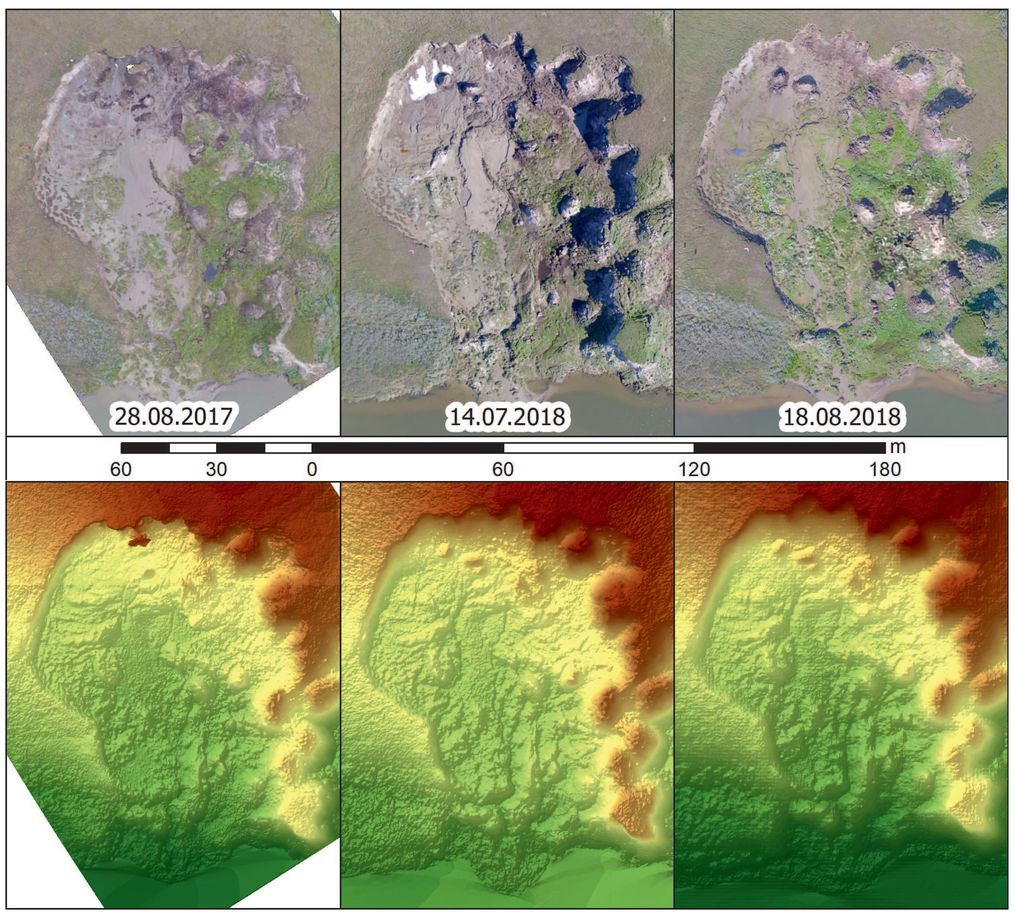
An overlay procedure was further applied to these two classifications in order to create a GEC prediction map. We have defined three final classes:

- Most hazardous: areas with TGI table depth < 10 m and with predominance of lakes with high dissolved methane concentration;
- Non-hazardous: lake-free areas or areas with TGI table depth > 10 m and areas with predominance of lakes with low dissolved methane concentration;
- Medium hazard: all other combinations.

Estimation of gas-emission crater formation hazard showed that in the image area of 8441 sq. km most hazardous are 2004 sq. km (24% of the territory), non-hazardous can be considered 1877 sq. km (22% of the territory).



Thermocirque №2 monitoring with UAV survey technology



UAV surveying was used as a compromise between field methods of monitoring and classical remote sensing.

UAV survey provides information about landscapes (mostly vegetation patterns and DEM) through 3D models or orthophotomaps with resolution up to 0,02 m/pix.

Ultra-high-resolution orthophotoplans allow very detailed survey being at the same time least time-consuming.

Detailed survey of thermocirque edges on Vaskiny Dachi research station in 2017 and 2018 helped relating the rate of retreat to the geologic section and amount of ground ice.

One more object, peat plateau near Gaz-Sale, was surveyed by UAV as well and orthophotomaps were compiled. At the same time, tacheometric survey was made to complement UAV survey. Orthophotomaps appeared to be efficient and precise.

Detailed survey of collapsing peat plateaus is useful in determining the rate of the process in inter-seasonal temporal scale.

Gaz-Sale peatland degradation monitoring with UAV survey technology