



Permafrost Monitoring in Alaska's Arctic National Parks

Subtle change so far, more to come

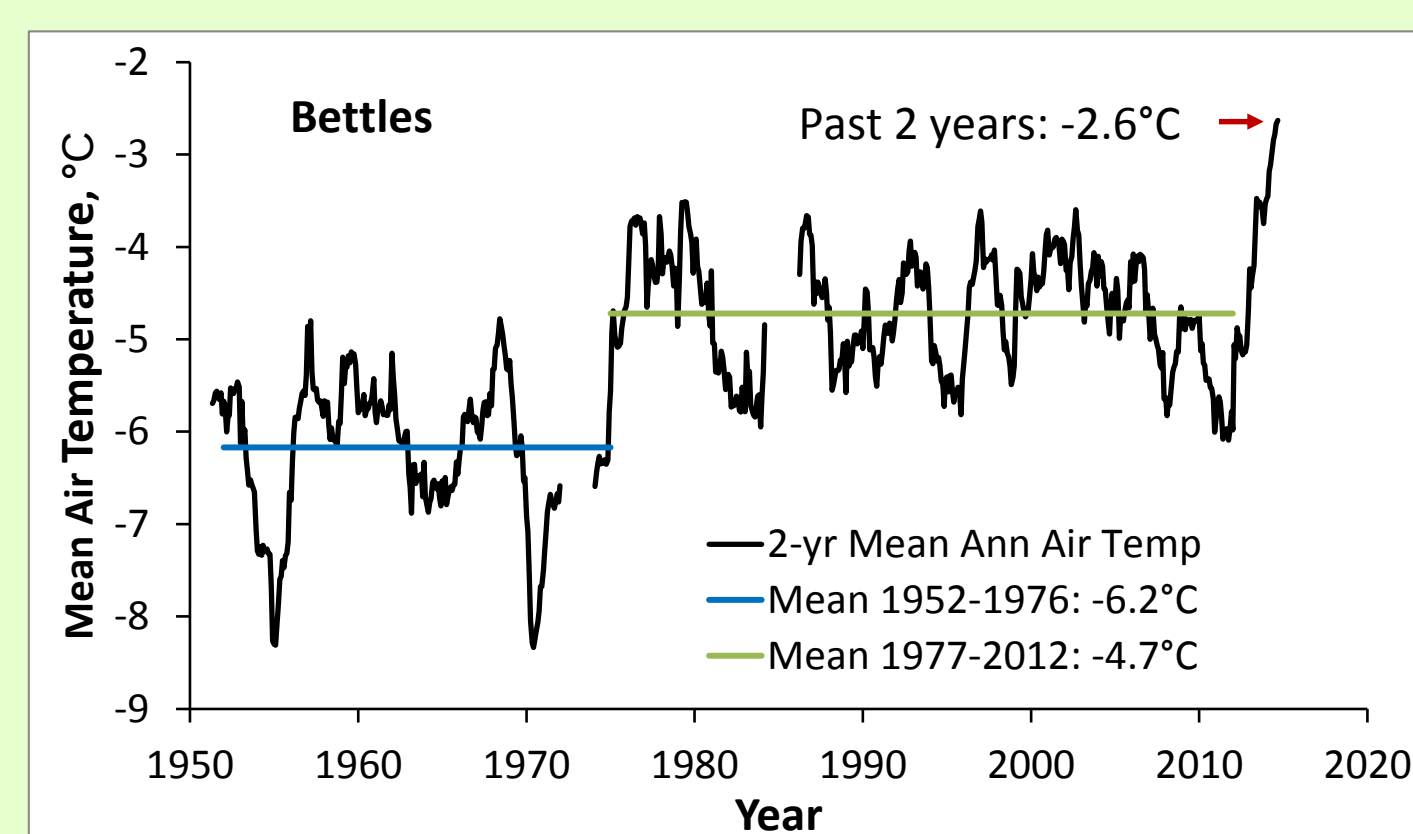
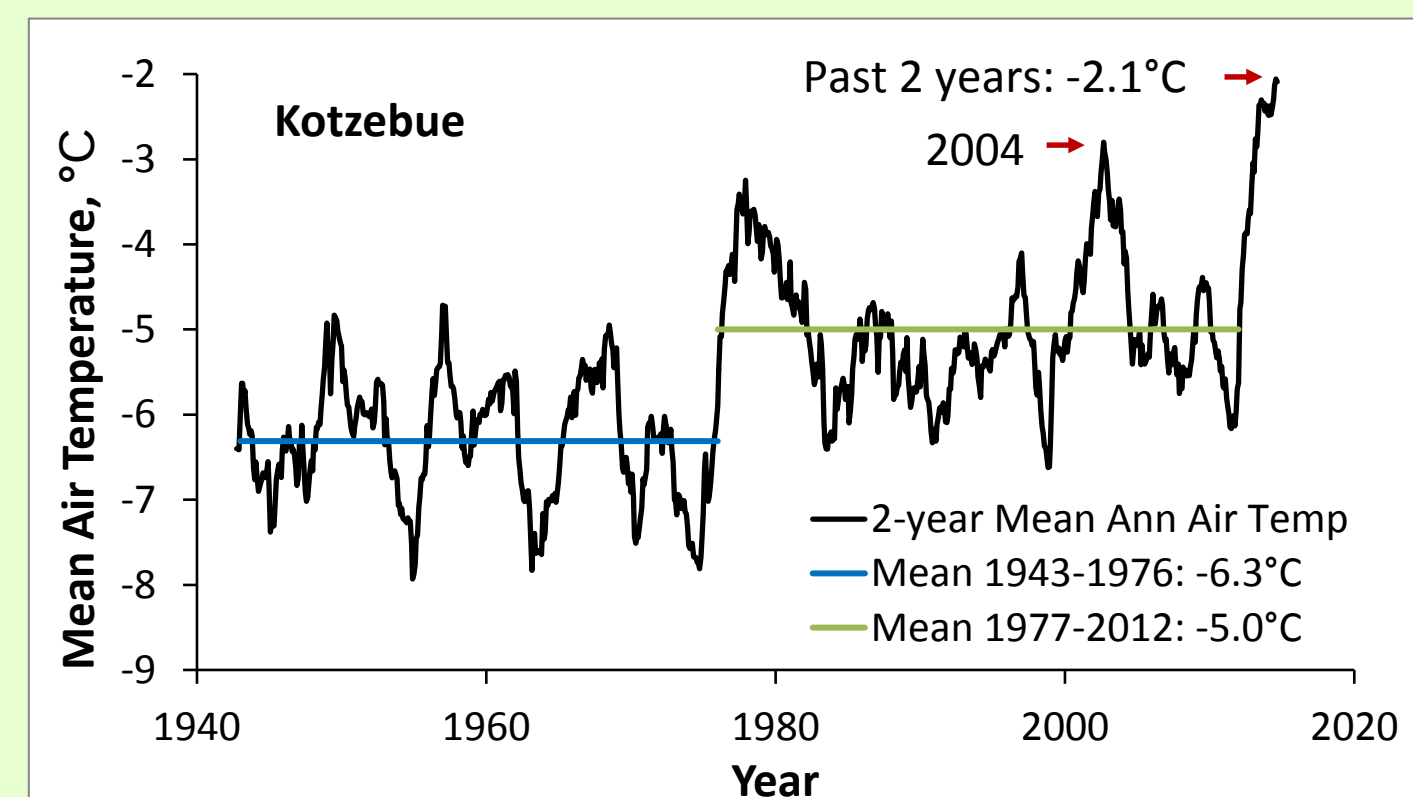
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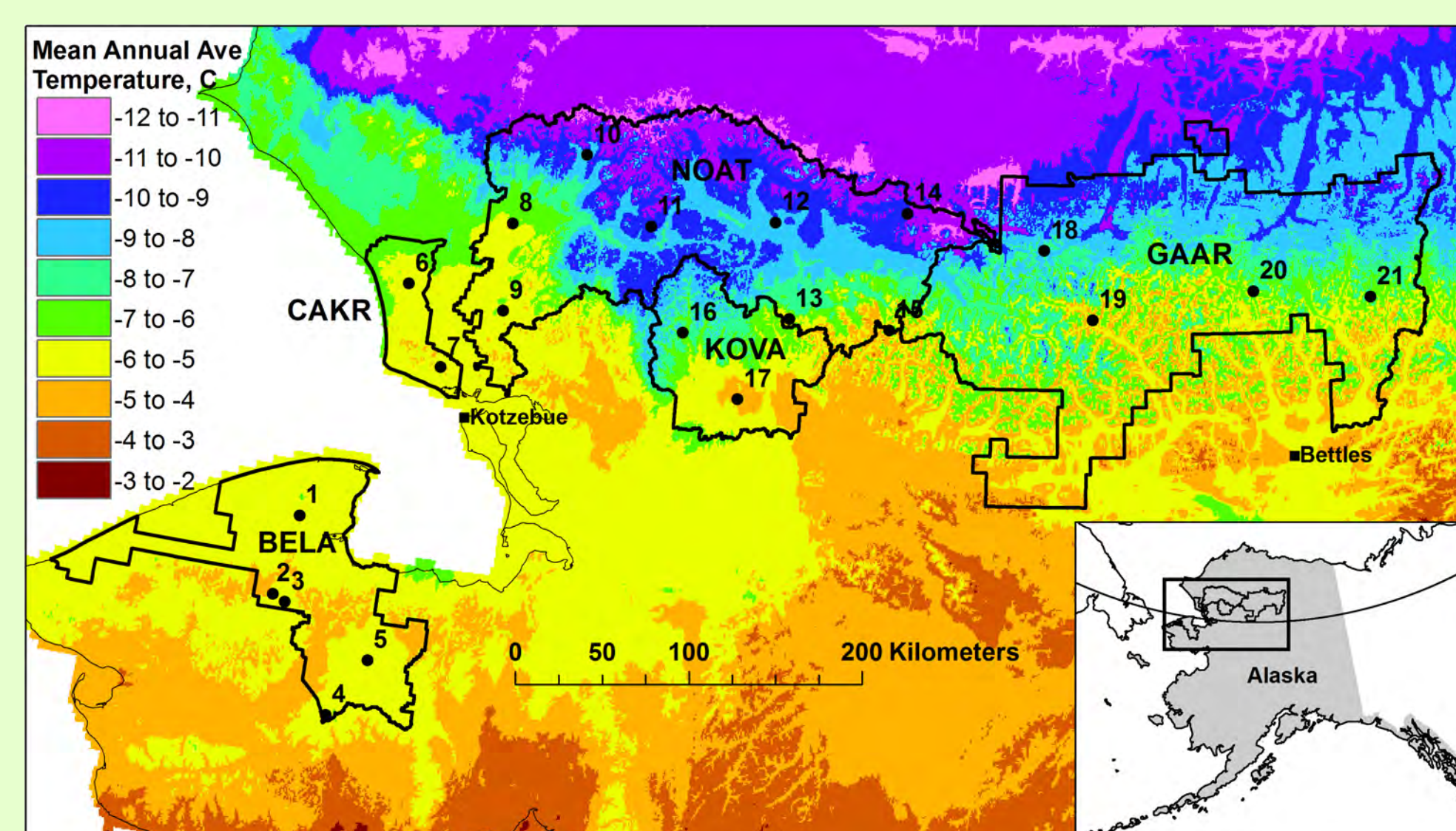
Introduction

Permafrost underlies most of Alaska's five arctic National Parks (the Arctic Inventory and Monitoring Network, ARCN). Permafrost is ground that remains frozen year-round due to a cold climate. Permafrost is one of the "vitals signs" of ARCN's monitoring program. We monitor both ground temperatures and permafrost landforms.

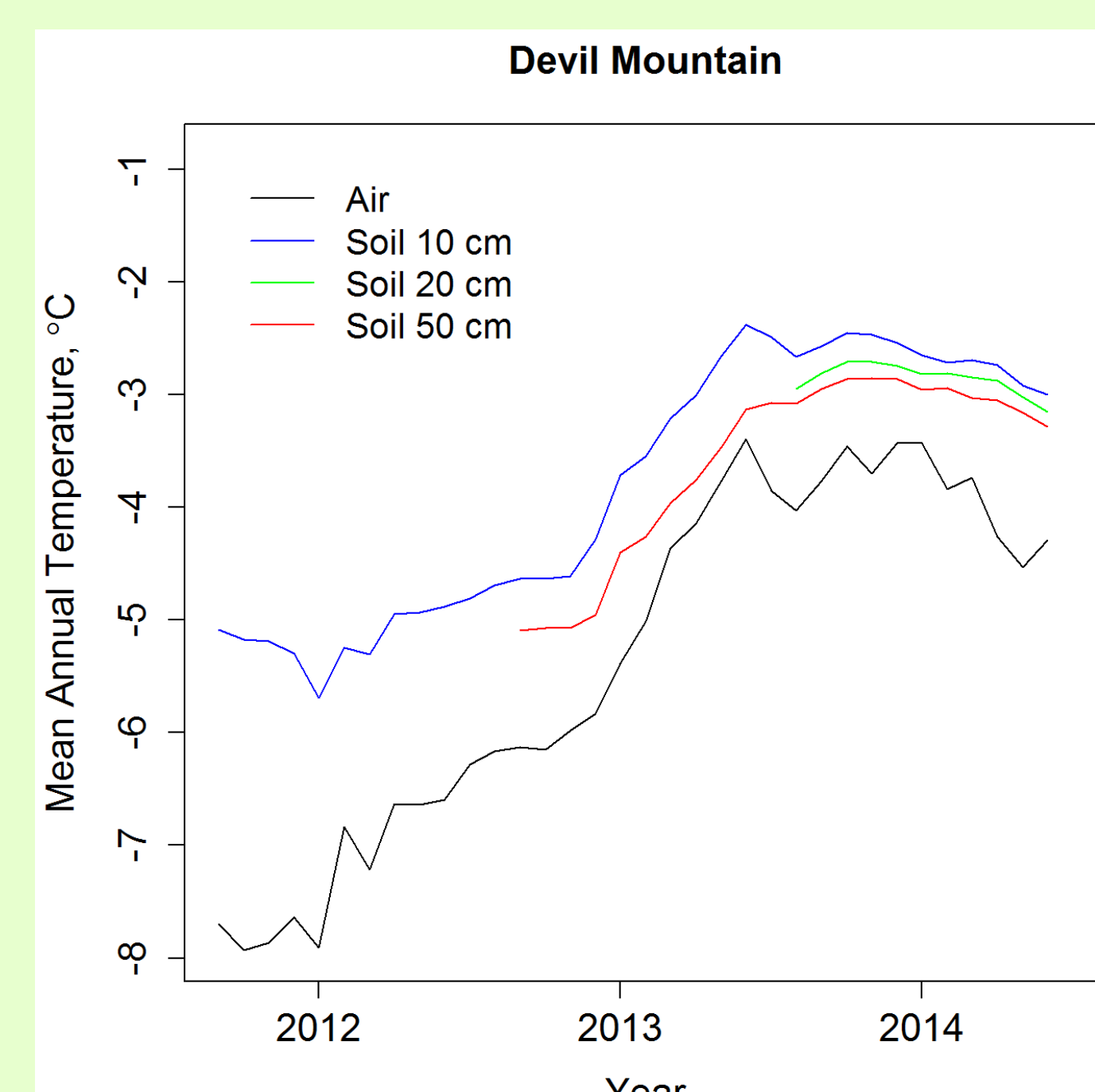


Soil Temperature Monitoring

We monitor soil temperatures at most of ARCN's climate monitoring stations. From 2011 to 2015, all stations showed increases in mean annual soil and air temperature of 3°C to 4°C. However, mean annual ground temperatures remained below 0°C at all except one station. Long-term climate records from Kotzebue and Bettles suggest that part of the recent increase was a rebound from a prior short-term cold cycle, but current mean annual air temperatures are the highest on record.

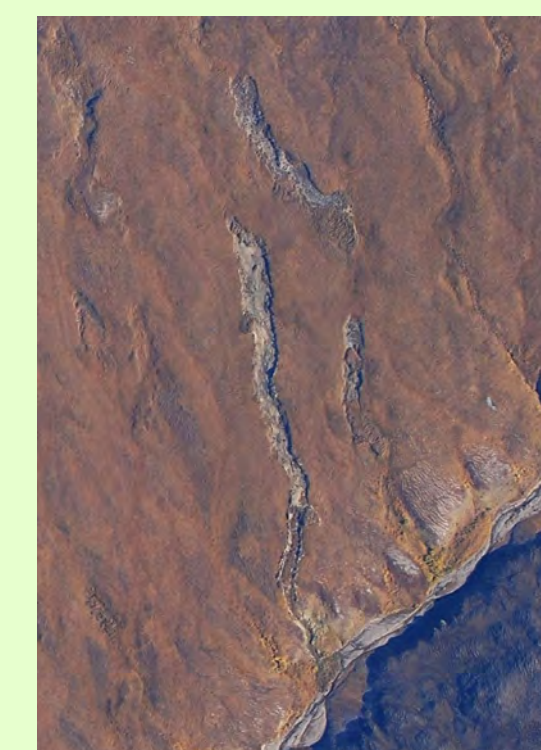


ARCN climate monitoring stations (1 through 21)



All ARCN monitoring stations, like this example (station #1 above, Devil Mtn in BELA), have warmed dramatically since 2013.

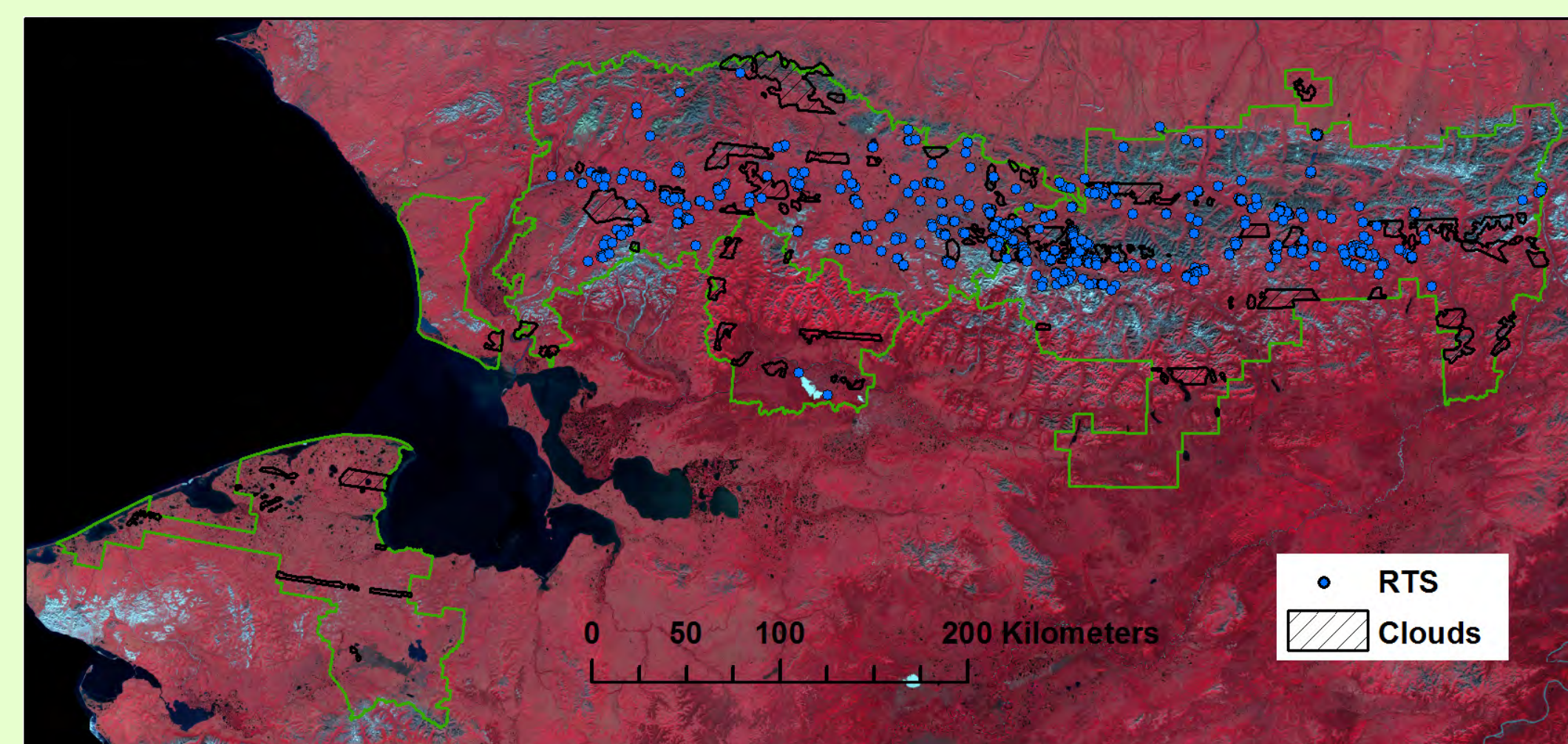
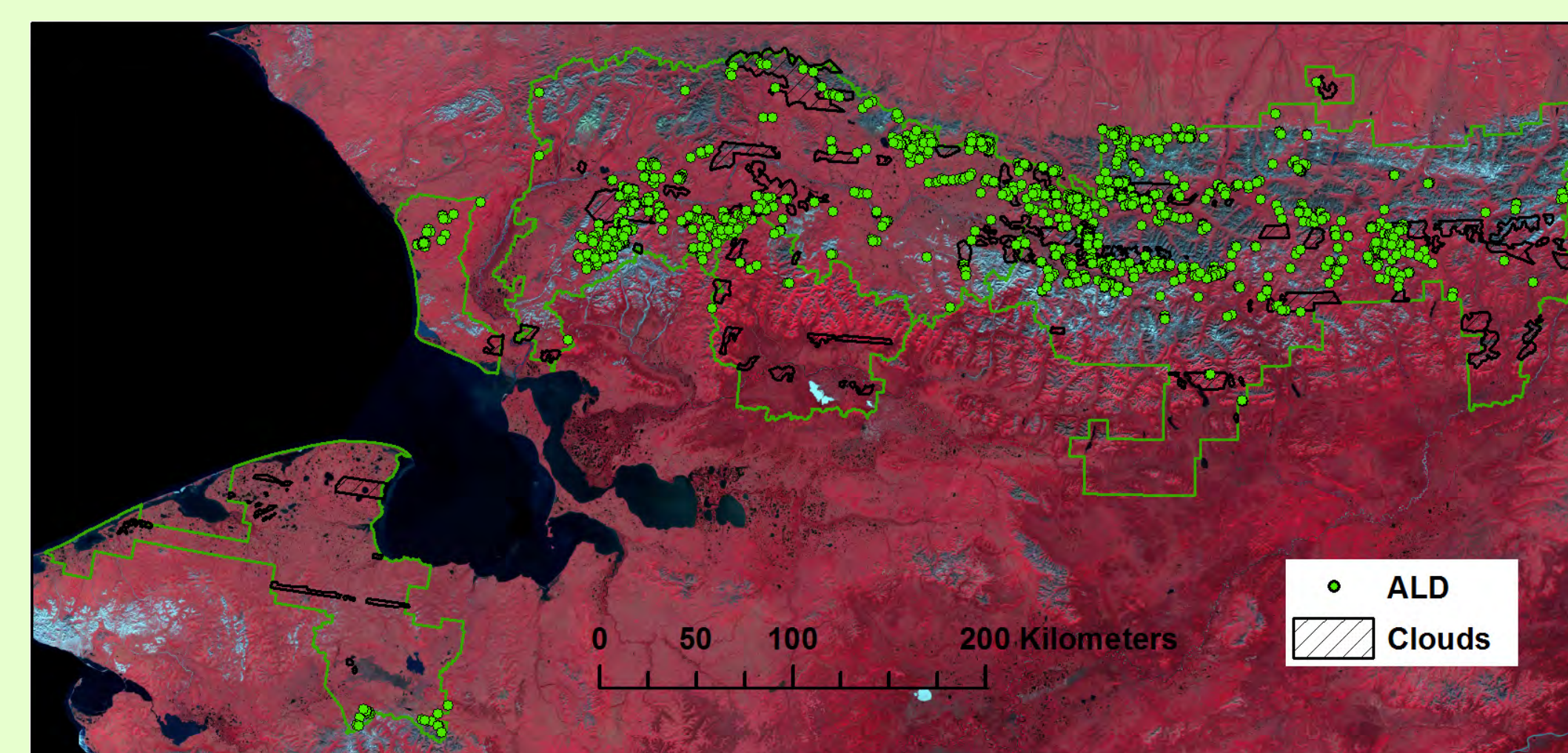
Mapping Thaw Slumps and Slides



Active-layer detachments are narrow, shallow landslides of thawed material over permafrost. They form in especially warm or wet summers

Comprehensive maps of active-layer detachments (ALD) and retrogressive thaw slumps (RTS) were made using a semi-automated method with high-resolution satellite images from 2006-09. Partial re-mapping is planned at 10-year intervals.

- 2246 ALD were mapped
- Total area of bare soil exposed: 300 ha (ARCN covers 8.2 million ha)
- Most of the ALD formed during the warm summer of 2004 and have since revegetated

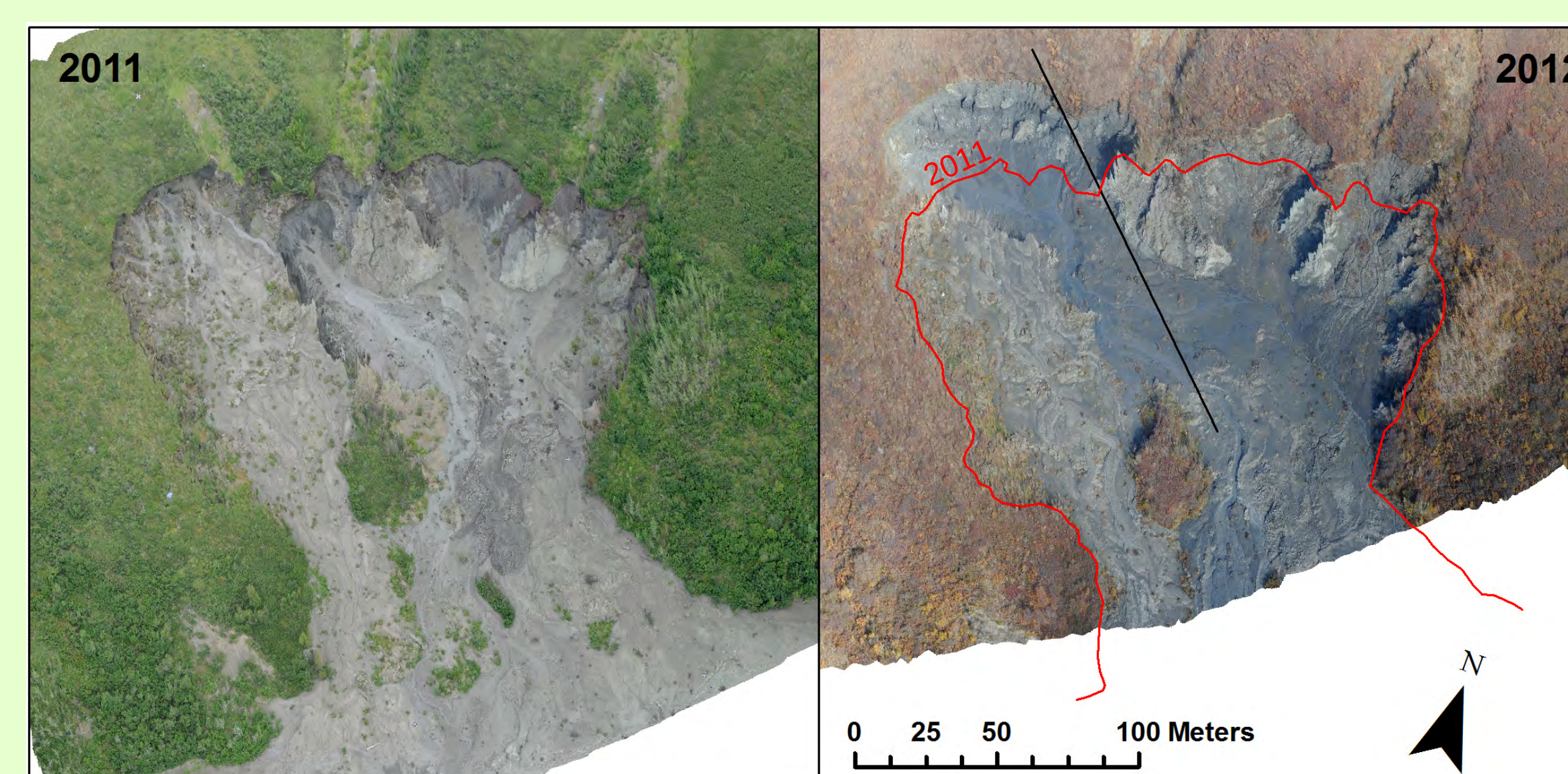


- 724 RTS were mapped
- Total area of bare soil exposed: 235 ha
- RTS are present on historical aerial photographs, though they appear to be more abundant now than around 1980

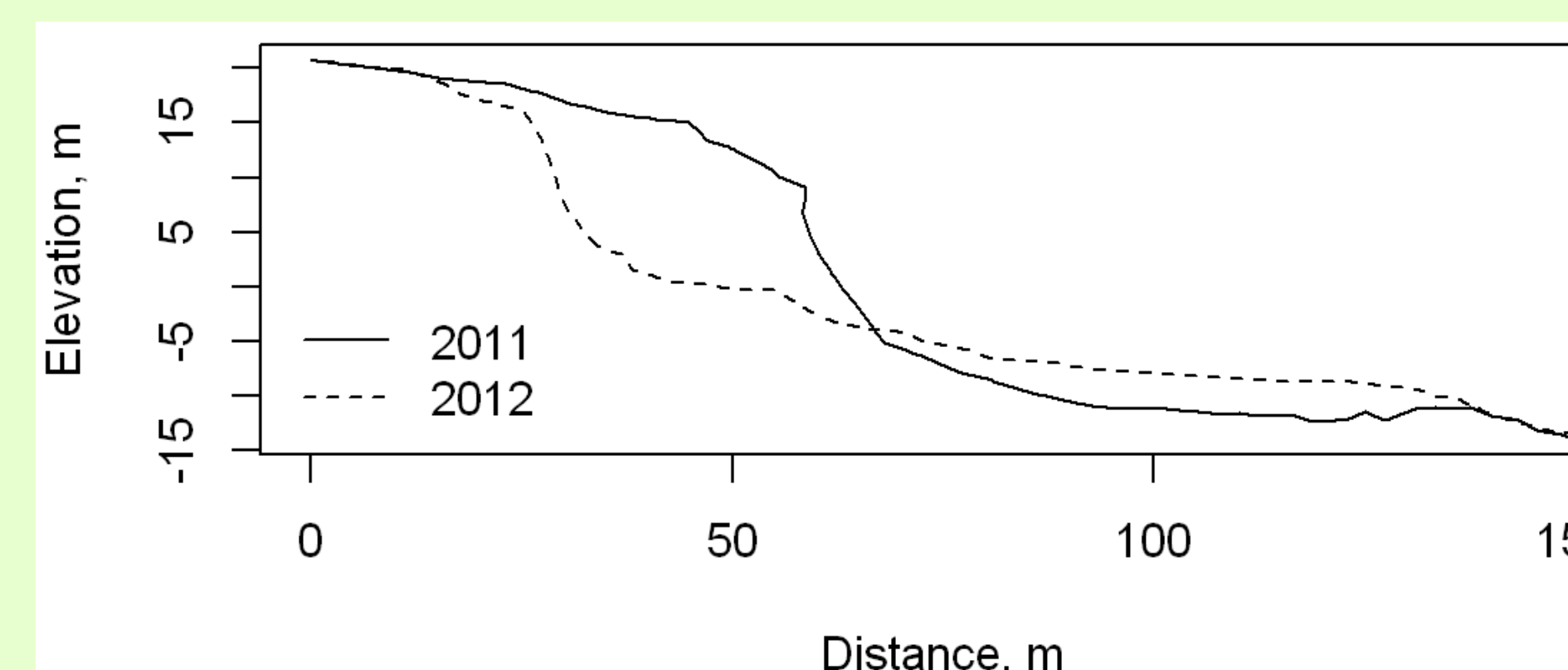
3D Modeling of Thaw Slumps

- Nineteen RTS were modeled in 3D using multiple overlapping low-altitude aerial photographs taken with a 35 mm camera.
- Oblique photos from 2010, 2011, and 2012 with ground control points were used to create orthophotographs and digital elevation models
- Analysis completed through 2012 showed scarp retreat rates up to 30 m/yr and tens of thousands of cubic meters of material lost per year, but rates were slowing down on all slumps
- Vertical photos of 11 slumps with accurate aerial GPS (M. Nolan) were taken in 2013, 2014, 2016
- We will report on the 2013-2016 data in 2017

Orthophotographs of a large slump on the Noatak river in July 2011 and September 2012. This slump had a main scarp about 15 m high that migrated up to 30 m between 2011 and 2012. The resulting loss of about 50,000 m³ volume in the upper part was balanced in part by a gain of about 10,000 m³ below.



Cross-section along the black line shown on the orthophoto above.

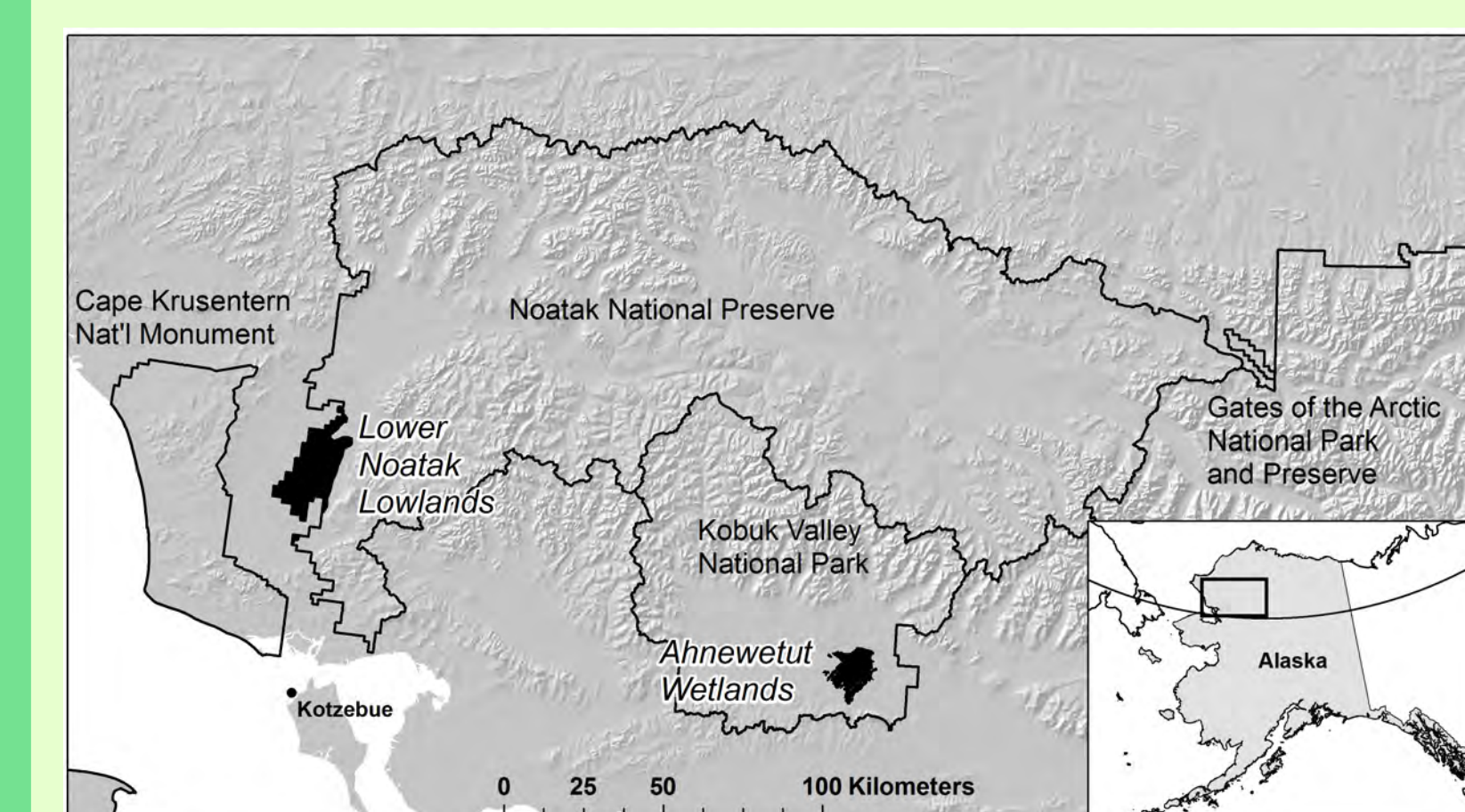


Conclusions

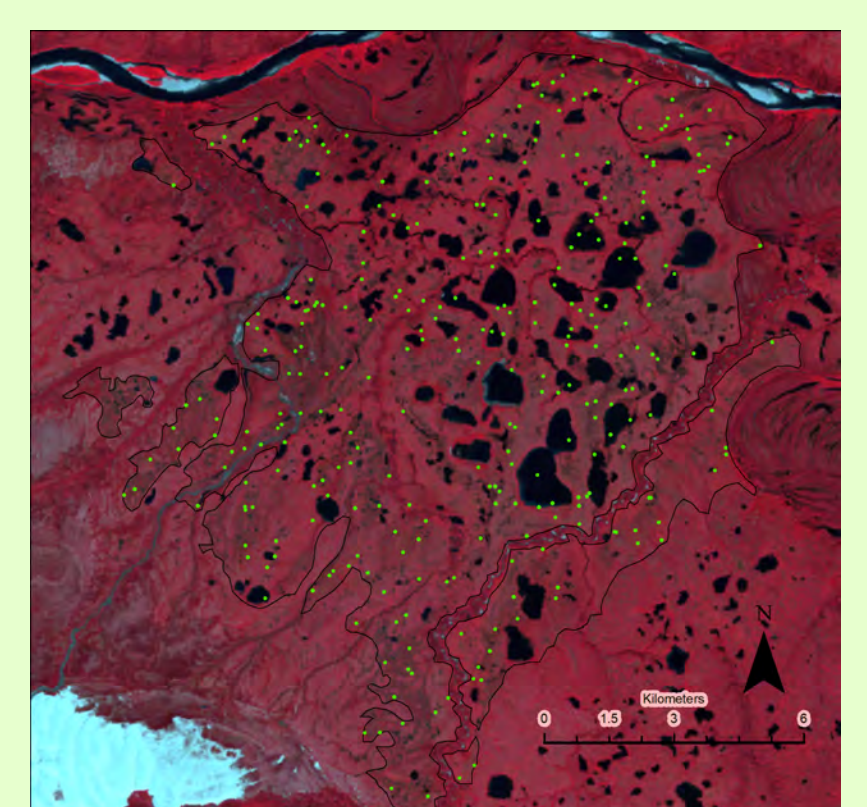
- Thaw slumps and slides have dramatic local effects, but currently their overall impact is minor because they have a small total area and they were present historically
- Local ice-wedge degradation has occurred since the 1950s
- The effects of climate change on permafrost in ARCN have been modest, thanks to the relatively stable climate from 1977 through 2012.
- Mean annual air and ground temperatures have increased dramatically in the last few years. This is likely to upset the post-1976 equilibrium and lead to widespread permafrost degradation in the near future
- For details see our reports at <http://science.nature.nps.gov/im/units/arcn/>

Ice-wedge Polygon Monitoring

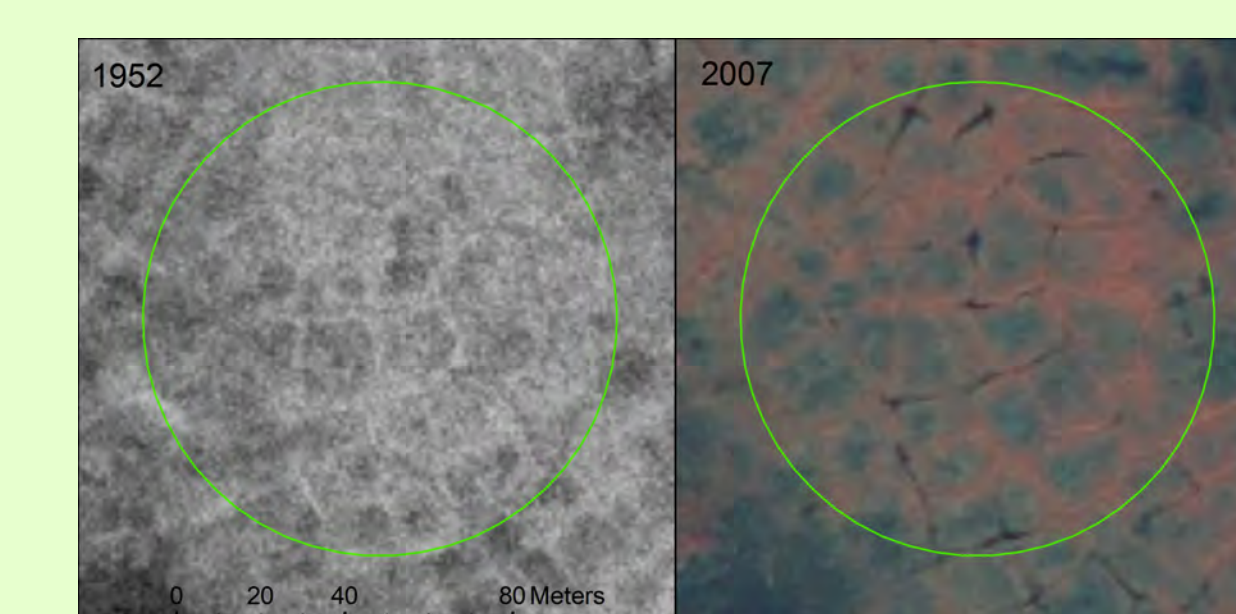
Thaw of ice wedges produces water-filled troughs along polygon margins. This water can be mapped on aerial images to monitor ice-wedge degradation



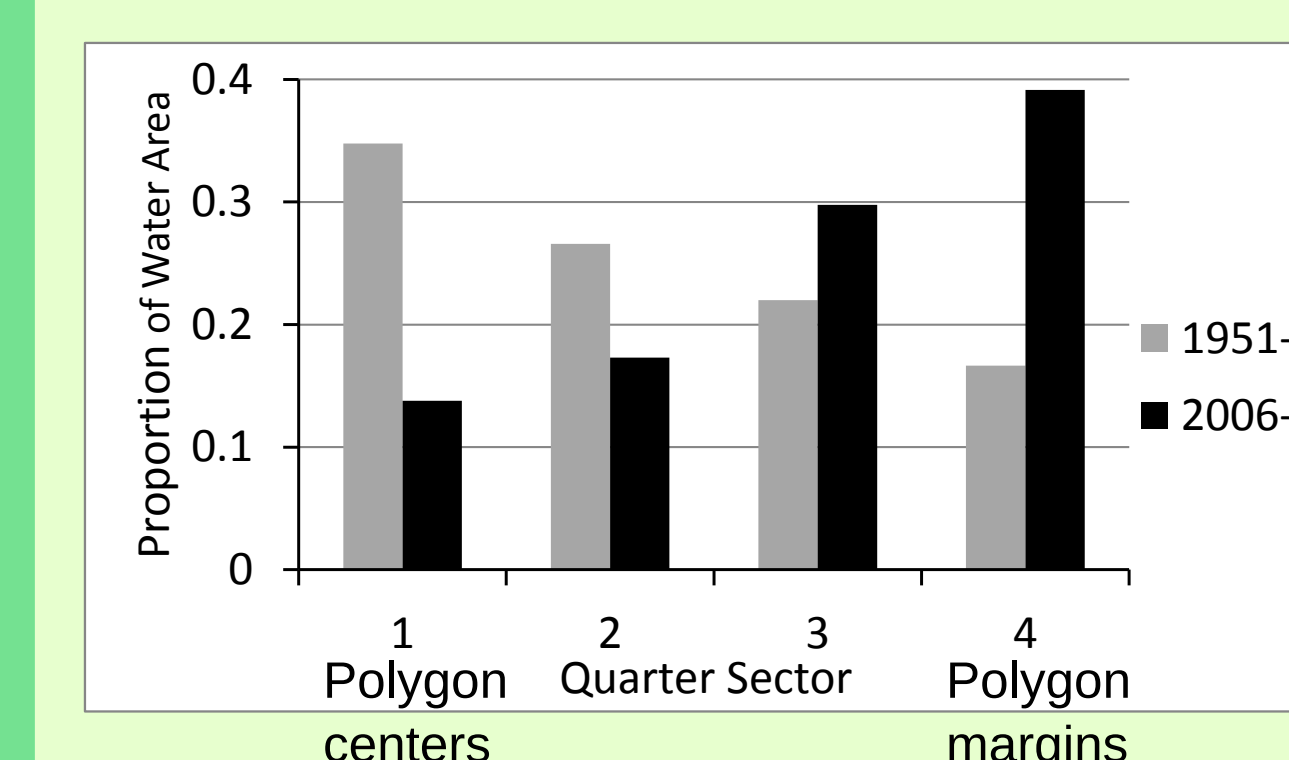
Two study areas were chosen that have the greatest density of ice-wedge polygons in ARCN outside of Bering Land Bridge NP



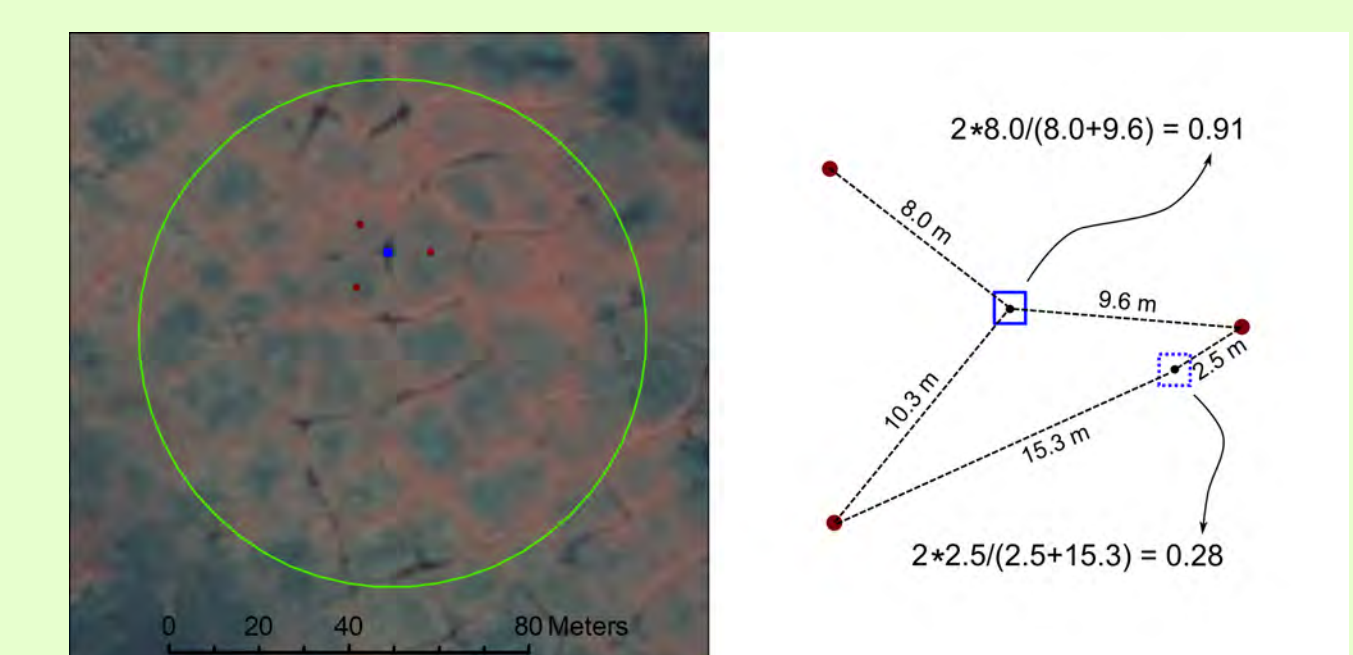
I placed 300 random 1-ha plots in each study area



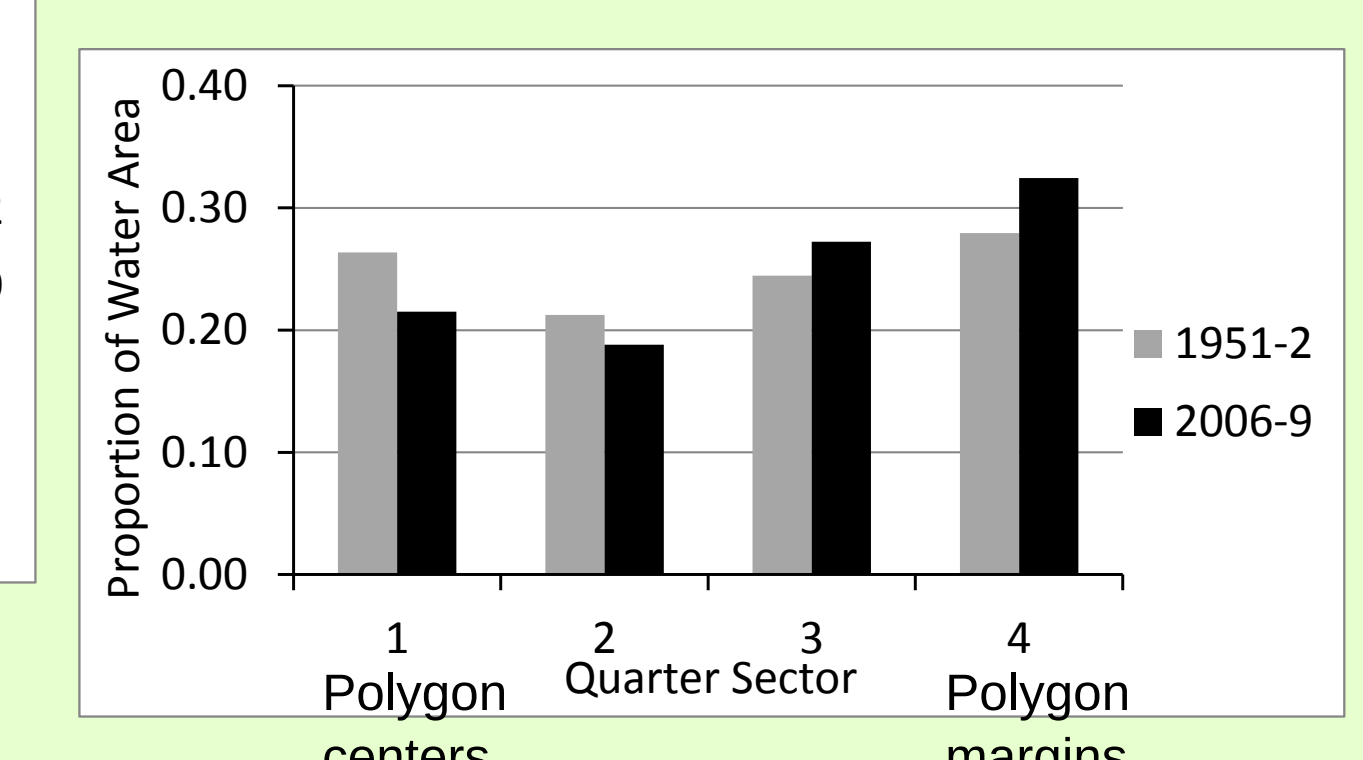
I mapped water by thresholding the pixel tone (dark pixels = water) on imagery from 1951-52 and 2006-09



Ice wedges degraded in the Kobuk Valley study area, as shown by a significant shift of water pixels to polygon margins between 1951-52 and 2006-09. The proportion of polygons with marginal ponds increased from 7% to 22%



I determined the location of each water pixel in relation to the nearest polygon centers using a distance index: polygon margin pixels have index near 1 polygon center pixels have index near 0



Degradation was much weaker in the Noatak Valley study area, though there was a shift of water toward the polygon margins there also.