

Landsat analysis of vegetation change in the Alaska North Slope Oilfields region using NDVI and tasseled-cap indices

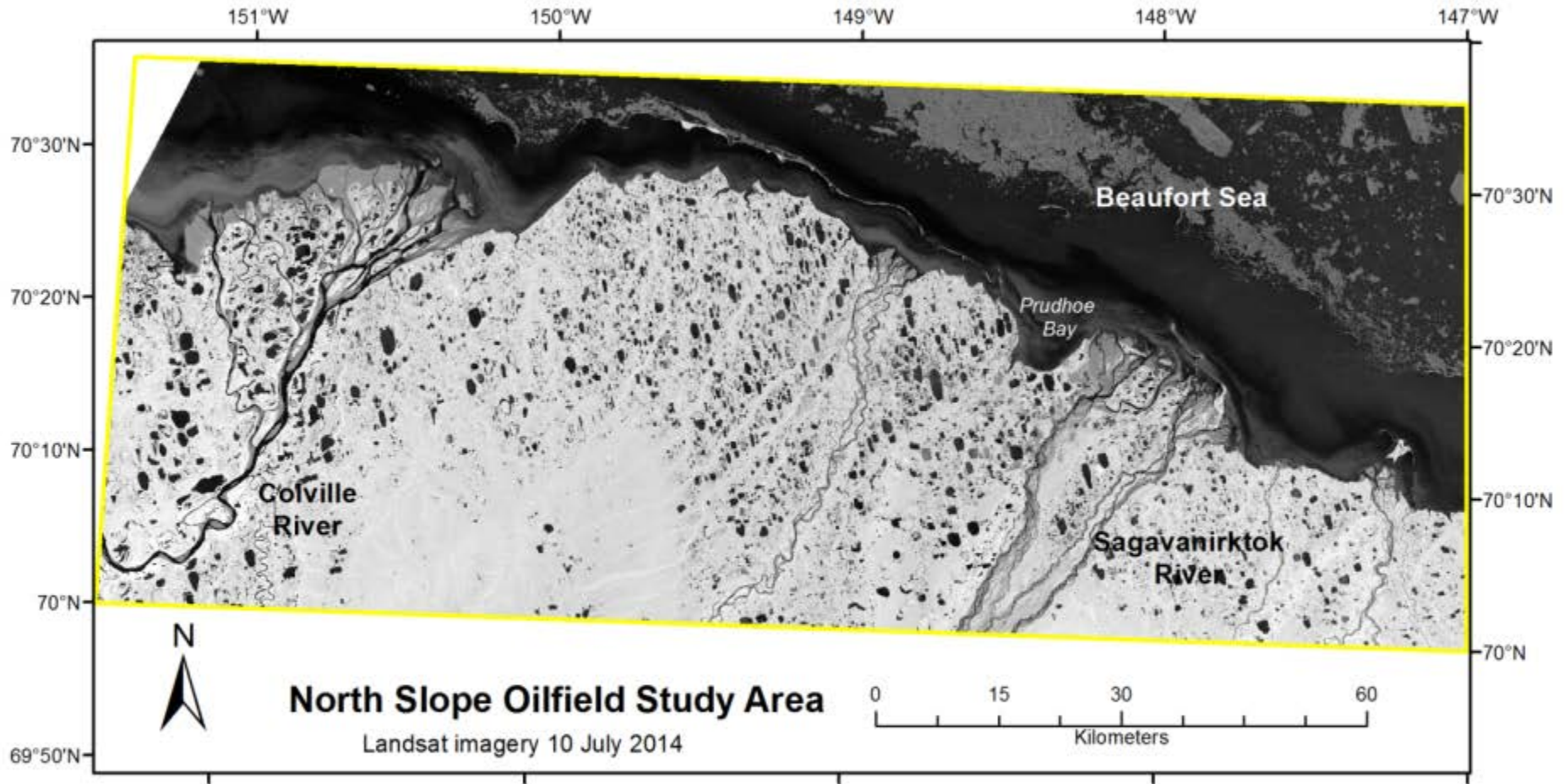
Martha Reynolds

University of Alaska Fairbanks

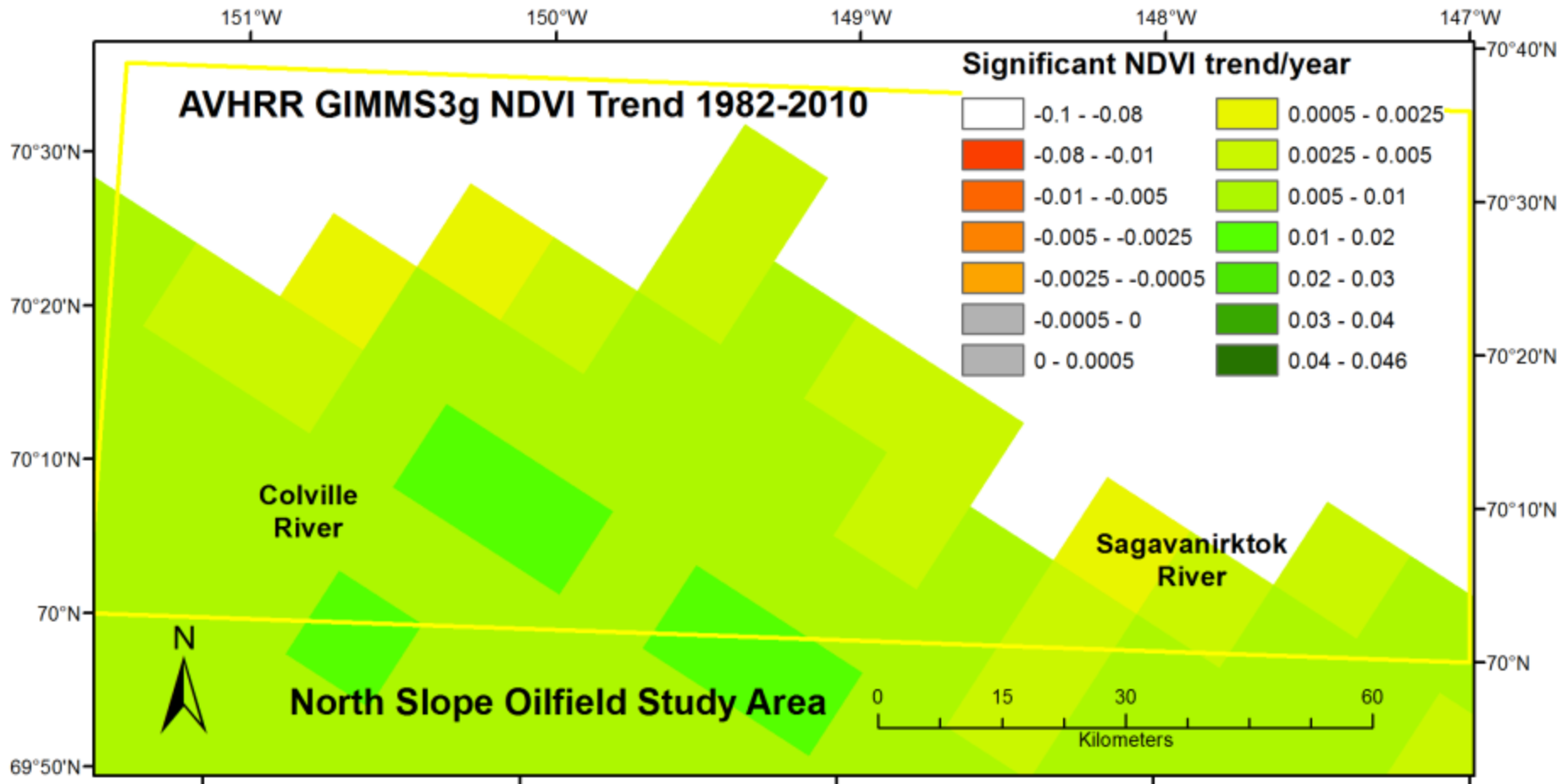
Arctic Biomass Final Workshop
20-23 October 2015
Longyearbyen, Svalbard



Study Area



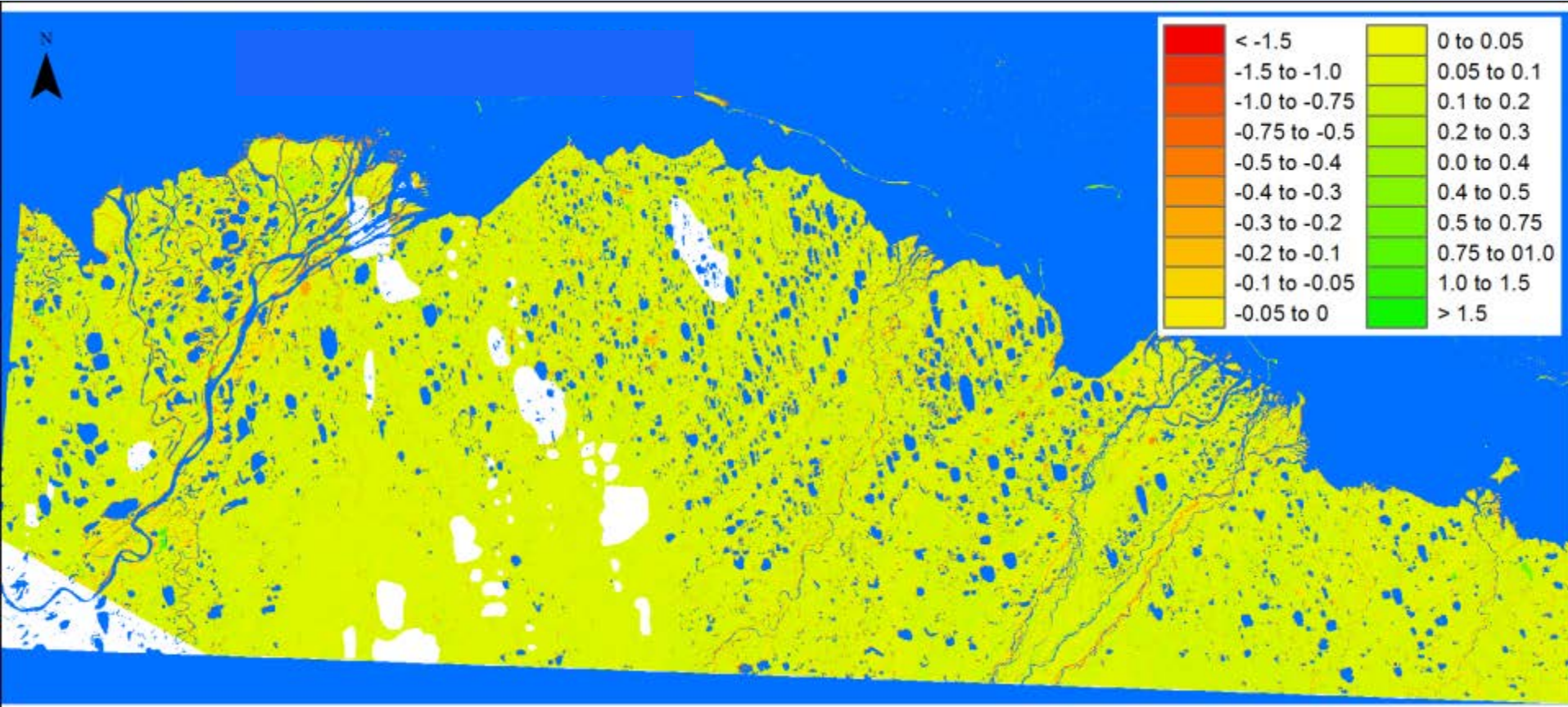
AVHRR GIMMS3g NDVI trend



- All trends are positive, though most are small

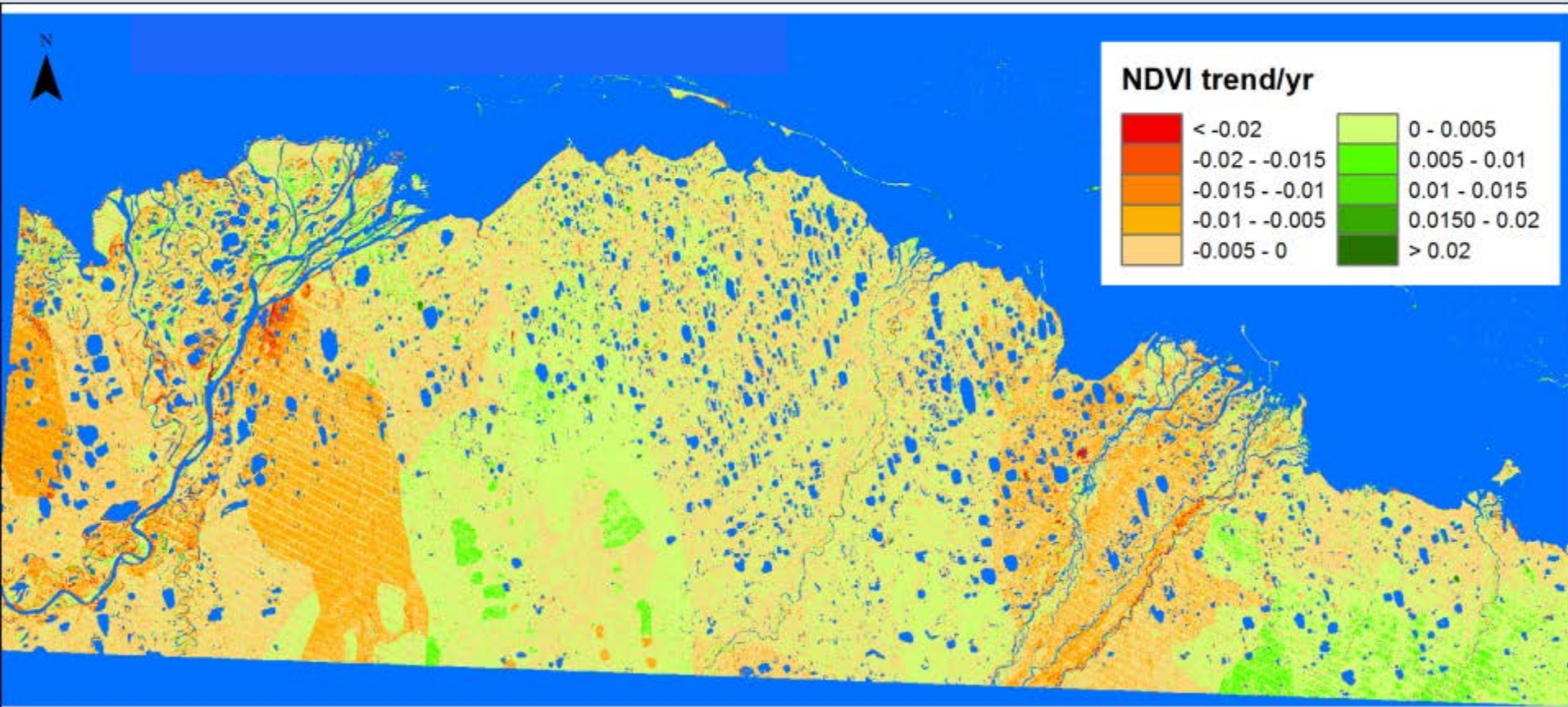
Landsat difference map

Subtracting 1977 from 2011

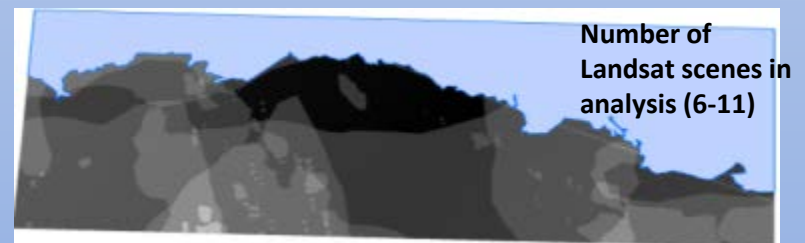


- The difference is positive overall (mean = 0.06 NDVI units = 0.002 NDVI units/year)
- Similar scale of NDVI change as seen with GIMMS data

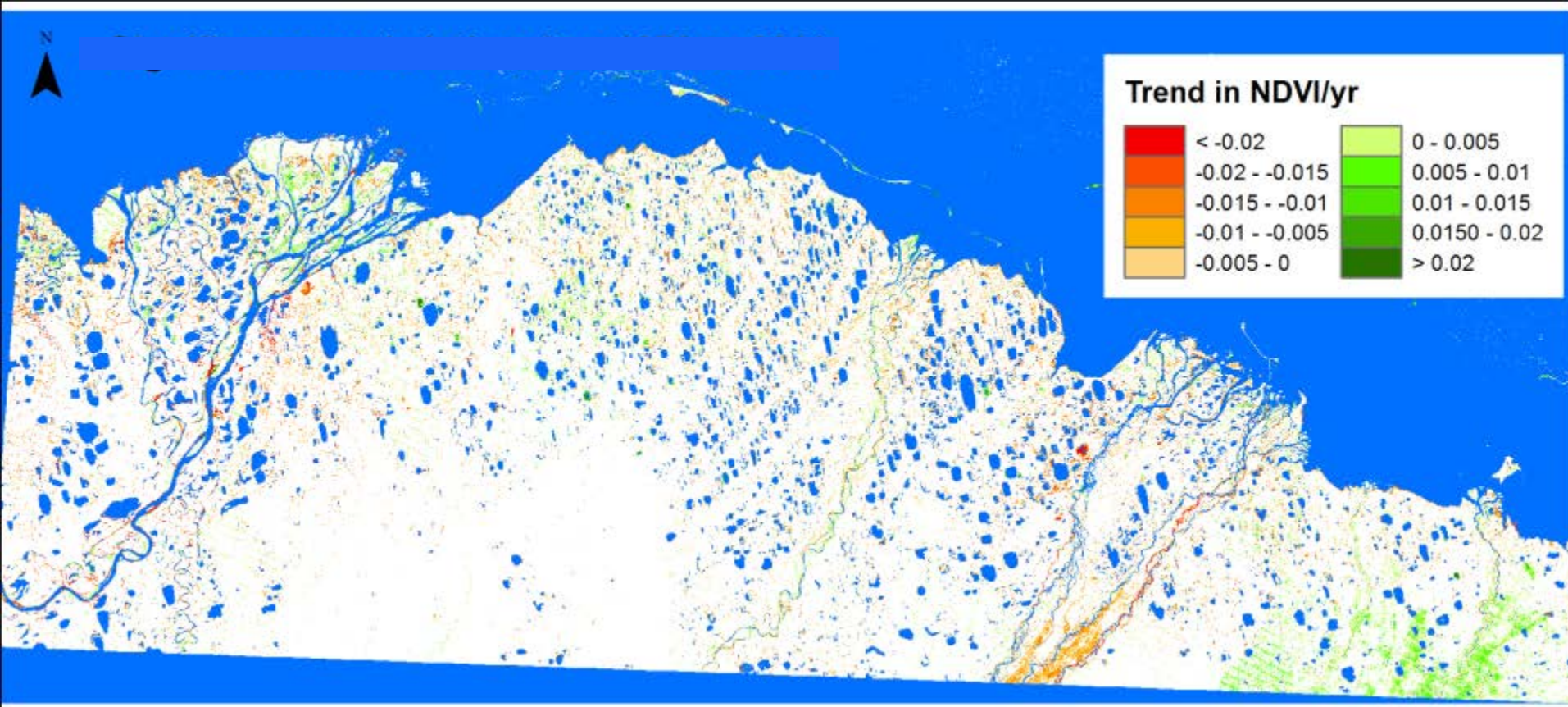
Landsat NDVI trend 1977 to 2011



- Average is negative: - 0.0024 NDVI units/yr
- Patchiness due to variable cloud cover in different years: 1977, 1979, 1985, 1986, 1989, 2001, 2002, 2005, 2007, 2008, 2009, 2011

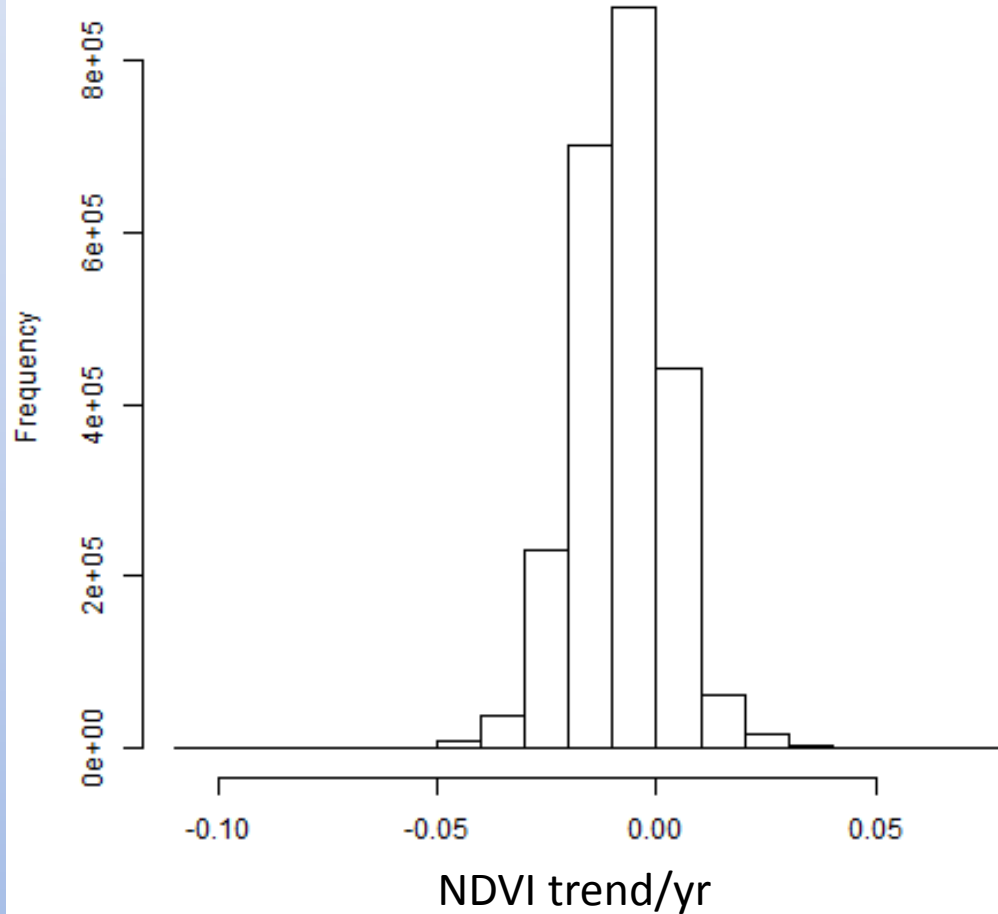


Significant trends in Landsat NDVI 1977 to 2011



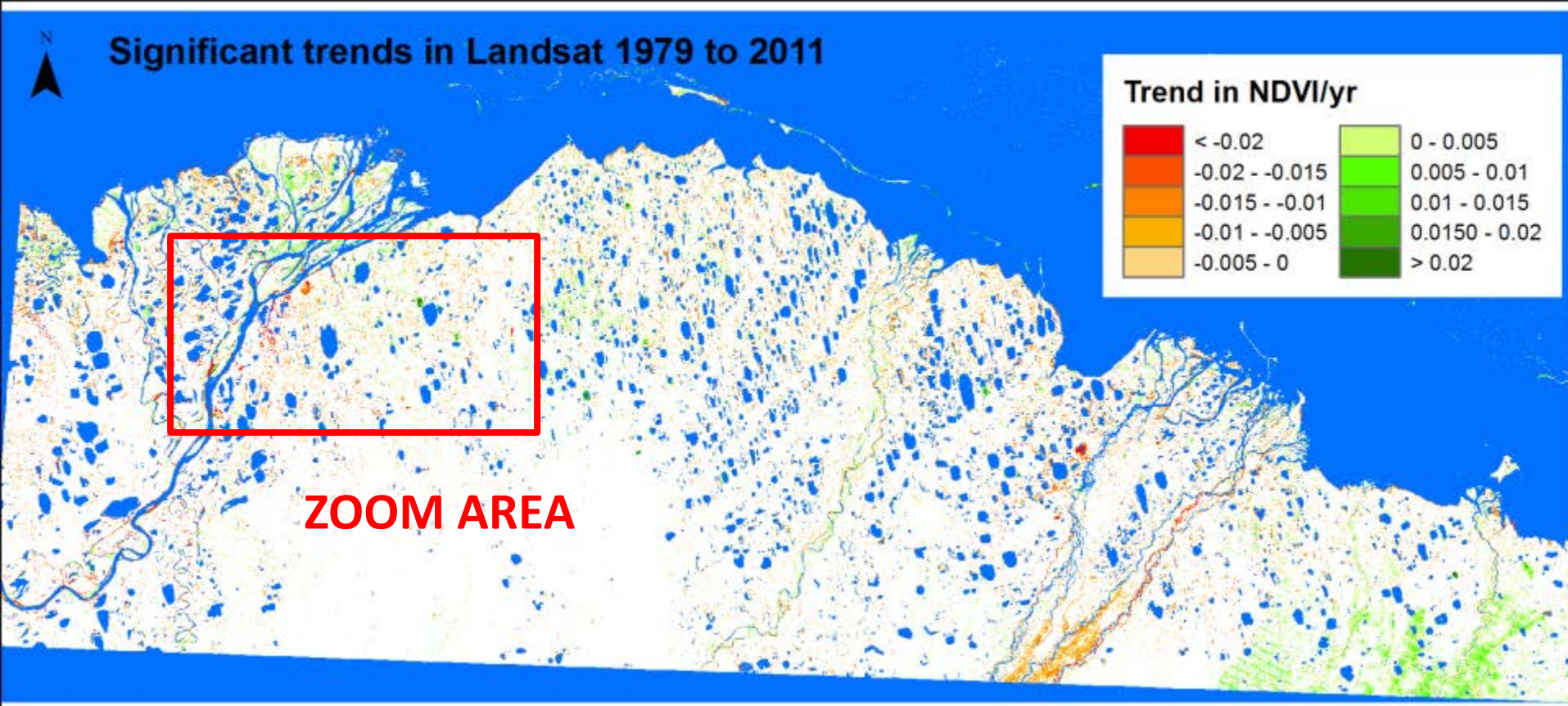
- Significant trends are negative overall (mean = - 0.0037 NDVI units/year)
- Small amount of area has significant trends (< 10 %)

Histogram of Significant Trends in Landsat NDVI 1977-2011

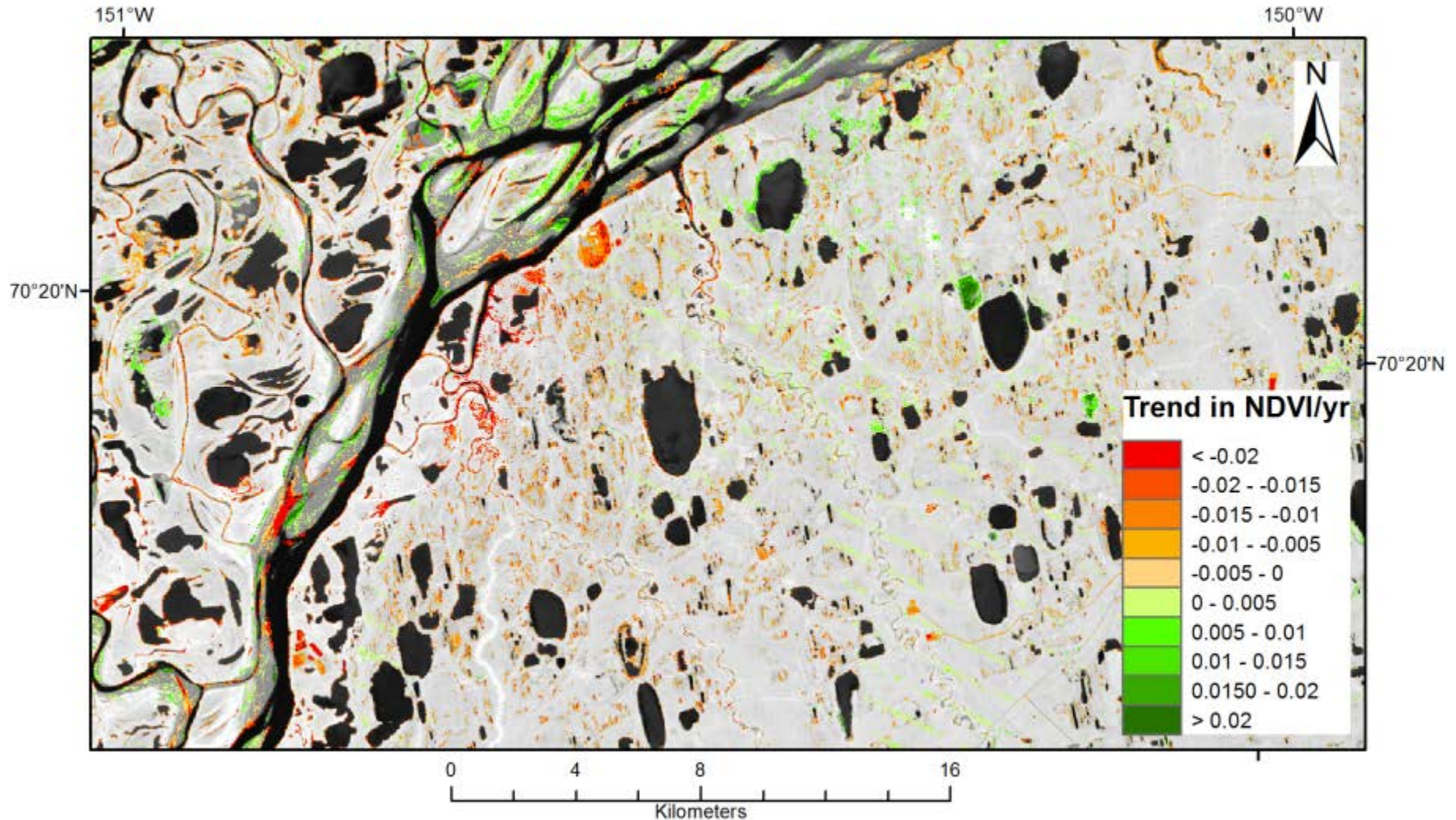


mean = - 0.0037 NDVI units/year

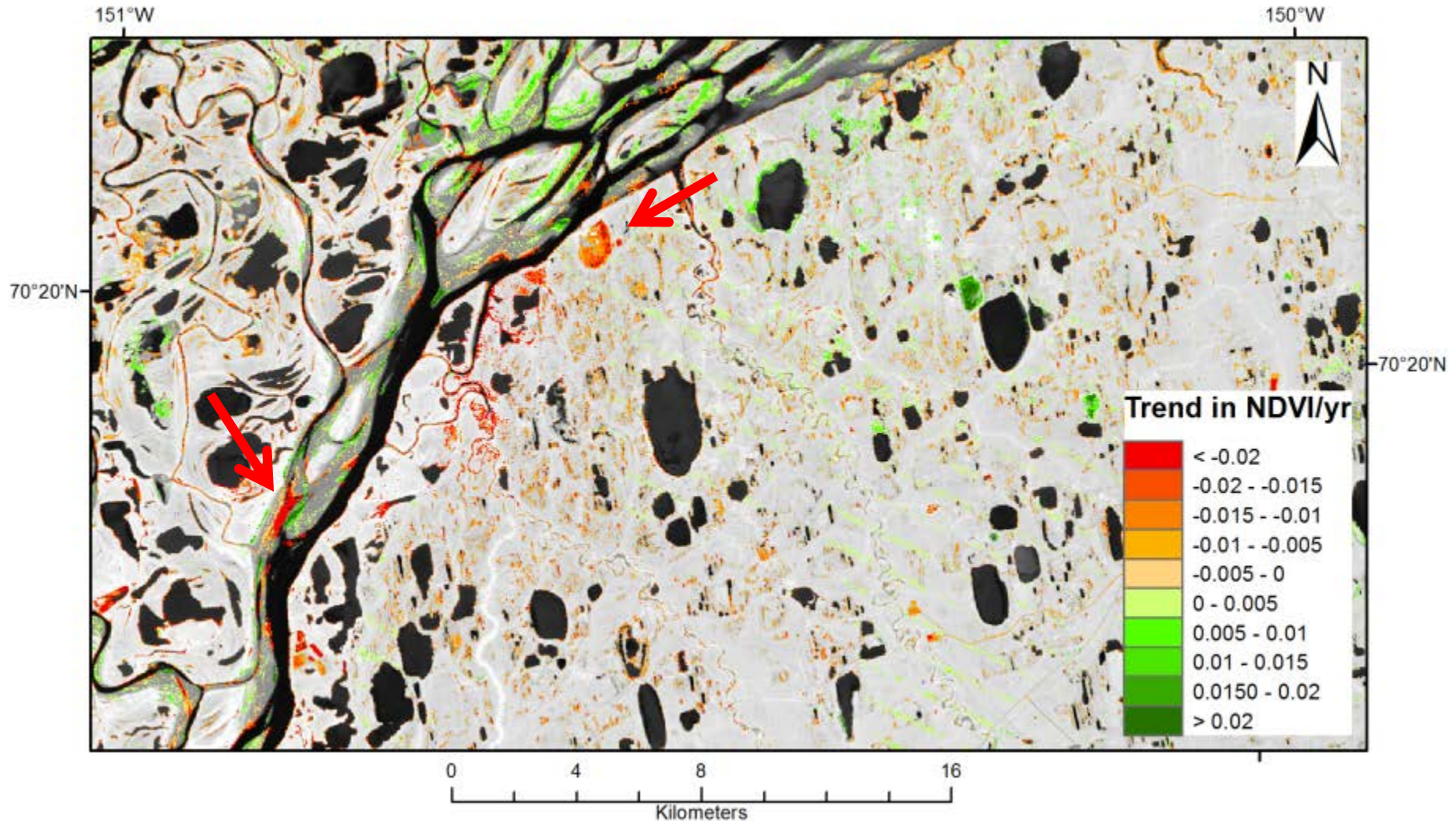
Significant trends in Landsat NDVI 1977 to 2011



Significant trends in Landsat NDVI 1977 to 2011

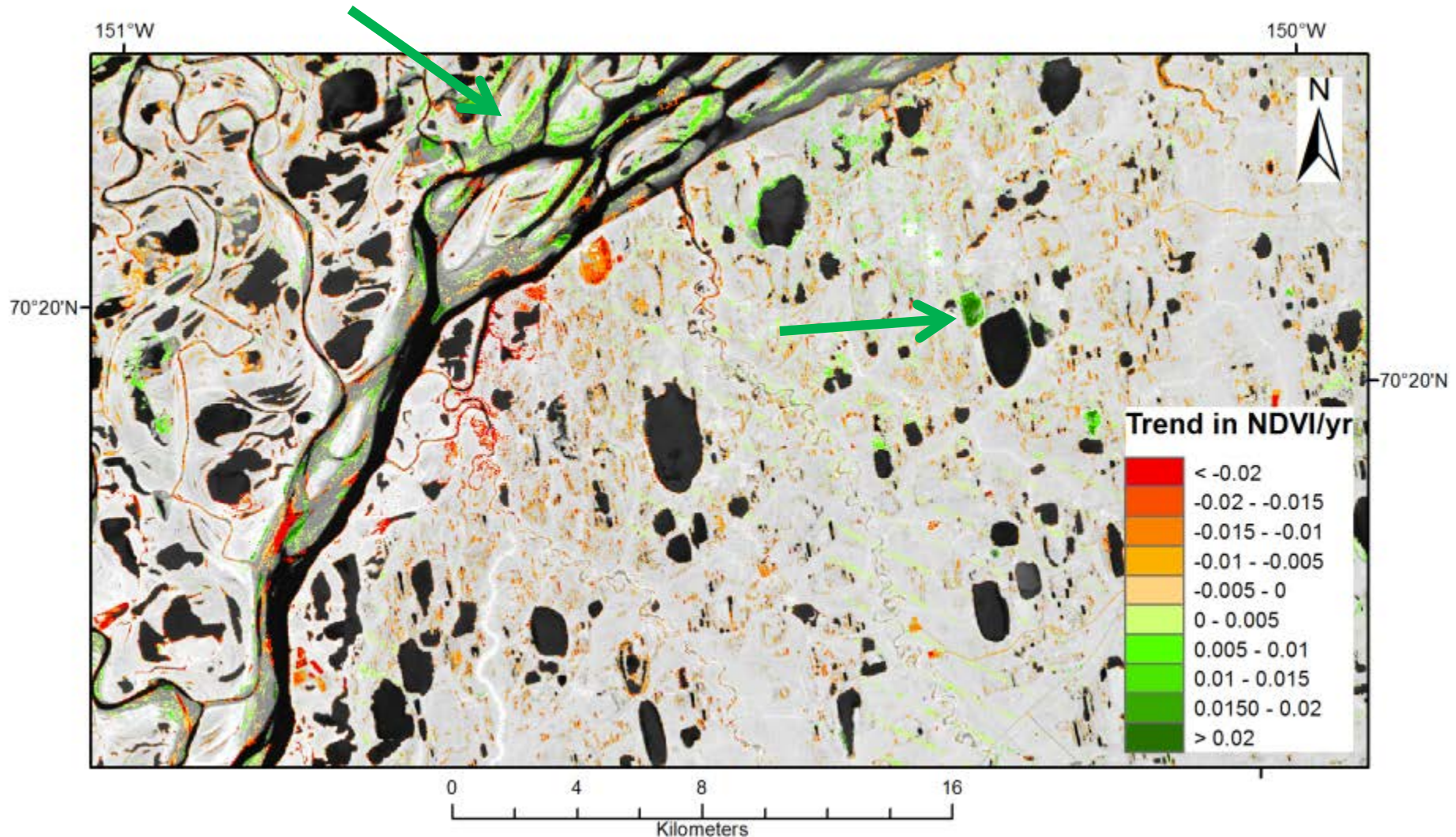


Significant trends in Landsat NDVI 1977 to 2011



Decreases in NDVI (orange) – changes in river channel, newly drained lake

Significant trends in Landsat NDVI 1977 to 2011



Decreases in NDVI (orange) – changes in river channel, newly drained lake

Increases in NDVI (green) – succession on river bars and previously drained lakes

Tasseled-Cap Index Transformation

- Orthogonal statistical analysis (like Principal Components Analysis (PCA))
 - Designed for Landsat data
 - Separate transformations developed for TM and ETM data, none available for Landsat 8 data yet
- Uses 6 Landsat bands (1, 2, 3, 4, 5 and 7)
- Returns 3 indices
 - Tasseled-Cap Index 1 – Brightness
 - Tasseled-Cap Index 2 - Greenness
 - Tasseled-Cap Index 3 – Wetness
- Processed in ENVI using the MSS and TM Tasseled-Cap Transformations
 - Used 1985, 1986, 1989, 2001, 2002, 2007, 2008, 2009, 2011
 - Could not use 1977, 1979 (MSS), or 2005 (SLC gaps)

(Crist and Cicone 1984)

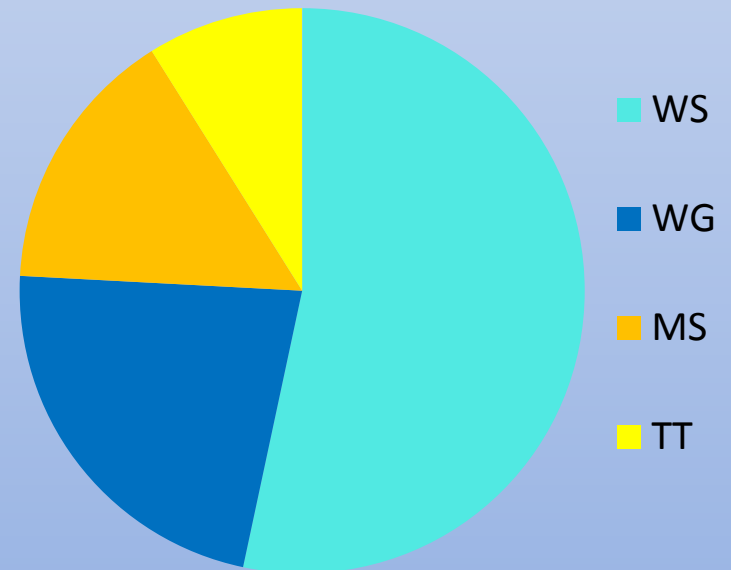
Circumpolar Vegetation Physiognomy Categories

from the Circumpolar Arctic Vegetation Map(CAVM)

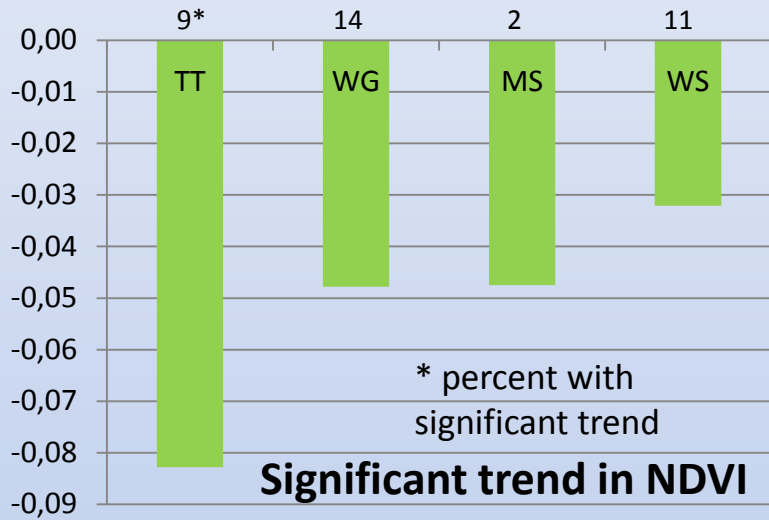


- MS** – Moist non-tussock sedge, dwarf shrub, moss tundra
- TT** – Moist tussock sedge, dwarf shrub, moss tundra
- WG** – Wet graminoid, moss tundra
- WS** – Wet sedge, moss tundra

CAVM cover types (% land area)



Circumpolar Vegetation categories (CAVM)



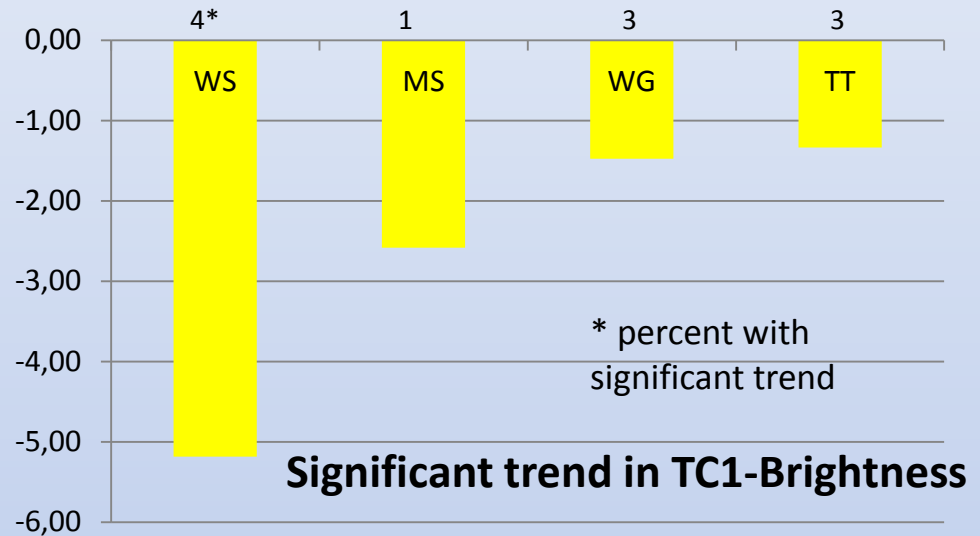
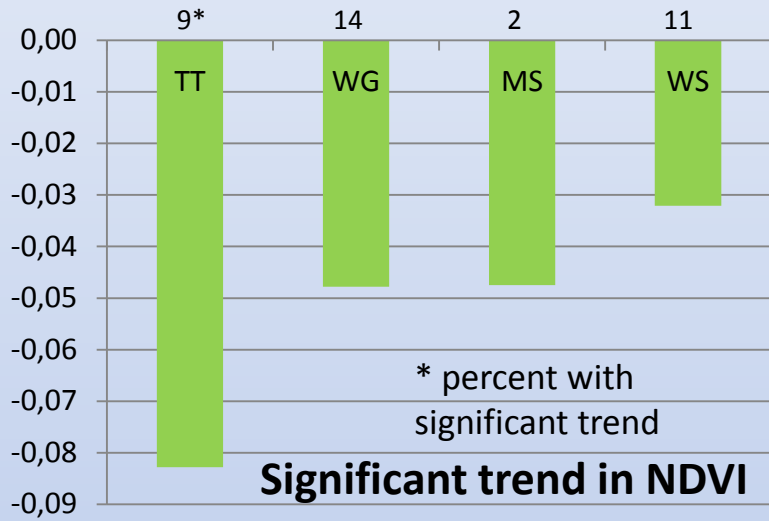
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Circumpolar Vegetation categories (CAVM)



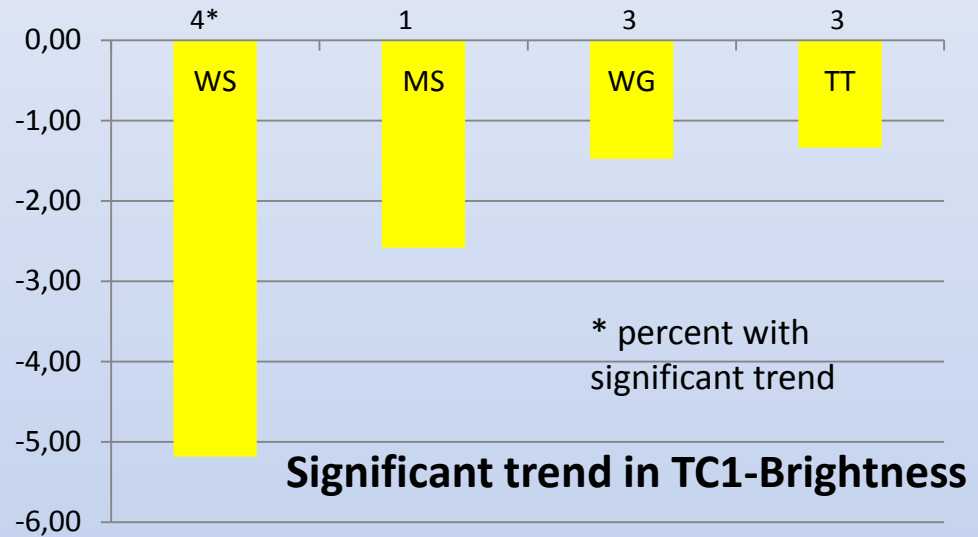
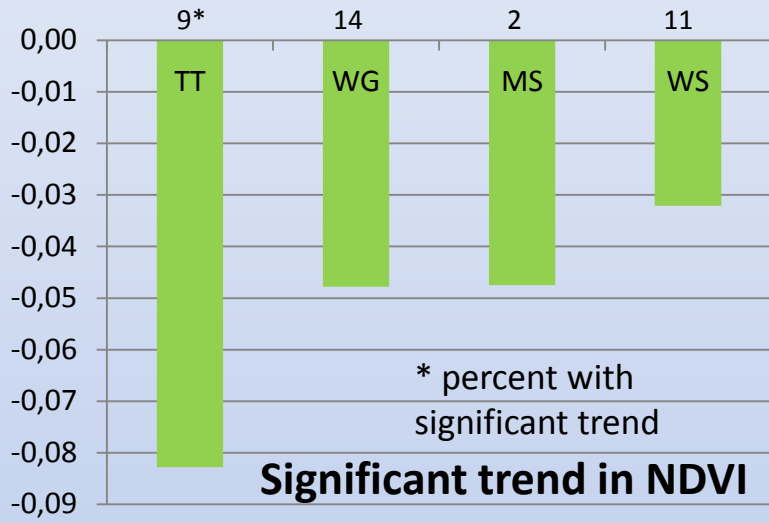
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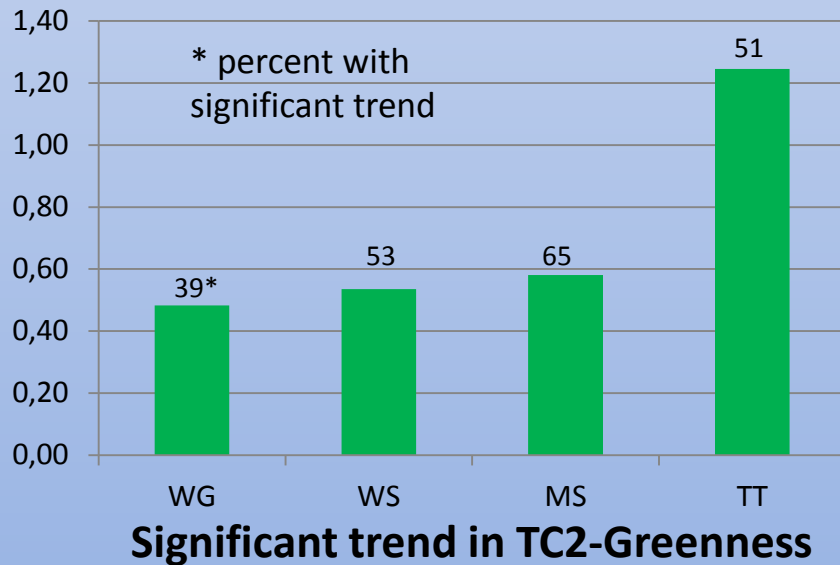
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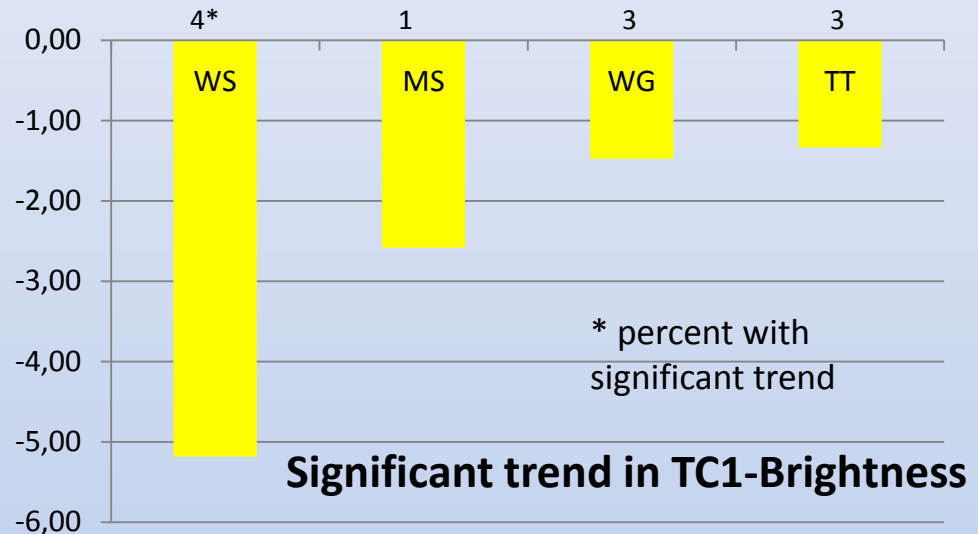
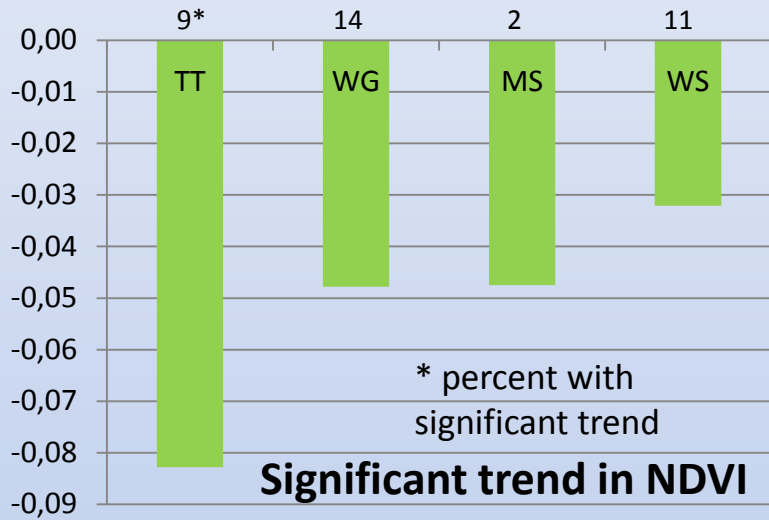
Circumpolar Vegetation categories (CAVM)



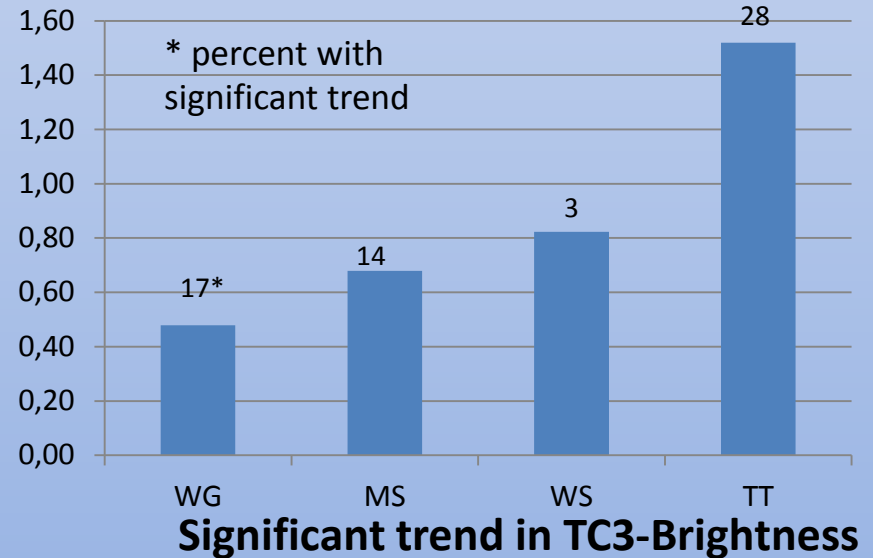
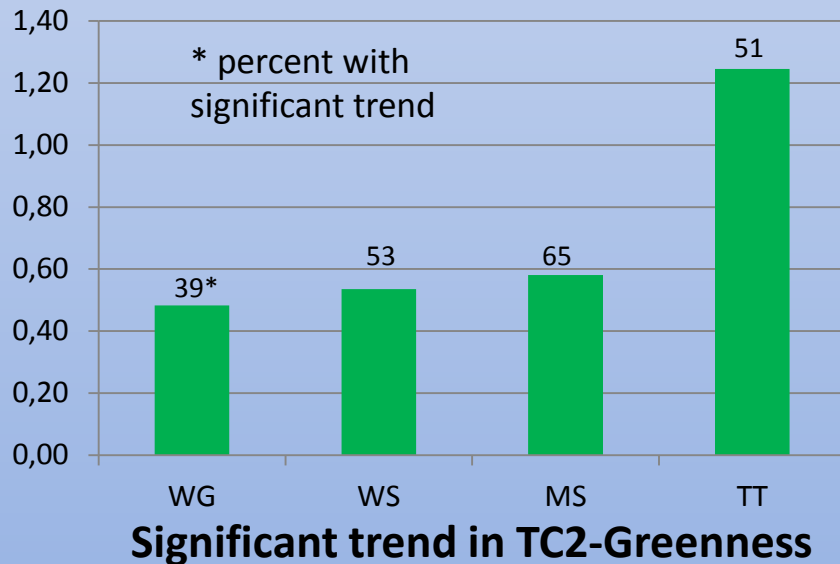
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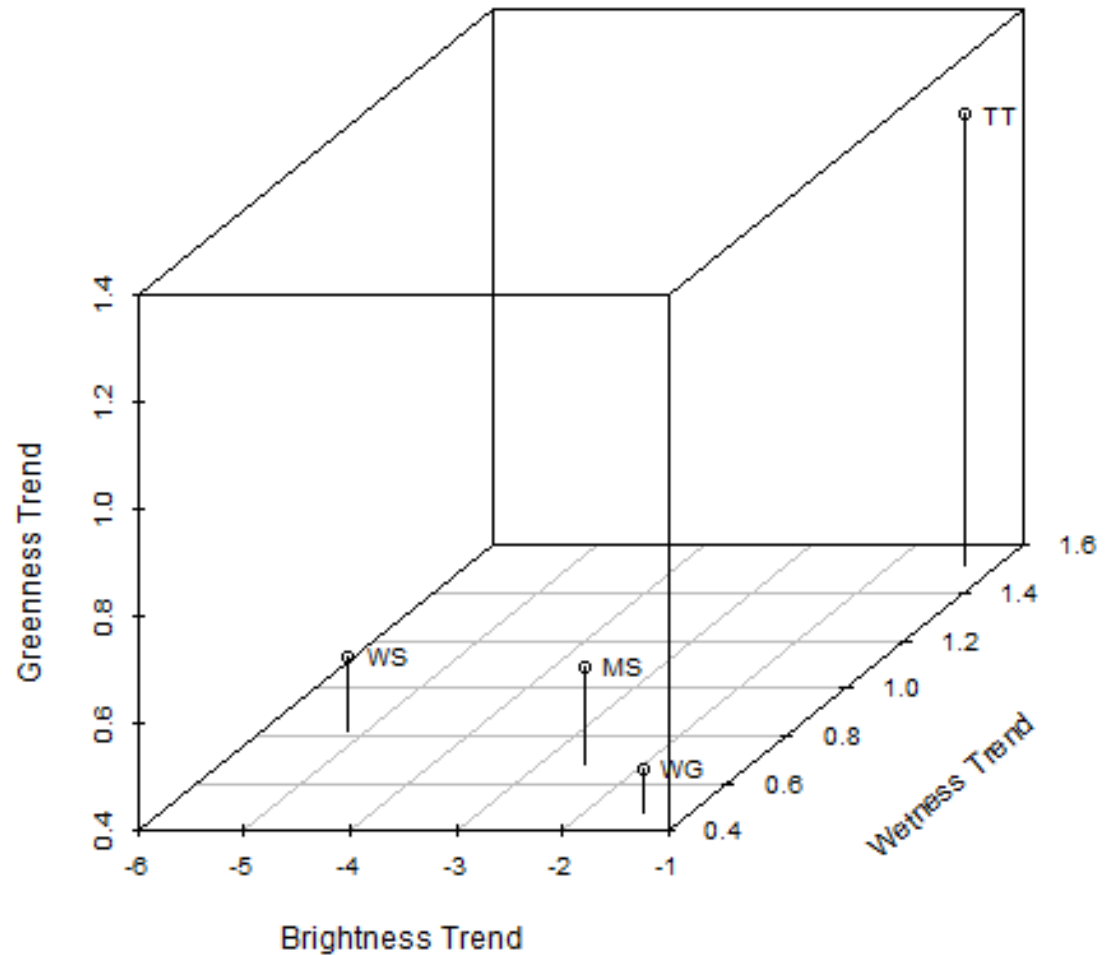
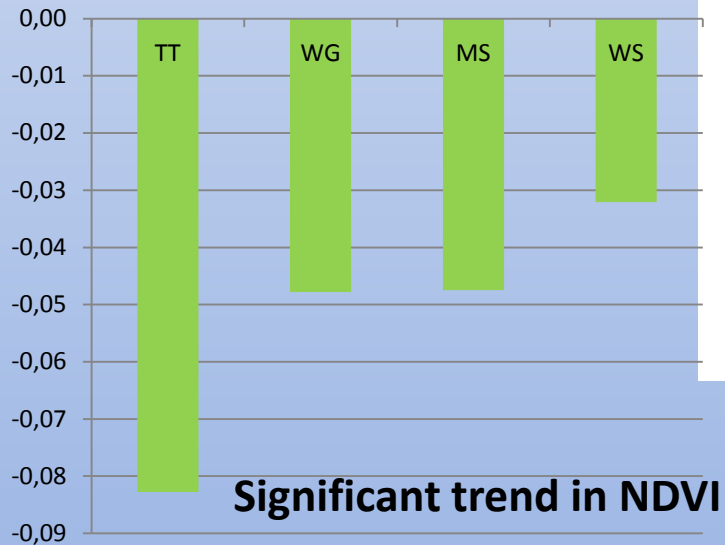
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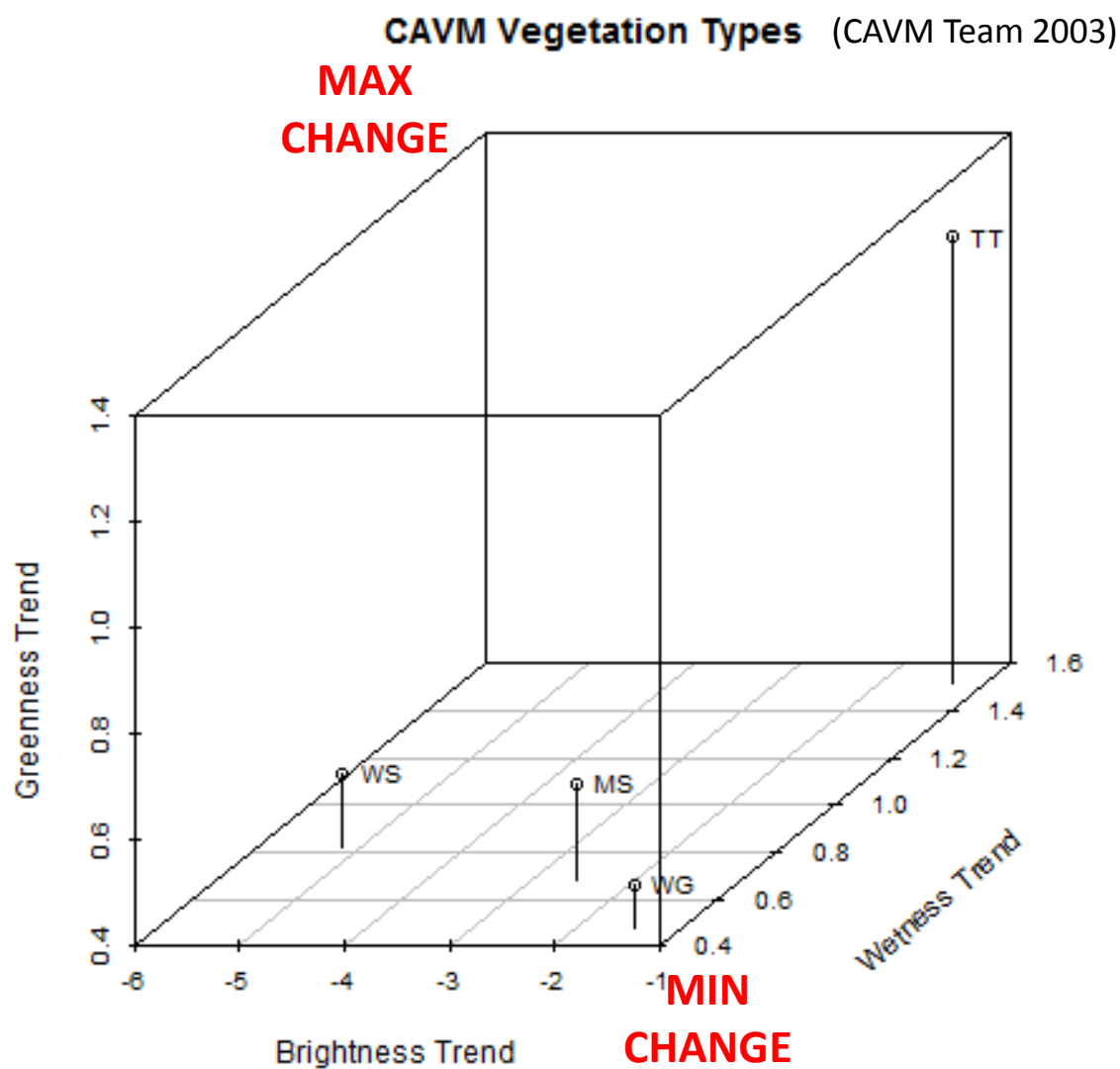
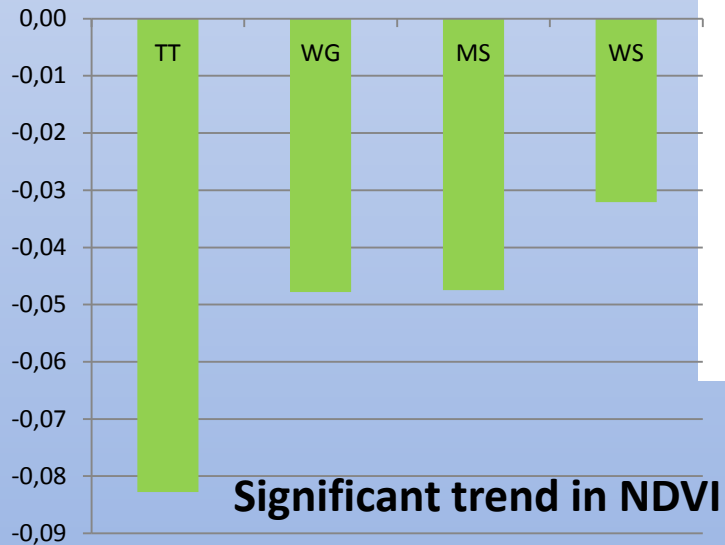


3-Dimensional view of significant trends in tasseled-cap indices, 1985 to 2011



MS – Moist non-tussock sedge, dwarf shrub, moss tundra
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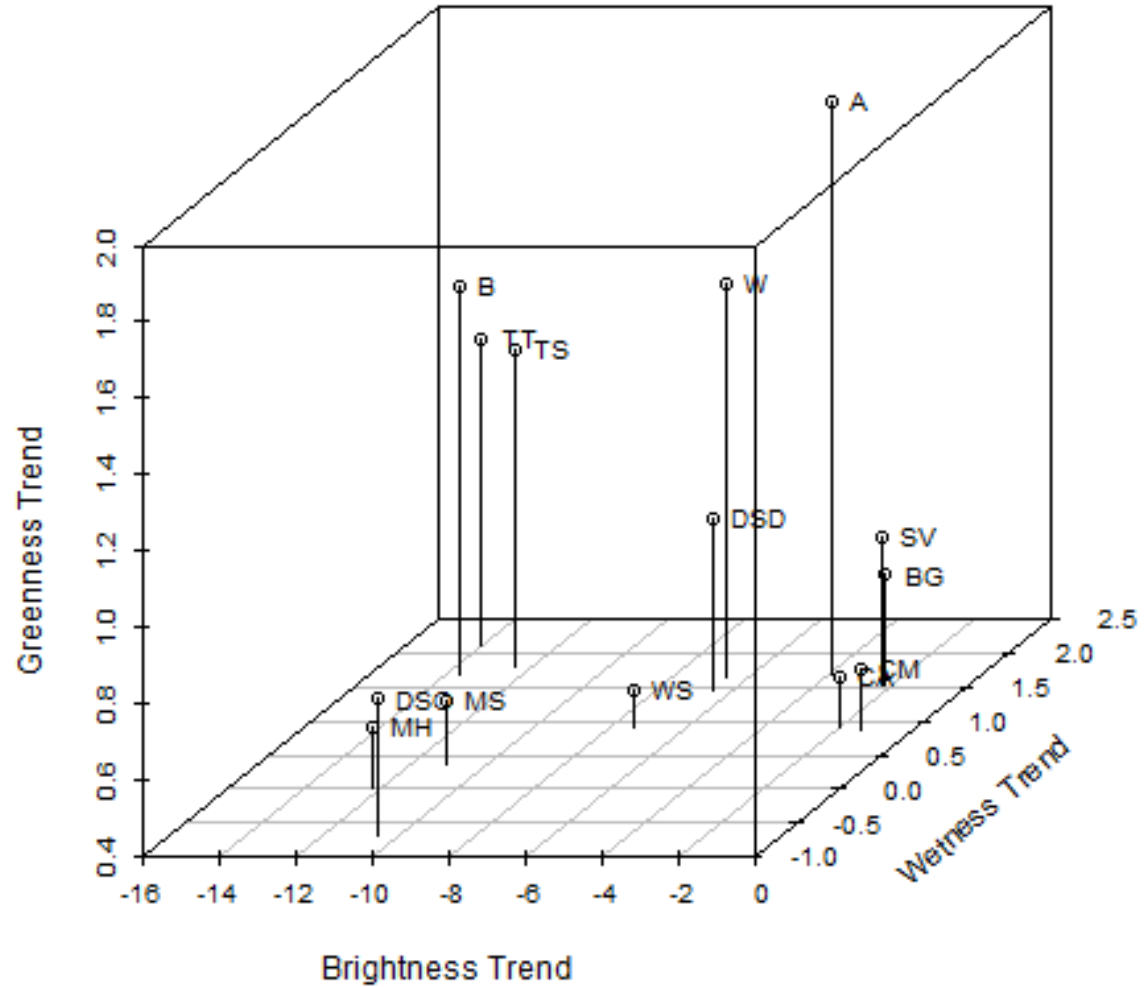
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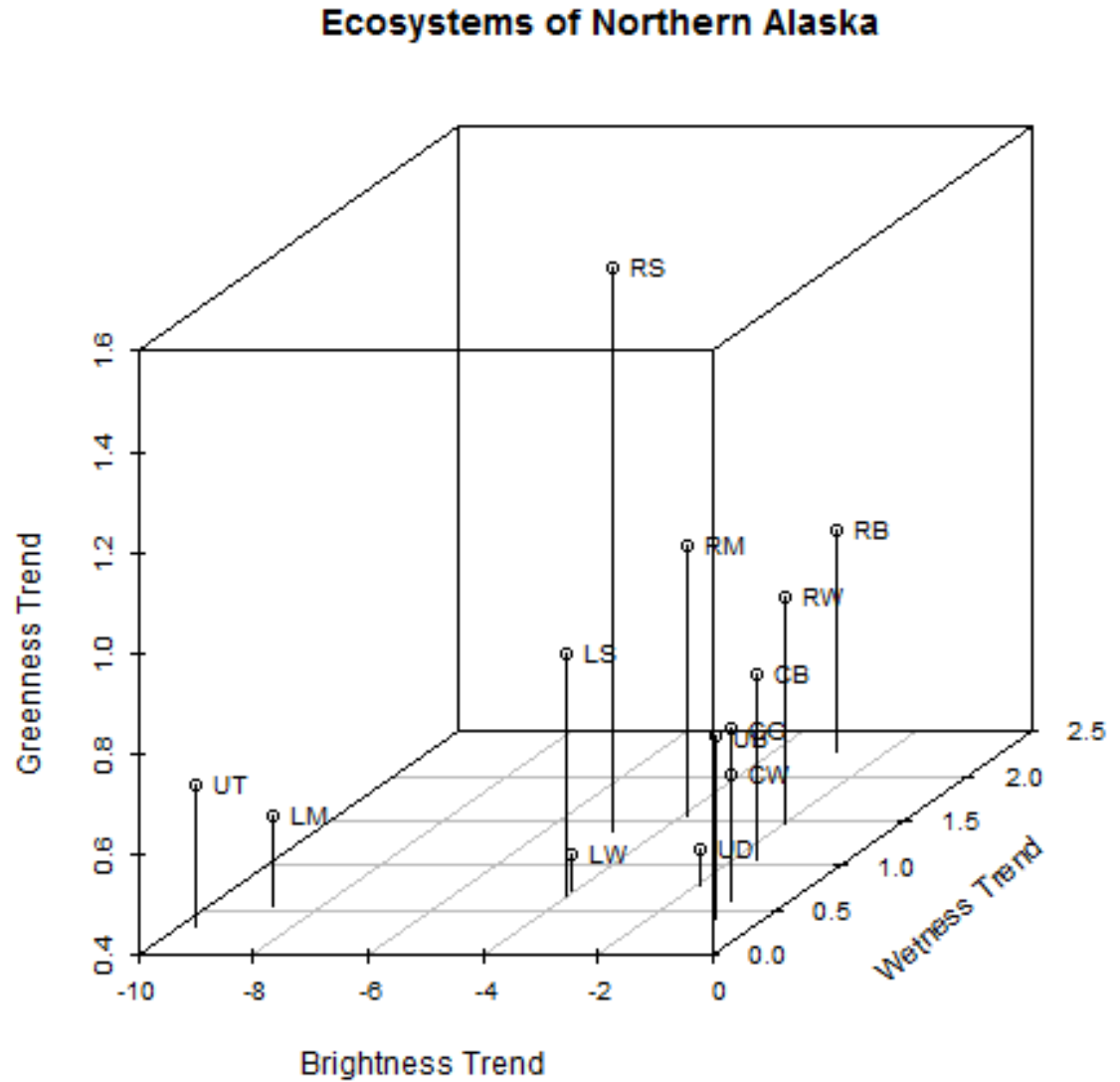
Code	Cover Type	Km ²
	Mesic Sedge-Dwarf Shrub	
MS	Tundra	2229
WS	Wet Sedge	1848
CA	FWM:Carex aquatilis	759
MH	Mesic Herbaceous	293
BG	Bare Ground	274
SV	Sparsely Vegetated	186
DSD	Dwarf Shrub - Dryas	175
TS	Tussock Shrub Tundra	128
W	Low-Tall Willow	88
CM	Coastal Marsh	72
TT	Tussock Tundra	19
A	Alder	3
DSO	Dwarf Shrub - other	2
B	Birch Ericaceous Low Shrub	1

NSSI Vegetation Types

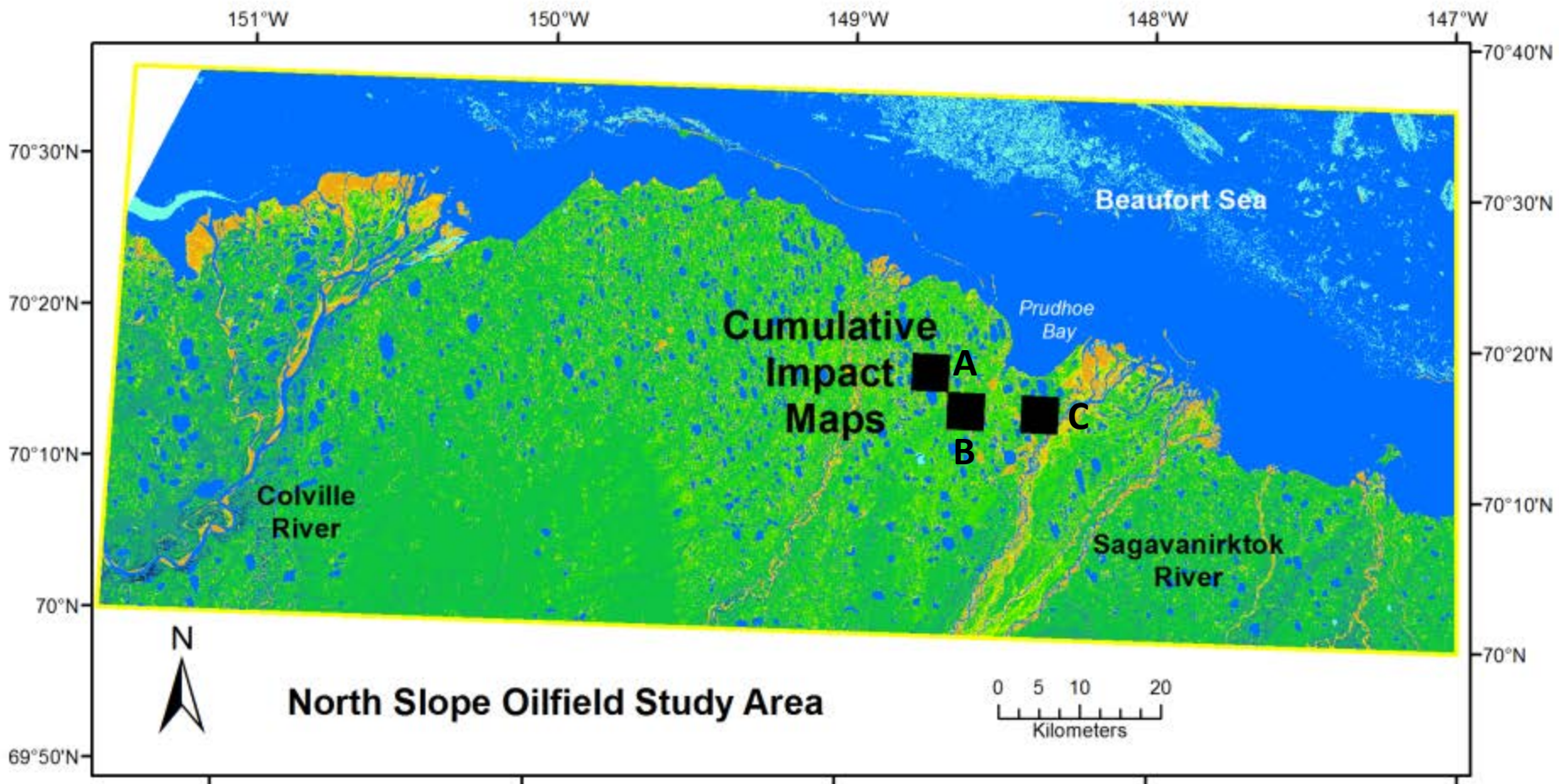


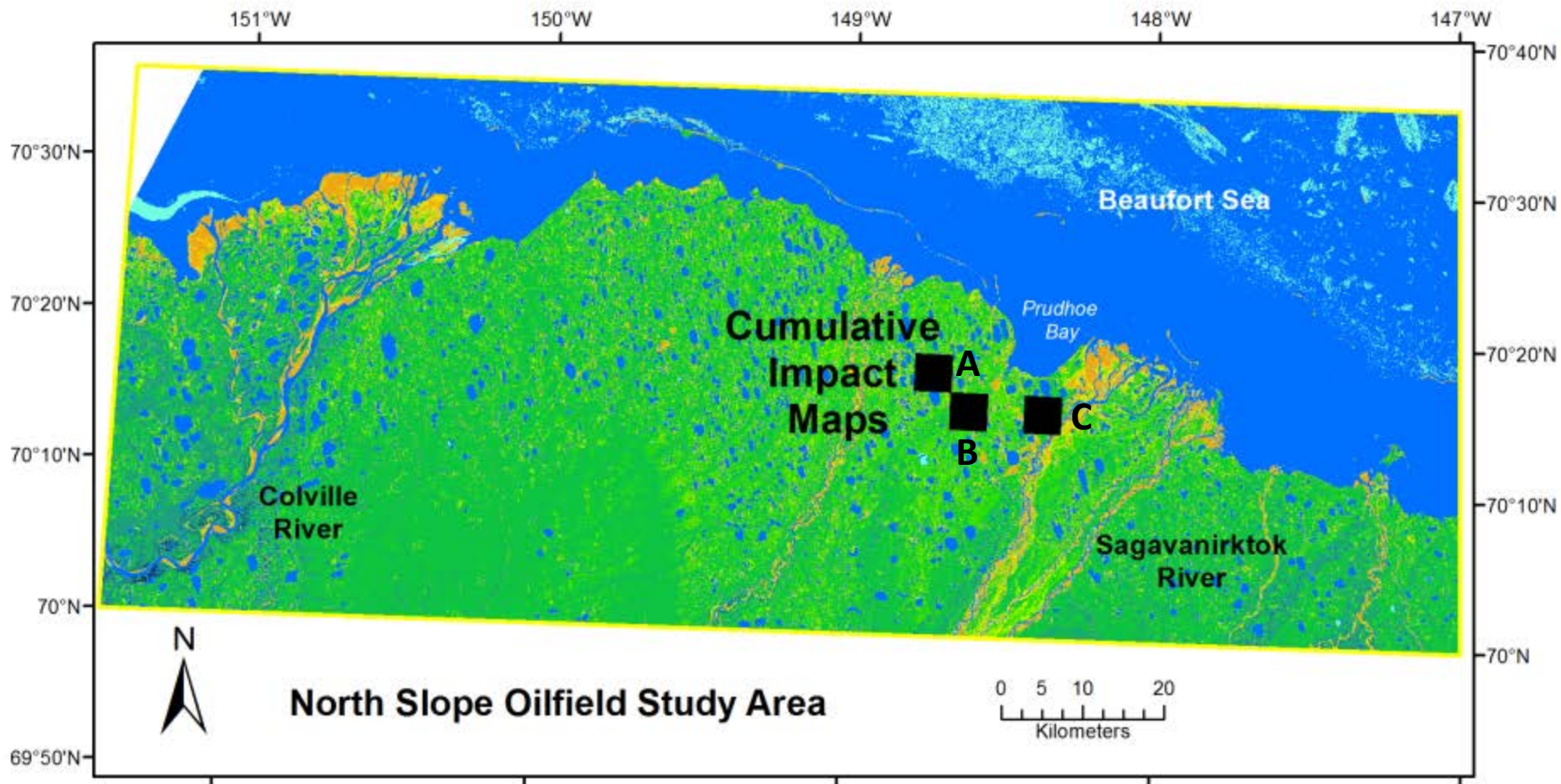
3-Dimensional graph of tasseled-cap index trends 1985-2011

Code	Cover type	Km ²
LM	Lowland moist sedge-shrub	2139
LW	Lowland wet sedge	1736
UT	Upland tussock	488
RM	Riverine moist sedge-shrub	431
RW	Riverine wet sedge	229
UD	Upland Dryas	196
RB	Riverine barren	189
CB	Coastal barren	181
CW	Coastal wet sedge	116
CG	Coastal grass	98
RS	Riverine shrub	31
LS	Lowland shrub	14
US	Upland shrubby tussock	5
UM	Upland moist sedge-shrub	2
UB	Upland low birch-willow shrub	1



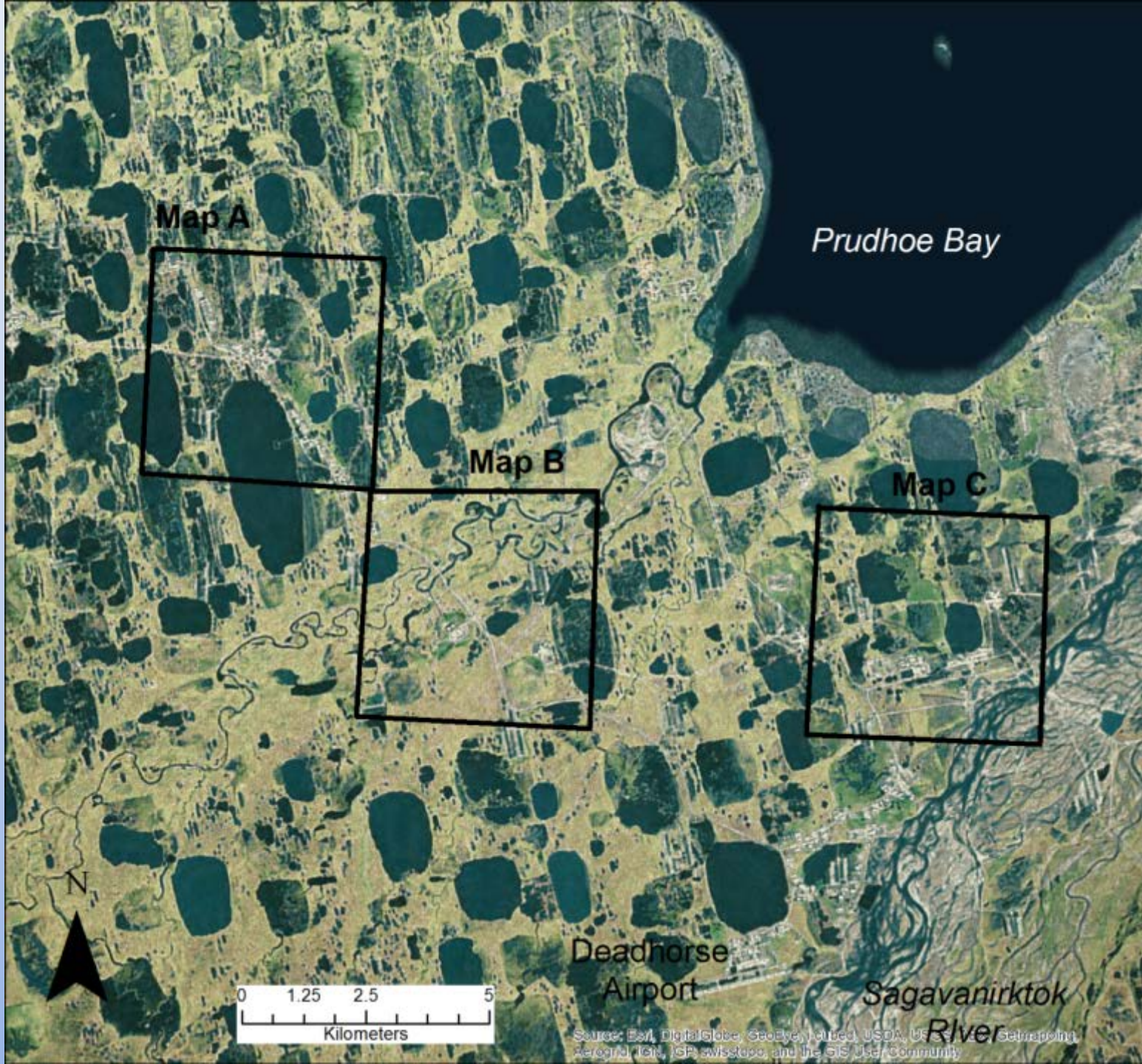
3-Dimensional graph of tasseled-cap index trends 1985-2011





Advantages to smaller area

- more consistent Landsat coverage
- ground knowledge of vegetation and changes

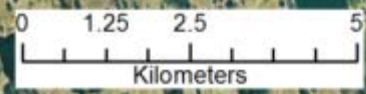


Map A

Prudhoe Bay

Map B

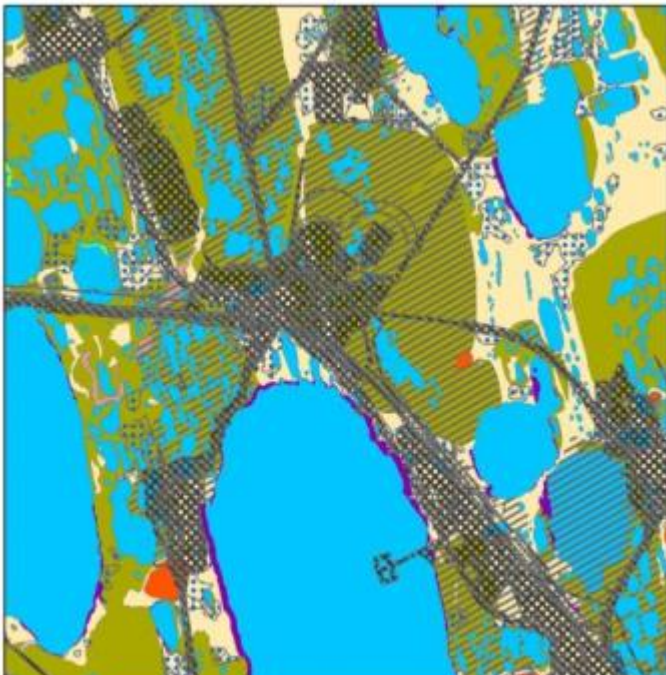
Map C



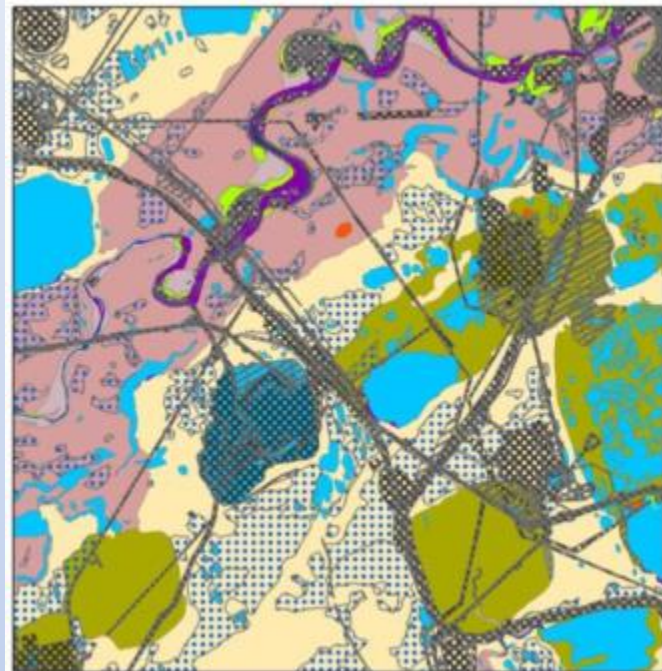
Deadhorse
Airport

Sagavanirktok
River

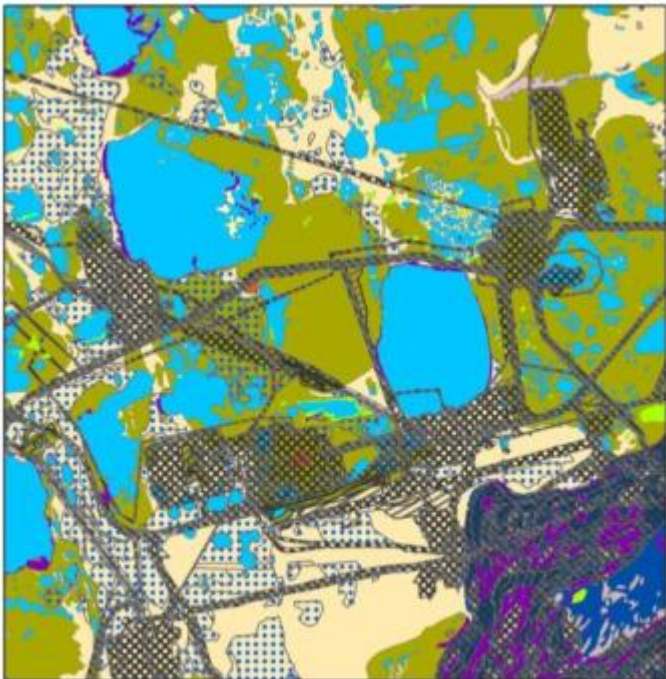
Source: Esri, DigitalGlobe, GeoEye, Earthstar (USA), USNA, AeroGRID, IGN, IGP, swisstopo, and the GIS User Community



Map A



Map B



Map C

Landform

-  Drained thaw-lake basin
-  Inter-thaw-lake area
-  Pingo
-  Active floodplain
-  Stabilized floodpl
-  Lake
-  River

Change 1968-2010

-  Direct industrial impacts
-  Flooding due to industrial infrastructure
-  Permafrost degradation
-  Changes in river channels and lakeside erosion
-  Revegetation

Raynolds *et al.* 2014

Tasseled-Cap Index Trends

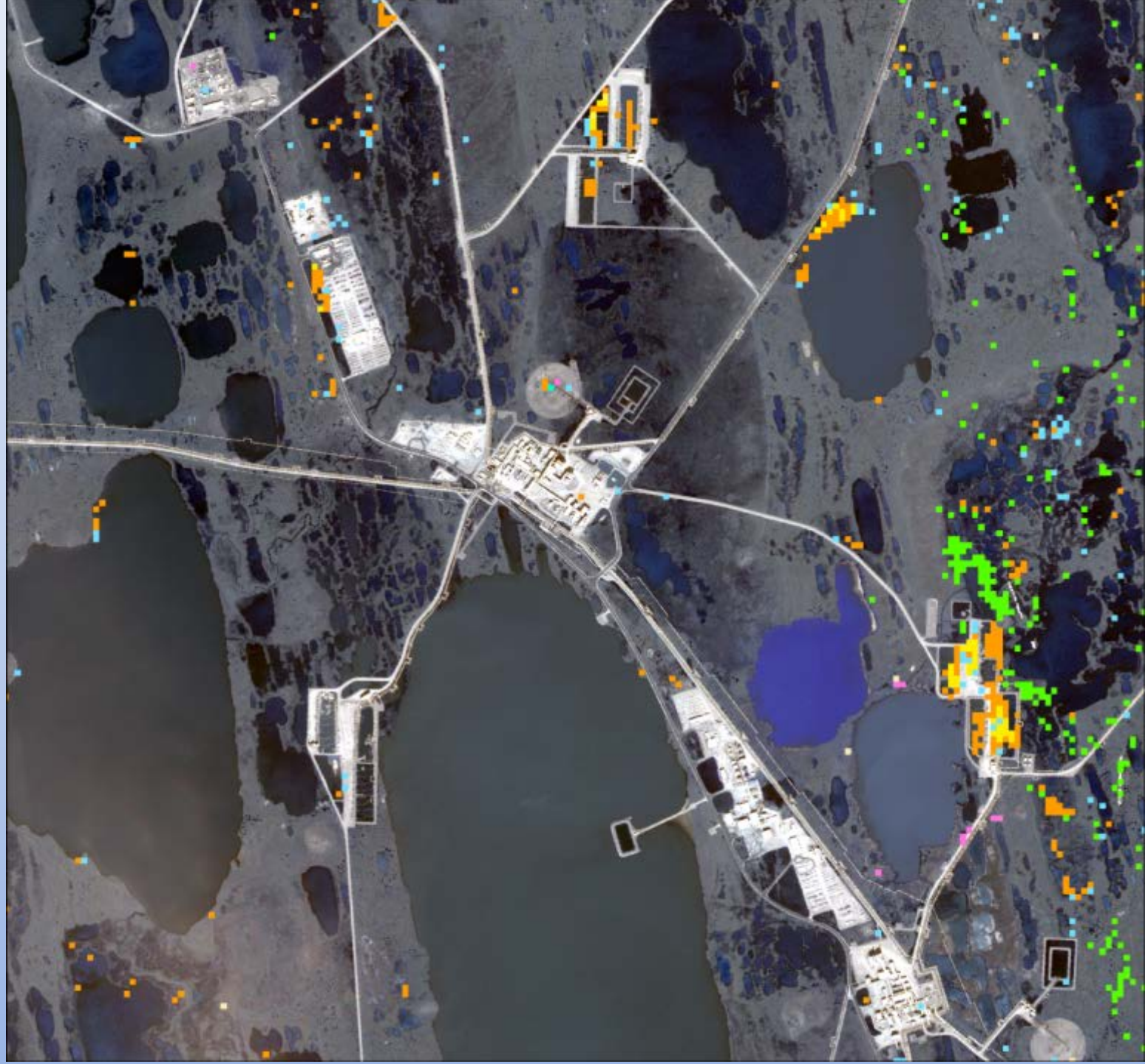
$p < 0.05$
1985 to 2011

Increase
brightness

Decrease
brightness

Increase
greenness


Increase
wetness





Map A


Tasseled-Cap Index Trends

$p < 0.05$
1985 to 2011

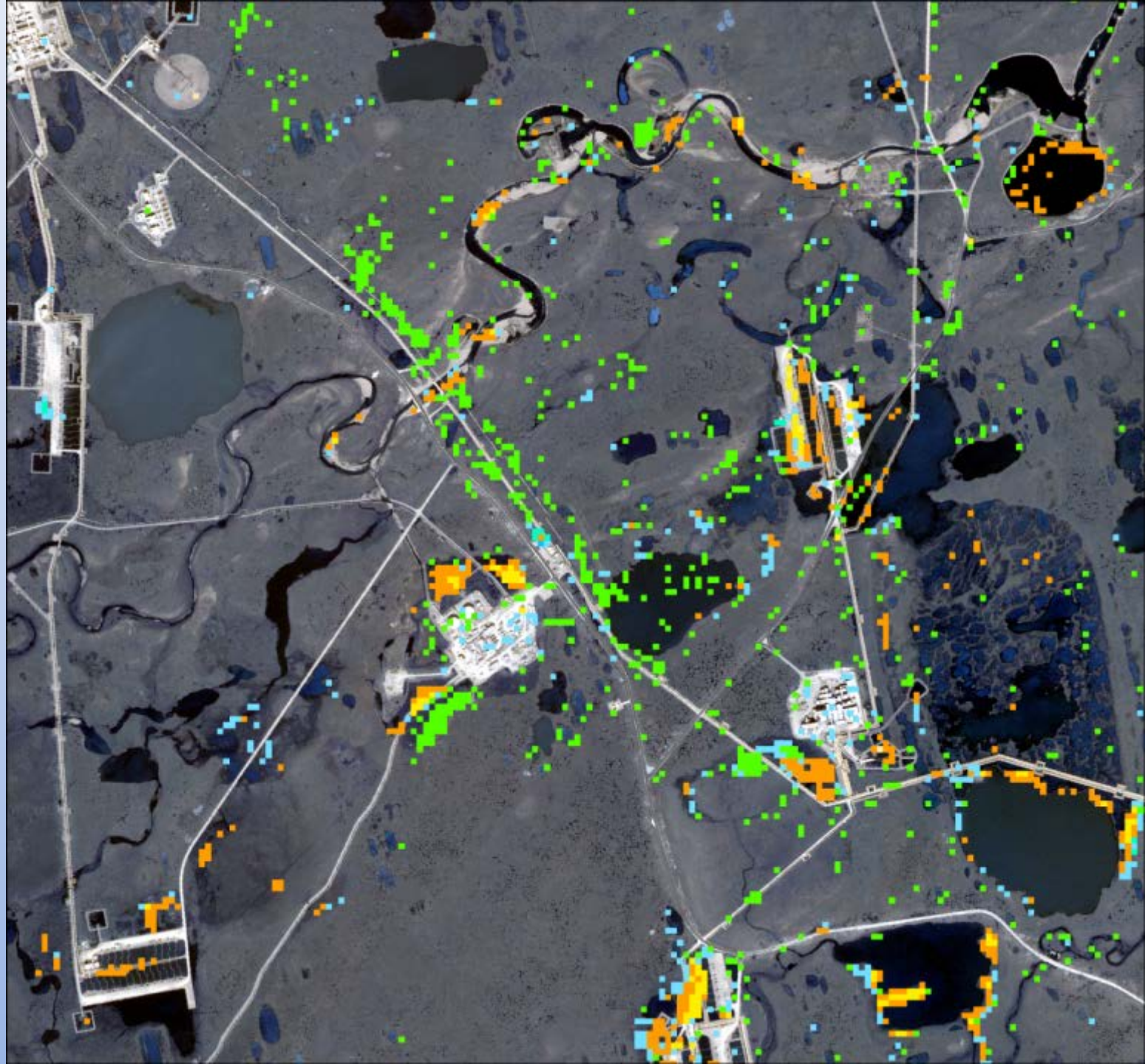
 Increase
brightness

 Decrease
brightness

 Increase
greenness

 Increase
wetness

Map B

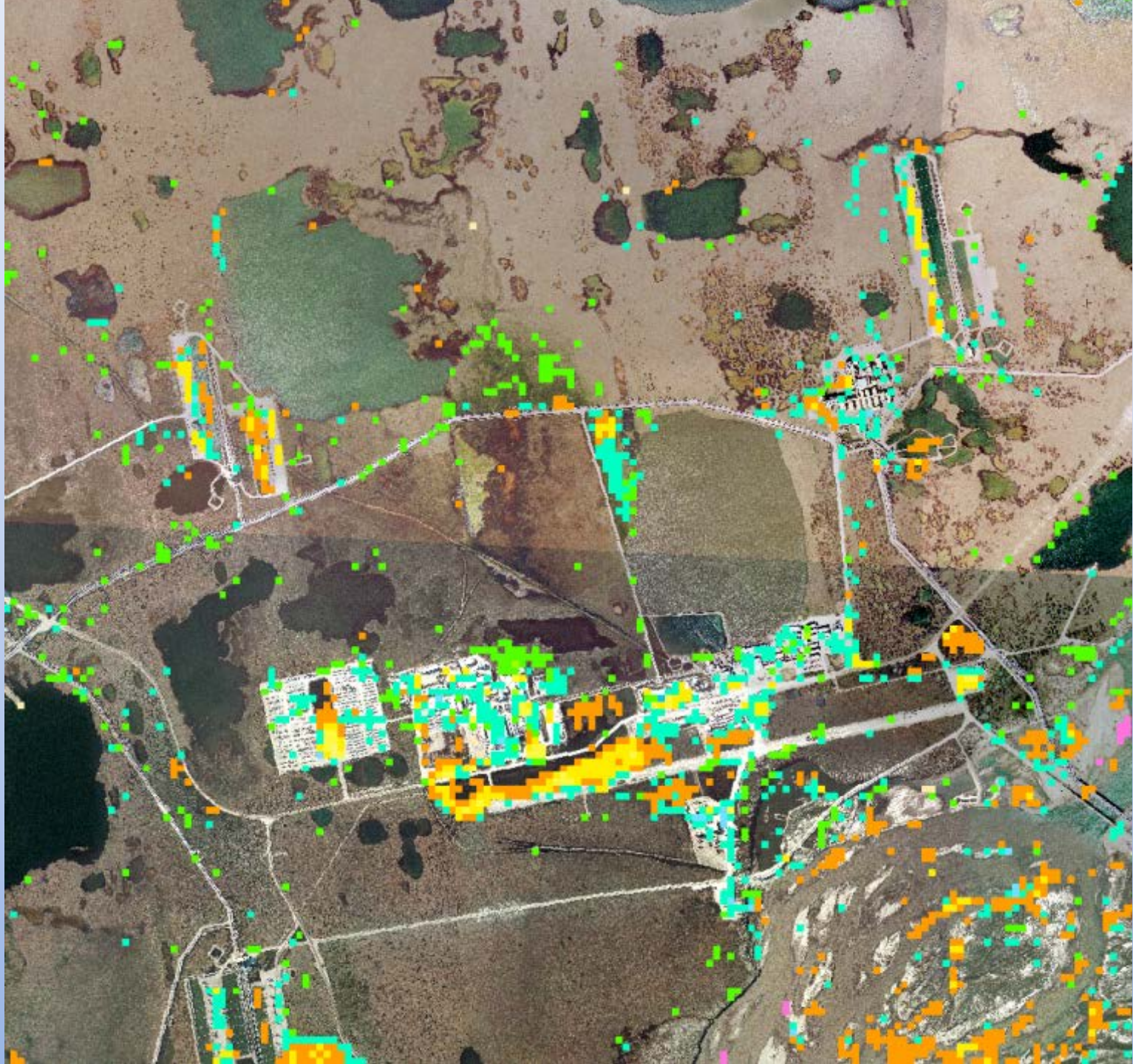


Tasseled-Cap Index Trends

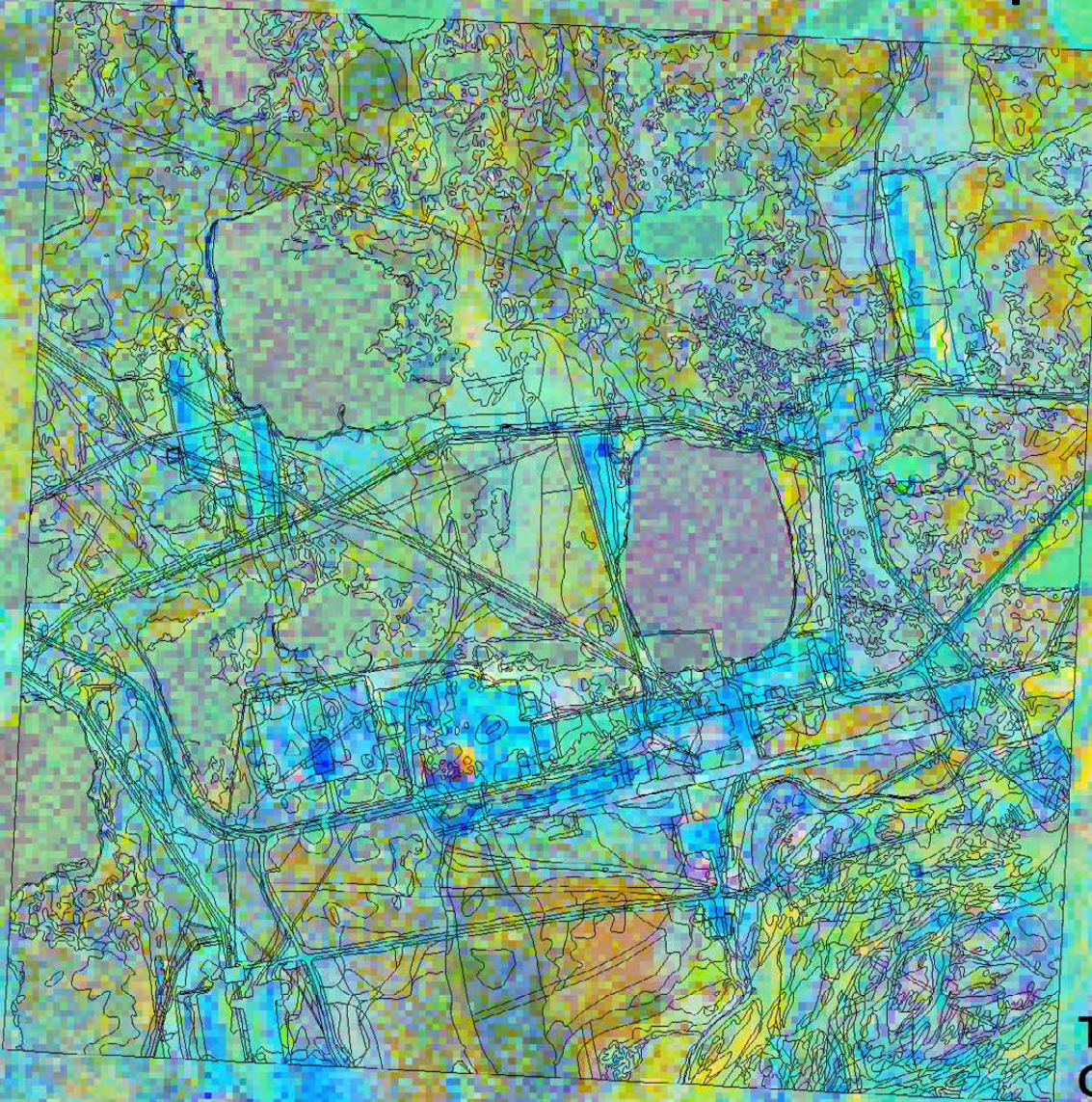
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- Increase
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- Increase
greenness
- Increase
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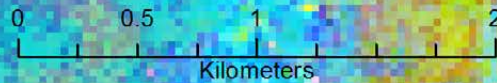
Map C



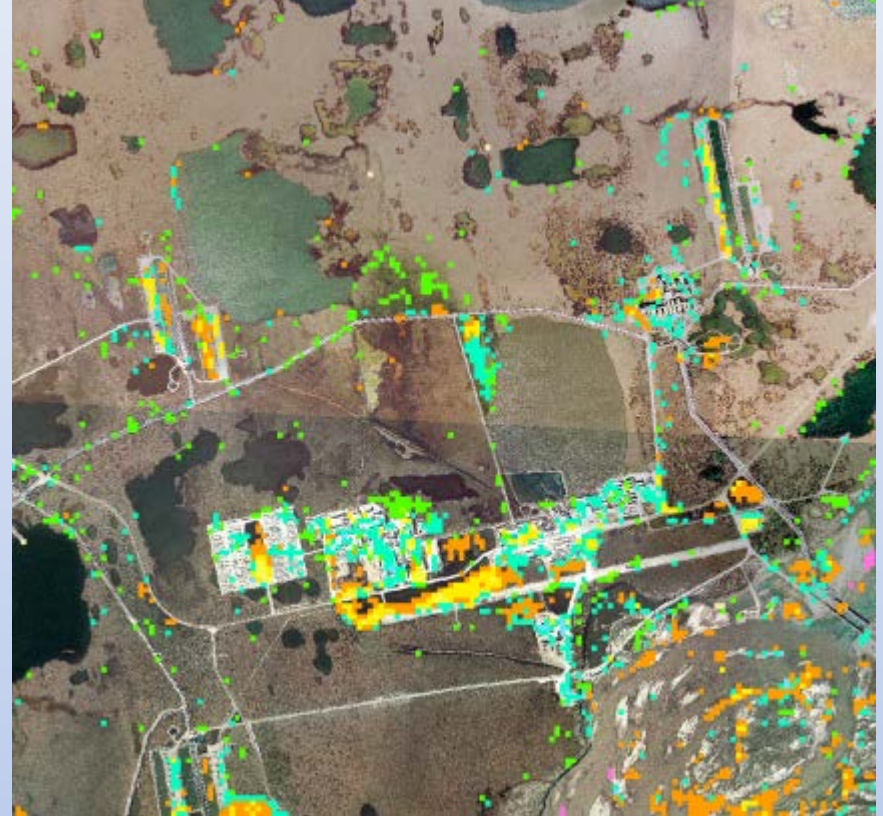
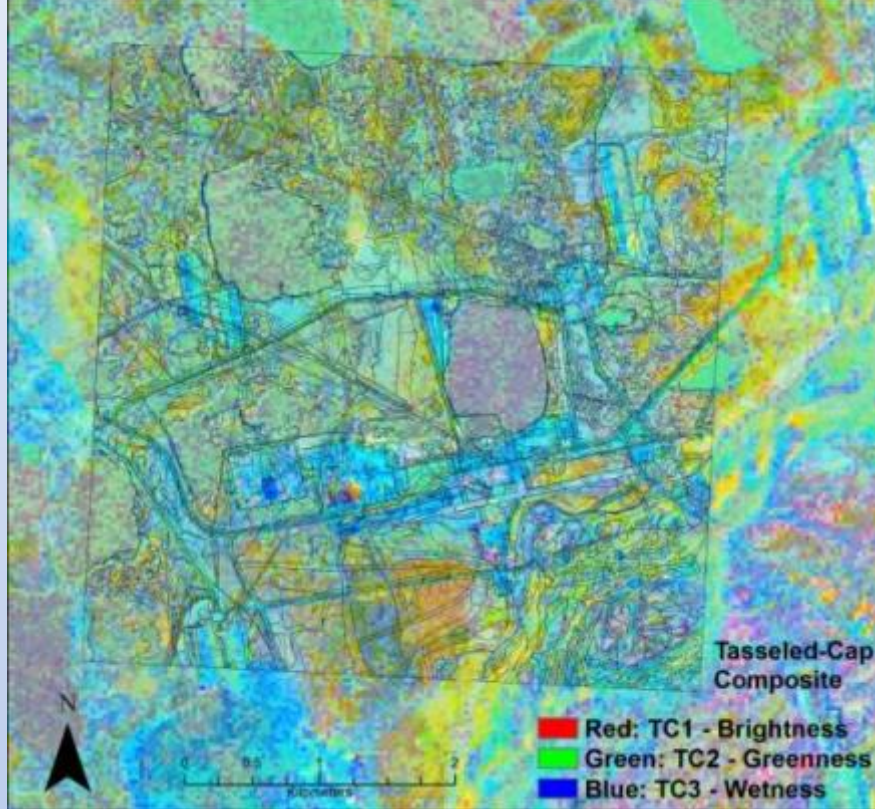
Cumulative Impacts Map C



**Tasseled-Cap
Composite**

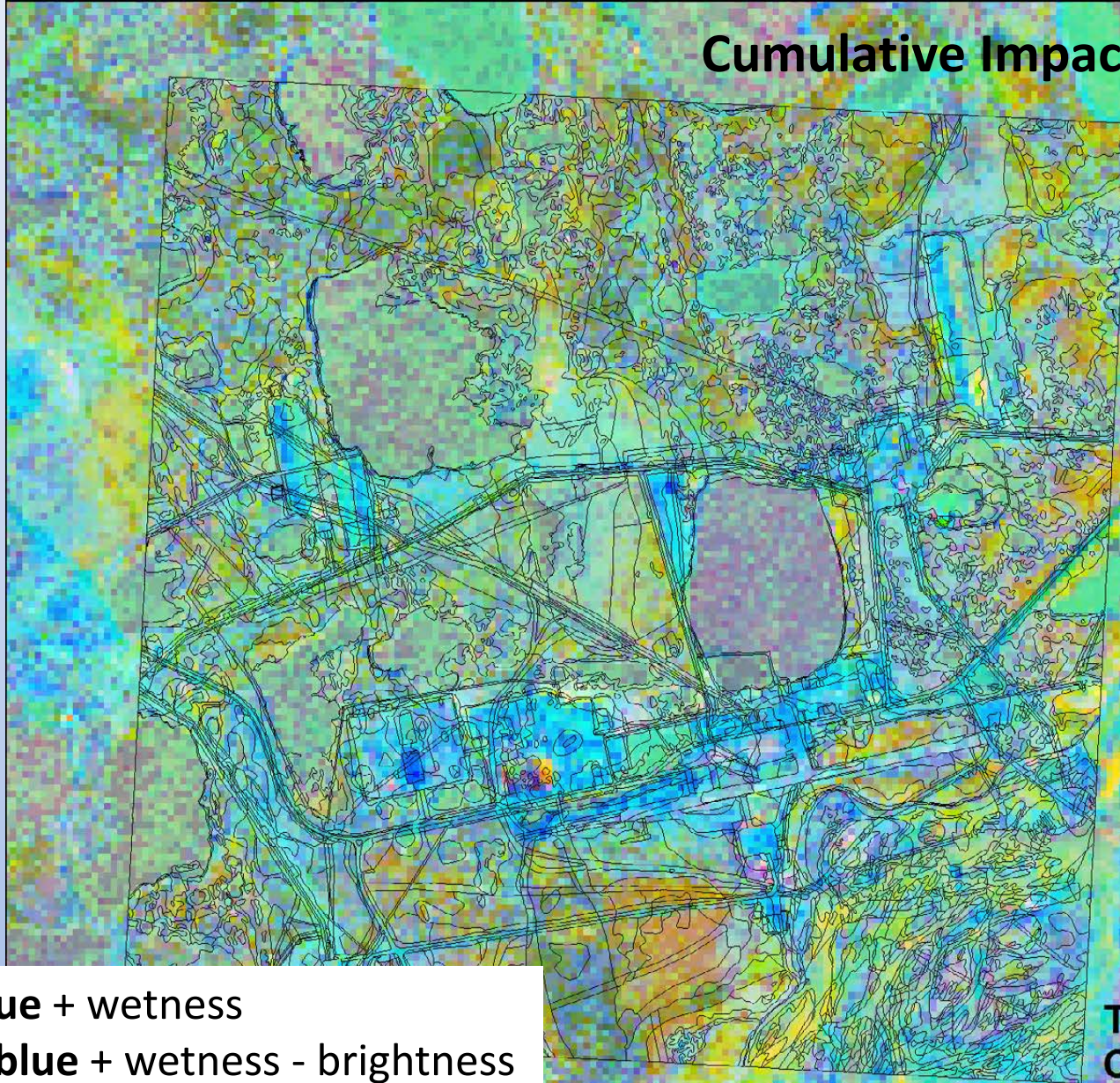


- Red: TC1 - Brightness**
- Green: TC2 - Greenness**
- Blue: TC3 - Wetness**



cyan blue areas are dominated by increased wetness
darker blue areas have increased wetness and decreased brightness
pale blue to white areas have increased greenness
yellow areas have decreased wetness and increased brightness
purple areas have no change

Cumulative Impacts Map C



Tasseled-Cap
Composite

cyan blue + wetness
darker blue + wetness - brightness
pale blue to white + greenness
yellow - wetness + brightness
purple no change

Red: TC1 - Brightness
Green: TC2 - Greenness
Blue: TC3 - Wetness



Summary

- AVHRR shows positive NDVI trends
- Simple difference with Landsat also shows positive NDVI trends
- Statistical trend analysis shows decreased NDVI trends
 - < 10% of area has significant NDVI trends ($p < 0.05$)
- Tasseled-Cap Indices provide additional information
 - Significant increased greenness on over 1/3 area
 - Increased wetness counters this, leading to negative NDVI
- In developed areas, changes on and adjacent to infrastructure are evident

References

CAVM Team. 2003. Circumpolar Arctic Vegetation Map, scale 1:7 500 000. *in Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska.*

Crist, E. P., and R. C. Cicone. 1984. A Physically-Based Transformation of Thematic Mapper Data--The TM Tasseled Cap. *IEEE Transactions on Geoscience and Remote Sensing* 22:256-263.

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Jorgenson, M. T., and M. Heiner. 2003. Ecosystems of Northern Alaska, 1:2.5 million-scale map. *in. ABR, Inc and The Nature Conservancy, Anchorage, AK.*

Raynolds, M. K., D. A. Walker, K. J. Ambrosius, J. Brown, K. R. Everett, M. Kanevskiy, G. P. Kofinas, V. E. Romanovsky, Y. Shur, and P. J. Webber. 2014. Cumulative geocological effects of 62 years of infrastructure and climate change in ice-rich permafrost landscapes, Prudhoe Bay Oilfield, Alaska. *Global Change Biology* 20:1211-1224.

An aerial photograph showing a vast coastal wetland area. In the foreground, a large, dark green body of water occupies the lower-left portion. To the right and extending into the middle ground, there is a complex of smaller, interconnected water bodies and marshy areas. In the center of the image, a small cluster of buildings and structures, possibly an industrial or residential development, is visible. The background shows a flat, open landscape extending to a distant horizon under a clear, light blue sky with a few wispy clouds.

Questions & Comments Please!