Evaluating climate-driven landscape changes and impacts on lakes and rivers in northern Yukon, Canada

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Dept. Geog. and Tour Studies
Dept. Earth Science

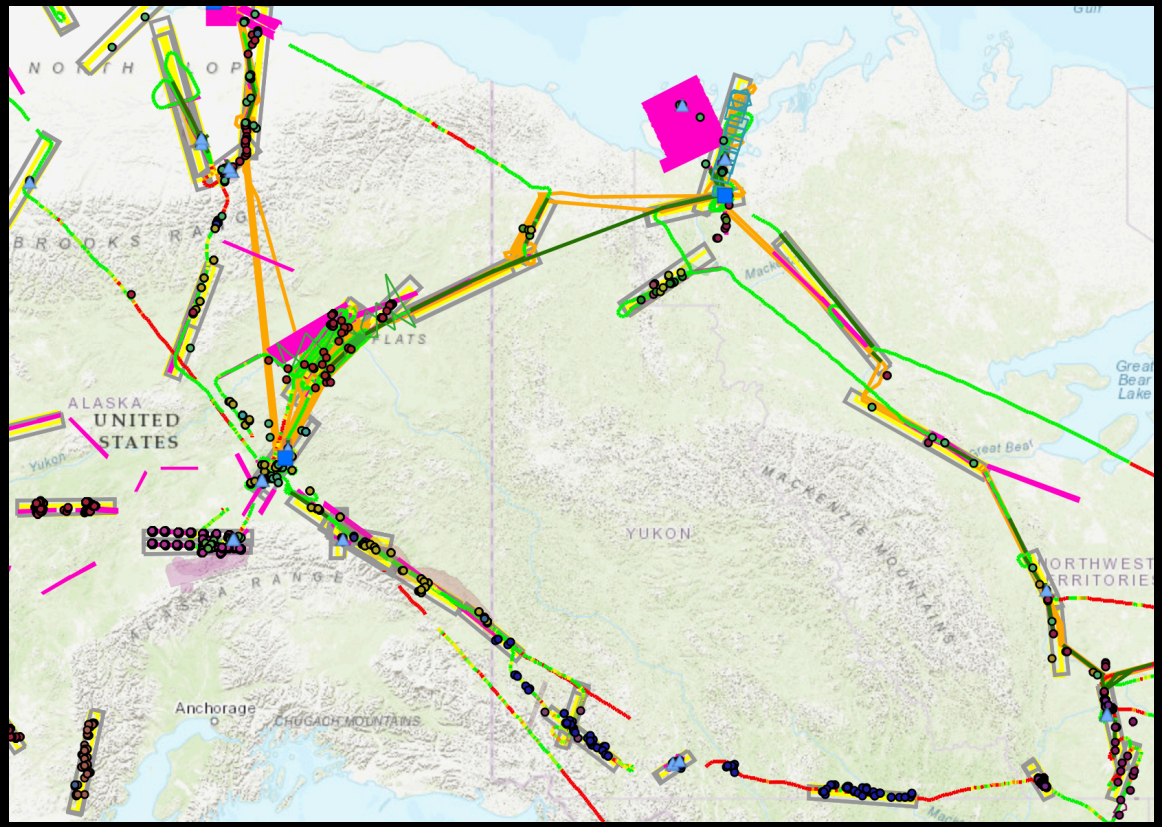
22-May-2019

NASA ABoVE
5th Science Team Meeting

Research in Yukon, Canada
(other than in Old Crow Flats)

Yukon Discussion Group

Sean Carey McMaster University
Ryan Danby Queen's University
Jason Edwards Canadian Forest Service
Scott J. Goetz Northern Arizona University
Ryan Gould Yukon Government
Meagan Grabowski Champagne and Aishihik First Nations
Peter Griffith NASA GSFC / SSAI
Dave Hik Simon Fraser University
Elizabeth Hoy NASA GSFC
Jill Johnstone University of Saskatchewan
Monica Krieger Champagne and Aishihik First Nations
Tyler Kuhn Yukon Government
Elisabeth K. Larson NASA GSFC / SSAI
Cyrielle Laurent Yukon Research Center
Charles Miller NASA JPL
Dennis Murray Trent University
Maribeth Murray Arctic Institute of North America
Aynslie Ogden Yukon Government
Finella Pescott Kluane Lake First Nation
Christopher Potter NASA ARC
Carolyn Relf Yukon Geological Survey
Stefanie Saal Yukon Research Center
Michael Schmidt Fellow of the RCGS
Merran Smith Council of Yukon First Nations
Merritt R. Turetsky University of Guelph
Kevin Turner Brock University
Scott Williamson University of Alberta
Isla Myers-Smith University of Edinburgh



Sean Carey, McMaster University

Wolf Creek near Whitehorse

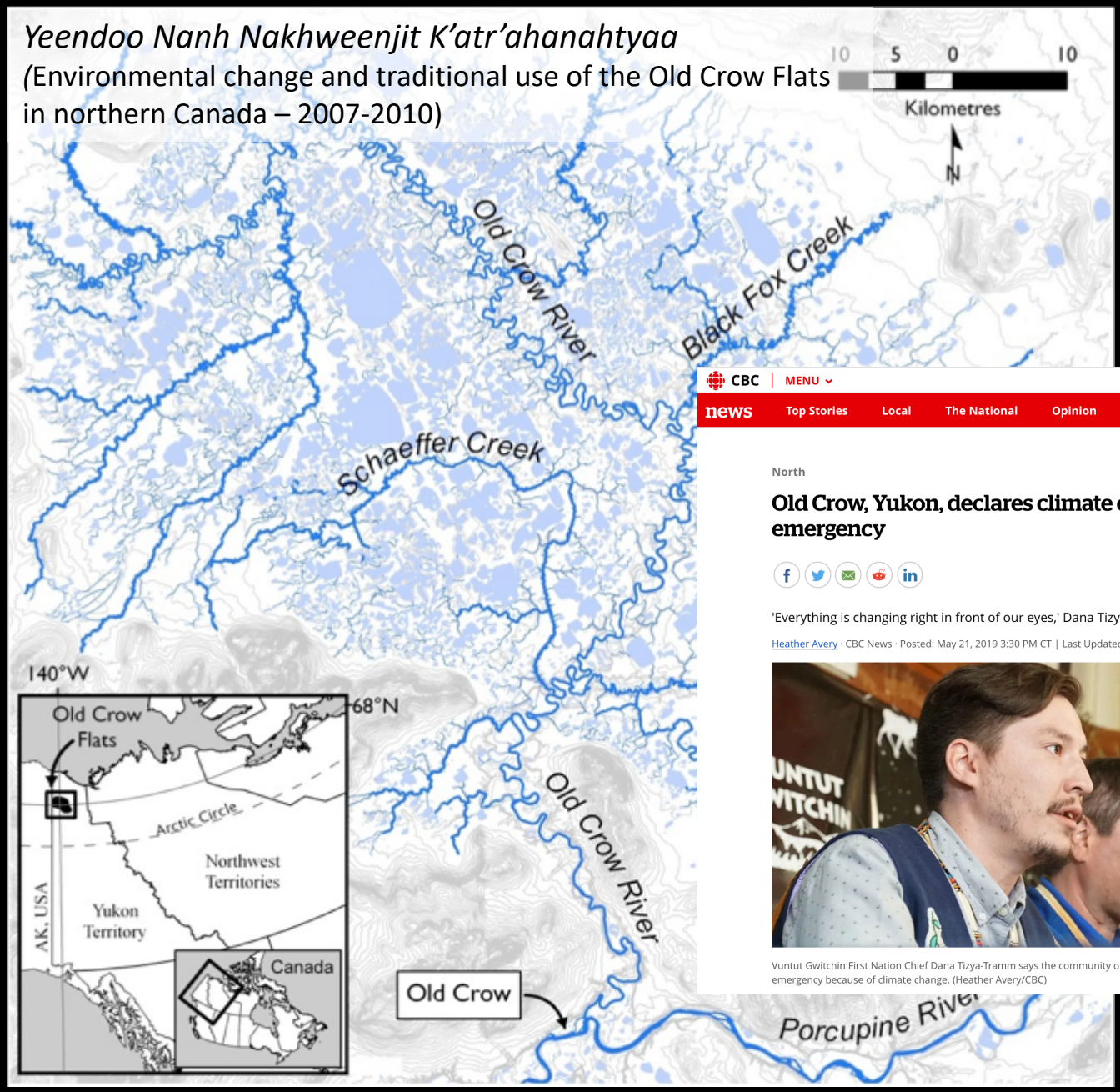
- 3 eddy covariance towers across different ecosystems
- Transpiration partitioning
- LiDAR 2018 compared to 2007 (vegetation differences)
- Updating land cover classifications

Dempster Highway (near NWT border)

- Headwater hydrology/snow study in area washing out road

Faro mine reclamation strategies and water flux

Old Crow Flats: Traditional territory of the Vuntut Gwitchin First Nation



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North

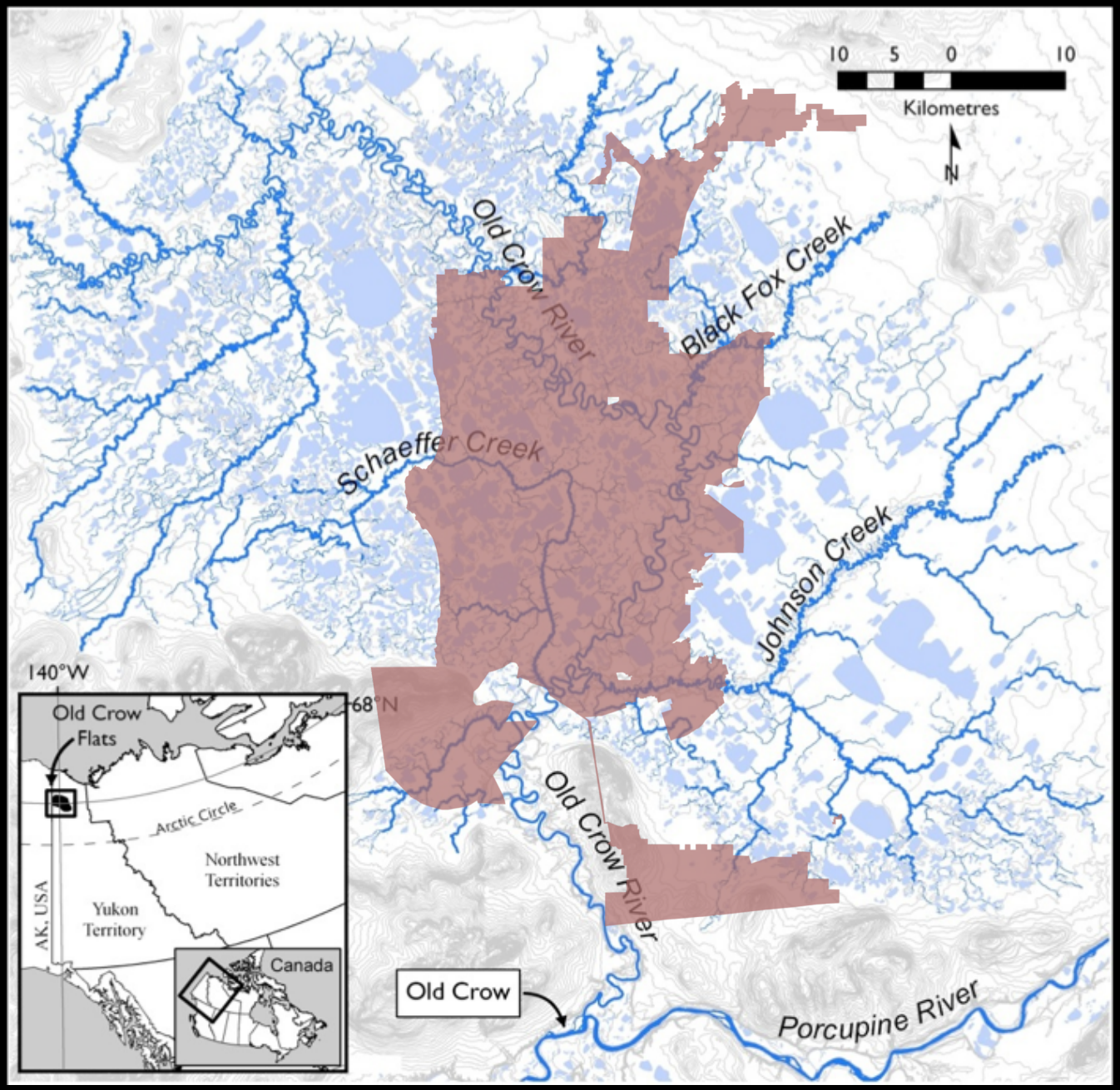
Old Crow, Yukon, declares climate change state of emergency

'Everything is changing right in front of our eyes,' Dana Tizya-Tramm says

Heather Avery · CBC News · Posted: May 21, 2019 3:30 PM CT | Last Updated: May 21

Vuntut Gwitchin First Nation Chief Dana Tizya-Tramm says the community of Old Crow, Yukon, faces a state of emergency because of climate change. (Heather Avery/CBC)

Old Crow Flats: Traditional territory of the Vuntut Gwitchin First Nation



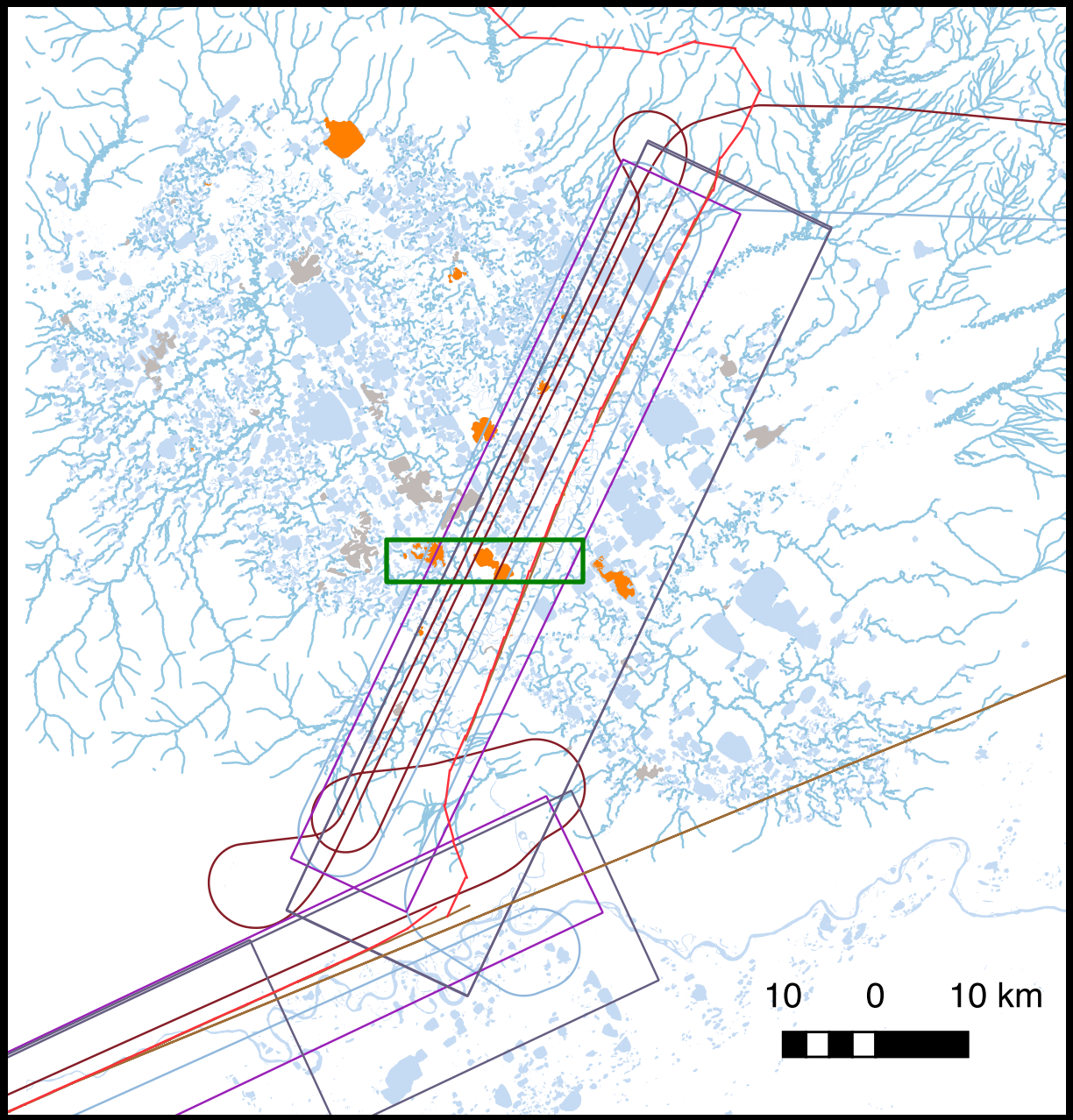
ABoVE Airborne Campaign in Old Crow Flats

<u>2017</u>

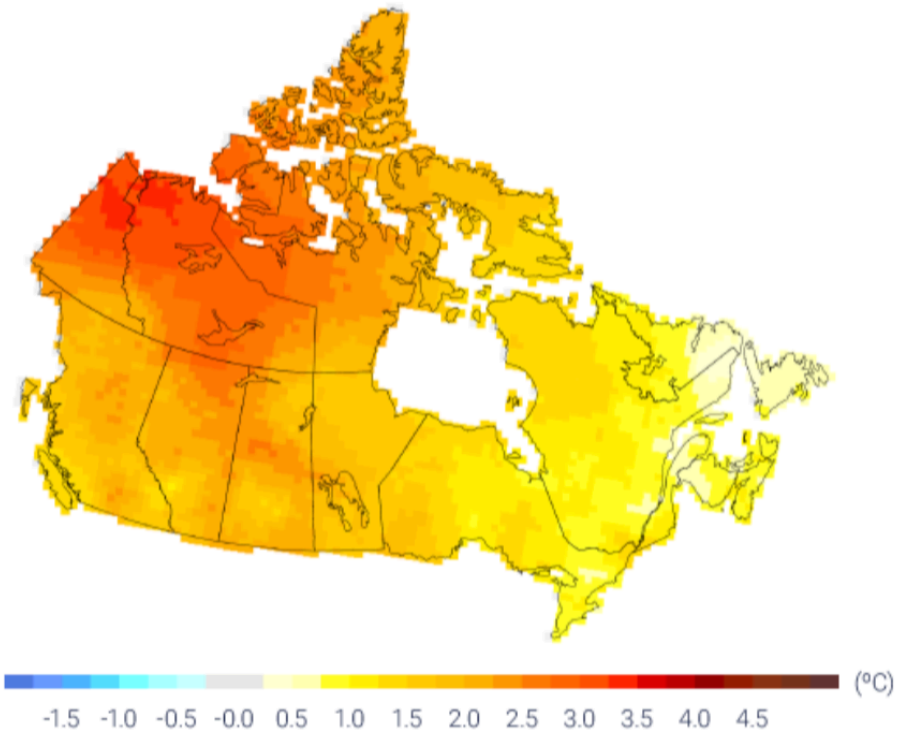
- AVIRIS-NG
- UAVSAR
  - L and P bands
- LVIS
- AirSWOT

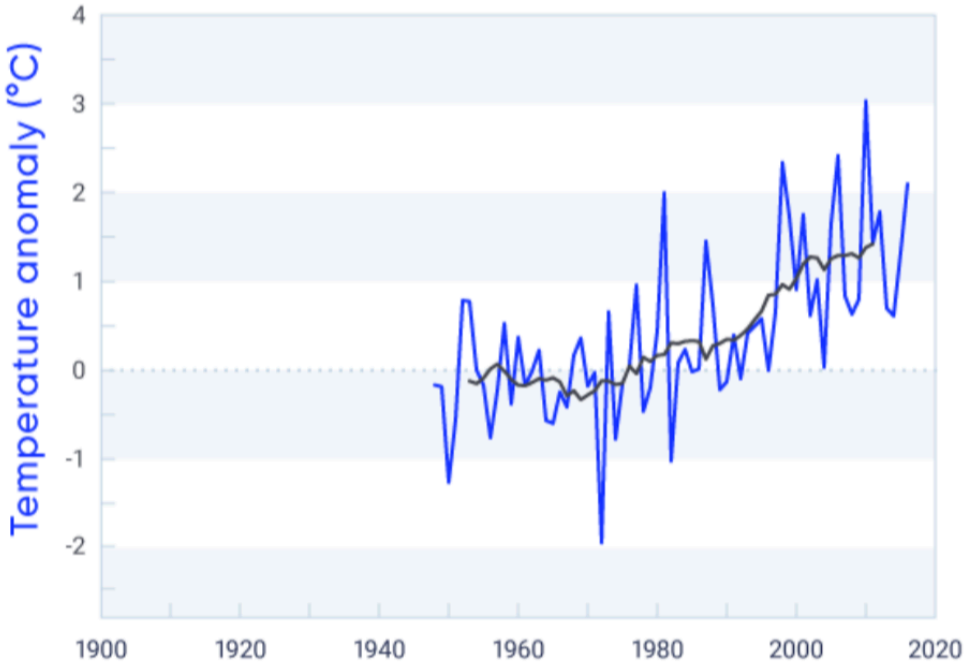
<u>2018</u>

- AVIRIS-NG
- UAVSAR
  - L band

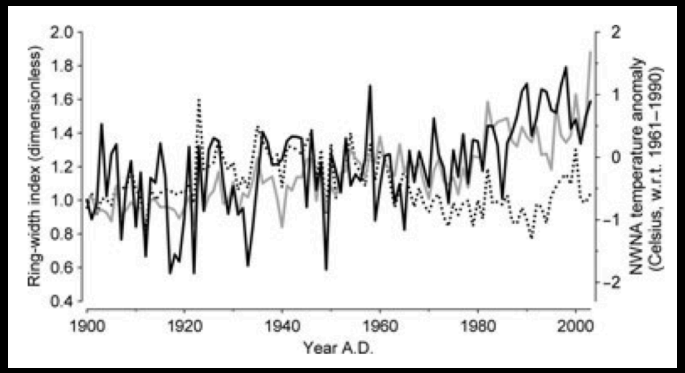


Canadian Changing Climate Report





Tree rings



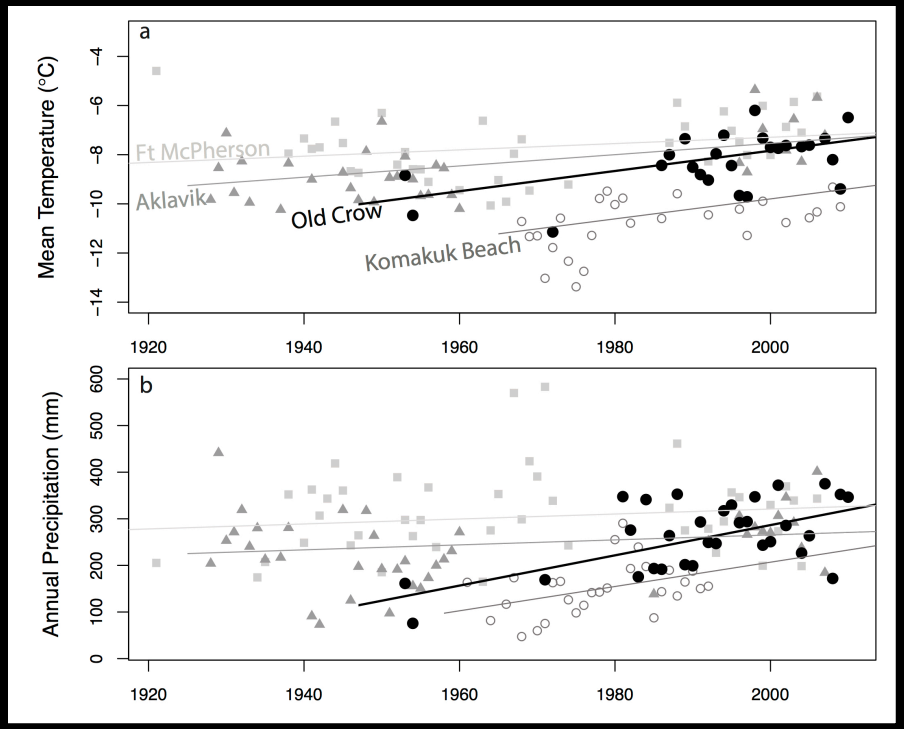
Porter and Pisaric, 2011

Temperature trend across Canada

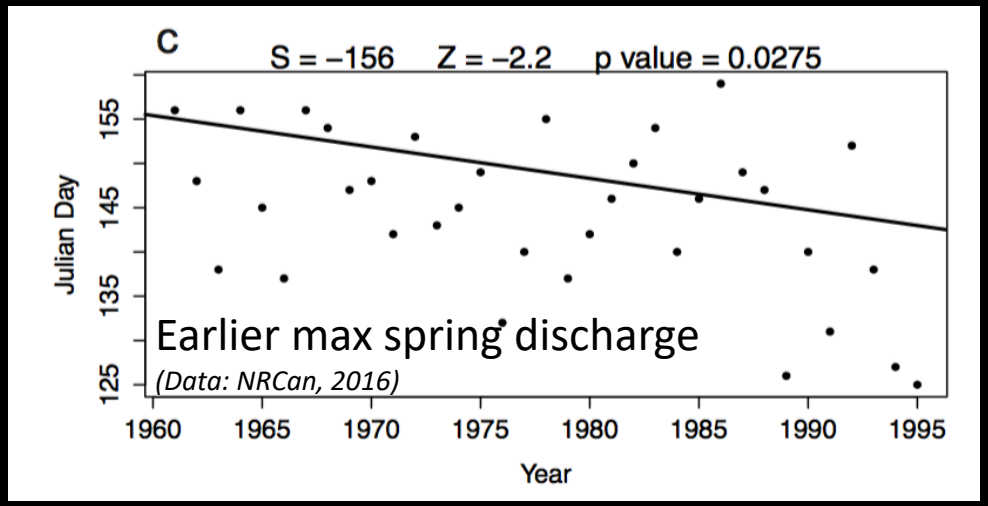
Environment and Climate Change Canada, 2019

(Figure updated from Vincent et al., 2015)

Old Crow Climate



- getting warmer and wetter
- longer ice-free season



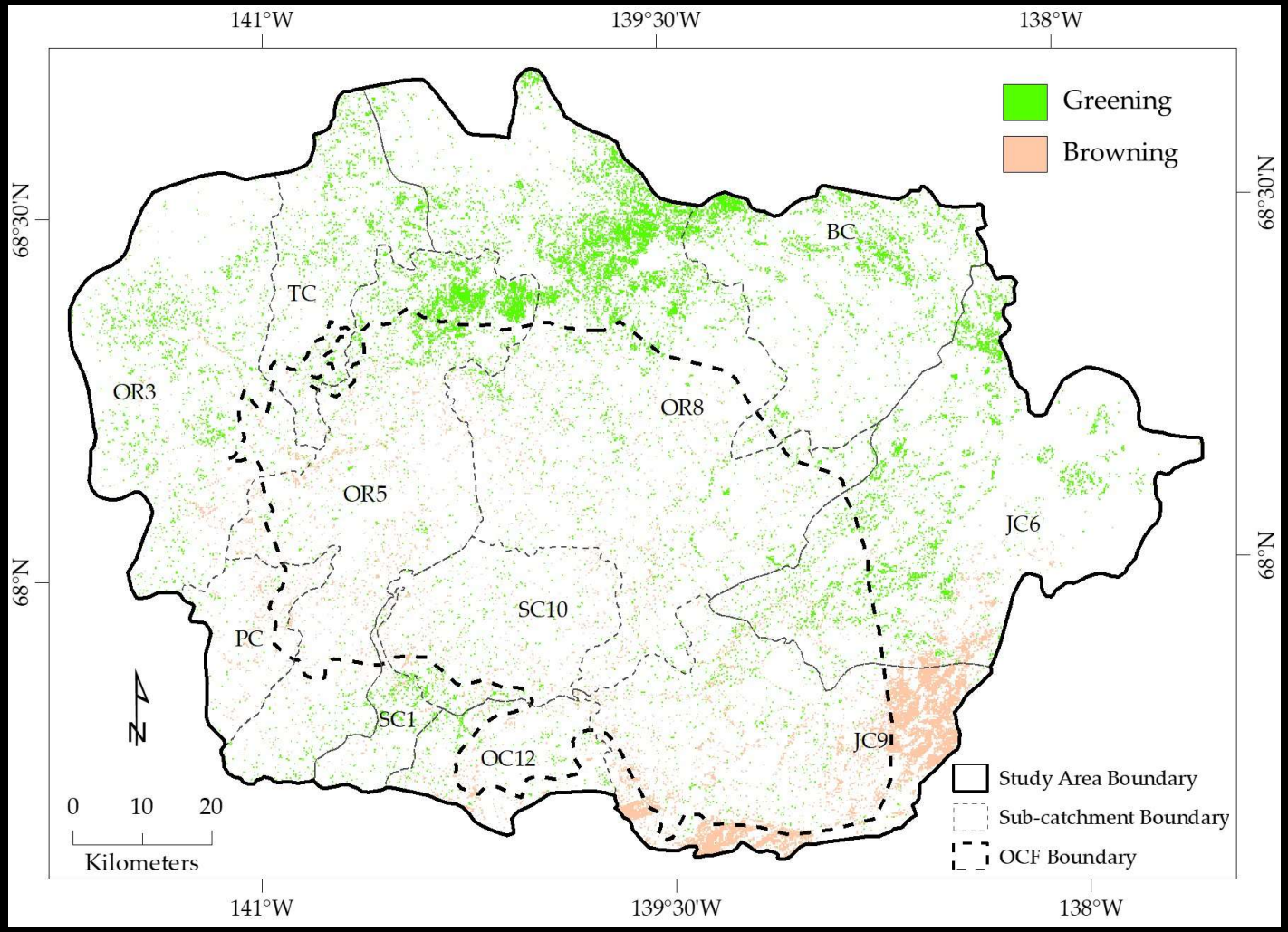
Turner, 2016, Report for Water Resources, Environment, Yukon Government

Landscape Changes:

1) Vegetation Greening in the Old Crow Flats Basin, YK

How will this influence lake and river hydrology and biogeochemistry?

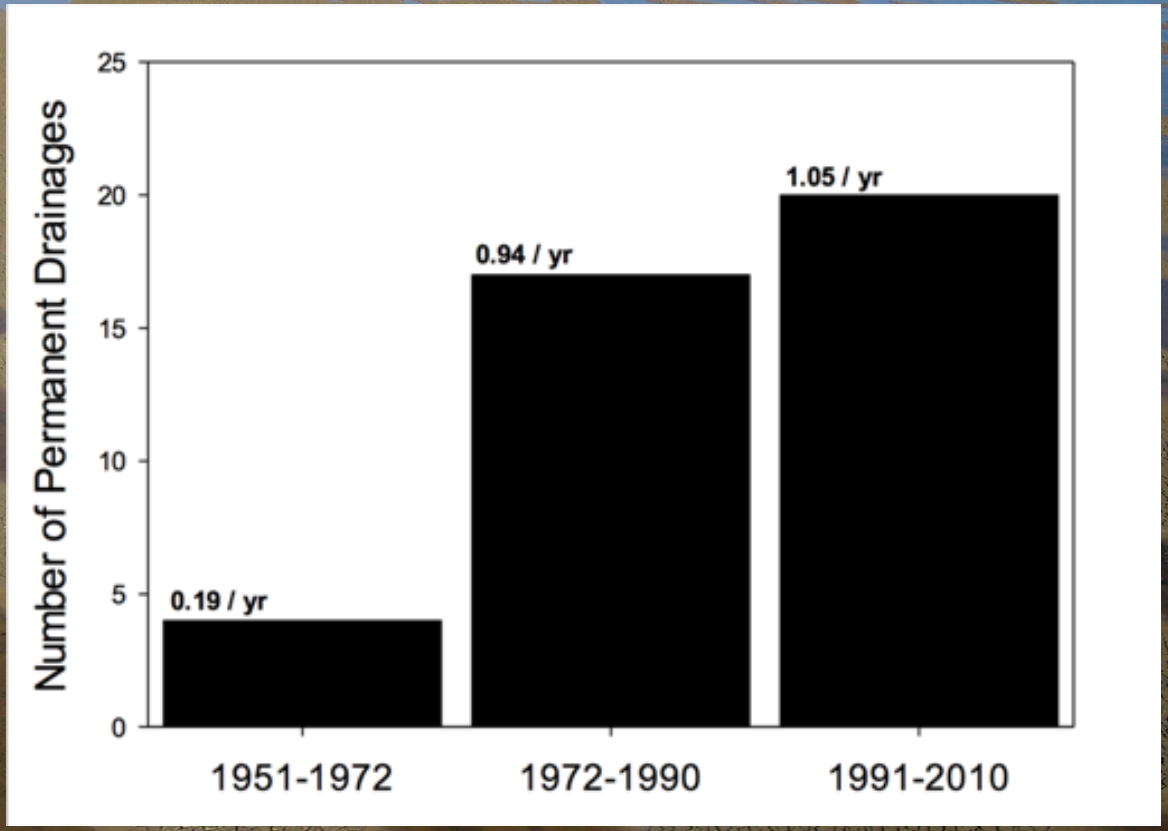
- Increased lake-river connectivity?
- More nutrient runoff?



Turner et al., in prep , Remote Sensing

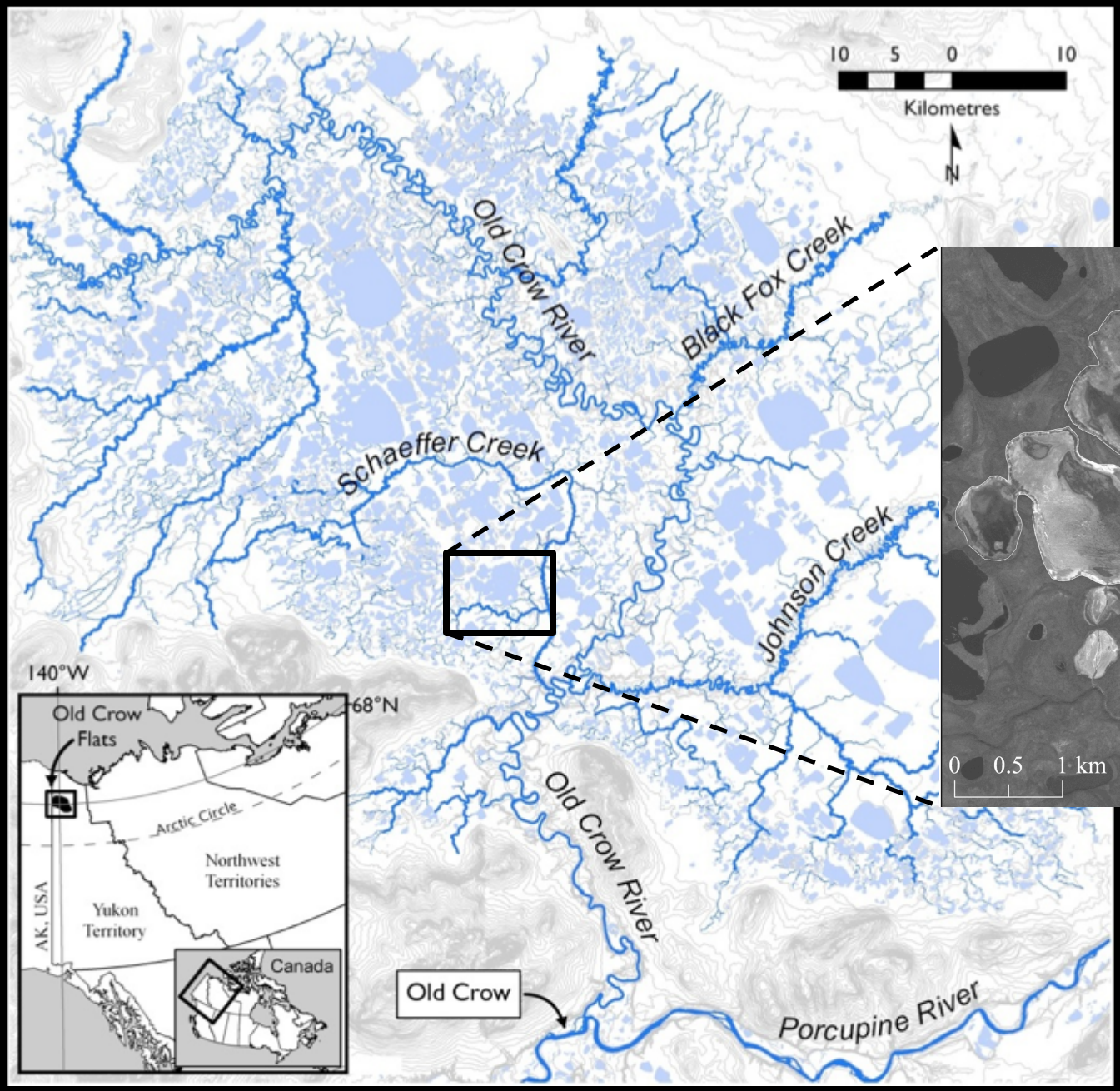
Landscape Changes:

2) Lake drainage (rapid lake-river connectivity)

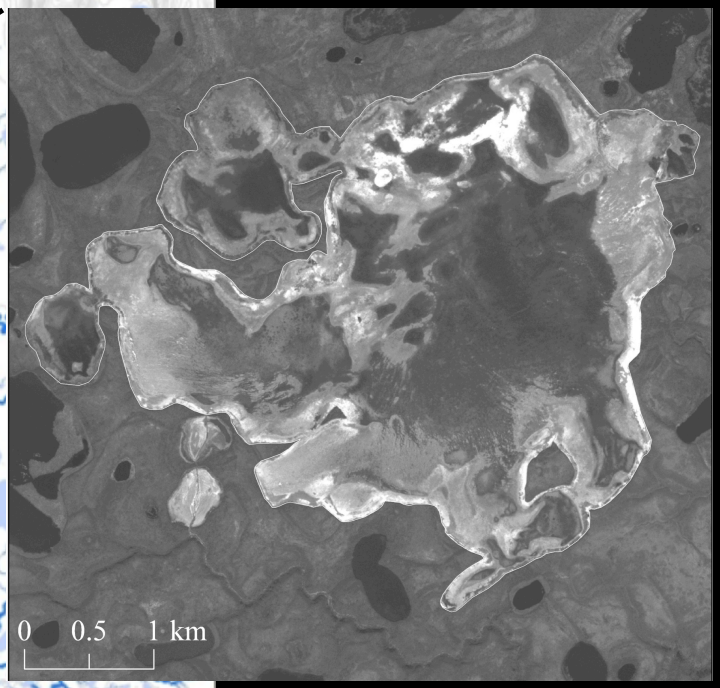


Lantz and Turner, 2015, J. Geoph. Res.

Zelma Lake drained during spring 2007. We've been monitoring it since.



Zelma Lake



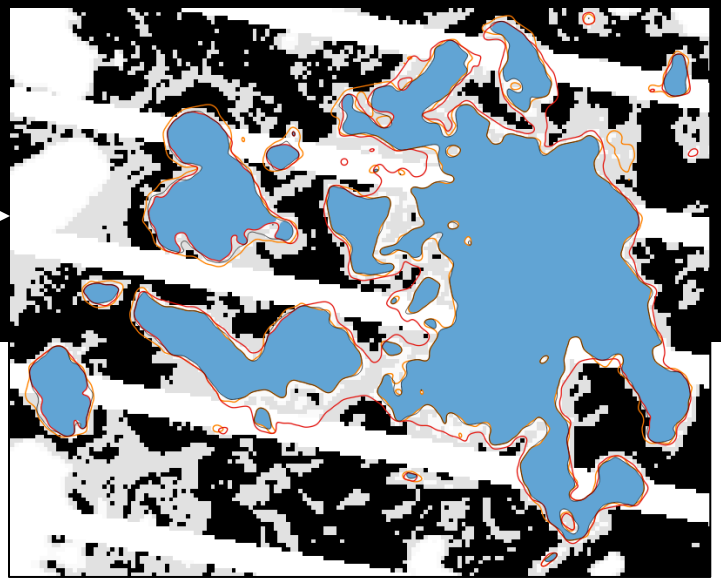
SPOT
24-Jul-2007

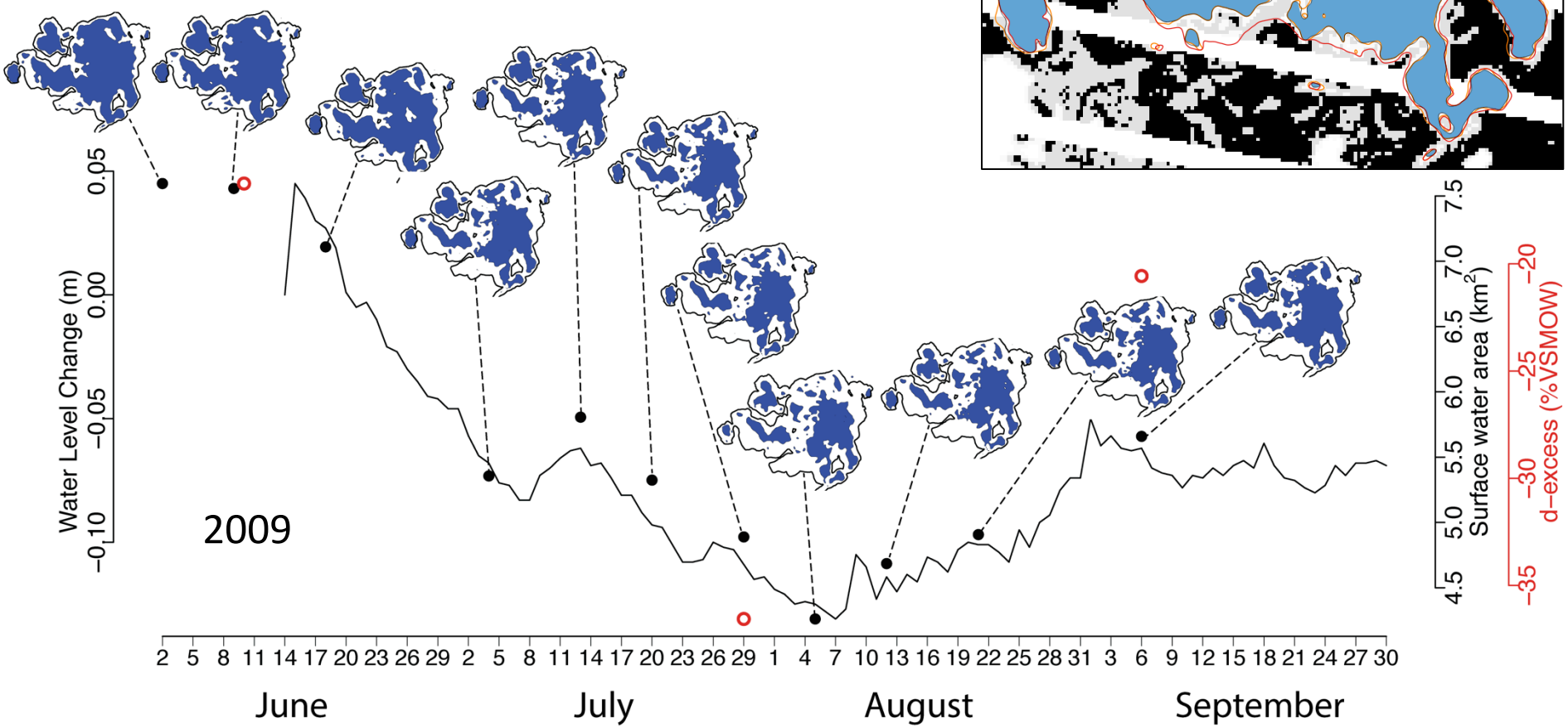
Turner et al., in prep.

Detecting hydrological responses of a drained thermokarst lake to drastic changes in catchment land cover

- using isotope tracers, water level and Landsat (NDVI, MNDWI, SWIR, NIR)

Comparison to DSWE

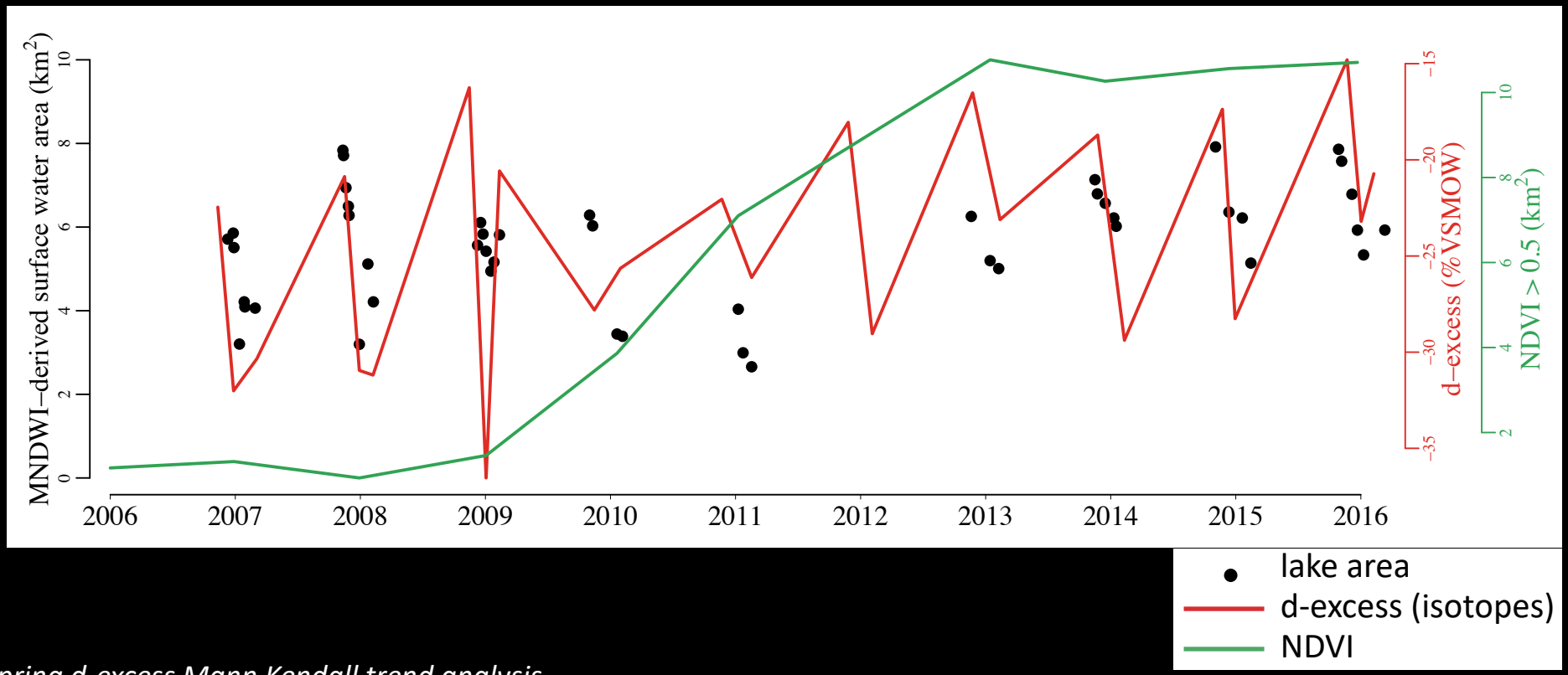




Detecting hydrological responses of a drained thermokarst lake to drastic changes in catchment land cover

- using isotope tracers, water level and Landsat

Summary figure



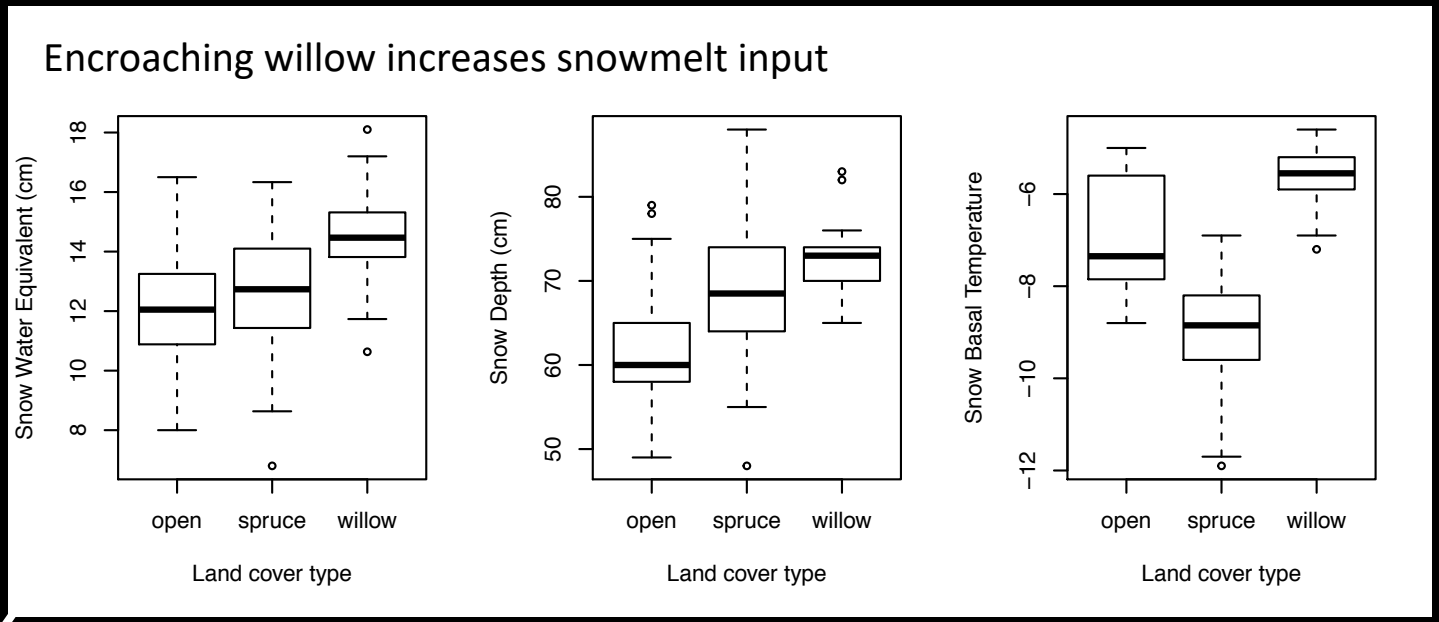
Spring d-excess Mann Kendall trend analysis

	S	tau	p
2007-2016	21	0.467	0.074
2010-2016	15	0.714	0.035

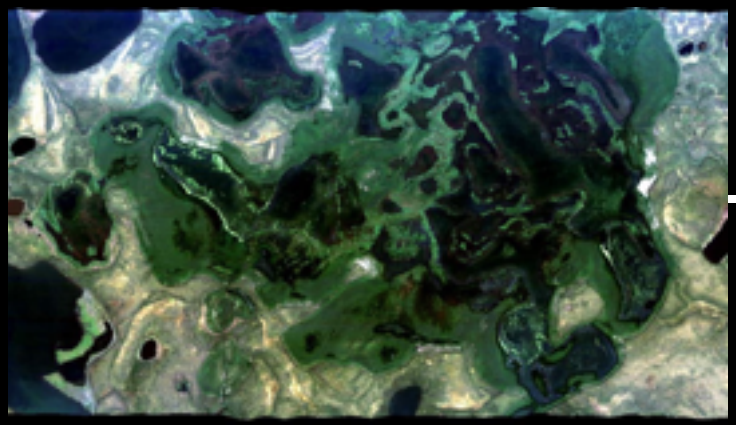
Suggests encroaching shrub is increasing snowmelt input to lake. However, need to control for amount of precipitation.

Detecting hydrological responses of a drained thermokarst lake to drastic changes in catchment land cover

- using isotope tracers, water level and Landsat



Combine with land cover classification

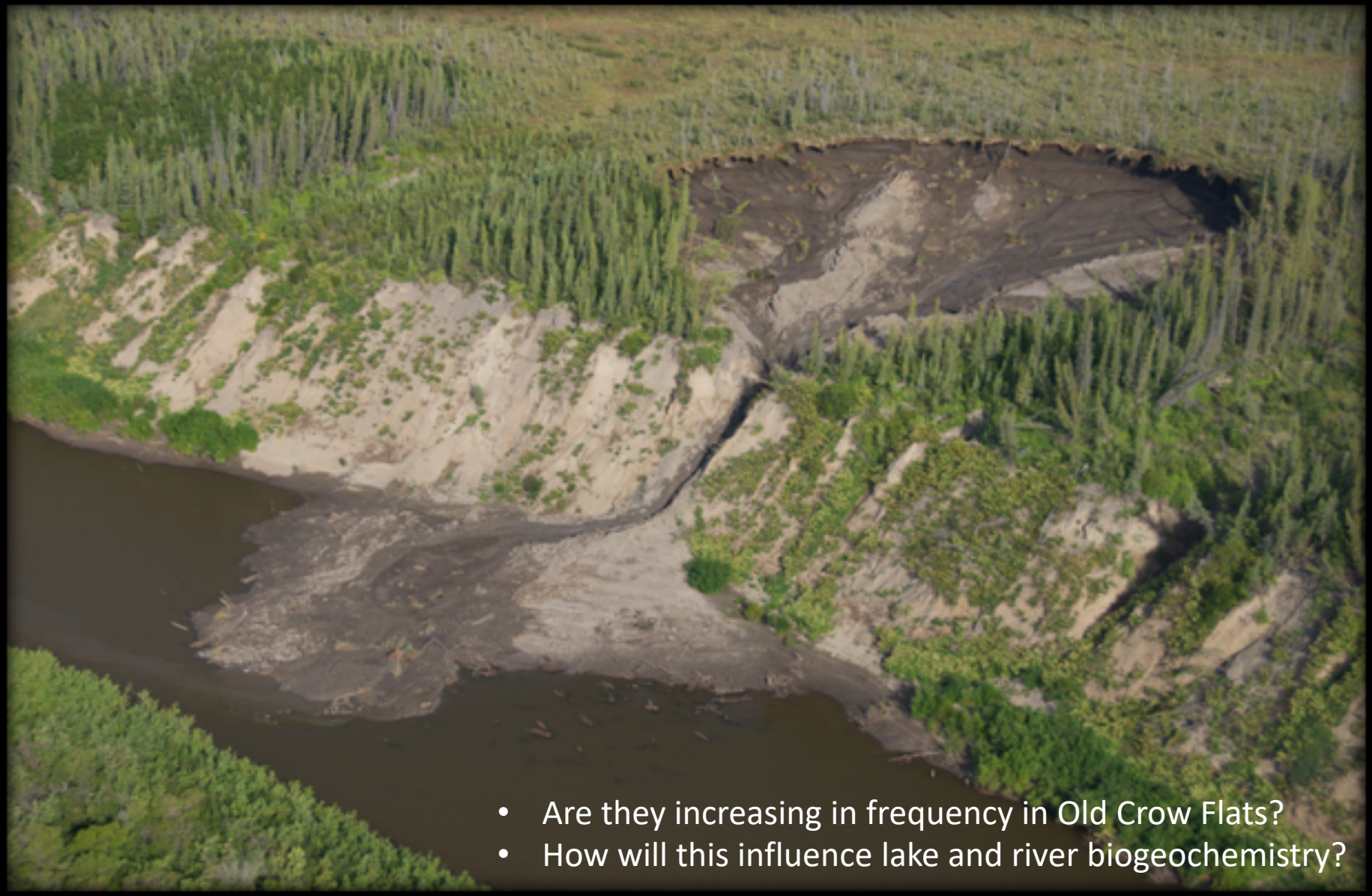


AVIRIS-NG (July 2017)

Difference in snowmelt input to lake with and without (known amount of) shrub encroachment

Landscape Changes:

3) Permafrost retrogressive thaw slumps



- Are they increasing in frequency in Old Crow Flats?
- How will this influence lake and river biogeochemistry?

Monitoring permafrost retrogressive thaw slumps and downstream biogeochemical impacts

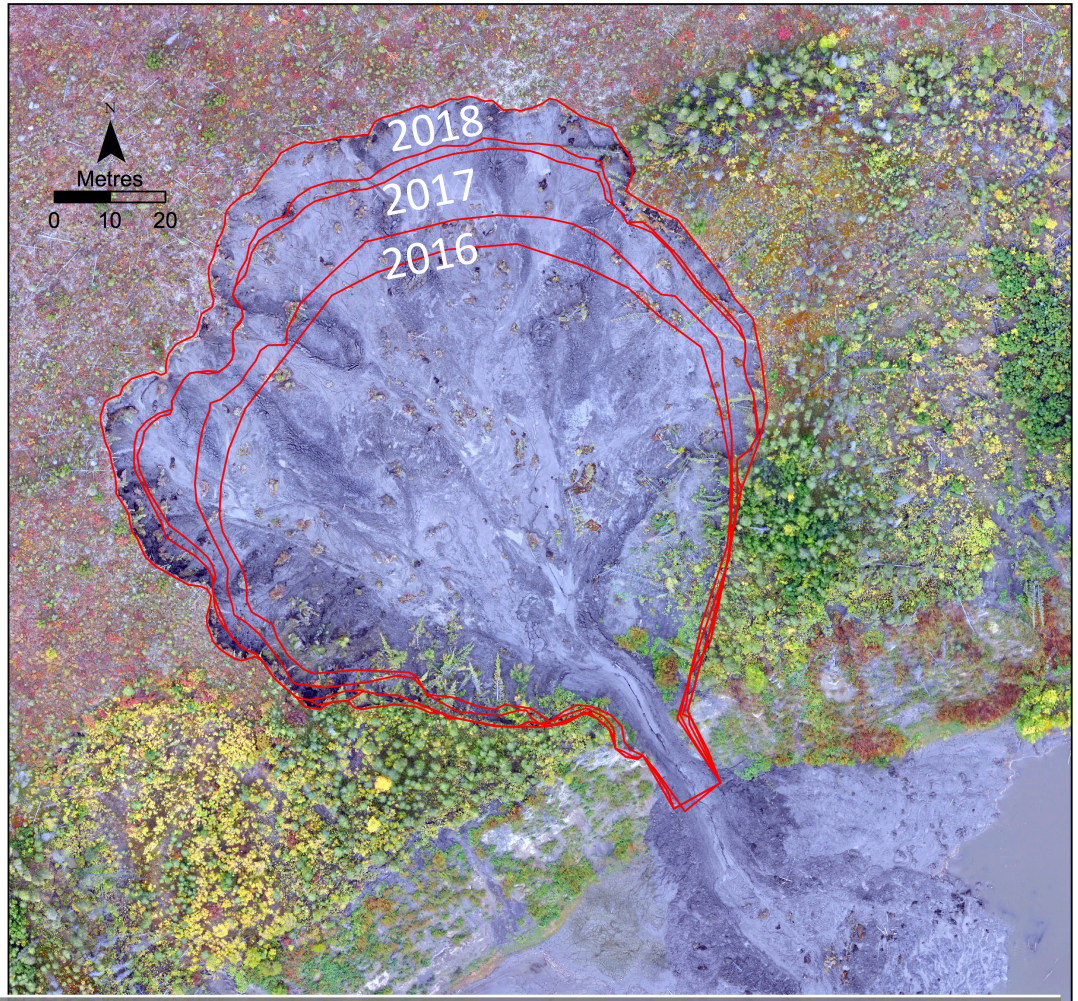
Turner et al., in prep.

Preliminary bulk density and carbon elemental and isotope analysis:

n = 15
mean BD = 1.5 g/cm3
range BD = 1.3 - 1.6 g/cm3

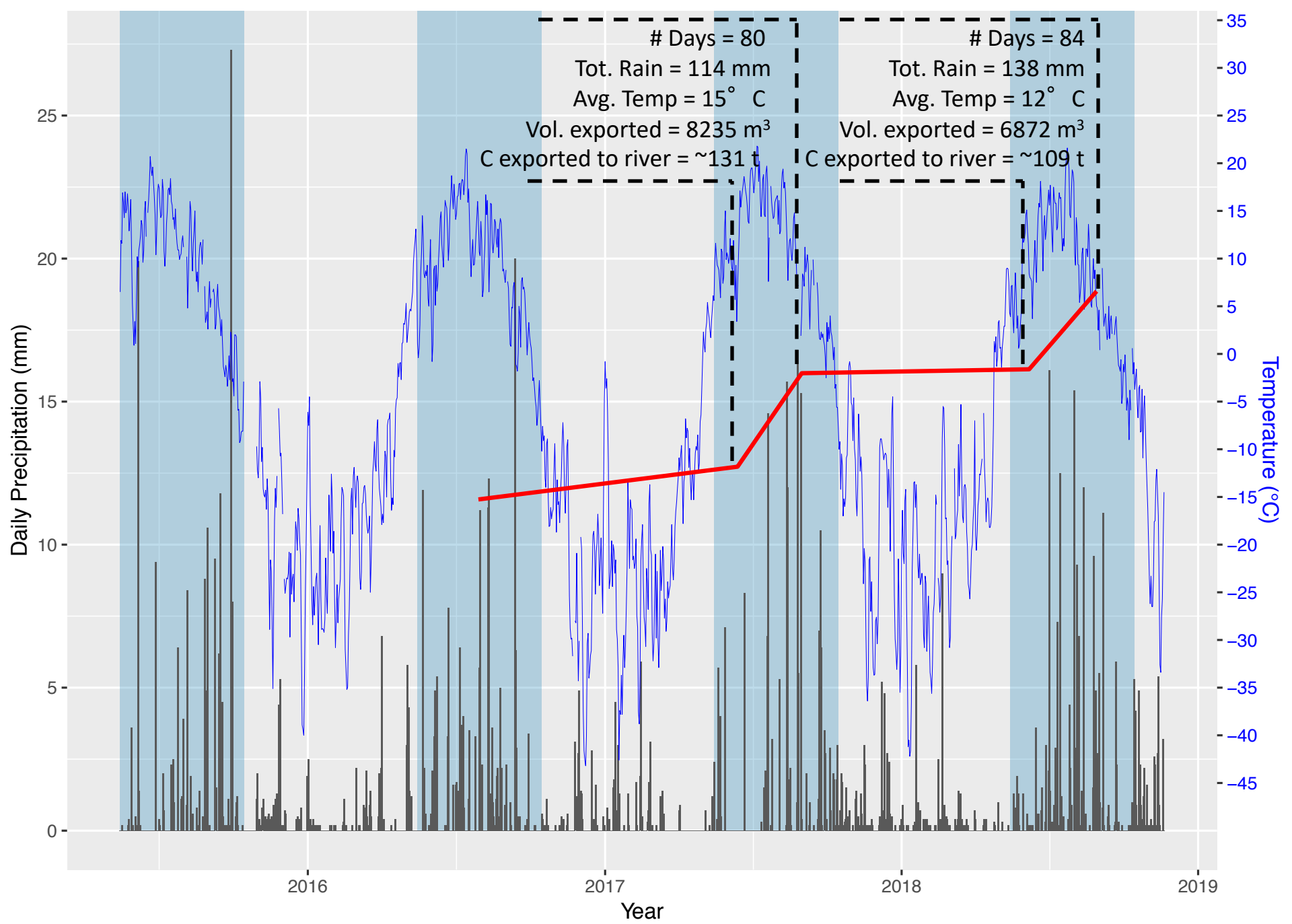
mean %C = 1.1%

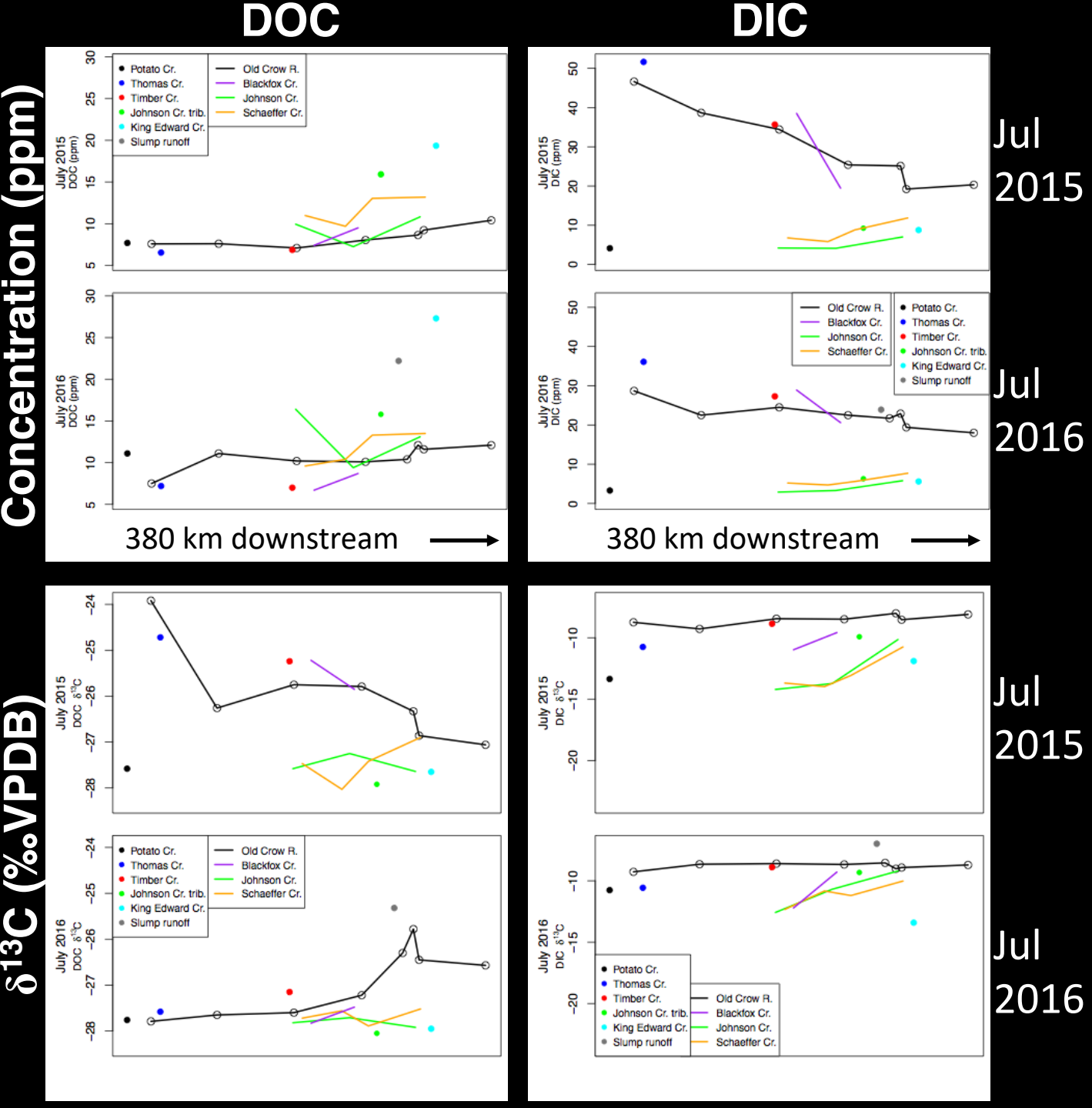
mean $\delta^{13}C$ = -26.1‰

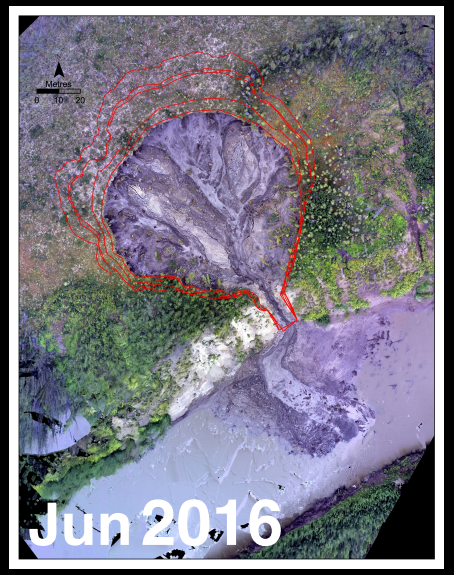


Preliminary values used to estimate total seasonal carbon export.

	Volume (m^3)	% Volume	Area (m^2)	% Area	# Dump Trucks	# Football fields
29 Jul 16	29,174		6,342		2,917	1.19
13 Jun 17	32,054	10	7,163	13	3,205	1.35
31 Aug 17	40,290	26	8,806	23	4,029	1.66
7 Jun 18	40,637	1	9,006	2	4,064	1.68
29 Aug 18	47,509	17	10,267	14	4,751	1.92


Days = 80
Tot. Rain = 114 mm
Avg. Temp = 15° C
Vol. exported = 8235 m³
C exported to river = ~131 t
Days = 84
Tot. Rain = 138 mm
Avg. Temp = 12° C
Vol. exported = 6872 m³
C exported to river = ~109 t
Daily Precipitation (mm)
Temperature (°C)
Year
2016
2017
2018
2019
0
5
10
15
20
25
35
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
−35
−40
−45





Slump is active

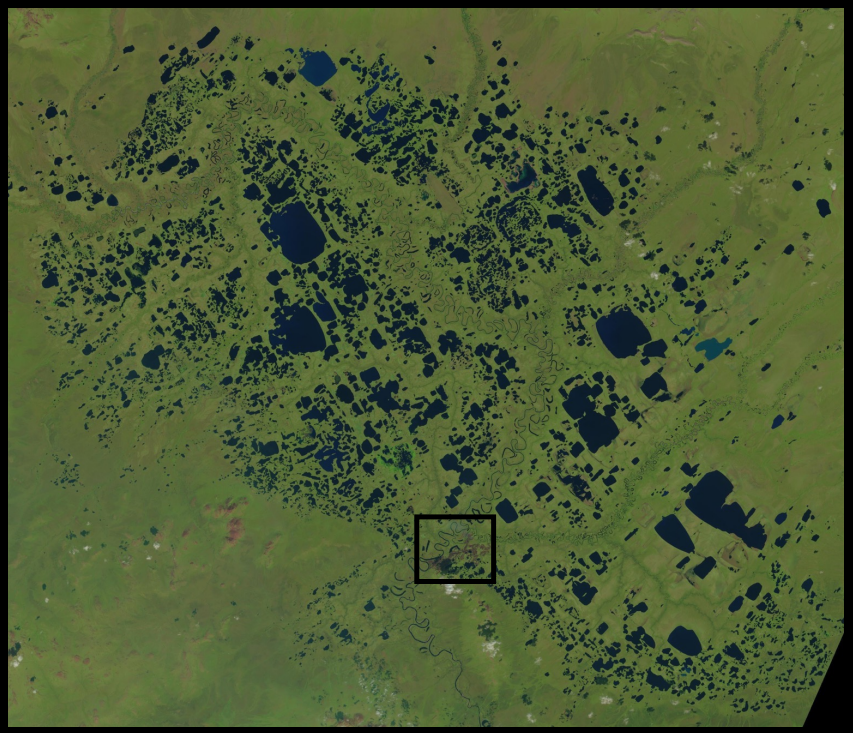
LVIS and UAVSAR

Want to inventory slumps and vulnerability to slumping along OC River

Landscape Changes:

4) Fire

2017

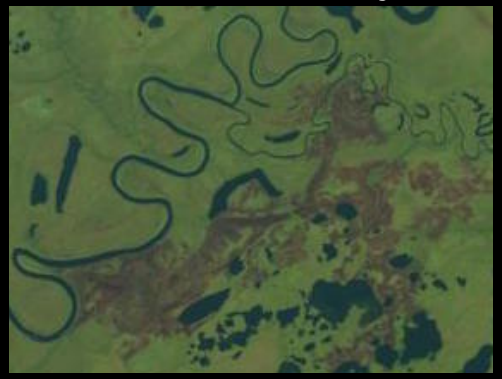


June 8

June 24

July 1

July 10

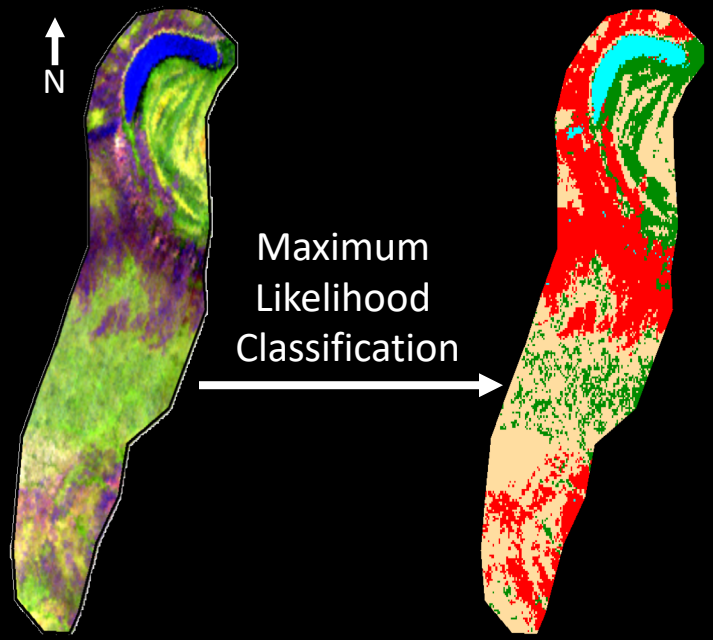


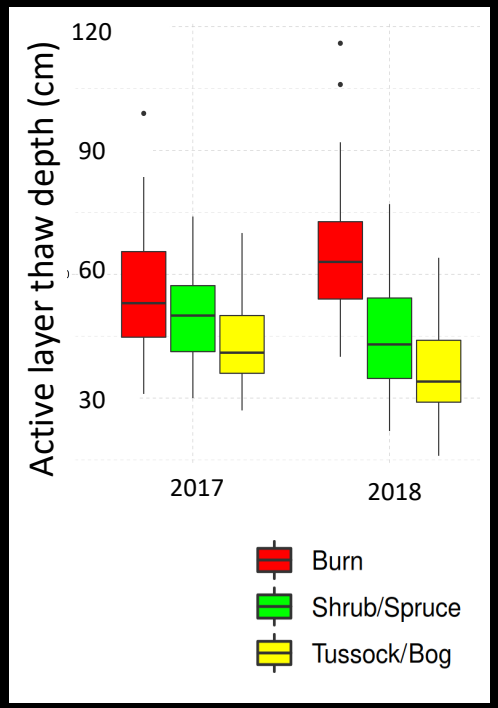
(Landsat quicklooks)

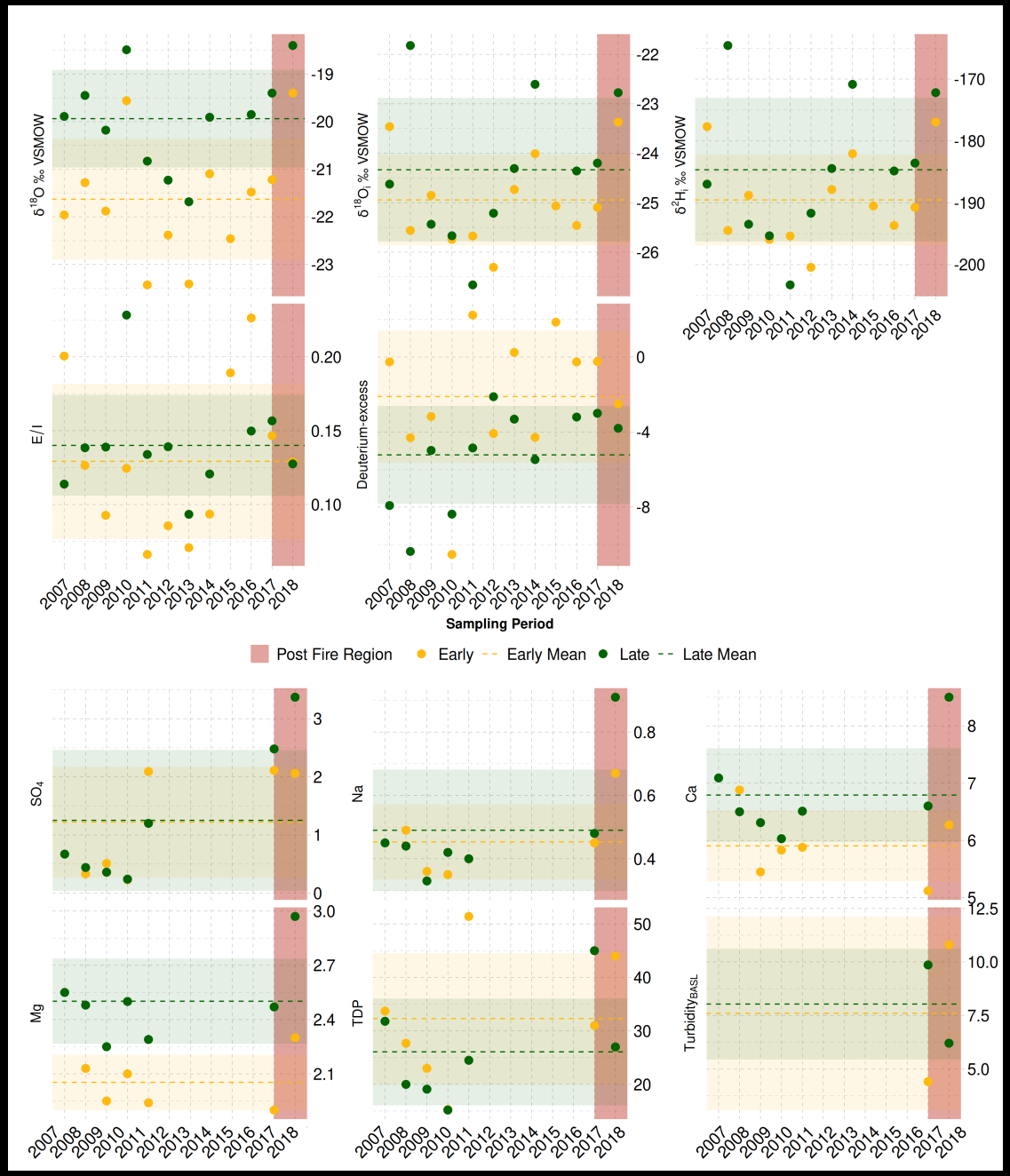
- How does fire influence lake and river biogeochemistry?
  - Direct and indirect (e.g., runoff from burn and shoreline slumping

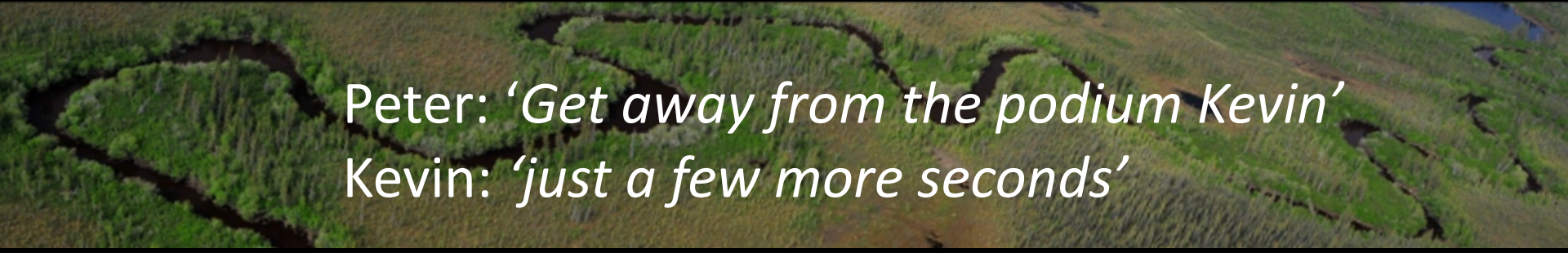
Influence of fire on catchment and lake conditions

Thorne and Turner, in prep. (poster 3-49)









Peter: *'Get away from the podium Kevin'*
Kevin: *'just a few more seconds'*

Old Crow Flats has experienced increasing temperature and precipitation

change or disturbance	shrub growth	lake drainage	thaw slumps	fire
RS Used More potential Not yet applied	UAV AVIRIS-NG Landsat	UAV AVIRIS-NG Landsat	UAV AVIRIS-NG LVIS UAVSAR	UAV AVIRIS-NG LVIS UAVSAR
in-situ measurements	ALT depth Moisture 14 lakes 24 creeks/rivers	SWE water chem/isotopes δ^{13}C DIC DOC	sediment C and N water chem/isotopes δ^{13}C DIC DOC	ALT depth moisture water chem/isotopes δ^{13}C DIC DOC

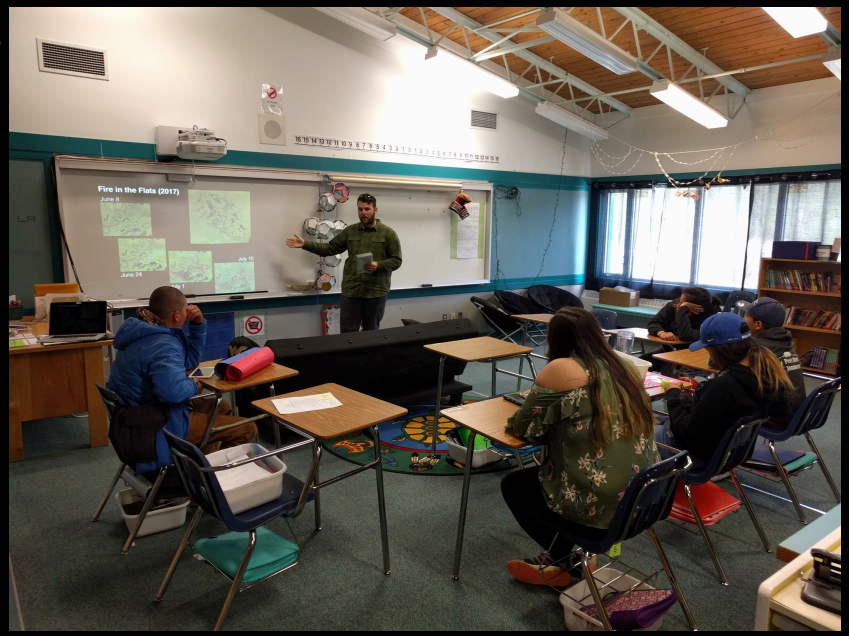
Findings are providing key insight of relations among terrestrial and aquatic systems

Peter: *'Seriously Kevin, you are done'*
Kevin: *'ok fine'*

@TheWEL_BrockU
@turner_kw

Mahsi' choo

Megan Williams, Mary Jane Moses, James Linklader, Robert Kyikavichik, George Nagwan, Danny Kassi, Dougie Charlie, Joel Peter.



Students currently involved in the field research

- Brent Thorne, Josef Viscek, Michelle Pearce

Check out his poster 3-49 (and mine 3-50)

Parks Canada Parcs Canada

NSTP PFSN
Northern Scientific Training Program
Programme de formation scientifique dans le Nord

VUNTUT GWITCHIN GOVERNMENT

POLAR CONTINENTAL SHELF PROJECT
ÉTUDE DU PLATEAU CONTINENTAL POLAIRE

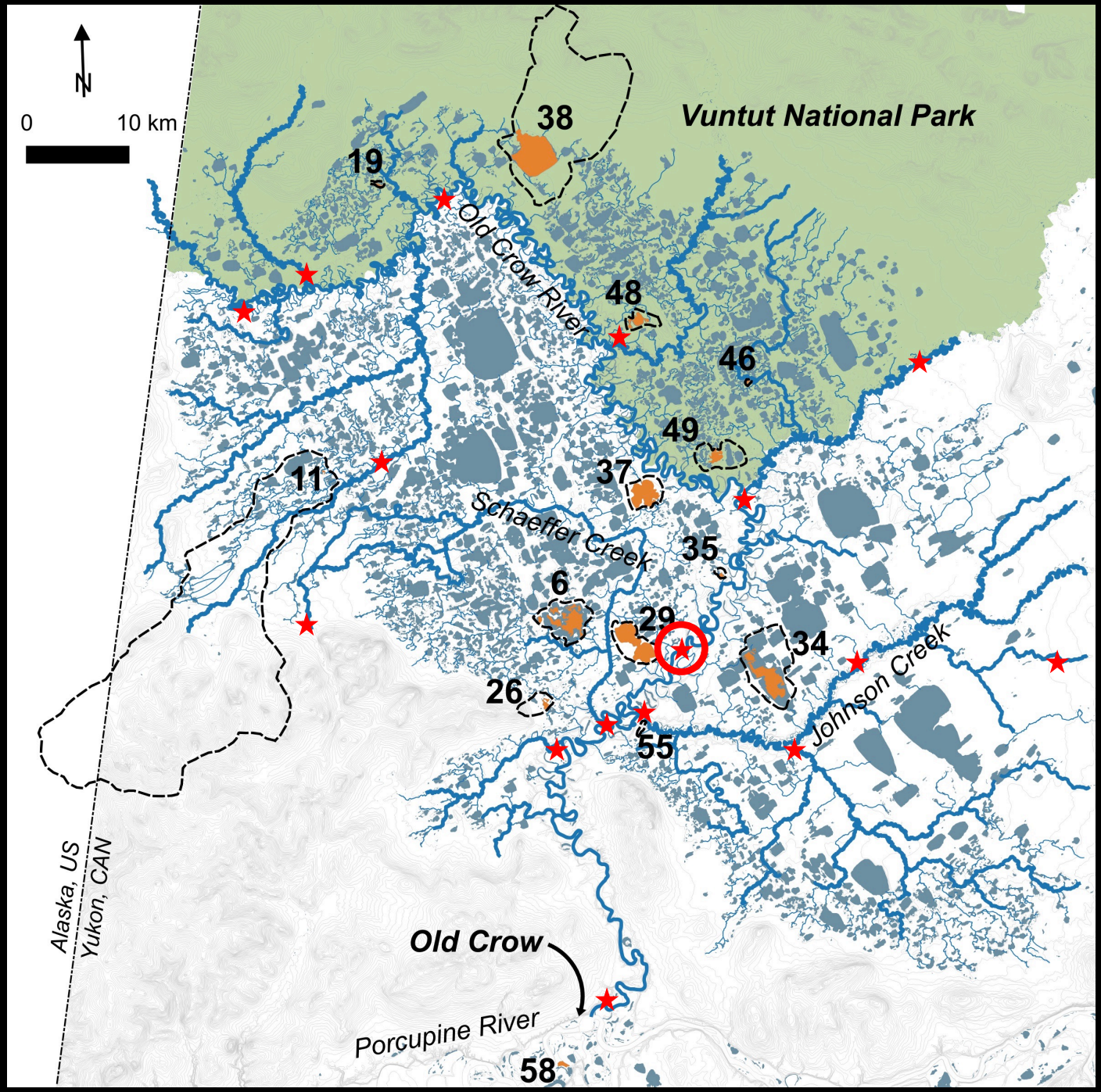
HOSKIN SCIENTIFIC LTD.

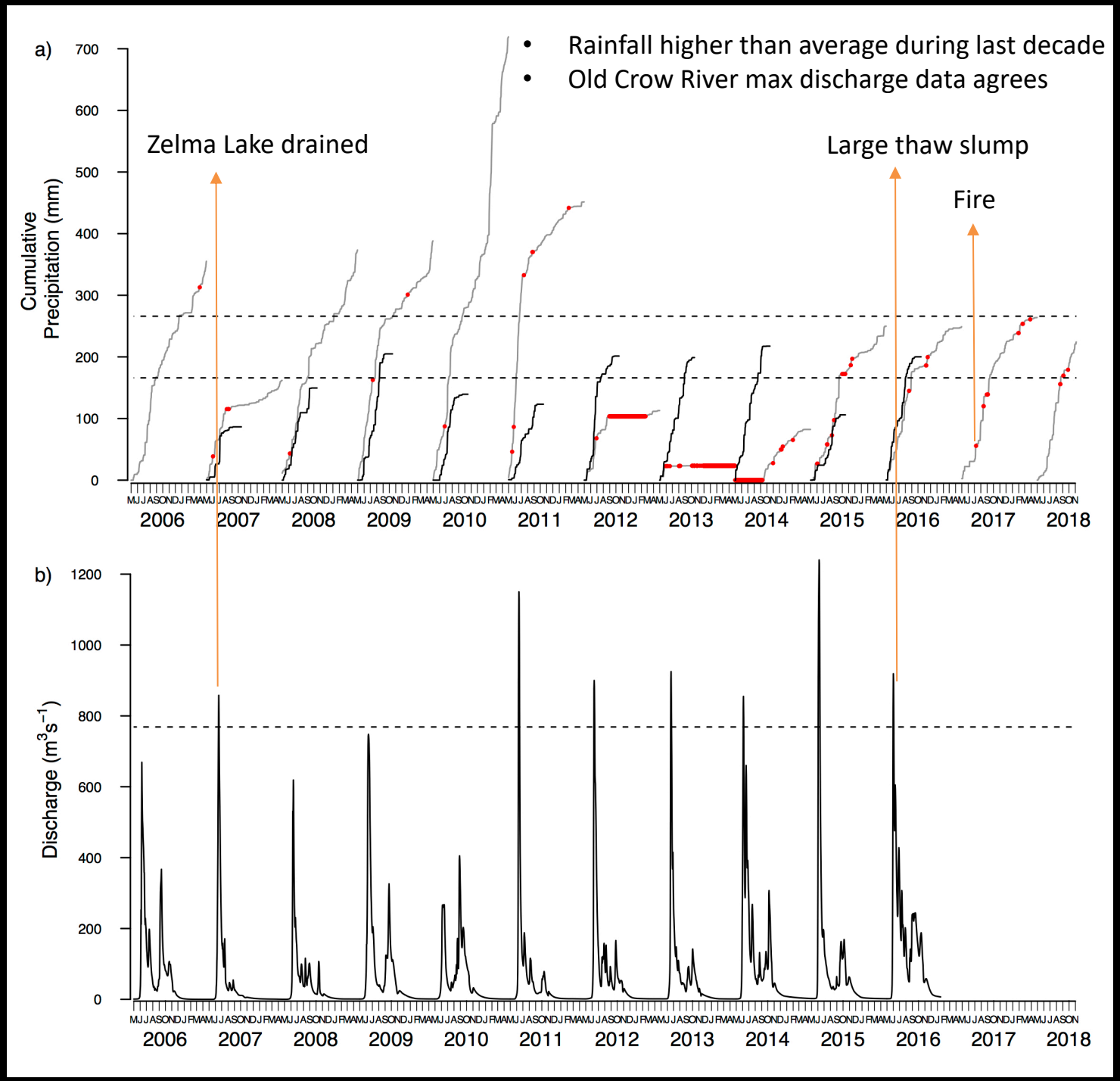
Brock University

ABoVE
ARCTIC – BOREAL VULNERABILITY EXPERIMENT

NSERC CRSNG

YUKON RESEARCH CENTRE
Yukon College


N
0
10 km
Vuntut National Park
38
19
Old Crow River
48
46
49
11
37
Schaeffer Creek
35
6
29
34
Johnson Creek
26
55
Alaska, US
Yukon, CAN
Old Crow
Porcupine River
58



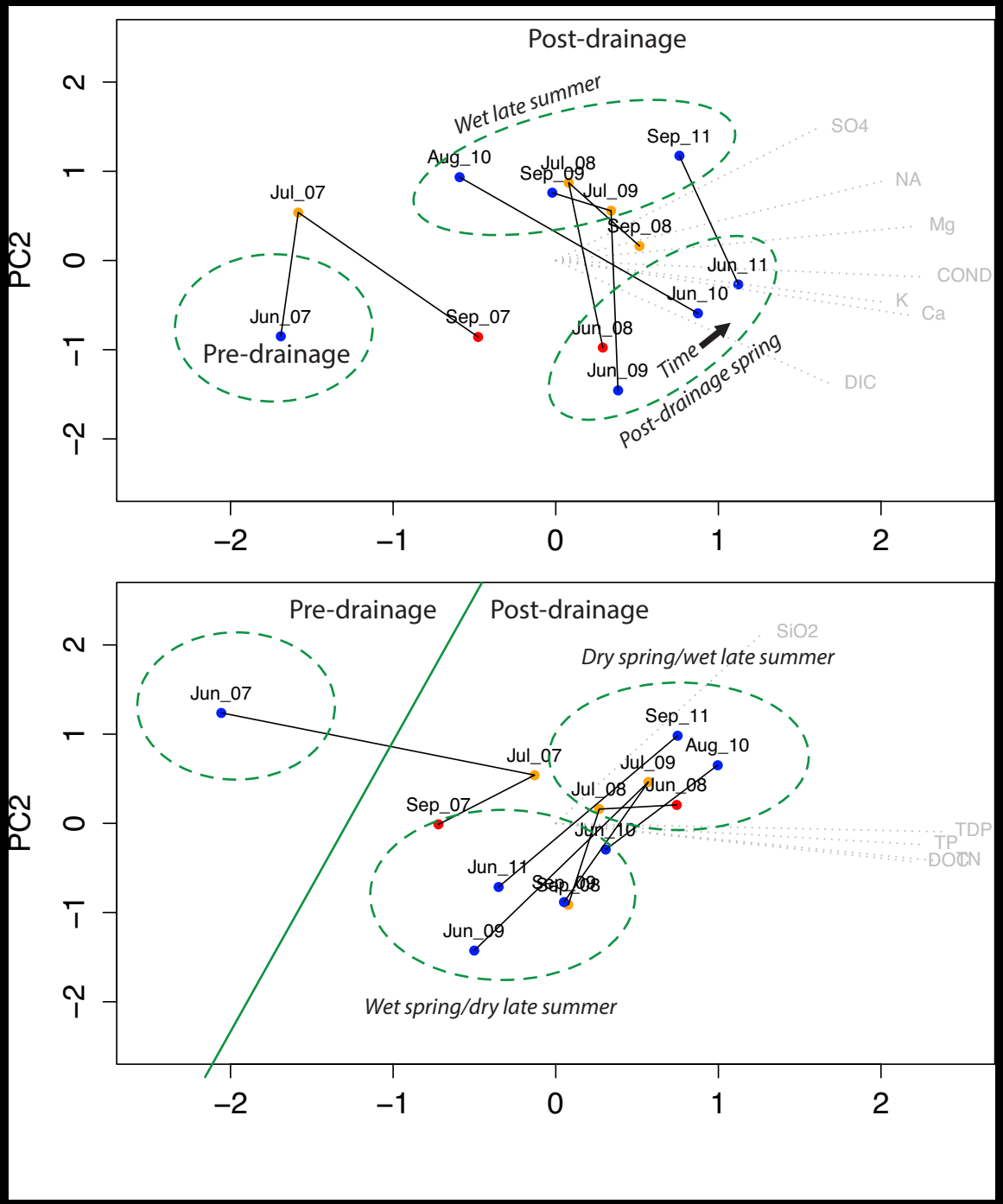
- Rainfall higher than average during last decade
- Old Crow River max discharge data agrees

Exploring changes in post-drainage water chemistry

Ions

Nutrients

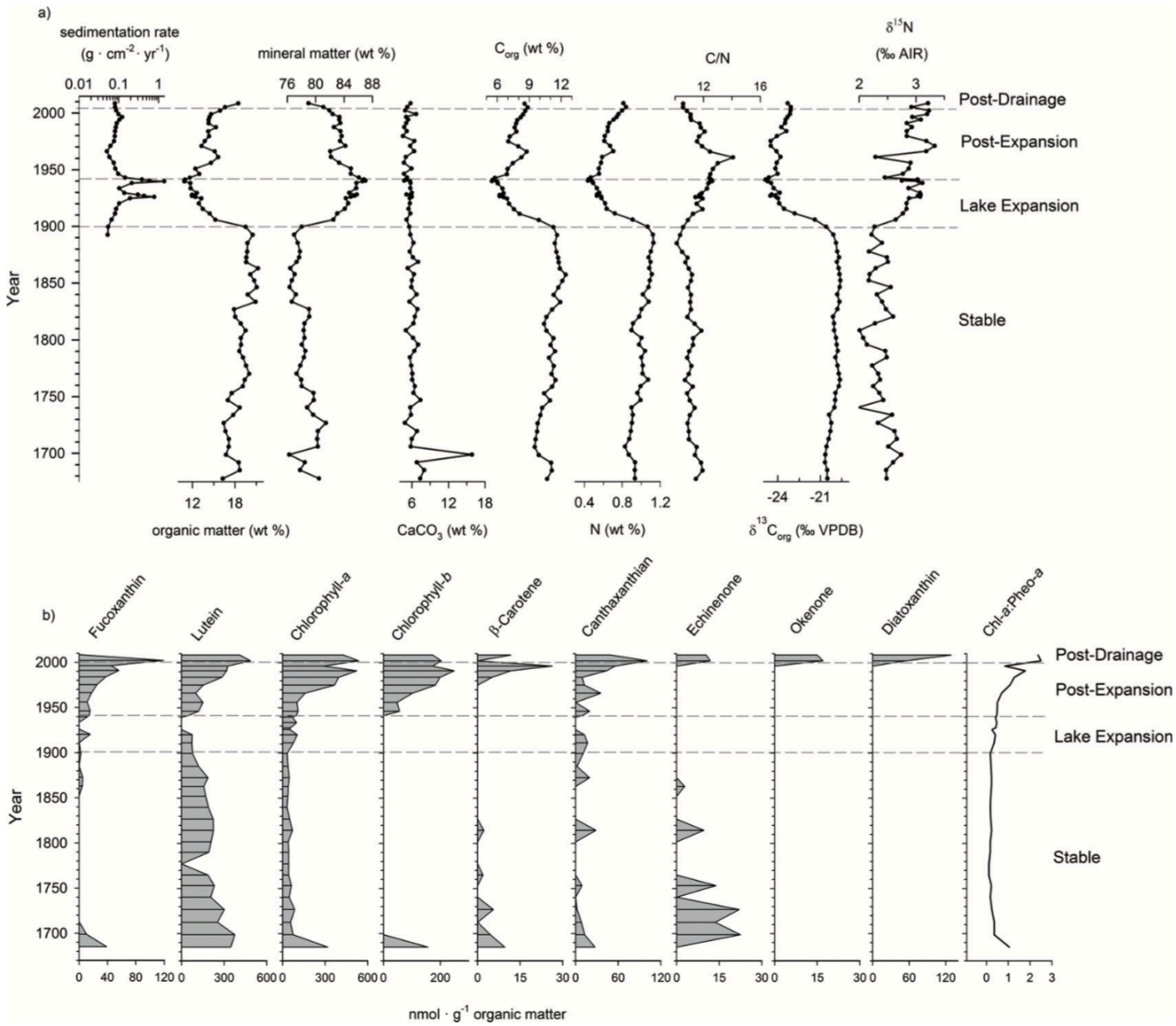
- Wet conditions
- Normal conditions
- Dry conditions



Long-term perspective with paleolimnological approaches

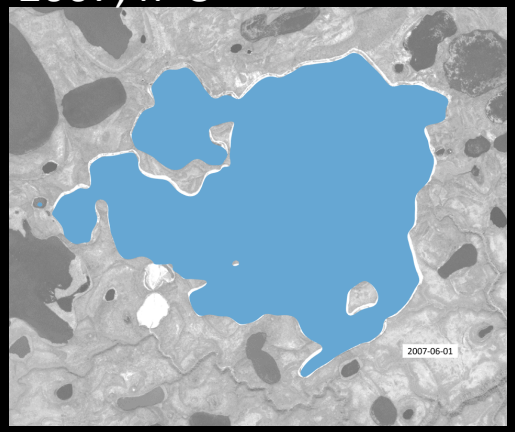
Eutrophic conditions following drainage as indicated by pigments.

Fig. 4. (*a*) Physical and geochemical stratigraphy of the Zelma Lake sediment core showing the CRS-determined sedimentation rate, organic matter content, mineral matter content, calcium carbonate content, percent dry weight organic carbon, percent dry weight nitrogen, carbon-to-nitrogen weight ratios (C/N), organic carbon isotope composition, and nitrogen isotope composition. (*b*) Pigment stratigraphy of the Zelma Lake sediment core showing the most abundant chlorophyll and carotenoid pigments.

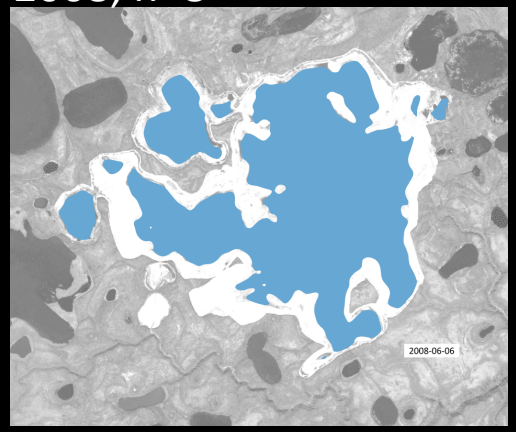


Tondu et al., 2017, Arctic Science

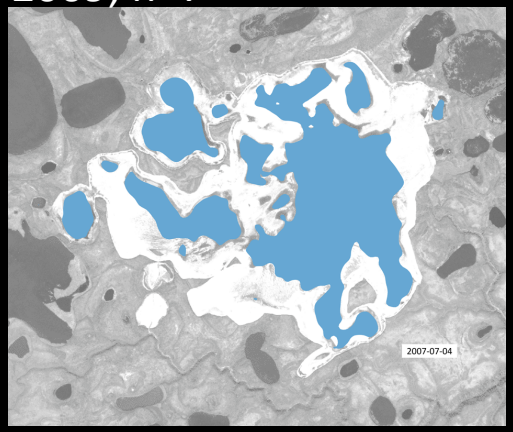
2007, n=8



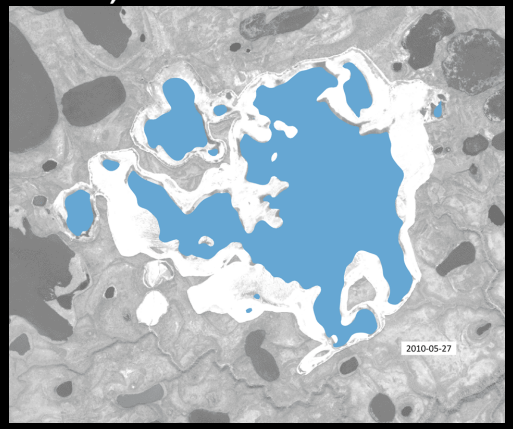
2008, n=8



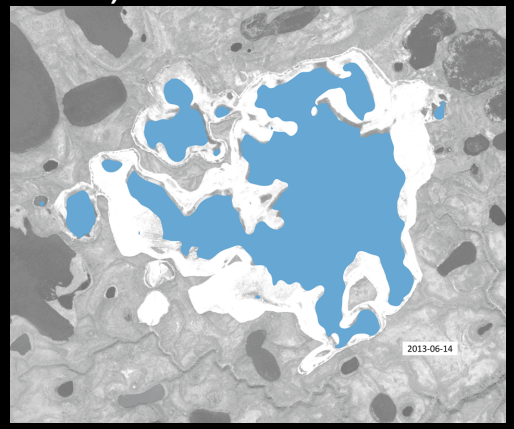
2009, n=7



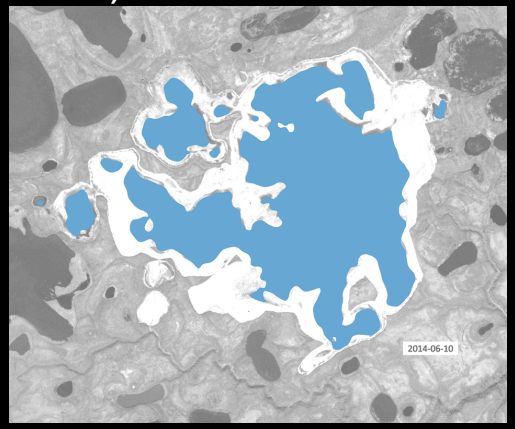
2010, n=4



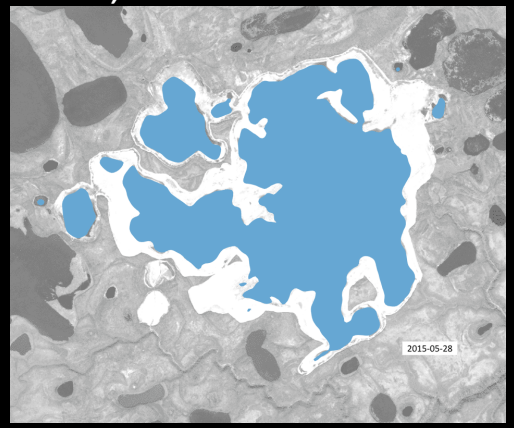
2013, n=3



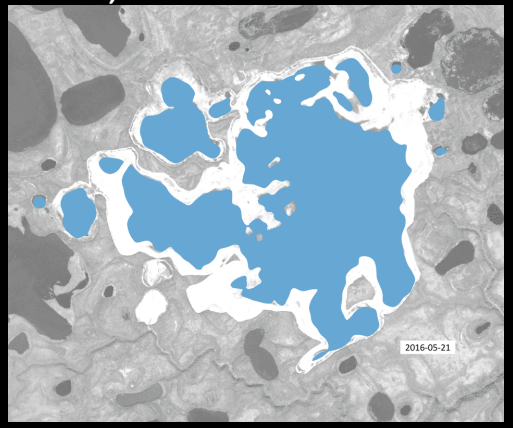
2014, n=5



2015, n=4



2016, n=6

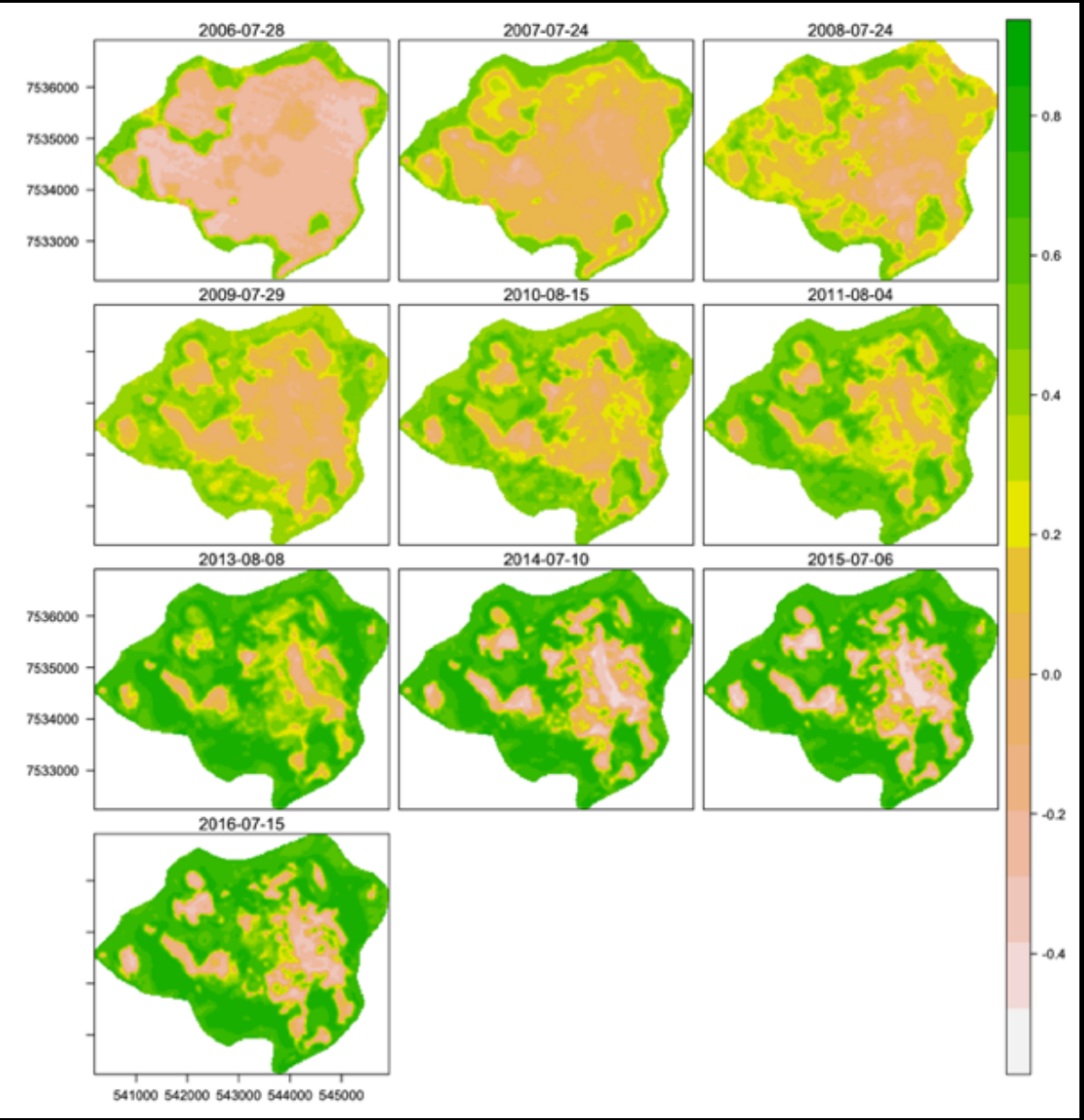


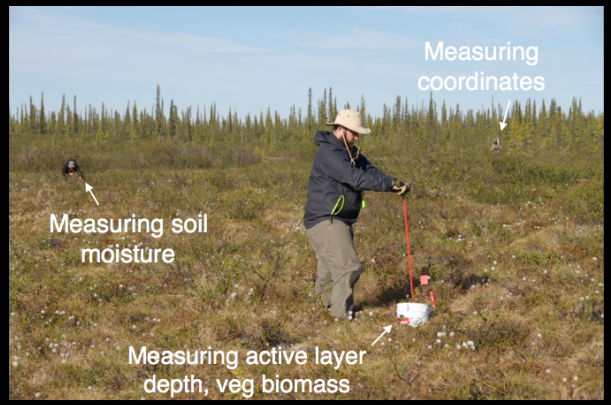
Surface water areal fluctuations

max = 12 km^2, min = 3 km^2

Detecting hydrological responses of a drained thermokarst lake to drastic changes in catchment land cover

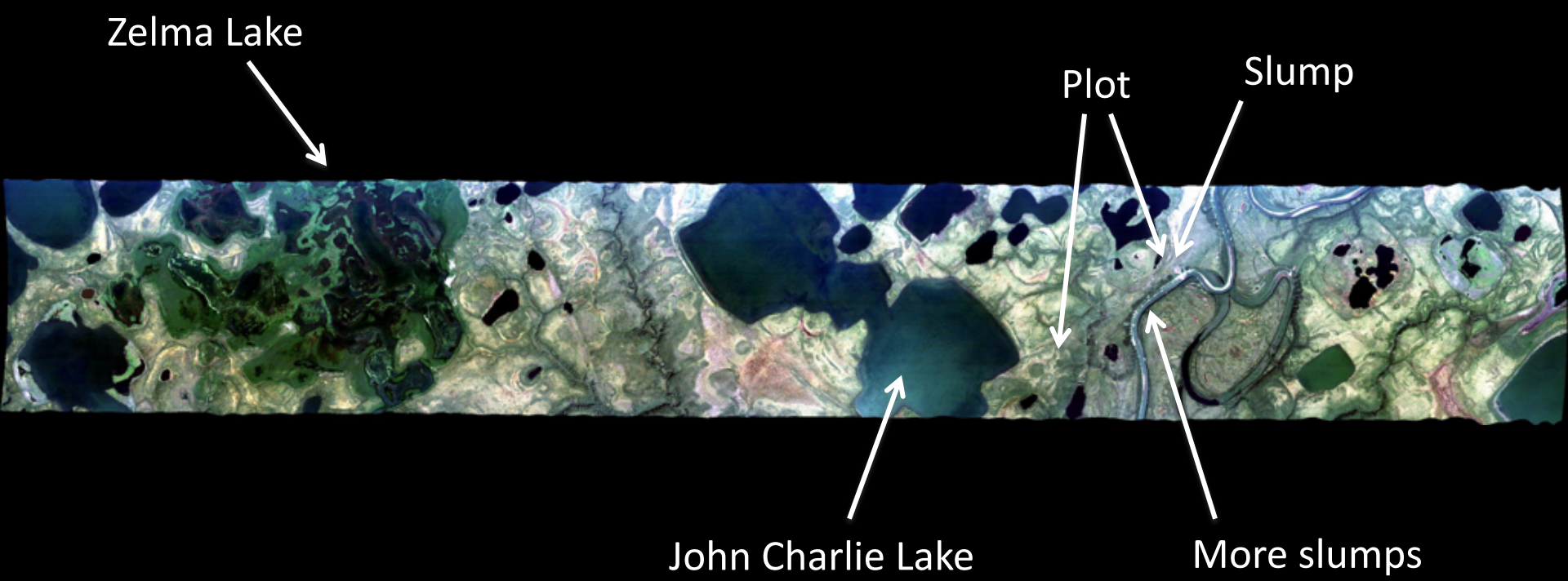
- using isotope tracers, water level and Landsat (NDVI, MNDWI, SWIR, NIR)





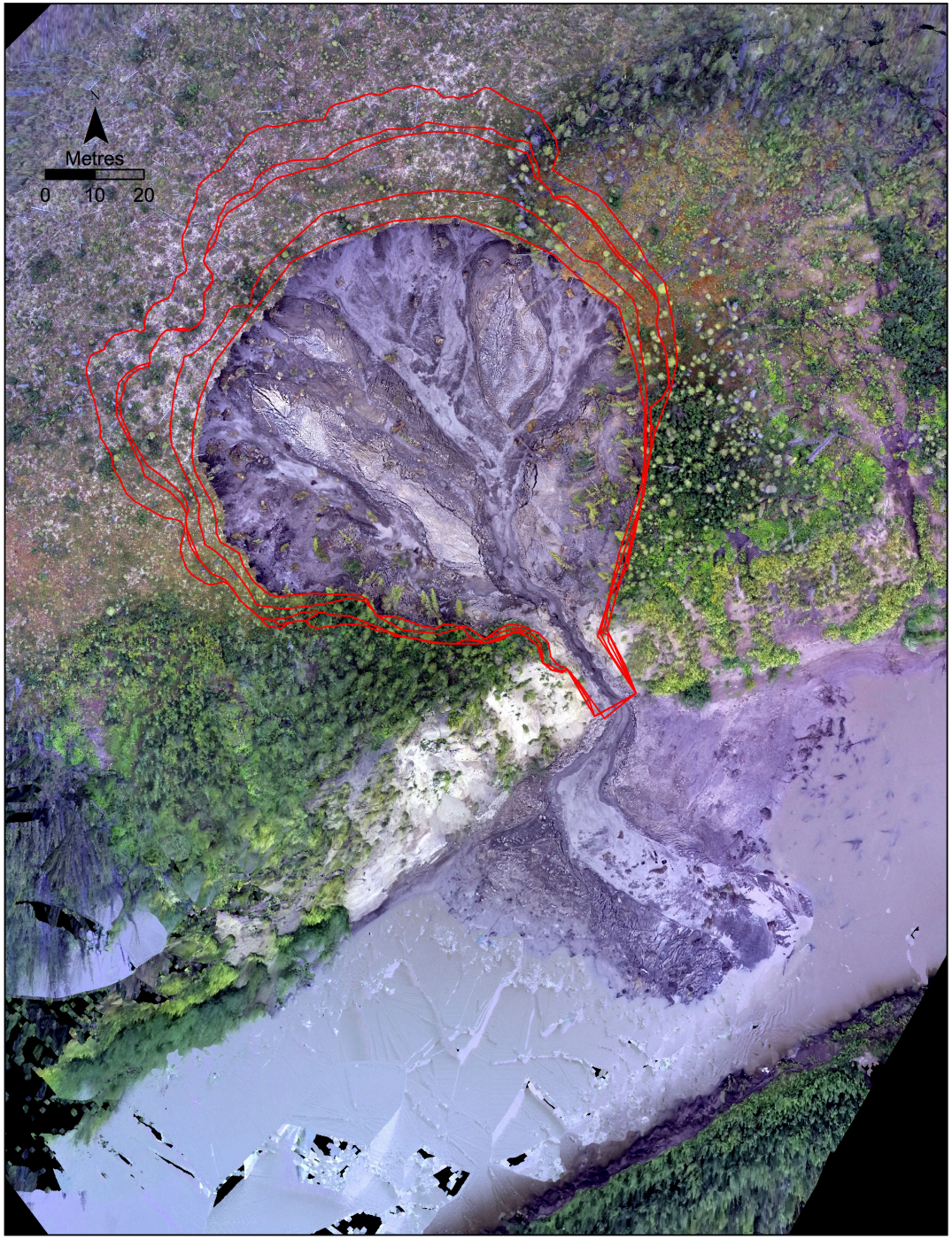
ABoVE
ARCTIC – BOREAL VULNERABILITY EXPERIMENT

Sample hyperspectral data (AVIRIS)



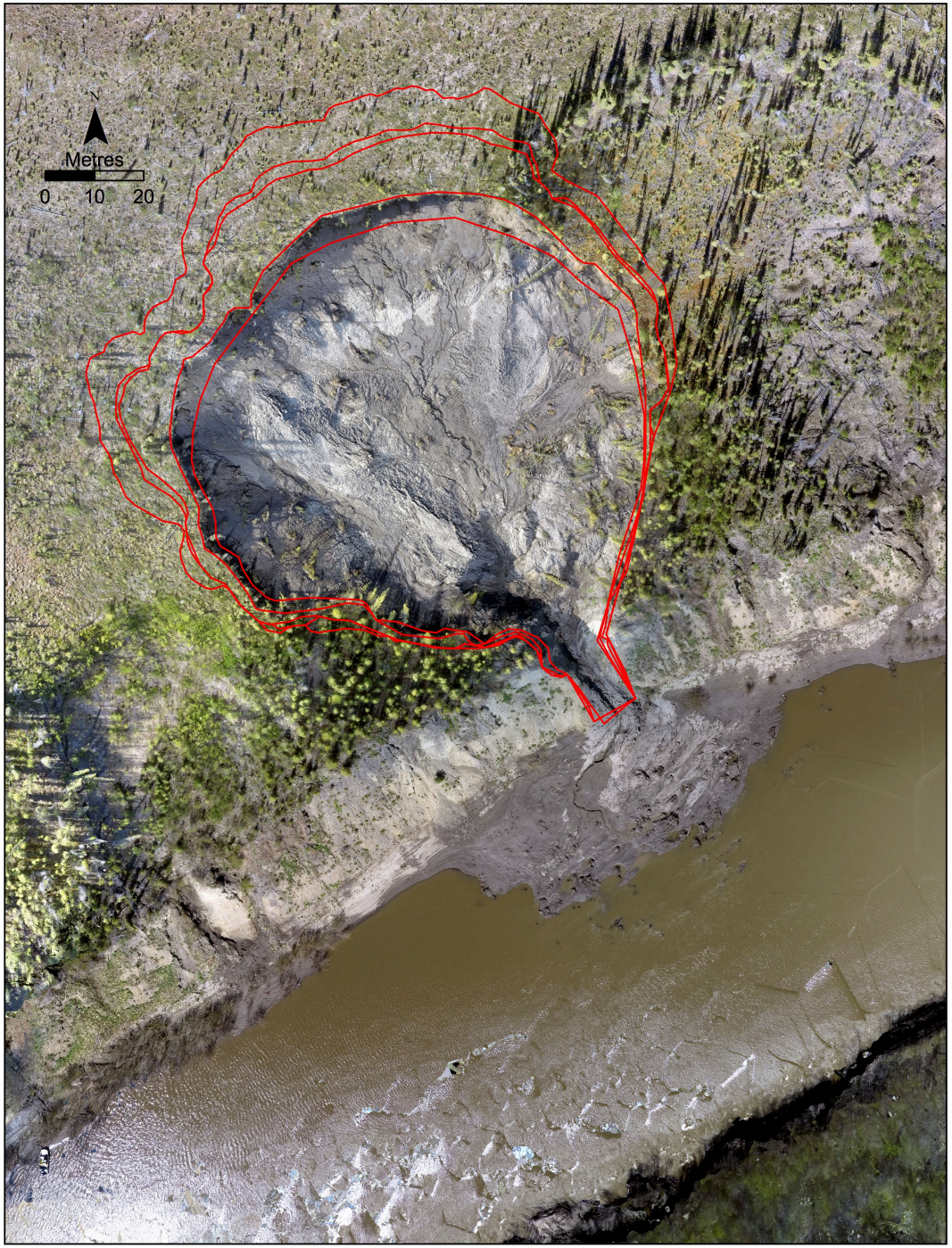
Tracking slump volumetric changes using photogrammetry of UAV images

Date	29 Jul 2016
volume (m^3)	29,174
% volume change	
area (m^2)	6,342
% area	
# dump trucks	2,917
# football fields	1.19



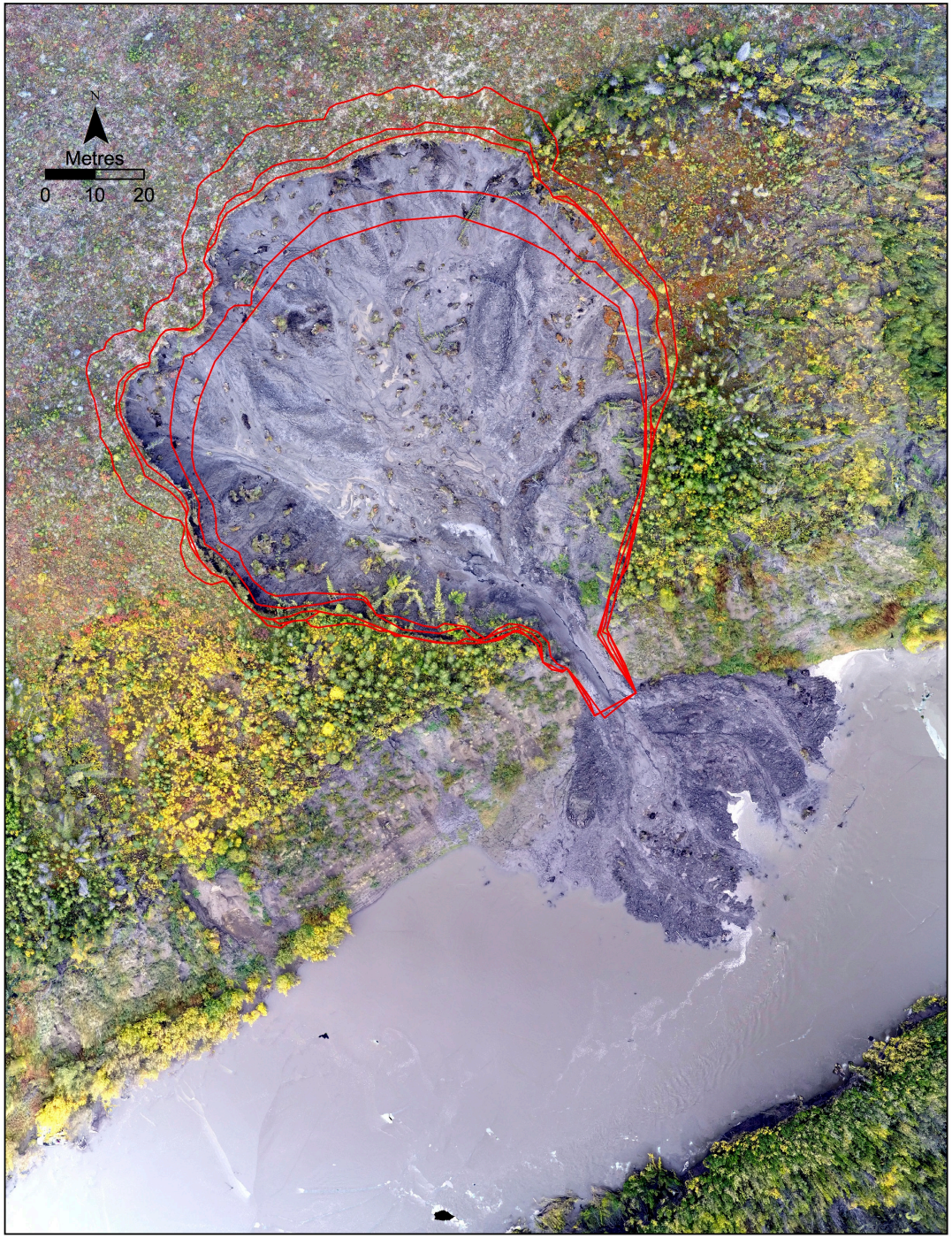
Tracking slump volumetric changes using photogrammetry of UAV images

Date	13 Jun 2017
volume (m^3)	32,054
% volume change	10
area (m^2)	7,163
% area	13
# dump trucks	3,205
# football fields	1.35



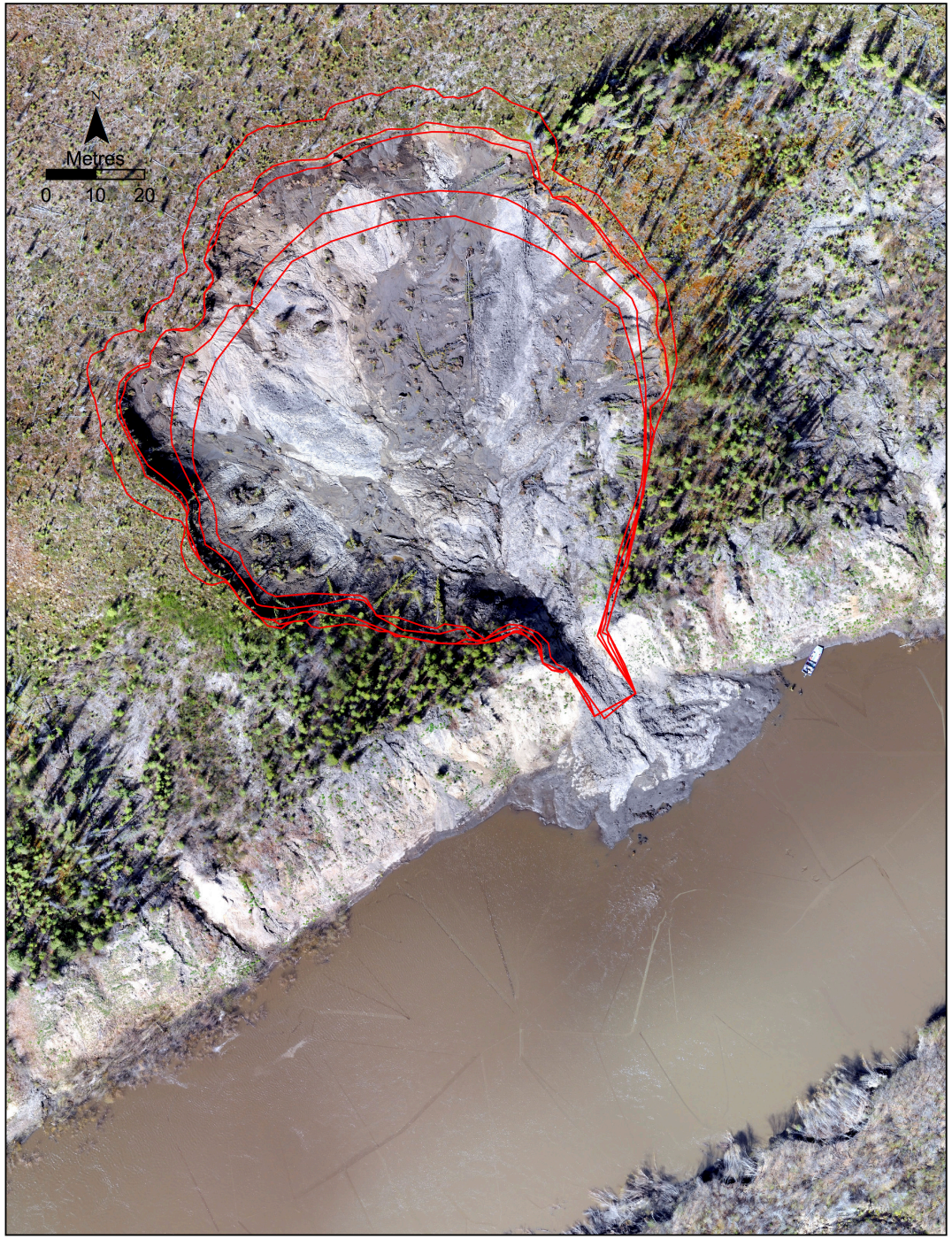
Tracking slump volumetric changes using photogrammetry of UAV images

Date	31 Aug 2017
volume (m^3)	40,290
% volume change	26
area (m^2)	8,806
% area	23
# dump trucks	4,029
# football fields	1.66



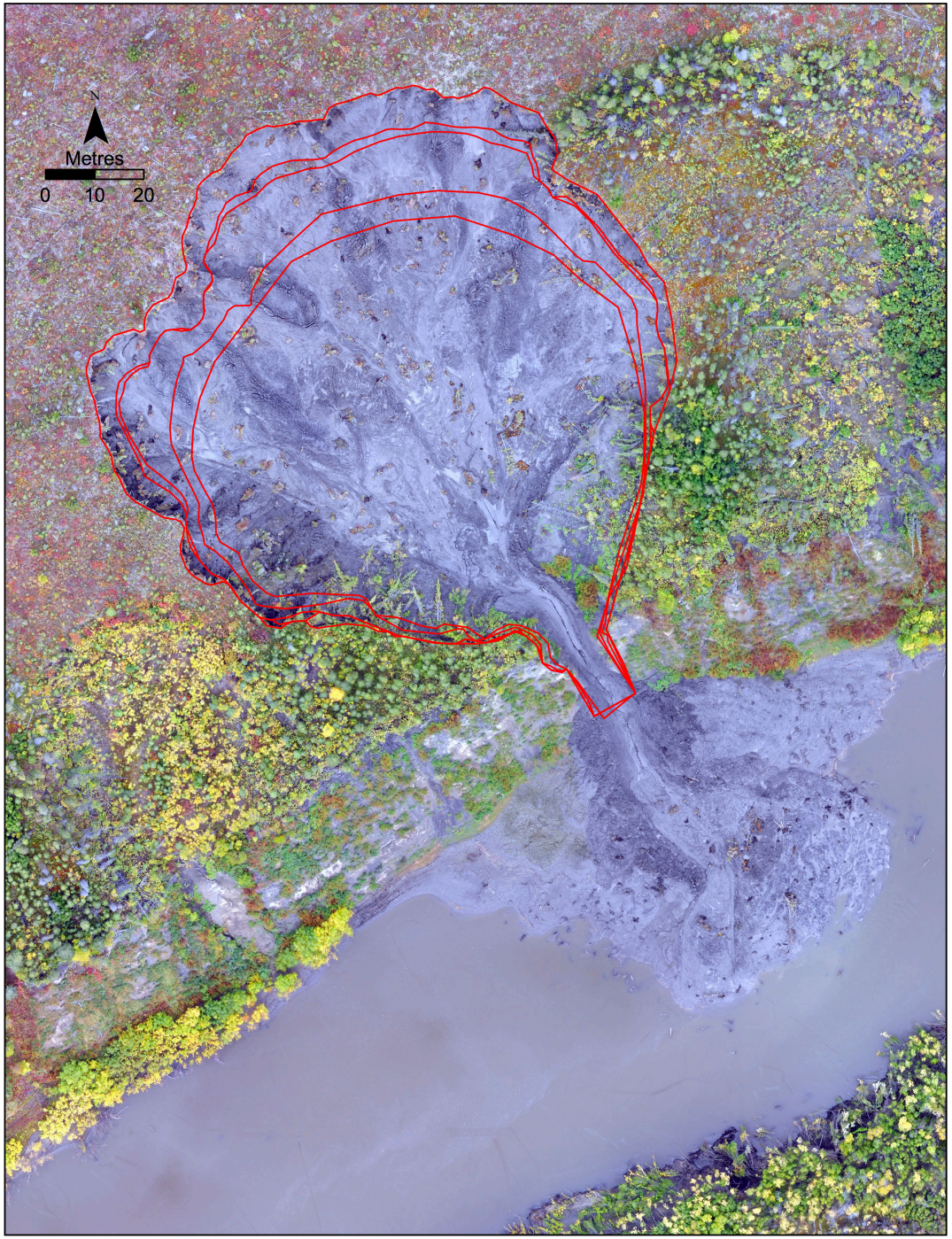
Tracking slump volumetric changes using photogrammetry of UAV images

Date	07 Jun 2018
volume (m^3)	40,637
% volume change	1
area (m^2)	9,006
% area	2
# dump trucks	4,064
# football fields	1.68



Tracking slump volumetric changes using photogrammetry of UAV images

Date	29 Aug 2018
volume (m^3)	47,509
% volume change	17
area (m^2)	10,267
% area	14
# dump trucks	4,751
# football fields	1,92

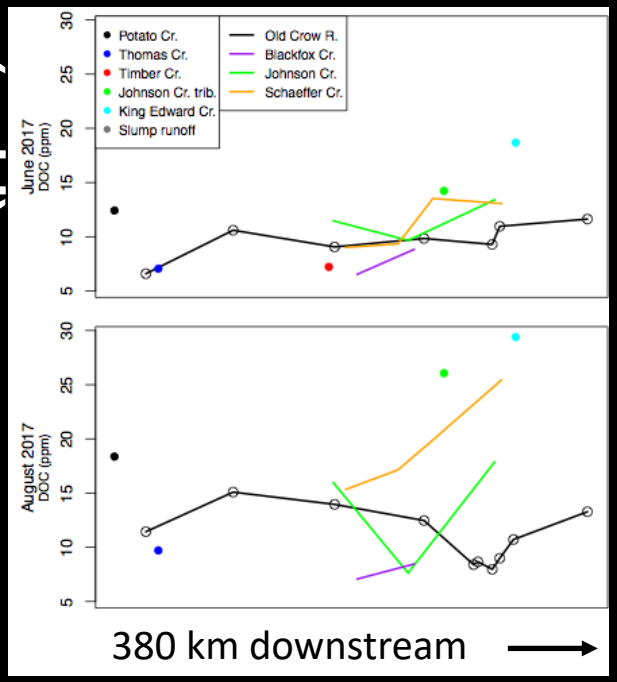


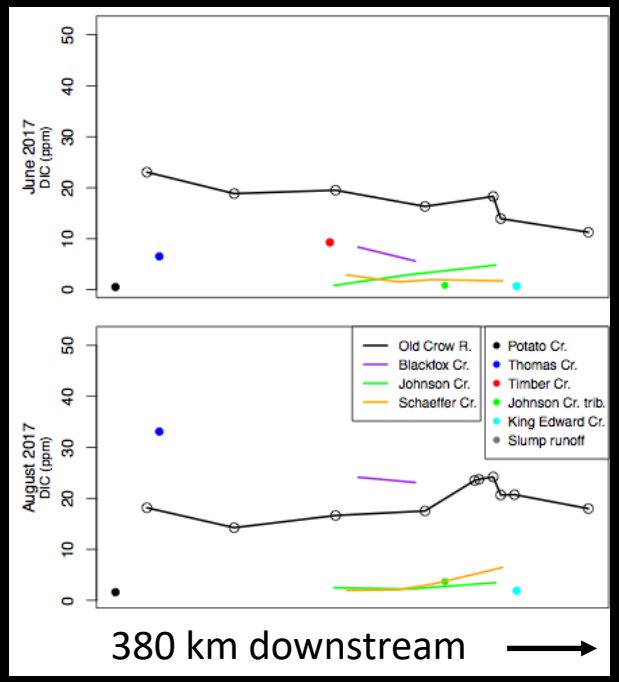
2017

DOC

DIC

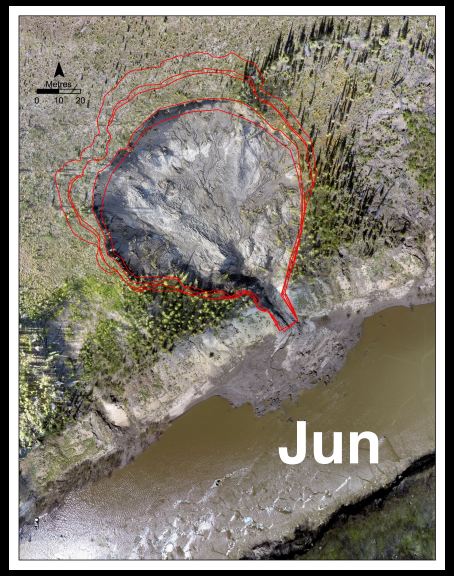
Concentration (ppm)



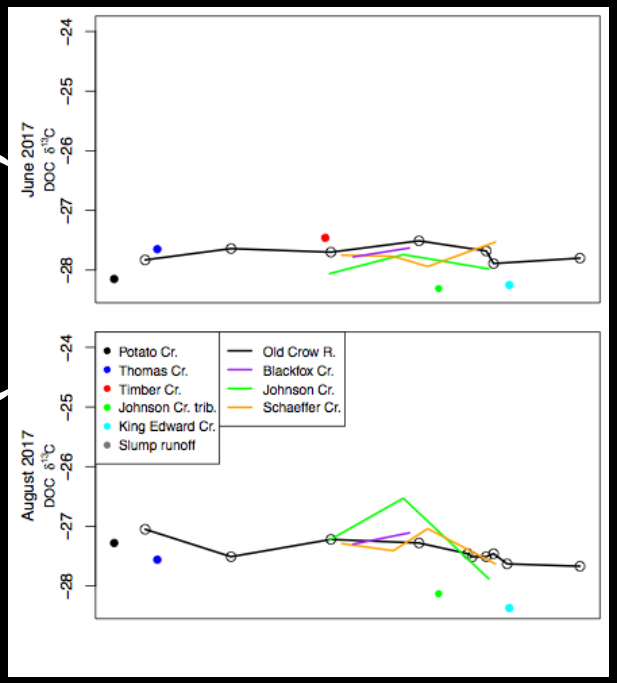


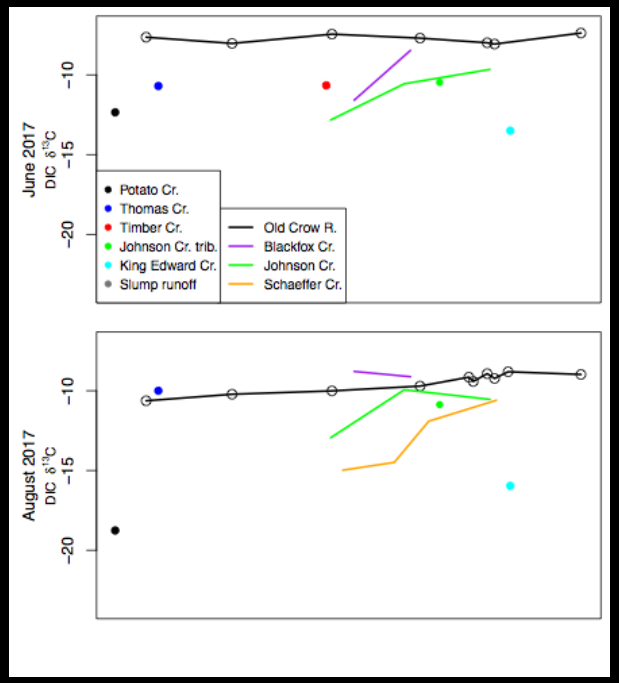
Jun

Aug



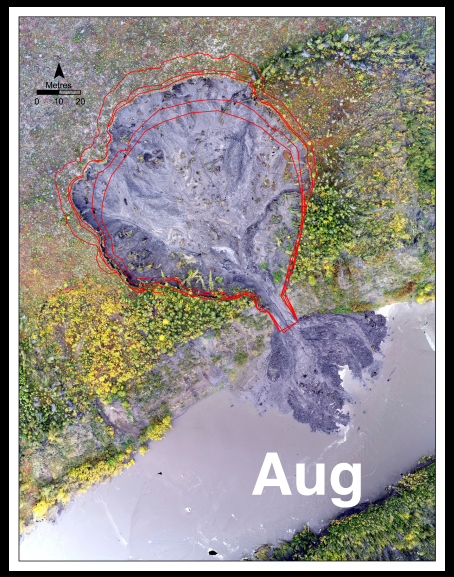
$\delta^{13}C$ (‰VPDB)





Jun

Aug

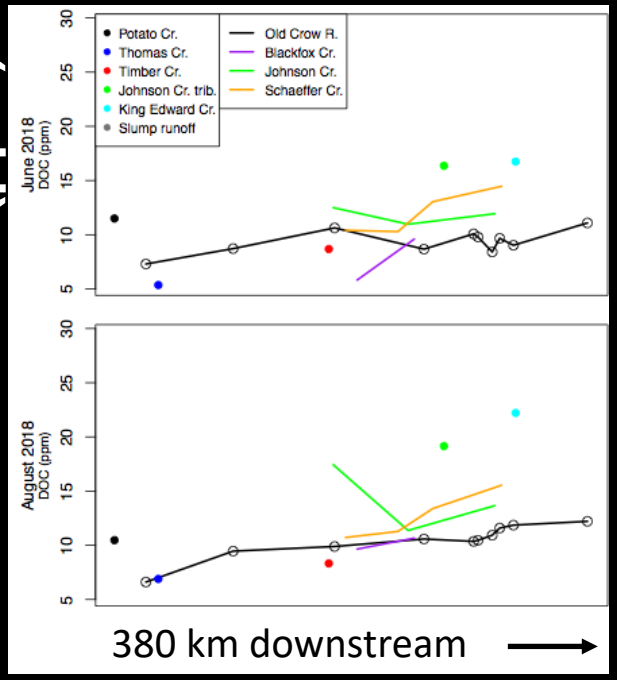


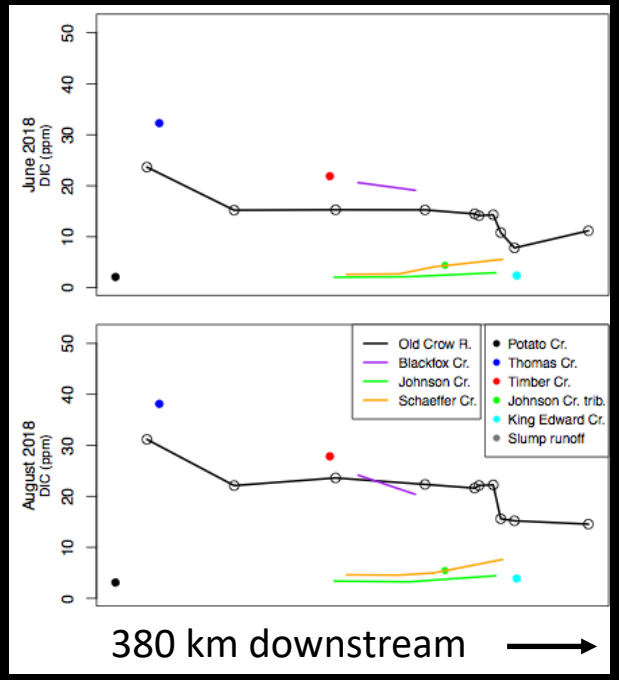
DOC

DIC

2018

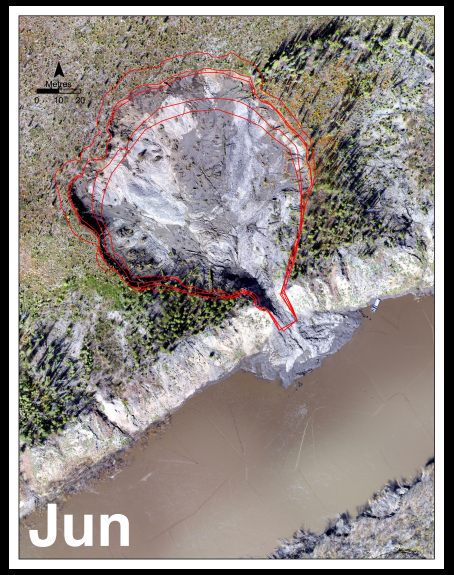
Concentration (ppm)



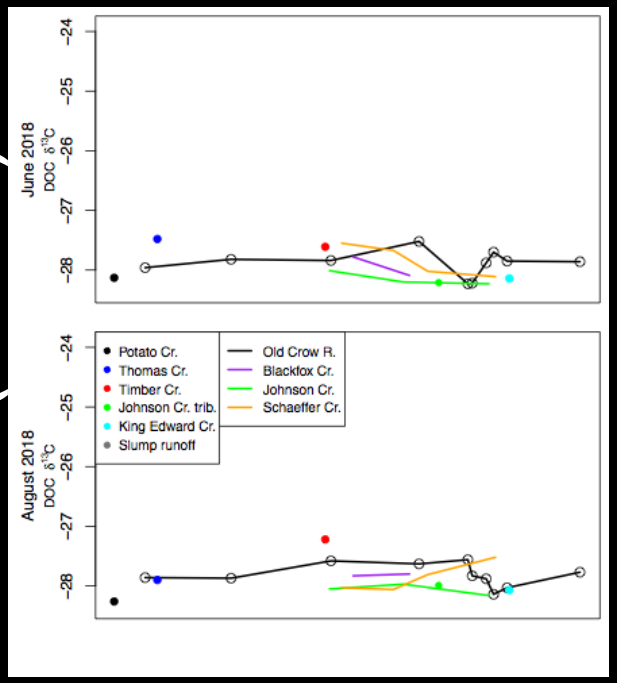


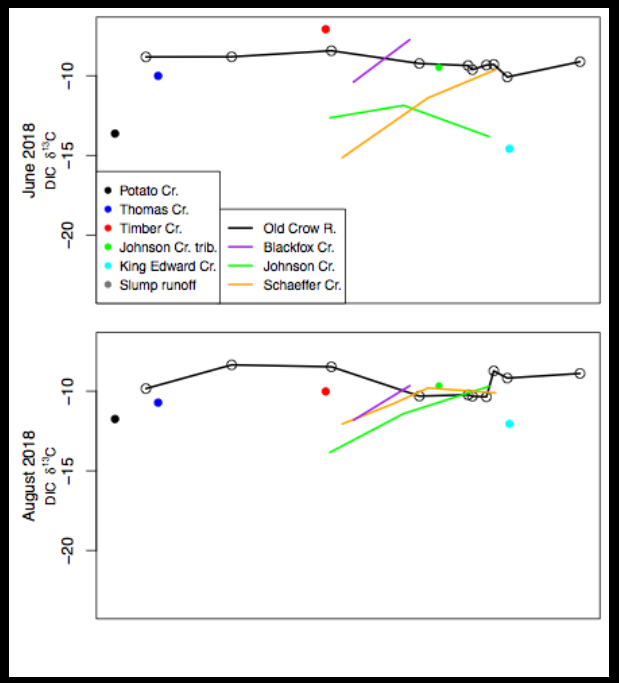
Jun

Aug



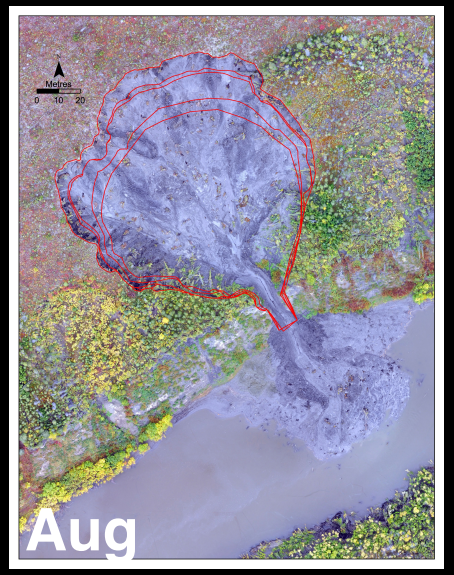
$\delta^{13}C$ (‰VPDB)





Jun

Aug



Back of the Envelope

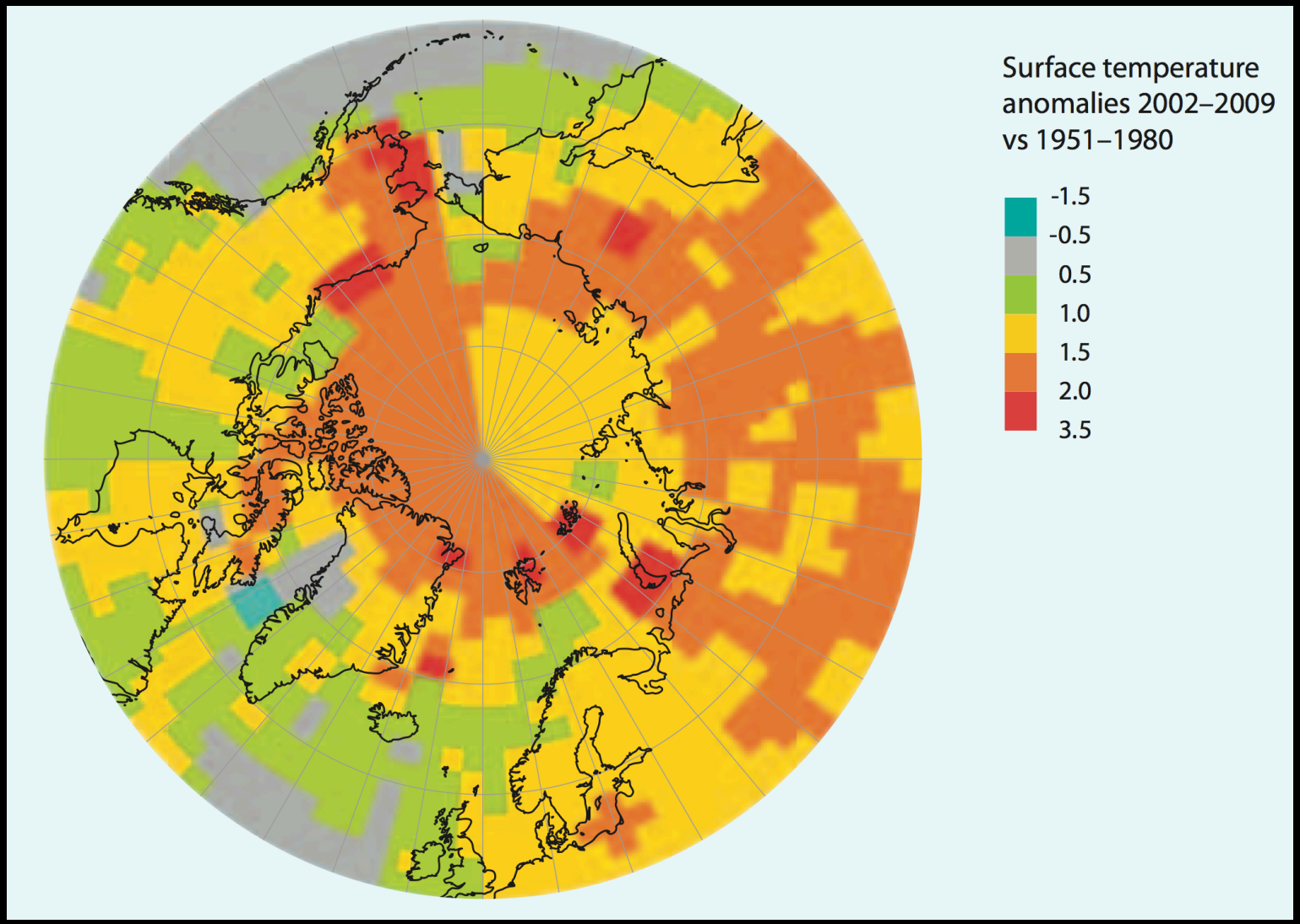
Avg_Dry_Bulk_Density_g_cm3	Carbon	Nitrogen	perc_C	perc_N	d13C	d15N
1.4737021	51.916	23.160	0.9920582	0.08071604	-26.34820	0.7214805
1.5970898	46.380	21.098	0.9209198	0.07640428	-25.61653	0.7194340
1.4623572	82.544	34.689	1.5867522	0.12161880	-26.46392	1.7543716
1.3768170	17.697	6.670	1.1385070	0.07826133	-24.15344	-3.0912145
1.4742459	56.708	26.077	1.1055196	0.09271822	-26.23398	1.5148319

```r
## Convert bulk density units from g/cm3 to kg/m3 by multiplying by 1000
bulkD_kg_m3 <- Sed_data$Avg_Dry_Bulk_Density_g_cm3[Sed_data$Description=="sed"] * 1000
## Calculate kg C/m3 by mulitplying by %C/100
C_kg_m3 <- bulkD_kg_m3 * Sed_data$perc_C[Sed_data$Description=="sed"] / 100
mean_C_kg_m3 = mean(C_kg_m3, na.rm = TRUE)
## Calculate total mass of carbon exported.  (UAV volume in m3, which is multiplied by C kg/m3)
Total_C_export <- Volume_data$Volume_m3 * mean_C_kg_m3
## Convert amount of carbon from kg to tonnes
Tonnes_C_export <- Total_C_export * 0.001
#plot(Tonnes_C_export)
#lines(Tonnes_C_export)

Volume_C_data <-  as.data.frame(cbind(Volume_data, Tonnes_C_export))
Volume_C_data$Date <- as.Date(Volume_C_data$Date, format="%d-%m-%Y")
```

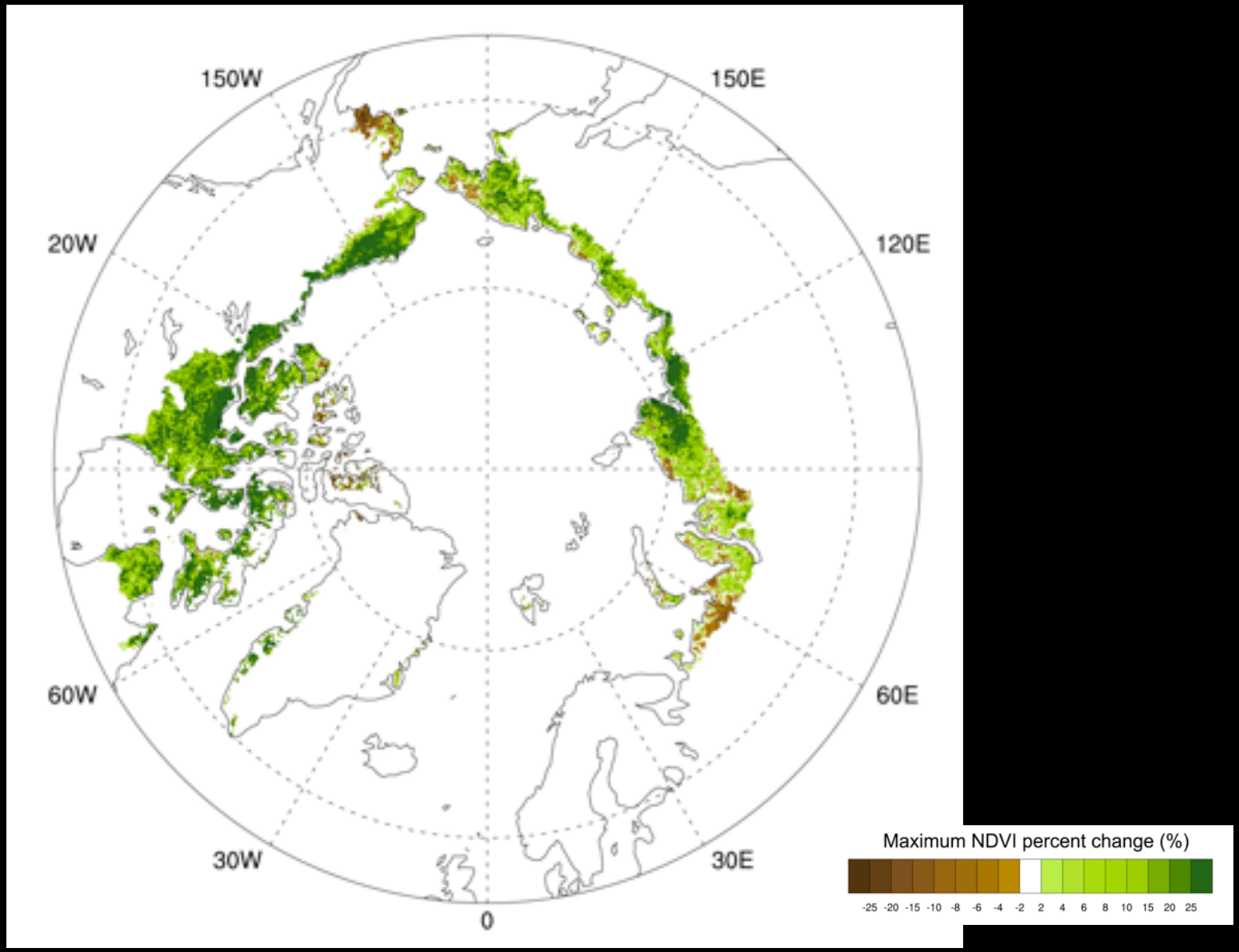
	Date	Volume_m3	Uncertainty	Area_m2	Tonnes_C_export
1	2016-07-29	29173.74	295	6342	463.2041
2	2017-06-13	32054.33	345	7163	508.9405
3	2017-08-31	40289.73	477	8806	639.6975
4	2018-06-07	40636.51	393	9006	645.2035
5	2018-08-29	47508.89	445	10267	754.3193

Temperature Change



NCEP-NCAR, generated online at www.cdc.noaa.gov

Arctic Vegetation Change



Epstein et al., 2013 - http://www.arctic.noaa.gov/reportcard/vegetation.html